ECOLOGICAL SIGNIFICANCE OF WETLANDS ON MINED LANDS

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Abstract

Wetland evaluation and mitigation criteria based on ecological principles is proposed as a guide to both regulatory agencies and the mining industry. These criteria may include Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and wildlife Service and/or other operational variables concerned with the severity of impact and the cost and technical aspects of mitigation. Regional numerical indices should be developed for established wetlands that impacted wetlands can be compared with on a regional basis. Mitigated wetlands should be concerned not only with the principal species being impacted by mining but also the ecology of the region. Wetlands may also be constructed for mine drainage abatement and also slurry pond reclamation. whenever possible, wetland developments should be encouraged to increase the diversity and productivity of mined lands.

Introduction

Concern over the decline in the number and size of wetlands has resulted in a revised federal regulatory strategy adopted in 1982. These revised regulations expanded the interpretation of normal or routine agricultural, mining, timber, and oil production activities so that regulatory agencies must evaluate the impact of these activities on wetlands prior to the issuance of a permit. Unless a variance is received, current regulations require that mining cannot occur within 90m (300 ft) of a wetland and cannot impact on the hydrologic or ecological balance of the wetland. In Pennsylvania for example, all wetlands, regardless of size or quality, are evaluated by at least two regulatory agencies, usually three or four, prior to the issuance of a mining permit. This current strategy of wetland protection will impact on mining activities in the glaciated and possibly other regions of the United States.

In some regions however, there is a strategy to relax the protection of wetlands associated with isolated water bodies, wetlands above the headwaters of tributaries to navigable streams and wetlands where designated activities are presumed to have only minor individual or cumulative adverse effects.[1] Unfortunately, this may not be the policy of individual state regulatory agencies, nor does it account for differences in the natural values of wetlands or their vulnerability to developmental pressure. The question is not whether the rationale should be an easing or strengthening of the regulations but that the regulations and resultant policies be based on sound ecological principles that enable wetlands to be evaluated in view of the ecology of the region as well as their potential for mitigation. The wetland impact and mitigation policy adapted by the U.S. Fish and Wildlife Service ranks the relative threat to wetlands according to their regional scarcity and their value to key wildlife species.[2] Many state and local regulatory agencies and private conservation organizations ignore these distinctions. Wetlands may be constructed on mined lands to: (1) enhance reclamation, (2) mitigate existing wetlands, (3) mine pollution abatement and (4) slurry pond reclamation. In the following discussions, a wetland evaluation and mitigation policy based on ecological principles is proposed as a guide to the mining industry that at the same time protect and enhance our wetland resources.

Rationale for Wetland-Evaluation

Wetland evaluation procedures must be specifically concerned with the effects of major disturbances, such as mining on wetland areas and, in addition, be able to evaluate a single wetland independently of others for its own intrinsic worth as a wildlife habitat or other functional value.[3] The Habitat Evaluation Procedure (HEP) developed by the U.S. Fish and Wildlife Service is applicable for determining habitat value as well as the development of a mitigation policy. The guidelines for evaluation and mitigation of wetlands are based on the following for resource categories:[4]

1. High value unique wetland. Wetland is of high value and irreplaceable on a national or regional basis. No loss of existing habitat will be allowed.
2. High value scarce wetland. Wetland is of high value for evaluating species and is scarce or becoming scarce on a national or regional basis. No loss of existing habitat value will be allowed, unless compensated for by replacement with the same type of wetland having the same habitat value.
3. High to medium value wetland. Wetland is of high or medium value for evaluation of species and is relatively abundant on a national basis. No loss of existing habitat value will be allowed, unless compensated for by replacement with wetland of comparable habitat (may not be same type) and every effort made to reduce impact or loss of existing wetland types.
4. Medium to low value wetland. Wetland is of medium to low value for evaluation of species (regardless of scarcity). If losses cannot be minimized, compensation with replacement or enhanced habitat may be recommended, depending on the significance of the potential loss.

