Journal of Coastal Research	7	1	137–149	Fort Lauderdale, Florida	Winter 1991

Experimental Dune Building and Vegetative Stabilization in a Sand-Deficient Barrier Island Setting on the Louisiana Coast, USA

Irving A. Mendelssohn, Mark W. Hester, Frank J. Monteferrante[†], and Fay Talbot[‡]

Laboratory for Wetland Soils and Sediments
Center for Wetland Resources
Louisiana State University
Baton Rouge, LA 70803, U.S.A.

ABSTRACT

MENDELSSOHN, I.A.; HESTER, M.W.; MONTEFERRANTE, F.J., and TALBOT, F., 1990. Experimental dune building and vegetative stabilization in a sand-deficient barrier island setting on the Louisiana coast. *Journal of Coastal Research*, 7(1), 137–149. Fort Lauderdale (Florida). ISSN 0749-0208.

The first large-scale dune building and stabilization project in Louisiana that utilized sand fencing to stimulate sand accretion was established on Timbalier Island, a sand-deficient barrier island of the Louisiana coast, in May 1981 and evaluated through August 1984. Along a 305 m length of beach three types of sand fencing orientation and three species of dune plants were tested. This study demonstrated that dune building and vegetative stabilization are possible in Louisiana's subsiding and sand-deficient coastal environment, although rates of sand accumulation were lower than in coastal areas with plentiful sand supplies. Straight sand fencing oriented parallel to the beach with perpendicular side spurs initially accumulated the most sand. However, after 27 months straight sand fencing (without perpendicular side spurs) placed either parallel or diagonal to the beach accumulated the most sand. Vegetative plantings without sand fencing accumulated very little sand. Of the three dune species planted, *Panicum amarum* had the highest survival rate. *Uniola paniculata* had a lower survival rate that was, however, comparable to those found in other studies. *Paspalum vaginatum* had the lowest survival rate.

Although a dune can effectively be created with sand fencing and stabilized vegetationally in Louisiana, beach nourishment is apparently necessary to maintain the created dune since coastline retreat is inevitable in this sand-deficient and subsiding environment.

ADDITIONAL INDEX WORDS *Barrier island, beach, erosion, sand fencing, vegetation,* Uniola paniculata, Panicum amarum, Paspalum vaginatum.

INTRODUCTION

Over the past 7500 years, the Mississippi River has built an extensive coastal plain consisting of six major delta complexes (FRAZIER, 1967). Two of these delta complexes, the Atchafalaya and the Balize, are active and are presently building seaward. The other four have been abandoned by the Mississippi River or its distributaries and are undergoing delta destruction. Barrier islands in Louisiana form as a consequence of delta abandonment and degradation (PENLAND *et al.*, 1988). With the cessation of active sedimentation at the mouth of the delta, marine processes erode the transgressive delta front and rework deltaic sands into barrier beaches. The barrier beaches are transformed into barrier islands after compaction and subsidence of the unconsolidated deltaic sediments result in the detachment of the barrier beach from the mainland (PENLAND *et al.*, 1988). Barrier beaches and existing barrier islands serve as erosional headlands, providing the primary sand source for the further development of Louisiana's barriers.

This unique mode of barrier island evolution has resulted in rates of landward migration averaging 5–20 m yr^{-1} (PENLAND and BOYD, 1981). Since sediment supply is limited and constantly diminishing in this type of system, island migration also results in decreased barrier island size over time (PENLAND and BOYD, 1981). During the past 100 years, Louisiana's barrier islands have lost over 40% of their land area (PENLAND and BOYD, 1981). Traditional methods of reducing barrier island

90004 received 18 January 1990; accepted in revision 15 July 1990.
[†]*Present Address: U.S. Department of Commerce, Economic Development Administration, Herbert C. Hoover Building, Rm. 7217, Washington, D.C. 20230*
[‡]*Soil Conservation Service, P.O. Box 1266, Houma, LA 70361*

erosion such as dune building with sand fencing and vegetative stabilization have not been attempted on a large-scale in Louisiana. In fact, because of the limited sand supply on these barriers, it was questionable whether continuous dunes could be built and stabilized using techniques that have proved successful in other coastal localities (WOODHOUSE *et al.*, 1976). Therefore, we initiated this investigation with the following objectives: (1) to determine if dune-building techniques developed along the Atlantic Coast could be utilized in Louisiana's sand deficient environment; (2) to compare rates of dune building (a) as a function of sand fencing design and (b) relative to other coastal locations; and (3) to evaluate the performance of three dune species planted.

MATERIALS AND METHODS

Study Area

Geology The experimental dune building and stabilization site was located on Timbalier Island (ca. 29° 3′ N latitude, 90° 31′ W longitude) (Figure 1). Timbalier Island formed as a result of longshore spit progradation from the Caminada-Moreau erosional headland (Figure 1) and subsequent breaching of the spit during storms (PENLAND and BOYD, 1985). The sand eroded from the Caminada-Moreau beach is the primary source of coarse-grained material (predominately fine sand) available to Timbalier Island. Since the Caminada-Moreau Beach is of limited and ever decreasing size, only a restricted amount of sand is available to maintain Timbalier Island. Hence, Timbalier Island is a relatively sand-deficient barrier island consisting of a sand body, which has a maximum thickness of 5–6 m, overlying regressive deltaic muds (PENLAND *et al.*, 1988). Timbalier Island is migrating in a northwest direction. The eastern half of Timbalier Island is eroding at a rate of 18.6 m yr^{-1} while the western end is accreting at 17.6 m yr^{-1} (PENLAND and BOYD, 1981). Timbalier Island is approximately 13 km in length and 1.2 km in width at its widest point.

Climatology The climate on Timbalier Island is semitropical. Water temperatures along the Louisiana shore range from an average of 18°C (64°F) in February to 29°C (84°F) in August (U.S. ARMY CORPS OF ENGINEERS, 1979).

Wind direction is primarily from the south and southeast during the summer and from the north and northeast during the winter (U.S. FISH AND WILDLIFE SERVICE, 1981). Wind direction controls wave direction, which is primarily from the southeast on Timbalier Island (Figure 2).

Mean monthly air temperature is 14°C (57°F) in January and 28°C (83°F) in July and August (U.S. ARMY CORPS OF ENGINEERS, 1979). Precipitation is generally heavy; the greatest rainfalls occur during the summer months, which bring frequent afternoon thundershowers. The average annual rainfall for the area is 160 cm (62.8 in.), and monthly averages range from 9 cm (3.5 in.) in October to 19 cm (7.5 in.) in July (U.S. ARMY CORPS OF ENGINEERS, 1979).

