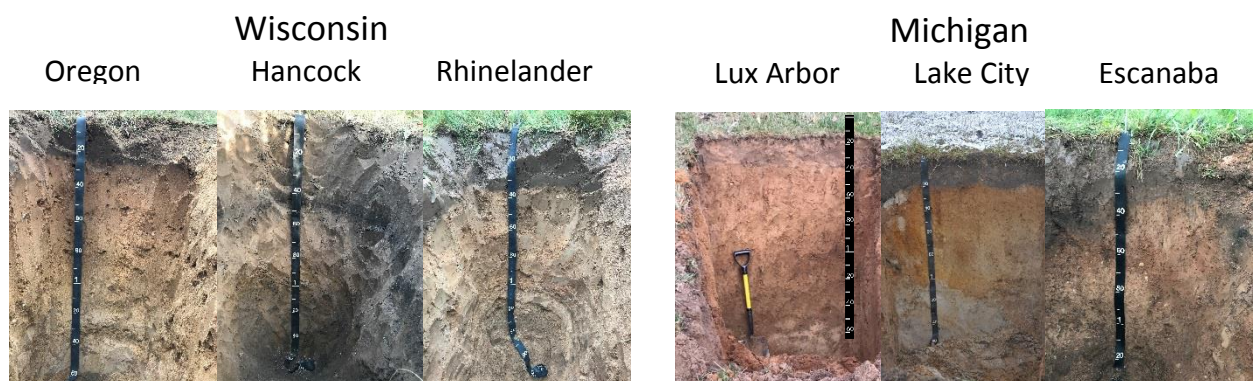
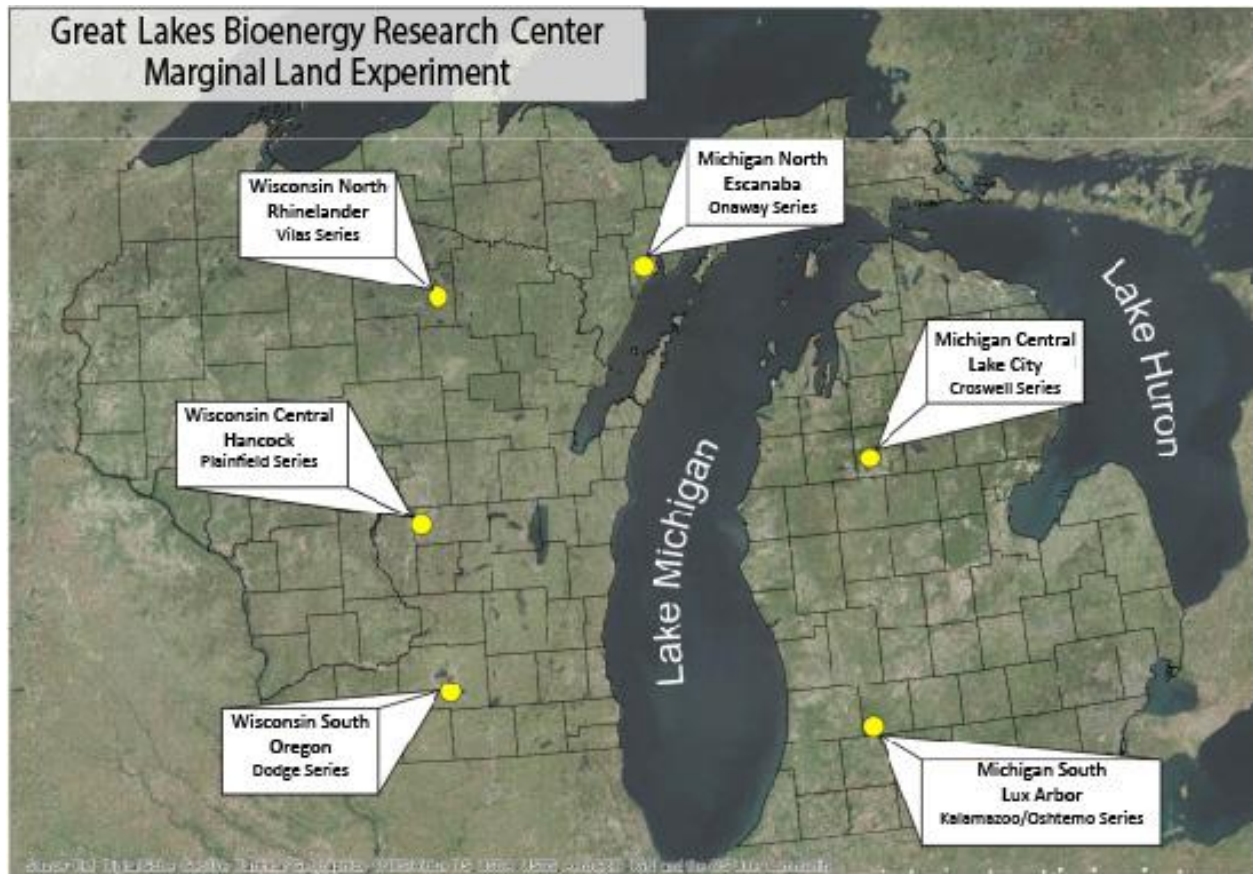


