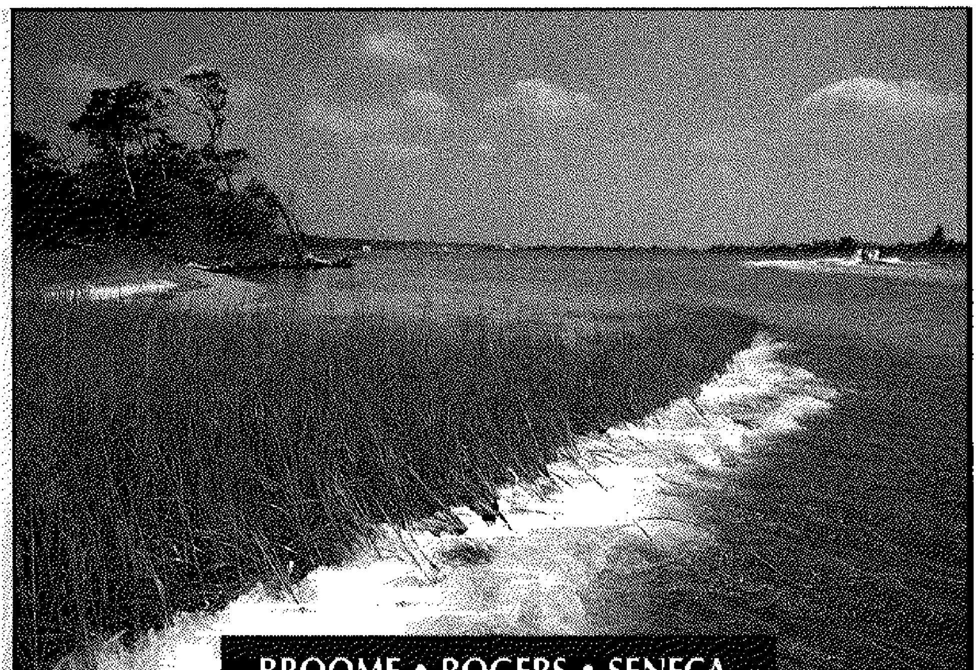
Shoreline Erosion Control Using Marsh Vegetation and Low-Cost Structures



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Front cover photo by Spencer M. Rogers Jr.

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The authors wish to acknowledge the contributions of Dr. W.W. Woodhouse Jr. (1910-1990). A significant portion of the information presented in this book resulted from his pioneering research efforts in the use of vegetation in coastal shoreline erosion abatement.

Introduction

Erosion is a serious threat to waterfront property along most of North Carolina's extensive estuarine shoreline. Shoreline erosion is a natural process caused by a gradual rise in sea level and prevailing wind and current conditions. But in many cases, it is accelerated by man's intensive use and mismanagement.

As demand for shoreline property increases — for homesites, recreational areas, marinas and industrial sites — its value increases, and landowners become more concerned about loss of land to erosion.

Almost every shoreline erosion problem is unique and must be dealt with individually. There is a variety of erosion-control methods — some beneficial, some useless and others that are even detrimental.

Structural methods such as bulkheads, groins, revetments and riprap are often effective. But they are expensive to build and maintain and may have adverse environmental effects. Transplanting salt marsh vegetation is an alternative erosion-control method that is relatively inexpensive and effective on some shorelines (Figs. 1, 2 and 3). Establishing vegetation is much cheaper than structural methods of erosion control, and the new marsh provides habitat, food and nutrients for organisms in the surrounding estuarine waters.

Figure 1. Transplanted salt marsh grasses are an alternative erosion-control method.

How Marsh Vegetation Reduces Shoreline Erosion

A fringe of marsh vegetation is a natural erosion barrier that causes a wave damping effect by breaking and dispersing waves (Fig. 4). As waves move through marshes, energy is dissipated and wave height reduced due to drag associated with the stems and leaves. Thus, marsh plants reduce the potential for shoreline erosion farther inland. One study indicated that 50 percent of wave energy was dissipated in the first 8 feet of marsh, and 100 percent was dissipated in 100 feet.

After several years, the plants develop a thick mat of live roots, stems, decaying plant material and trapped sediments. The root mat is typically about 1 foot thick and is far less erosion-prone than the pre-marsh sediments. In addition to the wave-dissipation effects of the stems, the marsh surface also allows the largest storm waves to break with little harm to the mat. Only smaller waves, reformed after breaking, reach higher ground, thus reducing the threat of erosion.

