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Peatlands and Histosols in Canaan Valley National Wildlife Refuge, West Virginia

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Peatlands and Histosols in Canaan Valley National Wildlife Refuge, West Virginia

Mitzy L. Schaney

**Dissertation submitted to the
Eberly College of Arts and Sciences
at West Virginia University
in partial fulfillment of the requirements
for the degree of**

**Doctor of Philosophy
in
Geology**

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2019

**Keywords: Holocene, Late Pleistocene, Peatlands, Histosols, Hypsithermal, Allegheny
Mountains, Appalachian Mountains, Canaan Valley, Soil Taxonomy, Pedomememory,
Pedology**

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Abstract

Peatlands and Histosols in Canaan Valley National Wildlife Refuge, West Virginia

Mitzy L. Schaney

Canaan Valley in West Virginia contains a greater area of peatlands than any other locality in the mid-Atlantic Highlands. Extensive fieldwork focused on peat stratigraphy and pedology, combined with high-resolution radiocarbon dating, was used to evaluate five peatlands within Canaan Valley National Wildlife Refuge (CVNWR) in the central Appalachian Mountains. One hundred soil cores were profiled and described, 30 with laboratory data, including 52 radiocarbon dates. Calibrated basal peat dates among the five mapped peatlands indicate a late Pleistocene timeframe for the onset of peat genesis, ranging from ~18,600 to ~15,200 cal yr BP. The dates for peat initiation are older than those published previously from other central Appalachian Mountain peatlands. Peat accumulation rates varied from 0.02 mm/yr to 1.34 mm/yr with a mean of 0.14 mm/yr. Results of age-depth profiles show similar trends in peat accumulation: moderately high peat accumulation during the late Pleistocene, below average peat accumulation in the early Holocene, the slowest peat accumulation (if any) during the mid-Holocene, and rapid peat accumulation in the early late Holocene. Very few samples were collected correlating to the last 2,000 years; however, those few suggest a possible decrease in peat accumulation.

CVNWR peatlands hold pedomemory of latest Pleistocene and Holocene climatic fluctuations in the central Appalachian Mountains. The field investigation revealed a distinct pattern of organic soil horizons throughout five study peatlands. The anaerobic lower portion of the peat soil profile consists of varied thicknesses of a combination of hemic and sapric soil materials, characteristically layered as a hemic horizon, underlain by a sapric horizon, underlain

by another hemic horizon, these also correlate with general trends in the age-depth plots. Late Pleistocene peat initiation and accumulation form the lower hemic horizon, correlating with general warming after the Last Glacial Maximum. Between 10,000 and 4,200 cal yr BP, low peat accumulation and decomposition of previously deposited peat prevailed, forming the sapric, or most decomposed, horizon in the anaerobic portion of the soil profile. This early to mid-Holocene interval of minimal accumulation and significant decomposition indicates a climatic change to a dryer environment. The upper hemic horizon within the anaerobic portion of the soil profile formed during the wetter early late Holocene. A sapric horizon at the water table is overlain by an aerobic fibric surface horizon in uppermost portion of the soil profile.

Soil profiles were classified according to *Soil Taxonomy*, and soil cores were mapped using the *Soil Survey Manual*. CVNWR Histosols were classified as Dysic, frigid Sapric Haplohemists and given an official series description and new soil series name of Canaan Valley peat. The five CVNWR peatland landforms are now mapped with a new map unit, Canaan Valley peat, moist, 0 to 3 percent slopes (map symbol CavA), totaling 246 hectares. These rare soils support unique ecosystems of high conservation value and ecological significance.

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Chapter 1

Introduction

The rare soils within the peatlands of Canaan Valley National Wildlife Refuge (CVNWR) support unique ecosystems of high conservation value and ecological significance. High-elevation peatlands of the central Appalachian Mountains are a southern extension of contemporary boreal ecosystems commonly associated with bogs and fens (Francl et al., 2004; Ingham, 1996; Snyder et al., 2006; Stewart and Nilsen, 1993; Stine et al., 2011; Whitehead, 1965). Peatlands act as archives of paleoenvironmental and paleoclimatic proxies, serve as both sinks (CO₂) and sources (CO₂ and CH₄) of greenhouse gases, and represent a substantial worldwide carbon pool, making them scientifically valuable to understand past, current, and future global and local climates (Beilman et al., 2010; Chimner et al., 2014; Franzen et al., 2012; Ireland et al., 2013; Langdon et al., 2013; Loisel and Garneau, 2010; Warren et al., 2012; Yu et al., 2011, 2009; Zauft et al., 2010). Peatland soils, or Histosols, are not common in the Appalachian Mountains; before this study, CVNWR (Figure 1-1) peatlands soils had not been pedologically classified according to *Soil Taxonomy* and had been only briefly investigated several decades ago (Cameron, 1970).

Figure 1-1. Landscape photograph of Canaan Valley National Wildlife Refuge Peatland 4 facing southwest.

A career as an environmental scientist and previous graduate education in geomorphology and soils provided a professional working knowledge of wetlands, a passion for pedology, and an interest in geomorphic landform development. This dissertation research, which began in 2014, concentrated an interest in peatland soils and wetland landform development. Synthesizing data and report preparations have been in progress since this research began. Fieldwork commenced in the spring of 2014 and concluded in the summer of 2015. Radiocarbon dates and lab analysis were completed during the 2015-2016 academic year. Manuscript preparation has proceeded the following two years.

This dissertation has three broad foci organized into chapters 2 through 4. Chapter 2 discusses the extensive fieldwork completed on these peatlands and the high-resolution radiocarbon-dated peat chronology developed from the peat cores; the Canaan Valley sequence is discussed in reference to chronologies from other Allegheny Mountain peatlands. Radiocarbon dates discussed in Chapter 2 will be archived in the International Soil Radiocarbon Database (ISRaD, <https://international-soil-radiocarbon-database.github.io/ISRaD/>). ISRaD has been developed as a collaboration between the U.S. Geological Survey Powell Center and the Max Planck Institute for Biogeochemistry. Database entry has been completed with a satisfactory quality assurance and quality control report (Appendix B); submission to ISRaD is awaiting a digital object identifier (doi) which will be received upon electronic theses and dissertation (ETD) submission of this dissertation to West Virginia University library system. This database includes profile descriptions for every single horizon recorded during this investigation, and laboratory data where sampled and analyzed. Chapter 2 entitled “Radiocarbon dating peatland development: key steps in reconstructing past climate in the central Appalachian Mountains” will be submitted for publication to *Quaternary Science Reviews*, published by

Elsevier, a journal of Quaternary science that includes geomorphology, soil science, and, paleoclimatology and the full range of applicable dating methods.

Chapter 3 covers the distinct soil horizon pattern identified within a majority of the 88 Histosol soil profiles. Pedomemory of CVNWR Histosol stratigraphy revealed proxy evidence of a dryer climate during the mid-Holocene Climatic Optimum in the central Appalachian Mountains. Chapter 3 entitled “Evidence of mid-Holocene (Northgrippian Age) dry climate recorded in organic soil profiles in the central Appalachian Mountains” will be submitted for publication to *Catena*, an interdisciplinary journal of soil science, hydrology, and geomorphology focusing on geoecology and landscape evolution published by Elsevier.

Chapter 4 documents the classification and mapping of CVNWR Histosols in cooperation with Natural Resource Conservation Service (NRCS). It was important to the author to incorporate dissertation data into the NRCS, not only as an example of academic endeavors contributing federal agencies, but also to be incorporated into public knowledge. The 100 soil profile descriptions with laboratory data and taxonomic classifications are included in Appendix A of this document. The official series description (OSD) for the Canaan Valley soil series (https://soilseries.sc.egov.usda.gov/OSD_Docs/C/CANAAN_VALLEY.html) lists this dissertation as the primary reference; NRCS does not archive soil profile descriptions beyond the typical pedon described in the OSD. Chapter 4 entitled “Classification and Mapping of Rare and Unique Histosols in the Central Appalachian Peatlands of Canaan Valley National Wildlife Refuge, West Virginia” will be submitted for publication to *Soil Science Society of America Journal* the flagship journal of the Soil Science Society of America and publishes basic and applied soil research in agricultural, forest, wetlands, urban settings and more.

Chapter 5 is a brief summary and future research ideas.

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This work would not have been possible without the support, assistance, collaboration, and guidance from many mentors, colleagues, friends, and family. I would like to thank my committee chairman and primary advisor, Dr. J. Steven Kite, and my secondary advisor, Dr. James A. Thompson with the continual encouragement to complete this dissertation. They both assisted with field work, generation of ideas and theories, interpreting data, manuscript editing, guidance through the PhD process, and emotional support. I would also like to thank Dawn Washington of Canaan Valley National Wildlife Refuge for granting me permission to access, core, and dig in these unique ecosystems. CVNWR also provided field assistants and equipment. Radiocarbon analysis was funded by the U.S. Fish & Wildlife Service for CVNWR and supported by the Radiocarbon Collaborative, which is jointly sponsored by the USDA Forest Service, University of California Irvine, and Michigan Tech University. That leads me to thanking Dr. Katherine Heckman, one of my committee members, and the liaison with the Radiocarbon Collaborative. Kate assisted with data interpretation and archiving for ISRaD. I would also like to thank Dr. Christopher Coughenour for timely completion of age-depth plots from the statistical modeling program Bacon in R.

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Chapter 2

Radiocarbon dating peatland development: key steps in reconstructing past climate in the central Appalachian Mountains

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Abstract

Canaan Valley in West Virginia contains a greater area of peatlands than any other locality in the mid-Atlantic Highlands. Extensive fieldwork focused on peat stratigraphy, combined with high-resolution radiocarbon dating, was used to evaluate five peatlands within Canaan Valley National Wildlife Refuge (CVNWR). One hundred soil cores were profiled and described, 30 with laboratory analysis, including 52 radiocarbon dates. Calibrated basal peat dates from the five peatlands indicate the onset of peat genesis ranged from ~18,600 to ~15,200 cal yr BP. Basal peat dates on the two oldest cores are 1,800 to 2,200 older than published dates on peat initiation in any other Appalachian Mountain peatlands. Peat accumulation rates have

varied from 0.02 mm/yr to 1.34 mm/yr, with a mean of 0.14 mm/yr. Results of age-depth profiles for six well-dated cores show similar trends in peat accumulation: rapid accumulation during the late Pleistocene (Heinrich Stadial 1, Bølling-Allerød interstadial, and Younger Dryas cold stadial), lower accumulation rates in the early Holocene (Greenlandian Age), even lower accumulation rates during the mid-Holocene (Northgrippian Age), and the most rapid peat accumulation at the onset of the late Holocene (early Meghalayan Age). A paucity of shallow peat dating younger than 2000 BP may reflect a reduction in peat accumulation, or mixing of surface vegetation into near-surface soil horizons. The well dated and carefully described soil cores from CVNWR suggest a somewhat different peat development history than the process of terrestrialization previously proposed for other peatland ecosystems in the region.

Keywords: Holocene, Peatlands, Histosols, Mid-Holocene Climatic Optimum, Allegheny Mountains, Appalachian Mountains, Canaan Valley

Introduction

Central Appalachian peatlands are a southern extension of contemporary boreal ecosystems commonly associated with bogs and fens (Ingham, 1996; Stine et al., 2011; Whitehead, 1965). Allegheny Mountain peatlands range in size from a few hectares to a few hundred hectares (Ingham, 1996). Byers et al. (2007) placed Allegheny Mountain peatlands within the High Allegheny Wetland Ecological System. This ecological system occurs in a southwest-northeast trending band about 40 km wide and 200 km long along the Allegheny Mountain section of the Appalachian Plateaus physiographic province in unglaciated Pennsylvania, Maryland, and West Virginia (Cameron, 1970).

Paleoecology and development history have been published previously for eight Allegheny Mountain peatlands (Figure 2-1): Big Run Bog (Larabee, 1986), Buckles Bog (Maxwell and Davis, 1972), Cranesville Swamp (Booth et al., 2016; Cox, 1968), four peatlands within Cranberry Glades (Bender et al., 1977, 1979; Darlington, 1943; Edens, 1973; Watts, 1979), and one peatland within Canaan Valley (Cameron, 1970), which was reexamined for this study. Most published Allegheny Mountain peatland chronologies share a proposed developmental history beginning in the late Pleistocene or Holocene as an open body of water accumulating limnic sediments that evolves through a transitional process of terrestrialization, first into a wetland accumulating organic-rich clays, and then into a peatland accumulating organic soils. The overall paleoecological record illustrates a general sequence of the vegetation changing from alpine tundra to open boreal forest, to closed boreal forest, and then finally transitioning into a mixed coniferous-deciduous forest that retained many boreal species. Before the logging era of the 1880s to 1920s, most vegetation in Allegheny Mountain peatlands consisted of hemlock (*Tsuga canadensis*), red spruce (*Picea rubens* Sarg.), and balsam fir (*Abies balsamea* (L.) Mill.) along the wetland edges with *Rhododendron* thickets in the understory, and *Sphagnum* and other mosses blanketing the forest and wetland floor (Franci et al., 2004). Allegheny Mountain peatlands have a rich biodiversity comprised partially of relict populations of once widespread boreal flora (Russell et al., 2009; Wieder et al., 1981). Biodiversity, prior to logging, resulted from dynamically changing landscapes and vegetation during the latest Pleistocene and Holocene climatic fluctuations (Barrington and Paris, 2007; Delcourt and Delcourt, 1986; Martin and Germain, 2016; Russell et al., 2009; Stine et al., 2011).

The primary goal of this research was to establish whether CVNWR, which contains the largest area of peatlands in the Allegheny Mountain physiographic region, has a similar

developmental history as the previously studied peatlands in the region. Extensive fieldwork and high-resolution radiocarbon dating were used in evaluation of the climatic and ecosystem developmental history of five peatlands within CVNWR. Climate-ecosystem dynamics are an ever-increasing concern in the face of current and forecasted regional climate change. Preservation of unique ecosystems in the face of anthropogenic use and climate changes is also a concern for the Allegheny Mountain peatlands. Understanding past climate-ecosystem dynamics can be especially useful not only for land-use management decisions but also for understanding future climate-ecosystem dynamics.

Depositional environments are difficult to interpret and compare from previous studies of other peatlands in the region due to inconsistency in sediment profile descriptions and widely varying radiocarbon sample density; however, some generalizations are revealed. Published dates for the eight previously studied Allegheny Mountain peatlands outside Canaan Valley were calibrated for this publication using OxCal 4.2 and IntCal13 Northern Hemisphere calibration curve (Bronk Ramsey, 2009; Reimer et al., 2013) for ease of comparison (Table 2-1). Larabee (1986) reconstructed the development of Big Run Bog in Tucker County, West Virginia, with pollen and sediment analysis of one core. Big Run Bog began as an open body of water, evidenced by inorganic silty clay and clayey silt, from ~20,400 to ~19,700 cal yr BP, transitioning into a wetland accumulating organic-rich clay around ~17,000 cal yr BP, and finally a peatland accumulating fibrous clayey peat by ~5,400 cal yr BP. Maxell and Davis (1972) completed a pollen and sediment analysis of one core from Buckles Bog (now known as The Glades) in Garrett County, Maryland. Buckles Bog began as an open body of water accumulating inorganic clay from ~22,400 to ~21,000 cal yr BP, transitioned into a wetland accumulating organic-rich clay beginning ~19,000 cal yr BP, and into a peatland accumulating

fibrous peat beginning at ~15,000 cal yr BP. Cox (1968), who completed a pollen analysis of one core from Cranesville Swamp, on the West Virginia-Maryland border, without the benefit of radiocarbon dates, surmised that a lake originated during the last glacial advance, and persisted until a warming trend facilitated the growth of *Sphagnum* and a transition to a peatland. Recently, Booth et al. (2016) examined two cores from Cranesville Swamp dating peat accumulating beginning at ~1,000 cal yr BP. Cranberry Glades in Pocahontas County, West Virginia, began as an open body of water accumulating clay and marl during the late Pleistocene (Darlington, 1943; Edens, 1973), transitioned into a wetland accumulating organic clay at ~14,100 cal yr BP and finally into a peatland accumulating peat beginning at ~5,600 cal yr BP (Bender et al., 1979, 1977; Watts, 1979). Darlington (1943) described over 150 cores from Cranesville Swamp, before the advent of radiocarbon dating. Cameron (1970) described peat and sedimentary deposits from 10 cores in one peatland in Canaan Valley in Tucker County, West Virginia (labeled by Cameron as peatland I-4, now labeled Peatland 5 in this study). Cameron (1970) obtained one radiocarbon date of ~6,000 cal yr BP from reed-sedge peat, not from the base of the organic soils. Collectively published data on Allegheny Mountain peatlands indicate a wide age range for the initiation of peat accumulation (Table 2-1), from ~16,400 cal yr BP (Cameron, 1970) and ~15,000 cal yr BP (Maxwell and Davis, 1972) at Buckles Bog, ~11,000 cal yr BP (Arnold and Libby, 1951) and ~5,600 cal yr BP (Bender et al., 1979, 1977; Watts, 1979) at Cranberry Glades, ~5,400 cal yr BP at Big Run Bog (Larabee, 1986), to ~1,000 cal yr BP at Cranesville Swamp (Booth et al., 2016).

Laboratory ID	Location	Publication	Material dated	Depth (cm)	¹⁴ C age ±		intCal13 Calibrated Dates 95% confidence interval		median cal yr BP
							From	To	
USGS-W2255	Canaan Valley	Cameron (1970)	reed-sedge peat	132	5250	250	6627	5477	6029
A-4261	Big Run Bog	Larabee (1986)	fibrous organic clay	38	210	200	538	20	259
A-4260	Big Run Bog	Larabee (1986)	clayey peat	69	4680	110	5640	5046	5403
A-4264	Big Run Bog	Larabee (1986)	slightly silty organic clay to fibrous organic clay	112	10760	160	13057	12190	12674
A-4263	Big Run Bog	Larabee (1986)	fibrous organic clay	154	12600	170	15436	14153	14858
A-4259	Big Run Bog	Larabee (1986)	fibrous organic clay to slightly silty organic clay	197	13990	220	17584	16322	16975
A-4262	Big Run Bog	Larabee (1986)	slightly silty clay	212	16380	290	20487	19057	19776
A-4258	Big Run Bog	Larabee (1986)	clayey silt	226	16910	340	21331	19591	20424
UGAMS 9988	Cranesville Swamp (1)	Booth et al. (2015)	<i>Sphagnum</i>	36	60	25	256	31	71
UGAMS 9987	Cranesville Swamp (1)	Booth et al. (2015)	Charred <i>Picea</i> needles & charcoal fragments	41	190	25	296	-4	178
UGAMS 10676	Cranesville Swamp (1)	Booth et al. (2015)	<i>Sphagnum</i> and <i>Picea</i> needles	57	230	20	307	-3	284
UCIAMS 105039	Cranesville Swamp (1)	Booth et al. (2015)	<i>Picea</i> needles	71	950	20	926	796	851
UCIAMS 105038	Cranesville Swamp (1)	Booth et al. (2015)	<i>Picea</i> needles	76	1260	20	1274	1176	1223
UGAMS 12021	Cranesville Swamp (1)	Booth et al. (2015)	wood fragment	100	8610	25	9622	9528	9548
UCIAMS 105041	Cranesville Swamp (2)	Booth et al. (2015)	<i>Picea</i> needles	72	1255	20	1275	1097	1221
Y-2436	Buckles Bog	Maxwell & Davis (1972)	fibrous peat	74	10530	160	12734	11848	12414
Y-2612	Buckles Bog	Maxwell & Davis (1972)	fibrous peat	161	12320	200	15110	13781	14423
Y-2437	Buckles Bog	Maxwell & Davis (1972)	fibrous peat	191	12640	200	15618	14157	14925
Y-2613	Buckles Bog	Maxwell & Davis (1972)	clayey gyttja	242	15900	240	19805	18703	19210
Y-2619	Buckles Bog	Maxwell & Davis (1972)	clay	249	17400	240	21719	20438	21031
Y-2438	Buckles Bog	Maxwell & Davis (1972)	clay	255	18550	250	22996	21847	22418
USGS-W2253	Buckles Bog	Cameron (1970)	peat	234	13620	600	18196	14691	16465
C-336	Cranberry Glades	Arnold and Libby (1951)	peat	280	9423	840	13082	8775	10890
WIS-794	Cranberry Glades	Watts (1979)	peat	254	4900	65	5879	5476	5641
WIS-933	Cranberry Glades	Watts (1979)	N/A	327	7325	80	8329	7983	8135
WIS-785	Cranberry Glades	Watts (1979)	organic clay	363	12185	140	14759	13737	14112

Table 2- 1. Calibrated radiocarbon dates compiled from previously published research on other peatlands in the Allegheny Mountains.

Study area description

Canaan Valley, in Tucker County, West Virginia (Figure 2-1), is a high-elevation (980 m), breached anticlinal valley, associated with the Blackwater anticline. Headwaters of Blackwater River, within Cheat River watershed, drain most of the valley, including all study sites. Resistant Pottsville Sandstone caps surrounding mountain ridges with elevations of 1,100 to 1,300 m, Mauch Chunk siltstones, shales, and immature sandstones form the more easily erodible valley slopes, and Greenbrier Limestone and lower Mauch Chunk siltstones and shales underlie most of the valley floor (Fortney and Rentch, 2003; Matchen, 2015; Matchen et al., 1999). Projecting through limestone bottomlands in the valley center, a low, elongated ridge corresponds to the axis of the anticline; it is comprised of coarse-grained sandstone of the Price Formation (Matchen, 2015).

Figure 2- 1. The Allegheny Mountain Physiographic Section, shaded in gray, compiled from West Virginia (West Virginia Geologic and Economic Survey, 2017), Pennsylvania (Sevon, 2018), and Maryland (Reger and Cleaves, 2008) state physiographic maps. The star represents the location of Canaan Valley, 1 denotes Big Run Bog (Cramer Bog), 2 denotes Buckles Bog (The Glades), 3 denotes Cranesville Swamp, and 4 denotes Cranberry Glades.

Canaan Valley lies within the Allegheny Mountain section of the Appalachian Plateaus physiographic province of unglaciated Pennsylvania, Maryland, and West Virginia (Cameron, 1970; Fenneman and Johnson, 1946; Reger and Cleaves, 2008; Sevon, 2018; West Virginia Geologic and Economic Survey, 2017). In general, the Allegheny Mountain section is higher in elevation than adjacent physiography and characterized by broad, open structural bedrock folds. Valley floors, and terraces and interfluvies within broad valleys at high elevations (> 730 m) of the plateau are typical locations for Allegheny Mountain peatlands (Cameron, 1970; Diehl and Behling, 1982). Some geographic niches in the Allegheny Mountain section are similar climatically to typical higher latitude boreal peatlands (Cameron, 1970) with high average annual precipitation and relatively low average annual temperature (Sencindiver et al., 2015; Walbridge, 1994; Western Regional Climate Center, 2016). Local topography, orographic precipitation, and the frost pocket effect where cold, nocturnal air drains downslope, decreasing temperatures on the valley floor, all accentuate the regional climatic conditions (Walbridge, 1994).

Structurally controlled bedrock valleys and concave bottomlands of the Allegheny Mountain section were formed by differential erosion. Impeded drainage developed within these valleys before the Holocene (Cameron, 1970), most likely by the blockage of drainage by periglacial activity (Larabee, 1986). Allegheny Mountain peatlands occur in or near the headwaters of first- or second-order streams or occur in specific geologic niches (Ingham, 1996), such as Canaan Valley located on a breached anticline. Cranesville Swamp is located behind a knickpoint of a dipping resistant strata cropping out within a drainageway. Resistant lithology in a dissected plateau created a local base level that controls low gradient wetlands like Big Run Bog (Diehl and Behling, 1982). Allegheny Mountain peatlands have also developed behind

drainage impediments of alluvial levees (Darlington, 1943; Diehl and Behling, 1982; Rigg and Strausbaugh, 1949).

The floor of Canaan Valley contains one of the largest inland freshwater wetland ecosystems of peatlands, marshes, wet meadows, and shrub and forested wetlands in the eastern United States (Fortney and Rentch, 2003) (Figure 2-2). CVNWR encompasses the northern portion of Canaan Valley, protecting most of West Virginia's largest wetland complex, including the five mapped peatlands totaling 246 hectares. These five minerotrophic peatlands are characterized by exceptionally high biodiversity and conservation value (Byers et al., 2007), and have the largest peat deposits located in the unglaciated uplands along the Allegheny structural front in West Virginia, Maryland, and Pennsylvania (Cameron, 1970). These peatlands are ecologically classified as very poor fens, characterized as very acidic, moderately influenced by ground water, and dominated by sedges with a continuous carpet of *Sphagnum* (Kost et al., 2007). Peatlands, such as bogs and poor fens, may contain sensitive records of paleoclimate and paleoenvironment, including past moisture variations (Booth, 2010). Other peatlands are present in CVNWR and elsewhere in Canaan Valley. Unpublished soil profile descriptions for Thompson Enterprise Peat Mine as well as peatlands in Canaan Valley State Park at the southern end of the valley (Davis et al., 1999; Fedorko, 1993) indicate a different horizon sequence than found for this study.

Figure 2-2. Landscape photograph of the wetlands and peatlands located on the floor of Canaan Valley National Wildlife Refuge.

Methods

Old Soil Conservation Service (SCS) map unit polygons, labeled as “muck and peat”, provided an initial base map for this research; data for which were collected between 1959 and 1964 and mapped on 1956 and 1958 aerial photographs (Losche and Beverage, 1967). Cameron (1968) used the SCS polygons originally published in the 1925 *Soil Survey of Tucker County* (Phillips, 1925). The five muck and peat polygons were designated as Peatlands 1 through 5 for this study. Soil morphology was interpreted in the field by describing 100 soil cores throughout and around the five peatlands (Figure 2-3). Soil profiles were classified based upon the field descriptions and laboratory data, using NRCS *Soil Taxonomy* (Soil Survey Staff, 1999).

Figure 2- 3. Locations of 100 soils cores within the five mapped peatlands of CVNWR. Peatlands were numbered 1 through 5 for ease of fieldwork. Cores are numbered after a decimal following each peatland number. Aerial imagery obtained from National Agriculture Inventory Program 2007 by United States Department of Agriculture.

Soil core locations were chosen according to the “free survey” method of sampling soils, which involves the individual development and application of soil-landscape concepts based on the observation that soils will vary repetitively and predictably with geomorphology, topography, and other environmental characteristics (Carlisle et al., 1998). Location of cores was representative of the immediately surrounding terrain. Local small-scale hummocks and hollows were avoided, as well as locations of known anthropogenic disturbance. GPS coordinates, location notes, surface vegetation, and geomorphology, were recorded for each soil profile.

Taking into account vegetation, ecosystem, microtopography, and water depth, a minimum of two specific core profile locations within each peatland were sampled for laboratory analysis. Locations selected for laboratory analysis were cored three separate times within a 30 cm radius of a central point. The first core at a location was used for soil profile description, the second core for bulk density samples, and the third core for all other laboratory analysis. Complete core samples were collected directly from a McCauley peat corer, placed in cut lengths of PVC tubes, wrapped with plastic, taped closed, and labeled.

CVNWR secured U.S. Fish and Wildlife Service funding to provide radiocarbon dating of 52 samples from 11 cores, in conjunction with the Radiocarbon Collaborative, jointly sponsored by the USDA Forest Service, University of California Irvine (previous mass spectrometry conducted at Lawrence Livermore National Lab in Livermore, California), and Michigan Technological University. Samples for radiocarbon dating were chosen and identified according to location and depth within the profile, focusing on basal peat dates, soil horizon breaks, and sedimentary sequence (Givelet et al., 2004; Piotrowska et al., 2010; Tuittila et al., 2013). The lack of compaction in the upper peat profile can introduce potential bias or incorrectly boost in average peat accumulation rate due to the topmost live and uncompacted section (Stivrins et al., 2011; Barber, 1981). Upper portions of the peat profiles were sparsely sampled for radiocarbon dating as to avoid uncertainty from anthropogenic disturbance and uncertainty from proximity to live plant tissue. Samples were treated with successive washes of 1 M HCl, 1 M NaOH, and 1 M HCl at 95°C, then rinsed twice with deionized water and dried. Bulk peat samples were graphitized in preparation for ^{14}C measurement at the Carbon, Water & Soils Lab in Houghton, Michigan. Samples were dried, weighed into quartz tubes, and sealed under vacuum. Samples were combusted at 900°C for six hours with cupric oxide (CuO) and

silver (Ag) in sealed quartz test tubes to form CO₂ gas. The CO₂ was reduced to graphite through heating at 570°C in the presence of hydrogen gas and an iron catalyst (Vogel et al., 1987). Graphite targets were sent to the Center for Accelerator Mass Spectrometry (CAMS) at Lawrence Livermore National Lab, analyzed for radiocarbon abundance (Davis et al., 1990), and corrected for mass-dependent fractionation using an estimated $\delta^{13}\text{C}$ value of -25‰, following Stuiver and Polach (1977). Dr. Vikas Agrawal of the IsoBioGeM laboratory in the Department of Geology and Geography at West Virginia University measured 14 of the 52 radiocarbon samples for $\delta^{13}\text{C}$ to ensure consistency with the estimated $\delta^{13}\text{C}$ value of -25‰. Measured $\delta^{13}\text{C}$ values ranged from -24.1‰ to -28.4‰, sufficiently consistent to use the estimated $\delta^{13}\text{C}$ value of -25‰. Standard radiocarbon ages were calibrated to calendar dates (cal yr BP) using OxCal 4.2 and IntCal13 Northern Hemisphere calibration curve (Bronk Ramsey, 2009; Reimer et al., 2013).

