2-1961

Bulletin No. 12: Connecticut's Coastal Marshes, A Vanishing Resource

Richard H. Goodwin
Connecticut College

CONNECTICUT'S COASTAL MARSHES

A VANISHING RESOURCE

ONCE UPON A TIME A YOUNGSTER COULD PURSUE A QUEST ON THE SHERWOOD ISLAND MARSH

THE CONNECTICUT ARBORETUM BULLETIN NO. 12
CONNECTICUT COLLEGE NEW LONDON, CONNECTICUT

"We know that engines and governments are organisms; that tampering with a part may affect the whole. We do not yet know that this is true of soils and water. Thus men too wise to tolerate hasty tinkering with our political constitution accept without qualm the most radical amendment to our biotic constitution."

ALDO LEOPOLD

COVER PHOTO BY LOUIS DARLING
For the fate of this marsh see
Mr. Darling's article on page 21.

THE CONNECTICUT ARBORETUM

BULLETIN NO. 12 **FEBRUARY 1961**

CONTENTS

THE CONNECTICUT ARBORETUM ASSOCIATION

Association membership comprises organizations and individuals interested in supporting the Arboretum and its program. Members receive Arboretum publications and enjoy other privileges, including notices of special field trips and Nature Screen Tours, and the use of the Arboretum facilities.

Individual memberships: annual, $5; sustaining, $10

Organization memberships: annual, $10; sustaining, $25; supporting, $100

Checks should be made payable to the Connecticut Arboretum and sent to the Director, Dr. Richard H. Goodwin, Connecticut College, New London, Conn.

Foreword

HAVE YOU EVER TAKEN a low-altitude flight along the Connecticut coast, or southward over the New Jersey marshes or the shores of Delaware Bay? It can be a most interesting experience, and alarming if one understands the biological significance of what one sees. Everywhere the cancer of dark dredged muck, light sandy fill, grey smoking dumps and parking lots of shimmering tar are spreading across the lush green marsh lands. Channels and harbors are being carved out of them for marinas. Factories, highways, sewage disposal works, oil depots, utility plants and housing developments are all pushing into this open space. Dark or discolored effluent issues from many of the streams and outfall sewers, and bay after bay is filled with fantastic numbers of small pleasure craft.

Why, you may ask, is this not the natural and necessary consequence of our tremendous population growth? In an unregulated and free society man tends to follow the path of least resistance, to exploit available resources to suit his immediate ends. Thus the marshlands, which cannot be walked across or dwelt in, have naturally enough been viewed as expendable. If the public should recognize these areas as a highly valuable and vanishing resource of great importance to our present and future welfare, however, their destruction would be drastically curtailed.

The purpose of this bulletin is to bring to public attention the great urgency of protecting our remaining coastal marshes. The very expansion of the human population demands that we give thought to the future of our food supply. Not only must we conserve our best agricultural land, but we must also give increasing attention to the productivity of the sea. It is here that the coastal marshes play a highly significant role little understood by the general public. But beyond this the marshes satisfy aesthetic and recreational needs of a growing proportion of our expanding population.

We are indebted to the authors for contributing the articles appearing in this bulletin and to Mr. Lambert Guenther for preparing the maps.

Richard H. Goodwin
Director

Our Disappearing Tidal Marshes

THEIR PRESENT STATUS[1]

THE FACTS

A second reprinting of this bulletin is undertaken with the aim of helping to reduce the rapid destruction of our tidal wetlands. From a recent survey[2] by the Fish & Wildlife Service, we can now revise the figures on the back cover of this bulletin. *In 1965 we had destroyed 50% of our marshes (based on 36.5 square miles in 1914). At this rate only 10% will be left by the year 2000. A total of 2,179 acres were obliterated in Connecticut during the past 10 years. This represents a 12.8% loss of the marshes existent in the state in 1954.* Major causes of this substantial loss involved miscellaneous fill (48%); waste disposal (14%); roads and parking (9%); industry (7%); airports (7%); marinas (6%); housing (5%); recreational developments (3%) and schools (1%).

Marsh destruction has been greatest in Fairfield county and progressively less eastward along the coast. Compared to the total marshland in existence in 1954, the percentage of losses during the past 10 years for these counties follows: Fairfield 923 acres (45%); New Haven 888 acres (13%); Middlesex 263 acres (6%); and New London 95 acres (3%). *Of the approximately 12,000 acres of Connecticut tidal marshes remaining in 1964, the survey revealed that unfortunately only 25% are judged safe from further destruction.* Such areas are owned by the State, the National Audubon Society, the Nature Conservancy or other such agencies.

SIGNS OF CHANGE

. . . In 1954 a land acquisition proposal assigning the highest priority to an accelerated program of tidal marsh acquisition was developed by the State Board of Fisheries and Game. Sufficient funds to implement this program were sought with varying degrees of success in subsequent legislatures. The Board now owns 3,500 acres, of which less than 700 acres were purchased since 1954. It has proposed in its Capitol Projects budget requests for over 7,500 acres.

. . . In 1962 and 1964 two professional state sponsored land-use surveys

---

[1]Supplement, Second reprinting, Connecticut's Coastal Marshes. A vanishing resource. Conn. Arb. Bull. No. 12, 1961.

[2]Supplementary Report, June 1965 on the Coastal Wetlands Inventory of Connecticut, U.S. Dept. Interior, Fish & Wildlife Service, Bureau-Sports Fisheries and Wildlife Region V, Boston, Mass., 1965.

gave number one priority to the acquisition of coastal salt water marshland. These were "Connecticut's Natural Resources—A Proposal for Action" done by William H. Whyte and "Connecticut Comprehensive Statewide Outdoor Recreation Plan" done by the Vollmer Associates.

. . . In 1964 the Board of Fisheries and Game set aside the Barn Island Peninsula as a Natural Area, a 50-acre tract largely salt marsh with three upland islands. Recently a master's thesis on the vegetation of this area and the adjacent unimpounded Brucker Marsh was completed by a graduate student' at Connecticut College.

. . . In 1964 through a generous gift, the National Audubon Society acquired 150 acres of the valuable East River Marshes in Guilford, known as the Guilford Salt Meadow Sanctuary.

. . . In 1965 denial of dredging for a boating facility at North Cove in the Town of Essex by the State Water Resources Commission reflects a favorable trend at the state level. In this case no actual marsh was to be touched but such a facility would have damaged the surrounding wetlands.

. . . In 1965 the Connecticut General Assembly gave impetus to the marshland acquisition program with a $100,000 appropriation. Estimates of funds needed to do a minimum acquisition program range from $3-million to $10-million.

. . . Now in 1966 existing tidal marshes in Hammonasset State Park will be set aside as a living museum to educate visitors on the value of these productive wetlands according to Mr. Donald C. Mathews, Director of the Park & Forest Commission. A proposed highway to Rocky Neck State Park will not encroach on the marshes; it will be restricted to the upland.

LEGISLATION IN MASSACHUSETTS & RHODE ISLAND

In Massachusetts protective legislation for marshland was passed in 1965. In support of this Massachusetts bill Mr. Allen H. Morgan, Executive Vice President of the Massachusetts Audubon Society said:

> The Governor's proposal (which subsequently became the law) makes it possible for those owners who wish to do so to retain ownership of their marshes in their present natural state—and there are many marsh owners who do wish to keep their marshes forever natural. Town Conservation Commissions will be aided by this legislation in their programs of marsh acquisition. The many private conservation organizations that now preserve marshes for the future will have added assurance that the marshes they preserve will be further protected from pollution spewed from neighboring marshes that have been victimized.
>
> Indeed, the only citizen whose interest would be thwarted is that marsh owner who plans to destroy the marsh over which he holds

dominion. I submit that we all are but temporary tenants of this earth. The opportunity to destroy exists for these few marsh owners only because recent advances in technology have made it profitable, and also because wiser men have refrained from such destruction. What they propose to destroy belongs as much to the future as to them. Their imagined right is no right at all, but unrestrained and unjustifiable license.

I suggest that this legislation is NOT for the limited few but for the whole citizenry of Massachusetts—those alive now and those yet to be born. I submit that this measure will rescind the license issued to the present generation by the accident of our burgeoning technology to destroy the heritage of future generations whose very standard of living hangs in the balance. Gentlemen, there is no more basic obligation than this.

The Massachusetts 1965 law in effect prohibits dredging and filling of 45,000 acres of marshland remaining in Massachusetts. This legislation Section 105 of Chapter 130 of the Massachusetts Statutes was effective November 23, 1965. It is interesting to note that when the vote was taken, not a single legislator voted against this public natural resource protective measure.

The state of Rhode Island also in 1965 passed a law which restricted the use of coastal wetlands for the benefit of public health, marine fisheries, wildlife and other conservation purposes. Sections 2-1-13 and following of the Rhode Island laws set forth the public policy on coastal wetlands, give definitions, set out a program, and provide for damages to aggrieved land owners.

ACTION IN CONNECTICUT

Citizens are also on the move in Connecticut. Early in 1966 a group of concerned Connecticut citizens, encouraged by state officials including the Governor, were spearheaded by Allan T. Kitchel, Jr. of Old Greenwich, Connecticut into forming the "Save the Wetlands Committee". The General Chairman of this committee is Roger Williams of New Canaan, Connecticut. The committee has announced its Statement of Aims as follows:

> To establish a program for the preservation and protection of Connecticut's coastal and inland wetlands with due consideration of their value to the public health, marine fisheries, wildlife, and the protection of life and property.

This committee plans to support legislation in the 1967 Connecticut General Assembly which will protect our dwindling supply of salt water marshland and other wetlands. If all concerned citizens support these efforts the State of Connecticut will follow the lead of its sister states and

adopt legislation in 1967 which will identify and protect our remaining coastal salt water marshes.

Time is running out—our irreplaceable tidal wetlands are in critical danger of being lost. Their basic value in feeding the coastal waters[1]—shellfish and finfish, important sources of food for present and future generations, must be recognized by all. Aesthetically, these marshes also lend a typical New England charm to many a coastal town. This vanishing resource will truly vanish as the facts show unless public action is taken immediately.

1966

William A. Niering
Richard M. Bowers

[1]Odum, E. P., The Role of tidal marshes in estuarine production. The Conservationist, State of New York Conservation Department, June-July 1961.

