FIRST YEAR EVALUATION OF MITIGATED WETLANDS ON TWO MINE SITES IN WESTERN PENNSYLVANIA[1]

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Abstract.--Twenty-two hectares (56 acres) of wetlands were established on two (Guarnieri abd Edwards) mine sites in western Pennsylvania at approximately the same cost that would have been incurred if the land had been returned to approximate original contour (AOC) according to current regulations. Of the 833 plants comprising 24 species that were found on 22 quadrates of the Guarnieri Mine, 752 or 90.3 percent and 19 species were volunteers, while on the Edwards Mine a total of 127 individual plants comprising 9 species occurred on the five quadrates. Of these, 63 or 40.6 percent comprising 7 species volunteered on this wetlands. The density of plants averaged 37/m^2 and 25/m^2 on the Guarnieri and Edwards Mines, respectively. During the first year over 40 species of wildlife, including six species of special concern in Pennsylvania, used these wetlands for some phase of the life history. These wetlands provide additional ecological diversity to the mine sites, and the excellent response by wildlife to these areas will enhance the overall ecology of the region.

INTRODUCTION

For over four decades, wetlands have been left as an aftermath of surface coal mining, especially in the eastern (Brenner and Steiner 1987) and midwestern (Jones et al. 1985) coal regions of the United States. These wetlands provide habitat for a variety of wildlife species, including amphibians (Brooks et al. 1985, Fowler et al. 1985), reptiles (Brooks et al. 1985), birds, and mammals (Brenner and Kelly 1981, Brenner et al. 1982, Brooks et al. 1985). In both the East and Midwest, several studies have documented the use of these wetlands by nesting waterfowl and shorebirds (Brenner 1973, Brenner and Mondok 1979, Sandusky 1978, Thompson 1984) as well as their use for resting and feeding during migration (Brenner and Steiner 1987). In addition to their value as wildlife habitats, many of these wetlands support valuable warm water fisheries (Brenner 1983).

Although these wetlands have been shown to be used extensively by wildlife, they were often left as an afterthought with little if any planning for their integration into the overall reclamation of the site. The primary objective of this paper is to describe and discuss how different types of wetlands may be integrated into the overall reclamation of mined lands as well as what additional costs may be incurred by coal companies. For over a decade, I have advocated the development of wetlands on mined lands (Brenner 1973, 1983) including special areas designed for rare and endangered species (Brenner 1985, 1986). In this paper, the construction, establishment of wetland vegetation, and their use by wildlife will be discussed in light of overall ecology of reclaimed mined lands.

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A total of approximately 22.4 ha (56 acres) of wetlands was developed on two mine sites in northwestern Pennsylvania as part of a mitigation and reclamation plan developed by Adobe Mining, Inc. On the site hereafter referred to as the Guarnieri Mine, seven Palustrine and one deep water habitat totaling 19.2 ha (48 acres)($\bar{X}$ 2.4 ha, 6 acres) were developed on a 73.6 ha (184 acre) mine site to replace approximately 4.8 ha (12 acre)($\bar{X}$ 1.2 ha, 7 acre) of Palustrine wetlands on an adjacent active mine. The Palustrine wetlands consisted of a sedimentation pond, a deep water habitat, and six other areas constructed during site reclamation. Water level control devices were installed on four of the Palustrine wetlands, the sedimentation pond, and the deep water habitat so that, if necessary, water levels could be controlled for the management of aquatic vegetation. All water courses installed on the site were diverted into the wetland complex. Six of the wetlands were designed to allow excessive rainfall (25 yr. event) to overflow from the emergency spillways into the deep water habitat, which could then overflow into the sedimentation pond which in turn drained into a natural wetland complex owned and managed by the Pennsylvania Game Commission. A 0.2 ha (0.5 acre) island was constructed approximately in the center of the deep water habitat to provide additional waterfowl nesting habitat.

On a second mine site hereafter referred to as the Edwards Mine, three Palustrine wetlands totaling 3.2 ha (8 acre) were constructed to replace a 1.8 ha (4.6 acre) Palustrine wetland removed during mining of the site. The total affected area was approximately 25 ha (100 acre). As with the Guarnieri Mine, one wetland was a converted sedimentation basin and two were constructed during reclamation. All water courses were diverted into these wetlands so that adequate water levels could be maintained. One 1.4 ha (3.5 acre) Palustrine wetland was constructed with irregular shorelines along with five islands to increase the amount of edge and thereby provide additional feeding and nesting areas available for waterfowl. On both mines, nonwetland areas were planted with trees and shrubs interspersed among the grasslands (grasses and legumes) to provide additional habitats for upland wildlife species.

