PREDICTING SOIL HEALTH AND FUNCTION OF THE BARNES CATENA USING EVAPOTRANSPIRATION, VEGETATIVE, GEOLOGIC, AND TERRAIN ATTRIBUTES IN THE EASTERN GLACIATED PLAINS OF NORTH DAKOTA

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Predicting Soil Health and Function of the Barnes Catena Using Evapotranspiration, Vegetative, Geologic, and Terrain Attributes in the Eastern Glaciated Plains of North Dakota

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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ABSTRACT

The benchmark Barnes soil series is an extensive northern Great Plains upland Hapludoll that is vital to the region. Accelerated erosion has degraded Barnes agricultural soil quality, but with unknown extent or severity. Samples from three extensive Barnes soil map units, stratified by evapotranspiration values, were collected to 50 cm and analyzed for chemical, morphologic, and physical properties germane to edaphic function. Multi-scale terrain attributes and remote-sensed soil proxies, and geologic covariates were implemented with Cubist to model soil properties. Best models included SOC, EC, pH, SOC-IC, and sand content. Pedons were classified with a clustering algorithm into six classes. Linear discriminant analysis of covariates and subsequent prediction of landscape grouped classes had moderate to nearly substantial agreement with field observations; only fair agreement was attained for all classes. Detailed morphologic observations confirmed extensive topsoil erosion for some landscape positions that merit investigation of soil function and potential state change.

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DEDICATION

To Grandpa Meyer and my Lord and Savior Jesus Christ, who have both loved me unconditionally and taught me to pursue my dreams with all of my heart, as if working for the Lord, not men (Colossians 3:23).

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INTRODUCTION

The Benchmark Barnes Soil Series

The Natural Resources Conservation Service (NRCS) identifies the Barnes soil series (fine-loamy mixed, frigid, superactive Calcic Hapludolls) (Soil Survey Staff, 2011a) as a benchmark soil because of its significant influence on agricultural production and ecosystem processes. Benchmark soils research is crucial to the development of soil system models and interpretations at the regional scale (Soil Survey Staff, 2013). Currently, there are just over one million hectares of Barnes soils mapped in total throughout Minnesota, South Dakota, and North Dakota, but 80% of the Barnes soils mapped reside in North Dakota. The highest quality map units have a Spring Wheat Productivity Index (PI) of 85, a clear indicator of the Barnes's reputation and historic role as an exceptional soil (Soil Survey Staff, 2010). Moreover, the Barnes has been widely recognized as a dominant soil order of the Great Plains, serving as the "type specimen" for the Chernozems (Mollisols) in the 1938 Yearbook of Agriculture (Aandahl, 1982; Thompson, 1992).

The Barnes soil series was named for Barnes County, ND and was first recognized and mapped in the LaMoure County, ND Soil Survey in 1914 (Anderson et al., 1917). The Barnes and other geographically associated soils occur in the historic Chernozem soil zone. Chernozems, otherwise known as the Mollisols, are an extensive soil order throughout the Glaciated Plains of North Dakota. Formed in calcareous drift, these "Black Earth" soils were first characterized by the Russian description of the fertile tall grass prairie soils of subhumid regions. Centuries of development under the under the prairie regime have created excellent soils for crop production having inherently high fertility, ideal structure, and high organic matter accumulation (Elder, 1960). Furthermore, these genetic processes have leached carbonates and bases into the lower part of the solum, acidifying the initially calcareous parent material to neutral pH levels (Hole and Nielsen, 1970). Consequently, the Chernozems are some of the most fertile soils in the world (Kellogg, 1975). Kellogg (1941; p. 107) recognized how important the Chernozems were to world food production declaring, "A large part of the bread grain for the people of the world is now grown on these soils." He further identified their vulnerability due to limited moisture availability stating, "Always there is the threat of drought and the eternal hope for friendly rains and a bumper crop" (1941; p. 108).

McClelland et al. (1959) analyzed over 100 profiles of the Barnes soil series and associated soils within the Chernozem soil zone in North Dakota in the mid-to late 1950s. A comprehensive set of field notes, and morphological and chemical data were used to develop a formalized description of the Barnes. The A horizons were thick, granular, and black (Munsell 10YR 2/1, moist). Organic matter was greater than 5%, the pHs ranging from 6.5 to 7.5. The cambic (Bw) horizons were about the same thickness as the A horizons and leached of carbonates. The Bw horizons occasionally had thin and patchy cutans with moderate prismatic structure. At the depth of leaching, the calcic horizon manifested itself, with characteristic violent effervescence upon addition of dilute hydrochloric acid.

The Impact of Accelerated Erosion on Soil Function

Human activity has emerged as the new and dominant influence on soil formation. Humans activities have been implicated repeatedly as a soil forming factor and several approaches have been proposed to develop a reformed discipline of pedology that accounts for man-made soil change (Bidwell and Hole, 1965; Richter, 2007; Yaalon and Yaron, 1966). Furthermore, anthropogenic activities are now characterized as the primary geomorphic force on the planet (Hooke, 2000).

Through advancements in technology, humans are altering the environment at alarmingly high rates. Extensive areas of once-natural surface soil resources are continuously degraded by cultivation, tillage, irrigation, fertilization, compaction, and other dynamic disruptive processes (Science, 2004). Accelerated modification of the landscape by drastic and rapid land use change contribute to disrupted natural ecosystems (Lin, 2011). Human activities have been found to accelerate soil-forming processes so much that new soils are forming in a matter of decades, whereas the temporal scale for natural soil formation was on the order of hundreds and thousands of years (Richter and Markewitz, 2001; Yaalon, 1983).

These drivers of change in combination with natural disturbances all contribute to changes in soil function (Tugel et al., 2005). Priorities of the modern soil survey are focused on assessment of soil change based on land use and ecosystem dynamics. The 2001 National Cooperative Soil Survey (NCSS) conference focused on the critical need for soil scientists to compile and quantify dynamic soil property data for "state and transition models" (Tugel and Brown, 2001). These models predict change based on factors that govern vegetative regime shifts for differing ecological sites (Bestelmeyer et al., 2003).

State and transition models require quantification of dynamic soil properties that influence soil resilience and resistance. These properties impact the stability of the soil's contribution to ecosystem function. Resilience describes the ability of a soil to recover and return to its original state of function. Resistance, on the other hand, is the soil's capacity to steadily function without change due to disturbance. These two concepts are controlled by soil qualities that influence the capacity of a soil to function and respond to environmental stresses (Seybold et al., 1999). If the resilience threshold is surpassed due to environmental inputs, a state change occurs, altering soil capabilities (Bestelmeyer et al., 2003). Dynamic properties such as soil organic carbon (SOC), pH, electrical conductivity (EC), porosity, structure, aggregate stability, and total nitrogen (N) markedly influence the functioning capacity of soils and how they respond to disturbance (Tugel et al., 2005).

State and transition models have been improved to account for ecological site properties other than vegetative cover. Relatively static properties such as soil texture or climate can also have an impact on ecosystem processes affecting land capability. Additionally, the importance to predict land use change in ecosystem models has become crucial due to the increase in conversion of marginal lands to cropland to meet food demands (Herrick et al., 2012). These concerns are particularly important in arid and semi-arid climates (Bestelmeyer et al., 2015).

Accelerated Erosion in the Glaciated Plains

Erosion is an intrinsic process for the soils of the Glaciated Plains. Their fine-loamy textures coupled with the climate and physiography make them naturally susceptible to erosive processes. When these factors are combined with tillage and cultivation, soil loss can be exacerbated. The region’s climate has extreme temperature variation in both the short and long term, with sporadic rainfall, and persistent winds (Enz, 2003). This abiotic regime modifies a landscape consisting of gently rolling lodgment till riddled with terminal and recessional moraines, kettle lakes, eskers, and other glacial features (Bluemle, 2000). The majority of the Glaciated Plains region is undulating with low relief around 30 m, but is contrasted by a variety of glacial and fluvial features that can have up to 100 m of local relief.

Wind and water erosion persist as serious threats to the nation’s soil resource. In 2007, the National Resources Inventory (NRI) reported that the national average of annual cropland soil lost to wind and water erosion amounted to 10,760 kg ha^{-1}. North Dakota’s cultivated lands markedly exceeded the national average, with losses of 13,000 kg ha^{-1} per year (NRI, 2007).

With the third highest acreage of cropland nationally and ranked as the number one producer of major commodities such as dry bean (*Phaseolus vulgaris*), canola (*Brassica napus*), flaxseed (*Linum usitatissimum*), sunflower oil, and spring wheat, erosion threatens the very foundation of the North Dakota economy (USDA-NRCS, 2013).

Evidence of degradation and truncation of the Barnes loam was repeatedly documented in early surveys. Knobel et al. (1924) reported, “Knobs, knolls, or rather sharply sloping areas are covered with material lighter in color than typical.” Anderson et al. (1917) stated, “Where erosion has been more excessive… the black soil has been largely removed, so that the unweathered drift lies at or near the surface.” Additional observations were made by Hutton et al. (1920) in Sargent County noting that the Barnes loam was starting to lose organic matter and should be replenished with manuring.

In 1985, former NRCS State Agronomist, Lyle Sampson, presented undeniable visual evidence of the dark topsoil loss in his slideshow presentation “Fragile land… handle with care.” This account contained a collection of time-lapse aerial photos from two cultivated fields in central North Dakota. The photos reveal obvious exacerbation of topsoil loss between time intervals, apparent in the ever expanding alkaline bleached knobs and ridges of the till plain landscape. Sampson noted, “These time lapse journeys emphasize that the tillage systems being applied to much of our fragile land are allowing soil to be lost at an excessive rate” (Sampson, 1985).

Anthropogenic influences from tillage disturbance have accelerated soil erosion and have markedly changed soil properties of Mollisols across agricultural landscapes in the Great Plains of the United States and the Prairie Provinces of Canada (Cihacek and Swan, 1994; De Alba et al., 2004; Papiernik et al., 2005; Malo et al., 2005; Veenstra and Burras, 2015). Topsoil truncation reduces the agricultural productivity of these soils. Organic matter losses and increased calcium carbonate introduced from the limy subsoil reduce phosphorus and micronutrient availability, limit available soil moisture, and promote the formation of massive soil aggregates (Lindstrom et al., 1986).

The Barnes series has experienced significant amounts of wind and water erosion accelerated by the use of tillage equipment, which warrants the need to investigate morphological and chemical change (Duey et al., 2008). Although the Barnes series is known for its inherent productivity, it is being damaged at a distribution and severity that is unknown. In recent years, high crop prices have driven producers to convert Conservation Reserve Program (CRP) fields back to cropland (Streitfield, 2008). North Dakota alone lost 214,000 ha of CRP lands to crop production from 2007-2008 (McCombie, 2009).

Montgomery (2015) found significant losses in surface SOC and major morphologic changes in a Barnes series resampling study of pre-1960 characterization pedons. Other soils adjacent to the Barnes are experiencing similar changes. Malo et al. (1974) performed a catenary study of the major hillslope profile pedons on the summit, shoulder, backslope, footslope, and toeslope positions associated with the Barnes series. Physical, chemical, and morphologic evidence confirmed that erosional and sedimentary processes were driving soil property variation along the catena. Erosional processes dominate the shoulder positions while fine-textured sediments accumulate in lower landscape positions.

The Buse series (fine-loamy, mixed, superactive Typic Calciudolls) (Soil Survey Staff, 2011b), a soil that typically occurs on the shoulder positions, is the eroded form of the Barnes. With time and exposure to accelerated erosion on summit and shoulder positions, the solum now encompasses a thin A horizon capping highly calcareous parent material. Field pedologists observed that erosional activity had altered the Buse soils to such a degree that a new taxonomic class was required to define them. This widely recognized soil was recorrelated to the Langhei series (fine-loamy, mixed, superactive Typic Eutrudepts) (NCSS, 1970; Soil Survey Staff, 2000).

Novel Methods for Benchmark Soils Research

It is evident that the Barnes and associated soils exist in a dynamic abiotic regime continuously threatened by accelerated erosion. The degradation incurred by these soils is poorly understood and insufficient documentation exists in both lay and scientific literature. The economic and ecologic importance of the benchmark Barnes soil series warrants that it serve as a regional platform to develop improved land use interpretations.

Currently, benchmark soils are an NCSS priority and research funds have been made available to quantitatively describe benchmark soils with limited data. Soil survey priorities reiterated at the 2013 NCSS National Conference called for efforts to populate the National Soil Information System (NASIS) database with surficial SOC, a property the NRCS has defined as a key indicator of soil health (USDA-NRCS, 2016). Furthermore, the need to investigate dynamic soil properties as drivers of state change was emphasized. Moreover, investigations that link soil properties to landscape processes for digital soil mapping (DSM) purposes have been eligible for support (NCSS, 2015). Consequently, these objectives fostered the need for rapid assessment of soil resources across extensive areas, which is best accomplished using remote sensing methods (Goldshleger et al., 2010). Recent developments in image resolution, hyperspectral sensing, LiDAR (Light Detection and Ranging) image processing software, and geostatistical techniques have created a new frontier of broad scale resource assessment pertinent to agriculture and ecology (Capolupo et al., 2015; Cohen and Goward, 2004; Loveland et al., 2011). Calculation of climatic and topographic attributes from remote-sensed data have been widely used to improve the accuracy, precision, and scale of digital soil maps (Brevik et al., 2017).

Soil Survey of the Future

Consistent accomplishments achieved by steady Federal and State funding, punctuated by novel technological advancements have accompanied the NCSS throughout its history. Field delineation has changed from using plane tables and paper maps in the early 1900s to the era of aerial orthophotographs in the mid-1970s. The first computerized soil data were entered in the 1960s and by the mid-1980s soil maps were spatially integrated into working Geographic Information Systems (GIS). Less than ten years later, digital maps were linked to state soil database records (property data) in NASIS. Today, the Web Soil Survey serves as the working GIS platform for soil resource management for the public (Soil Survey Staff, 2016).

By 2000, all state databases were joined at the national level and field soil mapping efforts were near completion (Fortner, 2007). As mapping efforts diminished, soil survey priorities shifted toward an interpretive focus as federal funding and support of survey activities declined (Prunty, 2004). Even though former NRCS Soil Science Division (SSD) Director, David Smith, described the future of soil survey as one where soil scientists would have to do "more with less," current and emerging soil survey interpretations still rely on pedologic principles that were the essence of traditional soil survey (NCSS, 2013).

Traditional soil surveys characterized the landscape to develop static maps at differing scales of detail. Soil map units and taxonomic classes described similar or geographically associated soils along with their properties. These units represented discrete delineations on the landscape. It was assumed that minor inclusions and variants of the named soil series were contained within the soil map unit, but were too small to identify at the scale of mapping (Soil Survey Staff, 1993).

The future of soil landscape interpretation focuses on methods that display soils as continuous bodies that allow the partitioning of fine spatial scale and temporal variability. Soils rarely exist as static, discrete units with defined boundaries, but resemble a continuum of properties that intergrade through space (Johnson, 1963). The goal of the future soil survey is to effectively "disaggregate" the fixed boundaries of soil map units and develop a spatial continuum of chemical, physical, and morphologic properties.

The need for disaggregated soil maps becomes increasingly important as precision agriculture continues to advance (Minasny and McBratney, 2016). Precision agriculture focuses on "farming soils not fields" (Carr et al., 1991), enabling fertilizer, seed, pesticides and herbicides to be distributed into management zones through linked digital soil maps and GPS in modern farming equipment (Franzen et al., 2002) The improvements in farming efficiency reduce production costs while benefitting crop, soil, and environmental quality (Talebpour et al., 2015).

Digital Soil Mapping

The primary tool in the development of the soil survey of the future is GIS software. Hammer et al. (1991) confirmed the notable capabilities of GIS software processing to model, predict, and display soil properties as well as aid in data sharing, storage, and analysis. Digital soil mapping techniques are primarily based on soil-landscape models derived from the factors of soil formation, a quantifiable framework for soil genesis originally developed by Jenny (1941). The factorial model describes soil as a function of climate, parent material, organisms, relief, and time or CLORPT. Advances in DSM led to the SCORPAN model proposed by McBratney et al. (2003):

$$[1]\ S_{c,a} = f(s, c, o, r, p, a, n)$$

whereby a soil class or property (target variable) is equal to the function of soils (s), climate (c), organisms (o), relief (r), parent material (p), age (a), and spatial location (n). This equation serves as the basis for modern DSM. Digital soil mapping creates predictive surfaces for soil classes and/or properties across a spatial and temporal continuum by integrating soil-forming inputs, process models, and spatial autocorrelation techniques in a GIS (Minasny and McBratney, 2016).

The SCORPAN model reflects the chief advances in DSM for several reasons. The model is particularly effective because it recognizes that environmental conditions are not always independent of one another. Thus, explanatory variables are referred to as environmental covariates. Additionally, the model uses quantitative inputs from soil samples, remote-sensed data, terrain attributes, and soil maps to model soil-environment relationships. Furthermore, spatial location was included as a means to deploy spatial autocorrelation techniques (Soil Survey Staff, 2017).

Spatial autocorrelation is based on Tobler's first law of geography, "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). Mathematically, this concept is explained by variograms which calculate the variability of properties between pairs of locations at various distances. Variograms are subsequently used with the kriging interpolation technique to generate a spatially predictive surface (Matheron, 1963). For DSM however, soil property relationships are explained by local and environmental variability. Therefore, hybrid techniques that utilize kriging with regression or ordination are required to predict target soil properties and/or classes. These include universal kriging, regression kriging, kriging with external drift, and factorial kriging (McBratney et al., 2000).

Discussion on general DSM methods and those particular to this study in regard to NCSS priorities are given below and include:

1. Sources, development, and pedogenic relevance of environmental covariates for regional DSM.
2. The issues of scale, resolution, and selection of covariates.

Remote Sensing Applications for Soil Survey

A plethora of environmental covariates for DSM can be calculated from a variety of remote-sensing techniques. An extensive review of the current literature is provided in Mulder et al. (2011). These methods pertain to spectral signatures from space and air borne sensory instruments that discern soil properties e.g., mineralogy, texture, moisture, salinity, organic carbon, and carbonates. Additionally, vegetative indices that reflect edaphic variability such as Normalized Difference Vegetation Index (NDVI) and Plant Functional Types (PFT) are useful as soil proxies.

Soil survey applications using Landsat imagery have been successful in delineating soil map units by differentiating influential patterns of land use, land cover, vegetation, topography, and drainage that correlate with specific soil associations (Keinast-Brown and Boettinger, 2007; Westin and Frazee, 1976; Westin and Lemme, 1978). Furthermore, Landsat-derived bare-soil and vegetative indices in combination with Digital Elevation Models (DEMs) are capable of modeling soil-landscape distributions effectively (Boettinger et al., 2008).

Remote-sensed Evapotranspiration Modeling

Soil moisture governs the rates of photosynthesis and subsequent transpiration in semi-arid ecosystems. In these regions, evapotranspiration (ET) consumes nearly all of the water inputs from precipitation (Noy-Meir, 1973). Soil water storage is a critical factor influencing ET rates and ecosystem energy balance (Sun et al., 2011). As a result, the indirect measure of soil moisture and water cycling in soil ecosystems can be derived by ET. Remote sensing applications via high resolution satellite imagery have been effective in mapping ET at regional scales through the development of surface energy balance algorithms (Allen et al., 2007a, 2007b; Bastiaanssen et al., 1998a, 1998b; Roerink et al., 2000). These methods are considered a residual modeling process by which they use both empirical and physical relationships gathered from remote-sensed and ground based weather data to estimate ET (Nouri et al., 2013).

The first of these models was the Surface Energy Balance Algorithm for Land (SEBAL) (Bastiaanssen et al., 1998a). The computational basis is described by the equation

$$[2]\ R_n = LE + H + G$$

which calculates the relationship of surface energy fluxes. The net radiant energy R_n (W m^{-2}) can be subdivided into three parts: LE (W m^{-2}) is the latent energy consumed by ET, H (W m^{-2}) is the sensible atmospheric heat flux, and G (W m^{-2}) is the soil heat flux. Inputs from remote-sensed thermal data from satellites and atmospheric data from local meteorological stations are used calculate the LE. Near surface temperature measurements are not required because SEBAL uses an equation to determine the near surface temperature gradient or dT.

The Mapping Evapotranspiration at High Resolution with Internalized Calibration (METRIC) model (Allen et al., 2007b) is a particularly useful method for estimating ET and has been effective in a variety of applications. Adapted from SEBAL, METRIC differs by using a reference ET (ETr) as a means to account for biases that arise with traditional remote sensing ET estimation methods. The internalized calibration process uses weather-based data to develop wet and dry extreme reference pixels that serve as the check for the ET estimates to calculate a fraction of ETr (ETrF). The ET rate of a well-watered alfalfa (*Medicago sativa*) or other fully transpiring crop serves as the wet extreme ETr for the calibrated extent. The METRIC algorithm is preferred over traditional surface energy balance algorithms for several reasons. Firstly, traditional methods calculate LE as a function of the evaporative fraction, which creates errors for semi-arid climate regions where advection rates can cause ET to be higher than net radiation. Secondly, the METRIC model removes bias associated with water shortage. Thirdly, METRIC does not require information on the specific crop type or stage to make estimations in agricultural fields. These primary differences make METRIC superior compared to many other ET models.

The METRIC model has been used for quantifying ET fluxes for irrigated agriculture, determining water use and water rights accounting, providing data for groundwater models, and determining crop ET coefficients (Allen et al., 2007a; Gowda et al., 2008). In addition, it has proven effective in distinguishing land cover types (Pôças et al., 2013). Remote-sensed ET models have been used to investigate soil water processes and function. Li and Lyons (2002) used the Advanced Very High Resolution Radiometer (AVHRR) to calculate radiometric surface temperature and modify estimated soil moisture in order to provide an ET estimate in central Australia. Boegh et al. (2002) applied Landsat TM spectral data to develop ET estimates for crops at different stages of development. Steele et al. (2015) and Büyükcangaz et al. (2017) observed increased ET estimates for soils that were irrigated compared with nonirrigated soils in the Devils Lake Basin of North Dakota using the SEBAL and $METRIC_{ND}$ (algorithm for North Dakota conditions) methods, respectively. In an additional study in North Dakota, Montgomery (2015) applied the $METRIC_{ND}$ model to a dynamic soil change study on the Barnes soil series and determined that ET could be used as a proxy for soil function. Therefore, the model holds promise in potentially differentiating soil function on the landscape at regional scales.

Landscape-scale Processes and Geomorphometric Parameters

The factor of relief commonly exerts a major influence on soil formation in many environments and topography is strongly related to soil properties and fertility (Franzen et al., 1998; Jones et al., 1989; Malo et al., 1974). Landscape morphometry (i.e. topography) is a potent agent because, as Zakharov stated, "While parent material, biota, and climate all shape the soil relief only conditions the redistribution of matter and energy without contributing anything new" (Joffe, 1949). These influences are profound at the landscape scale. Differentiation of hydrologic and sediment fluxes based on hillslope position are directly related to soil development. Soils along a catena, or transect of soils perpendicular to topographic lines, serve as an example of unique soil formation at each position on a hillslope (Schaetzl and Anderson, 2005).

Regional characterization of soils is premised on defining landscapes that have constant mass and energy inputs which govern consistent genetic processes in accordance with variations in hillslope hydrology and morphometry (Gerrard, 1990). Because soils are an amalgamation of properties that function as a singular unit (homomorphs), a functional model of soil genesis is required to explain the fluxes in a defined system. Huggett (1975) described this as the soil-landscape system or "valley basin" wherein the system is characterized three-dimensionally, and bounded by the soil surface, basin extent, and weathering front. These relationships have long been recognized throughout the history of soil science and are a core component of traditional soil survey. Hudson (1992) pointed out the weakness of what he dubbed the “soil-landscape paradigm”, explaining that, although powerful, it was heavily dependent on the soil surveyor’s tacit-knowledge and poorly communicated in scientific literature. However, due to advancements in DSM, the soil-landscape paradigm, so critical to field pedology, is becoming increasingly quantifiable and reproducible. These methods continue to serve as useful tools in digital soil map disaggregation (Bui and Moran, 2001; Miller and Schaetzl, 2015; Odgers et al., 2014).

Raster DEMs are gridded representations of the bare-earth surface generated from interpolated LiDAR point clouds. Geomorphometric parameters are calculated from DEMs to explain energy dynamics redistributed by relief. The gridded DEM is particularly useful for applying geomorphometric algorithms (Hengl and Reuter, 2009). Calculated basic land surface parameters such as first derivatives (slope and aspect) explain gravity and insolation dynamics and second derivatives (vertical and horizontal curvatures) characterize flow line direction i.e. convergent and divergent flow on a hillslope. Regional watershed calculations of terrain parameters i.e. catchment area and catchment slope further elucidate the spatial variability of hillslope surface hydrology (Olaya, 2009).

Flow accumulation and various wetness indices calculated from catchment area (or modified catchment area) such as the Topographic Wetness Index (TWI) (Quinn et al., 1991) and the SAGA Wetness Index (SWI) (Boehner et al., 2002) estimate the amalgamation of watershed and terrain morphometric parameters in order to simulate overall hydrologic behavior of a soil-landscape system.

Several of these land surface parameters have proven useful for predicting soil properties and classes. For example, Moore et al. (1993) predicted A horizon thickness, organic matter (OM) content, pH, extractable P, silt, and sand. Pennock et al. (1987) predicted thickness of A horizon, and depth to $CaCO_3$. Furthermore, Florinksy et al. (2002) predicted soil moisture, residual P, solum thickness, depth to $CaCO_3$, and organic carbon (OC). As opposed to individual soil properties, studies from Bell et al. (1992, 1994) were able to predict soil drainage classes.

In addition to hydrological geomorphometric parameters, topographic heterogeneity indices like the Topographic Position Index (TPI) (Weiss, 2001) and the Topographic Ruggedness Index (TRI) (Riley et al., 1991) assist to characterize the soil-landscape. The TPI also quantifies relative elevation and has been implemented as a mode of landform mapping (Deumlich et al., 2010). Landform mapping is an effective method to partition the landscape into discrete units that ultimately isolates similar terrain dynamics. It has been used in DSM to identify portions of a hillslope that have similar erosional and depositional regimes (Miller and Schaetzl 2015; Pennock et al., 1987).

Scale, Resolution, and Feature Selection Challenges

Remote-sensed data from satellite imagery and DEMs are distributed in a wide variety of resolutions and therefore selection of environmental covariate scales to characterize soil-landscape processes are generally determined most efficiently with expert knowledge (Kuhn and Johnson, 2013). Grunwald (2006) points out that the type and magnitude of landscape processes vary at different scales and are nonparametric. The complexity of scale-dependent soil processes also reflect the dynamics of thresholds and response to disturbances (Selby, 1982). Following suit, geomorphometric parameters are also scale-dependent (Wood, 1996). Therefore, the challenge of choosing the correct analysis scale(s) becomes increasingly complex due to the geographic phenomenon known as the Modifiable Areal Unit Problem (MAUP). Openshaw (1983) summarized this as a user bias stating, “The areal units (zonal objects) used in many geographical studies are arbitrary, modifiable, and subject to the whims and fancies of whoever is doing, or did, the aggregating."

Many previous studies utilizing geomorphometric parameters to predict soil properties and classes (Bell et al., 1992, 1994; Florinsky et al., 2002; Moore et al., 1993; Pennock, et al., 1987) calculated at a single analysis scale. They were, therefore, subject to the MAUP of DEM resolution. Studies that use multiple analysis scales and/or resolutions to calculate terrain attributes have proven to be flexible enough to identify the scales that best predict localized variations in soil properties (Maynard and Johnson, 2014; Miller et al., 2015; Roecker and Thompson, 2010).

It is quite apparent that the availability of remote-sensed data at differing scales can foster the generation of an overwhelming number of environmental covariates. Therefore, selection of the most important covariates for predictive modeling by expert knowledge can be exhaustive. One solution to this challenge is the implementation of rule-based regression trees such as the Cubist algorithm (Quinlan 1992, 1993, 1994).

Cubist iteratively selects the most important explanatory variables from the potential covariate feature space. Model trees are then created each with a particular linear regression model at the terminal leaves (terminal nodes). Intermediate models also exist at each branch (node) of the tree, but the specific prediction for a subset of the target variable population is made at the terminal leaves. The correlation coefficient results from a smoothing algorithm that is applied by accounting for the prediction from the node above, all the way up the tree. The tree is reduced to a set of rules, eliminated by pruning or combining to simplify the overall model.

The predictive power of Cubist has been effective in several DSM studies with a vast population of covariates (Bui et al., 2006; Miller et al., 2015; Minasny and McBratney, 2008). Furthermore, in a study conducted to predict daily surface air temperature, Noi et al. (2017) noted Cubist's effectiveness stating, "… [Cubist]… can account for the nonlinear and complicated relationship between the predictor and response variables under different conditions." Evidently, Cubist is an effective statistical tool to reveal the complex nonparametric relationships environmental covariates have with property target variables.

Classification and Prediction of Soil Series

Soil taxonomy is critical for scientists to effectively organize, interpret, and communicate soils information. Within U.S. Soil taxonomy, the soil series category is the lowest and most specific level of classification. Series are differentiated based on chemical, physical, and morphologic properties of the soil body. They are also classified by the environmental settings in which they occur. These differentia provide information on the specific assemblage of genetic processes that formed the representative soil series (Soil Survey Staff, 2017). However, it has long been understood that soils exist on a continuum rather than as discrete bodies and that geographically associated soils intergrade into one another (Jenny, 1941; Milne, 1935).

As opposed to the traditional taxonomic classification of soils, clustering algorithms are a mathematical approach to classify observations with multiple variables. Clustering algorithms aim to minimize the dissimilarity within a classified group while maximizing the dissimilarity between groups based on a distance metric. This metric is calculated from input variables of each observation and subsequent groups are generated based on the respective clustering algorithm's specific criterion to differentiate classes. An in depth description of the diverse array of clustering algorithms are explained in Kaufman and Rouseeuw (2005).

Cluster classification in soil science has proven to be an efficient technique to quickly and concisely partition datasets (Hot and Popovic-Bugarin, 2015; Niu et al., 2011; Powell, 1992). One particular clustering algorithm germane to this study, the Partitioning Around Medoids, (PAM) algorithm was effective in grouping soils based on geochemical characteristics in the Sacramento Valley (Morrison et al., 2011). The PAM algorithm calculates representative objects or "medoids" of the dataset that minimize the sum of dissimilarity between observations and their closest medoid. This algorithm is particularly suitable for soil classification as it can handle datasets that contain a variety of data types. It accepts continuous, ordinal, and/or a(s)ymmetric variables while also accommodating missing data in order to calculate dissimilarity matrices. Furthermore, many clustering algorithms require the user to determine the number of classes generated. However, a silhouette, or measure of how well an observation lies within its cluster, can be calculated for the PAM algorithm and therefore allows the user to choose the optimal number of clusters (Kaufman and Rousseeuw, 2005).

Contrary to the problem of classification, it may be necessary to determine which soil forming factors are most responsible for the origin, formation, and distribution of a particular soil class. Ordination techniques are commonly used to discriminate between known soil classes by reducing dimensionality of the covariate feature space to discriminant axes (Webster and Oliver, 1990). This function maximizes the ratio between specific means and the standard deviations of the variables for each class (Fisher, 1936). Multiple discriminant analysis or linear discriminant analysis (LDA) is an effective ordination technique that has been utilized in soil survey to assign soil observations to existing taxa (Webster and Burrough, 1974). Linear discriminant analysis applications in DSM have been successful in predicting soil drainage classes (Bell et al., 1992, 1994) and soil morphologic variables associated with landform units (Pennock et al., 1987).

OBJECTIVES

1. Assess the current soil health status of the Barnes soil series and catena members in the Eastern Glaciated plains of North Dakota via chemical, physical, and morphologic properties germane to edaphic function.
2. Implement a rule-based regression machine learning algorithm (Cubist) to predict Barnes soil chemical and physical properties with explanatory environmental covariates, particularly remote-sensed evapotranspiration.
3. Determine which environmental covariates and analysis scales are most important to predict variation in soil chemical and physical properties.
4. Classify Barnes soils and catena members with the PAM clustering algorithm based on chemical properties and characteristic morphology of associated taxa.
5. Use linear discriminant analysis to determine which combination of environmental covariates explain the greatest variation between soil classes.
6. Evaluate the efficacy of the linear discriminant function calculated from environmental covariates to predict soil classes.

MATERIALS AND METHODS

Study Area Development

There are approximately 2.15 million ha of Barnes soil map units in the physiographic regions of the Central and Northern Black Glaciated Plains of North Dakota (Fig. 1) (Soil Survey Staff, 2016). Due to the size of the potential study area, extensive examination of current geospatial datasets was required to attain a rational study size. The general study region (Fig. 2) extends from eastern Stutsman County across Barnes County and into the western portion of Cass County. An initial study region known as the “Large Study Area” based on the eastern border of Major Land Resource Area (MLRA) 55B and the approximate border of the James River was established to develop a representative sampling population of Barnes soils. The study region also reflects financial contributions from the Barnes, Cass, and Stutsman County Soil and Water Conservation Districts. Spatial processing of the Gridded Soil Survey Geographic (gSSURGO) Database (Soil Survey Staff, 2016) was carried out with ArcMap 10.4 (ESRI, Redlands, CA, 2016a). Spatial data calculations were performed in Universal Transverse Mercator (UTM) Spheroid World Geodetic System 1984 (WGS84) Datum WGS84 Zone 14 North (14N).

Barnes soil map units were included in selection criteria if Barnes was the first or second component and occurred on either B or C slopes. To reduce the extent to a more practical area, an “I-94 Corridor” consisting of two townships north and south of Interstate 94, was adopted. Three extensive map units within the corridor study region were selected as the sampling population (Table 1). The soil map units and study areas are shown in Figure 2.

Table 1. I-94 Corridor Barnes map unit sampling population.

Map Unit Name	Map Unit Symbol	Sum (ha)
Barnes-Svea loams 3-6% slopes	G143B	40,998
Barnes-Buse-Langhei loams 6-9% slopes	G143C	16,770
Barnes-Buse loams 3-6% slopes	G144B	50,497

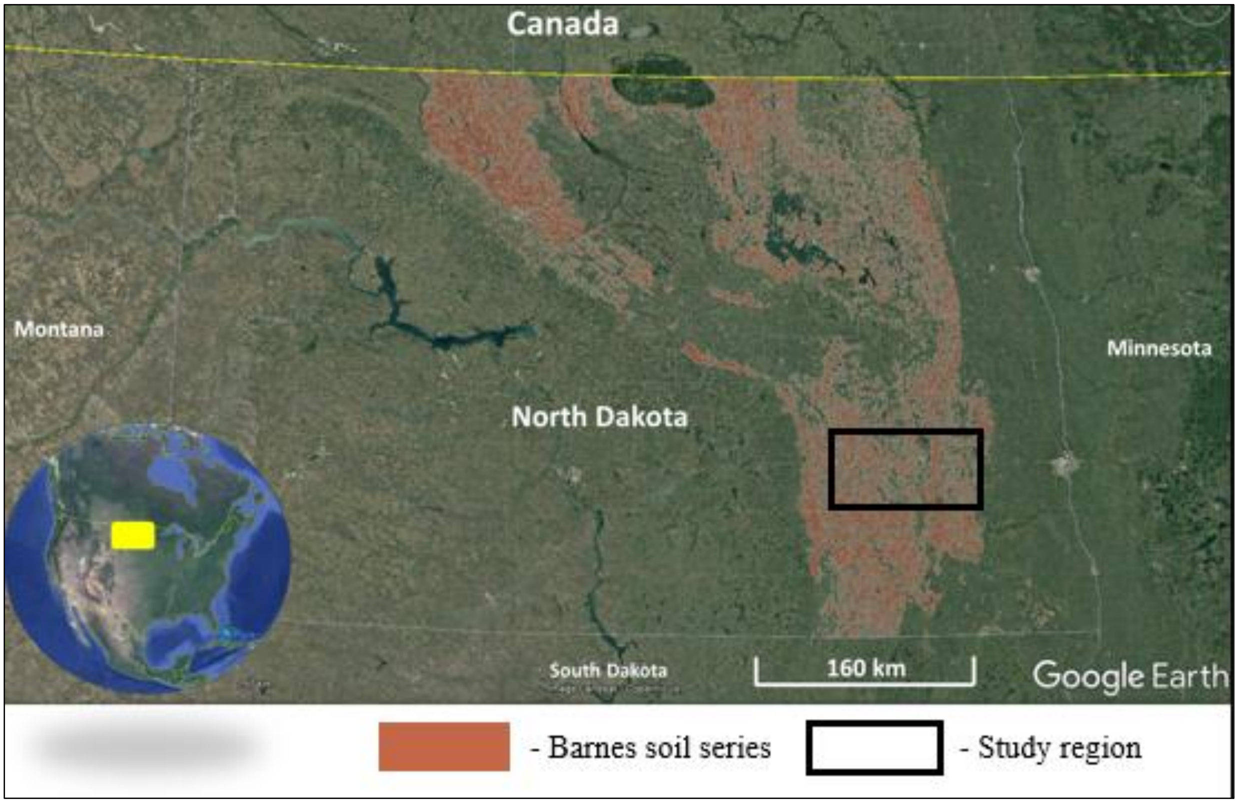

Figure 1. Extent of the Barnes soil series in North Dakota and approximate study region location.

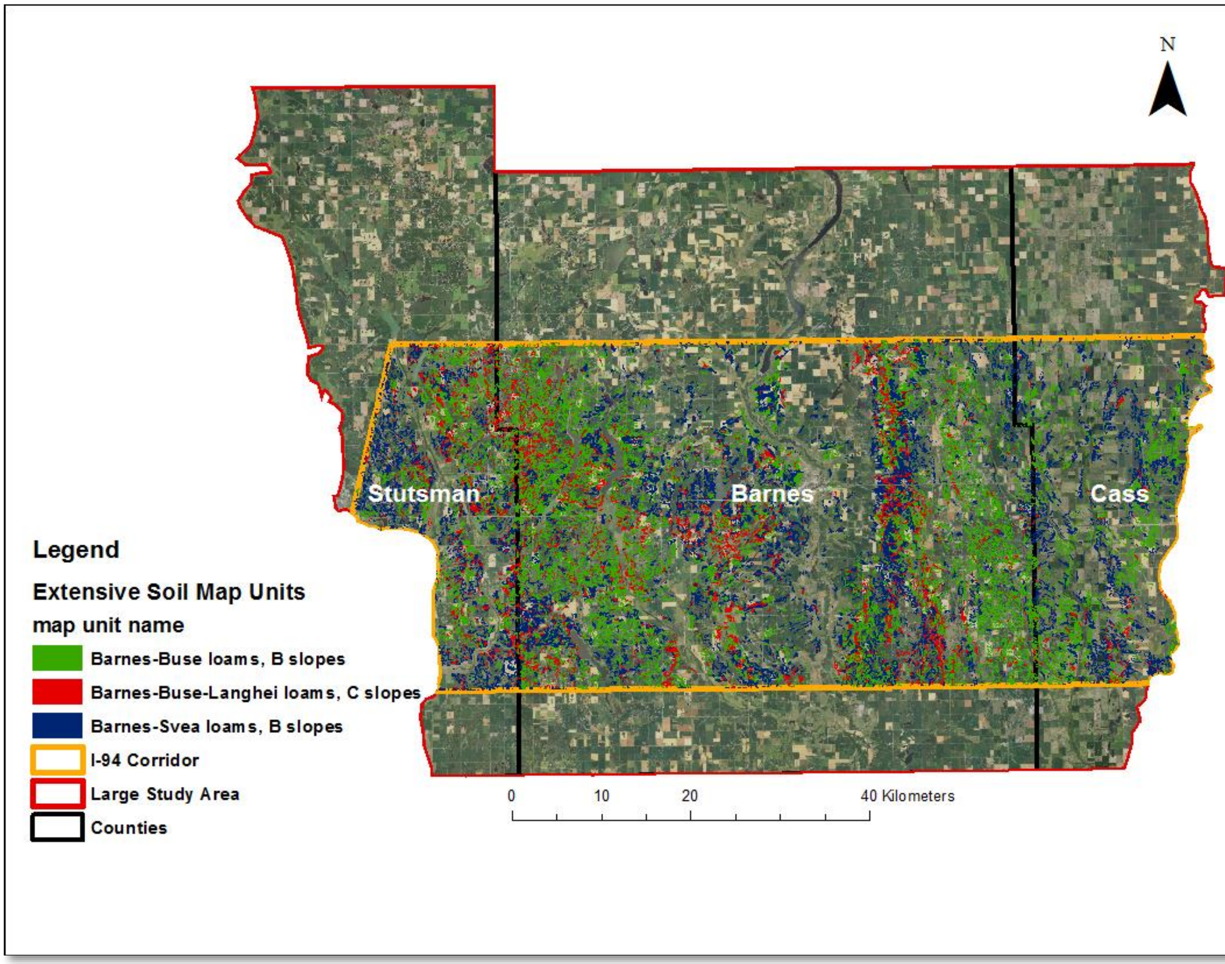

Figure 2. Geographic context for study area development in eastern North Dakota.

Setting

The eastern border of the study region is defined by the physiographic break between the Red River Valley of the North and the eastern Glaciated Plains where sandy shore lines of glacial Lake Agassiz transition to loamy, calcareous drift. Also known as the Drift Prairie, the Glaciated Plains region is covered in till deposits of late Wisconsin age (Clayton et al., 1980). The western portion of Cass County is mantled by drift with various components of calcareous till, some of which are rich in silt, and others that are predominantly clayey, but mixed with sand and gravel. The major landforms in this area consist of ground moraine, recessional moraines, and kettle chains that vary from nearly flat to strongly rolling relief up to 2-15 m. Stratified drift also exists where kame and esker features contain poorly sorted sand and gravel, some of which are mantled by till, and others that have been intermixed between till and glacioaqueous deposits (Klausing, 1968).

The I-94 corridor study area ranges across the Luverne drift unit in Barnes County and the Kensal-Oakes, and Eldridge drift units that extend from Barnes into eastern Stutsman County. The region is comprised of ground moraine, washboard moraine, and end moraine and contains calcareous sandy to very clayey and silty till. The landscape is characterized by gently to moderately rolling ground moraine topography interspersed with outwash channels that occurred at ice-marginal positions and stratified drift sediments from glacioaqueous features. The eastern-most and youngest unit, the Luverne unit, slopes east and drains into the Maple River. It has better integrated drainage than the other till units mapped in Barnes County and has more abundant argillic horizons than other areas in Barnes County (Hopkins and Franzen, 2003). The Kensal-Oakes unit has an abundance of dramatic ice-contact features, like kame and esker complexes, that rise greater than 25 m above the surrounding topography. They are chiefly composed of crossbedded sands and discontinuous poorly sorted sandy gravel lenses (Kelly and Block, 1967). The Eldridge drift, predominantly ground moraine, is the oldest of the three units and has common shallow closed depressions and many washboard moraines and kames. The washboard moraines in the study region portion of Stutsman County are remarkably well-developed, in which distinct, linear low hills are observed (Winters, 1963).

The region’s soils consist primarily of frigid Mollisols. The Barnes, Buse, and Forman (Fine-loamy, mixed, superactive, frigid Calcic Argiudolls) (Soil Survey Staff, 1998) series are the dominant well-drained soils on ground moraine and end moraines. In local alluvium, the

Svea (Fine-loamy, mixed, superactive, frigid, Pachic Hapludolls) (Soil Survey Staff, 2014d) series dominates footslope positions. The Sioux (sandy-skeletal, mixed, frigid Entic Hapludolls) (Soil Survey Staff, 2005) and Arvilla (sandy, mixed, frigid Calcic Hapludolls) (Soil Survey Staff, 1999a) series formed in high energy outwash plains, glacial lake beaches, and eskers. Somewhat poorly and poorly drained Calciaquolls such as the Hamerly (Fine-loamy, mixed, superactive, frigid Aeric Calciaquolls) (Soil Survey Staff, 2014b) and Vallers (Fine-loamy, mixed, superactive, frigid Typic Calciaquolls) (Soil Survey Staff, 2015b) also occur on till and lake plains. The Tonka series (Fine, smectitic, frigid Argiaquic Argialbolls) (Soil Survey Staff, 1999b) exist in depressions filled with local alluvium on the till plain. Average annual precipitation is around 40 to 50 cm with most rainfall occurring during the growing season. Land use is predominantly dry-farmed cropland (USDA-NRCS, 2006).

Evapotranspiration

The ET map creation involved several meetings with the NDSU Department of Agricultural and Biosystems Engineering (ABEN) who utilized ERDAS Imagine [ERDAS Inc.(now Hexagon Geospatial), Norcross, Georgia 2010] to follow the methods of Büyükcangaz et al. (2017) with some variations. Data inputs from the thermal band (band 6, 10.40 – 12.50 µm) were taken from Landsat 5 Thematic Mapper from Path 30 Rows 27 and 28. The thermal band of these images originally had a 120-m resolution and were resampled to 30-m via cubic convolution by the United States Geological Survey (USGS) (NASA Landsat Program, 2008).

An image captured July 21, 2008 satisfied the assumptions required to model ET effectively. These assumptions include an image without haze or cloud cover that would cover the ground surface and render the image unusable. Growing season timeliness was also crucial, a time frame after full ground cover was achieved and before the onset of crop maturation and senescence was required. This period is optimal for capturing crop transpiration spatial variability assumed to be correlated with soil quality variability at a single instance in time. Images captured too early were also considered unsuitable because of the potential to dampen anticipated soil-induced developmental irregularity that would be more severely expressed at a later stage of crop development (de Souza et al., 1997). Lozano-Garcia et al. (1991) suggest, “Acquisition dates should be selected with consideration of the phenological stages of vegetation.”

Additionally, the image selected had an acceptable range of NDVI, leaf area index (LAI), and surface albedo threshold values required to select the hot and cold anchor pixels which represent dry and wet surface conditions, respectively. Proximity to weather station was also necessary to assess atmospheric input variables and antecedent precipitation events at the time of image capture. The date the image had been taken met user-determined dry antecedent soil moisture conditions necessary to maximize the contrast between pixels with high and low ET. Weather data from the North Dakota Agricultural Network Center (NDAWN) at the Fingal, ND station (Lat 46.74600, Long -97.91100, elevation 454 m) were used (NDAWN, 2008).

Agricultural Land Cover Filtering

The objective of the study was to sample from typical agricultural Barnes catena soils in the eastern glaciated plains. Therefore, image processing methods were used to remove non-homogenous agricultural land cover. Roads, field boundaries, structures, municipalities, prairie potholes, drainages, shelter belts and other nonagricultural land cover types were removed to reduce surface energy balance errors and to optimize sampling location.

Land cover pixels were selected using the 2006 National Land Cover Database (NLCD) (Fry et al., 2011). The NLCD classes were recoded to analyze only agricultural land cover pixels.

All agricultural land cover pixels from the 2006 NLCD image were processed with a 7x7 focal density (FD) rectangular moving window in ERDAS model maker. Homogeneity is represented by the fraction of the sum of cells in the focal window. Therefore, in a 7x7 window, a value of 49 would indicate that the area surrounding the center pixel is 100 percent homogenous land cover. Using this layer, all ET map pixels that did not intersect with pixels of a 49 FD value were removed with ERDAS model maker.

The resultant map provides a 30-m resolution raster wherein each pixel contains an "ETrF" value otherwise known as the fraction of reference ET which is equivalent to the more commonly used ET crop coefficient in irrigation engineering literature (Fig. 3). The reference crop ET was assumed to be well-watered alfalfa (ETr) which was estimated using the computational techniques described in ASCE-EWRI (2005) used in the METRIC model.

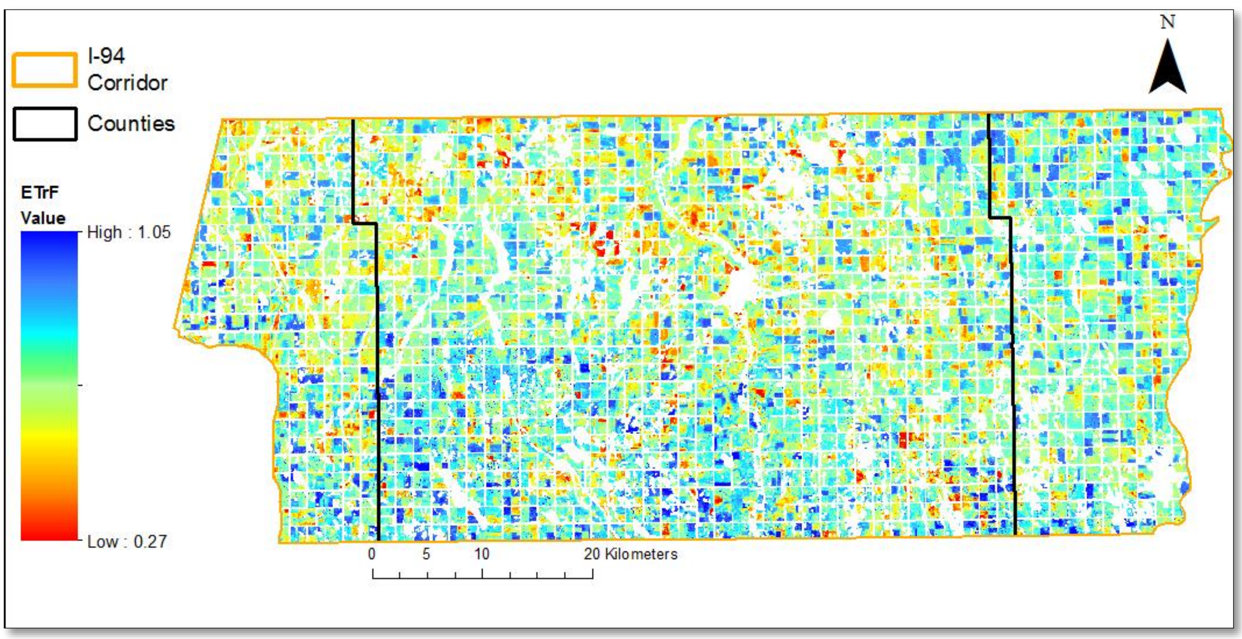

Figure 3. METRIC ETrF map in the I-94 Corridor study area.

Sampling Strategy

Using the geoprocessing buffer tool, a 60 m internal buffer was drawn within the Barnes map units to effectively eliminate all pixels from the ETrF map overhanging delineation boundaries. To further reduce confounding variables from the study, all ETrF pixels on the Barnes map units planted to soybeans for the growing season of 2008 were selected using the 2008 National Agricultural Statistics Service (NASS) cropland data layer (CDL) (Boryan et al., 2011). Soybean was selected because it was the most extensive crop planted on the Barnes map units of concern. Büyükcangaz et al. (2017) applied a 5x5 FD function to isolate "pure soybeans" or NASS CDL soybean pixels with an FD value of 25. A function in ERDAS model maker was used to select all pixels that intersected with the 2008 CDL soybean pixels and the 60 m internally buffered Barnes map units. This layer was exported as a geoTIFF (georeferenced Tagged Image File Format) file for post-processing in ArcMap 10.4.

The ETrF pixel frequency distributions for the three soil map units and the entire ETrF image (Fig. 3.) (herein referred to as the calibration region) were evaluated with Microsoft Excel (Microsoft Excel, 2010, Seattle, WA) to develop a design-based stratified random soil sampling strategy (Brus and De Gruijter, 1997). The objective was to create a non-biased sampling population with a number of samples large enough to perform meaningful statistical analyses to encompass a representative range of ETrF values on Barnes map units (Fig. 4). Pixel candidates from the histogram in ArcMap 10.4 were first stratified by map unit and then into tertiles as ranked classes of ETrF: A (low), B (medium), C (high) (Table 2). Sampling points for the three map units and corresponding ETrF classes were distributed proportionally between the three counties based on the amount of classified pixel area. The eligible sampling candidate pixels meeting all criteria were converted to a vector format with the *Raster to Polygon* tool in ArcMap

10.4. The map unit polygons were then aggregated with the *Dissolve* tool based on the ETrF class and the particular map unit. The polygons were aggregated again with the *Dissolve* tool based on County. The *Create Random Points* tool was used to generate sampling points resulting in a sampling population of 181 points (Fig. 5). The sample identification and location information are listed in Appendix A.

Table 2. ETrF class ranges for each Barnes soil map unit.

Barnes soil map unit	ETrF class range		
	A	B	C
G143B	0.357 - 0.773	0.773 - 0.830	0.830 - 1.05
G143C	0.420 - 0.751	0.751 - 0.815	0.815 - 1.05
G144B	0.424 - 0.767	0.767 - 0.828	0.828 - 1.05

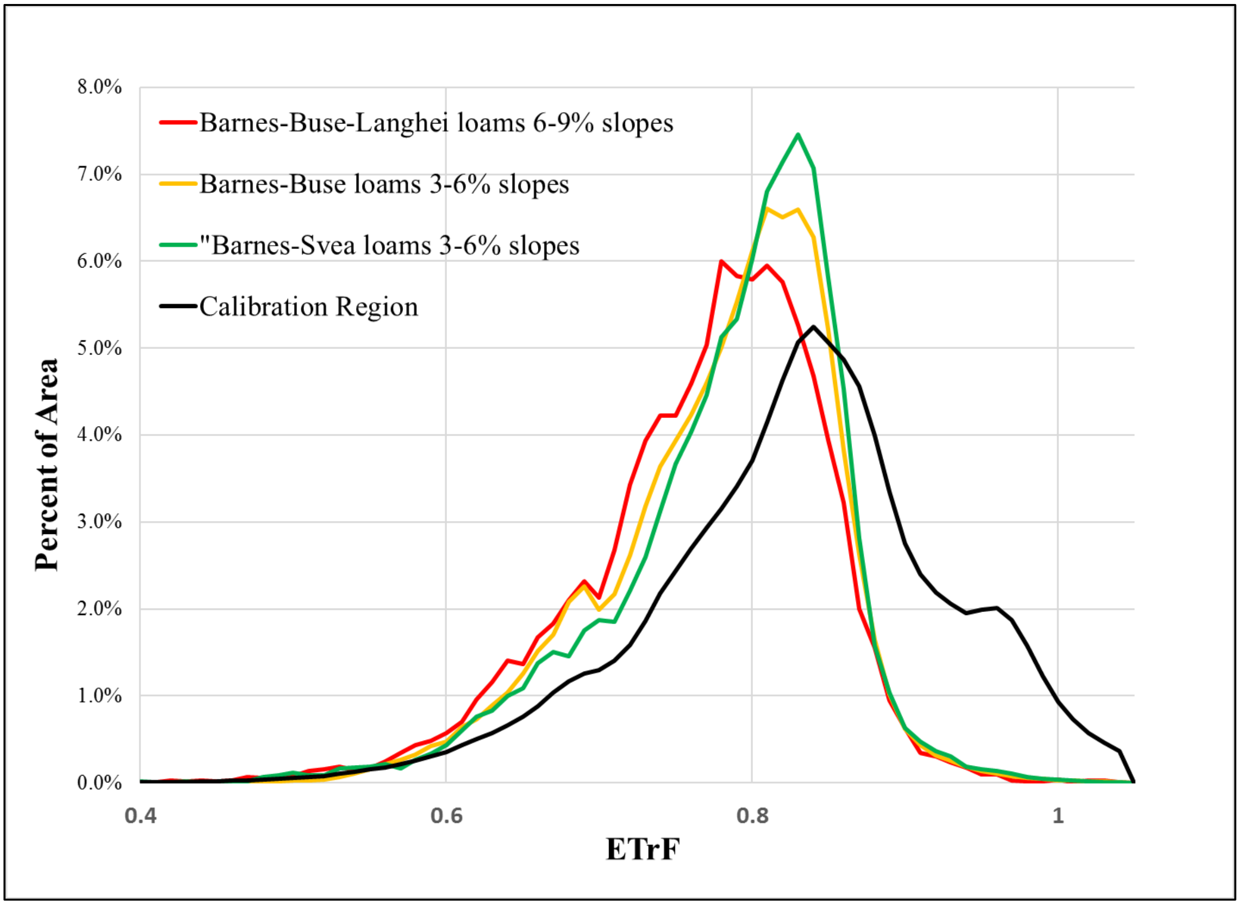

Figure 4. ETrF pixel frequency distribution of soil map units and calibration region.

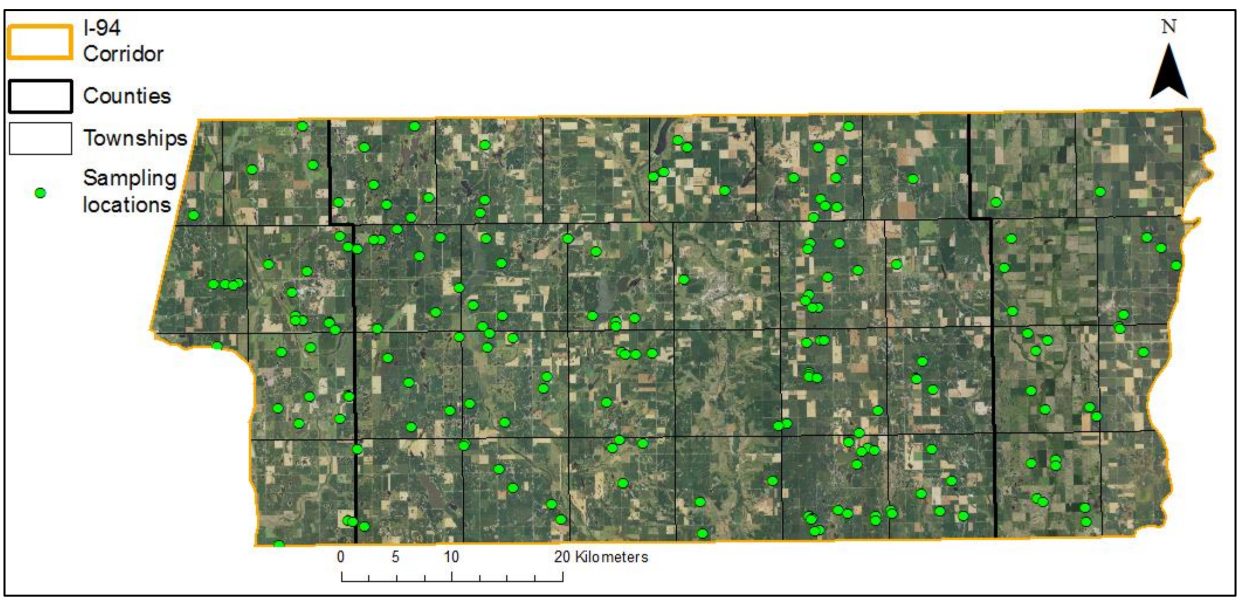

Figure 5. Geographic distribution of the 181 Barnes pedon sampling locations.

