Soils and Land Use at the Henning's Lonesome Apple Tree Ridge Site, Eau Claire County, Wisconsin

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Abstract

The purpose of this poster is to present the results of research designed to provide land use recommendations based on observed soil characteristics. University of Wisconsin-Eau Claire geography students investigated the study area, about ten acres located within the exurban fringe of the city Eau Claire, WI near the town of Bracket, in West Central, WI. The study area is characterized by a steep north facing bedrock controlled slope where sandstone bedrock is overlain by terminal late-Pleistocene loess. Pedestrian reconnaissance revealed that slope steepness is the most important soil forming factor to consider. Four soil pits were excavated on a transect along the slope from slope shoulder to the foot slope position. Soil profiles exposed in those pits were described using the standard USDA NRCS methods. Soils in the study area are mapped as Seaton Silt Loam, 12 to 18 percent slopes. Soil profiles observed are consistent with that map unit, and exhibit A-E-Bt-C-2C horizonation. Soils are composed of silty material, consistent with loess reworked by downslope movement, above sandy material consistent with sandstone reworked by similar processes. Our observations suggest downslope movement occurred before, during, and after loess deposition. Reworked loess is thickest, and soil development (including e-horizon thickness, structural grade, clay skin development, mottling and gleying) are strongest in lower slope positions. Soils at the study site are fertile but are associated with severe limitations. They are erosion prone when disturbed, especially on steep slopes. Therefore, mitigating soil erosion must be prioritized whatever land use decisions are made.

Introduction and Methods

In the fall of 2016, students in the Geography 350: Soils and the Environment course at the University of Wisconsin-Eau Claire investigated how soils vary across the landscape that is heavily influenced by slope. The study site (Figure 1) is located south of Eau Claire near the Town of Bracket, on the property owned by Mr. and Mrs. Roger Henning (N 44°24.742 W 091° 23.307). With the five soil forming factors in mind, the first action was a pedestrian reconnaissance observing all aspects of the study site. It was determined that slope is the most important variable to consider regarding soil formation. Four soil pits were hand excavated on a transect along the slope from the ridge top downhill approximately 220 meters. Soil profiles exposed in those pits were then described using NRCS methods (Buol et al. 2003). The purpose of this study was to assess and determine the best land management practices for the study site based on soil characteristics.

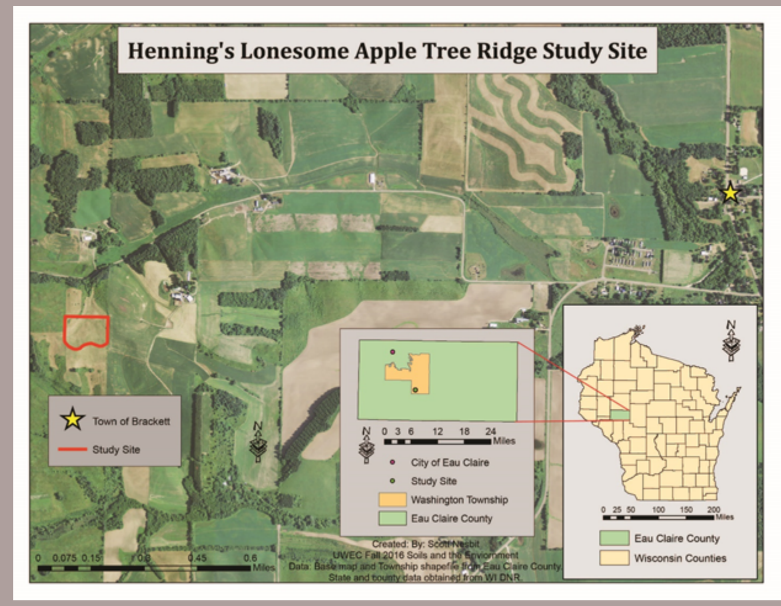

Figure 1. Location Map of the Study Site

Soil Forming Factors

The complexity of soils can be attributed to their existence at the "interface of the lithosphere, atmosphere, and biosphere" (Schaetzl and Anderson 2005, 295). Numerous factors influence how soils form including interactions of erosion, burial ,climate change, hydrology, topography, and, biomechanical movement and mixing. One model is designed to help make sense of soil formation processes and understand the how soils are form over time. This is the Clorpt model also known as the "five factors model", as depicted below.