Soils of the GLBRC Marginal Land Experiment (MLE) Sites

C. S. Kasmerchak and R. Schaetzl

Department of Geography, Environmental, and Spatial Sciences
Michigan State University

December 2018



Suggested citation: Kasmerchak, C. S. and R. Schaetzl. 2018. Soils of the GLBRC Marginal Land Experiment (MLE) Sites. Kellogg Biological Station Long-term Ecological Research Special Publication. Zenodo. <http://doi.org/10.5281/zenodo.2578238>.

INTRODUCTION

The Great Lakes Bioenergy Research Center (GLBRC) Marginal Land Experiment (MLE) was established in 2013 at various sites in Wisconsin and Michigan to evaluate the potential use of low productivity or abandoned agricultural fields for low input bioenergy feedstocks. Three sites in Michigan and three sites in Wisconsin were initially established and are distributed in the southern, central and northern part of each state (see front cover). In 2018 the Wisconsin South site (Oregon, WI) was retired from the MLE due to high fertility soils.

Six different biofuel cropping systems from the GLBRC Biofuel Cropping Systems Experiment (<https://lter.kbs.msu.edu/research/long-term-experiments/glbrc-intensive-experiment/>) are replicated in each of 4 blocks at each site. The systems include switchgrass (*Panicum virgatum* variety Cave-in-rock), miscanthus (G6, *Miscanthus x giganteus*), native Grasses (G7, a 5-species mix), hybrid poplar (G8, “NM-6”, *Populus nigra x populus maximowiczii*), early successional vegetation (G9), and restored prairie (G10, 18-species mix including forbs, grasses and legumes). There is also an historical vegetation (G11, unplanted) reference treatment.

For more information on the design and management of the MLE, as well as land use history, see <https://lter.kbs.msu.edu/research/long-term-experiments/marginal-land-experiment/>.

PURPOSE OF THE PRESENT STUDY

The present study represents a taxonomic survey of the physical, morphological, and chemical attributes of MLE site soils.

APPROACH

Soil pits were dug to about 1.5 m either by hand or by backhoe in October and November, 2017. Soil horizons were delineated, measured, and characterized. Composite soil samples were collected from each horizon and stored in plastic bags for further analyses. All physical and chemical variates, except for bulk density and carbon and nitrogen contents, were determined by the MSU Soil and Plant Nutrient Laboratory (<http://www.spnl.msu.edu/>). Bulk density was determined in a laboratory in the MSU Geography Department. Carbon and nitrogen contents were determined by the LTER core facilities laboratory.

Data tables are available for download at <https://lter.kbs.msu.edu/datatables/587>.

Michigan South – Lux Arbor

Location: Lux Arbor Reserve, Hickory Corners MI [42.4764, -85.4519]

Soil series: Kalamazoo/Oshtemo

Taxonomic class: Typic Hapludalf (Alfisol)

Description of soil profile:

This site consists of well-drained soils that formed in pitted outwash with a thin loess cap, as indicated by fine textures in the upper profile. It is found on a 0-3% slope. A lithological discontinuity is described between the loess and the underlying outwash. Erosion may have occurred by deep tillage at some point during past land cultivation. There is no evidence of a high or fluctuating water table (redoximorphic features were absent), and there are some vertical worm burrows into the Bt horizon indicating bioturbation. No effervescence was observed in the 2BC or 2C horizons, indicating that carbonates are absent in this profile.



Soil profile (to 1.6 m) at Lux Arbor.
Tape scale is in cm.

- Ap 0-19 cm; dull yellowish brown (10 YR 4/3 moist) loam; moderate medium and fine subangular blocky structure; moist friable to firm consistence; 2% gravel; abrupt irregular boundary.
- Bt1 19-52 cm; brown (7.5 YR 4/6 moist) clay loam; moderate medium and coarse subangular blocky structure; moist firm consistence; 2% gravel; gradual smooth boundary.
- Bt2 52-82 cm; brown (10 YR 4/4 moist) clay loam; moderate coarse and very coarse subangular blocky structure; moist firm consistence; 2% gravel; gradual smooth boundary.
- Bt3 82-104 cm; brown (10 YR 4/4 moist) loam; moderate medium and coarse subangular blocky structure; moist firm consistence; 2% gravel; gradual smooth boundary.
- Bw 104-123 cm; brown (10 YR 4/6 moist) loam; weak fine and medium subangular blocky structure; friable moist consistence; 2% gravel; gradual smooth boundary.
- 2BC 123-140 cm; brown (10 YR 4/6 moist) sandy loam; structureless; moist, very friable consistence; 2% gravel; abrupt wavy boundary.
- 2C 140+ cm; yellowish brown dull brown (10 YR 5/4 moist) sand with finer layers of dull yellowish brown (10 YR 4/3 moist); loamy sand matrix with loam texture in finer layers; structureless; moist friable consistence for matrix and moist loose consistence for finer layers; 2% gravel; sands with strata of loam that are 3-4 cm thick.

