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Department of Natural Resources
Coastal Restoration Division and
Coastal Engineering Division

2004 Operations, Maintenance, and Monitoring Report

for

ISLES DERNIERES RESTORATION EAST ISLAND

State Project Number TE-20
Priority Project List 1

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Terrebonne Parish

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2004 Operations, Maintenance, and Monitoring Report
For
East Island (TE-20)

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I. Introduction

East Island is part of the Isles Dernieres barrier island chain and is located along the southern Louisiana coast in Terrebonne Parish at 29^{o} 03' 41" N and 90^{o} 39' 35" W (figure 1). The Isle Dernieres, which separate Terrebonne Bay, Lake Pelto, and Caillou Bay from the Gulf of Mexico, is a 20 mile (32 km) long island arc segmented into four islands: Raccoon Island, Whiskey Island, Trinity Island, and East Island (McBride et al. 1989). Like all of Louisiana's barrier islands, East Island is experiencing island narrowing and land loss as a consequence of a complex interaction among global sea level rise, compactual subsidence, wave and storm processes, inadequate sediment supply, and significant anthropogenic disturbances (Penland et al. 1988, McBride et al. 1989, Penland and Ramsey 1990, List et al. 1997).

The Louisiana deltaic plain is fronted by a series of headlands and barrier islands that were formed as a result of the Mississippi River deltaic cycle. The Isles Dernieres is a barrier island arc transformed from the abandonment of the Caillou headland (part of the Lafourche delta complex), which occurred approximately 500 years B.P. (Frazier 1967, Penland and Boyd 1985). Following deltaic abandonment, headland sand deposits were reworked and deposited longshore forming flanking barriers (Penland et al. 1988). Submergence of the abandoned delta separated the headland from the shoreline forming the barrier island arc. The transgressive island arc cannot keep pace with the high rate of relative sea level rise and will eventually become an inner-shelf shoal (Penland et al. 1988).

Currently, the Isles Dernieres arc is exhibiting some of the highest rates of erosion of any coastal region in the world (Khalil and Lee *in press*). Erosional models have estimated that the Isles Dernieres would gradually narrow, fragment, and transgress through time eventually becoming subaqueous sand shoals between 2007 (McBride et al. 1991) and 2019 (Penland et al. 1988) unless restoration efforts are made. Between 1887 and 1988 the average annual rate of land loss was 69.6 ac yr^{-1} (28.2 ha yr^{-1}) while the average rate of shoreline retreat has been estimated between 36.4 – 60.4 ft yr^{-1} (11.1 – 18.4 m yr^{-1}; McBride et al. 1989, McBride et al. 1991). Between 1978 and 1988, shoreline erosion was even as high as 116.6 ft yr^{-1} (47.2 ha yr^{-1}; McBride et al. 1989). East Island has decreased in area from 432.4 acres (175 ha) in 1978 to 212.5 acres (86 ha) in 1988. These conditions have led to the rapid landward migration, termed barrier island rollover, and disintegration of the Isles Dernieres as well as a decrease in the ability of the island chain to protect the adjacent mainland marshes and wetlands from the effects of storm surge, saltwater intrusion, an increased tidal prism, and energetic storm waves (McBride and Byrnes 1997).

TE-20 (East Island) is considered Phase 0 of the Isles Dernieres Restoration Plan. This plan was designed to restore this barrier island in the Isles Dernieres chain in Terrebonne Parish, Louisiana by increasing the elevation and width of the island, closing existing breaches, and restoring back barrier marshes. The East Island Restoration project created approximately 242 acres (98 hectares) of dunes and wetland including supratidal (beach, dune, barrier flat) and

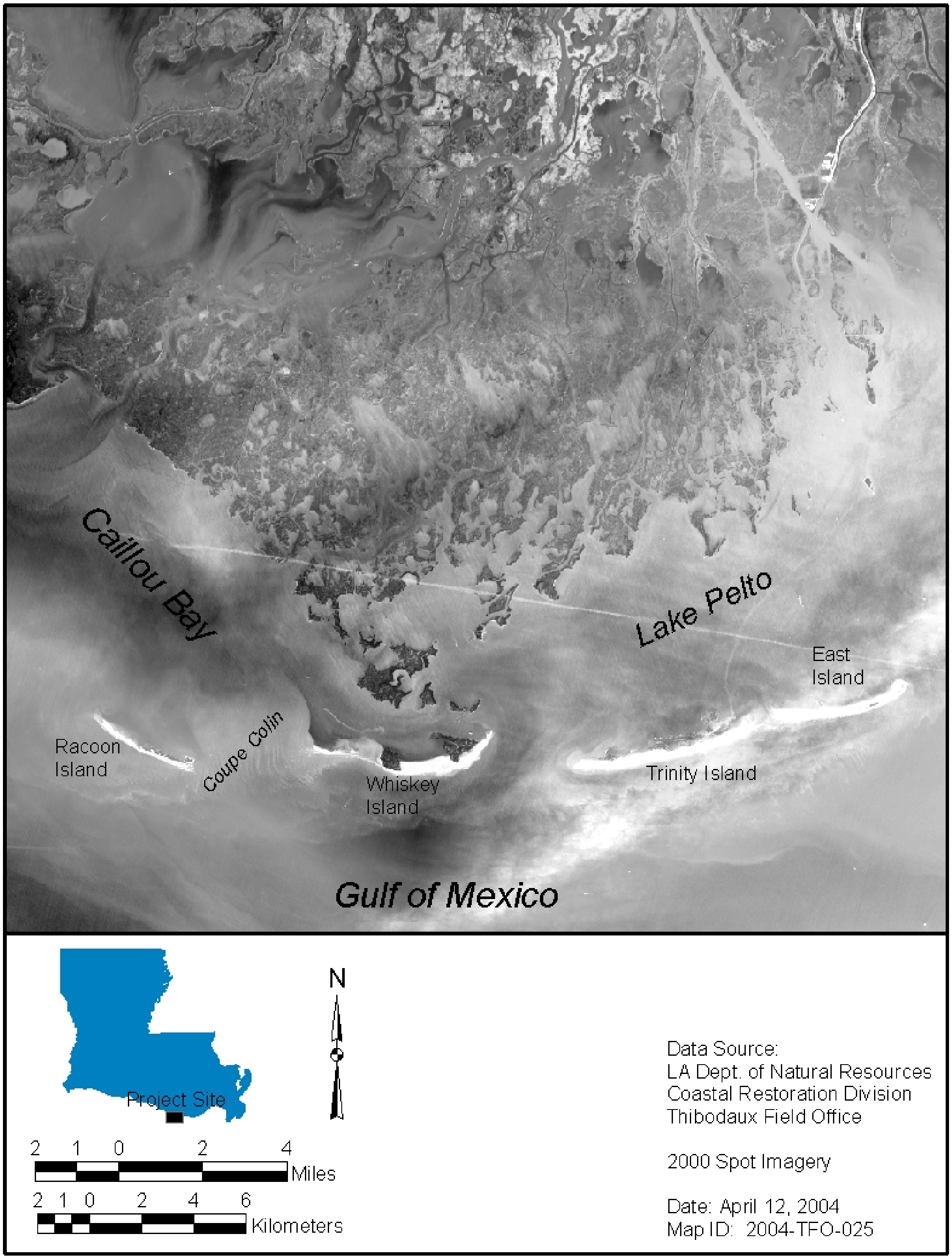

Figure 1: Isles Dernieres islands, Terrebonne Parish, Louisiana.

