

MONTANDON MARSH: A VEGETATION DESCRIPTION OF A POTENTIALLY ENDANGERED WETLAND¹

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ABSTRACT

A descriptive analysis of the vegetation and soils of Montandon Wetlands in Northumberland County, Pennsylvania was conducted to provide baseline data against which to compare future vegetation dynamics. Compositional and abundance changes within the vegetation communities may be linked to ongoing successional patterns and/or natural fluctuations in the hydrologic regime, or to nearby sand and gravel mining scheduled to begin within the next year or two. Montandon Wetlands provide habitat for notable populations of six Plants Of Special Concern In Pennsylvania: *Carex bullata*, *Leptoloma (Digitaria) cognatum*, *Juncus scirpoides*, *Ludwigia polycarpa*, *Rotala ramosior*, and *Schoenoplectus (Scirpus) fluviatilis*. Aerial photographs and extensive ground reconnaissance provided the basis for description of five vegetation associations: marsh, hummocks and hollows, wet meadows, woods, and communities that have established in the few sites that were mined during the 1950's and 60's. To quantitatively assess community composition, a series of parallel transects was placed at each of three sites within the 50-hectare (ha) wetland complex; each series was bracketed by transects in the uplands. The vegetation assemblages catalogued along these transects were correlated with underlying soils and topography. Vegetation assemblages and soil chemistry varied with topographical position and soil types. Dominant and characteristic

plant species at each transect differed, apparently due to topographic position (i.e., inundation levels), and soil type and chemistry. The percentage organic matter in the soil generally increased from uplands to wetlands, while phosphorus generally decreased with distance from the cultivated fields that border the western edge of the marsh. Recommendations for restoration of the area to be mined and for management of Montandon Wetlands include: maintaining the current hydrologic patterns in the naturally occurring wetlands, buffer zones, continued monitoring, creation of viable native wetlands in the mined area. Suggestions for the area to be mined consider creation of self-perpetuating wetlands. A conservation easement should be an integral component to preserving this valuable natural area.

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INTRODUCTION

Forty-eight percent of all species of special concern (those listed as threatened, endangered or rare by state or federal government) in the United States are associated with wetlands. Unfortunately, their number continues to grow. The United States is losing over 182,000 ha of wetlands per year (Kusler and Kentula 1990). Pennsylvania experienced a net loss of 11,330 ha of wetlands between 1956 and 1979. This level of wetlands destruction (on average 485 ha lost per year) continued through the 1980's (Davis 1989). If conservation efforts continue to be undermined by economic and political objectives, the loss of these valuable natural areas will continue.

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The Montandon Wetlands complex (the wetlands) consists of the most significant graminoid marsh within central Pennsylvania (U.S. Fish and Wildlife Service 1990). The wetlands are interspersed with upland habitats and sand dunes. Six extant Plants Of Special Concern In Pennsylvania (POSCIP, PA Code Title 25 1987) can be found within this complex of xeric to hydric habitats. Three of these species are listed as endangered: *Carex bullata* Schkuhr ex Willd. (bull sedge), *Juncus scirpoides* Lam. (scirpus-like rush), and *Ludwigia polycarpa* Short & Peter (false loosestrife). *Leptoloma (Digitaria) cognatum* (Schultes) Chase (fall witchgrass), is listed as threatened; and two POSCIP species are listed as rare: *Rotala ramosior* (L.) Koehne (tooth-cup) and *Schoenoplectus (Scirpus) fluviatilis* (river bulrush). The *Carex bullata* population is one of only two remaining populations in the state, the *Juncus scirpoides* stand is the only extant population within Pennsylvania (Pennsylvania Science Office, The Nature Conservancy, pers. comm.), the *Ludwigia polycarpa* population is one of only three known in Pennsylvania (the other two occurring downstream along the Susquehanna River), and the *Schoenoplectus fluviatilis* population is the only extensive stand in Pennsylvania. Two Pennsylvania threatened bird species, the American and least bittern, have been observed here occasionally and suspected of nesting in the marsh as well as several of birds of special concern (Pennsylvania Game Commission 1985, Schweinsberg 1988, Brauning et al. 1994). These unusual plant populations and the rarity of this habitat type have caused the marsh to be recognized as a valuable natural area by a number of state and national agencies (e.g., The Nature Conservancy, Pennsylvania Department of Environmental Resources-Bureau of Forestry, Environmental Protection Agency and the U.S. Fish and Wildlife Service).

