Gulf and Caribbean Research

Volume 7 | Issue 4

January 1984

Seedling Establishment of *Spartina alterniflora* and *Spartina patens* on Dredged Materials in Texas

James W. Webb
Texas Agricultural Experiment Station

J.D. Dodd
Texas Agricultural Experiment Station

B.H. Koerth
Texas Agricultural Experiment Station

A.T. Weichert
Texas Agricultural Experiment Station

Recommended Citation

Webb, J. W., J. Dodd, B. Koerth and A. Weichert. 1984. Seedling Establishment of *Spartina alterniflora* and *Spartina patens* on Dredged Materials in Texas. Gulf Research Reports 7 (4): 325-329.
Retrieved from https://aquila.usm.edu/gcr/vol7/iss4/3
DOI: https://doi.org/10.18785/grr.0704.03

Gulf Research Reports, Vol. 7, No. 4, 325–329, 1984

SEEDLING ESTABLISHMENT OF *SPARTINA ALTERNIFLORA* AND *SPARTINA PATENS* ON DREDGED MATERIAL IN TEXAS

JAMES W. WEBB,[1] J. D. DODD, B. H. KOERTH, AND A. T. WEICHERT
Texas Agricultural Experiment Station, College Station, Texas 77843

ABSTRACT Effects of fertilizer, elevation, and tidal inundation on seedling establishment of *Spartina alterniflora* and *Spartina patens* were tested at a wave-protected sandy dredged material site, Galveston Bay, Texas. No seedlings that grew from sown seeds became established at elevations below 36 cm (msl) while the greatest number established in the upper tier. Seedlings of *S. alterniflora* were more numerous than *S. patens* in the upper and middle tiers. Naturally occurring seedlings of *S. alterniflora,* which apparently germinated from seeds produced on transplants in adjacent plots, established at all elevations of the site during winter. The average time of tidal inundation at a particular elevation was less during winter than spring. Thus, establishment of plants by seed at low intertidal elevations appears feasible only during low seasonal winter tides and with *S. alterniflora.* Fertilizers did not enhance growth, and high concentrations of fertilizer caused stress to some *S. alterniflora* seedlings.

INTRODUCTION

Means of disposal of dredged material in U. S. coastal environments is a major environmental problem. One beneficial use of dredged material is the establishment of salt marshes. Successful establishment of salt marsh depends on proper location of the dredged material and planting of the material with *Spartina alterniflora* and *Spartina patens* or other intertidal plants (Lewis 1982).

When site conditions are suitable, sowing of seed has been shown to be the most economical method of plant establishment on dredged material (Woodhouse 1979). However, establishment has generally been with transplants since they are more tolerant of waves and currents than seeds and young seedlings (Lewis 1982).

Planting trials were carried out on dredged material to establish a new marsh in Texas (Webb et al. 1978). Seeds of *S. alterniflora* and *S. patens* were used: (1) to test the feasibility of using seeds for marsh establishment; (2) to determine how elevation in relationship to tidal inundation affects seed germination and seedling survival; and (3) to test the effects of various fertilizer treatments on seed germination and seedling growth. The occurrence of seedlings of naturally invading plants also was monitored in permanent quadrats in plots established at the site in 1976 (Webb et al. 1978). Comparisons of the number of naturally occurring seedlings to the number of seedlings that established from sown seeds showed that better establishment occurred during the seasonally lower tides of winter than spring. Fertilizer treatments did not enhance establishment.

DESCRIPTION OF STUDY AREA

A 7.3-ha (18-ac) study site with a northeasterly exposure to Galveston Bay was established in 1976 on dredged material deposited in 1974. Physical and chemical characteristics of the sediment prior to planting were reported by Dodd et al. (1978) and after planting by Lindau and Hossner (1981). Sediments were approximately 98% sand with low amounts of organic material. Because of a fetch length of over 15 miles, a sandbag dike was constructed to minimize wave action on the plantings (Figure 1).

The site was sloped to a 0.7 % grade. The lowest elevation at the site was -4.9 cm (-0.16 ft), in reference to mean sea level (msl), while the upper elevation was +1 m (msl). The mean low water (mlw) for Galveston Bay is actually 0.23 m (0.75ft) above msl while mean high water (mhw) is +0.55 m (1.79 ft) (Lankford and Rehkemper 1969). The mean annual water level is 0.3 m (msl).