intertidal (beach, marsh) habitat using sediments dredged from Whiskey Pass (figure 2). Sand fencing was constructed on the gulf side of the dune to trap blowing sand and to minimize wind-driven export of sediment (figure 3). Sand fencing was oriented across the width of the island in a southwest to northeast direction. The sediment transferal phase of the construction of the East Island Restoration project commenced January 19, 1998 and was completed October 31, 1998. Approximately 3.9 million cubic yards (3.0 million m^3) of sediment were dredged from the borrow area just north of the east side of the island and placed on East Island. Target elevations ranged from +2 ft (0.6 m) to +8 ft (2.4 m) North American Vertical Datum of 1988 (NAVD 88). Immediately post-dredging, aerial seeding with *Cynodon dactylon* (Bermuda grass) was conducted.

During the second phase of construction, vegetation was planted between May 26 and June 18, 1999 to stabilize the emplaced sediment on the newly created dune area, in the back-bay area, and on spurs from the dune area across the island to the back-bay area. Hand-planted vegetation included *Spartina patens* (marshhay cordgrass), *Spartina alterniflora* (smooth cordgrass), and *Panicum amarum* (bitter panicum). In total, 12,075 *S. alterniflora*, 5,431 *S. patens*, and 5,431 *P. amarum* were planted. The first vegetation sampling was conducted August 26 and 31, 1999 and additional vegetation sampling occurred September 18, 2001 and September 16, 2003.

II. Maintenance Activity

This project has no operations and maintenance budget and no maintenance has been done.

III. Operation Activity

This project has no operations and maintenance budget and no operations are required.

IV. Monitoring Activity

a. Monitoring Goals

The objectives for the Isles Dernieres Restoration Phase 0 (East Island) project were to restore the coastal dunes of East Island and reduce loss of sediment as well as enhance the physical stability of East Island by utilizing hand planted vegetation.

The following goals will contribute to the evaluation of the above objectives:

1. Increase the height and width of the eastern and central section of East Island and close breaches using dredged sediments.

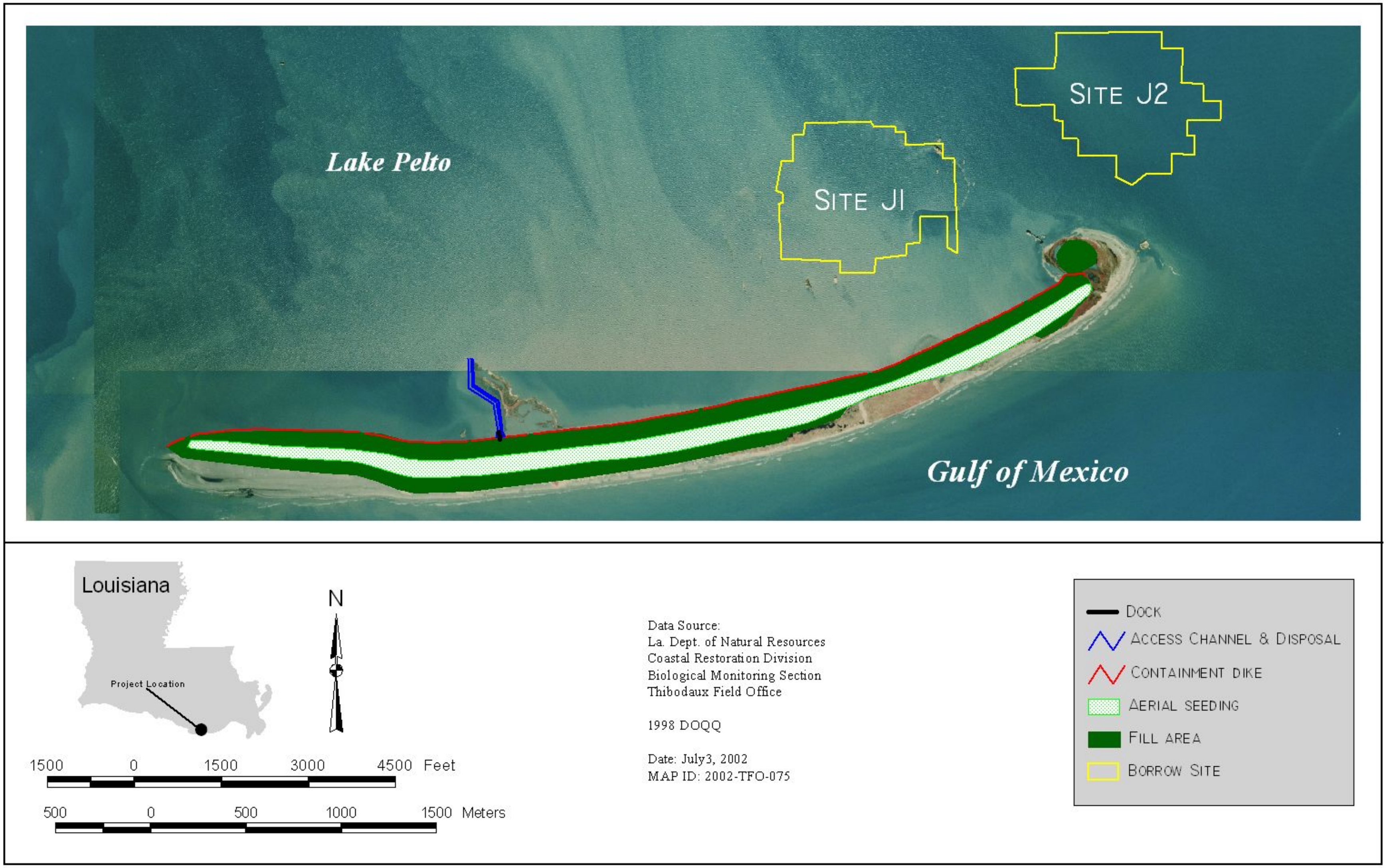

Figure 2: Isles Dernieres Restoration East Island (TE-20) project area showing fill areas, aerial seeding sites, and borrow sites.