S = f (cl, o, r, p, t, ...)

Where S = soil, cl = climate, o = organism factor, r = relief factor, p = parent material, and t = time factor

In this model, parent material is viewed as the "initial state of the system", including "physical, chemical, and mineralogical characteristics" and "inorganic and organic components" (Schaetzl and Anderson 2005, 297). Both slope and water table effects are included in the relief factor, while the time factor is important in understanding soil stages of development. The climate factor includes both regional climate and soil climate, or the "biotic cover that lies between the soil and the atmosphere," as well as slope aspect and snow cover (Schaetzl and Anderson 2005, 312). Soil formation is too complex to fully understand with a model. However, this model does provide a basic understanding of soil formation, using the five main soil forming factors as variables: climate, organisms, relief, parent material, and time. It continues to be the primary pedogenic model used throughout the world (Schaetzl and Anderson 2005). The soil forming factors relevant to the study site are subsequently discussed.

Climate

According to the Köppen Climate Classification system, Eau Claire, WI and the study site are classified as Dfa: a hot summer continental climate. The average temperature in Eau Claire, WI is 44.6°F. High temperatures vary from 83° in July to 23° in January, and the low temperatures range from 60° in July to 5° in January. On average, the study site experiences 31.02 inches of rain and 47 inches of snow annually (US Climate Data). Summers tend to be more humid, while winter months typically experiences less than 1 inch of precipitation.

Organisms

At the study site, various vegetation and animal life are present. The vegetation of the region is within Cold Hardiness Zone 4b, as classified by the US Department of Agriculture. Areas with Zone 4b classification have an average annual extreme minimum temperature between -20° and -25°F. The growing season extends from approximately the middle of May to the end of September. The area contains plants consistent with a pasture environment, some include goldenrod, Kentucky bluegrass, red clover, Solomon's seal, quack grass, apple tree, Vitis riparia (wild grape), dogwood, oaks and woody shrubs and trees along the fence line and north of the study site. Notably, woody species were found towards the base of the hill where soils were wetter. Evidence of rodents include burrows found in various locations in and around the study site.

Relief

Relief is examined in order to understand its effects on soil formation. Soil pits were located along a catena in order to understand the effects of relief on soil forming processes (Figures 2). A catena is a transect of soils from the top to the base of a hill, perpendicular to contour lines (Schaetzl and Anderson 2005). Pit 2016-1 is located near the top of the ridge while pit 2016-4 is located towards the base. The ridge runs from east to west. The slope between 2016-1 and 2016-4 is a 13% percent gradient and a north facing slope.

