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CRITERIA TO PROTECT WETLAND ECOLOGICAL INTEGRITY

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INTRODUCTION:

Wetlands are very complex ecological systems. They range from riverine and lacustrine wetlands associated with rivers and lakes, respectively, to isolated wet meadows. Most have surface water during part of the year but others may have short periods of surface water inundation with varying periods of soil saturation. Wetlands frequently occupy depressions in the landscape where surface and ground water accumulate and may be readily polluted by a variety of anthropogenic sources.

Wetlands have been a minor element in EPA's water quality regulatory frame but their importance will expand following their mandatory inclusion into Waters of the States in 1993 (EPA 1990). They have historically been regulated under Section 404 of the Clean Water Act, and although water quality is an issue in 404 decisions, it has not been the driving variable. The "no-net-loss" of wetland area and function as proposed by The Conservation Foundation (1988) and advocated by the president will also impact wetland regulations.

The goal of wetland regulation is to protect wetland ecological integrity. *Figure 1 is a simplified diagram* illustrating this relationship. The ultimate management objective is to achieve a state of ecological integrity, an acceptable condition of wetland health; the central circle in figure 1. The middle circle of this diagram represents factors which define ecological integrity. For the wetland to be healthy, these factors must collectively be at some level of acceptability. The outer ring represents examples of stressors which impact the middle ring elements. If one or a combination of the stressor exceeds the capacity of the wetland to maintain a "healthy" condition, ecological integrity will no longer be attained.

This presentation is based on the premise that a range of criteria are necessary to protect wetland ecological integrity, the center ring of figure 1, from a range of stressors. I will discuss possible protective criteria, some in use in existing regulatory programs and others under development. The order of presentation is biological, aquatic life, hydrologic, sediments and wildlife criteria. In the conclusion, I briefly discuss using landscape approaches to extrapolate criteria to spatial scales beyond the traditional site-specific analysis used in most water quality decisions.

DISCUSSION:

Biological Criteria

Biological criteria are a necessary part of wetland standards and criteria development. The existing aquatic life numeric criteria provide tools to protect the wetlands from specific contaminants while the biological criteria will provide tools to assess the wetland biological condition. Biological criteria are the measures of regulatory success. They also offer techniques to quantify effects of disturbance other than traditional contaminants, e.g., habitat alteration.

Biological criteria are being developed for surface waters and several states have included them in their state water quality standards. The approach used for wetland biological criteria development will likely follow that used for other surface waters. A very simplified description includes 1) wetland classification, 2) selection of reference sites based on spatial considerations and/or wetland types, 3) collection of biological data from the reference wetlands, 4) development of biological measures to analyze the reference sites, and 5) assignment of a range of acceptability to the biological measures.

There will also be differences in the development of wetland biological criteria. Wetland distribution and their relationship to the landscape is not as clearly defined as that for other surface waters. Wetland macroinvertebrates and fish communities are less well documented than those of surface waters and it will require extensive research to develop community measures using these organisms. Wetlands are frequently dominated by vegetation and biological criteria based on vegetative characteristics will be required.

Biological criteria may also be developed for specific functional processes. For example, nitrification/denitrification rates may provide a means of estimating the health of the microbiota and this could be related to general wetland health. Bird indices may provide measures to integrate trophic levels for wetlands similar to fish community structure and trophic information for surface waters. Biological criteria will be necessary components of habitat protection and biological diversity.

Example Research Needs:

1. Classification of wetlands for determination of reference sites.
2. Biological assessments of reference sites.
3. Development of biological measures of ecological integrity.
4. Testing biological criteria over a range of wetland types.

<u>Aquatic Life Criteria</u>

The existing aquatic life numeric criteria are the primary surface water effluent regulatory tools. They are generally chemical specific and are derived using specific test protocols (Stephan et. al., 1985). There have been questions raised on the applicability of these criteria to wetlands because of some important physical, chemical and biological characteristics that differ between wetlands and many other surface waters. Differences which have caused concern include a wider pH range, higher organic carbon content, water level fluctuations ranging from flooded to dry, a different faunal composition, and a biomass dominated by higher plants.

Because of the complexity of deriving the numeric criteria and water quality differences between many surface waters and wetlands, it is important that the numeric criteria be carefully evaluated before they are indiscriminately applied to wetlands. An initial evaluation of the application of numeric criteria to wetlands was done at the Environmental Research Laboratory-Duluth, MN (ERL-Duluth), by Hagley and Taylor (1990). They concluded that numeric criteria are probably protective of most wetland types with standing surface waters. This conclusion is based primarily on the methodology used in the derivation of numeric criteria. The testing is designed to maximize the toxicity to the test organisms; the tests create conditions where toxicity is most likely to be expressed. Many of the physical and chemical conditions present in the wetlands would likely reduce the predicted toxicity as determined by the laboratory bioassays. For example, the high dissolved carbon content in wetland waters would likely reduce the toxicity of many nonpolar organic substances. Where there are questions on the application of the existing numeric criteria, it is suggested that the existing site-specific guidelines may provide options for adjustment. These adjustments may be as simple as using organisms common to wetlands in the criteria development data set or may in the extreme case involve a complete toxicological analysis and development of new numeric criteria specific to wetlands.