Table 1. Soil physical and morphological attributes of Michigan South – Lux Arbor.*

Horizon	Depth (cm)	Munsell Color (moist)	Structure†	Boundary	Texture (%)			Texture Class	Bulk Density‡ (g/cm³)	Porosity§ (%)
					Sand	Silt	Clay			
Ap	0-19	10YR 4/3	m, m-f, sbk	abrupt irregular	51.1	31.7	17.2	Loam	1.75 ± 0.09	34.1 ± 3.5
Bt1	19-52	7.5YR 4/3	m, m-c, sbk	gradual smooth	59.1	15.7	25.2	Sandy Clay Loam	1.73 ± 0.12	33.2 ± 4.7
Bt2	52-82	7.5YR 4/6	m, c-vc, sbk	gradual smooth	57.1	23.7	19.2	Sandy Loam	1.73 ± 0.19	34.9 ± 7.1
Bt3	82-104	10YR 4/4	m, m-c, sbk	gradual smooth	64.1	20.7	15.2	Sandy Loam	1.73 ± 0.09	37.6 ± 3.2
Bw	104-123	10YR 4/6	w, f-m, sbk	gradual smooth	64.1	22.7	13.2	Sandy Loam	1.73 ± 0.03	34.5 ± 1.1
2BC	123-140	10YR 4/6	loose	abrupt wavy	80.0	12.4	7.6	Loamy Sand	1.69 ± 0.02	34.2 ± 0.6
2C	140-160+	10YR 5/4	loose	-	92.6	3.9	3.5	Sand	1.53 ± 0.01	34.8 ± 0.3

*sampled on 8 Nov 2017; soil pit at 42.4773, -85.4517

†w = weak; f = fine; m = medium; c = coarse; gran = granular; sbk = subangular blocky

‡gravel-free (n=2, ± standard deviation)

§based on bulk density calculations (n=2, ± standard deviation)

Table 2. Soil chemical attributes of Michigan South – Lux Arbor.*

Horizon	Depth (cm)	pH†	Inorg P‡	K	Ca	Mg	Na	CEC (cmol/kg)	Base Saturation	Org C	Total N	C:N	Inorg C (%)
Ap	0-19	5.8	12	52	674	70	6	8.80	46.7	0.77	0.06	12.6	<0.01
Bt1	19-52	5.9	25	85	1316	179	21	11.80	71.0	0.21	0.02	9.69	<0.01
Bt2	52-82	6.2	15	72	1047	225	8	10.00	73.3	0.13	0.01	10.2	<0.01
Bt3	82-104	6.0	20	51	673	184	10	7.70	65.9	0.09	0.01	9.25	<0.01
Bw	104-123	6.1	35	60	728	228	13	6.70	85.8	0.05	0.00	10.2	<0.01
2BC	123-140	6.2	28	39	494	131	0.1	4.10	89.3	0.04	0.01	7.55	<0.01
2C	140-160+	8.3	9	20	775	34	3	0.80	100	<0.01	0.00	<0.01	0.91

*sampled on 8 Nov 2017; soil pit at 42.4773, -85.4517

†1:1 dry soil/water suspension

‡Bray-Kurtz P1 extraction

Michigan Central – Lake City

Location: Lake City Experiment Station, Lake City MI [44.2961, -85.1996]

Soil series: Croswell

Taxonomic class: Oxyaquic Haplorthod (Spodosol)

Description of soil profile:

This site consists of moderately well-drained soils that formed in outwash or sandy till over sandy outwash and/or a redder, finer-textured, glacial till. It occurs on 0-3% slopes. No major evidence of erosion was observed at the site, although it may have occurred by deep tillage at some point during past land cultivation and land clearing practices. There is no evidence of a high-water table, but a few mottles (5 YR 4/6 moist) and patches of brown (7.5 YR 5/4 moist) silty clay to loam material were present in the lower profile, indicative of water table fluctuations. There is no evidence of bioturbation. No effervescence was observed in the BC, C, or 2C horizons, indicating that carbonates are absent in this profile.



Soil profile (to 1.6 m) at Lake City.
Tape scale is in cm.

