United States
Department of
Agriculture

**Forest
Service**

**North Central
Research Station**

**General Technical
Report NC-237**

Soils of the Sylvania Wilderness-Recreation Area, Western Upper Peninsula, Michigan

James G. Bockheim and Jim Jordan

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Published by:
North Central Research Station
Forest Service U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, MN 55108
2004

Web site: www.ncrs.fs.fed.us

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History of the Sylvania Wilderness and Recreation Area

The Sylvania Wilderness and Recreation Area (SWRA) is comprised of 7,420 ha and managed by the Ottawa National Forest (fig. 1). The area is unique in that it features old-growth forest, several threatened or endangered plants and animals, and 35 spring-fed lakes along the Lake Superior-Mississippi River drainage divide. The recorded history of the area begins with A.D. Johnston, a lumberman from Wisconsin, who in 1895 purchased a 32-ha tract south of Clark Lake. He and friends who purchased adjacent tracts eventually formed the Sylvania Club primarily for fishing and hunting. After a sequence of owners who protected the area from logging, the SWRA was purchased by the USDA Forest Service in 1967 and opened to the public. In 1987 the area was designated a Federal wilderness. Today the SWRA is used for year-round recreation including canoeing, swimming, hiking, skiing, picnicking, camping, fishing, and hunting. Motorized transport, such as automobiles, motorboats, and snow machines, is prohibited in the area.

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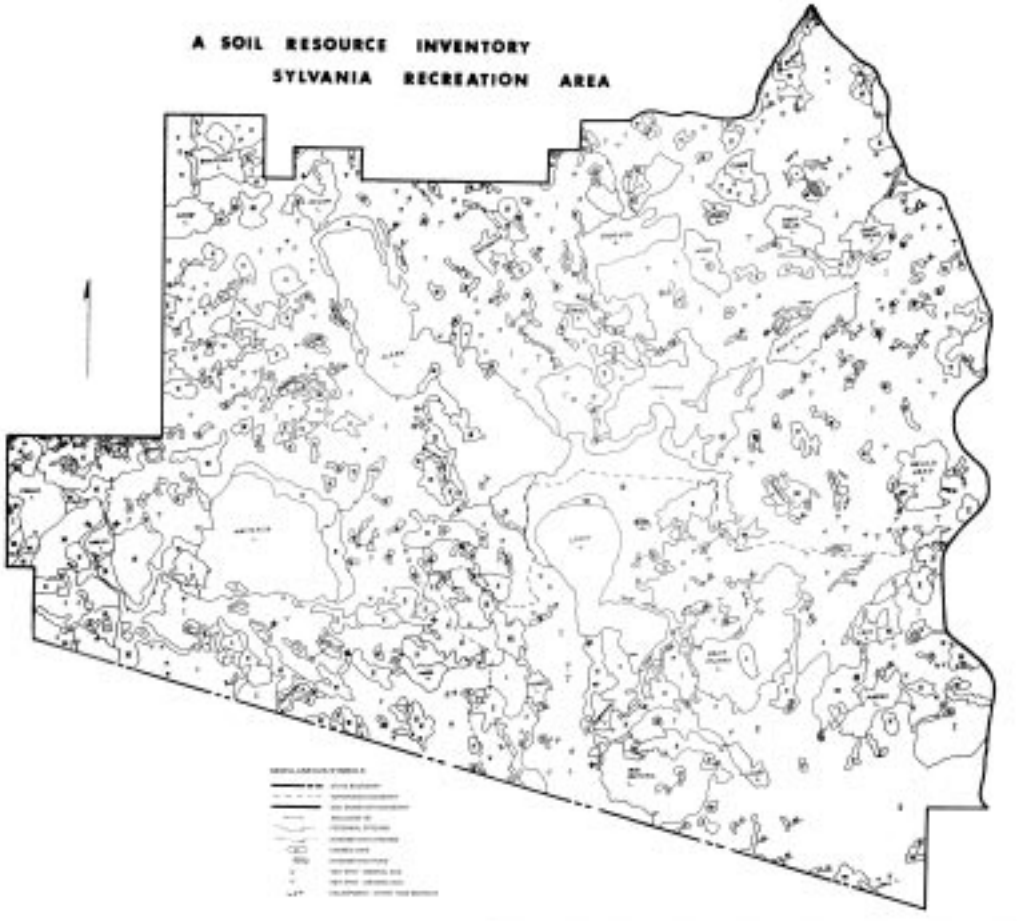

Figure 1.—Soil map of the Sylvania Wilderness-Recreation Area showing detailed sampling sites.

Previous Work

Because the SWRA is one of the few remaining areas undisturbed by humans in the Great Lakes region, it has been the focus of considerable research, including development of multiple-factor ecological classification systems (Pregitzer *et al.* 1983; Spies and Barnes 1985a,b), reconstruction of the presettlement (Frelich 1995, Manies and Mladenoff 2000) and Holocene (Brugham *et al*. 1997) vegetational history of the region, determination of the causes of spatial patchiness of vegetation (Pastor and Broschart 1990; Davis *et al*. 1993, 1998; Frelich *et al*. 1993; Frelich and Graumlich 1994; Pashall 1995), and nutrient dynamics studies (Ferrari 1999, Bockheim and Crowley 2002). Numerous other specialized studies have been conducted in the area.

Natural Resources of the SWRA

The SWRA is located within Landtype Association 212Jc02, the Morse/Winegar Moraines Subsection of the Southern Superior Uplands Section (Keys *et al.* 1995, Jordan 2000). The area contains a mosaic of small patches (1 to 20 ha) of hemlock (*Tsuga canadensis* (L.) Carr.), northern hardwoods, dominantly sugar maple (*Acer saccharum* Marsh.), yellow birch (*Betula alleghaniensis* Britton.), basswood (*Tilia americana* L.), and hardwood-hemlock cover types that commonly are between 200 and 400 years in age. Old-growth white pine (*Pinus strobus* L.) and red pine (*Pinus resinosa* Ait.) occur along lake margins.

Based on fossil pollen records, the SWRA experienced a periglacial climate immediately following recession of the glaciers about 10,000 years ago. During the early Holocene period approximately 6,000-8,000 years BP, warmer conditions allowed northern hardwoods to expand in the area. Hemlock became more abundant, particularly in depressions, in response to cooler climatic conditions during the past 3,200 years (Pastor and Broschart 1990; Davis *et al.* 1993, 1998; Frelich *et al.* 1993).

The present climate of the region is predominantly continental. Mean annual precipitation is 770 mm (Michigan Climate Normals 2000). Winter snowfall averages over 400 cm, yielding a spring snowpack between 1 and 2 m thick. The mean annual air temperature is 3.9ºC; the mean monthly temperatures for January (the coldest month) and July (the warmest month) are -13 and 19ºC, respectively. The growing season averages 100 days; the soil temperature and moisture regimes are udic and frigid, respectively. A National Atmospheric Deposition Program monitoring site is located at Trout Lake, WI, approximately 17 km southwest of the SWRA (http://nadp.sws.uiuc.edu/default.html). According to data collected since 1980, the area receives acidic deposition with a mean pH of 4.8.

The dominant landform of the area is the Winegar Moraine, which was deposited by the south-flowing Ontonagon Lobe during the late Wisconsin, ca. 25,000 to 10,000 years ago (Peterson 1982, Attig 1985). The moraine is hummocky and contains coarse-loamy till and debris flow sediments interspersed with patches of sandy outwash. Silt loam material interpreted here as loess is present in the area but rarely exceeds 1 m in thickness. Elevations range from 520 to 560 m, and slopes range from 0 to 50 percent. Approximately 21 percent of the SWRA is made up of lakes (Pastor and Broschart 1990).

Jordan (1973)[1] mapped the soils of the SWRA, identifying six soil map units and a miscellaneous land type. According to his mapping, the dominant soil (53.9 percent of the land area) is the Gogebic Series, which currently is recognized as a coarse-loamy, superactive, frigid Alfic Oxyaquic Fragiorthod. The Keweenaw Series, a sandy, mixed, frigid Alfic Haplorthod, occupies 10.6 percent of the land area. The Pence Series, a sandy, mixed, frigid Typic Haplorthod makes up 4.5 percent of the area. The coarse-loamy, mixed, frigid Alfic Haplorthod, identified as the Padus Series, accounts for 0.5 percent of the area. Organic soils and lake marsh make up the remaining 12 percent of the land area.

METHODS

Twenty-two sites representing an array of vegetation types, landforms, and parent materials were identified in the SWRA (table 1, fig. 1). The sites were selected as part of the comparative forest management study

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[1] Fieldwork completed by William A. Wertz, Sherman A. Radke, Duane Kick, Robert Kari, James K. Jordan, USDA Forest Service; and Loren Berndt, USDA Soil Conservation Service. Maps compiled, soils classified, and final report prepared by James K. Jordan.

Table 1.—*Soil-forming factors and classification of soils in the Sylvania Wilderness-Recreation Area*

Site	Forest type	Parent materials	Landform	Munsell color Bh or Bs horizon	Tentative soil series	Soil taxonomy
Sylvania 2A	No. hw	till/outwash	moraine	7.5YR 3/4	Gogebic msl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania 2B	Hemlock	till	moraine	5YR 3/4	Gogebic msl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania 4	Hemlock	loess/outwash	outwash plain	5YR 4/4	Wabeno sil	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania 6	No. hw	debris flow/outwash	outwash plain	5YR 3/3	Pence sl	sandy, mixed, frigid Typic Haplorthods
Sylvania 7	No. hw	outwash	outwash plain	2.5YR 2.5/2	Rubicon cos	sandy, mixed, frigid Entic Haplorthods
Sylvania 9	No. hw	ice-contact stratified drift	moraine	5YR 3/3	Gogebic fsl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania 11	No. hw	debris flow/outwash	outwash plain	5YR 3/3	Padus sl	coarse-loamy, mixed, superactive, frigid Alfic Haplorthods
Sylvania 14	No. hw	debris flow/outwash	outwash plain	5YR 3/3	Pence msl	sandy, mixed, frigid Typic Haplorthods
Sylvania 15	Hemlock	debris flow/outwash	outwash plain	5YR 3/4	Pence fsl	sandy, mixed, frigid Typic Haplorthods
Sylvania 16	Hemlock	loess/outwash	outwash plain	5YR 3/4	Padus sil	coarse-loamy, mixed, superactive, frigid Alfic Haplorthods
Sylvania 18	Hemlock	ice-contact stratified drift	moraine	5YR 3/3	Gogebic msl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania P1	Hemlock	outwash	outwash plain	5YR 4/6	Vilas ls	sandy, mixed, frigid Entic Haplorthods
Sylvania P3	No. hw	debris flow/outwash	outwash plain	5YR 5/6	Pence sl	sandy, mixed, frigid Typic Haplorthods
Sylvania P4	Hemlock	outwash	outwash plain	5YR 3/4	Pence sl	sandy, mixed, frigid Typic Haplorthods
Sylvania P5	Hemlock	loess/outwash	outwash plain	7.5YR 5/4	Wabeno sil	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania P6	No. hw	outwash	outwash plain	5YR 4/4	Pence sl	sandy, mixed, frigid Typic Haplorthods
Sylvania P7	Hemlock	outwash	outwash plain	2.5YR 4/6	Pence sl	sandy, mixed, frigid Typic Haplorthods
Sylvania P8	No. hw	till	moraine	5YR 3/3	Gogebic fsl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania P9	Hemlock	till	moraine	7.5YR 4/4	Gogebic sl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania P10	No. hw	ice-contact stratified drift	moraine	5YR 4/4	Gogebic fsl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania P11	Hemlock	till	moraine	5YR 3/4	Gogebic fsl	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods
Sylvania P12	No. hw	loess/outwash	outwash plain	5YR 4/4	Wabeno sil	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

(Bockheim 1997, Goodburn and Lorimer 1998) or of a special nutrient cycling study (Bockheim and Crowley 2002). A representative soil profile was dug to 1.4 m or to the C horizon, whichever came first. The soil was described in detail (Soil Survey Division Staff 1993); samples were collected from each horizon. The soils were classified using *Keys to Soil Taxonomy* (Soil Survey Staff 1998).

