Bog HELPR: Bog History, Ecosystem status and Land-use for Peatland Restoration in Ohio

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PART 1 – RESEARCH REPORT

1. Problem and Research Objectives

In Ohio historically-abundant wetland ecosystems have suffered declines of up to 85% since the 18th century (Dahl 1990). Wetlands provide a wide range of ecosystem services such as regulating hydrological processes, water quality improvement, sequestering atmospheric carbon via peat formation, supporting biodiversity including wildfowl and rare plants and providing opportunities for recreation and education (Zedler & Kercher 2005). The degradation of wetland ecosystems, such as peatlands, has large financial costs associated with the. For example, Zedler & Kircher (2005) estimated costs of up to \$7,600 ha^{-1} yr^{-1} from lost water supply, between \$3,677 and \$21,100 ha^{-1} yr^{-1} from alterations to nutrient cycling and between \$2 and \$3,008 ha^{-1} yr^{-1} from lost recreational opportunities.

Ohio once contained a diverse and abundant array of wetland ecosystems including marshes, swamps, fens, and bogs. Peatland ecosystems in Ohio are of significant conservation concern as, in addition to being degraded or destroyed during land-use conversion, remaining systems are at the limits of their climatic range (Halsey et al. 2000), and have been impacted by drainage, disturbance and nutrient inputs from surrounding human land-use. Ohio's bogs therefore are a "canary in the coalmine" for interactions between climate change and human disturbance. However, we currently have little quantitative evidence on their current status, history or condition. That is important as the restoration of remnant peatland areas could provide a significant opportunity to improve the ecological, hydrological and chemical characteristics of many catchments. Human impacts on peatland ecosystems in Ohio (and elsewhere) have left them in a parlous state. By the late 1980's only 2% of Ohio's peat bogs were thought to remain (Andreas & Knoop 1992) but there has been no intensive survey of their status since that time.

Developing a peatland restoration agenda will require better knowledge of Ohio's existing peatland resource and the links between historical disturbance, land-use and the ecological structure of these sites. Our project's draws on three important historical studies that collectively document the extent and location of Ohio's peatlands between the early- and mid-20th century (Dachnowski 1912, Herrick 1974, Andreas & Knoop 1992). These studies vary in coverage and completeness but include sufficient information to allow historical, degraded and intact sites to be relocated. They also provide some qualitative assessment of historical site vegetation. They do not provide information on how sites have changed over the last ca. 40 years or quantitative data on their ecological status, functioning, or restoration potential.

Our specific objectives were to:

- Use historic maps, reports and aerial imagery to identify and map the locations of existing and historic peat bogs in Ohio.
- Combine historic maps, aerial images and ground survey to quantify changes in peat bog extent during two key periods – the 1860s-1950s and 1950s-2010s.
- Map and quantify variation in broad vegetation composition and structure within and between bogs representing a range of historic disturbance/management histories.
- Relate variation in community composition to land-use and environmental gradients in soil, weather, and hydro-chemical conditions within and between bogs.

2. Methodology

2.1 Mapping and classifying Ohio's peat bogs

Peatland classification is complicated by the often interchangeable use of terms such as bog, fen, swamp, bog forest, marsh, wet prairie, and many others. In recent decades, the usage of these terms has been debated and standardized (Bridgham et al. 1996), but their definition in older texts can vary even within those by the same author (Wheeler and Proctor 2000). Our project was focused on Ohio's bog ecosystems, defined as acidic, low alkalinity peatlands dominated by *Sphagnum* mosses, conifers, and ericaceous shrubs without any assumptions about hydrological process, as suggested by Bridgham et al. (1996). We began by attempting to relocate all sites defined by Andreas (1985) as bogs, and when not included in her study, sites with the word bog in the name, or described as bogs in historical or current site descriptions.

Andreas and Knoop (1992) qualitatively documented changes in peatland extent in Ohio up to the 1980's. As the article does not include specific site locations, we relocated sites using the authors' primary sources: a turn-of-the-century survey of peat deposits in Ohio (Dachnowski 1912) and other historical peatland studies. Andreas and Knoop also referred to herbarium records for their study, but these have not been included in our study at this time. Historical studies included any of the following relevant information: township and section, location relative to natural and manmade landmarks, landowner names (which were searched in county deed records), and rarely, site coordinates. Protected bog sites with unchanged names were easy to locate by internet search.

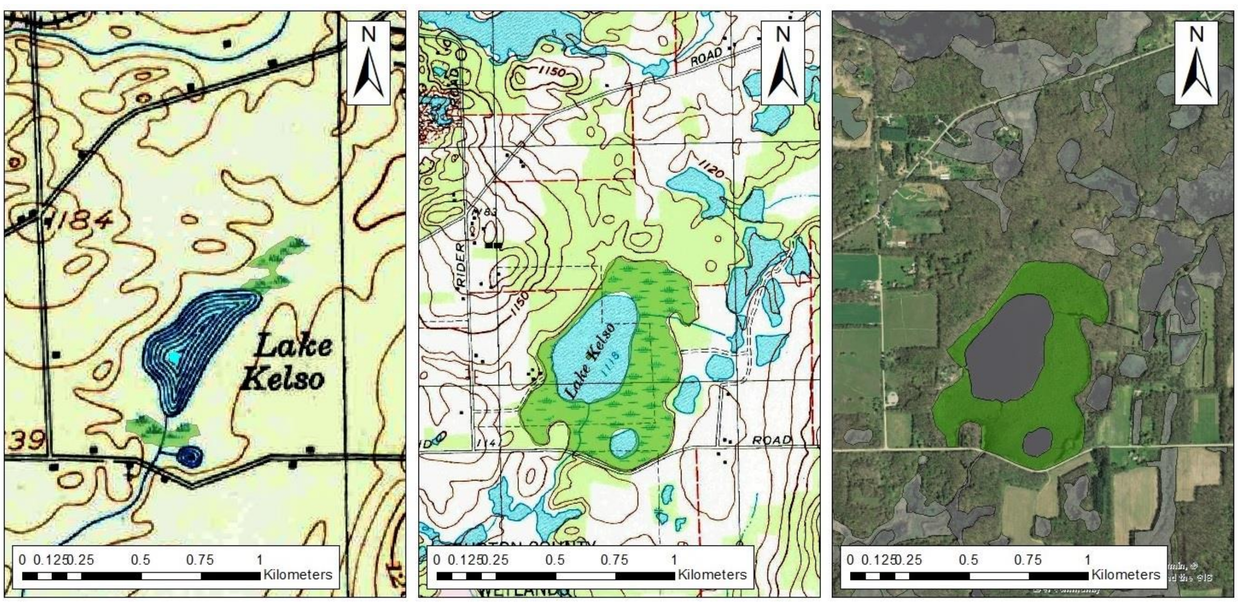


Figure 1: Examples of digitized maps used to evaluate the efficacy of utilizing historical sources to locate peat bog sites across Ohio and document changes in their extent. From left to right the pictures show a 1900's era USGS Topo Map, a 1994 USGS Topo Map and an aerial image from 2007. Areas mapped as peat bog are shown in green.