But some natural marshes are eroding even faster than unvegetated shorelines. This occurs when erosion and sea level rise increase water depths near shore. The marsh is very resistant to erosion during storms in which water levels are high and waves pass over or

Figure 2. A Nags Head shoreline planted with smooth cordgrass to curb erosion.

break on top of the marsh. But marsh erosion does occur as a result of offshore deepening and undermining of the root mat at the lower edge during low tide levels.

As a planted or natural marsh develops, its surface elevation increases because sediment and organic matter accumulate to form a tough root mat. At the same time, erosion may occur just offshore where the water is too deep for marsh plants to survive. Because these processes evolve in opposite directions, a small vertical scarp develops; the root mat is eventually undermined, and the marsh is lost for erosion control (Figs. 5 and 6). The marsh would need to be replanted landward of the original marsh where the proper elevation occurs.

There are many shorelines in North Carolina where environmental conditions such as fetch, tide range, salinity, waves and currents are unfavorable for a marsh. One of the most important factors is the size of the body of water — or fetch — over which waves can build in height. A longer fetch means bigger waves and more erosion potential. Where the fetch is greater than 2 miles, the success rate of exposed plantings decreases.

In some shorelines, the natural marsh fringe has been destroyed by severe storms, dredging, filling or foot traffic. Vegetation may re-establish very slowly or not at all because of exposure to waves. Transplanting accelerates revegetation and provides protection.

Each site must be evaluated to determine if plant-

Figure 3.
The same shoreline three years later.

ing marsh vegetation — alone or in combination with a breakwater or sill — would reduce erosion.

Site Suitability

It's not always obvious whether a shoreline can be stabilized by transplanted marsh grasses. Often, plantings may fail. If marsh grasses already exist within a short distance, chances for success are good.

Before you undertake extensive planting, try small test plantings. Various environmental factors may affect the degree of success and should be considered when deciding if vegetative stabilization is feasible. Several of the more important ones are outlined in this section.

Tides and Slope of the Shore

Periodic flooding and draining of the proposed planting area is necessary for good growth of smooth cordgrass. It is the plant most effective in estuarine shoreline stabilization. In North Carolina, the estuaries south of Cape Lookout and areas near inlets have regular, diurnal lunar tide cycles with a range of 2 to 5 feet. This provides for a relatively wide intertidal zone for growth of smooth cordgrass. In the larger estuaries

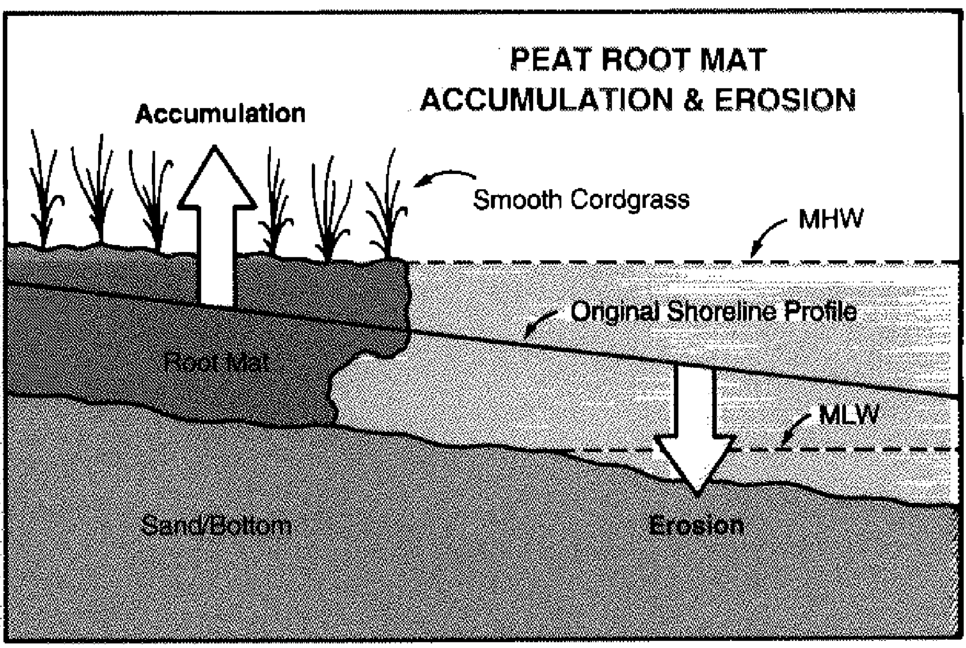
Figure 4. A fringe of marsh grasses causes a wave damping effect.