This important wetland ecosystem is threatened by the impacts of a sand and gravel mining project scheduled to begin within the next year or two. Even though the wetlands themselves will not be mined, nearby perturbations have the potential to affect the status of the ecosystem. Landscape modifications made during mining could alter the wetlands' hydrology and might increase sediment loading thus disturbing crucial habitat for species of special concern. In order to understand the vegetation dynamics following disturbance, it is crucial that we have an account of the vegetation patterns that are present before mining. The baseline data collected during 1990 through 1991 and reported here will allow us to observe future vegetation dynamics, help us distinguish between natural and mining-induced changes, and provide a rationale for monitoring and management.

STUDY SITE

Montandon Wetlands are located west of the West

Branch of the Susquehanna River directly east of Lewisburg on the western edge of the village of Montandon in the central Susquehanna Valley of central Pennsylvania (40°58'N lat., 76°52'W long.). The wetlands are bordered by farmlands on the ridges to the east, west, and south. The wetlands complex is bisected by Route 45 on an east-west axis. The area north of Route 45 is mainly emergent marsh and wet meadow surrounded by wet woods. Weak fens are scattered within both sections. The main focus of this study was the southern portion of the wetlands locally known as Montandon Marsh. The study site (marsh and surrounding upland) is approximately 50 ha.

Climate

The central Susquehanna Valley has a temperate climate with warm, humid summers and moderately cold, humid winters. The year 1991 was an unusually dry year with precipitation for March 1991-Dec. 1991 totaling 378 mm less than the long-term mean for these months (Bucknell University Geology Department). Low precipitation caused drought conditions in the marsh before and during the growing season with much of the marsh drying to mud-flat conditions by mid-July.

Geology and Hydrology

The wetlands complex is situated on a relict floodplain (the Binghamton Terrace) of the West Branch of the Susquehanna River (Peltier 1949). This terrace was part of the braided channel system that constituted the Susquehanna River during the mid- to late-Wisconsinian glacial period (prior to 10,000 years ago) (Clark et al. 1992). It is likely that the wetlands are located in one or several of the abandoned channels of this braided system (Richard Nickelsen pers. comm.). The bedrock underlying the marsh is Helderberg-Keyser and Tonoloway limestones, which may provide a minor contribution of calcium and magnesium to the nutrient supply of the wetlands, due to upwelling (Craig Kochel pers. comm.). The limestone bedrock is overlain by 4-8 m of alluvial gravel deposits, which are covered by silts and clay deposited as overbank sediments after the Susquehanna River abandoned these braided channels. These silts and clays laid the ground work for establishment of ponding and wetlands vegetation. Wind-laid sand dunes, 3-4 m high are found scattered throughout the wetlands and surrounding upland (Peltier 1949). These alluvial and eolian deposits create varied microtopography, soil textures, and ponding/drainage systems.

On-going studies suggest that there are three main sources for the water in Montandon Marsh: surface runoff, and both a deep and shallow aquifer in the gravel underlying the marsh (Kochel 1994). Recharge to this gravel aquifer is mainly due to regional flow from east to west (towards the river). There are two primary controls on

the water level in the marsh: a set of east-west dikes (running perpendicular to the long axis of the marsh) that act as dams to slow water flow from north to south, and a set of herring-bone channels that direct flow southward through the wet meadow, allowing little ponding in that area (Kochel 1994).

Soils

Soils within and surrounding the wetlands are primarily alluvial deposits of the Susquehanna River. The soil series encountered in the study area is representative of an association repeated throughout the Montandon Wetlands complex. Well-drained Barbour-Linden soils are found on the ridge to the west of the wetlands and on the peninsula, the highest topographical position. Basher soils are somewhat poorly drained and found at lower elevations than Barbour-Linden soils. On site, Basher soils are found in the wet woods bordering the eastern edge of the wetland. Holly soils, usually flooded, occupy the lowest relief position and underlie the wetland. Sand decreases while silt increases from Barbour to Basher to Holly soils. There are corresponding decreases in permeability and increases in nutrient-holding capacity (USDA, SCS 1985). Within the undisturbed wetlands, Holly soils include deep decomposed peat.

METHODS AND ANALYSIS

Vegetation Map

Major vegetation associations of the marsh and surrounding upland were determined during ground survey. These associations were delineated with the aid of aerial photographs (due to color differences on infra-red film), and traced onto a topographical map at a scale of 1:1200 with 60-cm contours provided by Survey Services, Inc. Approximately 200 plant specimens from the study site have been deposited in The Wayne E. Manning Herbarium (BUPL) at Bucknell University, Lewisburg, Pennsylvania (Hochman 1991). Nomenclature follows Rhoads and Klein (1993).

