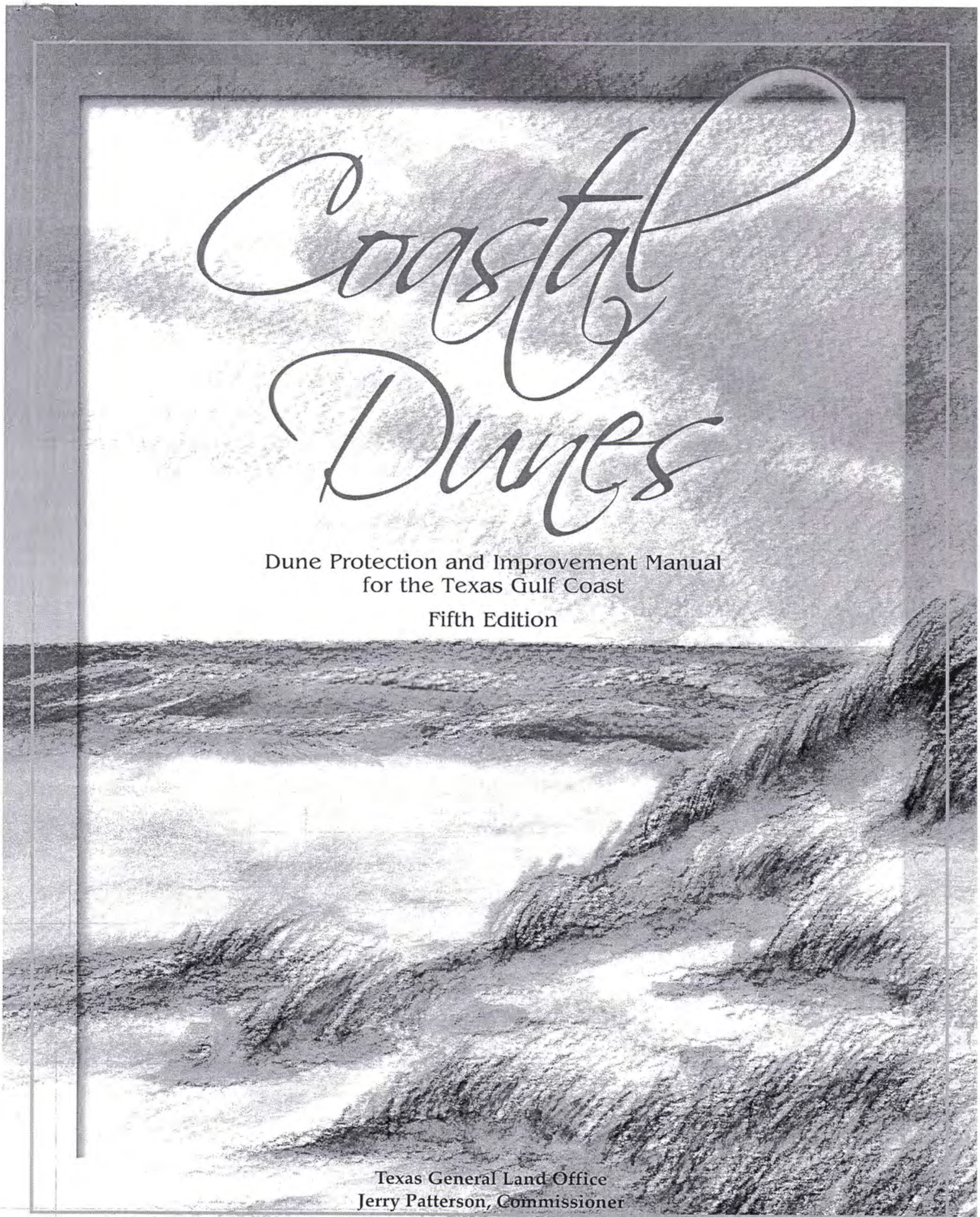
Coastal Dunes

Dune Protection and Improvement Manual
for the Texas Gulf Coast

Fifth Edition



Texas General Land Office
Jerry Patterson, Commissioner

VERNON'S TEXAS STATUTES AND CODES ANNOTATED
NATURAL RESOURCES CODE
TITLE 2. PUBLIC DOMAIN
SUBTITLE E. BEACHES AND DUNES
CHAPTER 63. DUNES

SUBCHAPTER A. GENERAL PROVISIONS

Sec. 63.001. Findings of Fact

The legislature finds and declares:

(1) that the mainland gulf shoreline, barrier islands, and peninsulas of this state contain a significant portion of the state's human, natural, and recreational resources;

(2) that these areas are and historically have been wholly or in part protected from the action of the water of the Gulf of Mexico and storms on the Gulf by a system of vegetated and unvegetated sand dunes that provide a protective barrier for adjacent land and inland water and land against the action of sand, wind, and water;

(3) that certain persons have from time to time modified or destroyed the effectiveness of the protective barriers and caused environmental damage in the process of developing the shoreline for various purposes;

(4) that the operation of recreational vehicles and other activities over these dunes have destroyed the natural vegetation on them;

(5) that these practices constitute serious threats to the safety of adjacent properties, to public highways, to the taxable basis of adjacent property and constitute a real danger to natural resources and to the health, safety, and welfare of persons living, visiting, or sojourning in the area;

(6) that it is necessary to protect these dunes as provided in this chapter because stabilized, vegetated dunes offer the best natural defense against storms and are areas of significant biological diversity;

(7) that vegetated stabilized dunes help preserve state-owned beaches and shores by protecting

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TEXAS GENERAL LAND OFFICE
ESTABLISHED 1836

FOREWORD

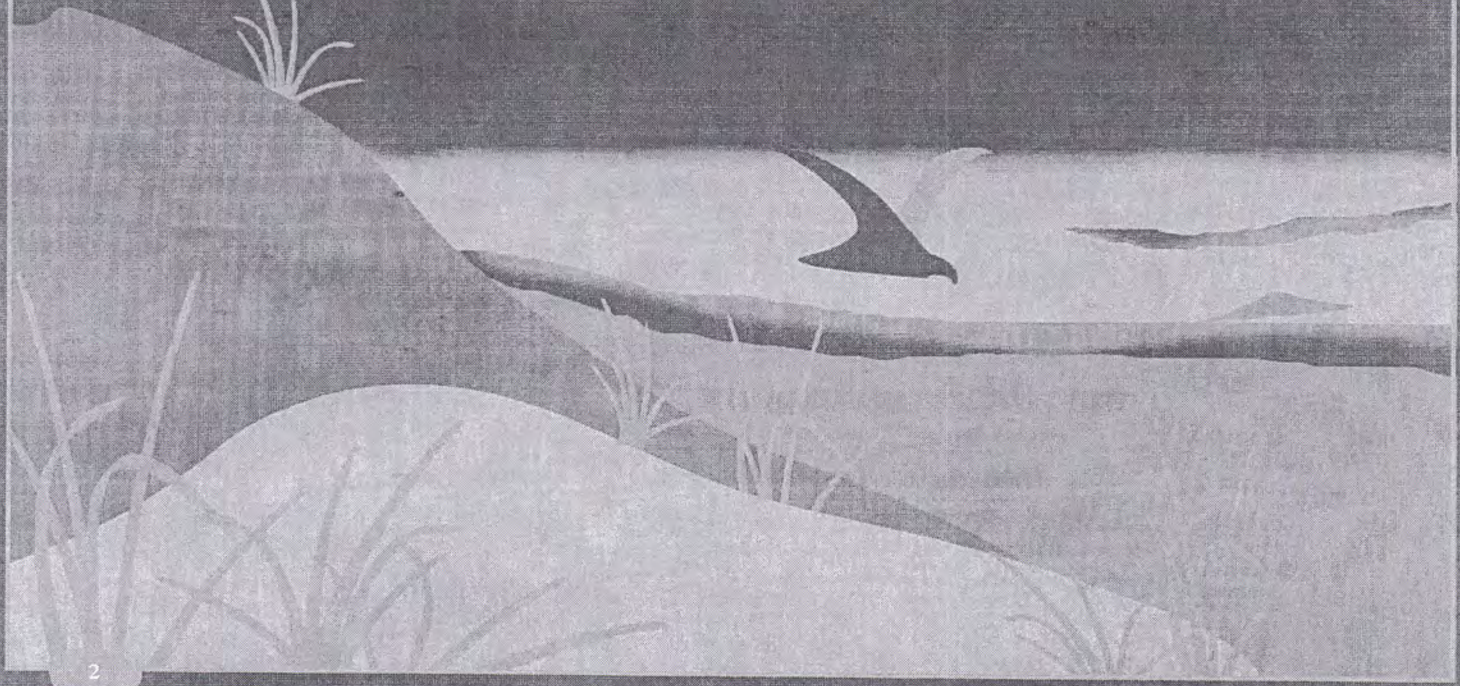
By Commissioner Jerry Patterson

The Texas Coast is an environmental and economic treasure composed of interlocking, interdependent ecological systems. Coastal sand dunes are a crucial part of that system. Dunes serve not only as a vital habitat for numerous native plants and animals, but an irreplaceable recreational resource upon which humans must tread lightly.

But the coast is changing. With every passing hurricane or tropical storm our coastline is physically altered through accretion and erosion. New mapping systems and new environmental science help us predict and mitigate the effect of these changes. As we consider these changes, we must also take into account the effect of human development along the coast. That is why this booklet is so important.

Through helpful definitions, concise standards and photographic examples, this book aims to raise awareness of the fragile beach/dune system and provide concise guidelines for dune protection and improvement along the Texas Gulf Coast. Now in its fourth edition, this publication continues to be updated to reflect the needs of the ever-changing Texas Coast.

The Texas Coast belongs to you. Consider this your Owner's Manual. Use it well.



INTRODUCTION

As a resilient natural barrier to the destructive forces of wind and waves, sand dunes are the least expensive and most efficient defense against storm-surge flooding and beach erosion. Dunes absorb the impact of storm surge and high waves, preventing or delaying intrusion of waters into inland areas. Dunes hold sand that replaces eroded beaches after storms and buffer windblown sand and salt spray. This natural defense can be strengthened by increasing the height and stability of existing dunes and by building new dunes.

