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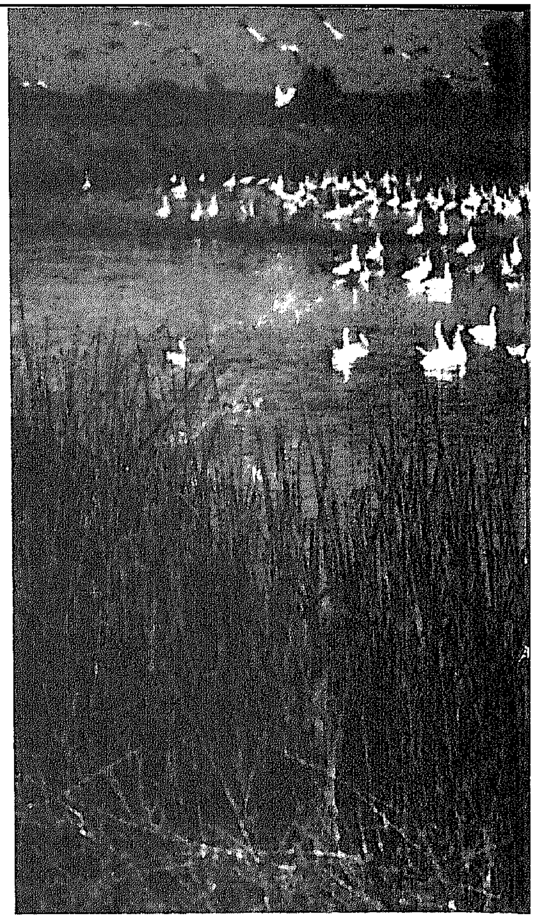
What value wetlands?

Effective wetlands conservation efforts require careful reasoning and strong incentives to landowners

By Michal J. Bardecki



ONE need only read the works of conservationists and naturalists to appreciate the aesthetic values of wetlands. Of course, wetlands do not provide the same aesthetic impact as do many other natural areas, perhaps because they lack broad vistas and dramatic landscapes. But they do provide natural beauty, albeit beauty that takes an appreciative eye.

One observer (8) puts it this way: "Wetlands are not conventional wild areas. They do not cater to established, classical concepts of vista, horizon, and landscape.... They force you inward, both upon yourself and upon the nonhuman world. They do not give you grand views; they humble you rather than reinforce your delusions of grandeur.... In a wetland you do not 'stand tall.' If you are to stand at all, you need to search for semi-firm ground, and you do not expect to find firm ground as a matter of course. When you move, you move slowly, tentatively, each step an exploration in its own right. You wait for things to come to you, rather than setting off to 'find out what's over the next ridge'."

Much of the recreational value of wetlands derives from these aesthetic values. Indeed, it is difficult to separate the aesthetic and recreational values of wetlands.

Wetlands are an important outdoor recreation resource. Recreational activities that depend upon or are enhanced by wetlands include sport fishing, hunting, camping, picnicking, hiking, nature study, and photography. The values of these uses have been reasonably well documented, but with the exception of hunting, there has been little investigation of the recreational uses of wetland areas.

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Biological value

Wetland conservation efforts, where they do exist, are often based on the biological significance of such areas. On a broad scale, wetlands may be among the most productive of ecosystems (23).

Wetlands, particularly shallow open water and marshes, provide food, shelter, spawning sites, and nursery areas for a wide variety of fish species.

Many wildlife species are thought of as wetland species. Probably a larger number of species are occasional wetland users. Although not essential to their survival, the presence of wetlands allows for greater populations and wider ranges than would otherwise be possible. Wetlands are often breeding sites and nursery areas for a regional ecosystem. Even for adults, wetlands may provide food, escape cover, and winter protection for upland wildlife. As upland areas are developed for various uses, wetland areas may become progressively more important.

Clearly, waterfowl depend upon wetlands. In addition, several species of furbearing animals, particularly beaver and muskrat, are wetland denizens.

For flood control?

The second most often cited reason for wetlands protection is their supposed role in flood control. There is an old maxim that wetlands act as sponges (9). This view holds that wetland areas provide for storage of water during periods of high flow, allowing the water to seep out gradually, augmenting low periods in streamflow.