Tidal Marshes

Their Use in Scientific Research

WILLIAM A. NIERING, *Associate Professor of Botany, Connecticut College*

TO THE CASUAL OBSERVER our tidal marshes may appear as uninteresting and valueless expanses of wetland. A closer look, however, reveals an intricate and fascinating community of plants and animals intimately adjusted to an ever-changing environment. Probably no habitat is more complex to interpret than these marshes. The tidal ebb and flow brings about a striking zonation of the plant life from the edge of the marsh to the upper borders, which are only occasionally inundated. Along with the many characteristic grasses, some of our most attractive wild flowers may be found there—sea lavender, marsh mallow, purple gerardia and seaside goldenrod. Here too, one encounters spectacular water birds—the herons, ducks, rails and many others—that feed and nest in this habitat. Along the Atlantic Flyway, marshes serve as vital resting and feeding areas for migrating waterfowl, as well as wintering sanctuaries. Perhaps even more significant is the contribution of marshes to the productivity of adjacent waters. From these marshes come the basic nutrients that start the food chain which ultimately supports the large numbers of fish and shell fish in the surrounding estuaries and bays. This will be more specifically described by Dr. Rankin in the following article. Thus it should be evident that the coastal marshes represent one of our unique and valuable natural resources that should be preserved wherever possible.

Our tidal marshes are disappearing at the alarming rate of one per cent per year (see back cover). Dredging, hydraulic fill, highway construction, industrial and housing developments have all contributed to this loss, various aspects of which will be dealt with in subsequent sections of this bulletin.

The picture is further complicated by what has and still is happening to those marshes that still remain. Unfortunately, it is now extremely difficult to find examples of coastal marshes still in their undisturbed state. Most of them have been ditched, as part of the extensive mosquito control program of the 1930's. This has already wrought profound changes detrimental to wildlife, as pointed out by Bourn and Cottam (1). Construction of impoundments and the excavation of pot holes, in an attempt to increase waterfowl usage, have tended further to modify natural conditions in some of the state-owned marshes under the jurisdiction of the State Board of Fisheries and Game.

There is an urgent need to preserve some sizable remnants of our coastal

marshes as nearly as possible in their natural state. Not only will these preserves be of great scientific interest, as places to study a community that has taken several hundred millions of years to evolve, but they will also provide check or control areas needed to serve as a guide for evaluating management procedures such as those mentioned in the previous paragraph. In addition, they will automatically support the marine productivity of the coastal waters. Some of these should be administered to provide sanctuaries for waterfowl during migration and the hunting season.

At present the Mamacoke Island Marshes in the Thames River at the Connecticut Arboretum are the only salt marshes in Connecticut that have been specifically set aside on a permanent basis as natural areas. The Mamacoke Island Natural Area was established in 1955 through the generous gifts of friends of the Connecticut Arboretum. The salt marshes account for about five of the 41 acres in the preserve, most of which are upland forest and rocky ledges. The marshes are of especial interest in that they have never been ditched. There are records of their having been mowed for salt hay in the very earliest days of white settlement (3). A stone wall occurs along the eastern edge of the largest marsh. Another formerly crossed it (see Fig. 1), but erosion has been cutting away this southernmost sector of the marsh and a portion of the wall is now submerged. Being situated about four miles up the Thames River estuary, the water is more brackish than it is directly on the Sound.

Although useful as a convenient research facility, the Mamacoke marshes are far too small to support an adequate sample of the typical marsh fauna and flora. Nevertheless, a brief description of the investigations which have been initiated on one of these marshes should serve to illustrate how natural areas may be used as a scientific resource.

Mamacoke Marsh Research Studies

Permanent Mapping.—In 1957 Connecticut College students, Miss Marion Whitney and Miss Ann Farinholt, permanently mapped the boundaries and present vegetational pattern on the larger marsh. Figure 1 shows clearly the definite zonation of species. Salt water grass *(Spartina alterniflora)* occurs as a narrow strip along the water's edge. Back from the margin it is replaced by black grass *(Juncus gerardi)*, actually a rush, along with a mixture of colorful species, including sea-lavender *(Limonium carolinianum)*, saltwort *(Salicornia europaea)*, purple gerardia *(Gerardia maritima)*, aster *(Aster tenuifolius)* and seaside goldenrod (*Solidago sempervirens)*. On the more extensive higher and drier portions of the marsh salt meadow grass *(Spartina patens)* is found in pure stands with the interior depressions occupied either by stunted salt water grass or by spike grass *(Distichlis spicata)*, the latter tending to preempt the wetter and deeper depressions. Skirting the upper borders of the marsh is a narrow band of switch grass *(Panicum virgatum)*, marsh elder (*Iva frutescens*), and, more locally, groundsel tree *(Baccharis halimifolia)*. This map has been simplified to show the major zones. As would be expected, considerable overlapping of species occurs between zones. With further

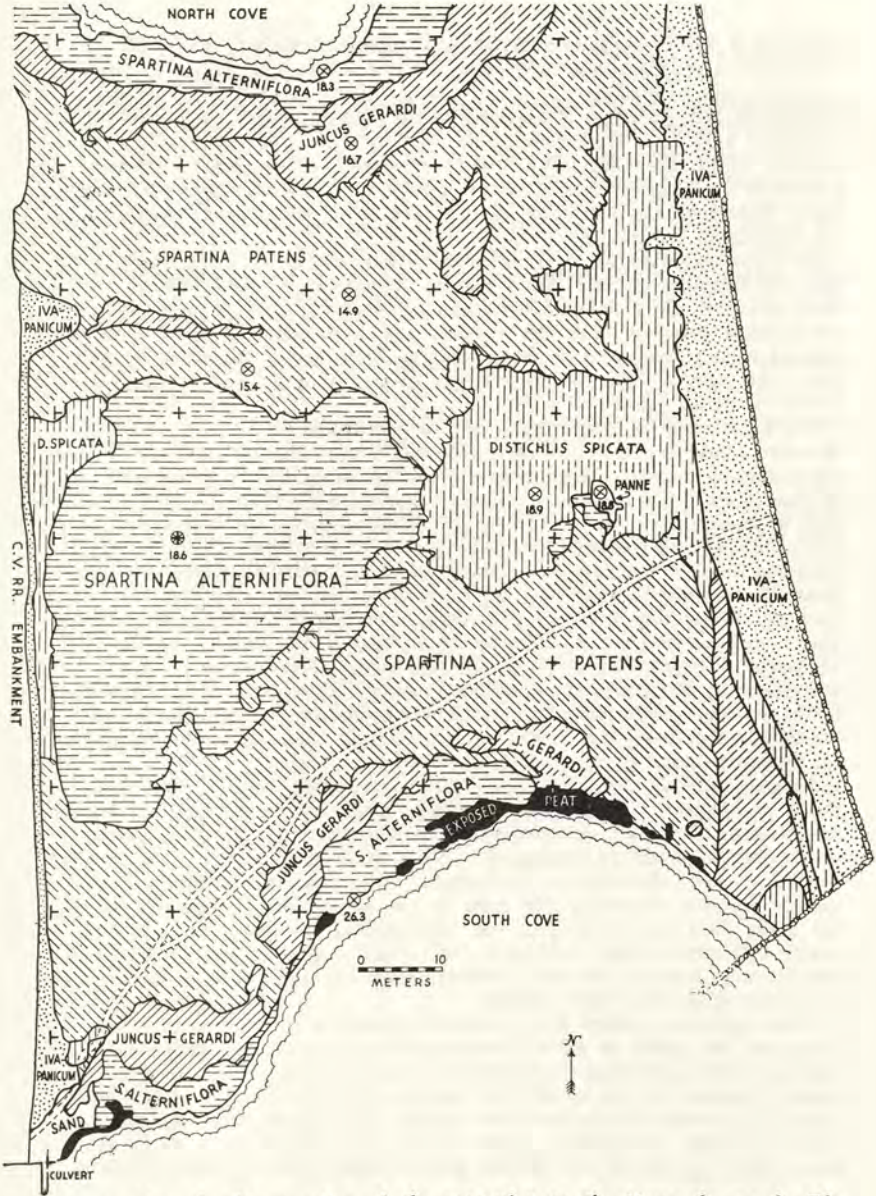


Fig. 1. Map showing zonation of the vegetation on the Mamacoke marsh. The position of the corners of the permanent 15 x15 m. quadrats are indicated. Points at which salinity measurements were taken are shown by circles, and low-tide salinity values are given in number of grams of salts per 1,000 grams of sea-water.

resurveys it will be possible to follow any changes which may take place in the vegetational pattern, and also to calculate the rate at which the marsh is either increasing in size or eroding.

Since the survey a rather striking change has occurred within the stunted central salt water grass area. During the summer of 1959 the grass in one-third of the area was killed. Excessive salinities and/or extensive silting in this depression as a result of dredging the channel of the river in 1958 may have been the principal cause. Colonization of this open area has been slow, with saltwort, an annual, as the conspicuous pioneer species.

In comparing Mamacoke with the Barn Island marshes on Long Island Sound near the Connecticut-Rhode Island border, the pattern is similar except for the black grass zone. At Barn Island black grass is frequently closer to the upland, with salt meadow grass adjoining the marginal salt water grass (2,4). Depressions, referred to as pannes, occur on both marshes. They may be dominated by stunted salt water grass, or broad-leaved flowering plants, or in some cases, they may be devoid of higher vegetation.

The development of these pannes has been attributed to the presence of levees or raised areas, formed at the edges of estuaries or artificial ditches and to local compaction of the peat. Observations at Mamacoke suggest another factor—the role of meadow mice. On these drier unditched marshes, much of the salt meadow grass zone is criss-crossed with mouse runways. With continued use the grass is killed and some compaction occurs in the runways. At the same time adjacent marsh peat along the edges of the runways continues to be built up, accentuating the depressions. At extremely high tide they become flooded. The water, thus trapped, evaporates and the salinity of the peat increases. This affects the vegetation adversely with a resultant enlargement or widening of these linear passages and in the development of depauperate stands of the salt meadow grass, which eventually may be replaced by other species, such as spike grass or salt water grass—more resistant to the flooding and increased salinity. The numerous natural pannes, so valuable to wildlife, may have been formed in this manner. The ditching of the marshes for mosquito control destroys these features of the marsh.

Salinity Determinations.—In 1959 determinations were made of the salinity in the various vegetation zones of the Mamacoke marsh in an attempt to evaluate the possible role of salt in determining the vegetational pattern. The data, summarized on the map in figure 1, are averages of two low-tide readings, which are the least variable of those obtained and are thought to represent the conditions most frequently prevalent adjacent to the roots of the marsh plants. Wherever possible, the upper six inches of the peat was collected and the water expressed from it analysed. Otherwise water standing on the surface of the marsh was collected. The analyses were made by the silver nitrate-titration technique with the assistance of an undergraduate, Miss Amelia Rechel.