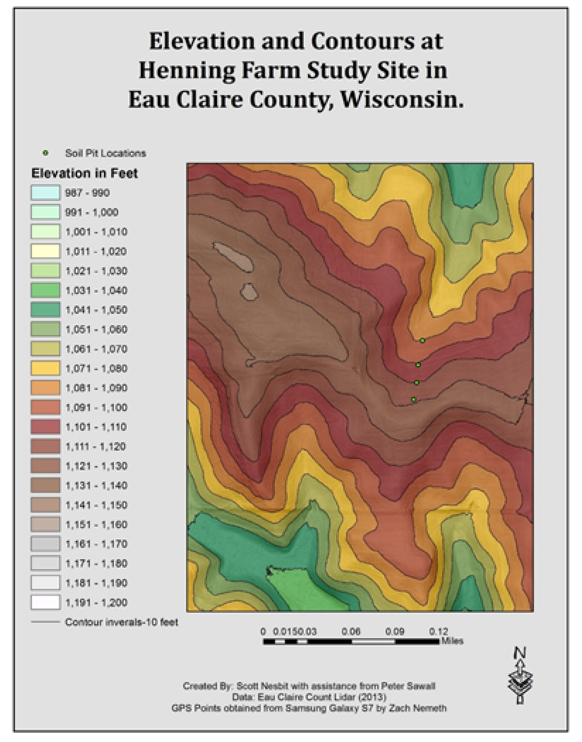

Figure 2. Elevation and Contours at study site in Eau Claire County, WI

Parent Material

Parent material is "the framework for the developing soil profile" (Schaetzl and Anderson 2005). Parent material contributes to soil variations within climatic and vegetative zones, (Soil Survey Division Staff 1993). It is important to recognize the parent material of an area in order to understand how various soils, landscapes, and biologic processes have converted parent material into a soil profiles. Parent material at the study site includes the bedrock Wonewoc Formation, a medium grained, well sorted, and almost exclusively quartz sandstone unit deposited during the transgressive/regressive stages of sea level during the Cambrian. It outcrops on most of the ridges near the study site and in western Wisconsin. The Eau Claire Formation underlies the Wonewoc Formation. It is a fine grained, well sorted, shaley sandstone and is found in underlying valleys near the study site, between Wonewoc ridges. Glacially derived loess is also a notable parent material present at the study site. Loess overlies bedrock and weathered bedrock, and is therefore a more influential parent material. Loess is a "terrestrial clastic sediment, composed predominantly of silt-size particles, which is formed essentially by the accumulation of wind-blown dust" (Scull and Schaetzl 2011, 143). It is understood to form in either desert or periglacially/glacially active landscapes (Scull and Schaetzl 2011). Most loess deposits are dominated by silt-sized (4–63 mm) quartz and feldspar grains, with some minor mica, carbonate, and clay constituents. Figure 3 depicts the extent and thickness of loess deposits in Wisconsin. Glacial activity is especially proficient at producing silt-sized grains in large quantities due to grinding of the ice with underlying rock (Scull and Schaetzl 2011). Loess deposits can vary compositionally and texturally on both a large and small scale due to variation in the mineral composition of the loess source areas (Roberts 2008).

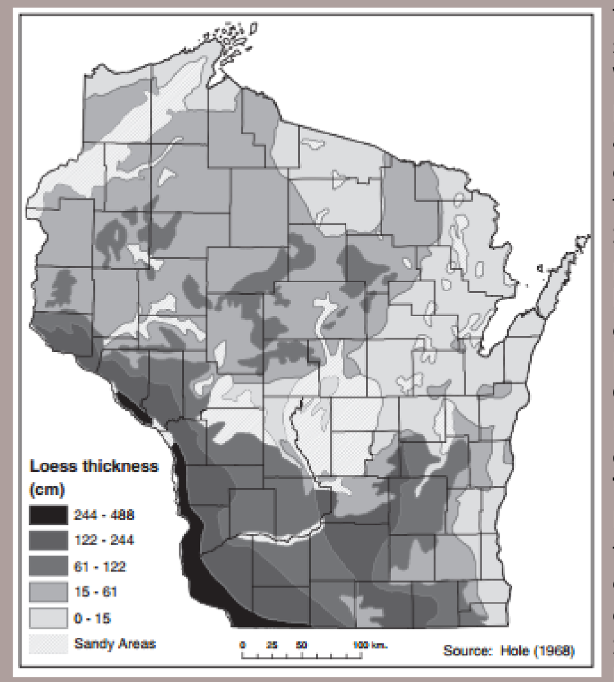

Figure 3. Loess Thickness in WI (Schaetzl et al. 2014).

Time

Bedrock units, the Wonewoc and Eau Claire Formations, that support the ridge underlying the study site, were deposited during the Cambrian period, between 540 and 490 millions of years ago. It is estimated that during the most recent glaciation, the glacier reached its maximum extent in the Chippewa River lowland around 22,000 years ago (Schaetzl et al. 2014). Since the end of glaciation, around 17,000 years ago, loess began to form, and continued to form until about 9,000 years ago (Scull and Schaetzl 2011). Loess has been the dominant soil forming parent material since then. Within the last 100-150 years, agriculture has impacted the soils of the region. A prominent, nearly horizontal line in the soil, known as a 9-inch plow line provides evidence for this agricultural impact.

Results

Table 1. Description of the soil profile exposed in soil pit 2016-1 (44.695329° N, 91.388548° W).