Sampling

Two weeks of field training with an experienced field pedologist (D. Hopkins) were performed at sampling locations in Cass County in order to accurately conduct morphologic descriptions which were made using the Field Book for Describing and Sampling Soils (Schoeneberger et al., 2012). Sampling location navigation was accomplished with ArcPad 10.2 (ESRI, Redlands, CA, 2016b) on the GPS handheld computer interface Trimble Nomad 800LC (Trimble, Inc., Sunnyvale, CA, 2008) which has an accuracy of 3 m. All points were recorded in UTM WGS84 14N.

Sampling points were verified in the field based on several factors. The GPS unit had to have a positional dilution of precision (PDOP) of less than four which is generally considered acceptable by natural resource investigation standards (J. Norland, Associate professor of Natural Resources Management, NDSU, personal communication, 2016). Because the instrument has an accuracy of 3 m, any sampling points that were within 3 m of the desired ETrF pixel border were relocated to a position that would prevent an error of sampling outside the pixel. Additionally, it was determined in the field that the land cover homogeneity filter had not completely removed imperfections resulting from coarse-scale resolution blindness and land use change. Therefore, if the sampling location appeared to be disturbed by land-leveling or located in a non-typical Barnes landscape position, it was moved to an adjacent location based on expert knowledge within the desired ETrF pixel.

Once the sampling location was selected and verified, an approximately 60 cm depth and 40 cm width pitwall was exposed to characterize the pedon to a depth of 50 cm (Fig. 6). Morphologic descriptions included: horizon designation, boundary, depth, structure, moist rupture resistance, roots, porosity, ped and void surface features, redoximorphic features, coarse fragments, 1 N HCl degree of effervescence, texture, and moist color with a Munsell Soil Color Book. Classes were assigned to cutans based on the degree of development (Table 3).

Figure 6. Example of pedon sampling method at site 1A4.

Table 3. Cutan class criteria by degree of development.

Class	Criteria
0	none mentioned
1	very fine or fines pores coated with cutans
	Any mention of 'strong cambic expression'
	Interstructural voids coated with few or common; faint or distinct; cutans
2	common; distinct; patchy or discontinuous
	If faint, must be continuous and/or many
	If ‘faint parting to distinct’, must be many
	Any mention of ‘borderline argillic horizon’
3	distinct or prominent; discontinuous or continuous; many or on all sides of peds
	Interstructural voids coated by many; distinct or prominent; continuous cutans

Notable properties related to solum truncation, horizon mixing, plow pan presence, depth, moist rupture resistance, porosity, roots, and geomorphic setting were also recorded. After establishing the horizons, a sample of about 0.5 L was collected from the most representative portion of each horizon for chemical and physical analyses.The table of pedon horizon depths, colors, and chemical data is listed in Appendix B. The field sampling log is available in Appendix H.

Development of Environmental Covariates

Normalized Difference Vegetation Index

Multiband image rasters from the National Aerial Imagery Program (NAIP) taken during the summer of 2012 were downloaded from the North Dakota State Water Commission (NDSWC) ND Aerial Photography Dissemination Mapservice to cover the entire extent of the study area (NDSWC, 2018a). These images are 1-m resolution and contain red, green, blue, and near infrared spectral bands. The images are required to have less than 10% cloud cover per quarter quad tile. Imagery dates include July 05, 27, 29, and 31st of 2012 (FSA, 2018). All rasters from all dates were combined into one file via the *Mosaic to New Raster* tool in ArcMap 10.4. The red and near infrared (NIR) bands were saved to new geoTIFF rasters with the *Make Raster Layer* tool. NDVI was calculated with the raster calculator as indicated by the equation:

$$[3]\ NDVI = \frac{NIR - Red}{NIR + Red}$$

where NDVI is calculated as the ratio between the near infrared band minus the red band and the near infrared band plus the red band.

Relative Evapotranspiration and Normalized Difference Vegetation Index

Decade old satellite and aerial imagery used as a means to capture vegetative vigor and instantaneous ET on the landscape presents several spatial and temporal challenges. The predominantly agricultural landscape is profoundly influenced by land cover and land use which significantly impacts the biophysical state of the earth's surface (Turner and Meyer, 1994). Variations in management practices such as the frequency and type of tillage, planting date, seeding rate, genetic variety, fertilizer, herbicide, and pesticide applications are dependent on the current land manager and historic land use. Moreover, natural spatial variation in biological and physical stresses often occurs at a scale too small to adequately capture scattered precipitation events, disease outbreaks, and weed infestations. Lastly, the coarse 30-m resolution of the NLCD doesn't precisely capture the finer spatial variability associated with field boundaries, shelter belts, and artificially cut surface drains. As a result, during the field-sampling stage, six sampling locations were mistakenly sampled from unsuitable locations and six other locations were sampled from fields that were not cropped to soybean during the 2008 growing season.

In order to address these challenges, a relative measure of ET and NDVI was calculated. This was accomplished following methods of the TPI, developed by Weiss (2001), with the following modifications. The TPI is typically used for DEMs, however, its application as a local measurement of heterogeneity can serve other purposes to describe spatial variability. The ETrF image was used as the input in the TPI from the http://www.geographer-miller.com/relief-analysis-toolbox (herein referred to as the *relief analysis toolbox)*. To capture multiple scales, 7x7, 5x5, and 3x3 cell rectangular focal windows were used to calculate relative ET. Similarly, the NDVI image was used as the input, however, it had not been filtered to remove non-typical agricultural land cover. This was accomplished with the identical methods used to develop the ET map, but the 2011 NLCD was substituted instead to provide an updated land cover filter (Homer et al., 2015). Because the NDVI image was 1-m resolution, it distinguished between planted rows, uncultivated portions of the field, and field boundaries undetected by the NLCD. Therefore, 10 m and 30 m circular search radii were used to calculate relative NDVI. This method assumes that there is within-field land management homogeneity. This novel attempt differentiates edaphic variability in the field via quantification of location-normalized ET and NDVI by accounting for vegetative differences due to land use and management.

DEM Preprocessing

LiDAR-derived DEMs for most locations sampled during the summer of 2016 were downloaded from the International Water Institute (IWI) Lidar download portal (IWI, 2016). The original DEMs were delivered as 1-m resolution, 32-bit signed integer type, ASCII grids with a vertical accuracy of 15 cm. Horizontal units were in meters and vertical units were in centimeters. The projected horizontal coordinate system was UTM NAD83 14N and the projected vertical coordinate system was North American Vertical Datum of 1988 (NAVD88), Geoid 2003. LiDAR-derived DEMs for the remaining locations, most of which were collected during the summer of 2017, were downloaded from the North Dakota State Water Commission (NDSWC) ND LiDAR Dissemination Mapservice (NDSWC, 2018b; 2018c).

The LiDAR-derived DEMs for the remaining sampling locations in the Red River basin LiDAR block were generated by the same method and in the same format as those from the IWI (NDSWC, 2018c). However, some discrepancies arose upon further investigation. The IWI DEMs were visually much smoother than those from the NDSWC (Figs. 7, 8). Digital elevation models for the remaining sampling locations were generated from the James River basin LiDAR Phase 1 project (NDSWC, 2018b). These DEMs were delivered as 1-m resolution, 32-bit floating point type, ASCII grids with a vertical accuracy of 15 cm. Horizontal units were in meters and vertical units were in feet. The projected horizontal coordinate system was UTM, NAD83 14N (NSRS2007) and the vertical projected coordinate system was NAVD88.

All DEM grids were downloaded to cover a minimum 200 m radius surrounding each sampling location. Digital elevation model preprocessing was performed in ArcMap 10.4. The DEMs were converted to 1-m resolution, 32-bit floating point ESRI file geodatabase rasters. The horizontal coordinate system was transformed to UTM WGS84 14N and the vertical coordinate system was unaltered. The z values for the DEMs from the James River basin LiDAR Phase 1 block were converted from feet to centimeters by multiplying cells by a factor of 30.48 using the *Raster Calculator* tool. All DEMs were then compiled into one raster dataset via the *Mosaic to New Raster* tool. To shorten processing time, a 200 m buffer polygon surrounding each sampling location point was made with the *Geoprocessing Buffer* tool and subsequently used to clip the DEM to the polygon extent with the *Data Management Clip* tool.

One-meter horizontal resolution DEMs can be problematic in regards to digital terrain attribute post processing. The amount of horizontal detail subsequently generated is often associated with low vertical precision and does not necessarily provide an improved soil-landscape model (Thompson et al., 2001). Five-meter and 3-m horizontal resolution DEMs are sufficient for most terrain modeling the eastern Glaciated Plains of North Dakota. Considering the high vertical variability in the DEMs from the SWC, it was critical to apply an appropriate method to smooth the data (Fig. 8). As a result, the DEM was converted to 32-bit unsigned integer with the *Int* tool and aggregated to 3-m resolution using the median z value as the resampling method with the *Aggregate* tool (Joseph Brennan, NRCS Soil Data Quality Specialist, personal communication, 4 Jan. 2018) (Fig. 9).

The resultant DEM was converted from 32-bit unsigned integer back to 32-bit floating point with the *Float* tool. The *Divide* tool was used to convert the DEM z values from centimeters to meters by dividing by 100. This elevation (Elev) DEM (herein referred to as the mDEM) was exported to a geoTIFF for post-processing.

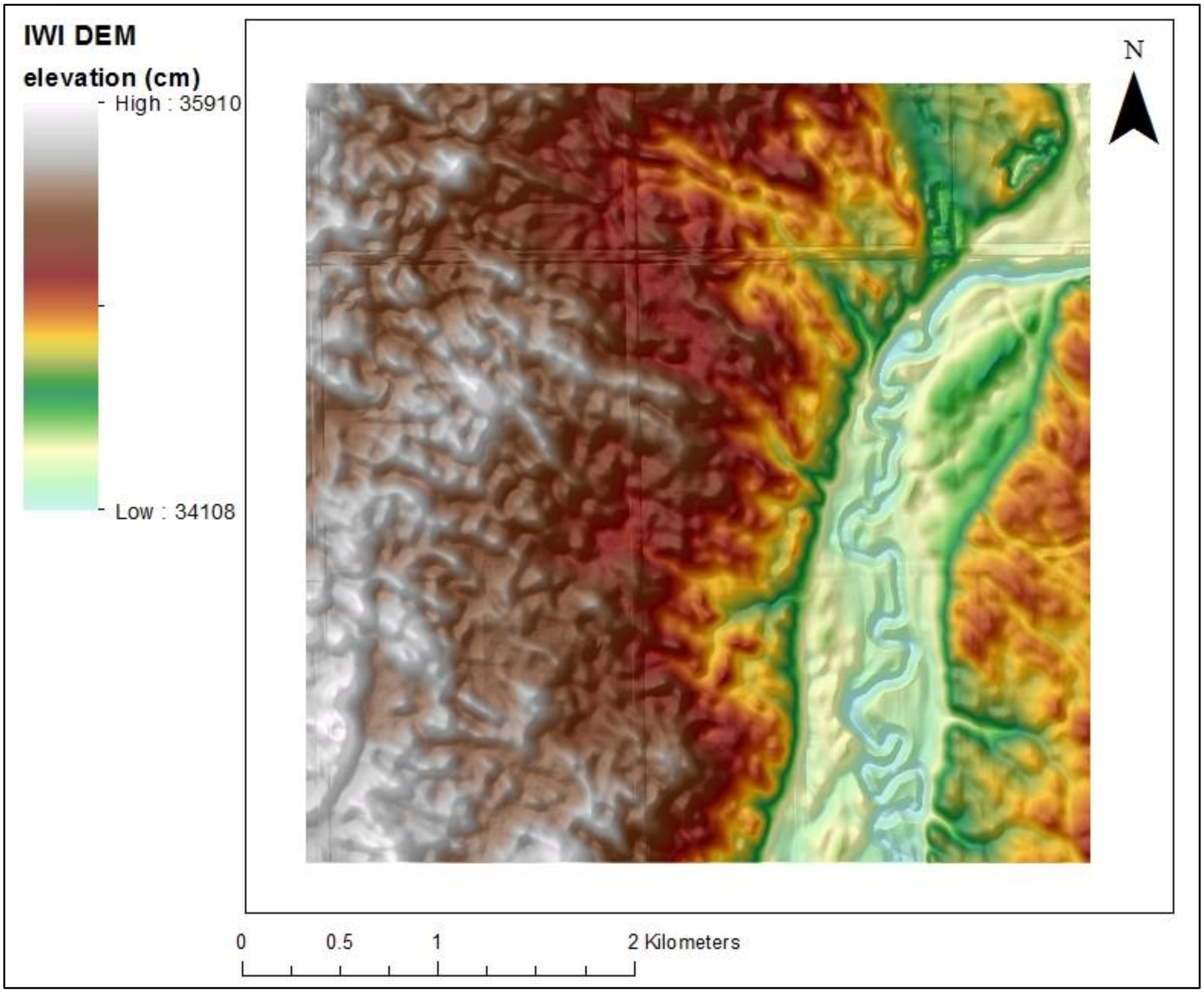

Figure 7. LiDAR-derived hillshade DEM from the International Water Institute near the Maple River surrounding section 21 of Hill Township, Cass Co., ND. The protruding linear ridges are roads and/or section boundaries.

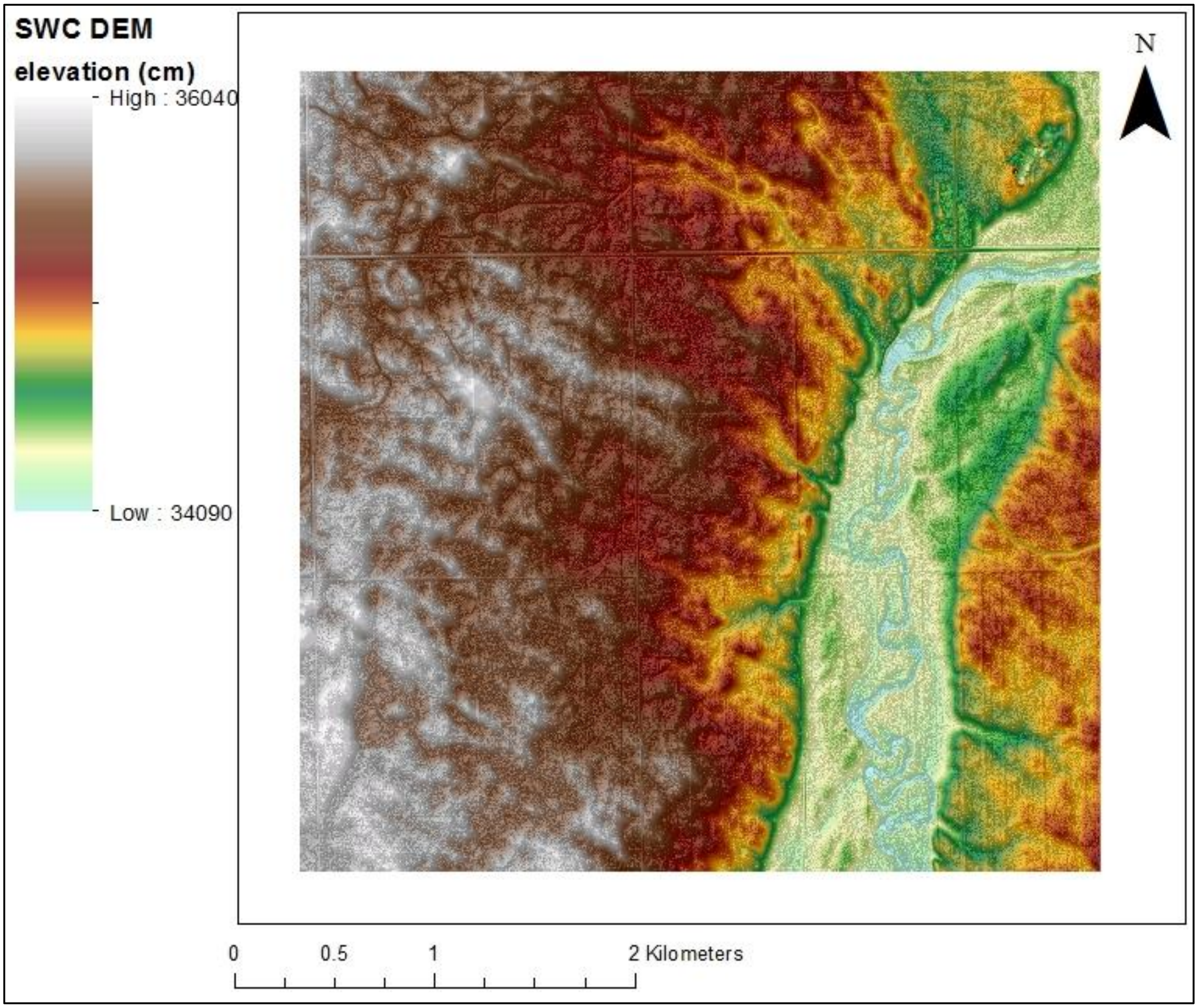

Figure 8. LiDAR-derived hillshade DEM from the State Water Commission near the Maple River surrounding section 21 of Hill Township, Cass Co., ND. The protruding linear ridges are roads and/or section boundaries. Note the fine-scaled roughness of the DEM.

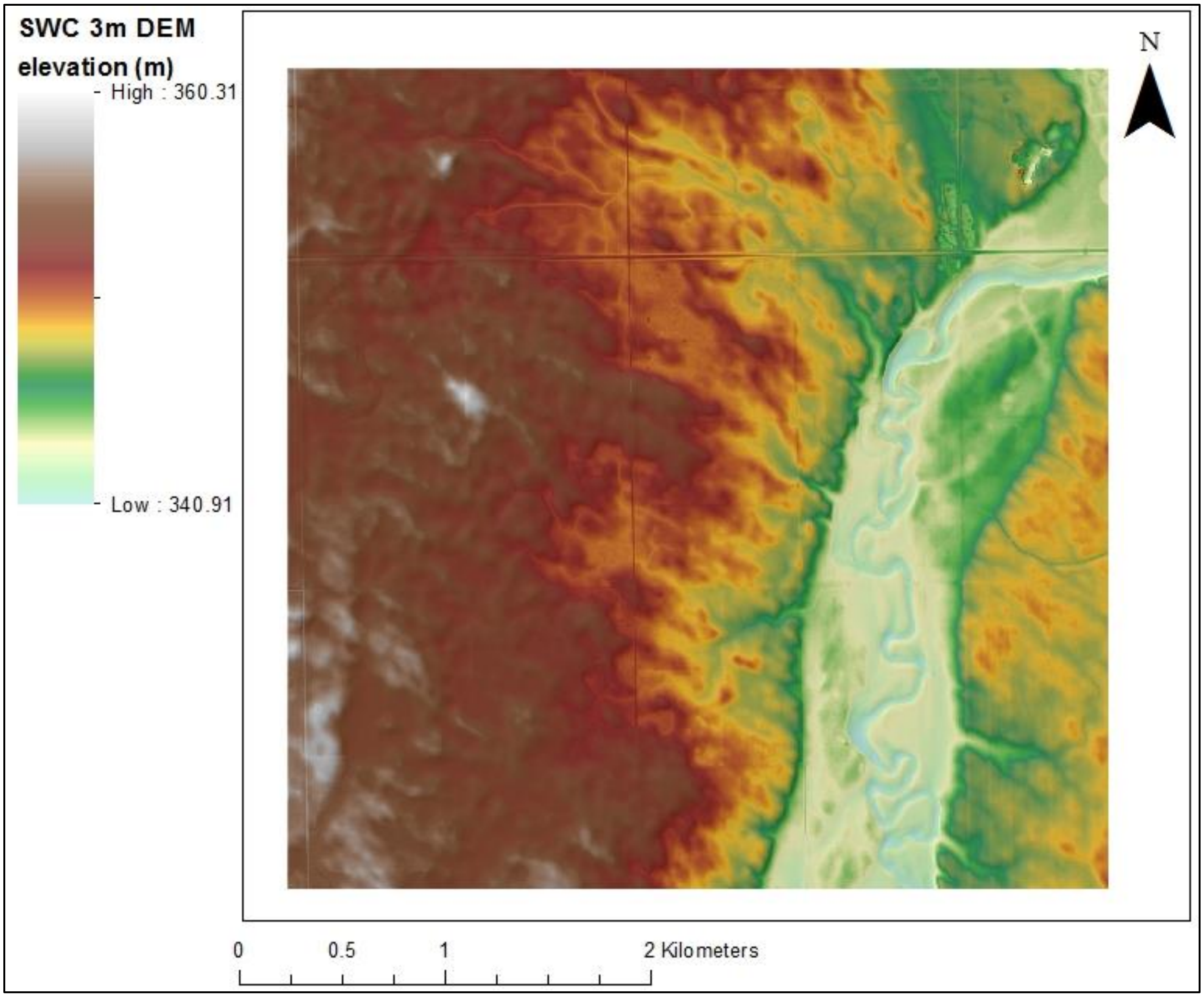

Figure 9. LiDAR-derived hillshade DEM from the State Water Commission aggregated to 3-m resolution by median method near the Maple River surrounding section 21 of Hill Township, Cass Co., ND. The protruding linear ridges are roads and/or section boundaries. Note that the DEM surface is much smoother after aggregation.

DEM Geomorphometric Parameters and Indices

DEM terrain parameter inputs to model hillslope position defined by Miller and Schaetzl (2015) were performed using the methods described by Miller (2014). Slope and profile curvature (Profc) were calculated by 3 cell (9-m analysis scale) and 21 cell (63-m analysis scale) processing windows, respectively. A 21 cell processing window was also used for cross-sectional curvature (Crosc). These terrain attributes were calculated using the r.param.scale function in

GRASS GIS 7.0.5 (GRASS Development Team, 2016). This function fits a bivariate quadratic equation at the desired scale of analysis for differing morphometric measures based on the algorithm developed by Wood (1996). Although current literature does not define a specific scale for Crosc, an identical analysis scale as Profc was used under the assumption that it plausibly explains hillslope-scale soil processes. Relative elevation (Relelev) was processed separately in ArcMap 10.4 with the *Relative Elevation* tool at a 135 m circular analysis scale from the *relief analysis toolbox*.

The TPI, an alternative method to define relative hillslope position, was calculated with ArcMap 10.4 via the *Topographic Position Index* tool from the *relief analysis toolbox* at 30 m, 60 m, and 150 m circular analyses scales. This method was adopted to capture variability that may not be explained by relative elevation at the 135 m analysis scale. As scale of analysis increases, terrain attributes tend to become smoother and the standard deviation of the raster decreases, resulting in loss of fine-scale variability (Maynard and Johnson, 2014).

In the case of complex slopes, fine-scale hillslope positions exist within the general hillslope model for simple slopes (Wysocki et al., 2000). For example, high-elevation landscape positions on collapsed end moraine surrounded by low-relief ground moraine may be relatively higher than the landscape at 135 m, but they may be in lower positions in the hummocky topography, and therefore require a smaller window of analysis to discern that difference. Moreover, the relative elevation of locations where low-relief ground moraine is proximal to deeply incised fluvial systems (Figs. 7-9) will be underestimated. Lastly, the smaller analysis scale has the potential to better explain whether a position is at the upper, middle, or lower third portion of the backslope. This is particularly important for the Barnes catena wherein organic matter increases and mean particle size decreases at the backslope with increasing distance below the summit (Malo et. al, 1974).

Slope aspect was calculated in ArcMap 10.4 with the *Aspect* tool to provide a measure of slope orientation in compass degrees from 0 to 360º. However, circular units of measure are not suitable for statistical modeling and therefore aspect was converted to northerness (N) and easterness (E) with the Sin and Cos tools respectively. The values then range from -1 to 1 in accordance with the cardinal directions.

Tools from the *Terrain Analysis* tool chain under *Hydrologic Indices* in SAGA GIS 5.0 were calculated to model potential surface saturation and flow accumulation (Conrad et al., 2015). The Convergence Index (CI) was calculated with the *Convergence Index* tool. The TWI was calculated with the *Topographic Wetness Index (one step)* tool. Additionally, the SAGA SWI was calculated with the *SAGA Wetness Index* tool. All calculations were made with default settings. This tool also generates catchment area (CA), modified catchment area (MCA), and catchment slope (CS) to perform the SWI calculation. These rasters were also included as covariates in the study. It should be noted that catchment boundaries were not specifically defined as DEM data was only processed 200 m around each sampling location. This has the potential to omit the entire upslope area within the catchment which can alter wetness indices values (Gruber and Peckham, 2009).

Temme et al. (2009), in a landmark publication predicting surface roughness on alluvial fans in the Basin and Range stated, "Errors in DEMs will propagate to derived land-surface parameters and modelling results in a way that is not easily predicted." [sic] Initial visual investigation suggested that the mDEM may not be suitable for highly sensitive secondary geomorphometric derivatives such as the SWI (Fig. 10). Therefore, an additional DEM was generated with the *Gaussian Filter* tool in SAGA GIS 5.0 (Conrad et al., 2015). The smoothing parameters were defined by one standard deviation of the 10 m kernel radius. This DEM (herein referred to as the gDEM) was exported to a geoTIFF for post-processing. All aforementioned geomorphometric derivatives were also calculated for the gDEM.

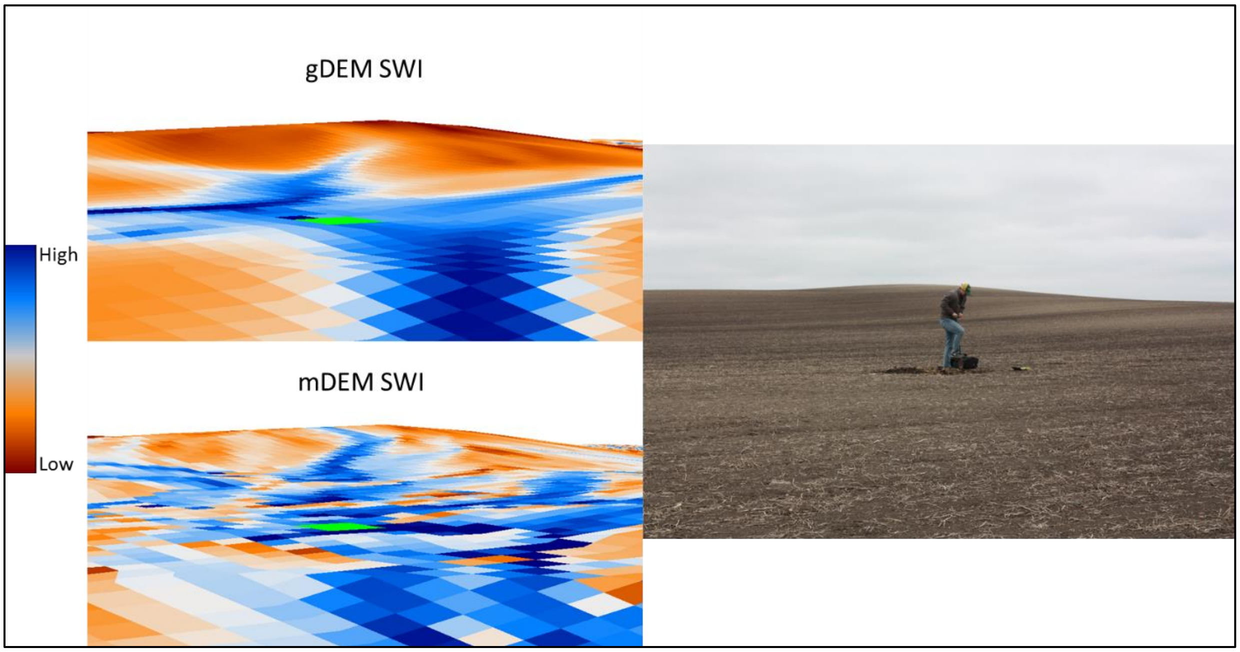

Figure 10. SAGA Wetness Index rasters calculated from the two DEMs, the gDEM (top left), and the mDEM (bottom left). The green square in both of these images represents the approximate sampling location shown in the landscape photo (right). The true landscape exhibits a relatively smooth surface, but the mDEM has high spatial variability in SWI values. The gDEM appears to capture the surface saturation expected in this landscape.

DEM Statistical Analysis

In order to quantify the visual differences in the DEMs, a statistical analysis of the above-mentioned DEMs was performed. Terrain roughness (or ruggedness) is one of the most common statistical geomorphometric parameters (Olaya, 2009). "This TRI provides a rapid, objective measure of terrain heterogeneity" (Riley et al., 1999). The TRI was therefore computed with the *Terrain Ruggedness Index* tool in SAGA GIS 5.0. The original 1-m resolution DEMs (Figs. 7, 8), mDEM (Fig. 10), and gDEM were calculated with a 65 cell circular analysis window. The TRI summary statistics for the DEMs are displayed in Table 4.

Table 4. Summary statistics of the TRI parameter for each DEM.

DEM	Resolution	Vertical units	Analysis scale	TRI			
	m		m	Min	Max	Mean	SD
SWC	1	cm	65	4.86	459	59.4	31.3
IWI	1	cm	65	3.24	249	45.7	25.1
mDEM	3	m	195	0.209	13.7	1.73	1.03
gDEM	3	m	195	0.182	11.5	1.65	1.00

Geologic Features

Linear geologic surface features within the study area were downloaded as shapefiles in coordinate system UTM WGS84 14N from the North Dakota Geological Survey (NDGS) GIS Hub Data Portal (NDGS, 2018). This map contains features from the 1:500,000-scale Geologic Map of North Dakota that includes: river channels, eskers, esker-like ridges (differential erosion or compaction ridges), ice margins, and beach ridges from glacial lake Agassiz (Clayton, 1980; Clayton et al., 1980). Distance to the nearest linear geologic feature was calculated for each sampling location with respect to each of the five aforementioned features with the *Generate Near Table* tool in ArcMap 10.4.

Laboratory Methods

Prior to all laboratory analyses, soil samples were air-dried and ground to pass a 2 mm sieve. Representative portions of each soil horizon described in the field were analyzed for total carbon (TC), inorganic carbon (IC), pH, and EC. Particle size distributions of the surface horizon for each sampling pedon were also determined.

Chemical Analysis

Carbon analysis was performed with a Skalar Primacs^{SLC} analyzer (Skalar Analytical B.V., Netherlands, 2017). This instrument determines TC by high-temperature combustion (1000 ºC) and IC by CO_2 release from addition of 20% H_3PO_4. Samples were ground with a mortar and pestle to pass a 250 μm sieve and approximately 150 to 250 g of sample were accurately weighed and used for TC and IC analyses. Two known standards were performed with each run (~40 samples) to ensure data integrity. Carbon content was recorded on a percent weight basis. The reaction time was set to 480 s for both TC and IC to ensure full recovery of the differing carbon forms. Soil organic carbon was determined as the IC content subtracted from the TC content. All IC values were converted to $CaCO_3$ equivalent percent weight.

Electrical conductivity and pH were performed on 1:1 soil water suspensions and measured with EC-calibrated and pH-calibrated sensION™ + portable meters (Hach-Lange Ltd., Kerava, Finland), respectively. About 20 g of sample and 20 mL of DI water were added to plastic cups and subsequently stirred with a glass stir-rod. The samples were allowed to equilibrate for 15 minutes, stirred again, and left to equilibrate for 15 minutes. The EC-calibrated meter was used to stir the sample again and subsequent EC readings were reported in dS m^{-1}. The pH-calibrated meter was immediately inserted into the suspension afterwards to determine pH. Results are reported as $EC_{1:1}$ in dS m^{-1} and $pH_{1:1}$. All chemical results are reported in Appendix B.

Particle Size Analysis

Gravimetric fractions of sand, silt, and clay of each surface horizon sample were determined by a modified hydrometer method based on that of Gee and Bauder (1986). About 20 g of sample were accurately weighed, oven-dried at 105 ºC for 24 hours, and immediately weighed again determine the oven-dry to air-dry mass ratio. The ratio was used to adjust the analysis sample weight. A known sample standard was also processed with each run (~20 samples). Approximately 20 g of soil and 10 mL of deionized (DI) water were added to 250 mL glass beakers. The beakers were placed in a fume hood and pretreated with 5 mL of 30% hydrogen peroxide to remove organic matter and carbonates. Once the reaction subsided, 1 to 2 mL of hydrogen peroxide were systematically added to samples until they changed color to a light yellowish brown (2.5Y 6/4). One to two drops of amyl alcohol were added to prevent the samples from frothing in the case of a violent reaction. All samples that didn't change color upon treatment with hydrogen peroxide were placed on a hotplate with a sand bed and heated to approximately 90 ºC. Hydrogen peroxide was continuously added in 1 to 2 mL volumes until the reaction completely subsided. Samples that had high levels of organic carbon (> 3% by weight) and/or $CaCO_3$ (> 15% by weight) violently reacted to the small additions of hydrogen peroxide and typically didn't change color with heating and additional treatment. It should be noted that three different laboratory technicians carried out these pretreatment methods, which vary based on the amount of flocculating material in the sample, consequently, some inconsistencies in the sample pretreatment process occurred.

Following pretreatment, 50 mL of 1 M sodium hexametaphosphate (Calgon solution) were added to the sample beakers, stirred for 15 s, and allowed to equilibrate overnight. The samples were transferred to metal dispersing cups and agitated with a commercial malt mixer for 5 minutes. After agitation, the samples were quantitatively transferred to 1000 mL sedimentation cylinders and filled to volume with DI water. A blank cylinder was filled to volume with 50 mL of Calgon solution and DI water. The samples were agitated with a plunger for 30 seconds and the start time was recorded. The temperature and hydrometer reading of the blank were recorded thereafter a digital thermometer and standard hydrometer respectively. Hydrometer readings were taken 4 h and 8 h after agitation to determine the clay fraction. The samples were passed through a 53 µm standard sieve, oven-dried at 105 ºC for 24 hours, and accurately weighed to determine the sand fraction.

Laser Diffractometer Comparison

Several erroneous observations of particle size distribution with the modified hydrometer method arose from inconsistency with pretreatment of samples high in organic carbon and/or $CaCO_3$. To maintain data integrity, 27 samples with inconsistent reruns were sent to the Department of Soil, Water, and Climate at the University of Minnesota for volumetric determination of particle size distribution by laser diffractometer. Samples for particle size analysis were air-dried, passed through a 2 mm sieve, and hand homogenized prior to subsampling. Three 0.5 g subsamples were then obtained and dispersed overnight in sodium hexametaphosphate prior to standard analysis on a Malvern Mastersizer 3000. The refractive indices of the soil and the water-based dispersant were assumed to be 1.549 and 1.33, respectively (Miller and Schaetzl, 2012). Extensive in-house validation was performed on known size fractions of sand, silt and clay to optimize laser particle size data for comparison with the more traditional hydrometer method. Based on this in-house compilation, the clay-silt break was set to 8 um, which is consistent with other studies (Konert and Vandenberghe, 1997). To eliminate bias due to small subsample sizes, the analyses was done in triplicate for each of the three subsamples and the data were compared statistically. The data from a single triplicate subsample with the greatest absolute difference from the other (two) subsamples were discarded.

The two most comparable triplicate sets were then used to calculate the mean particle size distribution (n=6) for use in subsequent analyses.

Particle size distributions determined by laser diffractometer were used to remove outlier observations determined by the modified hydrometer method. Forty-three percent of the surface horizon samples were processed more than once to ensure data quality. Questionable particle size distributions (abnormally high clay content > 40%) were compared with field notes, pictures, and landscape position to determine if they were plausible. Any observations with an absolute average difference > 5% in sand, silt, and clay content were deemed acceptable and subsequently averaged. The particle size results are listed in Appendix C.

Statistical Methods

Samples and Covariates

Each of the pixel values from all of the environmental covariate rasters were compiled into a data table in ArcMap 10.4 with the *Extract Multi Values to Points* tool. The table with nearest distance to a linear geologic feature was also joined with the data table based on the Site ID. A summary of the covariates is given in Table 5 and a summary of the geomorphometric parameters from the DEMs is given in Table 6. All covariates from the mDEM are indicated by a “m_” prefix and all covariates calculated from the gDEM are indicated by a “g_” prefix (not shown in table). References to covariates in the text from the mDEM and gDEMs are preceded by an “m” and “g” respectively.

Eleven sampling locations were removed from the initial dataset (n=181) prior to statistical analyses because they did not meet the requirement of a typical agricultural soil on a Barnes soil map unit. Therefore, the final database had 170 observations.

Table 5. A summary of the parameters, methods, and applications of the sample covariates.

Covariate	Source	Resolution	Raster	Units	Analysis scale	Method	Software	Relevance[†]
ET					m			
	Landsat 5 TM	30	ETrF	0 to 1.05		Modified Büyükcangaz et al. (2017)	ERDAS Imagine	Soil moisture; Soil health proxy[‡]
			relETfull_7X7		210	ETrF modified by TPI Weiss (2001)	*Relief analysis toolbox* ArcMap 10.4	
			relETfull_5X5		150			
			relETfull_3X3		90			
NDVI	NAIP	1	NDVI	-1 to 1		NIR - R / NIR + R	*Raster Calculator* tool ArcMap 10.4	Vegetative response to soil edaphic properties
			relNDVI30		30	NDVI modified by TPI Weiss (2001)	*Relief analysis toolbox* ArcMap 10.4	
			relNDVI10		10			
Geology	ND GIS Hub		near_riverchannel	m		Nearest distance to linear geologic feature	*Generate Near Table* tool ArcMap 10.4	Soil parent material class; Texture; Soil hydrology; Soil Class
			near_ridges					
			near_icemargins					
			near_eskers					
			near_beach					

Table 5. A summary of the parameters, methods, and applications of the sample covariates (continued).

Covariate	Source	Resolution	Raster	Units	Analysis scale	Method	Software	Relevance†
Elevation DEM	NDSWC & IWI	3	m_elev	m				Terrain derivatives

† Adapted from Mulder et al. (2011) and McBratney et al. (2003) unless otherwise noted.

‡ Montgomery (2015)

Table 6. A summary of the DEM morphometric parameters, methods, and applications.

Parameter	Raster	units	Analysis scale (m)	Method	Software	Relevance†
Aspect						
N	m_northerness	-1 to 1	3	sin(Aspect)	*Aspect, Cos, and Sin* tools ArcMap 10.4	Insolation
E	m_easterness		3	cos(Aspect)		
Slope	m_slope9deg	°	9	Wood (1996); Miller (2014)	*r.param.scale* GRASS GIS 7.0.5	Soil hydrology; Horizon thickness; SOC content; Soil Class‡; Hillslope position‡; Landform classification
Profc	m_profc63	m^{-1}	63			
Crosc	m_crosc63		63			
CI	m_ci	- 90° to + 90°			*Convergence Index SAGA GIS 5.0*	Soil hydrology; Horizon thickness, SOC content; Soil Class
SWI	m_swi				*SAGA Wetness Index SAGA GIS 5.0*	
CA	m_ca	m^2				
MCA	m_mca					
CS	m_cs	radians				
TWI	m_twi				*Topographic Wetness Index (one step) SAGA GIS 5.0*	
Relelev	m_relelev135	m	135	Miller (2014) Weiss (2001)	*Relief analysis toolbox* ArcMap 10.4	Soil Class‡; Hillslope position‡; Soil hydrology; Landform classification

Table 6. A summary of the DEM morphometric parameters, methods, and applications (continued).

Parameter	Raster	units	Analysis scale (m)	Method	Software	Relevance†
TPI						
	m_tpi30		30	Miller (2014) Weiss (2001)	*Relief analysis toolbox* ArcMap 10.4	Hillslope position; Soil hydrology; Landform classification; Elevation heterogeneity (hillslope complexity)
	m_tpi60		60			
	m_tpi150		150			
TRI						
	m_TRI65	m	195	Riley et al. (1991)	*Topographic Ruggedness Index SAGA GIS 5.0*	Elevation heterogeneity§

† Adapted from Mulder et al. (2011) and McBratney et al. (2003) unless otherwise noted.
‡ Miller (2014); Miller and Schaetzl (2015)
§ Riley et al. (1991)

Rule-based Regression of Pedon Chemical and Physical Properties

Soil SOC, IC ($CaCO_3$), $pH_{1:1}$, and $EC_{1:1}$ were weighted to 50 cm based on horizon depths. Target variables included the four weighted chemical properties, as well as SOC – IC, sand, silt, and clay. They were subsequently modeled via regression tree analysis using the Cubist algorithm with the ‘caret’ package (Kuhn, 2008) in R version 3.3.1 (R Core Team, 2016) and RStudio version 1.1.423 (RStudio Team, 2018). Predictive modeling is expressed by the formula P= f(covariates), where P are target variables that are a function of the explanatory environmental covariates given in Tables 5 and 6. The ‘trainControl’ function was used to set the parameters. Leave-one-out cross validation (LOOCV) was determined to be the most effective resampling method for a model training and prediction and the best model was chosen based on the number of committees (additional boosting iteration models) and nearest neighbors that produced a model with the lowest RMSE via the ‘train’ function in the ‘caret’ package.

The number of committees, average error, relative error, R^2, and percentage of covariates used as conditions and/or predictors in the best Cubist models for each respective target variable were reported to determine model performance and explanatory variable importance. The weighted chemical values are given in Appendix D and the covariates are listed in Appendices E, F, and G.

Pedon Classification via Clustering

Expert determination of pedon classification for statistical comparison was determined inappropriate because of the biases associated with field-experience of the investigator. Additionally, horizonation and morphologic properties were only described to 50 cm, which made it particularly difficult to assign a taxonomic class. Therefore a guided classification method was performed with the PAM algorithm with a dissimilarity matrix

(Kaufman and Rousseeuw, 2005) from the ‘cluster’ package in R (Maechler, 2017), with the goal to classify pedons into similar groupings, based on their chemical and morphologic data.

The Gower-distance dissimilarity matrix (Gower, 1971) was calculated with SOC, $CaCO_3$, depth to the calcic horizon, and asymmetric variable inputs for presence of calcic and argillic horizons. These variables were deemed most important to help classify and reduce bias associated with pedon horizon descriptions. The dissimilarity matrix was used as the input for the ‘pam’ function to perform the PAM algorithm. Based on the silhouette widths computed from ‘pam’, five clusters were determined to most effectively parse the dataset into similar pedons. The Algorithms for Quantitative Pedology or ‘aqp’ package developed by Beaudette et al. (2013) was used in RStudio to visualize pedon cluster classifications to assign a presumptive taxonomic class. Pedons more suitable for an alternative class were adjusted based on expert knowledge. General horizons were assigned within each class to make broader comparisons. One pedon class generated by the PAM algorithm was subset by the median depth to calcic horizon at 21 cm. Pedons with a calcic horizon within 21 cm were classified as “Thin Buse” and the remaining portion were classified as “Thick Buse”. Ultimately, pedons were classified as Barnes, Thick Barnes/Svea, Buse/Thin Barnes, moderately well-drained (MWD) Svea, and Forman. Chemical depth functions, profile plots, and summary statistics pertaining to chemical, physical, and morphologic properties were also generated for each subset with the ‘aqp’ and ‘lattice’ packages in R (Sakar, 2008).

Cluster Linear Discriminant Analysis of Covariates

In order to determine which environmental covariates best explain variation between the pedon classes, a linear discriminant analysis (LDA) was performed with the ‘MASS’ package via the ‘lda’ function (Venables and Ripley, 2002). Since the pedons have overlapping characteristics, they were subset into two groups to tease apart differences in covariate influences. Three well-drained upland pedons associated with a drier hydrologic regime were analyzed with LDA. Likewise, three lowland pedon classes with greater potential for moisture inputs were analyzed. As a result, the upland pedon classes included Barnes, Thick Barnes/Svea, and Thin Buse. The lowland pedon classes included Forman, MWD Svea, and Thick Buse.

Rather than using the entire suite of covariates, primary and secondary gDEM derivatives, near distance to linear geologic features, relative ET, and relative NDVI covariates were used as explanatory variable inputs. The LDA maximizes the variation between classes statistically and therefore determines numeric phenomena rather than what the covariates represent, i.e. a model to quantify energy and mass dynamics that govern and reflect soil morphology and chemistry. Linear discriminant biplots were generated with the ‘ggord’ package in R to visualize the LDA and the resultant linear discriminant correlations between covariates and the LDA coefficients were calculated (Beck, 2017). The linear discriminant functions for both the upland and lowland pedon classes were used to generate confusion matrices of pedons observed versus pedons predicted with the ‘predict’ function from the ‘stats’ package in R (R Core Team, 2016). An additional LDA was performed for all pedon classes and the subsequent linear discriminant function was used to predict and produce confusion matrices as aforementioned. Cohen’s kappa statistic for agreement was calculated with the ‘Kappa.test’ function at a 95% confidence interval from the ‘fmsb’ package in R (Nakazawa, 2017). If kappa is less than 0, "No agreement" (poor pedon class prediction accuracy), if 0 to 0.2, "Slight agreement", if 0.2 to 0.4, "Fair agreement", if 0.4 to 0.6, "Moderate agreement", if 0.6 to 0.8, "Substantial agreement", if 0.8 to 1.0, "Almost perfect agreement" (Landis and Koch, 1977).

RESULTS

Rule-based Regression to Predict Soil Properties

The SOC, pH, EC, SOC – IC, and sand content predictions from the higher performing Cubist models (Fig. 11) effectively explain variation (≥ 0.29 R^2) in decreasing order respectively (Table 7). The CaCO3, silt, and clay models explained less than 20% of the variation in the target variables. Unused geospatial covariates for all target variables included: mProfc, gProfc, gCrosc, mCrosc and gCA. Thus, Cubist utilized 41 of 46 covariates provided.

The SOC model was exceptional among the higher performing models, yielding the lowest error and the highest R^2 (Table 7). Three classes of covariates, those generated from the DEMs, near distance to geologic features, and NDVI covariates were used in nearly 30% of the SOC models (Fig. 11). The mTPI (150, 60, 30 m) and gTPI (150, 60 m) covariates were predominantly used as predictions in the committee models, whereas the gTPI (60 m) and mTPI (30 m) covariates also served as conditions in nearly 20% of the models. Values for mSlope and mMCA were used as predictors 40 to 50% of the time. Secondary derivatives, gCI and gTWI were slightly less effective, and were used as predictors about 30% of the time. Distances to river channels and ice margins were used 47% and 33% of the time as predictors, respectively. Moreover, the distance to ice margin was a condition in 17% of the models. For the NDVI covariates, relative NDVI (30 m) functioned as a predictor in nearly half the models, but actual NDVI was a condition only 5% of the time.

Table 7. Summary of Cubist model prediction performance for soil chemical properties weighted to 50 cm and surface texture particle size distribution.

Model	Committees	Avg. Error	Relative Error	R^2
SOC	10	0.39	0.82	0.64
pH	20	0.62	0.98	0.44
EC	10	0.29	1.01	0.40
SOC - IC	10	0.92	1.09	0.39
Sand	10	8.82	1.14	0.29
$CaCO_3$	20	7.13	1.10	0.19
Silt	1	8.96	1.26	0.17
Clay	10	7.27	1.33	0.11

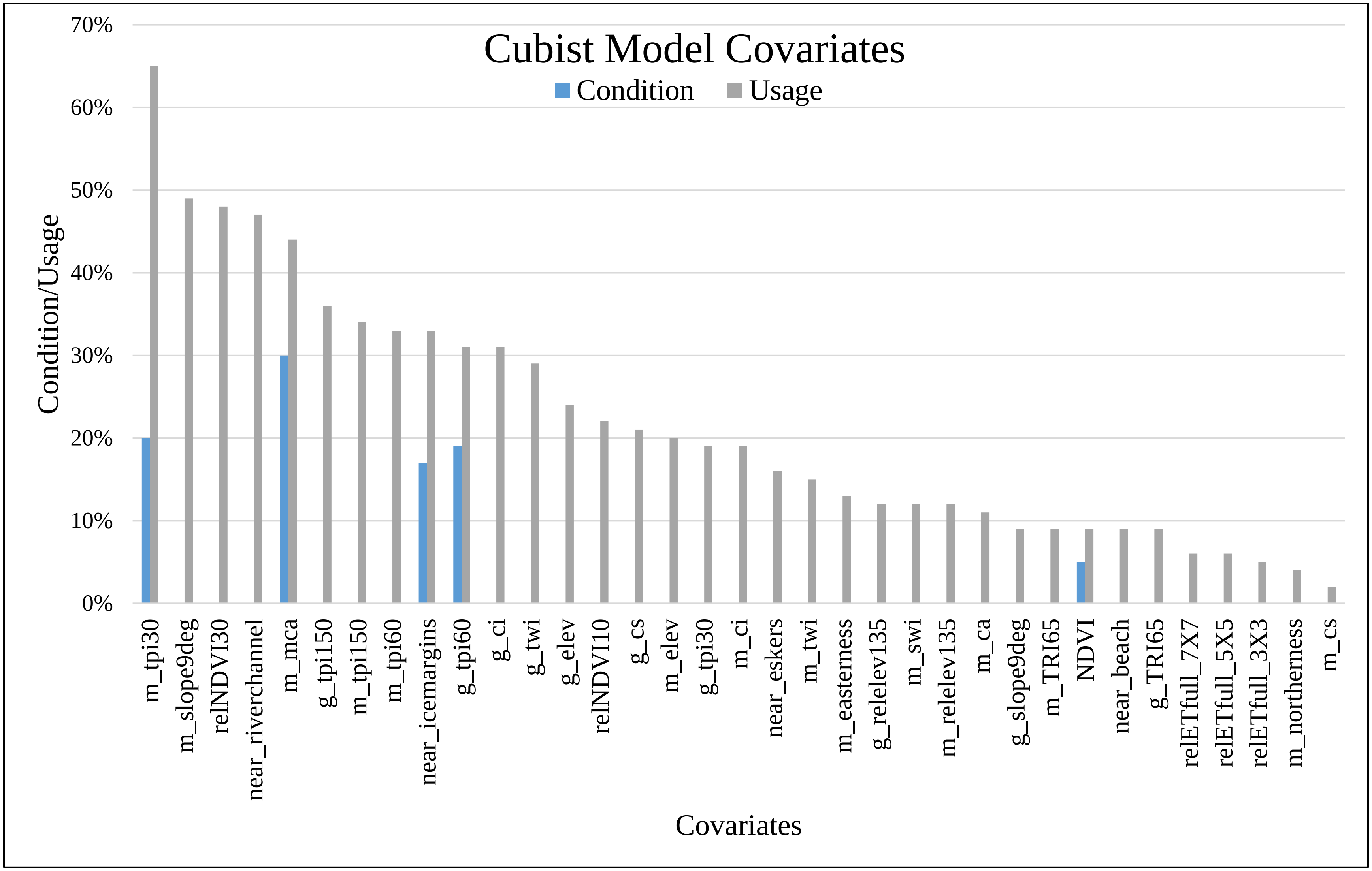

Figure 11. Covariates used as conditions or predictors in the Cubist SOC model.

To simplify overall evaluation of covariate usage and/or condition, a summary for all committee models was prepared from the top five performing models (Table 7) shown in Figure 12. The Cubist SOC results are based on the percentages from 10 committee models whereas the top five performing model variable pool contained 60 committee models. Therefore, the top five performing model usage/condition frequencies are relatively lower. Nonetheless, this method reveals which covariates were frequently applied to quantify relationships for multiple target variables.

Frequency for covariates selected as conditions was generally much greater. Cubist selected relative slope position covariates mTPI (60, 30 m) and gTPI (150, 60 m), to serve primarily as conditions, however they were also used quite frequently as predictors. The secondary derivatives, mMCA and gSWI were also selected as explanatory condition variables. Cubist chose the conditions, mTPI (30 m) and distance to ice margins, 24% and 17% of the time respectively. The mTPI (150 m) was the third most frequently used condition covariate in all the Cubist model iterations. Furthermore, distance to ridges, eskers, and beaches assisted the models as conditions in the model tree hierarchy. Cubist also included an additional ET covariate, relative ET (7x7), as a condition.

The frequently used condition covariates, mTPI (30 m), gTPI (150 m), and mMCA were often selected as predictors. Cubist repeatedly implemented relative slope position in the forms of mTPI (150, 30 m) and gTPI (150 m) 6 to 10% of the time to create linear models. The mElev and its most recurrent primary derivative, mSlope, were used in approximately 5% of the models. In regard to near distance of geologic features, excluding distance to beach, they were more frequently used as conditions rather than predictors. However, Cubist found near distance to river channels and ice margins to be particularly important predictors, ranging from 4 to 5%

usage. Additionally, gTPI (60 m), gSWI, relative ET (7x7), and NDVI were selected as conditions rather than predictors.

Convergence and wetness indices were used less often than the aforementioned predictors with usage ranging from 2 to 3%. Relative NDVI (30 m) and ET (7x7) performed fairly well at 1.6 to 2.3%, however, NDVI and ET actual and relative values were infrequently selected. Cubist did include slope aspect derivatives, N and E, to be particularly important covariates; they were selected in less than 0.5% of the models. However, mE did perform slightly better with at 2% prediction usage. Slope usage from the two DEMs was particularly contrasting. Cubist used the mSlope derivative 5% more frequently than the gSlope values.

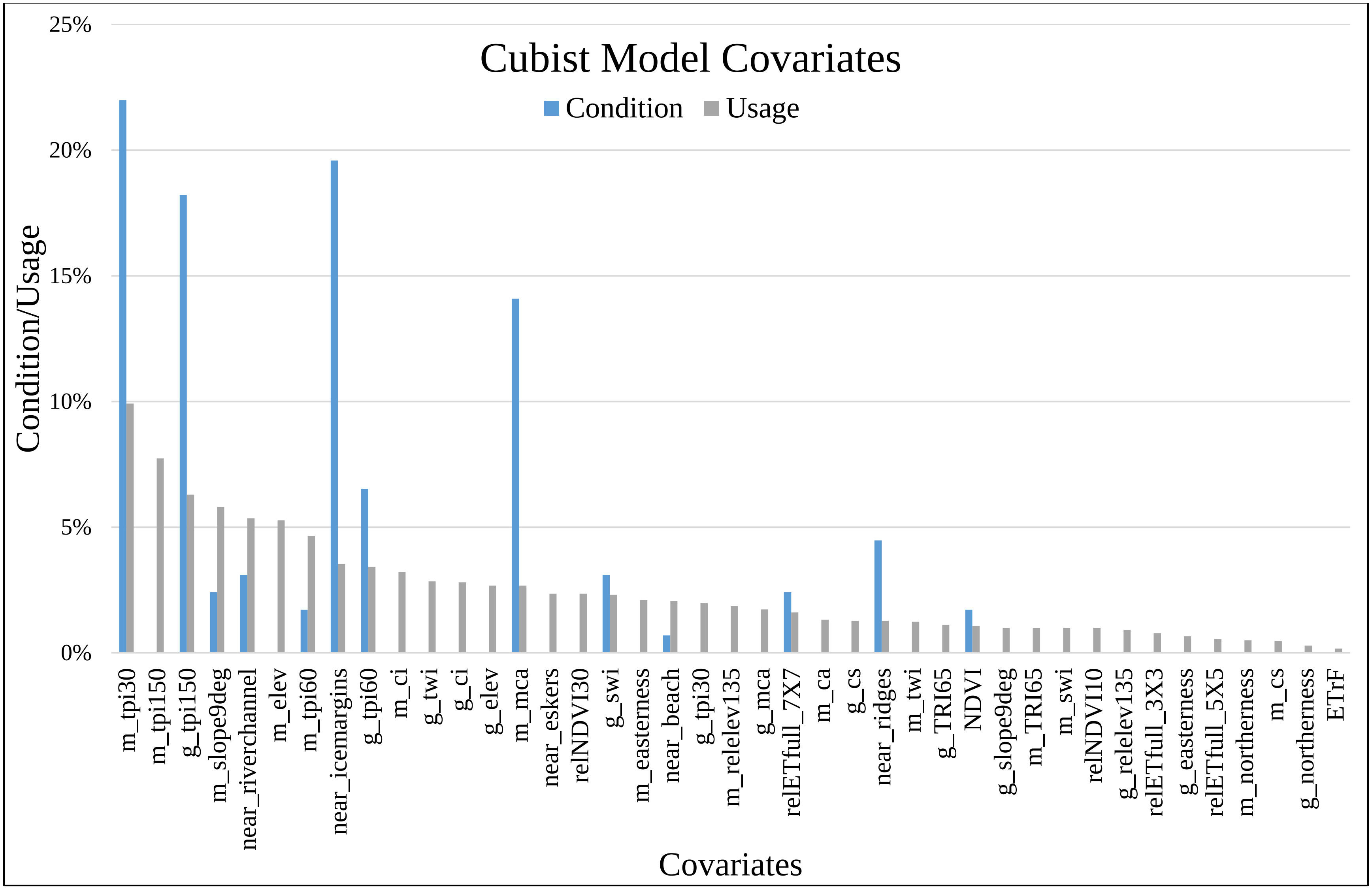

Figure 12. Percentage of covariates used as conditions or predictors in the higher performing Cubist models.

Unraveling the Soil-landscape Continuum

The guided PAM cluster method divided the soils into generally even quantities with the exception of the Forman series which only had 16 observations (Table 8). The Thin Buse (Fig. 13), Thick Buse (Fig. 14), Barnes (Fig. 15), and Forman (Fig. 18) classes all had some indication of carbonate presence, but contrasted in depth to carbonates, depth to calcic horizon, the depth of mollic colors, and cambic thickness (Table 8). General horizon types, their frequencies, depths, and other notable morphologic properties differentiated these pedons containing calcic horizons (Table 9).