Peat accumulation rates (Table 2-3) were calculated as peat horizon thickness divided by the corresponding time interval in calibrated radiocarbon dated calendar years (Borren et al., 2004). IntCal13 calibrated dates and known accumulation rates were used with Bacon in R to estimate the relationship between age and depth within the cores (Blaauw and Christen, 2011). Bacon, rather than simply finding a polynomial of best fit between sampled points, uses a Bayesian approach that incorporates other information about the samples that may be available to researchers. Bayesian methods incorporate "prior" knowledge to guide the analysis in making an assessment of final probability of occurrence. Prior information in age-depth modeling included changes in accumulation rate inferred on the basis of direct visual observation and soil profile analysis. Bacon assumes that accumulation rate is constant for a period of time and used the prior information in combination with sampled age-depth data (e.g. radiocarbon dates from different depths) to make the most probable "wiggle matches" between sampled points which

themselves contain some uncertainty (Blaauw et al., 2007). As part of the interpolation scheme, Bacon employs an autoregressive (AR) model that computes accumulation rate as a function of previous, underlying computed accumulation rates. The dependence of the model on previous values, the memory, defaulted to a reasonable value for peat soils (Blaauw and Christen, 2011). The AR model is also a function of a noise (residue) term, in this case a gamma function. This term determines the statistical distribution (probability density) of accumulation rates and determines how widely accumulation rates can differ from section to section within a core. The user-input shape factor controls the influence of user-input accumulation rate on the model. Low shape factor values allow for more variability in accumulation rates within a cored sequence. A shape factor of 2 was employed here and is generally considered reasonable for wetland ecosystems (e.g. Crann et al., 2015). Bacon simulates many runs using a self-adjusting Markov Chain Monte Carlo (MCMC) method, discarding implausible results such as negative accumulation rates. The most probable interpolation scenarios are reported (95% prediction interval depicted in gray on Figure 2-4) and accumulation rates are gamma distributed after many simulated runs.

Results

The five NRCS “peat and muck” soil polygons, originally mapped as comprising a total of 187 hectares, were re-mapped in this investigation as 246 hectares. Organic soil thickness in the cores within the five CVNWR peatlands ranged from 0.4 to 3.0 m; with most being less than 2.0 m. Mapping results for the five peatlands are summarized in Table 2-2.

Peatland #	Originally mapped as	Remapped as	Number of cores	Average peat thickness	Maximum peat thickness
Peatland 1	9 hectares	18 hectares	32	~100 cm	174 cm
Peatland 2	26 hectares	26 hectares	11	~95 cm	170 cm
Peatland 3	21 hectares	32 hectares	19	~125 cm	170 cm
Peatland 4	71 hectares	69 hectares	21	~130 cm	217 cm
Peatland 5	60 hectares	101 hectares	17	~170 cm	296 cm

Table 2- 2. Mapping results for the 100 soil cores in and around the five CVNWR peatlands.

Eighty-eight of the 100 soil profiles were classified as Histosols; 12 were classified as Entisols, were excavated outside of the peatland boundary for mapping purposes, and will not be discussed further. Silty and clayey sediments immediately underlie the peat soils in 61 of the 88 Histosol soil cores, whereas sandy sediments underlie peat soils in 12 profiled Histosols. The 12 soil cores with underlying sandy sediments varied spatially; some were near streams, some near higher elevation bedrock, and others in the center of the peatlands. No soil cores contained the interbedded organic sediments providing evidence of a gradual transition from open water to peatland. Underlying mineral sediment was not retrieved in 15 Histosol profiles.

Radiocarbon dating results are listed in Table 2-3. Forty-eight of the original 50 dates were consistent with stratigraphic order, but ages on samples CAMS-172765 and CAMS-172766 in Core 5.17 were inverted, most likely due to error at some step in the sampling or submission process. The problematic horizons in Core 5.17 were re-sampled and re-analyzed, yielding dates CAMS-174232 and CAMS-174233 that were consistent with stratigraphic order. Only age determinations on the reanalyzed samples were used for interpretation, peat accumulation rate calculation, and age-depth plots.

Each of the five CVNWR peatlands had two basal peat age determinations taken from different cores, except for Peatland 4, which had three. Four cores had only a basal peat date as

shown in Table 2-3. Sequential radiocarbon dates were obtained for seven cores. Basal peat samples were taken from immediately above lithologic breaks from underlying mineral soil to overlying organic soil. Initiation of peat accumulation was relatively consistent throughout the five study areas with nine basal peat dates from the five peatlands ranging from ~18,600 to ~15,200 cal yr BP, during or immediately after Heinrich Stadial 1, a timespan marked by retreat of the Lake Huron-Erie Lobe of the Laurentian Ice Sheet had already retreated >200 km north of

Laboratory ID	Sample #	Core #	Depth (cm)	Standard Radiocarbon Age		intCal13 Calibrated Dates 95% confidence interval		Median cal yr BP	Accumulation Rate mm/yr
				¹⁴ C age	±	From	To		
CAMS-171742	25	1.82	128-130	12810	40	15449	15109	15258	
CAMS-172756	32	1.86	2-4	1225	30	1260	1065	1153	0.05
CAMS-172757	33	1.86	40-42	7880	35	8953	8587	8675	0.08
CAMS-172762	38	1.86	59-61	9600	30	11128	10774	10928	0.18
CAMS-172763	39	1.86	86-88	10475	35	12560	12147	12451	0.82 ₊
CAMS-172764	40	1.86	100-102	10635	30	12690	12559	12621	0.08 ₊
CAMS-171738	21	1.86	127-129	13155	40	16002	15637	15807	
CAMS-171739	22	2.05	119-121	15045	40	18435	18099	18284	
CAMS-172760	36	2.09	15-17	3550	35	3960	3720	3844	0.05
CAMS-172761	37	2.09	40-42	8035	35	9021	8775	8909	0.04
CAMS-172758	34	2.09	65-67	12455	45	14961	14251	14598	0.16
CAMS-172759	35	2.09	80-82	12985	40	15732	15315	15528	0.33
CAMS-171737	20	2.09	92-94	13225	40	16069	15730	15896	
CAMS-172750	26	3.13	11-13	1925	30	1947	1817	1873	0.11
CAMS-170482	10	3.13	27-29	3155	30	3450	3269	3382	0.45
CAMS-172751	27	3.13	50-52	3590	30	3977	3833	3894	0.07
CAMS-170483	11	3.13	64-66	5180	30	5991	5905	5936	0.02
CAMS-172752	28	3.13	75-77	10095	40	11954	11404	11687	0.06
CAMS-172753	29	3.13	83-85	11085	35	13063	12824	12960	0.20
CAMS-170484	12	3.13	94-96	11680	30	13570	13445	13510	0.08
CAMS-172754	30	3.13	120-122	13815	40	16946	16488	16715	0.23
CAMS-170485	13	3.13	165-167	15375	35	18759	18544	18653	
CAMS-171740	23	3.14	121-123	13870	40	17009	16573	16802	

Table 2- 3. CVNWR radiocarbon dates and accumulation rates. Dated material consisted entirely of bulk peat samples. Accumulation rates were calculated as the thickness of accumulated peat divided by the corresponding interval between calibrated median radiocarbon ages. Samples 41 and 42 were reanalyzed due to a stratigraphic inversion, likely caused by procedural error. Dates on samples 41* and 42* were in expected stratigraphic order, so these age determinations were used in analysis and interpretation. The + symbol denotes radiocarbon dates with overlapping 95% confidence intervals; mid-points were used to calculate a peat accumulation rates which were used for data interpretation.

Laboratory ID	Sample #	Core #	Depth (cm)	Standard Radiocarbon Age		intCal13 Calibrated Dates 95% confidence interval		Median cal yr BP	Accumulation Rate mm/yr
				¹⁴ C age	±	From	To		
CAMS-170478	6	4.02	7-9	420	35	530	326	486	0.06
CAMS-170479	7	4.02	17-20	2130	30	2299	2001	2111	0.44
CAMS-170480	8	4.02	76-79	3240	30	3560	3388	3460	0.35
CAMS-170481	9	4.02	117-120	4095	35	4814	4446	4607	
CAMS-172755	31	4.09	151-152	4380	40	5212	4852	4942	
CAMS-172770	46	4.19	30-32	2490	30	2730	2460	2584	0.61
CAMS-172771	47	4.19	60-62	2925	30	3164	2971	3072	0.52
CAMS-172772	48	4.19	80-82	3235	30	3558	3385	3453	0.58
CAMS-172773	49	4.19	120-122	3775	35	4281	3992	4146	0.05
CAMS-172774	50	4.19	165-167	11235	35	13164	13041	13097	0.21
CAMS-171741	24	4.19	211-213	12850	40	15545	15160	15315	
CAMS-170473	1	5.12	16-20	2080	30	2140	1952	2050	0.64
CAMS-170474	2	5.12	51-53	2495	30	2732	2466	2585	1.34
CAMS-170475	3	5.12	82-85	2725	30	2873	2761	2817	0.04
CAMS-170476	4	5.12	114-116	9010	30	10235	10170	10204	0.15
CAMS-170477	5	5.12	197-199	13105	35	15940	15540	15733	
CAMS-171732	15	5.17	18-20	2070	30	2123	1950	2039	0.68
CAMS-171733	16	5.17	70-72	2705	30	2857	2756	2804	0.39
CAMS-172765	41	5.17	85-87	3800	30	4288	4088	4187	
CAMS-174232	41*	5.17	82-84	2970	30	3230	3007	3135	0.37
CAMS-172766	42	5.17	120-122	2930	30	3169	2974	3080	
CAMS-174233	42*	5.17	122-124	3820	40	4406	4091	4217	0.07
CAMS-172767	43	5.17	130-132	4580	30	5447	5066	5302	0.63 ₊
CAMS-172768	44	5.17	140-142	4720	45	5584	5322	5460	0.04 ₊
CAMS-171736	19	5.17	161-163	9160	45	10483	10231	10323	0.12
CAMS-172769	45	5.17	173-175	9930	30	11590	11241	11312	0.12
CAMS-171735	18	5.17	196-198	11360	35	13290	13115	13203	0.28
CAMS-171734	17	5.17	225-227	12310	35	14531	14075	14237	0.55
CAMS-171731	14	5.17	288-290	12890	40	15598	15210	15382	

Table 2-3. CVNWR radiocarbon dates and accumulation rates (continued).

its late glacial maximum position (Heath et al., 2018). The only exceptions occur in two cores from a small area in Peatland 4, where basal peat ages were ~4,900 and ~4,600 cal yr BP. Microtopography and hydrology of peatland surfaces and edaphic hydrology are irregular and dynamic (Ammann et al., 2013; Clymo, 1984; Holden, 2005) and were presumably the cause of two of the 11 basal peat dates being drastically younger. Core 3.13 had nine sequential radiocarbon dates that included a long interval from ~11,700 to ~5,900 cal yr BP, within only 10 cm of net peat accumulation. Core 5.17 had 11 sequential radiocarbon dates that included an interval from ~10,300 to ~5,400 cal yr BP, with less than 20 cm of net peat accumulation. These long intervals of very low peat accumulation in the two best-dated CVNWR Histosol cores span most of the early and middle Holocene (Chapter 3).

Accumulation rates (Table 2-3) and age-depth plots of the seven sequentially dated cores displayed varied accumulation rates in response to latest Pleistocene and Holocene climatic changes (Figure 2-4). Peat accumulation rates varied from a maximum of 1.34 mm/yr to a minimum of 0.02 mm/yr, with a mean of 0.14 mm/yr (calculated as the mean of the overall whole core rates at each core with sequential dates).

Four general trends are apparent in the age-depth plots (Figure 2-4) and accumulation rates (Table 2-3). Peat accumulation rates between ~15,800 and ~12,500 cal yr BP averaged 0.24 mm/yr. Net peat accumulation declined to a mean of 0.11 mm/yr between ~11,700 and ~8,600 cal yr BP generally correlating to the early Holocene Greenlandian Age. Few radiocarbon dates were obtained on peat of mid-Holocene Northgrippian Age, hence only two cores include well-constrained mid-Holocene peat accumulation rates. Core 3.13 had a peat accumulation rate of 0.02 mm/yr between ~11,700 and ~5,900 cal yr BP, and Core 5.17 had a peat accumulation rate of 0.04 mm/yr between ~10,300 and ~5,400 Cal yr BP. These appear to

Figure 2- 4. Bayesian age-depth models constructed with modeling software Bacon for seven cores (Cores 1.86, 2.09, 3.13, 4.02, 4.19, 5.12, and 5.17). Note that ^{14}C dates show peat in Core 4.02 dates only from the mid-Holocene and Late Holocene. Transparent blue displays the 95% probability ranges of calibrated ages for individual ^{14}C dates. Red curve shows single 'best' model based on the weighted mean age for each depth. Gray shaded areas indicate the model's 95% probability intervals. Four temporal trends are generally distinguishable: rapid accumulation during the latest Pleistocene, lower accumulation rates in the early Holocene (Greenlandian Age), even lower accumulation rates during the mid-Holocene (Northgrippian Age), and the most rapid peat accumulation at the onset of the late Holocene (early Meghalayan Age).

be the lowest rates of any time since the onset of peat accumulation, a trend reinforced by the scarcity of peat of this age. Exceptionally high peat accumulation rates between ~4,200 and ~2,000 cal yr BP averaged 0.50 mm/yr coeval with the onset of the late Holocene Meghalayan Age. The last 2,000 years of peat development in CVNWR was represented by only three dates, but generally show very low peat accumulations rates averaging 0.08 mm/yr which may reflect a reduction in peat accumulation, or mixing of surface vegetation into near-surface soil horizons.

Discussion

Motivation for this research was to reassess Allegheny Mountain peatlands by collectively using peatland development to reconstruct past climates concentrating on CVNWR. Radiocarbon dates obtained from Allegheny Mountains peatlands and trends in peat accumulation were interpreted in the context of published regional glacial chronology, paleoclimate, and paleoenvironmental literature.

During the Heinrich Stadial 2: 26,000 to 23,600 cal yr BP, glaciers advanced into Ohio and Pennsylvania (Heath et al., 2018) within 170 to 320 km from Allegheny Mountain peatlands in West Virginia and Maryland. Periglacial landforms caused by intense freeze-thaw activity and mass wasting occurred throughout higher elevations of the Appalachian Mountains, including the Allegheny Mountain physiographic section during the LGM (Braun, 1989; Clark and Ciolkosz, 1988; French and Millar, 2014; Ingham, 1996; Nelson et al., 2007; Whitehead, 1965). Open boreal woodlands and tundra were present along the ice margin north of 34°N, with alpine tundra in the high elevations of the Appalachian Plateau (Delcourt and Delcourt, 1986; Jackson et al., 2000; Whitehead, 1973). Boreal cool-temperature conifers dominated vegetation south of the glacial limit to 33°N (Jackson et al., 2000; Whitehead, 1965, 1967, 1973; Yann et

al., 2013). The mid-Atlantic region had forests ranging from cold temperate mixed conifer-hardwood to high boreal in character (Litwin et al., 2013). Sirkin (1977) found tundra vegetation was prevalent throughout the Delmarva Peninsula until 18,000 cal yr BP. Leigh (2008) found that cold and dry conditions with savanna vegetation existed in the southeastern United States coastal plain from 30,000 to 16,000 cal yr BP. High fire activity in central Tennessee coincided with the dominance of cool-temperature conifers from the Last Glacial Maximum (LGM) until 15,000 cal yr BP (Ballard et al., 2016).

As permafrost in the Allegheny Mountain section began to melt from 20,000 to 18,000 cal yr BP (French and Millar, 2014), tundra and alpine tundra vegetation retreated north and the colluvial geomorphic regime that dominated the tundra transitioned into a fluvial geomorphic regime (Delcourt and Delcourt, 1986). Basal peat dates from CVNWR, including ~18,700 and ~18,200 cal yr BP (Table 2-3), are the oldest published dates for peat initiation in the Allegheny Mountain section. CVNWR cores revealed no transitional interbedded organic and mineral sediments indicative of wetland phase. Larabee (1986) dated a sediment sequence interpreted as evidence that Big Run Bog began as an open body of water that transitioned first into a wetland and subsequently later evolved into a peatland (Table 2-1). Maxwell and Davis (1972) dated mineral limnic sediments underlying peat at Buckles Bog, followed by clayey gyttja (Table 2-1) also interpreted as evidence of open water that transitioned into a wetland. As a result of immature and transitioning integrated drainages (Halsey et al., 2000) and an increase in available water (Morris et al., 2018), the landscape was stabilizing and favored the initiation of peatland development during 20,000 to 18,000 cal yr BP.

The climate of the northeastern United States and the Appalachian region ameliorated to warmer conditions around 14,000 cal yr BP (Delcourt and Delcourt, 1986; Kneller and Peteet,

1993), roughly coinciding with the warm and moist Bølling-Allerød interstadial, from 14,500 to 12,600 cal yr BP (Williams et al., 2011; Yu, 2007). The warming and moistening climatic trend correlates with moderately high peat accumulation rates in CVNWR from ~15,800 to ~12,500 cal yr BP. Both Larabee (1986) at Big Run Bog and Maxwell and Davis (1972) at Buckles Bog show not only peat initiation, but also the most rapid peat accumulation during this interval. Watts (1979) dated organic clay from Cranberry Glades ~14,100 cal yr BP (Table 2-1), as this ecosystem transitioned into a wetland. Halsey et al. (2000) identified that the majority of peat accumulation in central Appalachians occurred during this time interval.

The Bølling-Allerød interstadial was followed by the Younger Dryas stadial, a cold period from 12,600 to 11,700 cal yr BP (Miller and Gingerich, 2013; Webb et al., 1993; Williams et al., 2011). The Younger Dryas saw significant vegetation changes throughout the eastern United States (Shuman et al., 2002). Webb et al. (1993), studying pollen assemblages in the northeastern United States, concluded that the low annual precipitation, but high soil moisture around 12,000 cal yr BP, suggested cold temperatures correlating with the Younger Dryas. Radiocarbon dating at CVNWR, may not have been at a fine-enough resolution to detect the Younger Dryas; peat ages in CVNWR Core 3.13 from 12,960 to 11,687 cal yr BP show a very low accumulation rate of 0.06 mm/yr (Table 2-3). Larabee (1986) and Maxwell and Davis (1972) both report fibrous organic clay ~12,600 cal yr BP, and fibrous peat ~12,400 cal yr BP, respectively, dating to this period (Table 2-1). It is unclear if Younger Dryas cold temperatures affected peatland development, as moisture balance is more essential than temperature in peat accumulation (Evans and Warburton, 2010; Loisel and Garneau, 2010; Vitt, 2006).

The Holocene Epoch, which began 11,700 cal yr BP, is an interglacial period with numerous smaller climatic fluctuations (Hou et al., 2011; Li et al., 2007; Webb III et al., 1998;

Willard et al., 2005). The early Holocene Greenlandian Age, defined as 11,700 to 8,236 cal yr BP (Cohen et al., 2013; Head and Gibbard, 2015; Walker et al., 2012, 2018), was characterized in the eastern United States as a cool and dry period (Stinchcomb et al., 2012; Zhao et al., 2010) with an available moisture at a postglacial minimum around 9,000 cal yr BP (Li et al., 2007; Stinchcomb et al., 2012, 2013; Webb et al., 1993; Willard et al., 2005). The Greenlandian Age closely correlates with modest peat accumulation rates in CVNWR from ~11,600 to ~8,600 cal yr BP. Kneller and Peteet (1993), at Brown's Pond, Virginia, found low water levels indicating dryer conditions between 10,000 and 8,000 cal yr BP. The end of Greenlandian Age was marked by a pronounced millennial scale cold event at 8,236 cal yr BP (Daley et al., 2016; Head and Gibbard, 2015; Hu et al., 1999; Mayewski et al., 2004; Viau et al., 2006; Walker et al., 2012, 2018; Wanner et al., 2015; Willard et al., 2005).

The mid-Holocene Northgrippian Age, defined as 8,236 to 4,250 cal yr BP (Cohen et al., 2013; Head and Gibbard, 2015; Walker et al., 2012, 2018), was characterized in eastern North America as a complex and dynamic climatic interval interposed with numerous regional droughts (Newby et al., 2014; Shuman and Marsicek, 2016; Stinchcomb et al., 2013; Viau et al., 2006), including a drought 5,500 cal yr BP that coincided with a widespread *Tsuga canadensis* decline (Booth et al., 2012; Delcourt and Delcourt, 1986; Williams et al., 2011; Zhao et al., 2010). Eastern North America generally experienced a rise in temperature culminating with mid-Holocene Climatic Optimum, during which temperatures were considerably warmer than today (Beget, 1983; Driese et al., 2005; Fairbridge, 1982; Mullins et al., 2011; Springer et al., 2009; Wanner et al., 2015). The exact timing of the Climatic Optimum varied from region to region as did the coinciding abundance of available moisture (Barber et al., 1999; Clarke et al., 2003; Shuman and Marsicek, 2016; Viau et al., 2006; Zhao et al., 2010).

Extremely low accumulation rates from CVNWR are consistent with very dry mid-Holocene climatic conditions. Research in central New York and eastern Lake Ontario indicate the overall-climate during the Climatic Optimum was generally warm and wet (McFadden et al., 2005; Mullins et al., 2011), whereas studies in eastern Pennsylvania, North Carolina, and Tennessee suggest warm and dry conditions (Ballard et al., 2016; Driese et al., 2008; Stinchcomb et al., 2013; Tanner et al., 2015). Webb et al. (1993) found slight increases in soil moisture and precipitation at 6,000 cal yr BP in the northeastern United States.

The Climatic Optimum in the central Appalachians has been identified in the central Appalachians. Watts (1979) found that late Quaternary vegetation of the central Appalachians indicated Climatic Optimum water tables were lower or less stable than today. Springer et al. (2009) found evidence of a warm Climatic Optimum in southeastern West Virginia while investigating stable isotopes in stalagmites and clastic cave sediments. Also working in southeastern West Virginia, Driese et al. (2005) found mid-Holocene warmer, dryer, climatic conditions weathered previously deposited fluvial gravel deposits. Cameron (1970) in Canaan Valley, Larabee (1986) in Big Run Bog, and Watts (1979) in Cranberry Glades all have recorded dates from this period; however, their dating resolution is not fine enough to determine accumulation rates and their varied soil profile descriptions did not follow soil science terminology to allow exact correlation. The Northgrippian Age ended with a pronounced climatic event at 4,250 cal yr BP which manifested in the mid-continent of North America as a widespread and severe drought (Booth et al., 2005; Shuman and Marsicek, 2016; Walker et al., 2012, 2018; Williams et al., 2011).

The late Holocene Meghalayan Age, from 4,250 cal yr BP to present (Head and Gibbard, 2015; Walker et al., 2012, 2018) brought wet conditions to the eastern United States (Willard et

al., 2005), with minor climatic fluctuations including intermittent droughts, the Medieval Warming Period, and the Little Ice Age (Li et al., 2007; Newby et al., 2014; Shuman and Marsicek, 2016; Stinchcomb et al., 2013; Willard et al., 2005). Age-depth plots and the accumulation rates at CVNWR show rapid peat accumulation in the early Meghalayan Age, concurring with wet conditions. However, peat accumulation slowed in the late Meghalayan Age of CVNWR. Cameron's (1970) one radiocarbon date from CVNWR indicates an accumulation rate of 0.22 mm/yr for the late Holocene. Booth et al. (2016) working on a single core in Cranesville Swamp dated peat accumulation beginning at ~1,000 cal yr BP. Larabee (1986) in Big Run Bog dated fibrous organic clay from the late Meghalayan Age. Although coarsely dated, overall Meghalayan Age, Allegheny Mountain peatland records do conform to the generally wet conditions for eastern United States regional paleoclimate reported by others.

Conclusions

Understanding peatland stratigraphy and development history is crucial to paleoclimatic reconstruction (Ovenden, 1990; Zhang et al., 2016). Extensive fieldwork coupled with high-resolution dating of peat stratigraphy provides the thorough baseline necessary for an understanding of variations and similarities among Allegheny Mountain peatlands. The quantity of complete soil profile descriptions as well as dated cores from CVNWR allows this ecosystem to inform peatland development history more fully than previous studies of peatlands in the region, particularly because previously published cores are very difficult to interpret with certainty because profile descriptions terminology varied greatly from study to study. Paleoenvironments interpreted from any one of the soil cores in this study could be considerably different from an interpretation based upon a comprehensive integration of the compiled history of peat development (Ovenden, 1990; Zhang et al., 2016).

Future peat research in the region should follow standard NRCS soil-profile description procedures and taxonomic classifications to ensure consistency of interpretation. Variable peat stratigraphy and peat accumulation rates require the analysis of multiple cores within well-constrained peatlands to avoid paleoclimatic interpretations skewed from individual peat cores that may be atypical of peatland-wide stratigraphy and regional events (Ovenden, 1990; Zhang et al., 2016).

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Chapter 3

Evidence of mid-Holocene (Northgrippian Age) dry climate recorded in organic soil profiles in the central Appalachian Mountains.

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Abstract

Peatlands in Canaan Valley National Wildlife Refuge hold a pedomemory of latest Pleistocene and Holocene climatic fluctuations in the central Appalachian Mountains. A field investigation profiling 88 organic soil profiles, coupled with 52 radiocarbon dates and peat accumulation rates, revealed a distinct sequence of organic soil horizons throughout five study areas. The dominant anaerobic lower portions of the organic soil profiles consist of varied thicknesses of a combination of hemic and sapric soil materials, typically layered as an upper hemic horizon, underlain by a sapric horizon, underlain by another hemic horizon. Peat deposition began after the Last Glacial Maximum with relatively high Heinrich Stadial 1 accumulation rates to form the lowest hemic horizon. Peat accumulated at significantly slower rates as the climate continued to ameliorate in the early Holocene Greenlandian Age. However, between 10,000 and 4,200 cal yr BP peat accumulation decreased even further and

decomposition of previously deposited peat prevailed, forming the sapric, or most decomposed, horizon. This interval of greater decomposition indicates a climatic change to a dryer environment with dates spanning the late Greenlandian Age through the mid-Holocene Northgrippian Age. The upper hemic horizon within the anaerobic portion of the soil profile formed from high peat accumulation rates during the wetter late Holocene Meghalayan Age. Very few samples were collected correlating to the last 2000 years of the late Meghalayan Age; however, those few do indicate a decreased peat accumulation rates.

Introduction

The Laurentide Ice Sheet advanced within 170 to 320 km from Allegheny Mountain peatlands in West Virginia and Maryland during the Heinrich Stadial 2, 26,000 to 23,600 cal yr BP (Clark and Ciolkosz, 1988; Lowell et al., 1990; Jackson et al., 2000; Heath et al., 2018). A cold dry climate with alpine tundra occupied this periglacial region of the central Appalachian Mountains during the Last Glacial Maximum (LGM) (Delcourt and Delcourt, 1988; Nelson et al., 2007; French and Millar, 2014). The climate of the eastern United States, including the Appalachian region, ameliorated to warmer conditions after the LGM, near the end of the late Pleistocene (Delcourt and Delcourt, 1987; Kneller and Peteet, 1993; Yu, 2007). The Holocene Epoch, which began 11,700 cal yr BP, was an interglacial with numerous climatic fluctuations in eastern North America (Webb et al., 1993; Willard et al., 2005; Li et al., 2007; Hou et al., 2011). The early Holocene Greenlandian Age, defined as 11,700 to 8,236 cal yr BP (Walker et al., 2012; Cohen et al., 2013; Head and Gibbard, 2015; Walker et al., 2018), was characterized in the eastern United States as a cool and dry period that ended with a pronounced millennial scale cold event at 8,236 cal yr BP (Zhao et al., 2010; Stinchcomb et al., 2013; Head and Gibbard, 2015; Daley et al., 2016). The mid-Holocene Northgrippian Age, defined as 8,236 to 4,250 cal yr BP

(Walker et al., 2012; Cohen et al., 2013; Head and Gibbard, 2015; Walker et al., 2018), was characterized in eastern North America generally as a rise in temperature culminating with the mid-Holocene Climatic Optimum (Viau et al., 2006; Zhao et al., 2010; Shuman and Marsicek, 2016). The Northgrippian Age ended with a climatic event at 4,250 cal yr BP that manifested in the mid-continent of North America as a widespread and severe drought (Booth et al., 2005; Williams et al., 2011; Walker et al., 2012; Shuman and Marsicek, 2016; Walker et al., 2018). The late Holocene Meghalayan Age, from 4,250 cal yr BP to present (Walker et al., 2012; Head and Gibbard, 2015; Walker et al., 2018) brought wet conditions to the eastern United States (Willard et al., 2005).

Climate, primarily temperature and precipitation, is the principal allogenic forcing factor in peatland development over millennial timescales (Barber et al., 2003; Charman et al., 2009; Gao et al., 2010; Charman et al., 2015; Kalnina et al., 2015; Morris et al., 2018), with successional vegetation change a significant autogenic influence (Charman et al., 2015; Galka et al., 2018). Peatlands form when net primary production of vegetation exceeds decomposition, resulting in accumulation of organic matter (Vitt, 2006). Peatland persistence requires a positive water balance for long-term growth and maintenance; positive water balance generally is favored by higher precipitation (Vitt, 2006; Evans and Warburton, 2010). Historically, wet climates tend to have greater peat growth rates (Tuittila et al., 2012). Woody peat and *Sphagnum* peat have relatively higher accumulations rates than peat derived from other vegetation types (Ovenden, 1990); *Sphagnum* and other bryophyte tissue decomposes more slowly than vascular plant litter and roots (Vitt et al., 2009).

Histosols are organic soils comprised of sapric, hemic, and fibric materials (Figure 3-1) and are primarily located within peatlands. The acrotelm is the aerobic upper portion of the soil

profile and generally consists of less humified fibric soil material that has a lower bulk density. The acrotelm-catotelm boundary is approximately the mean depth of minimum water table during the growing season (Clymo, 1984) and is marked by highly humified sapric soil material. The anaerobic catotelm is the lower portion of the organic soil profile and generally consists of various thicknesses of a combination of hemic and sapric soil materials with higher bulk densities. Histosols are in equilibrium with their environment, such that disturbance to the water balance or vegetation community may result in a change in character of the constituent organic soil materials (Lee and Manoch, 1974; Galka et al., 2018). A distinctive feature of Histosols is stratification resulting from accumulation of vegetation detritus under changing environmental conditions (Lee and Manoch, 1974). Barber (1981) showed a direct correlation of temperature and precipitation to peat stratigraphy, particularly peat humification and character of the peat. Identification of stratigraphic discontinuities in the degree of peat humification is a frequently utilized tool to assess past climatic and environmental conditions (Wieder et al., 2009). Peat decomposition and humification are a direct result of peatland surface wetness conditions (Lee and Manoch, 1974; Frohking et al., 2001; Gunnarson et al., 2003; Chambers et al., 2010; Kalnina et al., 2015). Peatland surface wetness relates to the depth from the surface of the water table. Peat decomposition is greater when the peatland surface is relatively dry, when water tables are lower than when the peatland surface is relatively wet (Castro et al., 2015). Surface wetness conditions are closely related to climatic fluctuations in precipitation and temperature, thus peat

stratigraphy can act as a proxy climate record (Clymo, 1984; Blackford, 2000; Barber et al., 2003; Chambers et al., 2010; Langdon et al., 2012; Kalnina et al., 2015).