These guidelines are applicable for the evaluation of wetlands as wildlife habitats but they should be based on developing habitat values for one or more key species.

Nelson and Weller proposed a rationale for the impact of development on wetlands which also applicable to mining. These authors suggest five orders of magnitude based on the extent of the impact and the cost of difficulty of mitigation.[1]

1. Immediate, total, and essentially irreversible impact due to draining, filling, or displacement of flooding, etc. which may be technically but not economically feasible to reverse.
2. Permanent, often far reaching and practically irreversible adverse change to the hydrology of the system resulting in loss of wetland vegetation and wet or dry cycles.
3. Enduring, often economically irreversible but gradual and relatively confined changes to wetland soils and substrate from erosion, sedimentation and chemical contamination.
4. Chronic, sometimes persistent and widespread, but usually low level water quality deterioration from nutrient enrichment or toxic compounds.
5. Temporary, usually localized damage to soils, water quality, vegetation, and environmental aspects due to increased turbidity or similar phenomena.

As with any evaluation criteria, there are numerous factors which may modify the severity of impact at any order of magnitude and these factors may vary from one geographic area to another. Nelson and Weller, therefore, developed four general categories as a guide for evaluating the impact on wetland systems.

1. Operations variables. Distribution, scale, and types of activity, frequency, duration and season of activity, location of activity within an ecosystem.
2. Physical and chemical variables. Hydrological regime and water dynamics, particulate composition of soils and sediments, chemical composition of water and sediments.

3. Biological and -ecological variables. Habitat diversity and carrying capacity, Population abundance, diversity, and productivity, ecosystem stability, resistance and resilience, presence of key species important to the ecosystem.

4. Public interest variables. Regional scarcity of affected habitat types, abundance of sport and commercial populations, presence of endangered or threatened species.

These five orders of impact and operational variables provide criteria for determining the severity of impact as well as a framework for mitigation. The five orders of impact are concerned with the cost of technical aspects of mitigation, whereas the modifying factors introduce ecological and public interest variables into the evaluation process. Cardamone et al. suggested that a numerical index be assigned to wetlands on the basis of a comparative analysis of wetlands in the region.[4] This index should be based on the biological, ecological, and hydrological features in conjunction with aesthetic values and uniqueness to the area. For example, a wetland that contains endangered species and a carrying capacity of 20 waterfowl/ha and was the only wetland in the region would have a higher numerical index than a wetland without endangered species, a carrying capacity of

5 waterfowl/ha and was one of several in the region. However, the total size and carrying capacity must be taken into account as well. Once a wetland has been evaluated as to the impact of mining, a determination must be made as to whether or not to mine the site in a manner that would not impact on the system or to mitigate the wetland in a manner that would be compatible with the ecology of the region.

Wetland - Acid Mine Drainage Abatement

Wetlands, in recent years, have been shown to be effective in reducing the impact of acid mine discharges on stream systems. This reduction may be a result of the precipitation of metal ions due to an increase in pH and retention time and/or the uptake of metallic ions by the plants themselves. Although the exact mechanisms are not understood, wetland plants take up and concentrate ferric ions and, to some degree, manganese oxidizing bacteria present in the soil, on the roots (rhizomes) of wetland plants or on the plant itself (algae). Preliminary data suggest that a significant relationship exists between the number of bacteria in the soil surrounding the root (rhizomes) of wetland plants and the concentration of iron ($r2 = 0.61$ 1 $P > 0.05$) and manganese ($r2$ 0.93, $P > 0.01$) concentrations in the tissues. Further research on the ecology and physiology of these systems will be necessary before we fully understand the physical, chemical and biological processes involved in the abatement of acid mine discharges. At present, they appear to be a promising alternative to the chemical treatment of acid mine drainage.

Table 1. Iron, manganese and aluminum concentrations in four plants growing in wetland receiving acid mine drainage in Butler County, Pennsylvania.