Two types of storm events are particularly damaging to barrier islands in Louisiana: hurricanes and winter cold fronts. In any given year, the coastline of the Mississippi River delta plain has a 14% chance of sustaining hurricane damage (CONNER *et al.*, 1989). Hurricanes generally occur between June and October, and generate violent, counterclockwise winds that produce high waves, storm surges, and torrential rainfall. The hurricane surge that inundates low coastal lands is the most destructive of these forces. Waves generated by hurricane winds also cause extensive damage to the Louisiana coastline. Winter cold fronts (low-pressure, cyclonic events) generate southerly winds, waves, and heavy rainfall that can also damage Louisiana's coastline. After the front passes, winds shift to the north and rainfall ceases.

Tides along Timbalier Island are generally diurnal. At Grand Isle, the average tidal range is approximately 37 cm and the maximum range about 58 cm. Storm and hurricane tides reach elevations of about 3 m on the coast, and strong northerly winds in the winter depress Gulf water levels as much as 79 cm below mean sea level (U.S. ARMY CORPS OF ENGINEERS, 1979).

Site location An unvegetated washover terrace was selected as the site for this dune building and stabilization study (Figure 3a). The study site breached in 1979 during storm

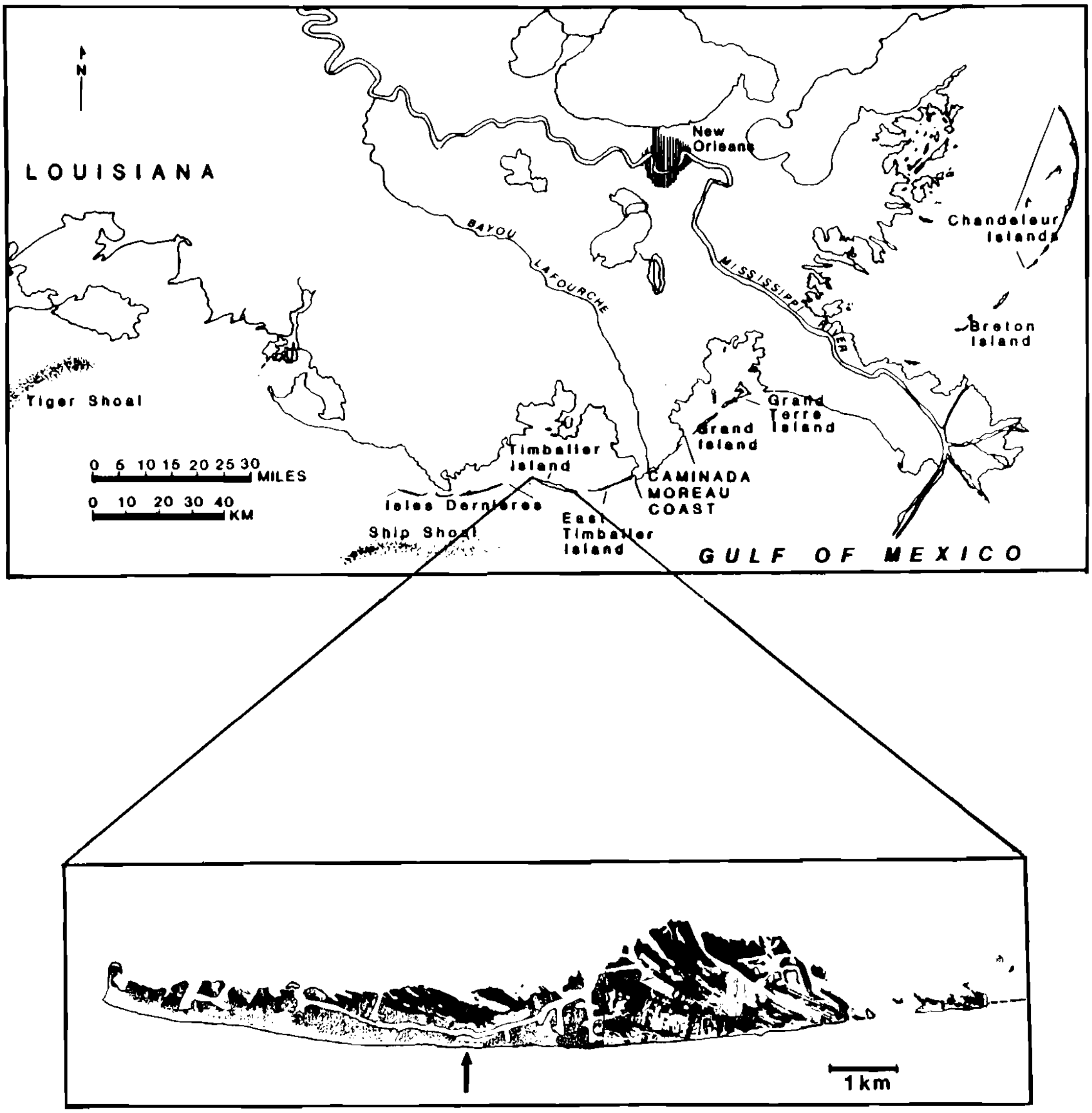

Figure 1. The Louisiana delta plain with Timbalier Island enlarged. The location of the dune building site is indicated with an arrow.

surges generated by tropical storms Bob, Claudette, and Frederick. In 1979 and 1980 the New Orleans Operations Division of Texaco USA pumped sand from immediately offshore of the island into these beaches to prevent further breaching and erosion. In addition, two parallel concrete pipes 0.46 m in diameter were placed 21 m apart over the dredged sand to help stabilize it (Figure 3a and b). Because the pipes only partially retained the sand, the dune-building and stabilization project was begun in May 1981.

Sand Fencing

Sand fencing was installed at the experimental site on 5 May 1981 along a 305-m linear distance of beach. We used standard snow fencing