Horizon	Depth (cm)	Color	Texture	Structure, Consistence, Inclusions, Boundary
A1	0-10	10YR 3/2 Very Dark Greyish Brown	Silty Loam	Moderate, fine, granular; friable, non-sticky, non-plastic; roots: very fine, vertical, many; abrupt, smooth
Ap	10-29	10YR 3/3-3/4 Dark Brown-Dark Yellowish Brown	Sandy Clay Loam	Moderate, fine, subangular blocky; friable, slightly sticky, non-plastic; abrupt, smooth
Bt1	29-46	10YR 4/4 Dark Yellowish Brown	Sandy Clay Loam	Moderate, fine, subangular blocky; friable, slightly sticky, slightly plastic; clay skins: continuous, thin, faint; roots: few, very fine to fine, vertical; burrow: many, very coarse, distinct, irregular; clear, wavy
Bt2	46-70	10YR 4/4 Dark Yellowish Brown	Sandy Clay Loam	Moderate, fine, angular blocky; friable, slightly sticky, slightly plastic; clay skins: continuous, thin, faint; roots: few, very fine, vertical; abrupt, smooth
Btg	70-87	10YR 4/4 Dark Yellowish Brown	Silt Loam	Moderate, fine, subangular blocky; firm to friable, moderately sticky, moderately plastic; clay skins: continuous, thin, faint; roots: few, very fine; abrupt, smooth
Cg	87-97+	7.5YR 5/8 Red to 10YR 2/2 Very Dark Brown	Silty Clay Loam	Moderate, coarse, subangular blocky; friable, non-slightly sticky, slightly plastic; clay skins: partial (40%), top horizontal face, thin, faint; roots: few, very fine, vertical

Table 2. Description of the soil profile in soil pit 2016-2 (44.695488 °N, 91.388503 °W).

Horizon	Depth (cm)	Color	Texture	Structure, Consistence, Inclusions, Boundary
A	0-10	10YR 3/3 Dark Brown	Silty Clay Loam	Moderate, very fine, granular; firm, slightly sticky, moderately plastic; roots: common, very fine, vertical; abrupt, smooth
Ap	10-21	10YR 3/4 Dark Yellowish Brown	Sandy Clay Loam	Moderate, very fine, granular; firm, slightly sticky, moderately plastic; roots: common, very fine, vertical; abrupt, smooth
Bt1	21-48	7.5YR 4/4 Brown	Silt Loam	Moderate, medium fine, sub-angular blocky; firm, slightly sticky, slightly plastic; mottles: few (2%), fine, faint, spherical; roots: few, very fine, vertical; abrupt, wavy
Bt2	48-62	10YR 3/4 Dark Yellowish Brown	Sandy Loam	Moderate, medium, platy to sub-angular blocky, clay skins: very few, patchy (15%); friable, non-sticky, moderately plastic; mottles: few (2%), medium, faint, spherical; roots: very fine, few, vertical; abrupt, broken
2C1	62-74	10YR 5/6 Yellowish Brown	Silty Loam	Massive; very friable, non-sticky, slightly plastic; burrow: 10YR 3/4 dark yellowish brown, 37 cm in length, 20 cm in height, diagonal lightning bolt shape; roots: very fine, very few, vertical; gradual, broken
2C2	74-97	10YR 3/4 Dark Yellowish Brown	Sandy Clay Loam	Massive; firm, non-sticky, moderately plastic

Table 3. Description of the soil profile exposed in the soil pit 2016-3 (N 44°24.742 W 091° 23.307).