Vegetation, Soils, and Topography

Three permanently marked sampling areas were chosen to observe the distribution of vegetation types, soil types and chemistry along topographical gradients (Figure 1). At each site, a series of permanently marked transects was placed with the length running parallel with the long axis of the marsh, perpendicular to the relief gradient from upland through bottomland woods. The transects were 10 or 20 m long. They were numbered from west to east at each site beginning with number 1, thus site **a** consists of transects 1-7, site **b** consists of transects 1-9 and site **c** consists of transects 1-5. A

line-intercept method (Brower et al. 1989) was used to record percentage cover of species along transects within ecotonal areas and the wetlands. Upland wooded transects were sampled by point-quarter technique (Brower et al. 1989). Data recorded included diameter at breast height for trees, crown diameter for shrubs, number of stems per individual for both trees and shrubs, and percentages cover for herbs within 1 x 0.5 meter quadrats. All point-quarter samples consist of 20 points spaced 10 m apart. Herbaceous cover was sampled by placing the upper corner of a 1 x 0.5 m frame one meter to the east of each point. All point-quarter transects consist of one line except for transect 5 at site 1 (southern woods). This

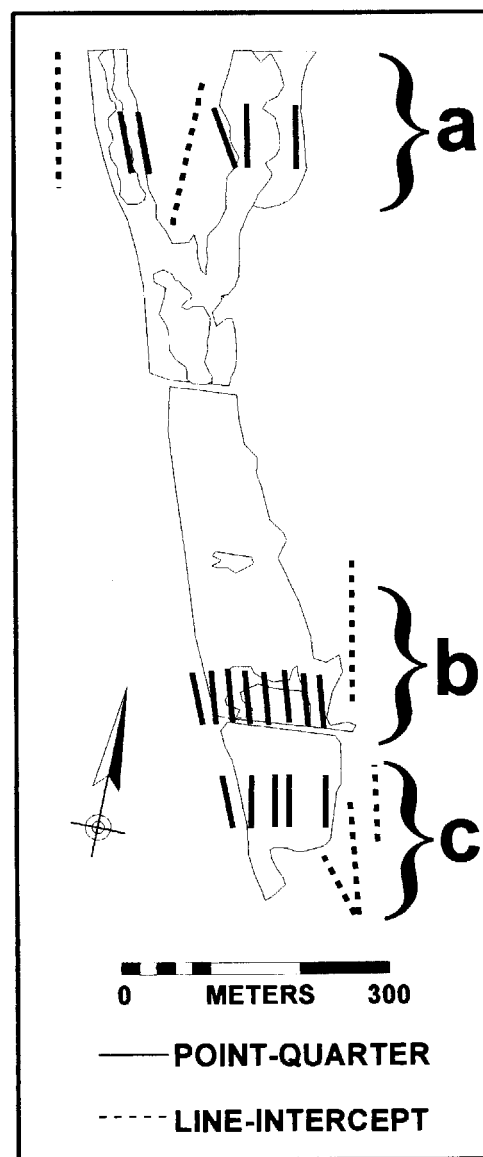


FIGURE 1. Map of Montandon Marsh. Locations of permanently marked sampling areas chosen to survey vegetation, soils, and topography are shown. Sampling was carried out using both line-intercept technique and point-quarter technique (Brower et al., 1989). Transects at each site are numbered beginning with number one on the west and proceeding east.

transect was composed of three separate lines of point-quarters. This was necessary due to paths cutting through the study area. Construction Engineering, Inc. (Millville, Pennsylvania) surveyed the sampling areas. Elevation data taken at each transect were used to determine water levels.

Data from point-quarter sampling were used to generate absolute and relative values of frequency, density, dominance, and importance value for woody species from the number of individuals per point, and diameter at breast height for trees or crown diameter for shrubs. The program Ecological Analysis, Vol. 3 (Eckblad 1989) was used to determine species diversity as the Shannon-Weaver index (H'). To minimize the difficulties of measuring plant species diversity in communities composed of vegetatively propagating individuals (e.g., sedges, grasses), percentage cover data were used with the Shannon-Weaver index (Abrahamson et al. 1984).