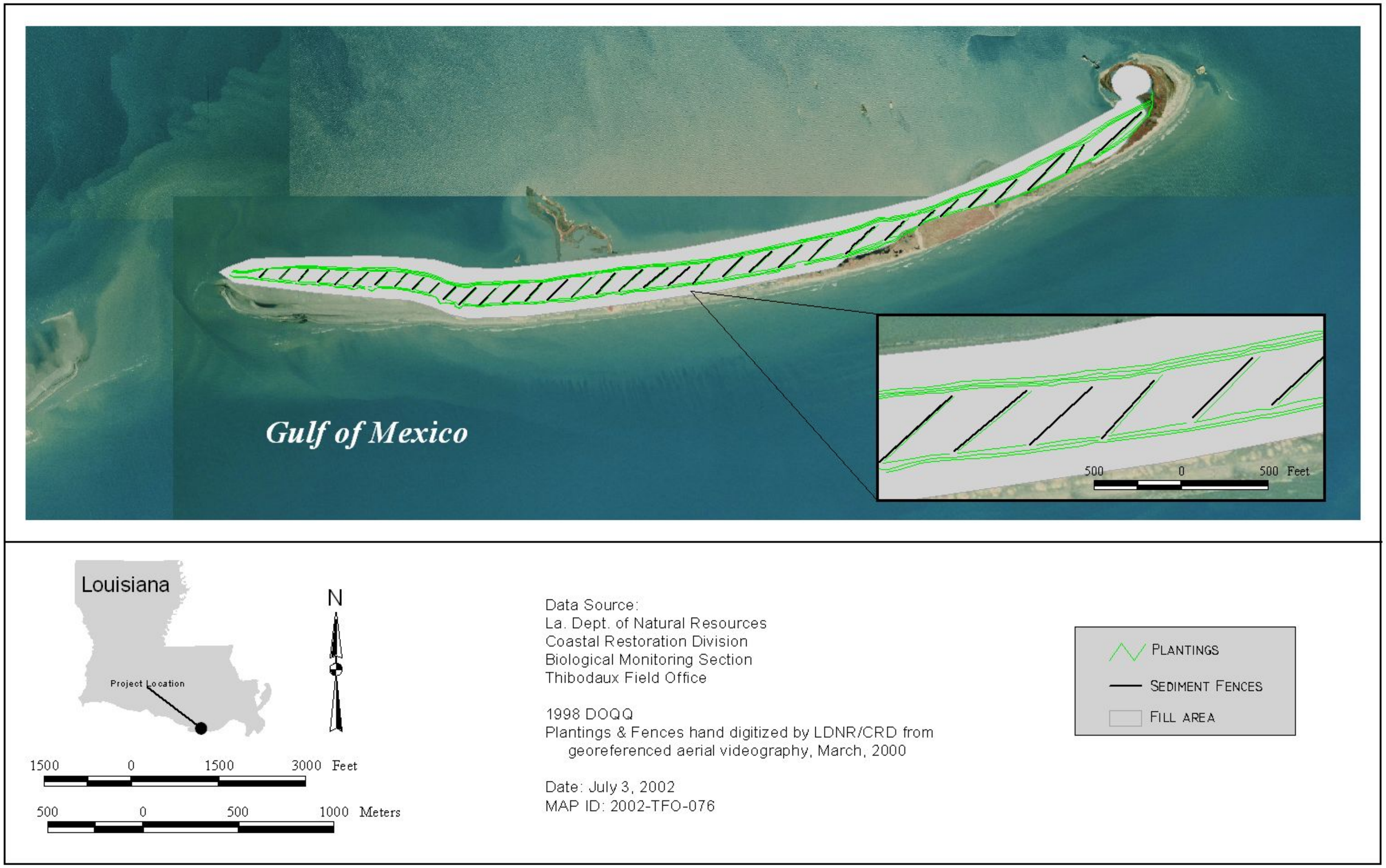

Figure 3: Location of fill area, orientation and location of sediment fences, and position of vegetation plantings.

2. Reduce loss of sediment through vegetative plantings therefore increasing the stability of the island.

b. Monitoring Elements

Aerial Photography

The 1993, 1994, and 1997, near vertical color-infrared 1:12,000 scale aerial photography, obtained by the United States Geological Survey/National Wetlands Research Center (USGS/NRWC) was checked for flight accuracy, color correctness, and clarity. The original film was archived and duplicate photography was indexed and scanned at 300 dots per inch. Using ERDAS Imagine[7], an image processing and geographic information systems (GIS) software package, individual frames of photography were geo-rectified using a real-time differentially corrected global positioning system (DGPS) data with sub-meter accuracy. These rectified frames were then assembled to produce a mosaic for the island. This mosaic provides a pre-construction picture of the island. Due to budgetary constraints and project goals and objectives, photography and analysis was removed from the project monitoring.

During April and November 2002, Coastal Research Laboratory, University of New Orleans (UNO) acquired color-infrared (CIR) aerial photographs of the project area [and also for Trinity Island (TE-24), Whiskey Island (TE-27), East Timbalier Phase 1 (TE-25), and East Timbalier Phase 2] for the purpose of Adaptive Management Review of constructed projects and post hurricane Lili assessments. Habitat analysis was conducted and change comparisons were provided by UNO to 1996 photography.

Elevation

To document both horizontal and vertical change along the constructed area of East Island, transect lines were established at 200 ft (60.9 m) intervals by professional surveyors before construction. Elevation was determined every 100 ft (30.5 m) across the island along each transect. Post-construction (as-built) surveys were conducted in December 1998 to correspond with vegetation sampling and to avoid disturbance of nesting birds on the island. Beginning in 2000, airborne light detection and ranging (LiDAR) surveys replaced conventional on-the-ground surveys. Airborne LiDAR surveys collect data along lines the entire length of the island versus the traditional transects used in conventional surveys. LiDAR surveys were conducted in October 2000 by Morris P. Hebert, and again in 2001 and 2002 by USGS. LiDAR surveys will be repeated in 2007 and 2016. Data collected was used to develop elevational triangulation-based (TIN) surface generation models and subsequent Grid models in ArcView®. Difference grids were created by subtracting earlier grids from succeeding grids. Volume change for these difference grids as well as volume for each of the 2000, 2001, and 2002 LiDAR grids were calculated with the cut/fill calculator in the LiDAR data handler extension of ArcView®. All grids were clipped to the same area as volume calculations that include areas with no data cannot be performed. The 2000 LiDAR survey has ± 10 cm accuracy while surveys performed in 2001 and 2002 have ± 15 cm accuracy (Sallenger et al. 2003). LiDAR grids were not filtered for vegetation.