Figure 3-1. Example of a Histosol profile from Core 5.1.

Analysis of peat stratigraphy and the physical characteristics of the peat have shown that peatlands hold an *in-situ* record of their initiation and subsequent development (Vitt and Wieder, 2006). Pedomemory is both the capacity of a soil system to record environmental conditions

through pedogenesis and the record that is retained within the soil profile (Targulian and Goryachkin, 2004; Lin, 2011; Nauman et al., 2015). Humification is one of the pedogenic processes that determines the pedomemory of peatland development and climatic conditions over time. Histosols may record climate-driven changes in stratigraphy in which dryer phases are represented by sapric soil material in dark well-humified horizons, and wetter phases are represented by hemic soil material in light less-humified horizons (Lee and Manoch, 1974; Froking et al., 2001; Gunnarson et al., 2003; Kalnina et al., 2015).

Using peat stratigraphy, the objectives of this study are to expand and improve understanding of the paleoclimatic history of five peatlands in Canaan Valley National Wildlife Refuge (CVNWR) and to provide insights into the pedomemory of peatlands in the central Appalachian Mountains. Worldwide, peat stratigraphy has been utilized for over a century to study late Quaternary climate change, but despite the recognized value of peat humification analysis for paleoenvironmental reconstructions (Halsey et al., 2000; Castro et al., 2015), it has not been used in the central Appalachians. This study adds to existing regional and local peat paleoclimate observations with the characterization of Histosols and peat stratigraphy revealing the peatland surface wetness dynamics within CVNWR. With 100 soil cores profiled and described, including 30 with lab data, the abundance of observations within this investigation adds breadth to existing regional and local paleoclimate reconstructions. An understanding of past paleoclimate in these peatlands, including how they evolved and responded to climatic change, is valuable knowledge for interpreting how they might respond to projected future climate change.

Project area

Peatlands commonly occur in boreal regions; however, high elevations along the Allegheny Mountains also sustain local boreal ecosystems (Wieder and Vitt, 2006). The Allegheny Mountain section of the central Appalachian Mountains (Fenneman and Johnson, 1946; Reger and Cleaves, 2008; Sevon, 2018; West Virginia Geologic and Economic Survey, 2017) includes geographic niches very similar climatically to more northern boreal peatlands, with high mean annual precipitation, low mean annual temperature, and low soil temperatures (Rigg and Strausbaugh, 1949; Cameron, 1970; Walbridge, 1994). Regional climatic conditions are intensified by orographic precipitation and local topographic frost pockets, where cold, dense nocturnal air drains downslope decreasing valley floor temperatures (Walbridge, 1994).

Allegheny Mountain peatlands range in size from a few hectares to a few hundred hectares (Ingham, 1996), and are typically situated at elevations above 730 m in the unglaciated plateau. Byers et al. (2007) placed Allegheny Mountain peatlands within the High Allegheny Wetland Ecological System, which occurs in a southwest-northeast trending ~40 km wide by ~200 km long band along the Allegheny Mountain section of the unglaciated Appalachian Plateaus physiographic province in Pennsylvania, Maryland, and West Virginia (Cameron, 1970). In general, the Allegheny Mountain section is higher in elevation than adjacent physiography and is characterized by broad, open structural bedrock folds.

Differential erosion has formed structurally controlled bedrock valleys and concave bottomlands of the Allegheny Mountains. Impeded drainage developed within these valleys before the Holocene (Cameron, 1970), most likely by the blockage of drainage by periglacial activity (Larabee, 1986). Allegheny Mountain peatlands occur in or near the headwaters of first- or second-order streams or occur in specific geologic niches (Rigg and Strausbaugh, 1949;

Ingham, 1996). Canaan Valley, in Tucker County, West Virginia (Figure 3-2), is a high-elevation (980 m), breached anticlinal valley, associated with the Blackwater anticline. Headwaters of the Blackwater River, within the Cheat River watershed, drain most of the valley. Resistant Pottsville Sandstone caps the surrounding mountain ridges, with elevations over 1,250 m, Mauch Chunk Formation siltstones, shales, and immature sandstones form the more easily erodible valley slopes, and Greenbrier Limestone and lower Mauch Chunk siltstones and shales underlie most of the valley floor (Matchen et al., 1999; Fortney and Rentch, 2003; Matchen, 2015). Projecting up to 80 m above the valley floor is a low, elongated ridge comprised of coarse-grained sandstone of the Price Formation exposed along the axis of the anticline (Matchen, 2015).

Figure 3- 2. Location of Canaan Valley National Wildlife Refuge boundary including Peatlands 1 through 5. Inset map displays CVNWR boundary within the Allegheny Mountain physiographic section (gray polygon). Aerial imagery obtained from the National Agriculture Inventory Program 2007 by United States Department of Agriculture.

The floor of Canaan Valley contains one of the largest upland freshwater wetland ecosystems of peatlands, marshes, wet meadows, and shrub-forested wetlands in the eastern United States (Fortney and Rentch, 2003). These are flood- and beaver-influenced wetlands encompassing shrub swamps, sedge fens, wet meadows, and open marshes (Byers et al., 2007). Forested swamps occupy the slightly higher elevation around the peatland margins. CVNWR encompasses the northern portion of Canaan Valley, protecting most of West Virginia's largest wetland complex, including five remapped peatlands totaling 246 hectares (Figure 3-2). Small-unnamed tributaries of the Blackwater River, bordered by shallow Entisols with thin histic epipedons or hydric components separate these five peatlands. These minerotrophic peatlands are characterized by exceptionally high biodiversity and conservation value; they contain some of the highest concentrations of globally rare plant and animal species within the eastern United States (Byers et al., 2007). They have the largest peat deposits located in the unglaciated uplands along the Allegheny structural front in West Virginia, Maryland, and Pennsylvania (Cameron, 1970). They are ecologically classified as very poor fens: very acidic, moderately influenced by ground water, and dominated by sedges with a continuous carpet of *Sphagnum* (Kost et al., 2007). Bryophyte groundcover vegetation in these peatlands consists of *Sphagnum rubellum*, *Sphagnum recurvum*, *Sphagnum palustre*, *Polytrichum commune*. Herbaceous vegetation includes of *Eriophorum virginicum* (tawny cottongrass), *Rhynchospora alba* (white beaksedge), and minor amounts of *Scirpus sp.* (bulrush). Woody shrub vegetation commonly consists of *Photinia melanocarpa* (black chokeberry), *Vaccinium oxycoccos* (small cranberry), *Vaccinium myrtilloides* (velvetleaf blueberry), and *Rubus hispidus* (bristly dewberry).

Methodology

Soil morphology is a record of past and current ecological and geomorphic processes (Daniels and Hammer, 1992); it can provide basic data for interpreting soil genesis (Buol et al., 1997), as well as insight into how ecosystems change (Nauman et al., 2015). Peat stratigraphy based upon soil morphologic descriptions, which are comprised of detailed soil profile descriptions and laboratory data, shed light upon the developmental and climatic history of peatlands (Yu et al., 2009).

Field methods

Old Soil Conservation Service (SCS) map unit polygons, labeled as “muck and peat”, provided an initial base map for this research. The SCS soil polygons were originally published in the *Soil Survey of Tucker County* (Losche and Beverage, 1967); the soil survey data were collected between 1959 and 1964, and mapped on 1956 and 1958 aerial photographs. The five muck and peat polygons were designated as Peatlands 1 through 5 for this study, which included re-mapping these polygons based on new data and updated imagery. Soil morphology was described (Schoeneberger et al., 2012) by profiling 100 soil cores throughout and around the five study areas, including 32 in Peatland 1, 11 in Peatland 2, 19 in Peatland 3, 21 in Peatland 4, and 17 in Peatland 5. Thirty of the 100 cores were sampled for laboratory analysis including radiocarbon dating, bulk density, total organic matter content, fiber content, and pyrophosphate color. Soil profiles were classified based upon the field descriptions and laboratory data, using U.S. Department of Agriculture, Natural Resources Conservation Service, *Soil Taxonomy* (Soil Survey Staff, 1999).

Soil core locations were chosen according to the “free survey” method of sampling soils, which involves the individual development and application of soil-landscape concepts based on

the observation that soils vary repetitively and predictably with geomorphology, topography, and similar information (Carlisle et al., 1998). Locations of cores were representative of the immediately surrounding terrain. Small-scale hummocks and hollows were avoided, as were locations of known anthropogenic disturbance. Geographic coordinates, location notes, surface vegetation, and geomorphology were recorded for each soil profile location. Excavating and coring equipment varied depending upon type of material encountered. A shovel was best suited for excavating acrotelm (aerobic zone) horizons, a McCauley peat corer was used to sample catotelm (anaerobic zone) horizons (De Vleeschouwer et al., 2010; Keys and Henderson, 1983; Klemetti and Keys, 1983), and a Dutch auger for underlying mineral soils. Profile descriptions consisted of horizon depth, Munsell® color, percentage of plant fiber content, rubbed fiber content, humification based on the von Post (1924) scale, boundary transitions, and description of identifiable plant fibers.

Percentage of plant fiber content was determined in the field. Plant fibers were defined as pieces of plant tissue showing remnant cellular structure that are less than 2 mm in cross section, but large enough to be retained on a 100-mesh (0.15 mm) sieve (Buol et al., 1997). *Soil Taxonomy* (Soil Survey Staff, 1999) specified that living plant tissue and organic materials greater than 2 mm in cross section were excluded from fiber content. Rubbed fiber content was determined by rubbing the samples between the thumb and forefinger ten times, rolling the sample into a ball, breaking the ball in half, and making a visual assessment of the percentage of fibers that remain (Malterer, 2014, personal communication). Percentage of rubbed plant fibers determined the organic soil horizon designations: Oi, Oe, or Oa. Oi designated organic horizons composed of slightly decomposed fibric material (peat), with greater than 40% of fibers present after rubbing. *Sphagnum* moss was a strong indicator of fibric material; usually only the upper 2

to 3 cm of *Sphagnum* is living tissue and is not considered part of the solum. The dead and decaying *Sphagnum*, below the upper 2 to 3 cm, is reddish and fibrous in nature (Figure 3-3). Oe designated organic horizons with intermediate decomposition hemic material (mucky peat), with 17% to 40% of fibers present after rubbing. Hemic material typically had the look and soft feel of mature compost, it was usually brown in color with easily discernable plant fibers (Figure 3-4). Oa designated organic horizons that were highly decomposed sapric material (muck), with less than 17% of fibers present after rubbing. Sapric material was usually black and had a greasy feel, when air-dried it was a light-weight moderately hard mass (USDA, 2010) (Figure 3-3).

Figure 3-3. Example of CVNWR fibric (decomposing *Sphagnum* is the reddish material near the top of the core) and sapric soil material (black material at the bottom of the core).

Figure 3-4. Example of CVNWR hemic soil material.

Peat humification was estimated visually with freshly extracted peat and gave a reasonably accurate assessment for field description of peat stratigraphy (Chambers et al., 2010). Humification, assigned an H value from 1 to 10 on the von Post scale, was gauged in the field by compressing a soil sample in one hand, catching the squeezed material and water/soil solution in the other hand. The color and turbidity of the free water and the distinctness of visible plant structure was used to assign a von Post H value (Smith et al., 2007; Verry et al., 2011). The von Post humification scale is used extensively outside of the United States because it is “quick and,

with practice, is consistent, more precise, and more accurate than sieving methods” (Verry et al., 2011).

Taking into account vegetation, ecosystem, microtopography, and water depth, a minimum of two individual core locations within each peatland were selected to sample for laboratory analysis. Locations selected for laboratory analysis were cored three separate times within a 30 cm radius of a central point. The first core at a location was used for soil profile description, a second core for bulk density samples, and a third core for all other laboratory analysis. Bulk density samples were collected to avoid compaction and utilized careful measurements of peat volume (Chambers et al., 2010; De Vleeschouwer et al., 2010). Core samples were collected directly from a McCauley peat corer, placed in cut lengths of PVC tubes, wrapped with plastic, sealed with tape, and labeled. Due to a legacy of surface disturbance (Schaney and Schaney, *in preparation*) sampling shallow peat cores and sampling the acrotelm were not a focus of this research.

Laboratory methods

CVNWR secured funding through U.S. Fish and Wildlife Service, in conjunction with the Radiocarbon Collaborative, sponsored jointly by the USDA Forest Service, University of California Irvine (previous mass spectrometry conducted at Lawrence Livermore National Lab in Livermore, California), and Michigan Technological University, to provide radiocarbon dating of 52 samples from 11 cores. Radiocarbon dating samples were chosen based on core location within the peatlands and horizon depth within the profile, focusing on basal peat dates, horizon breaks within the catotelm, and sedimentary sequence of the deepest cores (Givélet et al., 2004; Piotrowska et al., 2010; Tuittila et al., 2012). Standard radiocarbon ages were calibrated to dates

(cal yr BP) using OxCal 4.2 and IntCal13 Northern Hemisphere calibration curve (Bronk Ramsey, 2009; Reimer et al., 2013).

Bulk density, organic matter content, fiber content, and pyrophosphate color laboratory analysis on individual horizons in each of the 30 laboratory analysis cores were conducted in the labs of the Division of Plant and Soil Sciences of West Virginia University. Laboratory analysis procedures in the UDSA-NRCS *Kellogg Soil Survey Laboratory Methods Manual* (Soil Survey Staff, 2014) were followed, with the explicit intention of soil classification according to *Soil Taxonomy* (Soil Survey Staff, 1999).

Bulk density is an indirect measure of organic soil decomposition (Boelter, 1968). Less-decomposed peat tended to be of low bulk density and were likely deposited under wet conditions that promoted rapid accumulation and burial of organic matter (Chambers et al., 2010). More-decomposed, or humified, muck tended to be of higher bulk density and was likely deposited under dryer conditions with slow accumulation and burial of organic material. Organic matter bulk density was used as a simple proxy of the varying degree of total peat decomposition and to infer past surface moisture conditions (Boelter, 1968; Yu et al., 2003; Chambers et al., 2010). Bulk density was measured in the laboratory using oven-dried weight of a known volume of organic soil sample.

Organic matter content is naturally high in peatlands but can vary substantially because of mineral inputs including exogenous waterborne and wind-blown material (Chambers et al., 2010). Loss on ignition was utilized to determine mineral and organic matter contents of the soils. Mineral content consists of ash and mineral particles that remain after removal of organic matter. Determination of organic matter by loss on ignition was a taxonomic criterion for

organic soil materials (Soil Survey Staff, 2014). Organic matter content was calculated by taking the dry weight minus weight after ashing overnight at 550°C, divided by dry weight.

Percentage of plant fibers is used in *Soil Taxonomy* to determine sapric, hemic, and fibric organic materials for classification (Soil Survey Staff, 2010, 2014; Stolt and Bakken, 2014). Fiber content can be complex and variable, differing between soil horizons, as well as laterally across a peatland (Soil Survey Staff, 2014). Using known-volume samples and washing through a 100-mesh (0.15 mm) sieve with tap water, the percentage of fibers retained on the sieve was estimated, then rubbed and washed again, to determine rubbed fiber content and thus the decomposition state of soil organic matter and horizon designation (Soil Survey Staff, 1999; 2014).

Pyrophosphate color was another requirement utilized for determining decomposition class for taxonomic classification of Histosols (Soil Survey Staff, 2010; Stolt and Bakken, 2014). Procedures for testing pyrophosphate color entailed adding an aqueous sodium pyrophosphate solution to a pre-measured soil sample. Color value and chroma of the extract was evaluated by moistening a chromatographic strip in the solution and comparing color with the 10YR Munsell® soil color chart (Verry, 2011; Soil Survey Staff, 1999; 2014).

Results

Generally, most soil profiles in CVNWR peatlands had similar horizonation trends. The acrotelm consisted of approximately 20 cm of fibric soil material, typically underlain by less than 10 cm of sapric soil material located at the water table. The catotelm consisted of various thicknesses of a combination of hemic and sapric soil materials. Radiocarbon dates and peat accumulation rates reported in Table 3-1 were discussed in length in Chapter 2. Sequential radiocarbon dates were obtained for seven cores, six of which (Cores 1.86, 2.09, 3.13, 4.19, 5.12,

and 5.17) had basal peat dates ranging from ~18,600 to ~15,200 cal yr BP, during or immediately after Heinrich Stadial 1 correlating to a hemic soil horizon that also spanned the Greenlandian Age. These cores also all contained a sapric horizon dating to the Northgrippian Age and another hemic horizon dating to the Meghalayan Age. The seventh core (Core 4.02) with sequential radiocarbon dates, had a late Northgrippian Age basal peat date of ~4,600 cal yr BP. Peat accumulation rates (Table 3-1) were calculated as the thickness of accumulated peat in mm divided by the corresponding radiocarbon dated interval (Borren et al., 2004). Peat accumulation rates varied from a maximum of 1.34 mm/yr to a minimum of 0.02 mm/yr, with a mean of 0.14 mm/yr (calculated as the mean of the overall whole core rates at each core with sequential dates). Peat accumulation rates between ~15,800 and ~12,500 cal yr BP averaged 0.24 mm/yr. Net peat accumulation declined to a mean of 0.11 mm/yr between ~11,700 and ~8,600 cal yr BP, generally correlating to the Greenlandian Age. Few radiocarbon dates were obtained on peat of Northgrippian Age, hence only two cores include well-constrained mid-Holocene peat accumulation rates. Core 3.13 had a peat accumulation rate of 0.02 mm/yr between ~11,700 and ~5,900 cal yr BP, and Core 5.17 had a peat accumulation rate of 0.04 mm/yr between ~10,300 and ~5,400 Cal yr BP. These may be the lowest of any time since the onset of peat accumulation, a trend reinforced by the scarcity of peat of this age. Exceptionally high peat accumulation rates between ~4,200 and ~2,000 cal yr BP averaged 0.50 mm/yr, coeval with the onset of the Meghalayan Age. The last 2,000 years of peat development in CVNWR was represented by only three dates, but generally show very low peat accumulations rates averaging 0.08 mm/yr, which may reflect a reduction in peat accumulation, or mixing of surface vegetation into near-surface soil horizons.

Laboratory ID	Sample #	Core #	Depth (cm)	Standard Radiocarbon Age		intCal13 Calibrated Dates 95% confidence interval		Median cal yr BP	Accumulation Rate mm/yr
				¹⁴ C age	±	From	To		
CAMS-171742	25	1.82	128-130	12810	40	15449	15109	15258	
CAMS-172756	32	1.86	2-4	1225	30	1260	1065	1153	0.05
CAMS-172757	33	1.86	40-42	7880	35	8953	8587	8675	0.08
CAMS-172762	38	1.86	59-61	9600	30	11128	10774	10928	0.18
CAMS-172763	39	1.86	86-88	10475	35	12560	12147	12451	0.82±
CAMS-172764	40	1.86	100-102	10635	30	12690	12559	12621	0.08±
CAMS-171738	21	1.86	127-129	13155	40	16002	15637	15807	
CAMS-171739	22	2.05	119-121	15045	40	18435	18099	18284	
CAMS-172760	36	2.09	15-17	3550	35	3960	3720	3844	0.05
CAMS-172761	37	2.09	40-42	8035	35	9021	8775	8909	0.04
CAMS-172758	34	2.09	65-67	12455	45	14961	14251	14598	0.16
CAMS-172759	35	2.09	80-82	12985	40	15732	15315	15528	0.33
CAMS-171737	20	2.09	92-94	13225	40	16069	15730	15896	
CAMS-172750	26	3.13	11-13	1925	30	1947	1817	1873	0.11
CAMS-170482	10	3.13	27-29	3155	30	3450	3269	3382	0.45
CAMS-172751	27	3.13	50-52	3590	30	3977	3833	3894	0.07
CAMS-170483	11	3.13	64-66	5180	30	5991	5905	5936	0.02
CAMS-172752	28	3.13	75-77	10095	40	11954	11404	11687	0.06
CAMS-172753	29	3.13	83-85	11085	35	13063	12824	12960	0.20
CAMS-170484	12	3.13	94-96	11680	30	13570	13445	13510	0.08
CAMS-172754	30	3.13	120-122	13815	40	16946	16488	16715	0.23
CAMS-170485	13	3.13	165-167	15375	35	18759	18544	18653	
CAMS-171740	23	3.14	121-123	13870	40	17009	16573	16802	
CAMS-170478	6	4.02	7-9	420	35	530	326	486	0.06
CAMS-170479	7	4.02	17-20	2130	30	2299	2001	2111	0.44
CAMS-170480	8	4.02	76-79	3240	30	3560	3388	3460	0.35
CAMS-170481	9	4.02	117-120	4095	35	4814	4446	4607	
CAMS-172755	31	4.09	151-152	4380	40	5212	4852	4942	
CAMS-172770	46	4.19	30-32	2490	30	2730	2460	2584	0.61
CAMS-172771	47	4.19	60-62	2925	30	3164	2971	3072	0.52
CAMS-172772	48	4.19	80-82	3235	30	3558	3385	3453	0.58
CAMS-172773	49	4.19	120-122	3775	35	4281	3992	4146	0.05
CAMS-172774	50	4.19	165-167	11235	35	13164	13041	13097	0.21
CAMS-171741	24	4.19	211-213	12850	40	15545	15160	15315	
CAMS-170473	1	5.12	16-20	2080	30	2140	1952	2050	0.64
CAMS-170474	2	5.12	51-53	2495	30	2732	2466	2585	1.34
CAMS-170475	3	5.12	82-85	2725	30	2873	2761	2817	0.04
CAMS-170476	4	5.12	114-116	9010	30	10235	10170	10204	0.15
CAMS-170477	5	5.12	197-199	13105	35	15940	15540	15733	
CAMS-171732	15	5.17	18-20	2070	30	2123	1950	2039	0.68
CAMS-171733	16	5.17	70-72	2705	30	2857	2756	2804	0.39
CAMS-172765	41	5.17	85-87	3800	30	4288	4088	4187	
CAMS-174232	41*	5.17	82-84	2970	30	3230	3007	3135	0.37
CAMS-172766	42	5.17	120-122	2930	30	3169	2974	3080	
CAMS-174233	42*	5.17	122-124	3820	40	4406	4091	4217	0.07
CAMS-172767	43	5.17	130-132	4580	30	5447	5066	5302	0.63±
CAMS-172768	44	5.17	140-142	4720	45	5584	5322	5460	0.04±
CAMS-171736	19	5.17	161-163	9160	45	10483	10231	10323	0.12
CAMS-172769	45	5.17	173-175	9930	30	11590	11241	11312	0.12
CAMS-171735	18	5.17	196-198	11360	35	13290	13115	13203	0.28
CAMS-171734	17	5.17	225-227	12310	35	14531	14075	14237	0.55
CAMS-171731	14	5.17	288-290	12890	40	15598	15210	15382	

Table 3- 1. CVNWR radiocarbon dates and accumulation rates. Dated material consisted entirely of bulk peat samples. Accumulation rates were calculated as the thickness of accumulated peat divided by the corresponding interval between calibrated median radiocarbon ages. Samples 41 and 42 were reanalyzed due to a stratigraphic inversion, likely caused by procedural error. Dates on samples 41* and 42* were in expected stratigraphic order, so these age determinations were used in analysis and interpretation. The + symbol denotes radiocarbon dates with overlapping 95% confidence intervals; mid-points were used to calculate a peat accumulation rates which were used for data interpretation.

The field investigation resulted in re-mapping the five pre-existing NRCS soil polygons, originally totaling 187 hectares, now totaling 246 hectares (Figure 3-2). Out of the 100 soil profiles examined for this study, 12 were determined to be Entisols and will not be discussed further. The 88 remaining Histosol profiles were separated into five types (A, B, C, D, and E) based upon the sequence of horizons in the catotelm (Table 3-2 and Figure 3-5). Soil profiles investigated in CVNWR peatlands have very similar acrotelm horization. The acrotelm usually consists of ~20 cm of fibric soil material, underlain by ~10 cm of sapric soil material located near the water table. This sapric horizon at the water table has the greatest humification (Vitt et al., 2009) throughout the project area. Due to the legacy of surface disturbance possible with the CVNWR peatlands, it was determined by the authors that pedomemory within the peat stratigraphy was best retained within the catotelm, which has a slow decomposition rate (Clymo, 1984) and no apparent history of disturbance (Schaney and Schaney, *in preparation*). CVNWR soil profile catotelms consisted of varying thicknesses of a combination of hemic and sapric soil materials (Figure 3-6). Figure 3-6 shows the generalized pedogenic development of the five types (A, B, C, D, and E) of catotelm horizon sequences represented in the 88 Histosol profiles at CVNWR; each is discussed below.

Soil Profile Type		Peatland 1		Peatland 2		Peatland 3		Peatland 4		Peatland 5		Type Totals
		Cores	Data	Cores	Data	Cores	Data	Cores	Data	Cores	Data	
Type A (H)		2		0		4		3		1		10
	<i>with lab data and C14 dates</i>		0		0		0		0		0	
	<i>with C14 dates</i>		0		0		0		2		0	
	<i>with lab data</i>		0		0		0		0		0	
	<i>only field descriptions</i>		2		0		4		1		1	
Type B (SH)		17		4		2		0		1		24
	<i>with lab data and C14 dates</i>		2		2		0		0		0	
	<i>with C14 dates</i>		0		1		1		0		0	
	<i>with lab data</i>		2		1		0		0		0	
	<i>only field descriptions</i>		13		1		1		0		1	
Type C (HSH)		0		2		6		6		13		27
	<i>with lab data and C14 dates</i>		0		0		1		1		1	
	<i>with C14 dates</i>		0		0		0		0		1	
	<i>with lab data</i>		0		2		0		0		4	
	<i>only field descriptions</i>		0		0		5		5		7	
Type D (S)		3		3		3		2		0		11
	<i>with lab data and C14 dates</i>		0		0		0		0		0	
	<i>with C14 dates</i>		0		0		0		0		0	
	<i>with lab data</i>		0		0		0		0		0	
	<i>only field descriptions</i>		3		3		3		2		0	
Type E (HS)		3		0		4		8		1		16
	<i>with lab data and C14 dates</i>		0		0		0		0		0	
	<i>with C14 dates</i>		0		0		0		0		0	
	<i>with lab data</i>		0		0		3		3		1	
	<i>only field descriptions</i>		3		0		1		5		0	
Totals for each peatland		25		9		19		19		16		88

Table 3- 2. Profile type distribution amongst the five peatlands.

Figure 3- 5. Five CVNWR peatlands with soil cores labeled by soil profile type: 5a. Peatland 1, 25 cores, dominated by Type B (SH) profiles; 5b. Peatland 2 9 cores; 5c. Peatland 3 19 cores, including all five soil types; 5d. Peatland 4 19 cores, including Type C (HSH) profiles clustered at the thickest peat, surrounded by Type E (HS) profiles, and a cluster of Type A (H) profiles; 5e. Peatland 5, 16 cores, dominated by Type C (HSH) profiles.

Figure 3- 6. Possible development pathways for the five profiles types amongst CVNWR organic soil cores.

Type A soil profiles (Figure 3-7) had a catotelm comprised entirely of hemic soil horizons (H). This horizonation occurred in four of the five peatlands (Table 3-2 and Figure 3-5). Of these 10 soil profiles, two had radiocarbon dates and none had laboratory data. Sequential radiocarbon dates in Core 4.02 (Figure 3-7) and a basal peat date in Core 4.09, show that these Type A (H) profiles had basal peat dates of 4,600 cal yr BP and 4,900 cal yr BP respectively. The late Northgrippian peat initiation in these two Type A (H) soil profile was >10,000 years younger than the onset of peat accumulation in other dated CVNWR cores.

Type B soil profiles (Figure 3-8) had a catotelm sequence of a sapric horizon underlain by a hemic horizon (SH). This horizonation occurred in four of the five peatlands (Table 3-2 and Figure 3-5). This profile type was more numerous in the shallow peatlands. Type B (SH) profiles comprised almost all of Peatland 1, surrounded the cluster of Type C (HSH) profiles in Peatland 2, were nestled next to an upland bedrock area in Peatland 3, were not represented in Peatland 4, and were insignificant in Peatland 5. Of these 24 soil profiles, three had laboratory data and radiocarbon dates, two had only radiocarbon dates, and three had only laboratory dates. Two cores (1.86 and 2.09) with sequential radiocarbon dates had Type B (SH) soil profiles, with a catotelm sapric horizon spanning the Northgrippian Age (Figure 3-8).

Type C soil profiles had a distinct horizonation (Figures 3-6 and 3-9) with a catotelm layered as a hemic soil horizon, underlain by a sapric horizon, underlain by another hemic horizon (HSH). This distinct Type C (HSH) horizonation was the most numerous of the 88 profiles examined and occurred in four of the five peatlands (Table 3-2 and Figure 3-5). This profile type was more numerous in larger and deeper peatlands. Type C (HSH) soil profiles occurred clustered in the center of Peatlands 2, 3, and 4, and comprised almost all of Peatland 5. Of 27 Type C soil profiles, three had laboratory data and radiocarbon dates, one had only

radiocarbon dates, and five had only laboratory data. Four cores (3.13, 4.19, 5.12, and 5.17) with sequential radiocarbon dates had Type C (HSH) soil profiles, with a catotelm sapric horizon dating to the Northgrippian Age (Figure 3-9).