These data show a rather direct relationship between the location of the various zones and the degree of salinity. As might be expected, the highest reading—$26.3°/_{oo}$[1]—was recorded at the southern or oceanward edge of the marsh. In a comparable location on the up-river or northern side, a somewhat lower salinity ($18.3°/_{oo}$) occurred. As one leaves the margin and proceeds toward the interior the salinity decreases. It is $16.7°/_{oo}$ in the black grass zone and finally reaches a minimum ($14.9°/_{oo}$) in the salt meadow grass belt—the most elevated and the least

[1] This symbol designates number of grams of salts contained in 1,000 grams of sea water.

inundated. One reading, in a somewhat diffuse and less vigorous stand of salt meadow grass, revealed a slightly higher salinity (15.4°/$_{oo}$) than in the more vigorous adjacent stand.

In the middle of the marsh, tide water accumulates in the depressions dominated by salt water grass, and a salinity level (18.6°/$_{oo}$) is found that is comparable to or slightly higher than that occurring in the salt water grass along the north shore. This is probably due to repeated inundation followed by evaporation during the summer months. Here salt water grass and other marginal species are again encountered. The stunted aspect of the vegetation in these depressions may be contributing factors. Another species, spike grass, is also tolerant of these inundated conditions (18.9°/$_{oo}$), but exhibits normal growth. Where the vegetation dies out, open pannes are formed (18.8°/$_{oo}$), one of which has developed on the Mamacoke Marsh (see Fig. 1).

Marshes represent an invaluable resource for teaching and research. Many basic problems, both fundamental and applied, await attention. For example: What is the total productivity of the marsh? What are the interactions between species within this complex? What role does the intricately associated salt water grass-ribbed mussel community play in binding the shoreline and thereby lessening coastal erosion? Only by preserving samples of our tidal marshes will it be possible to attack these and other basic problems in the future.

BIBLIOGRAPHY

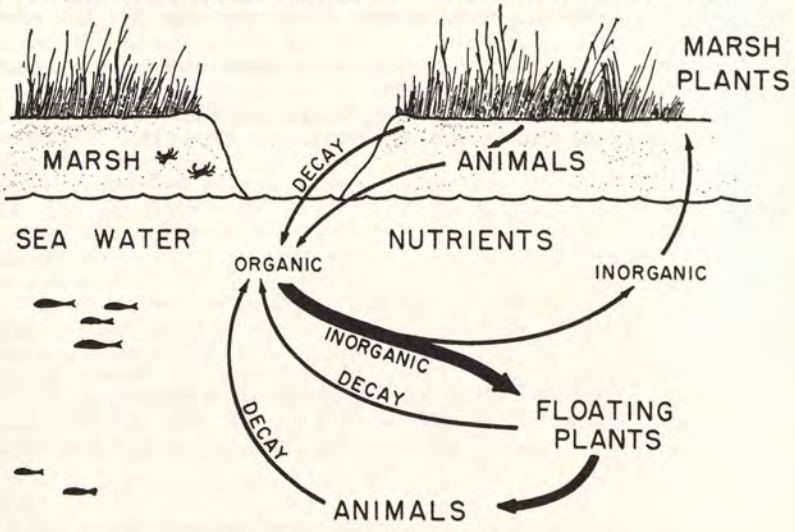
1. Bourn, W. S., and C. Cottam. Some biological effects of ditching tidewater marshes. U. S. Fish and Wildlife Service Research Report, *19*. 1950.
2. Egler, F. E. The Barn Island Marshes. Conn. Arboretum Bull. No. 9:3-8. 1956.
3. Goodwin, R. H. Mamacoke Island; the latest addition to the Arboretum. Conn. Arboretum Bull. No. 8:2-5. 1955.
4. Miller, W. R., and F. E. Egler. Vegetation of the Wequetequock-Pawcatuck tidal-marshes, Connecticut. Ecol. Monographs, 20:143-172. 1950.

Salt Marshes as a Source of Food *

JOHN S. RANKIN, JR., *Professor of Zoology and Director of the Marine Research Laboratory, University of Connecticut*

EVERYONE RECOGNIZES the great importance of fertile agricultural land in providing the very basis of our subsistence, but few people realize that tidal marshes and estuaries include some of the most productive acreage on the face of the earth. "The tonnage of vegetation that these marshes produce per acre each year is unrivaled by any other natural soil and difficult to equal, even in intensive agriculture using commercial fertilizers" (1). Furthermore, this growth takes place naturally, with no investment of human energy or natural resources. In Colonial times these marshes were harvested for salt hay, but more recently, due to ditching for mosquito control and to their unsuitability for heavy machinery, this use has been abandoned. One reason the productivity of the tidal marsh is overlooked is that the crop is not now directly exploited by man, but instead is recovered as high protein food from fish, shellfish and, to a minor extent, wildfowl that derive their nourishment at least indirectly from the marsh.

The exchanges of nutrients between tidemarshes and the tidal waters. The width of the arrows represents the relative amounts of the nutrients. (Reprinted from an article by F. A. Kalber, Jr. in the *Delaware Conservationist,* Summer 1959.)



* Contribution No. 3, Marine Research Laboratory, Noank.

Furthermore, although the total acreage of tidal marshes may be relatively small along our shores, their importance is vastly greater than any production figures that might be quoted on a per acre basis. One reason for this is that the tidal channels which dissect them provide the essential spawning and nursery grounds for such important species of fish as the menhaden, striped bass, bluefish and flounder, which, as adults, feed in deeper waters. They also provide essential stopping and feeding places for migratory waterfowl. Thus salt marshes are serving just as vital a role in the support of these fish and waterfowl as a water hole in the support of the big game on a semi-arid veldt.

A tidal salt marsh represents a special land form with distinct assemblages of plants and animals. Anyone who studies a marsh as the tide recedes becomes aware of the great variety and numbers of organisms that exist in pools, in ditches, on rocks and even on the drying soil—far more than on a comparable area of cultivated land. How is it possible for an "uncultivated" region to be so productive?

Marshes produce a tremendous amount of plant material. This is the *primary* productivity, that is, the amount of carbon that is converted into organic compounds by photosynthesis. Many of these plants and their uses as sources of energy and shelters for a great variety of birds and mammals (3) as well as for invertebrates such as snails, mussels, barnacles, insects, etc., have been described. Even more important are the huge quantities of marsh grass that are decomposed providing nutrient salts necessary for growth of organisms in the tidal waters. Valuable minerals and salts are washed from land and settle around the roots of marsh plants. At the same time, a constant inshore drift of nutrients from off-shore, concentrated by organisms such as scallops (4), enhances the total amount in the marshes. Furthermore, the droppings of birds and mammals should not be overlooked as an important source of organic materials. All of these nutrients have been proven valuable in building up the productivity of Long Island Sound (8). They are used up by microscopic organisms. These, in turn, are eaten by young fish and shellfish. Small fish and crustaceans are eaten by larger fishes.

Two fundamental phenomena are apparent: 1) the continuity of offshore and inshore waters and 2) the establishment of food chains. It should be emphasized that the sea, sounds and bays and tidal marshes form a living entity, not existing as separate units; and that life cycles of organisms in these areas depend on marshes for concentration of these nutrients.

The interaction between the marsh and the immediate and nearby waters results in a relatively stable concentration of nutrients. An hypothesis on the role of the tidal marsh in estuarine productivity has recently been presented for the Delaware River (2).

The natural productivity of marshes has been used to advantage by man for generations. In France, the salt marshes are used for fattening of oysters. Thousands of acres of shallow ponds are found in the marsh. These become recharged with brackish water every two weeks. The oysters are laid in these areas for growth and fattening. Dr. Thurlow Nelson tried this sort of procedure on the New Jersey marshes about 1932. Although not wholly successful, due primarily to the hot summer, he did demonstrate the stimulating effects of run-off and seepage from marshes on the oysters lying in adjacent waters. Microscopic plants are an important source of food for oysters, and are produced in large quantities in the run-off from these marshes " . . . where nutrients from the sod, combined with solar energy from the sky, produce the very 'grass of the seas' . . ." These and other observations led to the methods now used extensively in the cultivation of shellfish in this country. One of the main reasons for the decline in the oyster industry in Long Island Sound is probably the destruction of tide flats and marshes in the estuaries.

Most, if not all, salt marshes of the Atlantic Coast have undergone intensified ditching in mosquito control projects. The effects of such ditching are difficult to analyze. "It is to be deplored and regretted that not a single area of virgin unmodified or preserved tidal marsh exists in Connecticut for purposes of comparative study and research . . . Existing marshes have been lacerated with ditches with that admirable thoroughness and pseudo-foresightedness with which mankind is apt to treat the lands of his heritage." (5). The effects of mosquito ditching on the Wequetequock-Pawcatuck (Conn.) tidal marsh have been well documented (5). The immediate effect was to alter the entire aspect of the original marsh, by draining the small pools which supported a high wildlife population. It initiated a long series of vegetational changes. Far more fundamental and deep-seated effects were caused by affecting deposition and erosion and so changing the levels in every square foot of the marsh.

Recently, a more serious threat has developed—the actual dredging out of the marsh, with channels across the flats to deeper water, for marinas and for the commercial exploitation of the gravel deposits. The *total* removal of large sections of marshes would not only rob organisms of their basic nutrient supplies and so reduce drastically the productivity of such areas, but would also lead to vast changes of neighboring shores (1).

It is obvious from the foregoing that much observational data have been accumulated to show that marshes represent a most important land form and are necessary for the existence of many organisms. Also, it has been established that changes in marshes initiated by man have resulted in widespread changes in productivity and topography. Salt marshes are areas of natural land reclamation (13). But little attempt has been made to call to the attention of the general public the actual value of marshes in more

understandable terms. It is necessary, therefore, through basic research, to document these primary observations. Let us look at recent results that may help in this understanding. The most significant recent studies have been those on marshes in Georgia and Delaware.

The cordgrass *(Spartina alterniflora)* is produced on Georgia salt marshes at the rate of 4.8 tons of dry matter per acre per year (11). Investigators at the University of Delaware marine laboratory found a comparable production on the Canary Creek Marsh (Delaware), "which is a high-level tidal marsh, completely flooded only by the high spring tides. Upon its 123 acres grows each year a 323 ton (dry weight) plant crop, principally cordgrasses. Part of this crop, through decomposition, probably forms the major portion of an estimated 84 tons (dry weight) of organic matter that is flushed from the marsh each year." (10).

The nutrient value of the cordgrass from South Carolina marshes is due to its 3.3% protein content as air-dry hay (14), a figure that compares favorably with the 2.9% digestible protein in timothy hay. In an experiment using cordgrass hay infusion and bacteria and protozoa an initial vegetal protein yield was more than doubled through action of the micro-organisms. A similar build-up of protein undoubtedly occurs naturally in tidal marshes. Studies in Georgia (15) and in Delaware (10) show that insects, bacteria and crabs feed heavily on cordgrass. Other observations show that snails, isopods, spiders, mites, and birds also feed on this grass.