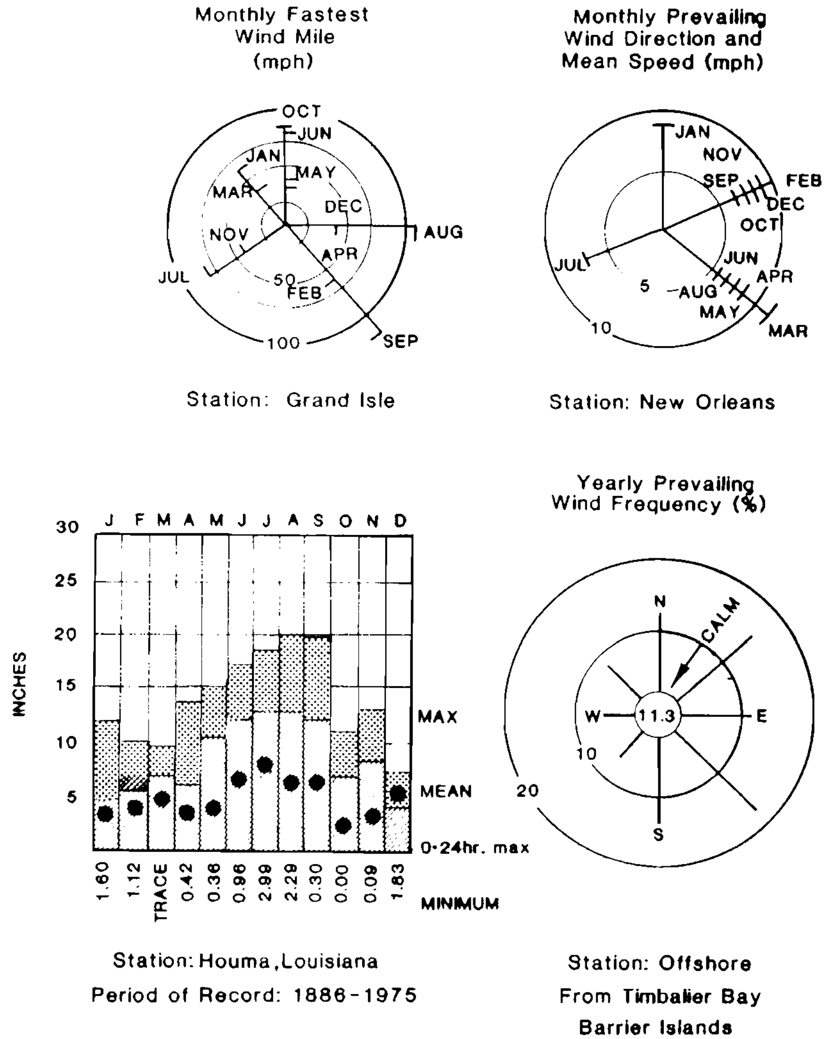

Figure 2. Wind statistics and precipitation data for the general area of the study (U.S. Fish and Wildlife Service 1981).

constructed from 3.8 cm by 1.2 m high wooden slats bound together with steel wire and with a porosity of 50%. The following three sand-fencing designs were used to trap sand: (1) straight sand fencing placed diagonal to the beach, (2) straight sand fencing placed parallel to the beach, and (3) straight sand fencing placed parallel to the beach with 7.6 m perpendicular side spurs spaced 15 m apart (Figure 3b). In addition, four locations within the planting site contained no sand fencing and served as controls. In May 1983, sand fencing was added at locations previously used as controls. The new sand fencing was installed in an attempt to build a continuous dune across the overwash site.

Vegetation Plantings

Three sand dune plant species, all indigenous to Louisiana barriers, were planted: *Panicum amarum* (bitter panicum), *Paspalum vaginatum* (seashore paspalum), and *Uniola paniculata* (sea oats). In late May 1981 5,000 *P. amarum* transplants were thinned from populations on

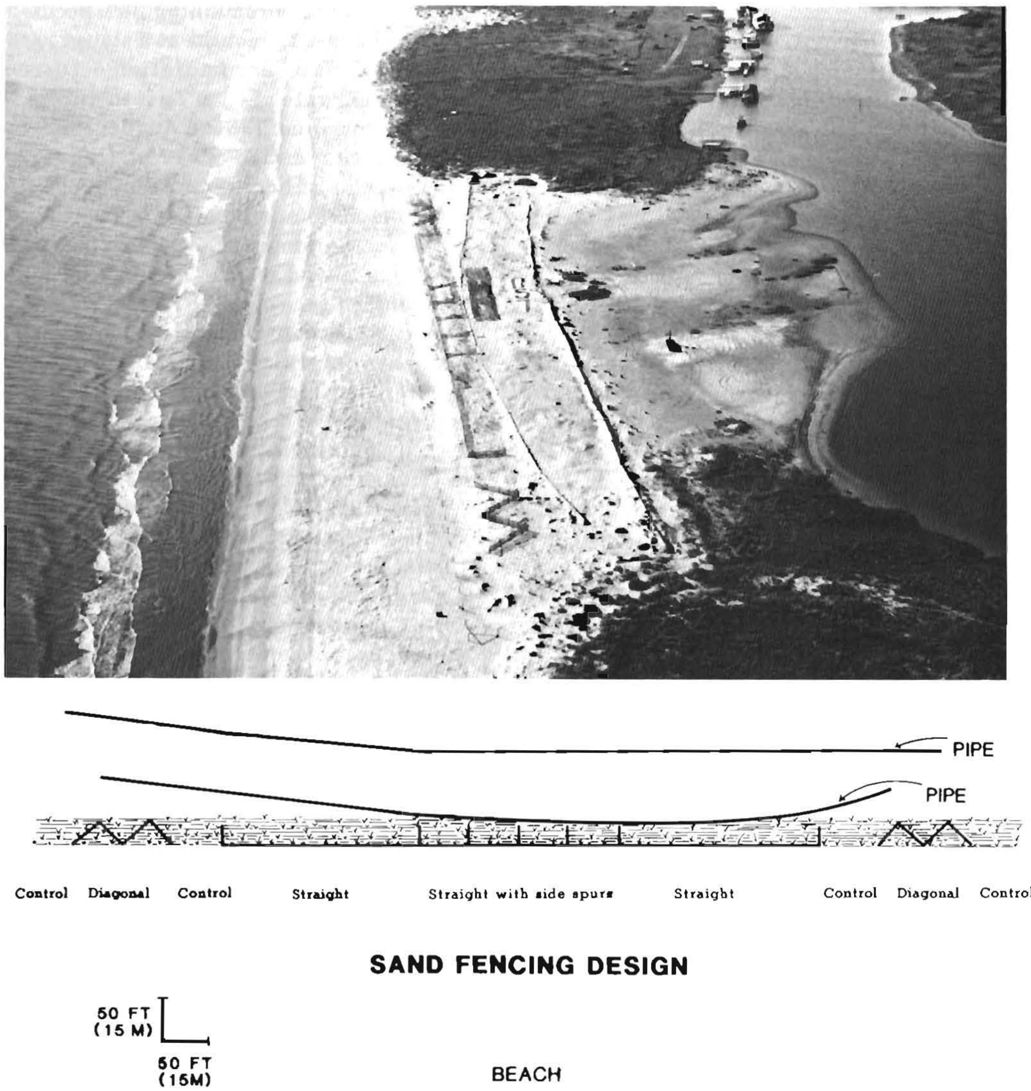

Figure 3. (a) Oblique aerial photograph of dune building and stabilization site on Timbalier Island, Louisiana. (b) Schematic of sand fencing designs and control areas as depicted in (a). Planted area is stippled.

the Caminada-Moreau barrier beach and planted at 1.4 m intervals throughout the 305 m × 7.6 m planting area, which paralleled the fence axis and extended behind it (away from the Gulf) 7.6 m. *Paspalum vaginatum* and *U. paniculata* transplants were purchased from a commercial source in Florida (Mangrove Systems, Inc.; Tampa, Florida) and were subsequently planted between the *P. amarum* in October and November 1981, respectively. A total of 13,200 plants, with the three species evenly spaced at 46-cm centers, were established at the project site. All planting was performed manually with a long-nose shovel. In late September 1981, we broadcast 227 kg of $NaNO_3$ and 68 kg of 0-20-20 fertilizer over the planting site.

