Ltttle John Soils – An Initial Assessment Based on 2011 Sampling

Michael Grooms, University of New Mexico

Introduction

This project will consist of a reassessment and in-depth analysis of soil samples from the Little John site, an archaeology site in the Yukon Territory. In the summer of 2011, initial field descriptions, photos, and profiles of the soils were completed of several soil pits, and samples of each horizon were obtained for analysis. This project will focus on one soil pit N8 W14 (Figure 1). However, these field observations were cursory, and an in-depth analysis, which will include refined soil descriptions, needs to be completed. This project will therefore build upon initial field observations, and include a more complete description of the soil characteristics. These observations will be placed in the context of the local landscape of the site and assessed in relation to the broader soil characteristics of the region.

Regional Archaeological Overview

Evidence of the earliest lithic technology in eastern Beringia during the late Pleistocene and early Holocene predominately consist of two, possibly culturally distinct, lithic technological complexes[1]: (1) Denali and (2) Chindadn/Nenana complexes. Both complexes have correlates in the Siberian Paleolithic (western Beringia), but are believed to have distinctly North American characteristics. The Denali complex is associated with microblade production[2] while the Chindadn/Nenana complex is associated with tear-dropped shaped bifaces and an absence of microblade technology. Both complexes occur in eastern Beringia after the Last Glacial Maximum

[1] Similar technological features define archaeological-constructed complexes that are within a constrained time period and geographic region.
[2] Microblades are defined as standardized elongate blades with parallel lateral margins, typically less than 20 mm in length and 5 mm in width (Wygal 2011).

(LGM) (~16 ka), and have yet to be found within in temporal or stratigraphic association. Further, the Chindadn/Nenana complex associated with older sedimentary deposits in the Nenana valley of Alaska, while the Chindadn/Nenana complex in the Tanana valley stratigraphically superimposes the Denali complex. To complicate the issue even more, the Chindadn/Nenana complex is thought to be older than the Denali complex in easternmost eastern Beringia at the Little John site, Yukon Territory, which is located in the eastern-most extension of the Tanana River drainage. Explanations offered for the variability in the two lithic technologies include raw material availability, climate, culture, and site-specific activities. However, these explanations tend to be more site-specific and do not correlate across eastern Beringia.

Little John Stratigraphy and Problems

The Little John site, located in easternmost eastern Beringia, is located on a knoll overlooking Mirror Creek, which lies within the easternmost extension of the Tanana River drainage. Unglaciated during the last glacial, archaeological materials at the site span the past 13,000 years. Basal regolith overlying sparse glacial till (Late Illionoian, c. 140000 BP or Early Wisconson, c. 70000BP) underlie the sedimentary deposits. Due to the undulating topography of the site (Figure 1), the stratigraphy consists of variable thickness of loess (from 10 cm in the west lobe to 450 cm in the east lobe). Soil development and depositional hiatuses are evident in the loess/paleosol sequences in the east lobe dating to 13,000 ky. Shallow deposits of loess and diagnostic artifacts of both complexes characterize the deflated west lobe. Additionally, B horizons, that represent Holocene soil formation, characterize the east and west lobes. White River Tephra (1900 kya) provides a chronological marker between the B1 and B2 horizons.

Several processes operate in subarctic environments that affect soil and sediment horizonization. Cryoturbation, the frost mixing of soils, can mix horizons, move organic matter into lower horizons, and orient lithics and clasts out of their depositional context (Boul et al. 2003).

Evidence of cryoturbation occurs across the site in the form of vertically oriented and displaced lithics, clasts, and organic matter. Solifluction, the slow flow of saturated soil and other consolidated materials, further disturb the horizons (Boul et al. 2003). Solifluction is evident in profile view of exposures in the form of plunging and distorted horizons.