Soil samples were taken at each transect within the three sites. Five to eight cores were taken to a depth of 20 cm along each transect and were then pooled into one sample. This depth is within the rooting zone of most trees in forested wetlands and constitutes the rhizosphere of most shrubs and herbs (Dunn and Stearns 1987). Samples were air dried on newspaper for three days. A&L Eastern Agricultural Laboratories Inc. (7621 Whitepine Road, Richmond, Virginia 23237) performed the following analyses on each sample: soil pH (1 to 1 soil to water solution), buffer pH (Shoemaker, McLean, and Pratt ISPM), organic matter (Walker-Blackman), available phosphorus in ppm (Weak Bray), Cation Exchange Capacity (meq/l), and exchangeable potassium, calcium, hydrogen, sodium and magnesium. A&L Agricultural Laboratories Inc. used the Walker-Blackman method to determine the percentage organic matter in these soils. This test is limited to organic matter levels of 9.9% and below so consequently values of 9.9% represent 9.9% and above.

RESULTS AND DISCUSSION

Vegetation Map

Five vegetation associations were described and delineated qualitatively: marsh, wet meadow, hummock/hollow, woods, and communities that developed in the few areas mined during the 1950's and 1960's (Figure 2). Bold letters and numbers refer to Figure 2.

The marsh association was recognized to have three phases. **A**—Patchy polydominant marsh, i.e., distinct patches with differing sets of dominants including: *Schoenoplectus fluviatilis*, *Impatiens capensis* (jewelweed), *Cicuta bulbifera* (water hemlock), *Sparganium eurycarpum* (burr-reed), *Sagittaria latifolia* (broad-leaved arrowhead), *Typha latifolia* (cattail), and *Decodon verticillatus* (swamp loosestrife). **B**—In the western arm and to the south of the peninsula is a polydominant com-

munity of *Cephalanthus occidentalis* (button bush), *Decodon verticillatus*, and *Cicuta maculata*. This area does not exhibit distinct patches. **C**—A monodominant stand of *Schoenoplectus fluviatilis* is present in this area.

The three phases of wet meadow communities are less

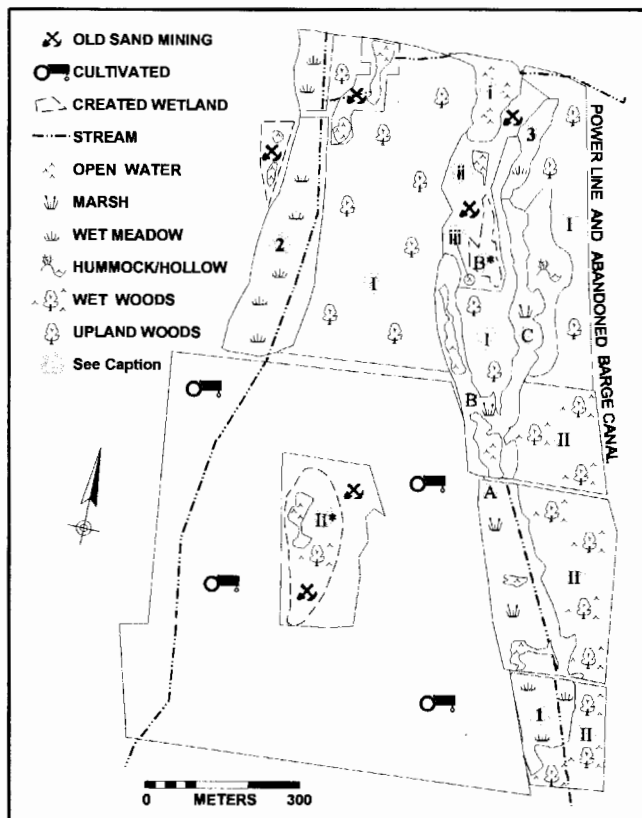


FIGURE 2. Vegetation map of Montandon Marsh. The wetlands and surrounding uplands have been divided into seven habitat types. The shaded circles represent phases of these habitat types.

Three phases of marsh.

A—Patchy polydominant marsh.

B—Polydominant community of *Cephalanthus occidentalis* (button bush), *Decodon verticillatus*, and *Cicuta maculata*.

C—Monodominant stand of *Schoenoplectus fluviatilis*.

Three phases of wet meadow.

1—*Phalaris arundinacea* (reed canary grass) meadow.

2—Graminoid meadow.

3—Most inundated of the meadow phases: *Bidens cernua* (beggars ticks), *Scirpus cyperinus* (wool-grass), and *P. arundinacea*.

Three phases of woodlands.

I—Upland woods *A. rubrum*, *Ulmus rubra* (slippery elm), *Quercus rubra* (red oak), *Q. velutina* (black oak), and *Sassafras albidum* (sassafras).