As a first step in evaluating the efficacy of historical maps for calculating historical bog extent we assessed 15 bog sites that could be clearly delineated from aerial photographs. This criteria favored kettle hole bogs and excluded large peatland complexes with wide variation in hydrology and plant communities. Topographic maps from three different time periods were evaluated for their efficacy in estimating historical bog extent. United States Geological Survey (USGS) maps from 1900-1920 were chosen to correspond with Dachnowski's 1910-1911 peat survey, USGS maps from 1960-1994 corresponded with Andreas and Knoop's 1976-1991 field inventories, and current National Wetland Inventory (NWI) maps based on data collected in 2007 were used to represent present-day extent (Figure 1).

When multiple options were available, the map created closest to 1911 and 1991, respectively, was selected. Georeferenced historical USGS maps were accessed using topoView, the USGS's historical map download portal. The NWI provides wetland extent for current USGS topographic maps. Shapefiles were created by digitizing wetland extent or selecting polygons that corresponded to descriptions in historical studies. Wetland area was calculated from these shapefiles in ArcGIS. We continue to add to this dataset by systematically searching for representations of peat bogs on older 19th Century county and township maps, to date relatively few of these have been found to reliably show areas of wetland.

Andreas (1985) uses the presence of indicator species to systematically classify Ohio's peatlands into bogs and fens, with the occurrence of a single indicator species enough to classify an entire site. However, few true bog indicator species exist; rather, bog vegetation is distinguished by a lack of calcareous fen indicator species (Wheeler and Proctor 2000). Tamarack, for example, is used by Andreas (1985) as a bog indicator, although it can be found outside that habitat. As a result, some fens appear to be misidentified as bogs. Frame Bog is thus defined by Andreas as a bog, but has now been protected under the name Herrick Fen, and in Andreas's own site description was said to have calcareous indicators. With this in mind, historical site descriptions were revisited, and plant community descriptions used to divide these "bogs" into high, medium, or low confidence in their classification as bogs. High confidence was assigned to bogs whose status was confirmed by historical site descriptions, medium confidence was assigned to bogs whose identity could be neither confirmed or denied due to lack of data (herbarium records were not referenced in the current project), and low confidence was assigned to sites whose descriptions included dominant characteristic fen vegetation.

2.2 Peat bog hydrochemistry

We selected nine sites for extensive monitoring of hydrochemistry. These sites selected to represent largely-intact peat bogs with differing land-use histories and surrounding land-use pressures. At each site we established multiple transects across the bogs to capture the ecological gradient from lag/moat conditions at the peatland margin to the core of the bog (Figure 2). Sites varied in their structure. While many had an open-water zone at their core others consisted of a floating peat dome. The depth and width of the lag or moat varied noticeably between sites and appeared to be a function of the physiography of the basin in which the peatland formed. Along each transect we placed multiple dipwells to monitor groundwater chemistry and measure water table depth. Dipwells were placed to capture representative locations within each broad vegetation zone crossed by the transect. We also installed one or more potentiometers to assess variation in water table position at fine temporal scales and collected monthly samples for detailed nutrient analyses. pH and electric conductivity (EC) of peat pore water was measured with a portable meter (YSI Pro1030). We completed five measurements per well approximately monthly from 20-Jun-2017 to 28-Nov-2017. Differences in environmental variables between broad vegetation type zones were investigated using linear mixed effects models with "site" as a random factor (R packages "nlme" Pinheiro et al., 2017 and "multcomp" Hothorn et al., 2008)

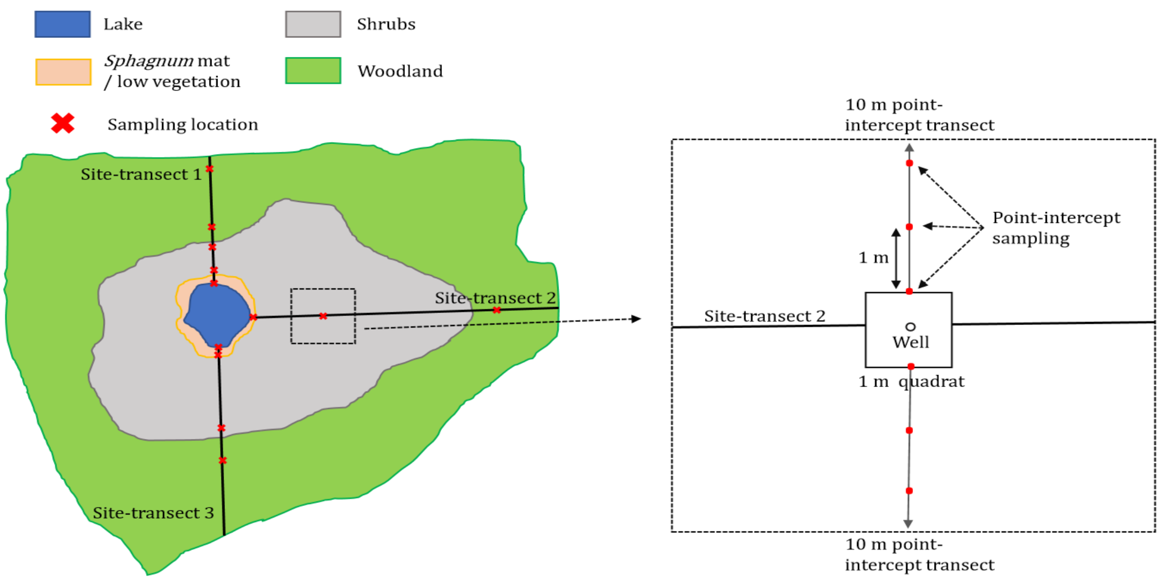


Figure 2: Example of sampling design for one site, showing (left) sampling locations within site-level transects, and (right) a quadrat and point-intercept transects for a single sampling location. Quadrats were centred at the well, and point-intercept transects were divided into two 10 m parts, starting at each side of the quadrat and perpendicular to the core to edge site-transect.

2.3 Vegetation community composition

We surveyed vegetation community composition at the nine extensively monitored peatlands used for the hyrdochemical monitoring. Within each transect we selected one to seven sampling locations to adequately represent the variety of broad vegetation zones (Figure 2). This resulted in 81 sampling locations across all sites (six to twelve per site, mean = 9). Initial surveying and data analysis has focused on assessing variation in bryophyte composition as we wished to test the extent to which this could act as an indicator of variation in abiotic and biotic conditions within and between peat bogs. Bryophyte abundance was surveyed once between 12-Jul-2017 and 15-Sep-2017 using quadrat and transect methods (Figure 2). We also recorded total cover of vascular plants by adding cover of individual species (well quadrats) and presence counts (point-intercept). Non-metric multidimensional scaling (NMDS) was used to visualise variation in bryophyte community composition (function “metaMDS” in package “vegan”; Oksanen et al., 2017). We fitted environmental variables onto ordination using the “envfit” function in “vegan”, restricting permutations to within-site groups.