- Ap 0-20 cm; dark brown (10 YR 3/3 moist) sandy loam; weak fine granular structure; moist, very friable consistence; 2% gravel; abrupt smooth boundary.
- Bs1 20-33 cm; brown (7.5 YR 4/6 moist) sandy loam; weak fine and medium subangular blocky structure; moist, very friable consistence; 2% gravel; gradual broken boundary.
- Bs2 33-62 cm; brown (10 YR 4/6 moist) loamy sand; weak fine and medium subangular blocky structure; moist, very friable consistence; 2% gravel; gradual irregular boundary.
- Bs3 62-95 cm; bright brown (10 YR 5/6 moist) loamy sand; weak medium and coarse subangular blocky structure; moist, very friable consistence; 2% gravel; gradual broken boundary.
- BC 5-120 cm; bright brown (10 YR 5/8 moist) loamy sand; structureless; moist loose consistence; 2% gravel; abrupt broken boundary; few fine and medium prominent mottles (5 YR 4/6 moist) and few patches of brown (7.5 YR 5/4 moist) silty clay to loam material 2-30 cm in diameter.
- C 120-160+ cm; dull brown (10 YR 6/3 moist) sand; structureless; moist loose consistence; 2% gravel.
- 2C bright reddish brown (5 YR 5/8 moist) intermittently on the side of the pit; silty clay; moist, very friable consistence; common brown (10 YR 5/3 moist) medium prominent mottles; 0% gravel.

Table 3. Soil physical and morphological attributes of Michigan Central – Lake City.*

Horizon	Depth (cm)	Munsell Color (moist)	Structure†	Boundary	Texture (%)			Texture Class	Bulk Density‡ (g/cm³)	Porosity§ (%)
					Sand	Silt	Clay			
Ap	0-20	10YR 3/3	w, f, gran	abrupt smooth	84.7	7.8	7.5	Loamy sand	1.51 ± 0.23	58.2 ± 8.5
Bs1	20-33	7.5YR 4/6	w, f-m, sbk	gradual broken	85.7	6.8	7.5	Loamy sand	1.45 ± 0.02	52.7 ± 0.7
Bs2	33-62	10YR 4/6	w, f-m, sbk	gradual irregular	87.7	5.8	6.5	Loamy sand	1.61 ± 0.05	52.0 ± 1.8
Bs3	62-95	10YR 5/6	w, m-c, sbk	gradual broken	93.7	1.9	4.4	Sand	1.70 ± 0.02	51.1 ± 0.6
BC	95-120	10YR 5/8	loose	gradual broken	93.7	1.8	4.5	Sand	1.53 ± 0.12	54.8 ± 4.6
C	120-160	10YR 6/3	loose	-	91.7	3.9	4.4	Sand	1.81 ± 0.01	58.2 ± 0.2
2C	Intermittent	10YR 5/8	w, m-c, sbk	-	58.4	14.6	27.0	Sandy clay loam	1.77 ± 0.04	57.4 ± 1.4

*sampled on 16 Nov 2017; soil pit at 44.2959, -85.1995

†w = weak; f = fine; m = medium; c = coarse; gran = granular; sbk = subangular blocky

‡gravel-free (n=2, ± standard deviation)

§based on bulk density calculations (n=2, ± standard deviation)

Table 4. Soil chemical attributes of Michigan Central – Lake City.*

Horizon	Depth (cm)	pH†	Inorg P‡	K	Ca	Mg	Na	CEC (cmol/kg)	Base Saturation (%)	Org C	Total N	C:N	Inorg C (%)
Ap	0-20	7.3	24	45	760	101	229	5.60	100	0.92	0.06	14.4	<0.01
Bs1	20-33	7.3	46	46	598	113	118	3.90	100	0.51	0.02	23.6	<0.01
Bs2	33-62	6.9	40	42	344	64	19	2.30	100	0.29	0.02	17.6	<0.01
Bs3	62-95	7.2	24	22	113	39	5	0.60	100	0.11	0.00	34.0	<0.01
BC	95-120	7.1	14	18	103	44	169	0.60	100	0.10	0.00	24.6	<0.01
C	120-160	7.1	10	22	35	45	20	0.40	100	0.04	0.00	23.3	<0.01
2C	Intermittent	6.8	4	144	905	482	92	7.50	100	0.13	0.01	12.7	<0.01

*sampled on 16 Nov 2017; soil pit at 44.2959, -85.1995

†1:1 dry soil/water suspension

‡Bray-Kurtz P1 extraction

Michigan North – Escanaba

Location: Forest Biomass Innovation Center, Escanaba MI [45.7627, -87.1877]

Soil series: Onaway

Taxonomic class: Inceptic Hapludalf (Alfisol)

Description of soil profile:

This site consists of well drained and moderately well-drained soils that formed in gravelly sandy loam till, on 0-3% slopes. No major evidence of erosion was observed at the site, although it may have occurred by deep tillage or erosion at some point during past land cultivation and land clearing practices. There is no evidence of a high water table or of bioturbation. Some faint mottles were observed in the lower profile, indicating some water table fluctuations. Strong effervescence was observed in the C horizon, indicating the presence of abundant carbonates in the soil parent material.