Monitoring

Beach profiles The U.S. Soil Conservation Service (Houma, Louisiana) surveyed 26 transects perpendicular to the beach and 15 m apart with a level and stadia rod and constructed beach profiles. Each transect was 91 m in length and was part of a grid system surveyed at 15 m centers that began approximately 60 m behind the fencing and extended approximately 30 m in front of the fencing towards the Gulf. Sand accumulation was based on the change in relative elevation of each survey point in the grid multiplied by the area of the grid represented by that point. Since the grid extended well beyond the influence of the fencing in both directions, we chose to report the sand volume accumulation based on the 15 m width of the fenced and planted area, although complete elevation profiles are also shown. The first survey was conducted on 11 June 1981 one month after sand fence installation. Subsequent surveys were made in August of 1982, 1983, and 1984.

Planting Success Percentage survival of transplants was measured in July 1981 and May and August 1982. Percentage survival was determined by counting the number of living (green) plants of each species in a plot (5 × 5 m) on each profile transect within the planting zone. This number was divided by the total number of stems of the species planted and multiplied by 100%.

RESULTS

Sand Accumulation

Total Planting Site Maximum sand accumulation was attained by August 1983. From June 1981 to August 1983, approximately 1,266 m^3 of sand had accumulated within the experimental site (305 × 15 m) (Table 1; Figure 4). Of this 1983 total, 64% of the sand accumulated within the first 14 months at an average rate of 58 m^3/month; the remaining 36% accumulated during the last 12 months at a slower rate of 38 m^3/month. Sand accumulation occurred at a fairly linear rate of 48 m^3/month during the 26 months from June 1981 to August 1983, a mean annual accumulation of 577 m^3 (Figure 4). Per linear meter of beach, an average of 2.7 m^3 of sand had accumulated after 14 months and 4.2 m^3 had accumulated after 26 months (Table 1).

Although sand accumulation at the dune area was substantial, coastline retreat in front of the project site was inevitable without beach nourishment. Several winter storms in 1983 and 1984 eroded sections of the developing dune, and resulted in scarps. Net sand accumulation decreased from the maximum accretion of 1,266 m^3 measured in August 1983 to 1,041 m^3 in August 1984. Mean accumulation per linear meter of beach dropped from 4.2 ± 0.6 m^3/m in 1983 to 3.4 ± 0.7 m^3/m in 1984 (Table 1). Figure 4 shows the relationship between sand accumulation and time in 1981–83 and 1981–84. Since there was a net loss of sand from the system in 1984, the average predicted monthly rate of accretion based on 1981–84 data decreased to 35.8 m^3 of sand per meter of beach per month (Figure 4), compared to 48.1 m^3 based on the 1981–83 data.

Sand-Fencing Designs Sand fencing proved indispensable for accumulating sand into dunes on Timbalier Island (Table 2; Figure 5). Sites originally designed without sand fencing showed no appreciable vertical accretion of sand (Table 2). These sites began to accumulate sand only after the installation of sand fencing in May 1983 (Figure 5).

The different sand-fencing designs produced obvious differences in sand accumulation (Table 2). The sand-fencing designs that accumulated the most sand during year 1, however, were not necessarily the most efficient after 2 or 3 years (Table 2).

During year 1 of the study (1981–82), the

Table 1. *Total and mean sand accumulation at Timbalier Island, Louisiana (site dimensions: 305 x 15 m).*

	1981–82	1981–83	1981–84
Total accumulation	816 m^3	1266 m^3	1041 m^3
Mean accumulation per linear meter of beach[a]	2.7 ± 0.7 m^3/m	4.2 ± 0.6 m^3/m	3.4 ± 0.7 m^3/m

[a] N = 20

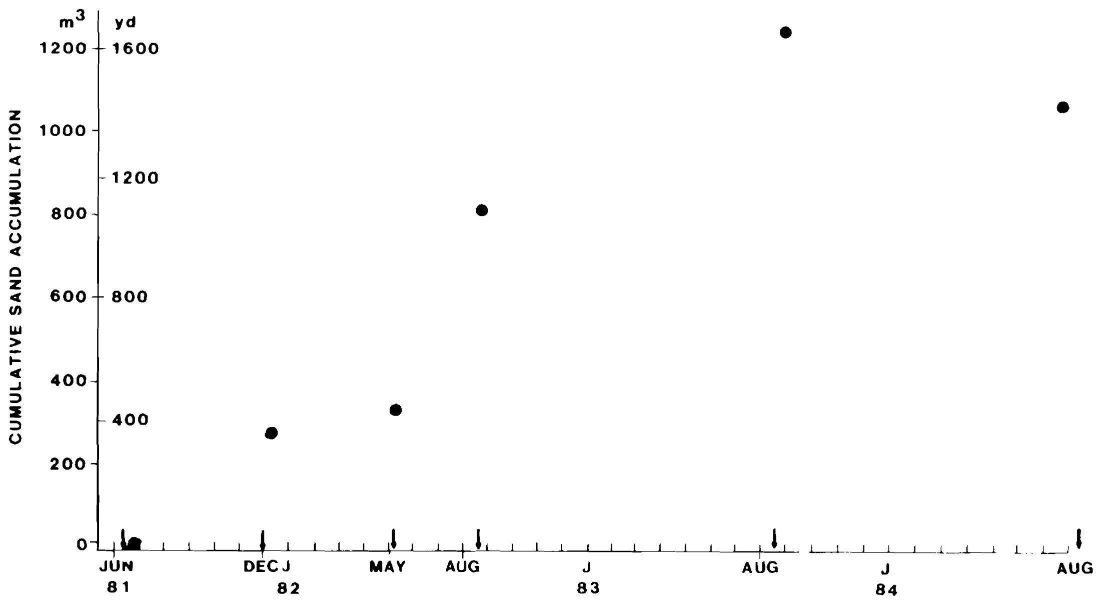

Figure 4. Sand accumulation as a function of time at Timbalier Island, Louisiana. Arrows on horizontal axis indicate dates of surveys.