2.4 Soil microbial community composition

Samples for microbial community characterization were collected from Browns Lake Bog (n=99) and Flatiron Bog (n=374), from several habitats at each site: Sphagnum mat zones at both sites, blueberry shrubland zones at both sites, and tamarack-dominated, historically disturbed, and runoff-impacted zones at Flatiron. Soil samples were kept at -20C until DNA extraction. DNA was extracted from 0.25g of soil sample using DNeasy PowerSoil Kit (Qiagen, Germantown, MD) following manufacturer’s procedures. Extracts were shipped to Argonne National Lab for amplification and sequencing; 16S rRNA gene amplicons were generated using the Earth Microbiome Protocol pre-2015 primers 515F/806R, and were sequenced on the Illumina MiSeq with the 2x150bp protocol. Amplicon data were processed with the bioinformatics software QIIME 1.9.1 (Caporaso et al., 2010) using the 16S-RDS pipeline (Nelson et al, 2014), and removing lineages assigned to the family mitochondria and the class chloroplast. Sequences in each sample were rarefied to 3000 for beta diversity analysis, and the results were visualized with principal coordinates analysis.

3. Principal Findings and Results

3.1 Mapping and classifying Ohio's peat bogs

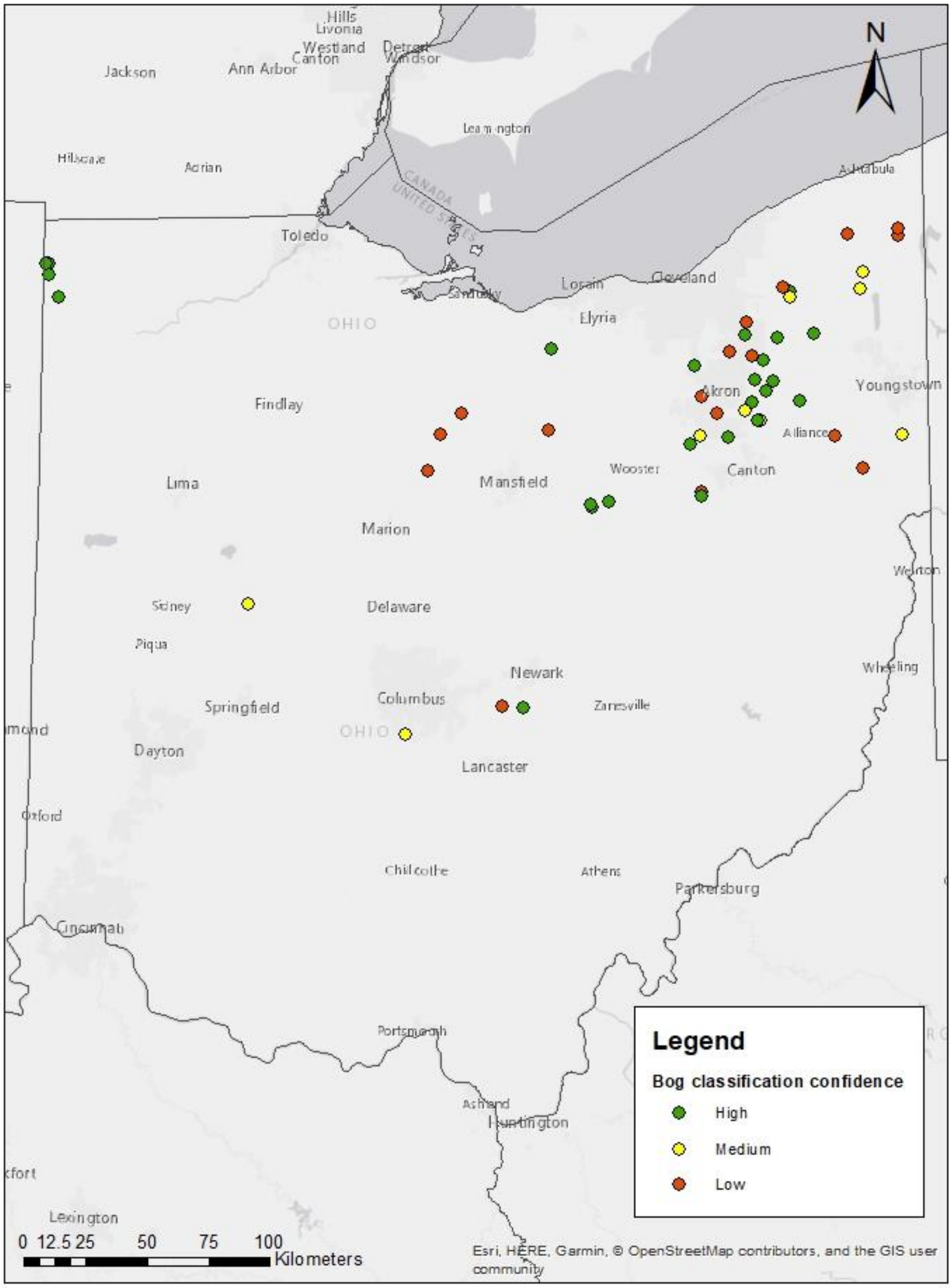


Figure 3: Distribution of relocated peatland sites, colored according to confidence in their bog classification.

A total of 70 potential bog sites were evaluated in our study (Appendix A), adding 10 sites to Andreas and Knoop's list of bogs (1992). Of these, 55 were relocated with a high degree of confidence (Figure 3). We were highly confident in the bog status of 40% of the sites. Bog classification confidence was moderate for 31.4%, of cases and low for 28.6%. Most large bogs, which in reality are likely to have consisted of wetland complexes including areas of fen, bog and swamp forest, have been lost or heavily mined. The majority of sites we identified were located in NE Ohio, though important clusters were found in NW Ohio, in the area formerly dominated by the Great Black Swamp, and in central Ohio.

In order to evaluate the efficacy of historical maps for calculating historical bog extent, 15 bog sites with clearly delineated margins were selected (Figure 4). Eight of fifteen (53%) sites are not indicated as wetlands on early 1900s historical maps. Bogs have not been created between then and the 1980s, so the discrepancy between maps of different time periods can be attributed to differences in scale or wetland mapping criteria. Early 1900s maps are at 1:62,500 scale, while more recent USGS topographic maps have a scale of 1:24,000. The criteria for wetlands to be marked on USGS maps in the early 1900s are unclear, but they appear to be less accurate and consistent when depicting wetland shape and area.