Soil samples were returned to the laboratory, air dried at 22^{0}C, and passed through a 2-mm screen. The samples were sent to the Missouri Soil Characterization Laboratory, where analyses were performed on the <2-mm fraction using methods established by the Soil Survey Staff (1996), including particle-size distribution with sand fractionation (method 3A), pH in distilled water (8C1a) and 0.1 M $CaCl_2$ (8C1e), organic C (6A1c), NH_4OAc-extractable bases (5B1), $BaCl_2$-triethanolamine-extractable acidity (6H1), and cation-exchange capacity (CEC) by NH_4OAc at pH 8.2 (5A2). Additional analyses included CEC by sum of cations (5A3a), KCl-extractable Al (5B3), Bray P-1 absorbed P (6S3), base saturation by summation (5C3), base saturation from NH_4OAc, and total N (method 6B).

RESULTS AND DISCUSSION

Soil Parent Materials

Of the 22 soil profiles, 18 were derived from outwash or ice-contact stratified drift, often with a cap of till, debris flow sediment, or loess; 4 of the soil profiles were developed entirely in till (table 1). Three of the soil profiles (Sylvania 4, 16, and P5) had a silt-loam cap between 58 and 150 cm in thickness that may represent local accumulation of loess or glaciolacustrine sediment.

Soil Classification

Soils derived from till and ice-contact stratified drift are classified as coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods, represented by the Gogebic Series (table 2). In contrast, soils on sandy outwash were classified as sandy, mixed, frigid Entic Haplorthods, represented by the Vilas or Rubicon Series. Soils on outwash capped with a coarse-loamy diamicton identified as debris flow sediment were classified as sandy, mixed, frigid Typic Haplorthods (Pence Series); and outwash containing a loess cap in excess of 50 cm contained coarse-loamy, mixed, superactive, frigid Alfic Haplorthods (Padus Series) or coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods, represented by the Wabeno Series (which is combined with the similarly classified Gogebic Series in figure 1).

Evidence for Podzolization

All of the soils have spodic materials in the upper sequum. In all but one soil profile (Sylvania 2A), the spodic materials underlie albic materials. In all but six soil profiles, spodic materials could be identified from color alone, i.e., a 5YR or redder hue, a value of ≤5, and a chroma ≤4 (table 1). Soil descriptions are provided in the appendix.

Evidence for Argilluviation

Thirteen of the twenty-two soil profiles have an argillic horizon in the lower sequum. The argillic horizons were identified on the basis of field properties such as the presence of clay coatings, pore infillings of clay, and bridging of sand grains by clay particles and laboratory measurements such as an increase in percent clay from an overlying epipedon (table 3).

The surface of the argillic horizon occurred at depths of 23 to 112 cm and averaged 75 cm; the thickness of the argillic horizon ranged from 28 to 88 cm,

Table 2.—*Legend for soil map units in the Sylvania Wilderness-Recreation Area*

Soil Map Unit	Area (ac)	% of land area	Soil classification	Dominant soil series
I	10,793	53.9	coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods	Gogebic fsl, msl, Wabeno sil
II, IV	2,121	11.1	coarse-loamy, mixed, superactive, frigid Alfic Haplorthods	Padus sil, sl
III	992	4.5	sandy, mixed, frigid Typic Haplorthods and Entic Haplorthods	Pence sl, Rubicon cos, Vilas ls
V	1,139	5.6	dysic Typic Borohemists	Greenwood muck
VI	847	4.2	euic Hemic Borosaprists	Carbondale muck
VII	431	2.2	Miscellaneous Land Type	(Lake Marsh)
Water	3,695	18.5		
	20,018	100		

Table 3—*Analytical data for soils of the Sylvania Wilderness-Recreation Area*

Site/soil/ forest type*	Horizon	Depth (cm)	Clay <0.002	Silt 0.002-0.05	Sand 0.05-2	Fine silt 0.002-0.02	Coarse silt 0.02-0.05	vfs 0.05-0.10	Fine sand 0.10-0.25	ms 0.25-0.50	cos 0.5-1	vcos 1-2	Text. class	NH4OAc exactable bases (cmol(+)/kg Ca	Mg	Na	K	Sum	Exch. acidity	Ex. Al	CEC Sum	CEC NH4OAc cats	Bases+	Al sat Al	Base sat. Sum	Base sat. NH4OAc	Org C	Total N (%)	pH CaCl2	pH H2O	Ex. P ppm
Sylvania 2A	A	1-8	6.0	31.7	62.3	16.4	15.3	9.2	22.2	17.2	10.8	2.9	MSL	3.1	0.8	0	0.1	4	8.8	0.2	12.9	9	4.2	5	31	44	1.8	0.17	4.9	5.3	45
AOF	Bs1	8-24	5.6	31.7	62.7	16.2	15.5	10.5	22	16	9.9	4.2	MSL	1.4	0.4	0.05	0.1	1.9	15.8	2.4	17.7	9.7	4.3	56	11	20	1.3	0.11	4.5	5.1	44
NHW	Bs2	24-35	4.8	38.5	56.7	19.3	19.1	10.1	20.9	14.3	8.6	2.9	FSL	0.5	0	0	0.05	0.5	12	1.8	12.5	6.6	2.3	78	4	8	0.8	0.06	4.5	5.2	36
	E/Bwx1	35-59	4.4	49.3	46.3	24.5	24.8	9.5	16.4	14.2	5.5	0.7	FSL	1	0.4	0.05	0.05	1.4	2.8	—	4.2	2.9	—	—	33	48	0.1	0.04	4.7	5.5	9
	E/Bwx2	59-70	4.2	54.5	41.3	25.8	28.8	13.2	15	7.6	4	1.6	SIL	1.2	0.4	0.05	0.05	1.6	3.3	—	4.9	4.1	—	—	33	39	0.1	0.03	4.7	5.5	10
	2BC/Bt lam.	70-130	5.5	48.9	45.6	24.2	24.7	10	16.6	11.2	5.9	2	FSL	1.5	0.4	0.05	0.05	1.9	3	0.6	4.9	4	2.5	24	39	48	0.1	0.04	4.7	5.4	7
	2BC/BT mtx.	70-130	0.4	4.1	95.5	2.5	1.7	1.7	19.1	35.4	29	10.2	COS	0.7	0	0.05	0	0.7	1.5	0.2	2.2	1.9	0.9	22	32	37	0.1	0.03	4.8	5.5	11
Sylvania 2B	E	5-11	2.8	36.4	60.8	18.5	17.9	10.9	26.9	13.5	7.5	1.9	FSL	0.2	0	TR	0.1	0.3	4.6	1.8	4.9	3.7	2.1	86	6	8	0.4	0.1	3.6	4.1	1.9
AOF	Bs1	11-18	7.8	37.3	54.9	17.3	20	10.3	23.7	11.8	7	2.2	FSL	0.2	0.4	TR	0.1	0.7	37.7	7.8	38.4	23.9	8.5	92	2	3	4.2	0.2	3.9	4.2	1.8
H	Bs2	18-40	4.8	45.3	49.9	19.3	26	10.4	19.8	10.8	6.4	2.5	FSL	0.2	0	TR	0.1	0.3	25.6	3.7	25.9	15.2	4	93	1	2	2.5	0.1	4.3	4.9	5.4
	Bs3	40-61	2.3	46.3	51.4	18.2	28.1	10.3	21.5	10.9	6.6	2	FSL	0.2	0	TR	0.1	0.3	11.7	1.7	12	6.7	2	85	3	4	0.9	0.1	4.5	5	6.7
	B/Ex	61-77	2.6	43.8	53.6	20.4	23.3	10.4	21.3	12.1	6.9	2.8	FSL	0.2	0	TR	TR	0.3	7.4	1	7.7	4.5	1.3	77	4	7	0.4	0.1	4.6	5.2	7.8
	Ex	77-112	2.5	35.1	62.4	14.3	20.8	12.2	26.2	12.8	8	3.2	FSL	1	0.4	TR	0.1	1.5	2.5	0.2	4	2.6	1.7	12	38	58	0.1	0	4.7	5.3	5.6
	Bt/Ex	112-140	3.3	33.5	63.2	14.2	19.3	11.1	26.7	13.6	8.6	3.3	FSL	1	0.4	TR	0.1	1.5	3.9	0.5	5.4	3.3	2	25	28	45	0.1	0	4.6	5.3	4.1
Sylvania 4	EB	12-23	10.1	66.3	23.6	35.2	31.1	8.4	6.6	4.7	2.8	1	SIL	3.7	0.4	0.05	0.1	4.2	12	3.7	16.2	9.8	7.9	47	26	42	1.4	0.12	3.9	4.6	13