The Thin Buse class on average had the shallowest depth of mollic colors, depth to carbonates and depth to calcic horizon. In fact, carbonates were at the surface for 64% of the pedons observed. The Thick Buse pedons generally had deeper calcic horizons with the upper boundary averaging 24 cm; the average depth to observed carbonates was also deeper (Table 8). However, two surface horizons did have an indication of effervescence (Table 9). The Thin Buse class included six pedons with cambic horizons, one of which was effervescent (Table 9). These cambic horizons were on average the thinnest (7 cm) of any pedon class. The Thick Buse had 23 cambic horizons that ranked the second thinnest of all classes, averaging 10 cm (Table 8).

The Barnes soils had deeper mollic colors, depth to effervescence, and calcic horizons, and greater cambic horizon thicknesses. Compared to the two Buse classes, Barnes soils were on average leached of carbonates to 37 cm (Table 8). They also had fewer surface (Ap) and cambic horizons with strong or violent effervescence (Table 9). The Barnes had a greater number of cambic horizons that were much thicker than either Buse class (Table 9). Cambic horizon thickness for the Barnes class nearly doubled the Thin Buse cambic at an average of 18 cm with an average lower boundary depth of 36 cm (Tables 8, 9).

The Forman class mollic color depths ranged from 22 to 40 cm and the depth to the calcic horizon averaged 35 cm. Given that some pedons were completely leached, the Forman class had the greatest standard deviation for depth to carbonates and depth to calcic horizon. Ten of the Forman pedons lacked a calcic horizon and did not have effervescence at or near the surface. In some cases, the Forman had cambic horizons that graded to argillic horizons (or vice versa) because they did not meet the degree of cutan development appropriate for Bt designation (Tables 8, 9).

The remaining classes, Thick Barnes/Svea (Fig. 16) and MWD Svea (Fig. 17), expressed no indications of carbonates, other than quite modest effervescence from calcic slope wash (n= 4) (Table 8). Both classes had the greatest average depths of mollic colors, 40 cm and 49 cm for Thick Barnes/Svea and MWD Svea, respectively (Table 8). The Thick Barnes/Svea differed from the MWD Svea class by a 12 cm greater average cambic thickness because the MWD Svea A horizons were much deeper at an average depth 49 cm. The cambic horizon depths of Thick Barnes/Svea pedons averaged 36 cm with a 9 cm SD (Tables 8, 9).

Root and pore sizes and quantities were summarized by horizon based on modal observations for each pedon class (Table 9). All six pedon classes had surface horizons with common fine roots. Fewer root quantities were generally observed in lower horizons. The Barnes cambic and calcic horizons had few very fine roots. The cambic horizons of the Thick Barnes/Svea class also had few very fine roots. Moreover, the calcic horizons of the Forman and argillic horizons of the MWD Svea had few very fine roots. All of the Thick Buse subsurface horizons had roots classified as moderately few very fine. Likewise, the Forman cambic and argillic horizons had moderately few very fine roots. For all pedon classes, common roots were most frequently observed in the A horizons. Additionally, common roots were most numerous in the calcic horizons of the Thin Buse and the cambic horizons of the MWD Svea (Table 9).

The surface horizons of the Thick Buse and Barnes pedons had few fine pores and the Thin Buse had very few very fine pores. These observations were contrasted by common pores in surface horizons of Thick Barnes, MWD Svea, and Forman classes. Additionally, the Thick Barnes/Svea pedons had medium pore sizes most frequently observed. The cambic and calcic horizons of all pedon classes contained many very fine pores. The argillic horizons in the MWD Svea and Forman classes also had many very fine pores (Table 9).

For surface horizons of the Thick Barnes, MWD Svea, and Forman pedon classes, 80 to 90% were either very friable or friable. The Barnes and Thin Buse classes had surface horizons that were around 70% very friable or friable. The Thick Buse surface horizons were either firm or very firm about half of the time. Nearly all the calcic horizons were either very friable or friable. However, 10 to 20% of the upper calcic horizons in the Thin Buse, Thick Buse, and Forman pedons had firm or very firm moist rupture resistance. Cambic horizons in the MWD Svea, Thick Barnes/Svea, Barnes, and Forman were very friable or friable around 90 to 100% of the time. These classes' cambic horizons were contrasted by the Thin Buse and Thick Buse classes that had 35 to 50% of the cambic horizons graded as firm or very firm. The argillic horizons in the MWD Svea were all friable whereas the 64% of the argillic horizons in the Forman were firm or very firm (Table 9).

Four properties that characterized impacts of tillage disturbance on soil morphology were noted. Plow pan frequencies and their firm or very firm moist rupture resistance are summarized by pedon class in Table 8. The other tillage disturbance properties: mechanical incorporation of adjacent horizons, and platy structure formed by mechanical compaction, are summarized for the horizons of each pedon class in Table 9. Only 17 of the 28 Barnes pedons expressed discernable plow pans. Almost 90% of those plow pans were firm or very firm. Over 60% of the Barnes Ap horizons had platy (mechanical) structure, but only 14% had indications of mechanical mixing. Furthermore, nearly 19% of the Barnes subsurface horizons had platy (mechanical) structure.

The MWD Svea class ranked second lowest in plow pan frequency with 22 observations. The plow pans were firm or very firm about 60% of the time. The MWD Svea class had the same number of Ap horizons with platy (mechanical) structure as the Barnes. Only five subsurface horizons showed evidence of mechanical mixing. The Thick Barnes/Svea and MWD Svea had comparatively fewer firm or very firm plow pans (<70%) than the Thin Buse, Thick Buse, Barnes, and Forman pedons (80 to 100%).

All Forman plow pans observed were firm or very firm and nearly 70% of surface horizons had platy (mechanical) structure. This trend did not continue with depth as only 19% of the Forman argillic horizons expressed platy (mechanical) structure. Of 16 pedons observed in the Forman class, only one surface horizon, one argillic horizon, and two calcic horizons, showed indications of mechanically mixed material.

The Thin Buse and Thick Buse classes had the greatest frequency of surface horizons with mechanically incorporated subsurface material, 44% and 38%, respectively. Almost 40% of the cambic horizons in the Thick Buse had mechanically mixed material, oddly enough, the few cambic horizons in the Thin Buse did not have any cases of mixing. Over half to two thirds of Ap and Bw horizons in the two Buse classes showed platy (mechanical) structure, respectively. About a quarter of the upper calcic horizons for both classes had platy (mechanical) structure.

Boundary distinctness and topography were determined by modal observations for each horizon by pedon class and are summarized in Table 9. All surface horizons of each class had very abrupt or abrupt smooth boundaries. The cambic horizons of the Thin Buse and Forman were clear and smooth whereas they were abrupt and smooth in the Thick Buse.

Degree of cutan development for each horizon by pedon class is listed in Table 9. Cutans were typically observed in the cambic and argillic horizons, except for two calcic horizons from Thick Buse and Forman pedons. One Barnes pedon Ap horizon had Class 3 cutans, but field notes indicated it was previously a Forman pedon that had been truncated and mixed. The Forman class had 25 of 27 argillic horizons with the highest-ranked cutan development. Two horizons, however, did not meet specified cutan criteria and were subsequently ranked Class 2. Two of three argillic horizons in the MWD Svea class had Class 3 cutans and 15% of the A and Bw horizons had Class 1 or 2 cutans.

Over 40% of cambic horizons from the Thick Barnes/Svea pedons had Class 1 cutans. An additional four cambic horizons were ranked at Class 2. The Barnes cambic horizons had almost 50% Class 1 or 2 cutans and the classes were nearly evenly split. The Thick Buse and Thin Buse pedons exhibited very few cutans. One Thin Buse cambic horizon had Class 1 cutans. The Thick Buse cambic horizons (n=23) had two Class 2 and four Class 1 cutans.

Table 8. Selected morphologic properties of the six pedon classes.

Pedon	n	Mollic colors†	Carbonates‡	Calcic§	Cambic		Plow pan#	
		(-------------depth (cm) †† ------------)			n	thickness††	n	% obs.
						cm		FI or VFI
Thin Buse	32	15 ± 6	5 ± 8	15 ± 4	6	7 ± 2	27	81
Thick Buse	33	24 ± 6	16 ± 11	24 ± 2	23	10 ± 3	30	90
Barnes	28	33 ± 8	37 ± 9	39 ± 6	28	18 ± 7	17	88
Thick Barnes/Svea	33	40 ± 11	-	-	33	29 ± 6	29	69
MWD Svea	28	49 ± 4	-	-	22	17 ± 6	24	63
Forman	16	31 ± 9	41 ± 14	35 ± 9	3	13 ± 5	15	100

† Depth to colors > 3 value and > 2 chroma.
‡ Depth to effervescence with 1 N HCl.
§ Depth to genetic calcic horizon.
# Moist rupture resistance of the plow pan; FI – Firm, VFI – Very Firm.
†† Reported as mean ± 1 SD.

Table 9. A summary of notable morphologic properties for each of the six pedon classes.

Pedon	Hor.	n	Depth†	Eff. ‡	Roots	Pores	Moist Rupture§				Boundary	Cutans¶			Mix#	Platy††
				ST or VE	quantity and size		VF	FR	FI	VFI		1	2	3		
			cm	% obs.	mode		% obs.				mode	n obs.			% obs.	
Thin Buse																
	Ap	32	14 ± 3	38	common fine	very few very fine	7	63	23	7	very abrupt smooth				44	56
	Bw	6	18 ± 4	17	common very fine	many very fine	0	50	17	33	clear wavy	1			0	67
	Bk1	32	35 ± 9	97	common very fine	many very fine	23	55	19	3	clear wavy				19	25
	Bk2	23	49 ± 4	91	common very fine	many very fine	56	44	0	0	-				0	9
	C	3	50 ± 0	67	few very fine	common very fine	0	50	0	50	-				0	0
Thick Buse																
	Ap	37	16 ± 5	5	common fine	few fine	8	46	35	11	very abrupt smooth				38	68
	A	2	22 ± 4	50	common fine	moderately few fine	0	100	0	0	abupt smooth				0	0
	Bw	23	25 ± 3	4	moderately few very fine	many very fine	0	65	35	0	abrupt smooth	4	2		39	65
	Bk1	33	42 ± 7	97	moderately few very fine	many very fine	45	45	10	0	abrupt wavy	1			21	24
	Bk2	21	49 ± 3	95	moderately few very fine	many very fine	50	50	0	0	-				0	0
	C	1	-	0	-	-	-	-	-	-	-				0	0
Barnes																
	Ap	28	18 ± 4	4	common fine	few fine	28	44	20	8	very abrupt smooth			1	14	61
	A	6	26 ± 6	0	common fine	common fine	0	67	33	0	very abrupt smooth				0	17
	Bw	37	36 ± 7	3	few very fine	many very fine	6	83	11	0	abrupt wavy	9	8		5	19
	Bk	34	48 ± 4	94	few very fine	many very fine	68	32	0	0	-				3	3
Thick Barnes /Svea																
	Ap	34	16 ± 4	0	common fine	common medium	21	71	9	0	very abrupt smooth				12	71
	A	11	26 ± 4	0	moderately few very fine	many very fine	30	30	40	0	clear smooth				18	82

Table 9. A summary of notable morphologic properties for each of the six pedon classes (continued).

Pedon	Hor.	n	Depth†	Eff. ‡	Roots	Pores	Moist Rupture§ VF	FR	FI	VFI	Boundary	Cutans¶ 1	2	3	Mix#	Platy††
				ST or VE	quantity and size											
			cm	% obs.	mode		% obs.				mode	n obs.			% obs.	
	Bt	1	-	0	few very fine	many very fine	0	0	100	0	-			1	0	0
	Bw1	33	36 ± 9	0	few very fine	many very fine	15	74	11	0	clear smooth	8	3		3	27
	Bw2	28	49 ± 2	0	few very fine	many very fine	17	70	13	0	-	14	1		0	0
MWD Svea																
	Ap	28	19 ± 5	4	common fine	common very fine	15	65	19	0	abrupt smooth				7	61
	A	27	36 ± 9	0	common very fine	many very fine	15	65	19	0	clear smooth	1	1		7	26
	Bw	25	49 ± 3	0	common fine	many very fine	15	75	10	0	-	5	1		4	8
	Bt	3	50 ± 0	0	few very fine	many very fine	0	100	0	0	-		1	2	0	0
Forman																
	Ap	16	18 ± 5	0	common fine	common fine	13	69	6	13	very abrupt smooth				6	69
	A	1	-	0	common very fine	many very fine	0	0	100	0	very abrupt smooth				0	0
	Bw	3	37 ± 2	0	moderately few very fine	many very fine	0	100	0	0	clear smooth		2		0	33
	Bt	27	40 ± 10	11	moderately few very fine	many very fine	4	32	64	0	abrupt wavy		2	25	4	19
	Bk	9	48 ± 4	100	few very fine	many very fine	67	17	17	0	-	1			22	11

† Depth to the bottom of the horizon reported as mean ± 1 SD.
‡ ST – Strongly effervescent; VE - violently effervescent; with addition of 1 N HCl.
§VFR – very friable; FR – friable; FI – firm; VFI – very firm.
¶ Degree of increasing cutan development based on amount, continuity, and distinctness (Table 3).
# Field notes indicated mechanical incorporation of other horizons (Appendix H).
†† Field notes indicated platy structure formed by mechanical compaction (Appendix H).

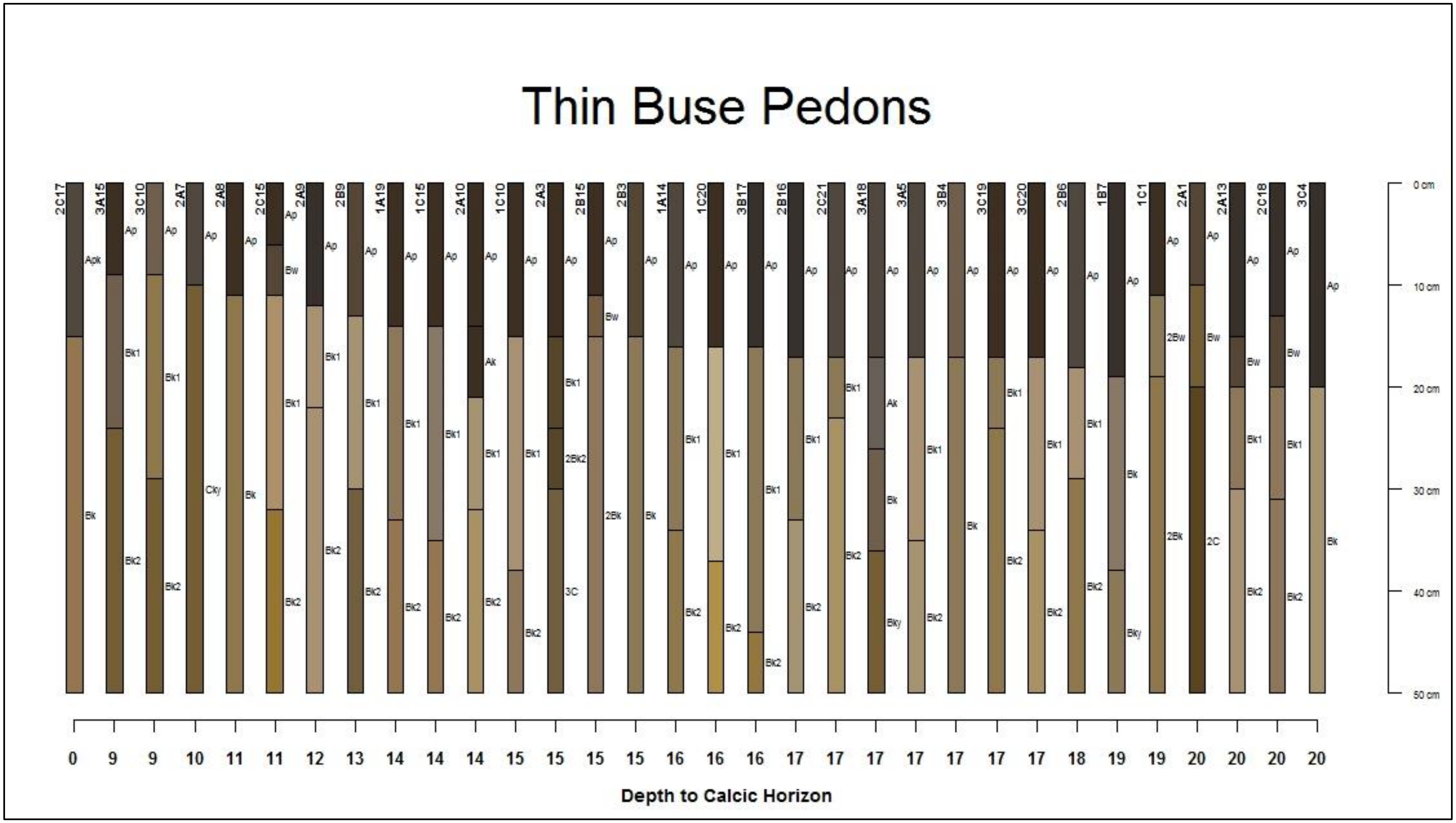

Figure 13. Thin Buse pedons (n=32) sorted in increasing order of depth (cm) to the calcic horizon or parent material. Specific site IDs are listed at the upper left of each pedon.

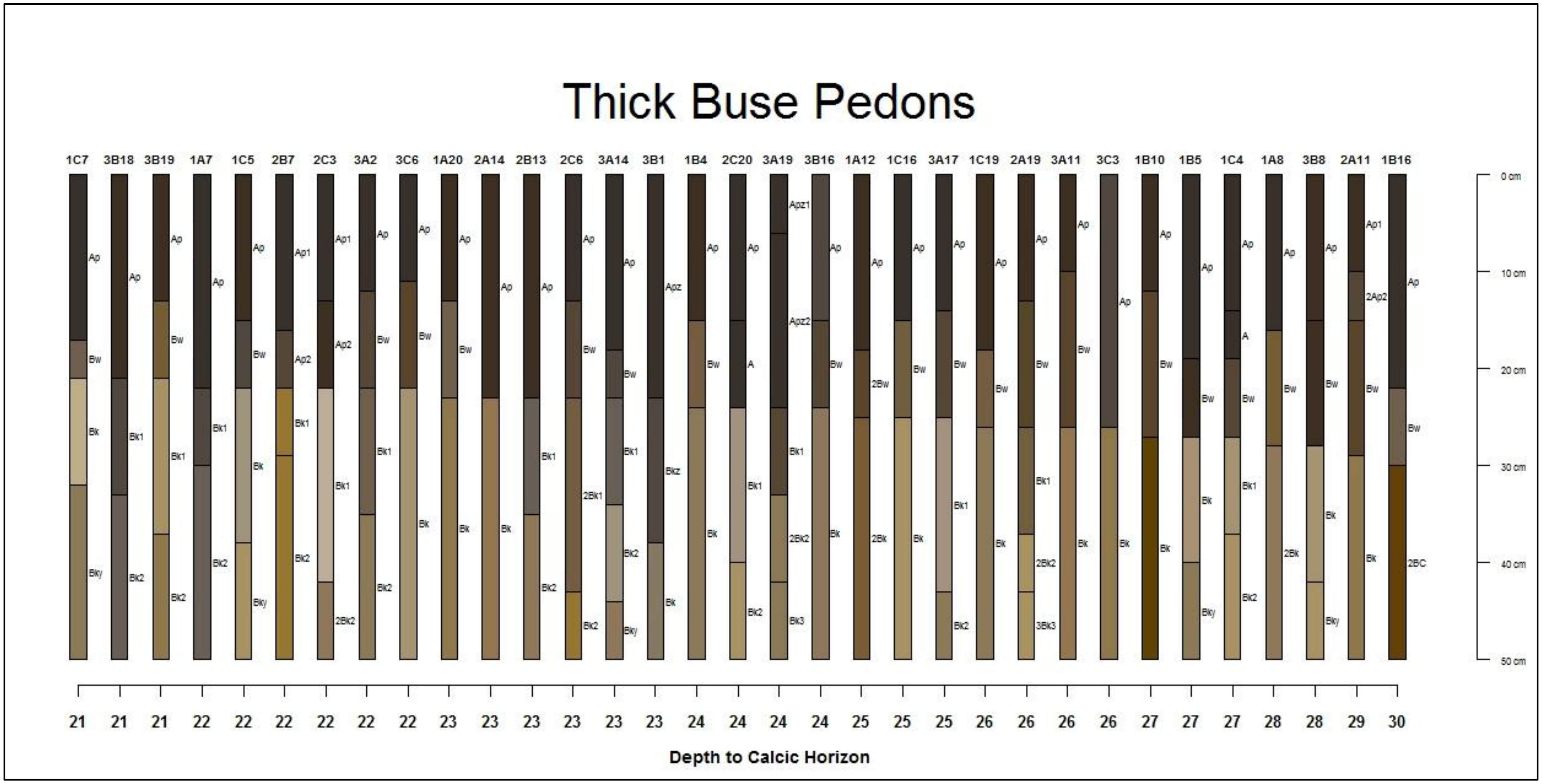

Figure 14. Thick Buse pedons (n=33) sorted in increasing order of depth (cm) to the calcic horizon or parent material. Specific site IDs are listed at the top of each pedon.

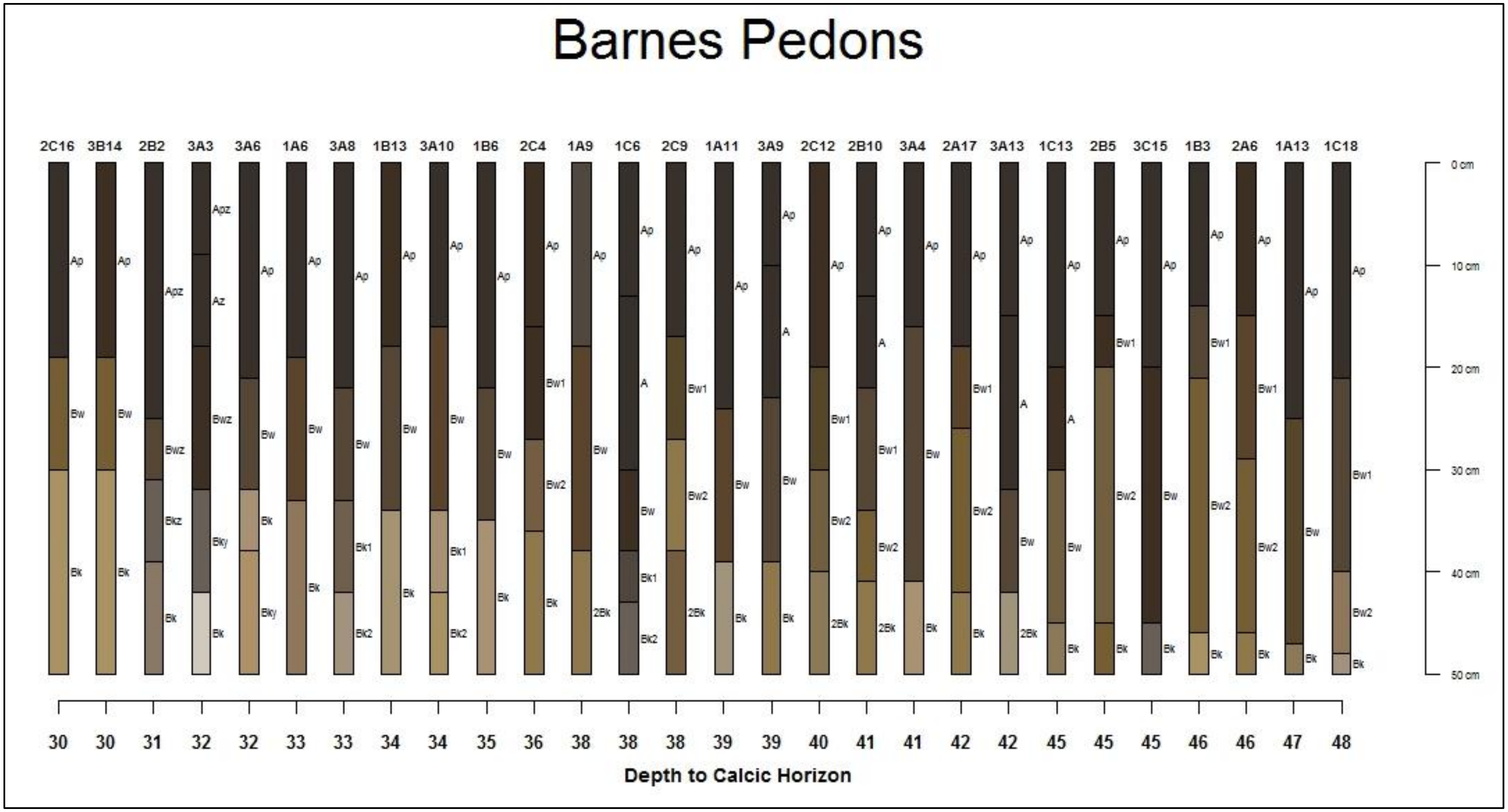

Figure 15. Barnes pedons (n=28) sorted by increasing order of depth (cm) to the calcic horizon. Specific site IDs are listed at the top of each pedon.

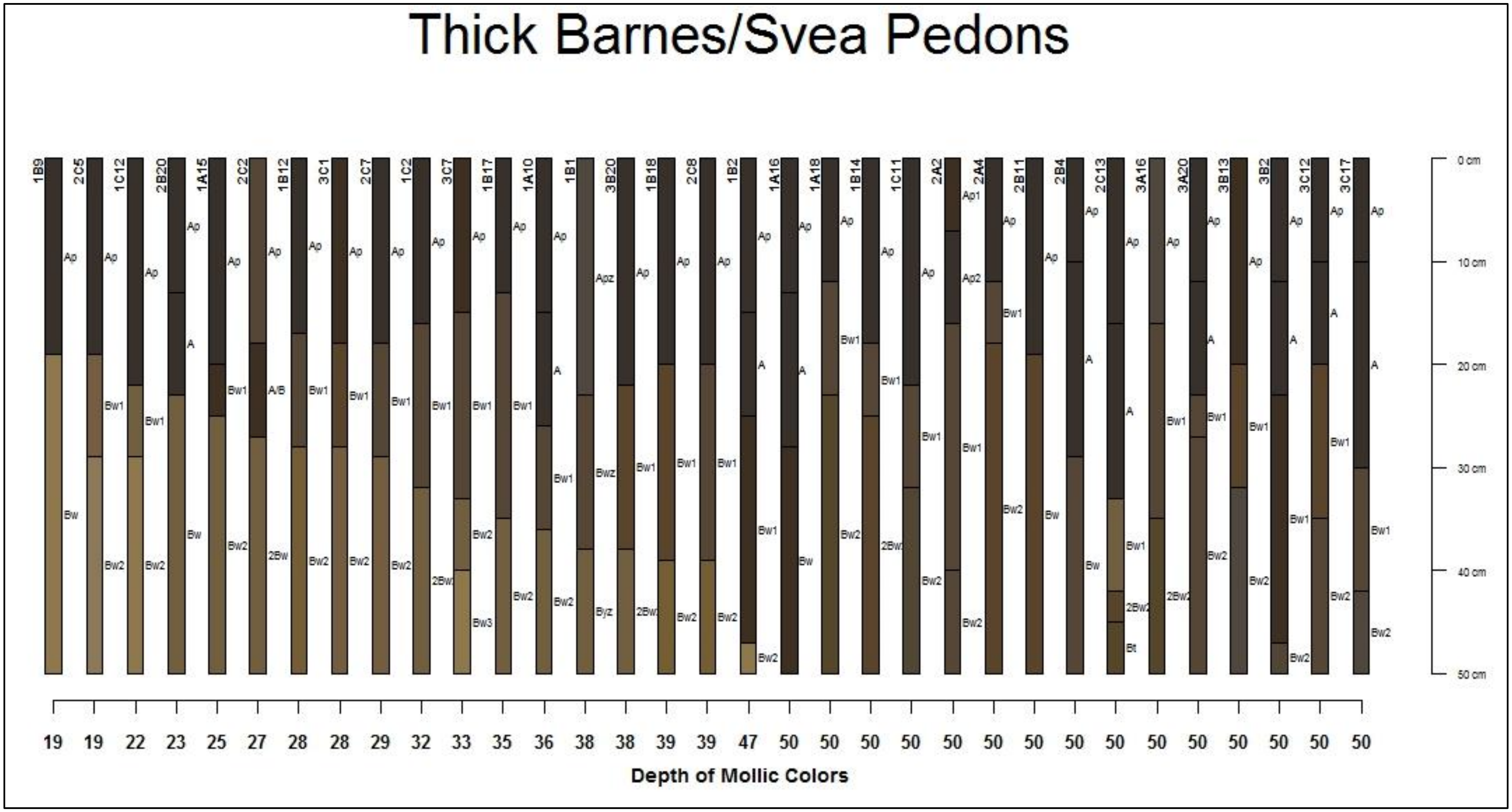

Figure 16. Thick Barnes/Svea Pedons (n=33) sorted by increasing order of depth (cm) of mollic colors. Specific site IDs are listed at the upper left of each pedon.

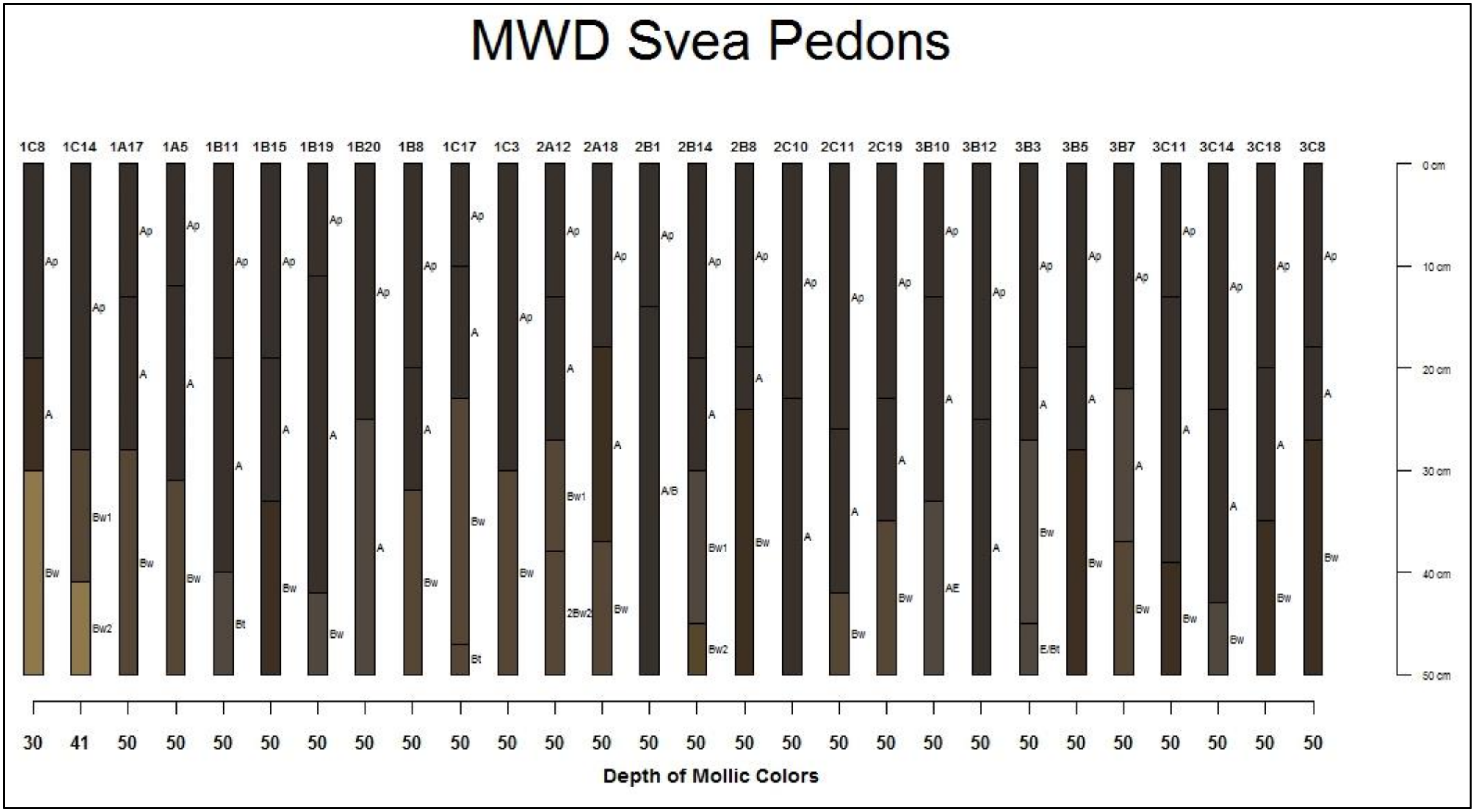

Figure 17. Moderately well-drained (MWD) Svea pedons (n=28) sorted by increasing order of depth (cm) of mollic colors. Specific site IDs are listed at the top of each pedon.

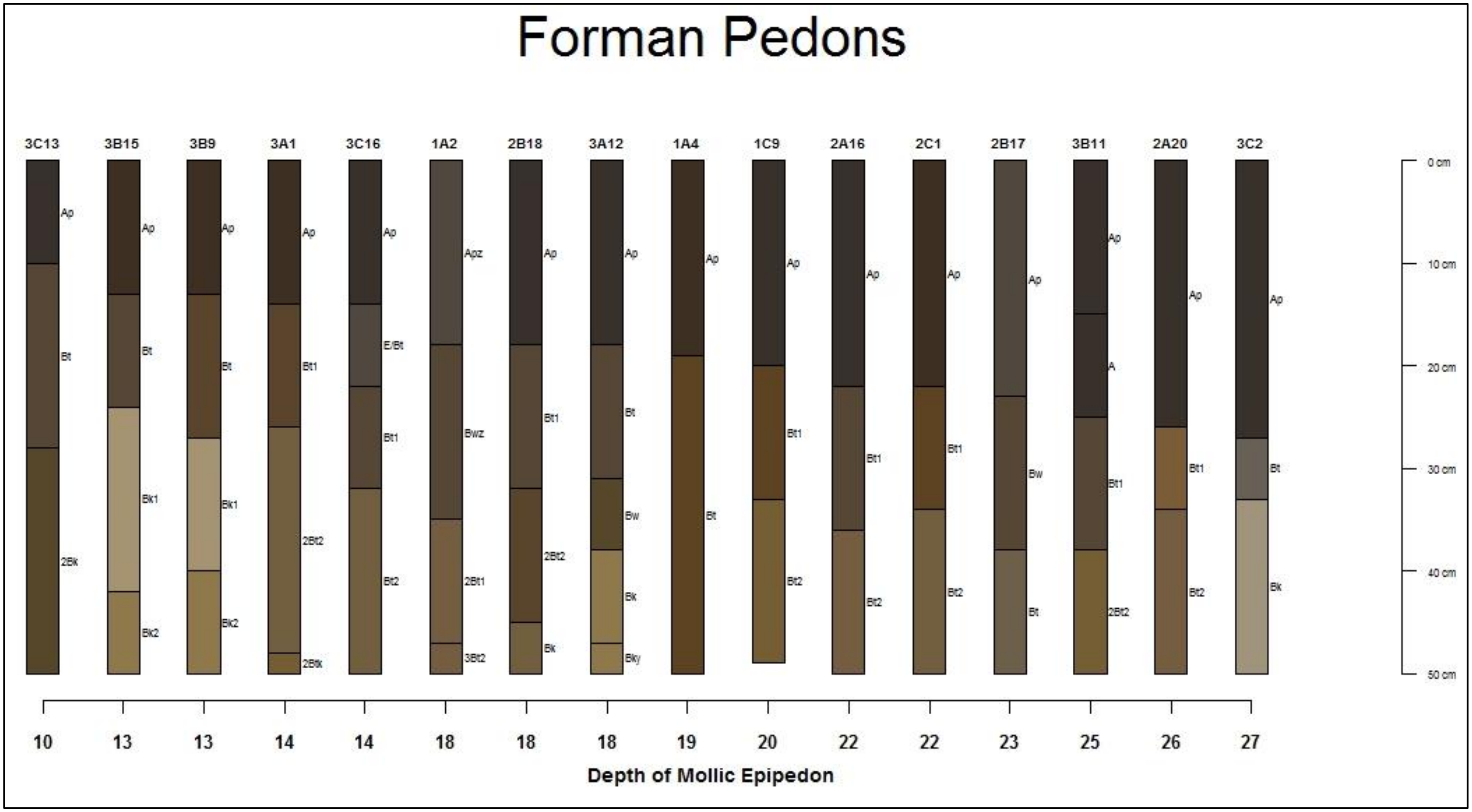

Figure 18. Forman pedons (n=16) sorted by increasing order of depth (cm) of the mollic epipedon. Specific site IDs are listed at the top of each pedon.

Pedon Chemical Properties

The chemical property by depth comparisons were analyzed for the upland pedons (Fig. 19) and the lowland pedons (Fig. 20) based on the median, 25th and 75th percentiles, partitioned by 1 cm depths. Several notable differences in every pedon class were recognized in the surface median chemical properties and the associated percentile distributions. The MWD Svea had the greatest SOC content at 3.4%. The Thick Barnes/Svea class and MWD Svea were the only classes lacking $CaCO_3$, however, the Thick Barnes/Svea had nearly 20% less SOC content. These two classes had the lowest pH values near 6, but also had greater ranges from about 5.6 to 7.3 pH. The Barnes SOC content ranged from 2 to 2.8% with a median value of 2.4, which was about 1% lower than the Thick/Barnes Svea pedons. Calcium carbonate content of the Barnes class ranged from nearly 0% to 1.5% and the pH varied around its median value of 7.2 from 6.3 to 7.8. The Forman class had very similar distributions of SOC, $CaCO_3$, and pH compared to the Barnes. The Thick Buse SOC content was greater than both the Barnes and Forman pedons with a range from 2.2 to 3.0%. Furthermore, the $CaCO_3$ content was highly variable, ranging from 0.2 to 3.7%. The Thick Buse pedons had the second highest pH median value of 7.7, which was only exceeded by the Thin Buse class with a pH of 7.96. The pH range of the Thin Buse was limited, from 7.8 to 8.0. Additionally, the Thin Buse pedons had the lowest median SOC content value of 2.2%. They also had the greatest $CaCO_3$ content median (5%) and percentile range (2.3 to 9.6%) of any pedon class for the surface horizons.

Median and percentile distributions of chemical property values at specific depths also differentiated the pedon classes. The Thin Buse SOC content median from 0 to 12 cm was around 2%, and decreased to about 1% from 12 to 16 cm. The SOC steadily decreased to 0.4% thereafter. The decrease in SOC content from 12 to 16 cm was coupled with a 7% increase in

$CaCO_3$ content to 14%. The $CaCO_3$ median ranged from 19 to 24% to a 50 cm depth. The pH percentile range only varied from 7.8 to 8.5 throughout the entirety of the Thin Buse pedons.

Barnes, Thick Buse, and Forman classes had median SOC contents that remained constant at around 2.5% from 0 to 13 cm, but steadily decreased to 1% from 14 to 27 cm. These classes differed by depth distribution of $CaCO_3$ and pH. The Thick Buse class $CaCO_3$ median barely increased to 5% from 0 to 22 cm, but rose markedly to 25% at a depth of 37 cm. The pH percentiles were 7.0 to 7.8 from 0 to 12 cm and 7.4 to 8 to a depth of 22 cm. The pH median increased somewhat from 8.0 to 8.3 below 22 cm. Calcium carbonate distribution in the Barnes remained less than 2% to a depth of 29 cm and increased to 26% from 30 to 50 cm. The Barnes pH percentile range spanned 6.3 to 7.8 from 0 to 12 cm and the median steadily increased with depth from 7.3 to 8.2 below 12 cm. The Forman pedons had very low median $CaCO_3$ content levels ranging from nearly 0 to 6%, however, because some pedons had calcic horizons and others did not, the percentile distribution range was elevated. The 75^{th} percentile was 3 to 8% from 27 to 32 cm and 13 to 20% to a depth of 50 cm.

The MWD Svea and Thick Barnes/Svea pedons had the highest SOC and lowest $CaCO_3$ and pH distributions. Both classes were virtually leached of $CaCO_3$, however, the MWD Svea had considerably greater SOC content compared to Thick Barnes/Svea class. The MWD Svea SOC median was on average 1.2% higher for every depth increment than the Thick Barnes/Svea class. The MWD Svea SOC median was 3.4% from 0 to 13 cm and did not show an appreciable decrease until around 28 cm where it dropped to 1.9%, consistently decreasing thereafter. The 75^{th} percentile limit did not drop below 3% until around 37 cm, but 25^{th} percentile SOC levels at this depth were about 1.2%. The average difference in depth increment values for pH medians for each class varied by topsoil and subsoil distribution. The MWD Svea class pH was 0.25

higher than the Thick Barnes/Svea from 0 to 12 cm. From 12 to 50 cm, the MWD Svea class pH was 0.22 lower than the Thick Barnes/Svea. The MWD Svea had a wide percentile distribution of pH values to 18 cm depth, ranging from 5.6 to 7.2 pH. The Thick Barnes/Svea class also had a similarly broad pH distribution to 18 cm with percentile limits from 5.6 to 7.7 pH.

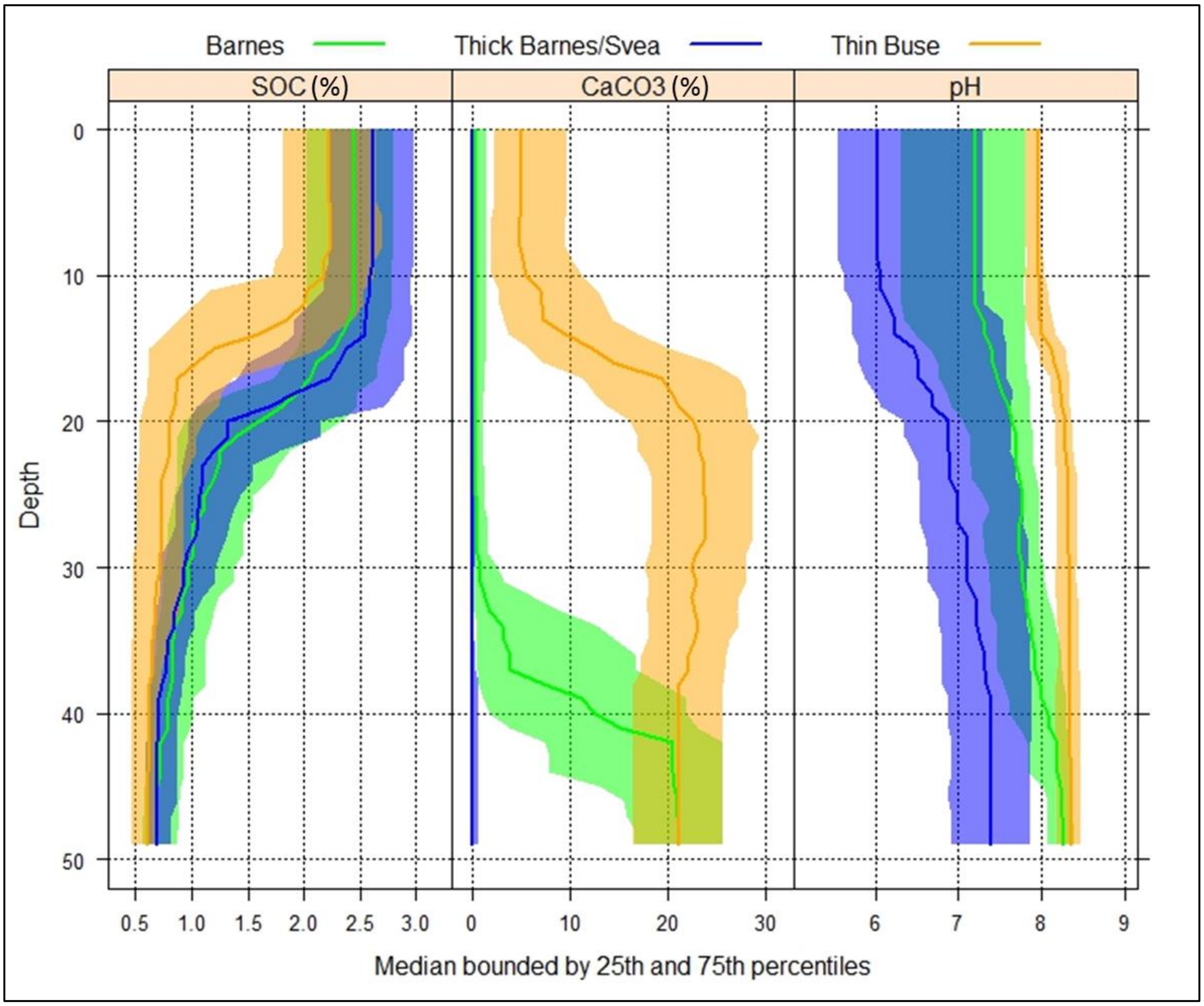

Figure 19. Comparative slice-wise aggregated chemical depth functions for the Barnes, Thick Barnes/Svea and Thin Buse pedon classes.

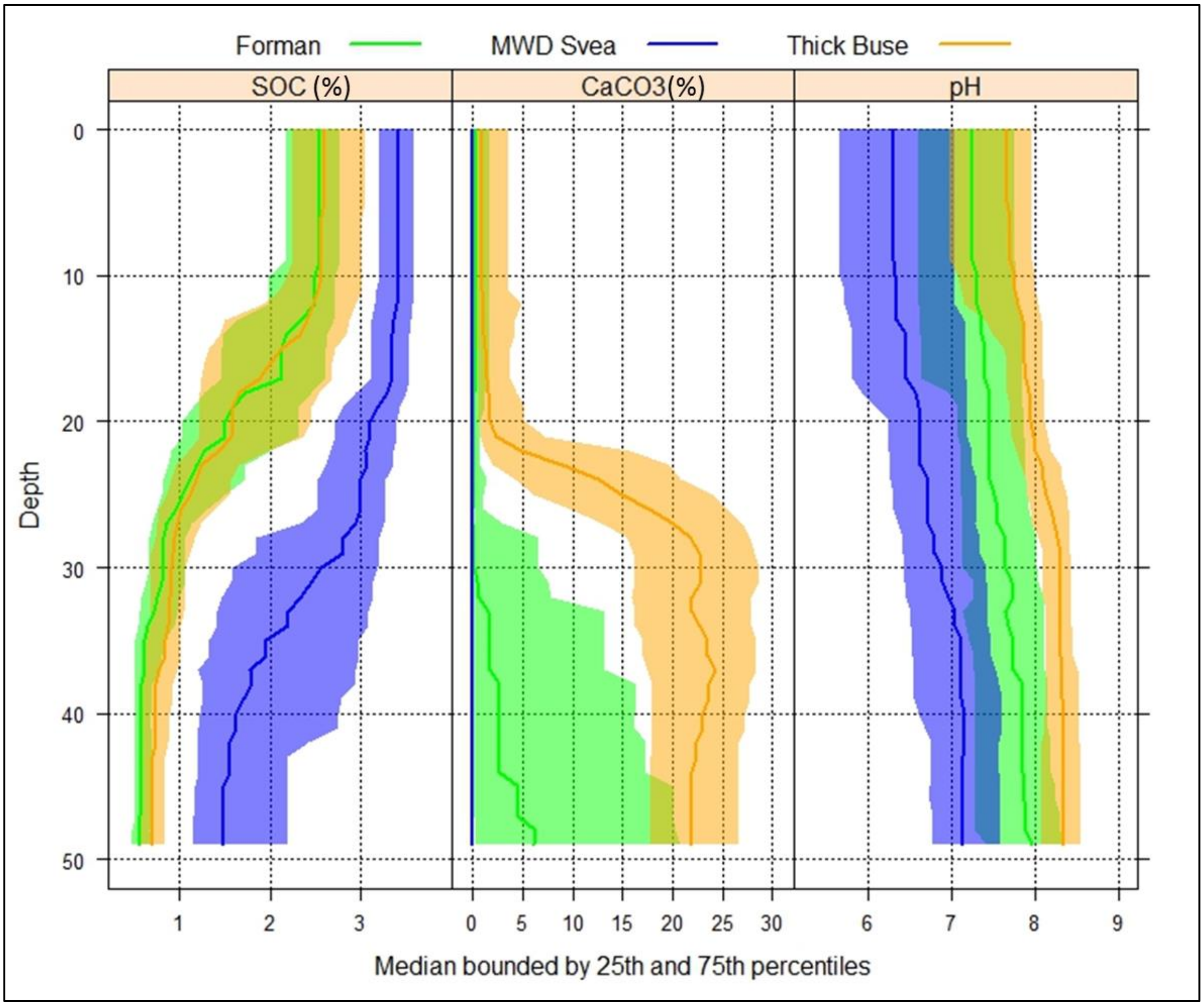

Figure 20. Comparative slice-wise aggregated chemical depth functions for the Forman, MWD Svea, and Thick Buse pedon classes.

Linear Discriminant Analysis

The first linear discriminant (LD1) explained 61% of the variation across upland pedons (Table 10). The covariates most positively correlated with LD1 were gTRI, gTPI (30 m), gCrosc, and gSlope. The gTRI had the highest *r* with a value of 0.482. The gSlope was relatively lower

(r = 0.339) and the remaining r values ranged from 0.426 to 0.446. All other input covariates had much lower r values ≤ 0.220. Notable negatively correlated variables with LD1 included gSWI, near ridges, and relative NDVI (30 m). These absolute r values were comparatively lower than the positively correlated variables. The gSWI had the greatest absolute correlation (r = -0.353). Near ridges and relative NDVI (30 m) absolute correlations were slightly lower with r = -0.325 and r = -0.289, respectively. These variables share a fairly low relationship with LD1, but r values for the remaining variables had considerably lower absolute correlations.

The second linear discriminant (LD2) explained the remaining variation in the upland pedons (Table 10). Near ice margins had the greatest positive correlation of any variable for either linear discriminant in the upland pedon group LDA (r = 0.590). The gTPI (30 m) covariate shared a notably greater relationship with both LD1 (r = 0.446) and LD2 compared to the remaining feature space; its correlation with the LD2 was the second highest positively correlated variable (r = 0.277) next to gProfc (r = 0.257), which was third greatest. The notable covariates negatively correlated with LD2 that had the greatest absolute r values included: gElev, relative ET (5x5), relative ET (7x7), and relative NDVI (10 m). The gElev covariate had the greatest absolute correlation in the upland pedon LDA (r = -0.593). The remaining notable negatively correlated variables' absolute r values of the feature space were about half or less than that of gElev.

For the lowland pedon group LDA, the LD1 explained the majority of variation between pedon classes (82%) (Table 10). The LD1 had the greatest positive correlations with proximity to geologic features including river channels, ridges, and eskers. River channel near distance correlation with LD1 was the greatest (r = 0.483), exceeding ridges (r = 0.389) and eskers (r = 0.316). Relative NDVI (30 m) was slightly lower with an r value of 0.282. The negative correlations with LD1 had comparatively greater absolute values than those positively correlated with LD1. Notable variables included gTPI (30 m), gCI, gProfc, and gCrosc. The gTPI30 variable had the greatest absolute correlation in the lowland LDA (r = -0.703). The second absolute highest negatively correlated variable was gCI (-0.631), surpassing gProfc (r = -0.585) and gCrosc (r = -0.490).

The remaining variation explained by LD2 for the lowland pedon group LDA had relatively lower correlations with the feature space. The only noteworthy positively correlated variables were near distance to eskers (r = 0.253), gSWI (r = 0.253), and near distance to ice margins (r = 0.218). The higher negatively correlated variables included relative ET (5x5) (r = 0.299), relative ET (7x7) (r = 0.287), and gSlope (r = 0.283).

The ordination biplots for upland and lowland pedon groups provide a visualization of the maximized variation between compared pedon groups explained by the two respective linear discriminants (Figs. 21, 22). The notably absolutely greater correlated variables aforementioned are shown with their respective axis and ordered by increasing absolute correlation with LD1 and LD2. The pedon group points on the biplot are enclosed by corresponding minimum bounding hulls.

The upland pedon group biplot has several pedons from the respective classes that intersect with the minimum bounding hulls of other pedon classes (Fig. 20). Within this region, variation between classes is minimal. However, the outer portions of each pedon class hull that do not intersect have specific trends. The Thick Barnes/Svea pedon class trends toward the negative side of the LD1 and LD2 axes. The Barnes pedon class extends mainly toward the negative side of the LD2 axis and the Thin Buse hull extends toward the positive portion of the LD1 axis.

The maximized variation between lowland pedon group classes is more clearly differentiated in the ordination biplot (Fig. 21). Very few points from the MWD Svea class intersected with Thick Buse and Forman hulls; MWD Svea points trended toward the positive side of the LD1 axis. A majority of MWD Svea pedons also trended toward the negative side of the LD2 axis while few trended in the direction of the positive portion. The majority of variation in the Thick Buse was explained by the negative side of the LD1 axis. Yet, nearly half of the pedons trended toward the positive portion of the LD2 axis while the remaining pedons plotted toward the negative side. The Forman pedon class was highly variable, but extremities of the hull extended greatly toward the negative portion of the LD2 axis. Almost all of the remaining Forman pedons existed within the Thick Buse hull and trended in the direction of the negative quadrant of the LD1 and LD2 axes.

Table 10. Correlation coefficients between the linear discriminants and the explanatory covariates for each pedon group LDA.

Covariate	Barnes, Thick Barnes/Svea, Thin Barnes		Forman, MWD Svea, Thick Buse	
	LD1 (61%)†	LD2 (39%)†	LD1 (82%)†	LD2 (18%)†
g_ci	0.220	0.072	-0.631	-0.121
g_easterness	-0.095	0.160	-0.237	0.128
g_elev	-0.180	-0.593	-0.075	0.037
g_northerness	-0.193	0.100	0.248	0.002
g_profc63	0.209	0.257	-0.585	-0.035
g_slope9deg	0.426	0.070	-0.111	-0.283
g_swi	-0.353	0.058	0.136	0.253
g_crosc63	0.432	0.149	-0.490	-0.148
g_tpi150	0.339	0.152	-0.472	-0.166
g_tpi30	0.446	0.277	-0.703	-0.034
g_TRI65	0.482	-0.155	0.112	0.010
near_eskers	-0.004	-0.136	0.316	0.253
near_icemargins	0.035	0.590	0.237	0.218
near_ridges	-0.325	-0.014	0.389	0.092
near_riverchannel	-0.156	0.045	0.483	-0.155
relETfull_5X5	-0.005	-0.315	-0.197	-0.299
relETfull_7X7	-0.019	-0.290	-0.172	-0.287
relNDVI10	-0.032	-0.284	0.179	0.077
relNDVI30	-0.289	-0.126	0.282	0.195

† Percentage of variation in pedon groups explained by the linear discriminant.

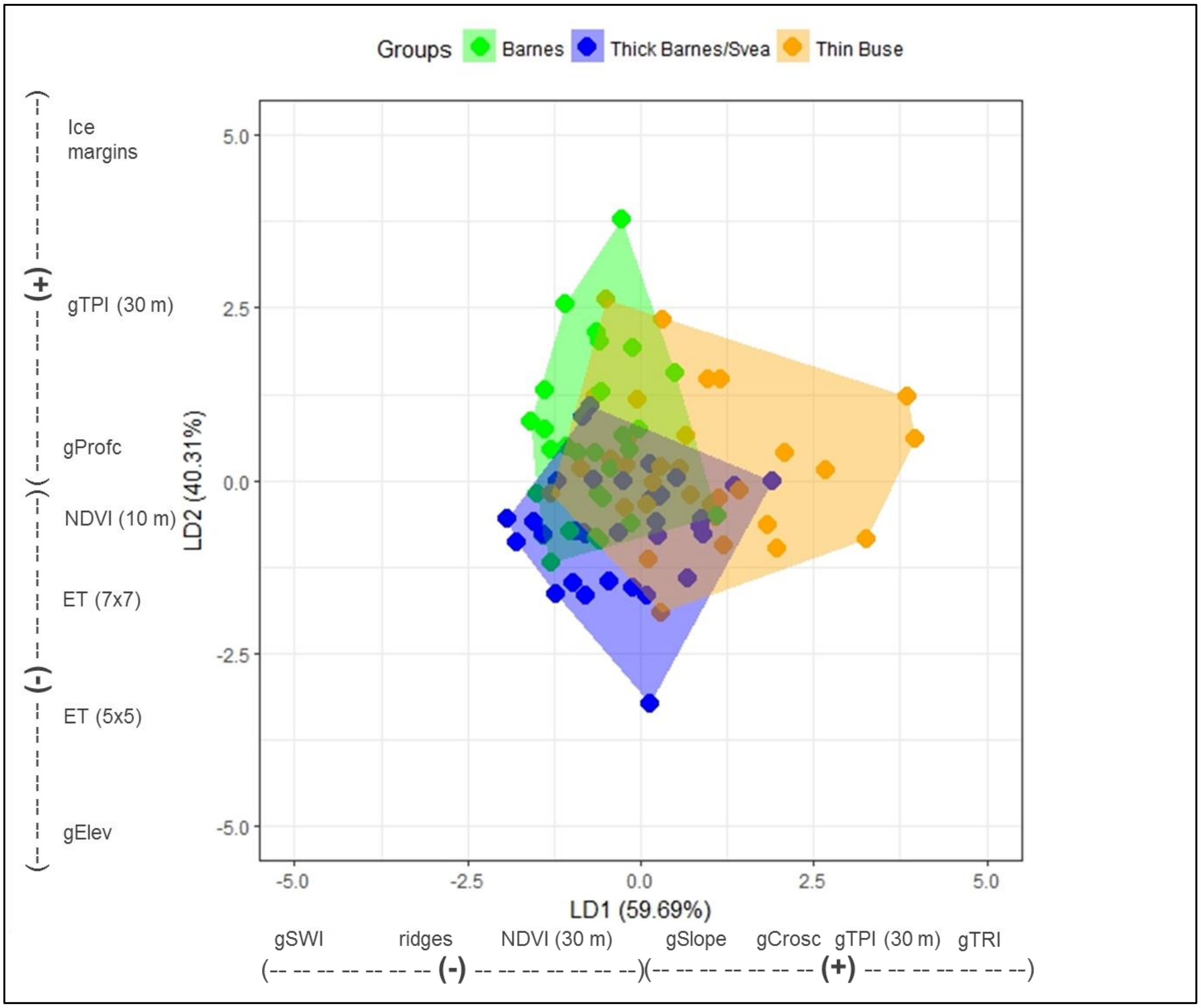

Figure 21. Ordination biplot of linear discriminants and notably higher correlated variables with LD1 and LD2 for the upland pedon group LDA.