Vegetation

Species composition and percent cover of vegetation in three treatments, spur, bay, and unplanted areas, were determined using the Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974) as described in Steyer et al. (1995). Species in 4 m^2 plots were recorded, and visual estimates of percent cover for the total plot and individual species were made. Cover classes used were: solitary, <1%, 1-5%, 6-25%, 26-50%, 51-75%, and 76-100%. Vegetation outside of each plot but within 33 ft (10 m) were also identified and recorded. Vegetation plots were chosen randomly in the planted areas (spur and bay). Each plot was established in August 1999 using a vegetation station marker stake as its southeast corner and plots were oriented in a North-South direction. Unplanted treatment plots were established between the spurs, using randomly chosen distances from the spur plots. Unplanted, bay, and spur treatments numbered 6, 12, and 10, respectively. Planted vegetation consisted of *P. amarum* and/or *S. patens* in the spur plots and *S. alterniflora* in the bay plots. Differential Global Positioning System (DGPS) coordinates were also collected at each stake to facilitate re-establishment of stations in the future. Vegetation sampling for each of the bay, spur, and unplanted 4 m^2 plots continued in September 2001 and 2003. Field personnel made visual estimates of percent cover for the total plot and each individual species. If a plot was unable to be located (i.e., the marker stake was gone), a new plot was established. However, a new plot was not established if the original plot was now underwater or had eroded. In these cases, percent cover was recorded as 100% open water for data analysis.

Importance values were calculated by adding the relative percent cover to the relative frequency for each species (Courtemanche et al. 1999). Mean importance values were determined by separating species into categories of planted, seeded, appearance via natural vegetative recruitment or re-colonization, and bare ground. Importance values provide a useful and more realistic measure of dominance. Plots located in open water were not used in importance value calculations.

c. Preliminary Monitoring Results and Discussion

Aerial Photography

Analysis done by UNO indicated that the project contributed to a 187.3 acre increase in the overall size of the island from pre- to post-construction (1996 to May 2002) (table 1). Penland et. al. (2003) stated that this project's gains accounted for a predicted 25 year increase in island longevity. However, after Tropical Storm Isidore and Hurricane Lili in 2002, post-storm photography showed 91.04 acres of land loss, or approximately one-half of the initial gains, to a total land mass of 289.34 acres. This extreme loss still allows for an almost doubling of the islands size since 1996 (table 1).

Elevation

Currently, we are still in the process of converting pre-construction and as-built survey data collected via conventional survey methods to the Louisiana Department of Natural Resources-South Louisiana Coastal Wetland GPS network datum. LiDAR surveys conducted in 2000, 2001, and 2002 displayed that initially East Island along with the other Isles Dernieres may have been gaining volume prior to Tropical Storm Isidore (September 2002) and Hurricane Lili (October 2002) striking the island (figure 4). Calculated changes for East Island include a 7% increase in volume between 2000 and 2001 and a 15% decrease between 2001 and 2002 surveys. These percentage changes in volume are consistent with other Isles Dernieres projects (see figure 4; West 2007a, b).

Vegetation

Initial monitoring indicated that fences have accumulated sand to create dunes, and that vegetation survival was high (>70%) after one growing season (Belhadjali et al. 2002). Vegetation survival was attributed to uncharacteristic low precipitation levels between initial planting and vegetation sampling (Townson et al. *Unpublished*). Percent survival was not measured in 2001 or 2003. Percent cover of vegetation in 1999 was low (<20%) indicating that an alternate planting design needs to be considered in future projects to maximize

Table 1: Habitat classification acreages for 1996 and 2002 Photography by UNO.

Classification	1996	5/14/2002	11/7/2002
beach	136.48	111.23	55.04
bare	0.60	213.36	198.77
marsh	39.57	18.17	9.33
barrier vegetation	16.35	37.62	26.20
structure	0.37	0.46	0.30
rip rap	0.00	0.06	0.02
intertidal	65.75	22.93	205.44
total land only	***192.99***	***380.38***	***289.34***