AOF	Bs	23-48	8.6	52.7	38.7	26.2	26.5	10.1	13.1	9.1	5	1.5	SIL	1.2	0.4	0.05	0.1	1.7	11.3	3.5	13	7.9	5.2	67	13	22	0.7	0.08	4.1	4.8	10
H	Ex	48-51	6.8	62.2	31	29.8	32.4	10.3	9.5	6.4	3.7	1	SIL	1.7	0.4	0.1	0.05	2.2	4.3	1.8	6.5	4.7	4	45	34	47	0.1	0.06	4.2	5	4
	Btx/E1	51-83	16.8	54.5	28.7	27.7	26.8	9.6	9	5.8	3.1	1.3	SIL	4.8	2	0.1	0.1	7	5.2	1.5	12.2	10	8.5	18	57	70	0.2	0.03	4.3	4.9	10
	Btx/E2	83-115	9.9	35.6	54.5	18.4	17.2	11.3	20.2	12.1	7	3.9	FSL	4.1	2	0.1	0.1	6.3	2.7	0.3	9	7.8	6.6	5	70	81	0.1	0.02	4.7	5.3	5
	2C	115-120	2.5	12	85.5	4.7	7.3	12.1	43.5	20.4	7.4	2.1	LS	1.5	0.8	0.05	0.05	2.4	1.8	—	4.2	2.6	—	—	57	92	0.1	0.02	5	5.6	7
Sylvania 6	E	7-17	2.8	28.1	69.1	14	14.1	10	29	19.4	8.8	1.8	MSL	1.7	0	0.05	0.05	1.7	3.2	0.3	4.9	4.3	2	15	35	40	0.5	0.08	4.2	4.8	9
TH	Bhs	17-23	7.2	28.3	64.5	15.7	12.6	9.5	27.1	18	7.8	2.2	FSL	2.4	0.4	0.05	0.05	2.8	21.4	3.3	24.2	16	6.1	54	12	18	1.9	0.19	4.2	4.7	100
NHW	Bs1	23-33	4.7	25.9	69.4	10.9	15	11.7	29.6	17.3	8.2	2.7	FSL	1.4	0	0.05	0	1.4	26.4	3.5	27.8	16.1	4.9	71	5	9	2	0.18	4.3	5.1	82
	2Bs2	33-64	1.7	23	75.3	7.9	15.1	14.7	34.1	17.4	7	2.2	LS	0.7	0	0.05	0	0.7	11.2	1.4	11.9	6.3	2.1	67	6	11	0.7	0.12	4.7	5.3	57
	2BC	64-78	0.9	11.3	87.8	0	11.3	10.8	40.7	25.8	9.3	1.1	S	0.5	0	0.05	0	0.5	4.2	—	4.7	2.3	—	—	11	22	0.2	0.07	4.9	5.5	52
	2C1	78-119	0.6	15	84.4	4.6	10.4	12.3	36.6	22.6	9.8	3.2	LS	0.7	0	0.05	0	0.7	3.2	—	3.9	2.5	—	—	18	28	0.1	0.08	4.9	5.6	27
	2C2	119-130	1.1	23.5	75.4	6.3	17.1	13	31.5	19.6	9	2.4	LS	1	0.4	0.05	0	1.4	1.9	—	3.3	2.3	—	—	42	61	0.1	0.03	4.8	5.6	10
Sylvania 7	E	6-13	2.0	11.1	86.9	7	4	1.5	14.3	31.7	29.3	10.1	COS	0.7	0	0.05	0.05	0.7	4.3	0.7	5	4.2	1.4	50	14	17	0.7	0.07	4	4.4	10
TH	Bhs	13-32	2.9	8.3	88.8	4.7	3.7	1.2	19.1	35.2	23.8	9.6	COS	1	0	0.05	0.05	1	19.2	2.6	20.2	11.5	3.6	72	5	9	1.9	0.1	4.3	4.9	60
NHW	BC	32-62	0.3	2.1	97.6	1.3	0.9	1.2	24.7	41.9	23.3	6.5	COS	0.2	0	0	0	0.2	5.1	0.3	5.3	2.5	0.5	60	4	8	0.4	0.05	4.8	5.4	57
	C1	62-101	0.6	1.1	98.3	0.3	0.8	0.2	11.9	35.9	36.4	14	COS	0.2	0	0.05	0	0.2	2.9	—	3.1	1.6	—	—	6	13	0.2	0.07	4.9	5.5	49
	C2	101-110	0.6	0.5	98.9	0	0.5	2.6	42.6	37.9	12.5	3.3	S	0.2	0	0.05	0	0.2	2.2	0.1	2.4	1.4	0.3	33	8	14	0.2	0.06	4.9	5.5	37
Sylvania 9	EB	6-17	4.6	35.6	59.8	18.6	17	8.2	22.7	17.3	8.8	2.7	FSL	1.7	0.4	0.1	0.05	2.2	12.8	2.3	15	9.5	4.5	51	15	23	1.4	0.06	4.3	4.9	25
AOF	Bhs	17-35	4.6	27.4	68	13.4	14	9.6	26.6	18.2	9.4	4.2	MSL	1	0	0.05	0	1	16.3	2.8	17.3	10.7	3.8	74	6	9	1.5	0.02	4.4	5.2	7
NHW	Bs1	35-49	3.7	22.5	73.8	8.7	13.7	11.5	28.6	17.8	9.4	6.5	LS	2.2	0	0.05	0	2.2	13	1.9	15.2	7.9	4.1	46	14	28	0.8	0.12	4.5	5.2	11
	Bs2	49-71	2.5	31.4	66.1	12.9	18.5	13.7	25.3	16.4	8.1	2.6	FSL	0.5	0	0.05	0	0.5	8.5	1.4	9	5.5	1.9	74	6	9	0.4	0.02	4.6	5.2	18
	Bw/Ex	71-96	2.6	31.2	66.2	14.5	16.7	11	24.5	17.3	9.5	3.9	MSL	1.2	0.4	0.05	0.05	1.7	3.1	0.5	4.8	3.6	2.2	23	35	47	0.1	0.12	4.6	5.4	12
	Btx	96-130	18.4	51.7	29.9	28.1	23.6	7.6	9.8	7	3.8	1.7	SIL	5.5	2.4	0.1	0.1	8.1	3.9	—	12	9.8	—	—	68	82	0.1	0.09	5	5.7	9
	C	130-168	7.2	27.4	65.4	11.9	15.5	11.9	25.6	15.5	8.8	3.5	FSL	3.1	1.2	0.05	0.05	4.4	1.5	—	5.9	5.4	—	—	75	81	0.1	0.05	5.2	6	5
Sylvania 11	E	6-14	5.3	40.2	54.6	20.1	20.1	9.2	20.7	14.6	7.7	2.4	FSL	1.2	0.4	0	0.1	1.7	7.1	1.1	8.8	6.5	2.8	39	19	26	0.9	0.106	3.9	4.5	22.4
AH	Bs1	14-21	7.8	39	53.2	19.6	19.4	8.7	20.5	12.5	8.5	44.5	FSL	1.7	0.4	0	0.1	2.2	22.3	3.8	24.5	15.9	6	63	9	14	2.4	0.172	4	4.6	7.2
NHW	Bs2	21-39	4.7	37.5	57.8	16.1	21.4	11.8	21.8	13.3	7.5	46	FSL	0.7	0	0	TR	0.7	22.5	3.9	23.2	13.9	4.6	85	3	5	2	0.117	4.2	4.8	44
	2Bs	39-57	2.0	25.6	72.4	10	15.6	14.3	31.2	14.3	8.9	3.7	LS	0	0	0	TR	TR	10.2	1.6	10.2	6	1.6	100	0	0	0.7	0.083	4.4	5	63.8
	3E	57-79	3.3	23.7	73	9.9	13.8	11.5	27.9	18.7	10.6	4.3	MSL	0	0	0	TR	TR	6.1	1	6.1	3.8	1	100	0	0	0.3	0.04	4.5	5.1	40.2
	4Bt	79-143	4.3	24.6	71.1	11.4	13.3	11.4	31.2	16.3	9.5	2.7	FSL	0.7	0.4	0	0.2	1.3	2.9	0.6	4.2	3.2	1.9	32	31	41	0.1	0.041	4.6	5.3	15
	5BC	143-150	4.6	17.4	77.9	8.4	9.1	9.2	28.9	21.7	13.6	4.5	LS	1.2	0.4	0	0.1	1.7	1.9	0.2	3.6	3	1.9	11	47	57	0.1	0.046	4.7	5.3	8
Sylvania 14	E	0-9	4.2	32.4	63.5	19.2	13.2	6.2	21.9	20.1	13	2.2	MSL	1.5	0.4	0.05	0.05	1.9	6.9	1.4	8.8	6.8	3.3	42	22	28	0.8	0.11	4.1	4.6	14
TH	Bhs	9-21	7.5	34.4	58.1	19.5	14.9	7.2	20.8	16.6	10.4	3.1	MSL	1.4	0.4	0.05	0.05	1.9	20.7	4.1	22.6	14.7	6	68	8	13	1.9	0.12	4.3	4.9	9
NHW	Bs	21-43	3.1	25.5	71.4	13.2	12.2	7.8	25.7	19.9	12.7	5.3	MSL	0.7	0	0.05	0.05	0.7	15.8	2.5	16.5	10.5	3.2	78	4	7	1.4	0.09	4.5	5.1	17
	2BC	43-67	1.5	16	82.4	7	9	9.3	31.2	23.4	13.1	5.4	LS	0.5	0	0.05	0	0.5	7.4	0.9	7.9	4.3	1.4	64	6	12	0.4	0.04	4.6	5.3	36
	2C1	67-107	0.4	9.2	90.4	1.1	8.1	6.8	30.4	26.8	17.1	9.3	COS	0.2	0	0.05	0	0.2	3.5	0.3	3.7	2.1	0.5	60	5	10	0.2	0.05	4.9	5.5	33
	2C2	107-120	0.1	3.2	96.7	2	1.2	4.1	31.9	32.2	18.4	10	COS	0.5	0	0.05	0	0.5	2.7	—	3.2	2	—	—	16	25	0.1	0.06	5	5.6	27
Sylvania 15	E	5-12	4.0	43.6	52.4	28.6	14.9	8.1	16.5	15	10	2.8	FSL	1.7	0.4	0.05	0.1	2.2	14	3.5	16.2	12	5.7	61	14	18	2.3	0.14	4.1	4.5	7
TH	Bs1	12-21	3.9	43.5	52.5	26.3	17.3	10	18.2	13.2	7.8	3.4	FSL	1.2	0.4	0.05	0.1	1.7	16.3	3	18	10.3	4.7	64	9	17	1.5	0.12	4.4	4.8	5
H	Bs2	21-42	3.9	41.4	54.8	25.5	15.9	8.4	17.2	15.5	9.8	3.7	FSL	0.5	0	0.05	0.05	0.6	10.6	2.4	11.2	7.3	3	80	5	8	1.2	0.07	4.3	4.7	15
	BC	42-60	1.6	39	59.4	22.6	16.4	9.8	19.9	16	10.4	3.2	FSL	3.9	0	0.05	0.1	4	10.9	2.2	14.9	7.3	6.2	35	27	55	0.8	0.06	4.4	4.9	22
	2C	60-100	0.7	2.9	96.4	2.1	0.8	0.8	7.2	24.4	39.9	24.1	COS	1.4	0	0.05	0.05	1.4	3.4	0.4	4.8	2.9	1.8	22	29	48	0.3	0.03	4.9	5.2	43
Sylvania 16	E	6-14	4.9	53.9	41.2	36.5	17.4	7.5	12.2	11.8	8.1	1.6	SIL	1.4	0.4	0.05	0.1	1.9	7.5	2.4	9.3	7.7	4.3	56	20	25	1.2	0.17	3.7	4.2	13
AH	Bs1	14-26	5.0	51.2	43.8	32.6	18.6	7.5	12.4	11.9	8.9	3	SIL	6.1	0.4	0.1	0.1	6.7	21.4	3.5	28.1	14.9	10.2	34	24	45	2	0.18	4.3	4.8	11
H	Bs2	26-44	2.8	54.9	42.3	34.4	20.5	7.9	12.6	11	8.1	2.7	SIL	1.7	0	0.05	0.05	1.8	11.1	1	12.9	7.8	2.8	36	14	23	1	0.08	4.8	5.4	9
	Bt	44-58	3.5	52	44.5	29.7	22.3	9.8	15.8	10.4	6	2.4	SIL	1.2	0	0.05	0.05	1.3	4.9	0.9	6.2	4.4	2.2	41	21	30	0.2	0.02	4.6	5.2	3
	2BC	58-107	0.7	14.3	85	8.7	5.6	6.5	16.9	21.8	23	16.9	LCOS	1.5	0.4	0.05	0.1	2	4	0.7	6	4.4	2.7	26	33	45	0.1	0.04	4.7	5.3	14
	2C	107-128	1.3	18.2	80.5	9.2	9	10.9	29.4	23.5	12.9	3.9	LS	1.5	0.4	0.05	0.05	2	1.9	—	3.9	2.8	—	—	51	71	0.1	0.03	5	5.5	20