Vitamin B_{12} is produced by micro-organisms and is used by them and other organisms for growth and development. The importance of tidal marshes in the production of this growth factor has been established (12). Waters draining from a tidal marsh in Georgia contained much more Vitamin B_{12} immediately after high tide than at any other time. The flushing process, brought about by tidal changes, causes continual exchange of nutrients between coastal and marsh waters. Similar exchange between the tide marshes and the Delaware River estuary has been described (10). It has been demonstrated conclusively that the marsh contributed inorganic nitrogen and inorganic and organic phosphorus to the tidal waters.

Through a study of the productivity of algae on the surface layers of Georgia salt marshes, it was estimated that the mean annual net production was 1,000 pounds of carbon per acre per year (7). Using data from these studies on salt marshes in Georgia, it was calculated (9) that a minimum crop of 547 pounds of sugar per acre per year are produced by microscopic plants on the Delaware marshes. "If only one-half of Delaware's 130,000 acres of tide marshes have this level of production, this is still an annual crop of 35,555,000 pounds which is food for estuarine animals. At ten cents a pound this tide marsh sugar crop produced by the microscopic plants is worth $3,555,500. To this must be added the value

of the food produced by the rooted plants, such as the marsh grasses and sedges."

The Niantic River estuary in Connecticut (4) yields a harvest of about 15,000 bushels of scallops a year. This amounts to "about 300 lbs. of net weight per acre per year, or more than the beef yield on good grazing land." Even so, this is only a fraction of the total production of this estuary, for quantities of quahogs, softshell clams, crabs, and several species of fish are also harvested. These, plus numerous non-commercial organisms, and the support of large flocks of wintering and migratory ducks add up to make the area a most productive one. This estuary is typical in being well-supplied by surrounding tidal marshes.

A summary of the world distribution of primary production (6) shows dramatic evidence of the high productivity of coastal lands and estuaries. Primary production may be recorded in pounds per acre per day. Three major production levels are recognized. 1) open oceans and deserts, the greatest surface area of the earth, but the least productive—about 1.2 pounds per acre per day; 2) coastal areas, shallow lakes, grasslands and ordinary agricultural crop land—6.1 to 60.5 pounds per acre per day; and 3) some estuaries, coral reefs, intensive terrestrial agriculture, etc., the greatest primary productivity—60.5 to 242 pounds per acre per day. It must be emphasized that salt marshes are in this latter group.

In conclusion, tidal marshes have been found to be exceptionally productive of many forms of life. Marshes are essential to the production and maintenance of waterfowl, furbearers, and especially, shellfish, crustaceans and fish. If all tidal marshes were lost, our fisheries harvest might well drop to less than half of its present volume. "A positive program of marsh utilization must be adopted so that industry, agriculture and recreation, with effective control of mosquitoes, can coexist with fisheries." (10). Although multiple use of some tidal marsh areas can be worked out between the boating population and others, some tide marshes *must* be managed for maximum benefit to the fisheries. To destroy all tide marshes, or even the major portion of them, is equivalent to the poor land-use methods that have resulted in "our plundered planet."

BIBLIOGRAPHY

1. Bishop, J. S., and Ruth Billard. Connecticut Tidal Marshes Need Protection. Conn. Wildlife Cons. Bull., 4(6):1, 4-5. 1958.
2. Kalber, F. A., Jr. A Hypothesis on the Role of Tide Marshes in Estuarine Productivity. Estuarine Bull., 4(1):2-3, 14-15. 1959.
3. McAtee, W. L. Wildlife of the Atlantic Coast salt marshes. U. S. Dept. Int., Fish and Wildlife Service, Wildlife Circular, 11:1-32. 1941.
4. Marshall, N. The yields of estuaries. Rhode Island Maritimes, 4(1):1-2. 1960. Studies of the Niantic River, Connecticut, with special reference to the bay. Scallops, *Aequipecten irradians*. Limnol. & Oceanogr., 5(1):86-105. 1960.

5. MILLER, W. R., AND F. E. EGLER. Vegetation of the Wequetequock-Pawcatuck Tidal-Marshes, Conn. Ecol. Monographs, 20(2):143-172. 1950.
6. ODUM, H. T., AND E. P. ODUM. Principles and concepts pertaining to energy in ecological sytems. In: E. P. Odum, Fundamentals of Ecology (2nd Ed.), pp. 68-87, W. B. Saunders Co., Philadelphia, 1959.
7. POMEROY, L. R. Algal productivity in salt marshes of Georgia. Limnol. & Oceanogr., 4(4):386-397. 1959.
8. RILEY, G. A., ET AL. Oceanography of Long Island Sound, 1952-1954. Bull. Bing. Oceanogr. Coll., 15:1-414. 1956.
9. SHUSTER, C. N., JR. Why estuarine research, education and conservation? Estuarine Bull., 3(3):2-3, 15. 1958.
10. SHUSTER, C. N., JR. A biological investigation of the Delaware River estuary. Univ. of Del. Marine Lab., Information series, Pub. No. 3: 1-77. 1959.
11. SMALLEY, A. E. The growth cycle of *Spartina* and its relation to the insect populations in the marsh. Proc., Salt Marsh Conf., 1958, Marine Inst. Univ. Georgia: 96-97. 1959.
12. STARR, T. J. Relative amounts of vitamin B_{12} in detritus from oceanic and estuarine environments near Sapelo Island, Georgia. Ecology, 37(4):658-664. 1956.
13. STEERS, J. A. Salt marshes. Endeavour, 18(70):75-82. 1959.
14. TASHDJIAN, E. A note on *Spartina* protein. Econ. Bot., 8(2):164-165. 1953.
15. TEAL, J. M. Energy flow in the salt marsh ecosystem. Proc. Salt Marsh Conf., 1958, Marine Inst. Univ. Georgia:101-104. 1959.

Wildlife of the Coastal Marshes

PHILIP BARSKE, *Wildlife Management Institute*

HIGH TIDE AND LOW tide are ordained in the scheme of nature, and man is insignificant in his attempt to alter or change these events. Between these eternal tide ranges, we have a zone, where ocean and land meet, a zone that man has profoundly affected.

Consider for a moment the extent of our natural coast line, stretching from Maine to Brownsville, Texas on the Atlantic and Gulf Coasts and from San Diego, California, to the Arctic Circle on the Pacific. Seemingly almost limitless in range, but fringing our coast line, this habitat actually represents less than 3/100,000 of the acreage of our entire country (1).

In this zone there occurs an array of wildlife not readily evident to the man in the street. To the naturalist and casual observer the marsh represents a fascinating diversity of waterbirds. To the hunter these offer exciting outdoor sport. And still others find these wetlands and the immediately adjacent waters a place where they can enjoy fishing, crabbing, clamming and just relaxing.

Of the wildlife associated with the marshes, birds are the most conspicuous. Among those that breed in or are completely dependent upon the salt marsh for their food are the rails and sparrows (2). Of the six species of rails perhaps the most characteristic is the clapper rail, also known as the marsh or meadow hen. The rails are narrow-bodied birds, uniquely adapted for slipping between the dense vertical stems of the grasses and reeds. They feed on insects, snails and small crustaceans. Being elusive and retiring and most active in the twilight hours, they are seldom seen by the casual observer.

Equally typical are two song birds: the sharp-tailed and seaside sparrows. They, too, are elusive, almost mouse-like in the way they move about in the vegetation. When flushed they merely flutter a short distance and drop again into the grassy cover. The nest is built among the drift and most of their diet includes insects, snails, and sand fleas. Other birds nesting in the marshes include the black duck, blue-winged teal, common bittern, willet, marsh hawk, short-eared owl, red-winged blackbird, meadowlark and marsh wren.

Besides these species, there are an even larger number which are dependent upon the marshes and adjacent estuarine waters for food. Among these are the large spectacular wading birds—the great blue heron, the American egret and a number of smaller herons. Gulls and terns, although breeding on islands and beaches, may be seen from time to time in the marshes. Related to the terns is the black skimmer, which skims the shallow waters for small fish. In the spring and fall and during the winter months large numbers of migratory waterfowl which breed in the far north frequent the marshes. Among these are the many species of ducks and geese. The geese are grazers and are, therefore, highly dependent upon the roots and stems of the marsh grasses.

Of the shore birds, approximately 40 additional species not yet mentioned occur along the Atlantic coast. Many are more typical of the sandy beaches; others of the marshes; but there is continual interchange between these habitats. Of those most commonly to be seen in and about the marsh, the yellow-legs, dowitcher, pectoral sandpiper and least sandpiper should be mentioned. Among the birds of prey are the marsh hawk, the osprey and the bald eagle. The latter, now becoming increasingly rare, should be preserved for its own sake and because it is the national emblem.

Numerous other birds not infrequently found visiting the marshes include the fish crow, cormorants, belted kingfisher, grackles and, on the south Atlantic marshes, pelicans and ibises.

The food for this great diversity of bird life is derived either directly or indirectly from the marshes. Here upwards of twenty genera of marsh insects, eighteen genera of bivalves, and fifteen genera of crustaceans con-

tribute not only to this avian food chain but also to man's prized shellfish resources. The small fish of the shallow adjacent waters, the killifishes, pursy minnow, and silversides are a vital part of this complex web of life. They serve several roles. They furnish a food source for this large and diverse bird population; they aid in reducing the population of mosquito larvae; and they may also become the prey of our larger fishes, thus contributing to our commercial and sports fishing resources.

Other animal life on the marsh includes the diamond-backed terrapin and several species of mammals. Muskrats and meadow mice inhabit the marshes the year round, and in some areas the muskrat is "harvested" for its fur. Other mammals frequently visiting the marsh include deer, fox, raccoon, skunk and opossum.

In this short resume we have shown how the tidal marshes support one of our richest wildlife populations, intricately adjusted and interdependent upon the existing natural setting. Furthermore, it has been emphasized that the tidal marshes cannot be isolated as a specific ecological entity. Instead, we find a closely-knit interacting complex of habitats involving not only the marshes but also the adjacent waters, the salt ponds, bays and estuaries.

What will be the fate of this unique wildlife population? Intensive coastal development means compromise for the hunters, the naturalists, the commercial fishermen, the developers of homes and marinas, various industries seeking coastal areas and various other interests seeking coastal land utilization. However, generally speaking, for the welfare of the coastal marshes, the best development is that which is accompanied by the least physical change in the marshlands and adjacent waters. Time is running out, we need no more prolonged, obtuse statistical research to prove what is plain and obvious to every intelligent and thinking citizen—that our coastal lands are shrinking rapidly. If we are to save these valuable habitats, action must be initiated right now, without fatal postponement.