Little John also lies in the discontinuous permafrost zone of North America, and permafrost is primarily evident in flat topography in and near the east lobe. The seasonal movement of the permafrost active layer (seasonal thaw layer), likely affects sediments and archaeological materials as well as soil development. The affects of permafrost at the site have not been fully analyzed.

Faunal remains of large and medium sized mammals have been recovered in the well-dated (14,050 cal BP to 9,855 cal BP) east lobe loess/paleosol sequences (Easton et al. 2011). Bison, caribou, and wapiti dominate the faunal remains. However, few diagnostic lithics have been recovered from the east lobe. Conversely, diagnostic lithics of the Chindadn/Nenana complex (believed to be Pleistocene in age) have only been recovered in the loess deposits of the west lobe. Additionally, lithics diagnostic of the Denali complex have only been recovered from the B horizons in the west lobe (Easton 2011). The time at that these complexes were deposited at Little John is confounded because the deflated west lobe loess deposits have not yet yielded faunal remains or charcoal suitable for radiometric dating. Therefore, it is key to create a high-resolution chronology at the site the correlates the timing of the cultural material between the east and west lobes. Comparison of soil and sedimentary deposits between both lobes may provide the initial correlation needed to make such an assessment.

N8 W14 Analysis

Soil pit N8 W14 (Figure 2), the soil pit analyzed for this study, is 10 m southwest of the east lobe. Permafrost is encountered within the basal loess of the pit at 54 cm below the surface, and inhibited further excavation. No archaeological materials were found in this soil pit, although two samples of charcoal were collected for radiometric dating.

Analysis of the sediment and soil samples from this soil pit is summarized in Table 1. Chris Merriman (UNM Archaeology Graduate Student) additionally analyzed the samples, in addition to the author, to crosscheck the descriptions. An arbitrary numerical designation was applied to each distinct layer to aid in the description. Stratum designations were assessed in the field and in the project analysis, and all possible horizon designations are noted in Column 3 of Table 1. Additionally, structure analysis was not completed in the field, and is impossible from the collected samples and omitted from this discussion.

Several overall trends are evident in this analysis and include (1) presence of carbonates; (2) clay films; (3) lower boundaries; and (4) field descriptions vs. project descriptions. Although carbonate accumulation is present on large clasts in the loess deposits of the east lobe, it is entirely absence in this soil pit. Explanations for the lack of carbonate include the absence of carbonate in the loess parent material and surfical material, and/or concentrations low enough to not be susceptible to 10% HCl reaction. However, similar depositional contexts from central Alaska along the Tanana River indicate higher concentrations and movement of carbonates within the soil (Dilley 1998). These differences may be a result of distance from the parent material source (fluvial deposits) and/or of the composition of the loess parent material (i.e. loess in central Alaska are derived from carbonate rich sources while loess at Little John is TBD).

Clay films were observed in the majority of the horizons, however none were observed the organic rich O/A horizon, or the layers 4 and 6 that were field categorized as tephra/ash deposits. 4 and 6 are both associated with charcoal and no volcanic glass was observed. Explanations for the few and faint amount of clay films in all other horizons may indicate a general absence of clay accumulation within the profile, and/or the relatively young age of the deposit.

The boundaries throughout the profile are all abrupt. 2 and 6 exhibited broken and irregular boundaries respectively, which may imply that these levels are significantly altered by cryo- or bioturbation. It is also possible that 6, with the associated charcoal, is an ash deposits associated with natural or anthropogenic disturbance. These two levels are not continuous in all walls of the exposure. The abrupt boundaries of the remaining stratum indicate that erosion or hiatuses in deposition are responsible for the observed stratigraphy, which likely affects soil development and classification observations. If these strata were deposited over a relatively short time frame, the Holocene, then the degree of soil development is likely low or obscured by erosion.