MATERIALS AND METHODS

During 1976 at Bolivar Peninsula, Texas, 270 plots (6 × 10 m in size) were established in randomized complete block design with three elevational tiers (Webb et al. 1978). Plots were sprigged in 1976 and others were sown with seed in 1977. Plots received one of five fertilizer treatments. The five fertilizer treatments were mixtures of ammonium sulfate, triple super phosphate, and potassium sulfate. Treatments were: F0–no fertilizer; F1–122 kg N/ha, 122 kg P_2O_5/ha, and 122 kg K_2O/ha; F2–double the amounts of F1; F3–split application of F1; F4–split application of F2.

In preparation for spring seeding, *S. alterniflora* and *S. patens* seeds from local marshes were collected and threshed during fall 1976. *S. patens* seeds were stored dry at ambient room temperature while *S. alterniflora* seeds were stored in an 8% salt solution (S. F. Broome, North Carolina State, pers. comm.) refrigerated at 6°C (Mooring et al. 1971). The percentage of glumes with a caryopsis was determined by physical examination of glumes. Samples of glumes with a caryopsis were placed into petri dishes in the dark at alternating thermoperiods (Mooring et al. 1971) to determine percent viability of filled glumes.

[1]Present address: Marine Biology Department, Texas A&M at Galveston.

Manuscript received December 12, 1983; accepted April 2, 1984.

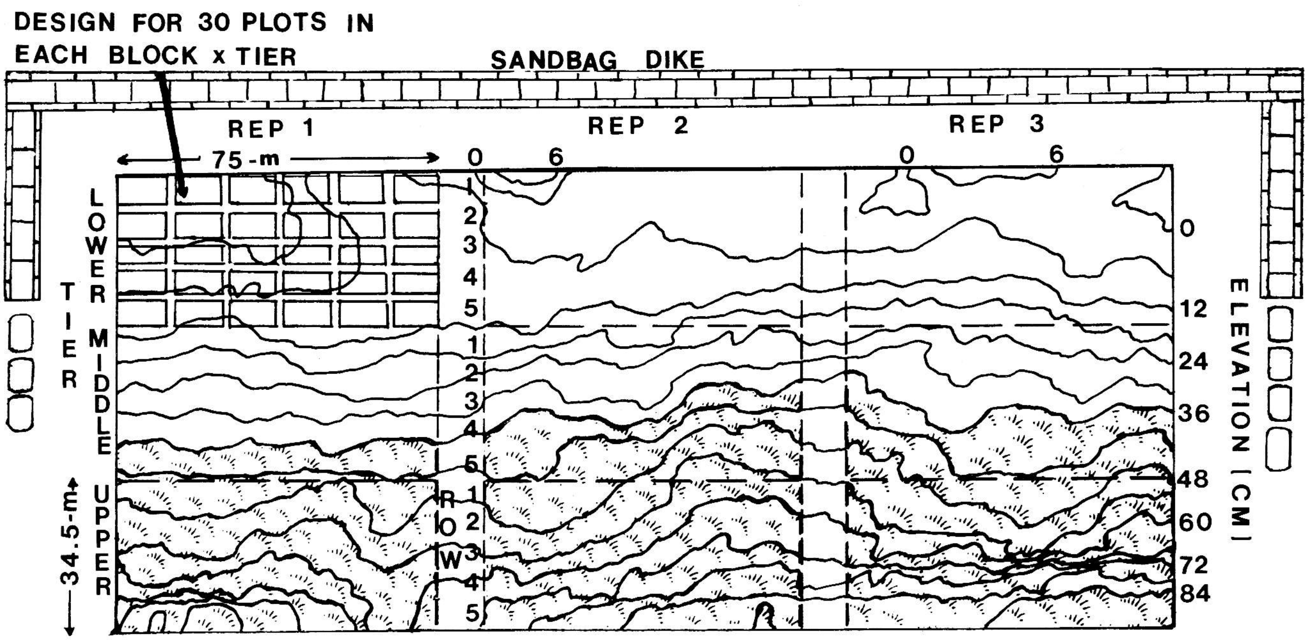

Figure 1. Design of Bolivar Peninsula site showing plot design and 6 cm contour intervals across the site. Establishment of seedlings from hand sown seeds occurred only above 36.6 cm elevation (shaded area).

Ninety unplanted plots, 45 plots sprigged with *S. alterniflora,* and 45 plots sprigged with *S. patens* in 1976 were monitored for plant invasion utilizing three permanent 3-m^2 quadrats in each plot. The data from 24 February 1977 were compared to plots seeded in 1977.