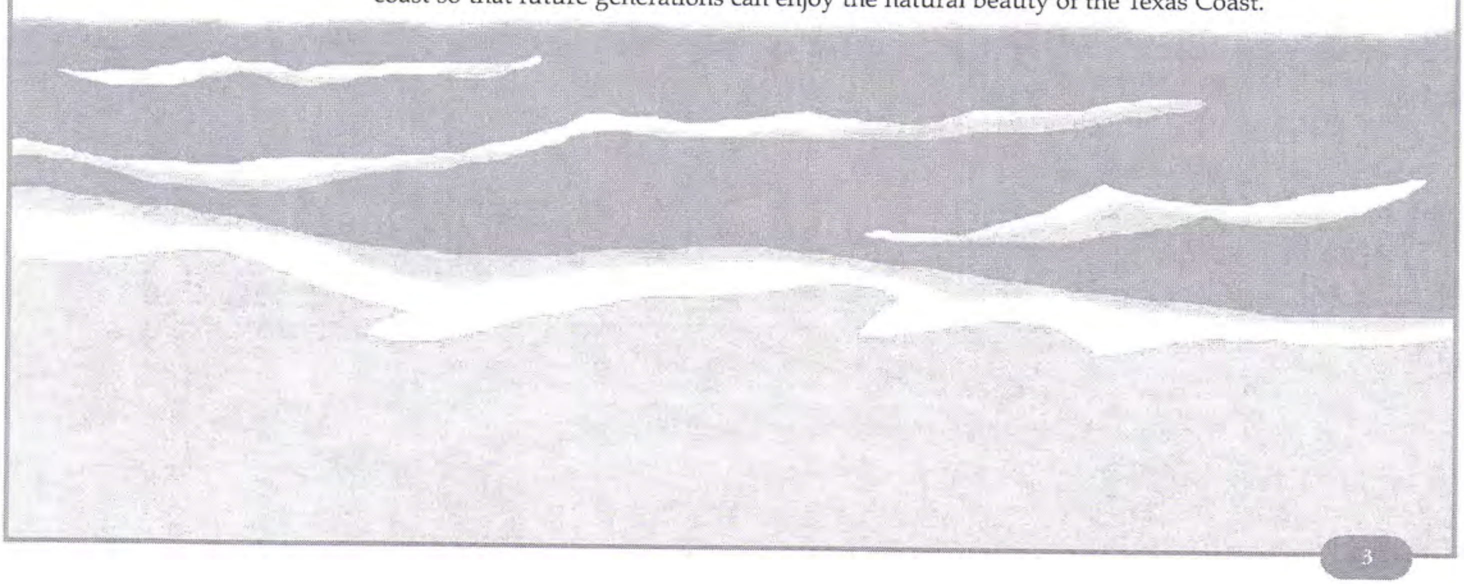
Beach and dune protection is important along the Texas Gulf Coast, particularly in areas experiencing shoreline erosion and concentrated urban development.

The growth of mainland coastal population centers and the increasing development and recreational use of the barrier islands can impact the stability of the dune environment. Construction and heavy recreational use of the beaches can contribute to fragmentation of the beach/dune system and deterioration of dunes. The vegetation that secures sand is destroyed, sand is lost, and the dune line is breached by roads, trails, and storm runoff. Dune damage that results from human activities accelerates the damage caused by wind and wave erosion.

Inland areas become more vulnerable to hurricanes and tropical storms when the dune line is weakened. Protecting dunes helps prevent loss of life and property during storms and safeguards the sand supply that slows shoreline erosion. Protecting dunes also preserves and enhances the beauty of the coast and coastal ecosystems.

To succeed, dune improvement and protection efforts must be undertaken by federal, state, and local governmental entities. But even more valuable are efforts by those who live on the coast.

The Texas Coast will continue to attract Texans and other visitors in ever-greater numbers for years to come. This manual describes measures that landowners, city and county planners, developers, and industry can use to preserve sand dunes and promote dune restoration on the coast so that future generations can enjoy the natural beauty of the Texas Coast.



Beaches and Dunes

Terminology

The beach extends from the mean low tide line to the line of natural vegetation along the shoreline **(fig. 1)**.

The foreshore (wet beach) is the area affected by normal daily tides.

The backshore (dry beach) is inundated only by storm tides and the higher spring tides. The backshore also supplies sand to the dunes.

Coppice mounds, the initial stages of dune growth, are formed as sand accumulates on the downwind side of plants and other obstructions on or immediately adjacent to the beach. The mounds are a source of sand that is exchanged via water with offshore bars. Coppice mounds may become vegetated and eventually increase in height, becoming foredunes.

Foredunes (also called fore-island dunes or primary frontal dunes) are the first clearly distinguishable, vegetated dune formations landward of the water. They are also the first to dissipate storm-generated wave and current energy. Although foredunes may be large and continuous, they typically are separate rounded knolls.

The foredune ridge is high, continuous, and well stabilized by vegetation. This ridge normally rises sharply landward from the foredune area but may rise directly from a flat, wave-cut beach immediately after a hurricane. The foredune ridge helps block storm surge and prevents it from washing inland.

Critical dunes are all dunes (coppice mounds, foredunes, foredune ridge, and some backdunes) that store sand to replenish eroding public beaches.

A dune protection line is established by a local government to preserve critical dunes and may be set no farther than 1,000 feet landward of mean high tide of the Gulf of Mexico. Special criteria apply to construction activities seaward of this line.

The beach/dune system includes all of the land from the line of mean low tide to the landward limit of dune formation.

A public beach is any beach, whether publicly or privately owned, extending inland from the line of mean low tide to the natural line of vegetation bordering on the Gulf of Mexico to which the public has acquired the right of use. This definition does not include a beach that is not accessible by a public road or public ferry.

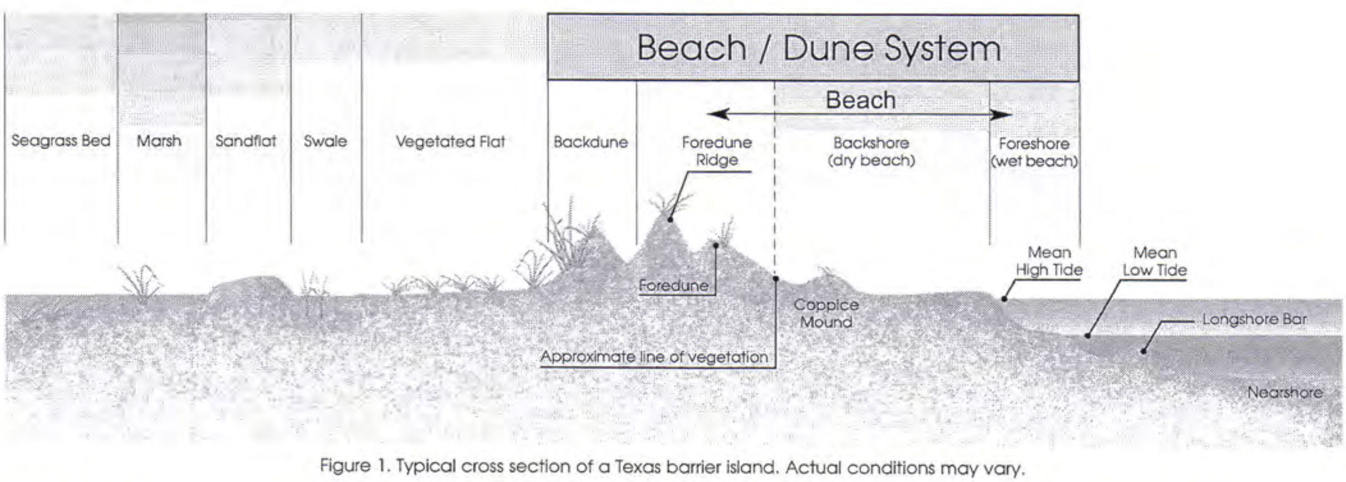


Figure 1. Typical cross section of a Texas barrier island. Actual conditions may vary.

The Sand Cycle

Beaches and dunes are integral parts of a dynamic environment in which sand is constantly exchanged.

During the calm conditions that prevail throughout most of the year on the Texas coast, waves average two to four feet in height and are less frequent than during storms. These calmer waves transport sand from offshore bars and the surf zone to the beach, causing the beach to gradually build up, or accrete. In time, sand is blown onto the foredune, where it is trapped by vegetation and stored until displaced by storms.

During a storm, high-energy waves flatten the beach. Waves washing against the base of the foredunes erode sand, undermining and collapsing the seaward dune face. In severe storms, the dune face commonly recedes several yards — in extreme cases as much as 100 yards — leaving a steep cliff **(fig. 2)**. Sometimes dunes are completely destroyed. Retreating waves carry the eroded sand offshore and deposit it just seaward of the surf zone in large bars. This process of dune erosion and sand movement dissipates much of the energy of storm waves. Sandbars also dissipate storm wave energy by causing waves to break further offshore.

Figure 2. Result of storm waves on beaches and foredunes.

If the supply of sand remains constant, the natural exchange between the beach, dunes, and offshore areas will repair and rebuild dunes to a height and width determined by local conditions. However, the loss of vegetation that traps and holds sand makes the beach and dunes more susceptible to wind and water erosion, thus inhibiting their recovery from storms. Bays, channels, marshes, and grass flats behind the weakened foredune are exposed to storm-surge flooding and to accumulation of windblown sand.

Dune Damage

When the height of approaching storm waves exceeds the height of depressions along the dune ridge, water overflows the low points and washes down the landward side of the dunes, eroding sand and carrying it inland **(figs. 3 and 4)**. These washover (or overwash) areas deepen and widen under continual wave attack, allowing larger volumes of water to spill across the dune line and flow farther inland. Eroded sand may be deposited behind the dunes or carried into the bay, channel, marsh, or grass flat. In very severe storms, washover waters may even cut into interior land areas.

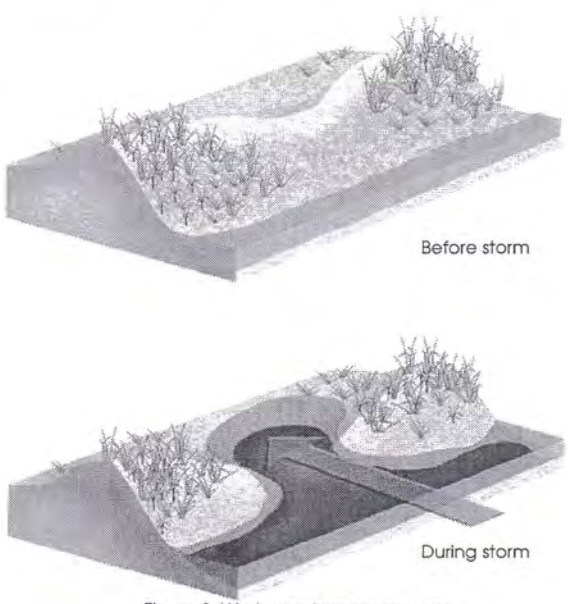


Figure 3. Washover from storm surge.

