Wetlands Preservation and Management on Chesapeake Bay: The Role of Science in Natural Resource Policy

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Abstract Wetlands preservation has recently become a favored cause of conservationists. Protection of wetlands is justified primarily on grounds of their beneficial biological and hydrological effects, so it is to the physical sciences that government and the public turn for the formulation of management policies. But scientific knowledge cannot be translated directly into good resource policy for society. Despite growing scientific sophistication, we are limited in our ability to understand and to predict the effects of man-induced change on natural systems, especially ones as complex as the Chesapeake Bay and its associated wetlands.

Moreover, an obsession with the exploration of physical processes obscures the more important task of understanding and controlling the social processes that lead man to alter nature. That is, natural resource management implies the management of social and economic, as well as natural, systems.

Within the last decade, wetlands preservation has become an environmental *cause celèbre.* Conservationists have persuaded legislatures in several states to pass laws to prevent or restrict the physical alteration of wetlands. In the Chesapeake Bay area, this important political hurdle has been overcome with the enactment of wetlands legislation in Maryland, Virginia, and Delaware.[1] These laws have significantly reduced the rate of wetlands destruction in those states.

The author wishes to thank Robert K. Davis, Garrett Power, Lee Walker, and M. Gordon Wolman for their comments on an earlier draft of this article.

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[1]Wetlands Act of 1970, #242, Section 15A of Article 15A and #241, Section 718 of Article 66c of the *Annotated Code of Maryland;* Wetlands Act of 1972, Title 62.1, Chapter 2.1 of the *Virginia Statutes;* The Coastal Zone Act, Act 175-1971, Chapter 70, Title 7 of the *Delaware Code.*

Coastal Zone Management Journal 1973, Volume 1, Number 1

What exactly is it that the public in these states is seeking to protect? "Wetlands" are a particularly ill-defined entity. The term is elastic enough to encompass everything from bogs to the Chesapeake Bay bottom, from permanently inundated lakes to occasionally inundated flood plains. Part of the confusion stems from the youthfulness of the word itself. "Wetlands" cannot be found in the 1948 list of words and phrases of Mencken's *American Language* (Mencken, 1965), although in excess of thirty meanings of the word "swamp" can be found there. On the other hand, different classifications and definitions also reflect different perceptions of what is important about the thing being categorized. For instance, completely different classification systems were used to inventory wetlands in Maryland and Virginia, as shown in Table 1. The Virginia system was created by researchers interested primarily in estuarine ecology, while the Maryland system is borrowed from the Department of the Interior's inventory of wetlands as waterfowl habitat. (Shaw & Fredine, 1956.)

The creation of the new category of "wetlands" in place of "swamps" is a response to a new perception of these environments and the need to bring them all under the aegis of a unified, non-pejorative term. The word "wetlands" is useful both for its positive symbolic value and its ability to be stretched to cover a broad range of environments which may have little in common naturally, but have one thing in common socially: various people would like to preserve them. In a sense, then, the political nature of the wetlands issue can be perceived in the word itself. It is to the political life of wetlands preservation and management that this paper is ultimately addressed.

Lack of definitional clarity about wetlands as natural systems parallels a general lack of clarity about the nature of wetlands as a political issue. Those people closest to the problem, usually natural scientists, seem to lack perspective outside their immediate time and field of inquiry.

The wetlands issue is, first, treated in isolation from other similar conservation issues, with little sense of history and hence little possibility of learning from the past. Wetlands protection has, for instance, many parallels with the Forest Conservation movement near the turn of the century: Forest conservation was sold politically mainly on the basis of contemporary scientific knowledge concerning the beneficial hydrological effects of forests and also on the belief that scientific timber management, so-called "sustained yield" forestry, was the rational way to use timber resources. (Hay, 1959; Schiff, 1962.) Similar arguments have been common among wetlands advocates, as we shall see. But much of past knowledge about forest hydrology and ecology, and about the economics of natural resource use has turned out to be in error. (Schiff, 1962; Raup, 1964.) Are we immune to such error today? More important, does the social worth, for this generation, of the forests preserved by our predecessors bear any necessary relation to the validity of their scientific justifications for preservation?

Second, wetlands conservation has been viewed principally as a technical and administrative problem of management in which scientific information about the natural systems plays the dominant role in public action. Thus far, the natural sciences have dominated the input into wetlands policy. The major portion of research effort has gone to scientific—especially ecological—studies in the belief that good scientific information about the biologic and physical processes affecting wetlands will foster good social policy. This belief must be questioned; the ability of science to ask the right questions and supply the right answers for social policy concerning natural systems is more limited than is commonly recognized. There has been little, if any, self criticism, however, by the scientific community as to the limits of science in generating valid public policy. This paper is an attempt to develop such a critique.

The first step of that critique entails a review of the state of current scientific knowledge about wetlands to determine if that knowledge is sufficient to justify the popular beliefs on which protective legislation has been based. Wetlands are routinely defended as essential primary food sources in estuarine ecosystems, as wildlife habitats, water purifiers, sediment traps, erosion protectors, and as storage basins for the absorption of flood waters and the replenishment of ground water.[2] Most wetlands protection literature, as well as the Maryland and Virginia wetlands acts, mentions some if not all of the above ways in which wetlands serve man and biota. Conservationists, the general public, and their representatives, have been led to believe that these arguments are based on established "facts"; when, indeed, as Marcellus and Bender observe:

> . . . marshes are the least understood of all aquatic and semi-aquatic resources and most statements made in defense of these environments are more frequently based upon theoretical considerations than on scientific facts. (Proposals, 1972, p. 6.)

It is necessary to make some judgment as to both the *qualitative* and *quantitative* accuracy with which science can describe the physical processes relating to wetlands, and, more important, the accuracy with which science can *predict* the effects of physical and chemical alteration of wetlands.

The second step of the critique is an effort to go beyond questions of the internal validity of science to discuss the relationship of scientific information to the emergence of wise public policy and natural resource management. Science

[2]It is ironic that wetlands have traditionally been drained for many of the same reasons they are now being preserved: public health, flood control, aesthetics, and productivity (agricultural), for instance. Is this so much a product of changing knowledge as it is of changing values?

has a rather different role to play in policy-making than that which the prevailing myth of technical management would have one believe.

The Scientific Defense of Wetlands

The following discussion is restricted to coastal wetlands in general, especially tidal marshes, because coastal marshes have attracted most attention among ecologists in recent years and are also the dominant type of wetland in the Chesapeake Bay area.

Productivity

Recent biological studies of estuaries and associated wetlands have led to a widespread belief that coastal wetlands are not worthless wastelands, as has long

Table 1
Maryland and Virginia Wetlands inventories
(in acres)

Virginia (tidal wetlands only)	*Total*	*Chesapeake Bay*	*Atlantic Coast*
Temporary lakes	763	0	763
Wooded marsh	60,128	38,058	22,070
Marsh	177,073	97,893	79,180
Open creeks	60,918	55,623	5,295
Woodland	2,628	2,500	128
Tidal flats	79,417	12,857	66,560
Sand	7,637	1,838	5,799
Ponds	4,595	4,187	408
Dredged areas	103	103	0
Total	393,262	213,059	180,203
Maryland			
Seasonally flooded basin	10	9	1
Inland fresh meadow	177	177	0
Inland shallow fresh marsh	268	268	0
Inland open fresh water	4,039	3,932	107
Shrub swamp	5,990	4,818	1,172
Wooded swamp	68,182	56,539	11,643
Bogs	791	791	0
Coastal shallow fresh marsh	69,774	68,597	1,177
Coastal deep fresh marsh	169	169	0
Coastal open fresh water	924	924	0
Coastal salt meadow	77,892	77,207	685
Irregularly flooded salt marsh	66,621	66,621	0
Regularly flooded salt marsh	12,581	267	12,314
Total	307,418*	280,319	27,099

Source: Wass and Wright, 1969, p. 10 and Maryland, 1970, Table VII-3.
*This does not include the more than 1,110,000 acres of bay bottom officially classified as wetlands in the State of Maryland.

been thought, but are instead significant sources of food and habitat for species of finfish, shellfish, waterfowl, and fur-bearing mammals of value to man. Chesapeake Bay is endowed with a plethora of coastal wetlands, roughly 490,000 acres within the influence of the tide (Table 1). Productivity of the Bay Fisheries is common knowledge; the Chesapeake has been described as probably the most valuable large estuary in the world. (Flemer, 1970, p. 117.)[3]

In the popular literature on wetlands, one finds repeated reference to marsh productivity and the fact that net primary productivity (net plant growth) of salt marshes, especially the cordgrass, *Spartina alternaflora,* exceeds that of all but the most intensely cultivated agriculture.[4] The transfer of this high primary productivity into fisheries output cannot be taken for granted, however; it represents potential only. The interesting question concerns the fate of this plant material in the estuarine ecosystem.