II—Swamp woods dominated by *A. rubrum* and *A. saccharinum*.

II*—Swamp woods dominated by *Acer* spp. but interspersed with *B. nigra*.

Four communities developed following sand and gravel mining.

i—Pond with steeply sloped sides and contains little aquatic vegetation.

ii—Pond with *Potamogeton* sp. (pondweed), *Utricularia macrorhiza* (bladderwort).

iii—Pond contains an unidentified *Utricularia* sp.

B*—Severe scraping of topsoil resulted in composition similar to the marsh at **B**.

inundated than the marsh areas. **1**—*Phalaris arundinacea* (reed canary grass) meadow with pockets of *T. latifolia*, *Solidago gigantea* (late goldenrod), and one large hummock on which *Acer rubrum* (red maple), *Toxicodendron vernix* (poison sumac) as well as other shrubs and trees grow. **2**—Graminoid meadow, species include: *Carex lurida* (sallow sedge), *C. lupulina* (hop-like sedge), *Juncus effusus* (soft rush), *P. arundinacea*, and *Polygonum* spp. (smartweeds). **3**—This is the wettest of the three wet meadow sites; *Bidens cernua* (beggar's ticks), *Scirpus cyperinus* (wool-grass), and *P. arundinacea* are present.

The hummock/hollow association consists of a patchwork of communities whose composition is dependent upon microtopography. Hollows consist of emergents such as *Schoenoplectus fluviatilis* and *Decodon verticillatus*. Hummocks are home to species such as: *Betula nigra* (river birch), *Vaccinium corymbosum* (high-bush blueberry), *Toxicodendron vernix*, and *Salix* spp. (willow), *Sphagnum squarrosum* (moss), *Osmunda cinnamomea* (cinnamon fern), and *Carex* spp. (sedges).

Woodland associations surround the wetlands on three sides. *Acer rubrum*, *Prunus serotina* (black cherry), *Lindera benzoin* (spice bush), *Viburnum dentatum* (northern arrow-wood), and *Toxicodendron radicans* (poison ivy) are typical in all the wooded areas. **I**—Upland woods dominated by *A. rubrum* with *Ulmus rubra* (slippery elm), *Quercus rubra* (red oak), *Q. velutina* (black oak), and *Sassafras albidum* (sassafras) scattered through the woodland. **II**—Swamp community dominated by *A. rubrum* and *A. saccharinum*. Wetter areas within this swamp contain *Quercus palustris* (pin oak), *Betula nigra*, and *Ilex verticillata* (winterberry). Swamp woods dominated by *Acer* spp. but interspersed with *B. nigra* have developed at **II***.

During the 1950's and 60's a few small areas were mined for sand and gravel. Three small ponds and two depressions were created. Communities that have established in these mined areas colonized the bare sands and gravels directly as these disturbed areas were never mitigated. A few of these areas continue to be disturbed by all-terrain vehicle traffic. Areas on Figure 2 outside the dotted lines and inside the mined region represent these highly disturbed open, sandy flats. Pond **i** has very steeply sloping sides and contains little aquatic vegetation. Pond **ii** contains *Potamogeton* sp. (pondweed), *Utricularia macrorhiza* (bladderwort), and *Polygonum* spp. Pond **iii** contains an unidentified *Utricularia* sp. Severe scraping of topsoil during mining at **B*** has resulted in a transitional polydominant community with species composition similar to the marsh at site **B** and to the hummock and hollow association. This small community includes: *Vaccinium macrocarpon* (large cranberry), *Typha latifolia*, *Scirpus cyperinus*, *Juncus* spp., and seedlings and saplings of *Betula nigra*, and *Salix* spp.

Vegetation, Soils, and Topography

Site **a** is emergent marsh, and in the western arm there is a polydominant community that includes *Decodon verticillatus*, *Cicuta maculata* (water hemlock), and *Cuscuta gronovii* (dodder). In the eastern arm, there is a monodominant community of *Schoenoplectus fluviatilis*. Disturbed woods characterized by *Acer saccharinum* and *Robinia pseudoacacia* (black locust) border on the west. The wooded peninsula is characterized by *Acer rubrum*. Site **b** is marsh characterized by a patchy distribution of plants such as *Sagittaria latifolia*, *Typha latifolia*, *Lemna minor* (duckweed), and *Sparganium eurycarpum*, bordered by hedgerow and wet deciduous woods. Site **c** in the southernmost wet meadow is dominated by *Phalaris arundinacea*. This meadow is bordered on the west by a hedgerow between the wetlands and cultivated fields to the east are *Acer rubrum* and *A. saccharinum* bottomland woods.