(table continued on next page)

(Table 3 continued)

Site/soil/ forest type*	Horizon	Depth (cm)	Clay <0.002	Silt 0.002-0.05	Sand 0.05-2	Fine silt 0.002-0.02	Coarse silt 0.02-0.05	vfs 0.05-0.10	Fine sand 0.10-0.25	ms 0.25-0.50	cos 0.5-1	vcos 1-2	Text. class	NH4OAc exactable bases (cmol(+)/kg Ca	Mg	Na	K	Sum bases	Exch. acidity	Ex. Al	CEC Sum cats	CEC NH4OAc	Bases+ Al	Al sat	Base sat. Sum	Base sat. NH4OAc	Org C	Total N (%)	pH CaCl2	pH H2O	Ex. P ppm
	107-128	1.3	18.2	80.5	9.2	9	10.9	29.4	23.5	12.9	3.9	LS	1.5	0.4	0.05	0.05	2	1.9	—	3.9	2.8	—	—	51	71	0.1	0.03	5	5.5	20	
Sylvania 18	E	7-16	3.3	28.2	68.5	16.5	11.7	8.9	28	20.5	9.7	1.3	MSL	1.2	0.4	0.05	0.05	1.7	4.4	1.4	6.1	4.7	3.1	45	28	36	0.6	0.07	3.8	4.3	5
AOF	Bhs	16-30	7.2	29.8	63	17	12.8	8.3	24.6	18.2	9.3	2.6	MSL	2.8	0.4	0.05	0.1	3.3	21.2	3.8	24.5	15.4	7.1	54	13	21	2.1		4.2	4.8	2
H	Bs	30-64	5.3	27.5	67.2	14.7	12.9	9.6	26.7	18.2	9.2	3.5	MSL	1.4	0.4	0.05	0.05	1.9	15.2	2.6	17.1	8.8	4.5	58	11	22	1.2	0.12	4.4	5.1	12
	2Bs1	64-87	3.0	12	85	6	6	9.9	39	25.3	9	1.8	LS	1.2	0	0.05	0.05	1.2	5.4	1.1	6.6	3.6	2.3	48	18	33	0.2	0.03	4.5	5.2	22
	2Bs2	87-111	2.5	9.9	87.6	5.3	4.7	7.7	34.2	29	13.3	3.3	S	1.2	0	0.05	0.05	1.3	3.4	0.7	4.7	3	2	35	28	43	0.2	0.02	4.6	5.3	9
	3Ex	111-124	2.8	27.3	69.8	12.9	14.4	16.5	34.1	13.8	4.4	0.9	FSL	1.4	0.4	0.1	0.05	1.9	2.3	0.4	4.2	3.3	2.3	17	45	58	0.1	0.02	4.6	5.3	4
	3Bt/Ex	124-175	12.8	53	34.2	22.5	30.6	15.9	10.8	4.5	2.3	0.7	SIL	5.4	2	0.05	0.1	7.5	3.2	—	10.7	8.7	—	—	70	86	0.1	0.03	5.2	5.9	4
	4BC	175-216	6.2	24.7	69.1	11.7	13	11.7	26.9	17.1	9.6	3.7	MSL	3.6	1.6	0.05	0.1	5.3	1.8	—	7.1	5.7	—	—	75	93	0.05	0.02	5.5	6.3	4
P1	A	2-7	1.8	15.7	82.4	9.4	6.3	5.1	33.1	27.5	13.7	3	LS	1.5	0.4	TR	0.1	2	9.5	0.7	11.5	8.3	2.7	26	17	24	3	0.187	3.9	4.2	40.8
EH	E	7-13	1.2	14.6	84.2	8.8	5.8	5.4	32.2	30.9	13.6	2.1	LS	0.5	0	TR	TR	0.6	4.5	1.5	5.1	3.6	2.1	71	12	17	0.5	0.055	3.9	4.2	7.6
H	Bs1	13-24	5.5	14.5	80	6.4	8.1	5.4	29.7	26.2	14.6	4.1	LS	0.5	0	0	0.1	0.6	15.9	3.9	16.5	10.7	4.5	87	4	6	1	0.093	4.2	4.5	21.6
	Bs2	24-52	2.2	14.3	83.5	4.3	10	5.6	29.9	29.6	14.8	3.7	LS	0.2	0	0	0	0.2	10.3	1.2	10.5	4.9	1.4	86	2	4	0.7	0.056	4.6	5	30.1
	Bs3	52-85	0.8	13.4	85.9	5.5	7.9	5.2	36	29.1	11.5	4	S	0.2	0	0	TR	0.2	4.6	0.6	4.8	2.8	0.8	75	4	7	0.2	0.027	4.8	5.3	44.4
	C	85-120	0.6	4	95.4	1.8	2.2	4.7	41.4	33.8	12.1	3.4	S	0.2	0	0	TR	0.2	3	0.3	3.2	2.1	0.5	60	6	10	0.1	0.008	4.9	5.3	38.2
P8	E	3-18	3.4	24.9	71.7	13.3	11.6	13.3	33.9	17.6	5.9	1	SL	1.7	0.4	0	TR	2.1	3.2	0.8	5.3	3.3	2.9	28	40	64	0.4	0.03	3.9	4.4	13.8
AOF	Bs1	18-35	8.3	21.1	70.6	9	12.1	14.7	35	13.2	5.2	2.4	SL	1.9	0.4	TR	TR	2.3	12.2	2.1	14.5	9.7	4.4	48	16	24	1.2	0.087	4.2	4.8	80
NHW	Bs2	35-53	5.8	24.7	69.5	10.7	14	14.8	32.7	14.8	5.6	1.6	SL	1.9	0.4	TR	TR	2.3	13	1.5	15.3	7.8	3.8	39	15	30	0.9	0.064	4.5	5	138.5
	BE'x	53-72	2.8	28.5	68.6	9.7	18.9	17.3	32.1	12.4	4.6	2.1	SL	1	0	TR	TR	1	8.4	1.2	9.4	4.7	2.2	55	11	21	0.4	0.025	4.5	5.3	129
	Bt/E'x	72-118	23.9	54	22.1	31.9	22.1	6.4	8.2	5.2	1.8	0.5	SIL	5.5	3.1	0.1	0.1	8.8	4.1	0.3	12.9	12	9.1	3	68	73	0.1	0.013	4.9	5.4	18.8
	BCx	118-216	25.8	63.7	10.5	39.4	24.3	7	2.3	0.7	0.4	0.1	SIL	6.5	4.7	0.2	0.1	11.5	4.3	0.1	15.8	14.4	11.6	1	73	80	0.1	0.011	5.4	6	10.5
P7	A	2-5	6.7	25.1	68.2	13.5	11.6	3.6	22.1	22.3	8.8	11.3	SL	9.2	1.2	TR	0.4	10.8	31.1	0.7	41.9	30.8	11.5	6	26	35	12.7	0.585	3.8	4.2	12.2
TH	E	5-15	3.1	13.9	83	7.6	6.3	10.5	41.1	23.1	6.8	1.4	LS	1	0.4	0	0.1	1.5	5	1.1	6.5	4.2	2.6	42	23	36	0.6	0.038	3.7	4.1	16.4
H	Bs1	15-26	4.8	11.1	84.2	4.8	6.3	7	34	26.2	10.5	6.5	LS	0.7	0	0	TR	0.7	12.5	3.1	13.2	7.9	3.8	82	5	9	1.2	0.054	4	4.5	22.6
	Bs2	26-41	2.2	11.5	86.4	3.4	8	8.6	37.2	23.2	11.1	6.3	S	0.5	0	0	TR	0.5	11.4	1.8	11.9	6.2	2.3	78	4	8	1	0.038	4.2	4.8	64.5
	BC	41-87	0.8	10.8	88.4	3.1	7.7	9.5	39.4	25.6	8.4	5.5	S	0.5	0	TR	TR	0.5	5.2	0.7	5.7	3.5	1.2	58	9	14	0.3	0.008	4.5	5.1	98
	C1	87-102	1.1	4.3	94.5	0.6	3.8	7.5	46.1	27.6	9.8	3.6	S	0.5	0	0	0	0.5	3.1	0.3	3.6	1.8	0.8	38	14	28	0.2	0.002	4.7	5.3	67
	C2	102-110	0.3	3.3	96.5	1.1	2.1	4.5	39	35.4	14.5	3.1	S	0.5	0	0	0	0.5	2.1	0.2	2.6	1.6	0.7	29	19	31	0.1	0.005	4.7	5.6	67.5
P9	E	7-15	3.1	37.2	59.7	18.1	19.1	14.6	27	12.4	4.6	1.2	SL	1	0	0	TR	1	4.1	1.2	5.1	4.4	2.2	55	20	23	0.7	0.041	3.9	4.5	15
AOF	Bs	15-23	10.7	40.8	48.6	19.4	21.3	14.4	20.5	9.4	3.6	0.7	L	1.7	0.4	TR	TR	2.1	13.2	2.9	15.3	9.5	5	58	14	22	1	0.059	4.1	4.7	40.8
H	Ex/Bt	23-36	18.7	66.1	15.2	36.3	29.7	9.3	3.8	1.6	0.5	0	SIL	1.7	1.2	0.1	0.1	3.1	8.6	2.5	11.7	8.6	5.6	45	27	36	0.3	0.006	4.1	4.7	16
	Btx	36-111	26.8	64.9	8.3	37.2	27.7	6.8	1.2	0.2	0.1	0	SIL	5.4	5.3	0.3	0.1	11.1	5.7	0.8	16.8	14.6	11.9	7	66	76	0.2	0.016	4.4	4.8	16
	BC	111-122	17.7	56.9	25.4	28.2	28.7	16.9	7.5	0.7	0.2	0	SIL	3.4	3.6	0.3	0.1	7.4	5.4	0.8	12.8	11.3	8.2	10	58	66	0.1	0.012	4.3	5	13.2
	C	122-	7.7	43	49.2	16.1	26.9	23.2	17.3	6.5	1.9	0.2	L	2	2.4	0.2	TR	4.7	2.9	0.5	7.6	6	5.2	10	62	78	0.1	0.007	4.4	4.9	13.2
P6	A	2-6	8.0	28.6	63.4	16.9	11.7	8.7	29.4	14	5.1	6.3	SL	15.3	1.6	TR	0.4	17.3	20.6	0.1	37.9	32.6	17.4	1	46	53	11.5	0.991	4.8	4.9	44.2
TH	E	6-19	2.4	23.4	74.2	10.9	12.4	14.4	36.6	15.1	6.1	2.1	LS	1	0	0	0.1	1.1	3	0.6	4.1	3.7	1.7	35	27	30	0.4	0.026	4.2	4.6	8.7
NHW	Bs1	19-51	2.6	27.5	70	11.2	16.2	19.1	34.3	8.6	4	4	SL	0.7	0	0	TR	0.7	12.3	2.3	13	7.2	3	77	5	10	0.9	0.046	4.2	4.9	18
	Bs2	51-71	0.8	17.3	82	6.2	11.1	24.3	43	9.5	3.5	1.7	LS	0.5	0	TR	0	0.5	6.2	0.9	6.7	3.7	1.4	64	8	14	0.4	0.016	4.4	5	108
	C1	71-82	0.4	4.6	95	1.1	3.5	12.1	53.2	23.2	5.3	1.3	S	0.2	0	0	0	0.2	3.4	0.4	3.6	1.8	0.6	67	6	11	0.2	0.007	4.5	5.2	78
	C2	82-	0.7	2.5	96.8	1.1	1.5	7.2	49.2	27.4	8.3	4.8	S	0.2	0	0	TR	0.2	2.8	0.3	3	1.9	0.5	60	7	11	0.2	0.002	4.5	5.2	64.5
P10	E	5.5-20	0.1	96.2	3.7	0.8	95.4	0.3	1.3	1.3	0.7	0.1	SI	0.7	0.4	0	TR	1.1	3.4	0.5	4.5	4	1.6	31	24	28	0.6	0.036	4.2	4.4	6
AOF	2Bs1	20-32	7.2	22.1	70.7	12.6	9.5	6.4	23.3	22.9	12.1	6	SL	1.2	0.4	TR	TR	1.7	20.5	3	22.2	13.9	4.7	64	8	12	2.1	0.11	4.2	4.9	36.4
NHW	2Bs2	32-47	1.7	20.3	78	7	13.4	12.4	33.8	19	8.3	4.3	LS	0.7	0	0	TR	0.7	17.1	2.2	17.8	10.4	2.9	76	4	7	1.4	0.07	4.4	5.1	77
	2Bs3	47-67	1.3	27.2	71.5	10.3	16.8	14	29.8	18	7	2.8	LS	0.2	0	0	0	0.2	7	1.1	7.2	4.2	1.3	85	3	5	0.6	0.011	4.5	5.1	82
	2Bs4	67-95	0.1	16.2	84	3.7	12.5	14.9	45.6	18.2	4.4	0.9	LS	0.2	0	0	0	0.2	3.5	0.4	3.7	1.9	0.6	67	5	11	0.2	0.012	4.7	5.3	54.5
	2Ex/Bt1	95-104	5.7	74.2	20.1	30.5	43.7	16.5	2.6	0.6	0.3	0.1	SIL	1.2	0.4	TR	TR	1.6	3.5	0.3	5.1	3.8	1.9	16	31	42	0.1	0.472	4.8	5.3	7.3
	2Ex/Bt2	104-137	16.4	60.1	23.5	25.8	34.3	15.4	4.8	2.1	1	0.2	SIL	4.9	2	0.1	0.1	7.1	3.8	0.3	10.9	9.6	7.4	4	65	74	0.1	0.001	4.9	5.2	7.5
	2BC	137-	6.3	27.5	66.3	12	15.5	11.5	27.5	19.5	6.7	1	SL	2.7	1.2	TR	0.1	4	2.2	0.2	6.2	4.8	4.2	4	64	83	0.1	0.004	4.9	5.3	10.2
P11	E	9-26	0.8	15	84.3	8.9	6.1	5.7	37.9	29	10.3	1.3	LS	0.2	0	0	TR	0.2	3	0.5	3.2	2.6	0.7	71	6	8	0.5	0.015	3.6	4.2	2.7
AOF	Bs1	26-36	3.8	20.9	75.3	10.5	10.4	8.7	34.6	20.4	11.1	0.5	LS	0.7	0	0	TR	0.7	23.3	4.8	24	14	5.5	87	3	5	2	0.046	4.2	4.6	51.2
H	Bs2	36-74	1.4	10.2	88.3	3.8	6.4	10.8	48.3	19.3	6.5	3.5	S	0.5	0	TR	TR	0.6	10.7	1.5	11.3	5.5	2.1	71	5	11	0.8	0.017	4.5	5.1	16.1
	C	74-94	0.8	1.9	97.2	1.9	0	4.4	49.1	36	7.4	0.3	S	0.2	0.4	TR	TR	0.6	2.2	0.5	2.8	1.5	1.1	45	21	40	0.1	0.012	4.7	5.4	19.9
	E'x	94-126	2.6	51.3	46.1	22.5	28.8	17	20.4	6.8	1.6	0.3	SIL	0.5	0	TR	TR	0.5	5.6	1.3	6.1	3.6	1.8	72	8	14	0.4	0.02	4.3	5	9.8
	Btx	126-210	7.5	50.4	42.2	18.2	32.1	25.7	15	1.2	0.2	0.1	SIL	1.2	0.4	TR	0.1	1.7	5.1	1.4	6.8	4.9	3.1	45	25	35	0.1	0.006	4.3	4.8	14.1
	BC	210-	7.0	41.4	51.6	13.9	27.5	26	24.4	0.9	0.1	0.1	SL	3.4	1.2	TR	0.1	4.7	1.8	0.1	6.5	5.4	4.8	2	72	87	TR	0.014	5.3	5.5	7.9
P5	A	3-10	7.1	66.7	26.3	36.3	30.4	8.2	7.5	5.8	4.1	0.7	SIL	0.7	0.4	TR	0.1	1.2	8.6	3.3	9.8	7.1	4.5	73	12	17	0.5	0.075	4	4.3	65
AOF	E/Bs	10-25	8.9	62.2	28.9	32.6	29.5	11.7	7.7	4.2	3.8	1.6	SIL	1	0	TR	0.1	1.1	13.4	3.4	14.5	10.2	4.5	76	8	11	0.8	0.078	4.1	4.4	70.5
H	Ex/Bt	25-65	18.5	63.4	18.1	33.9	29.5	12.1	4.4	0.8	0.5	0.2	SIL	3.4	1.2	TR	0.2	4.8	7.9	1.5	12.7	9.7	6.3	24	38	50	0.2	0.029	4.5	4.9	13.3
	Btx	65-99	20.1	66.5	13.4	31.6	34.9	10	2.4	0.5	0.4	0.1	SIL	6.7	3.1	0.1	0.2	10.1	3.7	0.3	13.8	12.8	10.4	3	73	79	0.1	0.015	5.1	5.5	12.6
	2BC	99-	4.5	13.4	82.1	7.1	6.3	6.2	43.6	22.3	6.1	3.9	LS	1.8	1.2	TR	0.1	3.1	2.3	0.2	5.4	4.2	3.3	6	57	74	0.1	0.011	5.1	5.6	10.7
P3	AE	1-11	7.1	28.2	64.7	13.4	14.8	6.5	21.9	22.5	12.7	1.1	SL	7.4	1.2	TR	0.3	8.9	16.5	0.3	25.4	18.1	9.2	3	35	49	4.3	0.328	4.8	5	45
TH	Bs1	11-37	4.5	25.1	70.3	11.4	13.7	7.4	22.3	22.4	13.1	5.1	SL	0.5	0.4	0	TR	0.9	10.3	2.1	11.2	6.4	3	70	8	14	0.7	0.066	4.4	5.1	54.5
NHW	Bs2	37-69	1.4	14.2	84.4	4.9	9.3	8.1	30.3	24.9	19.1	2	LS	0.5	0	TR	0.1	0.6	6.8	0.9	7.4	4	1.5	60	8	15	0.6	0.044	4.7	5.3	97.5
	C	69-107	-0.1	1.2	99	0	1.2	1.4	20.9	39.2	23.9	13.5	S	0.2	0	TR	TR	0.2	1.4	0.1	1.6	1.3	0.3	33	13	15	TR	0.014	4.9	5.4	31.4
P4	E	2-21	1.2	21	77.8	11.4	9.5	8.7	38.3	22.4	7.3	1.1	LS	0	0	0	TR	TR	4.3	1.1	4.3	3.6	1.1	99	0	0	0.5	0.041	3.5	4	2.2
TH	Bhs	21-24	8.2	25	66.8	14.9	10	6.1	28	22.6	9.4	0.6	SL	0	0	0	0.1	0.1	38.5	10	38.6	23	10.1	99	0	0	3.3	0.179	3.6	4	2
H	Bs1	24-34	3.4	20.8	75.8	9.9	10.8	8.6	36.2	21	8.1	2	LS	0	0	TR	TR	TR	34.9	5.9	34.9	17.8	5.9	99	0	0	2.7	0.172	4.2	4.6	3.7
	Bs2	34-52	3.7	26.2	70.1	11.8	14.4	9.3	30.9	20.4	7.6	1.9	SL	0	0	TR	TR	TR	20	3.2	20	9.7	3.2	99	0	0	1.3	0.086	4.3	4.7	13.1
	C	52-90	2.7	6.9	90.4	3	3.9	6.8	34.4	35.8	12.5	0.9	S	0	0	0	TR	TR	7.2	1.3	7.2	3.7	1.3	99	0	0	0.4	0.034	4.4	4.8	68
P12	EB	6-15	23.8	62.7	13.5	40.8	21.9	3.8	2.9	2.1	2.8	1.9	SIL	2.6	1.2	TR	0.3	4.1	23.5	4.7	27.6	21.4	8.8	53	15	19	2.4	0.294	4.2	4.7	14.9
AOF	E/Bx	15-25	16.0	72.2	11.9	43.3	28.9	5.4	2.8	1.8	1.4	0.5	SIL	1.5	0.8	TR	0.1	2.4	7.7	1.7	10.1	8.1	4.1	41	24	30	0.4	0.03	4.4	5	14.2
NHW	Btx1	25-40	25.2	66.5	8.3	39.7	26.8	4.8	1.6	1	0.7	0.2	SIL	3.9	2.4	0.1	0.1	6.5	7.2	1.3	13.7	12.3	7.8	17	47	53	0.1	0.01	4.6	5.2	18.5
	Btx2	40-63	29.8	64.5	5.7	40.8	23.7	4.5	0.8	0.2	0.1	0	SICL	6.3	4.8	0.2	0.1	11.4	4.7	0.5	16.1	15	11.9	4	71	76	0.1	0.014	4.9	5.4	16.2
	Btx3	63-105	24.2	71.1	4.7	43.4	27.6	3.9	0.7	0.1	0	0	SIL	6.3	5.6	0.2	0.1	12.2	3.2	0.1	15.4	13.9	12.3	1	79	88	0.1	0.011	5.6	6.2	5