Figure 4. Oblique aerial photo of washover channels on Padre Island following Hurricane Brett in August 1999. Photo courtesy of David M. Stephens.

Areas of frequent major washovers may regenerate dunes slowly because of the volume of sand removed through erosion and because vegetation has been scoured away. Dune development may be impeded if the sand in a washover is too wet to be blown by the wind. Evidence of hurricane washovers is apparent on many Texas barrier islands.

Storms may also produce washouts in dune areas. These are similar to washovers, differing primarily in the direction of eroding waters. Generally, storm runoff from barrier islands and peninsulas is directed toward the bays. If there are breaches or depressions in the dunes, however, rainwater that collects in the swales (valleys between the dunes) may be channeled through these low points and overflow onto the beach, carrying sand with it.

Washouts may also be formed by retreating bay waters. Hurricanes, particularly slow-moving ones, may pile water into bay systems. If natural channels to the Gulf are too narrow to accommodate water retreating from the bays, washouts may cut across the low areas of least resistance in the barrier islands.

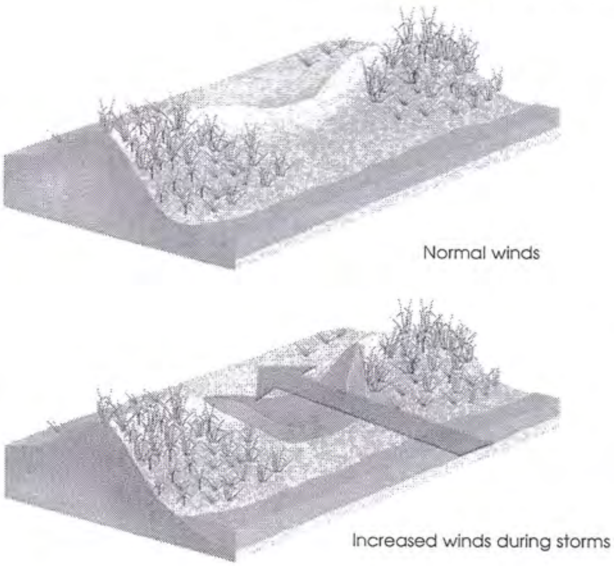


Figure 5. Formation of a blowout by wind in areas of a dune with little vegetative cover.

Blowouts are breaches in the dunes caused by wind erosion. They are aligned with prevailing southeasterly winds and are often cut down to the water table **(fig. 5)**. During storms, blowouts may become channels for storm-surge waters from the Gulf.

Eventually, following a storm, the natural beach/dune system can recover its pre-storm shape if enough sediment is available in the littoral system. In Texas, this process can take up to five years, first by beach accretion, then by dune formation, expansion, and vegetation colonization. Sometimes this process is interrupted by structures, such as buildings, that prevent winds from blowing sand that is necessary for dunes to form.

Human activities also take a toll on dunes. Construction, recreation, and grazing animals may accelerate or aggravate natural damage to the dunes by destroying vegetative cover and promoting development of breaches.

Seawalls, bulkheads, and groins may protect property landward of them against erosion. However, if waves persist, these structures can enhance shoreline erosion of adjacent properties and of the beach seaward of the structures. By withholding sand that would otherwise be transported alongshore, erosion-control structures such as groins inhibit dune development in areas downdrift of them. In general, rigid structures are less efficient than the naturally resilient dunes as defense for the beach against storm surge. The beach directly in front of a vertical seawall may be eroded by waves rebounding off the structure during storms. The seawall itself may eventually be undermined.

Disturbance of the foredunes by vehicles, pedestrians, construction work, or grazing animals can promote wind erosion. If unchecked, this erosion can lead to almost complete removal of dunes, depleting the supply of sand available for exchange during storms. Sometimes entire dunes are bulldozed to level a construction site or to lay pipelines. In these cases, damage is not limited to the immediate site. Dunes adjacent to the site are exposed to wind erosion.

Devegetation of dunes can ultimately be as damaging as direct removal or withholding of sand. Vegetation is often removed from a large area when a construction site is cleared. Plants are trampled and uprooted by pedestrian traffic, motor vehicles, horses, and grazing cattle **(fig. 6)**. As trails are established along frequently used routes through the dunes, the vegetation is destroyed and the wind begins to carry sand from the exposed area.

The continual loss of sand deepens the trail. Sloughing away of sand from the trail's sides widens it. As a greater area is exposed to wind erosion, a blowout, washout, or washover may develop.

Beach access roads through the dunes are subject to the same erosive processes and may become channels for storm surge.

Figure 6. Human influences on dune stability;
access through critical dune areas on Mustang Island.

Texas Coastal Dunes

The Texas coastline is composed of barrier islands, ancient deltaic headlands and peninsulas, bays and estuaries, and natural and man-made passes **(fig. 7)**. These are mobile environments, constantly reshaped by the processes of erosion and accretion.

Dune development varies with sediment supply to the beach. The supply is determined by the quantity of inner-shelf sand carried onshore by waves and wind, the amount and kind of sediment discharged by rivers, and the degree of human interference with natural sand transport (for example, the interruption of longshore currents by jetties and groins). Rainfall patterns also affect dune development.

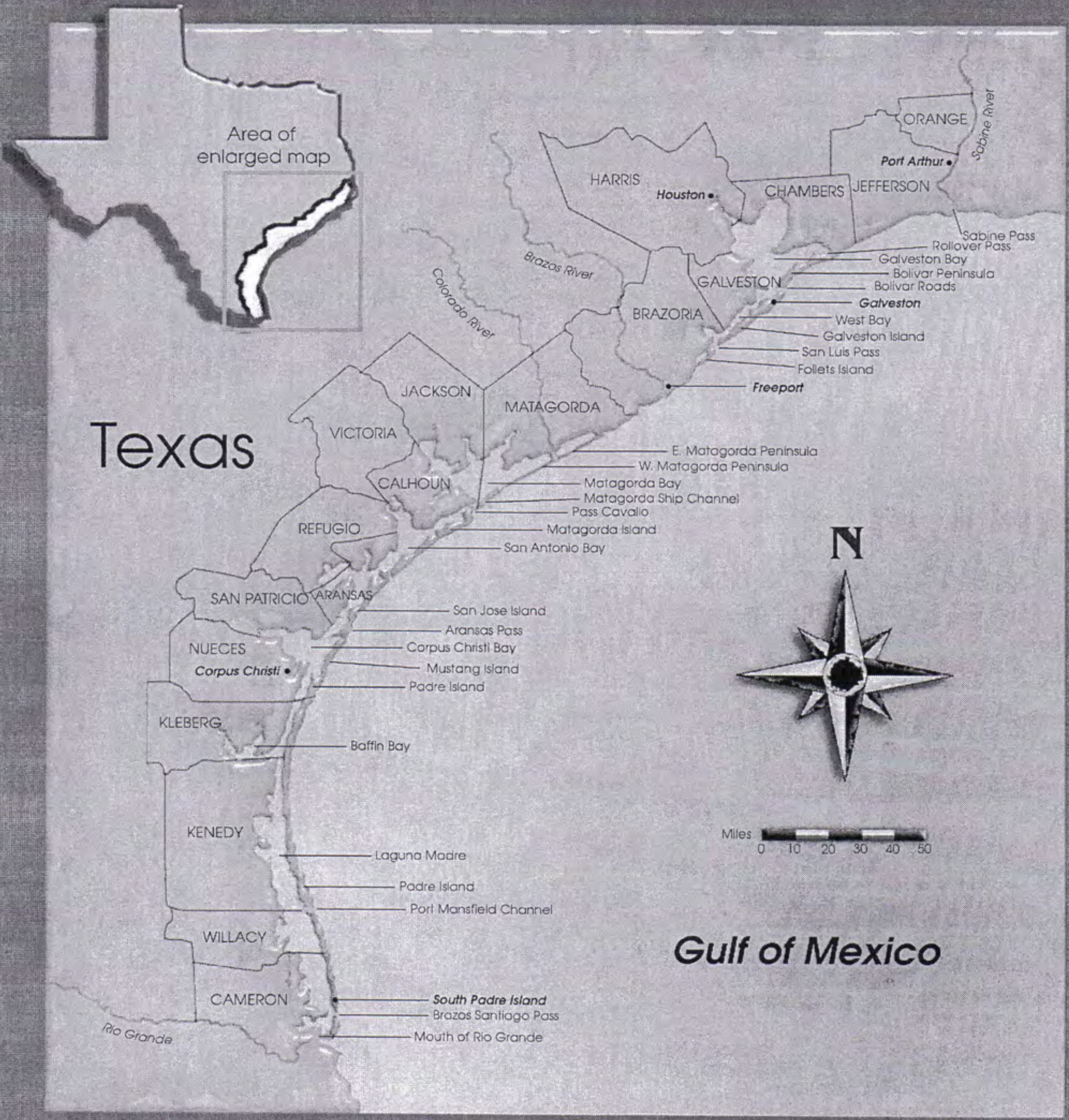


Figure 7. The Texas Coast.

On the upper coast, in Jefferson and Chambers counties, beach and dune development is limited. The Sabine River carries silt rather than sand to the coast. The shoreline is characterized by low-lying marshes and tidal flats with intermittent thin, linear sand ridges (chenier plain). Dunes are also scarce along the Brazos-Colorado river headland—the southern portion of the Brazoria County shoreline. Here, too, little dune-building sand is available to the longshore current.

Few naturally occurring dunes can be found on Galveston Island and portions of Follets Island because many of the foredunes were wiped out during Hurricane Alicia in 1983 and subsequent storms like Tropical Storm Francis in 1999 and Hurricane Claudette in 2003. Shoreline development and high erosion rates have inhibited dune recovery **(fig. 8)**.

Vegetated and relatively stable dunes occur on Mustang Island and North Padre Island. On Matagorda and San Jose islands, where there is limited shorefront development, there is a continuous, well-defined foredune ridge averaging 15 to 20 feet above sea level. The most highly developed dune formations are found in Nueces and northern Kleberg counties, where there is a foredune ridge consisting of several rows of dunes that average 20 to 25 feet in height. Some dunes reach an elevation of 40 feet. Sandflats and areas of low coppice mounds are also characteristic of this region **(fig 9)**.