	Iron (mg/kg)		Manganese (mg/kg)		Aluminum (mg/kg)	
Plant Species	Root	Leaf	Root	Leaf	Root	Leaf
Cattail (Typha latifolia)	225.3	199.0	3.1	9.6	3.1	2.1
sedge (Cyperus spp)	134.9	95.3	7.1	8.2	3.9	6.6
Spike Rush	260.5	57.7	1.3	2.4	3.0	9.5
(Eleocharis spp) Spirogyra	----	51.8		3.3		2.1

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Wetland Development From Slurry Ponds.

At several mine sites in the midwest, slurry ponds have been reclaimed as productive wildlife areas. 14,15 Slurry consists of a mixture of water and the fines that remain after the coal has been cleaned, this mixture is then discharged into a depression for storage. Because of its pyritic sulfur content and acid producing potential, slurry is considered a potentially toxic substance by OSM and must be disposed of in a prescribed manner. Current regulations require that slurry be covered with at least 1.2m (4 ft.) of non-toxic material and revegetated. This procedure is not only costly to the mine operator but also generally results in land that has limited potential for secondary reclamation.

As an alternative to the prescribed method of slurry pond reclamation, researchers at Southern Illinois University and AMAX Coal Company are developing viable wetlands on slurry disposable sites. The company received an Experimental Practices Permit under Section 711 of SMCRA which allows them to develop an alternative for slurry pond reclamation. Briefly, the procedure involves the determination of highly toxic materials and covering them with top soil according to OSM regulations; then the remainer of the pond are revegetated with wetland species. Species are selected and planted according to the water depth and available moisture in each zone (Appendix Table 1). This alternative to slurry pond reclamation enabled the development of a viable wetland with the pH of both the slurry and water returning to acceptable pH ranges. Reclaimed slurry ponds are currently being used by migrating and nesting Canada Geese (Branta canadenesis), blue and green-winged teal (Anas discors, A. carolinensis), great blue herons (Ardea herodias) and a variety of shore birds. The deep water portions are supporting a viable sport fishery (Thompson 1984). In addition to developing a valuable wildlife habitat, the company was able to reduce their reclamation costs by approximately 80 percent.[15] These procedures should be given serious consideration by regulatory agencies and the coal industry as an alternative to slurry pond reclamation.

Wetland Mitigation And Enhancement

For over four decades, wetlands have been left as an aftermath of surface mining and many of these areas have been shown to be beneficial for fish and wildlife,[5,6] especially waterfowl.[7,8,9] However, when wetlands have to be mitigated, prime consideration should be given the principal species affected by the disturbance of the natural system. For example, if the disturbed wetlands contained nesting and feeding areas for woodcock (Philohela minor), then habitat suitable for this species should be developed during mitigation. In the future, the development of woodcock habitat should be given prime consideration during reclamation regardless of whether mining impacted on woodcock habitat since breeding populations of this species has been declining in the northeast for several years.

In both the northeast and midwest, waterfowl and shorebirds nest on reclaimed mined lands as well as use these man-made wetlands for nesting and feeding during mitigation. Waterfowl and shorebird habitat developments on mined lands should include shallow areas for feeding along with nesting islands and appropriate nesting cover along the shore. Shorelines should be constructed as irregularly as possible, thereby providing sufficient edges for feeding and nesting by waterfowl. In some areas, it may be desirable to develo wetlands for specific species including those that may be threatened or endangered. 10,1 In other areas, it might be beneficial to the ecology of the region to provide diversity of habitats suitable for a variety of species. In general, a variety of species should be planted according to hydrologic regimes of the reclaimed wetland (Appendix Table 1), thereby developing a diverse and productive ecosystem which according to theoretical studies on ecosystem dynamics suggest that diversity and productivity are indicative of ecosystem stability. 12,13 In order to achieve diversity and reconstruct natural systems, studies are currently underway in Pennsylvania involving removing wetland vegetation and bottom sediments from natural wetlands and transporting them to a mitigated wetland on mined lands.