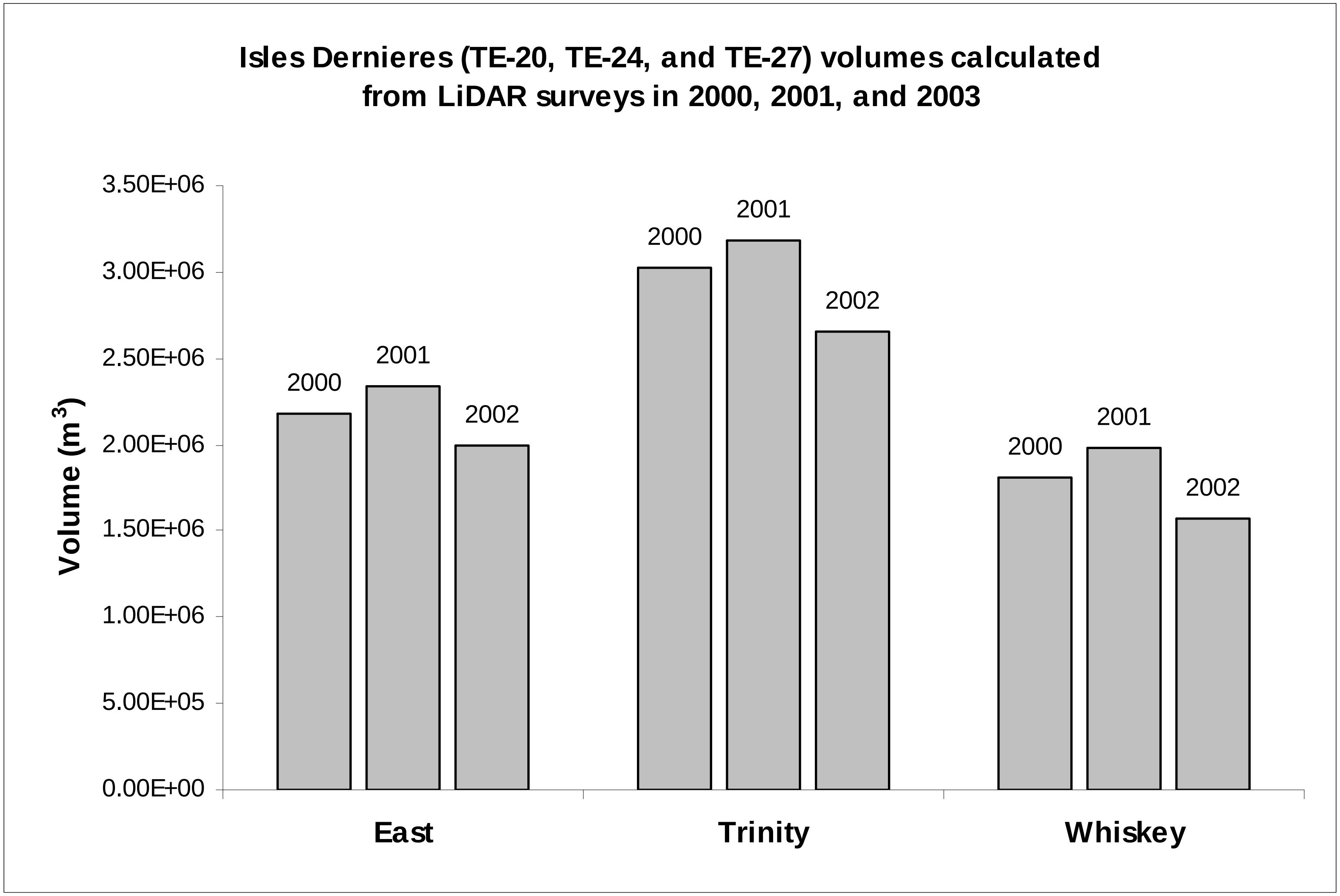

Figure 4: Volumes of East, Trinity, and Whiskey Isles Dernieres calculated from grids created from LiDAR surveys in ArcView®.

cover of bare sediment faster (Belhadjali et al. 2002). A subsequent sampling trip in 2001 revealed that vegetative cover was dominated by the planted and aerially-seeded vegetation. Percent cover may be attributed to several variables including precipitation, elevation, soil type, or soil nutrients (Townson et al. *Unpublished*).

Nine of the 12 bay plots in 2001 and all the plots in 2003 were under water at the time of the vegetative sampling trips (figure 5). These results suggest that East Island continues to narrow and to experience considerable erosion. In 2003, vegetation percent cover was 33.5% in unplanted plots and 48.9% in spur plots. Percent cover of bare ground tended to decrease with each subsequent year in unplanted and spur plots.

The only planted vegetation evident in 2003 was *P. amarum* with an 18.6% mean cover among spur plots. *S. patens* appeared in one-third of the unplanted plots which were previously dominated by *C. dactylon* in 1999 and 2001. These results suggest that *S. patens* has been successfully established on the island and is dispersing well. Non-planted and non-seeded vegetation colonization increased in both spur and unplanted plots from <1% cover in 2001 to >23% in 2003. The species in 2003 included *Eustoma exaltatum* (catchyfly prairie gentian), *Heliotropium curassavicum* (seaside heliotrope), *Croton punctatus* (beach tea), and *Strophostyles helvula* (trailing fuzzy bean) for the unplanted plots and *Sabatia stellaris* (annual small salt marsh pink) in the spur plots (table 2). *Heterotheca subaxillaris* (camphorweed) was observed in both unplanted and spur plots beginning in 2003. *C. dactylon*, which was aerially-seeded post construction in 1999, was rare (~0.7%) in both spur and unplanted plots in 2003 (a one order of magnitude decrease from 2001).

Vegetation sampling within the 4 m^2 plot consistently underestimated species richness as compared to the surrounding 10 ft (33 m) of the plot (figure 6). This result may indicate an insufficient number of plots established to accurately characterize the vegetative communities on the island. However, there was an observed increase in species richness with each successive sampling trip. The appearance of vegetation colonization via natural means resulted in an increased importance value in 2003 (figure 7). Bare ground importance value decreased with each sampling trip. These results indicate that as time increases after initial construction, more and more species are re-colonizing the island and displacing some of the seeded and planted species. These findings are consistent with observations at Trinity Island (West 2007a).

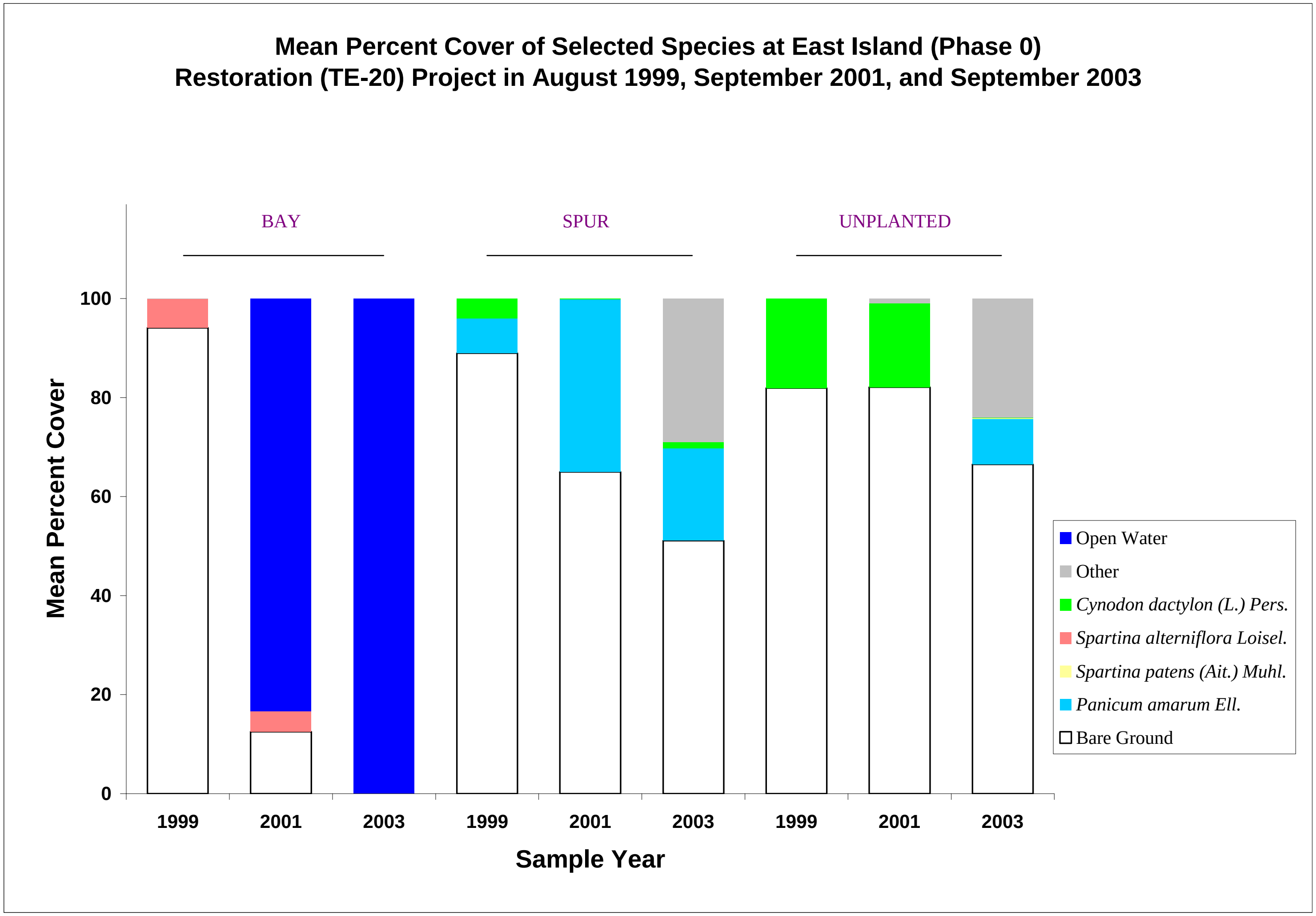

Figure 5: Mean percent cover for selected vegetation species at East Island Restoration (TE-20).