Marsh detritus is one of five major primary food sources for estuarine organisms: the others are phytoplankton, benthic (bottom) algae, submerged vegetation (seaweed) and detritus washed in from upland sources. The relative importance of these sources varies widely from estuary to estuary and should not be generalized. The popular view of the input value of marshes derives from studies in the warm, shallow, marshy embayments of Georgia, where, for instance, Teal (1962) estimated that *Spartina alternaflora* marshes contribute four-fifths of the primary production of the estuary, benthic algae one-fifth, and phytoplankton, upland drainage, and seaweed all negligible amounts. In a deeper estuary, Beaufort Bay, North Carolina, however, submerged grasses (eelgrass) and their algal epiphytes are the dominant production group, phytoplankton is second, and *Spartina* third. (Williams, 1972, p. 10.) In Chesapeake Bay, unlike either the North Carolina or Georgia study areas, upland drainage is extremely important and marshes are a relatively smaller part of the ecosystem. Keefe admits that: "The relative contribution of marsh detritus to freshwater ecosystems has not been determined, nor has the contribution of marsh detritus to a system like Chesapeake Bay been determined. . . . The population of consumers supported *to some extent* by detritus are large and would be reduced by almost half *in some estuaries* if there were no input of detritus from salt marsh production." (Keefe, 1972, p. 177, emphasis supplied.)

If the contribution of marsh detritus as a primary food source in coastal wetland areas varies with the location, the ability to predict the response of the

[3]Commercial fishing catches are impressive: in 1966 the Virginia take was 278,000,000 pounds, worth $21,000,000 (Wass and Wright, 1969, p. 33 & 79) and in 1967 the Maryland take was 73,412,000 pounds, worth $16,913,000 (Manning, 1968, p. 91). In addition, many species of importance to Atlantic coast fisheries and recreation fishermen spend some part of their lives in Chesapeake Bay (Wolman et al., 1972, p. 8).

[4]A figure of 10 tons per acre per year is often cited, based on Odum (1961)—cf Teal and Teal, 1969, p. 193.

estuarine system to marsh destruction is made more difficult. Consider the closely related instance of the elimination of another major marine plant community, eelgrass beds, which were decimated by disease in both Europe and America in the 1930's. Long before interest in salt marshes developed, eelgrass was considered an important primary producer in marine ecosystems.[5] But its disappearance had some surprising results for both the marine system and prevailing scientific theory. Gunnar Thorson, a Danish marine scientist, remarked:

> However devastating the epidemic was, it did help to change scientific opinion about conditions of production on the sea-bed. . . . There were still biologists who thought that the enormous amounts of dead and decomposing seaweed in shallow water areas must constitute by far the most important food source for bottom animals in coastal waters. Both Petersen and the Danish plant physiologist, P. Boysen Jensen, who collaborated to elucidate production conditions on the sea bed, were very enthusiastic about this line of thought, which according to the knowledge of the time seemed both justifiable and reasonable. But with the disappearance of eelgrass from large areas of our waters, biologists were presented with a completely unexpected demonstration on a really large scale. As mentioned, a number of small species directly connected with the eelgrass habitat suddenly became rather rare; but the animals living on the rest of the sea-bed did not appear to decrease either in numbers of species or in number of individuals. . . . Now it is nearly forty years since the large eelgrass meadows disappeared in the Kattegat, and there is still no indication that animal life on the bottom has been in any way affected. This, therefore, is proof that micro-algae either living or dead, must constitute the most important food on plants and detritus eaters living on the sea bed. (Thorson, 1971, p. 111, ~~emphasis supplied~~.)

Another unexpected result of the elimination of eelgrass occurred in the Niantic River, Connecticut. Following the disappearance of previously thick beds of eelgrass, scallops appeared in such numbers that a considerable commercial fishery developed for them. (Marshall, 1960.) Ironically, a well-known popular work on marshes erroneously attributes the richness of the Niantic scallop beds to the fertility of marshes, apparently in ignorance of the circumstances surrounding the creation of the scallop beds.[6] Marshall, on the other hand, theorizes that removal of eelgrass increased bottom currents which allowed more effective grazing of plankton in the tidal prism. (Marshall, 1960.) This suggests that the key factor in the production of a given species of interest

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[5] Wood, W. Odum and Zieman (1969) have recently "rediscovered" the important role of *Thallasia,* tropical equivalent of eelgrass, *Zostera,* and its detritus in tropical estuarine food chains.

[6] "Because of the high nutrient content of a tidal marsh, plants and animals are abundant, and some are of great value to man. At the mouth of the Niantic River in Connecticut, about 15,000 bushels of scallops are harvested each year." (Niering, 1966, p. 170.)

to man may not be the gross availability of food as measured by overall primary production. Food may be in surplus, while population growth is held in check by such factors as restricted habitat, predation, competitor species, light, or oxygen. This applies to producer as well as consumer organisms. Primary producers may themselves be in competition, and the reduction of one might allow an increase in another. For instance, at certain times of the year bacterial decomposition of *Spartina* debris can lower phytoplankton production because the bacteria can best algae in the competition for available nutrients. (Thayer, 1971, p. 251; Williams, 1972, p. 13.)

Destruction of a marsh affects food supply, habitat, and other environmental parameters that in turn affect estuarine organisms. Immediately dependent species may be destroyed, but the effect on finfish, shellfish and waterfowl of interest to man will be more difficult to determine because their dependency on the marsh is more indirect. In general not enough is known about life cycles, distribution, population dynamics, feeding habits, and so forth, to predict satisfactorily the ultimate significance of a particular marsh area to the overall population of a species. (Wolman et al, 1972, p. 7 and Proposals, 1972, p. 59.) Quantitative precision seems a distant hope indeed. Beyond the realm of generalization, then, there is a dearth of knowledge about the large-scale biological effects of wetlands destruction or alteration.

Waterfowl

Although waterfowl use of wetlands is direct and conspicuous, scientific knowledge about the relationship of waterfowl to wetlands in the Chesapeake Bay area suffers from much the same uncertainty as that of fish to wetlands. The Bay region attracts and supports prodigious quantities of animals, and is in fact one of the most important areas in North America for migrating and wintering waterfowl.[7] Wintering populations of migrating waterfowl have averaged more than one million birds in recent years, approximately 23 percent of the Atlantic flyway population. (Stewart, 1962.) Waterfowl are rather flexible in seeking out staging and feeding areas, and they can adapt more easily to change than other organisms. From her observations of the Hackensack Meadows in New Jersey, Geller notes that deteriorated water quality has caused the classic marsh grasses to be replaced by the tall reed *Phragmites,* often dismissed as a "useless" marsh plant, but the waterfowl have adapted to the change:

> If the *Spartina* cannot compete under unfavorable conditions, the wildlife will settle for the poorer Phragmites, even if some human beings do not. (Geller, 1972, p.11.)

On Virginia's eastern shore it was found, paradoxically, that spoil banks created by dredging—usually regarded as noxious eyesores—made excellent her-

[7] Actually seaside marshes, rather than bay marshes, support the largest populations.

onries, and were used by several species that had not been known to breed on the eastern shore previously. (Wass and Wright, 1969, p. 50.) This should cast doubt on the proposition that the best natural resource policy calls for preserving the status quo.

A great percentage of wetlands in the Chesapeake Bay area and the Mid-Atlantic region generally is not heavily utilized by migrating birds.[8] Government management programs in the wildlife refuges of Maryland, which include paying farmers on refuge land to leave unharvested corn for the birds to feed on, has been so effective in attracting geese that Maryland now attracts much of the large wintering population which once stopped further down the flyway in North Carolina.[9]

In other parts of the country, waterfowl management has often been successful in recreating wetland habitat from dry lake beds by diking and pumping, by building farm ponds, and even by damming up creeks in the process of highway construction. (Niering, 1966.) Major vegetative changes can be induced rather quickly by these methods whether they are for wildlife or domestic animals. (Shiflet, 1963.) It appears, then, that certain kinds of waterfowl habitat destruction can be compensated by good management, at least in non-breeding areas. What cannot be recreated, of course, is the quasi-wilderness value of wetlands and waterfowl that have not been tampered with by man; in this respect, preservation and management are not coincident goals. In preservation causes, science has no necessary place at all.[10]

Water Quality

Wetlands are also said to improve water quality by removing excess nutrients[11] from, and reoxygenating, polluted water. In what seems to be the first empirical study of a tidal marsh's impact on water quality, Grant and Patrick (1970) conclude that the heavily-polluted Tinicum Marsh in Philadelphia reduced nutrient levels and raised the oxygen content of water passing over it in a single tidal period. With the current political interest in pollution control, this finding raises a forceful argument for wetlands protection in the public mind. Nonetheless, it also raises technical questions which are glossed over in the popularization of the Tinicum study. (cf. Niering, 1972, p. 34.)