In three cases, bogs appear only on the most recent NWI maps. It is possible that smaller bogs were passed over in older maps, or that bogs with open water were less likely to be marked as wetlands due to already being displayed on the map as ponds. However, Young's Bog is a counterexample to both of these ideas, having no open water and being relatively large at 48 ha.

Two of the analyzed bogs show a decrease in area since the early 1900s. Cranberry Bog is a floating bog island in the Buckeye Lake reservoir, where wave action from boating activity has been decreasing the size of the island. The area of Camden Lake Bog in the early 1900s map included surrounding wetlands as well as the bog proper, resulting in an inflated estimate.

Seven sites display a noticeable trend of a slight decrease in wetland extent in the NWI compared to the 1980s-1990s USGS map. Areas extracted from these two more recent maps were visualized alongside areas listed by Andreas and Knoop (1992) in order to compare evaluate the accuracy of the three data sources (Figure 5). The NWI was more likely to feature peatlands listed by Andreas as historical (destroyed), as in the case of Camden Lake Bog and Fox Lake Bog, and less likely to not recognize an extant peatland, as in the case of Bonnett Pond Bog, and Young's Bog. However, the classification system used in NWI does not reflect the unique ecological and hydrological conditions of peat bog systems.

3.2 Peat bog hydrochemistry

Across the nine sites we sampled, average water table depth (WTD) was 0.6 cm, i.e. just below the ground but varied greatly between plots as indicated by its high standard deviation (21.2 cm) (Table 1). Water table was significantly higher (26.9 cm above the ground vegetation on average) in the central Sphagnum mat zone than in zones closer the margin of the bog. No significant differences in WTD fluctuation (8.9 ± 7.7 cm), pH (4.8 ± 0.6) and EC (0.097 ± 0.079 μS cm^{-1}) were observed between vegetation zones. As of May 2018 the potentiometers remain in position and lab analysis of hydrochemistry is on-going. Insights gained from stratigraphic peat sampling and depth measurements at Flatiron Bog (Figure 6) showed a maximum peat depth of > 10 m and a total below-ground peat carbon stock held in the bog of 1.31 x 10^6 kg.

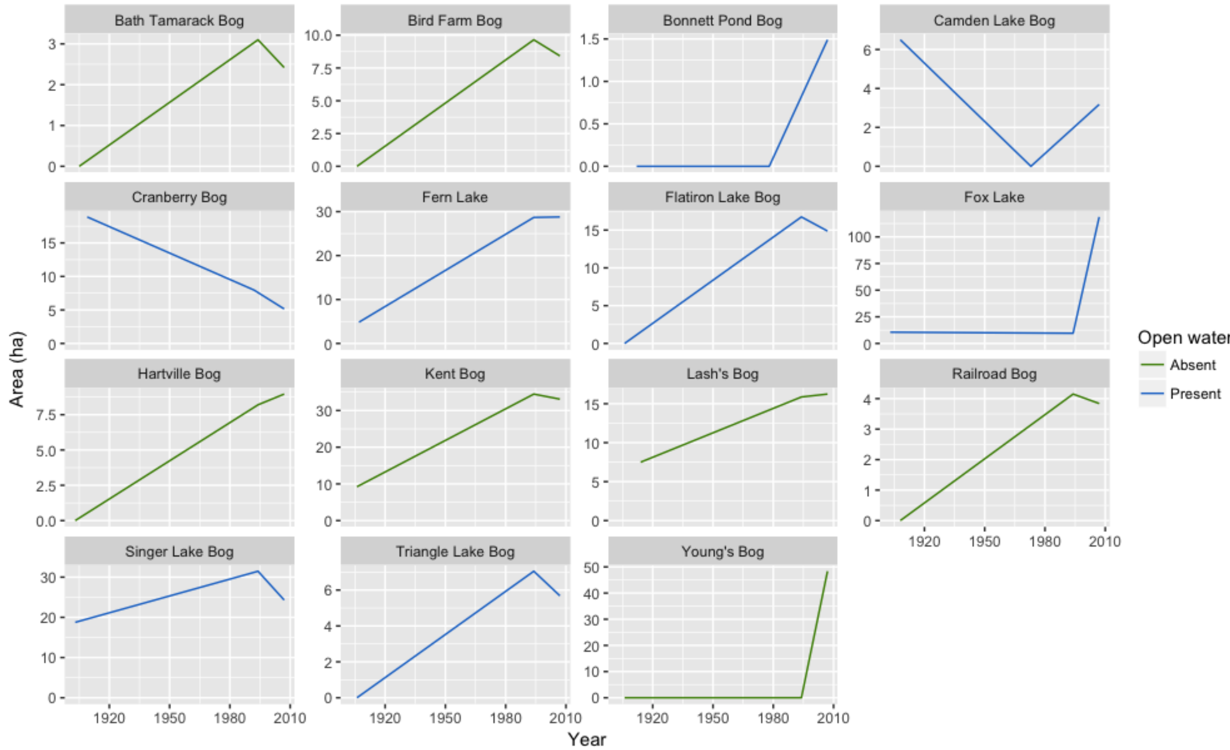


Figure 4: Change in extent of select Ohio bog sites as described by three historical USGS maps. Note that the y-axis varies, and graphs indicate patterns in relative (rather than absolute) area. Color indicates the presence or absence of open water at each site.

