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AN INVESTIGATION OF POSSIBILITIES FOR CREATING SALTMARSH IN THE ESTUARIES OF THE ATLANTIC AND GULF COASTS

By Edward J. Larimer

Today's conservationists are much concerned with unwise and ill-conceived dredging, filling, dumping, draining and polluting in our estuaries. The immediate and urgent need for an effective estuarine preservation program occupies much of our attention and energies.

Preservation, however, is but a part of the need. Development and restoration of damaged estuarine areas are equally important. There are, of course legitimate and essential uses for estuaries other than as sources of food, as propagation, nursery, and feeding habitat for fish and wildlife, and as recreation sites. National defense, navigation, water supply - including desalinization, population centers, mining, power production and waste desposal are such uses. Unfortunately, these activities do impair or destroy estuarine productivity.

Is it possible to compensate for these necessary and unavoidable losses? Can sterile estuaries be returned to biological productivity or can fertility be maintained despite man's essential activities? Our thinking, now santified by long reiteration, is that the estuarine ecosystem is irreplaceable. We have said that, once destroyed, it either cannot be duplicated or could be reproduced only at exorbitant costs.

This study is, in effect, a reexamination of our established posture. It was motivated by the evident need to restore basic productivity to severely damaged estuaries and to maintain a viable ecosystem despite unavoidable changes.

The primary objective of this investigation was simply to learn the feasibility of creating or rehabilitating saltmarsh. A secondary objective, assuming evidence of feasibility, was to plan field experiments to test this premise. In this approach saltmarsh has, in essence, been equated with estuarine productivity. There is some justification for this premise.

Estuaries are, of course, highly complex productive systems. Saltmarshes are but a part of the ecosystem - often a very small part in terms of area. Efforts and attention were centered on this relatively minor component of the estuarine environment for several reasons. First, the peripheral edge of the estuary - the bordering marshes, streams, tidal guts and protected shorelines, is of high value (Chapman 1966). The estuarine-dependent fishes of major commercial importance use this edge more extensively than any other part of the estuary.

Secondly, the marshes are singularly vulnerable to large-scale destruction from dredging and either land or water-based filling. In contrast to the open water areas, the marsh is usually privately owned. It is a common and doubly destructive practice to dredge fill from the marsh or the adjoining shallows and place this spoil on the remaining marsh to create an attractive and comparatively cheap development site.

Lastly, saltmarsh is an important - and perhaps the most important - producer of estuarine fertility - a premise developed further in the body of this report.

Certain perimeters were established for this study. Revitalization or enhancement based on the productivity of native and preferably climax vegetation was the goal. Thus, further changes in the ecosystem attendant to diking or other man-made structures were to be avoided. Finally, the desirability of avoiding the continuing costs of maintaining water control structures was recognized. In addition, the study was oriented toward the full biological productivity of the estuaries. Thus, the importance of the energy exchange and fertility to finfish and shellfish tended to eclipse the values to waterfowl, shorebirds, and mammals.

Procedures

Two basic procedures were used. A comprehensive survey of the available literature was undertaken. In addition, the considerable body of expertise available in biologists and ecologists stationed in the Washington-Patuxent area was explored. Finally, tentative plans were made to visit any worthwhile research or management projects on saltmarsh located through reviews of the literature or interviews.

As background, an earlier and incomplete review of the literature and discussions with colleagues in the Northeast indicated that little work had been done on creation or rehabilitation of saltmarsh. There was, of course, a large store of knowledge on management and development of diked marshes and on plant species adapted to fresh or brackish waters.

This investigation confirmed the fact that data on saltmarsh vegetation were not abundant. In 1965, Harold Irby of Bureau of Sport Fisheries and Wildlife surveyed a recent bibliography on estuarine literature. He reported that a list of 5,470 references included only 13 rather cursory publications on vegetation.

This dearth of information was not without compensation. It made possible the review, evaluation, and elementary analysis of a sizeable segment of the available information within a limited time. The potentials and limitations of important estuarine communities as well as the common, emergent, saltmarsh plant species could be assessed and compared.

Interviews were comparatively less productive. Few conferees had any direct experience in saltmarsh creation. Charles Chapman, Bureau of Commercial Fisheries, was an exception to this rule. Several of those interviewed, however, recommended useful publications or reports.