north of Cape Lookout, there is little lunar tide effect; rise and fall of the water level is determined by the wind (directions, speed and duration) and inflow of fresh water to the estuary. Under these conditions, the zone in which intertidal vegetation grows is relatively narrow, and a protective marsh fringe is more difficult to establish.

As a general rule, the wider the intertidal zone, the more effective a planting will be in controlling erosion. Of course, slope of the bottom is important in determining width of the intertidal zone; the more gentle the slope, the wider it is. Where water remains at the base of a steep bank or bulkhead at low tide, it is not possible to establish marsh grasses unless an intertidal zone is created by filling or grading the bank. In such cases, some type of structural help will be needed.

To determine the elevation zone that should be transplanted with smooth cordgrass at a given site, observe water levels on the nearest natural marsh. Observe when the water is standing at the upper limit of growth and mark this limit at the planting site. Do the same for the lower level of growth. A surveyor's level may also be used to relate the elevation limits of a natural marsh to a planting site.

Figure 5.
As offshore erosion continues and the root mat accumulates, the outer edge of the root mat is eventually undermined.



Salinity

Smooth cordgrass adapts to areas where the salinity of the floodwater and the soil solution is between 5 to 35 parts per thousand (Ocean water is 35 parts per thousand.). It will grow if transplanted in areas with fresher water, but will be eventually crowded out by other species. Some areas with poor surface drainage become too saline to support growth of smooth cordgrass. This situation can occur in depressions in which tidewater is trapped and salt becomes concentrated in the soil water because of evaporation.

Wave Climate

A marsh planting can tolerate only a limited amount of stress. It is most vulnerable to wave action just after being transplanted, before it has taken root. Wave climate is affected by fetch (distance the wind blows over water), wind speed and duration, depth of water, slope of the shore and orientation of the site. There is a greater risk of damage if a shoreline is facing the direction of storm winds. Shallow offshore waters, gently sloping bottoms and protected areas such as coves all reduce wave energy.

Sediment Supply

A moderate amount of sediment is supplied to a planting by wave action, by longshore drift or from the bank above. This stimulates growth by supplying nutrients. It also increases the elevation and width of the marsh, protecting the eroding bank. Where there is excessive accumulation of sediment — more than 12

Figure 6. Undermining of a marsh in Carteret County.

inches per year — damage due to burial may occur.

Nutrient Supply

In many cases, estuarine sediment is rich in nutrients and supplies adequate amounts for plant growth. But as in upland soils, the nutrient status varies from one location to another. At some sites, it is necessary to apply nitrogen and phosphorous fertilizers to establish a stand of marsh grasses. Fertilizers applied underground at the time of planting stimulate rapid growth, thus improving chances for survival. Maintenance fertilization can be applied during the second growing season — and subsequent years if necessary — by broadcasting on the surface.

Other Factors

Other factors that affect establishment and maintenance of shoreline vegetation at some sites include soil erodibility, availability of sunlight, pedestrian or vehicular traffic along the shoreline, erosion from upland runoff, boat wakes and currents.

Structural Aids

Breakwaters or Sills

Where wave exposure is too great for the marsh to survive on its own, small structures called offshore breakwaters or sills can be used with a planted marsh (Fig. 7, 8, 9 and 10). They provide longer lasting protec-

Figure 7.
An offshore breakwater, in combination with a planted marsh, can provide long-lasting erosion protection at relatively low cost.

tion at a relatively low cost. In North Carolina these breakwaters have typically been constructed with wood. In the Chesapeake Bay area they have been built with stone and are usually called offshore sills.

These small structures protect the outer edge of the marsh from erosion. The marsh, in turn, provides protection for the upland property during more severe storms. The combination of marsh and breakwater can be used successfully on many more shorelines than marsh planting alone. But it is still not appropriate for high-energy beaches.