As rainfall decreases southward along the Texas Coast, dunes have less of the vegetative cover necessary for stabilization. Migrating dunes—bare of vegetation and highly susceptible to wind erosion—are common in the arid environment of the lower coast **(fig. 10)**. Dunes of this type occur on Padre Island. In Kenedy, Willacy, and Cameron counties, the foredune ridge is poorly developed and breached by numerous washovers and blowouts.

Dune Construction, Improvement, and Repair

Several methods may be used to increase the height and stability of existing dunes, repair damaged dunes, encourage sand accumulation closer to the beach, or establish dunes where a low sand supply has inhibited dune formation or where dunes have been destroyed.

Where fresh sand deposits around obstructions such as grass clumps show conditions conducive to natural dune formation, plantings of native vegetation or structural barriers can be used to start and accelerate sand accumulation. Plantings of native vegetation should be the primary method for dune construction, improvement, and repair. Plant vegetation on grade in the backshore and close to the line of vegetation. Structures such as slatted wood or plastic sand fencing can help trap sand and stabilize dunes, but they should be used as a last resort and removed when vegetation is established.

In areas where the local sand supply is insufficient for these two sand-trapping methods to be effective, dunes can be artificially constructed with imported sand. All dune improvement project sites must be vegetated to maintain stability.

Figure 8. Oblique aerial photo of natural dune formations adjacent to shorefront development on Follets Island. Natural dunes exist where there is ample sediment and where the shoreline is allowed to migrate.

Figure 9. Natural dune formations on Padre Island in Kleberg County.

Figure 10. Migrating dune at Padre Island National Seashore.

"Beach Access and Dune Protection Laws" Refer to page 23

"Where to Get Help" Refer to page 25

Before any of the following procedures for dune construction or shoreline stabilization are employed, check with the local building official or the Texas General Land Office to avoid violation of state laws (see "Beach Access and Dune Protection Laws"). Agents from the U.S. Department of Agriculture Natural Resources Conservation Service can provide technical assistance for dune restoration projects (see "Where to Get Help").

Use of Vegetation

Three species of grass are appropriate for dune vegetation projects on the Texas coast: bitter panicum (*Panicum amarum*), sea oats (*Uniola paniculata*), and marshhay cordgrass (*Spartina patens*). Dune plants are not always available commercially in Texas. They usually are transplanted from natural stands.

Transplants from the vicinity of the project are more likely to survive than imported ones. If suitable stands cannot be found on the property where the vegetation project will be undertaken, it may be possible to obtain plants from neighboring property by agreement with property owners. A permit from the county commissioners court or from a city may be required if the harvesting or planting site is seaward of a dune protection line (see "Beach Access and Dune Protection Laws").

"Beach Access and Dune Protection Laws" Refer to page 23

The best time of year to transplant vegetation south of Corpus Christi is January or February. The optimum time for transplanting north of Corpus Christi is February, March, or April.

Take plants only from dense stands in areas that are not subject to erosion. Plants should not be taken from coppice mounds or from foredunes that are sparsely vegetated. Be careful not to trample plants. Remove individual plants in a scattered pattern at intervals of no less than two feet. Dig them out with a "sharpshooter" shovel. Pulling plants damages the small hair roots needed for re-establishment. Obtain a good root structure to ensure plant survival.

Figure 11. Recently planted dune vegetation.

Small areas and steep slopes at the project site are best vegetated by hand. Set single plants into individual holes made with a shovel or dibble and pack each planting firmly. Large, flat areas can be more economically planted with tractor-drawn transplanters such as one- or two-row tobacco transplanters with their shoes extended to make holes eight to 10 inches deep. One thousand plants should stabilize a 50- by 100-foot strip within a year **(fig. 11)**.

Immediate watering of transplants is not imperative, but success is increased if transplanting is done after a rain or if the dune is watered before transplanting. Apply mulch either before or after planting to minimize wind erosion, moderate soil temperature, and help retain moisture. Hay, burlap, and commercial screen or mesh made of natural fiber may be used for this purpose. Hay is the most economical mulch. Use at least 3,000 pounds of hay per acre. Pack the hay into the soil to prevent it from blowing away. In areas where high winds are common, burlap or screen anchored with stakes is recommended instead of hay. All of these materials are biodegradable and will eventually break down over time.

Transplanted vegetation needs little maintenance. While watering new plants is helpful, continued watering is necessary only in drought conditions.

Fertilization may be used during the first year after transplanting but is usually unnecessary thereafter. An approved soils testing laboratory can provide fertilizer recommendations for a particular location. In general, three or four applications of 12-6-6 fertilizer, 90 to 100 pounds per acre, are recommended beginning in April or May. Mowing dune grasses destroys their ability to trap sand and may kill the plants. Planted areas should be protected from vehicles, pedestrians, and grazing animals with temporary fencing. Signs can be placed at the site to explain the purpose and importance of the project **(fig. 12)**.

Figure 12. Sign for dune restoration project.

A transplant survival rate of 50 to 80 percent can be expected. If the survival rate is less than 10 percent, the area should be replanted. The vegetation should be fairly dense within one or two years. Any bare areas that remain after that time can be replanted with vegetation from the well-established sites.

Bitter Panicum

Figure 13. Bitter panicum (*Panicum amarum*).

Bitter panicum has proved to be the best species for dune stabilization on the Texas coast. This native beach plant has a higher salt tolerance than many other coastal species and is a hardy grower. Its leaves are smooth, bluish-green, 1/4 to 1/2 inch wide, and four to 12 inches long **(fig. 13)**. New plants are generated from tillers, shoots that grow from nodes on the roots. The seeds of bitter panicum are sterile and will not propagate new plants.

Bitter panicum plants taken for vegetation projects should be two to three feet tall. Cut off the tops of harvested plants about one foot from the roots to reduce water loss **(fig. 14)**. The plants can be stored for up to four weeks if the roots are wrapped in wet cloth or paper towels or immersed in fresh water.

The best period for planting bitter panicum is early winter to early summer, but survival is dependent mainly on adequate moisture. The plants can be placed in the ground either upright or horizontally. In areas of rapidly shifting sand, upright planting will prevent the plants from being buried. Generally, the plants should be planted six inches deep on two-foot centers, but closer placement is recommended on the tops of dunes and on steep slopes. The transplant site must be protected from grazing animals, as bitter panicum is palatable to them.

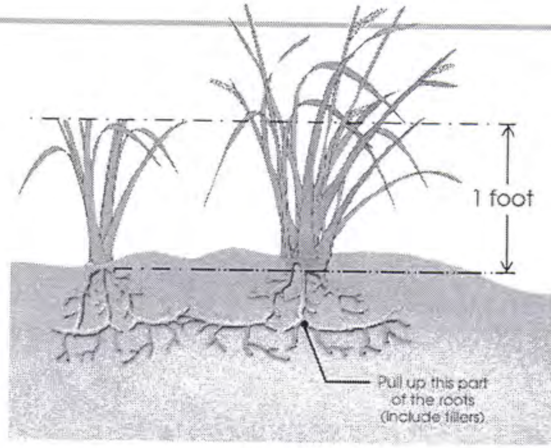


Figure 14. Harvesting and cutting bitter panicum.

Sea Oats

Sea oats, also native to the Texas coast, may be interspersed among plantings of bitter panicum. This grass has pale green, hardy leaves that die back each winter and stiff, seed-topped stems that grow to three feet or more in length **(fig. 15)**. Sea oats are less tolerant of salt spray than bitter panicum but grow rapidly enough to avoid being smothered in rapidly shifting sand. Interplanting sea oats and bitter panicum will reduce the risk of disease or pest infestation.

Harvest only healthy, vigorous plants for transplanting. The younger sea oats have a greater success rate than the older, longer-rooted plants. Do not take a plant that has a seed head. Transplant the plants as soon as possible after they have been harvested. The plants will generally remain alive for up to four days if the roots are wrapped in wet cloth or paper towels or immersed in fresh water. As with bitter panicum, the tops of the plants should be cut to within one foot of the roots to reduce water loss.


Figure 15. Sea oats (*Uniola paniculata*).

The best time for planting sea oats is from October through April. Place plants at least eight to 10 inches deep on 18-inch centers in the main area of the dune, with graduated plantings extending to four feet apart at the edges.

It is best to mix a sea oat planting with bitter panicum at a ratio of one to one. Sea oats usually take two growing seasons to fully stabilize a dune, while bitter panicum, which grows more rapidly, can become established in one year.

Marshhay Cordgrass

Marshhay cordgrass is a small, wiry perennial which spreads by rhizomes **(fig. 16)**. This grass does well on the landward side of dunes. If planted on the beach side, the grass is easily buried and destroyed by shifting sands. The most appropriate use for marshhay cordgrass is to repair the more stable portions of existing and new dunes.

June through November is the best time to plant marshhay cordgrass. Place the plants six to 10 inches deep and 12 to 36 inches apart to keep the base of each plant moist. Mixing marshhay cordgrass with plantings of bitter panicum produces best results.

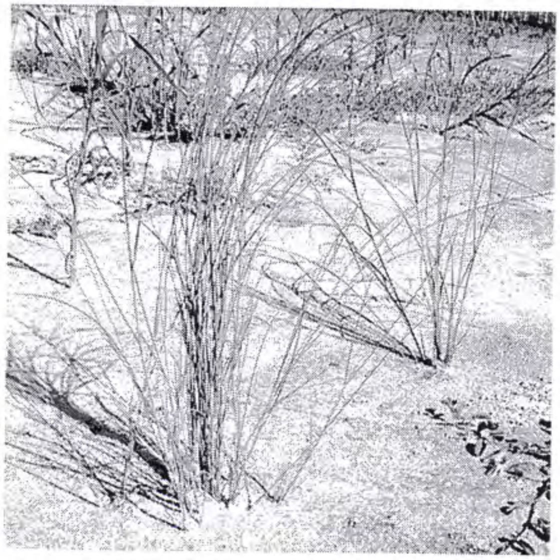


Figure 16. Marshhay cordgrass (*Spartina patens*). Photo courtesy of Frederique Perret.

Other Plants

Sea oats and bitter panicum, which commonly grow on the seaward face of foredunes, are highly erosion-resistant and easily established. However, other species of herbaceous plants also capture windblown sand and stabilize dunes.