To evaluate the success of this program, the diversity and productivity of these wetlands are being compared with mitigated wetlands revegetated with wetland species and natural systems in the same region. Three or four hedgerows of wildlife tree and shrub species separated by 6-7 m grass-legume strips should be planted around each wetland on the site.

Regardless of whether mine operators are required to mitigate wetlands, the development of these habitats should be encouraged whenever water conditions and terraine are suitable and the landowner(s) approves of their construction. In addition, it may be desireable to plant wetland species in sediment and treat slurry ponds once mining has been completed, thereby developing these areas as fish and wildlife habitats.[14,15] All wetland systems should be planned to be as resilient as possible: That is, developed to a successional stage suitable for the desired species as quickly as possible. As with all ecosystems, wetlands on mined lands will have to be managed so that they will remain in the successional stage(s) most advantageous to the principal species of concern.[11] Brooks and Hi11[16] reported that there were 18 percent more Palustrine wetlands on mined lands than on unmined lands in Pennsylvania and these authors as well as Brenner 10111 indicated that wetlands should be encouraged on mined lands and managed for either diverse communities or for individual or groups of species.

Conclusions

Criteria used to evaluate wetlands should include their value as wildlife habitat, hydrologic features, and their importance in the overall ecology of the region. Whenever possible, a numerical index should be assigned to wetlands on the basis of a comparative analysis of wetlands in the region. The criteria used in the evaluation should include a determination of the severity of impact and a framework for mitigation. Whenever wetlands are developed on mined lands, they may be either designed for specific species or contain a diversity of habitats suitable for a variety of species. wetlands should be encouraged on all mined lands regardless of whether wetlands were impacted by mining in order to increase the diversity and productivity of mined lands.

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APPENDIX

Table 1. Wetland species recommended for planting on mitigated wetlands in the eastern and midwestern United States.

	Common Name	Species Name
1 Wet Soils		
A. Herbaceous Species		
	Lovegrass -	Eragrostis reptans
	Orchard Grass	Dactylis glomerta

Fescue	Festuca elatior
B. Trees and Shrubs	
Lespedeza	Lespedeza spp.
Dogwoods	Cornus spp.
Smooth Alder	Alnus rugosa
Red Maple	Acer Rubrum
Pin Oak - Quercus	palustris
Red Oak	Quercus rubra
2. Intermediate Zone - periodic flooding	
A. Herbaceous Species	
Millet	Echinocloa spp.
Switch Grass	Panicum virgatum
Cord Grass	Spartina pectinata
Nut Sedge	Cyperus spp.
Reed Canary Grass	Phalaris arundinacea
B. Trees and Shrubs	
River Birch	Betula nigira
Pin Oak	Quercus palustris
Alder	Alnus rugosa
Buttonbush	Cephalanthus occidentalis
3. Shallow Water Zone	
A. Maximum Depth 15 cm (6 inches)	
Herbaceous Species	
Millet	Echinochloa spp.
Rice Cutgrass	Leersia spp.
Spike Rush	Eleocharis spp.
American Lotus	Nelumbo lutea
Trees and Shrubs	
Buttonbush	Cephalanthus occidentalis
Bald Cypress	Taxodium distichum
B. Maximum Depth - 25 7-m (10 inches)	
Herbaceous Species	
Burreed	Spargariaceae spp.
Smartweed	Polygonum spp.
Spike Rush	Eleocharis spp.
Cattail	Typha latifolia
Arrowhead	Sagittaria spp.
Hardstem Bulrush	Scirpus acutus
Trees and Shrubs	
Bald Cypress	Taxodium distichum
C. Maximum Depth - 45 (18 inches)	
Herbaceous Species	
Arrowhead	Sagittaris spp.
Wild Rice	Zizania aquatica
Hardstem Bulrush	Scirpus acutus
Pickerel Weed	Pontederia spp.
4. Deep Water Zone	
A. Depth 0.3 - 0.6 m (1-2 ft.)	
Arrowhead	<u>Sagittaria</u> spp.
Yellowwater Lilly	<u>Nuphar</u> spp.
B. Depth 0.3-1 m (2-3 ft.)	
Sago Pondweed	<u>Potamogeton pectinatus</u>
Wild Celery	<u>vallisneria</u> americana
C. Depth 1-2 m (3-6 ft.)	
Coontail	<u>Ceratophyilum demersum</u>
Elodean	<u>Anacharis canadensis</u>
Muskgrass	Characeae spp.