Table 2: Estimated mean percent cover for all species occurring during the 1999, 2001, and 2003 sampling of the 2x2 m Braun-Blanquet vegetation plots at East Island.

	Bay					
	1999		2001		2003	
	% Stations	Mean Cover	% Stations	Mean Cover	% Stations	Mean Cover
Bare Ground	100.00	94.08	16.67	75.00		
Baccharis halimifolia L.						
Conyza canadensis (L.) Cronq.						
Croton punctatus Jacq.						
Cynodon dactylon (L.) Pers.						
Cyperus oxylepis Nees ex Steud.						
Eustoma exaltatum (L.) Salisb. ex G. Don						
Heliotropium curassavicum L.						
Heterotheca subaxillaris (Lam.) Britt. &						
Panicum amarum Ell.						
Panicum repens L.						
Sabatia stellaris Pursh						
Sesuvium portulacastrum (L.) L.	8.33	1.00				
Solidago sempervirens L.						
Spartina alterniflora Loisel.	83.33	7.00	8.33	50.00		
Spartina patens (Ait.) Muhl.						
Strophostyles helvula (L.) Ell.						
Open Water			83.33	100.00	100.00	100.00

Table 2 cont.

	Spur					
	1999		2001		2003	
	% Stations	Mean Cover	% Stations	Mean Cover	% Stations	Mean Cover
Bare Ground	100.00	88.60	100.00	66.44	81.82	51.11
Baccharis halimifolia L.					9.09	25.00
Conyza canadensis (L.) Cronq.						
Croton punctatus Jacq.						
Cynodon dactylon (L.) Pers.	60.00	6.67	33.33	0.50	18.18	5.50
Cyperus oxylepis Nees ex Steud.					9.09	30.00
Eustoma exaltatum (L.) Salisb. ex G. Don						
Heliotropium curassavicum L.						
Heterotheca subaxillaris (Lam.) Britt. &					18.18	15.05
Panicum amarum Ell.	100.00	7.00	100.00	35.61	63.64	24.00
Panicum repens L.						
Sabatia stellaris Pursh					18.18	7.50
Sesuvium portulacastrum (L.) L.						
Solidago sempervirens L.						
Spartina alterniflora Loisel.						
Spartina patens (Ait.) Muhl.						
Strophostyles helvula (L.) Ell.					63.64	23.00
Open Water						

Table 2 cont.

	Unplanted					
	1999		2001		2003	
	% Stations	Mean Cover	% Stations	Mean Cover	% Stations	Mean Cover
Bare Ground	83.33	82.00	100.00	81.33	85.71	66.50
Baccharis halimifolia L.			16.67	0.10		
Conyza canadensis (L.) Cronq.			16.67	2.00	14.29	1.00
Croton punctatus Jacq.			33.33	0.10	14.29	5.00
Cynodon dactylon (L.) Pers.	83.33	18.10	100.00	16.75	14.29	1.00
Cyperus oxylepis Nees ex Steud.			16.67	0.10		
Eustoma exaltatum (L.) Salisb. ex G. Don					14.29	1.00
Heliotropium curassavicum L.					14.29	1.00
Heterotheca subaxillaris (Lam.) Britt. &					42.86	7.00
Panicum amarum Ell.					42.86	18.33
Panicum repens L.			16.67	0.50		
Sabatia stellaris Pursh						
Sesuvium portulacastrum (L.) L.						
Solidago sempervirens L.			16.67	3.00		
Spartina alterniflora Loisel.						
Spartina patens (Ait.) Muhl.					28.57	0.55
Strophostyles helvula (L.) Ell.					71.43	23.00
Open Water						