Beach morning glory and seagrape vines can form a dense cover on the seaward side of dunes within a few growing seasons. Low-growing plants and shrubs found on the back side of the dunes include seacoast bluestem, cucumber leaf sunflower, rose ring gallardia, partridge pea, prickly pear, and lantana. Many of these are flowering plants, an attractive alternative to dune grasses though less effective as dune stabilizers.

"Where to Get Help" Refer to page 25

Some of these species are available commercially in Texas. Contact the Texas General Land Office, the Kika de la Garza Texas Plant Materials Center, or the Lady Bird Johnson National Wildflower Center for a list of nurseries or if you have questions regarding the use of a specific plant species for a dune restoration project (see "Where to Get Help").

Use of Sand Fences

The planting of native vegetation to trap sand is always preferable to the use of man-made structures. For reasons of aesthetics, safety, and possible interruption of public access, dune-building structures other than trees or brush must be removed as soon as they have served their purpose.

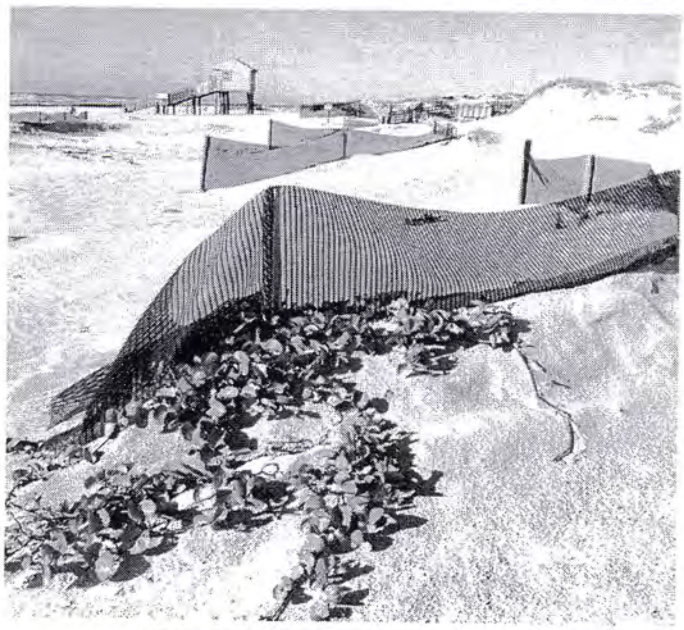


Figure 17. Sand fencing used to trap sand.

Standard slatted wood sand fencing is ideal for dune-building structures because it is inexpensive, readily available, easy to handle, and can be erected quickly.

Plastic fencing has the advantage of being strong, nondegradable, and reusable. Because plastic is non-flammable, it will not be taken for campfire fuel. Plastic fencing, however, is about three times as expensive as wooden sand fencing **(fig. 17)**. Successful experiments in stabilizing dunes and dune vegetation using porous jute netting as sand fencing and as protective ground cover have been conducted at the Padre Island National Seashore.

Trees (particularly discarded Christmas trees), brush, and seaweed can be also effective for trapping sand. Make sure that the piles are not too dense and that air can flow within them. Inorganic debris such as automobile bodies, concrete, wire, or tires must not be used for dune building. These materials are not biodegradable and are safety hazards.

A height of four feet, measured from the ground surface after installation, is recommended for dune-building structures. In areas where sand conditions are poor for dune building, a height of two feet is appropriate.

The fencing can be supported with wooden posts or metal poles at 10-foot intervals. Wooden posts should be black locust, red cedar, white cedar, or other wood of equal life and strength. Treated pine may be used as well.

The minimum practical length for posts is 6.5 feet; a length of 7 to 8 feet is optimum. Wooden posts should be no larger than three inches in diameter **(fig. 18)**.

Secure the fencing material by fastening it to each post with four ties of galvanized wire (no smaller than 12 gauge), and weave the material between the posts so that every other post has fencing on the seaward side.

Trees, brush, and seaweed can be held in place with smooth wire strung between support posts. Another method is to anchor the vegetation to stakes driven into the ground.

If the base of a sand fence is placed at ground level, dunes will build over the structure. If the base is elevated four to six inches above the ground, dunes will build on the downwind side of the structure, and the fencing can be retrieved for reuse as the dunes are formed. In this case, place the structures five to 10 feet gulfward of the damaged area.

Sand fencing should be placed in non-continuous, diagonal segments—at least 35 degrees to the shoreline—so as not to adversely affect nesting sea turtles.

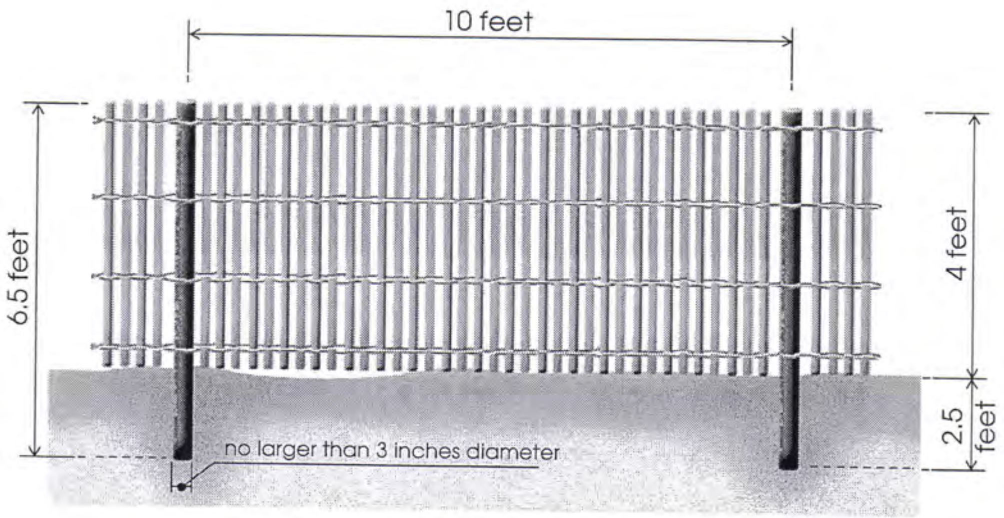


Figure 18. Sand fencing specifications for dune construction.

Breaches or Blowouts

In a breach or blowout, multiple tiers of dune-building structures can be used to increase sand entrapment and raise the ground elevation. Place the first structure at the landward end of the dune-building site. When sand has built up along this structure, erect a second structure about 20 feet seaward of it **(fig. 19)**. After sand accumulates here, place a third structure between the first two. Offset the breaks in the tiers to facilitate sand entrapment.

The dune-building structure should not extend gulfward of the dune line on either side of a breach or blowout. The area should be vegetated for natural stabilization.

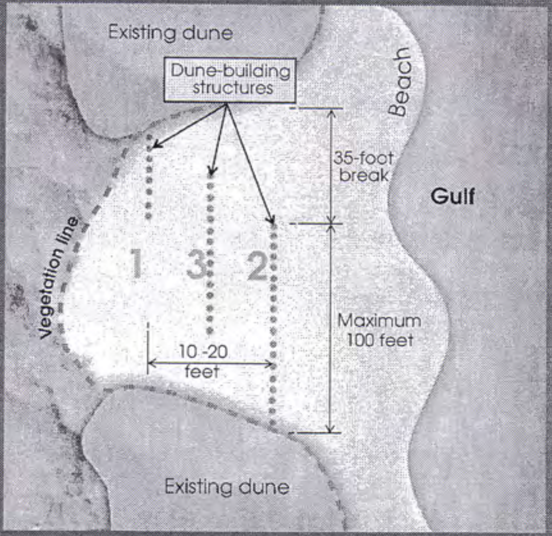


Figure 19. Placement of dune-building structures in breaches or blowouts.

Repairing Foredunes

To rebuild foredunes, place sand fencing or other appropriate structures perpendicular to the prevailing onshore wind. Leave a 35-foot gap between structures that are 100 feet long or more to prevent entrapment of storm surge water or rainwater in the trough between existing dunes and new dunes **(fig. 20)**.

Place the first tier of dune-building structures no more than 20 feet gulfward of the base of the existing dune (the point at which the gulfward slope of the dune increases sharply). Later, place a second tier of structures on the back slope of the dune created by the first tier. This will increase dune height and fill any trough between the existing dune and the newly formed dune. Repeat this process to build the dune line gulfward.

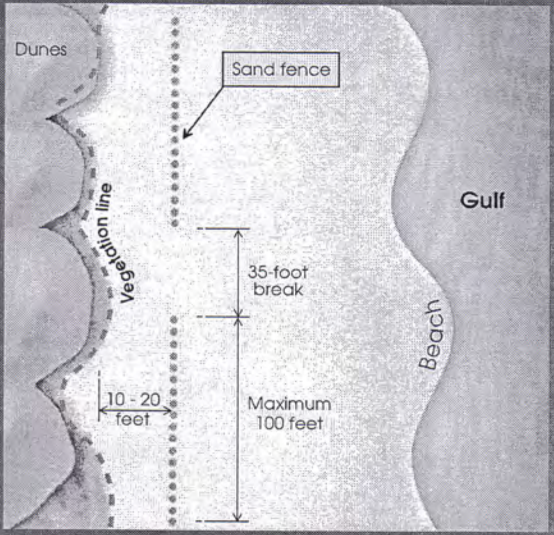


Figure 20. Placement of dune-building structures for repairing damaged foredunes.

Washover and Washout Areas

Dune-building structures should not be erected in washover or washout areas that extend all the way across a barrier island. These areas provide an avenue for the release of excess storm water from the bays, and they channel storm surge from the Gulf that might otherwise destroy dunes. In addition, washovers and washouts sometimes serve as migration routes for finfish and shellfish during storms. They also allow for the transportation of organic matter, an important component of the food chain, to the Gulf during high tides and storms.

A washover or washout that extends only partway across a barrier island can be filled with sand using the procedure described previously under "Breaches or Blowouts." If the sand gulfward of a washout or washover is water-saturated, or if there is standing water in depressions within the eroded area, sand may have to be imported to rebuild the dune.