How Low-Cost Breakwaters Are Built

The key to keeping the cost low is to prevent large waves from hitting the breakwater. That means keeping the top of the breakwater low — about 6 inches above normal high water level and only slightly higher than the eventual level of the marsh's root mat.

A suitable site should have a flat bottom and shallow water near the shoreline. The water should be less than 3 feet deep 50 to 100 feet offshore. In shallow water, the largest waves will break farther offshore before reaching the breakwater. The force of even a small wave can be very destructive. The breakwater is designed to be only strong enough to withstand the largest waves at normal water levels. But when higher water levels and

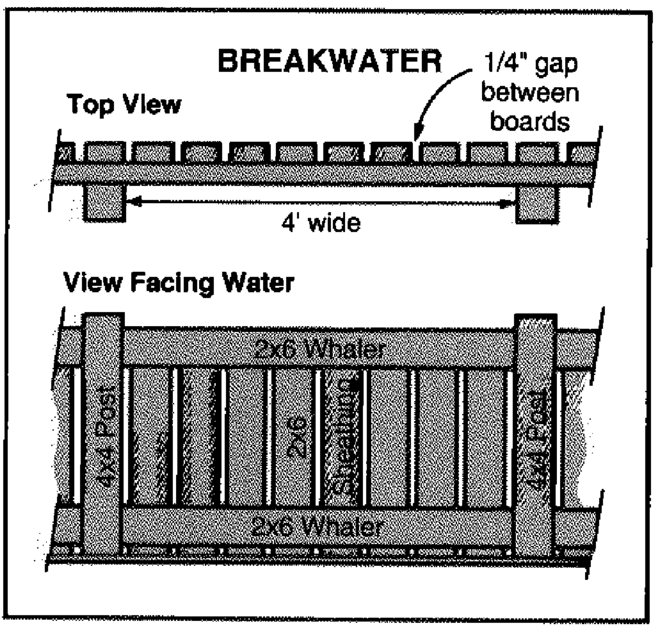


Figure 8. Dimensions of breakwater with view from above and facing water.

larger waves occur during a storm, the breakwater will be underwater and the worst of the waves will pass over the top. Under these conditions, the marsh will provide the primary erosion protection.

Breakwaters are usually located 20 to 50 feet offshore, depending on the bottom slope and the growing range of the marsh grasses. Flatter slopes may allow wider plantings.

After the breakwater is constructed, upland erosion may continue until a dense marsh is established; the structure is too small to work alone. But the breakwater provides a sheltered area where the new marsh can get started more easily. Once the root mat and dense stem growth are established — usually after one good growing season — the upland shoreline should be stabilized.

Although neither could work alone, planted marsh and breakwaters together are comparable to bulkheads in effective erosion control and longevity. Typical wooden breakwaters often cost one-third to one-half the price of a wooden bulkhead at the same site.

At first glance, a wooden breakwater may look a lot like a bulkhead. But there are significant differences. Bulkheads hold back the soil with pilings placed on the seaward side. Breakwaters must resist the waves without soil support and should have posts positioned on the landward side. Without the heavy soil forces on the top of a bulkhead, the breakwater does not require any

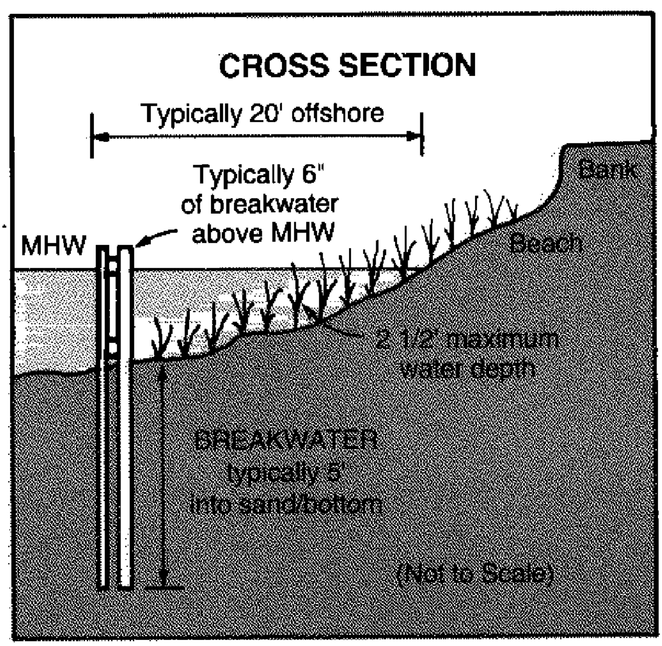


Figure 9.
Breakwater cross section.

tiebacks or deadmen. The breakwater is entirely supported by its imbedment in the bottom. It can be held together with nails; bolts are not required.