Soil: AOF = Alfic Oxyaquic Fragiorthod, AH = Alfic Haplorthod, TH = Typic Haplorthod, EH = Entic Haplorthod; Forest type: NHW = northern hardwoods, H = hemlock

averaging 58 cm (table 3). Evidence for clay movement into the 2Btx horizon ranged from a few, thin pore infillings to abundant, moderately thick clay coatings on ped faces and within pores. The increase in clay from the Ex to the 2Btx or Bt ranged from 0.8 to 21 percent and averaged 10.5 percent.

The argillic horizons occur in soils with textural discontinuities. Their formation appears to be favored by (1) highly porous parent materials low in calcium carbonate that are conducive to clay movement, (2) a textural discontinuity that enables the water bearing solutes to "hang up," (3) ample moisture from the melting snowpack and intense rainstorms that enable translocation of clay, and (4) conditions that enable synthesis of clay minerals from the soil solution.

Six soil profiles had evidence of silt movement, including Sylvania 2A, Sylvania 9, P8, P9, P10, and P11 (table 3). The increase in silt from the lower horizon of the upper sequum to the upper horizon in the lower sequum ranged from 5.2 to 58.0 percent and averaged 28.6 percent. Silt may move in soils due to translocation in suspension (Locke 1986) or from vertical frost sorting (Van Vliet-Lanoe 1985).

Evidence for Fragipan Formation

Eleven of the twenty-two soil profiles examined contain a fragic horizon (table 1). The fragipans were identified in the field from morphological properties such as the very hard and extremely hard consistence when dry, the prismatic primary structure and platy secondary structure, bleached prism faces, and a vesicular porosity and observations of root distribution and water movement during the spring (Habecker *et al*. 1990, Lindbo and Veneman 1993, Miller *et al*. 1993). In the laboratory the presence of fragic materials was confirmed from high bulk density values (average = 1.61 g m^{-3}, range = 1.51 to 1.70 g m^{-3}) and micromorphologic examinations. The Bs horizons overlying the fragipan had an average bulk density of 1.32 g cm^{-3} and the underlying sediments had a value of 1.46 g m^{-3} (Fujinuma, unpublished).

Five of the eleven fragic soils contain textural discontinuities (table 3). The fragipan surface ranged from 15 to 111 cm in depth, averaging 57 cm; the fragipan thickness ranged from 35 to 116 cm, averaging 71 cm. The effective rooting depth was limited to 43 cm (range = 16 to 79 cm).

In the upper Great Lakes region, fragipans rarely form in the absence of an argillic horizon and are most common in soils with lithological discontinuities (Yassaglou and Whiteside 1960, Franzmeier *et al*. 1989, Habecker *et al*. 1990, Schaetzl 1996). Six soil series containing fragipans have been identified in northern Wisconsin and the western Upper Peninsula of Michigan, and they invariably contain coarse-loamy materials over acid sandy loam till in an udic, frigid soil climate (Natural Resources Conservation Service 2001).

Soil Chemical Properties

The upper sequum of the soils is extremely acidic (pH 4.8), low in exchangeable bases (<20% base saturation), and high in exchangeable acidity (12 $cmol_c\ kg^{-1}$) and exchangeable aluminum (Al) (60% saturation) (table 3). In contrast, the lower sequum is very strongly acidic (pH 5.3), higher in exchangeable bases (45% base saturation), and lower in extractable acidity (4.5 $cmol_c\ kg^{-1}$ and exchangeable Al (18% saturation) than the upper sequum.

The acidity in the upper sequum likely originates from two sources. Northern hardwood vegetation has a high demand for base cations and pumps large amounts of bases from the soil (Franzmeier *et al*. 1989, Bockheim 1997). In addition, the study area receives large amounts of acidic deposition, from 0.10 to 0.15 kmol $ha^{-1}\ yr^{-1}$ (National Atmospheric Deposition Monitoring Program 2002).

The Al on exchange sites in the upper sequum originates from hydrolysis of the abundant aluminosilicate minerals in the parent materials (Brown and Jackson 1958, Whittig and Jackson 1956). The iron (FE) and Al complexes with organic matter and is important in the podzolization process.

Genesis of Bisequal Soils

Bisequal soils in the upper Great Lakes region generally have a medium sandy loam or finer (e.g., silt loam, fine sandy loam) texture in the upper sequum. Although an argillic horizon may occur in soils derived from sandy (loamy sand or sand)

materials, fragic soil properties most commonly occur in materials with a sandy loam or finer texture.

The argillic and fragic horizons in Alfic Fragiorthods may form exclusive of one another. Both horizons are common in soils with textural discontinuities. Based on estimates of gains and losses and chemical analysis of soil solutions, the clay in the argillic horizon forms from both translocation from eluvial horizons and neo-formation of secondary minerals from solutions percolating down through the profile (Bockheim 2003).

Fragipans in soils of the study area likely are of pedogenic origin in that they form within the zone of pedogenesis (ca., the upper 100 cm) and commonly occur at a textural discontinuity, particularly where loess overlays sandy loam till or debris flow sediments. Moreover, the fragipans occur in the upper part of the argillic horizon that appears to be degrading.

There is some uncertainty about the role that former permafrost played in the development of fragic soils in the upper Great Lakes region. Habecker *et al*. (1990) cited the occurrence of prismatic and platy structure, vesicular porosity, silt accumulation, and vertical sorting as evidence for former permafrost. However, all of these features could be explained on the basis of alternative mechanisms. For example, the prismatic structure could originate from wetting and drying of the lower sequum. The vesicular porosity may form as a result of saturation of the upper sequum during spring snowmelt. As the water penetrates into the underlying argillic horizon, the air must be displaced. As the Ex horizon above the argillic horizon dries, it may entrap some of the rising air, forming preserved vesicular pores (Miller *et al*. 1993). Silt may be translocated into the lower sequum by the same mechanism as clay, rather than by vertical sorting by frost action (Locke 1986).

The soils examined in this study differ from those studied by Beaver (1966) and Schaetzl (1996), in that they did not occur with a climate-vegetation "ecotone" and they were derived from acidic till or outwash in the lower sequum rather than base-enriched till. There is no evidence that the Spodosols within the upper sequum were derived from a thick E horizon in Udalfs developed during the warmer Hypsithermal interval (e.g., Hole 1975, Wang *et al.* 1995). The thickness of the material above the argillic horizon in 12 bisequal soil profiles averaged 76 cm (table 3). We are unaware of E horizons in Alfisols of the upper Great Lakes region of this thickness. Apparently hemlock invaded the forested landscape of northern Michigan during the past 3,200 years (Frelich *et al.* 1993). Hemlock became established especially in wet hollows. After the initial invasion, "overstory-understory interactions between sugar maple and hemlock and chance determined where in the uplands hemlock clumps formed and grew into large patches." Podzolization may have intensified since the more widespread establishment of hemlock (Hole 1975).

Bockheim (2003) presented a model of the evolution of soils on two kinds of parent materials in the western Upper Peninsula of Michigan. On sandy loam materials, a Typic Haplorthod requires at least 4,000 years to form (Barrett and Schaetzl 1992). In areas receiving extensive runoff from snowmelt, an argillic horizon may form at the depth of water percolation; this type of soil is represented by the Keweenaw Series (Alfic Haplorthod). In lower lying areas, the argillic horizon may impede water movement, which leads to the development of fragic soil properties. Bleached prism faces constitute evidence for degradation of the argillic horizon. The fragipan further inhibits internal drainage and leads to subsurface lateral flow and formation of an Ex horizon.