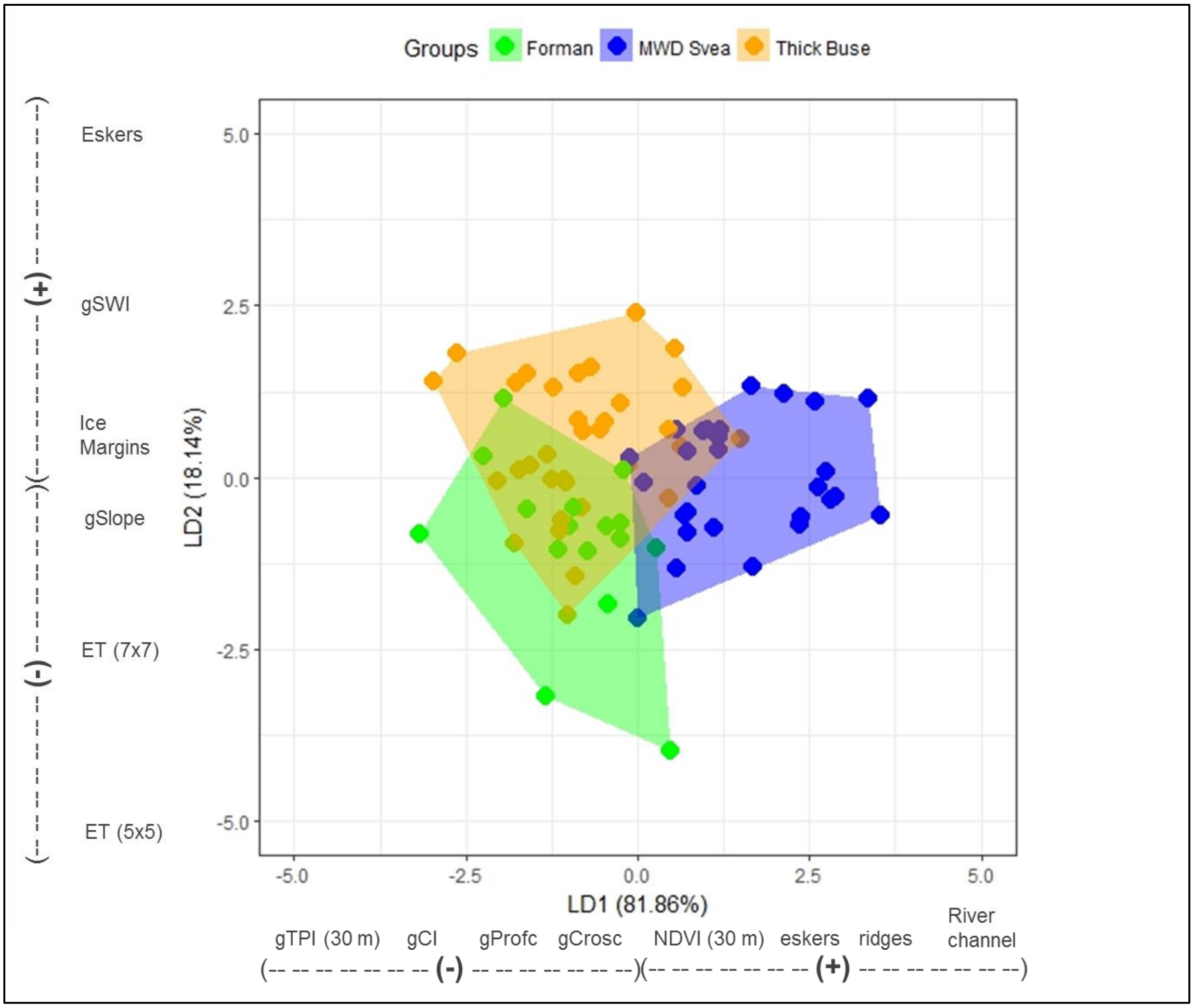

Figure 22. Ordination biplot of linear discriminants and notably higher correlated variables with LD1 and LD2 for the lowland pedon group LDA.

The linear discriminant function of the upland pedon group model predicted Barnes, Thick Barnes/Svea, and Thin Buse correctly 18, 22, and 19 times respectively (Figure 23). The kappa statistic explained moderate agreement between the linear discriminant classifier and ground truth observations. The Barnes class had the lowest user accuracy of 58.1% and incorrectly included four Thick Barnes/Svea and nine Thin Barnes pedons. The Thin Buse classifier had the highest user accuracy of 67.9% and produced false positive values for seven Thick Barnes/Svea and two Barnes pedons. The producer accuracies for the three upland pedons ranged from 59 to 67% and the Thick Barnes/Svea had the greatest producer accuracy, only excluding 11 pedons from correct classification.

The range in user and producer accuracies for the LDA prediction of the lowland pedon group varied markedly between pedon classes compared to the upland pedon group LDA. The kappa statistic was also the greatest for any of the three group LDAs (kappa = 0.589). The MWD Svea class had the greatest user and producer accuracies, 83.3% and 89.3%, respectively. Only one Forman and four Thick Buse pedons were incorrectly classified as MWD Svea pedons. The Forman accuracy was remarkably lower with a user value of 58.3% and producer value of 43.8%. Eight of the Forman pedons were incorrectly classified as Thick Buse and conversely, four Thick Buse pedons were classified as Forman.

Prediction accuracies and agreement statistics for the LDA of all pedon classes was expectedly lower. The kappa statistic (0.313) only achieved fair agreement with ground truth observations. The Thick Buse, Barnes, Thick Barnes/Svea user accuracies were generally lower from around 37 to 39%. The Barnes and Forman producer accuracies were over 10% lower than those of the MWD Svea, Thick Barnes/Svea, Thick Buse, and Thin Buse pedons. The MWD Svea class had the best user and producer accuracies with 54.5% and 64.3%, respectively. The classifier incorrectly predicted 11 total Thick Barnes/Svea and Thick Buse pedons as MWD Svea pedons. Fifteen Barnes pedons were incorrectly classified as Thick Barnes/Svea or Thick Buse pedons, but only misclassified as Thin Buse once. Additionally, Barnes and MWD Svea pedons were never classified as Forman; the Forman class was never incorrectly predicted as MWD Svea. The Thin Buse was most often misclassified as Thick Buse, whereas 14 actual Thick Buse observations were almost equally assigned to the Thick Barnes/Svea, MWD Svea, and Thin Buse classes.

A

Upland pedons	Observed: Barnes	Thick Barnes/Svea	Thin Buse	*User*†
Model: Barnes	18	4	9	58.1%
Thick Barnes/Svea	8	22	4	64.7%
Thin Buse	2	7	19	67.9%
Producer†	64.3%	66.7%	59.4%	

B

Lowland pedons	Observed: Forman	MWD Svea	Thick Buse	*User*†
Model: Forman	7	1	4	58.3%
MWD Svea	1	25	4	83.3%
Thick Buse	8	2	25	71.4%
Producer†	43.8%	89.3%	75.8%	

C

Pedon class	Observed: Barnes	Forman	MWD Svea	Thick Barnes/Svea	Thick Buse	Thin Buse	*User*†
Model: Barnes	9	1	3	3	3	4	39.1%
Forman	0	5	0	1	2	3	45.5%
MWD Svea	3	0	18	6	5	1	54.5%
Thick Barnes/Svea	7	4	5	14	4	4	36.8%
Thick Buse	8	4	1	3	14	6	38.9%
Thin Buse	1	2	1	6	5	14	48.3%
Producer†	32.1%	31.3%	64.3%	42.4%	42.4%	43.8%	

† User and producer accuracy calculated by correct classifications as a percentage of respective row and column totals.

Figure 23. Linear discriminant function predictive confusion matrices for the upland pedons (A) (kappa= 0.451), the lowland pedons (B) (kappa = 0.589), and all pedon classes (C) (kappa = 0.313)

DISCUSSION

Implications of Environmental Covariates Selected by Cubist

Soil Organic Carbon

Soil organic carbon is a product of prairie soil genesis that resulted in large accumulations of organic matter that have since been depleted and/or redistributed by accelerated erosion and agricultural practices (Hole and Nielsen, 1970; Duey et al., 2008). Soil movement by tillage increases proportionally with increasing slope and horizontal and vertical curvatures and is redistributed based on slope position and convergence (Govers et al., 1994; Lindstrom et al., 1992). The amount, type, and quality of organic matter is also redistributed in the landscape. Depositional areas have higher humic acids in the organic fraction, nutrient content and availability, C/N ratios, and microbial activity (Sarapatka et al., 2018).

Therefore, edaphic proxies and terrain attributes should have proportional relationships with SOC levels. The Cubist model used TPI to account for relative slope position in the landscape and isolated different functioning positions with condition statements. The frequent usage of the mMCA as a condition and predictor suggests potentials for hydrologic input and eroded topsoil accumulation are quite important in predicting SOC levels. Moreover, mSlope was used as a predictor frequently with the mMCA much more often than any wetness index. The 9-m analysis scale of slope coupled with the empirically derived MCA developed by Boehner et al., (2012) may serve as an improved SWI calculation considering it accounts for hillslope scale.

The relative NDVI (30 m) was utilized as a predictor for SOC in half of the models, whereas NDVI was used as a conditional statement very few times (5%). This high resolution (1-m) variable that accounted for localized heterogeneity is clearly an exceptional predictor. The relative NDVI (10 m) was used half as many times, but was likely implemented to adjust the regression value of relative NDVI (30 m). As stated in the methods, vegetative variation at high resolution was a concern, so multiple analysis scales were calculated to address the issue. Undoubtedly the NDVI measures functioned as excellent edaphic proxies to predict SOC. The ETrF covariate was never utilized, but Cubist did implement relative ET measures. These ET variables may have only been used to adjust values occasionally, considering it is a much coarser-scale (30-m) variable. Nonetheless, the evidence supports a relative calculation of proxies.

Lastly, Cubist utilized the proximity to river channels, ice margins, and eskers quite frequently. Organic matter content and accumulation is dependent on the textural and hydrologic properties of the parent material. These geomorphic covariates also complicate the spatial heterogeneity of SOC and landscape complexity in the study area. Proximity to ice margins was used most often as a condition which may be isolating portions of the landscape with stratified sand and gravel lenses derived from glaciofluvial processes.

Soil Electrical Conductivity

Soil salinity in the study region is controlled by potential ET and groundwater discharge. Rims of closed depressions or broad swales near the water table typically exhibit increased EC levels. Saline seeps may also form near permeable stratified drift deposit discharge locations (Sloan, 1972). Cubist selected TPI to explain variability in EC a majority of the time as a condition and predictor to discriminate slope positions that coincide with salinity patterns. Oddly, proximity to eskers, ridges, or ice margins were never used. Furthermore, the depth to water table decreases eastward toward the Red River Valley coinciding with increased EC from saline groundwater contributions (Strobel and Haffield, 1995). Perhaps Cubist detected this spatial trend by selecting elevation and proximity to beaches as predictors. Crop development and yields are negatively affected as EC increases beyond tolerance levels (U.S. Salinity Laboratory Staff, 1954). As expected, Cubist used the relative ET (7x7) as a condition to explain variation in salinity levels in lower landscape positions with high wetness indices.

Soil pH

Soil pH is governed predominantly by the amount of OM and carbonate content that have been redistributed in the landscape from accelerated erosion. Lower pHs occur in depositional areas where the accumulation of OM acidifies the system, but are increased by the amount of carbonate contributed from either groundwater influences or inputs from eroded upslope material high in $CaCO_3$. Higher pHs occur in eroded upslope areas due to incorporation of calcareous subsoil and a concomitant depletion of SOC. Reduced crop development and yields are also observed with an increase in pH. (Cihacek and Swan, 1994; Lindstrom et al., 1986; Papiernik et al., 2005).

The relationships of landscape morphometry and soil edaphic function with pH are quite similar to SOC. Thus, the environmental covariates used in the Cubist models should be also be similar. But, the groundwater influence on pH may affect Cubist model selection of covariates similar to those used to predict EC. Cubist chose the multiple scale TPI to predict and isolate relative slope positions as expected. Moreover, Cubist selected proximity to ice margins, river channels, and ridges as both predictors and conditions, which likely has connections similar to the usage and conditions of the SOC model. However, near beach was utilized as a condition and quite often as a predictor. This echoes the expectation of increased groundwater influence on soils eastward. The only notable edaphic proxies for pH were relative ET (7x7) and NDVI. Multiple relative ET scales were used to adjust the 7x7 measure occasionally. Quite interestingly, relative NDVI (30 m) was never used. The CA was preferred over the MCA and the mSlope was used as a condition and predictor, but these variables were less effective compared to their influence on the SOC model. In fact, the gSWI was used more often than slope which contrasted the postulated importance of a variable scale SWI calculation. Easterness usage was peculiarly high for the pH model; but it is difficult to determine why that variable stood out in the model.

Mutiple DEMs and Scales

Results from the Cubist models suggests that terrain attributes from multiple DEMs at multiple scales can be used to improve model accuracy. For this study, there were discrepancies with the DEM development and concern for error propagation in hydrologic terrain parameters. In many instances, Cubist selected the same terrain attribute from both DEMs in the linear regression to adjust the intercept or fine-tune the values of one another. Furthermore, this trend was also apparent for terrain and soil proxy variables with multiple scales. Miller et al., (2015) also commented that the Cubist usage of parameters at multiple scales likely assists in reducing model uncertainty. Finally, they concluded that "…digital soil mapping efforts would be enhanced by the greater consideration of predictor variables at multiple analysis scales."

Weaker Models and Unused Variables

Vertical and horizontal curvatures were never selected by Cubist, but the model was given convergence and wetness indices parameters which functioned as more robust measures of convergent and dispersive flow. The poor performance of the $CaCO_3$ model was unexpected considering the current understanding of genesis and accelerated erosion in the Drift Prairie. Although sand content was the highest particle-size fraction model, it performed poorly compared to the better chemical models. The model mostly used multiple scales of TPI, mSlope, gCI and gSWI coupled with near distance to eskers, but conditions were never used. There was no need to discuss the higher performing SOC-IC model because it was an amalgamation of the explained variability in the SOC and $CaCO_3$ models. Spatial variability of land management, accelerated erosion, and groundwater influences are unaccounted for in the model. Yet, they probably explain most of the variation in $CaCO_3$. Furthermore, these influences coupled with the capricious nature of parent material in the Drift Prairie could be responsible for the poor performance of the particle-size fraction models.

Extendibility

The top performing models were cross-validated as a means to make this study extendible to the greater Barnes landscape. Spatial information was explicitly omitted for this reason. Although spatial information was not provided for Cubist, spatial inferences are made by the model. Bui et al. (2006) stated, "…(condition statements) are more important in defining global spatial pattern than those used in regressions." Therefore, the conditions identify a locally harmonious area from which the other attributes can further explain the variability at finer spatial scales. Because pedogenic processes operate at differing scales in a nonparametric manner, the Cubist algorithm is quite effective at quantifying the complexities of the landscape. Most notably, Cubist's frequent preference of relative NDVI and ET suggests that the relative neighborhood is more effective than covariate proxies alone. This measure probably accounts for small scale agricultural management, microclimatic, biotic, and physical impacts. Based on this study's findings, it should therefore be extendible for digital soil modeling in the eastern Glaciated Plains. Other studies have found Cubist regressions with a large population of environmental covariates effective in predicting soil properties such as SOC, $CaCO_3$, pH, EC, sand, silt, and clay content (Bui et al., 2006 LaCoste et al., 2014; Miller et al., 2015; Minasny and McBratney, 2008).

Trends in Historic Morphologic Descriptions of the Barnes Catena

The PAM clustering algorithm identified the Thick Barnes/Svea class dissimilar enough to differentiate it from the Barnes and MWD Svea classes based on the initial inputs. Furthermore, it was determined that the depth to calcic horizon could split the greater 'Buse' class into Thin Buse and Thick Buse. These intergrades represent the continuum of soil properties through space (Johnson, 1963). Adequate descriptions of representative Barnes catena members and intergrades were described by Lores (1965). This is the first time such a scientific comparison has been made in over half a century

Lores (1965), trained and assisted by two expert North Dakota Agricultural Experiment Station (NDAES) pedologists, Schroer and Johnsgaard, performed three "superdetailed" 4 ha surveys on Barnes map units. One of these surveys was roughly 12 km away from the southernmost site in this study. Central concept profiles for members of the Barnes catena were developed based on investigations of over 100 soil profile descriptions and 400 examinations of soils in the survey. This survey documented very similar Barnes catena members and intergrades including the Buse, Buse-intergrade, Barnes, Barnes-Svea intergrade, Svea, and Svea-Tetonka (Fine, smectitic, mesic Argiaquic Argialbolls) intergrade as were recognized in the current study (Soil Survey Staff, 1997).

The Lores (1965) survey central concept Buse profile located on the tops of steep (10% slopes) convex knolls and ridges was quite similar to the Thin Buse pedon class. The Ap horizon had a depth to 13 cm, was noted as friable, and contained mixed calcic material from the subsurface. The pedons typically had a transitional Ak horizon above the genetic Bk horizon that ranged from 13 to 28 cm. The Bk horizon was also graded as firm when moist. In comparison, the Thin Buse Ap horizon bottom depth average was 14 cm and the average depth to the calcic horizon was 15 cm. The Buse intergrade central concept profile had a thicker A horizon and a transitional cambic horizon free of carbonates. Eighteen percent of the Thin Buse class and 60% of the Thick Buse class observations also had these carbonate-free cambic zones. Moreover, the consistence of almost a quarter of Thin Buse observations had a firm or very firm Bk horizon.

The Lores (1965) Barnes-Svea intergrade parallels the Thick Barnes/Svea pedon class. These soils were described as well to moderately well-drained and occurred on gently sloping convex slopes. The A horizons ranged from 15 to 30 cm thick, the B horizons ranged from 30 to 70 cm thick, and the calcic horizon was observed at around 75 cm. Similarly, the Thick/Barnes Svea class had average A horizon bottom depths near 30 cm and were leached of carbonates beyond 50 cm. The A horizon of the Barnes-Svea intergrade was characterized as friable whereas the Thick Barnes/Svea was firm 40% of the time and friable or very friable for remaining observations.

Lastly, the Lores (1965) study described a Svea and Svea-Tetonka intergrade. The Svea was moderately well-drained and occurred on a nearly level slope. It had mollic colors to a depth of nearly 50 cm. The Ap horizon (0 to 13 cm) was friable, the A horizon (13 to 30 cm) and Bw1 horizon (30 to 48 cm) were slightly firm. The Svea was described as commonly intergrading to either Barnes or Hamerly. The Svea-Tetonka intergrade was somewhat poorly drained to moderately well-drained on a nearly level slope and had mollic colors to a depth of 41 cm. The argillic horizon occurred below this depth. The A horizons were all friable and extended to 36 cm above the firm B horizon.

The Thick Barnes/Svea and MWD Svea pedons from this study fall within the range of characteristics of the Lores (1965) Svea and Svea-Tetonka intergrade central concept profiles. Nearly all of the MWD Svea pedons and half of the Thick Barnes/Svea pedons had a depth of mollic colors to about 50 cm. Similar to the Svea-Tetonka intergrade, the MWD Svea lower A horizon depth averaged 36 cm. Moreover, a majority of the Thick Barnes/Svea and MWD Svea pedons had very friable or friable Ap and A horizons. Interestingly, 40% of the A horizons in the Thick Barnes/Svea class were firm, similar to the slightly firm A horizon of the Svea described by Lores (1965). However, only about 10% of the B horizons in either Svea class from this study were described as firm.

Illuvial clay in Prairie Soils

Sixteen soils were identified with morphologic traits characteristic of the Forman series. The occurrence of these soils verifies the need for further investigation of argillic horizon formation in well-drained soils of the till plain. The Forman series is not currently listed as an inclusion in any Barnes map units (Soil Survey Staff, 2016). Ten of the Forman pedons (62%) had typical morphology associated with the Forman series (Soil Survey Staff, 1998). The remaining variants had thinner argillic horizons, shallower depths to carbonates, and/or underdeveloped cambic horizons associated with an argillic horizon. In the case of 3A12 (Fig. 18), a cambic horizon occurred below the argillic horizon.

Regardless, the edaphic importance of the argillic horizon is the implication for soil health and the impact of agriculture on the Barnes catena. Smith (1986) highlighted the influences of the argillic horizon whereby it increases soil water retention, nutrient richness and availability, while reducing permeability, effectively perching water in the solum. Argillic horizons also reflect the stability of genetic process rates of the soil system.

Pedologic studies on moderately well drained soils developed in calcareous till parent material showed that cutan thickness increases with depth, and the amount of strongly oriented clay nearly triples in lower argillic horizons (Smeck et al., 1968). Argillic horizons have been documented infrequently on well-drained soils of the eastern Glaciated Plains. However, Hopkins and Franzen (2003) verified that argillic horizons can form in morainal geomorphic settings where stratified drift enhances the required genetic processes governing clay illuviation.

Cutan development comparisons between Barnes pedons from the 1950s and 60s and observations from this study were challenging because standardized criteria for cutan description had not been formalized in the NCSS at that time. However, some consistencies are apparent. Early descriptions of cutan development from Omodt (1961) included "lips" on the bottom edges of pores associated with prominent cutans. The cases of "strong cambic expression" from Class 1 exhibited these illuvial cutan "lips" lining pores (Table 3). Classes 2 and 3 also exhibit these properties but they were associated with greater amounts, continuity and/or distinctness. Other descriptions of cutans (Buntley 1960; Lores, 1965; McClelland et al., 1959; Olson, 1959) were based on "thickness" to describe distinctness, but amounts, location, and continuity were very similar to current standards (Soil Survey Staff, 2017). Apparent descriptions, thin and thick, were considered to be synonymous with faint and prominent, respectively, to make comparisons. The "moderately thin" and "moderately thick" descriptions were assumed to be "faint parting to distinct" and "distinct parting to prominent", respectively.

McClelland et al. (1959) generalized cutan development for the modal description of the typical Barnes profile as exhibiting, "… clay films on ped faces that range from thin and patchy to thin and continuous." Nonetheless, Barnes soils descriptions from the 1950s and 60s tended to have higher cutan development in the lower cambic horizons. Buntley (1960) and Olson (1959) described Class 2 cutans in the upper cambic horizon and Class 3 cutans in the lower cambic horizon. Omodt (1961) described an increased degree of cutan development in the lower cambic horizon although both descriptions would be categorized today as Class 3.

Differentiation between Barnes and Forman pedons based on field descriptions is a subjective decision without micromorphologic, particle size distribution, and clay fraction data to confirm presence of a diagnostic argillic horizon according to Soil Taxonomy (Soil Survey Staff, 2014c). For instance, sample 3A12 (Fig. 18) was classified as Forman, though its upper cambic horizon contained Class 2 cutans and the lower argillic had Class 3 cutans. Many historic Barnes cutan descriptions (Buntley, 1960; Olson, 1959, Omodt, 1961) in the Bw horizon would suffice to be classified as the Forman series based on methods applied in this study. Furthermore, cutan development can be indefinitely variable in the profile. Lores (1965) stated that the central concept Barnes profile exhibited Class 2 cutans in the upper cambic horizon (15 to 30 cm) whereas no cutans were observed in the lower cambic horizon (30 to 38 cm). Similarly, samples 1B3 and 2C9 (Fig. 15) had Class 2 cutans in the upper cambic horizon and Class 1 cutans in the lower cambic horizon. The Buse central concept profile that graded to Barnes was also noted as containing a cambic horizon with Class 1 cutans. Likewise, the Thin and Thick Buse profiles had five cambic horizons with Class 1 cutans.

Lores (1965) observed cutans similar to Class 3 in the upper cambic horizon (20 to 35 cm) and Class 2 cutans in the lower cambic horizon (35 to 45 cm) of the central concept Barnes-Svea intergrade. The cutans from the Lores (1965) intergrade are congruent with the Class 3 descriptions. Class 3 cutans were only observed in the single exceptional argillic horizon of the Thick Barnes/Svea class. Otherwise, only four cambic horizons in the Thick Barnes/Svea pedons exhibited Class 2 cutans; 22 cambic horizons had Class 1 cutans, most of which were in the lower Bw2 horizon. Correspondingly, Lores' (1965) description of the central concept Svea-Tetonka intergrade had an upper argillic horizon (42 to 56 cm) including Class 3 cutans. The similar MWD Svea class had three pedons with an argillic horizon designation, two of which had Class 3 cutans.

The lower degree of cutan development in the members of the Barnes catena from this study compared to those from the 1950s and 1960s reflects the trends observed by Hopkins (unpublished data, 2011) (Table 11.) North Dakota county soil survey typifying Barnes pedons have shown a marked reduction in cutan presence over the years. These are likely supportive indications for Barnes soil degradation. Furthermore, cutans observed in the single cambic horizon of the Thin Buse and over a quarter of the cambic horizons in the Thick Buse class provide historic evidence of strong pedogenic processes that can no longer be observed due to truncation. That is, they may have been mapped as Barnes in the 1960s, but erosion processes have considerably altered these soils since.

Table 11. Changes in cutan recognition over time for Barnes series typifying pedons in progressive North Dakota county soil surveys.

	Publication date		
	1970s & earlier	1980s	1990s & later
No. of surveys	9	6	12
With cutans	5	4	2
Without cutans	4	2	10
With cutans (%)	55.0	66.0	16.7

The LDA for the lowland pedon groups provided information on the environmental covariates associated with the Forman that differentiate it from the Thick Buse and MWD Svea pedon classes (Fig. 21). Almost all Forman pedons were plotted toward the negative quadrant of LD1 and LD2. This quadrant is an indicator of increased horizontal and vertical curvature, degree of divergence, and higher relative position in the landscape. The LDA biplot also indicates that Forman soils are generally closer to geologic features, have lower wetness index values, and have greater slopes. Quite interestingly, these features have a concomitant increase in relative ET. There are two challenges with this LDA. Firstly, the Forman group is highly variable; the extremities of the outer hull trend toward landscape parameters intrinsically related to greater erosion, whereas a majority of the points are plotted toward the center, indicative of only a slight environmental covariate influence. Secondly, in a study on argillic horizon formation in Mollisols formed in calcareous till in North Dakota, Richardson (1989) claimed that over time, large amounts of illuvial clay could be moved if the rates of wetting/drying were accelerated or the amount of infiltrating water increased. Richardson's findings would indicate that convergent positions with greater catchment areas and/or porous media permit greater potential moisture inputs and higher energetics for clay translocation. However, the LDA comparison is made with respect to the MWD Svea and Thick Buse pedons. The high user and producer accuracies of the MWD Svea in the lowland pedon group LDA and LDA for all classes suggest that the class covariate parameters are quite specific (Fig. 23). Additionally, predictions for the LDA of all pedon classes never misclassified any Forman as a MWD Svea pedon or vice versa The MWD Svea pedons are plotted in discriminant space that point to a much greater catchment area, convergent flow, and tend to be further away from the geologic features. Therefore, although Forman pedons trend toward geomorphometric parameters that represent a decreasing degree of potential moisture and energy inputs, it does not necessarily specify those parameters.

Desiccation processes mentioned by Richardson (1989) may be governing the formation of argillic horizons. Furthermore, the increased proximity to ridges, eskers, and ice margins suggest a greater likelihood of stratified drift and complex slopes; i.e. greater potential for clay illuviation as suggested by Hopkins and Franzen (2003). Clearly, the LDA emphasizes the fact that MWD Svea and Forman classes have their own characteristic environmental regimes. One of the more notable features is that relative ET was increasingly positive on steeper slopes. This likely reflects increased water retention from the argillic horizon and may be a suitable method for future differentiation of the Forman series in complex glacial terrain. Quite interestingly, many of the Thick Buse pedons overlapped in the discriminant space of the Forman pedons, perhaps indicative of conditions that were suitable for clay illuviation, but have been subsequently altered by accelerated erosion.

In short, the mechanisms of clay translocation are highly variable and complex. Preferential flow both laterally and vertically, the modal wetting front, flocculation, dispersion, mineralogy, matrix chemistry, aquitards, and aquicludes all influence the rates, directions, and sources of argilluviation (Schaetzl and Anderson, 2005; p. 366-367). Pedons described with lithologic discontinuities (stratified drift) have the potential to accumulate illuvial clay at varying rates in different parts of the solum. In the case of sample 1A2, the cambic horizon was gravelly without cutans. Below, those gravels, two argillic horizons were described, both of which had Class 3 cutans.

Moreover, pedons with thin argillic horizons above calcic horizons (samples 3B9, 3B15, 3C2, 3C13) call into question the specific mechanisms controlling argillic horizon genesis, and how that impacts edaphic quality. The thin argillic horizons observed in this study may be a product of mechanical destruction of the original argillic horizon via tillage erosion. Incorporation of the argillic horizon into the Ap has been shown to negatively impact crop yields by 1) introducing less fertile subsoil material and 2) reducing available soil water content due to an increase in clay content (Frye et al., 1982). Conversely, the flocculated $CaCO_3$ may serve as a source of silicate clays whereby dissolution of the calcic horizon produces a concentration of liberated clay at the margins of the modal wetting front. Additionally, pedogenic processes may be sufficiently effective in a thin zone of the solum to form argillic horizons, but argilluviation ceases upon contact with flocculating material from the calcic horizon.

Impact of Tillage Disturbance on the Soil System

Several indicators of degradative effects due to tillage on the Barnes catena were noted in this study. In upland settings, the degree of erosion and horizon mixing in the solum was quite evident for cases where the Ap horizon had moist colors greater than 10YR 2/1. Colors mixed into the surface from the cambic horizon were more apparent when rubbed. There was clear evidence of truncation in soils with effervescent cambic horizons or eroded cambic remnants at the boundary with the calcic horizon (Fig. 24). Earthworm casts also displayed remnant colors no longer present in the profile. Homogenous 10YR 2/1 and cambic colored casts were often observed in the dominantly mixed color matrix (Fig. 24). These evidences give reference to past genetic processes that governed solum development, but are no longer apparent.

The degree of surface effervescence was a key indicator of erosion in the upland soils, but surface effervescence in lowland areas was either from natural groundwater influences or calcic slope wash alluvium. Although lowland soil surfaces typically had 10YR 2/1 moist colors, the degree of eroded topsoil accumulation was apparent when the soil exhibited lighter rubbed colors or had finely disseminated carbonates in the black A horizons. Thin strata of lighter colors or contrasting textures from slope wash alluvium also indicated individual depositional events.

Evidences of subsurface compaction due to tillage were observed in profiles that had platy structure resultant from mechanical processes rather than pedogenic formation. These plow pans were associated with firm or very firm rupture resistance. There was temporal variation of plow pan rupture resistance and thickness. As the growing season progressed, mature roots started to break up the plow pan. Therefore, plow pan thicknesses varied indefinitely. Yet, some plow pans were resistant to root penetration, wherein roots took the path of least resistance along horizontal fractures in the pan (Fig. 25). Very abrupt or abrupt smooth surface horizon boundaries were also frequently observed in this study (Fig. 24). This characteristic feature of agricultural soils has been documented in the Barnes series of ND in many studies (Buntley, 1953, 1960; Lores, 1965; Olson, 1959). The typical morphology of a native Barnes profile has a clear, wavy or irregular boundary associated "tongueing" of mollic material (Buntley, 1960; Omodt 1961).

Figure 24. A very abrupt boundary between the mollic epipedon (top) and the calcic horizon (bottom). Note the remnant light brown cambic material truncated and mixed into the profile. Cambic colored earthworm casts are also noticeable in the top horizon (2A10).

Figure 25. Roots matted against a mechanically compacted ped (2C10).

The extent of damage done to these systems is not documented quantitatively, but morphologic evidence from this study shows the potential negative impact on hydrologic processes. Firm, mechanically compacted layers capable of inhibiting root penetration should be quite capable of reducing infiltration and percolation. Moreover, plow pans have the potential to divert subsurface water laterally downslope. Whipkey and Kirkby (1978) identified that physical soil properties, soil depth, and layer thickness are important controls that govern rate and distribution of subsurface flow. Furthermore, they stated that subsurface flow has been confirmed above plow pans. This calls to question as to what degree of compaction has occurred and if the normal rates of pedogenic processes are still recoverable. Poinke et al. (1996; p. 69) state,

> "Preferential flow pathways may dominate, either over the surface or within the soil, and it is the nature and management of these flow domains, not necessarily the whole soil, that exerts control."

Thus, continued conventional tillage management may coincide with sustained dominance of subsurface hydrology via physical properties of the compacted plow pan. The potential for water infiltration and retention on shoulder and summit positions is likely to be reduced, therefore intensifying declines of soil edaphic function.

In more extreme cases of erosion, the surface horizon contained stratified lenses of subsurface horizon material elevated by the tillage tool (Fig. 26). In one particular case, accelerated erosion was so severe that the profile was inverted. That is, the eroded subsurface cambic and calcic horizons from soil upslope served as the new Ap horizon (Fig. 27). This phenomenon is known as "false truncation" and is described in detail for agricultural Mollisols formed in till in Minnesota by De Alba et al. (2004).

For a further description of soil morphologic traits associated with tillage degradation described above, see Appendix H.

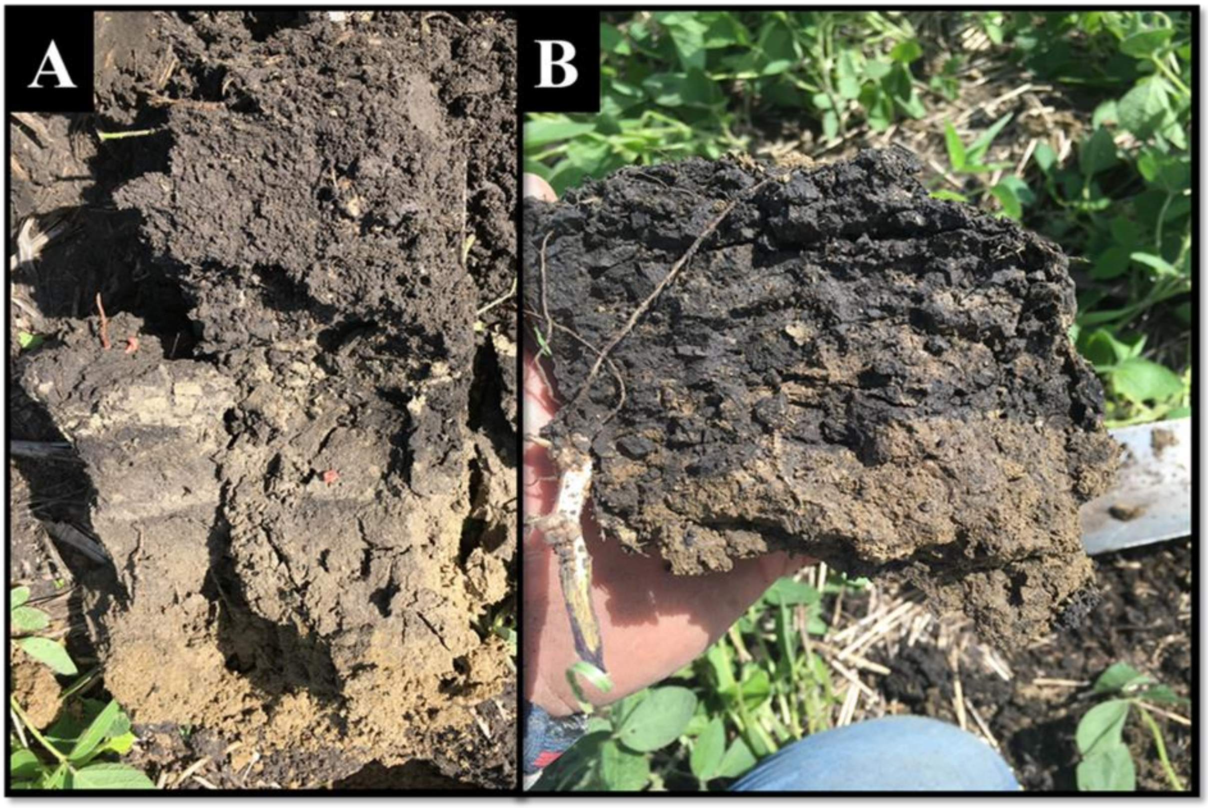

Figure 26. Stratified lenses of calcic (A, 3A18) and cambic (B, 2C16) material in the surface horizon. Note the platy (mechanical) structure in B.

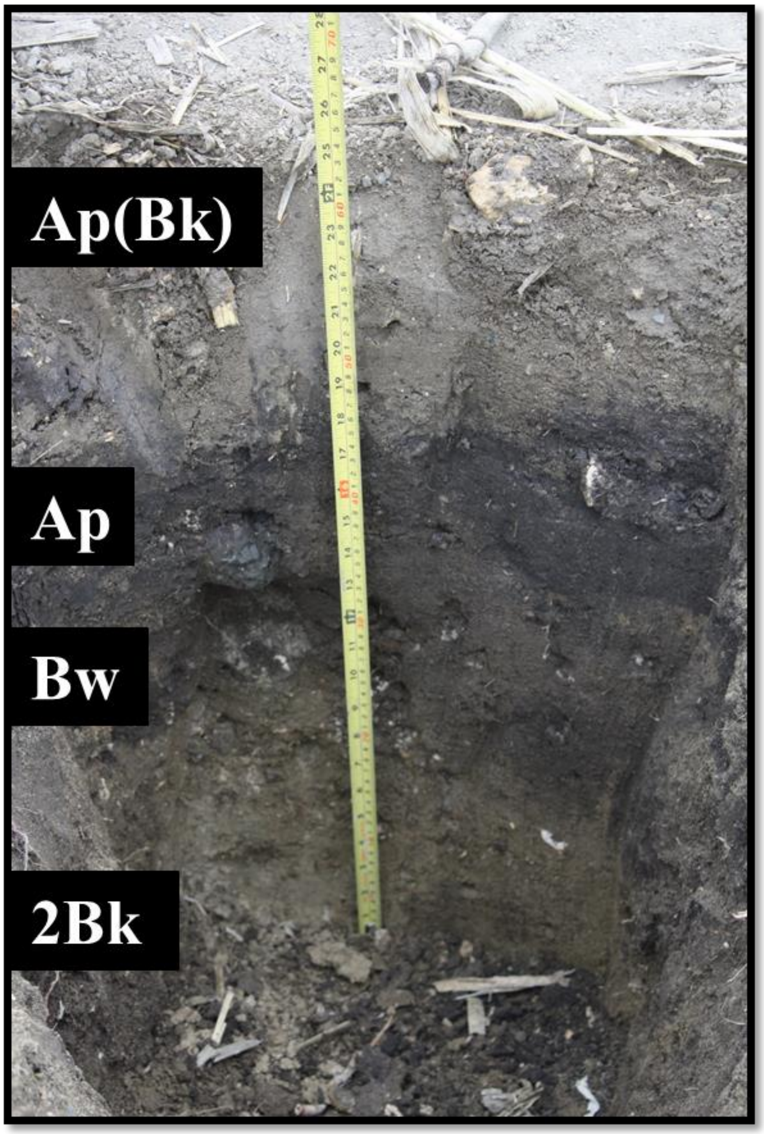

Figure 27. Example of a “false truncated” soil profile. The depth of the pitwall is just over 60 cm (2C14).

Modes of Classification: Clustering vs. Linear Discriminant Prediction

One of the major goals of this study was to determine if remote-sensed environmental covariates could serve as indicators to differentiate soil morphology, chemistry, and edaphic function of the Barnes catena in east central North Dakota. Specifically for objective five, this study attempted to define which combination of environmental covariates best explained variability between pedon groups. Furthermore, objective six sought to determine the predictive ability of the linear discriminant function calculated from the covariates.

Clustering with Partitioning Around Medoids

Although the modified PAM clustering algorithm method for classification was based on morphology and chemistry, these properties may be similar in significantly different landscape positions. The primary mechanisms in the upland, sloping, convex areas are erosion and truncation of the solum, resulting in decreased A horizon thickness, lower SOC levels, and shallower depth to the calcic horizon, whereas lowland positions are dominated by accumulation of eroded upslope topsoil resulting in an increase of A horizon thickness, higher SOC content, a greater proportion of fine sediments, and greater depth to the calcic horizon (De Alba et al., 2004; Lobb et al., 1995; Malo et al., 1974; Pennock et al., 1994; Pennock, 2003).

Because field investigations were limited to a 50 cm fixed sampling depth and subsurface hydrology information was lacking, the depth to calcic horizon is a confounding parameter for classification. This depth on well-drained upland soils depends on the thickness of the leached solum coupled with the modal wetting front depth (per descensum model) (Schaetzl and Anderson, 2005; p. 403). The thickness of the leached solum is contingent on intrinsic erosion processes at the site. The modal wetting front depth results from 1) the point of enriched $CaCO_3$ precipitation from carbonate leaching and acidification under the native prairie biological community coupled with the subhumid climate (Hole and Nielsen, 1970), and 2) modification of genetic processes due to prolonged cultivation (Veenstra and Burras, 2015). Conversely, the depth to the calcic horizon on nearly level, moderately well-drained grading to poorly drained positions is due to upward capillary flow of calcium rich groundwater (per ascensum model) and has a completely different set of mechanisms governing genesis and morphology

(Schaetzl and Anderson, 2005; p. 403). For such landscape positions, the Balaton (Fine-loamy, mixed, superactive, frigid Aquic Calciudolls) (Soil Survey Staff, 2014a), Hamerly, and Vallers series are increasingly influenced by groundwater, respectively.

Therefore, the Thin Buse pedons described in this study possibly exhibit similar morphologic and chemical characteristics as the Hamerly series. In fact, 22% of the Thin Buse were associated with footslope or toeslope positions based on the methods from Miller and Schaetzl (2015). The Barnes series was likely similar to the Balaton series and it was determined that 36% of the pedons were on footslope or toeslope positions. Lastly, the Thick Buse pedons could be similar to the Vallers or Balaton series and there were 37% Thick Buse pedons observed on footslopes or toeslopes.

Additional criteria for cluster classification were initially considered, but were disregarded for a variety of reasons. One specifically important characteristic for pedon drainage class differentiation used by Lores (1965) was soil color patterns through depth. Similarly, pedons from this study were also differentiated on the presence of a cambic horizon with mollic colors and/or lighter colors. But, cambic horizon designations were not always consistent. This is a recurrent disparity common to Barnes catena descriptions. McClelland et al. (1959, p. 53) noted,

> "The B horizon varies from brown to very dark grayish brown in color. Usually it is a color B with higher chroma than either the A or C horizons but it may be a textural B with clay films on ped faces that range from thin and patchy to thin and continuous."

In the Thick Barnes/Svea or MWD Svea pedons with mollic colors near 50 cm, cambic horizons were typically characterized by slightly higher chromas and/or values, whereas the lower A horizons had some indication of prismatic subsoil structure, but maintained very dark mollic colors similar to the Ap horizons. This condition is well documented in the literature (Buntley 1960; Lores, 1965; Olson, 1959; Omodt, 1961). The cambic horizons in the Barnes and Thick Barnes/Svea with shallower mollic color depths were quite often differentiated by color and/or texture. The two Buse pedon classes with thicker cambic horizons were sometimes based on the degree of cambic development (referred to as 'textural' by McClelland et al. (1959)), but the majority were based on color change.

Electrical conductivity and pH weighted to 50 cm were also considered as classification criteria. The EC distribution was too narrow with a mean of 0.46 and SD of 0.48 and had too many outliers (n=22). The pH was considered to be too confounding because of unpredictable variability induced by anthropogenic activity i.e. 1) acidification from historic nitrogen fertilization (Kennedy, 1986), and 2) increased pH from subsoil $CaCO_3$ incorporated into the upper solum and/or translocated to lower landscape positions (Cihacek and Swan, 1994; De Alba et al., 2004; Malo et al., 2005; Papiernik et al., 2005). Furthermore, surface texture and lithologic discontinuities were considered, but were often too variable due to run-on sand lenses from upslope and the dynamic nature of stratified sediments of the Drift Prairie. Nonetheless, the criterion were considered the most robust characteristics to classify soils based on similar properties and associated edaphic function in accordance with objective one.

Environmental Covariates as Classifiers

The linear discriminant analysis served as an exploratory tool to discern trends in a rather large covariate feature space in order to aid future soil survey efforts. Thus, the training data for prediction consisted of the entire dataset as opposed to a robust evaluation of a predictive model performance with cross-validation (e.g. the Cubist models). The analyses were computed seperately for upland pedons and lowland pedons so their trends could be plotted in linear discriminant space for simple interpretation. Because these soils are so closely interrelated within the landscape, plotting LDA for all pedon classes in discriminant space was considered an ineffective way to communicate the results. The interrelationship of catena members in the upland pedon group LDA was also quite apparent judging by the minimal dispersion between classes in the biplot (Fig. 20).

Despite the overlap in the upland pedon groups (Fig. 20), the trends in the outer hulls indicate the characteristic combination of covariate parameters that represent each class. The majority of Thin Buse pedons plotted in positive discriminant space. In respect to LD1, this region is associated with greater slope, horizontal curvature, relative elevation, and slope complexity concomitant with a lower wetness index and relative NDVI. In respect to LD2, this region is linked to greater relative elevation and vertical curvature concomitant with lower relative ET. Quite fittingly, terrain parameters linked to greater erosive potential describe the most eroded pedon class. Moreover, proxies of soil edaphic function indicate anticipated poor soil quality.

The Barnes outer hull was primarily explained by the positive axis of LD2, a region of greater landscape relative elevation, vertical curvature, and distance to ice margins coupled with lower relative NDVI and ET (Fig. 20). These pedons appear to represent the typical Barnes landscape positions, but contrast the expected soil quality. Many of Thick Barnes/Svea points plotted near the center of discriminant space, but the outer hull had several points in the negative quadrant of LD1 and LD2 (Fig. 20). Here, terrain attributes are characterized by reduced slopes, curvatures, complexity, relative elevation, and increased wetness index. Moreover, this space is associated with a concomitant increase in soil proxies, i.e. relative ET and NDVI. These parameters parallel the expected morphology, chemistry, and productivity in terrain less suceptible to erosion.

It is important to note that the upland pedon LDA is a comparative analysis of rather closely associated pedon classes (Fig. 20). The overlap in hulls suggests locations where these soils have similar parameters and increase the likelihood of misclassification (Fig. 23). Evidently, many of these soils have very similar terrain and/or soil quality proxies.

The pedon classes from the lowland pedon group LDA had much more dissimilar environmental parameters that allowed for better prediction accuracy (Fig. 23) and greater variance between classes (Fig. 21). The MWD Svea pedon class and Thick Buse pedons had exceptional prediction accuracies compared to the Forman class. The MWD Svea and Thick Buse were also clustered more intimately in discriminant space. The Thick Buse were generally distributed on the negative axis of LD1. Here, lower relative NDVI, closer proximity to eskers, ridges, and river channels, and increasing degree of erosion-dominated terrain attributes differentiate the Thick Buse from the MWD Svea. Futhermore, the Thick Buse pedons were split between the negative and postive axis of LD2. Those split on the positive axis of LD2 are linked to closer proximity to eskers and ice margins, higher wetness index, gentler slope, and lower relative ET; they are opposite to those on the negative side of the LD2 axis. The Thick Buse had several points within the Forman hull and few in the MWD Svea. Still, the predictive linear discriminant fuction misclassified Thick Buse as Forman and MWD Svea an equal number of times (Fig. 23).

Sources of Variability

The LDA of all pedon classes showed that the characteristic parameters of the MWD Svea and Thin Buse pedon classes enabled higher predictive accuracies (Fig. 23). These two classes have the most contrasting properties as they represent the pinnacle of the depositional and erosional landscape positions. It is apparent however that the remaining pedon classes (especially the Barnes and Forman) have indefinite terrain and soil proxy parameters. Moreover, individual weighted soil property prediction peformance with Cubist was exceptional for SOC, moderate for pH, EC, and SOC- IC and quite poor for $CaCO_3$, silt, and clay content. Although the sand model was considered higher performing it was still the lowest of the top five performing models. The sources of variability unaccounted for in this study are discussed below.

To reiterate, the pedon class morphology and chemistry do not necessarily reflect landscape position and morphometry. Although an effective soil-landscape model should represent the relationship between environmental covariates and soil classes or properties (McSweeney et al., 1994) there are a plethora of confounding factors that cannot currently be ascertained.

Firstly, the mechanisms of accelerated erosion for cultivated Mollisols formed in calcareous drift are inextricably variable through space, time, and magnitude. Tillage erosion translocation in these landscapes is clearly a primary erosive force (Lindstrom et al., 1992; Govers et al., 1994; Lobb and Kachanoski, 1999). Without historic documentation of tillage practices, tillage erosion and its spatial heterogeneity cannot be accounted for in the soil-landscape model.

Secondly, there are many scenarios documented in the literature where tillage erosion is quite apparent on complex topography, but erosion losses are not as apparent on nearly level slopes. The eastern North Dakota Drift Prairie varies greatly in slope complexity, charactized as gently undulating, but ranging from nearly level to hilly (Figs. 28 & 29). Nearly level slopes and low-relief terrain are most challenging to differentiate using geomorphometric parameters.

Wysocki et al. (2011) pointed out that terrain attributes of low-relief landscapes are limited as most energy is consumed by geochemical weathering and soil hydrologic processes. Pennock et al. (1994) identified this challenge noting the insignificance of erosion and curvatures in these positions, but mentioned that catchment area and relative elevation could assist to differentiate nearly level landforms. Cubist used the modified catchment area and TPI covariates as predictors and conditions quite frequently which corroborates Pennock et al. (1994) suggestions.

Figure 28. Typical landscape associated with complex slope patterns for a fallow field in SE central Barnes County.

Figure 29. Typical landscape associated with nearly level slope patterns in N central Barnes County (1A18). Photo courtesy of S. Croat.

Thirdly, inherent spatial variability of soil parent material in the eastern Glaciated Plains introduces complexity. Tills of different origin, stratified drift, and poorly sorted till deposits greatly influence rates of pedogenesis and soil edaphic function. Although this factor is indirectly accounted for via proximity to geologic features, the geologic map is not detailed enough to support the scale of the study. It might be expected that ET or NDVI could help differentiate texture based on soil-water relationships, but it was not observed. Parent material variability is likely responsible for the poor performance of Cubist particle-size models. Moreover, particle-size fractions were determined from surface texture. This variable can be quite confounding as it does not account for lithologic discontinuities within the pedon. Pennock et al. (1987) also encountered this challenge in a study using geomorphometric parameters to predict A horizons and depth to $CaCO_3$ of prairie soils formed in hummocky drift in southern Saskatchewan. They remarked that the capricious nature of glacial parent material was a chief source of variability in the study.

Fourthly, user-determined environmental covariates (and their scales) selected as explanatory variables for the LDAs was not likely an optimal process. Covariate selection is one of the most important processes in digital soil modeling (Vasques et al., 2012; Brungard et al., 2015). Despite the fact that Cubist calculated predictive models for individual soil properties, the frequently used covariates may have been more suitable for LDA analysis. Furthermore, the LDA assumes that the explanatory variables are normally distributed. Although Kaufman and Rousseeuw (2005) do suggest LDA is quite robust when this assumption is broken, it still may have negatively affected the LDA.

Lastly, high soil property or class correlations with proximity to geologic features and/or elevation may be more indicative of spatial location than actual covariate influence. Spatial location was intentionally omitted in order to make the study extendable to the greater Barnes landscape in North Dakota. If location is confounding explained variation between pedon classes or predicted soil properties, this may be a product of soil formation in different tills, microclimatic influences, land use and management patterns, and any other spatial trends that cannot be accounted for.

CONCLUSIONS

This study collected a comprehensive dataset of Barnes soil catena member important morphologic, chemical, and physical properties for a representative study area in eastern North Dakota. This is perhaps the most spatially comprehensive study of the Barnes landscape in over half a century. Typical Barnes catena members under agricultural land use were analyzed, partitioned, and modeled with a variety of statistical techniques.

Chemical and textural properties were modeled with the Cubist algorithm, with LOOCV, using multi-scale geomorphometric and remote-sensed soil proxy parameters in combination with near distance to linear geologic features as environmental covariate predictors. This study determined five top-performing models, SOC, EC, pH, SOC-IC, and sand content. The SOC model performed the best and it was concluded that TPI, mSlope, mMCA, were very important as predictors and conditions. Other robust measures of surficial hydrologic patterns i.e CI, SWI, and TWI were important predictor terrain attributes. Their predictive power was preferred over Profc and Crosc by Cubist, which were never used. Cubist's frequent use of slope at a 9-m analysis scale and the MCA suggest that a scale-dependent wetness index would serve as a more robust predictor of SOC. Proximity to geologic features and elevation were also important for modeling SOC, but it is difficult to determine whether the covariate selection is due to geomorphic or spatial controls.

The relative NDVI was a very important remote-sensed variable and was preferred over actual NDVI for prediction of SOC. Furthermore, the ETrF as a covariate was expected to perform better than it did for all models, yet relative ET variables were used more often in higher performing models. This study determined that scale-dependent remote-sensed soil proxies were superior to the original data for soil property prediction. Additionally, mutiple DEMs with multi-scale geomorphometric parameters could more effectively model soil properties. While the sand content model performed the best for textural variables, it was a relatively poor model compared to chemical properties. There is likely too much spatial variability in the Drift Prairie to model surface texture given current methods. The $CaCO_3$ poor model performance was likely due to the limited sampling depth and lack of subsurface hydrologic information.

This study also partitioned the sample pedons to associated catena members and intergrades with the modified PAM clustering algorithm. Six pedon classes, Thin Buse, Thick Buse, Barnes, Thick Barnes/Svea, MWD Svea, and Forman were identified and and summarized by chemical and morphologic trends. The Thin Buse class generally has the greatest degree of erosion indicated by high pHs, low SOC levels and shallow depth to the calcic horizon. The Thick Buse pedons rivaled the SOC and $CaCO_3$ content of the Barnes, but were differentiated by the Barnes thick cambic horizon. The Thick Barnes/Svea and MWD Svea pedons had similar morphology, but the MWD Svea pedons had lower pH's and much greater SOC content. The clustering method worked reasonably well to classify soils, but it was limited due to lack of terrain information. Therefore, more poorly drained soils associated with a different group of genetic processes were clustered together with the well-drained pedon classes because of similar chemical and morphologic properties.

This study discovered 16 pedons with morphology comparable to the Forman series which is not currently an inclusion for Barnes map units in the current SSURGO database. Furthermore, observed degree of cutan development for Barnes catena members has likely been reduced due to accelerated erosion and truncation. The argillic horizon has several important edaphic implications and it's distribution in the Drift Prairie should be further investigated.

This study also evaluated which environmental covariates best explain variability between upland group, lowland group, and all pedon classes via LDA. The analysis between closely interrelated soils in the upland group did not produce clearly discriminated groups, but the most representative Thin Buse pedons occurred on terrain more susceptible to erosion and lower ET. The Thick Barnes/Svea pedons occurred on gentle terrain with higher ET and NDVI than the Barnes class. In the lowland soils, the Forman discriminant outputs were highly variable and obscure. The predictive function showed moderate agreement for the upland pedon group and nearly substantial agreement for the lowland pedon group LDAs, but the classifier only had fair agreement for the LDA of all groups. The MWD Svea had the greatest predictive accuracies and the strongest relationship with input covariates. Unfortunately, the Barnes predictive accuracies were quite low. Differentiating closely interrelated soils on a catena is challenging due to natural variability, but also due to the covariate selection process, which requires improvements for future work.

Lastly, this study documented extensive morphologic evidence of accelerated erosion and tillage impacts on the Barnes catena. Observations of mixed adjacent horizons, remnant material of truncated horizons, very abrupt horizon boundaries, and plow pan compaction explain the varying degrees of soil degradation. These observations warrant investigation of the effect of plow pan compaction on subsurface flow. Furthermore, studies on the current soil productivity potential of the Barnes catena should be assessed to determine if a transition toward a new state-function has been induced by degradation.

SUGGESTIONS FOR FUTURE RESEARCH

Spatial Prediction of Soil Properties

DEM Limitations

Methods used to optimize the DEM for the study area could be improved. Firstly, a continuous DEM should be used as non-continuity introduces potential error by limiting the total catchment area. Secondly, the DEM should be iteratively aggregated and/or smoothed at varying scales to optimize the correlation coefficients between soil properties and geomorphometric parameters. Covariate pruning should then be performed with expert knowledge, the Cubist algorithm, variograms following methods of Vasquez et al. (2012), or recursive feature elimination employed by Brungard et al. (2015).

Temporal Variation Limitations and Advantages

Although the ET and NDVI covariates predictive power was improved by calculating local heterogeneity at different analysis scales with the TPI method, temporal variation limits their potential use. The author suggests generating relative NDVI and ET 1) near the end of the growing season (August to September) when spatial variation in crop senescence is exacerbated as suggested by de Souza et al. (1997), and 2) shortly after planting, in order to quantify delayed emergence in eroded areas as proven by Lindstrom et al. (1986), and 3) throughout the growing season, to capture developmental temporal variation.