CONSTRUCTION

Two different procedures were used for the construction and establishment of wetlands on these sites. On the Guarnieri Mine, two wetland sites received material transported to the sites from natural Palustrine wetlands located on an adjacent active mine site. Once the upper 60 cm (24 inches) of material was removed and stockpiled at the site, the underlying clay and muck was removed, transported, and spread in the newly constructed wetland. Once this phase was completed, the stockpiled material was transported and placed in the wetland. Within five working days, the construction and transportation phase of the project was completed and water was released into the sites. These areas did not receive supplemental plantings of wetland species. This project was scheduled to be completed either in late fall or early spring when the plants would be dormant but, due to excessive delays in the permitting process, it was not completed until late April. To date, on the remaining six wetland sites, a total of 14,150 individual plants, comprising 10 different species have been planted and the areas seeded with 50 lbs of coontail (Ceratophyllum demersum) along with 480 lbs of grasses and legumes, all according to the hydrologic regime existing at each site (table 1). In addition, a total of 3,750 trees and shrubs representing 16 species were planted either adjacent to the wetlands or in upland areas, depending on site conditions (table 2). The total cost of supplemental plantings was $7,325 which includes $5,509 and $1,816, respectively, for plant materials and labor.

Table 1.--Varieties and quantities of wetland species planted or seeded on the Guarnieri and Edwards Mines in 1987.

SPECIES	NUMBER PLANTED/LB SEEDED	
	Guarnieri Mine	Edwards Mine
Sago Pondweed (Potamogeton pectinatus)	1000	500
Wild Cherry (Vallisneria spinalis)	1000	500
Arrowhead (Sagittaria spp.)	1000	500
Duck Potato (Sagittaria rigida)	1000	500
Burreed (Sparganium eurycarpum)	2000	1000
Three Square Rush (Scirpus flaviatilis)	2000	1000
Sweet Flag (Acorus calamus)	2000	1000
Nodding Smartweed (Polygonum mahlenbergh)	2000	1000
Pickerel Weed (Pontederia cordata)	2000	1000
Buttonbush (Cephalanthus occidentalis)	150	100
Coontail (Ceratophyllum demersum)	50 lb	25 lb
Switchgrass (Panicum virgatum)	100 lb	40 lb
Reed Canary Grass (Phalaris arundinacea)	150 lb	60 lb
Millet (Echinochloa crusgalli)	100 lb	100 lb
Lespedeza Mixture (Lespedeza spp.)	80 lb	40 lb

The overall reclamation costs to the company were approximately the same as would have occurred if they were approximately the same as would have occurred if they would have returned the land to the approximate original contour (AOC) as required by current regulations.

On the Edwards Mine, a natural Palustrine wetland was transported into a 1.4 ha (3.5 acre) wetland constructed on the same site. The same procedure was followed as at the Guarnieri Mine for the removal, storage, and transportation of material between the natural and manmade system except that scrapers rather than trucks were used to transport the material. Since this project was initiated in the middle of August, water from the active pit (pH 7.0-7.2) was pumped into the site as soon as all material was in place. The total time lapse from the start of the project until there was sufficient water to maintain the system was approximately 10 days. To date, a total of 9050 individual plants and 265 lb of seeds representing 27 different species have been planted on the site (tables 1 and 2). The total cost of the establishment of vegetation at this entire 3.2 ha (8 acre) wetland complex was approximately $3,772 of which $2,866 and $906 was for material and labor, respectively. As with the Guarnieri Mine, reclamation costs to the company were approximately the same as would have been incurred if the land was returned to AOC as required by current regulations.