Table 2. *Relationship of sand-fencing design, mean dune growth, and mean sand accumulation from June 1981 to August 1982, June 1981 to August 1983, and June 1981 to August 1984 at Timbalier Island, Louisiana.*

	Dune Growth[a] (m)			Sand Accumulation[b] (m^3/m)		
Design	1981–82	1981–83	1981–84	1981–82	1981–83	1981–84
Diagonal fence (n = 4)	0.20 ± 0.05[c]	0.32 ± 0.09	0.14 ± 0.03	2.7 ± 0.7	4.9 ± 1.3	3.0 ± 1.0
Straight fence (n = 6)	0.26 ± 0.12	0.32 ± 0.05	0.34 ± 0.12	2.6 ± 2.0	4.9 ± 0.7	5.8 ± 1.1
Straight fence with perpendicular side spurs (n = 6)	0.20 ± 0.07	0.22 ± 0.10	0.14 ± 0.15	4.2 ± 1.0	3.3 ± 1.6	2.2 ± 2.0
No fence (n = 4)	0.07 ± 0.04	——d	——d	0.6 ± 0.7	——d	——d

[a] Height measured at fence.
[b] Data calculated for plots 15 x 15 m encompassing the planting width and sand fencing.
[c] Mean ± standard error.
[d] Fencing installed at control areas in May 1983.

straight sand fencing with perpendicular side spurs accumulated the most sand; 4.2 m^3 of sand per meter of beach (Table 2). Diagonal and straight fencing designs accumulated approximately 63% as much sand as the fencing with side spurs (Table 2). Sites planted with vegetation but without sand fencing accumulated only 0.6 m^3 of sand per meter of beach. Although dune heights increased from 0.3 to 0.6 m at some locations, average dune heights during year 1 varied from 0.26 m for the straight fencing design to 0.20 m for diagonal and side-spur fencing designs; dune heights at sites with no fencing averaged 0.07 m (Table 2).

Over a 2-year period (1981–83), the diagonal and straight sand-fencing designs accumulated the most sand; both accumulated 4.9 m^3 of sand per meter of beach. The straight sand fencing with side spurs had accumulated only 3.3 m^3 of sand per meter of beach, a sand loss of 21% during the 1982–83 period (Table 3). The diagonal and straight sand-fencing designs also pro-

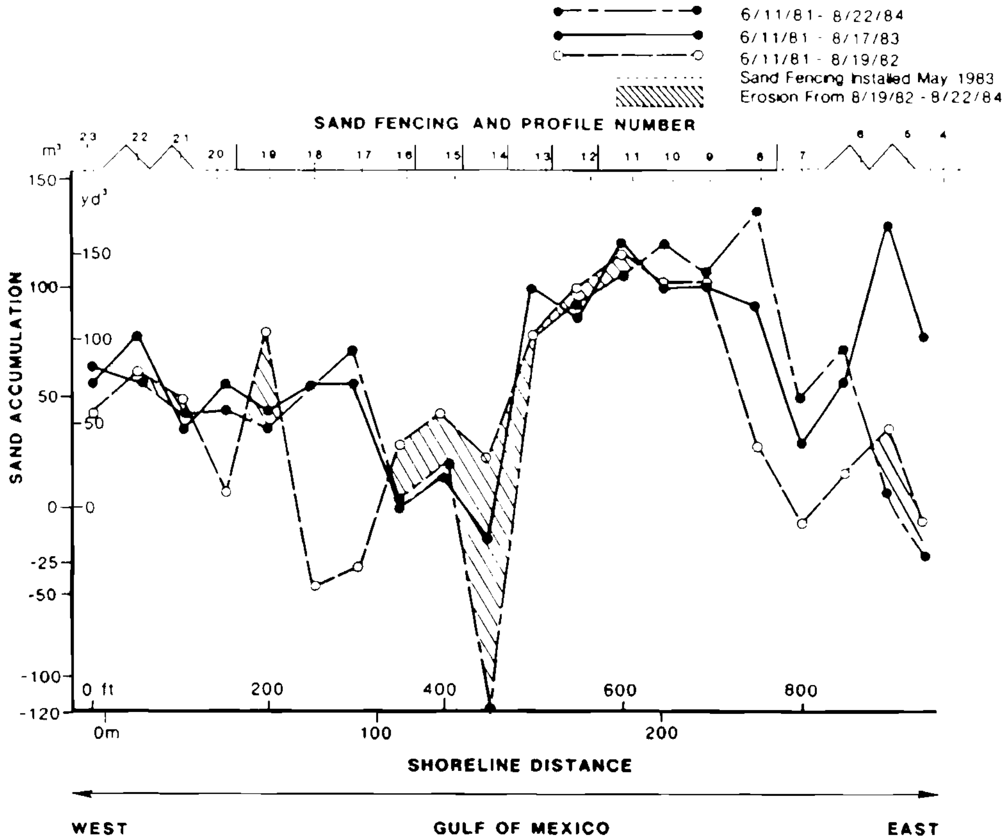

Figure 5. Sand accumulation as a function of location within the dune building site on Timbalier Island, Louisiana.

Table 3. *Percentage survival of dune plantings by species at Timbalier Island, Louisiana (n = 8).*

Species	Planting Date	Sampling Date July 1981	Sampling Date May 1982	August 1982
			—% Survival—	
Panicum amarum	May 1981	84±3[a]	76±3	73±3
Paspalum vaginatum	October 1981	—	32±7	3±2
Uniola paniculata	November 1981	—	25±2	23±2

[a]Mean ± standard error.

duced the greatest vertical dune growth, 0.32 m, whereas straight fencing with side spurs created a dune 0.22 m tall. Since sand fencing was later added to the locations that had no fencing before May 1983, sand accumulation and dune height for the "no fence" treatment (originally the controls) are not presented in the 1981–83 or 1981–84 columns of Table 2.

Over a 3-year period (1981–84), the straight sand-fencing design (without perpendicular side spurs) far exceeded the other designs in both capacity to build dunes and accumulate sand (Table 2). In fact, the straight sand-fencing design was the only one to increase sand accumulation and dune growth during the 1983–84 year (Table 2). Dune growth for the straight sand fencing increased 0.02 m to 0.34 m by 1984, and sand accumulation increased

0.9 m^3/m, resulting in 5.8 m^3 of sand accumulation per meter of beach over the 3-year period (Table 2). The site with diagonal sand fencing lost the most dune height in 1984, decreasing from 0.32 m in 1983 to only 0.14 m by 1984. Similarly, the dune height of the straight fencing with perpendicular side spurs decreased from 0.22 m in 1983 to 0.14 m in 1984 (Table 2).

The greatest loss in sand volume also occurred in plots with the diagonal sand fencing, which lost 1.9 m^3 of sand per meter of beach in 1984 and accumulated a net total of 3.0 m^3 per meter of beach during 1981–84 (Table 2). The straight sand fencing with perpendicular side spurs also lost volume (1.1 m^3/m) during 1984 and had the lowest 3-year net accumulation (Table 2). Figure 5 shows sand accumulation at the dune building site for each of the three time intervals as a function of location and fencing treatment.

Dune Profiles

Representative dune profiles confirm the data presented in Tables 1 and 2. All sand fencing stimulated sand accumulation (Figure 6). Initially the straight sand fencing with perpendicular side spurs accumulated the greatest volume of sand, although the straight sand fencing (without side spurs) accreted the tallest dunes. After 26 months, diagonal and straight sand fencing accumulated the greatest height and volume of sand. Figure 6 shows the rapidity of sand accumulation after the addition of sand fencing to the control areas (those originally without fencing). Coastline retreat is reflected in many of the profiles as a decrease in elevation at 91 m, the most gulfward survey point (Figure 6).