Conventional tillage practices common to the region may also provide useful environmental covariates during the spring and fall when fields are cleared of vegetative cover following harvest. The author suggests that bare-soil surface reflectance from satellite and airborne imagery of fallow fields be utilized in future studies.

Variograms of Soil Properties

The higher performance Cubist models suggest that this study's methods are quite applicable for developing a variogram in order to extrapolate across space and create a predictive surface for depth-weighted soil properties. However, these sampling locations were confined to three specific Barnes map units and sampled with the intent to capture variability of upland soils in the eastern Glaciated Plains of North Dakota. Therefore, the sampling population is biased with respect to the greater landscape. Furthermore, the sampling density of this study was 5.84×10^{-2} sites km^{-2} with an average nearest neighbor distance of 1.77 km.
McBratney and Pringle (1999) have found from extensive review of the literature that spatial autocorrelations for soil properties (often surface) such as SOC, pH, clay, and sand are less than 500 m. However, these data points are suitable to calculate an experimental variogram from which to develop an efficient sampling design.

The author suggests that the most influential terrain attributes calculated from an optimized continuous DEM coupled with multi-scale spatial and temporal relative ET and NDVI be deployed as continuous (land cover filtered) environmental covariates to create a feature space for sampling design. The Latin Hypercube Sampling (LHS) tool is suggested because it calculates the minimal amount of sampling points required to sample from the full range of environmental covariates. The LHS uses both the sample point data and the covariate feature space to develop an efficient sampling scheme (Minasny and McBratney, 2007).

Soil Classification

This study shows that the clustering criterion adopted partitioned the dataset based on similar morphology and chemistry, but the classes lacked terrain attributes and particle-size control section textural data. These variables should be included in the clustering criteria due to their overriding influence on soil pedogenic processes that govern soil quality. The close interrelationship of soils and terrain attributes in this landscape suggests that the dataset requires a more robust clustering algorithm, i.e., the Fuzzy C-means algorithm. This method is highly applicable for soils on a catena because it calculates a class membership rating for each observation (Bezdek, 1981). Alternatively, LDA can be used to classify with the predictive linear discriminant function. Regardless of the method chosen, the DEM geomorphometric parameter correlations with soil properties used for classification criteria should be optimized and subsequently pruned as previously mentioned.

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APPENDIX A. SITE LOCATIONS

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
1	1A1	STUTSMAN	G143B	-98.508403	46.902008	1	140-62-33	Spiritwood	A
4	1A10	BARNES	G143B	-98.030340	46.751092	1	138-58-20	Nelson	A
7	1A11	BARNES	G143B	-97.839210	46.938440	1	140-57-14	Alta	A
10	1A12	BARNES	G143B	-98.314257	46.887590	1	139-61-1	Mansfield	A
13	1A13	BARNES	G143B	-98.127484	46.894852	1	140-59-33	Hobart	A
16	1A14	BARNES	G143B	-98.280738	47.044098	1	141-60-9	Anderson	A
19	1A15	BARNES	G143B	-97.823313	46.734391	1	138-57-25	Norma	A
22	1A16	BARNES	G143B	-98.251947	46.764240	1	138-60-16	Svea	A
25	1A17	BARNES	G143B	-97.996720	47.004921	1	141-58-26	Getchell	A
28	1A18	BARNES	G143B	-98.080990	47.017090	1	141-58-19	Getchell	A
31	1A19	BARNES	G143B	-98.046904	46.932754	1	140-58-19	Valley	A
34	1A2	STUTSMAN	G143B	-98.628392	46.988006	1	141-63-35	Fried	A
37	1A20	BARNES	G143B	-98.127854	46.898648	1	140-59-33	Hobart	A
40	1A3	STUTSMAN	G143B	-98.490133	46.880554	1	139-62-3	Winfield	A
42	1A4	STUTSMAN	G143B	-98.507620	46.905582	1	140-62-33	Spiritwood	A
46	1A5	CASS	G143B	-97.631135	46.750371	1	138-55-21	Clifton	A

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
49	1A6	CASS	G143B	-97.637975	46.779240	1	138-55-9	Clifton	A
52	1A7	CASS	G143B	-97.623858	46.747690	1	138-55-21	Clifton	A
55	1A8	BARNES	G143B	-98.067837	47.020330	1	141-58-19	Getchell	A
57	1A9	BARNES	G143B	-97.866890	46.742955	1	138-57-27	Norma	A
60	1B1	STUTSMAN	G143B	-98.558159	47.024966	1	141-62-17	Rose	B
63	1B10	BARNES	G143B	-97.875618	46.932559	1	140-57-21	Alta	B
66	1B11	BARNES	G143B	-97.838050	46.790882	1	138-57-2	Norma	B
70	1B12	BARNES	G143B	-97.889948	46.850756	1	139-57-16	Cuba	B
73	1B13	BARNES	G143B	-98.261660	46.905076	1	140-60-33	Potter	B
76	1B14	BARNES	G143B	-97.894345	46.726403	1	138-57-32	Norma	B
79	1B15	BARNES	G143B	-98.121242	46.873708	1	139-59-10	Green	B
82	1B16	BARNES	G143B	-97.752698	46.840481	1	139-56-21	Springvale	B
85	1B17	BARNES	G143B	-98.435877	46.797123	1	138-61-6	Meadow Lake	B
87	1B18	BARNES	G143B	-97.898057	46.918590	1	140-57-29	Alta	B
92	1B19	BARNES	G143B	-97.852671	46.798450	1	138-57-3	Norma	B
96	1B2	STUTSMAN	G143B	-98.504585	46.818395	1	139-62-33	Winfield	B

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
101	1B20	BARNES	G143B	-97.913484	47.014447	1	141-57-21	Noltimier	B
105	1B3	STUTSMAN	G143B	-98.441374	46.737963	1	138-62-25	Ypsilanti	B
109	1B4	STUTSMAN	G143B	-98.601151	46.881955	1	139-63-2	Homer	B
112	1B5	CASS	G143B	-97.618920	46.822789	1	139-55-27	HIll	B
116	1B6	CASS	G143B	-97.524243	46.898747	1	140-54-32	Buffalo	B
119	1B7	CASS	G143B	-97.638747	46.884816	1	139-55-4	HIll	B
121	1B8	CASS	G143B	-97.635756	46.838154	1	139-55-21	HIll	B
123	1B9	BARNES	G143B	-97.902300	46.914597	1	140-57-29	Alta	B
126	1C1	STUTSMAN	G143B	-98.447237	46.738802	1	138-62-25	Ypsilanti	C
129	1C10	BARNES	G143B	-98.155198	46.904209	1	140-59-32	Hobart	C
132	1C11	BARNES	G143B	-97.831675	46.793237	1	138-57-2	Norma	C
135	1C12	BARNES	G143B	-97.898668	46.854087	1	139-57-17	Cuba	C
138	1C13	BARNES	G143B	-97.899204	46.855914	1	139-57-17	Cuba	C
141	1C14	BARNES	G143B	-97.862884	46.990169	1	141-57-35	Noltimier	C
144	1C15	BARNES	G143B	-98.139850	46.832886	1	139-59-28	Green	C
146	1C16	BARNES	G143B	-97.899849	46.852577	1	139-57-17	Cuba	C

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
149	1C17	BARNES	G143B	-98.335450	46.969014	1	140-61-2	Eckelson	C
152	1C18	BARNES	G143B	-98.280860	46.967298	1	140-60-5	Potter	C
154	1C19	BARNES	G143B	-97.936585	46.812771	1	139-58-36	Marsh	C
157	1C2	STUTSMAN	G143B	-98.491539	46.839896	1	139-62-22	Winfield	C
161	1C20	BARNES	G143B	-97.901123	46.738466	1	138-57-29	Norma	C
164	1C3	CASS	G143B	-97.574013	46.730071	1	138-55-36	Clifton	C
168	1C4	CASS	G143B	-97.656445	46.961650	1	140-55-8	Tower	C
171	1C5	CASS	G143B	-97.629160	46.870500	1	139-55-9	HIll	C
174	1C6	CASS	G143B	-97.566162	46.823358	1	139-55-25	HIll	C
178	1C7	CASS	G143B	-97.656933	46.903423	1	140-55-32	Tower	C
181	1C8	BARNES	G143B	-97.889776	46.727683	1	138-57-33	Norma	C
184	1C9	BARNES	G143B	-97.843977	46.780554	1	138-57-11	Norma	C
188	2A1	STUTSMAN	G143C	-98.468110	46.900723	2	140-62-35	Spiritwood	A
190	2A10	BARNES	G143C	-97.718925	46.736848	2	138-56-26	Binghampton	A
193	2A11	BARNES	G143C	-98.406367	46.967083	2	140-61-5	Eckelson	A
196	2A12	BARNES	G143C	-98.104519	46.872102	2	139-59-10	Green	A

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
200	2A13	BARNES	G143C	-98.085225	46.872990	2	139-59-11	Green	A
202	2A14	BARNES	G143C	-98.281193	46.879227	2	139-60-5	Hemen	A
205	2A15	BARNES	G143C	-97.768235	46.756019	2	138-56-20	Binghampton	A
208	2A16	BARNES	G143C	-98.124267	46.802508	2	138-59-4	Skandia	A
212	2A17	BARNES	G143C	-97.822887	46.737982	2	138-57-25	Norma	A
216	2A18	BARNES	G143C	-97.882402	46.996677	2	141-57-27	Noltimier	A
219	2A19	BARNES	G143C	-98.398234	46.996155	2	141-61-27	Brimer	A
222	2A2	STUTSMAN	G143C	-98.525323	46.876598	2	139-62-8	Winfield	A
225	2A20	BARNES	G143C	-97.746717	46.740756	2	138-56-28	Binghampton	A
227	2A3	STUTSMAN	G143C	-98.468361	46.900371	2	140-62-35	Spiritwood	A
229	2A4	STUTSMAN	G143C	-98.529842	46.830435	2	139-62-29	Winfield	A
232	2A5	STUTSMAN	G143C	-98.500535	46.902595	2	140-62-34	Spiritwood	A
235	2A6	STUTSMAN	G143C	-98.529748	46.719669	2	138-62-32	Ypsilanti	A
239	2A7	CASS	G143C	-97.608360	46.781476	2	138-55-10	Clifton	A
242	2A8	BARNES	G143C	-98.133565	46.796315	2	138-59-4	Skandia	A
246	2A9	BARNES	G143C	-98.413888	46.967013	2	140-61-5	Eckelson	A

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
249	2B1	STUTSMAN	G143C	-98.485910	47.028665	2	141-62-13	Rose	B
252	2B10	BARNES	G143C	-98.433384	46.959670	2	140-61-7	Eckelson	B
255	2B11	BARNES	G143C	-97.894269	46.907896	2	140-57-29	Alta	B
258	2B12	BARNES	G143C	-97.883603	47.039022	2	141-57-10	Noltimier	B
262	2B13	BARNES	G143C	-98.121705	46.767860	2	138-59-15	Skandia	B
265	2B14	BARNES	G143C	-98.340790	46.907984	2	140-61-26	Eckelson	B
269	2B15	BARNES	G143C	-98.260923	46.818187	2	139-60-33	Hemen	B
271	2B16	BARNES	G143C	-97.864520	47.013794	2	141-57-23	Noltimier	B
275	2B17	BARNES	G143C	-97.802754	46.739660	2	138-56-30	Binghampton	B
278	2B18	BARNES	G143C	-98.313523	46.927718	2	140-61-24	Eckelson	B
282	2B19	BARNES	G143C	-98.097866	46.799574	2	138-59-2	Skandia	B
285	2B2	STUTSMAN	G143C	-98.446248	46.840976	2	139-62-24	Winfield	B
288	2B20	BARNES	G143C	-98.116962	46.872385	2	139-59-10	Green	B
291	2B3	STUTSMAN	G143C	-98.591714	46.932014	2	140-63-23	Bloom	B
295	2B4	STUTSMAN	G143C	-98.444921	46.961953	2	140-62-12	Spiritwood	B
299	2B5	STUTSMAN	G143C	-98.539548	46.947678	2	140-62-17	Spiritwood	B

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
302	2B6	CASS	G143C	-97.608779	46.776918	2	138-55-10	Clifton	B
305	2B7	BARNES	G143C	-98.455722	46.998044	2	141-61-30	Brimer	B
309	2B8	BARNES	G143C	-97.895460	46.960962	2	140-57-8	Alta	B
312	2B9	BARNES	G143C	-97.847530	47.055110	2	141-57-1	Noltimier	B
315	2C1	STUTSMAN	G143C	-98.576612	46.932503	2	140-63-24	Bloom	C
319	2C10	BARNES	G143C	-97.899330	46.736285	2	138-57-29	Norma	C
324	2C11	BARNES	G143C	-97.896914	46.737031	2	138-57-29	Norma	C
327	2C12	BARNES	G143C	-98.277461	46.890455	2	139-60-5	Hemen	C
331	2C13	BARNES	G143C	-98.206382	46.750736	2	138-60-24	Svea	C
336	2C14	BARNES	G143C	-97.944213	46.768312	2	138-58-13	Nelson	C
339	2C15	BARNES	G143C	-98.360612	46.953748	2	140-61-10	Eckelson	C
343	2C16	BARNES	G143C	-97.876768	46.991235	2	141-57-34	Noltimier	C
347	2C17	BARNES	G143C	-97.823083	46.791102	2	138-57-1	Norma	C
351	2C18	BARNES	G143C	-98.027815	46.725684	2	138-58-32	Nelson	C
354	2C19	BARNES	G143C	-97.901057	46.879794	2	139-57-5	Cuba	C
359	2C2	STUTSMAN	G143C	-98.445391	46.840165	2	139-62-24	Winfield	C

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
362	2C20	BARNES	G143C	-97.887292	46.908195	2	140-57-28	Alta	C
365	2C21	BARNES	G143C	-97.839833	46.805918	2	139-57-35	Cuba	C
368	2C3	STUTSMAN	G143C	-98.461664	46.894169	2	140-62-35	Spiritwood	C
372	2C4	CASS	G143C	-97.550003	46.998888	2	141-54-29	Ayr	C
377	2C5	CASS	G143C	-97.573957	46.742320	2	138-55-25	Clifton	C
381	2C6	BARNES	G143C	-97.804652	46.743155	2	138-56-30	Binghampton	C
385	2C7	BARNES	G143C	-97.890337	46.981329	2	141-57-34	Noltimier	C
389	2C8	BARNES	G143C	-98.194741	46.738934	2	138-60-25	Svea	C
392	2C9	BARNES	G143C	-97.856141	46.740502	2	138-57-27	Norma	C
395	3A1	STUTSMAN	G144B	-98.512277	46.925052	3	140-62-21	Spiritwood	A
399	3A10	BARNES	G144B	-98.040166	47.040543	3	141-58-9	Getchell	A
403	3A11	BARNES	G144B	-98.104644	46.901408	3	140-59-34	Hobart	A
406	3A12	BARNES	G144B	-98.309452	46.799338	3	138-60-6	Svea	A
409	3A13	BARNES	G144B	-98.308516	46.800899	3	138-60-6	Svea	A
411	3A14	BARNES	G144B	-98.263012	46.947765	3	140-60-16	Potter	A
414	3A15	BARNES	G144B	-98.250502	46.886309	3	139-60-4	Hemen	A

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
418	3A16	BARNES	G144B	-98.214835	46.845607	3	139-60-23	Hemen	A
422	3A17	BARNES	G144B	-98.369682	46.985581	3	141-61-35	Brimer	A
426	3A18	BARNES	G144B	-97.856321	47.027711	3	141-57-14	Noltimier	A
429	3A19	BARNES	G144B	-98.424654	47.042438	3	141-61-9	Brimer	A
433	3A2	STUTSMAN	G144B	-98.455269	46.970197	3	140-62-1	Spiritwood	A
437	3A20	BARNES	G144B	-98.150179	46.956063	3	140-59-8	Hobart	A
440	3A3	STUTSMAN	G144B	-98.498574	47.060102	3	141-62-2	Rose	A
442	3A4	CASS	G144B	-97.461458	46.937969	3	140-54-14	Buffalo	A
446	3A5	CASS	G144B	-97.478794	46.952231	3	140-54-10	Buffalo	A
495	3A6	CASS	G144B	-97.495376	46.960610	3	140-54-9	Buffalo	A
498	3A7	BARNES	G144B	-97.860348	46.960728	3	140-57-10	Alta	A
502	3A8	BARNES	G144B	-98.182810	46.966886	3	140-59-6	Hobart	A
506	3A9	BARNES	G144B	-98.414297	47.011942	3	141-61-21	Brimer	A
509	3B1	STUTSMAN	G144B	-98.581261	46.931119	3	140-63-24	Bloom	B
513	3B10	BARNES	G144B	-97.926431	46.814238	3	139-57-31	Cuba	B
517	3B11	BARNES	G144B	-98.051690	47.045541	3	141-58-8	Getchell	B

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
520	3B12	BARNES	G144B	-97.880792	46.881357	3	139-57-4	Cuba	B
523	3B13	BARNES	G144B	-97.884981	46.881619	3	139-57-4	Cuba	B
525	3B14	BARNES	G144B	-97.772299	46.850182	3	139-56-17	Springvale	B
530	3B15	BARNES	G144B	-97.818607	46.823957	3	139-57-25	Cuba	B
534	3B16	BARNES	G144B	-98.372042	46.814394	3	139-61-34	Mansfield	B
538	3B17	BARNES	G144B	-98.287678	46.988677	3	141-60-33	Anderson	B
542	3B18	BARNES	G144B	-98.386269	46.976121	3	140-61-4	Eckelson	B
547	3B19	BARNES	G144B	-98.399094	46.871330	3	139-61-8	Mansfield	B
551	3B2	STUTSMAN	G144B	-98.494279	46.942323	3	140-62-15	Spiritwood	B
554	3B20	BARNES	G144B	-98.302465	46.833426	3	139-60-30	Hemen	B
558	3B3	STUTSMAN	G144B	-98.456557	46.821788	3	139-62-25	Winfield	B
561	3B4	CASS	G144B	-97.529279	46.887217	3	139-54-5	Howes	B
565	3B5	CASS	G144B	-97.559292	46.816446	3	139-55-36	HIll	B
570	3B6	CASS	G144B	-97.501131	46.868021	3	139-54-9	Howes	B
573	3B7	BARNES	G144B	-98.282039	46.999035	3	141-60-28	Anderson	B
576	3B8	BARNES	G144B	-97.771890	47.011665	3	141-56-21	Weimer	B

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
578	3B9	BARNES	G144B	-97.771714	46.849426	3	139-56-17	Springvale	B
581	3C1	STUTSMAN	G144B	-98.605620	46.932227	3	140-63-23	Bloom	C
584	3C10	BARNES	G144B	-97.731794	46.766017	3	138-56-15	Binghampton	C
587	3C11	BARNES	G144B	-98.349030	47.001409	3	141-61-25	Brimer	C
592	3C12	BARNES	G144B	-98.325227	46.828116	3	139-61-25	Mansfield	C
596	3C13	BARNES	G144B	-98.411432	46.895016	3	140-61-32	Eckelson	C
599	3C14	BARNES	G144B	-97.764210	46.863462	3	139-56-9	Springvale	C
603	3C15	BARNES	G144B	-98.268431	46.779677	3	138-60-9	Svea	C
606	3C16	BARNES	G144B	-98.364083	47.060011	3	141-61-2	Brimer	C
609	3C17	BARNES	G144B	-97.755269	46.792127	3	138-56-4	Binghampton	C
613	3C18	BARNES	G144B	-97.793661	46.942995	3	140-56-18	Oriska	C
616	3C19	BARNES	G144B	-98.296783	46.913584	3	140-60-30	Potter	C
620	3C2	CASS	G144B	-97.664955	46.938532	3	140-55-18	Tower	C
623	3C20	BARNES	G144B	-98.285392	46.896498	3	140-60-32	Potter	C
627	3C3	CASS	G144B	-97.530932	46.888795	3	139-54-5	Howes	C
630	3C4	CASS	G144B	-97.673525	46.991651	3	141-55-32	Cornell	C

No.	Site ID	County	Map unit symbol	Lat.	Long.	Map unit code	Legal	Township	ETrF class
634	3C5	CASS	G144B	-97.614913	46.878561	3	139-55-3	HIll	C
638	3C6	BARNES	G144B	-98.373685	46.851120	3	139-61-15	Mansfield	C
641	3C7	BARNES	G144B	-98.209570	46.854603	3	139-60-14	Hemen	C
644	3C8	BARNES	G144B	-97.898946	46.956428	3	140-57-8	Alta	C
647	3C9	BARNES	G144B	-98.427745	46.734139	3	138-61-30	Meadow Lake	C

APPENDIX B. SOIL HORIZONS AND CHEMICAL DATA

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
1	1A11	Ap	Ap	0	24	24	10YR 2/1	3.42	0.05	0.42	7.38	0.18
2	1A11	Bw	Bw1	24	39	15	10YR 3/3	1.16	0.17	1.42	8.05	0.193
3	1A11	Bk	Bk1	39	50	11	2.5Y 6/2	0.9	5.01	41.73	8.59	0.245
4	1A13	Ap	Ap	0	25	25	10YR 2/1	2.07	0.03	0.25	6.46	0.378
5	1A13	Bw	Bw1	25	47	22	2.5Y 3/3	0.65	0.15	1.25	8.14	0.315
6	1A13	Bk	Bk1	47	50	3	2.5Y 5/3	0.34	1.73	14.41	8.27	0.31
7	1A15	Ap	Ap	0	20	20	10YR 2/1	3.17	0	0	6.38	0.168
8	1A15	Bw1	Bw1	20	25	5	10YR 2/2	1.63	0	0	7.07	0.218
9	1A15	Bw2	Bw2	25	50	25	2.5Y 4/3	0.61	0	0	7.32	0.266
10	1A20	Ap	Ap	0	13	13	10YR 2/2	1.91	0.08	0.67	7.55	0.305
11	1A20	Bw	Bw1	13	23	10	10YR 4/2	1.32	0.18	1.5	7.82	0.392
12	1A20	Bk	Bk1	23	50	27	2.5Y 5/4	0.45	2.62	21.82	8.27	0.37
13	1A5	Ap	Ap	0	12	12	10YR 2/1	3.61	0.04	0.33	7.96	1.153
14	1A5	A	A	12	31	19	10YR 2/1	3.28	0.04	0.33	7.82	2.009

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
15	1A5	Bw	Bw1	31	50	19	10YR 3/2	1.84	0	0	7.72	0.33
16	1A6	Ap	Ap	0	19	19	10YR 2/1	1.98	0.55	4.58	8.17	0.221
17	1A6	Bw	Bw1	19	33	14	10YR 3/3	0.78	0.14	1.12	8.05	0.193
18	1A6	Bk	Bk1	33	50	17	10YR 5/3	0.56	2.89	24.03	8.53	0.163
19	1A7	Ap	Ap	0	22	22	10YR 2/1	3.3	0.2	1.67	8.18	0.273
20	1A7	Bk1	Bk1	22	30	8	10YR 3/1	2.1	3.08	25.66	8.51	0.38
21	1A7	Bk2	Bk2	30	50	20	10YR 4/1	0.92	3.58	29.82	8.76	0.405
22	1B10	Ap	Ap	0	12	12	10YR 2/2	2.37	0.31	2.58	7.93	0.413
23	1B10	Bw	Bw1	12	27	15	10YR 3/3	1.24	1.1	9.16	8.18	0.528
24	1B10	Bk	Bk1	27	50	23	2.5Y 3/7	0.66	2.84	23.66	8.81	0.603
25	1B11	Ap	Ap	0	19	19	10YR 2/1	3.54	0	0	6.86	0.423
26	1B11	A	A	19	40	21	10YR 2/1	2.34	0	0	6.49	0.578
27	1B11	Bt	Bt	40	50	10	10YR 3/1	1.17	0	0	7.08	0.898
28	1B12	Ap	Ap	0	17	17	10YR 2/1	2.58	0	0	5.16	0.176

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
29	1B12	Bw1	Bw1	17	28	11	10YR 3/2	0.88	0	0	6.09	0.167
30	1B12	Bw2	Bw2	28	50	22	2.5Y 4/4	0.64	0	0	6.83	0.218
31	1B15	Ap	Ap	0	19	19	10YR 2/1	3.22	0	0	5.58	0.337
32	1B15	A	A	19	33	14	10YR 2/1	3.08	0	0	6.33	0.237
33	1B15	Bw	Bw1	33	50	17	10YR 2/2	1.34	0	0	7.28	0.259
34	1B16	Ap	Ap	0	22	22	10YR 2/1	2.93	0.08	0.67	7.58	1.765
35	1B16	Bw	Bw1	22	30	8	10YR 4/2	1.7	0.02	0.17	7.58	2.04
36	1B16	2BC	C	30	50	20	10YR 3/6	0.95	1.82	15.16	7.83	1.993
37	1B18	Ap	Ap	0	20	20	10YR 2/1	3.2	0	0	5.5	0.167
38	1B18	Bw1	Bw1	20	39	19	10YR 3/3	0.88	0	0	6.47	0.216
39	1B18	Bw2	Bw2	39	50	11	2.5Y 4/4	0.54	0	0	7.08	0.32
40	1B20	Ap	Ap	0	25	25	10YR 2/1	3.21	0	0	5.29	0.212
41	1B20	A	A	25	50	25	10YR 3/1	3.22	0	0	5.92	0.115
42	1B5	Ap	Ap	0	19	19	10YR 2/1	2.38	0.72	6	8.23	0.33

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm	-------------	-------------)		(----------% wt.	----------	----------)		dS m^{-1}
43	1B5	Bw	Bw1	19	27	8	10YR 2/2	2.29	0.98	8.16	8.3	0.399
44	1B5	Bk	Bk1	27	40	13	10YR 6/3	1.13	3.9	32.49	8.2	0.851
45	1B5	Bky	Bk2	40	50	10	2.5Y 5/3	0.87	2.41	20.08	8	1.695
46	1B6	Ap	Ap	0	22	22	10YR 2/1	2.58	0.12	1	7.82	0.428
47	1B6	Bw	Bw1	22	35	13	10YR 3/2	1.28	0.91	7.58	8.08	0.421
48	1B6	Bk	Bk1	35	50	15	10YR 6/3	0.93	2.67	22.24	8.35	0.497
49	1B7	Ap	Ap	0	19	19	10YR 2/1	2.31	1.21	10.08	8.11	0.358
50	1B7	Bk	Bk1	19	38	19	10YR 5/2	1.41	2.93	24.41	8.33	0.506
51	1B7	Bky	Bk2	38	50	12	2.5Y 5/3	0.58	1.93	16.08	8.02	1.772
52	1B8	Ap	Ap	0	20	20	10YR 2/1	3.38	0	0	5.76	0.189
53	1B8	A	A	20	32	12	10YR 2/1	2.84	0	0	6.46	0.207
54	1B8	Bw	Bw1	32	50	18	10YR 3/2	1.27	0	0	7.35	0.35
55	1B9	Ap	Ap	0	19	19	10YR 2/1	2.81	0	0	4.68	0.285
56	1B9	Bw	Bw1	19	50	31	2.5Y 5/4	0.74	0.03	0.25	5.92	0.323

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm	-------------	-------------)		(----------% wt.	----------	----------)		dS m^{-1}
57	1C10	Ap	Ap	0	15	15	10YR 2/2	2.26	0.27	2.25	7.96	0.217
58	1C10	Bk1	Bk1	15	38	23	10YR 6/3	0.72	2.75	22.91	8.33	0.216
59	1C10	Bk2	Bk2	38	50	12	10YR 5/3	0.55	1.91	15.91	8.5	0.153
60	1C11	Ap	Ap	0	22	22	10YR 2/1	3.16	0	0	6.06	0.164
61	1C11	Bw1	Bw1	22	32	10	10YR 3/2	1.61	0	0	6.59	0.169
62	1C11	Bw2	Bw2	32	50	18	2.5Y 3/2	0.79	0	0	7.04	0.182
63	1C12	Ap	Ap	0	22	22	10YR 2/1	2.36	0	0	5.94	0.146
64	1C12	Bw1	Bw1	22	29	7	2.5Y 4/3	1.02	0	0	6.47	0.215
65	1C12	Bw2	Bw2	29	50	21	2.5Y 5/4	0.61	0	0	6.87	0.378
66	1C13	Ap	Ap	0	20	20	10YR 2/1	2.46	0	0	5.22	0.176
67	1C13	A	A	20	30	10	10YR 2/2	2.22	0	0	6.38	0.359
68	1C13	Bw	Bw1	30	45	15	2.5Y 4/3	0.92	0	0	7.43	0.388
69	1C13	Bk	Bk1	45	50	5	2.5Y 5/3	0.92	2.1	17.49	8	1.046
70	1C14	Ap	Ap	0	28	28	10YR 2/1	3.51	0	0	5.55	0.201

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
71	1C14	Bw1	Bw1	28	41	13	10YR 3/2	1.15	0	0	6.37	0.193
72	1C14	Bw2	Bw2	41	50	9	2.5Y 5/4	0.64	0	0	6.83	0.25
73	1C15	Ap	Ap	0	14	14	10YR 2/2	3.23	0.03	0.21	7.49	0.219
74	1C15	Bk1	Bk1	14	35	21	10YR 5/2	0.85	4.08	33.99	8.16	0.272
75	1C15	Bk2	Bk2	35	50	15	10YR 5/4	0.58	3.14	26.16	8.44	0.182
76	1C16	Ap	Ap	0	15	15	10YR 2/1	1.37	0	0	6.47	0.905
77	1C16	Bw	Bw1	15	25	10	2.5Y 4/3	0.72	0.03	0.25	7.37	1.951
78	1C16	Bk	Bk1	25	50	25	2.5Y 6/4	0.78	3.18	26.49	7.98	2.115
79	1C19	Ap	Ap	0	18	18	10YR 2/2	3.11	0	0	6.84	0.246
80	1C19	Bw	Bw1	18	26	8	10YR 4/3	1.59	0.26	2.17	7.7	0.456
81	1C19	Bk	Bk1	26	50	24	2.5Y 5/3	0.92	3.15	26.24	8.17	0.496
82	1C20	Ap	Ap	0	16	16	10YR 2/2	2.61	0.49	4.08	7.99	0.401
83	1C20	Bk1	Bk1	16	37	21	2.5Y 7/3	1.03	4.38	36.49	8.29	0.513
84	1C20	Bk2	Bk2	37	50	13	2.5Y 6/6	0.71	3.28	27.32	8.21	0.775

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
85	1C3	Ap	Ap	0	30	30	10YR 2/1	3.09	0.08	0.67	7.11	2.13
86	1C3	Bw	Bw1	30	50	20	10YR 3/2	2.45	0	0	7.32	0.75
87	1C4	Ap	Ap	0	14	14	10YR 2/1	2.82	0.09	0.75	7.11	1.175
88	1C4	A	A	14	19	5	10YR 2/1	2.7	0.15	1.25	7.56	0.587
89	1C4	Bw	Bw1	19	27	8	10YR 3/2	1.54	0.97	8.08	7.98	0.475
90	1C4	Bk1	Bk1	27	37	10	2.5Y 6/3	0.94	4.18	34.82	8.34	0.475
91	1C4	Bk2	Bk2	37	50	13	2.5Y 6/4	0.69	3.73	31.07	8.44	0.562
92	1C5	Ap	Ap	0	15	15	10YR 2/2	2.84	0.2	1.67	8.03	0.309
93	1C5	Bw	Bw1	15	22	7	10YR 3/1	1.63	0.21	1.75	8.02	0.837
94	1C5	Bk	Bk1	22	38	16	2.5Y 6/2	1.24	3.77	31.4	8.21	1.962
95	1C5	Bky	Bk2	38	50	12	2.5Y 6/4	0.59	2.41	20.08	8.21	3.11
96	1C6	Ap	Ap	0	13	13	10YR 2/1	3.06	0	0	6.57	0.283
97	1C6	A	A	13	30	17	10YR 2/1	2.7	0	0	7.6	0.363
98	1C6	Bw	Bw1	30	38	8	10YR 2/2	1.86	0.1	0.83	7.68	1.4

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
99	1C6	Bk1	Bk1	38	43	5	10YR 3/1	1.78	1.06	8.83	7.9	1.96
100	1C6	Bk2	Bk2	43	50	7	10YR 4/1	1.17	1.48	12.33	8.06	2.17
101	1C7	Ap	Ap	0	17	17	10YR 2/1	2.39	0.39	3.25	7.86	0.743
102	1C7	Bw	Bw1	17	21	4	10YR 4/2	1.09	0.43	3.58	8.08	0.825
103	1C7	Bk	Bk1	21	32	11	2.5Y 7/3	1.04	4.49	37.4	8.1	1.3
104	1C7	Bky	Bk2	32	50	18	2.5Y 5/3	0.76	1.84	15.33	8.05	2.195
105	2A12	Ap	Ap	0	13	13	10YR 2/1	3.56	0	0	7.1	0.153
106	2A12	A	A	13	27	14	10YR 2/1	3.24	0.04	0.33	7.57	0.135
107	2A12	Bw1	Bw1	27	38	11	10YR 3/2	0.13	0.91	7.58	7.46	0.251
108	2A12	2Bw2	Bw2	38	50	12	10YR 3/2	1.63	0.03	0.25	8.08	0.219
109	2A16	Ap	Ap	0	22	22	10YR 2/1	3.28	0.03	0.25	6.55	0.173
110	2A16	Bt1	Bt	22	36	14	10YR 3/2	1.39	0	0	7.01	0.24
111	2A16	Bt2	Bt	36	50	14	10YR 4/3	0.85	0	0	7.29	0.111
112	2A17	Ap	Ap	0	18	18	10YR 2/1	1.97	0	0	6.48	0.179

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
113	2A17	Bw1	Bw1	18	26	8	10YR 3/3	0.91	0	0	7.05	0.242
114	2A17	Bw2	Bw2	26	42	16	2.5Y 4/4	0.76	0.05	0.42	7.55	0.271
115	2A17	Bk	Bk1	42	50	8	2.5Y 5/4	0.57	3.21	26.74	8.46	0.333
116	2A18	Ap	Ap	0	18	18	10YR 2/1	3.41	0	0	5.54	0.14
117	2A18	A	A	18	37	19	10YR 2/2	1.94	0	0	6.35	0.139
118	2A18	Bw	Bw1	37	50	13	10YR 3/2	1.08	0	0	6.37	0.157
119	2A7	Ap	Ap	0	10	10	10YR 3/1	1.37	1.22	10.16	7.96	0.552
120	2A7	Cky	C	10	50	40	2.5Y 4/4	0.05	1.69	14.08	7.75	2.38
121	2B11	Ap	Ap	0	19	19	10YR 2/1	2.66	0	0	5.2	0.136
122	2B11	Bw	Bw1	19	50	31	10YR 3/3	0.96	0	0	6.48	0.169
123	2B12	Ap	Ap	0	19	19	10YR 2/1	4.53	0.05	0.42	7.34	0.373
124	2B12	Bw	Bw1	19	32	13	10YR 3/3	1.89	0.05	0.42	7.48	0.406
125	2B12	Bk	Bk1	32	50	18	2.5Y 6/3	1.05	3.27	27.24	8.32	0.388
126	2B16	Ap	Ap	0	17	17	10YR 2/1	3.02	0.4	3.33	7.76	0.384

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
127	2B16	Bk1	Bk1	17	33	16	2.5Y 5/3	0.76	2.52	20.99	8.32	0.403
128	2B16	Bk2	Bk2	33	50	17	2.5Y 6/3	0.71	3.53	29.4	8.44	0.386
129	2B17	Ap	Ap	0	23	23	10YR 3/1	2.66	0	0	6.61	0.217
130	2B17	Bw	Bw1	23	38	15	10YR 3/2	0.95	0	0	6.7	0.273
131	2B17	Bt	Bt	38	50	12	2.5Y 4/2	0.56	0	0	6.7	0.249
132	2B20	Ap	Ap	0	13	13	10YR 2/1	3.02	0	0	6.73	0.262
133	2B20	A	A	13	23	10	10YR 2/1	3.16	0	0	7.3	0.203
134	2B20	Bw	Bw1	23	50	27	2.5Y 4/3	0.77	0.03	0.25	7.94	0.282
135	2B6	Ap	Ap	0	18	18	10YR 3/1	1.94	0.64	5.33	8.17	0.196
136	2B6	Bk1	Bk1	18	29	11	10YR 6/3	0.86	3.55	29.57	8.55	0.255
137	2B6	Bk2	Bk2	29	50	21	2.5Y 5/4	0.68	2.69	22.41	8.6	0.317
138	2B8	Ap	Ap	0	18	18	10YR 2/1	4.22	0.02	0.17	5.39	0.172
139	2B8	A	A	18	24	6	10YR 2/1	3.44	0	0	6.49	0.231
140	2B8	Bw	Bw1	24	50	26	10YR 2/2	2.11	0	0	6.89	0.24

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
141	2B9	Ap	Ap	0	13	13	10YR 3/2	2.2	1.26	10.45	8.01	0.283
142	2B9	Bk1	Bk1	13	30	17	2.5Y 6/3	0.61	2.38	19.83	8.2	0.39
143	2B9	Bk2	Bk2	30	50	20	2.5Y 4/3	0.26	1.96	16.33	8.36	0.349
144	2C10	Ap	Ap	0	23	23	10YR 2/1	2.55	0.5	4.17	7.66	1.745
145	2C10	A	A	23	50	27	10YR 2/1	3.03	0.09	0.75	7.69	1.668
146	2C11	Ap	Ap	0	26	26	10YR 2/1	3.22	0.09	0.75	7.77	0.318
147	2C11	A	A	26	42	16	10YR 2/1	3.19	0.05	0.42	7.65	0.554
148	2C11	Bw	Bw1	42	50	8	10YR 3/2	1.9	0.02	0.17	7.43	0.725
149	2C16	Ap	Ap	0	19	19	10YR 2/1	1.94	0	0	6.84	0.204
150	2C16	Bw	Bw1	19	30	11	2.5Y 4/4	0.81	0.24	2	7.67	0.366
151	2C16	Bk	Bk1	30	50	20	2.5Y 6/4	0.65	2.1	17.45	8.3	0.317
152	2C17	Apk	Ap	0	15	15	10YR 3/1	1.63	1.62	13.49	7.94	0.289
153	2C17	Bk	Bk1	15	50	35	10YR 5/4	1.32	1.32	11	8.4	0.332
154	2C19	Ap	Ap	0	23	23	10YR 2/1	2.9	0.05	0.42	7.71	0.284

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------		-)		(----------% wt.		----------)		dS m^{-1}
155	2C19	A	A	23	35	12	10YR 2/1	2.49	0	0	7.62	0.163
156	2C19	Bw	Bw1	35	50	15	10YR 3/2	1.11	0	0	7.59	0.19
157	2C20	Ap	Ap	0	15	15	10YR 2/1	2.99	0.51	4.25	7.81	0.309
158	2C20	A	A	15	24	9	10YR 2/1	2.82	0.37	3.08	7.95	0.408
159	2C20	Bk1	Bk1	24	40	16	10YR 6/2	1.74	1.82	15.16	8.14	0.423
160	2C20	Bk2	Bk2	40	50	10	2.5Y 6/4	0.74	2.01	16.74	8.45	0.387
161	2C21	Ap	Ap	0	17	17	10YR 3/1	2.52	0.2	1.67	7.98	0.262
162	2C21	Bk1	Bk1	17	23	6	2.5Y 5/3	2	0.72	6	8.15	0.248
163	2C21	Bk2	Bk2	23	50	27	2.5Y 6/4	0.57	3.01	25.07	8.51	0.175
164	2C4	Ap	Ap	0	16	16	10YR 2/2	2.29	0.15	1.25	7.82	0.508
165	2C4	Bw1	Bw1	16	27	11	10YR 2/2	1.71	0.16	1.33	7.84	0.545
166	2C4	Bw2	Bw2	27	36	9	10YR 4/3	0.77	0.41	3.42	7.79	0.46
167	2C4	Bk	Bk1	36	50	14	2.5Y 5/4	0.66	2.69	22.41	8.22	0.451
168	2C5	Ap	Ap	0	19	19	10YR 2/1	1.49	0.48	4	7.79	0.387

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
169	2C5	Bw1	Bw1	19	29	10	10YR 4/3	0.95	0	0	7.62	0.377
170	2C5	Bw2	Bw2	29	50	21	2.5Y 5/3	0.5	0	0	7.84	0.383
171	2C7	Ap	Ap	0	18	18	10YR 2/1	2.42	0	0	5.31	0.115
172	2C7	Bw1	Bw1	18	29	11	10YR 3/2	1.13	0	0	5.68	0.094
173	2C7	Bw2	Bw2	29	50	21	10YR 4/3	0.68	0	0	6.3	0.172
174	3A18	Ap	Ap	0	17	17	10YR 3/1	2.97	1.86	15.49	7.83	0.416
175	3A18	Ak	A	17	26	9	10YR 4/1	1.96	3.04	25.32	8.18	0.482
176	3A18	Bk	Bk1	26	36	10	10YR 4/2	1.6	3.2	26.66	8.2	0.638
177	3A18	Bky	Bk2	36	50	14	2.5Y 4/4	0.85	1.72	14.29	7.95	1.658
178	3A4	Ap	Ap	0	16	16	10YR 2/1	2.63	0.19	1.58	7.9	1.522
179	3A4	Bw	Bw1	16	41	25	10YR 3/2	1.9	0.07	0.58	7.87	0.679
180	3A4	Bk	Bk1	41	50	9	10YR 6/3	1.01	3.4	28.32	7.96	1.473
181	3A5	Ap	Ap	0	17	17	10YR 3/1	1.72	1.05	8.75	8	0.519
182	3A5	Bk1	Bk1	17	35	18	10YR 6/3	0.93	3.29	27.41	8.18	0.59

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
183	3A5	Bk2	Bk2	35	50	15	2.5Y 6/3	0.68	2.52	20.99	8.21	0.678
184	3A6	Ap	Ap	0	21	21	10YR 2/1	2.44	0.04	0.33	7.44	0.256
185	3A6	Bw	Bw1	21	32	11	10YR 3/2	0.76	0.23	1.92	8.22	0.262
186	3A6	Bk	Bk1	32	38	6	10YR 6/3	0.75	3.91	32.57	8.44	0.367
187	3A6	Bky	Bk2	38	50	12	10YR 6/4	0.6	2.59	21.57	8.02	1.601
188	3B12	Ap	Ap	0	25	25	10YR 2/1	3.78	0	0	6.07	0.245
189	3B12	A	A	25	50	25	10YR 2/1	3.49	0	0	6.25	0.713
190	3B13	Ap	Ap	0	20	20	10YR 2/2	3.02	0	0	5.73	0.223
191	3B13	Bw1	Bw1	20	32	12	10YR 3/3	1.44	0	0	6.52	0.288
192	3B13	Bw2	Bw2	32	50	18	10YR 3/1	0.92	0	0	7.45	0.337
193	3B14	Ap	Ap	0	19	19	10YR 2/2	1.96	0.06	0.5	7.48	0.181
194	3B14	Bw	Bw1	19	30	11	2.5Y 4/4	0.9	0.03	0.25	7.78	0.271
195	3B14	Bk	Bk1	30	50	20	2.5Y 6/4	0.8	3.03	25.24	8.32	0.231
196	3B15	Ap	Ap	0	13	13	10YR 2/2	2.62	0.3	2.5	8.11	0.248

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
197	3B15	Bt	Bt	13	24	11	10YR 3/2	1.34	0	0	8.1	0.399
198	3B15	Bk1	Bk1	24	42	18	2.5Y 6/3	0.63	2.27	18.91	8.24	0.355
199	3B15	Bk2	Bk2	42	50	8	2.5Y 5/4	0.67	3.02	25.16	8.5	0.477
200	3B4	Ap	Ap	0	17	17	10YR 4/2	1.02	1.54	12.83	8	0.496
201	3B4	Bk	Bk1	17	50	33	2.5Y 5/3	0.69	2.64	21.99	8.36	0.246
202	3B5	Ap	Ap	0	18	18	10YR 2/1	3.54	0	0	6.57	0.321
203	3B5	A	A	18	28	10	10YR 2/1	2.82	0	0	6.9	0.275
204	3B5	Bw	Bw1	28	50	22	10YR 2/2	1.52	0	0	7.33	0.244
205	3B6	Ap	Ap	0	18	18	10YR 4/1	1.56	1.81	15.04	8.39	0.313
206	3B6	Az	A	18	32	14	10YR 4/1	1.28	1.8	14.95	8.53	0.432
207	3B6	Bk	Bk1	32	50	18	2.5Y 5/4	0.28	2.46	20.49	8.67	0.481
208	3B8	Ap	Ap	0	15	15	10YR 2/2	3.43	0	0	6.71	0.294
209	3B8	Bw	Bw1	15	28	13	10YR 2/2	2.05	0.27	2.25	7.7	0.402
210	3B8	Bk	Bk1	28	42	14	2.5Y 6/3	1.08	4.94	41.15	8.37	0.376

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
211	3B8	Bky	Bk2	42	50	8	2.5Y 6/4	0.87	3.24	26.99	7.91	1.665
212	3B9	Ap	Ap	0	13	13	10YR 2/2	2.49	0.03	0.25	7.28	0.26
213	3B9	Bt	Bt	13	27	14	10YR 3/3	1.33	0.29	2.42	8.02	0.386
214	3B9	Bk1	Bk1	27	40	13	2.5Y 6/3	0.84	4.77	39.73	8.52	0.342
215	3B9	Bk2	Bk2	40	50	10	2.5Y 5/4	0.81	3.28	27.32	8.73	0.276
216	3C14	Ap	Ap	0	24	24	10YR 2/1	3.53	0	0	6.67	0.177
217	3C14	A	A	24	43	19	10YR 2/1	3.03	0	0	7.31	0.188
218	3C14	Bw	Bw1	43	50	7	10YR 3/1	1.61	0	0	7.19	0.219
219	3C18	Ap	Ap	0	20	20	10YR 2/1	3.51	0.03	0.25	6.74	0.175
220	3C18	A	A	20	35	15	10YR 2/1	3.41	0	0	6.61	0.15
221	3C18	Bw	Bw1	35	50	15	10YR 2/2	1.66	0	0	7.67	0.165
222	3C2	Ap	Ap	0	27	27	10YR 2/1	2.49	0.32	2.67	8	0.343
223	3C2	Bt	Bt	27	33	6	10YR 4/1	0.12	0.41	3.42	8.12	0.439
224	3C2	Bk	Bk1	33	50	17	2.5Y 6/2	0.53	2.76	22.99	8.29	0.843

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
225	3C3	Ap	Ap	0	26	26	10YR 3/1	1.81	0.77	6.41	7.95	0.848
226	3C3	Bk	Bk1	26	50	24	2.5Y 5/4	0.36	1.9	15.83	7.98	1.554
227	3C4	Ap	Ap	0	20	20	10YR 2/1	2.1	0.95	7.91	7.7	0.303
228	3C4	Bk	Bk1	20	50	30	2.5Y 6/3	0.84	3.07	25.57	8.25	0.304
229	3C5	Ap	Ap	0	21	21	10YR 2/2	2.21	1.41	11.75	8.04	0.357
230	3C5	Ak	A	21	31	10	10YR 4/2	2.27	1.33	11.08	8.28	0.31
231	3C5	Bk	Bk1	31	50	19	10YR 6/2	0.54	3.47	28.91	8.2	0.282
232	3C8	Ap	Ap	0	18	18	10YR 2/1	3.07	0	0	6	0.173
233	3C8	A	A	18	27	9	10YR 2/1	2.42	0	0	5.55	0.093
234	3C8	Bw	Bw1	27	50	23	10YR 2/2	1.65	0	0	6.63	0.133
235	3C17	Ap	Ap	0	10	10	10YR 2/1	2.72	0.36	3	8.07	0.482
236	3C17	A	A	10	30	20	10YR 2/1	2.07	0.09	0.75	8	0.476
237	3C17	Bw1	Bw1	30	42	12	10YR 3/2	0.73	0	0	7.85	0.469
238	3C17	Bw2	Bw2	42	50	8	10YR 3/1	0.65	0	0	7.62	0.629

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
239	3C10	Ap	Ap	0	9	9	10YR 4/2	1.22	2.28	18.99	8.22	0.298
240	3C10	Bk1	Bk1	9	29	20	2.5Y 5/4	0.57	3.17	26.41	8.46	0.396
241	3C10	Bk2	Bk2	29	50	21	2.5Y 4/4	0.36	2.17	18.08	8.67	0.345
242	2C9	Ap	Ap	0	17	17	10YR 2/1	2.51	0	0	6.92	0.306
243	2C9	Bw1	Bw1	17	27	10	2.5Y 3/3	1.26	0	0	7.85	0.371
244	2C9	Bw2	Bw2	27	38	11	2.5Y 5/4	0.59	0.6	5	7.12	0.272
245	2C9	2Bk	Bk	38	50	12	10YR 4/3	0.53	2.21	18.41	8.29	0.232
246	1A9	Ap	Ap	0	18	18	10YR 3/1	1.99	0.16	1.33	8.03	0.344
247	1A9	Bw	Bw1	18	38	20	10YR 3/3	0.78	0.03	0.25	8.11	0.237
248	1A9	2Bk	Bk	38	50	12	2.5Y 5/4	0.53	3.62	30.15	8.62	0.43
249	1B19	Ap	Ap	0	11	11	10YR 2/1	3.28	0	0	5.51	0.265
250	1B19	A	A	11	42	31	10YR 2/1	2.81	0	0	6.16	0.208
251	1B19	Bw	Bw1	42	50	8	10YR 3/1	1.34	0	0	6.84	0.212
252	1C8	Ap	Ap	0	19	19	10YR 2/1	3.39	0	0	5.71	0.206

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
253	1C8	A	A	19	30	11	10YR 2/2	2.61	0	0	6.4	0.2
254	1C8	Bw	Bw1	30	50	20	2.5Y 5/4	0.8	0	0	6.94	0.32
255	1B14	Ap	Ap	0	18	18	10YR 2/1	3.45	0	0	5.98	0.268
256	1B14	Bw1	Bw1	18	25	7	10YR 3/2	0.97	0.86	7.16	6.75	0.261
257	1B14	2Bw2	Bw2	25	50	25	10YR 3/3	0.72	0.95	7.91	7.91	0.375
258	2A10	Ap	Ap	0	14	14	10YR 2/2	2.48	1.05	8.75	8.05	0.385
259	2A10	Ak	A	14	21	7	10YR 2/2	1.63	1.58	13.12	8.18	0.291
260	2A10	Bk1	Bk1	21	32	11	2.5Y 6/3	0.81	4.54	37.78	8.48	0.286
261	2A10	Bk2	Bk2	32	50	18	2.5Y 6/4	0.68	4.07	33.9	8.69	0.303
262	3A11	Ap	Ap	0	10	10	10YR 2/2	2.41	0.03	0.25	6.79	0.248
263	3A11	Bw	Bw1	10	26	16	10YR 3/3	1.19	0.05	0.42	8.09	0.33
264	3A11	Bk	Bk1	26	50	24	10YR 5/4	0.48	3.11	25.91	8.25	0.408
265	2A13	Ap	Ap	0	15	15	10YR 2/1	2.05	0.12	1	7.8	0.311
266	2A13	Bw	Bw1	15	20	5	10YR 3/2	0.96	0.55	4.58	8.23	0.275

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
267	2A13	Bk1	Bk1	20	30	10	10YR 5/3	0.42	2.94	24.49	8.52	0.259
268	2A13	Bk2	Bk2	30	50	20	10YR 6/3	0.66	2.61	21.74	8.39	0.3
269	2A8	Ap	Ap	0	11	11	10YR 2/2	2.41	0.45	3.75	8.01	0.263
270	2A8	Bk	Bk1	11	50	39	2.5Y 5/4	0.51	2.1	17.49	8.33	0.236
271	1A10	Ap	Ap	0	15	15	10YR 2/1	2.63	0	0	5.69	0.163
272	1A10	A	A	15	26	11	10YR 2/1	1.78	0.46	3.83	6.9	0.366
273	1A10	Bw1	Bw1	26	36	10	10YR 3/2	1.16	0	0	6.92	0.229
274	1A10	Bw2	Bw2	36	50	14	2.5Y 4/3	0.64	0.47	3.92	7.8	0.344
275	2A20	Ap	Ap	0	26	26	10YR 2/1	2.92	0.05	0.42	7.5	0.347
276	2A20	Bt1	Bt	26	34	8	10YR 4/4	0.91	0	0	7.78	0.234
277	2A20	Bt2	Bt	34	50	16	10YR 4/3	0.57	0.08	0.67	7.8	0.253
278	2B19	A1	A	0	12	12	10YR 2/1	3.39	0.07	0.58	7.48	0.353
279	2B19	A2	A	12	28	16	10YR 2/1	2.76	0.04	0.33	7.63	0.274
280	2B19	Bw1	Bw1	28	42	14	10YR 2/2	1.87	0	0	7.74	0.202

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
281	2B19	Bw2	Bw2	42	50	8	10YR 4/3	0.93	0	0	7.62	0.212
282	2A15	A1	A	0	10	10	10YR 2/1	4.18	1.07	8.91	7.74	0.403
283	2A15	A2	A	10	27	17	10YR 2/1	4.14	1.11	9.25	7.92	0.527
284	2A15	Bk	Bk1	27	50	23	2.5Y 6/1	2.17	3.2	26.66	8.07	0.638
285	1A19	Ap	Ap	0	14	14	10YR 2/2	2.38	0.47	3.92	7.62	0.518
286	1A19	Bk1	Bk1	14	33	19	10YR 5/3	0.49	3.62	30.15	8.07	0.342
287	1A19	Bk2	Bk2	33	50	17	10YR 5/4	0.46	2.86	23.82	8.22	0.363
288	1A17	Ap	Ap	0	13	13	10YR 2/1	3.2	0	0	5.26	0.186
289	1A17	A	A	13	28	15	10YR 2/1	2.95	0	0	5.95	0.257
290	1A17	Bw	Bw1	28	50	22	10YR 3/2	1.11	0	0	6.89	0.255
291	3A10	Ap	Ap	0	16	16	10YR 2/1	2.26	0	0	6.28	0.385
292	3A10	Bw	Bw1	16	34	18	10YR 3/3	1	0	0	7.09	0.356
293	3A10	Bk1	Bk1	34	42	8	10YR 6/3	0.84	1.69	14.08	8.03	0.293
294	3A10	Bk2	Bk2	42	50	8	2.5Y 6/4	0.66	3.27	27.24	8.24	0.251

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
295	3B11	Ap	Ap	0	15	15	10YR 2/1	2.52	0.15	1.25	7.1	0.246
296	3B11	A	A	15	25	10	10YR 2/1	2.24	0.15	1.25	7.37	0.243
297	3B11	Bt1	Bt	25	38	13	10YR 3/2	0.82	0	0	7.65	0.266
298	3B11	2Bt2	Bt	38	50	12	2.5Y 4/4	0.53	0.03	0.25	8	0.333
299	1A8	Ap	Ap	0	16	16	10YR 2/1	2.48	0.02	0.17	6.2	0.241
300	1A8	Bw	Bw1	16	28	12	2.5Y 4/4	1.14	0.35	2.92	7.6	0.291
301	1A8	2Bk	Bk	28	50	22	10YR 5/3	0.72	2.83	23.57	8.31	0.263
302	1C9	Ap	Ap	0	20	20	10YR 2/1	1.74	0.8	6.66	7.78	0.297
303	1C9	Bt1	Bt	20	33	13	10YR 3/4	0.81	0.03	0.25	7.85	0.423
304	1C9	Bt2	Bt	33	49	16	2.5Y 4/4	0.54	1.08	9	6.28	0.385
305	2C14	Ap(Bk)	Ap	0	10	10	10YR 4/2	1.44	1.77	14.74	8.13	0.329
306	2C14	Apb	Ap	10	17	7	10YR 2/1	2.35	0.26	2.17	7.99	0.277
307	2C14	Bwb	Bw1	17	36	19	10YR 3/2	1.09	0.04	0.33	7.89	0.278
308	2C14	2Bkb	Bk	36	50	14	2.5Y 4/4	0.74	1.6	13.33	8.08	0.31

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
309	1A16	Ap	Ap	0	13	13	10YR 2/1	2.37	0	0	6.11	0.191
310	1A16	A	A	13	28	15	10YR 2/1	1.76	0.05	0.42	6.96	0.211
311	1A16	Bw	Bw1	28	50	22	10YR 2/2	1.41	0.43	3.58	8.02	0.17
312	2C8	Ap	Ap	0	20	20	10YR 2/1	2.19	0	0	5.84	0.119
313	2C8	Bw1	Bw1	20	39	19	10YR 3/2	0.92	0	0	7.02	0.177
314	2C8	Bw2	Bw2	39	50	11	2.5Y 4/4	0.67	0	0	7.55	0.234
315	2C18	Ap	Ap	0	13	13	10YR 2/1	3.01	0.05	0.42	5.92	1.037
316	2C18	Bw	Bw1	13	20	7	10YR 3/2	1.31	0.58	4.83	7.42	0.404
317	2C18	Bk1	Bk1	20	31	11	10YR 5/3	0.88	2	16.66	7.7	0.358
318	2C18	Bk2	Bk2	31	50	19	10YR 5/3	0.63	2.88	23.99	8.06	0.351
319	2C13	Ap	Ap	0	16	16	10YR 2/1	2.54	0	0	6.27	0.322
320	2C13	A	A	16	33	17	10YR 2/1	1.52	0	0	6.44	0.189
321	2C13	Bw1	Bw1	33	42	9	2.5Y 4/3	0.76	0	0	6.64	0.22
322	2C13	2Bw2	Bw2	42	45	3	10YR 3/3	0.45	0	0	6.92	0.11