The procedure described under "Repairing Foredunes" can be used to strengthen and stabilize dunes on either side of washovers and washouts

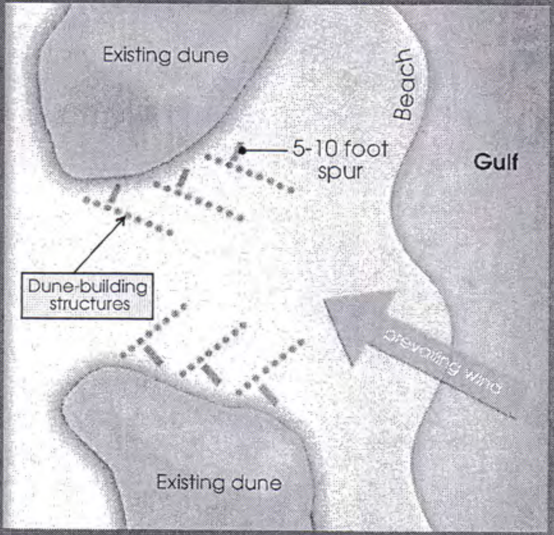


Figure 21. Placement of dune-building structures in washovers or washouts that do not extend across the barrier island.

that extend all the way or partway across barrier islands. Install dune-building structures at the base of the bordering dunes at a 30-45 degree angle to the sides of the washout or washover, facing the prevailing winds **(fig. 21)**.

Construction with Imported Sand

Some Texas beaches, particularly along the upper coast, are sand-starved. Natural sand accumulation occurs very slowly, and it may take as long as 20 years for a six-foot-high dune to form. Even with dune-building structures, the process is slow. In areas of limited sand supply, where the sand is saturated, or where it is restrained from blowing, dunes may be constructed of imported sand.

Sand for dune construction must not be taken from the beach. Doing so robs donor areas of the material necessary for maintenance of the beach and dunes, and may increase erosion. Removal of sand and other materials from barrier islands and peninsulas is strictly regulated by state laws (see "Beach Access and Dune Protection Laws"). Sand for dune construction can be obtained from construction-material suppliers or cement companies.

"Beach Access and Dune Protection Laws" Refer to page 23

The salt content of sand used to construct dunes should not exceed four parts per thousand (ppt). Higher salt concentrations will inhibit plant growth. For this reason, freshly dredged spoil material is usually not a good source of sand for dune construction projects. If dredged material is to be used, its salinity can be lowered by allowing it to sit until rain has leached the salt. Depending on the material, this may take from six months to three years. A local soils testing laboratory can conduct salinity tests at a particular location.

Imported sand should be similar in color, grain size, and mineral content to the sand at the dune-building site. If native sand is topped with imported finer sediment, the finer sediment will quickly erode.

Man-made dunes should be of the same general height, slope, width, and shape as the natural dunes in the vicinity. Generally, they should be no less than four feet high with a slope of no more than 45 degrees (a rise of one foot for every one horizontal foot). A slope of about 18.5 degrees (a rise of one foot for every three horizontal feet) is preferred. The initial width of the dune base should be at least 20 feet. A dune with a smaller base will not build to a height sufficient to provide storm protection **(fig. 22)**.

Where there is an ample supply of sand, construct dunes slightly landward of the location where foredunes would naturally occur to allow for natural seaward expansion. Dunes built too close to the Gulf can be destroyed by wave action during even minor storms and may interfere with public access along the beach.

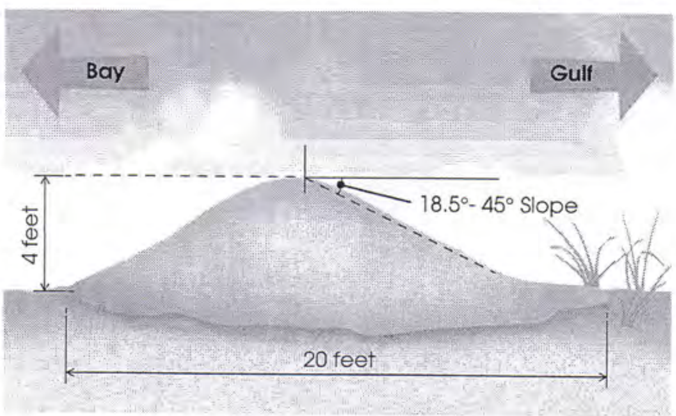


Figure 22. Minimum height, width, and slope of a dune constructed of imported sand.

Shoreline protection structures have been placed along portions of the coastline. While these structures protect property landward of them, they are not considered dunes and should not be used as a method of, or core for, dune restoration. These structures do not provide the same habitat for flora and fauna that dunes do or store and supply sand to the beach system.

Dune Walkovers

Damage to dunes from pedestrian traffic can be avoided by the use of elevated walkovers for access to the beach. If walkovers are conveniently placed near access roads, parking areas, beachfront subdivisions, and public facilities, pedestrians will be less likely to cut footpaths through the dunes. Also, providing walkovers may increase public awareness of the importance of dunes and promote an appreciation of the sensitivity of the dune environment **(fig. 23)**.

A walkover should begin landward of the foredune and extend no farther seaward than the most landward point of the public beach where it will not interfere with public use of the beach at normal high tide. The structure should be oriented at an angle to the prevailing wind direction. Otherwise, wind blowing directly up the path of the walkover may impede the growth of vegetation beneath it, erode sand from the seaward end, and increase the possibility of washout or blowout occurrences.

Construction Standards

Wood is the preferred construction material for walkovers because it is less expensive than metal, does not collect and retain heat as metal does, and is readily adapted to a number of designs. Although there are a few walkovers made from polyvinyl plastic, treated lumber and galvanized nuts and bolts may be used. Basic structural guidelines for walkovers are detailed in **figure 24**.

The width of a walkover should be based on the expected volume of pedestrian traffic. If a walkover will be infrequently used, a width of two feet should be sufficient. Walkovers intended for two-way passage should be wider, perhaps three or four feet. A width of six feet may be appropriate for a walkover subject to heavy use.

Figure 23. Dune walkover.

The structure's height should be at least one to one and a half times its width (three feet minimum) to allow sunlight to reach vegetation underneath. In any case, the deck of the walkover must be of sufficient elevation to accommodate the expected increase in dune height.

Space the slats forming the deck of the walkover 1/2 inch apart so that sunlight and rainfall can penetrate to plants below and so that sand will not accumulate on the deck.

Place the supporting piers as far apart as possible along the length of the structure. A distance of at least six feet between pairs of piers is recommended. Implant the piers at least three feet in the ground to ensure stability. A depth of five feet or more is advisable to allow for erosion around the piers during storms. Install the piers with a hand auger or posthole digger rather than with a tractor. Walkover piers should not be set with cement. Repair damage to the dune area as soon as possible.

Providing handrails on both sides of the walkover is recommended as a safety measure and to discourage people from jumping off into the dunes. Railings are particularly advisable on public walkovers and those that are high above the ground. Railings should be at least three feet high.

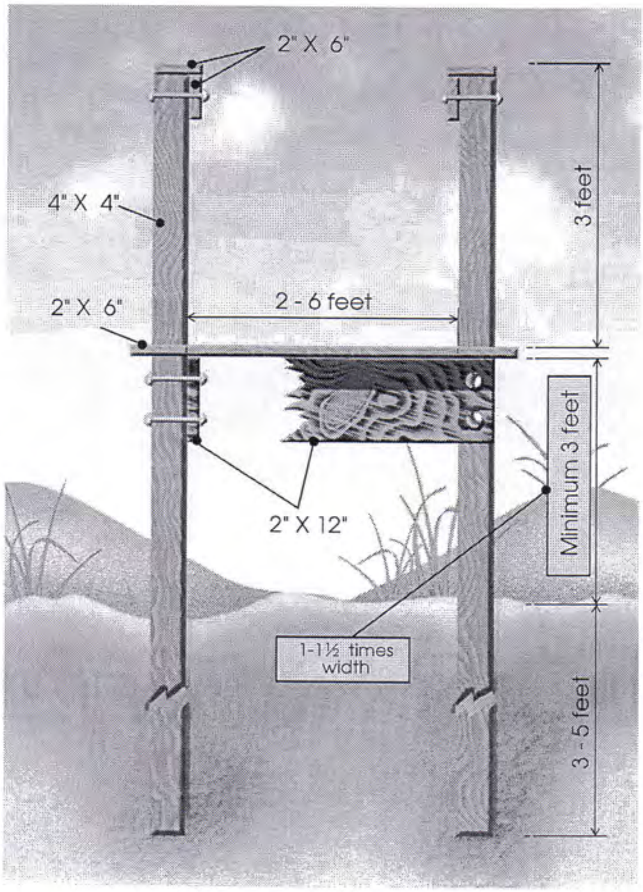


Figure 24. Construction details for a dune walkover.

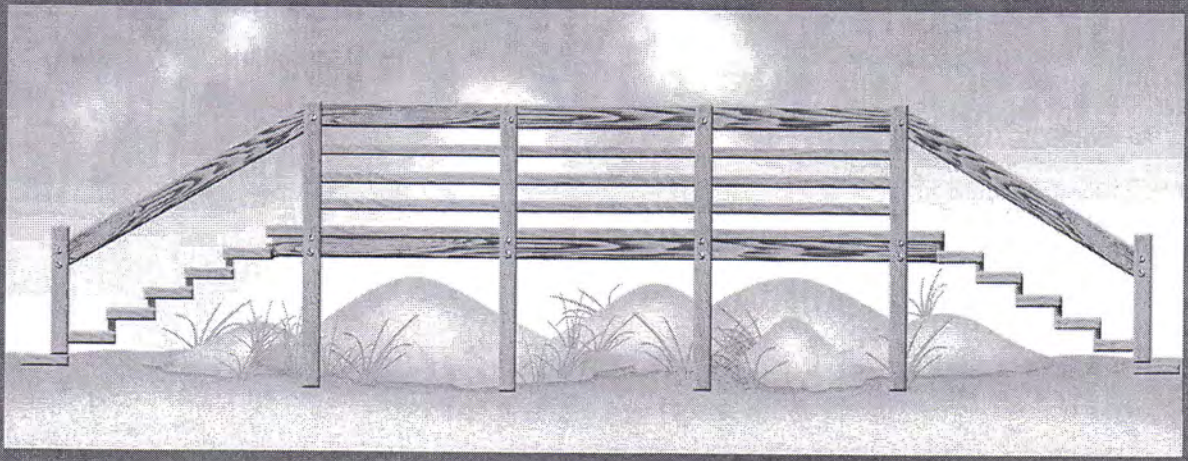
To enable wheelchair use on a walkover, inclined ramps with a 20 percent slope (a one-foot rise for every five feet in length) may be built at each end of the structure. Ramps are recommended for any large public walkover.