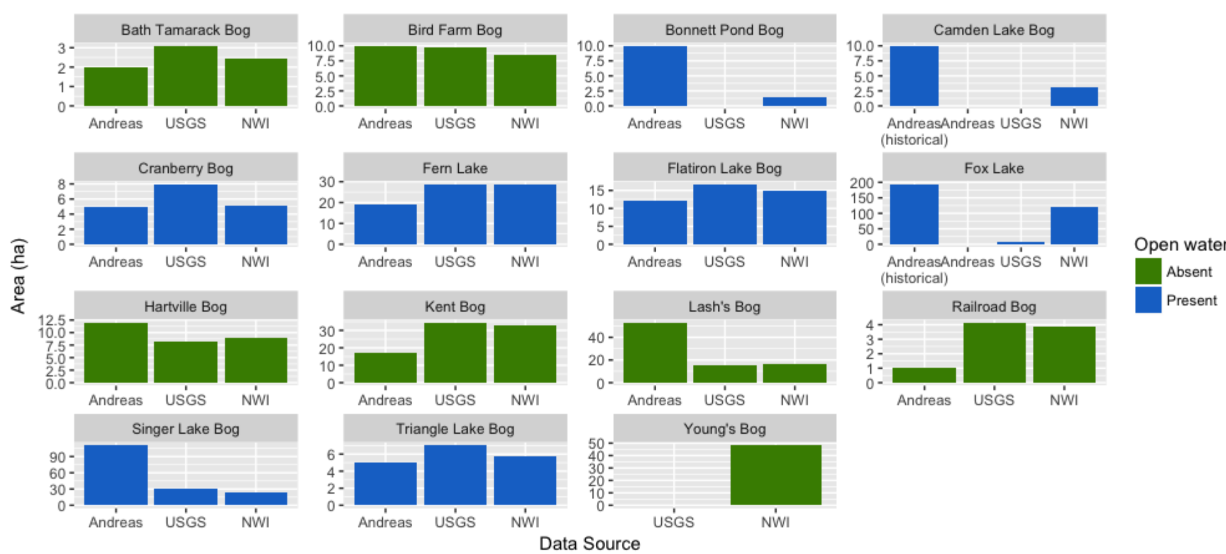


Figure 5: Comparison of bog extent listed by Andreas and Knoop (1992) to that displayed in USGS maps from the 1980s-1990s and NWI maps from 2007, including estimates of historic bog extent of destroyed bogs.

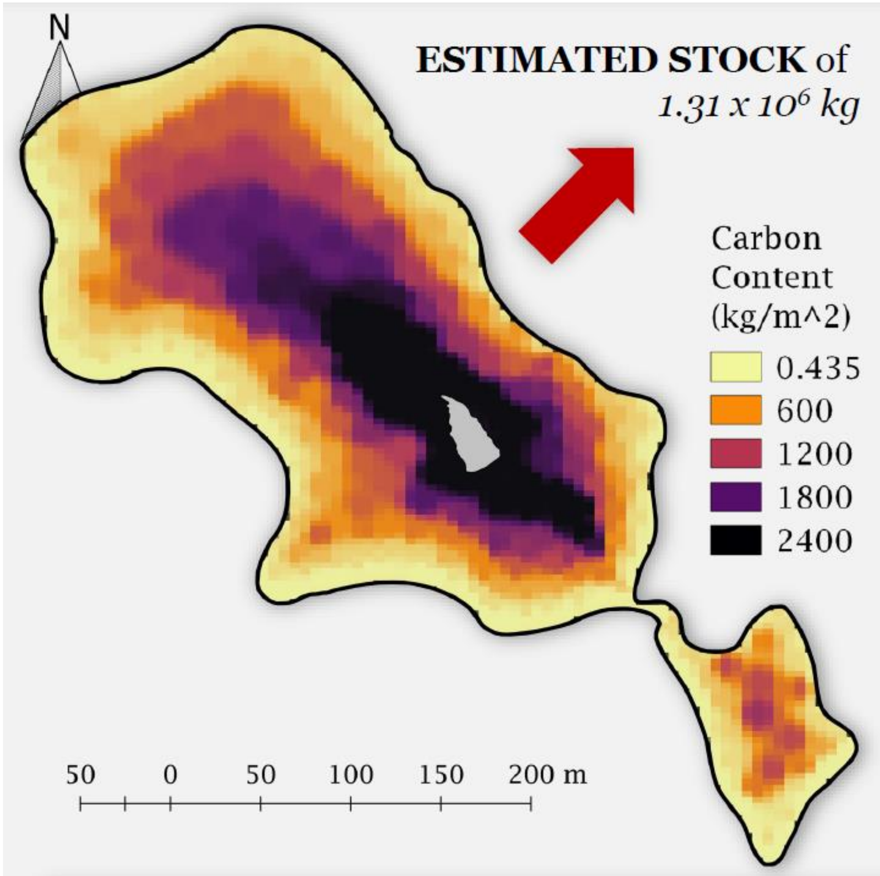
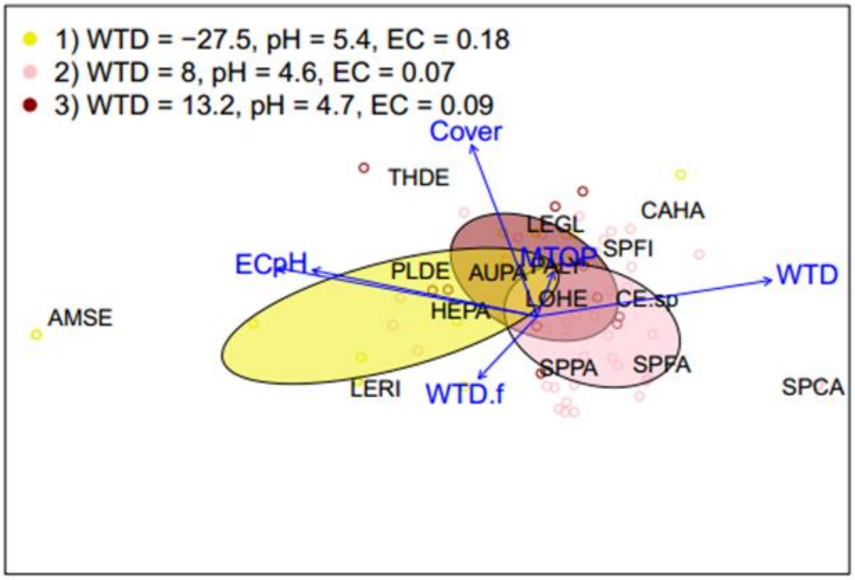


Figure 6: Distribution of peat carbon stocks across Flatiron Bog, Portage County, OH. Organic soil depths in the center of the bog were > 10 m. Note the central lake in gray was not sampled. Carbon stocks were estimated via spatial interpolation of point samples of soil depth and organic matter content.

Table 1: Average values (standard deviation in parenthesis) of the environmental variables per broad vegetation zone. Same letters within the same row indicate differences were not statistically significant (α = 0.05).

	Floating mat	Low shrubs	Tall shrubs	Woodland
Water table depth (cm)	-26.9 (15.6) a	9.9 (11.5) b	-5.3 (24) c	8.9 (16.6) bc
WTD fluctuation (cm)	9.6 (4.3) a	6.1 (5.4) a	10.6 (8.6) a	10.4 (9.5) a
Microtopography heterogeneity (cm)	17.6 (8.2) a	8.4 (4.2) b	9.4 (4.6) b	7.4 (5.4) b
pH	5.3 (0.7) a	4.7 (0.5) a	4.8 (0.6) a	4.7 (0.7) a
Electric conductivity (μS cm^{-1})	0.14 (0.1) a	0.07 (0.05) b	0.11 (0.1) a	0.08 (0.02) ab
Cover (%)	95 (44) a	101 (43) a	122 (44) a	175 (60) b