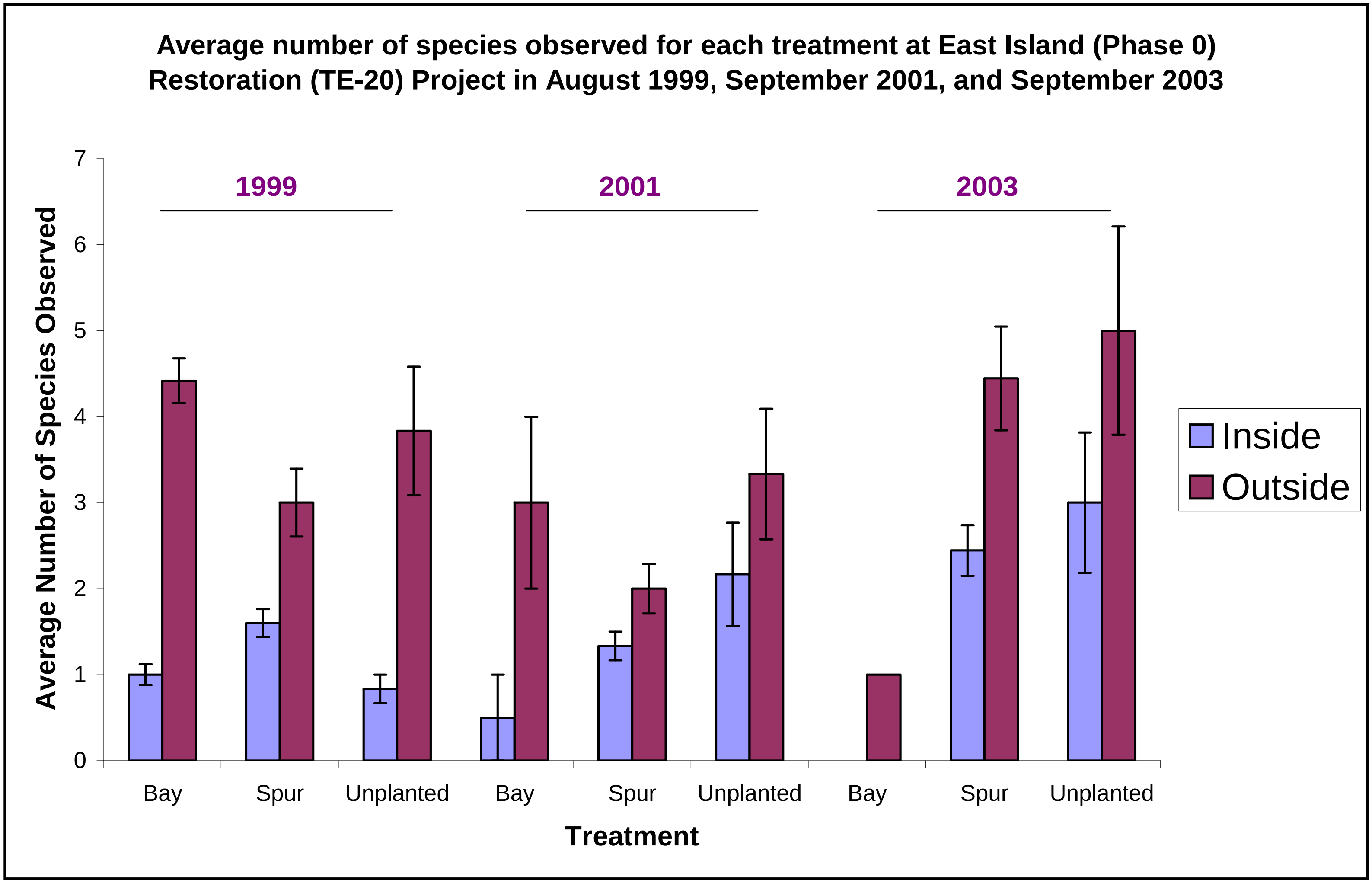

Figure 6: Average number of different vegetation species recorded inside and outside of each 4 m^2 plot at East Island Restoration (TE-20). Error bars represent one standard deviation from the mean.

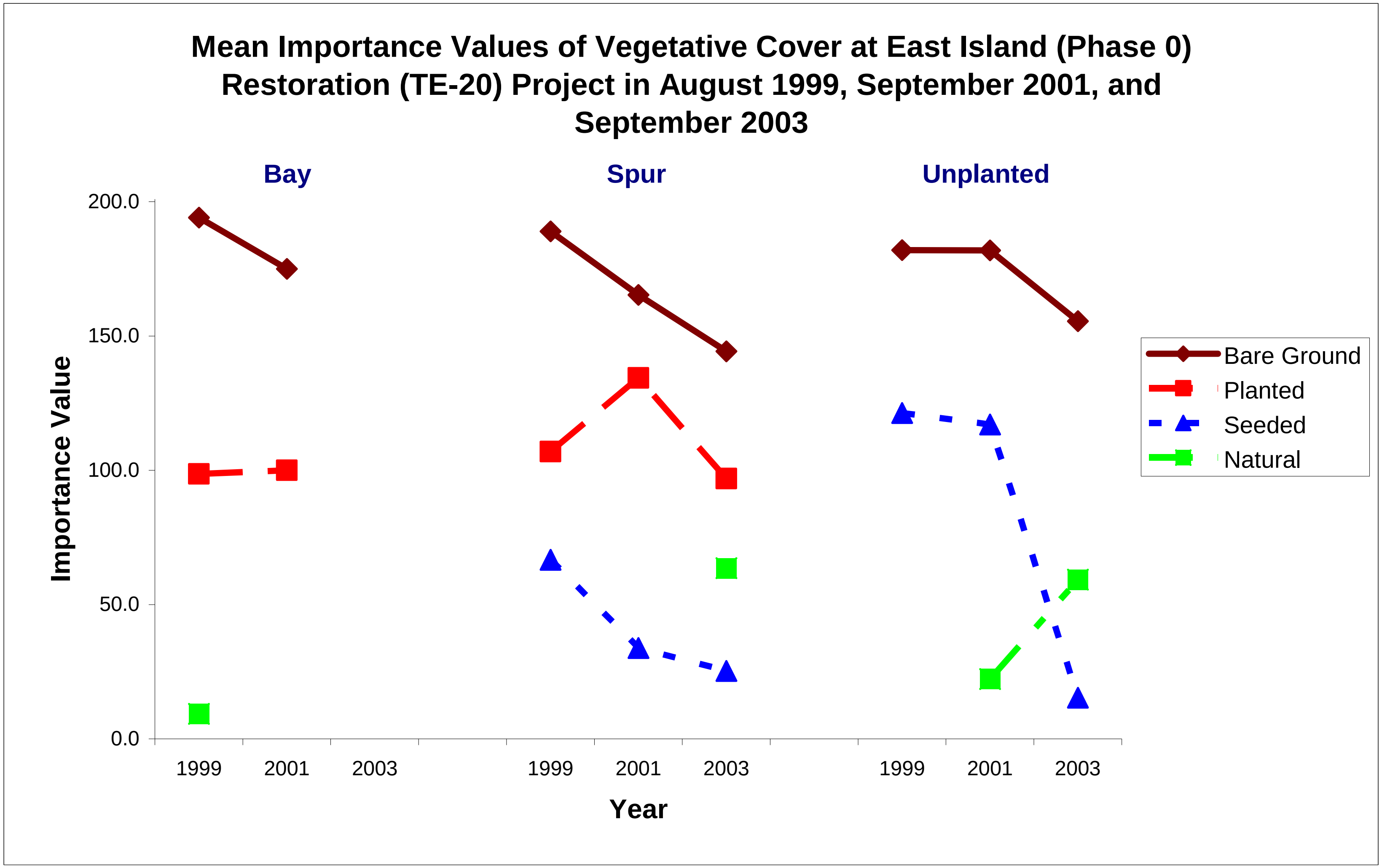

Figure 7: Mean importance values of different vegetation categories calculated at East Island Restoration (TE-20). The term natural represents species that were neither planted nor seeded and assumed colonized via natural means.

V. Conclusions

a. Project Effectiveness

Preliminary observations alleged that this project was effective at reducing barrier island erosion. Khalil and Lee (*in press*) reported that sand fencing aided in the trapping of sand and the formation of dunes prior to site visits in 2003. However, subsequent sampling trips, especially those after Tropical Storm Isidore and Hurricane Lili, revealed a considerable loss of land and volume. The loss of the bay plots, in particular, to open water was probably due to the narrowing of the island as well as back marsh subsidence and concomitant sea-level rise. LiDAR results after Isidore and Lili further help to support these findings and provide evidence of elevational/volume decreases.

An increase in the number of species in vegetation plots does suggest that planting along the spurs helped to anchor fill material and sand in place as well as to allow native vegetation to disperse into newly created habitat. The increase in vegetative cover each year (except in dune plots) may also be indicative of some success at project effectiveness. Species richness also increased in the spur and unplanted treatments suggesting that as the emplaced sediment ages, more native barrier island species are able to re-colonize the island. However, landward migration may continue and future sampling trips may yield more losses of vegetation stations to open water.