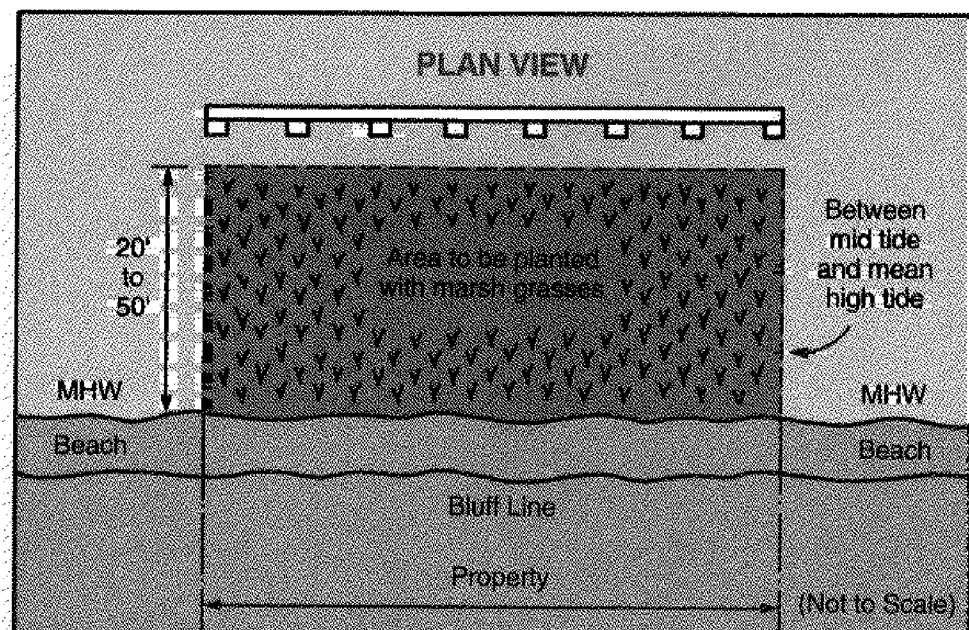
Unlike bulkheads, breakwaters should be porous, with a small gap left between each board to allow water circulation behind the structure. Both ends should be left open to allow additional circulation. When waves break over the top, water can accumulate behind the breakwater. It is better to spread the return flow over the entire length rather than risk excessive scour at widely spaced gaps. Breakwaters longer than 200 feet may also need larger openings along their length.

To allow the turbulence of breaking waves to dissipate before reaching the plants, a breakwater should be located about 10 feet seaward of the lower limit where the marsh can grow. On more active beaches, some sand may accumulate behind the breakwater.

Boat Wake Erosion and the Intracoastal Waterway

Along some shorelines, the primary cause of erosion is boat wakes rather than storm waves. For example, shorelines along the Intracoastal Waterway often experience severe erosion due to boat wakes. Unlike storm waves, the largest boat wakes may occur during

Figure 10. Layout of breakwater and planted marsh grasses.



lower tide elevations. It cannot be assumed that the largest waves will pass over the top of the breakwater. Because the full height of the breakwater will be exposed to much larger waves, a stronger breakwater design may be required to resist severe boat wakes.

Where Wooden Breakwaters Will Not Work

Low-cost breakwaters or sills are not recommended on high-energy beaches with steep offshore slopes or large movements of sand along the shoreline. If nearby groins or jetties stay filled all year, the breakwater may trap too much sand, leaving no proper water depths to plant the marsh grasses. In harsher wave exposures, much larger and more expensive breakwaters may be necessary.

Establishment Procedures

Plant Species Description

The most effective marsh species for transplanting in salt and brackish water areas are smooth cordgrass (*Spartina alterniflora*) (Fig. 11) and saltmeadow

Figure 11. Smooth cordgrass (Spartina alterniflora).

cordgrass (*Spartina patens*) (Fig. 12). Both are perennial grasses, but they differ in appearance and habitat.