Horizon	Depth (cm)	Color	Texture	Structure, Consistence, Inclusions, Boundary
A1	0-13	10 YR 3/3 Dark Brown	Silty Clay	Moderate, fine, granular; firm, slightly sticky, moderately plastic; roots: very fine, vertical, common; abrupt, smooth
Ap	13-25	10YR 4/3 Brown	Sandy Clay Loam	Moderate, fine, granular; friable, non-sticky, moderately plastic; roots: fine, vertical, common; abrupt, smooth
EBt	25-30	10YR 4/4 Dark Yellowish Brown	Heavy Sandy Loam	Moderate, fine, sub-angular blocky; firm, non-sticky, slightly plastic; roots: fine, vertical, common; clay skins: light color, 75% ped coverage; clear, smooth
Bt	30-55	10YR 4/4 Dark Yellowish Brown	Heavy Sandy Clay Loam	Moderate, medium, sub-angular blocky; friable, slightly sticky, non-plastic; roots: fine, vertical, few; clay skins: 100% ped coverage; mottles: few, fine, faint, spherical; clear, wavy
Btg1	55-61	10YR 5/3 Brown	Silt Loam	Moderate, medium to coarse, platy; firm, non-sticky, slightly plastic; roots: fine, vertical, moderately few; clay skins, 50% ped coverage; mottles: few, fine, faint, spherical; abrupt irregular
Btg2	61-68	10YR 5/4 Yellowish Brown	Silty Clay Loam	Moderate, medium, sub-angular blocky; friable, slightly sticky, moderately plastic; roots: fine, vertical; mottles: few, fine, faint, spherical; abrupt, wavy to irregular
Btg3	68-73	10YR 4/6 Dark Yellowish Brown	Silty Clay Loam	Moderate, medium-fine, granular; firm, slightly sticky, moderately plastic; roots: fine, vertical, few; mottles: common, fine, distinct, irregular; abrupt, wavy
2Bt	73-78	10YR 3/4 Dark Yellowish Brown	Sandy Loam	Moderate, fine, sub-angular blocky; friable, moderately sticky, moderately plastic; clay skins: 15% ped coverage; mottles: few, medium, faint, spherical; abrupt, wavy
2Bt2	78-81	10YR 4/4 Dark Yellowish Brown	Silty Clay	Moderate, medium to fine, platy; friable, slightly sticky, very plastic; clay skins: 25% ped coverage; mottles: few, fine, faint, threadlike; abrupt, wavy
2CB	81-88	10YR 4/4 Dark Yellowish Brown	Sand	Massive; mottles, few, fine, faint, threadlike, irregular; abrupt, broken
2C2	88-122+	10YR 4/2 Dark Grayish Brown to 7.5YR 4/3-4/4 Brown to 7.5YR 3/2 Dark Brown	Loamy Sand	Massive; mottles: few, medium, faint, threadlike and spherical

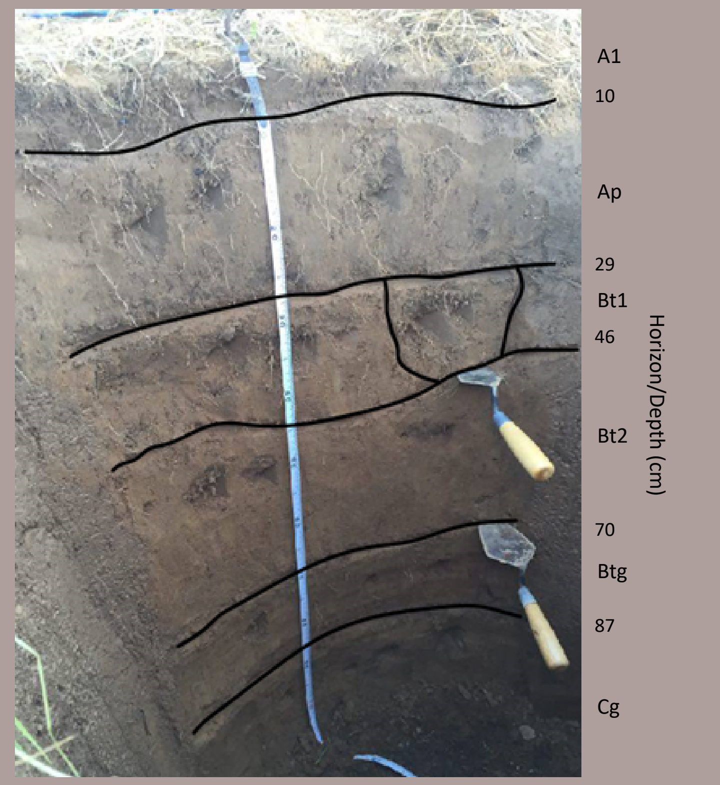

Figure 4. Photograph of soil profile 2016-1. Black lines show horizon boundaries. Master horizon designations are to the right. Top trowel is in the Bt1 - Bt2 boundary. Bottom trowel in the Bt2 - Btg boundary. Photograph by Ethan Nauman, 10-13-2016.