BIBLIOGRAPHY

1. BISHOP, J. S., AND RUTH BILLARD. Connecticut tidal marshes need protection. Conn. State Jour., July, 1958.

2. MCATEE, W. L. Wildlife of the Atlantic Coast salt marshes. U.S.D.A. Circ. 520. 1939.

Geological Aspects of Connecticut's Coastal Marshes

JOHN E. SANDERS, *Assistant Professor of Geology,* AND CHARLES W. ELLIS, *Department of Geology, Yale University*

CONNECTICUT'S DWINDLING COASTAL MARSHES find themselves subject to ever-increasing economic pressures toward obliteration. They are generally regarded by most segments of public opinion as being wastelands that could be put to better use by man than they are presently serving in the economy of nature. In addition, many marshes overlie sizable deposits of sand and gravel, sources of which are becoming rarer in Connecticut as more easily exploited inland deposits are exhausted.

The view that marshes are wastelands is due to general ignorance of the role of marshes in the balance of nature. The biological importance of Connecticut's coastal salt marshes in the natural economy is documented elsewhere in this bulletin. Various animals, such as wildfowl, shellfish and finfish, are partially or totally dependent on the marshes or products of the marshes during part or all of their life cycles.

Important policy decisions affecting irreplaceable natural resources, be they marshes, animals, sand and gravel, or anything else, should not be made without knowing as fully as possible the consequences of the various alternatives. The present paper describes some of the geological processes responsible for the development of coastal marshes and some of the consequences of their destruction.

THE GEOLOGY OF COASTAL SALT MARSHES

Coastal salt marshes are produced as a function of tides, of certain grasses that exist in shallow salt water, and of changes of sea level. These variables may be illustrated by first considering the formation of marshes at stationary sea level, and then examining the effects on them of a relative rise of sea level.

Marsh formation at stationary sea level.—Coastal salt marshes are the direct result of the tendency of tidal action to deposit fine-grained sediment in sheltered coastal areas, such as bays, lagoons, and estuaries. The principles of this process have recently been elucidated by van Straaten and Kuenen (7). Fine-grained sediment, which is put into suspension by the waves, is moved landward by the incoming tide (and also seaward by other currents). As current velocity of the incoming mass of tidal water decreases, the sediment particles begin to settle toward the bottom. They do so because the upward component of turbulent motion in the water has decreased to a value below that of the settling velocity of the particles. Owing to their slow settling velocities, the particles are carried landward between the time when they first begin to settle out of suspension and the moment that they come to rest on the bottom. This distance of landward movement depends on the size of the particles, depth of water, and current velocity. The effect of delayed settling is

called *settling lag*. As the tide turns, its flow direction reverses, and as velocity increases seaward, sediment particles may again be picked up and moved seaward by the outflow. But, a given mass of water will have moved outward beyond the point where our example particles had previously settled from it before the upward components of turbulence within it again attain the settling velocity of the particles—the minimum condition required to keep the particles in suspension. In addition, a greater velocity is required to lift small particles from the bottom than to keep them in suspension once they have been lifted from the bottom. Hence, the water mass will have moved outward even further before it is capable of picking up particles of the same size that it dropped on the previous inward cycle. This delayed effect is called the *scour lag*. Settling lag and scour lag combine to cause particles to be shifted progressively landward until finally they cannot be picked up at all by any part of the outgoing tide and they are left to accumulate.

After the shoreward parts of a bay, for example, have shoaled by deposition of tidal mudflats, grasses may colonize the area and marsh development begins. In the course of time, salt peat is formed near mean high water level by the thick mat of grassy turf that grows there. Initially, therefore, the marsh deposits, which have grown by the shoaling of formerly marine areas, will overlie fine-grained marine sediments that contain shells of shallow-water organisms (3, 5, 6, pp. 146-153).

Marsh development with relative rise of sea level.—Once established, a marsh may maintain its position near mean high water level and may shift gradually landward if sea level rises. During this rise of water level, the thickness of salt peat may increase by upward growth, and marsh deposits consisting entirely of salt peat formed originally near mean high water level may overspread various kinds of nonmarine deposits, such as peat from fresh-water swamps, sand or gravel deposited by streams, or even bedrock (1, 3, 4).

The coast of Connecticut has been enormously influenced in its later geologic history by the advance of a continental glacier with concomitant lowering of sea level and by the subsequent melting of the glacier and attendant rise of sea level. The advancing glacier, which reached southward to Long Island, laid down a carpet of unsorted material called *till*, which ranges in grain size from clay to huge boulders. The southern margin of the retreating glacier had moved considerably northward before the sea gained access to the depression that is now occupied by the waters of Long Island Sound. Valleys which probably had been deepened and enlarged by glacial erosion were then occupied by meltwater streams which drained southward away from the glacier. After the sea entered the Sound and began to rise, the gradients of these meltwater streams were progressively lowered, and the deep bedrock valleys were filled by sand and gravel (8). In addition, waves began to work on the carpet of till and to sort out the fine-grained components. These were put into suspension and carried away by currents. Some of it found its way via the tide into coastal indentations, where it eventually formed mudflats on which salt marshes grew. The coarser components of the till remained in place as a washed lag residue of sand and gravel.

After coastal salt marshes were established on the mudflats, they encroached landward as sea level slowly rose. The marshes locally covered the earlier-formed stream deposits of sand and gravel which originated during still earlier phases of sea level rise (3).

Marsh sediments.—The only detailed information on the properties of marsh sediments in Connecticut is contained in an unpublished report on the Westport-Norwalk area by Ellis (2). The following summary of the sediments of Great Marsh, just west of the mouth of the Saugatuck River, on the mainland opposite Sprite Island, was taken from Ellis' report.

Great Marsh consists of tidal channels that are underlain by fine-grained sediment and flat interchannel areas that are underlain by salt peat; its area is 0.3 sq. mi.

The median grain size of the channel sediments varies from very fine silt size (0.0065 mm; 7.37Ø) in a sample 4 feet below the surface, to clay size (8.17Ø) at the surface. These sediments are very poorly sorted and fine-skewed; their content of clay-size particles increases with distance away from Long Island Sound. Cores of channel sediment revealed no stratification nor evidence of channel shifting; they consist only of fine-grained sediment that was deposited from suspension.

The surface of the interchannel areas is underlain by a black, gelatinous, coherent mass of sediment that is full of organic material. Cores from the interchannel areas showed salt peat with scattered interbedded sediment layers. The salt peat is composed of interlocked plant stems and roots of the types that grow only at or near mean high water level. This salt peat is 7 feet thick on the average, but varies from a maximum of 9 feet in the middle of the marsh to a feather edge at its margins. The peat overlies glacial outwash sand and gravel, which is capped by a brownish layer that formed by oxidation during subaerial weathering. Both the non-marine characteristics of the sand and gravel and the subaerially-formed oxidized capping prove that this marsh has encroached over a former land surface as sea level has gradually risen; marsh growth managed to keep pace with the rising water. The amount of rise recorded by the marsh is 9 feet.

The marsh channels are kept open by tidal scour, for the large volume of water that spreads out over the flat interchannel areas as a thin sheet must enter and leave the marsh via them during each high tide cycle. The concentration of this flow in the channels results in larger water current velocities there. As a result, the mouths of many tidal channels are suitable harbors for small boats (6, pp. 151-152).

What Shall We Do with Our Coastal Salt Marshes?

In view of the increasing economic pressures in the direction of marsh destruction, important policy decisions will soon be confronting the people of Connecticut. Shall the marshes be let go by default to the obvious economic gains to be won by converting them to real estate for housing or industrial purposes, or by dredging them for their underlying gravel resources and/or making them into marinas? With the present lack of understanding about our marshes this seems the easy course. But, what assurances do we have that some other irreplaceable natural resource equally or even more valuable may not be destroyed in the process of cashing in on our marshes? Do not state officials have a serious responsibility to inform themselves on these questions before acceding to further requests to destroy marshes?

Persons contemplating converting marshes into real estate or marinas should bear in mind that the destruction of marshes does not alter the powerful geologic forces which tend to form marshes. If a marsh is destroyed, the volume of water that flows in and out of the channel at high tide will diminish and the natural scouring action that formerly maintained deep water at the channel mouth will be overpowered by the tendency for the channel to silt up or to be filled from the side by a laterally-moving sand bar.

If marshes are to be destroyed to mine gravel, then let us all frankly admit that gravel-mining is the objective and eliminate the disguise of various free "improvements" such as marinas that may be offered as "bait" to enlist local support for the proposed gravel-removal project. The offer of a "free" marina that may accompany a gravel-removal operation should be considered in the longer view and by others than local officials. It is not the initial cost, but the upkeep that requires careful scrutiny. Once a marina is established, its users come to expect public funds to be expended to keep the channel open. Any marina made from a former salt marsh is especially prone to rapid silting and expensive dredging is the inevitable consequence, if the channel is to be maintained. How "free" is such a marina when it is certain to be the source of constantly recurring public bills for channel dredging? The sand and gravel operators, who offered the supposedly free dredging in the first place for the privilege of removing sand and gravel, are not likely to return again to dredge silt free of charge!

What is needed before further destruction of Connecticut's coastal salt marshes is permitted is a careful evaluation of the marshes in the natural economy of the shore areas. Dare we risk the destruction of some irreplaceable natural asset, the value of which is now obscured from us by our ignorance, merely to allow someone to line his pockets with a quick, easy, obviously visible cash profit derived from marsh destruction? If our civilization cannot exist without destroying the marshes, then so be it; but let us first determine just what else we may lose in the process. It would be sheer negligence and stupidity to allow our marshes to be lost piecemeal without finding out beforehand just what we may be trading away in exchange for them! In this respect, the marshes are more a biological problem than a geological one. Their principal geologic function is as a stabilized reservoir of fine silt and mud; if marshes are destroyed, this material will simply go elsewhere, probably into our harbors and harbor channels. In our geologic setting of a slowly rising sea level, the forces which cause marshes will inevitably remain with us; marsh destruction will not alter them.