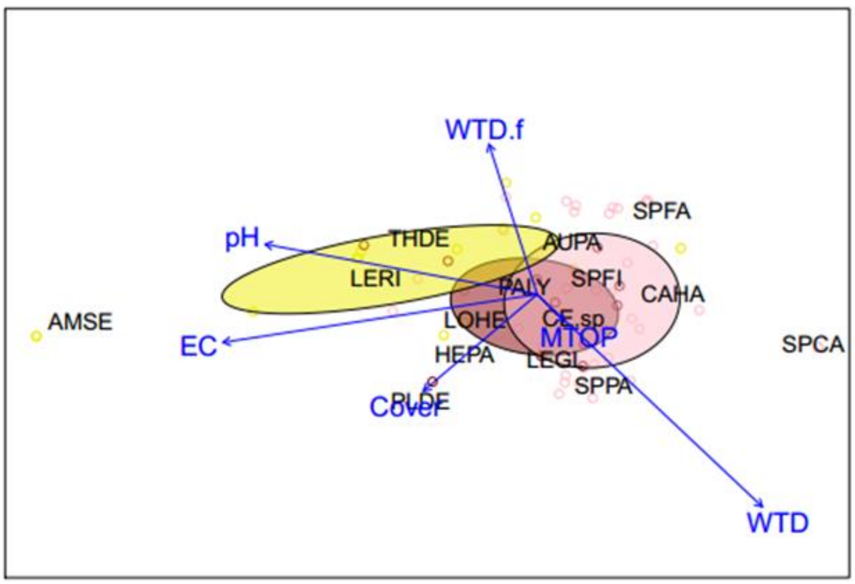


Figure 7: NMDS ordination of bryophyte cover in quadrats – top = axes 1 v 2, bottom = axes 1 v 3. Ellipses show standard deviations for clusters of plots with similar abiotic characteristics. Arrows are fitted covariates (length is proportional to the correlation with ordination): water table depth “WTD”, its fluctuation “WTD.f”, heterogeneity in microtopography “MTOP”, pH, electric conductivity “EC” and cover of vascular plants “Cover”.

3.3 Vegetation community composition

At our nine surveyed sites, we identified 39 different bryophyte taxa in 74 plots from the quadrat survey (7 plots were excluded due to lack of bryophytes). The point-intercept transect survey yielded 34 taxa from 69 plots. The ordination of bryophyte species composition varied along a first NMDS axis associated with WTD, EC and pH, and a second axis associated with vascular plant cover (Figure 7). These environmental vectors had a significant effect on community composition when fitted onto the ordination, and were used to classify sampling locations, resulting in three groups of distinct hydrology and hydrochemistry.

3.4 Soil microbial community composition

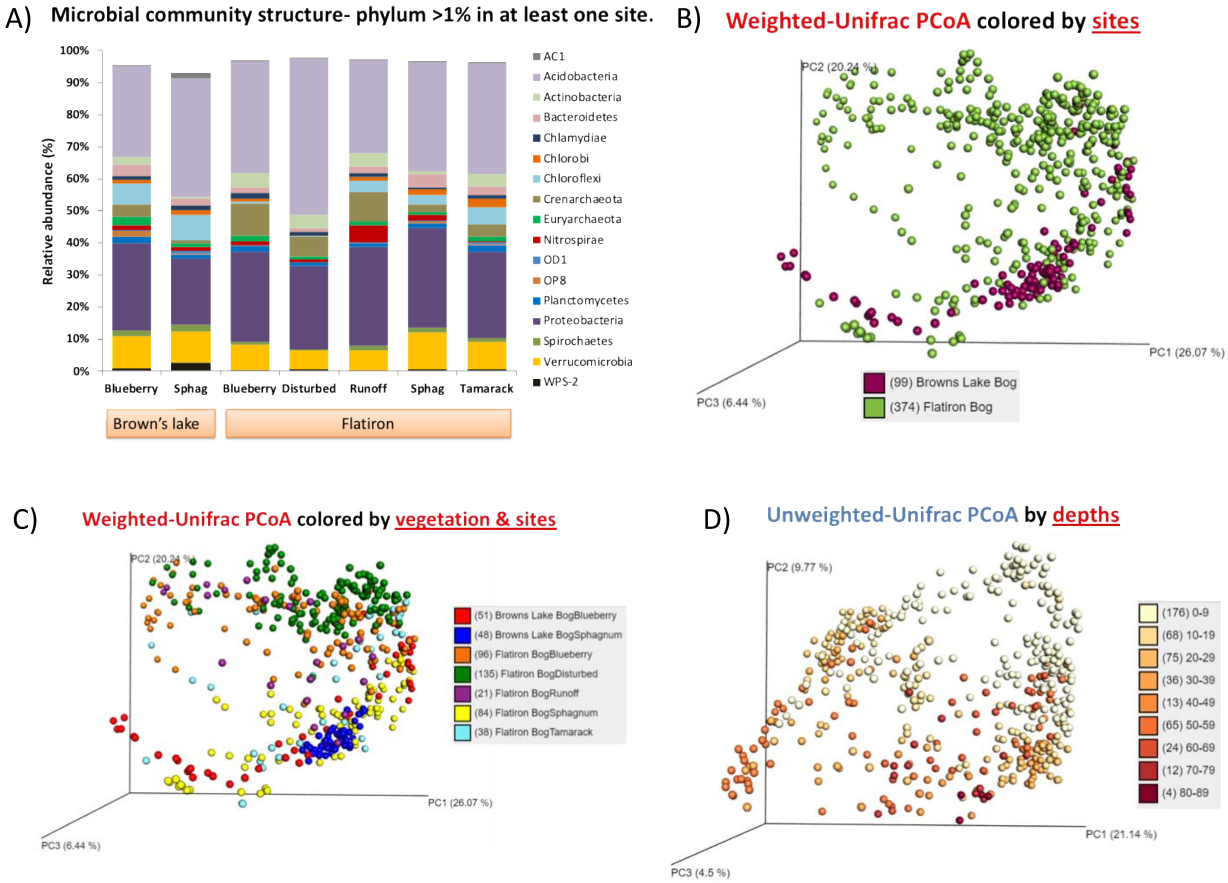


Figure 8: Microbiota differ by site, habitat, and depth. (A) Communities across all sites were consistently dominated by Acidobacteria and Proteobacteria, and showed similar overall phylum-level relative compositions among sites. (B) Principal coordinates analysis, accounting for genetic relatedness of communities (via Unifrac distances) and weighted by the relative abundances of members, indicated that Flatiron Bog was home to a larger diversity of microbial communities than Browns Lake Bog, and the latter was a discrete subset of the former. (C) Overlaying habitat type information on the same analysis suggested some habitat cohesion across sites. (D) Communities also diverged gradually by depth; this was clearest when plotting communities by genetic relatedness but not weighting by relative abundances, indicating that the presence/absence of rarer or more genetically divergence, low-abundance members may drive the depth patterning.