Whole effluent toxicity testing protocols are also being used to regulate surface water quality and could be extended to wetlands. This procedure uses a standardized toxicity test to assess effluent quality. An additional tool in this testing procedure is the toxicity identification evaluation (TIE), a tiered approach to identify classes of toxicants. However, before effluent testing and TIE can be applied to wetlands they will have to be tested using physical and chemical conditions typical of wetlands.

Example Research Needs:

1. Evaluation of existing aquatic life numeric criteria to determine their level of protection for wetlands.
2. Toxicological testing to determine if the exposure, duration and effects of toxicants on wetland organisms is similar to those of surface water organisms.
3. Development of toxicological testing protocols specific to wetland macrophytic vegetation.

Hydrologic Criteria:

There are no surface water criteria for the protection of wetland hydrology. Yet in terms of actual wetland impact, hydrologic change is the agent most responsible for loss. It is necessary to consider both insufficient and excess water in determining hydrologic criteria. With either condition, major changes in the wetlands will occur. Similarly, it is important to consider the hydroperiod because its variation will have serious structural and functional impacts. Hydrology is also one of the more complex parameters to monitor because it is necessary to continuously measure both surface and ground water. Techniques are, however, under development that relate long-term hydrologic measures, USGS river sampling data, to surface and ground water monitoring sites.

Because the knowledge and/or tools to develop hydrologic criteria are only beginning to be developed, it will likely be necessary to first regulate hydrology through a narrative criteria framework.

Example Research Needs:

1. Develop a theoretical basis for hydrologic criteria.
2. Develop relationships between hydrology and wetland structural and functional integrity.
3. Develop relationships between hydrology and the effects of other anthropogenic inputs, i.e., agricultural chemical runoff.
4. Develop indicators to assess the hydrologic state of a wetland.

Sediment Criteria

It is important to manage both wetland sediment quality and quantity. Excess sedimentation will modify the wetland hydrology. It is also necessary to judge whether a sediment is likely to be toxic if organisms become exposed to it because of normal habitat occupation or through sediment manipulation, e.g., dredge and fill activities.

The developmental philosophy for sediment toxicity criteria is somewhat different than traditional surface water numeric aquatic life criteria because the sediment toxicity criteria are being developed for classes of contaminants and sediment types rather than specific chemicals. An example of this approach follows. Acid volatile sulfide (AVS) (Di Toro, D.M., et.al., 1990) concentration in sediment is related to the capacity of the sediment to retain heavy metals. With increasing AVS, the sediments are able to retain additional heavy metals. Thus it is possible to determine the sediment carrying capacity for heavy metals and to assess whether this capacity is being exceeded. The AVS analysis also includes a toxicity identification component similar to the whole effluent testing procedure's TIE. It is important to define similar relationships in wetlands, where significantly different redox conditions exist, before it is presumed similar criteria are applicable.

Example Research Needs:

1. Determination of the effects of alternating sediment redox conditions on wetland sediment heavy metal retention.

2. Verify TIE approaches to toxicant identification for wetland sediments.
3. Development of procedures relating sediment carbon content and the toxicity of nonpolar organic substances.

Wildlife Criteria:

Wildlife support is one of the most visible and socially important wetland functional attributes and criteria to protect this are critical. Existing wildlife criteria focus on migratory waterfowl toxicity but they are being expanded to include additional avian and mammalian species. Criteria being developed for wildlife endemic to wetlands should have direct application to wetland organisms. Wildlife criteria may also represent a means to establish toxicity criteria for those wetlands lacking standing water. Wetlands of this type may require criteria more similar to terrestrial systems; criteria depending on chemical body burdens.

Example Research Needs:

1. Development of a toxicity database for wildlife specific to wetlands.

An important additional consideration in the development of wetland protective criteria will be defining "indicators" of wetland health. These will provide insight into the wetland condition without the necessity of extensive process level investigations. Ecological integrity could be determined by measuring surrogates of vegetation, hydrology, sediment or macroinvertebrate health. This research area is also being supported by EPA's Environmental Monitoring and Assessment Program (EMAP) and ORD's Wetland Research Program.

An approach integrating wetland protective criteria into a larger landscape management philosophy is being developed using landscape ecology principles (Gosslink et al. 1990). Studies assessing the importance of wetlands to landscape water quality improvement are being conducted at ERL-Corvallis. The approach uses a very general synoptic model which initially focuses on mapped data. The model will become more precise as additional model calibration data becomes available. Data derived while developing wetlands protective criteria will be an important model data source. The process will be iterative, the model's ability to estimate the water quality improvement function of wetlands on a broad spatial scale will become more precise as more of the data required for criteria development becomes available.