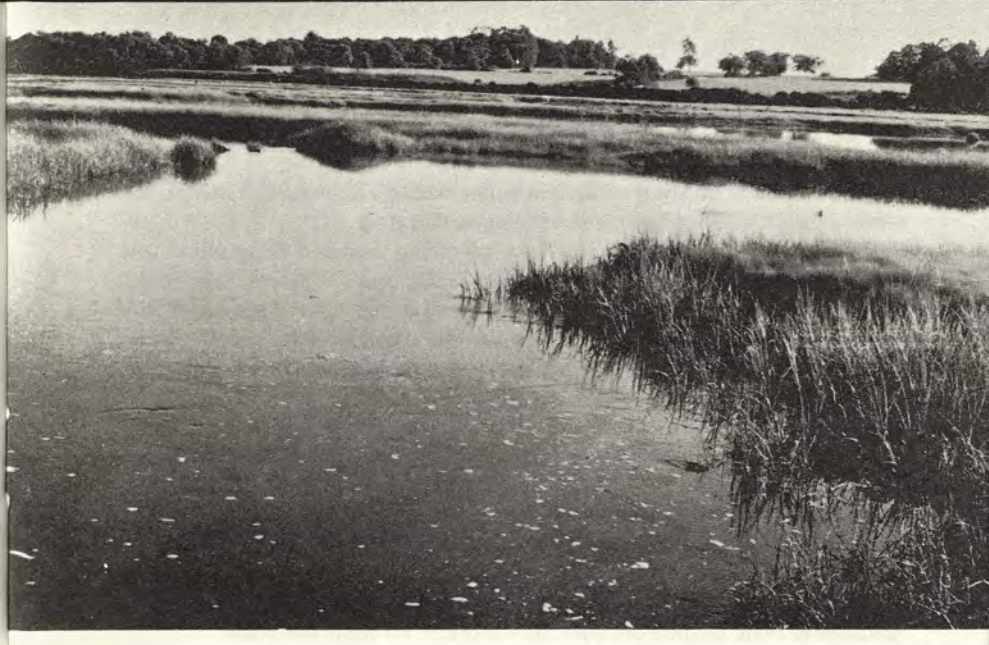
CONCLUSIONS. The geological aspects of marshes are principally concerned with the effects of the tide in bringing fine-grained sediment toward coastal indentations. Destruction of marshes would probably divert much of this silt and mud into harbors. Small-boat harbors at the mouths of marsh channels will be destroyed if marshes are converted to dry land.

The economic pressures for destruction of Connecticut's coastal salt marshes are more commonly aimed at the sand and gravel reserves that underlie many of these marshes. Before marshes are destroyed to exploit these resources, or for any other reason, a careful study of the total in-

fluence of marshes on the ecology of surrounding areas should be made in order to determine the price to be paid in natural resources by their destruction.

BIBLIOGRAPHY

1. DAVIS, *C. A.* Salt marsh formation near Boston and its geological significance. Econ. Geology, 5:623-639. 1901.
2. ELLIS, C. W. Marine sedimentary environments in the vicinity of the Norwalk Islands, Connecticut. Ph.D. Dissertation, Yale Univ. (unpublished), pp. 149. 1960.
3. KNIGHT, J. B. A salt-marsh study. Am. Jour. Sci., 5th ser., 28:161-181. 1934.
4. MUDGE, B. F. The salt marsh formations of Lynn. Essex Inst., Proc. (Salem, Mass.), 2:117-119. 1862.
5. SHALER, N. S. Sea coast swamps of the eastern United States. U. S. Geol. Survey, 6th Ann. Rept.: 353-398. 1885.
6. SHALER, N. S. The geological history of harbors. U. S. Geol. Survey, 13th Ann. Rept., Pt. 2:93-209. 1893.
7. STRAATEN, L. M. J. U. VAN, AND PH. H. KUENEN. Tidal action as a cause of clay accumulation. Jour. Sedimentary Petrology, 28:406-413. 1958.
8. UPSON, J. E., AND C. W. SPENCER. Glacial geology of buried bedrock valleys of the New England coast (abstract). Geol. Soc. America Bull., 71:1995. 1960.



The Death of a Marsh

The Story of Sherwood Island Marsh and its Political Consequences

LOUIS DARLING,[1] *Westport, Connecticut*

IF COASTAL MARSHES are such vital parts of the marine environment, why are they being destroyed with such dismaying regularity? That ignorance plus profit is responsible, is an oversimplified answer, true in many cases. Of course valid recreational and commercial requirements, as well as profit, politics, and expediency, contribute to the destruction of our marshes. Perhaps the actual case history of the death of one of our finest marshes and of the battle to preserve another one will help to develop an understanding of the causes of destruction so that they may be more effectively opposed in the future. Conservationists must be intensely realistic if they hope to preserve more than a few scattered samples of these unique and precious communities of plants and animals.

In the spring of 1956 it was learned that the salt marsh in Sherwood Island State Park, in Westport, was to be used to stockpile 3.5 million cubic yards of gravel taken from Long Island Sound by hydraulic dredging. Much of this gravel was to be used as fill in the construction of the

[1] First President of Connecticut Conservationists, Inc.

new Connecticut Thruway. The remainder would obliterate the marsh and create a huge parking space for patrons of the park.

At the same time a beach erosion project was initiated to improve and expand the bathing facilities of the park. The erosion project was financially independent of the gravel dredging, did not affect the marsh, involved a comparatively small yardage of material, and was to take place in any event—an entirely worthwhile improvement which would create considerably expanded recreational opportunities.[1]

Conservationists considered the *gravel* project to be destructive out of all proportion to its advantages. In the first place, the Sherwood Island marsh was the last one of any account, on the long stretch of coast west of the Housatonic River, which was not privately owned and thus threatened with eventual destruction. Due to skyrocketing land prices it would be most unlikely that the state or any private organization could afford to purchase and preserve any other marsh in this entire area. Very valuable seed oyster beds lay just offshore. The fertility of these beds was doubtless dependent upon the marsh, and siltation from the dredging would certainly injure them seriously. The huge trench to be dredged just offshore would be likely to hasten erosion of the newly rebuilt beach.[1] Many people enjoyed the marsh all year around. Crabbers, birders, naturalists, youngsters, as well as those who simply liked to look at a beautiful bit of the world, preferred the marsh the way it was. Duck hunters used it in season and the shoal waters offshore, again dependent upon the marsh for their fertility, provided excellent fishing and clamming which thousands enjoyed.

This proposal was peculiarly hard to oppose because of the opportunities for demagoguery. Proponents emphasized the parking facility aspect and played down the convenience and profit of the private highway contractor involved. The phrases "the greatest good for the greatest number" and "for the little fellow" were freely used. Those opposed to marsh filling were said to be "for ducks and against people." "Nature lover" can be a term of opprobrium when used in a certain context and with the right inflection. No one bothered, however, to define "the greatest good."

The fill necessary for the thruway could have been obtained from less unique and irreplaceable areas, as it was for most other sections of the road. The parking facilities which already existed on the uplands of the

[1] Recent studies (C. W. Ellis, "Marine sedimentary environments in the vicinity of the Norwalk Islands, Conn." Ph.D. Dissertation, Yale Univ. [unpublished], 1960.) have shown that the material added to the beach is very unstable and is being rapidly removed by wave action. The off-shore trench produced by the dredging operation, on the other hand, has not yet shown evidence of inducing alterations of the underwater contours of the beach. (Ed. note).

park, plus those which could have been built in marginal areas with little damage to the marsh, were entirely adequate for the amount of available beach. To illustrate this point it was estimated that if each car, which could be accommodated by the huge parking space to be left at the end of the operation, brought three people to the park (a conservative estimate), there would be but a three or four foot square of beach for each person at high tide. Even the most amorphous form of "little fellow" conjured up by the most demagogical politician doesn't enjoy or profit from being this crowded. The lack of sincerity behind this claim of benefit to the "little fellow" has since been confirmed by the announcement that fourteen acres of this "badly needed" parking space would be used for a helicopter landing field!

There was another aspect to the question which has led to a situation potentially far more serious than the elimination of this one marsh. In order to legalize the sale of gravel by state officials, our Attorney General gave an opinion which stated that all the material on the bottom of Long Island Sound was the *personal* property of the state. So classified it could be sold to anyone by a single state executive, the Commissioner of Finance and Control, just as he would sell an obsolete typewriter. Traditionally and legally the bottom of the Sound had always before been considered as *real* property of the state which could be sold only by an act of the legislature. With the modern-day demand for gravel, such a precedent could give rise to an uncontrolled, destructive, gravel-mining industry all along our coast.

There was a good deal of opposition to the Sherwood Island dredging proposal from conservation organizations and individuals all over the state. However, such opposition was disorganized and largely ineffective. As there was no state-wide conservation group in Connecticut that could represent all those interested in this issue, it was suggested that one be formed which could organize and finance an effective protest. The Westport Audubon Society called a meeting for this purpose. Thus Connecticut Conservationists Inc. was born. Today its membership consists of representatives of fifteen conservation organizations, state and local, whose interests reach all the way from those of the Federated Garden Clubs of Connecticut to those of the State League of Sportsmen's Clubs.

Connecticut Conservationists challenged the legality of the Attorney General's opinion. It raised funds to employ attorneys to present the case. Although it appeared twice before the Connecticut Superior Court, a decision was never obtained. Ranks of attorneys from the dredging company, the highway contractor, and the Attorney General's office obtained a dismissal because the plaintiffs representing Connecticut Conservationists could not show that they would suffer any unique financial damage—that is any loss *not shared by all the citizens of the state!* For practical purposes the case was lost.

Fig. 1. The Sherwood Island Marsh being buried by hydraulic fill. Compare this with the view at the beginning of this article. Photo by Louis Darling

When the dredging started, the marsh vanished under a sea of mud and gravel (see fig. 1). But the pressure of public opinion helped to establish safeguards stipulated by the Shellfish Commission, which protected shellfish grounds from actual dredging and siltation. The private initiative of an alerted citizenry helped to police the performance of the dredging operation and forced a shut-down until facilities could be constructed that reduced the effluent from the marsh to the specifications of the Shellfish Commission. The eventual success of oystermen in gaining compensation for damage done to their crop was also aided by the efforts of conservationists.

The marsh was gone and the legal precedent made. The only constructive step the Connecticut Conservationists could then take was to sponsor legislation which would provide some sort of effective control over gravel-dredging, marsh-destroying projects which were bound to come thick and fast in the future. From this effort came Public Act 554, which gave authority to grant or deny dredging applications to our newly formed Water Resources Commission. The bill provided for public hearings on all applications and stated that the protection of wildlife habitat,

the prevention of shore erosion, and the improvement of navigation were the primary purposes of the law. It allowed the commission to base their decisions upon true and long-range resource values.