First, there is difficulty in measuring net transport of material, given the complexity of marsh hydrology, with reversing currents and overlapping drain-

[8]Personal communication with Dr. Loren Jensen, Professor of Aquatic Biology, Department of Geography and Environmental Engineering, Johns Hopkins University.

[9]Personal communication with personnel of Blackwater National Wildlife Refuge, Maryland.

[10]This point is developed further under "Beyond Science," below.

[11]Usually refers to organic phosphorus and nitrogen.

age areas.[12] Measurements should be regarded as tentative at best. Nor does the Tinicum study attempt to measure or relate the significance of the improvement in that water which passes over the marsh with each tide to the overall quality of the creek on which the marsh borders, or, more difficult yet, to the estuary into which the creek empties. We have no way of knowing if the change in quality of the receiving body of water is perceptible. Again, this requires the ability to relate change in one area to the whole system; and one can only hazard a guess as to the net effect of the elimination of marshes on water quality of estuaries as large as Delaware or Chesapeake Bays.

Oxygen production and nutrient absorption are part of the processes of plant photosynthesis and growth, so there is much the same problem here of sorting out the influence of any single plant group that was found in regard to primary productivity: marsh grass, benthic algae, planktonic algae, seaweed, and even nitrogen and sulphur reducing bacteria in bottom mud[13] compete for nutrients and light and produce oxygen. For instance, the "degraded" Tinicum marsh was discovered to increase the oxygen levels of tidal waters eight times as much as an unpolluted marsh elsewhere on Delaware Bay. (Grant and Patrick, 1970.) This paradoxical result was owing to the increased algal photosynthesis in Tinicum Marsh because pollution levels there had reduced the density of marsh vegetation, allowing more light to filter through to the benthic algae.

Nutrient cycling is far from being completely understood; physical as well as biologic processes intervene. Pomeroy and his co-workers have concluded that, contrary to most previous opinion, biologically controlled exchange of phosphorus in salt water estuaries is trivial compared with direct chemical exchange with bottom sediments that "are a kind of reversible sink which will not be cleared of pollutants for a long time." (Pomeroy et al., 1966, p. 183.) The release of phosphate from sediments can support a phytoplankton bloom even though water concentrations of phosphorus are insufficient to do so. (Pomeroy et al., 1965, p. 172.) Hence, it seems that nitrogen, not phosphorus, is the limiting nutrient in salt water, while in fresh water just the opposite is the case. In the Potomac, for example, inorganic nitrogen is abundant in the fresh water sections below Washington during the summer when algal blooms occur, but it largely disappears in the lower, salty portions of the river. (Williams, 1972, p. 11.) Where does the nitrogen go and what is its impact on plant growth and eutrophication? Nitrogen is not stored easily in the estuarine system and is

[12]"Since it is the difference between flood and ebb transports in and out of the marsh that interest us, we find that if we lack knowledge of the confidence interval about the magnitude of that difference, we may well be uncertain as to its *direction.*" (Letter from John D. Boon III, Virginia Institute of Marine Science, dated January 19, 1973.)

[13]A point emphasized by Edward S. Deevey, cited in Niering, 1972, p. 34.

readily lost to the air or bacteria.[14] These may be the real buffers to nitrogen concentrations in the water, rather than green plants, including marsh vegetation, as the Tinicum study implies.

Nor does the simple concentration of nitrogen in the water regulate growth; as Williams observes:

> The data further suggest that light, grazing, tidal flushing, or some environmental factor other than nutrient concentration normally must limit the growth and production of estuarine phytoplankton. (Williams, 1972, p. 16.)

The relationship between pollution and biotic activity in estuaries is only loosely comprehended and the dangers are overstated. Phytoplankton blooms and resulting fish kills are a natural summer occurrence on Chesapeake Bay. Pollution may even, within limits, be equivalent to fertilization. While over-fertilization is a potential danger if other conditions are right for algal growth, the necessary conditions are hard to specify. Even so, blooms are not a fatal sign for an ecosystem. There are, of course, many clear situations of eutrophication and stagnation of coastal embayments, but in such cases marshes can themselves be overloaded. As at Tinicum, the buffering capacity of the marsh may increase as it degrades, but there is a trade-off between the biological quality of the water and esthetic quality of the marsh. As was noted in reference to waterfowl management, values of wetlands commonly arrayed together for purposes of argument may in fact turn out to be in conflict.

Hydrology

The control of erosion, sedimentation and flooding, and groundwater replenishment are commonly ascribed values of wetlands. The question is thus raised whether wetlands are really an active element affecting physical processes or merely a passive product of the forces around them. We need to ask two things. Why are wetlands where they are (what geographical characteristics of the land are associated with wetlands? And, once in place, do wetlands *biota* independently influence physical processes?

The latter question raises the traditional issue of the importance of vegetation in altering the movement of water over (or against) land. Hence, this aspect of the wetlands preservation discussion can be seen as a continuation of the classic debate–long central to forest and soil conservation–between those who feel that vegetation is critical in slowing down water and lessening its damaging erosional effects, and those who believe that vegetation is limited in what it can do to restrain major hydrologic processes.[15]

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[14]Personal communication with Richard Williams, Smithsonian Institution, Washington, June 18, 1973.

[15]Inherent also in this debate is the problem of whether normal flows of water or

Wetlands act in two ways to decrease flooding: up-river swamps act as reservoirs for excess water; and flood plain marshes allow the diffusion and storage of river waters over a wider area. In the first case, wetlands occupy natural depressions that act as catchment basins; vegetation plays no special role, since the same object could be achieved by an openwater reservoir in the same place. Of course, if the wetlands are filled, drained, and diked, or the stream channelized, the reservoir effect is lost.

Low-lying wetlands on the flood plain of a river also have a storage effect through the dispersal of flood waters. They thereby delay and lessen the flood peak downstream and lower the energy of the water (receiving deposits of suspended sediment as a result). The relative importance of physical obstruction by vegetation *vis à vis* the topography of the flood plain in dispersing and retarding flood waters is moot. If wetlands on the flood plain are drained or cleared, but the land is not otherwise altered, the change in flood patterns is likely to be slight. If, on the other hand, wetlands are filled or diked and the river cannot spread out, the full load of water will continue down-river and flooding may be made worse somewhere further on, perhaps covering land more poorly suited to being flooded than the original wetlands, such as a city.

Occasionally wetlands are said to be important in replenishing groundwater. (cf. Neiring, 1972.) Again this is directly related to the holding effect of low-lying areas where wetlands are found, and not to the presence of the biotic community. It is obvious, however, that where wetlands are drained, the reservoir effect no longer exists, and this may indeed have an adverse effect on groundwater, depending on the particular geologic circumstances. (Perekhrest, 1971.) The important point in both instances–flooding and groundwater–is that wetlands exist because of frequent inundation of the land and are therefore better suited to that environment than many human activities which are established in their place without thought for the long-term consequences. The best guide for public policy is not the preservation of wetlands per se–because the influence of wetlands *qua* plant community or hydrologic phenomena may only be modest–but rather the evaluation of the consequences of replacing a natural system of wetlands with human contrivances such as land fill or dredged channels.

Erosion and Sedimentation

Erosion and sedimentation (deposition) are two aspects of one related system–the removal, transport, and deposit of soil particles by moving water. Wetlands influence this process through physical obstruction by emergent vegetation and a broad expanse of shallow foreshore. The combination of these

"catastrophic" events are the critical variables in determining the shape of the land and the vegetation.

factors serves to reduce wave or current movement and thereby reduces the energy available to remove and carry away suspended particles. This has two effects. First, the marsh buffers the fast land behind it from the full force of waves or current. Second, sand and silt settle out, adding to the marsh's accumulation of plant litter.

The word "buffer" as opposed to "protect" is particularly apt in this context, because there are definite limits to what marshes can do to control erosion. A major storm can produce waves large enough to pass unimpeded over the marsh. A shift in local currents may soon eliminate the marsh. Nonetheless, some people harbor the naive notion that "marshes are nature's way of stabilizing soil banks and protecting the high land." (Wass and Wright, p. 69.) But it is just as much "nature's way" to destroy those same structures. The real issue in this area is: to what extent is the wetland a creature of hydrologic forces, and to what extent is it self-sustaining; that is, within what limits can a marsh buffer those forces, and thereby control erosion, sedimentation, or flooding over a wider range of stress than bare shore?