According to the model, soil development may be even more rapid on two-storied materials such as a coarse-loamy diamicton over sand and gravel outwash. The somewhat excessively drained Pence Series (Typic Haplorthod) represents an early stage in development of these soils. Under well-drained conditions, an argillic horizon may form at the contact between the two parent materials leading to the development of an Alfic Haplorthod (represented by the Padus Series). In moderately well drained areas, a fragipan may develop in the upper part of the argillic horizon and at the contact between the two parent materials. The fragipan further restricts internal drainage causing oxyaquic conditions. The Gogebic soils, classified as Alfic Oxyaquic Fragiorthods, are very common in the study area.

The soils examined in this study show intensive pedogenesis given the limited snow-free season (ca., mid-May to mid-October) and their young age (12,000 years old). The profiles range from deep to very deep and show evidence of podzolization, argilluviation, and formation of fragic soil properties. The upper portions of the profiles are strongly leached of bases, clay, and silt and have a "superactive" cation-exchange activity class. Aluminum dominates the exchange sites in the upper sequum.

The conditions contributing to this strong degree of development may include (i) lack of freezing of the soils during the winter, (ii) buildup of a 1- to 2-m snowpack that melts rapidly in the spring, (iii) permeable parent materials, and (iv) textural discontinuities that cause water to "hang up" thereby short circuiting the depth for leaching. These conditions enable rapid translocation of weathering products to form the various horizons, properties, and materials found in these soils.

ACKNOWLEDGMENTS

The Wisconsin Department of Natural Resources and the USDA Cooperative State Research Service (Hatch) provided funding for this project through the University of Wisconsin Agricultural Experiment Station. J. Rich and R. Fujinuma assisted in the field. We appreciate the cooperation of the Natural Resources Conservation Service in publishing this paper.

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APPENDIX: DESCRIPTIONS OF SOILS IN THE SYLVANIA RECREATION AREA

Pedon Ref. No.: Sylvania 2A, subplot #9
Date: 7-16-94
Location: Ottawa National Forest; Watersmeet ranger district; Gogebic Co., MI
Legal description: T44N, R10E, S.10; 46° 12' 05.427" N, 89° 16' 56.467" W
Landform: glacial lake plain
Parent materials: till / outwash
Relief: 8°; concave complex; 36°/Az.
Elevation (m): 542
Vegetation: Old-growth, unfragmented northern hardwoods
Drainage class: well
Effective rooting depth (cm): 37
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-1	mull	ab	-		-	-	-	-	-	-	-	-	-	-	
A	1-8	6-21	ai	7.5YR 3/2		msl	3mgr		mfr	wss/wps		2	0	0	2vf,f; 2m,co	
Bs1	8-24	0-17	aw	7.5YR 3/4		msl	1msbk		mfr	wss/wps	0	2	0	0	1vf, f; 2m, co	
Bs2	24-35	7-16	aw	7.5YR 4/4		fsl	1msbk		mfr	wss/wps	0	2	0	0	1f, m, co	
E/Bx1	35-59	10-25	cw	5YR 5/3(80%),2.5YR 5/4 (20%)		fsl,sil	1copl	2msbk	mfi	wss/wps	2mkfpo	0	0	0	1vf	
E/Bx2	59-70	11-25	aw	5YR 5/3(65%),2.5YR 3/4 (35%)		sil	1copl		mfi-mvfi	wss/wps	2mkpfpo	0	0	0	1vf	
2BC	70-130			5YR 4/4		fsl/cos	0sg/1copl		inl/mfr	wso/wpo(wss/wps)	2npfpo	7	2	0	0	

Pedon Ref. No.: Sylvania Wilderness 2B
Date: 5-24-96
Location: Ottawa National Forest, Watersmeet ranger district; Gogebic Co., MI
Legal description: T44N, R9E, S.10
Landform: ground moraine
Parent materials: till
Relief: 16°; concave complex; 300°/Az.
Elevation (m): 355
Vegetation: old-growth hemlock
Drainage class: well
Effective rooting depth (cm): 40
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-2	1-4	-	mor		-	-	-	mvfr	-	-	0	0	0	-	
Oa	2-5	2-5	as	2.5YR 2.5/1		-	-	-	-	-	--	0	0	0	3vf,f; 2m, 1co	
E	5-11	3-22	ai	5YR 4/2		fsl	1mpl	2fsbk	mfr	wso/wpo	-	2	0	0	1vf, f; 1m, co	
Bs1	11-18	6-8	aw	2.5YR 5/3		fsl	1fsbk	2fgr	mvfr	wso/wps	-	2	0	0	2vf, f; 2m, co	
Bs2	18-40	20-22	cw	5YR 3/4		fsl	2fsbk	2fgr	mfr	wso/wps	1vnpo	2	0	0	1f, 2m, 1co	
Bs3	40-61	14-23	cw	5YR 3/4		fsl	1mpl	2fsbk	mfr	wss/wps	3vnpo	5	0	0	1m, co	
B/Ex	61-77	14-18	cw	5YR 3/4 (60%),7.5YR 4/3 (40%)		fsl	2copl	2fbk	mfi	wss/wps	2npfpo	10	2	0	0	vesicular porosity
E'x	77-112	30-40	cw	7.5YR 5/3		fsl	1copl	2fsbk	mfi	wso/wpo	0	12	7	2	0	vesicular porosity
Bt/Ex	112-140	-	-	7.5YR 4/4 (55%),7.5YR 4/3 (45%)		fsl	1copl	1msbk	mfi	wso/wpo	0	20	7	2	0	vesicular porosity

Pedon Ref. No.: Sylvania #4, subplot #2
Date: 6-21-94
Location: Ottawa National Forest; Watersmeet ranger district; Gogebic Co., MI
Legal description: T44N, R40W, S.13; 46° 12' 37.754" N, 89° 15' 06.762" W
Landform: outwash plain
Parent materials: loess/outwash
Relief: 5°; hummocks complex; 48°/Az.
Elevation (m): 560
Vegetation: old-growth hemlock
Drainage class: well
Effective rooting depth (cm): 40
Soil classification: coarse-loamy, mixed, superactive, frigid, Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-6,6-9,9-12	mor	aw	-		-	-	-	-	-	-	-	-	-	2vf, f; 3m, co	
EB	12-23	9-15	ci	5YR 5/2		sil	2msbk	2fgr	mfr	ws/wps	0	2	0	0	1vf, f; 2m, co	
Bs	23-48	10-25	aw	5YR 4/4		sil	2msbk	2fsbk	mfr-mfi	wss/wps	1npfpo	2	0	0	1vf, f; 1mco	
E'x	48-51	1-11	cw	5YR 5/3		sil	1mpl	2msbk	mfi	wss/wp	1npfpo	2	0	0	1vf	
Btx/E1	51-83	23-33	cw	2.5YR 3/4 (80%),5YR 5/3 (20%)		sil	1copr	2msbk	mfi	ws/wp	1mkpfpo	2	0	0	1m	
Btx/E2	83-115	50-55	cw	2.5YR 3/4 (90%), 5YR 6/3 (10%)		fsl	1copr	2msbk	mfi	wss/wp	3mkpfpo	5	0	0	3vf	
2C	115-120	-	-	5YR 4/4		s	0sg		mvfr	wso/wpo	0	3	0	0	0	

Pedon Ref. No.: Sylvania #6, subplot #4
Date: 6-23-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: S.14; 46° 12' 27.630" N, 89° 15' 50.683" W
Landform: outwash plain
Parent materials: debris flow / outwash
Relief: ~2°; complex (hummocks)
Elevation (m): 554
Vegetation: old-growth, unfragmented northern hardwoods
Drainage class: well
Effective rooting depth (cm): 37
Soil classification: sandy, mixed, frigid Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-4,4-7	mor	aw	-		-	-	-	-	-	-	-	-	-	3vf, f; m, 2co	
E	7-17	5-18	aw	5YR 4/2		msl	1msbk	2fgr	mfr	wss/wps	0	2	0	0	1vf,f; 2m, co	
Bhs	17-23	3-8	aw	5YR 3/3		fsl	1msbk	2fgr	mfr	wss/wps	0	2	0	0	1vf,f; 2m, co	
Bs1	23-33	10-13	aw	2.5YR 2.5/4		fsl	1msbk	2fgr	mfr	wss/wps	0	2	0	0	1vf,f; 2m, co	
2Bs2	33-64	16-31	cw	2.5YR 3/4		ls	1msbk	2fgr	mfr	wss/wps	0	4	0	0	1vf,f; 2m	
2BC	64-78	8-16	cw	5YR 3/6		s	1copl	0sg	mfr-mfi	wso/wpo	2vnpfpo	4	0	0	1vf	
2C1	78-119	40-46	gw	5YR 4/4 (90%), 5YR 6/4 (10%)		ls	1copl	0sg	mfr	wso/wpo	2vnpfpo	6	1	0	1vf	
2C2	119-130	-	-	5YR 4/4 (80%),5YR 6/4 (20%)		ls	1fsbk	0sg	mvfr	wso/wpo	2vnpfpo	6	2	5	0	

Pedon Ref. No.: Sylvania #7, subplot #7
Date: 6-29-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R40W, S.24; 46° 11' 36.970" N, 89° 15' 38.317" W
Landform: outwash plain
Parent materials: outwash sand and gravel
Relief: 3°; complex; 126°/Az.
Elevation (m): 551
Vegetation: old-growth, unfragmented, northern hardwoods
Drainage class: somewhat excessive
Effective rooting depth (cm): 33
Soil classification: sandy, mixed, frigid, Entic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-4.5,4.5-6	mor	aw	-		-	-	-	-	-	-	-	-	-	3vf, f	
E	6-13	0-12	ab	5YR 4/2		cos	1mgr		mvfr,mfr	wso/wpo	0	5	0	0	2vf, f; 2m, co	
Bhs	13-32	9-26	aw	2.5YR 2.5/2		cos	1fsbk		mvfr	wso/wpo	0	20	2	0	2vf, f; m, co	
BC	32-62	14-32	aw	5YR 4/6		cos	1vfgr	0sg	ml,mfr	wso/wpo	0	20	2	0	1vf	
C1	62-101	37-54	cw	7.5YR 4/4		gcos	0sg		ml,mfr	wso/wpo	0	25	5	0	1vf	
C2	101-110	-	-	7.5YR 4/4, 5/4		gs	0sg		ml,mfi	wso/wpo	0	20	5	0	0	

Pedon Ref. No.: Sylvania #9, subplot #5
Date: 7-15-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R10E, S.23; 46° 12' 05.427" N, 89° 16' 56.467" W
Landform: ground moraine
Parent materials: ice-contact stratified drift
Relief: 3°; 64°/Az.
Elevation (m): 548
Vegetation: old-growth, unfragmented northern hardwoods
Drainage class: moderately well
Effective rooting depth (cm): 27
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-4,4-6	mor	aw	-												
EB	6-17	6-11	cw	5YR 4/3		fsl	1msbk		mfr	wss/wps	0	4	2	0	1vf, f; 2m, co	
Bhs	17-35	12-18	cw	5YR 3/3		msl	1msbk		mfr	wss/wps	0	4	1	0	1vf, f; 2m, co	
Bs1	35-49	14-17	cw	5YR 3/4		ls	1msbk		mfr	wss/wps	0	5	1	0	1f	
Bs2	49-71	4-22	cw	5YR 3/4		gfsl	1msbk		mfi	wss/wps	2npfpo	20	1	0	0	
Bw/Ex	71-96	18-27	aw	5YR 4/4 (90%),10YR 5/4 (10%)		msl	1vcopl		mfi	wss/wps	2mkpfpo	10	1	0	0	
Btx	96-130	-30-48	cw	2.5YR 3/4, 5YR 5/4		sil	3copl		mfi,mvfi	ws/wp	3mkpfpo	2	1	0	0	
C	130-168	-	-	5YR 4/4		fsl	1mgr		mfr	wss/wps	0	10	1	0	0	