Results of Literature Surveys and Interviews

The principle that the free ebb-and-flow water movements resulting from tidal action was a basic factor responsible for the high primary productivity of estuaries (Odum 1961) was accepted. Odum as well as Shuster (1966) attributed estuarine fertility to three different production units. These were tidal marsh grasses, benthic or "mud" algae, and phytoplankton. The relative productivity of these communities varied. Odum (1961) found that the wide cordgrass marshes were the most important food producers at Sapelo Island in Georgia. Mud algae, the green or golden-brown communities of diatoms, dinoflagellates, and other algae and heliotrophic micro-organisms found on exposed tidal creek bands, were not important at Boca Ciega Bay in Florida. Phytoplankton were most productive in deeper waters. He found that the shallows were equally productive whether covered with turtlegrass *(Thalassia spp)* or merely by benthic microflora. Shuster (1966) indicated that mud algae were perhaps more widely spread and productive than phytoplankton and might produce up to 25 percent of the yield of the marsh grasses along the north Atlantic Coast.

The emergent marshes are, then, highly productive estuarine units. In contrast to mud algae and phytoplankton, grasses can be grown, handled, and processed by relatively unskilled labor working with simple tools and equipment. The sods can be easily removed, stored for comparatively long periods of time, and replanted. In summary, the problems in creating saltmarsh appeared to be less formidable than those in creating algae or phytoplankton communities, and the saltmarsh was believed to be the more stable and permanent unit.

In addition, the marsh grasses have useful properties beyond that of producing nutrients. They are tough, long-lived, and resistant to high turbidities and chemical changes. The aquatic vegetation is one of several sources of the vital dissolved oxygen. The plants release produced or stored oxygen into the water during periods of submergence (BCDC 1966a). Pollution demands for oxygen have accentuated the importance of the comparatively minor role played by vegetation in aeration. The marshes also appear to help in preventing air pollution (BCDC 1966b). The plants change carbon monoxide, a common air pollutant, into a relatively harmless carbon dioxide. The plants also provide a part of the shelter needs of many fish and wildlife species.

The fringing marshes protect the uplands and are barriers to erosion, storms, and flooding (Steers 1958, Morgan 1958). In contrast to man's encroachments, the marshes are in equilibrium with the sea. The resilient grasses dissipate the battering forces of the storm. The vegetation is a barrier to waterflows and acts as a reservoir for silt and sand that might otherwise choke harbors, channels, and marinas (Johns 1967). The marshes have values as nesting, resting, and feeding areas for non-aquatic life and have recreational values for man.

Several species of salt-tolerant plants within three general groups were evaluated. These were: (1) *Spartina alterniflora* (saltmarsh grass or saltwater cordgrass) - the pioneer plant in saltmarsh succession growing in the intertidal zone between the mid- and high-tide levels; (2) *Scirpus americanus* (sword-grass) and *Scirpus maritimus* (saltmarsh bullrush) - these grow in a fairly narrow zone extending from a little below high tide level to the extreme high tide mark; (3) *Spartina patens* (saltmeadow grass or cordgrass), *Distichlis spicata* (spike-grass), and *Juncus gerardi* (black-grass) - these grow between the usual high tide and the extremely high tide marks (Cottam and Bourn 1938, Dexter 1947).

The above list was quickly reduced to *S. alterniflora* and *S. patens.* These species have similar attributes. Both are tough, sod-forming dominants in their respective ecological niches. Neither produces quantities of viable seeds and both spread chiefly by rhizomes. These grasses develop on all kinds of bottom materials - sand, mud, old mussel shells and rocks (Dexter 1947).

Once established, either *S. alterniflora* or *S. patens* will persist over long periods of time without maintenance by man. Both are unusually well adapted to withstand the strong stressful fluctuations in salinities, temperature, scouring, sedimentation, submergence, and exposure found in the rich but harsh estuarine environment.

S. alterniflora, however, was believed to make a greater contribution to the nutrient exchange because of its more luxuriant growth and because it is flooded twice daily. It was, therefore, selected as the more promising species despite the obvious problems attendant to establishment of a species in the intertidal zone.