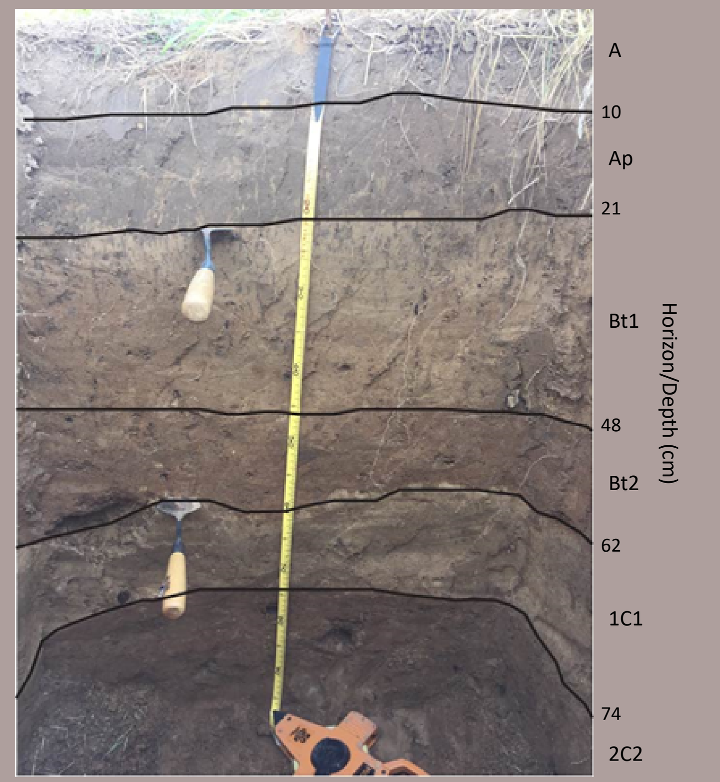

Figure 5. Photograph of soil profile 2016-2. Approximate horizon boundaries are shown by the black line, and master horizon designations are on the right. The top trowel is in the of the Ap-Bt1 boundary. The bottom trowel is in the Bt2-1C2 horizon. Photograph by Allison Hartwig, 10-13-2016.

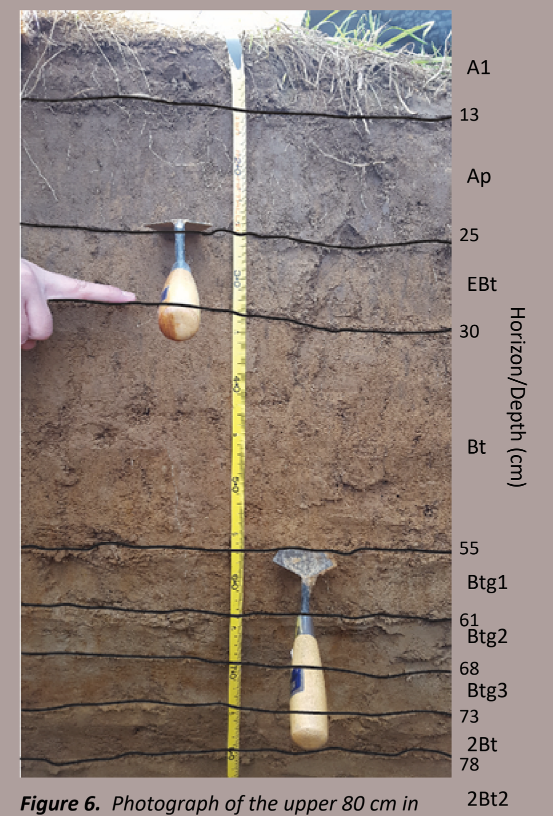

Figure 6. Photograph of the upper 80 cm in soil profile 2016-3. Black lines show horizon boundaries. Master horizon designations are shown on the right. The top trowel is in the Ap - EBt boundary. The finger points to the EBt - Bt boundary. The bottom trowel is in the Bt - Btg1 boundary. Photograph by Scott Nesbit 10-20-2016.

Figure 7. Photograph of 60 cm to the bottom of the pit in soil profile 2016-3. Black lines show horizon boundaries. Master horizon designations are listed to the right. The top trowel is in the 2Bt -2Bt2 boundary. Distinct mottling is shown directly above the top trowel. The bottom trowel is in the 2CB- 2C2. Photograph by Scott Nesbit, 10-20-2016.