There are at least two interesting trends, or similarities and differences, between the field descriptions and project descriptions: (1) Ash/tephra and (2) paleosols. The field designated ash/tephra horizons (4 and 6) upon further inspection did not appear to be volcanic in origin due to the lack of volcanic material. Color of both was 10 YR 4/4 and 4/3 respectively, moist, but 4 lightened to 7/3 when dry. Neither includes clay films and both had loose consistence dry and moist. The dark color, moist, and absence of tephra or ash structure may indicate post depositional mixing with other horizons or other origins (such as rills) for 4 and 6. All four paleosol strata (7-10) have similar characteristics. All are 7.5 YR 2.5/2 moist, and have similar structure, clay films, and boundaries. While it is likely that these horizons are buried, the association of these levels to paleosols in the east lobe will require organic carbon concentration comparisons or visual correlation.

B Horizons

The B Horizons likely represent a decrease in loess deposition during the Holocene that would allow for soil development to occur (Dilley 1998). The reddening of these sediments due to soil development may also be related to the expansion of the boreal forest into the area ~9,000 BP (Wolfe et al. 2011). Characteristics of these soils include the presence of clay films and Clay Loam texture. These B horizons extend across the entire site, and discerning the similarities and differences within the soil pit and across the site may provide a base in which to correlate the two excavation areas. The overall similarity of soil characteristics does correlate with Brown Cambic horizons found in central Alaska (Dilley 1998).

The relationship of the B horizons in the soil pit is difficult to determine. The horizons tend to merge in the east wall and be distinct on the south wall. Further analysis may elucidate these similarities by assessing the illuvial accumulation of organic matter and the organic content between B1, B2 and B3. The abrupt boundaries between the horizons and other stratum in the soil pit indicate intrusive disturbances. Additionally, the discontinuous nature of these horizons may be due to hillslope processes or cryoturbation. Identification of possible ash/tephra levels 4 and 6 may further elucidate the relationship of the B horizons in the soil pit and between the two excavation areas.

Soil Order Classification

A goal of this project is to assess likely soil orders and suborders at the Little John archaeology site. Initial soil order classifications were derived from Soil Order maps of the U.S. presented in class. Additionally, soil order and suborder classifications were derived from a STATSGO distribution map specifically of Alaska (Figure 3). Soil order and suborder descriptions were taken from Soil Survey Staff (2003)[3], Boul et al. (2003), and class lecture information. A visual comparison was made between U.S. and Canadian soil orders. U.S. Soil orders pertinent to Little John are: Gelisols, Spodosols, Inceptisols, and Entisols. Burinisols are the Canadian equivalent of Inceptisols. A brief definition of each soil and suborder will be provided, followed by a discussion of each order's applicability to Little John. Temperature regimes at Little John and central Alaska are pereglic (lower than 0°C) or Cryic (between 0-8°C). However, the undulating

[3] This citation will be noted (*SSS* 2003)

topography (variable insolation and drainage affects) and relatively dense vegetation at the site may alter the temperature regime during summer months. The high summer precipitation and the presence of permafrost likely create an Aquic moisture regime (soils that are saturated with water for at least a few days per year) for the region (Birkland 1999, Dilley 1998).[4]

Gelisols are classified as soils having permafrost within 100 cm of the soil surface or gelic material (mineral or soil that shows evidence of cryoturbation and/or ice segregation in the active layer and/or upper part of permafrost) within 100 cm of the soil surface and permafrost within 200 cm of the soil surface (Boul et al. 2003). Three possible suborders Histels, Turbels, and Orthels will be discussed. Histels have organic matter that overly volcanic material and are saturated with water for 30 or more cumulative days, and have 80% organic soil materials from soil surface to 50 cm (SSS 2003). The subgroup, lithic Folistels, may characterize these soils, as there is contact in some areas of the site with geologic lithic material at 50 cm depth. However, this classification is unlikely due to the predominance of sediments with unknown organic volume. Turbels are defined as “other Gelisols” that have one or more horizons showing cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of permafrost, ice or sand wedges, and oriented rock fragments (SSS 2003). The majority of boundaries within the soil pit are abrupt, but do not appear broken or irregular. However, this suborder cannot be completely eliminated due to the discontinuous nature of the observed strata. Othels are defined as other Gelisols (SSS 2003). Aquorthels may be a likely contender in the lower portions of the soil pit, and are defined as orthels that have, within 50 cm of the mineral surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years (SSS 2003). However, the redox conditions must be quantified to confirm this as the dominant soil great