The shoreline of rivers and bays varies from areas subject to strong erosion to areas of heavy deposition. Within a middle range of the spectrum the wetland *qua* biotic community may be significant in affecting the shape of the shore. For instance, the outside of a river bend generally erodes rapidly while the inside of the same bend receives deposits of sediment. A wetland will probably spring up on the new sediment; even if dredged away, the chances are that a new marsh will reappear in its place. No marsh is likely to appear on the outside bend. "[The] establishment of marsh plants occurs when gentle slopes inundated with each tidal cycle are retained. If gentle slopes disappear, the resulting clear-cut rises in elevation inhibit the natural open water progressive succession of salt marsh communities." (Kerwin and Pedigo, 1971, p. 129.)

In a less polar case, however, the growth of a wetland can change an area from one of light deposition, or even erosion, to one of greater deposition. A good example is the shifting tidal flats that appear in most shallow coastal bays. Left to themselves, these flats may never grow much above mean low water, and may shift about endlessly; but once *Spartina* grass is established, sedimentation increases rapidly and the mat of plants holds the mud together. (Redfield, 1972.) The marsh will then resist erosion and grow unless drastic changes take place that expose the spot to more severe erosion.[16]

In a larger perspective, however, the location of wetlands around Chesapeake Bay is largely determined by the geology of the Bay. The low relief of the eastern shore is ideal for supporting expanses of marshland. Much of the western shore in

[16]Wass and Wright (p. 72) cite the case of Virginia's eastern shore seaside where *Spartina* has been unable to colonize mudflats shifting rapidly due to the death of eelgrass in the area.

Table 2
Sources of wetlands lost in Maryland since 1942

Source	*Percentage*
Agricultural drainage	52.8
Housing development	13.5
Industry	6.7
Dredging and spoil disposal	5.3
Erosion	5.1
Marinas	4.8
Natural succession (*sic*)	4.5
Public works	4.2
Other	3.1
Total	100.0

Source: Maryland, 1970, Table X-1

Maryland, however, drops off abruptly and marsh is confined to protected coves and tributary streams. The Bay is still young[17] and is actively changing its shoreline, especially that which borders the main stem on both the east and west side. These areas are exposed to strong currents and wave action, and often show dramatic rates of erosion. Oft-cited cases include the rapid shrinkage of Poplar and Coaches Islands (529 acres since 1847) and the complete disappearance of Sharp's Island (438 acres in 1848). (Wolman, 1968, p. 31.) Ironically, the fastest rate of erosion on the Bay occurs in Dorchester County, which also has the most wetlands. (Wolman, 1968, p. 30.)

In places subject to this kind of dynamic change, marshes are the creatures of physical forces. It is not surprising, then, that the Maryland wetlands survey shows that 5.1 per cent of wetland losses (1942-68) were due to erosion and 4.5 per cent were due to marshes becoming dry land. (Maryland, 1970, Table X-1.)

Nevertheless, the greatest amount of change in the wetlands and shoreline of the Bay in the last two decades has been the work of man. (Maryland, 1970, Table X-1; see also Table 2.) Much of this development has been ill-advised because it ignored the dynamics of the Bay. Marshes may not prevent severe erosion, but in areas of marginal erosion, established wetlands do buffer the shore, and filling or dredging of those wetlands often creates a problem of erosion or sedimentation where none existed before. These problems are often not easily corrected. When one landowner tampers with the shore, it may induce shifts in the erosional and depositional character of riverine or littoral currents that create problems for other landowners or shipping channels. (Wolman, 1968,

[17]The Chesapeake is the drowned valley of the ice-age Susquehanna River, which was formed 10,000 years ago when ocean levels were 150-200 feet lower than now. (Wolman, 1968, p. 17.)

p. 33.) Our ability to predict such effects is limited. In fact, it is this very *lack* of predictive capability that makes man-made changes hazardous.

These kinds of "spillover" effects of one landowner's actions on another's land (or water) are so common that shoreline management as a unit, wetlands included, is essential for the avoidance of waste, counterproductive measures, and lawsuits. Even if wetlands are not "nature's way" of solving shoreline problems, the fact remains that it is almost impossible to fill a wetland without creating a new problem, usually for someone else. This is one of the best arguments for conservative wetlands management.

Irreversibility of Wetlands Alteration

In order to acquire a reasonable perspective on the reversibility of wetlands destruction, one must surmount certain intellectual predilections about "natural" ecosystems and their relation to man. One of the most important of these is the concept of pristine nature defined in terms of harmony, equilibrium, or natural stability. A good illustration of the problem is the following definition of coastal wetlands:

> A complete and concise definition of a coastal wetland, is, therefore, all the area between mean higher high water and mean lower low water and those contiguous areas (highland as well as subaqueous) deemed necessary to the *stability* of the wetland community. (Wass and Wright, 1969, p. 5, emphasis added.)

Unfortunately, in addition to being circular, this definition has no "complete and concise" meaning. Stability is often in the eyes of the beholder and can depend on the slice of time, space, or nature for which it is defined.[18] Ecological thinking has been long in the grip of the "stable climax" theory of vegetation propounded by Clement in the 1920's. Hugh Raup, former Director of the Harvard Forest, has put the matter well:

> Ecological and conservation thought at the turn of the century was nearly all in what might be called closed systems of one kind or another. . . . I believe there is evidence in all of these fields (ecology, geology, soil science) that the systems are open, not closed, and probably there is no consistent trend towards balance. Rather, in the present state of our knowledge and ability to rationalize, we should think in terms of massive uncertainty, flexibility and adjustability. . . . (Raup, 1964, p. 26)

For several reasons, stability is an inappropriate concept for understanding and managing coastal wetlands. First, the marsh environment is characterized by

[18]For example, a herd of lemmings with a suicidal bent certainly appear to be unstable in the short run, but over time there is enough method to their madness to ensure that the species survives. Isn't that stability? On the other hand, a river bottom forest may seem quite unchanged for a century or more, only to be destroyed by a 500-year flood. Do we define the forest ecosystem and its stability inclusive or exclusive of the catastrophic event?

great variability, to which only a few species have adapted successfully. Individual plants must be tolerant of great environmental stress in the form of tidal inundation, salinity changes, and wide temperature fluctuations; these are all conditions over which the marsh community as a whole has little stabilizing or buffering effect. But it is this same lack of stable environmental conditions and resultant *lack* of species diversity that makes for the unique productivity of marsh plants. Adaptation to an unstable environment has given wetlands a tremendous potential for recovery from environmental abuse, both natural and man-made.[19]

Second, marsh vegetation, especially *Spartina alternaflora,* colonizes new areas very rapidly. Intertidal flats in Massachusetts have been observed to develop a covering of *Spartina* and sediment a foot deep in six years. (Redfield, 1972, p. 235.) Dr. Edgar Garbisch[20] has reportedly succeeded in establishing new tidal marsh in Maryland in less than a year.[21]

Third, the existing complement of wetlands in Chesapeake Bay is not entirely a gift of nature. Extensive clearing for agriculture in colonial times, particularly tobacco farming, led to erosion in the Piedmont that resulted in an enormous deposition of sediments below the fall line on all western shore rivers. (Gottschalk, 1945.) Up to several miles of new delta land and marsh now occupy stream beds where sea-going vessels once put into port. Joppa Town, Port Tobacco, Bladensburg, Georgetown, and Dumphries are all examples of 18th century ports now well inland. Thus, new areas of wetlands have been formed by the activities of man.

Lastly, the Bay system, as noted previously, is extremely young in geologic terms, and is itself in active transition; its wetlands are thus a part of a dynamic system, even on the scale of human time. Sea level has been rising since the end of the Pleistocene (10,000 years ago) and is currently estimated to be moving upward at the rate of 1.5 feet per century in the Chesapeake area. (Wolman, 1968, p. 17.) Some marshes are slowly being drowned by the rising sea, while others outgrow it. New marshes are being created from fast land or on sedimen-

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[19]Personal communication with Professor Loren Jensen.

[20]Center for Applied Research in Environmental Sciences, St. Michaels, Maryland.

[21]However, high marsh in New England may take as much as a thousand years to become fully developed, because the once-glaciated coast has steep slopes, little available sediment, and high tides. (Redfield, 1972, p. 235.) In these circumstances, marsh destruction may be effectively irreversible and a more serious matter than on the unglaciated southeastern coast, where the availability of sediment, low relief, and small tides have combined to create several million acres of marsh, predominantly intertidal *S. alternaflora.* High marsh of *S. patens* is more characteristic of the northeast, and the acreage numbers only in the thousands. (Teal and Teal, 1969.) In this context, it should be noted that thousands of acres of previously unvegetated coast in England and France have been colonized by *Spartina Townsendii,* a hybrid discovered in 1870 which was probably a chance off-shoot of human commerce. (Keefe, 1972, p. 169.)

tary deposits, while others disappear because of erosion. Similarly, the system of barrier beaches stretching from New Jersey to Florida, in whose shelter coastal marshes thrive, is a dynamic system that can be drastically altered overnight by a serious storm, destroying old marshes and creating new ones. (Teal and Teal, 1969, p. 83.)