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
323	2C13	Bt	Bt	45	50	5	2.5Y 3/3	0.56	0	0	6.72	0.297
324	3C15	Ap	Ap	0	20	20	10YR 2/1	2.96	0	0	6.93	0.355
325	3C15	Bw	Bw1	20	45	25	10YR 2/2	1.18	0	0	7.7	0.298
326	3C15	Bk	Bk1	45	50	5	10YR 4/1	0.77	0.61	5.08	8.39	0.355
327	3A13	Ap	Ap	0	15	15	10YR 2/1	2.86	0	0	5.89	0.383
328	3A13	A	A	15	32	17	10YR 2/1	1.73	0	0	7.66	0.343
329	3A13	Bw	Bw1	32	42	10	10YR 3/2	0.73	0.66	5.5	7.97	0.341
330	3A13	2Bk	Bk	42	50	8	2.5Y 6/2	0.52	2.44	20.33	8.36	0.288
331	3A12	Ap	Ap	0	18	18	10YR 2/1	2.14	0	0	5.94	0.151
332	3A12	Bt	Bt	18	31	13	10YR 3/2	0.83	0	0	6.77	0.227
333	3A12	Bw	Bw1	31	38	7	2.5Y 3/3	0.51	0.54	4.5	7.72	0.396
334	3A12	Bk	Bk1	38	47	9	2.5Y 5/4	0.57	2.55	21.24	8.04	0.471
335	3A12	Bky	Bk2	47	50	3	2.5Y 5/4	0.49	2.49	20.74	7.75	1.521
336	1A18	Ap	Ap	0	12	12	10YR 2/1	2.15	0	0	5.36	0.118

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
337	1A18	Bw1	Bw1	12	23	11	10YR 3/2	1.26	0	0	5.8	0.176
338	1A18	Bw2	Bw2	23	50	27	2.5Y 3/3	0.7	0.04	0.33	6.8	0.177
339	3A20	Ap	Ap	0	12	12	10YR 2/1	3.26	0.06	0.5	7.93	0.253
340	3A20	A	A	12	23	11	10YR 2/1	3.12	0.06	0.5	8	0.221
341	3A20	Bw1	Bw1	23	27	4	10YR 3/2	1.99	0.08	0.67	8.19	0.33
342	3A20	Bw2	Bw2	27	50	23	10YR 3/2	1.11	0.44	3.67	8.08	0.286
343	3A8	Ap	Ap	0	22	22	10YR 2/1	2.75	0.59	4.91	7.93	0.423
344	3A8	Bw	Bw1	22	33	11	10YR 3/2	1.7	0.14	1.17	7.86	0.453
345	3A8	Bk1	Bk1	33	42	9	10YR 4/2	1.14	1.24	10.33	8.08	0.42
346	3A8	Bk2	Bk2	42	50	8	10YR 6/2	0.89	2.9	24.16	8.19	0.398
347	2B14	Ap	Ap	0	19	19	10YR 2/1	4.02	0	0	6.32	0.224
348	2B14	A	A	19	30	11	10YR 2/1	3.04	0	0	6.81	0.225
349	2B14	Bw1	Bw1	30	45	15	10YR 3/1	1.49	0	0	7.64	0.242
350	2B14	Bw2	Bw2	45	50	5	2.5Y 3/3	1.15	0	0	7.75	0.333

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
351	3B20	Ap	Ap	0	22	22	10YR 2/1	2.92	0.09	0.75	7.57	0.329
352	3B20	Bw1	Bw1	22	38	16	10YR 3/3	0.92	0	0	7.51	0.295
353	3B20	2Bw2	Bw2	38	50	12	2.5Y 4/3	0.65	0.18	1.5	7.7	0.297
354	3A14	Ap	Ap	0	18	18	10YR 2/1	3.62	0.11	0.92	7.76	1.754
355	3A14	Bw	Bw1	18	23	5	10YR 3/1	2.08	0.12	1	7.59	2.37
356	3A14	Bk1	Bk1	23	34	11	10YR 4/1	1.13	2.25	18.74	7.85	2.36
357	3A14	Bk2	Bk2	34	44	10	2.5Y 6/2	0.69	3	24.99	7.95	2.32
358	3A14	Bky	Bk2	44	50	6	10YR 5/3	0.6	2.57	21.41	7.96	2.001
359	1A14	Ap	Ap	0	16	16	10YR 3/1	2.01	1.37	11.41	7.97	0.377
360	1A14	Bk1	Bk1	16	34	18	2.5Y 5/3	1.31	2.62	21.82	8.09	0.405
361	1A14	Bk2	Bk2	34	50	16	2.5Y 5/4	0.73	3.55	29.57	8.17	0.645
362	3B7	Ap	Ap	0	22	22	10YR 2/1	3.58	0.05	0.42	7.04	0.325
363	3B7	A	A	22	37	15	10YR 3/1	2.61	0	0	7.38	0.286
364	3B7	Bw	Bw1	37	50	13	10YR 3/2	1.02	0	0	7.73	0.222

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
365	3B17	Ap	Ap	0	16	16	10YR 2/1	3.39	0	0	7.91	0.336
366	3B17	Bk1	Bk1	16	44	28	2.5Y 5/3	0.78	4.39	36.57	8.11	0.301
367	3B17	Bk2	Bk2	44	50	6	2.5Y 5/5	0.54	4	33.32	8.38	0.277
368	1C17	Ap	Ap	0	10	10	10YR 2/1	2.85	0	0	6.22	0.339
369	1C17	A	A	10	23	13	10YR 2/1	2.69	0	0	6.26	0.202
370	1C17	Bw	Bw1	23	47	24	10YR 3/2	1.19	0	0	6.43	0.2
371	1C17	Bt	Bt	47	50	3	10YR 3/2	0.95	0	0	6.68	0.224
372	2B10	Ap	Ap	0	13	13	10YR 2/1	2.44	0	0	5.88	0.399
373	2B10	A	A	13	22	9	10YR 2/1	1.95	0	0	6.01	0.31
374	2B10	Bw1	Bw1	22	34	12	10YR 3/2	0.93	0	0	6.49	0.329
375	2B10	Bw2	Bw2	34	41	7	2.5Y 4/4	0.63	0.03	0.25	7.05	0.331
376	2B10	2Bk	Bk	41	50	9	2.5Y 5/4	0.58	2.25	18.74	8.02	0.337
377	3A2	Ap	Ap	0	12	12	10YR 2/1	3.3	0.06	0.5	7.2	0.379
378	3A2	Bw	Bw1	12	22	10	10YR 3/2	1.46	0.99	8.25	8.09	0.322

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
379	3A2	Bk1	Bk1	22	35	13	10YR 4/2	0.88	1.71	14.24	8.43	0.255
380	3A2	Bk2	Bk2	35	50	15	2.5Y 5/3	0.66	2.1	17.49	8.48	0.257
381	2B7	Ap1	Ap	0	16	16	10YR 2/1	3.29	0.07	0.58	7.52	0.421
382	2B7	Ap2	Ap	16	22	6	10YR 3/2	2.79	0	0	7.67	0.402
383	2B7	Bk1	Bk1	22	29	7	2.5Y 5/6	1.5	2.04	16.99	7.9	0.411
384	2B7	Bk2	Bk2	29	50	21	2.5Y 5/6	0.65	3.42	28.49	8.32	0.36
385	3A17	Ap	Ap	0	14	14	10YR 2/1	2.7	0.11	0.92	7.48	0.56
386	3A17	Bw	Bw1	14	25	11	10YR 3/2	1.48	0.11	0.92	8.09	0.438
387	3A17	Bk1	Bk1	25	43	18	10YR 6/2	0.77	3.37	28.07	8.78	0.406
388	3A17	Bk2	Bk2	43	50	7	2.5Y 5/3	0.44	3.06	25.49	9.08	0.42
389	3C11	Ap	Ap	0	13	13	10YR 2/1	3.36	0.05	0.42	7.01	0.42
390	3C11	A	A	13	39	26	10YR 2/1	3.4	0.04	0.33	7.44	0.314
391	3C11	Bw	Bw1	39	50	11	10YR 2/2	1.45	0	0	7.87	0.338
392	2A1	Ap	Ap	0	10	10	10YR 3/2	1.45	0.63	5.25	7.99	0.374

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
393	2A1	Bw	Bw1	10	20	10	2.5Y 4/4	0.13	1.65	13.74	8.15	0.345
394	2A1	2C	C	20	50	30	2.5Y 3/4	0.09	1.45	12.08	8.37	0.256
395	2A3	Ap	Ap	0	15	15	10YR 2/2	1.36	0.56	4.66	7.77	0.483
396	2A3	Bk1	Bk1	15	24	9	2.5Y 3/3	0.36	1.46	12.16	8.25	0.369
397	2A3	2Bk2	Bk2	24	30	6	2.5Y 3/3	0.13	1.6	13.33	8.29	0.352
398	2A3	3C	C	30	50	20	2.5Y 4/3	0.26	1.7	14.16	8.08	0.598
399	2C3	Ap1	Ap	0	13	13	10YR 2/1	3.59	0	0	6.85	0.297
400	2C3	Ap2	Ap	13	22	9	10YR 2/2	2.73	0.04	0.33	8.28	0.256
401	2C3	Bk1	Bk1	22	42	20	10YR 7/2	0.54	3.88	32.32	8.75	0.233
402	2C3	2Bk2	Bk2	42	50	8	10YR 5/3	0.47	2.44	20.33	8.75	0.279
403	1A3	Ap	Ap	0	10	10	10YR 4/3	0.37	0.75	6.25	8.37	0.133
404	1A3	Bk1	Bk1	10	26	16	10YR 6/3	0.24	1.78	14.83	8.18	0.258
405	1A3	Bk2	Bk2	26	50	24	10YR 5/3	0.04	0.78	6.5	8.39	0.156
406	1A12	Ap	Ap	0	18	18	10YR 2/2	2.37	0.31	2.58	7.79	0.347

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
407	1A12	2Bw	Bw1	18	25	7	10YR 3/3	1.21	2.39	19.91	8.11	0.325
408	1A12	2Bk	Bk1	25	50	25	10YR 4/4	0.84	3.12	25.99	8.42	0.295
409	1A4	Ap	Ap	0	19	19	10YR 2/2	2.5	0	0	6.27	0.169
410	1A4	Bt	Bt	19	50	31	10YR 3/4	0.59	0	0	7.06	0.219
411	1A1	A1	A	0	10	10	10YR 2/1	4.87	0.03	0.25	6.71	0.248
412	1A1	A2	A	10	22	12	10YR 2/1	4.29	0	0	6.92	0.273
413	1A1	B	B	22	50	28	10YR 3/1	2.61	0.04	0.33	7.57	0.143
414	2A5	Bw	Bw1	0	4	4	10YR 3/2	1.67	0.03	0.21	7.9	0.569
415	2A5	Apb	Ap	4	22	18	10YR 2/2	1.8	0.07	0.58	7.77	0.775
416	2A5	A	A	22	43	21	10YR 2/1	2.43	0.02	0.17	7.35	0.962
417	2A5	Bw'	Bw1	43	50	7	10YR 3/2	1.41	0	0	7.06	0.933
418	3A1	Ap	Ap	0	14	14	10YR 2/2	1.52	0	0	7.27	0.318
419	3A1	Bt1	Bt	14	26	12	10YR 3/3	0.85	0.02	0.17	7.28	0.177
420	3A1	2Bt2	Bt	26	48	22	2.5Y 4/3	0.65	0.07	0.58	7.32	0.314

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
421	3A1	2Btk	Bt	48	50	2	2.5Y 4/4	0.35	1.15	9.58	7.32	0.133
422	2A11	Ap1	Ap	0	10	10	10YR 2/2	1.85	0.95	7.91	7.8	0.536
423	2A11	2Ap2	Ap	10	15	5	10YR 3/2	0.94	1.28	10.66	7.99	0.372
424	2A11	Bw	Bw1	15	29	14	10YR 3/3	0.76	0.43	3.58	7.82	0.456
425	2A11	Bk	Bk1	29	50	21	2.5Y 5/4	0.56	2.01	16.74	8.36	0.373
426	2A9	Ap	Ap	0	12	12	10YR 2/1	1.88	1.14	9.5	8.04	0.742
427	2A9	Bk1	Bk1	12	22	10	10YR 6/3	0.52	4.33	36.07	8.44	0.468
428	2A9	Bk2	Bk2	22	50	28	10YR 6/3	0.5	3.4	28.32	8.54	0.468
429	3A7	Apz	Ap	0	23	23	10YR 2/1	2.55	0.73	6.08	7.22	0.474
430	3A7	A/B	A	23	35	12	10YR 2/2	2.43	0	0	7.22	0.52
431	3A7	Bw	Bw1	35	47	12	10YR 3/1	1.53	0.02	0.17	7.23	0.449
432	3A7	Ab	A	47	50	3	10YR 2/1	3.58	0	0	7.16	0.484
433	3C7	Ap	Ap	0	15	15	10YR 2/2	2.61	0	0	5.89	0.298
434	3C7	Bw1	Bw1	15	33	18	10YR 3/2	1.3	0	0	7.11	0.199

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
435	3C7	Bw2	Bw2	33	40	7	2.5Y 4/3	0.62	0	0	7.18	0.257
436	3C7	Bw3	Bw2	40	50	10	2.5Y 5/4	0.47	0	0	7.2	0.219
437	2B15	Ap	Ap	0	11	11	10YR 2/2	2.5	0	0	6.82	0.266
438	2B15	Bw	Bw1	11	15	4	10YR 4/3	0.75	0	0	7.27	0.297
439	2B15	2Bk	Bk	15	50	35	10YR 5/3	0.47	2.26	18.78	8.35	0.301
440	2A14	Ap	Ap	0	23	23	10YR 2/2	2.41	0.61	5.08	7.95	0.287
441	2A14	Bk	Bk1	23	50	27	10YR 5/4	0.26	2.42	20.16	8.41	0.279
442	2C12	Ap	Ap	0	20	20	10YR 2/2	2.01	0.07	0.58	8.02	0.276
443	2C12	Bw1	Bw1	20	30	10	2.5Y 3/3	0.81	0.03	0.25	7.94	0.234
444	2C12	Bw2	Bw2	30	40	10	2.5Y 4/3	0.58	0.28	2.33	7.76	0.406
445	2C12	2Bk	Bk	40	50	10	2.5Y 5/3	0.5	1.78	14.83	8.21	0.331
446	3A15	Ap	Ap	0	9	9	10YR 2/2	2.85	0.55	4.58	7.86	0.488
447	3A15	Bk1	Bk1	9	24	15	10YR 4/2	1.38	1.89	15.74	8.25	0.339
448	3A15	Bk2	Bk2	24	50	26	2.5Y 4/4	0.69	2.33	19.41	8.49	0.353

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
495	3C19	Ap	Ap	0	17	17	10YR 2/2	2.11	0.7	5.83	8.02	0.345
496	3C19	Bk1	Bk1	17	24	7	2.5Y 5/3	0.85	2.24	18.66	8.31	0.272
497	3C19	Bk2	Bk2	24	50	26	2.5Y 5/4	0.42	2.18	18.16	8.46	0.292
498	2B18	Ap	Ap	0	18	18	10YR 2/1	2.78	0.26	2.17	7.87	0.283
499	2B18	Bt1	Bt	18	32	14	10YR 3/2	1.71	0.04	0.33	7.88	0.197
500	2B18	2Bt2	Bt	32	45	13	10YR 3/3	1.19	0.3	2.5	7.97	0.3
501	2B18	Bk	Bk1	45	50	5	2.5Y 4/3	0.75	2.77	23.07	8.36	0.364
502	2A2	Ap1	Ap	0	7	7	10YR 2/2	1.83	0	0	7.33	0.078
503	2A2	Ap2	Ap	7	16	9	10YR 2/1	1.81	0	0	7.33	0.078
504	2A2	Bw1	Bw1	16	40	24	10YR 3/2	0.95	0	0	7.34	0.12
505	2A2	Bw2	Bw2	40	50	10	10YR 3/2	0.78	0	0	7.33	0.125
506	1C2	Ap	Ap	0	16	16	10YR 2/1	1.65	0	0	6.42	0.147
507	1C2	Bw1	Bw1	16	32	16	10YR 3/2	1.16	0	0	6.7	0.109
508	1C2	2Bw2	Bw2	32	50	18	2.5Y 4/3	0.59	0.03	0.25	6.99	0.141

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
509	3B3	Ap	Ap	0	20	20	10YR 2/1	3.26	0	0	5.9	0.228
510	3B3	A	A	20	27	7	10YR 2/1	1.87	0	0	6.58	0.09
511	3B3	Bw	Bw1	27	45	18	10YR 3/1	1.62	0	0	6.44	0.117
512	3B3	E/Bt	E	45	50	5	10YR 3/1	1.26	0	0	6.24	0.161
513	2B2	Apz	Ap	0	25	25	10YR 2/1	2.03	0.79	6.58	7.23	0.358
514	2B2	Bwz	Bw1	25	31	6	10YR 3/2	1.08	0.11	0.92	7.24	0.441
515	2B2	Bkz	Bk1	31	39	8	10YR 4/1	1.16	1.28	10.66	7.25	0.358
516	2B2	Bk	Bk1	39	50	11	10YR 5/2	0.76	3.04	25.32	7.26	0.324
517	1B17	Ap	Ap	0	13	13	10YR 2/1	2.07	0	0	6.76	0.212
518	1B17	Bw1	Bw1	13	35	22	10YR 3/2	1.08	0.04	0.33	7.78	0.207
519	1B17	Bw2	Bw2	35	50	15	2.5Y 4/3	0.58	0.03	0.25	8	0.238
520	1B1	Apz	Ap	0	23	23	10YR 3/1	2.64	0.04	0.33	8.1	0.977
521	1B1	Bwz	Bw1	23	38	15	10YR 3/2	1.21	0.03	0.25	8	0.646
522	1B1	Byz	B	38	50	12	2.5Y 4/3	0.46	0.16	1.33	8.26	0.636

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
523	2B1	Ap	Ap	0	14	14	10YR 2/1	3.63	0	0	5.74	0.85
524	2B1	A/B	A	14	50	36	10YR 2/1	3.32	0.04	0.33	6.98	0.263
525	3A19	Apz1	Ap	0	6	6	10YR 2/1	3.07	0.09	0.75	7.35	1.663
526	3A19	Apz2	Ap	6	24	18	10YR 2/1	2.58	0.17	1.42	7.7	1.486
527	3A19	Bk1	Bk1	24	33	9	10YR 3/2	1.23	0.8	6.66	7.82	1.532
528	3A19	2Bk2	Bk2	33	42	9	2.5Y 5/3	1.38	2.09	17.41	8.18	1.132
529	3A19	Bk3	Bk2	42	50	8	2.5Y 5/3	1.73	2.16	17.99	8.21	1.309
530	3B2	Ap	Ap	0	12	12	10YR 2/1	2.65	0.04	0.33	5.76	0.201
531	3B2	A	A	12	23	11	10YR 2/1	2.1	0	0	6.2	0.171
532	3B2	Bw1	Bw1	23	47	24	10YR 2/2	1.39	0	0	6.66	0.169
533	3B2	Bw2	Bw2	47	50	3	2.5Y 3/2	0.74	0	0	6.81	0.209
534	2B5	Ap	Ap	0	15	15	10YR 2/1	1.85	0.95	7.91	5.43	0.151
535	2B5	Bw1	Bw1	15	20	5	10YR 2/2	0.94	1.28	10.66	6.17	0.194
536	2B5	Bw2	Bw2	20	45	25	2.5Y 4/3	0.76	0.43	3.58	6.84	0.2

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
537	2B5	Bk	Bk1	45	50	5	2.5Y 4/4	0.56	2.01	16.74	7.97	0.4
538	1C18	Ap	Ap	0	21	21	10YR 2/1	2.6	0.12	1	7.68	0.288
539	1C18	Bw1	Bw1	21	40	19	10YR 3/2	1.28	0.04	0.33	7.86	0.345
540	1C18	Bw2	Bw2	40	48	8	10YR 5/3	1.11	0.23	1.87	8.2	0.326
541	1C18	Bk	Bk1	48	50	2	10YR 6/2	0.87	2.33	19.41	8.64	0.303
542	2A19	Ap	Ap	0	13	13	10YR 2/2	2.15	1.06	8.83	8.28	0.239
543	2A19	Bw	Bw1	13	26	13	2.5Y 3/3	1.41	0.09	0.75	8	0.323
544	2A19	Bk1	Bk1	26	37	11	2.5Y 4/3	1.03	1.97	16.41	8.3	0.265
545	2A19	2Bk2	Bk2	37	43	6	2.5Y 6/4	0.8	3.05	25.41	8.52	0.297
546	2A19	3Bk3	Bk2	43	50	7	2.5Y 6/4	0.62	3.89	32.4	8.62	0.3
547	3C16	Ap	Ap	0	14	14	10YR 2/1	2.79	0.03	0.25	7.94	0.306
548	3C16	E/Bt	E	14	22	8	10YR 3/1	1.46	0	0	7.85	0.237
549	3C16	Bt1	Bt	22	32	10	10YR 3/2	1.06	0	0	7.98	0.251
550	3C16	Bt2	Bt	32	50	18	2.5Y 4/3	0.48	0.04	0.33	8.23	0.328

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
551	3C13	Ap	Ap	0	10	10	10YR 2/1	2.86	0.05	0.42	7.13	0.33
552	3C13	Bt	Bt	10	28	18	10YR 3/2	1.21	0	0	7.41	0.236
553	3C13	2Bk	Bk	28	50	22	2.5Y 3/3	0.62	2.15	17.91	8.08	0.38
554	2A6	Ap	Ap	0	15	15	10YR 2/2	1.76	0	0	6.11	0.144
555	2A6	Bw1	Bw1	15	29	14	10YR 3/3	0.82	0.03	0.25	6.47	0.214
556	2A6	Bw2	Bw2	29	46	17	2.5Y 4/4	0.6	0	0	7.12	0.177
557	2A6	Bk	Bk1	46	50	4	2.5Y 5/4	0.58	1.57	13.08	8.21	0.267
558	1C1	Ap	Ap	0	11	11	10YR 2/2	1.88	0.2	1.67	7.9	0.245
559	1C1	2Bw	Bw1	11	19	8	2.5Y 5/3	0.78	0.6	5	7.98	0.267
560	1C1	2Bk	Bk	19	50	31	2.5Y 5/4	0.49	1.73	14.41	8.26	0.271
561	1B3	Ap	Ap	0	14	14	10YR 2/1	2.65	0.02	0.12	5.51	0.138
562	1B3	Bw1	Bw1	14	21	7	10YR 3/2	1.31	0	0	6.77	0.351
563	1B3	Bw2	Bw2	21	46	25	2.5Y 4/4	0.97	0	0	7.39	0.351
564	1B3	Bk	Bk1	46	50	4	2.5Y 6/4	0.79	2.46	20.49	8.27	0.363

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
565	3C9	Ap	Ap	0	16	16	10YR 2/1	1.97	0	0	5.24	0.295
566	3C9	Bw	Bw1	16	24	8	10YR 3/2	1.41	0	0	5.9	0.15
567	3C9	EB	E	24	30	6	10YR 2/2	1.01	0	0	6.53	0.145
568	3C9	E	E	30	37	7	10YR 5/2	0.51	0	0	6.65	0.117
569	3C9	Bt	Bt	37	50	13	10YR 5/3	0.45	0	0	6.93	0.389
570	3C6	Ap	Ap	0	11	11	10YR 2/1	2.68	0	0	6.64	0.347
571	3C6	Bw	Bw1	11	22	11	10YR 3/3	1.28	0	0	7.02	0.431
572	3C6	Bk	Bk1	22	50	28	2.5Y 6/3	0.85	3.36	27.99	7.98	0.462
573	3C1	Ap	Ap	0	18	18	10YR 2/2	2.5	0.04	0.33	5	0.423
574	3C1	Bw1	Bw1	18	28	10	10YR 3/3	1.33	0	0	6.5	0.248
575	3C1	Bw2	Bw2	28	50	22	10YR 4/3	0.86	0	0	7.06	0.253
576	2B3	Ap	Ap	0	15	15	10YR 3/2	1.97	0.43	3.58	7.96	0.554
577	2B3	Bk	Bk1	15	50	35	2.5Y 5/3	0.99	2.87	23.91	8.37	0.312
578	3B1	Apz	Ap	0	23	23	10YR 2/1	2.91	0.05	0.42	7.94	3.26

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
579	3B1	Bkz	Bk1	23	38	15	10YR 3/1	1.05	1.05	8.75	8.39	1.642
580	3B1	Bk	Bk1	38	50	12	2.5Y 5/2	0.73	2.48	20.66	8.57	1.463
581	2C1	Ap	Ap	0	22	22	10YR 2/2	1.76	0.04	0.33	7.29	0.264
582	2C1	Bt1	Bt	22	34	12	10YR 3/4	0.75	0	0	7.21	0.184
583	2C1	Bt2	Bt	34	50	16	2.5Y 4/3	0.43	0	0	7.56	0.17
584	1B4	Ap	Ap	0	15	15	10YR 2/2	2.12	0	0	6.33	0.132
585	1B4	Bw	Bw1	15	24	9	10YR 4/3	1.42	0	0	7.32	0.181
586	1B4	Bk	Bk1	24	50	26	2.5Y 5/3	0.94	2.05	17.08	7.96	0.31
587	3A3	Apz	Ap	0	9	9	10YR 2/1	3.3	0.17	1.42	8.12	1.322
588	3A3	Az	A	9	18	9	10YR 2/1	2.88	0.13	1.08	8.1	1.29
589	3A3	Bwz	Bw1	18	32	14	10YR 2/2	1.66	0.06	0.5	7.91	1.402
590	3A3	Bky	Bk2	32	42	10	10YR 4/1	1.12	1.65	13.74	8.34	1.226
591	3A3	Bk	Bk1	42	50	8	10YR 8/1	0.59	3.68	30.65	8.39	1.054
592	3A9	Ap	Ap	0	10	10	10YR 2/1	4.32	0.07	0.58	7.8	3.11

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------		)		(----------% wt.		----------)		dS m^{-1}
593	3A9	A	A	10	23	13	10YR 2/1	3.6	0.05	0.42	7.65	3.97
594	3A9	Bw	Bw1	23	39	16	10YR 3/2	1.52	0.07	0.58	7.53	3.9
595	3A9	Bk	Bk1	39	50	11	2.5Y 5/4	0.98	1.73	14.41	8	3.35
596	2B4	Ap	Ap	0	10	10	10YR 2/1	2.96	0.13	1.08	8.06	0.545
597	2B4	A	A	10	29	19	10YR 2/1	2.93	0.08	0.67	8.04	0.916
598	2B4	Bw	Bw1	29	50	21	10YR 3/2	0.93	0.07	0.58	8.2	0.76
599	2C15	Ap	Ap	0	6	6	10YR 2/2	2.53	0.66	5.5	7.82	0.386
600	2C15	Bw	Bw1	6	11	5	10YR 3/2	2.84	0	0	7.92	0.303
601	2C15	Bk1	Bk1	11	32	21	10YR 6/4	0.8	3.87	32.24	8.43	0.307
602	2C15	Bk2	Bk2	32	50	18	2.5Y 5/6	0.74	2.35	19.58	8.68	0.346
603	1B13	Ap	Ap	0	18	18	10YR 2/2	2.84	0	0	7.44	0.251
604	1B13	Bw	Bw1	18	34	16	10YR 3/2	1.3	0	0	8	0.509
605	1B13	Bk	Bk1	34	50	16	2.5Y 6/3	0.83	2.84	23.66	8.37	0.51
606	3C20	Ap	Ap	0	17	17	10YR 2/2	2.79	0.21	1.75	7.99	0.434

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				$dS\ m^{-1}$
607	3C20	Bk1	Bk1	17	34	17	10YR 6/3	1.06	3.43	28.57	8.05	0.548
608	3C20	Bk2	Bk2	34	50	16	2.5Y 6/4	0.61	2.98	24.82	8.01	0.916
609	3C12	Ap	Ap	0	10	10	10YR 2/1	2.91	0	0	5.36	0.47
610	3C12	A	A	10	20	10	10YR 2/1	2.71	0	0	6.05	0.14
611	3C12	Bw1	Bw1	20	35	15	10YR 3/3	0.98	0	0	6.7	0.208
612	3C12	Bw2	Bw2	35	50	15	10YR 3/2	0.95	0	0	7.26	0.276
613	2C2	Ap	Ap	0	18	18	10YR 3/2	1.1	0.07	0.58	8.11	0.213
614	2C2	A/B	A	18	27	9	10YR 2/2	0.73	0.03	0.25	7.93	0.161
615	2C2	2Bw	Bw1	27	50	23	2.5Y 4/3	0.25	0	0	7.82	0.147
616	1B2	Ap	Ap	0	15	15	10YR 2/1	3.17	0	0	5.83	0.136
617	1B2	A	A	15	25	10	10YR 2/1	1.97	0	0	6.34	0.128
618	1B2	Bw1	Bw1	25	47	22	10YR 2/2	1.37	0	0	6.57	0.149
619	1B2	Bw2	Bw2	47	50	3	2.5Y 5/4	0.78	0	0	6.88	0.18
620	2A4	Ap	Ap	0	12	12	10YR 2/1	2.16	0	0	5.64	0.113

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
621	2A4	Bw1	Bw1	12	18	6	10YR 3/2	1.43	0	0	6.63	0.119
622	2A4	Bw2	Bw2	18	50	32	10YR 3/3	0.7	0	0	7.72	0.148
623	1A2	Apz	Ap	0	18	18	10YR 3/1	2.44	0	0	5.98	2.3
624	1A2	Bwz	Bw1	18	35	17	10YR 3/2	1.24	0	0	7.37	2.08
625	1A2	2Bt1	Bt	35	47	12	10YR 4/3	0.45	0	0	7.79	0.809
626	1A2	3Bt2	Bt	47	50	3	10YR 4/3	0.41	0.05	0.42	8.32	1.305
627	3B18	Ap	Ap	0	21	21	10YR 2/2	2.61	0.09	0.75	7.75	0.336
628	3B18	Bk1	Bk1	21	33	12	10YR 3/1	1.72	0.94	7.83	8.19	0.315
629	3B18	Bk2	Bk2	33	50	17	10YR 4/1	0.98	1.28	10.66	8.39	0.302
630	3B19	Ap	Ap	0	13	13	10YR 2/2	2.89	0	0	6.86	0.29
631	3B19	Bw	Bw1	13	21	8	2.5Y 4/4	1.02	0.07	0.58	7.69	0.402
632	3B19	Bk1	Bk1	21	37	16	2.5Y 6/4	1.08	2.35	19.58	8.39	0.294
633	3B19	Bk2	Bk2	37	50	13	2.5Y 5/4	0.62	2.49	20.74	8.63	0.309
634	2C6	Ap	Ap	0	13	13	10YR 2/1	2.12	0.97	8.08	7.96	0.314

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
635	2C6	Bw	Bw1	13	23	10	10YR 3/2	1.01	1.78	14.83	8.17	0.275
636	2C6	2Bk1	Bk1	23	43	20	10YR 4/3	1.05	2.12	17.66	8.25	0.305
637	2C6	Bk2	Bk2	43	50	7	2.5Y 5/6	0.73	1.87	15.58	8.28	0.344
638	3B10	Ap	Ap	0	13	13	10YR 2/1	3.74	0	0	6.95	0.258
639	3B10	A	A	13	33	20	10YR 2/1	3.67	0	0	6.89	0.252
640	3B10	AE	A	33	50	17	10YR 3/1	4.53	0	0	6.92	0.223
641	3A16	Ap	Ap	0	16	16	10YR 3/1	1.98	0.51	4.25	8.35	0.223
642	3A16	Bw1	Bw1	16	35	19	10YR 3/2	1.05	0	0	8.11	0.199
643	3A16	2Bw2	Bw2	35	50	15	2.5Y 3/3	0.69	0	0	8.04	0.259
644	2B13	Ap	Ap	0	23	23	10YR 2/2	2.38	0.58	4.83	8.26	0.322
645	2B13	Bk1	Bk1	23	35	12	10YR 4/1	0.92	1.84	15.33	8.48	0.493
646	2B13	Bk2	Bk2	35	50	15	10YR 5/3	0.5	3.5	29.16	8.67	0.547
647	3B16	Ap	Ap	0	15	15	10YR 3/1	1.99	0.13	1.08	8.09	0.228
648	3B16	Bw	Bw1	15	24	9	10YR 3/2	1.18	0.12	1	8.14	0.26

No.	Site ID	Horizon	Gen. horizon	Top	Bottom	Thickness	Color	SOC	IC	CaCO3	$pH_{1:1}$	$EC_{1:1}$
				(-------------cm-------------)				(----------% wt.----------)				dS m^{-1}
649	3B16	Bk	Bk1	24	50	26	10YR 5/3	0.68	3.11	25.91	8.5	0.396

APPENDIX C. SURFACE HORIZON PARTICLE SIZE DISTRIBUTION

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
1A1	1	60.3	17.8	21.8	SCL				
1A10	1	19.4	51.3	29.3	SiCL				
1A11	1	32.4	25.6	42.0	C				
1A12	1	42.7	34.2	23.1	L				
1A13	1	30.9	35.2	33.9	CL				
1A14	1	30.0	40.8	29.1	CL				
1A15	1	33.4	45.0	21.6	L				
1A16	1	64.2	19.9	16.0	SL				
1A17	2	37.1	34.9	28.0	CL				
1A18	2	51.9	24.6	23.5	SCL				
1A19	1	38.2	34.2	27.6	CL				
1A2	2	48.3	31.7	20.0	L	49.3	31.4	19.3	L
1A20	1	26.9	38.0	35.0	CL				
1A3	1	87.6	7.3	5.2	LS	82.1	7.9	10.0	LS
1A4	1	48.8	27.6	23.6	SCL				
1A5	2	24.1	47.3	28.6	CL				
1A6	1	32.7	45.8	21.5	L				
1A7	1	30.2	31.6	38.2	CL				
1A8	2	43.6	28.4	28.0	CL				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
1A9	1	46.4	28.5	25.0	L				
1B1	1	42.0	28.8	29.3	CL				
1B10	1	39.5	29.8	30.8	CL				
1B11	1	21.2	34.2	44.7	C				
1B12	1	40.9	26.4	32.7	CL				
1B13	1	32.1	43.4	24.4	L				
1B14	1	32.2	41.6	26.2	L				
1B15	1	30.9	41.1	28.0	CL				
1B16[¶]	2	25.3	31.4	43.3	C	20.7	35.5	43.7	C
1B17	1	51.3	25.9	22.8	SCL				
1B18	1	36.2	35.7	28.1	CL				
1B19	1	37.0	37.1	25.9	L				
1B2	1	52.8	24.7	22.5	SCL				
1B20	1	29.7	41.2	29.0	CL				
1B3	1	31.3	38.7	30.0	CL				
1B4	1	46.5	32.7	20.9	L				
1B5	1	30.0	36.4	33.7	CL				
1B6	1	42.7	20.6	36.7	CL	28.3	35.9	35.8	CL
1B7	1	32.7	30.8	36.5	CL				
1B8	2	30.9	23.7	45.5	C				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
1B9[†]	2	40.9	24.7	34.5	CL				
1C1	1	54.4	23.9	21.7	SCL				
1C10	2	47.0	32.9	20.1	L	27.1	39.3	33.6	CL
1C11	2	37.6	35.1	27.3	CL	39.3	35.0	25.8	L
1C12[‡]	1	38.4	19.5	42.1	C				
1C13	2	39.2	37.4	23.5	L				
1C14	2	31.6	39.3	29.1	CL				
1C15	2	44.5	30.1	25.4	L	38.2	33.4	28.4	CL
1C16	1	54.7	18.1	27.2	SCL				
1C17	1	26.7	48.4	24.9	L				
1C18	1	32.6	36.8	30.5	CL				
1C19	2	28.1	45.9	26.1	CL				
1C2	2	50.1	29.6	20.3	SCL				
1C20	2	30.3	39.9	29.8	CL				
1C3	2	30.0	46.0	24.1	L	27.0	40.9	32.1	CL
1C4	1	22.1	53.9	24.0	SiL				
1C5[‡]	1	32.1	21.6	46.3	C				
1C6	2	34.7	38.9	26.4	CL				
1C7	1	33.1	39.4	27.5	CL				
1C8	1	30.4	44.4	25.3	L				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
1C9	1	40.5	30.6	28.9	CL				
2A1	1	49.5	30.5	20.0	L				
2A10	1	48.8	27.0	24.2	SCL				
2A11	1	47.8	26.0	26.2	SCL				
2A12	1	46.6	30.0	23.4	L				
2A13	1	45.1	36.0	18.8	L				
2A14	1	54.6	16.5	28.9	SCL				
2A15	2	36.7	29.9	33.4	CL				
2A16	2	40.4	36.8	22.8	L	45.8	32.0	22.2	L
2A17	1	44.2	18.8	37.0	CL				
2A18[†§]	4	32.3	37.2	30.5	CL	30.3	39.8	30.0	CL
2A19	1	49.4	32.5	18.1	L				
2A2	1	66.3	18.4	15.3	SL				
2A20	1	38.2	27.6	34.2	CL				
2A3	1	43.9	36.1	19.9	L				
2A4	1	44.9	30.6	24.5	L				
2A5	1	66.5	19.0	14.5	SL				
2A6	1	51.9	22.3	25.8	SCL				
2A7	1	39.2	30.1	30.8	CL				
2A8	1	48.9	30.7	20.4	L				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
2A9	1	42.6	30.9	26.4	L				
2B1	1	21.4	46.6	31.9	CL				
2B10	2	40.3	32.4	27.4	CL				
2B11	1	44.6	26.4	29.0	CL				
2B12	1	33.3	17.6	49.2	C				
2B13	1	45.5	30.9	23.6	L				
2B14[†]	2	31.3	42.6	26.1	L	32.5	40.8	26.6	L
2B15	1	48.2	24.1	27.7	SCL				
2B16	1	33.8	30.4	35.8	CL				
2B17	2	40.7	30.9	28.5	CL				
2B18	1	53.1	25.8	21.1	SCL				
2B19	1	34.9	29.6	35.5	CL				
2B2	2	32.4	37.5	30.2	CL				
2B20	1	36.2	35.2	28.5	CL				
2B3	1	30.0	44.5	25.5	L				
2B4	1	27.3	43.3	29.4	CL				
2B5	1	47.1	27.1	25.9	SCL				
2B6	2	48.9	26.8	24.3	SCL				
2B7	1	31.0	26.9	42.0	C				
2B8	1	29.0	26.4	44.6	C				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
2B9	1	45.5	29.4	25.0	L				
2C1	1	45.6	30.3	24.2	L	39.9	33.7	26.4	L
2C10	2	34.9	42.0	23.1	L	25.9	37.1	37.0	CL
2C11	2	27.5	40.8	31.7	CL				
2C12	1	48.1	27.1	24.8	SCL				
2C13	1	45.8	31.8	22.4	L				
2C14	1	44.1	30.6	25.3	L				
2C15	1	49.1	26.1	24.8	SCL				
2C16	1	24.6	33.7	41.7	C				
2C17	1	41.4	36.6	21.9	L				
2C18	1	28.7	36.1	35.2	CL				
2C19	1	39.4	35.1	25.6	L				
2C2	1	60.4	24.8	14.7	SL				
2C20	2	36.7	22.1	41.2	C				
2C21	1	40.3	29.2	30.6	CL				
2C3	1	30.5	28.7	40.8	C				
2C4	2	54.1	23.8	22.1	SCL				
2C5	2	52.2	18.2	29.6	SCL	35.7	32.0	32.3	CL
2C6	1	41.7	24.2	34.2	CL				
2C7	2	54.9	23.6	21.6	SCL	55.2	24.6	20.2	SCL

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
2C8	2	33.8	45.8	20.3	L				
2C9	2	44.8	22.1	33.1	CL				
3A1	1	46.2	34.9	18.9	L	52.7	28.6	18.7	SL
3A10†	2	52.8	19.7	27.6	SCL				
3A11	2	43.3	34.4	22.3	L				
3A12	1	39.3	25.1	35.6	CL				
3A13	1	27.8	41.8	30.4	CL				
3A14	1	29.1	21.8	49.1	C				
3A15	1	40.6	29.3	30.1	CL				
3A16	1	57.3	21.5	21.2	SCL				
3A17	2	35.9	41.9	22.3	L	36.1	37.6	26.2	L
3A18	1	31.3	36.7	32.0	CL				
3A19	1	30.9	40.3	28.9	CL				
3A2‡	1	43.1	12.4	44.5	C				
3A20	1	34.4	37.2	28.4	CL				
3A3‡	1	42.8	11.9	45.3	C				
3A4	1	52.7	29.6	17.6	SL				
3A5	1	52.7	21.4	25.9	SCL				
3A6	1	42.4	20.4	37.2	CL				
3A7	1	36.9	28.2	34.9	CL				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
3A8	1	28.9	42.2	29.0	CL				
3A9	1	9.2	51.9	38.9	SiCL				
3B1	1	35.0	34.5	30.5	CL				
3B10	1	28.2	48.9	22.9	L				
3B11	2	48.1	26.6	25.3	SCL				
3B12	1	22.0	50.7	27.3	CL				
3B13	1	31.6	38.5	29.9	CL				
3B14	1	55.8	27.8	16.4	SL				
3B15	2	37.0	19.8	43.2	C				
3B16	1	44.7	34.4	20.9	L				
3B17	2	38.4	36.3	25.3	L	53.2	24.5	22.4	SCL
3B18	1	34.1	41.6	24.3	L				
3B19	1	28.9	46.4	24.7	L				
3B2	1	29.2	42.4	28.5	CL				
3B20	2	38.3	31.7	29.9	CL				
3B3	1	31.9	44.5	23.6	L				
3B4	1	44.8	23.1	32.0	CL				
3B5	1	33.6	43.5	22.9	L				
3B6	2	41.1	37.5	21.4	L	30.6	33.9	33.2	CL
3B7	1	19.3	43.8	36.8	SiCL	22.8	43.0	34.2	CL

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
3B8	1	37.5	39.2	23.3	L	39.6	33.8	26.6	L
3B9	1	39.7	38.3	22.0	L				
3C1	1	38.7	29.5	31.8	CL				
3C10	2	47.3	28.4	24.3	SCL				
3C11	1	28.5	45.6	25.9	L				
3C12	1	33.8	45.6	20.6	L				
3C13	1	38.2	28.5	33.3	CL	36.2	32.8	31.0	CL
3C14	1	30.2	45.4	24.4	L				
3C15	1	28.7	21.9	49.4	C				
3C16	1	28.4	39.8	31.8	CL				
3C17	2	40.4	30.0	29.6	CL				
3C18	1	38.1	37.3	24.6	L	38.2	35.1	26.7	L
3C19	1	44.3	36.4	19.3	L				
3C2	1	34.6	30.9	34.6	CL				
3C20	1	41.6	36.0	22.4	L				
3C3	1	41.6	21.7	36.7	CL				
3C4	1	39.7	23.8	36.5	CL	29.3	32.6	38.0	CL
3C5[†]	2	25.4	42.6	32.1	CL				
3C6	2	38.9	35.1	26.0	CL				
3C7	1	35.3	38.6	26.2	L				

Site ID	Reps	Modified Hydrometer Method				Laser Diffractometer			
		Sand	Silt	Clay	Texture	Sand	Silt	Clay	Texture
		(-----------% wt.------------)				(----------% vol.---------)			
3C8	1	48.9	29.9	21.2	L	51.2	28.4	20.3	L
3C9	1	41.4	34.9	23.7	L				

† Avg. absolute difference > 5%
‡ Lack of confidence in data
§ Avg. of 4 reps
¶ Average of one triplicate by laser diffractometer

APPENDIX D. SITE WEIGHTED CHEMICAL DATA

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(-------------------% wt.-----------------)				dS m^{-1}
		(---------------------------wtd. to 50 cm------------------------)				
1	1A11	2.19	9.8	1.18	7.85	0.20
4	1A13	1.34	1.5	0.18	7.31	0.35
7	1A15	1.74	0.0	0.00	6.92	0.22
10	1A20	1.00	12.3	1.47	7.99	0.36
13	1A5	2.81	0.2	0.02	7.82	1.17
16	1A6	1.16	10.2	1.23	8.26	0.19
19	1A7	2.16	16.8	2.01	8.46	0.34
22	1B10	1.24	14.3	1.71	8.41	0.53
25	1B11	2.56	0.0	0.00	6.75	0.58
28	1B12	1.35	0.0	0.00	6.10	0.19
31	1B15	2.54	0.0	0.00	6.37	0.28
34	1B16	1.94	6.4	0.77	7.68	1.90
37	1B18	1.73	0.0	0.00	6.22	0.22
40	1B20	3.22	0.0	0.00	5.61	0.16
42	1B5	1.74	16.1	1.93	8.19	0.75
46	1B6	1.75	9.1	1.09	8.05	0.45
49	1B7	1.55	17.0	2.04	8.17	0.75
52	1B8	2.49	0.0	0.00	6.50	0.25
55	1B9	1.53	0.2	0.02	5.45	0.31

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(------------------% wt.-----------------)				$dS\ m^{-1}$
		(---------------------------wtd. to 50 cm-----------------------)				
57	1C10	1.14	15.0	1.80	8.26	0.20
60	1C11	2.00	0.0	0.00	6.52	0.17
63	1C12	1.44	0.0	0.00	6.40	0.25
66	1C13	1.80	1.8	0.21	6.39	0.36
70	1C14	2.38	0.0	0.00	5.99	0.21
73	1C15	1.43	22.2	2.66	8.06	0.23
76	1C16	0.95	13.3	1.60	7.41	1.72
79	1C19	1.82	12.9	1.55	7.62	0.40
82	1C20	1.45	23.7	2.85	8.17	0.55
85	1C3	2.83	0.4	0.05	7.19	1.58
87	1C4	1.67	16.7	2.00	7.89	0.70
92	1C5	1.62	15.6	1.87	8.13	1.58
96	1C6	2.35	2.7	0.33	7.44	0.92
101	1C7	1.40	15.1	1.82	8.00	1.39
105	2A12	2.25	1.8	0.22	7.55	0.19
109	2A16	2.07	0.1	0.01	6.89	0.17
112	2A17	1.19	4.4	0.53	7.23	0.24
116	2A18	2.25	0.0	0.00	6.06	0.14
119	2A7	0.31	13.3	1.60	7.79	2.01
121	2B11	1.61	0.0	0.00	5.99	0.16

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(------------------% wt.-----------------)				dS m^{-1}
		(---------------------------wtd. to 50 cm-----------------------)				
126	2B16	1.51	17.9	2.14	8.17	0.39
129	2B17	1.64	0.0	0.00	6.66	0.24
132	2B20	1.83	0.1	0.02	7.50	0.26
135	2B6	1.17	17.8	2.14	8.43	0.26
138	2B8	3.03	0.1	0.01	6.30	0.21
141	2B9	0.88	16.0	1.92	8.21	0.35
144	2C10	2.81	2.3	0.28	7.68	1.70
146	2C11	3.00	0.6	0.07	7.68	0.46
149	2C16	1.17	7.4	0.89	7.61	0.28
152	2C17	1.41	11.8	1.41	8.26	0.32
154	2C19	2.26	0.2	0.02	7.65	0.23
157	2C20	2.11	10.0	1.20	8.07	0.38
161	2C21	1.40	14.8	1.78	8.29	0.21
164	2C4	1.43	7.6	0.91	7.93	0.49
168	2C5	0.97	1.5	0.18	7.78	0.38
171	2C7	1.41	0.0	0.00	5.81	0.13
174	3A18	1.92	19.2	2.30	8.00	0.82
178	3A4	1.97	5.9	0.71	7.90	1.09
181	3A5	1.12	19.1	2.30	8.13	0.59
184	3A6	1.43	9.7	1.16	7.87	0.59

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(-------------------% wt.-----------------)				dS m^{-1}
		(----------------------------wtd. to 50 cm------------------------)				
188	3B12	3.64	0.0	0.00	6.16	0.48
190	3B13	1.88	0.0	0.00	6.54	0.28
193	3B14	1.26	10.3	1.24	7.88	0.22
196	3B15	1.31	11.5	1.38	8.22	0.36
200	3B4	0.80	18.9	2.27	8.24	0.33
202	3B5	2.51	0.0	0.00	6.97	0.28
208	3B8	2.00	16.4	1.97	7.62	0.56
212	3B9	1.40	16.5	1.99	8.10	0.32
216	3C14	3.07	0.0	0.00	6.99	0.19
219	3C18	2.93	0.1	0.01	6.98	0.16
222	3C2	1.54	9.7	1.16	8.11	0.52
225	3C3	1.11	10.9	1.31	7.96	1.19
227	3C4	1.34	18.5	2.22	8.03	0.30
232	3C8	2.30	0.0	0.00	6.21	0.14
235	3C17	1.65	0.9	0.11	7.92	0.50
239	3C10	0.60	21.6	2.59	8.51	0.36
242	2C9	1.36	5.5	0.66	7.48	0.29
246	1A9	1.16	7.8	0.94	8.20	0.32
249	1B19	2.68	0.0	0.00	6.13	0.22
252	1C8	2.18	0.0	0.00	6.35	0.25

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(-------------------% wt.-----------------)				$dS\ m^{-1}$
		(---------------------------wtd. to 50 cm-----------------------)				
255	1B14	1.74	5.0	0.60	7.05	0.32
258	2A10	1.34	24.8	2.98	8.39	0.32
262	3A11	1.09	12.6	1.51	7.91	0.35
265	2A13	1.06	14.4	1.72	8.22	0.29
269	2A8	0.93	14.5	1.74	8.26	0.24
271	1A10	1.59	1.9	0.23	6.79	0.27
275	2A20	1.85	0.4	0.05	7.64	0.30
285	1A19	1.01	20.7	2.48	8.00	0.40
288	1A17	2.21	0.0	0.00	6.18	0.24
291	3A10	1.32	6.6	0.79	7.17	0.34
295	3B11	1.54	0.7	0.08	7.51	0.27
299	1A8	1.38	11.1	1.34	7.46	0.26
302	1C9	1.08	5.6	0.67	7.16	0.35
309	1A16	1.76	1.7	0.20	7.21	0.19
312	2C8	1.37	0.0	0.00	6.66	0.17
315	2C18	1.40	13.6	1.63	7.33	0.54
319	2C13	1.55	0.0	0.00	6.48	0.24
324	3C15	1.85	0.5	0.06	7.46	0.33
327	3A13	1.67	4.4	0.52	7.30	0.35
331	3A12	1.19	5.7	0.68	6.89	0.35

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(------------------% wt.-----------------)				dS m^{-1}
		(---------------------------wtd. to 50 cm-----------------------)				
336	1A18	1.17	0.2	0.02	6.23	0.16
339	3A20	2.14	2.0	0.24	8.04	0.27
343	3A8	1.93	8.1	0.98	7.98	0.43
347	2B14	2.76	0.0	0.00	6.97	0.24
351	3B20	1.74	0.7	0.08	7.58	0.31
354	3A14	1.97	12.1	1.46	7.82	2.09
359	1A14	1.35	21.0	2.52	8.08	0.47
362	3B7	2.62	0.2	0.02	7.32	0.29
365	3B17	1.59	24.5	2.94	8.08	0.31
368	1C17	1.90	0.0	0.00	6.36	0.23
372	2B10	1.40	3.4	0.41	6.60	0.35
377	3A2	1.51	10.7	1.29	8.08	0.30
381	2B7	1.87	14.5	1.74	7.93	0.39
385	3A17	1.42	14.1	1.70	8.31	0.46
389	3C11	2.96	0.3	0.03	7.42	0.35
392	2A1	0.37	11.1	1.33	8.25	0.30
395	2A3	0.59	10.9	1.30	8.04	0.49
399	2C3	1.72	16.2	1.95	8.17	0.26
406	1A12	1.44	16.7	2.01	8.15	0.32
409	1A4	1.32	0.0	0.00	6.76	0.20

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(------------------% wt.-----------------)				$dS\ m^{-1}$
		(---------------------------wtd. to 50 cm-----------------------)				
418	3A1	0.93	0.7	0.08	7.30	0.27
422	2A11	0.91	10.7	1.28	8.06	0.43
426	2A9	0.84	25.4	3.04	8.40	0.53
433	3C7	1.43	0.0	0.00	6.77	0.24
437	2B15	0.94	13.2	1.58	7.93	0.29
440	2A14	1.25	13.2	1.59	8.20	0.28
442	2C12	1.18	3.7	0.45	7.99	0.30
446	3A15	1.29	15.6	1.88	8.30	0.37
495	3C19	1.05	14.0	1.69	8.29	0.31
498	2B18	1.86	3.8	0.46	7.95	0.27
502	2A2	1.19	0.0	0.00	7.33	0.11
506	1C2	1.11	0.1	0.01	6.71	0.13
509	3B3	2.28	0.0	0.00	6.22	0.16
513	2B2	1.50	10.7	1.28	7.24	0.36
517	1B17	1.19	0.2	0.03	7.58	0.22
520	1B1	1.69	0.6	0.07	8.11	0.80
523	2B1	3.41	0.2	0.03	6.63	0.43
525	3A19	2.04	7.8	0.94	7.85	1.42
530	3B2	1.81	0.1	0.01	6.35	0.18
534	2B5	1.09	6.9	0.83	6.46	0.20

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(-------------------% wt.------------------)				$dS\ m^{-1}$
		(----------------------------wtd. to 50 cm-------------------------)				
538	1C18	1.79	1.6	0.19	7.87	0.32
542	2A19	1.34	13.7	1.64	8.29	0.28
547	3C16	1.40	0.2	0.02	8.04	0.29
551	3C13	1.28	8.0	0.96	7.65	0.32
554	2A6	1.01	1.1	0.13	6.72	0.18
558	1C1	0.84	10.1	1.21	8.14	0.26
561	1B3	1.47	1.7	0.20	6.85	0.29
570	3C6	1.35	15.7	1.88	7.47	0.43
573	3C1	1.54	0.1	0.01	6.21	0.31
576	2B3	1.28	17.8	2.14	8.25	0.38
578	3B1	1.83	7.8	0.93	8.23	2.34
581	2C1	1.09	0.2	0.02	7.36	0.21
584	1B4	1.38	8.9	1.07	7.36	0.23
587	3A3	1.90	8.2	0.99	8.14	1.28
592	3A9	2.50	3.6	0.43	7.72	3.64
596	2B4	2.10	0.7	0.09	8.11	0.78
599	2C15	1.19	21.3	2.55	8.40	0.33
603	1B13	1.70	7.6	0.91	7.92	0.42
606	3C20	1.50	18.3	2.19	8.02	0.63
609	3C12	1.70	0.0	0.00	6.47	0.27

No.	Site ID	SOC	$CaCO_3$	IC	$pH_{1:1}$	$EC_{1:1}$
		(-------------------% wt.-----------------)				$dS\ m^{-1}$
		(----------------------------wtd. to 50 cm------------------------)				
613	2C2	0.64	0.3	0.03	7.94	0.17
616	1B2	1.99	0.0	0.00	6.32	0.14
620	2A4	1.14	0.0	0.00	7.09	0.14
623	1A2	1.43	0.0	0.00	7.03	1.81
627	3B18	1.84	5.8	0.70	8.07	0.32
630	3B19	1.42	11.8	1.41	7.94	0.31
634	2C6	1.28	14.3	1.72	8.16	0.31
638	3B10	3.98	0.0	0.00	6.92	0.24
641	3A16	1.24	1.4	0.16	8.17	0.22
644	2B13	1.47	14.7	1.76	8.44	0.43
647	3B16	1.16	14.0	1.68	8.31	0.32

APPENDIX E. ET, NDVI, AND GEOLOGIC COVARIATES

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(----------------------------m----------------------------)				
1A10	0.554	-0.0318	-0.0022	0.0103	0.4841	0.0281	0.0189	1857	1316	7155	9597	40105
1A11	0.708	-0.0292	-0.0242	-0.0185	0.3987	0.0526	0.0584	7102	2187	25749	1058	29312
1A12	0.733	0.0027	0.0081	0.0095	0.2763	-0.0645	-0.0201	760	1756	8066	807	63062
1A13	0.666	-0.0220	-0.0108	-0.0048	0.4164	0.0286	0.0282	1752	648	4290	6209	49110
1A14	0.763	-0.0206	-0.0184	-0.0091	0.3872	0.0052	-0.0119	4896	2589	21578	8586	64630
1A15	0.755	-0.0148	-0.0124	-0.0101	0.3967	0.0005	0.0023	2208	3582	15160	6736	24182
1A16	0.758	-0.0187	-0.0141	-0.0097	0.3994	0.0607	0.0676	2045	7012	5266	5732	57091
1A17	0.587	-0.0200	-0.0146	-0.0040	0.4130	0.0020	0.0012	5450	2498	16989	11606	42629
1A18	0.752	-0.0138	-0.0115	-0.0072	0.4161	0.0100	0.0118	65	1964	16195	8153	49171
1A19	0.705	0.0188	0.0102	-0.0011	0.3099	0.0268	0.0018	1789	3843	11536	6448	44045
1A2	0.739	-0.0012	-0.0002	-0.0004	-0.0647	0.0121	0.0092	2547	890	3235	2879	88494
1A20	0.718	-0.0393	-0.0191	-0.0077	0.3949	-0.0016	0.0027	1523	953	4632	5786	49208
1A4	0.770	-0.0021	-0.0022	-0.0026	-0.2085	-0.0050	-0.0030	949	1613	1468	734	77925