Soil profile (to 1.2 m) at Escanaba.
Tape scale is in cm.

- Ap 0-23 cm; dark brown (10 YR 3/3 moist); sandy loam; weak fine granular structure; moist friable consistence; 2% gravel; abrupt wavy boundary.
- Bs1 23-44 cm; brown (7.5 YR 4/3 moist) sandy loam; moderate fine and medium subangular blocky structure; moist friable consistence; 5% gravel; abrupt broken boundary.
- Bs2 44-55 cm; dull reddish brown (5 YR 4/4 moist) sandy loam; moderate fine and medium subangular blocky structure; moist friable consistence; 5% gravel; irregular wavy boundary.
- Bt 55-70 cm; brown (7.5 YR 4/4 moist) loam; moderate medium and coarse subangular blocky structure; moist firm consistence; 10% gravel; gradual smooth boundary.
- C 70-180+ cm; dull yellowish brown (10 YR 5/4 moist) gravelly sandy loam; structureless; moist loose consistence; 10% gravel; few fine and medium faint mottles (7 YR 4/6 moist).

Table 5. Soil physical and morphological attributes of Michigan North – Escanaba.*

Horizon	Depth (cm)	Munsell Color (moist)	Structure†	Boundary	Texture (%)			Texture Class	Bulk Density‡ (g/cm³)	Porosity§ (%)
					Sand	Silt	Clay			
Ap	0-23	10YR 3/3	w, f, gran	abrupt wavy	57.1	27.7	15.2	Sandy Loam	1.26 ± 0.16	42.4 ± 6.1
Bs1	23-44	7.5YR 4/3	m, f-m, sbk	abrupt broken	55.1	28.7	16.2	Sandy Loam	1.30 ± 0.03	45.8 ± 1.3
Bs2	44-55	5YR 4/4	m, f-m, sbk	irregular wavy	49.1	23.7	27.2	Sandy Clay Loam	1.01 ± 0.18	40.1 ± 6.8
Bt	55-70	7.5YR 4/4	m, f-m, sbk	gradual smooth	55.1	25.7	19.2	Sandy Loam	1.25 ± 0.14	39.0 ± 5.4
C	70-108+	10YR 5/4	structureless	-	55.1	25.7	19.2	Sandy Loam	1.30 ± 0.05	41.6 ± 1.7

*sampled on 7 Oct 2017; soil pit at 45.7635, -87.18701

†w = weak; f = fine; m = medium; c = coarse; gran = granular; sbk = subangular blocky

‡gravel-free (n=2, ± standard deviation)

§based on bulk density calculations (n=2, ± standard deviation)

Table 6. Soil chemical attributes of Michigan North – Escanaba.*

Horizon	Depth (cm)	pH†	Inorg P‡	K	Ca	Mg	Na	CEC (cmol/kg)	Base Saturation	Org C	Total N	C:N	Inorg C (%)
Ap	0-23	7.0	14	43	1305	151	16	10.40	76.6	1.73	0.15	11.4	<0.01
Bs1	23-44	7.4	3	34	822	96	12	5.80	87.1	0.38	0.03	12.7	<0.01
Bs2	44-55	7.6	1	63	1480	212	14	10.80	86.9	0.51	0.06	9.20	0.35
Bt	55-70	8.1	1	43	4074	138	25	7.10	100	<0.01	0.01	<0.01	2.70
C	70-108+	8.1	1	44	4116	133	17	5.00	100	<0.01	0.01	<0.01	3.15

* sampled on 7 Oct 2017; soil pit at 45.7635, -87.18701

†1:1 dry soil/water suspension

‡Bray-Kurtz P1 extraction

Wisconsin North – Rhinelander

Location: Rhinelander WI [45.6656, -89.2180]

Soil series: Vilas

Taxonomic class: Entic Haplorthod (Spodosol)

Description of soil profile:

This site consists of well-drained soils that formed in sandy outwash deposits on outwash plains of 0-3% slopes. No major evidence of erosion was observed at the site, although it may have occurred by deep tillage or erosion at some point during past land cultivation and land clearing practices. There is no evidence of a high water table or of bioturbation. No effervescence was observed in the 2BC, 2C1, or 2C2 horizons, indicating that carbonates are absent in this profile.

- Ap 0-23 cm; dark brown (10 YR 3/3 moist) sandy loam; weak fine granular structure; moist friable consistence; 2% gravel; abrupt wavy boundary.
- Bw1 23-63 cm; brown (10 YR 4/4 moist) sandy loam; weak fine and medium subangular blocky structure; moist friable to firm consistence; 5% gravel; smooth gradual boundary.
- Bw2 63-84 cm; brown (7.5 YR 4/6 moist) sandy loam; weak medium subangular blocky structure; moist friable to firm consistence; 5% gravel; smooth gradual boundary.
- 2BC 84-100 cm; brown (10 YR 4/4 moist) sand texture; structureless; loose moist consistence; 10% gravel; gradual smooth boundary.
- 2C1 100-109 cm; dull yellowish brown (10 YR 5/4 moist); gravelly sand texture; structureless; loose moist consistence; 10% gravel.
- 2C2 109-150+ cm; yellowish brown (10YR 5/6 moist); gravelly sand texture; structureless; loose moist consistence; 10% gravel.