In view of the inconstancy of nature in coastal wetlands and significant previous human impact on them, the issue of wetlands destruction cannot be understood simply in terms of change brought about by man—because change is an integral part of the nature of coastal wetlands. And although man seems to be destroying wetlands at a faster rate than they are developing at the present,[22] it will not suffice to extrapolate from this limited post-war experience of limited areas of intensive development to predict the future of wetlands in so large an area as Chesapeake Bay.

Conclusion

Thus far I have shown that the scientific justifications for coastal wetlands preservation are not quite as clear cut as they appear at first blush. The primary productivity of marshes is evident, but little can be said about the dependence of important species on marshes, nor the response of the estuarine ecosystem to marsh destruction. Similarly, water quality seems to be improved by wetlands, but the dynamics of nutrient cycling is too poorly understood to predict the impact of wetlands on overall estuarine water quality. The erosion, sediment, and flood control capacities of wetlands may only be modest, and are rather unpredictable. Finally, coastal wetlands are a part of a dynamic system in which some change is neither extraordinary nor necessarily irreversible.

Although I have emphasized the negative so far in order to make a point, I am not interested in proving that the wetlands advocates and scientists are wrong—in fact, I rather hope that they are right. But they *may* be wrong, and that possibility makes wetlands conservation interesting as a political issue, not simply as a technical problem outside the ken of the general public.

Whether the issue is forests or wetlands, there are several factors at work in the translation of scientific information into natural resource policy that insures that the supposed impartial, factual scientific basis of public action is less solid than prevailing public opinion would have it.

First, the best contemporary scientific understanding of natural phenomena may turn out, in the light of later research, to have been in error. Scientific knowledge does not proceed in a smooth progression from ignorance to fact; it advances by lurching from one theoretical framework to another. Entire struc-

22The Maryland survey shows that 23,771 acres (7.2 per cent) of the inventoried acreage have been lost since 1942. (Maryland, 1970, p. VII-1.) (See Table 2.) It is noteworthy that over half of the total wetlands loss is in the category of wooded swamps, which have been extensively drained for agriculture on the eastern shore.

tures of explanation, based on many years of research, must often be discarded as a result of a major paradigm shift. (Kuhn, 1962.) As a result, public policy concerning natural resources is at any one time necessarily made on the basis of partial scientific evidence and prevailing scientific opinion whose validity may not stand up over time. For example, many of the problems of forest hydrology are still unresolved by science, a century after George Perkins Marsh (1864) first tried to document the relationship between forests and floods, groundwater, and climate. (Hewlett & Helvey, 1970)

Second, whenever its subject matter is a topic of political debate, science becomes politicized to some extent: this despite the myth that science is apolitical. Ashley Schiff (1962) has carefully documented this process in the history of forest conservation, and there is no reason to believe that science had grown more immune to politics when wetlands became a public issue. The mixing of political values and scientific data may come about within the discipline where the process may be one of individual ideology, organizational involvement, or selective funding. It may be as subtle as the researcher seeing what he is looking for, or as blatant as the institutional suppression of dissent, as in the case of the Forest Service (Schiff, 1962, p. 168.) Or the mixing may come about in the transition of science into public information. Most of the layman's scientific knowledge comes by way of secondary sources such as magazines and newspapers. While the true measure of a scientific theory may not be in its vulgarization, the *political* measure of a theory certainly is. The popularizers play a necessary role of translation and dissemination of information, but it is not an impartial one. Some are consciously political, while others are simply believers in scientific pronouncements. I am always bemused by the uncritical recycling of certain "facts" over and over in the wetlands popular literature. Such is the process by which a received doctrine is generated and politically the result can be potent.

An intriguing intermediate case is offered by the scientist who enters into public controversy himself. While his perceptions within the discipline may be beyond reproach, he often fails to realize the way in which scientific perceptions color his perspective toward issues outside his discipline. This is especially prevalent among ecologists, who come to regard ecological significance as being equivalent to social value. That may be a reasonable philosophical position, but not a self-evident truth. Nonetheless, one repeatedly witnesses the intellectual jump, either implicit or explicit, where an idea such as the productivity of marshes becomes synonomous with the value of marshes. While one may disagree with the way in which value is commonly determined under the economic arrangements of the capitalist market system, exchange value is currently the final measure of social worth, and the translation of detritus into dollars is a long and uncertain process.

Third, and at a different level, even if scientific data about natural resources is universally considered "true" or socially useful in some sense—and surely ignorance is not bliss—the implementation of scientific or technical management of those resources is itself a political position, because it means that social control of natural resource allocation passes into the hands of a limited number of persons, a scientific elite, who are capable of dealing with scientific data. Although Americans have come to regard this delegation of power to technocrats as an inevitable and natural consequence of modern society—usually carried out in the name of taking the politics out of government—in fact it has far reaching political implications.[23] Society may have to pay the cost of a certain amount of errors stemming from technical ignorance if that is the price of operational democracy. One might well argue that in a democracy the necessary role of science is in the formulation of political positions on major issues, not in the provision of technical solutions to those issues. Indeed, this is very much the role played by science in conservation issues, past and present.

Beyond Science: Economics and Politics in Wetland Policy

Conservation has never been a unified movement. It has embraced two distinct ideals. The first is preservation for its own sake: the inspiration provided by nature free of man's influence. The second is rational, scientific management of something called "natural resources" in order to assure continuing economic prosperity—what Samuel Hays has called "the gospel of efficiency." (Hays, 1959.) Both ideologies exist among advocates of wetlands protection today but scientific management has been the dominant ethos of conservation since Theodore Roosevelt's administration, especially among those with technical expertise who are eager to apply their methodological tools. This is nowhere more pronounced than with wetlands, whether it is Eugene Odum's "Zoning According to Ecosystem Principles" (Odum, 1966) or Walter Isard's "Ecologic Economic Systems" approach to development planning. (Isard et al., 1972.)

Let us first consider wetlands management and policy as a technical issue only. The basic flaw of scientific management is that it is founded on an understanding of the natural system and not the human system. Therefore, attention is focused on the internal relations of nature, e.g., the ecology of the system, while man's impact is regarded as an event outside the system. But by ignoring the character of human institutions and activities that impact nature and by concentrating only on controlling the physical results of that impact, one is dealing only with half the problem and cannot hope to formulate successful resource policy.

At one level, nature is used by man to produce input for the economic

[23]Samuel Hays has done the important job of alerting us to this fact in his brilliant reassessment of the first conservation movement. (Hays, 1959.)

system, that is, as a "natural resource." At this level, management requires that the natural resource be related to its use by the economy, because the economic system, not the physical system, is controlling. An ill-managed market can undo all the benefits of a scientifically well-managed resource. A good example of this dilemma is the Pacific Salmon Fishery, where the depletion of the resource is not due to problems of the fish, but with imperfections of the market. The efforts of the biologists to maintain a maximum sustained physical yield—that epitome of scientific management—has had little effect on the net economic yield from the fishery. The economic problem of open access to a common property resource has resulted in depletion of the fish stock and stagnation of the industry, and has insured "the essential futility of efforts to achieve an optimal fishery through control programs defined only in physical terms". (Crutchfield and Pontocorvo, 1969, p. 200.)

In a different type of natural resource management, water supply planning for Washington, D.C., James, Bower and Matalas (1970) went so far as to quantify the relative importance of planning variables, offering the following ranking:

1. the economic (demand projection);
2. the political (water quality objective);
3. the biological (estuarine system behavior);
4. the hydrological (rainfall and runoff).

Thus, in order to formulate successful wetlands management policies, one must be aware that the critical decisions affecting natural resources are generated by the private market system and the political process, not by science. This seems so obvious that one almost apologizes for saying it. Nonetheless, the lesson must be reiterated.

It is essential for coastal wetlands management that we understand and control the market system that generates the pressure to develop coastal wetlands.[24] That is, wetlands must be seen in their role as economic resources as well as ecosystems. Coastal wetlands are a particularly schizophrenic economic resource by virtue of being simultaneously a water resource and a land resource. Most arguments for preserving coastal wetlands have emphasized the *wet* aspects—their value as biotic input for fisheries, as contributors to water quality, as sediment traps, etc. Nonetheless, the most important economic value that wetlands have under current property conditions is their *dry* potential as reclaimed land; they yield a large return in investment due to low cost, proximity to the water, and easy manipulation. Shorefront land is in great demand by a recreation-minded populace seeking outlets for affluence by water-oriented industries, and by land developers seeking handsome profits.