Virtually every publication advocating wetland protection includes this as a key value of wetland areas. However, the scientific literature does not wholly support this contention and really presents a somewhat contrary picture. This is partly attributable to the variety of situations under study.

Investigations differ from one another in a variety of ways, particularly in whether or not a study examines the hydrology of an individual wetland or an entire basin containing wetland areas. The hydrological response of individual wetlands may not appear in studies of entire watersheds, or the response may even be enhanced, depending upon the synchronization of tributary channel peaks. For example, even a crude model indicates that if one assumes the "sponge" assumption to be correct, that is, that wetlands act to delay and diminish flood peaks, wetland drainage may, on a basinwide scale, reduce flood peaks. In light of the number of variables involved and different methods used, the lack of consensus concerning the capability

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of wetlands to control flood peaks is not surprising.

The hydrologically active layer of many wetland soils is quite shallow. The hydraulic conductivity of organic soils declines rapidly with depth, sharply limiting vertical penetration of water (3). Also, surface soil layers in wetlands are usually at or near saturation. Therefore, wetlands have little capacity to reduce streamflow peaks through absorption. High water tables during spring runoff further suggest that wetlands are poor streamflow regulators at that time of year.

Nonetheless, some authors, most notably those basing their conclusions on macroscale observations of wetland areas, suggest a much more significant role for wetlands in flood control. Many indicate a link between the presence of wetlands and the severity of flood damage. These studies are significant but may not be true indicators of wetland values per se. In fact, one can argue that it is the presence of topographically flat areas that reduces flood peaks. Many of these are, of course, occupied by wetlands, but it is not at all clear that removing the natural wetlands would significantly alter a river basin's hydrological response.

Contrary to such studies, wetlands may have little effect on streamflow. They may even act to enhance floods, according to many detailed investigations. For example, a comparison of runoff from drained and undrained peatlands showed that peak flow from heavy summer rain was considerably lower on drained peatland due to an increased water storage capacity resulting from a lowering of the water table (*13*). The snowmelt flood began earlier and lasted longer, producing a lower peak flow. Similar results have been reported elsewhere (*4*, *6*, *17*). This evidence certainly raises questions about the magnitude and universality of the flood control benefits of wetlands.

As far as low flow augmentation is concerned, the literature is virtually unanimous in its rejection of the sponge hypothesis—that wetlands act to release water in storage during periods of low streamflow (*2*, *5*).

There is no doubt that wetlands act as important water storage reservoirs. The question, however, is one of availability of this water. Much of the water may be associated with the wetland substrate and may be unavailable for low flow augmentation. It is likely that only in those situations where the wetlands act as groundwater discharge areas do wetlands contribute much to base flow.

Wetlands reportedly have value for groundwater recharge (*11*). Despite this, it is possible that most wetlands are not in fact good groundwater recharge areas at all. Evapotranspiration may be higher than inflow. Upland areas are often reported as recharge areas for wetlands, rather than vice versa.

The importance of a wetland for groundwater recharge lies in the hydrological transmissivity of the wetland. Hydraulic conductivity of many wetland soils is low, severely limiting the recharge capabilities of wetlands. The reported geographical association between wetlands and water wells may be simply a result of the dependence of both wells and wetlands on good aquifers.

What value for water quality?

However critical one may be of assertions about the water control benefits of wetlands, one can only attempt to emphasize more strongly their positive effects on water quality.

A broad range of recent studies deal with the impacts of wetlands on the quality of their discharge waters. It is widely accepted that wetlands do provide beneficial effects. Such studies have concentrated primarily on marshes and swamps. Because there is a strong association between the mobility and chemistry of wetland waters and the type of wetland vegetation (*18*, *20*), it is difficult to generalize from much of the published data on water quality so as to include the entire variety of wetland types.