The western woods at site **a** (transect 1) are dominated by *Acer saccharinum* and *Robinia pseudoacacia* (Figure 3). The woods are characterized by a very tangled understory of *Rubus* spp. (blackberries) and *Rosa multiflora* (multiflora rose). Transect 2 is located within open marsh; this polydominant community includes *Decodon verticillatus*, *Cephalanthus occidentalis*, *Cuscuta gronovii*, and *Cicuta maculata*. Because of variable microtopography this area is the most diverse site within the wetlands, $H' = 2.8$ (Figure 3). Woody swamp species such as *Nyssa sylvatica* (black gum) and *Ilex verticillata* (winterberry) characterize the ecotone between the wetlands and uplands at transect 3. The well-drained soils of the upland (transect 4) provide habitat for *Sassafras albidum*, *Quercus velutina*, and *Q. rubra* within the *Acer rubrum* woods. Transect 6 is located in a 1.6-ha monodominant stand of *Schoenoplectus fluviatilis*. Transect 7 crosses a series of hummocks and hollows. Because of variable microtopography this is a more diverse site within the wetland, $H' = 2.3$ (Figure 3).

Organic matter is higher in wetlands than uplands at site **a** (Figure 4). This is primarily a result of slow decomposition under varying levels of anoxia, but also may be due to the higher productivity found in wetlands than uplands. Phosphorus levels are abnormally high at site **a** relative to sites **c** and **b**, perhaps due to upwelling of water and unusual flow patterns from surrounding areas (Craig Kochel, pers. comm.).

The hedgerow at site **b** (transect 1) is dominated by *Acer negundo* (Figure 3). The wetlands consist of a series of polydominant patches whose vegetation composition is dependent upon elevation and hydroperiod. Characteristic species at each transect include: *Phalaris arundinacea* at highest elevation within the wetlands; *Cicuta bulbifera*, *Carex lacustris*, *Sagittaria latifolia*, and *Typha latifolia* occupy lower elevations; *Sparganium eurycarpum* and *Lemna minor* occupy the most inundated area. Transect 5 was the most inundated area which may account for it being the least species rich of transects

sampled at site **b** (# taxa = 8). Transect 8 which is located in the ecotone between wetlands and upland, is both the most species rich (# taxa = 31) and diverse $H' = 2.2$. The wetlands are bordered on the east by wet deciduous woods, dominated by *Acer rubrum*, *Lindera benzoin*, and *Prunus avium* (sweet cherry). *Betula nigra*, *Juglans nigra* (black walnut), and *Quercus palustris* are scattered through the canopy.

As at site **a**, organic matter at site **b** generally increases from upland to wetlands (Figure 4). Phosphorus generally declines with distance from the cultivated fields. These changes in phosphorus levels are most likely related to runoff and sedimentation from the cultivated fields because higher levels were measured in the hedgerow.

Most of the sediment eroded from the fields is caught here. At transect 7, phosphorus is relatively high compared to levels at the surrounding transects, this may be due to flow patterns adjacent this transect.

At site **c**, *Acer negundo* (boxelder) and *Viburnum dentatum* are co-dominant in the tree and shrub layer of the hedgerow (transect 1) (Figure 3). *Phalaris arundinacea* exhibits dominance throughout the wet meadow (transects 2, 3, 4). It is co-dominant at transects 2 and 3 with *Polygonum amphibium* var. *emerseum* (water smartweed). The predominance of a thick stand of *Phalaris arundinacea* appears to be excluding other species from colonizing this area. Consequently, it is the least diverse and least species rich of all sites sampled within the