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[24] I have attempted to go more deeply into the economics of land development in the coastal zone in a subsequent paper (Walker, 1973).

Hence, on one hand there is economic value in destroying coastal wetlands to make new fast land (or new deep water, for docking boats), and, on the other hand, economic value in keeping wetlands intact as water resources supplying biomass to the estuary. But the competition between these opposing values in the market is imbalanced due to certain market failures. Water-related contributions of wetlands are undervalued by the market while many activities which threaten to destroy wetlands are currently overvalued. As an example of the latter problem, agricultural drainage, the greatest single destroyer of wetlands in the United States as a whole, has been shown to be excessive because of various agricultural subsidies. (Goldstein, 1971.) Housing development is notoriously speculative and also contains many elements of subsidy by the public sector through its provision of services (water, sewerage, electricity, roads) at below cost, and by taxation and zoning policies that encourage speculation and unnecessary development in rural areas.[25] (Gaffney, 1964; Clawson, 1971.)

On the other hand, wetlands have historically been undervalued as water resources. The argument is often made by conservationists, with much merit, that the total impact of many small decisions to destroy marshland, all thought to have zero costs, may indeed impose a significant cost on others who share in the use of the common resources of the bay. Economists have amassed a literature on the problems involved in the exploitation of a common property resource by individuals acting on the basis of private—not social—cost minimization. Costs external to the individual property owner do not enter into his decision-making calculus and a misallocation of resources can result. This is exactly what happens in a typical fisheries industry, where each fisherman, acting to maximize his own catch, has the combined effect of depleting the fish stock and ultimately lowering everyone's catch.

If individuals have significant impact on other individuals, then collective action is necessary to insure the welfare of all. This collective action, or, if you like, "resource management", is usually carried on through the political and administrative systems of government.

An economist would maintain that if the government intervenes in the market process because of market failure, it should simulate the allocative mechanisms of the private market. Optimal allocative efficiency in the use of productive natural resources requires that price adequately reflect marginal cost, especially the "opportunity cost" of the lost chance to employ the resource in an alternative way. If, for example, wetlands are filled for housing developments, that precludes their use as biotic input to fisheries. If the fisheries output

[25]Worcester County, Maryland, where most wetlands development in that state is taking place, is typical of local governments which encourage speculative development. In the last ten years, only three of 52 requests for rezoning land for development have been refused. (Baltimore *Sun,* Feb. 5, 1973.)

actually had a greater economic value than the housing, then society has not used its resources well. The economist knows that if the price structure provides perverse incentives, the market will respond accordingly. Therefore, he seeks to restructure economic incentives so that every individual is made accountable for the full social (external) costs of his actions. In other words, the price of wetlands to the land developer should include the opportunity cost of lost fisheries resources.

Economists, like the scientists before them, prefer ~~economically~~ rational solutions. A typical economist's solution to the allocation of wetlands is that of Jack Knetsch, who suggests that the government impose a "development charge" for wetlands alteration. (Knetsch, 1972.)[26] This would be similar to the now familiar effluent charge proposal for pollution control. This approach has the virtue of coming to grips with the basic problem of economic incentives and market failure, but it, too, has some serious faults. First, as we have seen, sufficient ecological data does not exist on which to evaluate opportunity cost of wetlands alteration. Second, the raising of costs to one party, the developer, is an inadequate substitute for the full process of market exchange, because the beneficiaries, e.g. the consumers of fish products, do not pay for the benefits they realize when fewer wetlands are destroyed. (Ward, 1972.) Despite the overall increase in social output, there will be income distribution effects from government intervention and the separation of those paying costs from those receiving benefits. These income effects will give rise to political action on the part of the subsidized beneficiaries and the results of such politicking may only be the substitution of one system of inefficient allocation for another. A good example of this phenomenon is seen in the water resource field where government intervention, made necessary by the failure of private entrepreneurs to provide adequate water supplies in the past, has created an excessive demand for water projects because local areas that receive all the benefits pay only a small share of the costs. (Hanke and Walker, 1972.)

This new market "distortion" may undo all the economists' well-intentioned efforts to manage the resource with a pricing system. A case in point is the groundwater depletion problem that typically occurs throughout the west when farmers pump irrigation water from a common pool. Within a limited area of shared groundwater, it is possible for an economist to compute the real cost of pumping and for the farmers to be charged accordingly, thereby optimizing the allocation of the limited pool. In reality, however, this "rational" policy option has rarely been taken since government subsidies make it politically more acceptable to import water from elsewhere to solve the problem. (Hanke and Walker, 1972.)

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[26]Knetsch rejects direct government purchase and control as too inflexible and inefficient.

Similarly, the issue of wetlands exploitation by land developers who do not pay the cost of their destruction of biological resources is likely to continue to be dealt with (or not dealt with) for political reasons that have little correspondence to the "rational" solutions that are offered by economists and biologists. The Maryland Wetlands Act of 1970 exemplifies the actual process of social policy determination. It failed to pass the legislature in 1969 in a form less stringent than the present one, but when a scandal broke in 1970 over the granting of state wetlands for a million-dollar development near Ocean City, tremendous political pressure developed that forced the passage of a strict wetlands protection act.[27] This is a far cry from the approach to resource policy envisaged by most economists and ecologists. But is the result necessarily "irrational" in the long run?

With the "political" passage of a Wetlands Act, the wetlands have come under administrative management and this, one might hope, will be conducive to rational assessment of the value of wetlands in scientific and economic terms. Nevertheless, political pressures are still important, if not dominant, and it would be a serious mistake on the part of conservationists to think otherwise. Because there is no marketplace for most wetlands values, and thus no generally accepted measure of value, those interested in the wetlands, whether preservation or development, will continue to turn to the political marketplace to fix the value of this resource. The importance of this point is often missed by economists, though it is implicitly understood and capitalized on by the public and politicians.

Economics fails in another way to resolve questions concerning the social value of a natural system. Nature provides not only productive inputs, but also elements of final individual and collective consumption. Even if we reached that state of rational bliss in which there were perfect knowledge of the ecological relationships and perfect markets that took into account the contribution of wetlands to fisheries, etc., and if such a solution were politically feasible, there would still be "public goods" aspects of wetlands which the market could never supply or allocate properly through its pricing mechanism. In general, a public good cannot be used by one person without affecting or being used by others; that is, it is characterized by joint consumption. Scenery is probably the best example of a pure public good: exclusion is very difficult and quite unnecessary, because no one's enjoyment of a view is diminished by having shared that view with another person (aside from the problem of congestion). In such a case, however, the pricing mechanism of the market will not operate correctly to assure either the correct supply or allocation of the public good, and the

[27]Personal communication with Edward Wood, Department of Political Science, Johns Hopkins University.

government becomes the provider and allocator. Moreover, there is no way in which a final consumption good of this type can be evaluated by benefit-cost analysis as a substitute for the market. (Musgrave, 1969.) Its provision must of necessity be decided in the political market. Technical management by biologists and economists then becomes secondary to political resolution of the issues of the social use of nature.

We have returned now from the questions of technical resource management to the other side of conservation, that voiced by Muir, Leopold or Krutch. This brings me to a rather different "value" of wetlands that has not received much attention in this or any other discussion, and that is the purely esthetic experience of open expanses of marshland not visibly altered by works of man, with great flights of migrating waterfowl in spring and fall. On the populous east coast, especially the Chesapeake Bay region, wetlands afford some of the last remaining large tracts of undeveloped land. If the best use of wetlands is as scenic areas—pleasuring grounds for the people—we are in the realm of public goods, and the provision of areas to this end can only be decided through the political process. We must then work out our values in the public forum. Neither the private market nor technical experts can produce impartial answers to save us the embarassment and trouble of a conflict over values. Pricing fails as a criterion of choice, as do benefit-cost analysis, preserving stability, or maintaining a sustained yield. Our liturgy of scientifically and economically sacrosanct ideas cannot be used to make the choices between development and preservation of wetlands. Society must choose whether it is worthwhile for people to have the Bay and its fringes for their esthetic enjoyment and recreational inspiration or for condominiums and boat docks. The answer is not obvious.

Another problem in the social disposition of wetlands, even less often recognized than the public good paradox and equally unamenable to the rational calculus of the economists, is that of the effects of existing distribution of property rights on the utilization of wetlands. It is somewhat surprising that a public outcry is raised against the physical alteration of wetlands when in terms of the loss of *public* use of these areas, physical destruction is trivial compared with that which comes from public exclusion from private property. Indeed, most wetlands disappeared from the commonweal years ago. Looking at the Virginia survey of shoreline development, for instance, we find that the entire 4,477 miles of shoreline in the "no present use" category is in private ownership (Table 3). A similar lack of public ownership of and access to the shore of the Bay exists in Maryland. Under the circumstances, then, the common reference to the Bay or the wetlands as a "great public resource" seems rather dubious.