After processing, 8.15M reads remained for the 473 samples, with an average of 17,085 (SD 6,081) reads per sample. Acidobacteria (28-49%), proteobacteria (21-31%), and Verrucomicobia (6-12%) were the three most relatively abundant phyla across the sites irrespective of site or habitat (Figure 8A), with differences in known nitrogen- and methane-cycling organisms we are currently investigating. For example, markedly higher Nitrospirae, and high Crenarchaeota (which include the archaeal ammonia oxidizers), were present in the runoff-impacted site. PCoA analysis showed sample separation by site (flatiron vs brown lake), habitat, and sample depths (0-90cm) (Figure 8B-D). Notably, Sphagnum dominance caused similar overall community compositions between the two sites (Figure 8C), while the dominance of blueberry did not. *Sphagnum* spp., high in secondary compounds and generally lowering site pH as is well described in the literature, acted as a control on belowground community structure and processes. We continue to explore the specific lineages, and geochemical and vegetation correlations, in the microbiota at these two sites.

4. Finding Significance

Mapping historic peatlands: Shape files of our identified and classified bogs are available from the authors and will be publicly archived once the classification is complete and results published. The maps we've developed will provide an important resource for researchers wanting to understand Ohio's peatland ecology and managers seeking information relating to targets and contexts for wetland restoration. We conclude that attempts to estimate changes in historic bog extent based on early USGS maps are confounded by too many factors to be accurate. Differences in scale, wetland mapping criteria, and difficulty in identifying the borders of certain sites make accurate estimates of area prolematic. However, historical maps still contain valuable information on the locations of former peatlands and can provide insights into land use changes and site history. Our mapping will provide an invaluable resource that catalogues areas where peatland cover has been lost and that should be a priority for ground survey to assess restoration potential. The NWI can be used in conjunction with site descriptions from the literature to define current bog extent. On-going research is focused on quantifying uncertainty in changes in peatland extent and developing a conservative estimate of peatland loss. We also aimed to develop a more detailed classification of the sites' current and past land-use and land-cover to assess surrounding land-cover, this work is on-going. Our map of current bog extent can be used to examine current land use pressures on extant sites. Andreas and Knoop's (1992) study listed the cause of destruction of historic peatland sites, but the pressures facing Ohio's remaining bogs have not been quantified. Using the National Land Cover Database and aerial imagery, we can gain an understanding of the threats to Ohio's bogs at a landscape scale.

It appears that, being more difficult to drain, kettle hole peatlands such as those evaluated above are likely to diverge in land use history from much larger peatland complexes. While the latter pose unique challenges for delineation, historical maps could be an important source of information on the history of such sites.

Fifteen sites listed by Andreas and Knoop (1992) could not be located due to a lack of data. Records from throughout Ohio's herbaria, including Andreas's own collections, can be accessed online through the Consortium of Midwest Herbaria. These fifteen sites and more may be located relatively easily by searching for herbarium specimens used by Andreas and Knoop (1992).

Peatland hydrochemistry: We have established a detailed initial baseline to understand variation in hydrochemistry within and between remaining peat bogs. This information can be used as a basis against which to assess hydrochemistry in sites undergoing restoration. Our sites had a pH at the higher end of the range typical for bogs. This could indicate some influence from surrounding land use and/or a non-negligible influence of surface run-off and groundwater. The latter finding would suggest that, hydrologically, Ohio's peat bogs are more likely poor fen systems. This is supported by the high EC with a wide range (33–597 μS cm^{-1}; median = 70 μS cm^{-1}) compared to 35–78 μS cm^{-1} reported by Andreas and Bryan (1990). Our results have demonstrated significant hydrochemical gradients within Ohio's peat bogs that serve to differentiate important differences in above- and below-ground community structure. Carbon stock estimates confirm that, despite their small size and total area, peat bogs are a critical store of ancient carbon. Protecting, enhancing and restoring this function should be a key priority for restoration and management.

Community composition: Our research has revealed the utility of using bryophytes as indicators of peatland hydrochemical status. This will facilitate monitoring where resources for detailed assessments of varying water table and water quality conditions is not possible. Our microbial data will help us understand the above- below-ground linkages that determine the carbon balance and ecosystem function of remaining peatland sites.

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PART II. PUBLICATION CITATIONS

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Slater JM, Davies GM, Rich VI, Bohrer G. (2017). Plant community composition across environmental and disturbance gradients in Ohio's peat bogs [poster]. Ohio Academy of Science Annual Meeting. University of Cincinnati, Cincinnati, Ohio, 8th April 2017.

PART III.STUDENTS SUPPORTED

- MS Student – Yushan Hao – Environmental Science Graduate Program
- MS Student – Julie Slater – Environment and Natural Resources

- PhD Student – Camilo Rey Sanchez – Environmental Engineering
- Undergraduate Student – Yuchen Liu – Environmental Science
- Undergraduate Student – Charles Davis – Environmental Science
- Post-doctoral Research Associate – Roger Grau Andres

PART IV. PROFESSIONAL PLACEMENT OF GRADUATES

- PhD Student Camilo Rey Sanchez -

  Co-instructor, Applied Hydrology. Department of Civil, Environmental and Geodetic Engineering. The Ohio State University. Fall 2017.

  Post-Doctoral Research Associate, Department of Environmental Science, UC Berkeley
- MS Student Yushan Hao –

  Teaching Assistant, Forest Ecology. School of Environment and Natural Resources. The Ohio State University. Fall 2017

  Teaching Assistant, Water Law. School of Environment and Natural Resources. The Ohio State University. Spring 2018
- Yuchen Liu –

  MS degree at Columbia University (Environmental Science)
- Roger Grau Andres –

  Postdoctoral Research Associate, Umea University Sweden
- Julie Slater

  Ecological Consultant, Stantec, Ohio
- Charles Davis

  MS Student, The Ohio State University, Ohio

PART V. AWARDS OR ACHIEVEMENTS

- PhD Student Camilo Rey Sanchez received the prestigious OSU Presidential Fellowship for the final year of his studies in recognition of his outstanding progress to date.
- Undergraduate student Charles Davis was awarded an SROP Fellowship to continue to MS study at OSU

APPENDIX A – LIST AND CLASSFICIATION OF CURRENT AND HISTORIC PEAT BOGS IN OHIO

Table A.1: Peat bogs identified based on analysis of records reported in Dachnowski (1912), Andreas (1985) and Andreas & Knoop (1992). Where not Latitude and Longitude are given it was not possible to identify even an approximate location beyond the county and township. Confidence reflects our reanalysis of the ecological status of the sites and our confidence the vegetation community was reflective of an acidophilous vegetation type. It is not a reliable indicator of the sites' current or historic hydrological regime. Status reports our assessment of whether the site is extant (E), degraded (D) or historic/destroyed (H).