CONCLUSION:

Crucial to all aspects of wetland standards and criteria programs is integration of a variety of approaches into protocols that protect wetlands. Biological criteria are critical and their development is a high research priority. They will be extremely important in determining regulatory success and protecting ecological factors which currently lack protective criteria; e.g., habitat. Analysis of existing chemical specific numeric criteria suggests they are probably as protective of wetland water quality as they are of other surface waters. For those criteria that are not, existing mechanisms within the existing criteria development framework need to be evaluated as means to adjust the criteria. Hydrology is a primary driving variable for wetlands and criteria to protect wetlands from human induced hydrologic modifications are critical. It is important to develop narrative criteria because the experimental frame for numeric hydrologic criteria is lacking. Research into the development of sediment and wildlife criteria must include wetland environmental conditions. To extrapolate from the protection of single wetlands to the protection of the wetland resource, further landscape model development is essential.

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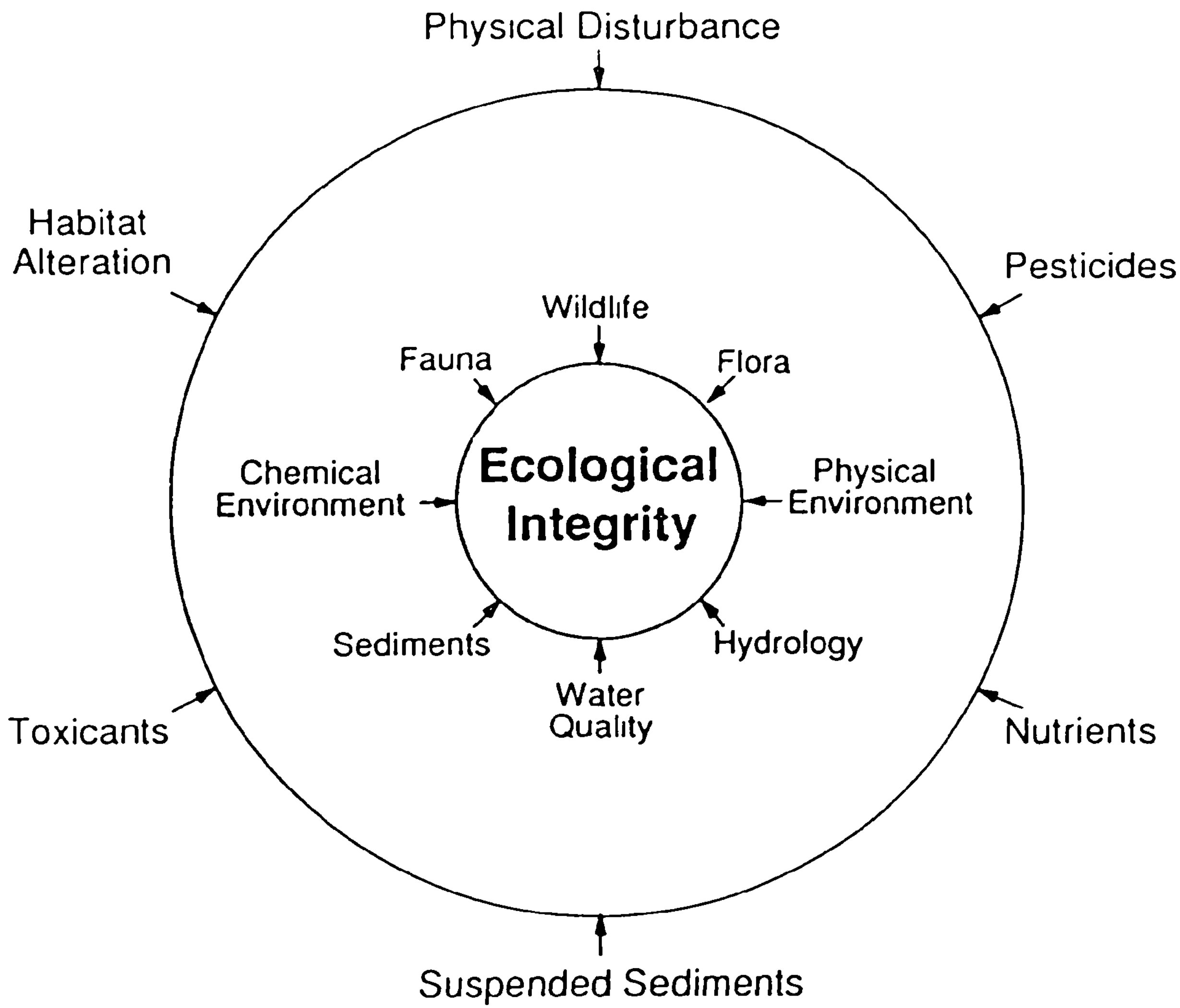
FIGURE 1


Physical Disturbance
Habitat Alteration
Pesticides
Wildlife
Fauna
Flora
Chemical Environment
Ecological Integrity
Physical Environment
Sediments
Hydrology
Water Quality
Toxicants
Nutrients
Suspended Sediments