During 21–23 March 1977 at low tides, *S. alterniflora* at 100 viable seeds per m^2, and *S. patens* at 125 viable seeds per m^2 were hand spread in 90 plots along with phosphate and potassium fertilizers. Plots were then disced with a tractor to cover seeds with soil to a depth of 2.5 cm, which is ideal planting depth (Tanner 1979, unpublished data).

Nitrogen as ammonium sulfate was broadcast on the soil surface on 26–28 April 1977 rather than at time of seeding to lessen chances of damage by nitrogen salts. To avoid disturbance of seedlings, nitrogen fertilizer was not disced into the soil. Thus, there was a possibility of loss during tidal exchange and by volatilization. F3 and F4 plots (split rates) were refertilized 26 July by broadcast application.

Nine permanent 0.1-m^2 quadrats were established in each seeded plot (three in each 1/3 of each plot). Seedlings were counted on 14 April, 27 April, 2 June, 27 June, and 14 October 1977 and converted to number per m^2. In addition to measuring density on 27 June and 11–14 October 1977, the following measurements were taken: height of extended leaves; visual estimates of foliage cover; growth characteristics, such as presence of flowers and amount of seed production; and plant stress as exhibited by chlorosis, stunted growth, or wilted leaves. Root and shoot biomass also was randomly sampled in each plot (outside of permanent quadrats) with a 25-cm deep circular coring device with a 0.1-m^2 surface area. Biomass was reported as dry weight after oven drying at 83°C to a constant weight.

Height of tides was automatically punched on ticker tape at 15-minute intervals by a tide gauge established at the site. The raw data was converted by computer programs to histograms showing the percent inundation at 0.1-ft contour intervals for selected time periods, winter and spring. Bench marks, which were established at the site by the Galveston District, Corps of Engineers, allowed the establishment of the tidal datum (1.42 ft below msl) for the tide gauge and furnished the basis for site elevations, which were taken at one corner of each of the 270 plots (Webb et al. 1978).

RESULTS

Natural Seed Germination

The number of seedlings on 24 February 1977 in plots which were monitored for plant invasion indicated that winter germination of *S. alterniflora* seeds had occurred. In the low tier the number of naturally occurring *S. alterniflora* seedlings was much greater in *S. alterniflora* sprigged plots (3.87/m^2) than in *S. patens* sprigged plots (0.28/m^2) or unplanted plots (0.18/m^2). Significant differences ($P<0.0001$) among tiers in the number of naturally occurring seedlings also occurred in *S. alterniflora* sprigged plots (3.87, 2.50, and 0.44/m^2 in lower, middle, and upper tiers, respectively). No significant differences in the number of seedlings were detected between fertilizer treatments.

During the evaluation period scheduled for May 1977, wind elevated tides prevented counts of seedlings in plots at low elevations. However, 0.43 seedlings/m^2, which was the same number as February, were counted in 43 *S. alterniflora* sprigged plots in the upper tier. In the middle tier 0.50 seedlings/m^2 were counted in 19 of the *S. alterniflora* plots as compared to 2.50 in February. These data indicated that survival and growth of seedlings occurred after germination. Seedlings could not be distinguished from shoots growing from sprigged plants at the June 1977 evaluation.

In early December 1977, many seedlings with two to three leaves and less than 5 cm tall were observed at the Bolivar site. Most seedlings were at the elevation of mean high water (mhw), but many were in soil depressions at lower elevations. Seeds probably were produced at the site since there were at least 92 kg of *S. alterniflora* seeds produced at the site by 14 October 1977 (Webb et al. 1978). Seedlings also were observed in late January 1979 in natural marshes of the area. Additional evidence of winter germination has been presented by Tanner (1979), who reported 14.6 *S. alterniflora* seedlings/m^2 in a marsh several miles from our site. However, Tanner reported that the number of seedlings declined 50% between 27 February and 24 April. Rhizome production caused the number of shoots to increase after 24 April. Seedlings also were located only above 36 cm (msl) elevation and in a wave protected area.

Spring Seed Sowing Experiments

The number of seedlings of *S. alterniflora* was greater than that of *S. patens* in the upper and middle tiers (Table 1). The greatest number of seedlings occurred in the upper tier while no survival for either species was recorded in the lower tier. Examination of contour maps (Figure 1) of the study area showed that no seedlings were observed below an elevation of 36.6 cm (msl). An 84% decline in the number of *S. alterniflora* seedlings in the middle tier occurred between 14 April and 27 April, indicating that most seedlings failed to establish after germination. An increase in the number of *S. patens* seedlings in the upper tier from April to June indicated that germination of *S. patens* occurred several weeks later than *S. alterniflora.*

Fertilizers apparently did not enhance survival or growth since stem density and height of plants were not significantly different among fertilizer treatments. Single (versus split) applications of fertilizers may have been detrimental to seedling growth and reduced chances of survival since plants of F1 and F2 fertilizer treatments of *S. alterniflora* were the only plants to exhibit stress (plant chlorosis and stunted growth). This was significant at $P<0.10$.