Pondweed	<u>Potamogeton</u> spp.
Water Millfoil	<u>Myiphyllum</u> spp.

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   - A. Herbaceous Species
     - Lovegrass - <u>Eragrostis reptans</u>
     - Orchard Grass - <u>Dactylis glomerta</u>
     - Fescue - <u>Festuca elatior</u>
   - B. Trees and Shrubs
     - Lespedeza - <u>Lespedeza</u> spp.
     - Dogwoods - <u>Cornus</u> spp.
     - Smooth Alder - <u>Alnus rugosa</u>
     - Red Maple - <u>Acer Rubrum</u>
     - Pin Oak - <u>Quercus palustris</u>
     - Red Oak - <u>Quercus rubra</u>
2. Intermediate Zone - periodic flooding
   - A. Herbaceous Species
     - Millet - <u>Echinocloa</u> spp.
     - Switch Grass - <u>Panicum virgatum</u>
     - Cord Grass - <u>Spartina pectinata</u>
     - Nut Sedge - <u>Cyperus</u> spp.
     - Reed Canary Grass - <u>Phalaris arundinacea</u>
   - B. Trees and Shrubs
     - River Birch - <u>Betula nigra</u>
     - Pin Oak - <u>Quercus palustris</u>
     - Alder - <u>Alnus rugosa</u>
     - Buttonbush - <u>Cephalanthus occidentalis</u>
3. Shallow Water Zone
   - A. Maximum Depth - 15 cm (6 inches)
     - Herbaceous Species
       - Millet - <u>Echinochloa</u> spp.
       - Rice Cutgrass - <u>Leersia</u> spp.
       - Spike Rush - <u>Eleocharis</u> spp.
       - American Lotus - <u>Nelumbo</u> lutea
     - Trees and Shrubs
       - Buttonbush - <u>Cephalanthus occidentalis</u>
       - Bald Cypress - <u>Taxodium distichum</u>
   - B. Maximum Depth - 25 cm (10 inches)
     - Herbaceous Species
       - Burreed - <u>Spargariaceae</u> spp.
       - Smartweed - <u>Polygonum</u> spp.
       - Spike Rush - <u>Eleocharis</u> spp.
       - Cattail - <u>Typha latifolia</u>
       - Arrowhead - <u>Sagittaria</u> spp.
       - Hardstem Bulrush - <u>Scirpus acutus</u>
     - Trees and Shrubs
       - Bald Cypress - <u>Taxodium distichum</u>
   - C. Maximum Depth - 45 cm (18 inches)
     - Herbaceous Species
       - Arrowhead - <u>Sagittaris</u> spp.
       - Wild Rice - <u>Zizania aquatica</u>
       - Hardstem Bulrush - <u>Scirpus acutus</u>
       - Pickerel Weed - <u>Pontederia</u> spp.

4. Deep Water Zone
   A. Depth 0.3 - 0.6 m (1-2 ft.)
      Arrowhead - *Sagittaria* spp.
      Yellowwater Lilly - *Nuphar* spp.
   B. Depth 0.3-1 m (2-3 ft.)
      Sago Pondweed - *Potamogeton pectinatus*
      Wild Celery - *Vallisneria americana*
   C. Depth 1-2 m (3-6 ft.)
      Coontail - *Ceratophyilum demersum*
      Elodean - *Anacharis canadensis*
      Muskgrass - *Characeae* spp.
      Pondweed - *Potamogeton* spp.
      Water Millfoil - *Myriphyllum* spp.