Nonetheless, many wetlands have potential for removing plant nutrients from incoming waters. The uptake of nitrogen and phosphorus in particular may be beneficial in reducing the potential for adverse eutrophic effects downstream. This storage may be long term (eventually as peat or muck deposits within the wetland), or it may merely be a short-term delay of nutrient transport from summer to the flushing of the following spring thaw, thus reducing the growing-season nutrient load downstream.

Nutrient removal is not the only beneficial water quality effect reported for wetland areas. Sediments, pathogens, and toxic substances may be removed as well.

Low flow velocities through wetlands lead to the deposition of suspended materials in the quiescent waters. The effect is similar to that of a reservoir. The wetland vegetation also acts to trap material.

Wetlands have potential for wastewater clean-up by removing pathogens, though studies show considerable variablility of results (*15*). Wetlands with organic substrates may be better than those with mineral soils at reducing pathogens. Humic acid from peat even appears to possess certain antiviral properties (*16*).

Similarly, organic soils have potential for removing toxic substances through the absorption of metal ions by peat. By retaining sediments, wetlands can remove adsorbed metals and pesticides from waters. Furthermore, certain wetland plants absorb toxic pollutants, including heavy metals and organic chemicals (*15*).

The potential of wetlands for treatment of wastewater has produced considerable interest in the enhancement of these properties or even in the development of artificial wetlands specifically for wastewater treatment. Several such systems exist currently (*7*, *12*, *19*).

Despite this optimistic outlook, a word of caution is needed in considering the water purifying benefits of wetlands. A question still remains as to the ecological impact of pollution loads on wetlands. Marshes may deteriorate as a result of increased sediment loads introduced from engineering works, and although certain species of wetland vegetation may recover quickly, wetland ecosystems are somewhat difficult to reestablish.

A further value attributed to wetlands, at least shoreline wetlands, is that they also provide protection from erosion. Most investigations of the shoreline protection values of wetlands involve qualitative descriptions. Despite several problems, wetlands can provide a low energy environment. However, high energy shorelines normally preclude growth of aquatic plants. Marsh development, therefore, does not seem to be a feasible alternative for stabilizing actively eroding shorelines, although it may be useful in less severe situations.

Atmospheric interactions

The interplay between wetland areas and the atmosphere is not particularly well documented. Nonetheless, a variety of climatic and atmospheric effects have been attributed to wetlands. These range in scale from the local to the truly global.

Particularly interesting is the microclimatology of wetlands. Wetlands in distinct topographic depressions normally exhibit cooler soil temperatures (largely a result of heat losses through evaporation) and lower air temperatures (resulting from cold air drainage) than surrounding uplands. Frosts are much more prevalent. Indeed, in many ways such wetlands have conditions that might be expected at higher latitudes. This appears to play a significant role in the distribution of boreal species; wetlands often provide refuges for such species far south of their normal geographical limits.

Large wetlands often exert regional climatic effects as well. It is not clear how these effects differ from those of a body of open water, although the high surface-area-to-volume ratio and the presence of vegetation may well play a significant role.

Research and educational values

Concerning a final value of wetland areas, the U.S. Department of Interior has this to say: "Wetlands of all types have a high intrinsic value for education and research purposes because of the great number and variety of life forms they support. The biological, intimate associations of plant and animal communities present in marshes and swamps represent an important resource for teaching and study. They are especially valuable to the researcher interested in tracing the intricate relationship of plants and animals under an ever-changing envi·onment" (*22*).

But other than general statements of this nature, little has been written about the use of wetlands for education or research. But such use may be extensive. For example, about one-half of the high schools in Ontario incorporate at least one annual wetland visit as part of their science curriculum (*1*).

Numerous scientific papers on wetlands illustrate the general significance of wetland areas for research. Particularly noteworthy are the unique uses of wetland areas in palynology for the re-creation of past climatic and vegetative environments.

An economic perspective

From a purely economic point of view, a wetland owner is faced with a classic problem in resource allocation. In general, the owner may preserve the wetland area in a largely natural state, or decide to alter its use so as to reduce or destroy its naturalness.