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m--------------------------)				
1A5	0.671	-0.0148	-0.0085	0.0040	0.3268	0.0386	0.0205	1197	202	28327	6875	10308
1A6	0.696	-0.0014	0.0078	0.0124	0.0773	-0.1052	-0.1059	1620	344	29430	6808	10929
1A7	0.754	0.0108	0.0046	0.0018	0.2384	0.0456	0.0309	584	345	28701	6377	9679
1A8	0.757	0.0006	-0.0014	-0.0043	0.4169	0.0185	0.0149	333	1223	15591	8941	48291
1A9	0.722	0.0113	0.0032	-0.0068	0.2192	-0.0046	0.0002	5387	5308	13787	10197	27598
1B1	0.787	-0.0172	-0.0145	-0.0093	0.3508	0.0197	0.0668	1822	1265	2928	2745	84253
1B10	0.818	0.0046	0.0029	0.0005	-0.1477	0.0088	0.0052	8501	4773	22917	3861	31652
1B11	0.793	-0.0396	-0.0248	-0.0242	0.4110	0.0579	0.0093	5178	2013	19481	5222	26003
1B12	0.815	-0.0045	-0.0050	0.0021	0.3797	-0.0169	-0.0172	7848	5055	20530	6060	30495
1B13	0.773	-0.0161	-0.0132	-0.0095	0.4129	0.0119	0.0118	3544	3169	7643	2032	59381
1B14	0.820	-0.0079	-0.0104	-0.0106	0.2964	-0.0003	-0.0023	6018	8051	11127	11790	29525
1B15	0.793	-0.0275	-0.0267	-0.0186	0.3355	0.0161	0.0086	853	1592	3104	8587	48298
1B16	0.777	0.0038	0.0140	0.0143	0.3312	0.0481	0.0151	3458	244	27662	615	19978

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(--------------------------m-------------------------)				
1B17	0.827	0.0062	0.0005	-0.0074	0.3826	0.0056	0.0103	3048	2603	4042	6344	71456
1B18	0.814	0.0133	0.0115	0.0109	0.2266	0.0165	0.0138	6955	3754	20804	5803	32764
1B19	0.802	-0.0402	-0.0422	-0.0313	0.4079	0.0113	0.0132	6543	2984	19701	5834	27104
1B2	0.793	-0.0094	-0.0097	-0.0091	0.3478	-0.0029	0.0050	1560	745	4502	3051	76872
1B20	0.795	-0.0134	-0.0124	-0.0112	0.3313	0.0079	0.0022	10044	3608	17628	6143	36851
1B3	0.781	0.0056	0.0032	0.0017	0.4137	0.0166	0.0147	1989	7072	10274	1373	71339
1B4	0.774	-0.0004	-0.0030	-0.0020	-0.0914	0.0018	0.0011	1076	156	6022	2716	84669
1B5	0.805	-0.0114	-0.0073	-0.0028	0.0983	-0.0770	-0.0238	574	564	33399	5036	9638
1B6	0.796	0.0012	-0.0057	-0.0062	0.3896	0.0232	0.0052	1751	132	44332	480	4976
1B7	0.773	-0.0172	-0.0104	-0.0056	0.3506	0.0236	0.0044	1894	85	36984	983	12933
1B8	0.820	-0.0177	-0.0117	-0.0048	0.4045	0.0035	0.0023	844	341	33500	3588	11103
1B9	0.807	0.0266	0.0223	0.0210	0.2049	0.0029	0.0007	6720	3677	20367	6247	32928
1C1	0.840	0.0143	0.0074	0.0081	0.4026	0.0124	0.0115	1773	6618	10395	1699	71790

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m---------------------------)				
1C10	0.849	0.0610	0.0595	0.0371	0.3766	-0.0147	-0.0056	551	2913	4618	5060	51366
1C11	0.850	-0.0156	-0.0093	0.0020	0.3967	0.0259	0.0089	5104	1542	19953	4672	25509
1C12	0.853	0.0014	0.0067	0.0065	0.2344	-0.0253	-0.0234	7131	4374	19845	6662	31207
1C13	0.878	0.0084	0.0088	0.0044	0.2484	-0.0203	-0.0254	7062	4213	19795	6680	31271
1C14	0.849	0.0728	0.0606	0.0570	0.1198	-0.0152	0.0075	8918	1440	21244	1859	32377
1C15	0.836	0.0016	0.0020	0.0038	0.4430	0.1159	0.0505	3651	1423	2226	5538	49154
1C16	0.875	0.0364	0.0326	0.0226	0.2515	0.0312	0.0277	7069	4419	19764	6775	31274
1C17	0.855	-0.0025	-0.0030	-0.0022	0.4467	0.0183	0.0131	1453	1248	16343	7216	66298
1C18	0.843	-0.0304	-0.0267	-0.0160	0.4211	0.0220	0.0091	1791	64	14348	3922	62229
1C19	0.892	0.0389	0.0277	0.0151	0.1805	-0.0276	-0.0156	3426	6454	16894	10826	33542
1C2	0.849	0.0277	0.0241	0.0136	0.4019	0.0193	0.0171	2114	1536	1950	525	75970
1C20	0.889	-0.0179	-0.0158	-0.0059	0.3464	0.0075	-0.0006	5968	7888	12095	12587	30143
1C3	0.871	0.0224	0.0221	0.0229	0.1474	0.0273	0.0128	3554	591	31508	4186	5404

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m---------------------------)				
1C4	0.835	-0.0075	-0.0032	-0.0007	0.4230	0.0078	0.0072	2576	546	32504	5532	16463
1C5	0.833	-0.0086	-0.0097	-0.0126	0.2915	0.0129	0.0025	1316	339	36334	578	11652
1C6	0.927	0.0570	0.0453	0.0307	0.1462	-0.0961	-0.1014	4265	261	36699	2550	5641
1C7	0.857	0.0070	0.0052	0.0036	0.3526	0.0180	0.0146	761	28	37383	3327	14946
1C8	0.896	0.0222	0.0155	0.0110	0.2767	-0.0075	-0.0036	6388	7681	11423	11473	29184
1C9	0.961	0.0733	0.0686	0.0406	0.2607	0.0156	0.0409	4696	2736	18262	6275	26519
2A1	0.698	-0.0139	-0.0051	0.0017	-0.0144	-0.1197	-0.0776	1672	528	3988	3730	74869
2A10	0.645	-0.0068	-0.0135	-0.0230	0.2716	0.0226	0.0129	1992	174	21700	17	16315
2A11	0.709	-0.0109	-0.0118	-0.0078	0.2665	-0.0758	-0.0377	3162	3651	11432	9864	71497
2A12	0.584	-0.0070	0.0020	0.0044	-0.1662	0.0057	0.0063	192	2358	4258	8932	47012
2A13	0.630	0.0003	0.0024	0.0024	-0.1685	-0.0101	-0.0056	1288	2631	5714	9238	45576
2A14	0.720	-0.0299	-0.0300	-0.0137	0.4219	0.0616	0.0112	1436	2976	6440	1528	60433
2A16	0.693	0.0223	0.0218	0.0156	0.1628	-0.0339	-0.0066	5055	1183	3372	2750	47831

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(----------------------------		m		----------------------------)
2A17	0.666	-0.0331	-0.0207	-0.0043	0.3399	-0.0230	-0.0176	2107	3240	15467	6837	24194
2A18	0.727	0.0025	-0.0018	-0.0069	0.3291	-0.0021	-0.0022	10395	2566	20100	3395	34004
2A19	0.695	-0.0125	-0.0151	-0.0097	0.4059	0.0301	0.0224	3569	1239	13349	7012	71683
2A2	0.610	0.0032	-0.0075	-0.0097	0.3927	0.0067	0.0123	1441	183	976	655	78860
2A20	0.693	0.0274	0.0193	0.0079	0.3439	0.0215	0.0038	3676	500	20138	1786	18481
2A3	0.704	-0.0076	-0.0011	0.0054	0.1661	0.0726	0.0513	1675	569	3958	3715	74882
2A4	0.697	-0.0155	-0.0108	-0.0080	0.4045	0.0543	0.0100	2064	85	4531	3601	78839
2A6	0.740	-0.0077	-0.0059	-0.0013	0.3896	0.0346	0.0268	1249	3784	14886	4473	78050
2A7	0.732	0.0001	-0.0016	-0.0064	0.0182	-0.1224	-0.0343	480	1158	31494	4570	8666
2A8	0.708	0.0222	0.0220	0.0188	0.2262	-0.0240	-0.0044	4781	1794	2791	1772	48542
2A9	0.743	0.0075	-0.0077	-0.0119	0.2000	0.0456	0.0577	3725	4047	10915	9683	72053
2B1	0.758	-0.0050	-0.0078	-0.0075	0.3333	0.0325	0.0132	3136	3464	8292	998	79085
2B10	0.808	0.0278	0.0125	0.0078	0.3435	0.0036	0.0044	3740	3201	9223	8618	73330

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(--------------------------m--------------------------)				
2B11	0.792	-0.0115	-0.0138	-0.0039	0.0867	-0.0981	-0.0704	7503	4601	20763	5986	32119
2B13	0.758	-0.0172	-0.0091	-0.0063	0.3851	0.0181	0.0063	5582	2540	4395	2580	47254
2B14	0.761	-0.0085	0.0090	0.0156	0.2853	0.0208	0.0153	2140	240	10075	1815	65390
2B15	0.796	-0.0233	-0.0248	-0.0140	0.3292	0.0325	0.0510	1518	2584	255	3262	58291
2B16	0.756	0.0223	0.0063	-0.0018	0.0779	-0.1186	-0.0846	8532	1609	18742	2908	33315
2B17	0.813	-0.0132	-0.0050	-0.0143	0.1178	-0.2011	-0.1179	562	2415	16701	5476	22692
2B18	0.810	-0.0126	-0.0062	-0.0045	0.4106	0.0484	0.0205	648	451	12090	3859	63695
2B2	0.805	-0.0150	0.0022	0.0128	0.3313	0.1271	0.0458	222	1929	52	3034	72528
2B20	0.780	-0.0110	-0.0058	0.0011	-0.1077	0.0130	0.0113	511	1825	3357	8766	47951
2B3	0.761	-0.0124	-0.0058	0.0023	0.2745	0.0319	0.0138	2438	52	2957	3489	84681
2B4	0.765	-0.0092	-0.0093	-0.0079	0.2745	0.0056	-0.0099	2829	2733	8522	8067	74241
2B5	0.813	0.0199	0.0166	0.0092	0.3225	-0.0680	-0.0586	331	1055	1326	1890	81023
2B6	0.802	-0.0045	-0.0026	0.0038	0.1333	-0.0104	0.0037	605	865	31213	4787	8821

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(--------------------------m--------------------------)				
2B7	0.803	0.0330	0.0298	0.0195	-0.0998	0.0231	0.0112	1696	3114	9559	4994	75959
2B8	0.766	-0.0223	-0.0197	-0.0123	0.2606	0.0631	0.0274	7568	4835	22827	4897	34057
2B9	0.774	0.0047	0.0133	0.0206	0.1852	-0.0402	-0.0135	6073	2471	15236	2546	33684
2C1	0.822	0.0055	0.0062	0.0079	0.4238	0.0254	-0.0089	1346	231	1932	2342	83551
2C10	0.846	-0.0150	-0.0148	-0.0129	0.3166	0.1294	-0.0384	6132	7859	11932	12396	29984
2C11	0.886	0.0153	0.0095	0.0096	0.3791	0.0871	0.0115	6305	7656	12085	12236	29807
2C12	0.836	0.0072	0.0019	-0.0017	0.3529	0.0030	-0.0018	2058	3675	7214	1386	60345
2C13	0.970	0.0662	0.0579	0.0348	0.3616	0.0110	0.0077	884	8947	1722	3208	53493
2C15	0.826	-0.0072	-0.0045	0.0020	0.3980	0.0057	0.0122	512	1414	13855	7061	67777
2C16	0.816	-0.0018	-0.0082	-0.0090	0.3446	0.0010	-0.0027	9980	2289	20802	2921	33425
2C17	0.824	-0.0022	0.0045	0.0106	0.2843	-0.0898	-0.0378	4568	870	20097	4302	24860
2C18	0.840	-0.0214	-0.0240	-0.0260	0.4315	-0.0084	-0.0111	1037	2756	5043	11126	39711
2C19	0.834	-0.0468	-0.0287	-0.0102	0.3462	-0.0066	-0.0034	7017	3141	19726	6712	31839

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m--------------------------)				
2C2	0.823	0.0046	0.0083	0.0015	0.3419	-0.0105	-0.0156	115	1890	97	3107	72458
2C20	0.825	-0.0154	-0.0139	-0.0044	0.3248	0.0323	0.0091	8003	5023	21287	5506	31622
2C21	0.856	-0.0179	0.0013	0.0059	0.3684	0.0076	0.0304	6630	1754	20882	4645	26136
2C3	0.844	0.0205	0.0186	0.0135	-0.1547	-0.0315	-0.0274	1038	703	4203	4211	74280
2C4	0.868	0.0101	0.0077	0.0048	0.1411	0.0330	0.0370	5524	6182	36256	3137	10456
2C5	0.834	-0.0128	-0.0084	-0.0032	0.3993	0.0440	0.0259	3262	274	31977	5269	6053
2C6	0.869	-0.0017	-0.0029	-0.0045	0.3052	0.0052	-0.0125	649	2071	16861	5761	22892
2C7	0.864	0.0460	0.0311	0.0180	0.2745	0.0175	0.0231	8921	3712	21596	3954	34146
2C8	0.872	0.0208	0.0176	0.0124	0.3355	0.0188	0.0013	1600	8505	1443	3880	52520
2C9	0.879	0.0213	0.0142	0.0041	0.3041	0.0057	-0.0001	4593	4755	14032	9332	26750
3A1	0.662	-0.0030	-0.0019	-0.0045	0.2795	-0.0083	-0.0074	1010	2962	2167	1507	78585
3A10	0.764	0.0170	0.0160	0.0118	0.4207	0.0290	0.0235	1236	2894	13014	10711	46902
3A11	0.623	0.0045	0.0052	0.0028	0.0029	0.0961	0.0515	2187	604	5953	5770	47522

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m---------------------------)				
3A12	0.648	-0.0107	-0.0084	-0.0031	0.3754	-0.0035	-0.0049	2521	2065	1606	6517	61937
3A13	0.630	0.0121	0.0126	0.0086	0.3758	-0.0201	-0.0217	2383	1898	1443	6334	61891
3A14	0.758	-0.0101	-0.0032	0.0026	0.3631	0.1361	0.0102	2036	131	11800	1493	60385
3A15	0.660	-0.0193	0.0094	0.0168	0.3639	0.0197	0.0140	2738	2148	5464	728	58243
3A16	0.713	-0.0288	-0.0226	-0.0183	0.2790	0.0124	0.0262	1055	105	353	3511	54970
3A17	0.599	-0.0206	-0.0099	-0.0059	0.3727	-0.0106	-0.0075	1430	869	14816	9117	69280
3A18	0.673	-0.0144	-0.0091	-0.0064	0.3553	-0.0037	-0.0066	7456	1267	17575	2878	33229
3A19	0.744	0.0088	0.0066	0.0043	0.3424	-0.0067	-0.0057	6628	5206	13177	1548	75114
3A2	0.757	-0.0060	-0.0062	-0.0035	0.4032	0.0100	-0.0001	1796	2492	8201	7650	75203
3A20	0.535	0.0415	0.0305	0.0146	0.2283	0.0950	0.0703	2261	5003	10393	325	52316
3A3	0.747	0.0173	0.0165	0.0095	0.3553	0.0382	-0.0049	3291	2192	8089	1399	81060
3A4	0.728	-0.0202	-0.0212	-0.0146	0.1829	0.0504	0.0331	6697	6561	45605	4801	1588
3A5	0.733	-0.0167	-0.0198	-0.0176	0.0716	-0.0310	0.0166	6436	6918	43622	4685	3417

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(--------------------------m--------------------------)				
3A6	0.613	-0.0100	-0.0046	0.0023	0.2931	0.0009	0.0003	6300	5935	42055	4825	4956
3A8	0.646	-0.0490	-0.0338	-0.0091	0.2012	0.0157	-0.0050	421	3607	11721	2130	55039
3A9	0.761	0.0066	0.0033	-0.0038	0.3103	0.0269	0.0139	5165	2939	13066	4918	73339
3B1	0.781	-0.0060	-0.0024	-0.0062	0.4521	0.0228	0.0056	1731	210	2318	2692	83880
3B10	0.777	-0.0110	-0.0135	-0.0064	0.3560	0.0144	0.0048	4216	6618	17519	10065	32776
3B11	0.797	0.0160	0.0169	0.0106	-0.1214	0.0115	0.0105	305	3379	12595	9716	47907
3B12	0.823	-0.0195	-0.0157	-0.0055	0.4129	0.0156	0.0096	8567	4689	21280	5194	30365
3B13	0.814	0.0004	-0.0005	0.0015	0.3057	0.0203	0.0090	8257	4372	20965	5515	30683
3B14	0.822	-0.0164	-0.0166	-0.0163	0.3443	0.0527	0.0264	5233	187	27716	1307	21597
3B15	0.826	0.0210	0.0237	0.0192	0.2011	-0.0193	-0.0191	7902	118	23413	2964	24662
3B16	0.777	-0.0282	-0.0270	-0.0112	0.3871	0.0584	0.0078	1144	683	469	7775	66753
3B17	0.784	-0.0067	-0.0080	-0.0085	0.4211	0.0434	0.0191	1369	111	16710	5891	63375
3B18	0.816	-0.0026	-0.0011	0.0042	0.3727	0.0034	0.0020	1602	1972	13247	9414	70240

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m--------------------------)				
3B19	0.805	-0.0014	0.0002	-0.0031	0.3924	0.0111	0.0112	888	409	4620	5142	69234
3B2	0.785	0.0068	0.0061	0.0059	0.3245	0.0026	0.0042	1406	1723	4228	3751	77527
3B20	0.813	0.0115	0.0275	0.0142	0.3939	0.0120	0.0019	931	461	2005	3544	61533
3B3	0.823	-0.0192	0.0051	0.0099	0.4032	0.0111	0.0069	1193	3569	2270	3230	73219
3B4	0.794	-0.0112	-0.0078	-0.0022	0.2586	-0.0094	0.0056	1845	127	43213	990	5098
3B5	0.813	-0.0130	-0.0124	-0.0099	0.4145	0.0057	0.0058	4969	712	36716	1649	5044
3B7	0.774	0.0135	0.0118	0.0103	0.4267	0.0167	0.0079	1447	605	17588	6131	63309
3B8	0.795	-0.0058	-0.0018	-0.0004	0.3707	-0.0120	-0.0123	2069	168	22516	2088	26580
3B9	0.825	-0.0110	-0.0126	-0.0085	0.3438	-0.0006	-0.0047	5190	165	27669	1216	21540
3C1	0.841	0.0191	0.0145	0.0083	0.3333	0.0183	0.0153	3405	100	3861	2818	85733
3C10	0.865	0.0153	0.0178	0.0084	-0.1895	0.0032	0.0000	2612	76	22727	3383	18093
3C11	0.865	0.0451	0.0295	0.0143	0.3645	0.2054	0.1069	3398	180	16975	8438	68250
3C12	0.837	0.0282	0.0191	0.0121	0.4129	0.0115	0.0099	2145	403	1673	5367	63236

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m--------------------------)				
3C13	0.844	0.0087	0.0088	0.0101	0.3537	-0.0079	0.0219	839	1875	6461	6270	70506
3C14	0.835	0.0077	0.0020	-0.0019	0.3645	-0.0146	-0.0145	4041	1162	29295	2447	21260
3C15	0.855	-0.0114	-0.0058	-0.0045	0.3677	0.0282	0.0051	1431	4918	4245	6982	58533
3C16	0.873	0.0031	0.0055	0.0014	0.4257	0.0145	0.0127	8041	1915	18123	2274	71197
3C17	0.870	0.0526	0.0396	0.0299	-0.1253	-0.0313	-0.0181	3833	311	23386	3336	19684
3C18	0.851	0.0042	-0.0035	-0.0022	0.2827	0.0005	-0.0146	3601	696	28125	2446	26062
3C19	0.854	0.0157	0.0068	0.0048	0.3987	-0.0066	-0.0085	971	2176	10071	2923	62171
3C2	0.869	-0.0005	-0.0049	-0.0051	0.2237	0.0778	0.0567	1563	91	33963	4328	16371
3C20	0.854	0.0176	0.0128	0.0106	0.4153	0.0048	-0.0006	1581	3841	8113	2210	61036
3C3	0.834	0.0284	0.0227	0.0144	0.2500	-0.0681	-0.0139	1641	43	43228	1118	5246
3C4	0.849	0.0428	0.0303	0.0165	0.2484	-0.0179	-0.0008	2530	25	29246	6649	18790
3C6	0.849	0.0117	0.0236	0.0232	0.4084	0.0023	0.0033	1492	223	3284	4400	67089
3C7	0.858	0.0220	0.0193	0.0162	0.4618	0.0192	0.0152	393	665	778	3971	54671

Site ID	ETrF	Rel. ET (7X7)	Rel. ET (5X5)	Rel. ET (3X3)	NDVI	Rel.NDVI 30 m	Rel.NDVI 10 m	River channel	Ridges	Ice margins	Eskers	Beach
								(---------------------------m---------------------------)				
3C8	0.847	0.0320	0.0266	0.0168	0.2848	0.0140	0.0194	7155	4308	22355	5272	34209

APPENDIX F. MEDIAN AGGREGATED DEM AND DERIVATIVES

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
1A10	426.06	0.931	-0.366	1.2	5.45	348	0.01165	369	4.78	0.0000	0.0001	1.08	8.44	0.59	0.05	0.00	2.95
1A11	405.37	-0.548	-0.836	13.4	5.82	1755	0.01898	131	-0.01	0.0002	-0.0001	0.54	8.10	0.00	0.01	0.02	0.86
1A12	450.69	0.809	-0.588	68.3	6.84	1122	0.00423	17	0.94	0.0003	0.0004	0.34	6.77	0.60	0.28	0.11	0.98
1A13	449.70	-0.851	-0.526	17.6	6.53	5759	0.01675	84	-0.53	0.0003	0.0002	1.13	6.95	0.37	0.20	0.07	2.16
1A14	437.27	0.764	-0.645	18.6	4.21	96	0.02250	59	1.80	0.0002	0.0007	2.32	6.40	1.10	0.43	0.18	1.49
1A15	409.56	0.880	0.475	1.4	5.88	874	0.01205	153	0.32	0.0000	0.0001	0.99	7.69	0.32	0.07	0.02	1.04
1A16	448.59	0.405	-0.914	33.0	5.90	842	0.01156	46	1.24	0.0001	0.0005	0.85	6.50	0.64	0.18	0.07	1.00
1A17	428.68	0.684	-0.729	-2.3	4.44	419	0.03830	123	-0.13	-0.0003	-0.0003	1.15	7.54	-0.01	-0.21	-0.19	1.17
1A18	444.79	0.827	0.562	9.1	5.10	1295	0.03478	59	-0.43	0.0001	0.0004	2.40	6.01	-0.05	0.11	0.10	2.70
1A19	436.74	-0.982	-0.188	14.0	4.42	206	0.02703	75	2.35	0.0004	0.0002	1.49	6.56	0.88	0.25	0.08	2.39
1A2	460.23	0.964	0.265	2.7	6.78	1620	0.00586	115	-0.73	0.0000	-0.0001	0.46	10.15	-0.06	0.00	0.01	0.70
1A20	448.73	0.851	0.525	17.7	4.34	240	0.03204	67	2.85	0.0007	0.0006	2.56	5.87	1.52	0.53	0.17	2.73
1A4	444.06	-0.831	0.556	8.7	4.24	422	0.04776	75	2.24	0.0006	-0.0001	2.14	6.25	0.45	0.08	-0.09	2.69
1A5	351.84	0.603	0.798	-30.6	6.94	13719	0.01715	265	-2.49	-0.0002	-0.0002	0.47	8.94	-0.56	-0.17	-0.04	1.03
1A6	355.53	0.556	-0.832	27.0	3.94	136	0.03615	55	2.20	0.0009	0.0008	2.86	5.57	1.67	0.70	0.21	1.94
1A7	349.91	-0.060	0.998	3.7	6.51	8421	0.02107	123	-0.62	0.0001	-0.0002	1.00	7.55	-0.28	-0.09	-0.02	0.69
1A8	449.35	0.208	-0.978	21.2	5.25	1608	0.03320	67	1.24	0.0003	0.0004	2.25	6.01	0.40	0.31	0.05	2.28

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
1A9	411.91	0.586	-0.810	-15.7	6.04	3460	0.02158	189	-0.30	-0.0003	-0.0002	1.39	7.77	-0.25	-0.23	-0.05	1.03
1B1	455.86	0.870	-0.492	-40.0	5.67	2840	0.02892	407	-1.69	-0.0005	-0.0008	1.48	9.40	-0.78	-0.49	-0.23	1.50
1B10	438.58	0.999	0.037	4.4	5.65	2378	0.02677	172	-2.23	0.0000	0.0001	1.22	7.55	-0.74	0.02	0.06	2.10
1B11	411.46	-0.997	-0.076	-19.5	6.00	2351	0.01827	2199	0.52	-0.0004	0.0000	0.92	11.21	-0.37	-0.14	-0.04	2.02
1B12	438.69	-0.619	0.785	5.2	5.29	746	0.02132	205	2.98	0.0002	0.0002	1.53	7.79	0.55	0.15	0.04	3.24
1B13	448.14	0.551	0.835	4.4	6.22	574	0.00624	12	0.18	0.0001	0.0000	0.39	6.76	0.11	0.05	0.02	0.50
1B14	428.20	0.629	-0.778	25.6	7.18	5169	0.00737	66	1.24	0.0003	0.0002	0.46	7.69	0.44	0.16	0.04	1.59
1B15	447.57	-0.903	0.429	-18.3	5.60	1181	0.01939	1132	-1.44	-0.0005	-0.0001	1.41	9.33	-0.44	-0.24	-0.08	1.95
1B16	377.11	-0.269	-0.963	-11.1	6.73	6468	0.01430	327	-1.60	-0.0002	-0.0002	0.83	10.65	-0.46	-0.14	-0.04	1.18
1B17	445.49	-0.326	-0.945	70.6	6.10	352	0.00527	9	-0.51	0.0012	0.0014	0.33	6.11	0.69	0.94	0.55	1.65
1B18	440.83	0.764	0.645	-2.8	4.41	262	0.03105	234	-0.92	-0.0001	0.0004	2.47	7.26	-0.26	0.09	0.03	2.56
1B19	412.29	0.739	0.674	8.5	5.98	3548	0.02347	121	-0.76	0.0002	-0.0001	1.32	7.26	0.15	0.04	0.00	1.34
1B2	444.66	0.366	-0.930	-16.2	5.91	740	0.01054	10	0.46	-0.0002	-0.0001	0.68	5.66	0.11	-0.15	-0.02	0.98
1B20	431.61	0.517	0.856	-64.7	6.84	8744	0.01485	2288	-1.42	-0.0006	-0.0005	0.44	13.30	-0.69	-0.41	-0.14	1.48
1B3	443.77	-0.456	-0.890	-11.9	6.16	1343	0.01118	67	0.61	-0.0002	0.0002	0.97	6.98	0.45	0.05	0.00	1.19
1B4	452.41	0.853	-0.523	21.1	3.64	61	0.03241	47	7.62	0.0017	-0.0005	1.93	5.78	1.80	0.61	0.16	3.93
1B5	347.20	-0.793	0.609	0.6	7.07	6365	0.00952	115	1.42	0.0000	-0.0001	0.76	8.42	0.22	-0.02	0.00	1.44

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
1B6	358.48	0.913	0.409	-4.0	5.79	1273	0.01636	144	0.32	-0.0001	0.0002	1.63	7.38	0.25	0.06	0.01	1.28
1B7	353.14	0.537	0.844	-2.2	6.58	2314	0.00944	115	0.04	0.0000	0.0001	0.79	7.74	0.06	0.00	-0.01	0.43
1B8	351.98	-0.969	0.245	4.5	6.19	2119	0.01398	125	0.05	0.0001	0.0001	1.07	7.35	0.27	0.10	0.03	1.00
1B9	441.51	0.662	0.750	12.1	4.98	210	0.01480	163	0.69	0.0002	0.0004	1.12	7.69	0.58	0.24	0.07	1.81
1C1	443.19	-0.890	-0.455	0.1	4.90	611	0.02885	295	-0.21	-0.0001	-0.0001	2.14	10.97	0.12	-0.11	-0.09	1.13
1C10	441.18	-0.637	-0.771	20.3	6.21	731	0.00734	61	1.16	0.0002	0.0002	0.50	7.33	0.53	0.14	0.04	0.89
1C11	414.69	0.179	-0.984	-11.5	4.03	316	0.05085	316	-2.70	-0.0007	-0.0005	3.50	7.41	-0.86	-0.45	-0.18	2.63
1C12	450.03	0.557	0.830	2.3	6.20	2465	0.01504	273	-0.12	0.0000	0.0000	0.61	8.83	-0.03	0.01	0.00	1.26
1C13	451.54	-0.801	-0.598	54.3	7.73	4137	0.00297	22	0.99	0.0003	0.0002	0.19	6.21	0.36	0.19	0.07	1.17
1C14	420.16	0.576	0.817	15.6	4.80	416	0.02628	101	0.63	0.0006	-0.0003	1.60	6.78	0.52	0.14	0.04	1.75
1C15	448.82	0.422	-0.907	-12.2	6.43	5204	0.01762	64	-2.22	0.0002	-0.0006	0.74	7.77	-0.66	-0.24	-0.05	1.48
1C16	449.25	0.719	-0.695	-0.1	6.58	4766	0.01420	172	-0.17	0.0000	0.0000	0.80	8.37	-0.14	0.01	0.01	1.26
1C17	443.01	0.561	-0.828	-41.9	5.97	2162	0.01809	127	-1.05	-0.0005	-0.0004	0.95	11.07	-0.44	-0.28	-0.09	0.94
1C18	440.72	-0.770	-0.638	-25.2	6.09	912	0.00969	14	-0.37	-0.0004	-0.0003	0.93	6.20	0.17	-0.12	-0.05	0.59
1C19	433.94	-0.227	-0.974	21.0	3.55	86	0.04278	68	-0.79	0.0011	0.0005	3.01	5.88	0.79	0.53	0.29	3.34
1C2	444.42	0.809	-0.588	17.1	5.48	399	0.01211	24	2.95	-0.0002	0.0012	0.80	6.08	1.26	0.40	0.06	1.98
1C20	434.66	0.942	-0.335	16.9	6.13	2748	0.01725	68	1.91	0.0003	0.0007	1.61	6.43	0.45	0.35	0.14	2.69

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------	--------)	°		(---------------	m	---------------	---)
1C3	343.46	-0.917	-0.400	5.6	5.10	292	0.01560	152	2.27	0.0001	0.0000	1.07	7.76	0.81	0.10	0.01	1.98
1C4	355.86	-0.959	-0.283	-7.9	5.47	645	0.01613	372	0.13	-0.0002	0.0001	0.94	8.73	-0.13	-0.04	0.00	1.41
1C5	352.94	-0.476	-0.880	-3.3	5.80	1892	0.02028	94	-0.32	0.0003	-0.0005	0.73	7.64	-0.07	-0.08	-0.05	0.56
1C6	349.22	-0.995	-0.096	-3.4	6.71	7013	0.01522	130	-0.21	0.0000	0.0000	1.30	7.26	-0.16	0.00	0.00	0.77
1C7	352.08	-0.270	-0.963	-8.5	5.76	1999	0.02170	123	0.14	0.0000	-0.0002	1.35	7.22	-0.18	-0.13	-0.05	1.01
1C8	425.17	-0.026	-1.000	8.7	5.61	1212	0.01949	142	-0.21	0.0002	-0.0001	1.09	7.69	0.17	0.05	0.00	1.36
1C9	413.76	-0.897	-0.441	19.2	3.54	65	0.03700	65	2.26	0.0009	0.0009	2.99	5.83	1.47	0.68	0.21	2.05
2A1	455.48	0.959	-0.282	22.5	2.62	57	0.08998	57	3.34	0.0020	-0.0003	5.40	5.32	3.31	0.84	0.22	4.57
2A10	368.43	0.880	0.475	1.8	7.36	1610	0.00249	10	-1.14	0.0001	0.0001	0.11	9.42	-0.08	0.06	0.09	2.66
2A11	453.64	-0.932	-0.364	22.0	3.10	50	0.05140	43	2.20	0.0008	0.0008	3.37	5.25	1.38	0.58	0.21	2.49
2A12	441.35	1.000	-0.023	4.3	3.85	191	0.04716	83	1.44	0.0002	0.0006	4.04	5.72	0.99	0.28	0.07	3.83
2A13	443.88	0.849	-0.528	14.6	4.64	252	0.02378	71	3.11	0.0004	0.0004	1.82	6.52	0.92	0.33	0.11	1.72
2A14	452.89	0.309	0.951	16.6	4.70	267	0.02305	14	2.79	0.0001	0.0012	1.24	4.88	0.99	0.41	0.24	2.27
2A16	437.06	-0.995	0.103	-0.3	3.62	266	0.07121	266	-0.93	0.0000	0.0004	5.30	6.65	0.78	0.15	0.04	4.43
2A17	413.64	0.769	-0.639	16.4	4.01	96	0.02788	90	2.45	0.0005	0.0000	1.57	6.85	1.52	0.24	0.06	2.62
2A18	449.98	-0.973	-0.229	-11.6	5.42	1651	0.02834	116	-0.71	0.0005	-0.0013	1.21	7.28	0.01	-0.26	-0.11	1.58
2A19	447.50	-0.577	0.816	46.0	2.61	38	0.07323	38	5.02	0.0009	0.0027	5.02	4.70	2.40	1.28	0.31	3.27

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			º		m^2	radians	m^2	m	(--------m^{-1}--------	--------)	º		(---------------	m	---------------	)
2A2	452.20	-0.845	-0.534	-13.8	4.45	911	0.05674	112	-0.87	0.0000	-0.0011	4.39	5.85	-0.18	-0.44	-0.18	1.64
2A20	378.52	0.724	0.690	4.3	4.10	128	0.02945	57	1.77	-0.0004	0.0014	3.07	5.61	1.61	0.43	0.02	2.49
2A3	455.65	-0.322	-0.947	19.8	2.68	64	0.08958	64	3.54	0.0019	-0.0006	4.84	5.28	3.44	0.63	0.12	4.74
2A4	451.23	-0.350	-0.937	11.2	3.32	86	0.05385	63	-1.42	0.0004	0.0001	4.34	5.27	0.54	0.24	0.09	1.28
2A6	453.26	-0.990	-0.144	35.7	5.70	163	0.00538	9	4.55	0.0003	0.0010	0.46	6.96	2.07	0.60	0.18	3.34
2A7	343.33	-0.246	0.969	6.0	3.76	143	0.04465	143	-0.03	0.0004	0.0003	4.60	6.09	0.20	0.28	0.14	2.44
2A8	441.30	0.222	-0.975	8.9	5.09	1588	0.03911	130	-1.06	0.0004	-0.0007	1.74	7.03	-0.01	-0.12	-0.06	1.60
2A9	447.00	-0.332	-0.943	-0.6	4.92	320	0.02013	289	-1.84	0.0000	0.0003	2.99	9.25	-0.49	0.13	0.09	1.55
2B1	455.56	-0.666	0.746	-68.6	5.79	4247	0.03137	409	-0.96	-0.0008	-0.0008	0.81	11.35	-0.46	-0.62	-0.42	1.67
2B10	456.13	0.711	0.703	12.7	5.09	328	0.01679	170	1.01	-0.0001	0.0006	1.03	7.80	0.74	0.26	0.01	1.06
2B11	454.77	-0.254	-0.967	-20.7	5.74	5135	0.03670	803	-3.45	-0.0007	-0.0005	2.04	8.94	-1.29	-0.57	-0.18	2.95
2B13	439.38	0.485	-0.875	25.5	4.40	361	0.03716	46	-2.05	0.0005	0.0009	2.86	5.42	0.34	0.47	0.15	2.01
2B14	455.73	-0.787	0.617	-16.9	4.65	1153	0.05237	56	0.62	0.0001	-0.0015	2.12	5.99	0.39	-0.44	-0.14	1.55
2B15	457.49	-0.514	0.858	-8.3	3.36	178	0.07536	57	3.35	-0.0011	0.0008	2.76	6.08	1.89	-0.02	-0.08	3.76
2B16	423.23	0.980	-0.200	-7.4	4.48	433	0.03737	433	0.34	-0.0005	0.0006	3.51	7.52	0.11	0.01	0.01	2.24
2B17	400.35	-0.499	0.867	-7.8	5.52	3271	0.03647	170	-1.31	-0.0001	-0.0006	1.41	10.69	-0.15	-0.24	-0.09	0.66
2B18	447.72	0.995	-0.102	0.8	3.89	422	0.06809	83	-0.33	0.0005	-0.0013	3.34	5.94	0.18	-0.27	-0.21	1.86

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
2B2	442.90	0.994	0.110	-18.0	6.27	7324	0.02528	163	-3.58	-0.0003	-0.0005	1.48	9.91	-1.55	-0.38	-0.07	2.99
2B20	452.84	0.947	0.321	-7.8	4.71	899	0.04317	128	0.26	0.0001	-0.0009	2.19	6.66	0.50	-0.22	-0.13	2.26
2B3	463.04	-0.961	-0.275	81.0	4.81	56	0.00833	9	5.89	0.0019	0.0015	0.38	5.89	3.58	1.44	0.47	4.41
2B4	453.20	0.297	-0.955	-3.3	4.55	708	0.04526	168	-3.25	-0.0001	-0.0010	1.32	8.15	-0.83	-0.33	-0.06	1.65
2B5	449.97	-0.350	0.937	-21.5	4.07	491	0.06090	125	0.78	-0.0011	-0.0007	4.58	5.88	-0.57	-0.70	-0.23	3.08
2B6	343.48	-0.910	-0.415	9.7	6.12	5484	0.02532	85	1.06	0.0003	0.0001	1.89	6.65	0.37	0.20	0.07	1.82
2B7	455.87	0.161	0.987	31.4	3.73	218	0.05737	62	1.80	0.0017	-0.0003	2.25	5.89	1.01	0.42	-0.01	2.61
2B8	450.64	0.461	-0.887	-14.3	5.23	9212	0.08349	332	-4.23	0.0000	-0.0019	1.98	8.01	-2.12	-0.78	-0.27	5.04
2B9	423.58	-0.090	-0.996	19.7	3.77	147	0.04474	147	-0.26	0.0011	0.0004	2.90	6.55	0.97	0.60	0.23	4.79
2C1	457.62	-0.649	0.760	12.5	4.71	176	0.01811	82	4.82	0.0011	0.0013	0.83	7.17	2.50	0.83	0.20	3.21
2C10	432.08	0.056	0.998	1.8	5.95	16983	0.05455	122	-4.34	0.0005	-0.0012	2.37	6.77	-1.20	-0.31	-0.09	2.61
2C11	427.69	0.639	-0.770	-24.1	5.27	7375	0.07200	287	-3.32	-0.0008	-0.0020	2.72	7.38	-1.63	-1.06	-0.37	2.85
2C12	452.28	0.945	0.326	-8.0	4.85	442	0.02575	513	4.77	0.0000	0.0010	2.16	8.91	1.94	0.34	0.08	3.70
2C13	446.54	0.247	0.969	-17.2	5.07	1905	0.04393	220	-2.49	0.0000	-0.0008	2.08	8.33	-0.56	-0.29	-0.21	2.13
2C15	445.19	-0.971	0.239	21.2	3.96	191	0.04219	23	-0.39	0.0030	-0.0012	2.25	5.07	-0.33	0.58	0.47	1.40
2C16	439.19	-0.631	-0.776	13.6	4.69	192	0.01947	123	2.03	0.0004	0.0006	1.40	7.12	1.17	0.42	0.11	2.54
2C17	407.48	0.999	0.046	0.5	4.29	454	0.04704	421	-1.67	0.0000	0.0002	2.65	7.73	-0.76	-0.02	0.03	4.21

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
2C18	430.48	0.998	0.066	-6.4	4.31	1303	0.07926	90	-2.21	-0.0005	0.0004	4.76	5.60	0.35	0.08	-0.08	5.17
2C19	453.30	-0.548	-0.837	-13.8	5.48	1180	0.02202	384	1.42	-0.0006	0.0000	1.15	8.76	0.56	-0.16	-0.07	2.05
2C2	446.66	-0.743	-0.669	-22.4	5.61	1901	0.02481	223	1.19	-0.0010	0.0002	1.95	7.58	0.05	-0.26	-0.14	1.95
2C20	452.62	0.515	-0.857	-18.4	6.18	6363	0.02583	145	-1.46	-0.0005	-0.0004	1.55	7.39	-1.02	-0.35	-0.04	2.01
2C21	410.75	-0.244	-0.970	0.7	5.32	316	0.01276	86	3.64	-0.0004	0.0006	1.10	7.06	1.86	0.11	0.05	3.12
2C3	449.35	-0.426	0.905	-7.9	5.17	1007	0.02819	70	-1.40	0.0001	-0.0004	1.92	6.23	-0.09	-0.05	0.02	1.02
2C4	370.53	0.479	-0.878	8.0	4.01	147	0.03486	88	2.91	-0.0004	0.0014	4.32	6.03	0.67	0.35	0.09	1.70
2C5	345.20	-0.151	0.988	23.9	4.14	63	0.01935	63	3.62	0.0006	0.0005	1.67	6.35	1.93	0.47	0.14	2.95
2C6	404.31	-0.966	0.257	24.5	5.36	454	0.01487	55	2.14	0.0001	0.0005	1.27	6.42	1.11	0.23	0.06	1.77
2C7	457.85	-0.356	-0.934	-2.5	3.60	136	0.05117	131	4.47	-0.0001	0.0002	4.32	6.02	1.25	0.06	0.00	3.36
2C8	445.56	0.646	0.763	-1.1	6.33	1647	0.01026	20	1.96	0.0003	0.0000	0.54	6.39	0.67	0.18	0.06	1.69
2C9	410.86	-0.951	-0.310	0.2	3.76	164	0.04803	164	0.18	0.0001	-0.0002	2.84	6.66	0.39	-0.02	-0.02	1.93
3A1	449.13	-0.104	0.995	18.2	4.49	365	0.03383	45	0.45	0.0003	0.0003	2.59	5.45	0.63	0.26	0.00	1.15
3A10	434.36	-0.541	-0.841	5.8	4.90	378	0.02243	216	1.22	0.0002	0.0007	1.79	7.60	0.67	0.38	0.09	1.83
3A11	458.49	-0.987	-0.158	22.7	4.74	73	0.01071	69	6.88	0.0002	0.0009	1.14	6.90	2.51	0.47	0.12	4.46
3A12	452.56	0.976	0.217	14.4	5.14	722	0.02458	41	0.04	0.0003	0.0000	1.49	5.83	0.29	0.14	0.02	1.03
3A13	451.50	-0.955	-0.298	-14.6	5.19	1168	0.02984	372	-1.13	-0.0004	0.0000	0.60	10.01	-0.28	-0.17	-0.03	0.87

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
3A14	442.39	-0.856	-0.517	17.5	5.36	729	0.01941	102	-0.18	0.0003	0.0004	0.64	7.75	0.01	0.15	0.02	0.91
3A15	453.53	0.786	0.618	-23.7	6.07	2729	0.01833	26	-0.31	-0.0007	-0.0007	1.16	5.86	-0.02	-0.39	-0.01	1.40
3A16	455.72	0.889	-0.457	24.6	3.37	74	0.04737	66	3.30	0.0003	0.0011	3.87	5.47	1.49	0.45	0.00	2.89
3A17	445.10	-0.940	-0.340	28.6	4.89	459	0.02508	60	0.06	0.0005	0.0001	1.58	6.45	0.32	0.17	0.00	1.14
3A18	416.29	0.692	0.722	22.8	6.09	2752	0.01804	51	-1.31	0.0004	0.0001	1.37	6.52	-0.06	0.17	0.08	1.03
3A19	455.23	-0.984	-0.177	-2.9	4.91	756	0.03213	53	-0.84	0.0001	-0.0006	1.63	6.13	-0.60	-0.15	0.02	1.71
3A2	456.20	0.240	-0.971	-7.2	5.31	1403	0.02911	81	-1.84	-0.0008	0.0009	2.24	7.90	-0.83	0.00	0.13	1.99
3A20	437.56	0.928	0.372	-2.5	5.22	1165	0.02891	127	-2.32	0.0000	-0.0002	1.67	7.12	-0.35	-0.12	-0.08	1.53
3A3	447.40	-0.073	-0.997	-7.6	5.80	2429	0.02304	36	-0.70	-0.0003	0.0000	1.12	6.47	-0.20	-0.14	-0.10	0.95
3A4	343.94	-0.072	-0.997	11.3	5.09	1188	0.03357	79	0.78	0.0003	0.0002	2.28	6.26	0.07	0.20	0.09	0.80
3A5	352.37	0.929	0.370	30.0	4.39	224	0.02906	29	0.64	0.0008	0.0005	2.49	5.04	0.49	0.48	0.30	1.15
3A6	358.40	0.793	-0.609	-0.1	5.21	729	0.02283	101	-0.20	-0.0001	0.0001	1.46	7.12	-0.07	-0.04	0.05	0.97
3A8	434.75	-0.745	0.667	2.8	4.87	699	0.03218	133	0.38	0.0002	0.0001	1.94	6.93	0.23	0.01	-0.08	1.75
3A9	449.53	0.894	-0.448	-7.8	5.24	452	0.01707	78	0.06	0.0003	-0.0005	0.32	9.14	0.10	-0.06	-0.04	0.77
3B1	453.91	0.661	0.750	-11.9	5.24	715	0.02181	109	-0.23	-0.0003	-0.0001	1.16	7.28	0.05	-0.12	-0.08	0.70
3B10	445.26	-0.030	-1.000	-44.5	5.37	2379	0.03609	1036	-0.41	-0.0011	-0.0009	0.97	9.42	-0.02	-0.60	-0.34	3.23
3B11	425.30	0.497	0.868	44.0	5.46	645	0.01619	26	2.06	0.0008	0.0003	0.64	6.95	0.49	0.32	0.08	1.08

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
3B12	430.23	1.000	0.019	-2.6	6.14	13397	0.03965	379	-3.69	0.0000	-0.0007	1.41	8.40	-1.06	-0.30	-0.10	2.60
3B13	442.47	-0.568	-0.823	-1.5	4.79	510	0.02966	510	0.95	0.0000	-0.0002	1.63	8.44	0.61	-0.08	-0.03	3.27
3B14	381.15	0.685	0.728	38.1	5.77	806	0.01301	29	2.11	0.0008	0.0004	0.92	6.26	0.97	0.49	0.19	1.75
3B15	400.78	-0.385	-0.923	18.4	6.42	2956	0.01304	74	0.14	0.0001	0.0004	0.84	7.21	0.21	0.19	0.07	1.18
3B16	448.83	0.822	-0.569	29.4	3.43	66	0.04218	39	1.50	0.0010	0.0002	2.90	5.49	1.09	0.51	0.22	1.47
3B17	443.09	0.284	-0.959	27.5	5.20	566	0.02004	101	3.01	0.0007	0.0006	1.24	6.97	1.53	0.56	0.07	2.25
3B18	448.45	-0.891	-0.454	-15.5	6.59	2253	0.00916	109	0.16	-0.0002	-0.0001	0.70	8.63	-0.04	-0.13	-0.01	0.57
3B19	452.38	-0.045	-0.999	13.0	4.62	276	0.02552	53	1.08	0.0000	0.0006	2.19	5.91	0.54	0.19	0.10	1.25
3B2	454.27	-0.930	0.367	-20.2	5.74	1349	0.01799	72	0.03	-0.0004	-0.0002	0.05	15.36	0.18	-0.15	-0.16	1.31
3B20	458.38	-0.227	-0.974	37.2	4.25	163	0.02850	130	3.51	0.0012	0.0007	1.10	7.46	1.79	0.68	0.08	2.31
3B3	444.27	0.495	-0.869	-54.0	6.25	11128	0.03227	4388	-2.55	-0.0001	-0.0010	0.54	12.64	-0.87	-0.36	-0.17	1.73
3B4	358.77	0.943	-0.332	6.9	3.78	97	0.03555	97	1.95	0.0003	0.0009	3.28	6.00	1.37	0.50	0.15	1.94
3B5	347.89	-0.973	-0.231	-21.3	5.71	1533	0.01997	474	-0.31	-0.0004	-0.0001	0.47	9.85	-0.15	-0.20	-0.11	0.73
3B7	440.80	0.938	-0.345	-21.9	6.81	804	0.00346	11	0.30	0.0002	-0.0006	0.23	7.27	0.21	-0.04	-0.04	0.60
3B8	380.77	0.995	0.105	1.3	5.81	1213	0.01570	99	0.71	-0.0004	0.0006	1.47	6.95	0.28	0.13	0.03	1.21
3B9	381.02	-0.157	0.988	-2.8	6.00	3020	0.02084	69	-0.98	0.0000	-0.0001	1.40	6.58	0.22	0.00	-0.03	1.58
3C1	458.60	0.952	0.306	29.4	5.57	344	0.01005	42	1.67	0.0006	0.0004	0.78	7.91	1.07	0.38	0.12	2.09

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}--------)		°		(---------------m---------------)			
3C10	372.69	-0.888	-0.459	34.6	2.70	38	0.06710	39	3.47	0.0017	0.0002	5.28	4.65	1.87	0.88	0.35	2.45
3C11	443.68	-0.839	-0.545	13.8	6.36	1158	0.00806	16	-0.15	-0.0001	0.0001	0.32	6.00	0.20	0.07	0.08	0.80
3C12	457.02	0.958	-0.288	12.0	5.40	898	0.02091	83	-0.19	0.0003	-0.0004	0.74	7.52	0.36	-0.04	-0.05	0.94
3C13	450.61	0.513	0.858	7.6	5.10	549	0.02204	75	-0.19	0.0001	0.0006	1.76	6.35	0.39	0.36	0.27	1.78
3C14	377.57	0.021	-1.000	-3.4	6.05	2198	0.01668	211	-0.40	-0.0001	0.0000	1.38	7.60	0.04	-0.05	-0.03	1.14
3C15	449.72	-0.663	-0.749	-16.1	5.28	1787	0.03394	113	-0.88	-0.0005	-0.0004	1.81	6.69	-0.29	-0.28	-0.06	0.97
3C16	442.86	0.195	0.981	53.0	5.85	513	0.00914	26	1.13	0.0005	0.0007	0.72	6.15	0.72	0.42	0.15	1.02
3C17	378.79	0.794	-0.608	-35.8	5.01	1057	0.03422	573	-2.55	-0.0013	-0.0002	1.40	12.51	-0.88	-0.58	-0.32	1.21
3C18	387.82	0.088	-0.996	25.0	7.07	1206	0.00317	26	-1.02	0.0000	0.0003	0.27	7.13	0.50	0.12	0.04	1.37
3C19	447.99	-0.601	-0.799	45.6	6.19	896	0.00849	38	1.81	0.0002	0.0011	0.56	6.87	1.00	0.50	0.22	1.52
3C2	353.46	0.411	-0.912	-8.9	6.64	2827	0.00986	189	-0.66	-0.0001	0.0002	0.87	7.89	-0.12	0.01	0.02	0.79
3C20	445.82	-0.884	0.468	14.7	5.67	1095	0.01735	33	0.23	0.0002	0.0001	0.83	6.73	0.22	-0.01	0.09	0.81
3C3	358.05	0.963	-0.270	33.8	5.43	270	0.01026	42	1.13	0.0002	0.0007	0.73	6.96	1.01	0.37	0.12	1.50
3C4	355.79	0.898	-0.440	25.4	4.98	303	0.01818	55	1.63	0.0006	0.0003	1.34	6.67	0.85	0.34	0.11	1.28
3C6	452.60	0.936	-0.353	30.1	5.29	681	0.02014	42	0.83	0.0005	0.0001	1.48	6.15	0.64	0.24	0.07	0.93
3C7	454.27	-0.716	0.698	-20.1	5.89	593	0.00944	31	-0.22	-0.0002	-0.0001	0.20	8.07	0.21	-0.05	-0.03	0.79
3C8	443.93	0.236	0.972	-1.6	4.51	735	0.04800	340	-3.57	0.0000	-0.0003	2.41	7.66	-0.96	-0.18	-0.03	3.94

APPENDIX G. GAUSSIAN FILTERED DEM AND DERIVATIVES

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
1A10	426.06	0.642	0.766	2.6	5.46	331	0.0111	331	4.33	0.0000	0.0001	1.01	8.40	0.62	0.07	0.01	2.87
1A11	405.35	0.065	0.998	7.9	6.22	3408	0.0177	168	0.06	0.0001	-0.0001	0.74	8.03	-0.02	-0.01	0.00	0.84
1A12	450.59	0.715	-0.699	54.5	7.32	2404	0.0036	30	0.74	0.0002	0.0003	0.29	7.30	0.51	0.20	0.07	0.89
1A13	449.64	0.923	0.384	12.6	6.04	2580	0.0184	134	-0.58	0.0002	0.0002	1.03	7.52	0.31	0.16	0.05	2.11
1A14	437.10	-0.869	0.496	9.0	5.44	803	0.0188	87	1.38	0.0002	0.0006	1.74	6.52	0.93	0.30	0.09	1.32
1A15	409.54	0.952	0.307	3.1	6.44	2444	0.0115	192	0.23	0.0001	0.0001	0.93	7.93	0.31	0.07	0.02	1.02
1A16	448.53	0.548	-0.837	43.8	7.96	3985	0.0019	20	1.36	0.0000	0.0004	0.16	7.48	0.58	0.14	0.05	0.91
1A17	428.86	0.982	-0.188	-5.6	5.89	1643	0.0170	257	0.23	-0.0001	0.0000	1.20	8.22	0.18	-0.03	-0.01	1.18
1A18	444.70	-0.424	-0.906	-3.4	4.65	412	0.0306	292	-0.51	-0.0002	0.0002	1.89	7.69	-0.15	0.00	0.02	2.67
1A19	436.67	0.994	-0.107	10.3	4.85	302	0.0209	143	2.16	0.0003	0.0002	1.74	7.01	0.82	0.20	0.07	2.29
1A2	460.22	-0.522	-0.853	2.5	6.98	2973	0.0067	320	-0.63	0.0000	0.0000	0.29	9.68	-0.07	-0.01	0.00	0.66
1A20	448.58	-1.000	0.023	16.5	4.52	254	0.0272	72	2.60	0.0006	0.0005	2.17	6.10	1.37	0.46	0.13	2.61
1A4	444.15	-0.070	-0.998	8.7	4.40	149	0.0234	128	2.37	0.0003	0.0002	1.81	6.88	0.56	0.18	0.05	2.66
1A5	351.88	0.670	0.742	-30.0	7.31	26339	0.0163	325	-2.21	-0.0002	-0.0002	0.41	9.43	-0.52	-0.16	-0.05	0.98
1A6	355.33	0.980	0.199	27.1	4.99	628	0.0267	56	2.12	0.0007	0.0007	2.13	5.93	1.47	0.59	0.18	1.73
1A7	349.93	-0.169	-0.986	-0.1	7.08	19074	0.0177	155	-0.51	0.0000	-0.0002	1.01	7.80	-0.26	-0.08	-0.02	0.64
1A8	449.31	-0.967	-0.255	10.4	6.19	3149	0.0175	75	1.06	0.0002	0.0005	1.50	6.52	0.35	0.30	0.09	2.24

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
1A9	411.96	0.675	-0.738	-19.5	6.00	2623	0.0195	225	-0.14	-0.0003	-0.0002	1.07	8.16	-0.18	-0.22	-0.06	0.98
1B1	456.07	-0.425	-0.905	-30.6	6.76	10926	0.0184	262	-1.05	-0.0004	-0.0003	1.17	8.05	-0.57	-0.27	-0.12	1.33
1B10	438.52	-0.811	0.585	-3.6	5.48	2003	0.0295	318	-2.38	-0.0001	0.0000	1.19	8.21	-0.80	-0.08	0.00	2.09
1B11	411.50	-0.836	0.549	-15.1	6.17	2742	0.0166	2327	0.57	-0.0003	0.0000	0.89	9.76	-0.34	-0.13	-0.04	1.97
1B12	438.66	-0.490	0.872	5.9	5.12	513	0.0209	218	2.98	0.0002	0.0002	1.49	7.79	0.53	0.14	0.04	3.19
1B13	448.12	-0.841	0.541	7.9	7.55	8809	0.0065	273	0.38	0.0000	0.0000	0.19	9.92	0.09	0.03	0.01	0.43
1B14	428.16	0.240	-0.971	21.0	6.76	2669	0.0083	95	1.17	0.0002	0.0002	0.49	8.06	0.38	0.15	0.04	1.54
1B15	447.64	-0.633	-0.774	-13.8	5.68	1384	0.0195	879	-1.20	-0.0004	-0.0001	1.31	9.11	-0.37	-0.18	-0.06	1.90
1B16	377.15	0.984	-0.180	-11.2	7.33	19429	0.0134	505	-1.59	-0.0002	-0.0001	0.80	9.19	-0.43	-0.12	-0.04	1.13
1B17	444.98	0.542	-0.841	48.0	7.16	5463	0.0078	21	-1.06	0.0005	0.0007	0.58	6.23	0.18	0.39	0.19	1.44
1B18	440.80	-0.190	-0.982	-4.2	4.49	318	0.0317	318	-0.92	-0.0002	0.0003	2.29	7.61	-0.30	0.05	0.02	2.52
1B19	412.29	-0.812	0.584	12.8	5.97	2969	0.0213	111	-0.70	0.0003	-0.0002	1.13	7.26	0.15	0.06	0.01	1.30
1B2	444.68	-0.455	0.891	-26.6	6.63	3625	0.0115	132	0.68	-0.0002	-0.0001	0.34	8.89	0.14	-0.14	-0.04	0.94
1B20	431.74	-1.000	0.025	-53.7	7.31	24205	0.0156	1438	-1.19	-0.0002	-0.0006	0.35	12.69	-0.56	-0.31	-0.11	1.41
1B3	443.77	0.954	0.301	0.9	7.28	4960	0.0064	92	0.91	0.0000	0.0001	0.38	8.18	0.44	0.07	0.01	1.13
1B4	452.26	0.026	-1.000	34.3	4.19	94	0.0227	44	6.39	0.0013	-0.0001	1.43	6.11	1.71	0.53	0.16	3.68
1B5	347.20	0.738	0.675	3.0	7.88	24182	0.0080	110	1.51	0.0000	-0.0001	0.51	8.03	0.23	-0.02	-0.01	1.39