The credentials of *S. alterniflora* are impressive. It grows from Maine to Texas in that part of the coastal marsh inundated daily by tide water. Its optimum salinity range is 1.2-5.0 percent (U.S.D.A. 1957) but it thrives in fresh, brackish, or salt water. Optimum water depth for *alterniflora* ranges from 0 to -12 inches on the Gulf Coast to the upper two-thirds of the much greater tidal range found along the New England Coast. It withstands a wide range of conditions (Miller and Engler 1950) including high turbidity, varying pH, and soils. It is obviously well adapted to the many complications in natural salt marsh development.

Dr. Rankin of the University of Connecticut reported that saltmarsh cordgrass contained 3.3 percent digestible protein - as compared to 2.9 percent for timothy hay (Johns 1967). The tonnage of vegetation produced by these marshes is unrivaled in nature.

The direct value of *Spartina* species to waterfowl is questionable. Chamberlain (1951) rated these grasses as being among the "plants of value to waterfowl." Most researchers, however, have not rated the cordgrasses so highly.

Earlier Saltmarsh Restoration or Creation

Few records of attempts to restore or create saltmarsh were found. Smith (1942) reported some success in reestablishing *S. alterniflora* in salt marsh areas denuded by snow geese. Sods were transplanted at intervals of several feet. The greatest difficulty was in preventing further depredation by the geese until the stands could be renewed. As an aside, Smith reported that *Scirpus robustus* (saltmarsh bullrush), *S. olneyi* and *S. americanus* (three-square bullrushes), and *Acnida* spp. (waterhemp) may be established by direct seeding.

The U. S. Fish and Wildlife Service (1950) reported on the development and management of dike cover on an experimental basis. Aggressive perennial sod formers developing into dense stands capable of existing as ecological climax and spreading by rhizomes were sought. The Service reported that *S. patens* filled these specifications. The grass was successfully established by implanting sods. The implants, a few inches square, were spread 10-12 inches apart or closer. *S. patens* proved to be an excellent soil binder. It was found that the best method of establishing the species was propagation by rootstocks and that plantings on sand should be fertilized with 40 pounds of nitrogen per acre or, better, by 300 pounds of 16-20-0 (ammonium phosphate) per acre.

R. A. Schmidt, Bureau of Sport Fisheries and Wildlife (pers. comm.), described the history of an attempt to rehabilitate the Drakes Island marsh at Wells Harbor, Maine. Spoil deposited on this marsh in some depth was subsequently removed by court order. That the original saltmarsh and saltmeadow is recovering appeared to indicate that the native marsh vegetation can survive spoil deposition for a limited period of time.

Chapman (1966 and pers. comm.) described experiments of the Bureau of Commercial Fishery biological laboratory at Galveston, Texas. He indicated that habitat restoration could yield significant rewards and found a need to develop methods of rehabilitating estuaries where aquatic vegetation, marshes, and shallow bays have been damaged or destroyed. He stated that either submerged or emergent aquatics would restore or maintain productivity on barren shores. Unfortunately, vegetation seldom develops on the shallow flats created by dredging or on the unstable slopes of islands formed by spoil deposition. Successful establishment of plant cover in these circumstances is dependent on control of turbidity and stabilization of the shores. In Galveston Bay, *S. alterniflora* was planted as sods, rhizomes, and seeds on new spoil banks. These plantings covered a band extending from below mean low tide to well above mean high tide. It was reported that the sods and rhizomes did well in the narrow intertidal zone. Seed germination was not satisfactory and the results of stratification efforts were inconclusive.

Fuss (1965) reported on similar Bureau of Commercial Fisheries experiences at the St. Petersburg Beach Biological Station in Florida. This work centered on the feasibility of restoring *Diplanthera Wrightii* and *Thalassia testudinum* on denuded bottoms. Both of these submergent grasses grow below low tide.

The necessity for drainage and attendant aeration of the soil are not entirely clear. Redfield (1958) and others have noted that *Spartina* spp. grow vigorously along the margins of creeks where levees are found, whereas the enclosed areas are muddy and frequently bare despite being well above the lower limit of growth on surrounding islands.

Steers (1959) stated that marshes are characterized by an intricate drainage pattern of tidal creeks, the bottoms of which mark the approximate level of the original surface. Russell (1958) found many complications in natural saltmarsh development and included subsidence, compaction and development of tidal channel systems in this list. Chapman (1958) noted that *Spartina* spp., once established, will determine where the creeks go as it is difficult to erode once it has got hold in the mud.