Soil profile (to 1.4 m) at Rhinelander. Tape scale is in cm.

Table 7. Soil physical and morphological attributes of Wisconsin North – Rhinelander.*

Horizon	Depth (cm)	Munsell Color (moist)	Structure†	Boundary	Texture (%)			Texture Class	Bulk Density‡ (g/cm³)	Porosity§ (%)
					Sand	Silt	Clay			
Ap	0-23	10YR 3/3	w, f, gran	abrupt wavy	59.1	25.8	15.1	Sandy Loam	1.35 ± 0.20	47.5 ± 7.6
Bw1	23-63	10YR 4/4	w, f-m, sbk	gradual smooth	72.6	18.4	9.0	Sandy Loam	1.48 ± 0.02	52.4 ± 0.6
Bw2	63-84	7.5YR 4/6	w, m, sbk	gradual smooth	78.1	13.4	8.5	Sandy Loam	1.42 ± 0.01	51.7 ± 0.4
2BC	84-100	10YR 4/4	structureless	gradual smooth	87.6	5.9	6.5	Gravelly Loamy Sand	1.60 ± 0.01	51.1 ± 0.4
2C1	100-109	10YR 5/4	structureless	diffuse smooth	92.6	1.4	6.0	Gravelly Sand	1.28 ± 0.16	55.1 ± 6.2
2C2	109-150+	10YR 5/6	structureless	-	95.1	0.4	4.5	Gravelly Sand	1.45 ± 0.09	61.9 ± 3.3

*sampled on 7 Oct 2017; soil pit at 45.6658, -89.2157

†w = weak; f = fine; m = medium; c = coarse; gran = granular; sbk = subangular blocky

‡gravel-free (n=2, ± standard deviation)

§based on bulk density calculations (n=2, ± standard deviation)

Table 8. Soil chemical attributes of Wisconsin North – Rhinelander.*

Horizon	Depth (cm)	pH†	Inorg P‡	K	Ca	Mg	Na	CEC (cmol/kg)	Base Saturation (%)	Org C	Total N	C:N	Inorg C (%)
Ap	0-23	5.7	193	105	409	53	2	7.60	36.4	1.09	0.07	15.9	<0.01
Bw1	23-63	5.9	27	81	234	67	3	3.30	59.1	0.13	0.00	29.0	<0.01
Bw2	63-84	5.5	22	74	294	76	8	3.90	59.7	0.08	0.01	14.9	<0.01
2BC	84-100	5.9	26	88	262	41	8	2.40	79.7	0.04	0.00	13.6	<0.01
2C1	100-109	5.6	23	68	159	18	n.d.	1.00	100	0.02	0.00	26.6	<0.01
2C2	109-150+	6.1	22	76	165	18	n.d.	0.40	100	0.03	0.00	15.3	<0.01

*sampled on 7 Oct 2017; soil pit at 45.6658, -89.2157

†1:1 dry soil/water suspension

‡Bray-Kurtz P1 extraction

Wisconsin Central – Hancock

Location: Hancock WI [44.1194, -89.5338 and 44.1129, -89.5334]

Soil series: Plainfield

Taxonomic class: Typic Udipsamment (Entisol)

Description of soil profile:

This site consists of excessively drained soils that formed in sandy outwash on outwash plains of 0-3% slopes. No major evidence of erosion was observed at the site, although it may have occurred by deep tillage or erosion at some point during past land cultivation and land clearing practices. There is no evidence of a high water table or of bioturbation. No effervescence was observed in the BC or C horizons, indicating that carbonates are absent in this profile.

- | | |
|-----|--|
| Ap | 0-23 cm; dark brown (7.5 YR 3/3 moist) loamy sand ; weak fine granular structure; moist, very friable consistence; 2% gravel; abrupt smooth boundary. |
| Bw1 | 23-59 cm; brown (10 YR 4/4 moist) loamy sand; weak fine and medium subangular blocky structure; moist, very friable consistence; 2% gravel; gradual smooth boundary. |
| Bw2 | 59-89 cm; yellowish brown (10 YR 5/6 moist) loamy sand; weak fine and medium subangular blocky structure; moist, very friable consistence; 2% gravel; diffuse smooth boundary. |
| Bw3 | 89-107 cm; yellowish brown (10 YR 5/6 moist) sand; weak medium subangular blocky structure; moist, very friable consistence; 2% gravel; gradual smooth boundary. |
| BC | 107-133 cm; yellowish gray (2.5 Y 5/4 moist) sand; structureless; moist loose consistence; 2% gravel. |
| C | 133-150+ cm; light yellow (2.5 Y 7/4 moist) sand; structureless; moist loose consistence; 2% gravel. |



Soil profile (to 1.6 m) at Hancock.
Tape scale is in cm.