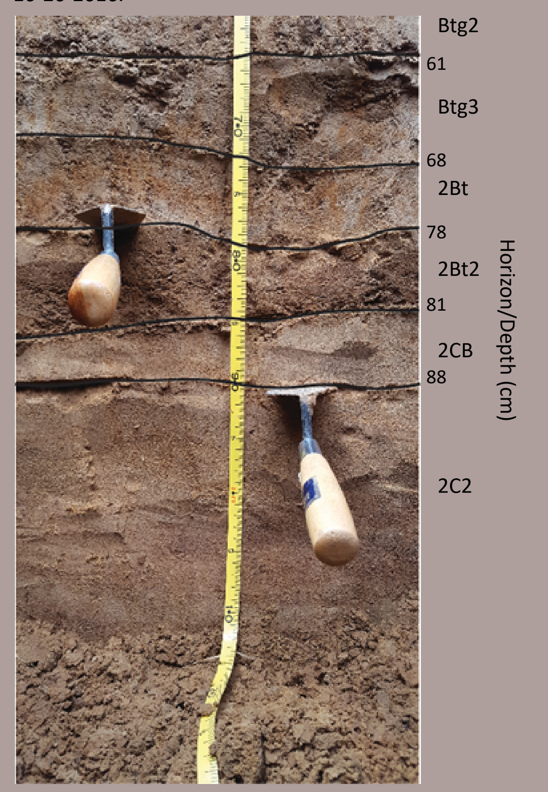

Table 3. Description of the soil profile exposed in soil pit 2016-4 (44.695488°N, 91.388503°W).

Horizon	Depth (cm)	Color	Texture	Structure, Consistence, Inclusions, Boundary
A1	0-2	10YR 3/4 Dark Yellowish Brown	Sandy Clay Loam	Moderate, medium, subangular granular; very-friable, slightly sticky, non-plastic; roots: many, fine to moderate, throughout, vertical, common; clear, smooth
Ap	2-22	10YR 4/3 Brown	Sandy Clay Loam	Moderate, medium, angular blocky; very-friable, slightly sticky, non-plastic; mottles: fine, medium, distinct, 10YR 4/4, cylindrical; roots: few, very fine, vertical; clear, smooth
E	22-30	10YR 5/4 Yellowish-Brown	Silty Clay Loam	Moderate, medium, platy; firm, slightly sticky, non-plastic; roots: common, fine, vertical; clear, smooth
Bt	30-65	10YR 4/4 Dark Yellowish Brown	Silty Clay	Moderate, fine to medium, platy to blocky; very firm, moderately sticky, moderately plastic; mottles: common, fine, faint, 2.5YR 5/8, cubic to platy; clay skins: very few, continuous, on all faces of peds, faint; roots: few, fine, vertical; clear, wavy
Btg	65-92	2.5Y 5/3 Light Olive Brown	Silt Loam	Strong, very coarse, platy to blocky; friable, moderately sticky, very plastic; mottles: few, medium to coarse, distinct, 2.5 YR 4/8, cubic to platy; roots: few, fine to moderate, vertical; gradual, smooth
2Cg	92+	2.5Y 6/3 Light Yellowish-Brown	Loamy Sand	Strong, very coarse to coarse, platy to blocky; non-cemented, slightly sticky, non-plastic; clear, wavy

Figure 8. Photograph of soil profile 2016-4. Approximate horizon boundaries are shown by black line, and master horizon designations are on the right. The trowel is in the Ap-E boundary. Finger is pointing to Bt -Btg. Photograph by Elizabeth Fedewa, 10-13-2016.

Conclusions

The slope of our study area allowed for some variation in the soil profiles. Soil morphology varies systematically across the study site as a function of slope position. The pits towards the bottom of the slope shows signs of E horizons based on the lighter colors and loss of clay within that horizon. Profiles towards the bottom of the hill contained more pronounced E horizons due to the occurrence of water running through the subsurface. Pits 1 and 2 do not contain E horizons. The soil profile in pit 3 has an EBt, while the fourth pit contained a pronounced E horizon.

Major horizons present in our soils are A, E, B, and C horizons. Each profile has an A1 layer, which is also where the roots are most prominent. All of the profiles contain an Ap horizon with the 'p' indicating disturbance through tilling or another cultivation process. This evidence is indicative of agricultural practices employed by the previous owners of the property.