Type D soil profiles (Figure 3-10) had a catotelm comprised entirely of sapric soil horizons (S). This horizonation occurred in four of the five peatlands (Table 3-2 and Figure 3-5). Most Type D (S) soil profiles occurred along the periphery of the shallow peatlands. None of these 11 soil profiles had laboratory data or radiocarbon dates.

Type E soil profiles had a catotelm sequence of a hemic horizon underlain by a sapric horizon (HS) (Figure 3-11). This horizonation occurred in four of the five peatlands (Table 3-2 and Figure 3-5). Type E (HS) soil profiles typically occurred surrounding clusters of Type C (HSH) soil profiles. Type E (HS) profiles were generally shallower than Type C (HSH) profiles. Of 16 soil Type E profiles, seven had laboratory data but none had radiocarbon dates.

Figure 3-5 summarizes the geographical distribution of soil profile types. Peatland 1 had the most cores and was dominated by Type B (SH) profiles. Peatland 1 was the easiest to access for field visits, and had the most soil profiles, biasing statistics on Type B (SH) profiles. Peatland 2 had the fewest cores, and a pattern of Type C (HSH) profile in the center surrounded by Type B (SH) profiles, and Type D (S) profiles in shallow areas peats along the periphery. Peatland 3 had clusters of all five profile types. Peatland 4 had Type C (HSH) profiles clustered on the thickest peat, surrounded by Type E (HS) profiles, and a patch of Type A (H) profiles. Peatland 5 was the largest peatland and was dominated by Type C (HSH) profiles.

Figure 3- 7. Soil profile of Core 4.02, representing Type A (H) profiles.

Figure 3- 8. Soil profile of Core 1.86, representing Type B (SH) profiles.

Figure 3- 9. Soil profile of Core 5.17, representing Type C (HSH) profiles.

Figure 3- 10. Soil profile of Core 2.07, representing Type D (S) profiles.

Figure 3- 11. Soil profile of Core 3.17, representing Type E (HS) profiles.

Discussion

Peatlands formed after the LGM hold a pedomemory of latest Pleistocene and Holocene climatic fluctuations (Booth, 2010; Zaretskaya et al., 2013). This study begins reconstruction of Central Appalachian paleoclimate through peat stratigraphy which is the characterization of the peat horization of Histosols that reveal the peatland surface wetness dynamics within CVNWR. A key observation for this reconstruction is the fact that sapric horizons are considered indicative of drier warmer conditions; whereas hemic horizons are associated with wetter cooler conditions (Blackford, 2000; Wieder et al., 2009). When drained, fibric and hemic materials decompose to form sapric materials (Soil Survey Staff, 1999). Warmer temperatures generally increase rates of plant matter decomposition. Humification data indicate changes in the time span from the time of the plant death to the deceased plant matter being incorporated into the anaerobic catotelm (Blackford, 2000). Plant matter decomposition rates sharply decrease in the catotelm, and become independent of all but the most extreme climatic fluctuations (Clymo, 1984, Yu et al., 2003). A lowered water table would expose previously buried peat to aerobic conditions, adjusting the acrotelm-catotelm boundary, exposing hemic material formerly in the catotelm to aerobic conditions and secondary decomposition (Tipping, 1995; Borgmark and Schoning, 2006). Climate influences water table depth, which determines whether organic soil material will accumulate rapidly, accumulate slowly, not accumulate, or decompose. A lowered water table could result from a warmer, drier climate, and therefore increase decomposition of peat formerly preserved within the catotelm. Thus, Histosol horizons represent a proxy for water table position at the time of deposition and thereafter (Blackford, 2000). While peat humification is aided by other paleoclimate proxies to reconstruct past climates (Castro et al., 2015), the abundance of observations within this investigation adds

breadth to existing regional and local peat paleoclimate reconstructions and provides new data useful to assess synchronization of observed paleoclimate data within the region (Chapter 2).

The mid-Holocene Northgrippian Age, defined as 8,236 to 4,250 cal yr BP (Walker et al., 2012; Cohen et al., 2013; Head and Gibbard, 2015), was characterized in North America by a rapid rise in temperature, with the maximum warmth, the mid-Holocene Climatic Optimum, for which records indicate varied in onset and conclusion from region to region (Viau et al., 2006; Zhao et al., 2010; Shuman and Marsicek, 2016). The Climatic Optimum saw climactic conditions considerably warmer than today (Fairbridge, 1982; Beget, 1983; Driese et al., 2005; Springer et al., 2009; Mullins et al., 2011; Wanner et al., 2014); however, evidence from the eastern North America suggests significant regional variability of moisture associated with that warmth (Barber et al., 1999; Clarke et al., 2003; Viau et al., 2006; Newby et al., 2014). Isotopic analysis of soil organic matter from eastern Pennsylvania, North Carolina, and Tennessee and microscopic charcoal from lake sediments in Tennessee suggest warm, dry conditions during the mid-Holocene Climatic Optimum (Driese et al., 2008; Stinchcomb et al., 2013; Tanner et al., 2015; Ballard et al., 2016).

The warm and dry signature of the Climatic Optimum has been identified in the central Appalachian region. Watts (1979) found that the paleo-vegetation of central Appalachia indicated mid-Holocene water tables were lower or less stable than today. Springer et al. (2009) found evidence of a mid-Holocene warm climate in southeastern West Virginia in stable isotopes of stalagmites and clastic cave sediments. Driese et al. (2005) found mid-Holocene warm and dry climatic conditions accelerated weathering of previously deposited fluvial gravel deposits in southeastern West Virginia. The mid-Holocene Northgrippian Age ended with a pronounced climatic event at 4,200 cal yr BP that manifested in the mid-continent of North America as a

widespread and severe drought (Booth et al., 2005; Williams et al., 2011; Booth et al., 2012; Walker et al., 2012; Cohen et al., 2013; Shuman and Marsicek, 2016).

Microtopography and hydrology of peatland surfaces and edaphic hydrology are irregular and dynamic (Ammann et al., 2013; Clymo, 1984; Holden, 2005) and are presumably the reason for the initiation of peat accumulation in the late Northgrippian Age as displayed in the Type A (H) soil profiles. Decomposition during the mid-Holocene Climatic Optimum in these specific locations may have been so great, resulting from a drastically lowered water table, that the earlier deposited peat may have decomposed completely not leaving behind a remnant sapric horizon as in the Type E (HS) soil profile scenario (Figure 3-6). Observations of Peatland 4 during this field investigation did include both small ponds and localized depressional areas with no surface vegetation and an absent acrotelm. As in Type C and E profiles, Type A (H) soil profiles do exhibit the rapid peat accumulation in the middle Meghalayan Age represented by a hemic horizon within the catotelm.

Type B (SH) soil profiles, as represented by Core 1.86 (Figure 3-8), show rapid peat accumulation in the late Pleistocene, corresponding to the catotelm hemic soil materials in these soil profiles (Figure 3-6). As the local climate of the early Holocene Greenlandian Age continued to warm, peat continued to slowly accumulate, followed by even slower peat accumulation during the mid-Holocene Northgrippian Age represented as a sapric horizon spanning the Greenlandian Age to the middle Meghalayan Age. This is consistent with a dryer mid-Holocene Climatic Optimum resulting in a lowered water table. However, Type B (SH) soil profiles do not show the late Meghalayan Age hemic horizon of rapid peat accumulation found in Type C (HSH) and E (HS) soil profiles. It is possible that the hydrology of Peatland 1, where most Type B (SH) soil profiles are located, changed during the Northgrippian Age, possibly

because of local channel incision or differential level development affecting peatland surface wetness. Without a return of the wetter, high-groundwater conditions, these locations did not develop a hemic horizon at the soil surface.

Type C (HSH) soil profiles within CVNWR contain a pedomemory of a wet-dry-wet sequence for local post LGM climate (Figure 3-6), which is supported by radiocarbon dates taken from these cores and concurs with other central Appalachian paleoclimate records. Type C (HSH) soil profiles, as represented by Core 5.17 (Figure 3-9), record late Pleistocene peat deposition in the catotelm as a hemic horizon. Peat accumulated at a slower rate during the early Holocene Greenlandian Age. However, during the Northgrippian Age, peat accumulation slowed drastically, likely in response to a lowered water table under a relatively dry climate. The sapric horizon in the Type C (HSH) soil profiles spans the Greenlandian, Northgrippian, and early Meghalayan ages. The hemic horizon deposited above this sapric material in Type C (HSH) soil profiles is associated with renewed peat accumulation in the middle and late Meghalayan Age, indicating a wetter local climate with a raised water table following the mid-Holocene Climatic Optimum.

Type D (S) soil profiles are shallow and primarily located along the edges of the peatlands where water table depths fluctuate the greatest, exposing the catotelm frequently to aerobic conditions and promoting decomposition. Because of their dryer setting and lack of radiocarbon dates these Histosols cannot be used to infer climate.

Although no Type E (HS) soil profiles have radiocarbon dates, the pattern is consistent with Northgrippian Age low peat accumulation, where peatland surface wetness was reduced so greatly in these generally shallow areas that secondary decomposition altered most of the previously deposited hemic material and is now represented as sapric material (Figure 3-6).

More hemic material was deposited into the catotelm late in peat development, possibly because climatic moisture increased in the Meghalayan Age resulting in a raised water table.

Conclusions

Using peat stratigraphy and well-dated soil profiles we have found proxy evidence of a dryer local climate during the mid-Holocene Climatic Optimum in the central Appalachian Mountains. Correlating the calibrated radiocarbon dates with the soil profile descriptions and laboratory data revealed that the catotelm in the Histosols of CVNWR contains the pedomemory of a climatic change dating to the mid-Holocene Climatic Optimum. The extremely low peat accumulation rate during this time, represented in CVNWR soil profiles as a sapric horizon, most likely results from an increase in decomposition rate of material at the top of the catotelm (Belyea and Warner, 1996) due to a lowered water table associated with a climatic change from cool and wet in the Greenlandian Age to warm and dry during the Northgrippian Age (Figure 3-6). The pedomemory revealed in the CVNWR soil profiles concurs with other central Appalachian paleoclimate records and also confirms and compliments the existing published literature on regional paleoclimate for the eastern United States. Peat humification and peat stratigraphy are useful proxy paleoclimate records; understanding how these ecosystems have responded to past climatic changes will help land use managers interpret how these ecosystems might respond to projected future climate change.

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Chapter 4

Classification and Mapping of Rare and Unique Histosols in the Central Appalachian Peatlands of Canaan Valley National Wildlife Refuge, West Virginia

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Abstract

Canaan Valley in West Virginia contains a greater area of peatlands than any other locality in the mid-Atlantic Highlands. Eighty-eight soil cores in five Canaan Valley National Wildlife Refuge (CVNWR) peatlands were described, sampled, characterized using field and laboratory data, classified according to *Soil Taxonomy*, and mapped following the NRCS *Soil Survey Manual*. The most representative Histosols were classified as Dysic, frigid Sapric Haplohemists and assigned a new formal NRCS soil series name of Canaan Valley peat with an official series description. The five peatland landforms now are associated with a new map unit: Canaan Valley peat, moist, 0 to 3 percent slopes (map unit symbol CavA), covering a total of 246 hectares within CVNWR. These rare soils support unique ecosystems of high conservation

value that hold a concentration of biodiversity in the eastern United States. These soils also contain a pedomemory of valuable paleoclimatic and paleoenvironmental proxies; the interpretation of which contributes to the regional paleoclimatic and paleoenvironmental body of knowledge. This new mapping, classification, and naming of these Histosols conveys their significance and roles they play as the interface of the lithosphere, biosphere, atmosphere, and hydrosphere within these ecosystems.

Introduction

Soils are classified to meet several objectives. These include facilitating the organization of knowledge, improving communication among scientists, and promoting a clearer understanding of the relationship soils have to their landforms, ecosystems, and surrounding soils (Buol et al., 1997; Schimel and Chadwick, 2013). The United States Department of Agriculture Natural Resource Conservation Service (USDA-NRCS) maintains the national program for soil mapping and the official soil classification system presented in *Soil Taxonomy*. Not only does this taxonomic classification facilitate communication with other scientists, but also conveys the soil's morphologic properties (Buol et al., 1997; Schimel and Chadwick, 2013). Soil information is fundamental to site descriptions for ecosystem-scale research and management (Schimel and Chadwick, 2013), and taxonomic information allows us to establish linkages between the results of various studies and observations of soil characteristics. A proper taxonomic classification accurately establishes the presence of diagnostic horizons and features as well as the physical, chemical, and mineralogical properties that are used to interpret a soil's suitabilities and limitations. Each piece of the taxonomic classification offers information and allows inferences to be made, not only about the soil itself, but also about the ecosystem and how it functions (Schimel and Chadwick, 2013). At the most specific level in *Soil Taxonomy*, the official series

description is the narrative that designates the horizonation and associated morphological properties of a soil, its geomorphic setting, and its relationship to other known soil series.

Peatlands occupy about 2.7% of the earth's terrestrial surface, and Histosols are the primary soil order within these peatlands (Chimner et al., 2014; Kolka et al., 2016; Loisel and Garneau, 2010; Yu et al., 2011, 2010; Zaufert et al., 2010). Peatlands act as archives of paleoenvironmental and paleoclimatic proxies, serve as both sinks (CO_2) and sources (CO_2 and CH_4) of greenhouse gases, and represent a substantial worldwide carbon pool, making them scientifically valuable to understanding past, current, and future global and local climates (Beilman et al., 2010; Chimner et al., 2014; Franzen et al., 2012; Ireland et al., 2013; Langdon et al., 2012; Loisel and Garneau, 2010; Warren et al., 2012; Yu et al., 2011, 2009; Zaufert et al., 2010). Soil is the largest active terrestrial reservoir in the global carbon cycle (Rumpel and Kögel-Knabner, 2011; Rumpel, 2014). Peatlands constitute approximately 30% of the world's soil carbon (Beilman et al., 2010; Chimner et al., 2014; Franzen et al., 2012; Holden, 2005).

Peatlands form when net primary production of vegetation exceeds decomposition, resulting in accumulation of organic matter and the formation of organic soils (Vitt, 2006; Yu et al., 2009). This process is primarily related to hydroclimatic conditions of abundant moisture and relatively low temperature (Loisel and Garneau, 2010). Globally, peatland occurrence is strongly related to topography and climate (Franzen et al., 2012). Flat topography in boreal climates with abundant moisture and relatively low temperature is particularly conducive to peatland formation; large areas of tropical peatlands also exist due to rapid vegetation growth (Cameron et al., 1989; Dommain et al., 2014; Kolka et al., 2016; Page et al., 2011; Yu et al., 2010). Organic soils are most abundant within two regions of the contiguous United States, the

upper Midwestern states of Michigan, Minnesota, and Wisconsin; and the Southern states of Florida, Louisiana, and North Carolina (Cameron et al., 1989; Kolka et al., 2016). Histosols are not common in the Appalachian Mountains and no Histosols classified to the soil series level were mapped in West Virginia prior to this research.

High-elevation peatlands of the central Appalachian Mountains are a southern extension of contemporary boreal ecosystems commonly associated with bogs and fens (Francel et al., 2004; Ingham, 1996; Snyder et al., 2006; Stewart and Nilsen, 1993; Stine et al., 2011; Whitehead, 1965). Some central Appalachian geographic niches are similar climatically to numerous northern boreal peatlands (Cameron, 1970), with abundant moisture and relatively low temperature (Sencindiver et al., 2015; Vogel and Leffler, 2015; Walbridge, 1994; Western Regional Climate Center, 2016). Local topography, orographic precipitation, and the frost pocket effect (where cold, dense, nocturnal air drains downslope decreasing valley floor temperatures), all contribute to microclimates supportive of peat accumulation (Byers et al., 2007; Stewart and Nilsen, 1993; Vogel and Leffler, 2015; Walbridge, 1994).

The floor of Canaan Valley contains one of the largest inland freshwater wetland ecosystems of peatlands, marshes, wet meadows, and shrub and forested wetlands in the eastern United States (Fortney and Rentch, 2003). These minerotrophic peatlands are characterized by exceptionally high biodiversity and conservation value (Byers et al., 2007), and have the largest peat deposits located in the unglaciated uplands along the Allegheny structural front in West Virginia, Maryland, and Pennsylvania (Cameron, 1970). Peatlands in the Unglaciated Allegheny Plateau range in size from a few hectares to a few hundred hectares (Ingham, 1996), and are typically situated in geomorphic depressions at higher elevations (above 730 m) (Byers et al., 2007; Diehl and Behling, 1982; Ingham, 1996). Byers et al. (2007) placed peatlands within the

High Allegheny Wetland Ecological System, which contains some of the highest concentrations of globally rare plant and animal species within the northeastern United States (Byers et al., 2007). Loss of any of the few Allegheny Mountain peatlands would compromise regional biodiversity (Walbridge, 1994). The high conservation value of Canaan Valley peatlands and their associated ecosystems originates from a few fundamental factors, including a distinctive biota that stems from their location south of the Last Glacial Maximum ice margin, their complex topography and geology, and their extent as one of the largest inland freshwater wetland ecosystems in the eastern United States (Bartgis et al., 2015; Byers et al., 2007; Fortney and Rentch, 2003; Fortney et al., 2015).

A dynamic component of these distinctive ecosystems in Canaan Valley are the soils that support the rare plant and animal communities. Canaan Valley ecosystems have been extensively studied, named, and classified (Allard and Leonard, 1952; Bartgis et al., 2015; Bonner et al., 2009; Byers et al., 2007; Chadbourne and Anderson, 2015; Core, 1950; Faust and Petersen, 2015; Fortney and Rentch, 2003; Fortney et al., 2015; Grafton and Fortney, 2015; McDonald, 2015; Rentch et al., 2008; Rentch and Anderson, 2000; Snyder et al., 2006). Although the accompanying soils have been briefly examined and discussed (Cameron, 1970; Franci et al., 2004; Sencindiver et al., 2015), a full investigation, mapping, description, and classification of these natural soil bodies was lacking prior to this study. Goals of this research were to characterize, apply soil taxonomy principles to, and classify these previously undescribed natural bodies of soil highlighting the value of classification of these rare and unique Histosols within Canaan Valley National Wildlife Refuge (CVNWR). The naming and consequent taxonomic classification of these natural bodies of soil not only elevate its importance, but also improve communication regarding this soil and the unique ecosystems it

supports. These efforts were facilitated by working closely and coordinating with NRCS soil scientists to establish a new official series description.

Landscape setting

The High Allegheny Wetland Ecological System occurs in a southwest-northeast trending band about 40 km wide and 200 km long within the Allegheny Mountain section of the Appalachian Plateaus physiographic province in unglaciated Pennsylvania, Maryland, and West Virginia (Byers et al., 2007; Fenneman and Johnson, 1946; Reger and Cleaves, 2008; Sevon, 2018; West Virginia Geologic and Economic Survey, 2017). This physiographic subdivision correlates with the USDA Major Land Recourse Area (MLRA) 127, the Eastern Allegheny Plateau and Mountains (Figure 4-1). In general, the Allegheny Mountain section is higher in elevation than adjacent physiography, and characterized by broad, open structural bedrock folds (Matchen, 2015). Allegheny Mountain peatlands originate in depressions or behind knickpoints in, or near, headwaters of first or second order streams (Byers et al., 2007; Diehl and Behling, 1982; Ingham, 1996; Rigg and Strausbaugh, 1949). Canaan Valley is a high elevation (965-1000 m), breached anticlinal valley; almost the entire valley is drained by the headwaters of Blackwater River, a Cheat River tributary. Surrounding mountain ridges, with elevations of 1,100 to 1,300 m, are capped by resistant Pottsville Sandstone; the more easily erodible valley slopes are formed on Mauch Chunk shale, sandstone, and limestone; whereas most of the valley floor is underlain by Greenbrier Limestone and shaley members of the lower Mauch Chunk (Fortney and Rentch, 2003). Projecting through bottomlands in the valley center is a low, elongate ridge, known as Middle Ridge, which is comprised of coarse-grained sandstone of the Price Formation, exposed along the axis of an anticline (Matchen, 2015).

Figure 4- 1. Canaan Valley represented by a star, with USDA Major land Resource Area (MLRA) 127 (from NRCS 2006 MLRA Geographic Database, version 4.2) shown shaded in gray.

CVNWR encompasses the northern portion of Canaan Valley, protecting most of West Virginia's largest wetland complex. Within this valley, the study areas consist of five interfluvial fen landforms. These five landforms were previously mapped as Soil Conservation Service soil map units labeled as muck and peat (Losche and Beverage, 1967). Small-unnamed tributaries of the Blackwater River bordered by Entisols with histic epipedons or hydric components separate these five peatlands (Losche and Beverage, 1967). The five peatlands are classified ecologically as very poor fens: very acidic, moderately influenced by ground water, and dominated by sedges with a continuous carpet of *Sphagnum* (Kost et al., 2007). They are flood- and beaver-influenced wetlands encompassing shrub swamps, sedge fens, wet meadows, and open marshes (Byers et al., 2007). Forested swamps occupy the slightly higher elevation margins around most of the peatlands. Bryophyte groundcover vegetation in these peatlands commonly consists of *Sphagnum rubellum*, *Sphagnum recurvum*, *Sphagnum palustre*, and *Polytrichum commune*. Herbaceous vegetation includes *Eriophorum virginicum* (tawny cottongrass), *Rhynchospora alba* (white beaksedge), *Solidago uliginosa* (bog goldenrod), *Carex folliculata* (northern long sedge),

and minor amounts of *Scirpus sp.* (bulrush). Woody shrub vegetation primarily consists of *Photinia melanocarpa* (black chokeberry), *Aronia arbutifolia* (red chokeberry), *Vaccinium oxycoccos* (small cranberry), *Ilex verticillata* (common winterberry), *Hypericum* (St. Johnswort), *Viburnum nudum* (northern wild raisin), *Vaccinium myrtilloides* (velvetleaf blueberry), and *Rubus hispidus* (bristly dewberry). Overstory vegetation is sparse, usually isolated on hummocks, and typically comprised of *Picea rubens* (red spruce), *Pinus strobus* (white pine), and *Abies balsamea* (balsam fir).

Methods

Soils within the five peatlands were described, sampled, characterized using both field and laboratory data, classified, and mapped. Soil mapping, as defined in the *Soil Survey Manual* is “the process of delineating natural bodies of soils, classifying and grouping the delineated soils into map units, and capturing soil property information for interpreting and depicting soil spatial distribution on a map” (Soil Science Division Staff, 2017). Initial stages of this research were guided by preexisting NRCS muck and peat map unit delineations in CVNWR, which encompassed 187 hectares (Losche and Beverage, 1967). These areas were designated as Peatland 1 through 5 for the purposes of this study. A focus of this research was to determine what types of soils exist within these delineations, and whether the map unit polygon boundaries were accurate.

Soil morphology describes and measures a wide range of soil properties, it deals with form, structure, and organization of the soil materials; it is a record of past and current ecological and geomorphic processes (Daniels and Hammer, 1992). Soil morphology is observed and described in the field and can be augmented with laboratory data. It can provide insight into how ecosystems change (Nauman et al., 2015), basic data for interpreting soil genesis (Buol et al.,

1997), and shed light upon the developmental and climatic history of peatlands (Yu et al., 2009). Soil morphology was determined by profiling 100 soil cores throughout and around the five study areas. All profiles were classified based upon the field descriptions using *Soil Taxonomy* (Soil Survey Staff, 1999). Thirty of the 100 cores were sampled for laboratory analysis, including radiocarbon dating, bulk density, loss on ignition, fiber content, and pyrophosphate color; this data was also included in classification.

Field methods

Soil core locations were chosen according to the “free survey” method of sampling soils, which involves the application of soil-landscape concepts based on the premise that soils vary repetitively and predictably with geomorphology, topography, and related factors (Carlisle et al., 1998). Location of cores was representative of the immediately surrounding terrain. Hummocks and hollows were avoided, as were locations of known anthropogenic disturbance. Taking into account vegetation, ecosystem, microtopography, and water depth, a minimum of two individual soil core profile locations within each peatland were sampled for laboratory analysis.

Laboratory methods

CVNWR secured funding through U.S. Fish and Wildlife Service, in conjunction with the Radiocarbon Collaborative, sponsored jointly by the USDA Forest Service, University of California Irvine (previous mass spectrometry conducted at Lawrence Livermore National Lab in Livermore, California), and Michigan Technological University, to provide radiocarbon dating of 52 samples from 11 cores. Radiocarbon dating samples were chosen based on core location within the peatlands and horizon depth within the profile, focusing on basal peat dates, horizon breaks within the catotelm, and sedimentary sequence of the thickest/deepest cores (Givelet et al., 2004; Piotrowska et al., 2010; Tuittila et al., 2012). Standard radiocarbon ages were

calibrated to dates (cal yr BP) using OxCal 4.2 and IntCal13 Northern Hemisphere calibration curve (Bronk Ramsey, 2009; Reimer et al., 2013).

Bulk density, loss on ignition (LOI), fiber content, and pyrophosphate color laboratory analysis were conducted in the labs of the Division of Plant and Soil Science of West Virginia University. Individual horizons were sampled within each of the 30 cores chosen for laboratory analysis. Laboratory procedures from the *Kellogg Soil Survey Laboratory Methods Manual* (Soil Survey Staff, 2014) were followed for the laboratory analysis, with the explicit intention of soil classification.

Classification

The *Kellogg Soil Survey Laboratory Methods Manual* (Soil Survey Staff, 2014) in conjunction with *Soil Taxonomy* (Soil Survey Staff, 1999) were utilized for classification of the soil profiles described in the field. Field descriptions matched well with laboratory data for horizon designations, but lab data took priority over field descriptions when they differed.

Soil properties necessary for classifying Histosols to the family level of *Soil Taxonomy* include the thickness of organic soil materials, degree of organic material decomposition, and soil pH (Bakken and Stolt, 2018). However, soil series, not families or higher-level taxa, are the dominant component of most soil map units and, consequently, series are most commonly used as map units in U.S. soil surveys (Soil Science Division Staff, 2017). In order to determine if a new soil series and map unit designation were warranted, soil pedons from this investigation were classified and compared to geographically associated soils series, Histosol soil series mapped within MLRA 127, and the only recognized soil series within the same family.

Results

The five map unit polygons, previously mapped as 187 hectares, were remapped as 246 hectares (Table 4-1 and Figure 4-2). Updating these soil map unit polygons was facilitated by the 100 soil cores throughout and around the five study areas. Of these 100 soil profiles, 12 were determined to be Entisols; these were all outside of the peatland landforms and will not be discussed further. The 88 Histosol soil profiles were characterized and classified down to the subgroup level (Table 4-1). Ruts from a late 20th Century off-road vehicle race (Dirt Wheels Magazine, 2018) were still present within all five peatlands; however, these ruts did not disturb the natural bodies of soil below the water table into the catotelm (Schaney and Schaney, *in preparation*). Remnants of early 20th Century rail beds, a long abandoned logging road, and incised historic logging skids were also present throughout the five peatlands (Schaney and Schaney, *in preparation*).

	Peatland 1	Peatland 2	Peatland 3	Peatland 4	Peatland 5	Totals
Previous hectares	9	26	21	71	60	187
Mapped hectares	18	26	32	69	101	246
Maximum peat thickness	180 cm	170 cm	180 cm	220 cm	300 cm	
Average peat thickness	120 cm	109 cm	125 cm	139 cm	183 cm	
Terric Haplosaprists (1)	8	7	7	6	2	30
Terric Haplohemists (2)	7	0	2	0	2	11
Typic Haplosaprists (3)	1	1	0	0	1	3
Typic Haplohemists (4)	2	1	4	4	0	11
Hemic Haplosaprists (5)	7	0	1	0	2	10
Sapric Haplohemists (6)	0	0	5	9	6	20
Fibric Haplohemists (7)	0	0	0	0	1	1
Hemic Haplofibrists (8)	0	0	0	0	2	2
Totals	25	9	19	19	16	88

Table 4- 1. Mapping results of the five peatlands. Parenthetic numbers following taxonomic classifications coordinate with the number scheme of Figure 4-3.

Figure 4- 2. Peatlands 1 – 5 with previously mapped muck and peat (MP) soil map unit polygons outlined in black, and remapped Canaan Valley (CavA) soil map unit polygons in white. Aerial imagery obtained from the 2007 United States Department of Agriculture National Agriculture Inventory Program.

Peatland 1 (Figure 4-3a) was bound to the northwest by footslope wetlands, to the southwest by riparian areas, to the southeast by a tree-covered, bedrock high, and to the northeast by historic logging skids. Of 25 Histosol profiles in Peatland 1, eight were classified at the subgroup level as Terric Haplosaprists, seven as Terric Haplohemists, and seven as Hemic Haplosaprists. Hemic Haplosaprists were the most numerous soil profiles in the center of Peatland 1 where peat thickness was greatest.

Peatland 2 (Figure 4-3b) was irregular in shape, bound to the south by a riparian area and in other directions by uplands with very shallow bedrock. Seven of nine Histosol soil profiles in

Peatland 2 were classified at the subgroup level as Terric Haplosaprists. One Typic Haplohemist and one Typic Haplosaprist were located in the center of Peatland 2 where peat thickness was greatest.

Peatland 3 (Figure 4-3c) was bound to the east by footslope wetlands, to the west and south by upland areas of shallow bedrock, and to the east by a riparian area. Seven of 19 Histosol soil profiles in of Peatland 3 were classified at the subgroup level as Terric Haplosaprists, with four Typic Haplohemists and five Sapric Haplohemists located in the center of Peatland 3 where peat thickness was the greatest.

Peatland 4 (Figure 4-3d) was bordered to the northwest and southwest by riparian areas, to the east by footslope, with two areas of uplands (Schaney and Schaney, *in preparation*). Peatland 4 had a few small areas of open water and some small areas of exposed mineral soil. Six of 19 Histosol soil profiles in of Peatland 4 were classified at the subgroup level as Terric Haplosaprists, with four Typic Haplohemists and nine Sapric Haplohemists located in the center of Peatland 4 where peat thickness was the greatest.