Table 9. Soil physical and morphological attributes of Wisconsin Central – Hancock.*

Horizon	Depth (cm)	Munsell Color (moist)	Structure†	Boundary	Texture (%)			Texture Class	Bulk Density‡ (g/cm³)	Porosity§ (%)
					Sand	Silt	Clay			
Ap	0-23	7.5YR 3/3	w, f, gran	abrupt smooth	87.6	5.9	6.5	Loamy Sand	1.44 ± 0.03	35.8 ± 1.0
Bw1	23-59	10YR 4/4	w, f-m, sbk	gradual smooth	90.6	4.4	5.0	Sand	1.62 ± 0.07	34.7 ± 2.6
Bw2	59-89	10YR 5/6	w, f-m, sbk	diffuse smooth	93.6	3.9	2.5	Sand	1.84 ± 0.07	34.7 ± 2.6
Bw3	89-107	10YR 5/6	w, m, sbk	diffuse smooth	95.1	0.4	4.5	Sand	1.55 ± 0.01	36.3 ± 0.3
BC	107-133	2.5Y 5/4	structureless	diffuse smooth	94.6	2.9	2.5	Sand	1.15 ± 0.20	41.4 ± 7.5
C	133-150+	2.5Y 7/4	structureless	-	94.6	0.9	4.5	Sand	1.54 ± 0.16	42.4 ± 6.1

*sampled on 6 Oct 2017; soil pit at 44.1192, -89.5340

†w = weak; f = fine; m = medium; c = coarse; gran = granular; sbk = subangular blocky

‡gravel-free (n=2, ± standard deviation)

§based on bulk density calculations (n=2, ± standard deviation)

Table 10. Soil chemical attributes of Wisconsin Central – Hancock.*

Horizon	Depth (cm)	pH†	Inorg P‡	K	Ca	Mg	Na	CEC (cmol/kg)	Base Saturation	Org C	Total N	C:N	Inorg C (%)
Ap	0-23	6.3	128	84	413	74	42	3.40	90.6	0.69	0.05	12.7	<0.01
Bw1	23-59	6.1	216	86	232	49	17	1.60	100	0.23	0.02	11.8	<0.01
Bw2	59-89	6.4	321	40	113	9	8	0.50	100	0.12	0.01	14.6	<0.01
Bw3	89-107	6.6	136	36	99	15	8	0.20	100	0.09	0.01	8.28	<0.01
BC	107-133	6.6	132	25	89	2	16	0.20	100	0.06	0.01	11.1	<0.01
C	133-150+	6.1	115	53	84	5	n.d.	0.10	100	0.06	0.01	6.98	<0.01

*sampled on 6 Oct 2017; soil pit at 44.1192, -89.5340

†1:1 dry soil/water suspension

‡Bray-Kurtz P1 extraction

Wisconsin South – Oregon

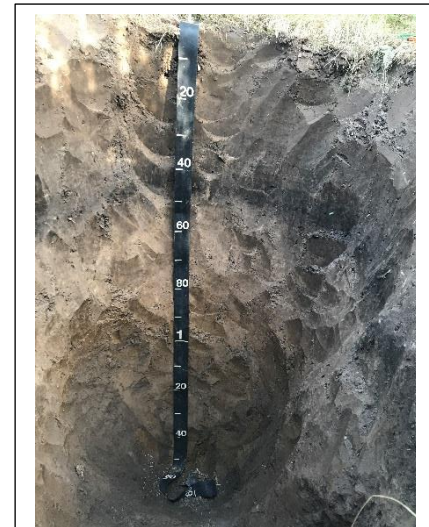
Location: Oregon WI [42.9661, -89.3561]

Soil series: Dodge

Taxonomic class: Typic Hapludalf (Alfisol)

Description of soil profile:

This site consists of well-drained soils that formed in loess over sandy clay loam glacial till, on 0-3% slopes. No major evidence of erosion was observed at the site, although it may have occurred by deep tillage or erosion at some point during past land cultivation and land clearing practices. There is no evidence of a high-water table or of bioturbation. No effervescence was observed in the lower horizons, indicating that carbonates are absent in this profile. The soil pit was excavated to 150 cm, which did not penetrate the lowest Bt horizon. It may be possible that carbonates exist deeper in the parent material.



Soil profile (to 1.5 m) at Oregon.
Tape scale is in cm.