From the individual's point of view the option to alter the wetland's use should be taken if the marginal benefits exceed the marginal costs. Herein lies the crux of the problem. The individual need only consider those costs and benefits that may be "internalized," those that are private costs. But does this private economic decision consider all benefits and all costs? Does such a decision result in a social misallocation of resources? Most benefits from a wetland in its natural state are external. They cannot be realized by the landowner. The landowner can realize benefits only if the area is converted to some other use, such as agriculture. In either case the costs are generally private.

Several studies have attempted to place a value on the benefits derived from wetlands. There are many problems with such methods, largely related to the intangible or incommensurable character of many wetland benefits. There are no prices for determining relative values of the various commodities and services of wetlands. Methods have evolved, but none are wholly satisfactory. Nonetheless, studies using these methods do provide some general insight into the problem of public versus private benefits. I will discuss three such studies.

Economic values for the approximately 32,000 acres (13,000 hectares) of coastal marsh in Michigan have been derived (*14*). The wetland uses included waterfowl hunting, trapping, and sport and commercial fishing as well as "non-consumptive recreation." It was concluded that Michigan's coastal wetlands generate a gross annual value of $490 per wetland acre per year ($1,210/hectares/year). By including other values, for example, for nutrient uptake and for "ecological functions," the average return increased to more than $3,000 per wetland acre per year ($7,413/

hectares/year). Even assuming that all those benefits included in the detailed analysis may be wholly internalized (an unlikely possibility), private benefits would still total only one-fifth the suggested value of the more general societal benefits of nutrient uptake and "ecological functions."

Wetland values in Virginia have been developed based on the market value of the products produced, on the expenditures by recreationists, on the costs of providing conventional tertiary treatment, and on "total life support" values from a study of energy input-output in the United States economy (*10*). Annual potential benefits derived were fisheries production, $108 per acre ($267/hectare); aquaculture, $350 to $900 per acre ($865-$2,224/hectare); waste assimilation, $2,500 per acre ($6,178/hectare); and "total life support" value, $4,150 per acre ($10,255/hectare). Hence, the total annual potential benefit to be derived from an acre of marsh is estimated to be $7,108 to $7,658 per acre ($17,564 to $18,923/hectare), of which a maximum of only 6 to 13 percent (fisheries and aquaculture) could reasonably be internalized as a private benefit to the owner.

The U.S. Army Corps of Engineers study of the Charles River estimated the annual benefits to be derived from 8,421 acres (3,408 hectares) of wetlands designated for acquisition to be $771,800, of which $124,800 (16.2%) was for recreation and fish and wildlife benefits and the remainder for flood control benefits (*21*). Given private ownership, the 16.2 percent figure would be an upper limit to the proportion of private benefits.

It is difficult to reach definite conclusions about the private and public benefits of wetlands. Nevertheless, in none of the studies cited above did the benefits that might conceivably be internalized exceed one-sixth of the total benefits. If this were to hold true, and there is little reason to believe otherwise, it is easy to understand the economic basis for wetland conversion.

Many products and services that make wetlands a valuable resource for society are public goods that are largely external to the individual's proprietary rights. In other words, the owner of a wetland area may have to bear the costs of ownership, taxes, for example; yet he or she cannot fully realize the benefits that accrue from retaining the wetland in its natural state, for example, migratory bird habitat, groundwater recharge, or downstream water quality effects. As a result of the landowner's difficulty in capturing the value of his or her land, the benefits derived from preserving wetland areas, although they may play a part in any land use decision, are likely to be outweighed by the benefits of conversion, to agriculture, for example.


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Cypress trees in the Okefenokee swamp: A strong public commitment to wetland protection is needed to counter incentives for conversion.

Added to this are certain potentially detrimental aspects of wetlands. For example, it takes longer and costs more to plant crops in irregular patterns to avoid wet spots. Machinery may become mired. And crop losses to waterfowl and other birds may reduce yields. From the owner's point of view, therefore, conversion of wetlands from their natural state may be highly desirable. The net public benefit may be reduced by such action, however.

Wetland owners convert their land because it is economically logical for them to do so. To rely upon their economic altruism is naive.

Without strong policies to promote wetland protection, wetlands will continue to disappear, and those benefits that people enjoy because of these areas' presence will disappear with them.

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