Peatland 5 (Figure 4-3e) was bordered to the north, west, and south by riparian areas and to the east by Middle Ridge. Extensive areas of standing water from numerous beaver dams occur south of the rail bed (Snyder et al., 2006). Of 16 Histosol soil profiles in Peatland 5, six were located where peat thickness is the greatest were classified at the subgroup level as Sapric Haplohemists. Peatland 5 also had a small area, just south of the beaver ponds, where one soil profile was classified as Fibric Haplohemist and two as Hemic Haplofibrists.

Figure 4- 3. The five mapped CVNWR peatlands with soil profiles labeled by classification.

Terric Haplosaprists are labeled as 1,
 Terric Haplohemists as 2,
 Typic Haplosaprists as 3,
 Typic Haplohemists as 4,
 Hemic Haplosaprists as 5,
 Sapric Haplohemists as 6,
 Fibric Haplohemist as 7, and
 Hemic Haplofibrists as 8.

The five peatland landforms comprising the study areas had the thickest peat deposits in the interior of each landform and shallow peat along the edges. Generally, most soil profiles in CVNWR peatlands had similar horizonation trends. The acrotelm typically consisted of approximately 20 cm of fibric soil material, underlain by less than 10 cm of sapric soil material located at the water table. The catotelm in these profiles consisted of various thicknesses of a combination of hemic and sapric soil materials.

In the thickest deposits of Peatlands 2, 3, 4, and 5, the most common catotelm horizon sequence was hemic-sapric-hemic, which was also the most common horizon sequence in all CVNWR Histosols (Chapter 3), regardless of taxonomic control section. *Soil Taxonomy* has established an arbitrary control section for Histosols that extends to a depth of 130 cm, soil classification does not extend past this depth (Soil Survey Staff, 1999). Horizon sequence does not always match taxonomic classification because 48 of the 88 Histosol profiles for this study extend deeper than the control section. Sequential radiocarbon dates from six cores, (Cores 1.86, 2.09, 3.13, 4.19, 5.12, and 5.17) yielded late Holocene dates correlating to the upper hemic horizon, mid-Holocene dates correlating to the sapric horizon, and late Pleistocene basal peat dates correlating to the lower hemic horizon (Chapters 2 and 3).

Sapric Haplohemists were the second-most numerous (19) CVNWR Histosol soil classification and contained the highest number of profiles with the hemic-sapric-hemic horizon sequence. All Sapric Haplohemists were located in the interior of the landforms where peat thickness is greatest, and best represent the horizons that characterize these natural bodies of soil, making them the best candidate as an official NRCS soil series. Terric Haplosaprist were the most numerous (30) soil profile classification, but only occur on the periphery of peatland landforms (Table 4-1 and Figure 4-3). Terric Haplosaprist profiles were shallow because of their

landscape position and represent an ecotone transition from peatlands to the surrounding wetlands, and were considered inappropriate for designation as a new soil series. A modest number of soil profiles classified as Typic Haplohemists (11), Terric Haplohemists (11), Hemic Haplosaprists (10), or Typic Haplosaprists (3) (Table 4-1) vary in location and are too few to be represented as soil series. Hemic Haplofibrists (2) and Fibric Haplohemists (1) were the least numerous soil profiles characterized; all these profiles contained the hemic-sapric-hemic horizon sequence present in more common CVNWR Histosols, with the addition of a fibric horizon in the upper catotelm.

To ensure the characteristic natural bodies of soil in these five peatlands were not equivalent to existing soil series, the Sapric Haplohemist classification was compared to geographically associated Atkins, Blago, Brinkerton, and Lickdale soils series, located adjacent to the five study areas as identified by Losche and Beverage (1967). These series were all mineral soils and did not correlate to the Sapric Haplohemist classification.

Our Sapric Haplohemist classification was also compared to pre-existing Histosol soil series mapped within MLRA 127: Carlisle muck (Euic, mesic, Typic Haplosaprist) and Palms muck (Loamy, mixed, euic, mesic Terric Haplosaprist). CVNWR soil profiles from this investigation were best represented as Haplohemists, not Haplosaprists, and have a pH less than 4.5 in all parts of the organic material in the control section, making them dysic rather than euic. Furthermore, due to Canaan Valley's climate, the soil temperature was frigid rather than mesic (Sencindiver et al., 2015); hence, CVNWR soil profiles did not correlate to the two pre-existing MLRA 127 Histosols, which remain unrecognized in West Virginia.

Lastly, comparing our results to the only pre-existing Sapric Haplohemist soil series recognized by the NRCS, revealed that Mosesprairie peat in western Washington formed in

organic materials over glaciolacustrine sediments and occurs in an isomesic temperature regime. In contrast, CVNWR soil profiles had a frigid soil temperature regime and were not formed over glaciolacustrine sediments, so Mosesprairie peat, was not correlative.

Working with NRCS soil scientists in state and local offices and in MLRA Soil Survey Region 6 Office, it was determined the Histosols investigated in CVNWR were outside the limits of any previously recognized NRCS soil series and had a unique set of properties. Hence, a new soil series was warranted. The family level characterization of the taxonomic classification of these soils was Dysic, frigid, Sapric Haplohemists. Canaan Valley series was assigned as the name of the new soil series (Schaney et al., 2018). Subsequently, the five peatlands within CVNWR were designated by a new soil survey map unit: Canaan Valley peat, moist, 0 to 3 percent slopes, represented by the map unit symbol CavA.

Discussion

Soils are a dynamic ecosystem constituent that act as the interface between the lithosphere, biosphere, atmosphere, and hydrosphere; they provide the foundation and structure of ecosystems. Meaningful ecosystem research regularly requires site-specific information on the processes affected by soils, and soil taxonomy is a critical component of such studies (Holden, 2005; Schimel and Chadwick, 2013). Goals of this research include characterizing, applying soil taxonomy principles to, and classifying these previously undescribed natural bodies of soil highlighting the value of classification of these rare and unique Histosols within CVNWR.

The *Soil Survey Manual* (Soil Science Division Staff, 2017) lists four main purposes of *Soil Taxonomy* (i) to facilitate communication among soil scientists, (ii) to provide names for

taxa that are based on formative elements, (iii) to provide a link between the conceptual classes in *Soil Taxonomy* and actual natural bodies of soils, and (iv) to provide a way to transfer information and technology. Continuing research in the taxonomy and classification of soils is a priority within the broad movements of modern soil science, including classification of mine and quarry soils (Sencindiver and Ammons, 2000; Strain and Evans, 1994), urban soils (Capra et al., 2013; Effland and Pouyat, 1997), and subaqueous soils (Bakken and Stolt, 2018; Demas et al., 1996; Millar et al., 2015; Wessel et al., 2018; Wessel and Rabenhorst, 2017). These newly understood soils play a critical role in natural and anthropogenic ecosystems. Advancing such research contributes to the understanding of anthropogenic landscapes, land use change, newly recognized and rare ecosystems, and the global carbon cycle. Unique ecosystems such as CVNWR provide excellent locations and topics for taxonomic research. Coordinating such research with the NRCS not only provides extensive reliable experience, but also ensures research outcomes will be incorporated into national soils databases available for public use, such as the *Web Soil Survey* (Soil Survey Staff).

Soil series serve as a bridge between observed soils and conceptual taxonomic classes; they are important tools for naming, preserving, and communicating information about soils. Soil series also serve as tools for transferring knowledge about soil genesis, properties, and interpretations from place to place, wherever a given soil series is correlated to a map unit component (Soil Science Division Staff, 2017).

Although relatively homogenous soil map units are desirable, they are rarely attainable due to natural variations in individual soil properties and, in peatland landscapes, internal hydrology (Campbell and Edmonds, 1984). In most map units, areas of soil occur that do not meet all of the taxonomic criteria of the soil used to name the map unit and they normally

consists of one or more components (Soil Science Division Staff, 2017). The new map unit CavA designates the new Canaan Valley series (Dysic frigid Sapric Haplohemists) and also contains components. Updated map units aid researchers and land use managers working in the Central Appalachians to understand the genesis and extent of these Histosols.

Conclusions

Histosols are important in both location and management, and they favor many special functions (Aandahl et al., 1974), including protected natural areas like CVNWR. The limited extent of Histosols in the Central Appalachians is a key aspect that makes them so important regionally. Histosols not only support unique ecosystems of high biodiversity and regionally rare plants (Bartgis et al., 2015; Byers et al., 2007; Fortney and Rentch, 2003; Fortney et al., 2015), but they also hold valuable paleoclimatic and paleoenvironmental proxies that record a pedomemory of these landscapes within their distinctive horizonation (Chapter 3). The interpretation of this pedomemory contributes to the regional paleoclimatic and paleoenvironmental body of knowledge. Current and future regional paleoclimate and paleoenvironmental studies conducted in similar Allegheny Mountain peatlands greatly benefit from taxonomic classification of soil to assist in interpreting the genesis and development of the individual ecosystems.

Peatland ecosystems and their carbon-rich organic soils have been studied for several decades, mainly as archives of paleoclimate and paleoenvironmental proxies, but more recently for their importance in the global carbon budget (Yu et al., 2009). Understanding the depth, extent, and differing decomposition of organic-rich horizons in Histosols can lead to more accurate accounts of peatland carbon storage (Millar et al., 2015; Zauft et al., 2010; Malmer et al., 2011). The representative horizonation as documented in official series descriptions and the

variability in this horizonation within the peatland soil map units will yield even more accurate inventories of terrestrial carbon stocks. Distribution of the Canaan Valley series includes other high elevation peatlands in MLRA 127 (Schaney et al., 2018). Small-scale ecosystems are underestimated in the global carbon budget (Millar et al., 2015); future carbon research in the relatively small Appalachian peatlands will contribute to the greater knowledge of carbon storage. Specifically, the USDA Forest Service Forest Inventory and Analysis Program includes soil carbon calculations by state for public and private forested areas (Chimner et al., 2104; USDA Forest Service, 2015).

Formal recognition of the Canaan Valley series and its associated taxonomic classification convey a level of significance that was not apparent when these Histosols were mapped as unnamed and unclassified muck and peat. The Canaan Valley official series description and Dysic, frigid Sapric Haplohemists classification impart key information about, the makeup of the soils, how they formed, and insight into how they should be managed. Ecologists, soil scientists, paleoenvironmental scientists, and U.S Fish and Wildlife Service land-use managers may all benefit from this research contributions to a more complete understanding of CVNWR Histosols and the ecosystems they support.

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Chapter 5

Summary

The preceding dissertation research can be characterized as an investigation of the organic soils of five CVNWR peatlands. Obtaining radiocarbon dates was a primary goal and procuring funding for dating was initiated early in this process. The Radiocarbon Collaborative and USFWS funding enabled more dates than anticipated to be obtained, and allowed a more comprehensive high-resolution chronology than would have otherwise been possible. As discussed in Chapter 2, the radiocarbon chronology turned out to be more complex and older than suggested by other regional studies. Comparing and interpreting previous research of Allegheny Mountains peatlands proved to be difficult due to inconsistency in sediment profile descriptions. It is suggested that future peatland research, whatever the intent may be, include full soil profile descriptions using standardized NRCS soil science terminology.

Coring and describing the soils was a second goal for this research, which led to the unexpected results of observing a distinct pattern within the sequence of soil horizons as discussed in Chapter 3. Pedomemory recorded in the soil profiles revealed a paleoclimate proxy that was substantiated by the large number of soil cores profiled. Peat stratigraphy is a useful tool in paleoclimate research, but has not been utilized previously in the Allegheny Mountains and very little in the eastern United States. Proper peat stratigraphy descriptions and interpretations require a working knowledge of soil science. Again, reinforcing full soil profile descriptions using standardized USDA soil science terminology should be standard for peatland research.

The third goal of this research was to classify these organic soils according to *Soil Taxonomy* and submit that classification to the NRCS for formal series adoption, as discussed in

Chapter 4. The process of designating a new soil series and incorporating new soil map units into the federal database and websites advanced faster than anticipated and has already been finalized. It is anticipated that Chapters 2, 3, and 4 of this dissertation will be published in geomorphology, quaternary, or pedology journals. Cores collected for laboratory analysis are currently stored frozen in the basement of Krebs Hall of the University of Pittsburgh at Johnstown, the author's current location of employment.

As good research tends to do this study brought forth many new research questions regarding pedology, geomorphology, and paleoclimate of Canaan Valley National Wildlife Refuge (CVNWR) peatlands and Histosols. Pollen analysis, peat humification, loss on ignition, and macroscopic charcoal analysis of the two thickest peat cores is being conducted currently by Environmental Science undergraduate researchers at Berry College led by Dr. Zachary Taylor. Preliminary analysis of peat humification based upon high light transmissivity and low organic matter content with high macrocharcoal counts corroborates a dry mid-Holocene Climatic Optimum as discussed in Chapters 2 and 3. Mapping efforts will also continue within CVNWR by creating a three-dimensional digital map of the peat thickness within the five peatlands. Depth probe data was previously collected and will be processed as part of undergraduate student research at University of Pittsburgh at Johnstown Geography Department led by myself. Further research could also be conducted using ground penetrating radar to map the organic soil - mineral soil interface. Pairing that information with mineral soil samples already collected will further the inquiry of landform development of the five CVNWR peatlands. Calculating carbon storage in CVNWR peatlands, as well as other Allegheny Mountain peatlands, to be incorporated into the soil carbon data collected by the USDA Forest Service Forest Inventory and Analysis Program, is also a future goal of this continuing research. Coupling a carbon balance exercise

with projected future climate change scenarios would be beneficial for the land-use managers of the Allegheny Mountain peatlands.

I would also like to expand this research to the other Allegheny Mountain peatlands. The four peatlands in Cranberry Glades Botanical Area have thick peat deposits and a large surface area. Preliminary soil sampling revealed thick, intact organic soil deposits. Cranberry Glades will be prioritized for future research. Preliminary soil sampling and site reconnaissance has also been completed at Big Run Bog, Buckles Bog (The Glades), and Cranesville Swamp. It is of scientific value to explore these Histosols to determine if they are of similar age and if they show a similar pedomemory of late Pleistocene and Holocene climatic fluctuations. Several other locations, reported as peatlands, also were visited for soil sampling but did not contain Histosols.

Appendix A: Soil Profile Descriptions and Data

The following written soil profile descriptions are organized by core number and include lab data where applicable. Each individual soil profile states the taxonomic classification, the date described in the field, and by whom. Some include location or surface vegetation descriptions where noted. Location is given in latitude and longitude decimal degrees with negative values indicating longitude west.

Classification assumptions:

- Mineral Soil if organic content (by LOI) is less than 20%
- Histosol if:
 - No andic soil properties
 - Saturated 30 days or more (these peatlands are saturated year-round)
 - 40cm + of organic sapric or hemic soil material
- Control section down to 130cm
 - Surface tier 0-30cm
 - Subsurface tier 30-90cm
 - Bottom tier 90-130cm
- Suborders
 - Fibrist if majority fibric soil in subsurface tier
 - Saprist if majority sapric soil in subsurface tier
 - Hemist – other Histosols
- Great Groups
 - No sulfur
 - Not cryic
 - All are Haplo
- Subgroups
 - Lithic if bedrock contact in control section (130cm)
 - Limnic if 5cm or more limnic horizon in control section
 - Not Halic
 - Terric if mineral layer within control section (130cm)
 - Not fluvial
 - Hemic if 25cm or more of hemic in control section, below surface tier
 - Sapric if 25cm or more of sapric in control section, below surface tier
 - Fibric if 25cm or more of fibric in control section, below surface tier
 - Typic if other
- Fibric horizon designation if:
 - contains 75% or more of fibers after rubbing or 40%
 - a pyrophosphate color of 7/1, 7/2, 8/1, 8/2, or 8/3
 - bulk density of less than 0.1g/cm³
- Sapric horizon designation if:
 - Fiber content after rubbing is less than 17% AND
 - Pyrophosphate color as designated on Diagram 2 in Soil Taxonomy (p. 88)
 - Bulk density usually greater than 0.2g/cm³

- Hemic horizon designation if organic soil does not meet either Fibric or Sapric requirements
 - Bulk density usually between 0.07 and 0.18g/cm³
- Lab data was preferred over field descriptions if different.
- For terric subgroup classification, it is assumed that mineral soil continues to depth even if 30cm of mineral was not retrieved in core.

Individual Soil Profiles

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

4 June 2014

Profile 1.01, **Terric Haplosaprist**

Location: 39.1337, -79.384

Compiled by M. Schaney, J. Teets, and S. Marsh

Oi - - 0 to 12 centimeters; dark brown (10YR 3/3) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers.

Oa1 - - 12 to 26 centimeters; black (10YR 2/1) unrubbed sapric muck with 20 per cent silty clay; 10 per cent unrubbed fibers; 7 per cent rubbed fibers.

Oa2 - - 26 to 62 centimeters; black (10YR 2/1) unrubbed sapric muck; 25 per cent unrubbed fibers; 5 per cent rubbed fibers; coniferous needles.

Oa3 - - 62 to 80 centimeters; very dark gray (5YR 3/1) unrubbed sapric muck with 25 per cent silt, 30 per cent unrubbed fibers; 3 per cent rubbed fibers.

C- - 80 to 93 centimeters; dark brown (7.5YR 3/2) silty clay.

Cg1- - 93 to 98 centimeters; grayish brown (2.5Y 5/2) silty clay.

Cg2- - 98 to 99 centimeters; weak red (2.5YR 5/2) silty clay; 5 per cent decayed sandstone pebbles and 15 per cent siltstone fragments.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
4 June 2014

Profile 1.02, **Terric Haplohemist**

Location: 39.13310, -79.38370

Compiled by M. Schaney, J. Teets, and S. Marsh

Oi1 - - 0 to 9 centimeters; dark brown (10YR 3/3) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers.

Oi2 - - 9 to 19 centimeters; very dark brown (7.5YR 2.5/3) unrubbed fibric peat; 60 per cent unrubbed fibers; 50 per cent rubbed fibers. Water table at 20 centimeters.

Oa - - 19 to 38 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; 65 per cent unrubbed fibers; 3 per cent rubbed fibers; black round seeds.

Oe - - 38 to 95 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge mucky peat, 80 per cent unrubbed fibers; 25 per cent rubbed fibers.

Oa- - 95 to 123 centimeters; dark brown (7.5YR 3/2) unrubbed sapric muck; 80 per cent unrubbed fibers; 10 per cent rubbed fibers; lighter appearance.

Cg- - 123 to 132 centimeters; grayish brown (2.5Y 5/2) silt loam with visible sand and 15 per cent fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
4 June 2014

Profile 1.03, **Typic Haplohemist**

Location: 39.1324, -79.3836, decrease in heather increase in sedges

Compiled by M. Schaney, J. Teets, and S. Marsh

Oi1 - - 0 to 9 centimeters; dark brown (10YR 3/3) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers.

Oi2 - - 9 to 21 centimeters; very dark brown (7.5YR 2.5/3) unrubbed fibric peat; 60 per cent unrubbed fibers; 50 per cent rubbed fibers. Water table at 20 centimeters.

Oa - - 21 to 35 centimeters; black (10YR 2/1) unrubbed sapric muck; 35 per cent unrubbed fibers; 3 per cent rubbed fibers.

Oe1 - - 35 to 107 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge mucky peat, 70 per cent unrubbed fibers; 22 per cent rubbed fibers.

Oe2 - - 107 to 148 centimeters; dark brown (7.5YR 3/2) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 22 per cent rubbed fibers; spongy consistence.

Cg - - 148 to 150 centimeters; grayish brown (2.5Y 5/2) silt loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
5 June 2014

Profile 1.04, **Terric Haplohemist**

Location: 39.13200, -79.38300, decrease in heather increase in sedges

Compiled by M. Schaney and S. Marsh

Oi1 - - 0 to 9 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers.

Oi2 - - 9 to 18 centimeters; very dark brown (7.5YR 2.5/3) unrubbed fibric peat; 95 per cent unrubbed fibers; 90 per cent rubbed fibers.

Oa1 - - 18 to 34 centimeters; black (10YR 2/1) unrubbed sapric muck with clay; 30 per cent unrubbed fibers; 1 per cent rubbed fibers.

Oa2 - - 34 to 55 centimeters; black (5YR 2.5/1) unrubbed sapric muck, 60 per cent unrubbed fibers; 5 per cent rubbed fibers.

Oe- - 55 to 122 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat; 85 per cent unrubbed fibers; 25 per cent rubbed fibers.

Cg- - 122 to 125 centimeters; grayish brown (2.5Y 5/2) fine sandy loam with 7 per cent fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
5 June 2014

Profile 1.05, **Terric Haplosaprist**

Location: 39.13180, -79.38280, more shrubs

Compiled by M. Schaney and S. Marsh

Oi1 - - 0 to 14 centimeters; dark brown (10YR 3/3) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers.

Oi2 - - 14 to 27 centimeters; very dark brown (7.5YR 2.5/3) unrubbed fibric peat; 60 per cent unrubbed fibers; 50 per cent rubbed fibers.

Oa - - 27 to 62 centimeters; black (10YR 2/1) unrubbed sapric muck; 25 per cent unrubbed fibers; 3 per cent rubbed fibers; wood fragment at 50 centimeters.

Oe - - 62 to 126 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge mucky peat, 70 per cent unrubbed fibers; 22 per cent rubbed fibers; clear smooth boundary.

Cg- - 126 to 136 centimeters; grayish brown (2.5Y 5/2) silt loam with very fine sand.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
5 June 2014

Profile 1.06, **Entisol**

Location: 39.13150, -79.38270, at treeline

Compiled by M. Schaney and S. Marsh

Oi - - 0 to 8 centimeters; yellow (2.5Y 7/6) unrubbed fibric peat; 90 per cent unrubbed fibers; 85 per cent rubbed fibers; smooth abrupt boundary.

A- - 8 to 14 centimeters; black (10YR 2/1) clay loam; small granular structure.

Cg1- - 14 to 24 centimeters; gray (2.5Y 5/1) clay, thin lens of dark gray (2.5Y 4/1) clay; few very fine roots; very weak angular blocky structure; smooth abrupt boundary.

Cg2- - 24 to 40 centimeters; dark yellowish brown (10YR 4/6) with 40 per cent brown (10YR 5/3) clay; massive; common fine to medium roots.

R- - 40 centimeters; Greenbrier Limestone - collected sample.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

5 June 2014

Profile 1.07, **Entisol**

Location: 39.13380, -79.38100, next to logging skid/open water, bullrush, small sedges, wetter vegetation

Compiled by M. Schaney and S. Marsh

Oi - - 0 to 11 centimeters; yellow (2.5Y 7/6) unrubbed fibric peat; 90 per cent unrubbed fibers; 85 per cent rubbed fibers; clear smooth boundary.

Oa - - 11 to 28 centimeters; black (10YR 2/1) unrubbed sapric muck with clay; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; clear smooth boundary; clay lens at 15 centimeters.

Cg1 - - 28 to 65 centimeters; dark grayish brown (10YR 4/2) clay.

Cg2 - - 65 to 92 centimeters; dark greenish gray (10Y 4/1) with 5 per cent yellowish brown (10YR 5/6) clay; more compact.

Cg3 - - 92 to 118 centimeters; dark reddish gray (5YR 4/2) sandy clay loam.

R - - 118 centimeters; Greenbrier Limestone - collected sample.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
5 June 2014

Profile 1.08, **Terric Haplosaprist**

Location: 39.13370, -79.38150, more sedges and grasses, no shrubs, no forbs

Compiled by M. Schaney and S. Marsh

Oi1 - - 0 to 14 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oi2 - - 14 to 34 centimeters; black (10YR 2/1) unrubbed fibric peat with some clay; 60 per cent unrubbed fibers; 50 per cent rubbed fibers; smooth gradual boundary; charcoal fragments at 28 centimeters.

Oa - - 34 to 46 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; very abrupt smooth boundary.

Cg1 - - 46 to 77 centimeters; dark grayish brown (10YR 4/2) clay.

Cg2 - - 77 to 106 centimeters; dark greenish gray (10Y 4/1) with 5 per cent yellowish brown (10YR 5/6) clay; more compact.

Cg3 - - 106 to 122 centimeters; dark reddish gray (5YR 4/2) sandy clay loam.

R - 122 centimeters; fossiliferous limestone.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

5 June 2014

Profile 1.09, **Entisol**

Location: 39.13320, -79.38190, reeds and less sedges, lower water table, near motorcycle rut

Compiled by M. Schaney and S. Marsh

Oi1 - - 0 to 9 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oi2 - - 9 to 21 centimeters; black (10YR 2/1) unrubbed fibric peat with some clay; 60 per cent unrubbed fibers; 50 per cent rubbed fibers; smooth clear boundary.

Cg- - 21 to 51 centimeters; grayish brown (2.5Y 5/2) clay; gradual smooth boundary.

CR- - 51 to 121 centimeters; reddish brown (5YR 4/3) coarsening downward from clay to clay loam to sandy clay loam to decayed shale bedrock - possibly Mauch Chunk.

R- - 121 centimeters.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

5 June 2014

Profile 1.10, **Terric Haplohemist**

Location: 39.13290, -79.38260

Compiled by M. Schaney and S. Marsh

Oi1 - - 0 to 12 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oi2 - - 12 to 20 centimeters; black (10YR 2/1) unrubbed fibric peat; 85 per cent unrubbed fibers; 60 per cent rubbed fibers.

Oa - - 20 to 28 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; clear smooth boundary.

Oe - - 28 to 83 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat, 85 per cent unrubbed fibers; 25 per cent rubbed fibers, diffuse boundary.

Cg1 - - 83 to 110 centimeters; olive gray (5Y 4/2) fine sandy loam with 50 per cent fibers.

Cg2 - - 110 to 146 centimeters; grayish brown (2.5Y 5/2) clay.

Cg3 - - 146 to 170 centimeters; dark reddish gray (5YR 4/2) clay with limestone pebbles.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
5 June 2014

Profile 1.11, **Terric Haplohemist**

Location: 39.13270, -79.38310

Compiled by M. Schaney and S. Marsh

Oi1 - - 0 to 13 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oi2 - - 13 to 22 centimeters; black (10YR 2/1) unrubbed fibric peat; 85 per cent unrubbed fibers; 60 per cent rubbed fibers.

Oa - - 22 to 69 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; clear smooth boundary.

Oe1 - - 69 to 123 centimeters; reddish brown (5YR 4/3) unrubbed hemic mucky peat, 90 per cent unrubbed fibers; 30 per cent rubbed fibers, diffuse boundary.

Oe2 - - 123 to 150 centimeters; dark reddish brown (5YR 3/3) unrubbed hemic mucky peat, 90 per cent unrubbed fibers; 30 per cent rubbed fibers, diffuse boundary.

C - - 150 to 152 centimeters; fine sandy loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

6 June 2014

Profile 1.12, **Terric Haplohemist, Full Core Sample**

Location: 39.13250, -79.38360

Compiled by M. Schaney, C. Schaney, and R. Fedders

Oi1 - - 0 to 10 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oi2 - - 10 to 26 centimeters; black (10YR 2/1) unrubbed fibric peat; 85 per cent unrubbed fibers; 60 per cent rubbed fibers; clear smooth boundary.

Oa - - 26 to 58 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; clear smooth boundary.

Oe - - 58 to 98 centimeters; dark reddish brown (5YR 3/3) unrubbed hemic mucky peat, 90 per cent unrubbed fibers; 35 per cent rubbed fibers, clear smooth boundary.

C- - 98 to 148 centimeters; very dark brown (7.5YR 2.5/2) fine sandy muck grading into a fine sandy loam; 68 per cent unrubbed fibers; 30 per cent rubbed fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

6 June 2014

Profile 1.13 **Terric Haplosaprist**

Location: 39.13200, -79.38500, under pine tree, in motorcycle rut.

Compiled by M. Schaney, C. Schaney, and R. Fedders

Oi - - 0 to 4 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oa1 - - 4 to 28 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 2 per cent rubbed fibers; common fine roots.

Oa2 - - 28 to 62 centimeters; black (10YR 2/1) unrubbed sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; few fine roots.

Oe - - 62 to 80 centimeters; dark brown (7.5YR 3/4) unrubbed hemic mucky peat, 85 per cent unrubbed fibers; 35 per cent rubbed fibers, clear smooth boundary.

C1 - - 80 to 135 centimeters; very dark brown (7.5YR 2.5/2) fine sandy loam; 15 per cent unrubbed fibers; 1 per cent rubbed fibers.

C2 - - 135 centimeters; dark gray (2.5Y 4/1) silt loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

6 June 2014

Profile 1.14, **Terric Haplohemist**

Location: 39.13110, -79.38580

Compiled by M. Schaney, C. Schaney, and R. Fedders

Oi1 - - 0 to 9 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oi2 - - 9 to 23 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 2 per cent rubbed fibers; charcoal at 23cm.

Oa - - 23 to 56 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 1 per cent rubbed fibers; 20% charcoal.

Oe - - 56 to 65 centimeters; dark reddish brown (5YR 3/3) unrubbed hemic mucky peat, 90 per cent unrubbed fibers; 35 per cent rubbed fibers, clear smooth boundary.

C- - 65 to 94 centimeters; very dark brown (7.5YR 2.5/2) silt loam, clear smooth boundary.

C - - 94 to 110 centimeters; grayish brown (2.5YR 5/2) silty clay loam; 5 per cent fibers.

C - - 110 to 113 centimeters; gray (2.5Y 5/1) silt.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

6 June 2014

Profile 1.16, **Terric Haplosaprist**

Location: 39.13050, -79.38700

Compiled by M. Schaney, C. Schaney, and R. Fedders

Oi1 - - 0 to 18 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; clear smooth boundary.

Oa1 - - 18 to 32 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 2 per cent rubbed fibers; common fine roots.

Oa2 - - 32 to 40 centimeters; black (10YR 2/1) unrubbed sapric muck with silty clay; 10 per cent unrubbed fibers; 1 per cent rubbed fibers.

C - - 40 to 70 centimeters; dark yellowish brown (10YR 4/4) silt loam; gradual boundary.

Cg1 - - 70 to 120 centimeters; grayish brown (2.5Y 5/2) silt loam; gradual boundary.