In the fall of 1957 this new law met its first real test. A brief history of this second case illustrates a different cause which brings about marsh destruction. A New York sand and gravel company, joined by private owners of a marsh between Westport and Norwalk, applied for permission to undertake a colossal dredging operation which would have created a huge channel a mile and a half long, three hundred feet wide, and thirty feet deep. This channel was to lead to an eighty-acre salt marsh which was to be completely excavated. This commercial gravel project was thinly disguised as being for the "improvement of navigation." It would have produced a large, but very private, yacht basin. It was typical of just the sort of destructive gravel-mining operation conservationists were trying to prevent. The huge channel—large enough for an aircraft carrier—would have cut through rich oyster beds, extensive public clam flats, fishing waters, and valuable feeding grounds for wintering water birds. It would undoubtedly have caused extensive shore erosion, subjected residential shoreline to storm damage, and so on. It would have eliminated the last salt marsh of significant size, now that the Sherwood Island marsh was gone, between the Housatonic River and New York. It would also have firmly established gravel-mining off Connecticut's coast. After a public hearing, the Water Resources Commission denied the application. The gravel interests promptly appealed the decision to the courts. Connecticut Conservationists found itself in a legal battle again, this time on the side of the State. The Superior Court denied the appeal and supported the findings of the Water Resources Commission. The gravel people then took the case to the Supreme Court of Errors which upheld the decision of the Superior Court. The matter was over for the moment.

In the meantime the 1959 session of the State Legislature convened and a new bill was introduced by the gravel interests. This bill stipulated that the granting of any application for channel dredging would be mandatory. If passed, it would have completely removed the power of the State to control its marine resources. This new emergency involved another statewide conservation alert, appearances at hearings, and so forth. Eventually the bill was reported unfavorably and another hurdle in this long fight was cleared.

However, even this was not the end. One of the marsh owners, who was already filling in parts of his property for building purposes, applied for permission to undertake a similar but smaller dredging project. Access to and from deep water would vastly increase the value of his property and he planned to sell a good deal of the gravel obtained from this channel. It seemed that the plan was now to be one of slow attrition. However, as

this article was being written, the Water Resources Commission denied this application by a large majority.

This second marsh and channel-dredging project has been quite different from the one at Sherwood Island. Although political influence and other shenanigans have entered into the matter, they have not done so effectively. Because of the new law and the fine caliber of the Water Resources Commission, opposition to this project could be made on a sound, scientific basis which emphasized the true worth to all the people of the State of the resources involved.

Despite the improvement in situation, it is still not ideal. Certain ambiguities exist in Public Act 554 due to the fact that its wording was an attempt to compromise between strictly commercial and conservation interests. Furthermore, confusion exists as to standards for evaluating the various conflicting interests involved in any such project. Certainly boating facilities, beaches, and housing are important resources. No constructive conservationist would deny that these should be developed. But what he will insist on is that they should be developed in such a way as to promote the best broad *long-range* public interest! When will the construction of a given boat basin, for instance, do more damage to other marine resources than it is worth? When will a housing development on a filled in marsh affect the recreation or livelihood of hundreds or thousands who look to the marsh as a resource? When will the expediency of the moment destroy food producing potential which will become increasingly valuable, perhaps vital, as our population expands far, far into the future? It is difficult to balance the "practical" values of everyday life against the equally practical but less obvious ecological and esthetic values.

These questions are endless and they can be solved only by study and research. Long-range studies must be made to determine just how much damage is done by such projects. Our entire coast should be surveyed to determine where natural coastal areas can be disturbed and where they must be preserved. It is only through an approach of this sort that the state government can intelligently use its powers to maintain its resources in a healthy and balanced condition. We are just beginning to handle our fresh water resources in this manner. But most of the complex, interrelated network of cause and effect which operates in the natural world is not as obvious as the need for good future supplies of clean fresh water; and there is no method at all by which to appraise esthetic values. Yet a widespread understanding and appreciation of both these aspects is vital to our future.

Several things are to be learned from these two cases which will help future conservation efforts. First, conservationists must always be extremely careful to make it perfectly clear that our principles, backed by scientific findings, *are for people* in the long run—something we some-

times neglect to do in the enthusiasm of the moment. Second, we must be constructive and positive—not merely preventionists. We must back every effort to conduct further research, both public and private, which will give us facts and add to the growing body of evidence that the values we are concerned with are as practical as the more commercial values—perhaps a good deal more so in the last analysis. We must do everything we can to disseminate this information far and wide and to make the relevant scientific concepts clear and simple. Third, conservationists must also "hold the line" by promoting the purchase, again both public and private, of marshes for the purpose of preserving them. The acreage of salt marsh that still remains to us is probably the very minimum that we require for the future. We must be forever on the alert, co-operate with each other, and organize to make our various efforts effective. No conservation battle is ever over.

Valuable Vistas

A Way to Protect Them

RICHARD H. POUGH, *President of the Natural Areas Council*[1]

North America is a continent of varied and unrivaled scenic beauty, as the perusal of even a few issues of a magazine like the *National Geographic* quickly demonstrates. Dramatic pictures of the West show towering mountains, gleaming blue lakes and vast deserts, while the East has the quiet beauty of winding rivers, coastal bays and rolling hills.

Today, as our power to alter the face of the land grows, we are faced with the problem of preserving this landscape. Can we grow and develop the cities, industry, roads and other necessities of a modern civilization without destroying our heritage? It is fragile, especially the quiet intimate beauty that is characteristic of the eastern scene.

The beauty of America is based on land forms and patterns created by geological forces acting slowly over periods of millions of years. We have now come into the possession of machinery capable of completely

[1] The Natural Areas Council, 33 Highbrook Ave., Pelham, New York.

"remaking" a landscape in a matter of hours or days. It is well recognized that all power necessitates the development of restraints, and it behooves us to develop them rapidly here in the East, if we are to preserve the beauty of our scenery. Without careful planning, we run the risk of converting vast areas into a monotonous urbanized sameness and of having incongruous structures blight every pleasant vista.

As much of the above is probably inevitable under modern conditions, we ought to compensate by at least preserving certain strategic spots. Scenery must be seen to be enjoyed, and the picture we carry in our minds of some beloved area is based on outlooks from which the eye can take in at a glance a sweeping view of the landscape. Vistas require a certain amount of openness in the foreground such as is created by a meadow, a marsh or a body of water. Especially important in this auto age are places where vistas open up from the side of a road.

It would seem that a major key to the preservation of the East's landscape beauty is the safeguarding of such vistas. That would mean leaving the borders of ponds and rivers free from human structures and their contours undisturbed. It would mean leaving marshes to the grass, the wildflowers and the birds that nature designed for such places, and not filling them with old auto bodies or waste dumps.

Nowhere is the problem more acute than along the deeply indented borders of our eastern coastline. Many of our most attractive coastal towns built in the pre-bulldozer age fringe coastal inlets and bays which provide the community with a setting of quiet beauty. Most of the buildings in such towns are set so as to face out over and take advantage of the vista such a body of water provides. The rise and fall of the tides and the changing color of the salt grasslands through the seasons give constant variations to such vistas and the eye never tires of them.

Are the citizens of these towns conscious of the important role such areas play in making them pleasant places in which to live? Alas, no. Everywhere we see dumping and filling creeping out from the shore over the marsh and into the shallow water, defiling the beauty of the natural shoreline. Where highways cross marshy arms of the bay and afford a sudden sweeping vista across the water, we find dumping going on, followed by buildings that hem in the road and cut off the view.

Most incredible of all, developers are being allowed to fill marshes with silt pumped from the bay bottom, destroying both as a habitat for the birds and marine life that do so much to make the coast enjoyable. Soon, low cost houses go up, crowded on lots as small as the developer can get approved, and another lovely old coastal town looks out on a squalid vista of modern housing at its worst—housing that may well be little better than a slum in a few years and a death trap to its inhabitants if a hurricane tide hits the area.

A beautiful tract of land that you have enjoyed and cherished, and that may have been in your family for generations, deserves a better fate than to be thrown on the market without any protection after you are gone. Your heirs may not be willing to make the sacrifices you have made to preserve its undisturbed natural beauty, or, even if they want to do so, inheritance taxes may make such action impossible.

Few land owners are aware of some of the ways in which they can stabilize the future use of their land. Some, of course, may be willing to give the land for a park, a scout reservation, a nature center or a wildlife preserve; but although every community needs such areas, it also needs tracts that remain in private ownership and continue to be used and enjoyed much as their present owners are using them.

The legal device known as an easement provides a method for doing just this. By means of it, you can deed to some non-profit civic organization dedicated to the preservation of the beauty of America and its wildlife the right to do all the things you wouldn't think of doing to the property and would like to prevent any subsequent owner from doing, whether they are a member of your family or not. Such an easement could transfer to the "watchdog" organization that you select such rights as to cut timber, construct roads, erect buildings, drain or fill marshes, change the contours of the land, etc. By deeding these rights or "attributes of ownership" to be held unused, your heirs and subsequent owners of the property would only retain the right to use the property in ways not inconsistent with its preservation as an attractive open area.

In several of the states where urbanization is proceeding rapidly, it has become a matter of public policy to encourage communities to use easements to preserve the natural beauty and openness of strategic tracts of land. In America, where we pride ourselves on not leaning on government for everything, it seems especially appropriate to try to accomplish as much of this job as possible through a collaboration between civic organizations and public-spirited land owners.

> *"To be whole and harmonious, man must also know the music of the beaches and the woods. He must find the thing of which he is an infinitesimal part and nurture it and love it, if he is to live."*
>
> JUSTICE WILLIAM O. DOUGLAS

The Future

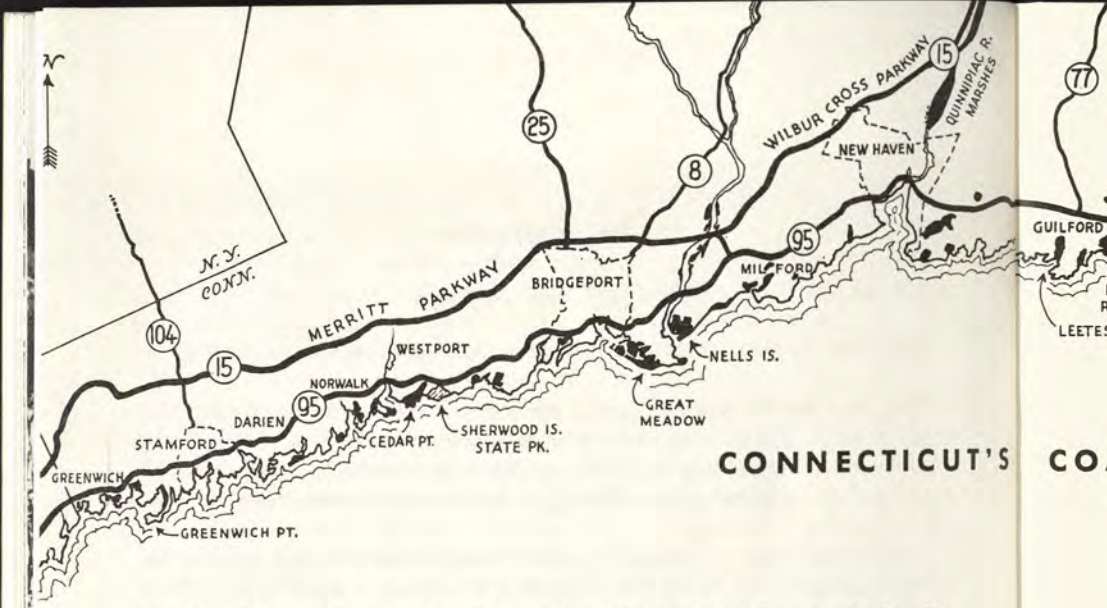
A Call for Action

RICHARD H. GOODWIN, *Professor of Botany, Connecticut College*

THE PRECEDING ARTICLES have set forth the case for preserving the tidal marshes. They are valuable to us as a source of food, as a stabilizing protection to our eroding shoreline, as open space enjoyed by millions of boating, fishing, hunting and birding enthusiasts and as an important part of our aesthetic heritage.