[4] Description of the soil order and suborders will only include pertinent information for the context.

group. Gelisol classification at Little John is difficult because it remains unclear how a Gelisol differentiates from a Spodosol or Inceptisol. Does permafrost immediately designate any soil with other order characteristics as a Gelisol? In a discontinuous permafrost setting, where permafrost is variable, do profiles without permafrost classify to a different order? If permafrost is at depth, does soil development above permafrost undergo classifications of different orders? If the answers to these questions are all yes, then Gelisols should be classified as the soil order.

Spodosols, present at central Alaskan archaeology sites, key diagnostic elements are the presence of a spodic horizon and the accumulation of humus and sesquioxides (Boul 2003). A spodic horizon is an illuvial later with 85% or more spodic materials, and they typically form in boreal forest environments. Spodic materials are dominated by illuviated active amorphous materials and are composed of organic matter and aluminum (SSS 2003). The boreal forest cover at Little John favors this soil order. The suborders of gelods and cryods may apply. Gelods are other Spodosols that have a mean annual soil temperature of 0°C or colder, and a mean summer temperature that is 5°C or colder if there is an O horizon. The paleosols in the east lobe have greater than 6% carbon, which may classify them under the Humigelods (SSS 2003). Cryods, spodosols with a cryic moisture regime, may also be a possibility. However the differential geomorphic setting that creates uneven heating of the ground and the absence of permafrost in the west lobe may eliminate this suborder. The recent age of the soils, and abrupt boundaries may eliminate this order altogether. Although there are some characteristics of Spodosols within the B-horizons, Dilley (1998) noted that the moisture regime is not wet enough for Spodosol development. Further, processes affecting these deposits may erase indications of Spodosols and may favor Inceptisols.

Inceptisols, which dominate the area and are indicative of more recent soils, are defined as embryonic soils with few diagnostic features that resemble parent material (Boul 2003, Dilley

1998). One defining criteria from this catchall order is a cryic temperature regime and a cambic horizon (SSS 2003). Aquepts, gelepts and cryepts may be applicable. Aquepts are in layers above densic, lithic, or paralithic contact or in a layer at depths between 40 and 50 cm from the mineral soil surface, and/or in aquic conditions for some time in normal years. Additionally they may have a histic epipedon, 50% chroma of either 2 or less with redox concentrations, or 50 cm of mineral soil surface active ferrous iron >15% exchangeable soil sodium percentage in half or more of the soil volume. Cryaquepts have a cryic temperature regime and gelaquepts have a mean soil temperature of 5°C or colder with an O horizon. Cryepts and Gelepts are Inceptisols with a cryic moisture regime. Subgroup designation within these classifications requires base saturation analysis that is not within the scope of this project. Due to the dominance of the Inceptisol order in the region, this order is likely applicable to Little John. The young age of the deposits may also indicate that if soil processes are occurring, they do not have the diagnostic traits of other horizons, thus falling into the Inceptisol order.

Entisols, are defined as soils that have little or no evidence of the development of pedogenic horizons (Boul 2003 from Soil Survey Staff 1999). The presence of reddening and clay films may indicate that this order can be eliminated, however, there is not ample evidence of clay movement between horizons. Redoximorphic features are likely present as evidenced by gelying of the loess horizons, which would indicate they maybe aquents. Fluvents are another possibility due to the less than 25% slope and organic carbon content (Organic carbon content ranges from 1% in loess to ~20% in paleosols/buried horizons). However, the likely presence of gelic materials in the soil pit could eliminate this suborder.