Pedon Ref. No.: Sylvania #11, subplot #4,5
Date: 5-25-95
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R40W, S.22; 46° 11' 48.092" N, 89° 18' 04.381" W
Landform: outwash plain
Parent materials: debris flow/outwash
Relief: 7°; complex; 30°/Az.
Elevation (m): 544.6
Vegetation: Old-growth unfragmented, Northern Hardwood
Drainage class: well
Effective rooting depth (cm): 41
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-4,4-5	2-12	aw	moder		-	-	-	-	-	-	-	-	-	3vf,f; 1m, co	
A	5-6	0-2	ab	5YR 2.5/1		sl	2fgr		mvfr	-	-	3	0	0	-	
E	6-14	2-9	aw	7.5YR 4/2		fsl	1msbk		mfr	wss/wps	0	3	0	0	2vf, f; m, co	
Bs1	14-21	8-9	cw	5YR, 7.5YR 3/3		fsl	1msbk		mfr	wss/wps	0	3	10	12	1vf, f; 2m, co	
Bs2	21-39	13-19	cw	5YR 4/6		fsl	1msbk		mfr	wss/wps	0	12	5	12	1vf, f; 2m, co	
2Bs	39-57	16-20	cw	5YR 4/6		gls	1copl	1msbk	mfi	wss/wps	0	18	13	12	1vf, f, m	
3E	57-79	18-24	cw	5YR 4/6		gmsl	2fpl	1fgr	mfi	wso/wpo	0	20	13	2	1vf, f, m	
4Bt	79-143	50-68	gw	5YR 4/4		gfsl	1copl	1fgr	mfr	wso/wps	2n	17	7	2	1f	
5BC	143-150	-	-	5YR 4/4		gls	1fgr		mfr	wso/wpo	0	17	7	2	0	

Pedon Ref. No.: Sylvania #14, subplot #5
Date: 6-16-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: 46° 11' 11.269" N, 89° 15' 53.979" W
Landform: outwash plain
Parent materials: debris flow / outwash
Relief: ~2°; convex complex
Elevation (m):
Vegetation: old-growth, unfragmented northern hardwoods
Drainage class: well
Effective rooting depth (cm): 33
Soil classification: sandy, mixed frigid Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-3,3-4	mor	aw	-		-	-	-	-	-	-	-	-	-	2vf, f	
E	0-9	4-11	aw	5YR 4/2		msl	1fsbk	2fgr	mvfr	wss/wps	0	4	1	0	1vf, f; 2m, co	
Bhs	0-21	9-13	cw	5YR 3/3		msl	1fsbk	2fgr	mvfr	wss/wps	0	4	1	8	2vf, f; 2m, 1co	
Bs	21-43	18-24	cw	5YR 4/4		msl	1msbk	2fgr	mvfr	wss/wps	0	6	1	8	1vf, f; 1m, co	
2BC	43-67	22-27	cw	5YR 4/6		ls	slm	2fgr	mfr,mfi	wso/wpo	0	10	3	5	1vf	
2C1	67-107	39-46	cw	5YR 4/6		gcos	slm	1fgr	mfr,mfi	wso/wpo	0	20	7	0	1vf	
2C2	107-120	-	-	5YR 4/6		gcos	osg		mvfr	wso/wpo	0	20	5	0	0	

Pedon Ref. No.: Sylvania #15
Date: 6-15-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: 46° 10' 49.836" N, 89° 15' 20.023" W
Landform: outwash plain
Parent materials: debris flow/outwash
Relief: 5°; complex (hummocks)
Elevation (m):
Vegetation: old-growth, unfragmented hemlock-hardwoods
Drainage class: well
Effective rooting depth (cm): 52.1
Soil classification: sandy, mixed, frigid Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-1,1-4,4-5	mor	aw	-		-	-	-	-	-	-	-	-	-	3vf, f	
E	5-12	1-8	ai	5YR 4/3		stfsl	1msbk	2fgr	mvfr	wss/wps	0	5	10	15	2vf, f; 3m, co	
Bs1	12-21	8-11	aw	5YR 3/4		stfsl	1msbk	2fgr	mvfr	wss/wps	0	5	10	15	1vf, f; 3m, co	
Bs2	21-42	21-39	cw	5YR 4/3, 3/4		stfsl	1msbk	2fgr	mfr	wss/wps	0	5	10	15	1vf, f; 2m, co	
BC	42-60	7-20	cw	5YR 3/4		kfsl	1msbk	2fgr	mfr	wss/wps	0	20	30	0	1vf, f; 3co	
2C	60-100	20-25	gw	5YR 4/6		klcos	osg		mvfr	wso/wpo	0	25	35	0	1vf	

Pedon Ref. No.: Sylvania #16, subplot #4
Date: 6-22-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: S.26; 46° 10' 42.343" N, 89° 15' 57.134" W
Landform: outwash plain
Parent materials: loess/outwash
Relief: 5°; concave complex; 20°/Az.
Elevation (m): 538.5
Vegetation: old-growth, unfragmented hemlock-hardwoods
Drainage class: well
Effective rooting depth (cm): 35
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-5,5-6	mor	aw	-		-	-	-	-	-	-	--	-	-	3vf, f	
E	6-14	5-9	aw	5YR 4/2		sil	1msbk	2fgr	mfr	wss/wps	0	4	0	0	2vf, 1f, 1m, co	
Bs1	14-26	7-14	cw	5YR 3/4		sil	1msbk	2fgr	mvfr	wss/wps	0	4	0	0	1vf, f; 2m, co	
Bs2	26-44	17-29	cw	7.5YR 4/4		sil	1msbk	2fgr	mfr	wss/wps	0	5	0	0	1vf, f; 3m, 2co	
Bt	44-58	6-37	ci	7.5YR 5/4		sil	1mpl	2fsbk	mfr	wss/wps	2vnpfpo	5	0	0	1f, m	
2BC	58-107	48-52	cw	5YR 4/4		glcos	osg		ml	wso/wpo	0	25	5	1	1vf	
2C	107-128	-		5YR 3/4		ls	massive		mfr	wss/wpo	0	10	2	0	0	

Pedon Ref. No.: Sylvania #18, subplot #2
Date: 6-30-94
Location: Ottawa National Forest, Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R40W, S.23; 46° 11' 27.934" N, 89° 16' 50.475" W
Landform: moraine
Parent materials: till / ice-contact stratified drift
Relief: 9°; concave complex; 250°/Az.
Elevation (m): 541.5
Vegetation: old-growth, unfragmented hemlock-hardwoods
Drainage class: well-drained
Effective rooting depth (cm): 66
Soil classification: coarse-loamy, mixed, superactive frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe/Oa	0-2,2-4,4-7	mor	aw	-		-	-	-	-	-	-	-	-	-	3vf, m; 2co	
E	7-16	7-21	aw	5YR 5/2		msl	1msbk		mfr	wss/wps	0	1	2	0	1vf, f, 3m, co	
Bhs	16-30	14-17	aw	5YR 3/3		msl	1fsbk		mvfr	wss/wps	0	2	2	0	1vf, f; 2co	
Bs	30-64	34-55	cw	5YR 3/4		stmsl	1msbk		mfr	wss/wps	1mpo	2	5	20	1vf, f; 1m, co	
2Bs1	64-87	18-25	cw	5YR 4/4		ls	1msbk	0sg	mfi	wss/wpo	0	2	2	0	1f	
2Bs2	87-111	14-25	aw	5YR 4/4		s	massive	0sg	mfr	wso/wpo	2vnpfpo	2	1	0	1f, m	
3E'x	111-124	6-15	aw	5YR 5/3,5/4		fsl	massive	1cosbk	mfi	wss/wps	2vnpfpo	2	0	0	1f	
3Bt/Ex	124-175	51	cw	2.5YR 4/49 (60%),10YR 6/2 (40%)		sil	3copr		mfi	ws/wp	3mkpfpo	2	0	0	0	
4BC	175-216	-	-	5YR 4/4,wet		gmsl	-			wss/wps	-	20	2	0	0	

Pedon Ref. No.: Clark L.S. / Sylvania Plot 1
Date: ?
Location: Sylvania, Ottawa National Forest, Watersmeet Ranger District, MI
Legal description:
Landform: outwash plain
Parent materials: outwash
Relief: 4°; 142°/Az.
Elevation (m):
Vegetation: Old-growth hemlock
Drainage class: somewhat excessive
Effective rooting depth (cm): 69
Soil classification: sandy, mixed, frigid Entic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oe	0-2	1-4	cw	-		-	-	-	-	-	-	0	0	0	-	
A	2-7	5-12	cw	5YR 2.5/2		ls	1vfgr		mvfr	wss/wpo	0	0	0	0	3vf, f	
E	7-13	3-6	cw	5YR 5/3		ls	1vfgr		mvfr	wss/wpo	0	0	0	0	2vf, f	
Bs1	13-24	4-12	cw	5YR 4/6		ls	1vfgr		mvfr	wss/wpo	0	0	0	0	2vf, f, 1m	
Bs2	24-52	25-42	aw	7.5YR 5/6		ls	1vfgr		mvfr	wss/wpo	0	0	0	0	2vf, f, 1m	
Bs3	52-85	31-42	aw	5YR 5/8		ls	1fbk	1fgr	mvfr	wss/wpo	0	0	0	0	1vf, f, m	
C	85-120	-	-	5YR 6/8		s	1fgr		mvfr	wso/wpo	0	0	0	0	-	

Pedon Ref. No.: Clark L. S. / Sylvania Plot 3
Date: 7-27-01
Location: Sylvania Wilderness Area, Ottawa National Forest, Watersmeet Ranger District, Gogebic Co., MI
Legal description:
Landform: outwash plain
Parent materials: debris flow / outwash
Relief: 2°; 11°/Az.
Elevation (m):
Vegetation: old-growth northern hardwoods
Drainage class: somewhat excessive
Effective rooting depth (cm): 73
Soil classification: sandy, mixed, frigid Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-1	1-2	cw	-	-	-	-	-	-	-	-	0	0	0	-	
AE	1-11	8-13	cw	5YR 3/2		sl	1vfgr		mvfr	wss/wps	-	0	0	0	3vf, f, 2m	
Bs1	11-37	14-27	aw	7.5YR 5/6		ls	1mbk	1vfgr	mvfr	wss/wpo	-	0	0	0	2vf, f; m, 1co	
Bs2	37-69	26-42	aw	5YR 5/6		s	1vfgr		mvfr	wso/wpo	-				2vf, 1f	
C	69-107	-	-	7.5YR 5/4		s	1vfgr		mvfr	wso/wpo	-				-	

Pedon Ref. No.: Sylvania, Plot 4
Date: 5-20-01
Location: Ottawa National Forest, Watersmeet Ranger District, Gogebic Co., MI
Legal description: T44N, R9E, S.16
Landform: outwash plain
Parent materials: outwash sand
Relief: 5°; complex; 213°/Az.
Elevation (m): 532
Vegetation: old-growth hemlock
Drainage class: somewhat excessive
Effective rooting depth (cm): 42
Soil classification: sandy, mixed, frigid Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi/Oe	0-1,1-2	1-4,1-2	aw	mor?		-	-	-	-	-	-	-	-	-	3vf, f; m, co	
E	2-21	10-30	aw	-		ls	1mpl	2msbk	mfr	wso/wpo	0	0	0	0	1vf, f; 2m, co	
Bhs	21-24	1-7	aw	7.5YR 3/3		sl	2msbk		mfr	wss/wps	0	0	0	0	1vf, f; m, co	
Bs1	24-34	9-18	cw	5YR 3/4		ls	1msbk	1fgr	mvfr	wso/wpo	0	0	0	0	1vf, 2f; m, 1co	
Bs2	34-52	10-18	gw	5YR 3/4		sl	1cosbk	2fgr	mfr	wso/wpo	0	0	0	0	1vf, f; 2m, 1co	
C	52-90	-	-	5YR 4/6		s	1fsbk	2fgr	mfr		0	0	0	5	1vf, f; m, co	

Pedon Ref. No.: Sylvania Plot 5
Date: 6-21-99
Location: Ottawa National Forest, Watersmeet Ranger District, Gogebic Co., MI
Legal description: T44N, R40W, S.16
Landform: outwash plain
Parent materials: loess / outwash
Relief: 3°;
Elevation (m): 535.4
Vegetation: Old-growth hemlock
Drainage class: moderately well
Effective rooting depth (cm): 26
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-3	1-7	cw	-		-	-	-	-	-	0	0	0	0	-	
A	3-10	3-10	cw	5YR 2.5/2		sil	1fpl	1fgr	mvf	wss/wps	0	0	0	0	3f, 2vf	
E/Bs	10-25	3-23	cw	7.5YR 5/4		sil	1fpl	1vfgr	mvf	wss/wps	0	0	0	0	2f, 1m	
Ex/Bt	25-65	28-45	cw	7.5YR 6/2, 2.5YR 4/6		sil	1fbk	1fgr	mvf	wss/wps	3	0	0	0	0	
Btx	65-99	30-42	cw	5YR 4/4		sil	1fbk	1fgr	mvf	wss/wps	3	0	0	0	0	
2BC	99-	-	-	2.5YR 3/6		ls	1fgr		mf	wso/wpo	0	0	0	0	0	