Smooth cordgrass grows from 1 foot to 6 feet tall in the intertidal zone of saline areas from about mean tide level to mean high tide (Fig. 13). The leaves are usually smaller than a half inch in width and are relatively smooth on both upper and lower surfaces and on the margins. Saltmeadow cordgrass grows from 1 foot to 3 feet tall from about mean high tide to the high water line of storm tides. Its leaves are often rolled inward, giving a wiry appearance, and are usually less than half the width of smooth cordgrass leaves.

A third perennial grass, giant cordgrass (*Spartina cynosuroides*) (Fig. 14), grows 8 to 9 feet tall and is usually the tallest of the salt and brackish-water marsh plants. It occurs only in brackish water areas where salinity is less than 10 parts per thousand. Its leaves are usually twice as wide as those of smooth cordgrass, and there is a prominent midrib region along the center of each leaf. Both the underside of the leaf and the leaf margins are roughish.

Above the elevation of the storm tide line, American beachgrass (*Ammophila breviligulata*) and coastal bermudagrass (*Cynodon dactylon*) may be used in sandy soils. Tall fescue (*Festuca arundinacea*) may be used in areas with fertile, finer-textured soils to help prevent erosion from wind and rainfall runoff.

Figure 12. Saltmeadow cordgrass (Spartina patens).

Obtaining Transplants

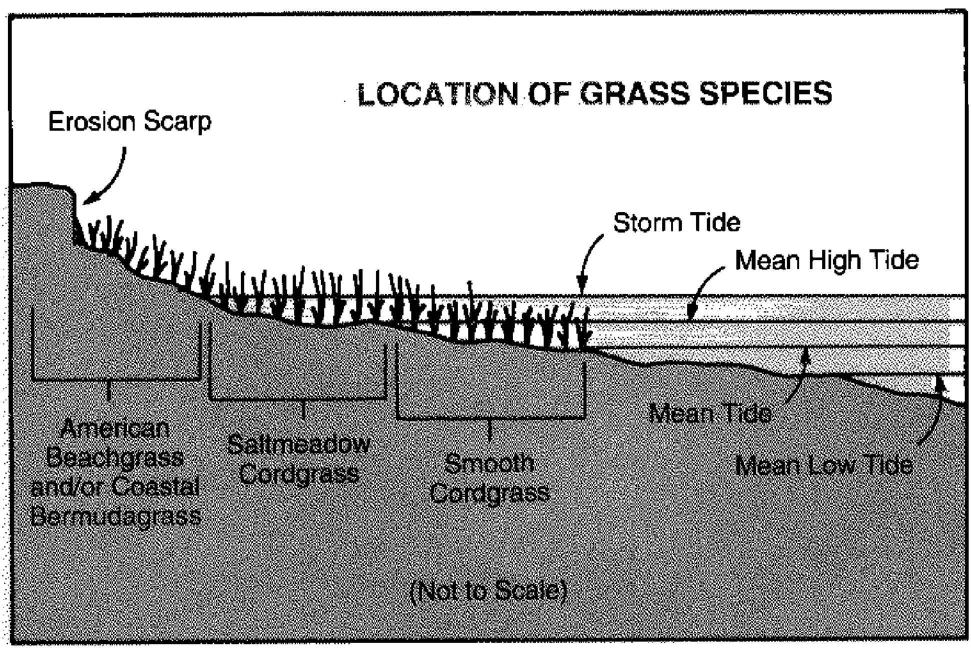
Transplants of marsh species are available from a few commercial growers. Obtain plants by digging from natural stands, or collect seed and grow seedlings in pots.

The best sites for digging plants are in recently established marshes with open stands or along marsh edges. Avoid older, well-established marshes that have developed a dense root mat. Plants in open stands or along marsh edges are more vigorous, have larger stems and are easier to obtain. Digging and separating plants is also much easier in sand.

Be careful to minimize damage to the existing marsh. Sandy, dredged-material disposal areas or areas in which sand has accumulated naturally often provide a good source of transplants. Contact your local Cooperative Extension agent or Sea Grant agent to see if such an area is available near you. Once the plants are dug, don't let them dry out. Pack the roots in sand and keep them moist until you transplant them.

Smooth cordgrass may also be propagated from seed. The seed should be collected when mature (late September), kept refrigerated and moist for two to three weeks, threshed and stored in a covered container filled with salt water (35 parts per thousand) at 35 F to 40 F. Use storage water collected from the area where the

Figure 13. Location of grass species in relation to tide level.



seeds are harvested or a solution of artificial seawater.