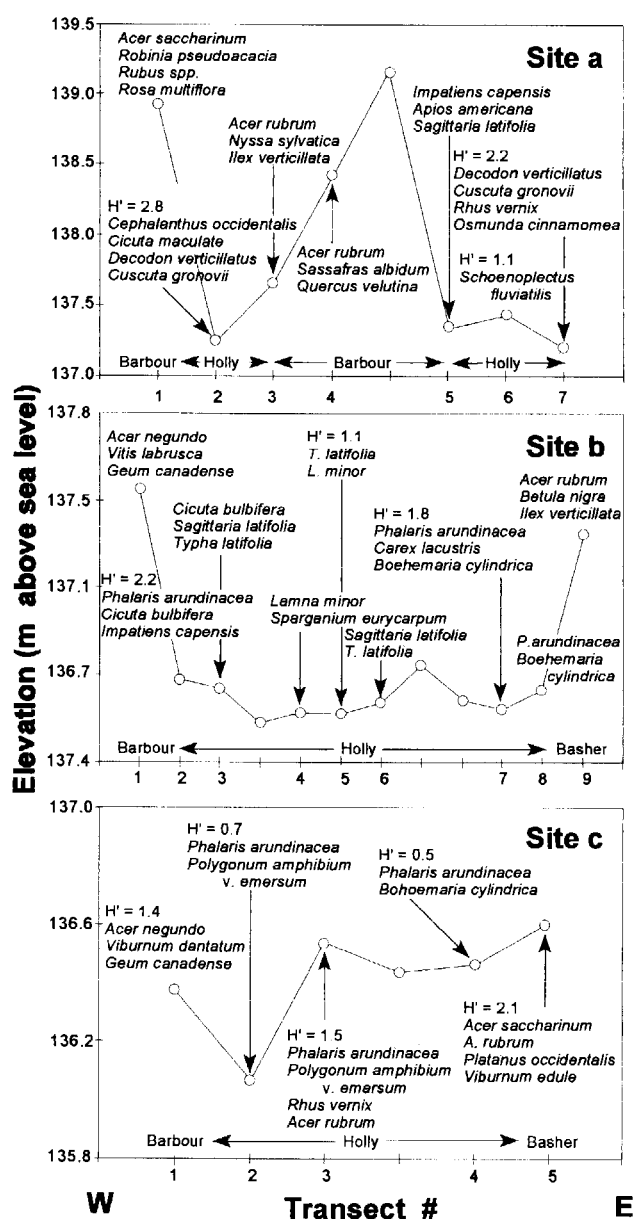


FIGURE 3. Characteristic species at sites **a**, **b**, and **c** superimposed onto plots of the relief gradient in meters. Where a transect number is not shown only elevation data were obtained. X-axis is not to scale.

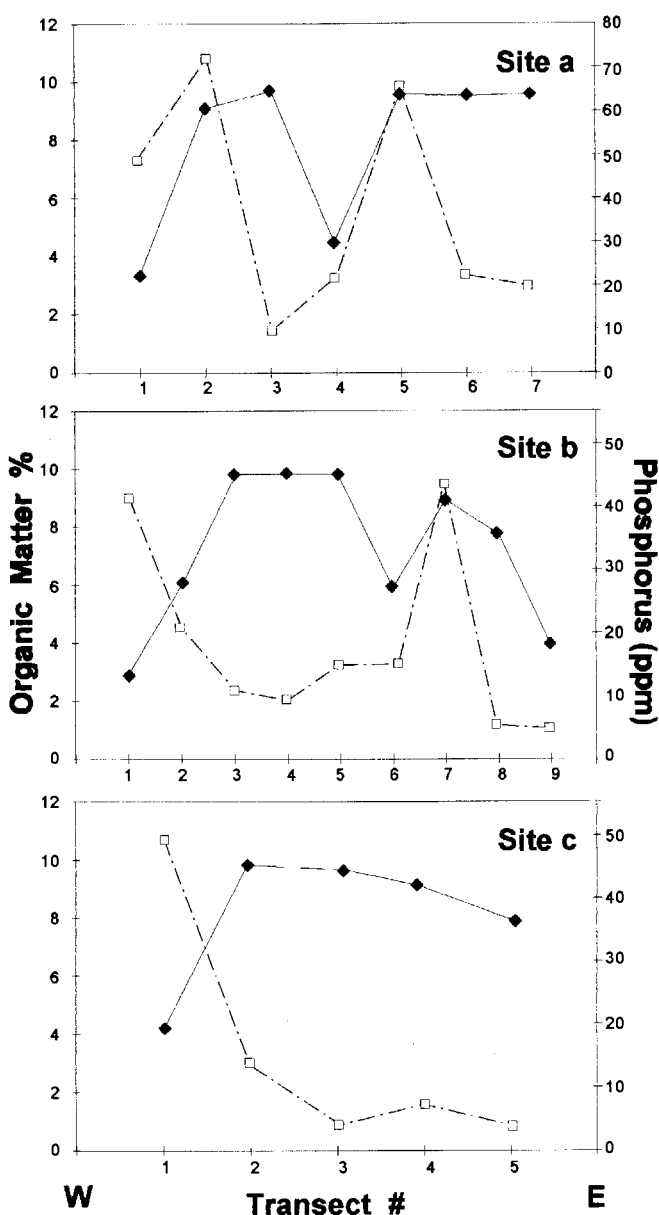


FIGURE 4. Soil chemistry at sites **a**, **b**, and **c**. Percentage organic matter (filled symbols) and available phosphorus in ppm (open symbols) are plotted, for each transect (transect 1 being the closest to cultivated fields). X-axis is not to scale.