Plant Survival

Of the three species transplanted, *Panicum amarum* (bitter panicum) had the highest survival rate, 73% after 15 months. The survival rate of *Uniola paniculata* (sea oats) was 23% after 9 months, whereas *Paspalum vaginatum* (seashore paspalum) had only 3% survival after 10 months (Table 3). Although some herbivory occurred, it was minor compared to other plantings on Timbalier Island (MENDELSSOHN and HESTER, 1988), apparently because of the proximity of the planting site to summer camps and, hence, human activity. *Panicum amarum* showed more signs of herbivory (some grazing of new leaf tips, or tillers) than did *U. paniculata*, but rarely enough to result in plant death. Overall, the total plant cover was very good; certain areas had nearly 80% cover. Some invading species (those not transplanted) such as *Spartina patens* (marshhay cordgrass), often contributed as much as 15%–25% of the total cover.

DISCUSSION

The sand accumulation during the 3-year period of this study proved that sand fencing in conjunction with vegetative plantings can successfully be used to build dunes in the sand-deficient Louisiana environment.

Annual sand accumulation measured over 3 years was 82%–90% less than the average reported for dune-building sites in Massachusetts, North Carolina, Texas, and Oregon (Table 4). For example, a dune-building project at Cape Cod, Massachusetts, produced sand accumulations of 14 m^3 per meter of beach after 1 year (KNUTSON, 1980), compared to 2.6–4.2 m^3 of accumulation per meter of beach in Louisiana. However, rates of dune building can vary, even within a single region or locality. For example, at Drum Inlet, North Carolina, sand accumulated at a rate of 3.7–5.0 m^3 per meter of beach during a 2-year period (SENECA *et al.*, 1976), but at Ocracoke Island, North Carolina, the rate was 16 m^3 per meter of beach (SAVAGE and WOODHOUSE, 1969). Although the rate of sand accumulation at Timbalier Island, 3.3–4.9 m^3 per meter of beach after 2 years, was similar to that measured at Drum Inlet, North Carolina, sand fencing generally did not accumulate sand or build dune height as rapidly on Timbalier Island as at locations with greater supplies of sand (Table 4.)

Dune building on Timbalier Island was most efficient when sand fencing was used. Since winds along the Louisiana coast frequently have some east-west component to them (RITCHIE and PENLAND, 1982), fencing with either perpendicular or diagonal segments oriented to this direction initially accumulated the most sand (Table 2). The straight fencing with perpendicular side spurs accumulated sand the most efficiently the first year. Although the main axis of the straight fencing

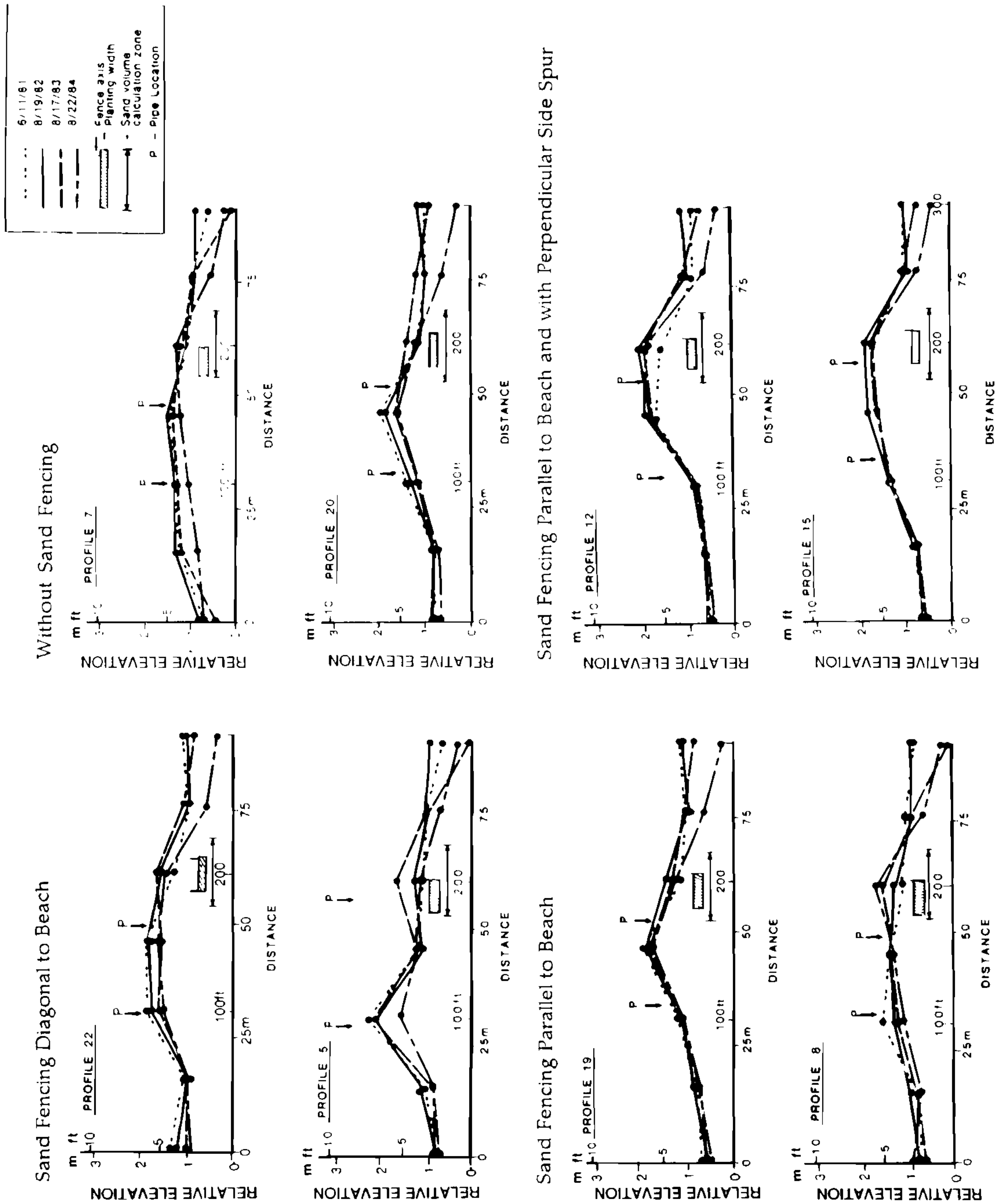

Figure 6. Elevation profiles resulting from the different sand fencing designs at the dune building site on Timbalier Island, Louisiana. Profiles begin approximately 60 m behind (left of) the sand fencing and extend approximately 30 m in front (right) of the sand fencing.