Marsh grass seed can be planted directly on protected sites in April or May. However, direct seeding is not recommended on most shorelines because they are too exposed to wave action. There is a greater chance of success if seedlings are grown in pots and transplanted on the shoreline. The plants can be grown in any good potting soil in plastic containers. A mixture of equal volumes of topsoil, sand and vermiculite works well.

If grown in a greenhouse, seed should be planted about Feb. 1 to produce seedlings ready for field planting in late April or May. For this method, soak the seed in a 25 percent solution of household bleach for 15 minutes; then rinse. Then cover the seed with about one-half inch of soil. Keep the soil moist and the greenhouse warm. The seedlings grow slowly for about three weeks, but rapidly after that. They are ready for transplanting in May (Fig. 15). Seedlings should also be fertilized with a nutrient solution or some other suitable fertilizer such as Osmocote.

If no greenhouse is available, seeding must be delayed until after danger of frost is past. Transplants or

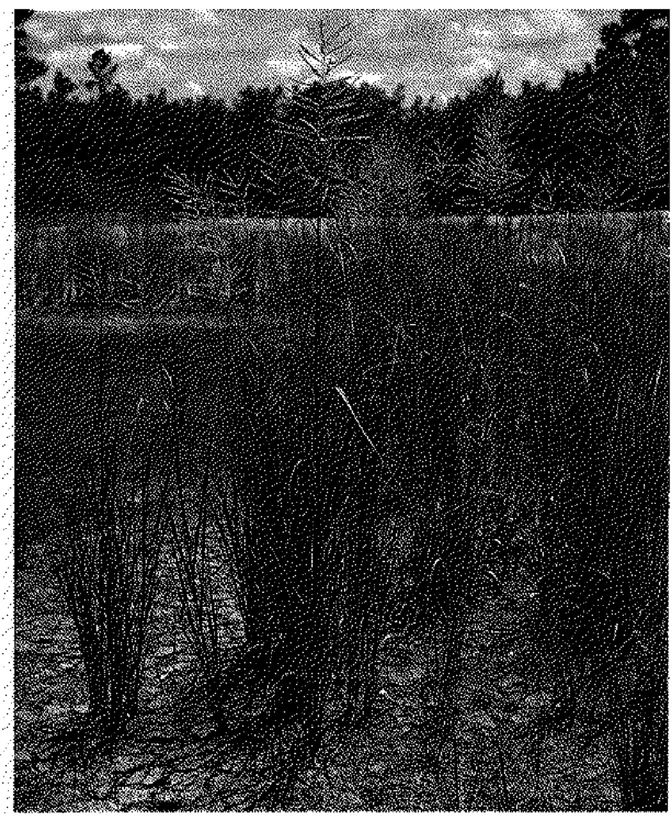


Figure 14. Giant cordgrass (Spartina cynosuroides) *is less salt tolerant and grows in brackish water areas.*

seed should be collected as near as possible to the planting site — no more than 50 miles north or south — because of genetic variation.

Transplanting Date

You should transplant between April 1 and June 15, if possible. You may transplant later, but first-year growth is reduced by the shortened growing season.

Spacing

The closer the spacing, the greater the chance of success on an exposed shoreline. However, the number of transplants required must be considered. For example, a 1-by-1-foot spacing requires four times as many transplants as a 2-by-2-foot spacing to transplant a given area. A 2-by-2 spacing has been effective on most shorelines in providing cover by the end of the first growing season. Wider spacings reduce the chance of successful establishment. Check plantings frequently, and replace any that have been washed out.

Transplanting Methods

To handplant, use a dibble or shovel to open a hole 4 to 6 inches deep. Insert the plant and pack the soil

Figure 15. Giant cordgrass seedlings in the greenhouse.

around it (Fig. 16). You may plant large areas with a tractor-drawn mechanical transplanter if there are no stumps or other obstacles.

Fertilizing

The need for fertilization varies by location, depending on the fertility of the soil and sediments that may accumulate. On many eroding shorelines in North Carolina, particularly the reddish, clayey banks of rivers, it is critical to supply transplants with nitrogen and phosphorous fertilizers. Fertilizing at planting gets the plants off to a fast start, which helps prevent washing out (Fig. 17). Place the fertilizer material below the surface to reduce its escape to tidal waters.