Considerations, Conclusions and Future Work

Inceptisols are the most probable soil order applicable to Little John. Loess deposition at the site has occurred for the past 44,000 years, however Holocene age sediment alterations of the B horizons does not have enough features to classify it under another soil order. Soil development within the paleosol levels in the east lobe may speak to longer-term processes, but are erased due to depositional and erosional factors. Although the B horizons show soil development indicative of Spodosols, as Dilley (1998) noted, there may not be enough moisture or time available for their development. It could be argued that the presence of cryoturbation and permafrost at the site indicate the soils are indeed Gelisols. Differentiating how Gelisol are designated in a discontinuous permafrost zone needs further analysis. The distinct horizonization observed in the profiles likely eliminates Entisols, but much more analysis is needed for such a conclusion.

There are several textural differences in the soil descriptions of this project with a lab-based study by Easton (2005). For instance, paleosols in east lobe are Silt Loam, while field identified paleosols in this analysis are Sandy Clay. This may call into question this projects designation of paleosols. This discrepancy may also highlight the difference between the paleosols in the east lobe with those of the soil pit. In addition, textural analysis of loess in this project designated it Silty Clay, while loess Easton's study in the east lobe is Silt Loam. Are there differences across the site in terms of loess texture and is this enough to correlate loess deposits across site?

In-depth analysis of the soil characteristics in a lab setting would help to elucidate these differences, as well a assign soil orders and suborders to the site. The use of radiocarbon dating and optically stimulated luminescence (OSL) are underway, and would provide a temporal correlation and control at the site. The geomorphic setting at Little John provides a challenging context for soil scientist and archaeologist alike, and careful soil analysis may provide a foundation for answering questions from both disciplines.

References:

Birkland, P.W.
1999 *Soil Geomorphology,* 3rd ed. Oxford University Press, New York.

Boul, S.W. and R.J. Southhard, R.C. Graham, P.A. McDaniel
2003 *Soil Genesis and Classification,* 5th ed. Iowa State Press, Ames.

Dilley, Thomas Edward
1998. Late Quaternary Loess *Stratigraphy, Soils, and Environments of the Shaw Creek Flats Paleoindian Sites, Tanana Valley, Alaska*. Ph.D. Dissertation, Department of Geosciences, University of Arizona.

Easton, N.A. and C. Baker
2005 Analysis of Sediments of the Little John Site (KdVo6), Yukon Territory, Canada. Unpublished report.

Soil Survey Staff
2003 *Keys to Soil Taxonomy*, 9th ed. USDA-Natural Resources Conservation Service, Washington, DC.

Wolfe, S. and J. Bond, M. Lamothe
2011 Dune stabilization in central and southern Yukon in relation to early Holocene environmental change, northwestern North America. *Quaternary Science Reviews* 30: 324-334