Table 4. *Comparison of annual dune growth and sand accumulation rates in Massachusetts, North Carolina, Louisiana, Texas, and Oregon (after Knutson, 1980).*

Location	Dune Growth (m)	Sand Accumulation (m^3/m)
Nauset Beach,		
Cape Cod, MA[a]	0.25	8.3
Ocracoke Island, NC	0.18[b]	8.4[c]
Timbalier Island, LA[d]	0.05–0.26	0.7–4.2
Padre Island, TX[e]	0.46	10.8
	0.60	
Clatsop Plains, OR[f]	0.27	13.7

[a]Knutson (1980), 7 years' growth.
[b]Woodhouse *et al.* (1976), 10 years' growth.
[c]Savage and Woodhouse (1969), 3 years' growth.
[d]Present study, 3 years' growth.
[e]Dahl *et al.* (1975), approximately 4 years' growth.
[f]Myer and Chester (1977), 30 years' growth.

was oriented east-west, the side spurs caught much of the sand carried by southeast or northeast winds. Fencing with segments oriented only in the east-west direction, the straight fencing, accumulated less sand the first year.

After 2 years, the diagonal and straight fencing designs had accumulated the most sand, surpassing the fencing with side spurs, although this difference was not statistically significant. The diagonal fencing, like the fencing with perpendicular side spurs, was able to trap sand moving east-west. After 3 years, the straight fencing design had accumulated the most sand, 93% more than the diagonal fencing and 164% more than the straight fencing with perpendicular side spurs. No significant difference in sand accumulation between the diagonal fencing and the fencing with perpendicular side spurs was noted after the 3-year period. It is difficult to say whether the change in the efficiency of various fencing designs over time was actually a result of time since installation, or due to changing conditions during the study period. KNUTSON (1980) found that adding side spurs to straight fencing at Cape Cod did not improve long-term sand accumulation. This may also be the case on Timbalier Island, although during the first year the fencing designs with segments perpendicular to the dominant winds accumulated sand more quickly than the other designs (Table 2). The temporal changes in the sand accumulation of the various fencing types may have also been a function of the location of the particular fencing type within the overall planting site. For example, since the side-spur fencing type was located in the middle of the planting site between two straight fencing treatments (Figure 3), this site may have been in the "sand shadow" of the rapidly accumulating straight fencing treatments. Hence, as the straight fencing accumulated more sand over time, less eolian-transported sand penetrated into the side-spur fencing plot.

The proximity of the specific fencing treatment to localized sites of overwash may also have significantly influenced sand accumulation over time, especially for the diagonal fencing type. It is clear from the beach profiles in Figure 6 that the beach was receding landward during this dune-building project. Hence, the potential for overwash became greater during 1983–84 than it had been the previous two years. The sites where the diagonal fencing was located were overwashed to a greater extent than the other fencing sites because they bordered the lower-elevation area not fenced during 1981–82. These lower-elevation areas tended to direct overwash to the adjacent diagonal fencing treatments.

During the first 14 months of this study, vegetation played a very small role in sand accumulation. Without sand fencing, vegetation accumulated only 0.6 m^3 of sand per meter of beach. This result supports the conclusions of SAVAGE and WOODHOUSE (1969) and KNUTSON (1980) that sand fences initially trap more sand than newly established stands of dune vegetation. Hence, sand fencing is essential for increasing the rate of sand accumulation during the initial stage of the dune-building process. The vegetation initially helps to bind the sand. With time, however, the vegetation will become more dense and will also stimulate greater sand accumulation (KNUTSON, 1980).

Planting success varied with the species planted. *Paspalum vaginatum* (seashore paspalum), which had the lowest percentage survival, grows slowly and was rapidly buried by accumulating sand. Although this plant expanded vegetatively and provided continuous cover at sites where only small amounts of sand had accumulated, it is apparently not suitable for dune stabilization where sand burial is probable. In addition to being easily buried, the *Paspalum* transplants, which were obtained as 8-cm cubes, were also exhumed by winds that stripped away surrounding sand. Dessication could then readily occur. The relatively poor success of *Uniola paniculata* (sea oats) in comparison with that of *Panicum amarum* (bitter panicum) may be due to the difference in the time of planting or the initial quality of the transplants. Many of the *Uniola* transplants were already brown and senescent when transplanted. Although their initial survival rate (25%) was not as great as that of *P. amarum* (84%), the survival rate of *Uniola* transplants at Timbalier Island was higher than the 16% survival rate of *Uniola* planted in North Carolina (SENECA *et al.*, 1976) and within the range (5%–68%) of the survival rate in Texas (DAHL *et al.*, 1975). *Uniola* may still prove to be a hearty and efficient substrate stabilizer in Louisiana.

Panicum amarum had the highest percentage survival after transplanting. This was probably due to both the time of planting and the transplant material used. Green tillers of panicum were planted in late May, the beginning of the summer rainy period, and hence had a good chance for survival and growth. In addition, this plant vegetatively reproduces swiftly and produces new roots at buried nodes that allow rapid establishment. The survival rate of *P. amarum* compares favorably with its 62% survival rate in North Carolina (SENECA *et al.*, 1976) and its 10%–70% rate in Texas (DAHL *et al.*, 1975).

Approximately 1 month after the August 1984 survey, a localized storm in the Gulf of Mexico between September 22 and 29 generated water levels approximately 0.5 m above normal and waves of 1.5–2.0 m (B. Acosta, Texaco Caillou Island camp, personal communication). Caillou Island crews reported that waves broke through the camp catwalks, which are several feet above mean high water. Because of the already-shortened beach width and the localized severity of this storm, the dune building site was almost entirely overwashed. The planting site was completely destroyed; however, the island was not breached into the shore-parallel canal behind the planting site (Figure 3). We believe that this was largely due to the greater wave-dissipating ability and sand reservoir created by the artificial dune ridge. However, in the absence of this dune barrier and with an even narrower shoreface, the site finally breached during hurricane Danny in the summer of 1985. This breach has subsequently filled in with sand to reform a continuous beach, but at a location further landward.

CONCLUSIONS

This study demonstrates that sand fencing and vegetative stabilization can be used effectively to create sand dunes on Louisiana's barrier islands. The only way to maintain a healthy, well-vegetated dune on Louisiana's transgressive barriers, however, appears to be through beach nourishment in conjunction with dune building and vegetative stabilization techniques. Without beach nourishment, the shoreline will erode back toward the dune. Even a well-established, vegetated dune cannot prevent the natural transgression of the shoreline in front of it and will eventually be eroded as the shoreline continues to narrow. Although the dune can effectively serve as a sand reservoir during a severe storm and reduce the probability of island breaching, the dune itself is likely to be scoured if beach nourishment is not used to maintain a beach wide enough to dissipate wave energy.

ACKNOWLEDGEMENTS

This project was supported by the New Orleans Operations Division of Texaco, U.S.A., U.S. Soil Conservation Service, and the Coastal Energy Impact Program of the Louisiana Office of Coastal Zone Management. Special appreciation is extended to Mr. Jesse Jordan, Texaco engineer, for his assistance in sand fencing design and installation and the graduate students of the Department of Marine Sciences, Louisiana State University for their help and enthusiasm in planting of vegetation.

LITERATURE CITED

CONNER, W.H.; DAY, J.W., JR.; BAUMANN, R.H.; and RANDALL, J.M., 1989. Influence of hurricanes on coastal ecosystems along the northern Gulf of Mexico. *Wetlands Ecology and Management,* 1, 45–56.