Walkovers should be inspected on a regular basis and promptly repaired as needed. To avoid damage, workers should enter the dune area on foot rather than by vehicle.

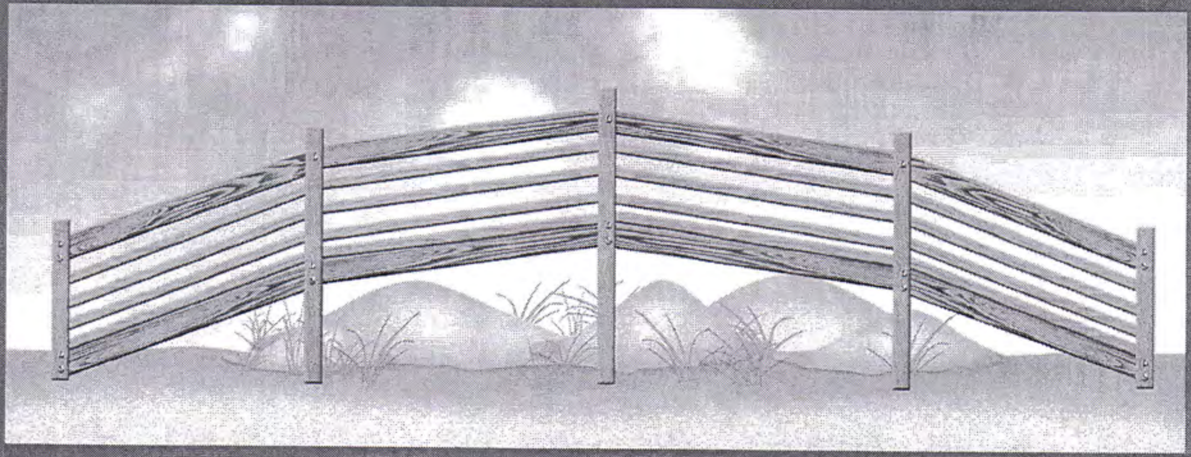
Common walkover structures are preferred for subdivisions to minimize damage to dunes by the proliferation of walkovers.

Walkover Designs

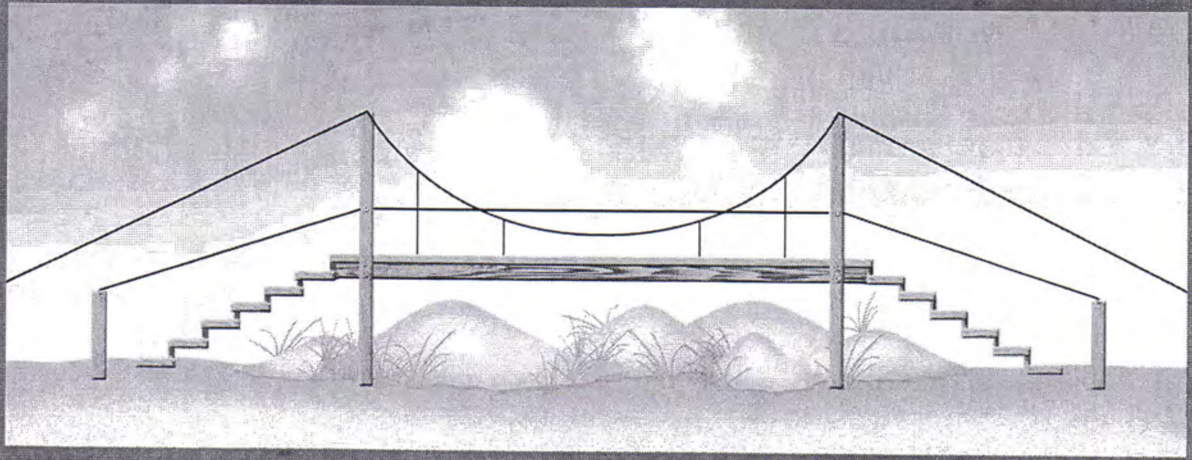
Figure 25 A and B show two of the most common designs for dune walkovers in Texas and are variations of the common pier-supported structure employing telephone pole or fence post piers. Design A has a flat deck with steps at each end. Design B has ramps instead of steps, and the deck is arched where dune formations are highest. **Figure 25 C** may be adapted for access over areas that cannot be disturbed. The conventional pier-supported walkover is relatively easy to build, but the services of a qualified contractor or architect may be required for more accommodating designs. Prior to construction, check with the local building inspector for preferred specifications for dune walkovers.



(A) Pier-supported with steps



(B) Pier-supported with ramps



(C) Suspended

Figure 25. Dune walkover designs.

Beach access and Drainage

Access Roads

The need for public roads to provide access to beaches often conflicts with the need to protect dunes; however, damage to dune areas by access roads can be minimized if the roads are properly designed.

Roads constructed parallel to the shoreline should be located as far landward of the dunes as possible. Beach access roads built perpendicular to the beach should be located in washover or blowout areas whenever possible, following natural land contours.

Beach access roads should be oriented at an angle to the prevailing wind direction. This will reduce the chance that water and wind will be channeled along them and erode the dunes at the sides of the road cuts **(fig. 26)**. Access roads near beaches should be elevated (similar to a speed bump) to reduce channelization of water during high tides **(fig. 27)**.

To minimize dune destruction, access roads should be as narrow as practicable. Any dune area damaged during road construction should be revegetated. Sand fencing can be used to retard erosion along the sides of the roads.

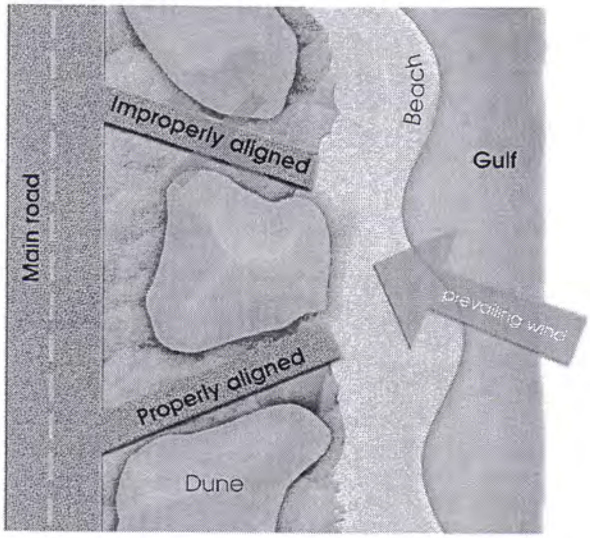


Figure 26. Alignment of beach access roads.

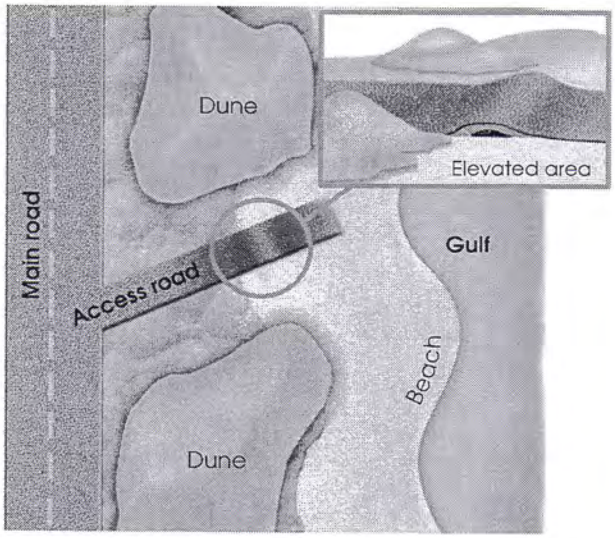


Figure 27. Elevating beach access roads at beach juncture.

Drainage

On an undeveloped barrier island, rainwater generally seeps into the ground or drains toward open water. As an island is developed and land is covered with buildings and pavement, the amount of permeable land surface exposed to absorb rainfall is reduced, and runoff increases. On barrier islands with dense urban development or areas where the contour of the land has been altered, storm runoff does not follow the natural course to the Gulf and can create a washout, resulting in flooding of shorefront property. In addition, the washout exposes land and buildings behind the dunes to further flooding by storm surge.

Drainage patterns resulting from construction must not erode dunes, the public beach, or adjacent properties. General Land Office rules require that new channels be directed inland instead of through critical dunes toward the gulf. Damage to dunes and to property behind them can be prevented or halted by the installation of a retention pond to collect and contain rainwater until it can seep into the ground. Either man-made or natural swales will serve this purpose. The pond should be large enough to contain the anticipated volume of runoff and located where it will receive the maximum amount of drainage **(fig. 28)**. A qualified professional should design the system and oversee its construction.

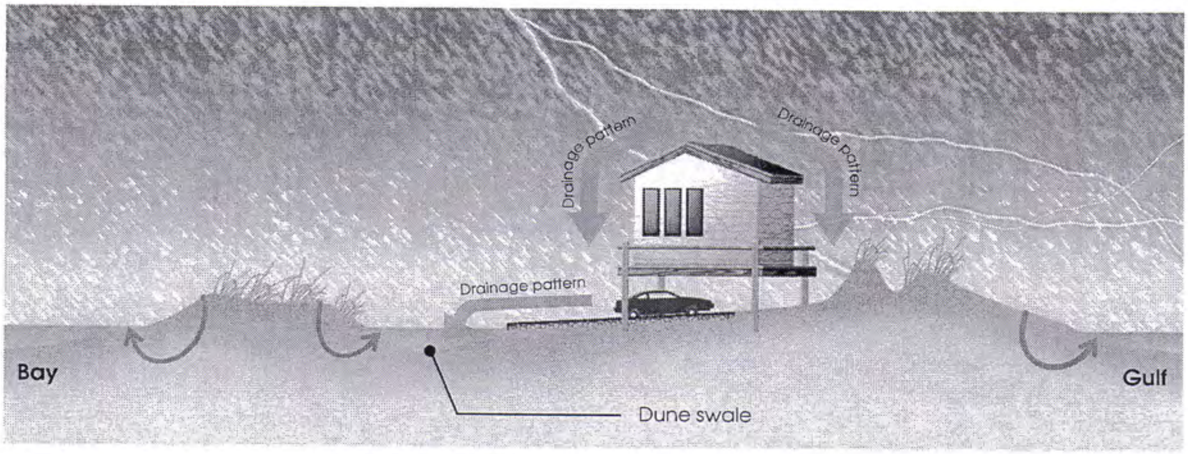


Figure 28. Utilizing a retention pond for drainage.