TABLE 1

Number of seedling shoots per m^2 in dredged material plots seeded 21–23 March 1977 at 100 viable seeds per m^2.

Species[1]	Tier[2]	Evaluation Date			
		14 April	27 April	2 June	27 June
Spartina alterniflora	Lower	0.0	0.0	–[3]	0.0
	Middle	5.5	0.9	–	4.2
	Upper	23.8	19.4	21.1	53.4
Spartina patens	Lower	0.0	0.0	–	0.0
	Middle	0.1	0.1	–	1.6
	Upper	1.2	1.5	6.1	33.2

[1] Differences between species significant at $P<0.05$ by analysis of variance F-test on 14 April and 27 April.

[2] Differences between tiers significant at $P<0.05$ by analysis of variance F-test at all evaluations.

[3] Low and middle elevations not evaluated because of high tides.

Plant Measurements on 14 October 1977

The number of shoots of *S. alterniflora* (37.8/m^2) and *S. patens* (30.1/m^2) indicated that seedlings that survived were growing and spreading by rhizomes. However, foliage covered less than 10% of the ground in all treatments. Average shoot biomass was 191 g/m^2 for *S. alterniflora* and 435 g/m^2 for *S. patens.* Root biomass was 325 and 457 g/m^2 for *S. alterniflora* and *S. patens*, respectively.

Immature and mature seed heads on *S. patens* were present 7 September 1977. *S. alterniflora* also produced some seeds by 14 October 1977.

Tidal Differences Between Spring and Winter

During the period 1 January to 20 March 1977 when seedlings became naturally established, mlw was -0.6 cm and mhw was 26.2 cm (msl) (Figure 2). In contrast, during the period from 21 March to 27 April, a 5-week period following sowing of seeds, mhw was 21.3 cm greater in elevation than mhw of the winter time period. Percent time of inundation at each elevation was considerably greater during the latter time period and apparently negatively affected survival of seedlings established from sown seeds.

DISCUSSION

Keeping seeds in place until they germinate is one of the problems when seeds are sown in an intertidal location (Woodhouse et al. 1972). Consequently, April was recommended for sowing of seeds in North Carolina to avoid some of the stormy weather that occurs during March. With waves attenuated by the sandbag dike, sowing of seeds in March appeared ideal due to warmer weather in Texas than North Carolina. However, even with the dike, waves and blockage of light for photosynthesis occurred in association with wind-generated high tides and appeared to be the primary limiting factors for seedling establishment.

Naturally available seeds apparently settled most readily in sprigged plots where some wave protection was provided by plants. The larger number of seedlings in *S. alterniflora* sprigged plots than *S. patens* also indicates that seeds originated from mature plants in *S. alterniflora* plots and not from other marshes.

Saltmarsh inundation does not occur equally throughout the year since a seasonal water level cycle occurs on the northern Gulf coast (Gosselink et al. 1979, Shew et al. 1981). The water regime displays two highs, in spring and in fall, and a winter low (Gosselink et al. 1979, Marmer 1954). Part of the reason for a seasonal fluctuation is that the magnitude of the tidal range is small, being at most