Cg2 - - 120 to 131 centimeters; dark reddish gray (5YR 4/2) silt clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
21 March 2014

Profile 1.17, **Typic Haplosaprist**

Location: 39.13200, -79.38410

Compiled by M. Schaney, J. Teets, J. Thompson, J.S. Kite, M. Purtill, and C. Patterson

- -15 to 0 centimeters; living sphagnum

Oi - - 0 to 43 centimeters; very dark brown (10YR 2/2) unrubbed fibric peat; von Post 3.

Oa - - 43 to 99 centimeters; 85 per cent black (10YR 2/1) unrubbed sapric muck, and 15 per cent reddish black (2.5YR 2.5/1) unrubbed sapric material; clear smooth boundary.

Oe - - 99 to 152 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge mucky peat, with 30 per cent sedge fibers that disappear after first rub; clear smooth boundary.

Cg1 - - 152 to 167 centimeters; dark grayish brown (2.5Y 4/2) silt loam; massive; clear smooth boundary.

Cg2 - - 167 to 175 centimeters; dark grayish brown (2.5Y 4/2) very fine sandy loam; massive; clear smooth boundary.

C1 - - 175 to 183 centimeters; reddish brown (5YR 4/3) very fine sandy loam; massive; 1 per cent, small, rounded, carbonate gravel; clear smooth boundary.

C2 - - 183 to 203 centimeters; dark reddish brown (2.5YR 3/3) silty clay; massive; carbonate crust; highly reactive.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
21 March 2014

Profile 1.18, **Typic Haplohemist**

Location: 39.13300, -79.38300

Compiled by M. Schaney, J. Teets, J. Thompson, M. Purtill, and C. Patterson

-10 to 0 centimeters; living sphagnum

Oi - - 0 to 30 centimeters; very dark brown (10YR 2/2) unrubbed fibric peat.

Oa - - 30 to 68 centimeters; black (5YR 2.5/1) unrubbed sapric muck; clear smooth boundary.

Oe - - 68 to 135 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic mucky peat, with 80 per cent sedge fibers; clear smooth boundary.

- - 135 to 177 centimeters; unsampled organic material

Cg - - 177 to 178 centimeters; greenish gray (10Y 6/1) very fine loamy sand.

C - - 178 to 182 centimeters; greenish black (10BG 2.5/1) clay loam; massive; 20 per cent brown (7.5YR 5/3), slightly reactive, lenses.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
7 May 2014

Profile 1.19, **Hemic Haplosaprist**

Location: 39.13277, -79.38363

Compiled by M. Schaney, M. Purtill, J. Burkhart, K. Yost, T. Talbolt, and R. Fedders

Oi1 - - 0 to 6 centimeters; yellowish red (5YR 4/6) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed brown (5YR 2.5/2) fibers; von Post scale 2; field pH 4.2.

Oi2 - - 6 to 17 centimeters; dark reddish brown (5YR 3/4) unrubbed fibric peat; 95 per cent unrubbed fibers; 90 per cent rubbed brown (7.5YR 2.5/1) fibers; von Post scale 2; field pH 4.2.

Oa1 - - 17 to 44 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 3 rubbed fibers; von Post scale 7; field pH 4.5.

Oa2 - - 44 to 66 centimeters; black (10YR 2/1) unrubbed sapric muck with charcoal, 15 per cent unrubbed fibers; 5 per cent rubbed fibers; gradual boundary; field pH 4.6.

Oe1 - - 66 to 92 centimeters; dark reddish brown (5YR 3/3) unrubbed hemic mucky peat, 40 per cent unrubbed fibers; 30 per cent (5YR 2.5/1) rubbed fibers; field pH 4.5.

Oe2 - - 92 to 115 centimeters; dark brown (7.5YR 3/2) unrubbed hemic mucky peat with charcoal, 60 per cent unrubbed fibers; 30 per cent rubbed fibers; field pH 4.7.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
7 May 2014

Profile 1.20, **Hemic Haplosaprist**

Location: 39.13297, -79.38390

Compiled by M. Schaney, M. Purtill, J. Burkhart, K. Yost, T. Talbolt, and R. Fedders

Oi1 - - 0 to 14 centimeters; dark reddish brown (2.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed dusky red (2.5YR 3/2) fibers; Von Post scale 2; field pH 4.2.

Oi2 - - 14 to 25 centimeters; reddish black (2.5YR 2.5/1) fibric peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; Von Post scale 2; field pH 4.7.

Oa1 - - 25 to 49 centimeters; reddish black (2.5YR 2.5/1) sapric muck; 10 per cent unrubbed fibers; 7 rubbed fibers; Von Post scale 7; field pH 4.7.

Oa2 - - 49 to 68 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck with charcoal, 30 per cent unrubbed fibers; 5 per cent rubbed fibers; gradual boundary; field pH 5.

Oe1 - - 68 to 135 centimeters; dark brown (7.5YR 3/2) unrubbed hemic mucky peat, 75 per cent unrubbed fibers; 35 per cent very dark brown (7.5YR 2.5/2) rubbed fibers; field pH 5.

Oe2 - - 135 to 146 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat with 5 per cent very fine to fine sand coated with organics; 85 per cent unrubbed fibers; 40 per cent rubbed fibers; field pH 5.25.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

7 May 2014

Profile 1.21, **Hemic Haplosaprist**

Location: 39.13313, -79.38397

Compiled by M. Schaney, M. Purtill, J. Burkhart, K. Yost, T. Talbolt, and R. Fedders

Oi1 - - 0 to 10 centimeters; yellowish red (5YR 4/6) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed dark reddish brown (5YR 3/3) fibers; Von Post scale 2; field pH 4.7.

Oi2 - - 10 to 19 centimeters; reddish black (2.5YR 2.5/1) unrubbed fibric peat; 95 per cent unrubbed fibers; 90 per cent rubbed black (5YR 2.5/1) fibers; Von Post scale 2; field pH 4.7.

Oa1 - - 19 to 33 centimeters; 15 per cent reddish black (2.5YR 2.5/1) unrubbed sapric muck; 7 rubbed fibers; Von Post scale 7; viscous consistence; field pH 4.7.

Oa2 - - 33 to 48 centimeters; dark reddish brown (5YR 2.5/2) unrubbed sapric muck with charcoal, 20 per cent unrubbed fibers; 7 per cent rubbed fibers; field pH 4.7.

Oa3 - - 48 to 72 centimeters; very dusky red (2.5YR 2.5/2) unrubbed sapric muck, 50 per cent unrubbed fibers; at 56 centimeters thin charcoal lens; 7 per cent reddish black (2.5YR 2.5/1) rubbed fibers; field pH 4.7.

Oe - - 72 to 145 centimeters; dark brown (7.5YR 3/2) unrubbed hemic mucky peat; 65 per cent unrubbed fibers; 30 per cent rubbed fibers; field pH 4.7.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

9 August 2014

Profile 1.50, **Hemic Haplosaprist**

Location: 39.13286, -79.38428

Compiled by M. Schaney, S. Marsh, and N. Funk

Described in Lab on 18 December 2014

Oi - - 0 to 20 centimeters; dark reddish brown (2.5YR 3/4) fibric peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2; removed in field.

Oa1 - - 20 to 37 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oa2 - - 37 to 65 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; common fine roots; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6; gradual boundary.

Oe1 - - 65 to 116 centimeters; very dark brown (7.5YR 2.5/3) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4; gradual boundary.

Oe2 - - 116 to 174 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5, wet particle board/ wet sawdust; very abrupt boundary.

Cg - - 174 to 178 centimeters; dark gray (2.5Y 4/1) fine to medium sand.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

9 August 2014

Profile 1.60, **Hemic Haplosaprist, Full Core Sample**

Location: 39.13115, -79.38404

Compiled by M. Schaney, S. Marsh, and N. Funk

Described in Lab

Oi - - 0 to 28 centimeters; dark reddish brown (2.5YR 3/4) fibric peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2; removed in field.

Fiber Content 20%: Hemic

Pyrophosphate Color 10YR 5/4, 10YR 6/4: Sapric

Lab pH 2.97

Mineral Content = 0.61%

Organic Content = 99.39%

Oa1 - - 28 to 50 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7, crumbly consistence.

Fiber Content 2%: Sapric

Pyrophosphate Color 10YR 8/3, 10YR 3/3: Fibric and Sapric

Lab pH 2.85

Mineral Content = 9%

Organic Content = 91%

Oa2 - - 50 to 80 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6; gradual boundary.

Fiber Content 2%: Sapric

Pyrophosphate Color 10YR 4/3, 10YR 3/3: Sapric

Lab pH 3.0

Mineral Content = 12.24%

Organic Content = 87.76%

Oe1 - - 80 to 105 centimeters; very dark brown (7.5YR 2.5/3) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4; gradual boundary.

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 5/4, 10YR 3/6: Sapric

Lab pH 3.13

Mineral Content = 10%

Organic Content = 90%

Oe2 - - 105 to 137 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5, wet particle board; very abrupt boundary.

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 6/4: Sapric

Lab pH 3.17

Mineral Content = 34.11%

Organic Content = 65.89%

Cg - - 137 to 140 centimeters; grayish brown (2.5Y 5/2) fine sandy loam.

Lab pH 3.4

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
19 May 2015

Profile 1.70 – **Terric Haplosaprist, in GPR survey**

Location: 39.13354, -79.38383

Compiled by M. Schaney, A. Moore, and W. Tuttle

Oi - - 0 to 20 centimeters; yellowish red (5YR 5/8) fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa1 - - 20 to 27 centimeters; black (5YR 2.5/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Oa2 - - 27 to 53 centimeters; black (10YR 2/1) unrubbed sapric muck with 40% silt loam; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oa3 - - 53 to 88 centimeters; dark brown (7.5YR 3/3) unrubbed sapric muck; 40 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 5.

C - - 88 to 105 centimeters; dark olive brown (2.5Y 3/3) silty clay; abrupt boundary.

Cg - - 105 to 120 centimeters; gray (2.5Y 5/1) silty clay (higher percentage of clay); dense.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

1 June 2015

Profile 1.80, **Terric Haplosaprist**

Location: 39.13300, -79.38400

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oi - - 0 to 20 centimeters; yellowish red (5YR 4/6) fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; von Post scale 2.

Oa - - 20 to 27 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Oe - - 27 to 31 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat; 40 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4.

Oa - - 31 to 61 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck with some clay; 15 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Cg - - 61 to 67 centimeters; gray (5Y 5/1) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

1 June 2015

Profile 1.81, **Terric Haplosaprist**

Location: 39.13283, -79.38276

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oi - - 0 to 30 centimeters; yellowish red (5YR 4/6) fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; von Post scale 2.

Bulk Density 0.048 Fibric

Oa1 - - 30 to 64 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; 7 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Bulk Density 0.152 Hemic

Oa2 - - 64 to 116 centimeters; dark brown (10YR 3/3) unrubbed sapric muck; 40 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6.

Bulk Density 0.161 Hemic

C1 - - 116 to 123 centimeters; olive gray (5Y 5/2) clay loam; abrupt boundary.

C2 - - 123 to 124 centimeters; olive gray (5Y 5/2) loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

1 June 2015

Profile 1.82, **Terric Haplohemist**

Location: 39.13221, -79.38553

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oi - - 0 to 20 centimeters; dark yellowish brown (10YR 4/6) fibric peat; 95 per cent unrubbed fibers; 92 per cent rubbed fibers; von Post scale 2.

Bulk Density 0.016 Fibric

Oa - - 20 to 59 centimeters; black (10YR 2/1) unrubbed sapric muck; 12 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Oe1 - - 59 to 77 centimeters; very dark brown (10YR 2/2) unrubbed hemic mucky peat; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6.

Bulk Density 0.157 Hemic

Oe2 - - 77 to 103 centimeters; very dark brown (10YR 2/2) unrubbed hemic mucky peat; 40 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 5.

Bulk Density 0.126 Hemic

Cg - - 103 to 125 centimeters; very dark grayish brown (2.5Y 3/2) silty clay with 25 per cent organic matter (twigs); diffuse boundary.

Bulk Density 0.359 Sapric

128-130cm Radiocarbon age 12810 ± 40 (median cal yr BP 15258) – depth measured off lab sample core

C - - 125 to 135 centimeters; olive (5Y 4/3).

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
22 June 2015

Profile 1.83, **Entisol**

Location: 39.12887, -79.38115

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oa - - 0 to 8 centimeters; black (10YR 2/1) sapric muck; 15 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Cg1 - - 8 to 17 centimeters; very dark grayish brown (10YR 3/2) loam; clear boundary.

Cg2 - - 17 to 40 centimeters; dark yellowish brown (10YR 4/4) silt loam; massive, with redox.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
22 June 2015

Profile 1.84, **Entisol**

Location: 39.12974, -79.38166

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oi - - 0 to 8 centimeters; dark yellowish brown (10YR 3/4) fibric peat; 95 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 3.

Oa - - 0 to 8 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

C - - 8 to 17 centimeters; dark brown (10YR 3/3) loamy sand; massive.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
22 June 2015

Profile 1.85, **Entisol**

Location: 39.13008, -79.38198

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oi - - 0 to 16 centimeters; very dark brown (10YR 2/2) fibric peat; 95 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Fiber content 48% Fibric

Pyrophosphate Color 10Y 8/1 Fibric

Lab pH 2.8

Mineral Content = 9.41%

Organic Content = 90.59%

A - - 16 to 27 centimeters; black (10YR 2/1) silt loam; medium granular structure.

Fiber content 4% Sapric

Pyrophosphate Color 10YR 3/2, 10YR 4/3 Sapric

Lab pH 3.1

Mineral Content = 59.29%

Organic Content = 40.71%

BC - - 27 to 38 centimeters; light gray (7.5YR 7/1) sandy loam; very weak platy structure.

Lab pH 2.95

Mineral Content = 97.36%

Organic Content = 2.64%

C - - 38 to 54 centimeters; light gray (7.5YR 7/1) loam with strong brown (7.5YR 5/8) redox concretions; massive.

Lab pH 3.13

Mineral Content = 98.26%

Organic Content = 1.74%

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

23 June 2015

Profile 1.86, **Hemic Haplosaprist**

Location: 39.13230, -79.38382

Compiled by M. Schaney, J. Bernosky, E. Davis, and M. Eltahir

Oi - - 0 to 5 centimeters; reddish brown (5YR 4/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; clear smooth boundary; von Post scale 2.

2-4cm Radiocarbon age 1225 ± 30 (median cal yr BP 1153)

Oa - - 5 to 64 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Bulk Density 0.22 g/cm^3 Sapric

Fiber content 8% Sapric

Pyrophosphate Color 10YR 4/4, 10YR 4/4 Sapric

Laboratory pH 2.87

Mineral Content = 5.70%

Organic Content = 94.30%

40-42cm Radiocarbon age 7880 ± 35 (median cal yr BP 8675)

59-61cm Radiocarbon age 9600 ± 30 (median cal yr BP 10928)

Oe - - 64 to 130 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4/5.

Bulk Density 0.11 g/cm^3 Hemic

Fiber content 20% Hemic

Pyrophosphate Color 10YR 7/2 Fibric, 10YR 7/4 Sapric

Laboratory pH 3.2

Mineral Content = 7.10%

Organic Content = 92.90%

86-88cm Radiocarbon age 10475 ± 35 (median cal yr BP 12451)

100-102cm Radiocarbon age 10635 ± 30 (median cal yr BP 12621)

127-129cm Radiocarbon age 13155 ± 40 (median cal yr BP 15807)

Cg - - 130 to 133 centimeters; light gray (7.5YR 7/1) sand; massive.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
23 June 2015

Profile 1.87, **Entisol**

Location: 39.13417, -79.38454

Compiled by M. Schaney, J. Bernosky, E. Davis, and M. Eltahir

Oi - - 0 to 13 centimeters; very dark brown (7.5YR 2.5/3) fibric peat; 95 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Fiber content 24% Hemic

Laboratory pH 3.55

Mineral Content = 5.17%

Organic Content = 94.83%

A - - 13 to 28 centimeters; black (5YR 2.5/1) sandy clay loam; large strong granular structure.

Laboratory pH 3.47

Mineral Content = 79.73%

Organic Content = 20.27%

Bgt - - 28 to 42 centimeters; strong brown (7.5YR 5/8) silty clay with very dark brown (7.5YR 2.5/2) redox depletions; subangular blocky structure.

Laboratory pH 3.19

Mineral Content = 80.04%

Organic Content = 19.96%

Cg - - 42 to 53 centimeters; strong brown (7.5YR 5/8) silty clay with grayish brown (2.5YR 5/2) redox depletions; massive.

Laboratory pH 3.59

Mineral Content = 95.31%

Organic Content = 4.69%

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

21 October 2016

Profile 1.88, **Hemic Haplosaprist**

Location: 39.13200, -79.38500

Compiled by M. Schaney, and SEFOP team

Oi - - 0 to 31 centimeters; dark reddish brown (2.5YR 2.5/3) fibric peat; 100 per cent unrubbed fibers; 99 per cent rubbed fibers; von Post scale 2.

Oa1 - - 31 to 48 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8.

Oa2 - - 48 to 77 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; 35 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oe - - 77 to 106 centimeters; very dark brown (5YR 2.5/2) unrubbed hemic mucky peat; 65 per cent unrubbed fibers; 35 per cent rubbed fibers; von Post scale 5.

Oa - - 106 to 142 centimeters; dark brown (7.5YR 3/3) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
24 March 2015

Profile 2.01, **Entisol**

Location: 39.13836, - 79.36923

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 15 centimeters; dark brown (7.5YR 3/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 15 to 38 centimeters; black (10YR 2/1) sapric muck; 7 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8.

C - - 38 to 47 centimeters; very dark grayish brown (10YR 3/2) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
24 March 2015

Profile 2.02, **Terric Haplosaprist**

Location: 39.13953, - 79.37124

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 5 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa1 - - 5 to 23 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8.

Oa2 - - 23 to 47 centimeters; black (10YR 2/1) sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Oa3- - 47 to 60 centimeters; very dark grayish brown (10YR 3/2) sapric muck with silty clay; 30 per cent unrubbed fibers; 15 per cent rubbed fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
24 March 2015

Profile 2.03, **Entisol**

Location: 39.14100, -79.37200

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 12 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Cg - - 12 to 22 centimeters; dark gray (7.5YR 4/1) clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
24 March 2015

Profile 2.04, **Terric Haplosaprist**

Location: 39.14000, -79.37300

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 5 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2.

Oa1 - - 5 to 37 centimeters; black (10YR 2/1) sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Oa2 - - 37 to 60 centimeters; black (10YR 2/1) sapric muck; 40 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 7.

Oa3 - - 60 to 75 centimeters; very dark grayish brown (10YR 3/2) sapric muck with silty clay; 30 per cent unrubbed fibers; 15 per cent rubbed fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
24 March 2015

Profile 2.05, **Terric Haplosaprist**

Location: 39.139084, -79.372111

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 5 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2.

Oa1 - - 5 to 14 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oa2 - - 14 to 57 centimeters; black (10YR 2/1) sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oa3 - - 57 to 82 centimeters; dark brown (10YR 3/3) sapric muck; 20 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

Oe - - 82 to 120 centimeters; dark brown (7.5YR 3/4) hemic mucky peat; 40 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

119-121cm Radiocarbon age 15045 ± 10 (median cal yr BP 18284)

Cg - - 120 to 150 centimeters; greenish gray (10Y 5/1) clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

24 March 2015

Profile 2.06, **Typic Haplohemist**

Location: 39.13800, -79.37200

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 5 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2.

Oa1 - - 5 to 17 centimeters; very dark grayish brown (10YR 3/2) sapric sedge muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Oa2 - - 17 to 50 centimeters; black (10YR 2/1) sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oe1 - - 50 to 100 centimeters; dark brown (10YR 3/3) hemic sedge mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oe2 - - 100 to 170 centimeters; dark brown (7.5YR 3/4) hemic mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4; gradual transition.

Cg - - 170 to 190 centimeters; greenish gray (10Y 5/1) clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
24 March 2015

Profile 2.07, **Terric Haplosaprist**

Location: 39.13654, -79.37278

Compiled by M. Schaney, and Z. Haidar

Oi - - 0 to 7 centimeters; yellowish brown (10YR 5/6) fibric sphagnum peat; 70 per cent unrubbed fibers; 50 per cent rubbed fibers; von Post scale 3.

Oa1 - - 7 to 20 centimeters; black (10YR 2/1) sapric sedge muck; 5 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 8.

Oa2 - - 20 to 46 centimeters; black (10YR 2/1) sapric muck; 15 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Oa3 - - 46 to 108 centimeters; dark yellowish brown (10YR 3/4) sapric muck; 40 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Cg - - 108 to 110 centimeters; grayish brown (10YR 5/2) silt loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
23 July 2015

Profile 2.08, **Terric Haplosaprist**

Location: 39.13577, -79.37446

Compiled by M. Schaney, R. Fields, H. Black, M. Gunderson, J. Hardy, and J. Johnson

Oi - - 0 to 13 centimeters; yellowish brown (10YR 5/4) fibric sphagnum peat; 80 per cent unrubbed fibers; 75 per cent rubbed fibers; von Post scale 3.

Oa1 - - 13 to 39 centimeters; black (10YR 2/1) sapric muck; 1 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 8.

Fiber Content 20%: Hemic

Pyrophosphate Color 10YR 3/1, 10YR 4/3: Sapric

Lab pH 2.96

Mineral Content = 9%

Organic Content = 91%

Oa2 - - 39 to 62 centimeters; very dark brown (10YR 2/2) sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 5/4, 10YR 4/6: Sapric

Lab pH 2.93

Mineral Content = 24%

Organic Content = 76%

Oa3 - - 62 to 80 centimeters; dark yellowish brown (10YR 3/4) sapric muck; 35 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Fiber Content 4%: Sapric

Pyrophosphate Color 10YR 5/6, 10YR 4/6: Sapric

Lab pH 3.09

Mineral Content = 26%

Organic Content = 74%

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
23 July 2015

Profile 2.09, **Terric Haplosaprist**

Location: 39.13589, -79.37254

Compiled by M. Schaney, R. Fields, H. Black, M. Gunderson, J. Hardy, and J. Johnson

Notes: No surface sphagnum; a different moss in a very thin layer. Dryer location.

Oa1 - - 0 to 40 centimeters; black (10YR 2/1) unrubbed sapric muck; 1 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 8; wet and soupy consistence.

Bulk Density 0.18 g/cm³: Sapric

15-17cm Radiocarbon age 3550 ± 35 (median cal yr BP 3844)

Oa2 - - 40 to 70 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; 5 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 8; dry consistence.

Fiber Content 2%: Sapric

Pyrophosphate Color 10YR 3/4, 10YR 3/6: Sapric

Lab pH 3.01

40-42cm Radiocarbon age 8035 ± 35 (median cal yr BP 8909)

65-67cm Radiocarbon age 12455 ± 45 (median cal yr BP 14598)

Oa3 - - 70 to 109 centimeters; dark brown (10YR 3/3) unrubbed sapric muck; 35 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Bulk Density 0.27 g/cm³: Sapric

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 7/4, 10YR 4/6: Sapric

Lab pH 3.29

Mineral Content = 35%

Organic Content = 65%

80-82cm Radiocarbon age 12985 ± 40 (median cal yr BP 15528)

92-94cm Radiocarbon age 13225 ± 40 (median cal yr BP 15896)

Cg - - 109 to 120 centimeters; grayish brown (10YR 5/2) fine sandy loam.

Lab pH 3.29

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

23 July 2015

Profile 2.10, **Typic Haplosaprist**

Location: 39.13729, -79.37213

Compiled by M. Schaney, R. Fields, H. Black, M. Gunderson, J. Hardy, and J. Johnson

Oi - - 0 to 13 centimeters; yellowish brown (10YR 5/4) unrubbed fibric sphagnum peat; 80 per cent unrubbed fibers; 75 per cent rubbed fibers; von Post scale 3.

Oa1 - - 13 to 34 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Pyrophosphate Color 10YR 5/4: Sapric

Lab pH 2.72

Oa2 - - 34 to 60 centimeters; very dark grayish brown (10YR 3/2) unrubbed sapric sedge muck; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4.

Bulk Density (30-35cm) 0.18 Hemic, and (55-60cm) 0.22 g/cm³: Sapric

Fiber Content 16%: Sapric

Pyrophosphate Color 10YR 6/4, 10YR 6/4: Sapric

Lab pH 2.75

Mineral Content = 4%

Organic Content = 96%

Oa3 - - 60 to 90 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8.

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 5/4: Sapric

Lab pH 2.95

Mineral Content = 14%

Organic Content = 86%

Oa4 - - 90 to 159 centimeters; dark brown (10YR 3/3) unrubbed sapric muck; 50 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 5.

Bulk Density (90-95 and 140-145 cm) 0.21 g/cm³: Sapric

Fiber Content 16%: Sapric

Pyrophosphate Color 10YR 5/4, 10YR 5/6: Sapric

Lab pH 3.15

Mineral Content = 33%

Organic Content = 67%

Cg - - 159 to 163 centimeters; grayish brown (10YR 5/2)

Lab pH 3.41

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
23 July 2015

Profile 2.11, **Terric Haplosaprist**

Location: 39.13853, -79.37293

Compiled by M. Schaney, R. Fields, H. Black, M. Gunderson, J. Hardy, and J. Johnson

Oa1 - - 0 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Fiber Content 40%: Fibric/Hemic

Pyrophosphate Color 10YR 3/3, 10YR 3/3: Sapric

Lab pH 2.97

Mineral Content = 10%

Organic Content = 90%

Oa2 - - 20 to 40 centimeters; black (7.5YR 2.5/1) unrubbed sapric sedge muck; 50 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5.

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 5/4, 10YR 5/6: Sapric

Lab pH 3.07

Mineral Content = 4%

Organic Content = 96%

Oa3 - - 40 to 70 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; 45 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Fiber Content 2%: Sapric

Pyrophosphate Color 10YR 4/4, 10YR 3/3: Sapric

Lab pH 3.19

Mineral Content = 20%

Organic Content = 80%

Oa4 - - 70 to 100 centimeters; dark brown (10YR 3/3) unrubbed sapric muck; 35 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

Pyrophosphate Color 10YR 5/6: Sapric

Lab pH 3.28

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
7 August 2014

Profile 3.01, **Terric Haplosaprist**

Location: 39.14272, -79.35528, next to loan white pine, cotton grass vegetation

Compiled by M. Schaney and R. Fedders

Oi - - 0 to 18 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa1 - - 18 to 38 centimeters; black (10YR 2/1) unrubbed sapric muck; very soft and loose consistence; 5 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 8.

Oa2 - - 38 to 83 centimeters; black (10YR 2/1) unrubbed sapric muck; firmer than horizon above; 10 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 7; small traces of charcoal at 42 centimeters.

Oa3 - - 83 to 88 centimeters; black (10YR 2/1) unrubbed sapric muck with (7.5YR 5/1) gray clay; 0 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 8.

Oa4 - - 88 to 107 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 7.

Oe - - 107 to 116 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge material; 40 per cent unrubbed fibers; 18 per cent rubbed fibers; von Post scale 5; grading into clay.

Cg1 - - 116 to 132 centimeters; gray (10YR 5/1) clay; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; charcoal lens at 122 centimeters.

Cg2 - - 132 to 154 centimeters; dark reddish gray (5YR 4/2) very fine sandy clay; very little organic matter.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
7 August 2014

Profile 3.02, **Terric Haplosaprist**

Location: 39.14232, -79.35720

Compiled by M. Schaney and R. Fedders

Oi - - 0 to 11 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 95 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2; grass and rush fibers.

Oa1 - - 11 to 25 centimeters; black (10YR 2/1) unrubbed sapric muck; very soft and loose consistence; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oa2 - - 25 to 50 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 7.

Cg - - 50 to 60 centimeters; dark grayish brown (10YR 4/2) clay; no visible vegetation fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

7 August 2014

Profile 3.03, **Terric Haplosaprist**

Location: 39.14235, -79.35689

Compiled by M. Schaney and R. Fedders

Oi - - 0 to 9 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 95 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa - - 9 to 21 centimeters; black (10YR 2/1) unrubbed sapric muck; 8 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8; not wet.

Oe - - 21 to 31 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge material; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 5.

Oa1 - - 31 to 63 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 7 per cent rubbed fibers; von Post scale 7; coniferous needle layer 40 to 43 centimeters.

Oa2 - - 63 to 103 centimeters; dark brown (7.5YR 3/3) unrubbed sapric muck; 30 per cent unrubbed fibers; 12 per cent rubbed fibers; von Post scale 6.

Oe - - 103 to 121 centimeters; brown (7.5YR 4/4) unrubbed hemic sedge material; 90 per cent unrubbed fibers; 40 per cent rubbed fibers; von Post scale 4.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

7 August 2014

Profile 3.04, **Terric Haplosaprist**

Location: 39.14426, -79.35707

Compiled by M. Schaney and R. Fedders

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 95 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa1 - - 10 to 18 centimeters; black (10YR 2/1) unrubbed sapric muck; loose consistence; 3 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8.

Oa2 - - 18 to 50 centimeters; black (10YR 2/1) unrubbed sapric muck; 25 per cent unrubbed fibers; 7 per cent rubbed fibers; von Post scale 7; some wood fragments.

C1 - - 50 to 59 centimeters; dark brown (10YR 3/3) silty clay; no organic matter.

C2 - - 59 to 70 centimeters; brown (10YR 4/3) clay; no organic matter.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
7 August 2014

Profile 3.05, **Terric Haplosaprist**

Location: 39.14359, -79.35509

Compiled by M. Schaney and R. Fedders

Oi - - 0 to 8 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 80 per cent unrubbed fibers; 55 per cent rubbed fibers; von Post scale 3.

Oa1 - - 8 to 27 centimeters; black (10YR 2/1) unrubbed sapric silty muck; weak granular structure; charcoal fragments; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oa2 - - 27 to 52 centimeters; black (10YR 2/1) unrubbed sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6; some wood fragments.