Beach access and Dune Protection Laws

Any group or individual planning to undertake a dune protection or improvement project on the Texas coast must be aware of federal, state, and local laws and regulations that apply to the proposed action.

Federal Guidelines

In 1987, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture Natural Resources Conservation Service (then the Soil Conservation Service) drafted the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*. Federal permits must be obtained from the Corps of Engineers for activities in these areas. Jurisdictional wetlands are identified on the basis of plant type, soils, and local hydrology.

In many cases, activities in coastal sand dunes will not affect jurisdictional wetlands and no federal permit will be required; however, seasonally wet swales between dunes may be considered wetlands. Questions regarding jurisdictional wetlands in Texas and procedures for obtaining proper permits can be directed to the local county commissioners court or to the U.S. Army Corps of Engineers, Galveston District (see "Where to Get Help").

The Federal Emergency Management Agency (FEMA) classifies all foredunes as "coastal high-hazard areas," or "high-velocity zones" (V-zones). A "V-zone" is defined as "a special flood hazard area extending from offshore to the inland limit of a foredune along the open coast, and any other area subject to high velocity wave action from storms or seismic sources."

Foredunes are included in V-zones because they absorb the brunt of storm attack. FEMA requires more rigorous construction standards within V-zones and also prohibits "any human-caused alterations of sand dunes which could increase potential flood damage." For more information concerning V-zones, and to obtain flood maps, contact a FEMA representative or your local floodplain coordinator. The Texas Natural Resource Conservation Commission is the FEMA state liaison for the National Flood Insurance Program (see "Where to Get Help").

State Laws

The Open Beaches Act (Chapter 61 of the Texas Natural Resources Code), passed by the Texas Legislature in 1959, codified the public's common law right of free and unrestricted access to the "public beach," which extends from the line of mean low tide to the line of vegetation on the shoreline bordering the Gulf of Mexico. The act makes it unlawful to prevent or impede access to or use of the public beach by erecting barriers or by posting signs declaring a beach closed to the public.

The Texas General Land Office (Land Office) can help determine whether a dune vegetation project, a dune-building structure, a dune walkover, or signs or fencing erected to protect a dune vegetation project site violates the provisions of this act (see "Where to Get Help").

The Dune Protection Act (Sections 63.001-63.181 of the Texas Natural Resources Code), enacted in 1973 and amended by the Texas Legislature in 1991, requires the commissioners court of any county with public beaches bordering on the Gulf of Mexico to establish a dune protection line on the Gulf shoreline. This requirement applies to mainland shoreline fronting the open Gulf as well as to the Gulf shoreline of islands and peninsulas. The county may allow the governing body of a municipality to assume this responsibility within its corporate limits and extraterritorial jurisdiction.

The dune protection line can be established up to 1,000 feet landward of the mean high tide line. A permit from the county commissioners court or city is required for most activities seaward of the line.

Questions about dune regulations should be directed to the county commissioners court, city, the Land Office, or the Attorney General's Office (see "Where to Get Help").

"Where to Get Help" Refer to page 25

Texas Coastal Management Program

The Texas Coastal Management Program (CMP) contains a series of goals and policies aimed at protecting the Texas coastal environment. Texas receives funding from the federal government for coastal projects and the Land Office administers the grants program for these projects. The CMP directive is to review federal actions, any activity or project, and applications for federal assistance under other federal programs for consistency with the goals and policies of the CMP. CMP guidelines allow the Texas Coastal Coordination Council (CCC) to review coastal projects for consistency. The CCC may review applications for federal assistance, beachfront construction certificates and dune protection permits issued by local governments, funds for dune restoration and walkovers, and local government dune protection and beach access plan certifications.

Coastal Erosion Planning and Response Act

In 1999, the Texas Legislature passed the Coastal Erosion Planning and Response Act (CEPRA) to provide funding to coastal communities for projects that slow the effects of coastal and shoreline erosion. Dune restoration and beach nourishment projects may be funded through this program. Communities may submit proposals to the Land Office for such projects.

Removal of Sediments

Sections 61.211 through 61.227 of the Texas Natural Resources Code regulate the removal of sand, marl, gravel, and shell from islands, peninsulas, and land within 1,500 feet of mainland public beaches outside corporate limits. A permit must be obtained from the relevant county commissioners court for the excavation of any of these materials unless the material is to be moved by a landowner, or with a landowner's consent, from one location to another on the same piece of property. No permit is required if the removal is officially undertaken by a federal, state, or local governmental entity. An incorporated city, town, or village may not authorize the removal of sand, marl, gravel, or shell from a public beach within its boundaries for any purpose other than the construction of a public-sponsored recreational facility or a shoreline protection structure.

The Texas Parks and Wildlife Department, under Chapter 86 of the Parks and Wildlife Code, regulates the disturbance and removal of marl, sand, gravel, shell, or mudshell located within tidewater areas for any purpose other than that necessary or incidental to navigation or dredging under state or federal authority. Questions may be directed to this department (see "Where to Get Help").

"Where to Get Help" Refer to page 25

Where to Get Help

FEDERAL

For construction standards in floodplains and coastal high-velocity zones:

★**Federal Emergency Management Agency, Region VI**
Federal Center
800 N. Loop 288
Denton, Texas 76201-3698
(800) 424-8802
www.fema.gov

For information on permitting in jurisdictional wetlands:

★**U.S. Army Corps of Engineers Galveston District**
P.O. Box 1229
Galveston, Texas 77553-1229
(409) 766-3004
www.swg.usace.army.mil

Corps of Engineers - Corpus Christi
5151 Flynn Parkway, Suite 306
Corpus Christi, Texas 78411
(361) 814-5847

For technical assistance in designing a dune restoration project:

★**U.S. Department of Agriculture Natural Resources Conservation Service**
101 S. Main Street
Temple, Texas 76501-7682
(817) 774-1261
www.tx.nrcs.usda.gov

★**Kika de la Garza Plant Materials Center**
3409 N. FM 1355
Kingsville, Texas 78363
(361) 595-1313
john.reilly@tx.usda.gov

STATE

For information on permitting coastal construction:

★**Texas General Land Office**
Coastal Resources
P.O. Box 12873
Austin, Texas 78711-2873
(800) 998-4GLO
www.glo.state.tx.us

Texas GLO - Upper Coast
11811 North D Street
La Porte, Texas 77571
(281) 470-1191
(281) 470-8071 fax

Texas GLO - Middle/Lower Coast
6300 Ocean Drive, Ste. 2400
Corpus Christi, Texas 78412
(361) 825-3030
(361) 825-3040

★**Coastal Coordination Council**
Permit Service Center
Texas A&M University-Corpus Christi
Natural Resources Building
Suite 2800
6300 Ocean Drive
Corpus Christi, Texas 78412-5599
(866) 894-3578

For information on sand, marl and gravel removal from tidal waters:

★**Texas Parks and Wildlife Department**
Resource Protection Division
4200 Smith School Road
Austin, Texas 78744-3292
(512) 389-4864
www.tpwd.state.tx.us

For information on the state's floodplain maps:

★**Texas Commission on Environmental Quality**
Floods and Floodplains
P.O. Box 13087
Austin, Texas 78711-3087
(512) 239-4771
www.tceq.state.tx.us

COASTAL COUNTIES

Coastal counties that administer dune protection and beachfront construction programs:

★**JEFFERSON COUNTY**
County Engineer
Jefferson County Courthouse
1149 Pearl Street, 5th floor
Beaumont, Texas 77701-3619
(409) 835-8584

★**CHAMBERS COUNTY**
Floodplain Administrator
P.O. Drawer H
Anahuac, Texas 77514-1708
(409) 267-8379

★**GALVESTON COUNTY**
Asst. Floodplain Administrator
123 Rosenberg, Suite 4157
Galveston, Texas 77550-1403
(409) 770-5552

★**BRAZORIA COUNTY**
County Floodplain Administrator
200 E. Locust, Room 8
Angleton, Texas 77515-4684
(979) 849-5711

★**MATAGORDA COUNTY**
Floodplain Management
2200 7th Street
Bay City, Texas 77414-0571
(979) 244-2717

★**NUECES COUNTY**
County Engineer
901 Leopard St., Suite 103
Corpus Christi, Texas 78401-3697
(361) 888-0490

★**CAMERON COUNTY**
Director
Cameron County Park Systems
P.O. Box 2106
South Padre Island, Texas 78597-2106
(956) 761-5493

COASTAL MUNICIPALITIES

Coastal municipalities that administer dune protection and beachfront construction programs:

★**CITY OF PORT ARTHUR**
Director of Planning
P.O. Box 1089
Port Arthur, Texas 77641-1089
(409) 983-8138

★**CITY OF GALVESTON**
Director of Planning and Community Development
823 Rosenberg, Room 401
Galveston, Texas 77550-2198
(409) 797-3660

★**VILLAGE OF JAMAICA BEACH**
City Administrator
P.O. Box 5264
Jamaica Beach, Texas 77554-5264
(409) 737-1142

★**VILLAGE OF SURFSIDE BEACH**
Mayor
1304 Monument Drive
Surfside Beach, Texas 77541-9999
(979) 233-1531, ext. 4

★**TOWN OF QUINTANA**
Mayor
814 N. Lamar
Quintana, Texas 77541
(979) 233-0848

★**CITY OF PORT ARANSAS**
City Manager
P.O. Box 1090
Port Aransas, Texas 78373-1090
(361) 749-4111

★**CITY OF CORPUS CHRISTI**
Director of Planning and Development
Planning Department
P.O. Box 9277
Corpus Christi, Texas 78469-9277
(361) 880-3560

★**TOWN OF SOUTH PADRE ISLAND**
Department of Public Works
P.O. Box 3410
South Padre Island, Texas 78597-3410
(956) 761-1025

OTHER SOURCES OF VEGETATION INFORMATION

For native plant information:

★ **Lady Bird Johnson National Wildflower Center**
4801 La Crosse Avenue
Austin, TX 78739-1702
(512) 292-4200
www.wildflower.org

For native dune plant availability:

★**Texas A&M University-Galveston**
Marine Biology Department
Galveston, Texas 77553-1675
(409) 740-4528
www.tamug.tamu.edu/mars/

★**Apache Ecological Service**
27426 Dobbin Hufsmith Road
Magnolia, Texas 77354
(281) 356-3135
www.apacheco.com

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Contributors

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