This project may have succeeded its goal of increasing the height and volume of the island prior to the compounding effects of Isidore and Lili. Although some sediment was lost, this island did not become subaqueous due to proactive sediment fill and maintained some protection for mainland areas from these storms. Increases in species richness and vegetative cover in some areas of the island may further promote sediment stability facilitate further synergistic effects of vegetation growth and volume maintenance.

b. Recommended Improvements

Funding for maintenance of barrier island restoration projects was not considered due to the expense involved with replenishment of dredge material over the life expectancy of the project. In forgoing the funding of a barrier island maintenance program to replenish sediment lost to normal storm events, claims for FEMA assistance resulting from extensive or catastrophic storm damage to barrier islands from unexpected storms events such as tropical storms and hurricanes are considered ineligible. Based on monitoring activity of these islands, it has been documented that these barrier island are experiencing significant land loss due to barrier island rollover and island narrowing resulting from such unexpected storm events. Therefore, it is recommended that maintenance funds be provided for the implementation of an inspection and maintenance program for assessment and replacement of dredged sediment and sand fencing necessary to maintain the integrity of these islands. The implementation of a maintenance program for barrier island projects would enable these projects to qualify for assistance under the Federal Emergency Management Program.

c. Lessons Learned

Initial lessons learned include adjusting the establishment of planting survival plots to better analyze the yearly success of planted vegetation (cf. Townson et al. *Unpublished*). This adjustment can include resizing plots or increasing the number of the plots established. Increasing the number of the established plots may also help accurately characterize the vegetative communities on the island.

The use of dredged sediment, sand fencing, and vegetative plantings are plausible ways to create quasi-stabilization and further prolong the lives of barrier islands. These three techniques should be used in conjunction and the construction of sand fencing as well as vegetative planting should occur as soon as possible after the placement of dredged sediment to minimize soil loss. Furthermore, a different vegetative planting design must be determined to allow vegetative colonization in a sufficient time frame as to maximize sediment stabilization.

Barrier islands are often exposed to storm events resulting in substantial over-wash and breaching. To combat these processes, it is important that a continuous dune of sufficient height and width is maintained on these islands. Other than periodically replenishing sediment by hydraulic dredge, sand fencing has proven to be an effective technique in rebuilding dunes by capturing wind blown sediment. We have learned from past projects that orienting the sand fencing parallel to the shore face and perpendicular to the predominant wind direction has maximized the potential for maintaining a viable dune section.

VI. References

Belhadjali, K., C.F. Robertson, and K.R. Balkum. 2002. Coastal Restoration Division Annual Project Reviews: December 2002. Louisiana Department of Natural Resources, Baton Rouge, LA. 96 pp.

Courtemanche, R.P., M.W. Hester, and I.A. Mendelssohn. 1999. Recovery of a Louisiana barrier island marsh plant community following extensive hurricane-induced overwash. Journal of Coastal Research 15:872-883.

Frazier, D.E. 1967. Recent deposits of the Mississippi River, their development and chronology. Transactions, Gulf Coast Association of Geological Societies 17: 287-311.

Khalil, S.M. and D.M. Lee. *In Press*. Restoration of Isles Dernieres, Louisiana: some reflections on morphodynamic approaches in the northern Gulf of Mexico to conserve coastal/marine systems. Journal of Coastal Research.

List, J.H., B.E. Jaffe, A.H. Sallenger, and M.E. Hansen. 1997. Bathymetric comparisons adjacent to the Louisiana barrier islands: processes of large scale change. Journal of Coastal Research 13:670-678.

McBride, R.A., and M.R. Byrnes 1997. Regional variations in shore response along barrier island systems of the Mississippi River Delta Plain: historical change and future prediction. Journal of Coastal Research 13: 628-655.

McBride, R.A., M.W. Hiland, S. Penland, S.J. Williams, M.R. Byrnes, K.A. Westphal, B.E. Jaffee, and A.H. Sallenger, Jr. 1991. Mapping barrier island changes in Louisiana: techniques, accuracy, and results. Seattle, WA: Coastal Sediments '91 Proceedings. pp 1011-1025.

McBride, R.A., S. Penland, B.E. Jaffe, S.J. Williams, A.H. Sallenger, and K.A. Westphal. 1989. Erosion and deterioration of the Isles Dernieres barrier island arc-Louisiana, U.S.A.: 1853-1988: Transactions of the Gulf Coast Association of Geological Societies 39:431-444.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York. 547 pp.

Penland, S., P. Conner, F. Cretini, and K. Westphal. 2003. CWPPRA adaptive management: Assessment of five barrier island restoration projects in Louisiana. Prepared for LA Dept. Natural Resources, Office of Coastal Restoration and Management, Baton Rouge, LA by the Pontchartrain Institute for Environmental Sciences, Univ. of New Orleans. New Orleans, LA. 64 pp + appendices

Penland, S., and R. Boyd. 1985. Transgressive depositional environments of the Mississippi River delta plain: A guide to the barrier islands, beaches and shoals of Louisiana: Louisiana Geological Survey Guidebook Series No. 3, 233 pp.

Penland, S. and K.E. Ramsey. 1990. Relative sea-level rise in Louisiana and the Gulf of Mexico: 1908-1988. Journal of Coastal Research 6:323-342.

Penland, S., J.R. Suter, and R. Boyd. 1988. The transgressive depositional systems of the Mississippi River delta plain: A model for barrier shoreline and shelf sand development. Journal of Sedimentary Petrology 58:932-949.

Sallenger, A.H., W.B. Krabill, R.N. Swift, J. Brock, J. List, M. Hansen, R.A. Holman, S. Manizade, J. Sontag, A. Meredith, K. Morgan, J.K. Yunkel, E.B. Frederick, and H. Stockdon. 2003. Evaluation of airborne topographic LiDAR for quantifying beach changes. Journal of Coastal Research. 19:125-133.

Steyer, G.D., R.C. Raynie, D.L. Steller, D. Fuller and E. Swenson. 1995. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.

Townson, M.A., C.K. Armbuster, and N. Clark. *Unpublished*. Isles Dernieres Restoration Project Phase 0 (TE-20) Progress Report.

West, J.L. and D. Dearmond. 2007a. 2004 Operations, Maintenance, and Monitoring Report for Isles Dernieres Restoration Trinity Island, *Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana.* 21pp.

West, J.L. and D. Dearmond. 2007b. 2004 Operations, Maintenance, and Monitoring Report for Whiskey Island Restoration (TE-27), *Louisiana Department of Natural Resources, Coastal Restoration Division, Thibodaux, Louisiana.* 23pp.