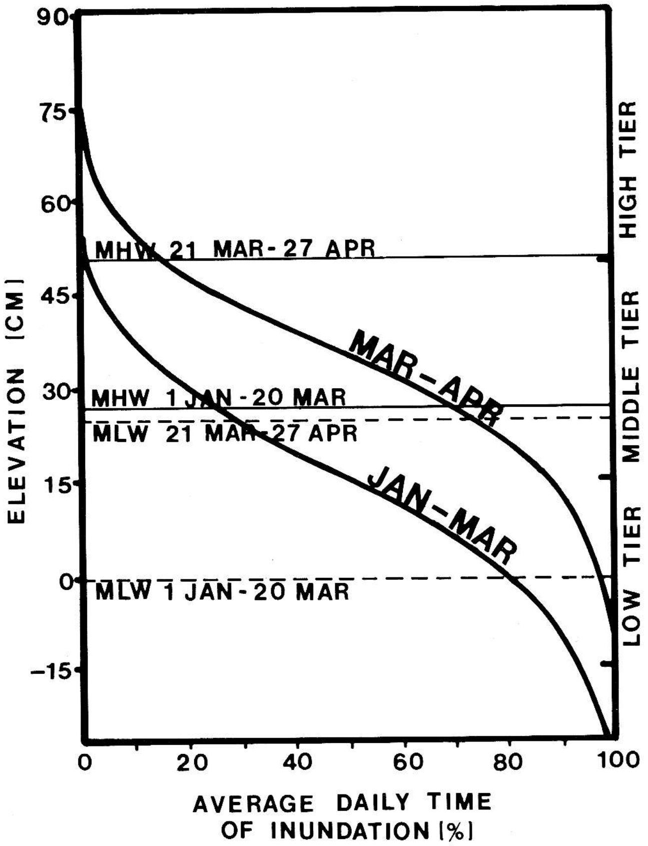

Figure 2. Percent of time each elevation was inundated in marshland plots. Period of monitoring was January 1 to March 20 and March 21 to April 27, 1977. Approximate elevations of each tier are indicated.

places not more than 30 to 40 cm on the average; therefore, the effect of wind on water fluctuation is proportionately large in comparison to other areas where tidal range is greater (Marmer 1954, Shew et al. 1981). Water levels are also affected by seasonal heating and cooling of water and seasonal variability in river discharge (Whitaker 1971, Sturges and Blaha 1976, Gosselink et al. 1979).

Better seedling establishment in winter than spring apparently was because of the seasonally low tides of winter. Galveston Bay waters generally have many suspended soil particles which cause low light penetration into the water; therefore, poor seedling growth may have occurred as photosynthesis of plants was prevented when leaves of seedlings were constantly beneath high tidal waters caused by strong winds during the spring. A coating of clay and silt particles that was observed on many plants also may have hampered photosynthesis and respiration. Because of low tides caused by northerly winds, wave action and light availability were probably not problems to seedlings which germinated in the winter.

Seeds produced during fall 1977 in plots transplanted in 1976 at the Bolivar site were the most likely source of seeds that germinated in early December 1977. The fact that seeds cannot be kept in storage for prolonged periods (Woodhouse and Knutson 1982) rules out delayed germination of seeds planted during the spring. Although Seneca (1974), Woodhouse et al. (1972), and Mooring et al. (1971) state that prolonged cold storage is necessary for germination to occur, Woodhouse and Knutson (1982) reported that cold conditions of 2 or 3 weeks duration will break dormancy. Accordingly, December germination of seeds produced during fall could be expected to occur.

Dry conditions at the highest elevations also may have prevented seedling establishment. Average daily inundation was less than 2.5 hours in all plots in the high tier and some plots were only infrequently flooded. Plants at some of the higher elevations remained in the one or two leaf stage several weeks before dying. Death of plants at the high elevation was not because of hypersalinity of the sediment since soil water salinity was only 11–13 ppt (Webb 1983).

Fertilizers have been shown to enhance growth of transplanted shoots of *S. alterniflora* (Woodhouse et al. 1972, Garbisch et al. 1975), but fertilizers apparently were not beneficial to plants in this study. Despite a delayed application, nitrogen fertilizers did not enhance growth of plants and may have caused some stress. The probable cause of injury was soluble salts from nitrogen, phosphorus, and potassium fertilizers, which may cause injury when applied too close to seedlings (Tisdale and Nelson 1966). The possibility of fertilizer salt damage is further substantiated by Garbisch et al. (1975), who reported detrimental effects and increased mortality when fertilizers were applied to *S. alterniflora* seedlings at the time of transplanting.

The value of using seeds is demonstrated by the greater number of shoots in plots with good survival when compared to the number of shoots in sprigged plots after equivalent evaluation periods (Webb et al. 1978). However, the inability to establish seeds at all elevations without a great chance of failure makes the use of sprigs more reliable than seeds. Establishment from seeds may be possible at all elevations under a low tidal regime, which may occur only during the winter on the U. S. Gulf of Mexico coast.

CONCLUSIONS

Successful establishment of seedlings of *S. alterniflora* and *S. patens* on dredged material is prevented by factors associated with tidal inundation. This was demonstrated by lack of seedling survival at low intertidal elevations during March while establishment of seedlings occurred at all elevations of the study site during low tidal regimes of winter. Therefore, if sowing of seeds is to be accomplished, winter is the best season because of favorable low tides.