Oa3 - - 52 to 70 centimeters; dark brown (7.5YR 3/4) unrubbed sapric sedge muck; 30 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

Cg - - 70 to 80 centimeters; grayish brown (2.5Y 5/2) clay; 3 per cent organic matter.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
8 August 2014

Profile 3.06, **Sapric Haplohemist**

Location: 39.14320, -79.35838

Compiled by M. Schaney, C. Schaney, and S. Marsh

Oi - - 0 to 8 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 3.

Oa - - 8 to 14 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; light foamy texture; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 8.

Oe - - 14 to 38 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge mucky peat with horsetails; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

Oa1 - - 38 to 53 centimeters; black (10YR 2/1) unrubbed sapric muck; wet loose consistence; slimy texture; 30 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 7; coniferous needles layer at 43 centimeters.

Oa2 - - 53 to 68 centimeters; black (10YR 2/1) unrubbed sapric material; light foamy texture; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oe - - 68 to 164 centimeters; brown (10YR 4/3) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 35 per cent rubbed fibers; von Post scale 5 grading down to 3.

Cg - - 164 to 180 centimeters; dark grayish brown (2.5Y 4/2) clay.

Remarks: This profile is 30cm hemic and 30cm sapric in subsurface tier, for classification, neighboring core profiles were consulted.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

8 August 2014

Profile 3.07, **Typic Haplohemist**

Location: 39.14300, -79.35992

Compiled by M. Schaney, C. Schaney, and S. Marsh

Oi - - 0 to 6 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 6 to 15 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; light foamy texture; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 8; clear smooth boundary.

Oe1 - - 15 to 48 centimeters; dark brown (10YR 3/3) unrubbed hemic muck; 30 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5; wet loose consistence.

Oe2 - - 48 to 156 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4; abrupt boundary.

Cg - - 156 to 180 centimeters; dark grayish brown (2.5Y 4/2) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
8 August 2014

Profile 3.08, **Typic Haplohemist**

Location: 39.14200, -79.36200

Compiled by M. Schaney, C. Schaney, and S. Marsh

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 15 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; light foamy texture; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 8; clear smooth boundary.

Oe1 - - 15 to 47 centimeters; dark brown (10YR 3/3) unrubbed hemic muck; 30 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5; wet loose consistence; thick charcoal at 24 centimeters; gradual boundary.

Oe2 - - 47 to 160 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4; inter-fingered boundary.

Cg - - 160 to 170 centimeters; dark grayish brown (2.5Y 4/2) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
8 August 2014

Profile 3.09, **Typic Haplohemist**

Location: 39.14168, -79.36290

Compiled by M. Schaney, C. Schaney, and S. Marsh

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 23 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7; light and foamy texture.

Oe1 - - 23 to 60 centimeters; dark brown (10YR 3/3) unrubbed hemic sedge muck; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 6.

Oe2 - - 60 to 130 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 40 per cent rubbed fibers; von Post scale 5; wet sawdust.

Cg - - 130 to 165 centimeters; dark grayish brown (2.5Y 4/2) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
8 August 2014

Profile 3.10, **Terric Haplohemist**

Location: 39.14210, -79.36400

Compiled by M. Schaney, C. Schaney, and S. Marsh

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 34 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 6; coniferous needle layer at 16 centimeters.

Oe - - 34 to 70 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic sedge material; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4/5.

Oe- - 70 to 82 centimeters; dark brown (10YR 3/3) unrubbed hemic mucky peat clay; 60 per cent unrubbed fibers; 40 per cent rubbed fibers; von Post scale 4; gradual transition.

Cg - - 82 to 100 centimeters; dark grayish brown (2.5Y 4/2) clay; streaks of greenish gray 5/10GY.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
8 August 2014

Profile 3.11, **Typic Haplohemist**

Location: 39.14280, -79.36210

Compiled by M. Schaney, C. Schaney, and S. Marsh

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 49 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 6/7; light and foamy texture.

Oe1 - - 49 to 102 centimeters; dark brown (10YR 3/3) unrubbed hemic sedge mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oe2 - - 102 to 160 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 40 per cent rubbed fibers; von Post scale 4; wet sawdust.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

9 August 2014

Profile 3.12, **Terric Haplosaprist**

Location: 39.14480, -79.36000

Compiled by M. Schaney, C. Schaney, and T. Talbott

Oi - - 0 to 8 centimeters; dark brown (7.5YR 3/4) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 8 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 8.

Oe - - 20 to 48 centimeters; brown (10YR 4/3) unrubbed hemic sedge material; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4.

Oa1 - - 48 to 66 centimeters; black (10YR 2/1) unrubbed sapric muck material; common cranberry roots; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Oa2 - - 66 to 123 centimeters; black (10YR 2/1) unrubbed sapric muck material; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7/8; diffuse boundary.

C - - 123 to 135 centimeters; very dark grayish brown (10YR 3/2) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

9 August 2014

Profile 3.13, **Sapric Haplohemist**

Location: 39.14566, -79.35989, softer, wetter core with no woody vegetation on surface.

Compiled by M. Schaney, C. Schaney, and T. Talbott

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

11-13cm Radiocarbon age 1925 ± 30 (median cal yr BP 1873)

Oe - - 20 to 62 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge mucky peat with horsetails; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4/5.

27-29cm Radiocarbon age 3155 ± 30 (median cal yr BP 3382)

50-52cm Radiocarbon age 3590 ± 30 (median cal yr BP 3894)

Oa - - 62 to 76 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; common cranberry roots; 30 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

64-66cm Radiocarbon age 5180 ± 30 (median cal yr BP 5936)

75-77cm Radiocarbon age 10095 ± 40 (median cal yr BP 11687)

Oe - - 76 to 92 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5; wet particle board.

83-85cm Radiocarbon age 11085 ± 35 (median cal yr BP 12960)

Oa - - 92 to 170 centimeters; very dark brown (7.5YR 2.5/2) unrubbed sapric muck, 25 per cent unrubbed fibers; 12 per cent rubbed fibers, von Post scale 6; no identifiable plant fibers resemble wet sawdust.

94-96cm Radiocarbon age 11680 ± 30 (median cal yr BP 13510)

120-122cm Radiocarbon age 13815 ± 40 (median cal yr BP 16715)

165-167cm Radiocarbon age 15375 ± 35 (median cal yr BP 18653)

Cg - - at 170 centimeters; dark grayish brown (2.5Y 4/2) clay.

Remarks: deferred to lab data on repeat core at same location for classification.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

28 July 2015

Profile 3.13, **Sapric Haplohemist - REAPEAT– Full Core Sample**

Location: 39.14566, -79.35989

Compiled by M. Schaney, S. Morris, and J. Baker

Oi - - 0 to 7 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Fiber Content 80%: Fibric

Pyrophosphate Color N 8/1: Fibric

Mineral Content = 1.76%

Organic Content = 98.24%

Oa - - 7 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Bulk Density (10-15cm) 0.15 g/cm³: Hemic

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 4/4, 10YR 5/6: Sapric

Lab pH 2.87

Mineral Content = 1.81%

Organic Content = 98.19%

Oe - - 20 to 80 centimeters; dark yellowish brown (10YR 4/4) unrubbed hemic sedge mucky peat; 50 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

Bulk Density (35-40cm) 0.12 and (60-65cm) 0.09 g/cm³: Hemic

Fiber Content 32%: Hemic

Pyrophosphate Color 10YR 8/3, 10YR 6/3: Fibric/Sapric

Lab pH 3.16

Mineral Content = 2.85%

Organic Content = 97.15%

Oa - - 80 to 90 centimeters; reddish black (2.5YR 2.5/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Bulk Density (80-85cm) 0.17 g/cm³: Hemic

Fiber Content 16%: Sapric

Pyrophosphate Color 10YR 3/3, 10YR 5/4: Sapric

Lab pH 3.21

Mineral Content = 23.54%

Organic Content = 76.46%

Oe - - 90 to 170 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic mucky peat, 25 per cent unrubbed fibers; 15 per cent rubbed fibers, von Post scale 5.

Bulk Density (105-110cm) 0.19 and (135-140) 0.34 g/cm³: Hemic/Sapric

Fiber Content 24%: Hemic

Pyrophosphate Color 10YR 5/4, 10YR 5/6: Sapric

Lab pH 3.69

Mineral Content = 36.07%

Organic Content = 63.93%

Could not get to mineral soil.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
16 May 2017

Profile 3.13, **Sapric Haplohemist - REPEAT for pollen analysis**

Location: 39.14566, -79.35989,

Compiled by M. Schaney, Z. Taylor, M. Albritton, and C. Anderson of Berry College

Oi - - 0 to 19 centimeters; dark reddish brown (5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; von Post scale 2.

Oa - - 19 to 31 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Oe - - 31 to 82 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 40 per cent rubbed fibers; von Post scale 4.

Oa - - 82 to 96 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Oe1 - - 96 to 120 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat; 20 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4/5.

Oe2 - - 120 to 193 centimeters; dark brown (7.5YR 3/2) unrubbed hemic mucky peat, 50 per cent unrubbed fibers; 30 per cent rubbed fibers, von Post scale 3/4; section 150 cm to 173 cm missing for description but collected for sampling.

Oe3 - - 193 to 221 centimeters; brown (10YR 4/3) unrubbed hemic mucky peat, 40 per cent unrubbed fibers; 50 per cent rubbed fibers, von Post scale 5.

Cg - - 221 to 226 centimeters; dark gray (10YR 4/1) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
9 August 2014

Profile 3.14, **Sapric Haplohemist - Full Core Sample**

Location: 39.14321, -79.36038

Compiled by M. Schaney, S. Marsh, and N. Funk

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 60 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Oe - - 60 to 155 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge material; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

121-123m Radiocarbon age 13870 ± 40 (median cal yr BP 16802)

Cg - - 155 to 167 centimeters; dark grayish brown (2.5Y 4/2) clay.

Remarks: This profile is 30cm hemic and 30cm sapric in subsurface tier, for classification, neighboring core profiles were consulted.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

9 August 2014

Profile 3.15, **Hemic Haplosaprist**

Location: 39.14486, -79.35818

Compiled by M. Schaney, C. Schaney, T. Talbott, S. Marsh, and N. Funk

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 85 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 19 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Oe - - 19 to 49 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oa - - 49 to 87 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7; coniferous needles at 43 centimeters and from 67 to 73 centimeters.

Oe - - 87 to 136 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5, wet particle board.

Cg - - 136 to 150 centimeters; dark grayish brown (2.5Y 4/2) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

2 June 2015

Profile 3.16, **Sapric Haplohemist**

Location: 39.14295, -79.35909

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oi - - 0 to 10 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 23 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Oi - - 23 to 53 centimeters; dark brown (10YR 3/3) unrubbed fibric sedge peat; 55 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5.

Bulk Density (35-40cm) 0.071g/cm³: Fibric

Oe - - 53 to 130 centimeters; very dark brown (7.5YR 2.5/3) unrubbed hemic sedge mucky peat; 50 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 5.

Bulk Density (80-85cm) 0.104g/cm³: Hemic

Bulk Density (115-120cm) 0.156g/cm³: Hemic

Oa - - 130 to 180 centimeters; very dark brown (7.5YR 2.5/3) unrubbed sapric muck; 80 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 6, wet particle board.

Bulk Density (155-160cm) 0.20g/cm³: Sapric

Remarks: deferred to lab data for classification and horizon designation.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

2 June 2015

Profile 3.17, **Terric Haplohemist**

Location: 39.14220, -79.36052

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oi - - 0 to 8 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 8 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Oe - - 20 to 70 centimeters; dark brown (10YR 3/3) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 35 per cent rubbed fibers; von Post scale 4/5.

Bulk Density (30-35cm) 0.172g/cm³: Hemic

Oa1 - - 70 to 95 centimeters; very dark grayish brown (10YR 3/2) unrubbed sapric muck; 30 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

Bulk Density (75-80cm) 0.190g/cm³: Sapric

Oa2 - - 95 to 106 centimeters; very dark brown (7.5YR 2.5/3) unrubbed sapric muck with clay; 30 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

Bulk Density (95-100cm) 0.379g/cm³: Sapric

C - - 106 clay

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

28 July 2015

Profile 3.18, **Terric Haplosaprist**

Location: 39.14376, -79.35604

Compiled by M. Schaney, S. Morris, and J. Baker.

Oi - - 0 to 28 centimeters; dark brown (7.5YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa1 - - 28 to 73 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 1 per cent rubbed fibers.

Bulk Density (58-63cm) 0.16g/cm³ Hemic

Fiber Content 4% Sapric

Pyrophosphate Color 10YR 4/3, 10YR 4/4: Sapric

Lab pH 2.8

82% Organic content

Oa2 - - 73 to 90 centimeters; dark brown (10YR 3/3) unrubbed sapric muck; 60 per cent unrubbed fibers; 35 per cent rubbed fibers; 20 per cent silt.

Bulk Density (78-83cm) 0.24g/cm³: Sapric

Fiber Content 0%: Sapric

Pyrophosphate Color 10YR 3/2, 10YR 3/4: Sapric

Lab pH 2.92

86% Organic content

Oa3 - - 90 to 117 centimeters; very dark grayish brown (10YR 3/2) unrubbed sapric muck; 30 per cent unrubbed fibers; 15 per cent rubbed fibers; gradual boundary.

Bulk Density (98-103cm) 0.30 g/cm³: Sapric

Fiber Content 2%: Sapric

Pyrophosphate Color 10YR 5/6, 10YR 5/6: Sapric

Lab pH 3.31

62% Organic content

Cg - - 117 to 122 centimeters; dark gray (2.5Y 4/1) sandy loam.

Lab pH 3.91

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
1 October 2014

Profile 4.01, **Typic Haplohemist, Full Core Sample Collected and Frozen**

Location: 39.13157, -79.35680

Compiled by M. Schaney, J. Teets, S. Bell, and T. Dilliplane

Oi - - 0 to 19 centimeters; red (2.5YR 4/6) unrubbed fibric sphagnum material; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; von Post scale 2.

Oa - - 19 to 25 centimeters; black (10YR 2/1) unrubbed sapric material; 5 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8; abrupt smooth boundary.

Oe1 - - 25 to 118 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge and horsetail material; 75 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4.

Oe2 - - 118 to 182 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge and horsetail material; 60 per cent unrubbed fibers; 18 per cent rubbed fibers; von Post scale 5; less identifiable sedge and horsetail fibers.

C1 - - 182 to 220 centimeters; very dark brown (7.5YR 2.5/2) mucky silt loam.

C2 - - 220 to 230 centimeters; dark brown (7.5YR 3/2) silty clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

1 October 2014

Profile 4.02, **Typic Haplohemist, Full Core Sample**

Location: 39.12964, -79.35961, no *Sphagnum*, different moss on surface.

Compiled by M. Schaney, J. Teets, S. Bell, and T. Dilliplane

Oi - - 0 to 7 centimeters; dark reddish brown (5YR 3/2) unrubbed fibric moss material; 100 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa - - 7 to 18 centimeters; black (10YR 2/1) unrubbed sapric material; 5 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8; abrupt smooth boundary.

7-9cm Radiocarbon age 420 ± 35 (median cal yr BP 486)

17-20cm Radiocarbon age 2130 ± 30 (median cal yr BP 2111) – measured off lab sample core

Oe1 - - 18 to 110 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge and horsetail material; 75 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4.

76-79cm Radiocarbon age 3240 ± 30 (median cal yr BP 3460)

Oe2 - - 110 to 150 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge and horsetail material; 60 per cent unrubbed fibers; 18 per cent rubbed fibers; von Post scale 5; small wood fibers from 150 to 160 centimeters.

117-120cm Radiocarbon age 4095 ± 35 (median cal yr BP 4607)

Cg - - 150 to 186 centimeters; gray (7.5YR 5/1) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
25 March 2015

Profile 4.03, **Entisol**

Location: 39.13503, -79.36017

Compiled by M. Schaney, Z. Haidar, P. Hopkins, and G. Stewart

Oa - - 0 to 15 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8; clear boundary.

C - - 15 to 30 centimeters; brown (10YR 5/3) clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
25 March 2015

Profile 4.04, **Sapric Haplohemist**

Location: 39.13363, -79.36000

Compiled by M. Schaney, Z. Haidar, P. Hopkins, and G. Stewart

Oe1 - - 0 to 40 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic sedge and horsetail mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4.

Oe2 - - 40 to 90 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4.

Oa1 - - 90 to 123 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8.

Oa2 - - 123 to 140 centimeters; dark brown (7.5YR 3/3) unrubbed sapric muck with silt clay; 15 per cent unrubbed fibers; 5 per cent rubbed fibers.

C - - 140 to 150 centimeters; brown (10YR 4/3) silt loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
25 March 2015

Profile 4.05, **Sapric Haplohemist**

Location: 39.13071, -79.36214

Compiled by M. Schaney, Z. Haidar, P. Hopkins, and G. Stewart

Oi - - 0 to 6 centimeters; dark yellowish brown (10YR 3/4) unrubbed fibric peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2.

Oe - - 6 to 110 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4.

Oa1 - - 110 to 127 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oa2 - - 127 to 217 centimeters; dark brown (7.5YR 3/3) unrubbed sapric muck; 30 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6.

Cg - - 217 to 226 centimeters; dark grayish brown (2.5Y 4/2) clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
25 March 2015

Profile 4.06, **Terric Haplosaprist**

Location: 39.12697, -79.36158

Compiled by M. Schaney, Z. Haidar, P. Hopkins, and G. Stewart

Oi - - 0 to 4 centimeters; dark yellowish brown (10YR 3/4) unrubbed fibric peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oe - - 4 to 8 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4.

Oa1 - - 8 to 13 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; Von Post scale 8.

Oa2 - - 13 to 42 centimeters; dark brown (7.5YR 3/4) unrubbed sapric muck; 40 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Cg - - 42 to 50 centimeters; dark grayish brown (2.5Y 4/2) clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.07, **Sapric Haplohemist**

Location: 39.12982, -79.35217

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oi - - 0 to 5 centimeters; dark yellowish brown (10YR 3/4) unrubbed fibric peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa - - 5 to 10 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oe - - 10 to 110 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oa - - 110 to 136 centimeters; dark brown (7.5YR 3/3) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 4; gradual boundary.

Cg - - 136 to 150 centimeters; grayish brown (2.5Y 5/2) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.08, **Sapric Haplohemist**

Location: 39.13188, -79.35464

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oi - - 0 to 12 centimeters; dark yellowish brown (10YR 3/4) unrubbed fibric peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa - - 12 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oe - - 20 to 90 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oa - - 90 to 143 centimeters; black (10YR 2/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Oe - - 143 to 160 centimeters; dark brown (7.5YR 3/4) unrubbed hemic mucky peat; 70 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5; gradual boundary.

Cg - - 160 to 185 centimeters; grayish brown (2.5Y 5/2) silt loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.09, **Typic Haplohemist**

Location: 39.13077, -79.3595, grass and thin moss layer as surface vegetation

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oa1 - - 0 to 8 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oa2 - - 8 to 26 centimeters; dark reddish brown (5YR 2.5/2) unrubbed hemic sphagnum mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 7.

Oe - - 26 to 140 centimeters; dark brown (7.5YR 3/4) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

C - - 140 to 150 centimeters; olive brown (2.5Y 4/3) silty clay.

Collected next 150 to 200 cm.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.10, **Sapric Haplohemist**

Location: 39.12900, -79.36200

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oi - - 0 to 5 centimeters; dark yellowish brown (10YR 3/4) unrubbed fibric peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa - - 5 to 10 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oe - - 10 to 90 centimeters; dark yellowish brown (10YR 3/4) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 35 per cent rubbed fibers; von Post scale 5.

Oa1 - - 90 to 110 centimeters; black (10YR 2/1) unrubbed sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7.

Oa2 - - 110 to 170 centimeters; dark brown (7.5YR 3/4) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6. Texture of wet particle board; could not get deeper.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.11, **Sapric Haplohemist**

Location: 39.12875, -79.36046

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oi - - 0 to 8 centimeters; dark yellowish brown (10YR 3/4) unrubbed fibric peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2.

Oa - - 8 to 18 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oe - - 18 to 120 centimeters; dark brown (10YR 3/3) unrubbed hemic sedge mucky peat; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oa1 - - 120 to 138 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8.

Oa2 - - 138 to 160 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6.

C - - 160 to 170 centimeters; gray (2.5Y 5/1) loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.12, **Terric Haplosaprist**

Location: 39.13500, -79.35200

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oi - - 0 to 23 centimeters; yellowish brown (10YR 5/6) unrubbed fibric peat; 90 per cent unrubbed fibers; 60 per cent rubbed fibers; von Post scale 2.

Oa - - 23 to 38 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oe - - 38 to 53 centimeters; dark reddish brown (2.5YR 3/4) unrubbed hemic sedge mucky peat with woody material; 80 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 6.

Oa - - 53 to 113 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 7 per cent rubbed fibers; von Post scale 8; gradual boundary.

C - - 113 to 143 centimeters; gray (5YR 5/1) clay loam, with a rounded quartz pebble.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
26 March 2015

Profile 4.13, **Terric Haplosaprist**

Location: 39.13156, -79.35192

Compiled by M. Schaney, L. Fox, P. Hopkins, and T. Messenger

Oi - - 0 to 8 centimeters; yellowish brown (10YR 5/6) unrubbed fibric peat; 90 per cent unrubbed fibers; 60 per cent rubbed fibers; von Post scale 2.

Oa1 - - 8 to 24 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8; field pH 4.7.

Oe - - 24 to 44 centimeters; dark brown (10YR 3/3) unrubbed hemic sedge mucky peat; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5; field pH 4.7.

Oa - - 44 to 66 centimeters; very dark grayish brown (10YR 3/2) unrubbed sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6; gradual boundary; field pH 4.6.

Oa - - 66 to 92 centimeters; dark brown (10YR 3/3) unrubbed sapric muck; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7; gradual boundary; field pH 4.7.

C - - 92 to 98 centimeters; dark grayish brown (10YR 4/2) clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
20 May 2015

Profile 4.14, **Sapric Haplohemist**

Location: 39.13200, -79.36000, no *Sphagnum* moss on surface.

Compiled by M. Schaney, A. Hoss, A. Moore, and W. Tuttle

Oa - - 0 to 8 centimeters; black (10YR 2/1) unrubbed sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Oe1 - - 8 to 90 centimeters; very dark brown (7.5YR 2.5/2) unrubbed hemic sedge mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; few fine cranberry roots; von Post scale 5.

Oe2 - - 90 to 130 centimeters; dark brown (7.5YR 3/3) unrubbed hemic mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4.

Oa1 - - 130 to 157 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; wood fragments; von Post scale 6; gradual boundary.

Oa2 - - 157 to 213 centimeters; dark brown (10YR 3/3) unrubbed sapric muck with 10 per cent silty clay; 20 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6; gradual boundary.

Cg1 - - 213 to 225 centimeters; dark grayish brown (2.5Y 4/2) silty loam; faint depositional lenses; abrupt boundary.

Cg2 - - 225 to 237 centimeters; dark greenish gray (5G 4/1) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
20 May 2015

Profile 4.15, **Terric Haplosaprist**

Location: 39.13167, -79.36342, near vegetation change at western end, no *Sphagnum* moss on surface.

Compiled by M. Schaney, A. Hoss, A. Moore, and W. Tuttle

Oa - - 0 to 15 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8.

Oe - - 15 to 54 centimeters; very dark grayish brown (10YR 3/2) unrubbed hemic sedge mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4; gradual boundary.

Oa1 - - 54 to 80 centimeters; very dark brown (10YR 2/2) unrubbed sapric muck; 15 per cent unrubbed fibers; 2 per cent rubbed fibers; wood fragments; von Post scale 7.

Oa2 - - 80 to 103 centimeters; dark brown (10YR 3/3) unrubbed sapric muck with 15 per cent silty clay; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8.

C - - 103 to 116 centimeters; dark yellowish brown (10YR 3/4) silty loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

3 June 2015

Profile 4.16, **Typic Haplohemist**

Location: 39.13022, -79.35808

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oi - - 0 to 13 centimeters; very dusky red (2.5YR 2.5/2) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 13 to 30 centimeters; reddish black (2.5YR 2.5/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7;

Oe - - 30 to 135 centimeters; dark reddish brown (5YR 2.5/2) unrubbed hemic sedge material; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5.

Bulk Density (75-80cm) 0.0937 g/cm³: Fibric

Bulk Density (120-125cm) 0.1099 g/cm³: Hemic

Oa - - 135 to 142 centimeters; black (7.5YR 2.5/1) unrubbed sapric muck; 35 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

C - - 142 to 152 centimeters; gray (5YR 5/1) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
3 June 2015

Profile 4.17, **Terric Haplosaprist**

Location: 39.12885, -79.35269, in hollow (large depression), no surface *Sphagnum*.

Compiled by M. Schaney, J. Bernosky, H. Jewell, and E. Davis

Oa - - 0 to 28 centimeters; black (5YR 2.5/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7; field pH 5.

Bulk Density (5-10cm) 0.19 g/cm³: Hemic

Oe - - 28 to 47 centimeters; black (5YR 2.5/1) unrubbed sapric muck; 2 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 7; field pH 5.

Bulk Density (35-40cm) 0.15 g/cm³: Hemic

Lab and field data differ, go with lab data

Oa1 - - 47 to 60 centimeters; black (10YR 2/1) unrubbed sapric muck; 3 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 7; field pH 5.

Bulk Density (55-60cm) 0.33 g/cm³: Sapric

Oa2 - - 60 to 67 centimeters; black (10YR 2/1) unrubbed sapric muck with 20 per cent silty clay; 1 per cent unrubbed fibers; 0 per cent rubbed fibers; von Post scale 7; field pH 5.

C1 - - 67 to 71 centimeters; weak red (2.5YR 5/3) silty clay loam; field pH 6.

C2 - - 71 to 76 centimeters; weak red (2.5YR 5/2) silty clay; field pH 6.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
25 June 2015

Profile 4.18, **Terric Haplosaprist**

Location: 39.12755, -79.35993

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oi - - 0 to 30 centimeters; dark brown (7.5YR 3/3) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 30 to 47 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

C1 - - 47 to 58 centimeters; very dark brown (10YR 2/2) silty clay.

C2 - - 58 to 65 centimeters; very dark grayish brown (10YR 3/2) clay loam.

C3 - - 65 to 80 centimeters; dark grayish brown (10YR 4/2) sandy clay loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

25 June 2015

Profile 4.19, **Sapric Haplohemist**

Location: 39.13032, -79.36110

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oi - - 0 to 8 centimeters;

Oa - - 20 to 28 centimeters; black (10YR 2/1) unrubbed sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7.

Oe1 - - 28 to 140 centimeters; very dark grayish brown (10YR 3/2) unrubbed hemic peaty muck; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Bulk Density (30-35cm, 80-85cm, and 125-130cm) 0.09 g/cm³: Fibric/Hemic

Fiber Content 28%: Hemic

Pyrophosphate Color 10YR 8/2, 2.5YR 8/2: Fibric

Lab pH: 3.18

99.61% organic matter

30-32cm Radiocarbon age 2490 ± 30 (median cal yr BP 2584)

60-62cm Radiocarbon age 2925 ± 30 (median cal yr BP 3072)

80-82cm Radiocarbon age 3235 ± 30 (median cal yr BP 3453)

Oe2 - - 140 to 163 centimeters; dark brown (10YR 3/3) unrubbed hemic peaty muck; 40 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 5.

Bulk Density (150-153cm) 0.16g/cm³: Hemic

Fiber Content 24%: Hemic

Pyrophosphate Color 10YR 7/3, 10YR 4/2: Hemic/Sapric

Lab pH: 3.74

97.42% organic matter

120-122cm Radiocarbon age 3775 ± 35 (median cal yr BP 4146) – measured from lab sample core

Oa1 - - 163 to 178 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 4/3, 10YR 4/4: Sapric

Lab pH: 3.78

81.61% organic matter

Oa2 - - 178 to 205 centimeters; very dark brown (7.5YR 2.5/3) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7.

Bulk Density (195-200cm) 0.17g/cm³: Hemic

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 5/3, 10YR 4/6: Sapric

Lab pH: 4.21

98.47% organic matter

165-167cm Radiocarbon age 11235 ± 35 (median cal yr BP 13097) – measured from lab sample core

Oe - - 205 to 232 centimeters; dark reddish brown (5YR 2.5/2) unrubbed hemic mucky peat; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6.

Bulk Density (205-210cm) 0.16g/cm^3 : Hemic

Fiber Content 36%: Hemic

Pyrophosphate Color 10YR 6/4, 10YR 6/4: Sapric

Lab pH: 4.69

70.81% organic matter

211-213cm Radiocarbon age 12850 ± 40 (median cal yr BP 15315)

C - - 232 to 235 centimeters; dark grayish brown (10YR 4/2) silty clay loam.

Lab pH: 5.13

22.61% organic matter

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

25 June 2015

Profile 4.20, **Sapric Haplohemist**

Location: 39.13340, -79.35962

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oa - - 0 to 12 centimeters; black (10YR 2/1) unrubbed sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8.

Bulk Density (30-35cm) 0.21g/cm³: Sapric

Fiber Content 20%: Hemic

Pyrophosphate Color 10YR 4/4, 10YR 4/6: Sapric

Lab pH: 2.74

90.98% organic matter

Oe - - 12 to 108 centimeters; very dark brown (7.5YR 2.5/3) unrubbed hemic peaty muck; 40 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 5.

Bulk Density (30-35cm) 0.12g/cm³ and (80-85cm) 0.09g/cm³: Hemic/Fibric

Fiber Content 28%: Hemic

Pyrophosphate Color 10YR 8/4, 2.5YR 8/2: Hemic/Fibric

Lab pH: 2.96

97.89% organic matter

Oa1 - - 108 to 132 centimeters; black (10YR 2/1) unrubbed sapric muck; 3 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8.

Bulk Density (115-120cm) 0.16g/cm³: Hemic

Fiber Content 0%: Sapric

Pyrophosphate Color 10YR 4/3, 7.5YR 4/3: Sapric

Lab pH: 3.07

77.68% organic matter

Oa2 - - 132 to 157 centimeters; dark yellowish brown (10YR 4/4) unrubbed sapric muck; 2 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8/9.