Slow-release fertilizers such as Osmocote and Mag Amp are more effective than ordinary soluble materials because they provide nitrogen over a longer period. Slow-release fertilizers can be placed in the planting hole with little risk of salt injury. Place soluble material in a hole about 2 inches from the plant. Or put it in the planting hole and cover with 2 inches of soil before inserting the plant. If you use ordinary fertilizer materials, a second application of fertilizer may be needed after six to eight weeks. Suggested amounts of fertilizer materials are listed on page 20 (Fig. 18).

Figure 16. Handplanting of smooth cordgrass.

Fertilization at some sites is necessary in the second and subsequent growing seasons. The need for fertilization can be determined by appearance of the plants. Broadcast ordinary soluble fertilizer materials on the surface at low tide, and the fully developed root system will be able to absorb a portion of the nutrients. Apply fertilizers three times during the growing season (May 1, June 15 and Aug. 1) at the rate of 100 pounds/acre N and 100 pounds/acre P_2O_5 on the first date and 100 pounds/acre N on the second and third dates.* Fertilizer materials recommended for surface application are ammonium sulfate (or ammonium nitrate) and concentrated superphosphate.

Other Plants

Plants other than — or combined with — smooth cordgrass may be useful in controlling shoreline erosion. In the intertidal zone of fresh to brackish water (salinity below 10 parts per thousand), giant cordgrass

*100 pounds/acre is equivalent to about 2.3 pounds/1,000 square feet. This rate is expressed in terms of actual N and P_2O_5. For example, to apply 100 pounds of N, 1,000 pounds of 10-10-10 fertilizer would be needed (23 pounds/1,000 square feet). If ammonium sulfate (21 percent N) is used, 476 pounds are needed to supply 100 pounds of N (11 pounds/1,000 square feet).

Figure 17.
The effect of fertilizer on growth of smooth cordgrass was obvious at the end of the first growing season. The row on the left was unfertilized, the center row received nitrogen, and the row on the right received nitrogen and phosphorous.

may be used. The same general planting instructions apply as for smooth cordgrass.

Black needlerush (*Juncus roemerianus*) may also be planted in brackish-water and irregularly flooded areas where it is adapted. Pot-grown seedlings are better transplants than field-dug plants. Seed should be collected in early June and stored dry in refrigeration. Seedlings grow slowly and require about five months before plants are ready for the field.

Saltmeadow cordgrass can be planted at higher elevations (between mean high water and high water of storm tides) along most estuarine shorelines in the state. Propagation procedures are similar, except for seed storage and fertilization. Seed may be stored dry under refrigeration. Because of less frequent flooding in this zone, it is not as critical to place fertilizer below the ground or to use slow-release materials. Fertilization is necessary, but broadcasting fertilizer on the surface is sufficient in most cases. Above the level of high tides, a cover of vegetation should be maintained to control runoff from rainfall. In North Carolina, American beachgrass or bermudagrass (coastal or common) are good choices for sandy sites, and fescue may be used on some of the better soils.

Vegetation is an effective and economical means of erosion control on some shorelines. However, it is not a cure-all, and many sites are too severe for vegetation to help significantly. When deciding whether to transplant salt marsh vegetation or use a structural means of erosion control, seek the advice of Sea Grant, Soil Conservation Service or County Cooperative Extension agents.

Figure 18. Recommended applications of fertilizer.

Fertilizer Material	Analysis N-P_2O_5-K_2O	Approximate Amount/Plant
Osmocote (8-9 month release)	18-6-12	0.5-1.0 oz.(2-4 tsp.)
Osmocote (3 month release)	14-14-14	0.5-1.0 oz. (2-4 tsp.)
{ Mag Amp	7-40-6	0.5 oz. (2 tsp.)
{ Osmocote	14-14-14	0.3-0.6 oz. (1-2 tsp.)
Ammonium sulfate[1]	21-0-0	0.4-0.8 oz. (1-2 tsp.)
Concentrated superphosphate	0-46-0	0.2-0.4 oz. (0.5-1 tsp.)
Mixed fertilizers	10-10-10	0.8-1.6 oz. (2-4 tsp.)

[1]Ammonium nitrate may be substituted if ammonium sulfate is not available.

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