RESPONSE OF WETLAND VEGETATION

On both mines, there was good survival and growth of vegetation on both the transplanted wetlands as well as those receiving supplemental plantings of wetland species. In order to assess the response of natural revegetation of wetland species on the Guarnieri Mine, 22 m^2 quadrates were established on five wetlands, three of which received supplemental plantings and two which received wetland soil and plant material from the adjacent mine site. Of the total 833 individual plants found on the quadrates (not including Nitella and Lemna minor), 752 or 90.3 percent were volunteer species. Nitella and Lemna minor had a density of approximately 15/cm^2, respectively. Nineteen of the 24 species identified on these wetlands were a result of volunteer invasions and/or from seeds or root stocks present in the material transported from the adjacent mine site. The number of species/m^2 and the density of plants/m^2 on those wetlands that received supplemental plantings did not differ from those that received the transplanted wetland material. Between 8 and 13 different species occurred on the individual quadrates receiving supplemental plantings compared to the 8 or 9 species that occurred on the transplanted sites, and the average number of plants was 36 (32-41) and 38 (23-53) individuals/m^2 for those areas that received supplemental plantings and those that received wetlands soils, respectively. The principal species occurring on all wetlands on the Guarnieri Mine included Echinochloa muricata, Eleocharis obtusa, Bidens frondosa, Panicum capillare, and Polygonium sagittatum (table 3). In addition to these species, sensitive fern (Onochlea sensiblis), skunk cabbage (Symplocarpus foetidus) along with rushes (Juncus spp.), and sedges (Carex spp.) were observed on the transplanted wetlands, but they did not occur on the randomly selected quadrates. Throughout the transplanted wetlands, numerous dogwoods (Cornus spp.), black willow (Salix nigra), and buttonbush (Cephalanthes occidentalis) were observed sprouting from root stocks present in the soil. On the wetlands that received supplemental plantings of wetland species, the species in the shallow and intermediate depth zones became established within two

Table 2. Varieties and quantities of trees and shrubs planted on the Guarnieri and Edwards Mines in 1987.

SPECIES	NUMBER PLANTED	
	Guarnieri Mine	Edwards Mine
Red Oak (Quercus rubra)	300	200
Pin Oak (Quercus palustris)	300	100
Bur Oak (Quercus macrocarpa)	200	100
White Oak (Quercus alba)	100	—
Swamp Oak (Quercus bicolor)	200	—
Scrub Oak (Quercus ilicifolia)	200	—
Washington Hawthorne (Crateagus phaenopyrum)	300	200
Amerucan Plum (Prunus americana)	150	100
American Crabapple (Pyrus coronaria)	100	—
White Ash (Fraximus america)	—	100
Silky Dogwood (Cornus amomum)	700	300
Gray Dogwood (Cornus racemosa)	150	100
Buckthorn (Rhomnus cathartica)	200	100
European Black Alder (Alnus glutinosa)	500	500
Norway Spruce (Picea abies)	150	100
Black SPruce (Picea mariana)	100	50
Scotch Pine (Pinus sylvestris)	100	—

Table 3.--Plant species found on quadrates on wetland sites on the Guarnieri and Edwards Mines during September and October 1987.

SPECIES	NUMBER OF INDIVIDUALS Guarnierei Mine	EDwards Mine
Arrow Leaved Tearthumb (Polygonium sagittatum)	45	0
Smartweed (Polygonium natens)	3	0
Water Smartweed (Polygonium obtusa)	1	0
Spike Rush (Eleocharis obtusa)	118	8
Wild Millet (Echinochloa muricata)	130	2
Bur- marigold (Bidens frondosa)*	115	19
Panic Grass (Panicum capillare)	212	16
Bur-reed (Sparganium eurycarpum)	45	3
Rice Cut Grass (Leersia oxyzoides)	5	0
Goldenrod (Solidago lepida var. elongata)	23	0
Sedge (Cyperus strigosus)	10	0
Shepherd's Purse (Capsella Bursa-pastoris)	7	0
Cup Grass (Eriochloa contracta)	31	0
Red Clover (Trifolium pratense)*	21	35
White Clover (Trifolium repens)*	2	26
Cattail (Typha latifolia)	47	2
Ragweed (Ambrosia artemisiifolia)	0	16
Arrowhead (Sagittaria spp.)*	4	0
Sago Pondweed (Potomageton pectinatus)	4	0
False Loosestrife (Ludwigia spp.)	3	0
Birdsfoot Trefoil (Lotus corniculatus)*	5	0
Pokeweed (Phytolacca americana)	1	0
Foxtail (Setaria glauca)	1	0
Musk Grass (Nitella spp.)	15/cm^2	10/cm^2
Duckweed (Lemna minor)	74/cm^2	0
TOTAL	752	127

*Planted during reclamation

months of planting and those in the deep zone are beginning to become established. The success of these species, however, cannot be firmly established until the end of the second growing season.

On the Edwards Mine, the response of vegetation on the site that received the transplanted material was not as rapid as it was on the Guarnieri Mine. Significant natural regeneration of wetland plants did not occur until the following spring, probably due, at least in part, to the fact that natural material was not placed into the newly constructed wetland until August. During the following spring and summer months, however, the response of those species that did regenerate naturally as well as the supplemental species in the shallow water zone showed excellent survival and growth.