Pedon Ref. No.: Sylvania, Plot 6
Date: 6-10
Location: Ottawa National Forest, Ottawa Ranger District, Gogebic Co., MI
Legal description: T44N, R9E, S.16
Landform: outwash plain
Parent materials: outwash
Relief: 21°/Az.
Elevation (m): 544.6
Vegetation: old-growth northern hardwoods
Drainage class: somewhat excessive
Effective rooting depth (cm): 53
Soil classification: sandy, mixed, frigid, Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
O	0-2	1-3	-	mull		-	-	-	-	-	0	0	0	0	3vf, f	
A	2-6	3-6	aw	5YR 2.5/1		sl	1fgr			wso/wpo	0	0	0	0	2vf, f, 1m	
E	6-19	4-17	aw	5YR 4/3		ls	1fbk	1fgr		wso/wps	0	0	0	0	2vf, f, 1m	
Bs1	19-51	20-36	aw	5YR 4/4		sl	1fbk	1fgr		wss/wps	0	0	0	0	1f, m	
Bs2	51-71	36-34	cw	5YR 4/6		ls	1fbk	1fgr		so/po	0	0	0	0	1f, m	
C1	71-82	10-12	aw	7.5YR 4/4		s	1fpr			wso/wpo	0	0	0	0	0	
C2	82-	-	cw	7.5YR 5/6		s	1fgr			wso/wpo	0	2	0	0	0	

Pedon Ref. No.: Sylvania Plot 7
Date: 6-3-99
Location: Ottawa National Forest, Watersmeet Ranger District, Gogebic Co., MI
Legal description: T44N, R9E, S.16
Landform: outwash plain
Parent materials: outwash
Relief: 6°; complex; 352°/Az.
Elevation (m): 544.6
Vegetation: old-growth hemlock
Drainage class: somewhat excessive
Effective rooting depth (cm): 56
Soil classification: sandy, mixed, frigid Typic Haplorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-2	2-6	aw	mull		-	-	-	-	-	-	-	-	-	-	
A	2-5	1-7	aw	5YR 2.5/1		sl	3fgr		ml	wss/wps	0	2	0	0	2vf, f	
E	5-15	0-13	ab	5YR 4/3		ls	1msbk	2fgr	mvfr	wso/wpo	0	2	0	0	1vf, f, 2m	
Bs1	15-26	10-22	cw	2.5YR 3/6		ls	1fsbk	2fgr	mvfr	wso/wpo	0	0	0	0	2vf, f, 3m	
Bs2	26-41	14-33	cw	5YR 4/6		s	1fsbk	2fgr	mvfr	wso/wpo	0	0	0	0	2vf, f, 1m	
BC	41-87	33-47	cw	5YR 4/6		s	m	1fgr	mfr	wso/wpo	0	0	0	0	1vf, f, co	
C1	87-102	10-17	aw	7.5YR 4/4		s	1fgr			wso/wpo	0	0	0	0	1vf	
C2	102-110	-	-	7.5YR 4/4		s	1fgr			wso/wpo	0	0	0	0	0	

Pedon Ref. No.: Sylvania Plot 8
Date: 6-3-99
Location: Sylvania National Forest, Watersmeet Ranger District, Gogebic Co., MI
Legal description: T44N, R9E, S.16
Landform: moraine
Parent materials: till
Relief: 10°; complex; 358°/Az.
Elevation (m): 542
Vegetation: old-growth northern hardwoods
Drainage class: well
Effective rooting depth (cm): 46
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-2	1-6	-	-		-	-	-	-	-	-	-	-	-	-	
A	2-3	1-3	vaw	7.5YR 3/2		sil	2fgr		mvfr	wss/wp	0	0	0	0	3vf, 2f	
E	3-18	11-18	aw	5YR 5/3		sl	1mpl	2fsbk	mfr	wss/wps	0	3	0	0	1vf, 1f; 2mco	
Bs1	18-35	16-18	cw	5YR 3/3		sl	1mpl	2fsbk	mfr	wss/wps	0	3	0	0	1vf, 1f; 2mco	
Bs2	35-53	12-19	aw	7.5YR 4/4		sl	2fpl	2fsbk	mfr	wss/wps	0	0	0	0	1vf, 1f; m,co	
BEx	53-72	15-21	aw	5YR 4/6		sl	1fpl	2fgr	mfi	wss/wps	0	0	0	0	1vf	
Bt/Ex	72-118	28-32	cw	5YR 5/4 (5%),2.5YR 4/4 (95%)		sil	3copr		mvfi	wss/wp	3mkpfpo	0	0	0	0	
BCx	118-216	-	-	2.5YR 3/4		sil	3copr	2fpr	mfi	wss/wps	0	0	0	0	0	

Pedon Ref. No.: Sylvania Plot 9
Date: 6-4-99
Location: Ottawa National Forest; Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R9E, S.16
Landform: moraine
Parent materials: till
Relief: 7°; single;
Elevation (m): 541.5
Vegetation: old-growth hemlock
Drainage class: well
Effective rooting depth (cm): 38
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
O	0-2	1-3	-	-		-	-	-	-	-	0	0	0	0	3vf, 2f	
A	2-7	1-3	aw	5YR 2.5/1		sl	1fpr	1fgr	mvfr	wss/wpo	0	0	0	0	3vf, 3f, 1m	
E	7-15	0-9	aw	5YR 6/2		sl	1mpl	1fgr	mvfr	wss/wpo	0	0	0	0	2vf, 1f	
Bs	15-23	7-14	aw	7.5YR 4/4		l	1mpl	1fgr	mfr	wss/wps	0	0	0	0	2vf, 1f, 1m	
Ex/Bt	23-36	10-13	aw	5YR 6/3, 2.5YR 4/4		sil	1fpl	1fgr	mfi	wss/wps	2pf	0	0	0	1vf, 1f	
Btx	36-111	73-85	cw	2.5YR 4/6		sil	2copr	2fgr	mvfi	ws/wp	3pf	0	0	0	0	
BC	111-122	9-11	aw	5YR 5/3		sil	2fgr	-	mfr	wss/wps	1po	0	0	0	0	
C	122-	-	-	5YR 5/6		l	1fgr	-	ml	sp	0	0	0	0	0	

Pedon Ref. No.: Sylvania Plot 10
Date: 6-14-99
Location: Ottawa National Forest; Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R40W, S.16
Landform: moraine
Parent materials: ice-contact stratified drift
Relief: 7°; complex; 15YAz.
Elevation (m): 535
Vegetation: old-growth northern hardwoods
Drainage class: moderately well
Effective rooting depth (cm): 60
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-15	1-2	cw	mull		-	-	-	-	-	-	-	-	-	-	
A	15-55	2-5	cw	5YR 2.5/1		sl	1fgr		mvfr	wss/wps	0	0	0	0	3vf, f	
E	55-20	3-17	cw	5YR 5/3		sl	1fgr		mvfr	wss/wpo	0	0	0	0	2vf, f, 1m	
2Bs1	20-32	3-15	aw	5YR 3/3		sl	1fbk	1fgr	mvfr	wss/wpo	0	5	0	0	2vf, f, 1m	
2Bs2	32-47	10-18	aw	5YR 4/6		ls	1fbk	1fgr	mvfr	wss/wpo	0	5	0	0	1vf, f, m	
2Bs3	47-67	20-25	cw	5YR 4/4		ls	1fbk	1fgr	mvfr	wss/wpo	0	0	0	0	1f, m	
2Bs4	67-95	25-31	cw	5YR 4/6		ls	1fbk	1fgr	mfr	wss/wpo	0	0	0	0	1f, m	
2Ex/Bt2	95-104	8-10	cw	7.5YR 4/6		sil	2fbk	1fgr	mvfr	wss/wps	3	0	0	0	0	
2Ex/Bt1	104-137	30-35	cw	7.5YR 5/4, 2.5YR 4/6		sil	2fbk	1fgr	mvfr	ws/wp	3	0	0	0	0	
2BC	137-	-	-	2.5YR 3/4		sl	1fgr	1fgr	mfr	wss/wpo	0	20	0	0	0	

Pedon Ref. No.: Sylvania Plot 11
Date: 6-15-99
Location: Ottawa National Forest; Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R40W, S.16
Landform: moraine
Parent materials: till
Relief: 4°;
Elevation (m): 535
Vegetation: old-growth hemlock
Drainage class: well
Effective rooting depth (cm): 79
Soil classification: coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	(cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi	0-4.5	3-7	cw	-		-	-	-	-	-	0	0	0	0	-	
A	4.5-9	2-5	cw	5YR 2.5/1		sl	1fgr		mvfr		0	0	0	0	2vf,f	
E	9-26	7-24	cw	5YR 6/3		ls	1fgr		mvfr	ss/po	0	0	0	0	2vf,f; 1m	
Bs1	26-36	4-12	aw	5YR 3/4		ls	1fgr		mvfr	ss/po	0	2	2	0	2vf,f; 1m	
Bs2	36-74	15-47	cw	5YR 5/8		s	1fgr		mvfr	so/ps	0	2	2	0	2vf,f; 1m	
C	74-94	11-23	cw	7.5YR 5/4		sil	1fsbk	1fgr		ss/ps	2npfpo	0	0	0	1vf, f	
Ex	94-126	30-38	cw	5YR 5/6		ls	1fgr			so/po	0	0	0	0	0	
Btx	126-210	60-65	cw	2.5YR 4/6		sil	1fsbk	1fgr		ss/p	3npfpo	0	0	0	0	
BC	210-	-	-	5YR 4/6		sl	1fbsk	1fgr		so/po	0	0	0	0	0	

Pedon Ref. No.: Sylvania Plot 12
Date: 5-19-91
Location: Silvania Wilderness Area; Ottawa National Forest; Watersmeet Ranger District; Gogebic Co., MI
Legal description: T44N, R9E, S.16; SW 1/4 of NW1/4
Landform: outwash plain
Parent materials: loess/outwash
Relief: 0 deg slope
Elevation (m): 550
Vegetation: old-growth northern hardwoods
Drainage class: well
Effective rooting depth (cm): 16
Soil classification: coarse-silty, mixed, superactive, frigid Alfic Oxyaquic Fragiorthods

	Depth	Thickness	Boun-	Munsell color (moist)		Field	Structure		Consistence		Clay	Gravel	Cobbles	Stones		
Horizon	(cm)	cm)	dary	matrix	mottles	texture	Primary	Secondary	Moist	Wet	films	%	%	%	Roots	Miscellaneous
Oi, Oe	0-1, 1-2															
Oa	2-6		aw	10R 2.5/1		muck	3fgr		mvfr	wso/psp	0	0	0	0	3m,co	
EB	6-15		aw	7.5YR 4/3		sil	3fgr		mfr	wss/wps	0	0	0	0	1vf	fine charcoal
E/Bx	15-25		cw	7.5YR 4/3 (70%); 5YR 4.4 (30%)		sil	1copl	2vfsbj	mfi	ws/wps	0	0	0	0	1co	
Btx1	25-40		cw	2.5YR 4/4		sil	2mpl	1fsbk	mfi	ws/wp	0	0	0	0	0	
Btx2	40-63		cw	2.5YR 3/3		sicl	2mpl	1fsbk	mfi	ws/wp	0	0	0	0	0	
Btx3	63-105		cw	2.5YR 4/4		sil	massive		mfi	wvs/wp	0	0	0	0	0	
BC	105-150					sil				wss/wps	0	0	0	0	0	
C	150-165					sil				wss/wps	0	0	0	0	0	
2C	165-180					fsl				wso/wps	0	0	0	0	0	
3C	180-185					sl				wso/wps	0	0	0	0	0	

Bockheim, James G.; Jordan, J.K.
2004. **Soils of the Sylvania Wilderness-Recreation Area, western Uppper Peninsula, Michigan**. Gen. Tech. Rep. NC-237. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 18 p.

Characterizes 22 soil profiles in the Sylvania Wilderness-Recreation Area on the Ottawa National Forest, including soil descriptions and laboratory data. A soil map at a scale of 1:24,000 is provided. The genesis of the soils is discussed.

KEY WORDS: parent soils, soil development, soil classification, bisequal soils.

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