wetlands (# taxa = 2, $H' = 0.7$) (Figure 3). Transect 3 is located on a large hummock within the wet meadow. The hummock has an appreciable tree and shrub layer consisting mainly of *Acer rubrum* and *Toxicodendron vernix*. The wet woods at transect 5 are dominated by *A. rubrum*, *A. saccharinum*, *Platanus occidentalis* (sycamore), and *Fraxinus nigra* (black ash). These woods are the most diverse and species rich woods sampled within the wetland (# taxa = 35, $H' = 2.2$) (Figure 3). This diversity is probably due to varied microtopography and soil permeability within this area. See (Hochman 1991) for more detailed listing of diversity indices.

Organic matter at site **c** is higher in the wetlands than in the hedgerow and bottomland woods, and higher in the woods than in the hedgerow (Figure 4). Phosphorus generally declines with distance from the cultivated fields.

Organic matter and available phosphorus at sites 1, 2 and 3 show the most consistent patterns of all soil chemistry parameters measured. Values for other soil constituents are cited in Hochman (1991).

Management and Mitigation

Gravel mining near the wetlands is scheduled to begin within the next year or two. It is proposed that a series of smaller ponds or a lake totaling approximately 30-ha in surface area and up to 9 m deep will be created by mining. These water bodies will stretch in a north to south direction along the ridge just west of the wetlands. To preserve the unique natural wetlands, mining activities must include: (1) Minimizing disruption of the existing hydrologic regime, (2) Creation of a buffer zone surrounding the wetlands so that the system is not negatively affected by sediment loading or agricultural chemicals, (3) Creation of a self-perpetuating wetland system within the mined area that is similar in species composition to Montandon Wetlands, (4) Design of haul roads, overburden dumps, pond and drainage systems (for the mined area) with goals 1 through 3 in mind, (5) Design of a long-term monitoring scheme for the created wetlands, and (6) Continued long-term monitoring of the naturally occurring Montandon Wetlands.

CONCLUSIONS

The plant communities and soil chemistry of the Montandon Wetlands vary with topography and soil types even though there are additional factors that likely contribute to the location of plant assemblages. These additional factors include water-flow patterns, inundation levels and periodicity, and micro-variation in the permeability of soils. Organic matter and available phosphorus at sites **a**, **b**, and **c** showed the most consistent patterns of all soil chemistry parameters measured. Organic matter is higher in wetter areas than in upland or well-drained sites. This was primarily due to varying

levels of anoxia in wetlands/bottomland areas. At sites **b** and **c**, phosphorus levels generally declined with distance from the cultivated fields, but it is difficult to explain phosphorus level at site **a** without a better understanding of water flow. There may be upwelling and/or unusual flow patterns that cause the high phosphorus levels found at site **a**.

It is likely that the drought of the summer 1991 initiated a dry-marsh phase in the vegetation of Montandon Wetlands. The high species diversity we measured was due to the presence of a large number of seedlings of annual and opportunistic species that took advantage of the high organic matter and low-water table to germinate in the wetlands. It is unlikely that this diversity is due to phenological changes because censusing took place in mid-June to the end of July, after the major spring and early summer growth-spurt had occurred. It will be important for future studies to compare diversity measures, species composition, and overall life-history strategies from data collected during this drought year to data collected during wetter years, to assess vegetation changes due to natural hydrological cycles, on going successional patterns, or to the nearby sand and gravel mining.

Montandon Wetlands is a significant natural area, providing crucial habitat for species of special concern in Pennsylvania. Its stewardship is being addressed by the local community, the Merrill Linn Land and Waterways Conservancy (a land trust operating in the central Susquehanna Valley), the gravel mining company, and Bucknell University students of both hydrology and biology. A conservation easement through the local Merrill W. Linn Land and Waterways Conservancy would provide the integral component for the preservation of this natural area. This paper represents a summary of a larger study that surveyed rare plant stands and habitats, and presented detailed recommendations for management and long-term monitoring (Hochmann, 1991). These baseline data will provide a foundation for future investigation, conservation, and partnership between mining interests and preservation.

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