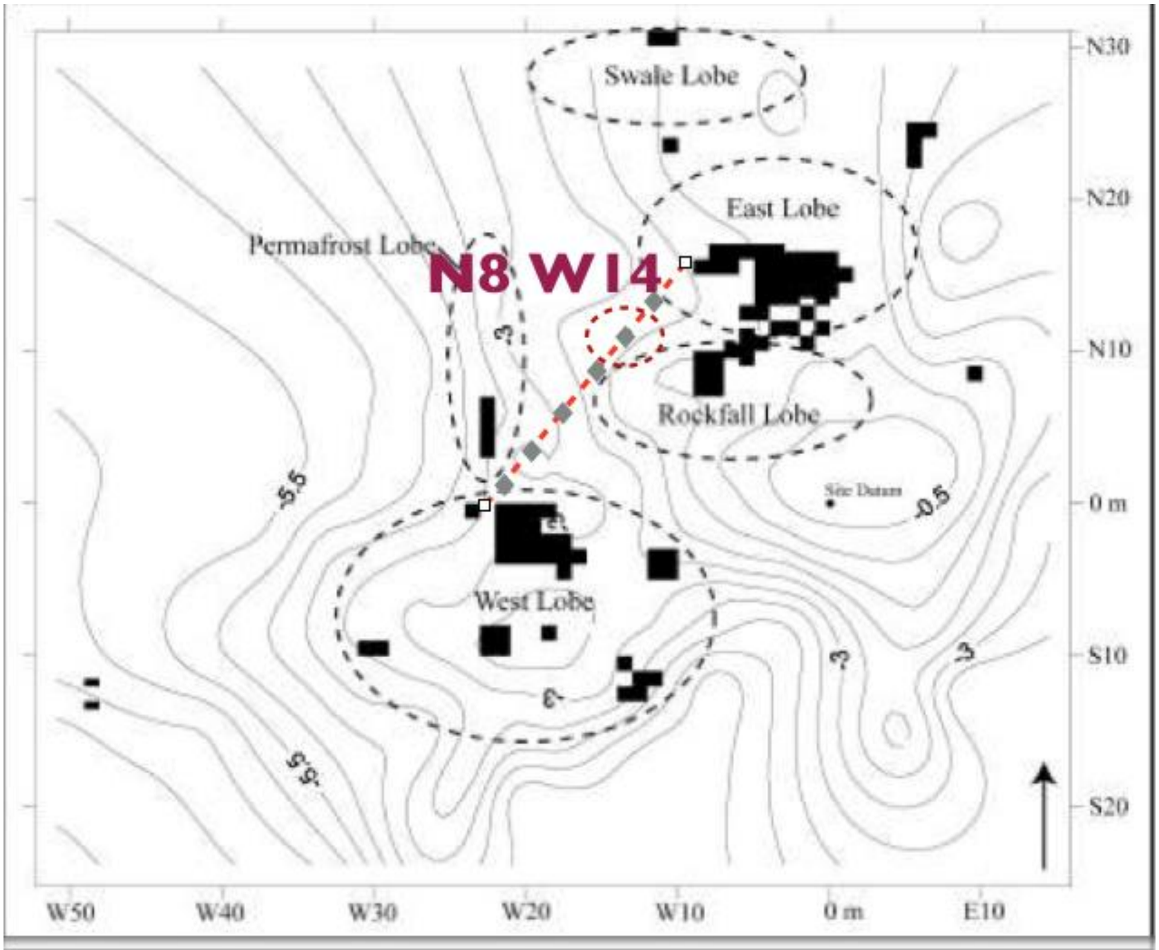


Figure 1: Topography of Little John. Excavation units and excavation areas are noted in black. The transect for this project is noted.