Although it is often argued that large private landholdings are valuable buffers against the inroads of subdivision and development, most such owners hold land idle only until it is most profitable to develop it. (Gaffney, 1964.) Moreover, the

Table 3
Shoreline uses in Virginia

Shoreline use	*Number of miles*
Harbors and ports	21
Recreation	47
Residential	463
Industrial	21
Conservation	199
Military	174
No present use	4477
NASA	30
Total	5432
(Marsh)	2719

Source: Wass and Wright, 1969, p. 13.

public has come to see subdivision-type development as about the only means of acquiring shore access and so they rush to buy from developers in those limited areas left to them. It seems, therefore, that the virtual exclusion of the general public from the Bay shore by private owners is a strategy counter-productive to Bay and wetlands preservation in the long run.

Conclusion

The wetlands conservation debate, like so many natural resource issues, has been dominated by the input of scientific information and misinformation, when, in fact, natural science has only a partial role to play in complex social decisions about the character of man's continual redesign of his environment. Science can define relationships in natural systems but it cannot define values for use by human systems. So far, science has only served to concentrate excessive attention on nature in the wetlands and insufficient attention on man in the wetlands.

In our society, the question of "value" is largely determined through the market system, so wetlands should be understood and managed first of all as economic resources. Because of market failures and subsidies, wetlands are undervalued in the terms that guide the private sector's activities. One strategy for the management of coastal wetlands is the readjustment of economic incentives. While this strategy has serious difficulties in assigning positive prices to wetlands, no such problem attends the removal of existing subsidies for development in current government tax and expenditure policies.[28] (Walker, 1973.)

[28] I applaud the recent Environmental Protection Tax Bill of 1973 (HR 14669) submitted to Congress, which removes certain tax advantages for wetlands developers.

The failure of the market to deal with a common property resource like coastal wetlands and Chesapeake Bay, however, and the public goods aspect of their preservation, may mean that the market mechanism will have to be precluded entirely from some wetland areas. If so, we are left without the shelter of economic and scientific rationalizations for our actions as a society, and must instead hammer out our values through the political process. In other words, coastal wetlands preservation and management comes down in the last analysis to be a political issue, not only a biologic, geologic, or economic one.

The current controversy over the preservation and management of wetlands is not unique. It is a part of a philosophical conflict over the human use of natural resources that has deep roots in American politics and culture. The issues involved in wetlands conservation do not spring full-grown out of thin air, but have strong historical antecedents. Nor do we confront those issues innocent of commitments to pre-existing threads of ideology passed down from those who have grappled with similar problems before; we come armed with a set of opinions on such things as the proper scope of government intervention, the rights of private property, or the role of scientific knowledge in decision-making. No one who enters the controversy surrounding wetlands is free of either history or politics. This paper, too, has political implications and may actually serve to weaken the political position of the conservationists,[29] but it is my hope that insofar as it helps to improve our understanding of the issues of wetlands policy, it will accordingly aid in the creation of wiser and better policy. And also, as I do not necessarily have answers to the questions raised, I hope that taking a critic's position will start debate that can eventually lead to greater understanding.

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[29] My thanks to John Clark for forcefully bringing this to my attention.

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Comments

WETLANDS PRESERVATION AND MANAGEMENT: A REJOINDER–ECONOMICS, SCIENCE AND BEYOND

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Note This article is a short response to a critique by William Odum and Stephen Skjei of an earlier article by this author in this *Journal*, entitled "Wetlands Preservation and Management on Chesapeake Bay: The Role of Science in Natural Resource Policy." It is a continuation of themes begun in that paper. It focuses on the question of determining the social value of wetlands preservation and the contradictory positions which ecologists fall into when discussing the value of wetlands.

I have been taken to task by William E. Odum and Stephen S. Skjei of the University of Virginia for my article in a previous issue of this *Journal* on wetlands policy and the roles of science, economics, and politics in guiding public action. (Odum & Skjei, in this issue). I knew that my views would run into stiff opposition among ecologists,[1] but I had not expected that in their haste to refute me they would so completely misunderstand and misrepresent my arguments as Odum and Skjei have done. It is thus necessary to respond to their arguments which I believe to be a fairly representative statement of the ecologists' position on matters of wetlands preservation and the biologist's role in public policy formation.

The first half of Odum and Skjei's paper concerns the biological evidence on the relation of wetlands primary productivity to estuarine fish and shellfish production and on the relationship between wetlands destruction and declines in estuarine fisheries. Although they seek to show that I have misrepresented the state of biological knowledge about wetlands-estuarine relationships, much to my surprise they repeat many of the same points I made. The following three statements by Odum and Skjei, for instance, could serve as a fair summary of my arguments in Section I-A on "Productivity:" (1) the estuarine system is an "holistic concept," and "to attempt to consider the function of only one of

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[1] I use the term "ecologist" very broadly. My apologies to Prof. Skjei, who is a planner and economist by training.

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[its] components [i.e. tidal marshes] separated from the whole, can be unrealistic and misleading" (p. 153). (2) The connection between wetlands plant production and aquatic fish and shellfish production "is an extremely difficult relationship to measure with precision;" (p. 154) and (3) the "effects of wetlands destruction have not been studied adequately, particularly for the larger estuaries such as Chesapeake Bay" (pp. 155-56). I wholeheartedly concur with these views and sought to argue from them that current ecological knowledge about wetlands, while impressive and generally convincing in its broad outlines, is neither quantitatively precise nor necessarily beyond reproach on even its most fundamental concepts. Odum and Skjei, however, proceed to the indefensible conclusion that the current state of understanding constitutes a "Scientific Proof for the Value of Wetlands."[2] The jump from "impressive evidence" to "scientific proof" cannot be justified here, and pretending that it can only leads to a mystification of the nature of scientific proof and of the validity of scientific statements about wetlands.

My intent in presenting a "biased" view of the evidence about wetlands (a charge to which I readily accede) was not to deny the weight of evidence *per se,* but to challenge the myth of "scientific proof" surrounding that evidence. As I emphatically stated, and Odum and Skjei even quote me on this, in part: "Although I have emphasized the negative so far in order to make a point, I am not interested in proving that wetlands advocates are wrong–in fact, I rather hope that they are right. But they *may* be wrong, and that possibility makes wetlands conservation interesting as a political issue, not simply as a technical problem outside the ken of the general public." (Walker, 1973, p. 90) The need was there for a general awakening on the dual problems of assessing the "truth" of scientific knowledge at any moment in history, and the extent to which the public needs scientists and scientific knowledge to make social decisions.

What I question is not the value of wetlands preservation, but rather the validity of the ecologists' method of determining that value. This brings us head to head with two fundamental issues: (1) how "value" is defined, and (2) by what means that "value" is demonstrated in practice. "Value" can refer to market, or exchange value, which is a specific quantity, or to any number of judgments on the worth of things, including, for example, scientific research value, aesthetic value, or religious value. There is no limit to the judgments which people have about worth, but there is currently only one international market system, and the tangible nature of its judgments as to exchange value is beyond dispute. Economists have grappled with the relationship between exchange value and the several kinds of subjective "use" values since the time of

[2] The title of the first section of the Odum and Skjei paper

Adam Smith.[3] Odum and Skjei claim full awareness of the problem of use- versus exchange-value, but continue to use the word "value" loosely—as in "The Scientific Proof for the Value of Wetlands"—as if its meaning were self-evident. These authors are not only unclear about the system of value under which they are operating, they cavalierly switch *between* systems, creating confusion and contradiction in their arguments.

The contradiction is this: In the first section where Odum and Skjei discuss the biological "value" of wetlands, they are clearly implying the benefit that should be imputed to wetlands by virtue of the numbers of commercial and game fish supported by wetlands productivity. (see e.g. Table I, p. 156) The relevant measure of value in this context is necessarily the market value of fish landings. In the second section, on the other hand, they declare that simple market values are often insufficient, and that society overrides the market in determining value in numerous instances—"Quite obviously," they state, "wetlands preservation is now one of these issues." (p. 158) It seems that Odum and Skjei would have their fish and eat them too.