Redfield (1965) noted that the developing peat and marsh stablized the meandering channel systems and that these systems remained virtually unaltered during the buildup. He stated that a quasi-equilibrium determined by tidal forces appeared to be reached. Width, depth, and velocity varied with a power of the mean discharge. Exponents of hydraulic geometry of tidal estuarines in Virginia and Massachusetts were given in this reference. Redfield also stated that the accumulation of sediments in shallow areas and a degree of protection from the sea were prerequisites for marsh expansion. Sand spits were found to provide both factors.

Costs

Creation of saltmarsh will necessitate either developing a planting site or use of an existing unvegetated area. In the first case, spoil must be taken from one location and deposited at another. In either case, water turbidity must be controlled and sites stabilized prior to planting. These can be expensive operations. The Corps of Engineers moves spoil at costs ranging from $.40 per cubic yeard to $6.00 or higher. Careful control of turbidity would, of course, increase these prices.

Cost of stabilization can be predicted with reasonable accuracy on the basis of comparable work on impoundments. Chaubeck (1967) reported costs of impoundments in the Louisiana coastal marshes in some detail. He recommended that materials be sufficiently durable to last the intended life of the structure. He found that wood, steel, and aluminum pilings all had certain advantages. Life expectancy and cost per foot of construction were: steel, 25 years and $55.55; wood, 20 years and $51.11; and aluminum, 15 years and $48.89. These costs were based on 30 foot pilings set at 9 foot intervals and 4" x 8" creosoted timber wales. The steel was U. S. Steel interlocking sheet piling. The wood was creosote-treated sheet piling 4" x 10" tongue and groove. The aluminum was Alcoa "Porta Plant."

Chaubeck also reported that the weirs were set six inches below the level of the surrounding marsh, thereby permitting water to move in and out of the drainage system over the structure. He recommended that the length of the pilings be three times the water depth, that rip-rap or splash boards be used to prevent water erosion and undercutting as water spilled over the weir, and that bracing to prevent outward collapse at low tide might be needed.

Conclusions and Recommendations

There do not appear to be any insurmountable physical, chemical, hydraulic, or ecologic obstacles to the creation of saltmarsh. The results of very limited experiments in this field by the two Bureaus of the U. S. Fish and Wildlife Service are encouraging.

Spartina alterniflora appears to be the saltmarsh grass best suited to experimental planting. Planting sites for this grass should be so located as to be protected from excessive wave action. A bed of sediment as well as suitable tide levels and a free tidal exchange are desirable. The plantings should consist of sods or rhizomes and should be confined to sites lying in the upper two-thirds of the intertidal zone. Salinities and currents should be considered. Sites protected from foreseeable future development should, of course, be selected.

Tampering with complicated estuarine ecosystems can lead to unanticipated side effects. These effects are no less destructive if they result from attempts to develop or restore estuarine productivity. The desirability of preserving productive shellfish beds, spawning and nursery areas for finfish, and sites rich in other biota is obvious. Avoiding locations where newly created spoil banks and saltmarsh would upset water temperatures and salinities, interfere with tidal exchange, and affect deposition patterns may be equally important but much more difficult.

During the experimental stages, considerable attention should be given to developing the most economic methods, procedures, and equipment for establishing and stabilizing planting sites and establishing the saltmarsh vegetation.

Fully allocated costs of saltmarsh creation would undoubtedly be high. Minimal expenditures would include those of creating or stabilizing a suitable planting site as well as the outlay for establishing vegetation. In addition, any large-scale saltmarsh replacement would necessitate site purchase or easement proceedings in sectors where land prices tend to be high indeed.

Out-of-pocket costs, however, could be very much less. The dredge and fill projects so damaging to saltmarsh require site purchase or easement for spoil deposition. This requirement is independent of any consideration of estuarine productivity or natural resources. Thus, the costs of deposition sites and of transporting spoil from the dredge to the site are largely or wholly fixed costs and not chargeable to mitigation of fish and wildlife losses.

Cost of site stabilization has comparable aspects. Here, too, the need for spoil containment by the dredger or filler in order to prevent runback of semi-liquid spoil and excessive turbidity is independent of natural resource considerations. Stabilization efforts planned specifically for saltmarsh creation would be a supplementary effort and, as such, comparatively cheap. The life expectancy of structures designed for these purposes would not need to exceed 3-5 years.

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