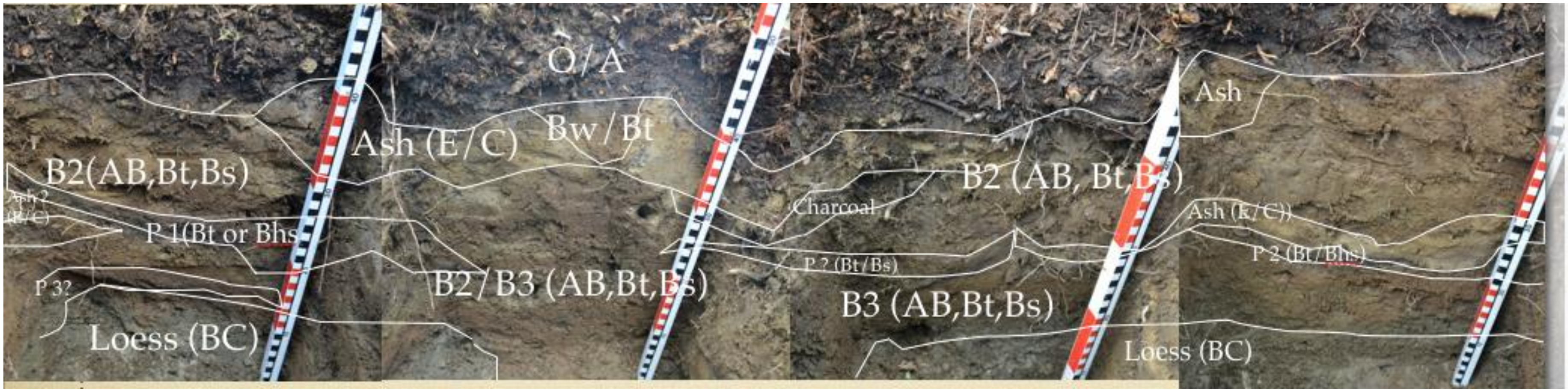
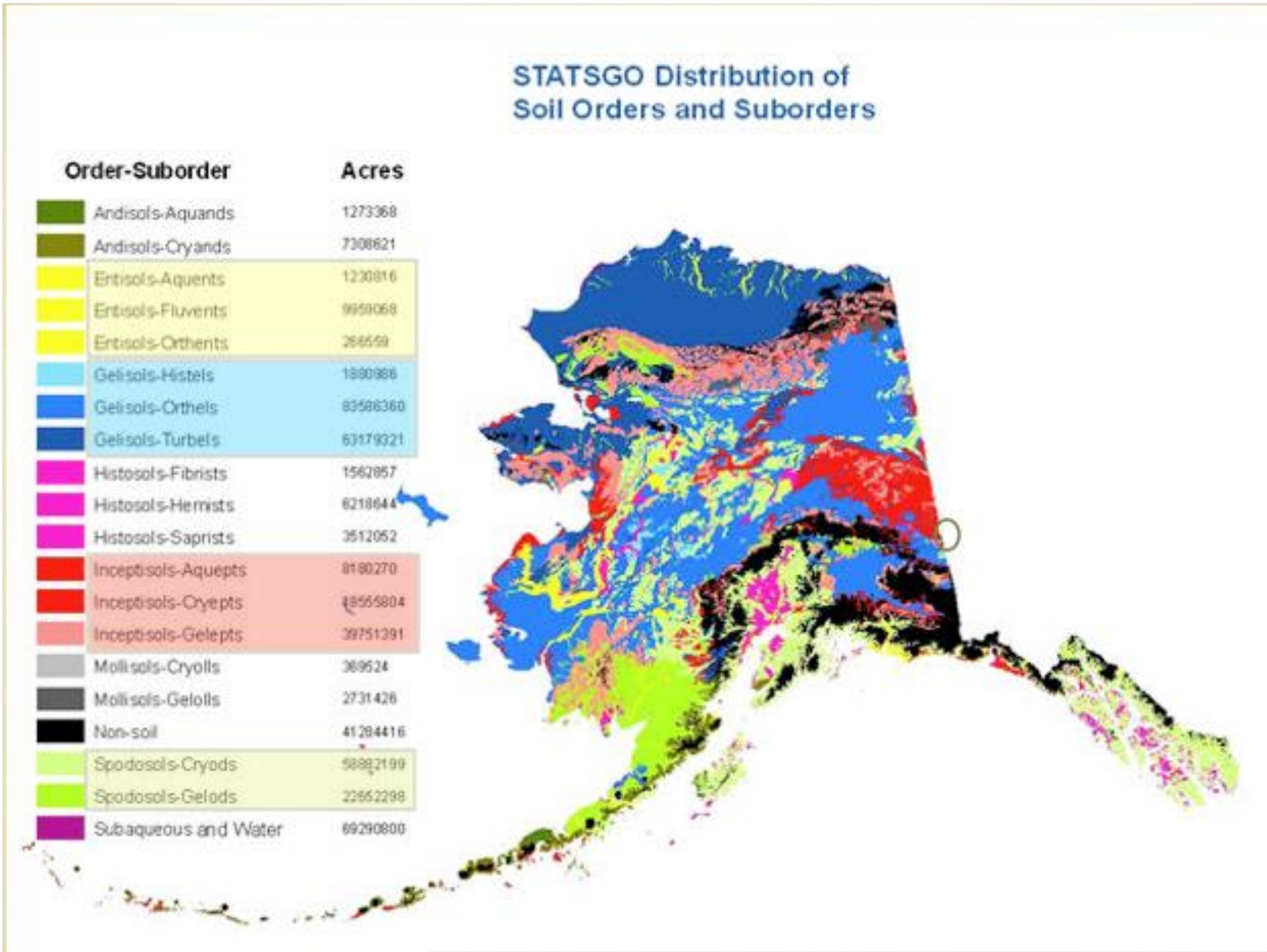