Site Name	Alternate names	Latitude	Longitude	County	Township	Section	Andreas 1985 Classification	Confidence	Status
Atwater Center		41.0451	-81.1377	Portage	Atwater		Bog	H	D
Barnacle Bog				Portage	Ravenna		Bog	M	
Bath Tamarack Bog		41.1773	-81.6437	Summit	Bath			H	E
Baughman Bog		40.7194	-81.6151	Stark	Sugar Creek			L	E
Bird Farm Bog	Bird Bog	41.0841	-81.2955	Portage	Rootstown		Bog	H	E
Bloody Run Swamp		39.9375	-82.5706	Licking	Harrison		Bog	L	H
Bloomfield Bog		41.4515	-80.8336	Trumbull	Bloomfield		Bog	M	H
Bonnett Pond Bog	Bonnet Lake, Long Lake, Cranberry Marsh	40.6631	-82.1388	Holmes	Washington		Fen	H	E
Brown's Lake Bog		40.6821	-82.0627	Wayne	Clinton		Bog	H	E
Bucyrus Bog		40.7972	-82.9333	Crawford	Bucyrus			L	H
Burned Bog				Portage	Hiram		Bog	M	H
Camden Lake Bog	Cambden Lake Bog	41.2428	-82.3351	Lorain	Camden		Bog	H	D
Caston Pond Bog	Caston Road Bog	40.9576	-81.5287	Summit	Green		Bog	M	E
Congress Lake		40.9776	-81.3263	Stark	Lake		Bog	M	H
Cranberry Bog	Cranberry Island, Buckeye Lake	39.9314	-82.4687	Licking	Licking			H	D
Eagle Creek Bog		41.2919	-81.0619	Portage	Nelson			H	E
Eckert Bog		41.1959	-81.3093	Portage	Ravenna		Bog	H	H
Fern Lake	Lake Kelso, Bradley Pond, Kellmore Lake	41.4444	-81.1750	Geauga	Burton		Bog	H	E
Flatiron Lake Bog		41.0448	-81.3665	Portage	Suffield		Bog	H	E
Florence Bog		41.5331	-84.7786	Williams	Florence			H	H
Forquier Bog				Richland	Cass		Bog	M	
Fox Lake Bog		40.8913	-81.6661	Wayne	Baughman	1 & 12	Bog	H	D

Frame Bog	Herrick Fen, Frame Lake Fen	41.2112	-81.3666	Portage	Streetsboro		Bog	L	E
Garfield Bog		40.9173	-80.9659	Mahoning	Goshen	30 & 31	Bog	L	D
Grand River Terraces				Ashtabula	Morgan		Bog	M	E
Guilford Bog		40.7942	-80.8396	Columbiana	Center	7 & 8	Bog	L	D
Hartville Bog		40.9752	-81.3422	Stark	Lake		Bog	H	E
Infirmary Road Bog	Tummonds Nature Preserve	41.2784	-81.2407	Portage	Mantua		Bog	H	D
Karlo Bog	Karlo Fen			Summit	Coventry		Bog	M	
Kent Bog	Brimfield Bog? Check	41.1256	-81.3542	Portage	Brimfield		Bog	H	E
Kline Farm Bog		41.5352	-84.7972	Williams	Florence			H	H
Lake Township Bog				Stark	Lake		Bog	M	
Lash's Bog	Brewster Bog	40.7011	-81.6143	Stark	Sugar Creek	16		H	E
Lehman Bog	Big Lake, Leman's Lake, Lehman Lake	41.4121	-84.7270	Defiance	Milford	2 & 11	Bog	H	D
Leon Bog		41.6468	-80.6456	Ashtabula	Morgan		Bog	L	D
Similar to Leon Bog		41.6700	-80.6414	Ashtabula	Dorset			L	D
Long Lake Bog		41.0024	-81.5371	Summit	Coventry			L	E
Luna Lake Bog		40.9216	-81.6211	Summit	Clinton		Bog	M	D
Lyman Bog				Stark	Sugar Creek		Bog	H	
McCracken Bog		40.3048	-83.7858	Logan	Liberty			L	E
Morgan Swamp		41.6516	-80.8937	Ashtabula	Morgan		Bog	L	E
Mud Lake Bog		41.2302	-81.4719	Summit	Hudson		Bog	L	D
New Haven Bog	New Haven Marsh, Huron Bog	41.0088	-82.7691	Crawford/ Huron	Auburn/ New Haven		Bog	L	D
New Washington Bog	Crawford Bog, Cranberry Marsh	40.9297	-82.8698	Crawford	Cranberry	24,25,26		L	H
Norton Bog	Part of Copley Swamp, Copley Bog			Summit	Norton		Bog	H	
Orrville Bog	Orville Bog			Wayne	Orrville	29	Bog	L	H
Orwell Tamarack Bog	Orwell Swamp, Orwell Bog	41.5157	-80.8216	Ashtabula	Orwell		Bog	M	D
Panzer wetland	Part of Copley Swamp, Copley Bog	41.0662	-81.6098	Summit	Copley			L	D
Pettibone Swamp				Cuyahoga	Solon		Bog	M	
Punderson Lake		41.4624	-81.2102	Geauga	Newberry		Bog	L	E

Railroad Bog	Railroad Cranberry Bog	41.2917	-81.3973	Summit	Twinsburg		Bog	H	E
Rider Road Bog				Geauga	Burton			L	
Rockwell Bog				Portage	Franklin		Bog	M	
Round Lake	Mud Lake	40.6722	-82.1448	Ashland	Lake		Bog	H	H
Savannah Lakes		40.9456	-82.3518	Ashland	Clear Creek			L	D
Seville Bog				Lorain	Camden		Bog	M	
Singer Lake Bog		40.9167	-81.4862	Summit	Green	33	Bog	H	E
Snow Lake	South Pond	41.4259	-81.1755	Geauga	Troy		Bog	M	E
Snyder Bog		40.9167	-80.6415	Mahoning	Beaver		Bog	M	H
Solon Bog	Geauga Lake/Pond, Aurora Lake/Pond	41.3377	-81.3859	Cuyahoga	Solon		Bog	L	H
St Joseph Bog		41.4959	-84.7763	Williams	St Joseph	8	Bog	H	H
Steinert's Bog				Summit	Bath		Bog	M	
Stratton Pond				Portage	Franklin		Bog	M	
Torrens Bog				Licking	Burlington		Bog	H	
Triangle Lake Bog		41.1181	-81.2617	Portage	Rootstown		Bog	H	E
Turkeyfoot Lake Bog				Summit	New Franklin		Bog	H	
Utica Bog	Cranberry Prairie			Licking	Washington		Bog	M	
Utzinger Bog		39.8333	-83.0289	Franklin	Jackson			M	H
West Swamp				Trumbull	Braceville		Bog	M	
Youngs Bog		41.0149	-81.4038	Summit	Springfield			M	E