DAHL, B.E.; FALL, B.A.; LOHSE, A.; and APPAN, S.G., 1975. Construction and stabilization of coastal foredunes with vegetation: Padre Island, Texas. *MP 9-75,* U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Virginia.

FRAZIER, E.E., 1967. Recent deltaic deposits of the Mississippi River: Their development and chronology. *Transactions—Gulf Coast Association of Geological Societies,* 27, 287–315.

KNUTSON, P.L., 1980. Experimental dune restoration and stabilization, Nauset Beach, Cape Cod, Massachusetts. *TP 80-5,* U.S. Army Corps of Engineers, Coastal Engineers, Coastal Engineering Research Center, Fort Belvoir, Virginia.

MENDELSSOHN, I.A. and HESTER, M.W., 1988. Coastal Vegetation Project, Timbalier Island. Final report submitted to Texaco, USA, New Orleans Operations Division, New Orleans, LA. *Agreement No. RC-84-01.* 244p.

MYER, A.L. and CHESTER, A.L. 1977. The stabilization of Clatsop Plains, Oregon. *Shore and Beach,* October, pp. 34–41.

PENLAND, S. and BOYD, R. 1981. Shoreline changes on the Louisiana barrier coast. Proceedings, *Oceans,* 81, IEEE, 209–219.

PENLAND, S.; BOYD, R., and SUTER, J.S., 1988. Transgressive depositional systems of the Mississippi Delta Plain: A model for barrier shoreline and shelf sand development. *Journal of Sedimentary Petrology,* 58, 932–949.

PENLAND, S. and BOYD, R., 1985. Transgressive depositional environments of the Mississippi River Delta Plain: A guide to the barrier islands, beaches, and shoals is Louisiana. *Guidebook Series No. 3.* Louisiana Geological Survey, Baton Rouge, 233p.

RITCHIE, W. and PENLAND, S., 1982. The interrelationship between overwash and aeolian processes along the barrier coastline of south Louisiana. *First International Conference on Meteorology and Air/Sea Interaction of the Coastal Zone,* Hauge. pp. 358–362. American Meteorological Society.

SAVAGE, R.P. and WOODHOUSE, W.W., Jr., 1969. Creation and stabilization of coastal dunes. Proceedings, *11th Congress on Coastal Engineering,* London, Sept. 1968, pp. 672–700.

SENECA, E.D.; WOODHOUSE, W.W., Jr., and BROOME, S.W., 1976. Dune stabilization with *Panicum amarum* along the North Carolina coast. *MR 76-3,* U.S. Army Corps of Engineers, Coastal Engineering Research Center, Ft. Belvoir, Virginia.

U.S. ARMY CORPS OF ENGINEERS, 1979. *Grand Isle and vicinity Louisiana. Phase I General design memorandum, beach erosion and hurricane protection.* U.S. Army Engineering District, New Orleans, 10p.

U.S. FISH AND WILDLIFE SERVICE, 1981. *Mississippi Deltaic Plain Region Ecological Atlas.* FWS/OBS-81/16.

WOODHOUSE, W.W. Jr.; SENECA, E.D., and BROOME, S.W., 1976. Ten years of development of man-initiated coastal barrier dunes in North Carolina. *Bulletin 453,* Agricultural Experiment Station, North Carolina State University, Raleigh, 52p.

□ RÉSUMÉ □

De mai 1981 à août 1984 a été réalisé sur l'île barrière de Timbalier (Côte de Louisiane) le premier projet à grande échelle utilisant des clayonnages pour stimuler l'accrétion des sables. On a testé sur 305 m de plage trois types d'orientation des clayonnages et trois espèces de plantes dunaires. Cette étude montre qu'il est possible de stabiliser cette côte subsidente, à l'environnement déficient, ce, malgré des taux d'accumulation plus bas que ceux des zones littorales bien alimentées en sable. Les clayonnages orientés parallèlement à la plage avec des éperons perpendiculaires provoquent au départ la meilleure accumulation. Mais après 27 mois, les clayonnages droits (sans éperons) piègent mieux le sable, qu'ils soient parallèles ou diagonaux à la plage. Les plantations sans clayonnage n'accumulent presque pas de sable. Sur les trois espèces plantées c'est *Panicum amarum* qui a le meilleur taux de survie. *Uniola paniculata* a un taux de survie moins bon, mais comparable à celui observé dans les autres études. *Paspalum vaginatum* a le plus mauvais taux de survie. Bien qu'en Louisiane, il y ait des dunes crées par clayonnage te stabilisées par la végétation, un approvisionnement de plage est apparemment nécessaire au maintien de la dune créee car le recul de la côte est inévitable dans cette zone pauvre en sable et subsidente.—*Catherine Bressolier-Bousquet, Géomorphologie EPHE, Montrouge, France.*

□ ZUSAMMENFASSUNG □

Das erste großmaßstäbliche Dünenbildungs- und Sicherungs-Projekt in Louisiana, das Sandschutzvorrichtungen nutzt, um Sandzunahme zu bewirken wurde im Mai 1981 auf Timbalier Island, einer sandarmen Strandwallinsel an der Küste Louisianas gegründet und im August 1984 ausgewertet. Entlang einer Strandlänge von 305 m wurden drei Arten von Sandschutzvorrichtungen mit unterschiedlicher Ausrichtung und drei Arten von Dünenpflanzen getestet. Diese Studie veranschaulicht, daß Dünenbildung und Sicherung durch Bepflanzung möglich sind in Louisianas absinkender und sandarmer Küstenumgebung, obwohl Sandanhäufungsgeschwindigkeiten niedriger waren als in Küstenzonen mit reichlichem Sandangebot. Gerade Schutzvorrichtungen mit vertikalen Seitenausläufern, parallel zum Strand gestellt, häuften anfänglich den meisten Sand an. Aber nach 27 Monaten häuften gerade Schutzvorrichtungen (ohne vertikale Seitenausläufer) entweder parallel oder diagonal zum Strand gestellt, den meisten Sand an. Bepflanzungen ohne Sandschutzvorrichtungen häuften sehr wenig Sand an. Von den drei Pflanzenarten hatte *Panicum amarum* die höchste Überlebensrate. *Uniola paniculata* hatte eine geringere Überlebensrate, was jedoch vergleichbar war mit Ergebnissen aus anderen Studien. *Paspalum vaginatum* hatte die geringste Überlebensrate. Obwohl in Louisiana eine Düne wirkungsvoll mit Sandschutzvorrichtungen geschaffen und mit Pflanzenbewuchs gesichert werden kann, ist anscheinend ein Strand-Nährgebiet notwendig, um die geschaffene Düne zu erhalten, da der Küstenlinien-Rückzug in dieser sandarmen und absinkenden Umgebung unvermeidlich ist.—*Gabriele Lischewski, Essen, FRG.*