Before outlining a course of action, it might be revealing to describe what happened recently in the Village of Lawrence, a small Long Island community with a lovely outlook across the salt marshes to the sea. A large tract of marshland—approximately 1,000 acres with an assessed valuation of slightly over $100,000—for many years held by a well-to-do-family, finally came into the hands of a Philadelphia trust company and was put up for auction. A group of residents raised $115,000 to bid for the property so that it might be kept as open space. However, a developer purchased it for $265,000! The citizens were then faced with the prospect of seeing 2,000 houses constructed on this low land in the foreground of their view. This would have more than doubled the size of the village, with the consequent problems of sewers; roads, utilities and schools to be coped with. The Village voted almost unanimously to float a $100,000 bond issue and to appropriate enough additional funds from the Village treasury to make up the difference between the $115,000 originally raised and the purchase price. Although the developer brought suit in three different courts, the Village action was sustained. Here was a community that averted a catastrophe. But might they not have done so earlier by careful planning at a fraction of the cost?

Mamacoke Island might be cited as another example of successful conservation. This property, including its small salt marsh, was acquired by friends of the Connecticut Arboretum and given to Connecticut College with the stipulation that the land should forever remain "in its wild character with its natural features preserved" (1). A reverter clause in the deed provides for its transfer to the Connecticut Forest and Park Association or to the Nature Conservancy, in case the College fails to observe these restrictions. The property had not been acquired more than two years before the College was approached by a dredging firm that was bidding for a navy contract to deepen the Thames River channel. A price of three times the value of the entire Mamacoke Island purchase would have been paid for the privilege of using the salt marsh as a re-



pository for the hydraulic fill. Most fortunately this had been made legally impossible.

Within the last half century Connecticut's tidal marshes have been disappearing at an average rate of about one per cent per year, as shown by the figures on the back cover of this bulletin (2, 3, 4). This rate of attrition gives every indication of accelerating in the face of increasing population pressure. If this destruction continues we can look forward to their total loss early in the next century.

Once a piece of tidal marsh has been destroyed, it is gone, gone forever. It cannot be restored. An effective conservation program, therefore, can only hope to "hold the line"—that is to prevent or reduce further losses. What are the ways in which citizens can take action in protecting this valuable resource? In order to preserve our remaining 20 square miles of marshes it will be necessary to attack the problems on many fronts.

First, we must take immediate steps to get as much of the acreage as possible into the hands of suitable organizations and agencies. These include private conservation groups such as The Nature Conservancy, The National Audubon Society and Wildlife Preserves—organizations that have stability and a philosophy of nature preservation—and governmental agencies such as the State Board of Fisheries and Game, which presently owns the largest acreage of tidal marshes in Connecticut, and the Federal Fish and Wildlife Service—agencies that have a real stake in the integrity of the marshes.

Private land owners can be alerted to the problem and appealed to to co-operate in various ways in a conservation program. Some may be willing to give their marshes to organizations that will permanently protect them as preserves; some may be willing to sell at a reasonable price; and still others, to grant conservation easements (see Mr. Pough's article).

S COASTAL MARSHES

0 1 2 3 4 5
MILES

The State Board of Fisheries and Game has funds available for land purchase. Although some conservation-minded people may oppose hunting, in a state-wide program is it not better to preserve some of the marshes for this purpose than to lose them entirely?

At the present time there is no Federal Wildlife Refuge along the coast of Connecticut. Should not the possibility of a Connecticut refuge be actively explored?

Pending legislation in Connecticut to permit towns and the State to purchase lands or easement for the establishment of "green belts" should be expanded specifically to include coastal areas, and action along these lines should be supported.

Second, we must take vigorous action to protect acreage presently in public ownership. This includes state land now under the jurisdiction of the State Park and Forest Commission and lands to be acquired for park purposes. The threat here is so effectively illustrated by what happened at Sherwood Island State Park (see Mr. Darling's article) that it needs no further elaboration. Marshes adjacent to the beaches must be preserved. Parking areas must be located on the higher ground. We should remember that the marshes provide a year-round resource, while the beaches get maximum use only during the mid-summer months. The parks particularly in need of attention here are (1) Hammonasset State Park, (2) Rocky Neck State Park and (3) the Bluff Point area, which the State hopes to acquire. Pressure is also likely to be felt at Barn Island, one of the finest remaining marshes in Connecticut, presently under the jurisdiction of the State Board of Fisheries and Game.

Town-owned land must also be given attention. All too frequently dumps, sewage disposal works and other encroachments are permitted by selectmen who do not understand the vital importance of the tidal

marshes. A small dump may exert far-reaching effects upon adjacent marshland. Leaching pollutants, escaping fires and ever-present rats spread out from the dump and alter the vegetation and the fauna over a wide area. An alert group of citizens can do much to persuade those responsible for town property to preserve the wetlands.

Third, continuing action should be taken to control the dredging and filling of the marshes. The newly formed Water Resources Commission, if thoroughly back and politically protected by an aroused public can do much to prevent large-scale raids on our offshore (underwater) gravel deposits. The financial incentive to selfish interests, however, is so great, that it will be necessary to be continually alert. Broad moral and financial support of Connecticut Conservationists, Inc., will strengthen a state-wide organization that has already proved itself effective in this cause.[1]

The dredging of privately-owned marshes for small marinas will continue to be a most difficult problem, as the pressure for increased boating facilities continues to grow. The best solution to this encroachment has already been outlined—*viz.* the prior acquisition of these private wetlands by conservation agencies.

The most powerful public agency that is likely to make further inroads on the marshes is the State Highway Commission. The source of its power lies in the basic public support of better highway communication. The only answer to this threat is the awakening of responsible people to the enormous importance of our marshes as a vital natural resource.

Fourth, the tidal marshes should be zoned against real estate development. Entirely aside from the importance of preserving this habitat, it is in the public interest to keep housing and factories out of low-lying areas that are subject to periodic flooding by hurricane tides. This lack of planning creates hardships not only to those occupying these premises, but also to our society that has to provide relief of one sort or another to the destitute or displaced in time of disaster.

Fifth, education on a broad front is essential. Some of the actions already recommended must be promoted as a "crash" program, but this will only be achieved through hard work by dedicated people. Education of the general public is a long-range proposition. The man on the street must be persuaded by hard facts that the preservation of our tidal marshes is really for the people and not just "for the birds." This bulletin has been prepared for those who are willing to help promote this cause. The following sources of further information are recommended (5, 6, 7, 8, 9, 10).

[1] The President of Connecticut Conservationists, Inc. at the present time is Mr. Alexander Bergstrom, 37 Old Brook Road, West Hartford, Connecticut.

BIBLIOGRAPHY

1. The Mamacoke Island Deed. Conn. Arboretum Bull. No. 8:607. 1955.
2. First Annual Report of the New Jersey Mosquito Extermination Association. 1914.
3. Wetlands Inventory of Connecticut. U. S. Fish and Wildlife Service. 1954.
4. Wetlands Inventory of Connecticut, Revised June, 1959. U. S. Fish and Wildlife Service. 1959.
5. COTTAM, C., AND W. S. BOURN. Coastal marshes adversely affected by drainage and drought. 17th North American Wildlife Conf., Trans., pp. 414-421. 1952.
6. DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT. Why estuarine research, education and conservation. New Jersey Outdoors, August, 1959.
7. MCATEE, W. L. Wildlife of the Atlantic Coast salt marshes. U. S. D. A. Circ. No. 520, Washington, D. C. 1939.
8. NIERING, W. A. Nature in the Metropolis. Regional Plan Association (230 W. 41st St., New York 36, N. Y.), pp. 64. 1960. Price $3.00.
9. STATE OF NEW YORK. Act No. 3156: An act to amend the conservation law, in relation to authorizing the State to assist the towns and counties in the preservation, development and management of the Long Island wetlands. 1959.
10. STEARNS, L. A., D. MACCREARY, AND F. C. DAIGH. Effect of ditching for mosquito control on the muskrat population of a Delaware tidewater marsh. Univ. Del. Agr. Exp. Sta. Bull. No. 225:1-55. 1940.

Professional Opinions

From The State Board of Fisheries and Game

The consistent and accelerating destruction of tidal marshes and wetlands should be a grave concern to Connecticut people. The careless disregard for marshes culminating in the feeling that "the only good marsh is a reclaimed one" has resulted in severe depletion of this irreplaceable resource and now threatens the existence of a unique habitat.—James S. Bishop and Ruth Billard, Game Management Technicians, Connecticut State Board of Fisheries and Game.

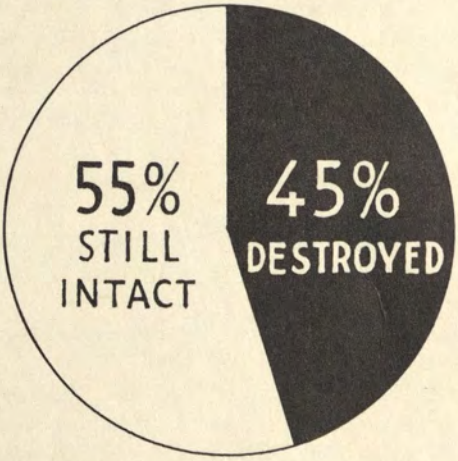
From The State Shellfish Commission

Dredging in Long Island Sound is still one of the major concerns facing this agency. Connecticut once had about 43 square miles of coastal marsh, of which all but 13 are now destroyed. Although every effort has been made by this Commission, other conservation agencies and local conservation groups to save the remnants by purchase and by moral persuasion, destruction still goes on. It is known, from studies made, that these marsh areas serve as nursery areas and sources of food for some species of fish and shellfish.—*Digest of Connecticut Administrative Reports to the Governor, 1957-1958.*

What is Happening to

CONNECTICUT'S TIDAL MARSHES?

36.5 Square Miles in 1914



IN

1959

BY

2000