This ambiguity between embracing the market and rejecting it is a recurrent theme in the literature of political ecology. On one hand, ecologists argue for preserving wetlands on such grounds as their contribution to scientific understanding, the enjoyment of future generations, aesthetics, or even the basic integrity of all living organisms—all of which are perfectly valid beliefs. On the other hand, when ecologists assemble all their data on wetlands, what do they always try to show? That wetlands are *productive*. Yet none of the above mentioned reasons for preservation bears any relation to productivity. In terms of aesthetics or natural integrity, a marsh rates no higher in value than the most "unproductive" desert. Productivity is only a virtue when one is interested in utilizing estuarine output for direct consumption or as input into commercial production. This is basically an *economic* conception of estuaries and wetlands, and it implies acceptance of a market system of value.[4]

If one is operating with market values and the market system, however, it demands an understanding of economics, because in that context the problem of wetlands policy is one of the evaluation and management of an economic

[3] Despite assertions of the neo-classical school of economics that this problem has been solved theoretically, few outside the Chicago school would maintain that market prices should be taken as the final judge of social value. See Harvey (1973) for a good discussion of use and exchange value.

[4] This is not exactly true. As Odum and Skjei point out, redistribution can change relative prices, resulting in different market values (p. 12). However, they never relate this point to their "productivity" arguments for wetlands value. Nor does a change in relative prices negate the usefulness of economic theory for dealing with "resource management"-type problems.

"resource" in an efficient way. Ecologists have rarely bothered to carry out the necessary economics to substantiate the supposed market value of wetlands which their scientific data "proves," and where they have attempted to do so, they have shown only the most casual understanding of the techniques developed by economists for market analysis (cf. Pope and Gosselink, 1973; Odum and Odum, 1972): the article by Pope and Gosselink in the first issue of this *Journal* is a case in point.

Odum and Skjei correctly argue, in the second part of their paper, that market values must be transcended in many social decisions. I appreciate their suspicion of economists, who tend to argue that the decisions of the market are inherently good as they stand, and that the more sectors of society and nature that conform to the principles of the market, including the "allocation of wetlands" to various uses, the better off we would all be (cf Knetsch, 1971). I clearly critique this position in my original article (Walker, 1973, p. 30), and will not repeat those arguments here, even though Odum and Skjei appear to have missed them completely. The important point is this: both the market system and economists' techniques have their limitations, and to pretend that they do not by offering complex problem-solving devices that cannot in reality solve anything is simply an exercise in the exaltation of economic technique over other kinds of human problem-solving methods, such as legislative deliberation. Unfortunately, a similar conclusion applies to ecology, but ecologists have not learned from the mistakes of the economists they criticize. We turn to this problem now.

In the second section of their paper, Odum and Skjei reject the market as the measure of wetlands value and the techniques of economics as the appropriate means of formulating wetlands policy. What, then, do they propose as substitutes? Although they eschew any *explicit* value system, and concentrate instead on the political process and the role of the ecologist in it, it is important to consider the implicit values that fall out of their scheme.[5] These authors depend on the theory of a pluralist political process, the currently dominant theory in the field of political science, in which the key problems of policy making are defined as uncertainty and the availability of information to "interest groups" or "decision-makers."[6] They then propose that the key role of science in the political process is in yielding information and lowering uncertainty.

[5]One should note that there is strong ideological content in the proposition of pluralist political theory that one need not declare an explicit value system, because social values fall out of the struggle of competing political interests in an ultimately fair and neutral fashion.

[6]They seem to believe the pluralism is the definitive word on the nature of politics and government, and that the "pluralist political process" adequately solves the problem of social valuation of wetlands. There is not sufficient space here to take up a general

But the "information" that scientists bring to the political arena is not neutral. Scientists are not impartial. They bring with them, hidden beneath their "scientific" arguments, a set of values. Once science becomes involved in social issues there is no such thing as scientific "facts," free from interpretation or implication, although the illusion of impartiality is often fostered by scientists and accepted by laymen who have been taught the myth of objective science. Historically, the role of science in conservation issues has been a very political one (Hays, 1959; Schiff, 1962), and there is no reason to think that wetlands conservation is an exception to an established pattern.[7] Odum and Skjei agree with me that scientists are politicized: "Because of the uncertainty that surrounds the political debate about what objectives are relevant and what means should be pursued in responding to the issue of wetlands preservation, the data raised by scientists takes on a normative cast, for it does reflect or support those whose main concern is preservation. It becomes, in other words, almost inherently political" (p. 160). But they regard this "politicization" process as the exception rather than the rule, because they still cling to the idea that "facts" and "values" are clearly distinguishable entities (pp. 159-160).[8] This is a reiteration of conventional propositions of positivism, a system which I emphatically reject.

Ecology is a particularly politicized field at this time, and comes very close to being a "social science" in that the view of the world which it creates is a force for change in society—think what Aldo Leopold's land ethic would imply for American society if it were adopted as a guiding principle. To presume that ecology, any more than economics, is a system of thought and a set of

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discussion of pluralist ideas, but I refer them to Theodore Lowi's *The End of Liberalism* (1969) for a thought-provoking critique of the supposed virtues of the theory and practice of pluralism.

[7] Incredibly, Odum and Skjei misinterpreted me as saying that scientists should be denied *any* role in policy formation: "Given the plural nature of contemporary society there is no reason why scientists in general and preservationists in particular should be excluded or limited to partial involvement in the political process, yet this is a position that Walker clearly takes." (p. 15) Not only is this clearly *not* a position I take, or even vaguely infer, it reveals an excessive defensiveness. My argument never was that ecology should be excluded from the political process, but that, on the contrary, it was never out of politics for long in the first place.

[8] Gunnar Myrdal summarizes the facts/values problem as follows:

> This implicit belief in the existence of a body of scientific knowledge acquired independently of all valuations is, as I now see it, naive empiricism. Facts do not organize themselves into concepts and theories just by being looked at; indeed, except within the framework of concepts and theories, there are no scientific facts but only chaos. There is an inescapable *a priori* element in all scientific work. Questions must be asked before answers can be given. The questions are an expression of our interest in the world, they are at bottom valuations. Valuations are thus necessarily involved already at the stage when we observe facts and carry on theoretical analysis, and not only at the stage when we draw political inferences from facts and valuations.

techniques that are objective and which can offer neutral, technical solutions or information which is alone sufficient as a basis of social choice is fallacious.

Nonetheless, ecologists who reject economics as a basis for social choice are only too eager to replace it with a new system of their own creation. They would have us depend on another kind of technical knowledge, ecological research, as the means of legitimizing preservationist positions. This, in turn, gives their work legitimacy. The "proof" of wetlands value requires research and data which only the ordained specialist can command and disseminate to the lay public. This is the "information" function of science which Odum and Skjei have in mind. It is not quite as innocent as it appeared at first glance.

I believe, however, that a dependence on the *technique* of ecology (as opposed to the philosophy of ecology), like dependence on the techniques of economics, is a mistake for preservationists. Why is it that aesthetics, or wilderness values, or a sense of responsibility for all living things are not sufficient of themselves to legitimize wetlands preservation? Why must we always trot out scientific or economic "proof" for propositions that any person can understand and judge for himself? In reality, the problem is not always, or even primarily, a lack of information or the presence of uncertainty in social decisions, as Odum and Skjei believe, but the basic illegitimacy of preservationist values in a materialistic, commercial American society. The preservationist is thought to be an oddball, a freak, who is basically "out of touch with reality" by conventional standards. Therefore, preservationists are besieged by experts plying their intellectual wares, offering legitimacy by an indirect route.

In the short run, it is tempting to use the technique of ecology, the compilation of endless data and the construction of complex scientific arguments as a weapon against the hostility of a commercial world in order to win a few preservationist victories. In the long run, however, the picture is less comforting. In agreeing to fight fire with fire, the devotees of technical arguments are accepting fire as a legitimate weapon–in this case, the exaltation of technical solutions to problems of human choice. But it seems to me that the subordination of man to technique is a legacy of the commercial-technical society against which preservationists are fighting. If preservationists are unhappy with the results of modern society's treatment of nature, it is contradictory to adopt the methods of that society which create the undesirable result. Preservationist ecologists who do not confront this contradiction squarely are changing nothing fundamental in society, and as time passes they will find their victories short-lived and the dominant commercial interests and values in control. Look at what the energy crisis has done for the Alaska pipeline and air pollution controls. So it will be with wetlands. Developers will continue to swallow up wetlands to make profits whenever there is a bull market in land, unless the rules of private property and the market in these areas are altered drastically. I do not see arguments about wetlands productivity doing this; they only lead us to economics and the acceptance of existing rules of the game.[9] Real change requires a major revolution in human values and the legal and social organization of society. The preservationists have more to contribute to such change than the scientists.

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[9] Compare my arguments here with those of Mumy (1974) on the inability of the law to solve problems of environmental pollution.

Special note: The article by Richard A. Walker, "Wetland Preservation and Management on Chesapeake Bay: The Role of Science in Natural Resource Policy," which was contained in Volume 1, Number 1 of *Coastal Zone Management Journal,* was made possible with funds provided to the Chesapeake Research Consortium Inc. by the research applied to national needs section of the National Science Foundation, grant number G.E. 34869.