- | | |
|------|--|
| Ap | 0-14 cm; dark brown (10 YR 3/3 moist) silt loam; moderate fine granular structure; moist friable consistence; 2% gravel; abrupt smooth boundary |
| Bt1 | 14-27 cm; dark brown (10 YR 3/4 moist) silt loam; weak fine and medium subangular blocky structure; moist friable consistence; 2% gravel; gradual smooth boundary. |
| Bt2 | 27-50 cm; dull yellowish brown (10 YR 4/3 moist) silty clay loam; moderate fine and medium subangular blocky structure; moist friable consistence; 2% gravel; gradual wavy boundary. |
| Bt3 | 50-73 cm; dull yellowish brown (10 YR 4/3 moist) silty clay loam; moderate medium and coarse subangular blocky structure; moist friable consistence; 2% gravel; gradual smooth boundary. |
| Bt4 | 73-92 cm; dull yellowish brown (10 YR 4/3 moist) silty clay loam; moderate coarse subangular blocky structure; moist firm consistence; 2% gravel; diffuse smooth boundary. |
| 2Bt5 | 92-140 cm; dull yellowish brown (10 YR 4/3 moist) sandy clay loam; moderate medium to coarse subangular blocky structure; moist firm consistence; 2% gravel; gradual smooth boundary. |
| 2Bt6 | 140+ cm; dull yellowish brown (10 YR 4/3 moist) sandy clay loam; moderate coarse subangular blocky structure; moist firm consistence; 2% gravel. |

Table 11. Soil physical and morphological attributes of Wisconsin South – Oregon.*

Horizon	Depth (cm)	Munsell Color (moist)	Structure†	Boundary	Texture (%)			Texture Class	Bulk Density‡ (g/cm³)	Porosity§ (%)
					Sand	Silt	Clay			
Ap	0-14	10YR 3/3	m, f, gran	abrupt smooth	9.1	74.8	16.1	Silt Loam	1.11 ± 0.37	30.4 ± 14.2
Bt1	14-27	10YR 3/4	w, f-m, sbk	gradual smooth	11.1	71.8	17.1	Silt Loam	1.13 ± 0.41	31.3 ± 15.5
Bt2	27-50	10YR 4/3	m, f-m, sbk	gradual wavy	9.1	71.8	19.1	Silt Loam	0.87 ± 0.03	41.5 ± 1.0
Bt3	50-73	10YR 4/3	m, m-c, sbk	gradual smooth	11.1	69.8	19.1	Silt Loam	1.14 ± 0.27	48.1 ± 10.3
Bt4	73-92	10YR 4/3	m, c, sbk	diffuse smooth	13.1	59.8	27.1	Silty Clay Loam	1.09 ± 0.05	56.6 ± 1.7
2Bt5	92-140	10YR 4/3	m, m-c, sbk	gradual smooth	11.1	51.8	37.1	Silty Clay Loam	1.19 ± 0.31	49.7 ± 11.5
2Bt6	140-150+	10YR 4/3	m, c, sbk	-	13.1	51.8	35.1	Silty Clay Loam	1.05 ± 0.01	41.8 ± 0.4

*sampled on 5 Oct 2017; soil pit at 42.9668, -89.3569

†w = weak; f = fine; m = medium; c = coarse; gran = granular; sbk = subangular blocky

‡gravel-free (n=2, ± standard deviation)

§based on bulk density calculations (n=2, ± standard deviation)

Table 12. Soil chemical attributes of Wisconsin South – Oregon.*

Horizon	Depth (cm)	pH†	Inorg P‡	K	Ca	Mg	Na	CEC (cmol/kg)	Base Saturation	Org C	Total N	C:N	Inorg C (%)
Ap	0-14	6.9	9	81	1451	392	7	13.00	82.8	1.58	0.16	10.2	<0.01
Bt1	14-27	6.5	9	56	1329	272	8	11.80	77.0	1.18	0.12	10.2	<0.01
Bt2	27-50	6.9	14	52	1634	287	9	14.50	74.0	1.68	0.13	12.6	<0.01
Bt3	50-73	6.8	27	73	1173	251	13	10.70	76.6	0.53	0.06	9.12	<0.01
Bt4	73-92	6.9	23	132	1798	446	18	13.70	95.8	0.39	0.05	8.07	<0.01
2Bt5	92-140	6.2	46	178	2378	662	25	22.10	81.3	0.33	0.04	8.54	<0.01
2Bt6	140-150+	5.5	57	189	2271	680	27	21.60	81.6	0.30	0.04	8.19	<0.01

*sampled on 5 Oct 2017; soil pit at 42.9668, -89.3569

†1:1 dry soil/water suspension

‡Bray-Kurtz P1 extraction

Acknowledgments

Support for this research was provided by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research (Awards DE-SC0018409 and DE-FC02-07ER64494), by the National Science Foundation Long-term Ecological Research Program (DEB 1637653) at the Kellogg Biological Station, and by Michigan State University AgBioResearch.