Figure 2: Soil Pit N8 W14 in North, East, South, and West format. Text not in parenthesis correspond to field observations, while text within parenthesis includes analysis from this project.



Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. 12/1/2011

Figure 3

#	Texture	Stratum/ Horizon	Depth (cm)		Munsell Dry	Munsell Moist	Gravel %	Consistence Dry	Consistence Moist	Consistence Wet Stky	Consistence Wet Plst	Clay Films Amt	Clay Films Dist	Clay Films Loc	Lower Boundary Dist	Lower Boundary Topo
1	Loam	O/A	0	~15	10 YR 2/1	10 YR 2/1	<1	Weakly Coherent	Very Friable	Non-Sticky	Slightly Plastic	None	None	None	Abrupt	Wavy
2	Sandy Clay Loam	Bw or Bt	~15	~20	7.5 YR 3/3	7.5 YR 3/3	<1	Weakly Coherent	Friable	Sticky	Plastic	Very Few	Faint	Coats & Bridges	Abrupt	Broken
3	Clay Loam	Bt or Bs	~20	~30	5 YR 3/2	5 YR 2.5/2	1	Weakly Coherent	Friable	Sticky	Plastic	Few	Faint	Coats & Bridges	Abrupt	Wavy
4	Sandy Loam	E or C	~20	~26	10 YR 7/3	10 YR 4/4	0	Loose	Loose	Non-Sticky	Non-Plastic	None	None	None	Abrupt	Wavy
5	Clay Loam	AB, Bt or Bs	~33	~42	7.5 YR 4/2	7.5 YR 2.5/2	1	Weakly Coherent	Friable	Sticky	Plastic	Few	Faint	Coats & Bridges	Abrupt	Wavy
6	Sandy Loam	E or C	~28	~26		10 YR 4/3	0	Loose	Loose	Non-Sticky	Non-Plastic	None	None	None	Abrupt	rregula
7	Sandy Clay Loam	ABb,Ab, Bt or Bhs	~35	~40		7.5 YR 2.5/2	0	Weakly Coherent	Friable	Sticky	Plastic	Few	Faint	Coats & Bridges	Abrupt	Wavy
8	Sandy Clay Loam	ABb,Ab, Bt or Bhs	~35	~40		7.5 YR 2.5/2	0	Weakly Coherent	Friable	Sticky	Plastic	few	Faint	Coats & Bridges	Abrupt	Wavy
9	Sandy Clay Loam	ABb,Ab, Bt or Bhs	~35	~40		7.5 YR 2.5/2	<1	Weakly Coherent	Friable	Slightly Sticky	Slightly Plastic	Few	Faint	Coats & Bridges	Abrupt	Wavy
10	Sandy Clay Loam	ABb,Ab, Bt or Bhs	~41	~44		7.5 YR 2.5/2	<1	Weakly Coherent	Friable	Sticky	Slightly Plastic	Few	Faint	Coats & Bridges	Abrupt	Wavy
11	Silty Clay	BC	~46	~52		10 YR 3/2	1	Weakly Coherent	Loose	Sticky	Plastic	Very Few	Faint	Coats & Bridges	Abrupt	Wavy

Table 1: Soil Description