In contrast to the Guarnieri Mine, only a total of nine species were present on the five quadrates and of those, two species (Trifolium pratense and T. repens) probably invaded from adjacent upland areas. A total of 127 individual plants were found on this wetland, and of these, 63 or 40.6 percent were volunteers. Between four and six species were on the individual quadrates and the average density was 25 (22-29) individuals/m^2. This wetland has a dense grass and legume cover immediately adjacent to the relocated wetland, and this dense cover, in conjunction with elevated water levels over the transplatned wetland materials, may be factors in the reduction in the number of volunteer species becoming established on this wetland.

WILDLIFE USE

Over 30 species of birds, including 5 species of special concern in Pennsylvania (Genoways and Brenner 1985) were observed using these wetlands and adjacent uplands during the first year (table 4). At least five broods of Canada geese and three mallard broods were observed using this wetland complex. During the summer months between 100-300 Canada geese and over 100 mallards, black ducks (Anas rubripes), blue-winged teal, and wood ducks, along with approximately 20 spotted sandpipers and several great blue herons and green herons (Butorides striatus) were observed feeding on these wetlands and adjacent uplands on a regular basis. The use of the Edwards Mine by wildlife was not as great as it was on the Guarnieri Mine, with only 20 species of birds including three species of special concern (Genoways and Brenner 1985) being observed using this site on a frequent basis (table 4). These wetlands were used for

Table 4.--Species of birds using the Guarnieiri adn Edwards Mines during the spring and summer months of 1987.

FAMILY	COMMON NAME	GUARNIERI MINE	EDWARDS MINE
Ciconiiformes	Great Blue Heron - Ardea herodias*	X	X
	Green Heron - Butprides striatus	X	X
Anseriformes	Whistling Swan - Olor columbians	X	
	Canada Geese - Branta canadensis	X	X
	Mallard - Anas platyrhynchos	X	X
	Black Duck - Anas rubripes	X	
	Blue-winged Teal - Anas discors	X	X
	Gadwall - Anas streperea	X	
	Wood Duck - Aix sponsa	X	X
	Ring-necked Duck - Aythya collaris	X	
	Greater Scaup - Aythya marila	X	
	Bufflehead - Bucephala albeola	X	
	Ruddy Duck - Oxyura jamaicensis	X	
	Hooded Merganser - Lophodytes cucullatus	X	
Podicioedifornes	Pied-billed Greb - Podilymbus podiceps	X	
Falconiformes	Red-tailed Hawk - Buteo jumaicensis	X	
	American Kestrel - Falco sparverius	X	
	Northern Harrier - Circus cyaneus*		X
Gruiformes	American Coot - Fulica americana	X	
	King Rail - Rallus elegans*	X	
Charadriiformes	Herring Gull - Larus argentatus		X
	Killdeer - Charadrius vociferus	X	X
	Spotted Sandpiper - Actitis macularis	X	X
	Upland Plover - Bartramia longacauda*	X	
	American Woodcock - Philohela minor	X	
	Willet - Catoptrophorus semipalmatus	X	
Columbiformes	Mourning Dove - Lenaida macroura	X	X
Coraciiformes	Belted Kingfisher - Megaceryle alcyon		X
Passeriformes	Red-winged Blackbird - Agelaius phoeniceus	X	X
	Eastern Meadowlark - Sturnella magna	X	
	Bobolink - Dolichonyx oryzivorus*	X	
	Song Sparrow - Meospiza melodia	X	X
	Field Sparrow - Spizella pusilla	X	X
	Vesper Sparrow - Pooecetes gramineus*	X	X
	Chipping Sparrow - Spizella passerina	X	X
	Common Grackle - Quiscalus quiscula	X	
	Barn Swallow - Hirundo rustica	X	X
	Tree Swallow - Iridoprocne bicolor	X	X

* Listed as species of special concern in Pennsylvania.

feeding on a regular basis by between 25-50 Canada geese and between 15-25 mallards, blue-winged teal, and wood ducks. During the past summer, six and four wood duck nesting boxes were placed on the Guarnieri and Edwards Mines, respectively, and six blue bird nesting boxes were placed on each mine.

In addition to birds, these areas were also used by several mammal species, including muskrat, mink, raccoon (Procyon lotor) and white-tailed deer (Odocoileus virginianus). On both the Guarnieri and Edwards Mines, wetlands provided additional ecological diversity to these sites and the excellent response of wildlife to these areas will enhance the overall ecology of the region. The response of the vegetation and the use of these areas by wildlife will be studied over the next several years to determine feasibility and economic benefits of wetland relocation and/or development to the overall ecology of the region.

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