Fertilizers did not increase survival or growth. In fact, heavy applications of fertilizer resulted in slight salt damage to *S. alterniflora.*

ACKNOWLEDGMENTS

This study was funded by the U. S. Army Corps of Engineers, Waterways Experiment Station under contract DACW 39-76-C-0109 with the Texas Agricultural Experiment Station.

REFERENCES CITED

Dodd, J. D., D. J. Herlocker, B. W. Cain, B. J. Lee, L. R. Hossner & C. Lindau. 1978. Habitat development field investigations, Bolivar Peninsula upland and marsh habitat development site, Galveston Bay, Texas, Appendix B. Baseline inventory of terrestrial flora, fauna, and sediment chemistry. TR D-78-15. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. 74 pp.

Garbisch, E. W., Jr., P. B. Woller & R. J. McCallum. 1975. Salt marsh establishment and development. U.S. Army Corps of Engineers, Coastal Engineering Research Center. TM-52. 110 pp.

Gosselink, J. G., C. L. Cordes & J. W. Parsons. 1979. An ecological characterization study of the chenier plain coastal ecosystem of Louisiana and Texas. U.S. EPA and U.S. FWS, FWS/OBS-78/9. Vol. 1.

Lankford, R. & L. J. Rehkemper. 1969. The Galveston Bay complex: a summary of characteristics. Pages 1–11 *in:* R. R. Lankford and J. W. Rogers (eds.), *Holocene geology of the Galveston Bay Area.* Houston Geological Society, Houston, Texas.

Lewis, R. R., III. 1982. *Creation and restoration of coastal plant communities.* CRC Press, Inc. Boca Raton, Fla. 239 pp.

Lindau, C. W. & L. R. Hossner. 1981. Substrate characterization of an experimental marsh and three natural marshes. *Soil Sci. Soc. Am. J.* 45(6):1171–1176.

Marmer, H. A. 1954. Tides and sea level in the Gulf of Mexico. *U.S. Fish Wildl. Serv. Fish. Bull.* 55(89):101–118.

Mooring, M. T., A. W. Cooper & E. D. Seneca. 1971. Seed germination response and evidence for height ecophenes in *Spartina alterniflora* from North Carolina. *Am. J. Bot.* 58(1):48–55.

Seneca, E. D. 1974. Germination and seedling response of Atlantic and Gulf Coasts populations of *Spartina alterniflora. Am. J. Bot.* 61(9):947–956.

Shew, D. M., R. H. Baumann, T. H. Fritts, L. S. Dunn, J. B. Johnston & R. M. Rogers. 1981. Texas barrier islands region ecological characterization: environmental synthesis papers. U.S. Dept. Interior, FWS/OBS-81/32. 413 pp.

Sturges, W. & J. P. Blaha. 1976. A western boundary current in the Gulf of Mexico. *Science* 192:367–369.

Tanner, G. W. 1979. Growth of *Spartina alterniflora* within native and transplant-established stands on the upper-Texas Gulf Coast. Ph.D. Dissertation, Texas A&M University, College Station, Texas. 149 pp.

Tisdale, S. L. & W. L. Nelson. 1966. *Soil fertility and fertilizers.* The MacMillan Co., London. 694 pp.

Webb, J. W. 1983. Soil water salinity variations and their effects on *Spartina alterniflora. Contrib. Mar. Sci.* 26:1–13.

_______, J. D. Dodd, B. W. Cain, W. R. Leavens, L. R. Hossner, C. Lindau, R. R. Stickney & H. Williamson. 1978. Habitat development field investigations, Bolivar Peninsula marsh and Upland Habitat Development site, Galveston Bay, Texas, Appendix D. Propagation of vascular plants and postpropagation monitoring of botanical soil, aquatic biota, and wildlife resources. TR-D-78-15. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. 521 pp.

Whitaker, R. 1971. Seasonal variations of steric and recorded sea level of the Gulf of Mexico. Texas A&M University, College Station, Texas. Ref. 71-14T.

Woodhouse, W. W., Jr. 1979. Building salt marshes along the coast of the continental United States. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Sr-4. 96 pp.

_______, E. D. Seneca & S. W. Broome. 1972. Marsh building with dredged spoil in North Carolina. *N. C. Agric. Exp. Stn. Bull.* 445. 28 pp.

_______ & P. L. Knutson. 1982. Atlantic Coastal Marshes. Pages 45–70 *in:* R. R. Lewis, III (ed.), *Creation and restoration of coastal plant communities.* CRC Press, Boca Raton, Fla.