Bulk Density (140-145cm) 0.19g/cm³: Hemic

Fiber Content 2%: Sapric

Pyrophosphate Color 10YR 3/4, 10YR 4/6: Sapric

Lab pH: 3.43

75.33% organic matter

C - - 157 to 170 centimeters; dark grayish brown (10YR 4/2) silty clay.

Lab pH: 3.62

12.41% organic matter

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

25 June 2015

Profile 4.21, **Entisol**

Location: 39.13402, -79.35921

Compiled by M. Schaney, J. Bernosky, and M. Eltahir

Oi - - 0 to 6 centimeters; very dusky red (2.5YR 2.5/2) unrubbed fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa1 - - 6 to 13 centimeters; black (10YR 2/1) unrubbed sapric muck; 2 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Oa2 - - 13 to 20 centimeters; black (10YR 2/1) unrubbed sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

C1 - - 20 to 30 centimeters; brown (10YR 5/3) silty clay.

C2 - - 30 to 50 centimeters; grayish brown (10YR 5/2) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

16 June 2014

Profile 5.01, **Hemic Haplosaprist**

Location: 39.11890, -79.38280

Compiled by M. Schaney, S. Bell, K. Yost, S. Marsh, E. Byers, J. Teets, J. Burkhart, and R. Polakovsky

Oi - - 0 to 16 centimeters; 60 per cent brown (7.5YR 5/4) and 40 per cent dark red (2.5 YR 3/6) unrubbed fibric sphagnum peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; von Post scale 2; field pH 4.5.

Oa - - 16 to 30 centimeters; black (5YR 2.5/1) sapric muck; 15 per cent unrubbed fibers; 7 per cent rubbed fibers; von Post scale 7; field pH 4.5.

Oi - - 30 to 49 centimeters; reddish black (2.5YR 2.5/1) fibric peat; 80 per cent unrubbed fibers; 50 per cent rubbed fibers; von Post scale 3; field pH 4.5.

Oe - - 49 to 63 centimeters; dark reddish brown (5YR 3/3) hemic mucky peat; 60 per cent unrubbed fibers; 35 per cent rubbed fibers; von Post scale 5; field pH 4.8.

Oa - - 63 to 120 centimeters; black (2.5/N) sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; wood fragments at 70 centimeters; von Post scale 6; gradual boundary; field pH 4.8.

Oe1 - - 120 to 160 centimeters; very dark brown (7.5YR 2.5/2) hemic mucky peat; 60 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4; field pH 4.5.

Oe2 - - 160 to 220 centimeters; vary dark brown (7.5YR 2.5/2) hemic mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 5; gradual boundary; field pH 4.5.

Cg - - 220 to 249 centimeters; dark gray (2.5Y 4/1) massive very fine sandy loam; field pH 5.3.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
17 June 2014

Profile 5.02, **Hemic Haplofibrist**

Location: 39.11880, -79.38330

Compiled by M. Schaney and R. Polakovsky

Oi - - 0 to 10 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 10 to 18 centimeters; black (10YR 2/1) sapric muck; 20 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 7.

Oe - - 18 to 56 centimeters; dark brown (7.5YR 3/4) hemic sedge mucky peat; 80 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

Oi - - 56 to 102 centimeters; reddish black (2.5YR 2.5/1) fibric sedge peat; 80 per cent unrubbed fibers; 55 per cent rubbed fibers; von Post scale 3.

Oa - - 102 to 160 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; coniferous needles; von Post scale 7.

Oe - - 160 to 175 centimeters; dark brown (7.5YR 3/3) hemic sedge mucky peat; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4; field pH 4.5.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

17 June 2014

Profile 5.03, **Hemic Haplofibrist**

Location: 39.11860, -79.38400

Compiled by M. Schaney and R. Polakovsky

Oi - - 0 to 7 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 7 to 12 centimeters; black (10YR 2/1) sapric muck; 20 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 7.

Oe - - 12 to 36 centimeters; strong brown (7.5YR 4/6) hemic sedge mucky peat with cranberry roots; 80 per cent unrubbed fibers; 35 per cent rubbed fibers; von Post scale 4.

Oi - - 36 to 68 centimeters; dark reddish brown (5YR 2.5/2) fibric sedge peat; 80 per cent unrubbed fibers; 50 per cent rubbed fibers; von Post scale 3.

Oa1 - - 68 to 115 centimeters; dark brown (7.5YR 3/2) sapric sedge muck; 60 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 6.

Oa2 - - 115 to 197 centimeters; black (10YR 2/1) sapric muck with wood fragments, leaf fragments, and coniferous needles at 145 centimeters; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 8.

Oa3 - - 197 to 232 centimeters; dark brown (7.5YR 3/2) sapric muck with grass inflorescence; 40 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6.

Oa4 - - 232 to 237 centimeters; dark brown (7.5YR 3/2) sapric mucky clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
17 June 2014

Profile 5.04, **Fibric Haplohemist**

Location: 39.11840, -79.38470

Compiled by M. Schaney and R. Polakovsky

Oi - - 0 to 15 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2.

Oa - - 15 to 28 centimeters; black (10YR 2/1) sapric muck; 20 per cent unrubbed fibers; 15 per cent rubbed fibers; von Post scale 7.

Oe - - 28 to 76 centimeters; very dark brown (7.5YR 2.5/2) hemic sedge mucky peat; 70 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4; gradual boundary.

Oi - - 76 to 104 centimeters; dark reddish brown (5YR 2.5/2) fibric sedge peat; 90 per cent unrubbed fibers; 60 per cent rubbed fibers; von Post scale 3.

Oa - - 104 to 170 centimeters; black (10YR 2/1) sapric sedge muck with 20 per cent clay; at 115 to 130 centimeters wood fragments; at 142 centimeters coniferous needles; 20 per cent unrubbed fibers; 3 per cent rubbed fibers; von Post scale 7.

Oe - - 170 to 227 centimeters; dark brown (7.5YR 3/3) hemic sedge mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4; gradual boundary.

C - - 227 to 230 centimeters; dark brown (7.5YR 3/3) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

14 July 2014

Profile 5.06, **Terric Haplohemist**

Location: 39.11758, -79.39110

Compiled by M. Schaney, S. Marsh, and R. Polakovsky

Oi - - 0 to 18 centimeters; dark brown (7.5YR 3/2) fibric peat; 65 per cent unrubbed fibers; 40 per cent rubbed fibers.

Oa - - 18 to 30 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers.

Oe - - 30 to 38 centimeters; very dark brown (7.5YR 2.5/2) hemic sedge mucky peat; 30 per cent unrubbed fibers; 20 per cent rubbed fibers.

Oa - - 38 to 61 centimeters; black (10YR 2/1) sapric muck with some clay; 10 per cent unrubbed fibers; 5 per cent rubbed fibers. Black round seeds.

Oe - - 61 to 103 centimeters; dark brown (7.5YR 3/2) hemic sedge mucky peat; 25 per cent unrubbed fibers; 20 per cent rubbed fibers.

C - - 103 to 115 centimeters; brown (7.5YR 4/2) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
14 July 2014

Profile 5.07, **Hemic Haplosaprist**

Location: 39.11600, -79.38840

Compiled by M. Schaney, S. Marsh, and R. Polakovsky

Oi - - 0 to 17 centimeters; reddish brown (5YR 4/4) fibric peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Oa - - 17 to 97 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; concretion at 83 centimeters.

Oe1 - - 97 to 145 centimeters; very dark brown (7.5YR 2.5/2) hemic sedge mucky peat; 30 per cent unrubbed fibers; 20 per cent rubbed fibers.

Oe2 - - 145 to 231 centimeters dark brown (7.5YR 3/3) hemic mucky peat; 65 per cent unrubbed fibers; 30 per cent rubbed fibers; gradual boundary.

C - - 231 to 237 centimeters; brown (7.5YR 4/2) silty clay; lens of fine sand with 30 per cent fibers.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

14 July 2014

Profile 5.08, **Typic Haplosaprist**

Location: 39.11800, -79.38900

Compiled by M. Schaney, S. Marsh, and R. Polakovsky

Oi - - 0 to 25 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 98 per cent rubbed fibers; von Post scale 2; clear smooth boundary. Water table at 25 centimeters.

Fiber Content 56%: Fibric

Pyrophosphate Color 10YR 7/4, 10YR 7/3: Hemic

Lab pH: 3.36

Organic matter: 99.32%

Oa1 - - 25 to 65 centimeters; black (10YR 2/1) sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8; clear smooth boundary. Coniferous needles at 65cm, sampled.

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 4/3, 7.5YR 4/3: Sapric

Lab pH: 3.15

Organic matter: 99.20%

Oa2 - - 65 to 120 centimeters; black (10YR 2/1) sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 7; clear smooth boundary; cranberry roots; 100 to 107 cm and at 130 centimeters layer of coniferous needles.

Fiber Content (65-107cm) 2%: Sapric

Pyrophosphate Color 10YR 3/3, 10YR 5/4: Sapric

Lab pH: 2.98

Organic matter: 98.54%

Oe1 - - 120 to 208 centimeters; dark brown (7.5YR 3/2) hemic sedge mucky peat, 50 per cent unrubbed fibers; 20 per cent rubbed fibers, von Post scale 4; clear smooth boundary. Insect remains at 180 centimeters collected.

Fiber Content (120-160) 20%: Hemic

Pyrophosphate Color 10YR 8/2, 10YR 7/2: Fibric

Lab pH: 3.28

Organic matter: 93.68%

Oe2 - - 208 to 280 centimeters; dark brown (7.5YR 3/4) hemic mucky peat, 90 per cent unrubbed fibers; 50 per cent rubbed fibers, von Post scale 5, consistency of wet particle board, coniferous needles at 225; clear smooth boundary.

Fiber Content (120-160) 20%: Hemic

Pyrophosphate Color 10YR 8/2, 10YR 6/4: Fibric, Sapric

Lab pH: 3.47

Organic matter: 97.66%

C - - 280 to 290 centimeters; dark grayish brown (2.5YR 4/2) fine sandy loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
16 July 2014

Profile 5.09, **Terric Haplosaprist**

Location: 39.12016, -79.38890, mostly woody shrubs

Compiled by M. Schaney, S. Marsh, and T. Harris

Oi - - 0 to 5 centimeters; reddish brown (5YR 4/4) fibric sphagnum peat; 100 per cent unrubbed fibers; 95 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Oa - - 5 to 14 centimeters; black (7.5YR 2.5/1) sapric muck; 15 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 8.

Oi - - 14 to 58 centimeters; dark brown (7.5YR 3/3) fibric peat; 80 per cent unrubbed fibers; 50 per cent rubbed fibers; von Post scale 3.

Oa1 - - 58 to 89 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 7 per cent rubbed fibers; 7. 82-89 centimeters spruce/hemlock needles, sample collected.

Oa2 - - 89 to 110 centimeters; dark brown (7.5YR 3/3) sapric muck; 30 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 6; diffuse boundary.

C - - 110 to 119 centimeters; dark brown (7.5YR 3/3) silty clay. Sample collected.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
16 July 2014

Profile 5.10, **Terric Haplosaprist**

Location: 39.12135, -79.38362

Compiled by M. Schaney, S. Marsh, and T. Harris

Oi - - 0 to 23 centimeters; reddish yellow (7.5YR 6/6) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2.

Oe - - 23 to 28 centimeters; dark brown (7.5YR 3/3) hemic sedge mucky peat; 60 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5.

Oa1 - - 28 to 66 centimeters; black (7.5YR 2.5/1) sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8. Black round seeds, some clay content, only root fibers visible.

Oa2 - - 66 to 90 centimeters; very dark brown (7.5YR 2.5/2) sapric muck; 30 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 6. Very few needles present, and wood fragments.

C - - 90 to 97 centimeters; brown (7.5YR 4/2) silty clay.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
16 July 2014

Profile 5.11, **Terric Haplosaprist**

Location: 39.12205, -79.38067, drier location, less woody vegetation

Compiled by M. Schaney, S. Marsh, and T. Harris

Oi1 - - 0 to 10 centimeters; reddish yellow (7.5YR 6/6) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2.

Oi2 - - 10 to 14 centimeters; very dark brown (7.5YR 2.5/2) fibric sphagnum peat; 80 per cent unrubbed fibers; 50 per cent rubbed fibers; von Post scale 3.

Oa - - 14 to 38 centimeters; black (7.5YR 2.5/1) sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7. Some clay content, only root fibers visible.

Oe - - 38 to 100 centimeters; dark brown (7.5YR 3/3) hemic sedge mucky peat; 30 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

C - - 100 to 105 centimeters; brown (7.5YR 4/2) silty clay with very fine sand.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

16 July 2014

Profile 5.12, **Sapric Haplohemist, Full Core Sample**

Location: 39.12408, -79.37626, softer, wetter core with no woody vegetation on surface.

Compiled by M. Schaney, S. Marsh, and T. Harris

Oi - - 0 to 5 centimeters; reddish yellow (7.5YR 6/6) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Oa - - 5 to 10 centimeters; black (7.5YR 2.5/1) sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7; clear smooth boundary.

Oe1 - - 10 to 36 centimeters; dark brown (7.5YR 3/3) hemic sedge mucky peat; many cranberry roots; 80 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 4.

16-20cm Radiocarbon age 2080 ± 30 (median cal yr BP 2050)

Oe2 - - 36 to 62 centimeters; black (7.5YR 2.5/1) hemic mucky peat; many cranberry roots; 50 per cent unrubbed fibers; 40 per cent rubbed fibers; von Post scale 4. 44 to 55 cm mostly spruce with some hemlock (Z. Fowler, 2015) needles.

51-53cm Radiocarbon age 2495 ± 30 (median cal yr BP 2585)

Oa1 - - 62 to 84 centimeters; black (7.5YR 2.5/1) sapric muck; 50 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 7; wet, soft horizon; spruce needles throughout horizon, only identifiable vegetation that remained after rubbing.

82-85cm Radiocarbon age 2725 ± 30 (median cal yr BP 2817)

Oa2 - - 84 to 118 centimeters; black (7.5YR 2.5/1) sapric muck, 5 per cent unrubbed fibers; 2 per cent rubbed fibers, von Post scale 8; thicker, denser, not as moist horizon.

114-116cm Radiocarbon age 9010 ± 30 (median cal yr BP 10204)

Oe - - 118 to 202 centimeters; dark brown (7.5YR 3/3) hemic sedge mucky peat, 30 per cent unrubbed fibers; 20 per cent rubbed fibers, von Post scale 4; wood chunk; rubbed to very small fibers.

197-199cm Radiocarbon age 13105 ± 35 (median cal yr BP 15733)

Cg - - 202 to 210 centimeters; gray (7.5YR 5/1) fine to medium sand.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
16 July 2014

Profile 5.13, **Sapric Haplohemist**

Location: 39.11973, -79.38237

Compiled by M. Schaney, S. Marsh, and T. Harris

Oi - - 0 to 22 centimeters; reddish yellow (7.5YR 6/6) fibric sphagnum peat; 100 per cent unrubbed fibers; 90 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Oa - - 22 to 42 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7; clear smooth boundary.

Oe - - 42 to 74 centimeters; very dark brown (7.5YR 2.5/2) hemic mucky peat; 40 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 6.

Oa - - 74 to 97 centimeters; black (10YR 2/1) sapric muck; 5 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8; spongy consistence.

Oe - - 97 to 180 centimeters; dark brown (10YR 3/3) hemic sedge mucky peat; 40 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

Cg - - 180 to 190 centimeters; dark grayish brown (10YR 4/2) very fine sand.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
4 June 2015

Profile 5.14, **Sapric Haplohemist**

Location: 39.12100, -79.38300

Compiled by M. Schaney, J. Bernosky, H. Jewell, E. Davis, and T. Brangs

Oi - - 0 to 20 centimeters; dark brown (7.5YR 3/4) fibric sphagnum peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Bulk Density (0-5cm) 0.16g/cm³: Hemic

Oa - - 20 to 32 centimeters; black (10YR 2/1) sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7; field pH 4.3.

Oe - - 32 to 85 centimeters; dark brown (7.5YR 3/3) hemic mucky peat; 40 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 5; field pH 4.5.

Bulk Density (30-35cm) 0.10g/cm³: Hemic

Bulk Density (55-60cm) 0.06g/cm³: Fibric

Oa - - 85 to 140 centimeters; black (10YR 2/1) sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7; field pH 4.5.

Bulk Density (85-90cm) 0.15g/cm³: Hemic

Bulk Density (133-138cm) 0.33g/cm³: Sapric

C - - 140 to 180 centimeters; dark brown (10YR 3/3) silty clay with 30 per cent organic material; field pH 4.5.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
4 June 2015

Profile 5.15, **Sapric Haplohemist**

Location: 39.12200, -79.37900

Compiled by M. Schaney, J. Bernosky, H. Jewell, E. Davis, and T. Brangs

Coniferous needles throughout soil profile.

Oi - - 0 to 20 centimeters; dark brown (7.5YR 3/4) fibric sphagnum peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Oa - - 20 to 34 centimeters; black (10YR 2/1) sapric muck; 7 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Oe - - 34 to 70 centimeters; black (7.5YR 2.5/1) hemic mucky peat; 30 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 4. 29 to 32 centimeters macrofossil sample collected.

Bulk Density (35-40cm) 0.12g/cm³: Hemic

Oa - - 70 to 110 centimeters; black (10YR 2/1) sapric muck; 5 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 7.

Bulk Density (75-80cm) 0.15g/cm³: Hemic

Oe - - 110 to 170 centimeters; dark brown (10YR 3/3) hemic mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 6.

Bulk Density (130-135cm) 0.24g/cm³: Sapric

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

29 July 2015

Profile 5.16, **Sapric Haplohemist**

Location: 39.11989, -79.38625

Compiled by M. Schaney, S. Morris, J. Baker, and A. Cimarolli

Oi - - 0 to 17 centimeters; dark brown (7.5YR 3/4) fibric sphagnum peat; 60 per cent unrubbed fibers; 50 per cent rubbed fibers; von Post scale 3/4; clear smooth boundary.

Bulk Density (10-15cm) 0.08g/cm³: Fibric

Fiber Content 56%: Fibric

Pyrophosphate Color 2.5YR 8/2: Fibric

Lab pH: 2.64

Oe1 - - 17 to 50 centimeters; very dark grayish brown (10YR 3/2) hemic sedge mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 5; clear boundary.

Bulk Density (30-35cm) 0.10g/cm³: Hemic

Fiber Content 44%: Hemic

Pyrophosphate Color 10YR 8/3, 10YR 8/4: Fibric/Hemic

Lab pH: 2.87

Organic matter: 99.57%

Oe2 - - 50 to 72 centimeters; dark reddish brown (5YR 2.5/2) hemic mucky peat with cranberry roots and sphagnum macrofossils; 70 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 4.

Bulk Density (50-55cm) 0.15g/cm³ and (63-68cm) 0.19g/cm³: Hemic

Fiber Content 22%: Hemic

Pyrophosphate Color 10YR 8/3, 10YR 8/2: Fibric

Lab pH: 2.65

Organic matter: 99.72%

Oa1 - - 72 to 121 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8; clear boundary. 80 to 85 centimeters pine needles, at 85 pinecone.

Bulk Density (80-85cm) 0.24g/cm³: Sapric

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 6/3, 10YR 5/4: Sapric

Lab pH: 2.96

Oa2 - - 121 to 171 centimeters; dark brown (10YR 3/3) sapric material; 35 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7; texture similar to wet particle board.

Bulk Density (140-145cm) 0.28g/cm³: Sapric

Fiber Content 8%: Sapric

Pyrophosphate Color 10YR 6/4, 10YR 3/4: Sapric

Lab pH: 3.17

Organic matter: 90.07%

C - - 171 to 177 centimeters; dusky red (2.5YR 3/2) sandy loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

29 July 2015

Profile 5.17, **Sapric Haplohemist**

Location: 39.11749, -79.38399

Compiled by M. Schaney, C. Schaney, S. Morris, J. Baker, and A. Cimarolli

Oi - - 0 to 16 centimeters; dark brown (7.5YR 3/4) fibric sphagnum peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Bulk Density (5-10cm) 0.11g/cm³: Hemic

Oa - - 16 to 30 centimeters; black (10YR 2/1) sapric muck; 10 per cent unrubbed fibers; 2 per cent rubbed fibers; von Post scale 8; abrupt boundary.

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 6/4, 10YR 6/3: Sapric

Lab pH: 3.52

Organic matter: 92%

18-20cm Radiocarbon age 2070 ± 30 (median cal yr BP 2039)

Oe - - 30 to 94 centimeters; very dark brown (10YR 2/2) hemic sedge mucky peat; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 5; diffuse boundary.

Bulk Density (35-40cm) 0.10g/cm³, (60-65cm) 0.10g/cm³, and (85-90cm) 0.13g/cm³: Hemic

Fiber Content 24%: Hemic

Pyrophosphate Color 10YR 6/4, 10YR 7/3: Sapric/ Hemic

Lab pH: 2.88

Organic matter: 97%

70-72cm Radiocarbon age 2705 ± 30 (median cal yr BP 2804)

82-84cm Radiocarbon age 2970 ± 30 (median cal yr BP 3135)

Oa1 - - 94 to 170 centimeters; black (10YR 2/1) sapric muck; 15 per cent unrubbed fibers; 5 per cent rubbed fibers; von Post scale 7; some sedge macrofossils at top of horizon and coniferous needles at 145 centimeters.

Bulk Density (130-135cm) 0.19g/cm³, (165-170cm) 0.25g/cm³: Sapric

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 5/3, 10YR 4/4: Sapric

Lab pH: 3.23

Organic matter: 90%

122-124cm Radiocarbon age 3820 ± 40 (median cal yr BP 4217)

130-132cm Radiocarbon age 4580 ± 30 (median cal yr BP 5302)

140-142cm Radiocarbon age 4720 ± 45 (median cal yr BP 5460)

161-163cm Radiocarbon age 9160 ± 45 (median cal yr BP 10323)

Oa2 - - 170 to 205 centimeters; very dark brown (10YR 2/2) sapric muck; 20 per cent unrubbed fibers; 10 per cent rubbed fibers; von Post scale 7; texture similar to wet particle board; wood fragment at 185 to 189 centimeters; at 205 centimeters fine lens of (10YR 5/2) sand; seeds and a deciduous leaf imprint; abrupt boundary.

Bulk Density (185-190cm) 0.18g/cm³: Sapric

Fiber Content 12%: Sapric

Pyrophosphate Color 10YR 5/3, 10YR 5/4: Sapric

Lab pH: 3.26

173-175cm Radiocarbon age 9930 ± 30 (median cal yr BP 11312)

196-198cm Radiocarbon age 11360 ± 35 (median cal yr BP 13203)

Oe - - 205 to 296 centimeters; dark brown (10YR 3/3) hemic sedge mucky peat; 40 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 6.

Bulk Density (220-225cm) 0.16g/cm^3 , (270-275cm) 0.36g/cm^3 : Hemic, Sapric

Fiber Content 36%: Hemic

Pyrophosphate Color 10YR 7/3: Hemic

Lab pH: 3.71

Organic matter: 55%

225-227cm Radiocarbon age 12310 ± 35 (median cal yr BP 14237)

288-290cm Radiocarbon age 12890 ± 40 (median cal yr BP 15382)

Cg - - 296 to 300 centimeters; gray (10YR 5/1) fine to medium sand.

Lab pH: 3.25

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia

17 May 2017

Profile 5.17, **Sapric Haplohemist - REPEAT for pollen analysis**

Location: 39.11708, -79.38451

Compiled by M. Schaney, Z. Taylor, M. Albritton, and C. Anderson of Berry College

Oi - - 0 to 25 centimeters; dark brown (7.5YR 3/4) fibric sphagnum peat; 90 per cent unrubbed fibers; 80 per cent rubbed fibers; von Post scale 2; clear smooth boundary.

Oa - -25 to 47 centimeters; black (10YR 2/1) sapric muck; 20 per cent unrubbed fibers; 1 per cent rubbed fibers; von Post scale 8; abrupt boundary.

Oe1 - - 47 to 62 centimeters; very dark brown (10YR 2/2) hemic mucky peat; 40 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 6.

Oe2 - - 62 to 75 centimeters; black (10YR 2/1) hemic mucky peat; 30 per cent unrubbed fibers; 20 per cent rubbed fibers; von Post scale 5.

Oe3 - - 175 to 129 centimeters; very dark brown (7.5YR 2.5/2) hemic mucky peat; 50 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5.

Oa - - 129 to 176 centimeters; black (10YR 2/1) sapric muck; 30 per cent unrubbed fibers; 17 per cent rubbed fibers; von Post scale 6.

C - - 176 to 190 centimeters; dark brown (7.5YR 3/2) silty clay.

Oe1 - - 190 to 283 centimeters; black (7.5YR 4/3) sapric muck; 60 per cent unrubbed fibers; 25 per cent rubbed fibers; von Post scale 6.

Oe2 - - 283 to 317 centimeters; dark brown (7.5YR 3/2) hemic mucky peat; 70 per cent unrubbed fibers; 30 per cent rubbed fibers; von Post scale 5.

Cg - - 317 + centimeters; gray (10YR 5/1) silt loam.

Canaan Valley National Wildlife Refuge, Davis, Tucker County, West Virginia
29 July 2015

Profile 5.18, **Entisol**

Location: 39.12293, -79.39152

Compiled by M. Schaney, S. Morris, J. Baker, and A. Cimarolli

Oi - - 0 to 7 centimeters; root mass.

Fiber Content 20%: Hemic

Pyrophosphate Color 10YR 2/2: Sapric

Lab pH: 2.86

A - - 7 to 13 centimeters; reddish black (10R 2.5/1) silt loam; moderate medium to coarse granular structure; clear boundary.

Fiber Content 28%: Hemic

Pyrophosphate Color 7.5YR 2.5/3: Sapric

Lab pH: 2.94

Organic matter: 67.06%

Bw - - 13 to 26 centimeters; dark brown (10YR 3/3) silty clay loam with 20 per cent organic matter; coarse subangular blocky structure; wavy clear boundary.

Lab pH: 3.26

Cg - - 26 to 45 centimeters; brown (7.5YR 5/3) massive loamy sand.

Lab pH: 3.20

Appendix B

International Soil Radiocarbon Database QA/QC report

Thank you for contributing to the ISRaD database!
Please review this quality control report.
Visit <https://international-soil-radiocarbon-database.github.io/ISRaD/contribute/> for more information.

File: Schaney_2019.xlsx

Checking file type...

Checking file format compatibility with ISRaD templates...

Template format detected: ISRaD_Master_Template.xlsx

Template info file to be used for QA/QC: ISRaD_Template_Info.xlsx

Checking for empty tabs...

NOTE: empty tabs detected (flux interstitial incubation)

Checking dataset doi...

Checking for extra or misspelled column names...

metadata tab...

site tab...

profile tab...

flux tab...

layer tab...

interstitial tab...

fraction tab...

incubation tab...

Checking for missing values in required columns...

metadata tab...

WARNING: missing values where required: doi (rows: 4)

site tab...

profile tab...

flux tab...

layer tab...

interstitial tab...

fraction tab...

incubation tab...

Checking that level names match between tabs...

site tab...

profile tab...

flux tab...

layer tab...

interstitial tab...

fraction tab...

incubation tab...

Checking numeric variable columns for inappropriate values...

metadata tab...

```
site tab...
profile tab...
flux tab...
layer tab...
interstitial tab...
fraction tab...
incubation tab...
```

Checking controlled vocab...

```
site tab...
profile tab...
flux tab...
layer tab...
interstitial tab...
fraction tab...
incubation tab...
```

```
- - - - -
1 WARNINGS need to be fixed
```

It might be useful to manually review the summary statistics and graphical representation of the data hierarchy as shown below.

Summary statistics...

```
metadata tab...1 observations
  entry_name : 1
  curator_name : 1
  curator_organization : 1
  curator_email : 1
  modification_date_y : 1
  modification_date_m : 1
  modification_date_d : 1
  contact_name : 1
  contact_email : 1
  contact_orcid_id : 1
  bibliographical_reference : 1
  template_version : 1
site tab...5 observations
  entry_name : 5
  site_name : 5
  site_lat : 5
  site_long : 5
  site_elevation : 5
profile tab...99 observations
  entry_name : 99
  site_name : 99
  pro_name : 99
  pro_lat : 99
  pro_long : 99
  pro_treatment : 99
  pro_MAT : 99
  pro_MAP : 99
  pro_usda_soil_order : 99
  pro_soil_series : 87
```

```

    pro_soil_taxon : 99
    pro_soil_taxon_sys : 99
    pro_land_cover : 99
    pro_lc_photosyn_path : 99
    pro_veg_note : 90
    pro_depth_water : 87
    pro_drainage_class : 99
flux tab...0 observations
layer tab...568 observations
    entry_name : 568
    site_name : 568
    pro_name : 568
    lyr_name : 568
    lyr_obs_date_y : 568
    lyr_obs_date_m : 556
    lyr_obs_date_d : 556
    lyr_top : 568
    lyr_bot : 568
    lyr_hzn : 535
    lyr_comp : 12
    lyr_note : 188
    lyr_color : 527
    lyr_bd_samp : 54
    lyr_ph_h2o : 69
    lyr_loi : 53
    lyr_rc_lab : 53
    lyr_rc_lab_number : 53
    lyr_rc_year : 48
    lyr_14c : 48
    lyr_14c_sigma : 48
    lyr_fraction_modern : 48
    lyr_fraction_modern_sigma : 48
interstitial tab...0 observations
fraction tab...106 observations
    entry_name : 106
    site_name : 106
    pro_name : 106
    lyr_name : 106
    frc_name : 106
    frc_input : 106
    frc_scheme : 106
    frc_scheme_units : 106
    frc_lower : 106
    frc_upper : 106
    frc_agent : 106
    frc_note : 106
incubation tab...0 observations
- - - - -

```

Please email info.israd@gmail.com with concerns or suggestions
 If you think there is an error in the functioning of this code please post to
<https://github.com/International-Soil-Radiocarbon-Database/ISRaD/issues>