The A, E, and B horizons at this particular site were either formed in loess or redeposited loess. The C horizon is composed of redeposited weathered bedrock and loess. The presence of sandy material in the bottom layers of the soil profiles is indicative of the alteration of the sandstone parent material. The accumulation of silicate clays is indicated by the presence of clay skins on ped faces. In the B and C horizons of pits 2, 3, and 4 there is also evidence of gleying, which is more prominent in the lower pits. This is usually seen in with a low chroma color and is an indicator of reducing conditions.

The presence of clay skins is most prominent in the B and C horizons. The largest ped coverage with clay skins is in the Bt or Btg horizons specifically. The most ped coverage was in the Bt horizon with about 100% coverage. Ped coverage decreased downward.where clay skins are very few, continuous, thin, and faint clay skins. The existence of mottles also varied across the soil profiles. Pit 1 does not have mottles and pit 2 has very few. In pits 3 and 4 , mottles are most noticeable. They are few, fine/medium, faint and irregular/spherical. Typically, granular ped shapes are found towards the top of the soil profiles because roots are present to break up the structure of the soil. Towards the bottom of the profiles roots become less concentrated, so more ped development is present. Soil horizonsbecome more developed further down the profile. At the very bottom of the profiles, when the texture of the soil becomes mostly sandy, peds are weakly developed or non-existent.

The National Resource Conservation Service defines the soil at the site as Seaton Silt Loam (Figure 9) (USDA 2016). This series is characterized as "very deep, well drained soils formed in coarse loess," which are typically round on ridge tops and side slopes (USDA 2016). Seaton Silt Loam series is typically found on 12 to 18 percent slopes and is moderately eroded (USDA 2016). These characterizations are consistent with the soil profiles we observed.

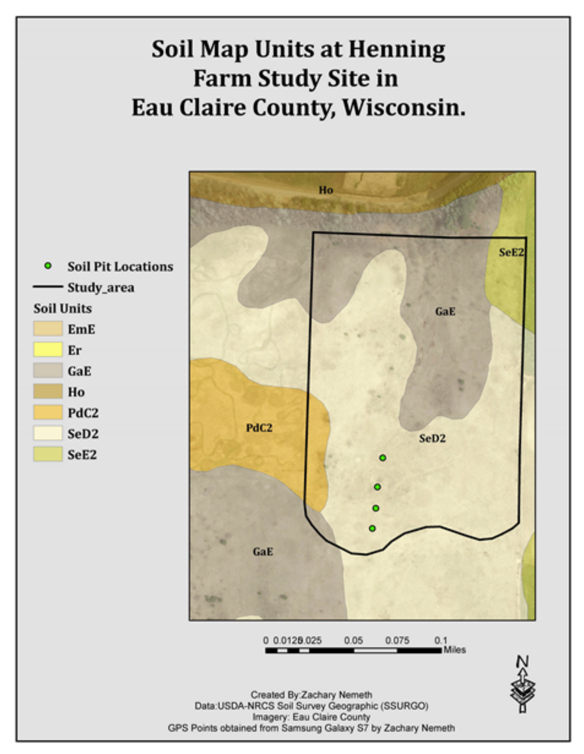

Figure 9. Location Map of the Study Site

Recommendations

Erosion is the quintessential parameter for land use decision making for areas containing Seaton Silt Loam. According to the Web Soil Survery, erosion-prone land is not suitable for common cash crop farming (USDA 2016). Due to a slope of 13%, commercial building is not advised. The erosion hazard restricts the possibility for dwellings, roads, and structures (USDA 2016). Recreational infrastructure such as campgrounds or parks are not advisable due to the erosion potential. The soil series is suitable for pasture, which is its recent historical use. Since the study area is prone to erosion, suitable plants are limited. Traditional grazing vegetation, due their low management needs, are recommended. Vegetation cover will also decrease the likelihood of erosion on this easily erodible landscape. Another land use possibility is reforestation; this includes economic or naturally beneficial reforestation. Ideal trees for native species include: red pine, eastern white pine and white spruce. Proper species for productivity include: northern red oak and sugar maple. Since the site is primarily a north facing slope it receives limited light. These lighting conditions reduce seedling mortality.

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