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(--------------m--------------)			
1B6	358.47	0.999	0.034	0.3	6.59	5371	0.0150	99	0.31	0.0000	0.0002	1.24	7.27	0.24	0.07	0.02	1.24
1B7	353.15	-0.422	0.906	-2.6	7.40	7937	0.0073	119	0.09	0.0000	0.0000	0.55	8.07	0.07	0.01	0.01	0.40
1B8	351.95	0.576	-0.818	5.9	6.65	4967	0.0135	152	0.05	0.0001	0.0001	0.97	7.66	0.25	0.08	0.03	0.97
1B9	441.44	0.027	1.000	8.1	4.97	213	0.0151	213	0.57	0.0002	0.0003	1.14	7.88	0.53	0.19	0.06	1.75
1C1	443.28	0.774	-0.633	-2.4	6.07	1562	0.0135	304	0.03	0.0000	-0.0001	1.65	7.96	0.22	-0.01	0.00	1.10
1C10	441.14	-0.811	-0.585	19.3	6.91	2604	0.0067	69	1.21	0.0002	0.0001	0.48	7.58	0.50	0.13	0.04	0.84
1C11	414.86	-0.525	0.851	-8.3	4.11	313	0.0468	313	-2.20	-0.0005	-0.0003	3.21	7.44	-0.69	-0.31	-0.11	2.54
1C12	450.03	0.434	-0.901	2.4	5.87	1235	0.0148	373	-0.18	0.0000	0.0000	0.65	8.97	-0.03	0.00	0.00	1.25
1C13	451.48	-0.920	0.392	38.1	7.83	5233	0.0030	35	0.89	0.0002	0.0001	0.22	7.66	0.30	0.14	0.05	1.14
1C14	420.13	0.965	-0.262	15.1	5.00	493	0.0233	117	0.56	0.0005	-0.0002	1.50	6.96	0.48	0.13	0.04	1.71
1C15	448.86	-0.631	0.776	-34.6	7.44	20715	0.0124	157	-2.11	0.0000	-0.0005	0.47	8.75	-0.59	-0.26	-0.06	1.38
1C16	449.24	0.729	-0.684	-1.4	6.45	3377	0.0135	228	-0.19	0.0000	0.0000	0.77	8.44	-0.14	-0.01	0.00	1.24
1C17	443.09	0.987	-0.163	-45.6	7.60	18159	0.0095	183	-0.72	-0.0003	-0.0002	0.68	11.22	-0.36	-0.21	-0.08	0.87
1C18	440.77	-0.533	0.846	-20.4	6.88	3014	0.0077	155	-0.05	-0.0002	0.0000	0.72	8.08	0.21	-0.05	-0.04	0.58
1C19	433.67	-0.712	-0.702	13.2	3.81	153	0.0437	153	-1.14	0.0007	0.0000	2.80	6.85	0.53	0.27	0.11	3.23
1C2	444.37	0.474	-0.880	39.1	7.32	2963	0.0043	19	3.46	0.0002	0.0008	0.27	7.11	1.22	0.42	0.12	1.91
1C20	434.53	0.524	0.852	6.6	5.71	1605	0.0203	207	1.71	0.0001	0.0005	1.40	7.69	0.34	0.24	0.09	2.63

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
1C3	343.45	0.663	0.749	8.5	5.10	257	0.0146	131	2.26	0.0002	0.0001	1.03	7.67	0.82	0.14	0.03	1.95
1C4	355.86	-0.931	0.365	-9.9	5.52	645	0.0153	384	0.18	-0.0002	0.0001	0.93	8.83	-0.12	-0.06	-0.01	1.38
1C5	352.99	0.961	0.277	-1.0	6.81	8587	0.0153	90	-0.15	0.0002	-0.0003	0.71	7.55	-0.03	-0.03	-0.01	0.49
1C6	349.22	-0.939	-0.345	-2.2	7.03	8629	0.0119	143	-0.26	0.0000	0.0000	1.12	7.47	-0.16	0.00	0.00	0.74
1C7	352.12	0.493	-0.870	-9.0	5.92	1858	0.0175	168	0.35	-0.0001	-0.0001	1.08	7.94	-0.14	-0.10	-0.03	0.97
1C8	425.17	0.949	0.315	10.3	5.93	2002	0.0181	150	-0.18	0.0003	-0.0001	1.11	7.84	0.17	0.07	0.01	1.32
1C9	413.57	0.805	-0.593	18.1	4.08	135	0.0310	69	2.04	0.0007	0.0007	2.51	6.14	1.29	0.56	0.17	1.84
2A1	455.28	-0.982	-0.189	23.2	2.98	62	0.0646	62	4.31	0.0017	0.0001	4.25	5.48	3.14	0.80	0.21	4.35
2A10	368.34	-0.112	0.994	-7.7	5.31	980	0.0240	608	-0.92	-0.0002	0.0001	0.75	9.32	-0.12	-0.05	0.00	2.57
2A11	453.45	-0.342	0.940	11.6	3.84	78	0.0300	78	2.10	0.0004	0.0007	2.61	6.09	1.21	0.45	0.14	2.31
2A12	441.28	0.815	0.580	3.3	4.25	212	0.0329	112	1.51	0.0001	0.0005	2.85	6.43	0.92	0.26	0.07	3.75
2A13	443.77	0.306	0.952	11.0	5.53	1059	0.0198	80	2.97	0.0003	0.0004	1.62	6.73	0.82	0.26	0.08	1.63
2A14	452.66	0.843	0.538	17.2	6.63	3107	0.0105	30	2.72	0.0006	-0.0002	0.52	7.00	0.77	0.21	0.06	2.07
2A16	437.03	-0.684	-0.730	0.4	3.61	249	0.0691	249	-0.55	0.0000	0.0003	5.12	6.63	0.78	0.14	0.04	4.35
2A17	413.58	0.969	-0.248	18.0	4.06	89	0.0255	89	2.59	0.0005	0.0000	1.54	6.76	1.49	0.24	0.06	2.54
2A18	450.09	0.997	-0.073	-8.2	6.37	7629	0.0231	112	-0.41	0.0005	-0.0009	0.97	7.49	0.11	-0.14	-0.07	1.52
2A19	447.22	-0.559	0.829	50.7	4.84	350	0.0229	36	4.99	0.0006	0.0021	2.13	5.46	2.13	1.12	0.38	3.01

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
2A2	452.36	0.233	-0.973	-13.7	5.58	3026	0.0328	163	-0.12	0.0000	-0.0007	2.95	6.66	0.03	-0.30	-0.10	1.57
2A20	378.51	-0.883	0.469	19.8	4.34	135	0.0235	101	2.14	0.0005	0.0008	1.52	6.80	1.59	0.54	0.11	2.43
2A3	455.54	0.777	-0.630	20.5	3.04	66	0.0628	66	4.44	0.0014	0.0002	4.21	5.48	3.36	0.73	0.14	4.59
2A4	451.15	0.823	-0.568	7.4	4.72	625	0.0355	106	-0.74	0.0003	0.0001	2.91	6.22	0.47	0.18	0.06	1.16
2A6	453.10	0.692	-0.722	39.8	6.43	1312	0.0080	33	4.62	0.0003	0.0009	0.67	6.86	1.93	0.52	0.15	3.17
2A7	343.20	0.416	-0.909	3.8	4.18	264	0.0396	178	-0.31	0.0002	0.0001	3.91	6.45	0.08	0.15	0.07	2.39
2A8	441.35	0.807	0.591	10.9	5.82	5064	0.0336	131	-0.77	0.0004	-0.0005	1.62	7.09	0.06	-0.05	-0.03	1.57
2A9	446.92	0.723	0.691	1.0	6.49	5057	0.0162	755	-1.95	0.0000	0.0001	2.13	8.46	-0.59	0.03	0.02	1.53
2B1	455.95	0.878	0.479	-66.4	7.54	12031	0.0080	210	-0.42	-0.0004	-0.0002	0.42	10.83	-0.07	-0.21	-0.12	1.55
2B10	456.12	0.390	0.921	31.8	6.31	1434	0.0098	50	1.48	0.0001	0.0007	0.84	6.81	0.73	0.31	0.08	0.99
2B11	454.94	-0.149	-0.989	-15.2	5.61	3242	0.0331	785	-3.12	-0.0005	-0.0006	1.93	8.87	-1.12	-0.47	-0.14	2.83
2B13	439.24	-0.905	-0.426	37.6	6.12	3674	0.0204	47	-1.85	0.0004	0.0005	1.62	6.02	0.20	0.34	0.13	1.91
2B14	455.86	0.771	-0.636	-19.9	4.81	739	0.0350	119	1.50	-0.0002	-0.0007	2.16	6.70	0.52	-0.28	-0.13	1.46
2B15	457.57	0.898	0.440	-17.2	4.42	146	0.0225	146	4.38	-0.0009	0.0010	2.55	6.95	2.01	0.17	0.00	3.75
2B16	423.22	-0.602	0.799	-6.0	4.50	408	0.0356	408	0.33	-0.0004	0.0004	3.27	7.55	0.10	0.00	0.00	2.17
2B17	400.43	0.111	-0.994	-2.4	6.37	11793	0.0291	133	-0.84	0.0000	-0.0004	1.34	10.49	-0.08	-0.15	-0.06	0.58
2B18	447.92	0.836	0.548	9.7	4.98	1403	0.0412	93	0.44	0.0004	-0.0006	2.21	6.45	0.40	-0.03	-0.04	1.82

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
2B2	442.96	0.590	-0.808	-34.8	7.23	36146	0.0213	348	-3.47	-0.0005	-0.0005	1.13	11.01	-1.50	-0.41	-0.09	2.88
2B20	452.96	-0.998	0.069	1.9	5.22	1496	0.0331	117	0.84	0.0002	-0.0005	1.85	6.75	0.64	-0.06	-0.05	2.23
2B3	462.61	-0.243	0.970	85.6	4.93	25	0.0043	10	5.35	0.0017	0.0012	0.26	6.34	3.16	1.16	0.35	3.97
2B4	453.25	0.801	-0.599	-3.5	5.51	3701	0.0393	205	-2.80	-0.0001	-0.0007	1.71	10.44	-0.77	-0.29	-0.10	1.53
2B5	450.18	0.425	0.905	-20.0	4.52	482	0.0381	325	0.90	-0.0009	-0.0004	2.93	7.33	-0.31	-0.51	-0.19	2.99
2B6	343.41	0.810	-0.587	6.1	6.24	5272	0.0220	110	1.00	0.0001	0.0002	1.58	6.92	0.31	0.14	0.05	1.77
2B7	455.88	0.973	0.231	28.2	4.76	684	0.0356	58	3.71	0.0012	0.0001	2.15	6.06	1.06	0.50	0.14	2.51
2B8	450.89	-0.463	-0.886	-5.5	4.36	1373	0.0770	348	-3.48	0.0000	-0.0015	2.40	7.89	-1.84	-0.64	-0.19	4.86
2B9	423.36	-0.859	-0.513	14.2	3.94	218	0.0462	218	-0.64	0.0008	0.0002	2.82	6.96	0.76	0.42	0.15	4.69
2C1	457.44	0.380	0.925	21.3	3.92	60	0.0240	60	4.60	0.0008	0.0011	2.10	6.00	2.32	0.78	0.23	3.00
2C10	432.16	0.928	0.373	4.8	5.93	12084	0.0468	157	-4.09	0.0004	-0.0010	1.97	7.21	-1.10	-0.27	-0.08	2.50
2C11	428.03	0.987	0.161	-18.8	5.57	10451	0.0629	279	-2.23	-0.0007	-0.0014	2.82	7.30	-1.28	-0.80	-0.26	2.66
2C12	452.21	0.666	-0.746	-0.5	5.01	315	0.0181	310	5.04	0.0001	0.0008	2.50	7.43	1.89	0.34	0.08	3.60
2C13	446.74	0.952	0.305	6.2	5.86	5307	0.0329	292	-1.86	0.0002	-0.0005	1.52	7.85	-0.37	-0.10	-0.05	2.02
2C15	444.75	0.867	-0.498	15.5	5.64	4578	0.0382	50	-1.05	0.0010	-0.0007	1.68	6.00	-0.77	0.07	0.10	1.49
2C16	439.09	0.956	-0.294	13.8	4.51	146	0.0205	116	1.83	0.0005	0.0005	1.51	6.97	1.05	0.39	0.11	2.46
2C17	407.45	0.895	-0.447	-3.5	4.45	571	0.0448	571	-1.70	-0.0002	0.0001	2.59	8.06	-0.79	-0.10	0.00	4.16

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
2C18	430.56	-0.371	-0.929	2.9	3.57	224	0.0686	224	-1.75	0.0002	0.0002	3.82	6.72	0.39	0.21	0.03	5.08
2C19	453.36	0.764	-0.645	-11.4	5.17	539	0.0204	505	1.66	-0.0004	0.0001	1.36	8.56	0.66	-0.07	-0.04	2.02
2C2	446.79	0.912	-0.410	-18.2	5.31	626	0.0189	537	1.60	-0.0007	0.0003	1.67	8.38	0.20	-0.12	-0.06	1.90
2C20	452.66	-0.860	0.511	-23.2	6.22	9897	0.0313	284	-1.46	-0.0003	-0.0006	1.00	8.26	-0.96	-0.40	-0.09	1.95
2C21	410.70	-0.927	-0.375	-3.1	5.38	245	0.0103	93	3.82	-0.0004	0.0005	0.90	7.39	1.83	0.12	0.02	3.03
2C3	449.33	0.880	-0.474	5.5	5.80	2358	0.0228	131	-0.90	0.0001	-0.0003	1.20	7.31	-0.10	-0.07	-0.03	0.96
2C4	370.45	0.627	-0.779	2.6	5.23	785	0.0232	108	2.36	-0.0001	0.0007	2.55	6.42	0.58	0.30	0.10	1.61
2C5	345.07	-0.859	-0.512	24.7	4.22	63	0.0177	62	3.34	0.0006	0.0004	1.36	6.62	1.83	0.42	0.12	2.81
2C6	404.26	-0.783	0.622	30.1	5.55	262	0.0088	53	2.24	0.0002	0.0004	0.74	6.89	1.07	0.23	0.06	1.70
2C7	457.85	0.564	0.825	-0.6	3.75	133	0.0433	133	4.62	0.0000	0.0002	3.71	6.19	1.29	0.10	0.01	3.30
2C8	445.51	-0.586	0.810	-0.9	5.76	938	0.0143	167	1.88	0.0000	0.0003	0.86	7.99	0.62	0.14	0.04	1.63
2C9	410.88	0.625	-0.781	1.4	3.83	153	0.0428	153	0.70	0.0001	-0.0001	2.78	6.61	0.42	0.02	0.00	1.89
3A1	449.13	-0.951	0.310	23.7	6.44	4121	0.0153	58	1.23	0.0003	0.0004	1.26	6.53	0.65	0.29	0.09	1.11
3A10	434.28	-0.094	0.996	15.0	4.91	370	0.0220	95	1.08	0.0004	0.0003	1.78	6.80	0.59	0.31	0.11	1.76
3A11	458.38	-0.394	0.919	23.8	4.61	63	0.0114	62	6.70	0.0002	0.0008	1.11	6.80	2.46	0.45	0.12	4.32
3A12	452.54	0.741	0.672	17.2	5.93	1601	0.0160	85	0.26	0.0003	0.0000	1.02	7.03	0.28	0.14	0.04	0.98
3A13	451.53	0.662	-0.750	-15.3	6.32	7710	0.0246	293	-1.05	-0.0002	-0.0002	0.73	8.85	-0.25	-0.16	-0.04	0.83

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
3A14	442.37	-0.304	0.953	6.3	6.99	10092	0.0136	1370	-0.19	0.0001	0.0003	0.88	7.44	-0.01	0.13	0.05	0.88
3A15	453.53	0.816	0.578	-34.1	6.03	5807	0.0288	256	0.08	-0.0006	-0.0005	1.00	8.25	-0.01	-0.41	-0.14	1.33
3A16	455.73	-0.648	0.762	19.8	5.72	1446	0.0191	66	4.01	0.0006	0.0008	1.85	6.17	1.53	0.54	0.16	2.85
3A17	445.10	-0.878	0.478	23.3	7.03	8311	0.0118	63	0.64	0.0003	0.0002	0.86	6.94	0.34	0.18	0.06	1.11
3A18	416.22	0.147	-0.989	22.5	6.95	9977	0.0142	67	-1.30	0.0004	-0.0001	0.84	7.25	-0.13	0.09	0.04	1.02
3A19	455.21	0.671	0.742	-6.5	5.73	2664	0.0262	172	-0.76	0.0000	-0.0005	1.44	7.39	-0.62	-0.20	-0.06	1.66
3A2	456.07	-0.200	-0.980	-14.9	5.53	2264	0.0296	1077	-2.33	-0.0007	0.0004	2.21	8.38	-0.94	-0.22	-0.03	1.98
3A20	437.64	0.932	-0.363	0.7	5.81	2328	0.0224	222	-1.52	0.0000	-0.0001	1.54	7.80	-0.26	-0.04	-0.01	1.47
3A3	447.50	-0.861	0.508	-2.9	6.82	9046	0.0156	221	-0.69	-0.0001	-0.0001	1.04	8.02	-0.11	-0.04	-0.02	0.88
3A4	343.86	-0.847	0.531	8.4	5.72	2627	0.0262	93	0.68	0.0002	0.0001	1.95	6.65	-0.01	0.12	0.05	0.75
3A5	352.09	-0.071	-0.997	14.1	6.39	5367	0.0188	80	0.03	0.0003	0.0003	1.55	6.56	0.21	0.19	0.09	1.01
3A6	358.35	-0.999	-0.053	-6.8	5.76	1825	0.0208	237	-0.19	-0.0002	-0.0001	1.42	7.72	-0.10	-0.11	-0.02	0.91
3A8	434.83	0.457	0.889	4.0	4.41	183	0.0256	165	1.01	0.0001	0.0001	2.02	7.07	0.32	0.10	0.03	1.73
3A9	449.56	-0.987	-0.161	4.4	6.51	3181	0.0122	124	0.45	0.0002	-0.0003	0.51	8.30	0.12	-0.01	-0.02	0.67
3B1	453.98	-0.990	-0.139	-9.1	6.59	4341	0.0134	115	0.21	-0.0002	0.0001	0.92	7.45	0.12	-0.06	-0.03	0.63
3B10	445.58	-0.455	0.890	-27.2	5.17	689	0.0230	349	0.65	-0.0006	-0.0001	1.36	8.47	0.32	-0.24	-0.14	3.22
3B11	425.23	0.461	0.887	31.6	6.27	1441	0.0102	43	1.87	0.0004	0.0002	0.78	6.61	0.42	0.26	0.10	1.00

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			°		m^2	radians	m^2	m	(--------m^{-1}-------)		°		(---------------m---------------)			
3B12	430.32	0.356	-0.935	-3.1	6.37	20375	0.0389	554	-3.68	-0.0001	-0.0005	1.47	8.79	-1.00	-0.25	-0.07	2.55
3B13	442.50	0.460	0.888	-0.4	4.72	436	0.0294	436	1.07	0.0000	-0.0002	1.78	8.18	0.66	-0.05	-0.02	3.25
3B14	380.97	0.515	0.857	26.3	6.27	2183	0.0129	52	1.70	0.0005	0.0004	0.96	6.92	0.79	0.36	0.12	1.62
3B15	400.72	0.843	0.537	12.4	6.37	3118	0.0142	124	-0.02	0.0001	0.0003	0.81	7.73	0.15	0.14	0.05	1.15
3B16	448.62	0.685	0.728	21.6	5.70	2517	0.0262	62	1.44	0.0006	0.0002	1.93	6.18	0.89	0.34	0.11	1.27
3B17	443.03	-0.908	-0.419	53.0	5.79	1086	0.0150	35	3.17	0.0006	0.0008	1.16	6.19	1.49	0.56	0.17	2.16
3B18	448.46	0.613	0.790	-37.0	7.72	10853	0.0059	383	0.12	-0.0002	-0.0001	0.33	9.97	-0.03	-0.11	-0.04	0.55
3B19	452.29	0.665	0.747	-4.5	5.89	824	0.0114	244	1.38	-0.0001	0.0004	1.47	7.74	0.46	0.11	0.04	1.16
3B2	454.42	-0.700	0.714	-0.6	7.61	11149	0.0069	75	1.21	-0.0001	0.0000	0.27	8.45	0.34	0.05	-0.02	1.30
3B20	458.31	-0.980	0.197	43.3	4.30	93	0.0201	39	3.54	0.0010	0.0007	1.48	5.88	1.72	0.74	0.21	2.20
3B3	444.43	-0.659	-0.752	-57.1	7.13	28124	0.0205	24096	-2.20	-0.0004	-0.0002	0.09	15.38	-0.72	-0.22	-0.08	1.59
3B4	358.63	0.945	0.326	6.6	4.34	242	0.0321	96	1.70	0.0003	0.0007	2.93	6.11	1.23	0.43	0.13	1.78
3B5	348.00	0.947	0.321	-16.3	6.30	2293	0.0129	166	0.17	-0.0003	0.0000	1.00	7.73	-0.04	-0.11	-0.03	0.66
3B7	440.84	-0.946	0.325	-6.2	7.87	7762	0.0039	48	0.56	0.0001	0.0000	0.09	8.93	0.24	0.02	-0.02	0.58
3B8	380.74	0.501	0.865	-1.0	7.05	9323	0.0121	107	0.68	-0.0003	0.0005	1.14	7.29	0.25	0.12	0.03	1.17
3B9	381.05	-0.888	0.460	4.4	6.80	5054	0.0114	73	-0.79	0.0001	0.0000	0.83	7.30	0.24	0.06	0.00	1.55
3C1	458.49	0.103	0.995	25.7	5.91	1097	0.0132	67	1.57	0.0005	0.0003	0.83	7.02	0.97	0.32	0.10	1.99

Site ID	Elev	N	E	CI	SWI	MCA	CS	CA	Relelev 135	Crosc 63	Profc 63	Slope 9	TWI	TPI 150	TPI 60	TPI 30	TRI 65
	m			º		m^2	radians	m^2	m	(--------m^{-1}-------	-)	º		(---------------	m	---------------	-)
3C10	372.37	-0.642	-0.767	36.6	4.55	340	0.0308	44	3.17	0.0012	0.0003	2.12	5.74	1.56	0.62	0.21	2.10
3C11	443.61	-0.992	0.124	4.4	6.78	4966	0.0116	142	-0.08	0.0000	0.0000	0.28	8.81	0.14	0.00	0.00	0.74
3C12	457.07	0.845	-0.535	13.7	6.32	3059	0.0148	117	0.23	0.0002	-0.0002	0.81	7.62	0.41	0.03	0.00	0.93
3C13	450.36	1.000	-0.029	2.3	4.98	505	0.0240	254	-0.62	0.0001	0.0003	1.82	7.55	0.15	0.12	0.05	1.70
3C14	377.60	0.184	-0.983	-3.0	6.76	6075	0.0134	229	-0.14	0.0000	0.0000	1.34	10.89	0.07	-0.02	-0.01	1.10
3C15	449.77	0.181	0.984	-13.2	6.10	5377	0.0256	144	-0.88	-0.0003	-0.0004	1.40	7.23	-0.24	-0.24	-0.08	0.90
3C16	442.72	-0.700	0.714	58.7	7.03	1958	0.0048	26	0.98	0.0003	0.0005	0.39	6.80	0.59	0.30	0.11	0.89
3C17	379.09	-0.059	0.998	-26.9	6.22	6322	0.0246	348	-1.64	-0.0004	-0.0004	1.01	10.89	-0.59	-0.31	-0.12	0.91
3C18	387.78	0.657	-0.754	17.8	7.30	3428	0.0049	67	-0.90	0.0000	0.0002	0.25	8.31	0.46	0.09	0.03	1.31
3C19	447.79	-0.938	0.345	30.2	6.66	2525	0.0090	39	1.28	0.0001	0.0007	0.66	6.76	0.80	0.32	0.11	1.33
3C2	353.44	-0.996	0.093	-5.5	7.44	15936	0.0106	787	-0.71	-0.0001	0.0001	0.87	9.55	-0.14	-0.01	0.00	0.76
3C20	445.73	-0.869	-0.495	-5.7	6.38	3130	0.0140	173	0.13	-0.0002	-0.0001	1.04	7.75	0.13	-0.09	-0.02	0.73
3C3	357.94	-0.619	0.786	28.4	6.10	889	0.0094	48	1.01	0.0001	0.0006	0.72	6.98	0.90	0.30	0.09	1.38
3C4	355.69	-0.602	0.798	23.0	6.00	1660	0.0151	68	1.48	0.0005	0.0002	1.11	6.90	0.76	0.28	0.09	1.19
3C6	452.53	0.361	0.932	26.8	6.47	2510	0.0112	54	0.67	0.0004	0.0001	0.71	7.16	0.57	0.21	0.06	0.82
3C7	454.30	-0.834	0.552	-18.2	7.24	3428	0.0053	271	0.68	-0.0002	0.0001	0.42	9.13	0.25	-0.02	-0.02	0.73
3C8	443.96	0.257	-0.967	-3.1	4.42	569	0.0461	441	-3.40	-0.0001	-0.0003	2.27	8.01	-0.95	-0.20	-0.05	3.89

APPENDIX H. FIELD NOTES AND PROFILE DESCRIPTIONS

Investigators: MPB – Meyer Bohn; DGH – David Hopkins; RE – Ross Effertz; BM – Brittney Morse; DS – Dean Steele; ST – Sheldon Tuscherer; SC – Samantha Croat; MR – MacKenzie Ries; JS – J. Stanley; CG – Caley Gasch

Abbreviations; C – Concave; V – Convex; L – Linear; SU – Summit; SH – Shoulder; BS – Backslope; FS – Footslope; TS – Toeslope; LD – lithologic discontinuity

Sample ID: 411 **Soil Series:** Svea **Site ID:** 1A1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.508403, 46.902008 **Legal:** 140-62-33

Date: 7/21/2017 **Time:** 9:00 AM **Weather:** Overcast **Temperature (ºF):** 75 **PDOP:** 1.7

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** > 50 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: 6 to 9 percent slope; CC lower BS; uncultivated area; many visible bleached sand grains throughout profile.

A1- 0 to 10 cm; sandy clay loam, (10YR 2/1) moist; moderate medium granular parting to weak fine granular; very friable; many fine roots; many very fine parting to fine pores; many earthworm casts; noneffervescent; smooth abrupt boundary.

A2- 10 to 22 cm; (10YR 2/1) moist; moderate medium granular parting to weak fine granular; very friable; common parting to many very fine parting to fine roots; many very fine parting to fine pores; high earthworm activity; medium granules are all earthworm casts; noneffervescent; wavy clear boundary.

B- 22 to 50 cm; (10YR 3/1) moist; moderate medium prismatic; very friable; common parting to many very fine parting to fine roots; many very fine pores; bleached sand grains increase with depth; common earthworm casts; common fine pores; noneffervescent.

Sample ID: 271 **Soil Series:** Barnes/Svea **Site ID:** 1A10 **Crew:** MPB & RE

County: Barnes **DDD:** -98.03034, 46.751092 **Legal:** 138-58-20

Date: 5/18/2017 **Time:** 1:45 PM **Weather:** Sunny **Temperature (ºF):** 55 **PDOP:** 1.7

Depth of mollic colors: 36 cm **Depth of mollic epipedon:** 26 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 6 to 17 cm, friable

Site notes: 1 percent slope, nearly level; BS.

Ap- 0 to 15 cm; silty clay loam, (10YR 2/1) moist; weak medium subangular blocky parting to weak fine parting to medium granular; very friable; common very fine roots; moderately few very fine pores; bleached sand grains; few medium earthworm casts; noneffervescent; smooth abrupt boundary.

A- 15 to 26 cm; (10YR 2/1) moist; moderate medium prismatic; very friable; moderately few very fine roots; moderately few fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; smooth clear boundary.

Bw1- 26 to 36 cm; (10YR 3/2) moist; moderate medium prismatic; very friable; common fine roots; common fine pores; common very fine pores and fine pores; fine pores contain Bw2 material from earthworm casts; noneffervescent; smooth clear boundary.

Bw2- 36 to 50 cm; (2.5Y 4/3) moist; moderate medium prismatic; very friable; moderately few very fine roots; common fine pores; noneffervescent.

Sample ID: 1 **Soil Series:** Barnes **Site ID:** 1A11 **Crew:** MPB & BM

County: Barnes **DDD:** -97.83921, 46.93844 **Legal:** 140-57-14

Date: 7/7/2016 **Time:** 7:40 AM **Weather:** Sunny **Temperature (ºF):** 66 **PDOP:** 1.9

Depth of mollic colors: 39 cm **Depth of mollic epipedon:** 24 cm **Depth to carbonates:** 39 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 21 to 28 cm

Site notes: Wet conditions; recent rain.

Ap- 0 to 24 cm; clay, (10YR 2/1) moist; weak coarse subangular blocky parting to weak medium parting to coarse granular; friable; common very fine parting to fine roots; common very fine pores; conditions are too moist to determine plow pan; most obvious platy (mechanical) structure from 21 to 28 cm; common earthworms; noneffervescent; smooth abrupt boundary.

Bw- 24 to 39 cm; (10YR 3/3) moist; moderate coarse prismatic; friable; few fine roots; many very fine parting to fine pores; many medium pores; fine carbonate masses at 28 cm, could be biotic or from plowing; biotic mixing of calcic material in medium pores; unmixed zones are leached of carbonates; noneffervescent; wavy abrupt boundary.

Bk- 39 to 50 cm; (2.5Y 6/2) moist; very friable; strongly effervescent.

Sample ID: 406 **Soil Series:** Sioux **Site ID:** 1A12 **Crew:** MPB & RE

County: Barnes **DDD:** -98.314257, 46.88759 **Legal:** 139-61-1

Date: 6/22/2017 **Time:** 3:40 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.6

Depth of mollic colors: 25 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 25 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 3 to 19 cm, firm

Site notes: Common coarse gravels and cobbles while digging; summit of broad flat 3 to 6 percent slope; 10 percent surface gravels.

Ap- 0 to 18 cm; loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; few very fine roots; few very fine pores; parts to platy (mechanical) structure; moderately smeared; few fine tubular earthworm pores filled with calcic and cambic material; 10 percent mixed eroded remnant cambic; noneffervescent; smooth very abrupt boundary.

2Bw- 18 to 25 cm; loamy sand, (10YR 3/3) moist; weak medium prismatic; friable; very few very fine roots; parts to platy (mechanical) structure at top of prismatic structural units; noneffervescent; wavy clear boundary.

2Bk- 25 to 50 cm; gravelly loamy sand, (10YR 4/4) moist; weak medium parting to coarse prismatic; few very fine roots; common very fine pores; strongly effervescent.

Sample ID: 4 **Soil Series:** Barnes **Site ID:** 1A13 **Crew:** MPB, DS, & ST

County: Barnes **DDD:** -98.127484, 46.894852 **Legal:** 140-59-33

Date: 8/22/2016 **Time:** 12:00 PM **Weather:** Sunny **Temperature (ºF):** 83 **PDOP:** 1.6

Depth of mollic colors: 47 cm **Depth of mollic epipedon:** 25 cm **Depth to carbonates:** 32 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 5 to 25 cm, very firm

Site notes: Initial dig exposed large 25 cm diameter krotovina at mid depth of the cambic horizon; krotovina was highly bioturbated; contained cambic, mollic, and calcic material.

Ap- 0 to 25 cm; clay loam, (10YR 2/1) moist; weak fine granular parting to strong coarse subangular blocky; firm parting to very firm; many very fine parting to fine roots; very few very fine pores; parts to weak fine granular structure from 0 to 5 cm where soybean roots are most dense; few medium tubular earthworm pores; parts to strong platy (mechanical) structure; noneffervescent; wavy clear boundary.

Bw- 25 to 47 cm; (2.5Y 3/3) moist; weak medium prismatic; friable; moderately few very fine roots; common very fine pores; few fine carbonate masses around 32 cm, areal coverage of carbonate masses increases to common with depth; higher sand content; light clay loam; slightly effervescent parting to strongly effervescent; wavy clear boundary.

Bk- 47 to 50 cm; (2.5Y 5/3) moist; friable; common small and medium gravel sized pieces of shale; common fine carbonate masses and few threadlike carbonate masses; strongly effervescent.

Sample ID: 359 **Soil Series:** Buse **Site ID:** 1A14 **Crew:** MPB & RE

County: Barnes **DDD:** -98.280738, 47.044098 **Legal:** 141-60-9

Date: 6/20/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 1.4

Depth of mollic colors: 16 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 7 to 22 cm, firm

Site notes: VL BS; 6 percent slope.

Ap- 0 to 16 cm; clay loam, (10YR 3/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine roots; few very fine pores; raindrop surface impact crust; smeared; parts to platy (mechanical) structure; few carbonate stains from plow mixing; few casts; strongly effervescent; wavy very abrupt boundary.

Bk1- 16 to 34 cm; (2.5Y 5/3) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) structure at top of prismatic structural units; few medium tubular earthworm pores filled with mollic casts; strongly effervescent; wavy parting to irregular abrupt boundary.

Bk2- 34 to 50 cm; (2.5Y 5/4) moist; moderate medium prismatic; very friable; few very fine roots; many very fine pores; slightly effervescent parting to strongly effervescent.

Sample ID: 7 **Soil Series:** Heimdal **Site ID:** 1A15 **Crew:** MPB & BM

County: Barnes **DDD:** -97.823313, 46.734391 **Legal:** 138-57-25

Date: 7/21/2016 **Time:** 1:55 PM **Weather:** Sunny **Temperature (ºF):** 84 **PDOP:** 2.2

Depth of mollic colors: 25 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 8 to 20 cm, firm

Site notes:

Ap- 0 to 20 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky; firm; common very fine roots; few very fine pores; parts to platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 20 to 25 cm; sandy clay loam, (10YR 2/2) moist; moderate medium parting to coarse prismatic; friable; few fine roots; many very fine pores; noneffervescent; smooth clear boundary.

Bw2- 25 to 50 cm; sandy loam, (2.5Y 4/3) moist; few very fine parting to fine roots; many very fine pores; few faint discontinuous cutans; few medium tubular earthworm pores filled with mollic material; noneffervescent.

Sample ID: 309 **Soil Series:** Embden **Site ID:** 1A16 **Crew:** MPB & RE

County: Barnes **DDD:** -98.251947, 46.76424 **Legal:** 138-60-16

Date: 5/25/2017 **Time:** 3:30 PM **Weather:** Sunny **Temperature (ºF):** 60 **PDOP:** 1.6

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 28 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 6 to 23 cm, friable

Site notes: Broad flat on a 2 percent slope; sandy textured area.

Ap- 0 to 13 cm; sandy loam, (10YR 2/1) moist; weak parting to moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common very fine parting to fine pores; parts to platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

A- 13 to 28 cm; sandy loam, (10YR 2/1) moist; weak parting to moderate medium prismatic; friable; moderately few very fine roots; common very fine parting to fine pores; platy (mechanical) structure; common fine tubular earthworm pores; few parting to common casts; noneffervescent; smooth very abrupt boundary.

Bw- 28 to 50 cm; sandy loam, (10YR 2/2) moist; weak parting to moderate medium prismatic; friable; moderately few parting to common very fine roots; many very fine pores; common fine tubular earthworm pores; noneffervescent.

Sample ID: 288 **Soil Series:** Svea/Thick Barnes **Site ID:** 1A17 **Crew:** MPB & RE

County: Barnes **DDD:** -97.99672, 47.004921 **Legal:** 141-58-26

Date: 5/24/2017 **Time:** 11:00 AM **Weather:** Partly cloudy **Temperature (ºF):** 60 **PDOP:** 1.8

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 28 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 13 cm, friable

Site notes: LC 2 percent slope; common bleached sand grains.

Ap- 0 to 13 cm; clay loam, (10YR 2/1) moist; weak fine granular; friable; common very fine parting to fine roots; common fine pores; parts to platy (mechanical) structure; common medium earthworm casts; noneffervescent; smooth clear boundary.

A- 13 to 28 cm; (10YR 2/1) moist; moderate fine parting to medium prismatic; friable; common very fine roots; common very fine pores; noneffervescent; smooth abrupt boundary.

Bw- 28 to 50 cm; (10YR 3/2) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; faint discontinuous cutans on sides and tops of peds; common fine pores; noneffervescent; smooth abrupt boundary.

Sample ID: 336 **Soil Series:** Barnes **Site ID:** 1A18 **Crew:** MPB, RE, & SC

County: Barnes **DDD:** -98.08099, 47.01709 **Legal:** 141-58-19

Date: 6/8/2017 **Time:** 9:34 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.8

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 12 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 7 to 22 cm, firm

Site notes: 3 percent slope LV BS; shallow drainage 30 meters to the S; Bk horizon at 50 cm; extremely dry here; tried to compensate for how I would anticipate the soil to behave under moist conditions.

Ap- 0 to 12 cm; sandy clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; very few very fine pores; parts to platy (mechanical) structure; roots matted against horizontal platy (mechanical) structural units; smeared; thirty percent organic stains on sides and tops of peds; noneffervescent; smooth abrupt boundary.

Bw1- 12 to 23 cm; (10YR 3/2) moist; moderate medium prismatic; friable; moderately few very fine roots; common very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; smooth clear boundary.

Bw2- 23 to 50 cm; (2.5Y 3/3) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; few fine carbonate masses from 45 to 50 cm; noneffervescent.

Sample ID: 285 **Soil Series:** Buse **Site ID:** 1A19 **Crew:** MPB & RE

County: Barnes **DDD:** -98.046904, 46.932754 **Legal:** 140-58-19

Date: 5/24/2017 **Time:** 9:00 AM **Weather:** Sunny **Temperature (ºF):** 60 **PDOP:** 1.9

Depth of mollic colors: 14 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** 14 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 4 to 14 cm, firm

Site notes: LL 3 percent slope; large gravels and small cobbles to the SW.

Ap- 0 to 14 cm; clay loam, (10YR 2/2) moist; moderate medium subangular blocky; friable parting to firm; moderately few very fine roots; very few very fine pores; common tubular earthworm pores filled with calcic material; smeared; parts to platy (mechanical) structure; noneffervescent parting to very slightly effervescent; smooth very abrupt boundary.

Bk1- 14 to 33 cm; (10YR 5/3) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; remnant cambic colors; 5 to 10 percent carbonate masses; few fine tubular earthworm pores filled with mollic; violently effervescent; smooth clear boundary.

Bk2- 33 to 50 cm; (10YR 5/4) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; 30 percent carbonate masses; violently effervescent.

Sample ID: 623 **Soil Series:** Saline Forman w/ LD **Site ID:** 1A2 **Crew:** MPB & DGH

County: Stutsman **DDD:** -98.628392, 46.988006 **Legal:** 141-63-35

Date: 9/1/2017 **Time:** 9:30 AM **Weather:** Rainy **Temperature (ºF):** 60 **PDOP:** 1.6

Depth of mollic colors: 35 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 5 to 33 cm, firm

Site notes: FS; long gently undulating field near saline affected soybeans.

Apz- 0 to 18 cm; loam, (10YR 3/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; common very fine roots; few fine pores; tighter loam; run on sands; parts to thin platy (mechanical) structure near boundary; common fine salts at plow pan and the Bwz boundaries; noneffervescent; smooth very abrupt boundary.

Bw- 18 to 35 cm; gravelly (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; common fine salt crystal nests where horizon parts to platy (mechanical) structure at the top of prismatic structural units at boundary; noneffervescent; wavy clear boundary.

2Bt1- 35 to 47 cm; sandy clay loam, (10YR 4/3) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; distinct continuous cutans 90 percent by coverage on interstructural voids; many bridged bleached sand grains; noneffervescent; wavy abrupt boundary.

3Bt2- 47 to 50 cm; silty clay loam, (10YR 4/3) moist; light silty clay loam (sandier); silt lens below coarse textured horizon; noneffervescent.

Sample ID: 10 **Soil Series:** Truncated Barnes **Site ID:** 1A20 **Crew:** MPB, DS, & ST

County: Barnes **DDD:** -98.127854, 46.898648 **Legal:** 140-59-33

Date: 8/22/2016 **Time:** 10:00 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.4

Depth of mollic colors: 13 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 23 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 13 cm, firm

Site notes: VV 3 to 6 percent slope; soybean field; NE aspect.

Ap- 0 to 13 cm; clay loam, (10YR 2/2) moist; weak fine granular parting to moderate medium subangular blocky; friable parting to firm; common very fine roots; few very fine pores; few fine parting to medium tubular earthworm pores; few fine earthworm casts; upper 4 cm are weak fine granular; parts to weak platy (mechanical) structure, plate cleavage is not as planar; lacks matted roots usually associated with platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw- 13 to 23 cm; (10YR 4/2) moist; moderate coarse prismatic; friable parting to firm; moderately few very fine roots; common very fine pores; few parting to common organic stains on sides and tops of peds; few medium pores; faunal mixing of calcic material; noneffervescent; smooth abrupt boundary.

Bk- 23 to 50 cm; (2.5Y 5/4) moist; moderate coarse prismatic; very friable; moderately few very fine roots; many very fine pores; few fine carbonate masses; strongly effervescent.

Sample ID: 403 **Soil Series:** Beach sand; misfit stream terrace **Site ID:** 1A3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.490133, 46.880554 **Legal:** 139-62-3

Date: 6/22/2017 **Time:** 1:50 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.6

Depth of mollic colors: 0 cm **Depth of mollic epipedon:** 0 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: LV; roughly 1 acre sandy outcrop, 1 km east of river valley, sand and gravel pits nearby; corn is yellow and stunted; old flood plain terrace; plow pan too difficult to determine.

Ap- 0 to 10 cm; loamy sand, (10YR 4/3) moist; weak very fine subangular blocky; loose; moderately few very fine roots; very moist conditions; couldn't determine plow pan or pores; slightly effervescent; smooth very abrupt boundary.

Bk1- 10 to 26 cm; fine sand, (10YR 6/3) moist; weak medium prismatic; loose; irregular undulating carbonate masses at boundary; strongly effervescent; irregular very abrupt boundary.

Bk2- 26 to 50 cm; (10YR 5/3) moist; weak medium prismatic; loose; common fine carbonate masses irregularly distributed throughout matrix; slightly effervescent parting to strongly effervescent.

Sample ID: 409 **Soil Series:** Truncated Forman **Site ID:** 1A4 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.50762, 46.905582 **Legal:** 140-62-33

Date: 7/21/2017 **Time:** 7:58 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.4

Depth of mollic colors: 19 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 10 to 25 cm, firm

Site notes: Complex 3 to 6 percent slope; gentle depression on SH; soil is extremely dry; moved site 3 meters N to stay in sampling pixel; few coarse gravels and pebbles while digging.

Ap- 0 to 19 cm; sandy clay loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to moderate medium parting to coarse granular; friable; common parting to many very fine roots; common parting to many very fine parting to fine pores; moderately smeared; platy (mechanical) structure; where there is a dense concentration of wheat roots at the surface, parts to weak fine granular structure; higher clay content and medium granular aggregates; noneffervescent; smooth very abrupt boundary.

Bt- 19 to 50 cm; sandy clay (10YR 3/4) moist; strong medium parting to coarse prismatic parting to moderate parting to strong medium angular blocky; friable parting to firm; moderately few very fine roots; many very fine parting to fine pores; 60 percent distinct discontinuous parting to continuous cutans on all sides of peds; common medium tubular earthworm pores filled with mollic material; very fine pores lined with cutans; common bridged sand grains; noneffervescent; wavy clear boundary.

Sample ID: 13 **Soil Series:** Svea **Site ID:** 1A5 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.631135, 46.750371 **Legal:** 138-55-21

Date: 6/13/2016 **Time:** 2:19 PM **Weather:** Sunny **Temperature (ºF):** 82 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 31 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: Leached of carbonates beyond 50 cm; very few salts in A horizon; abundant salts about 30 to 40 m away.

Ap- 0 to 12 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky; firm; common very fine roots; few very fine pores; noneffervescent; smooth very abrupt boundary.

A- 12 to 31 cm; (10YR 2/1) moist; moderate very coarse prismatic; firm; common very fine roots; common very fine pores; noneffervescent; wavy clear boundary.

Bw- 31 to 50 cm; (10YR 3/2) moist; friable; noneffervescent.

Sample ID: 16 **Soil Series:** Barnes **Site ID:** 1A6 **Crew:** MPB & DGH

County: Cass **DDD:** -97.637975, 46.77924 **Legal:** 138-55-9

Date: 6/17/2016 **Time:** 1:44 PM **Weather:** Sunny **Temperature (ºF):** 77 **PDOP:** 1.6

Depth of mollic colors: 33 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 33 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Barnes site on shoulder; surface is effervescent from calcic slope wash colluvium; Wetlands to the N and W of knoll.

Ap- 0 to 19 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky; friable; common fine roots; few fine pores; common medium tubular earthworm pores; common earthworm casts; platy (mechanical) structure 4 cm thick above horizon boundary; slightly effervescent; smooth very abrupt boundary.

Bw- 19 to 33 cm; (10YR 3/3) moist; moderate coarse parting to very coarse prismatic; friable; few fine roots; many very fine pores; mixed inclusions of finely disseminated carbonates that are strongly effervescent; majority of matrix is leached; noneffervescent; smooth abrupt boundary.

Bk - 33 to 50 cm; (10YR 5/3) moist; very friable; strongly effervescent.

Sample ID: 19 **Soil Series:** Buse **Site ID:** 1A7 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.623858, 46.74769 **Legal:** 138-55-21

Date: 6/10/2016 **Time:** 1:00 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2

Depth of mollic colors: 30 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** 9 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes:

Ap- 0 to 22 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky; very friable parting to friable; moderately few fine roots; very few very fine pores; noneffervescent; smooth abrupt boundary.

Bk1- 22 to 30 cm; (10YR 3/1) moist; weak coarse prismatic parting to weak parting to moderate medium subangular blocky; very friable parting to friable; many fine roots; many fine pores; strongly effervescent;

Bk2- 30 to 50 cm; (10YR 4/1) moist; common very fine roots; many fine pores; strongly effervescent.

Sample ID: 299 **Soil Series:** Barnes **Site ID:** 1A8 **Crew:** MPB & RE

County: Barnes **DDD:** -98.067837, 47.02033 **Legal:** 141-58-19

Date: 5/24/2017 **Time:** 3:30 PM **Weather:** Partly cloudy **Temperature (ºF):** 60 **PDOP:** 1.7

Depth of mollic colors: 16 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 28 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 5 to 19 cm, firm

Site notes: Matrix becomes coarser with depth; increase in coarse sands to medium gravels.

Ap- 0 to 16 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine roots; moderately few parting to common very fine parting to fine pores; parts to platy (mechanical) structure; slightly smeared; noneffervescent; smooth very abrupt boundary.

Bw- 16 to 28 cm; (2.5Y 4/4) moist; moderate medium prismatic; friable parting to firm; moderately few parting to common very fine parting to fine roots; many very fine pores; 10 percent small to medium gravels and coarse sands; 30 to 40 percent faint parting to distinct continuous cutans (2.5Y 3/2) on interstructural voids; noneffervescent; smooth clear boundary.

2Bk- 28 to 50 cm; fine sandy loam, (10YR 5/3) moist; moderate medium prismatic; very friable; moderately few parting to common very fine parting to fine roots; common very fine parting to fine pores; slightly effervescent parting to strongly effervescent.

Sample ID: 246 **Soil Series:** Coarse-mantled clayey Barnes **Site ID:** 1A9 **Crew:** MPB & RE

County: Barnes **DDD:** -97.86689, 46.742955 **Legal:** 138-57-27

Date: 5/15/2017 **Time:** 3:12 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.1

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 38 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Glaciofluvial outwash; slightly convex SH/upper interfluve 3 percent slope; stone line from 34 to 38 cm (7.5YR 4/6); lower portion was heavier textured.

Ap- 0 to 18 cm; loam, (10YR 3/1) moist; moderate medium subangular blocky parting to weak fine granular; very friable; common very fine roots; moderately few very fine pores; noneffervescent; wavy abrupt boundary.

Bw- 18 to 38 cm; sandy clay loam, (10YR 3/3) moist; moderate medium prismatic; very friable; common very fine roots; many very fine pores; few organic stains on sides and tops of peds; few tubular earthworm pores filled with mollic; noneffervescent; smooth clear boundary.

2Bk- 38 to 50 cm; clay loam, (2.5Y 5/4) moist; weak medium parting to coarse prismatic; very friable; many very fine roots; many very fine pores; violently effervescent.

Sample ID: 520 **Soil Series:** Saline Barnes **Site ID:** 1B1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.558159, 47.024966 **Legal:** 141-62-17

Date: 8/1/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.1

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 25 cm, firm

Site notes: Original site near artificially cut surface drain; moved site 10 m south within sampling pixel; stunted soybeans most likely salt effected; at the lower third of a 3 to 6 percent slope BS.

Apz- 0 to 23 cm; clay loam, (10YR 3/1) moist; strong medium parting to coarse subangular blocky parting to moderate medium granular; friable; common very fine parting to fine roots; moderately few very fine parting to fine pores; heavy clay loam; platy (mechanical) structure; roots matted against horizontal faces of platy structural units; salts more soluble than gypsum visible with 10x lens; noneffervescent; wavy very abrupt boundary.

Bwz- 23 to 38 cm; (10YR 3/2) moist; strong medium parting to coarse prismatic; friable; moderately few very fine parting to fine roots; common very fine pores; parts to platy (mechanical) at the top of prismatic structural units; salts more soluble than gypsum visible with 10x lens; noneffervescent; wavy abrupt boundary.

Byz- 38 to 50 cm; (2.5Y 4/3) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; few fine gypsum crystal nests; some nests are in filament shape; noneffervescent.

Sample ID: 22 **Soil Series:** Truncated Barnes **Site ID:** 1B10 **Crew:** MPB & BM

County: Barnes **DDD:** -97.875618, 46.932559 **Legal:** 140-57-21

Date: 7/7/2016 **Time:** 9:00 AM **Weather:** Partly cloudy **Temperature (ºF):** 73 **PDOP:** 2.2

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 12 cm **Depth to carbonates:** 17 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 8 to 15 cm, firm

Site notes: Pit wall has broken cambic horizon boundaries; wheat field.

Ap- 0 to 12 cm; clay loam, (10YR 2/2) moist; moderate coarse subangular blocky parting to weak medium granular; friable; many very fine roots; few very fine pores; parts to platy (mechanical) structure; common fine earthworm casts noneffervescent; smooth abrupt boundary.

Bw- 12 to 27 cm; (10YR 3/3) moist; moderate coarse prismatic; friable; common very fine roots; many fine pores; severely truncated and mixed; organic stains on sides of peds; slightly effervescent; smooth gradual boundary.

Bk- 27 to 50 cm; (2.5Y 3/6.5) moist; moderate coarse parting to very coarse prismatic; friable; few parting to common very fine roots; many very fine pores; few fine carbonate masses from 40 to 50 cm; strongly effervescent.

Sample ID: 25 **Soil Series:** Argillic Svea **Site ID:** 1B11 **Crew:** MPB & BM

County: Barnes **DDD:** -97.83805, 46.790882 **Legal:** 138-57-2

Date: 7/25/2016 **Time:** 3:30 PM **Weather:** Sunny **Temperature (ºF):** 88 **PDOP:** 2.1

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 40 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 24 cm

Site notes: Very western edge of sampling pixel; had to move 4 meters E.

Ap- 0 to 19 cm; clay, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine parting to medium granular; common very fine roots; very few very fine pores; few medium tubular earthworm pores; fine quartz sand grains more noticeable with the dark mollic colors; noneffervescent; smooth very abrupt boundary.

A- 19 to 40 cm; (10YR 2/1) moist; moderate coarse prismatic; friable; common very fine roots; many very fine pores; noneffervescent; smooth gradual boundary.

Bt- 40 to 50 cm; (10YR 3/1) moist; friable; few very fine roots; many very fine pores; distinct continuous cutans on all sides of peds; noneffervescent.

Sample ID: 28 **Soil Series:** Barnes **Site ID:** 1B12 **Crew:** MPB & BM

County: Barnes **DDD:** -97.889948, 46.850756 **Legal:** 139-57-16

Date: 7/20/2016 **Time:** 2:40 PM **Weather:** Partly cloudy **Temperature (ºF):** 85 **PDOP:** 2

Depth of mollic colors: 28 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 17 cm, friable to firm

Site notes:

Ap- 0 to 17 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine parting to medium granular; friable; common very fine parting to fine roots; moderately few very fine pores; noneffervescent; smooth very abrupt boundary.

Bw1- 17 to 28 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; moderately few fine roots; many very fine pores; common medium parting to coarse pores either void or filled with mollic casts; few faint discontinuous cutans on all sides of peds; borderline transitional zone between Ap and Bw; noneffervescent; smooth clear boundary.

Bw2- 28 to 50 cm; (2.5Y 4/4) moist; moderate coarse prismatic; friable; few fine roots; many very fine pores; noneffervescent.

Sample ID: 603 **Soil Series:** Barnes **Site ID:** 1B13 **Crew:** MPB, DGH, & MR

County: Barnes **DDD:** -98.26166, 46.905076 **Legal:** 140-60-33

Date: 8/25/2017 **Time:** 9:22 AM **Weather:** Overcast **Temperature (ºF):** 60 **PDOP:** 2.1

Depth of mollic colors: 34 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 34 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 3 to 27 cm, firm

Site notes:

Ap- 0 to 18 cm; loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; few fine roots; few fine pores; platy (mechanical) structure; corn roots matted against horizontal faces of platy structural units; fine parting to medium tubular earthworm pores; very few parting to few earthworm casts; mixed eroded cambic material; tight clay loam; noneffervescent; smooth very abrupt boundary.

Bw- 18 to 34 cm; clay loam, (10YR 3/2) moist; moderate coarse prismatic; few very fine roots; many very fine pores; light clay loam; 40 percent organic stains on interstructural voids; few medium earthworm pores, some filled with calcic material; parts to platy (mechanical) structure at top of prismatic structural units; strong cambic development; very fine pores lined with cutans; noneffervescent; wavy abrupt boundary.

Bk- 34 to 50 cm; (2.5Y 6/3) moist; moderate coarse prismatic; very friable; few very fine roots; many very fine pores; 10 percent gravel lens at 50 cm; strongly effervescent.

Sample ID: 255 **Soil Series:** Renshaw **Site ID:** 1B14 **Crew:** MPB & RE

County: Barnes **DDD:** -97.894345, 46.726403 **Legal:** 138-57-32

Date: 5/17/2017 **Time:** 12:30 PM **Weather:** Overcast **Temperature (ºF):** 50 **PDOP:** 1.9

Depth of mollic colors: 50 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 7 to 15 cm

Site notes: A broad flat; artificial drainage cut to the NE; long esker ridge to the N, oriented E to W; similar to Renshaw, but with a lithologic discontinuity at 25 cm; leached of carbonates beyond 50 cm; shallow Spottswood.

Ap- 0 to 18 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky; friable; common very fine roots; common fine pores; few fine parting to medium pores filled with cambic material; smeared plowed structure; noneffervescent; smooth abrupt boundary.

Bw1- 18 to 25 cm; (10YR 3/2) moist; moderate fine parting to medium prismatic; friable; common very fine roots; many very fine pores; common organic stains on sides of peds; few medium pores filled with mollic; noneffervescent; wavy clear boundary.

2Bw2- 25 to 50 cm; gravelly coarse sandy loam, (10YR 3/3) moist; moderate medium prismatic; friable; moderately few fine roots; common very fine pores; glaciofluvial outwash; noneffervescent.

Sample ID: 31 **Soil Series:** Svea **Site ID:** 1B15 **Crew:** MPB, DS, & ST

County: Barnes **DDD:** -98.121242, 46.873708 **Legal:** 139-59-10

Date: 8/22/2016 **Time:** 3:00 PM **Weather:** Sunny **Temperature (ºF):** 83 **PDOP:** 1.8

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 33 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 15 to 23 cm, friable

Site notes:

Ap- 0 to 19 cm; clay loam, (10YR 2/1) moist; weak fine granular parting to moderate coarse subangular blocky; very friable; common very fine parting to fine roots; common medium pores; parts to weak fine granular from 0 to 6 cm; weak platy (mechanical) structure; common medium tubular earthworm pores and few fine pores; noneffervescent; smooth abrupt boundary.

A- 19 to 33 cm; (10YR 2/1) moist; moderate very coarse prismatic; friable; common very fine roots; many very fine pores; common medium tubular earthworm pores with moderately few medium casts; noneffervescent; smooth gradual boundary.

Bw- 33 to 50 cm; (10YR 2/2) moist; moderate coarse prismatic; friable; moderately few very fine roots; many very fine pores; noneffervescent.

Sample ID: 34 **Soil Series:** Sioux/Arvilla **Site ID:** 1B16 **Crew:** MPB & BM

County: Barnes **DDD:** -97.752698, 46.840481 **Legal:** 139-56-21

Date: 7/19/2016 **Time:** 8:10 AM **Weather:** Sunny **Temperature (ºF):** 68 **PDOP:** 1.9

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** 30 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 9 to 24 cm, very firm

Site notes: Beyond 50 cm, below the discontinuity there is a 3C horizon; slightly to strongly effervescent; light clay loam; oxidized colors in gravel lens above layer of lower permeability; may indicate presence of an oxygenated perched water table.

Ap- 0 to 22 cm; clay, (10YR 2/1) moist; moderate coarse subangular blocky; firm; common fine roots; few very fine pores; noneffervescent; smooth very abrupt boundary.

Bw- 22 to 30 cm; (10YR 4/2) moist; moderate coarse prismatic; moderately few fine roots; many very fine pores; common faint continuous organic stains on sides and tops of peds; typical cambic morphology, but has lower chroma and a higher value than normally observed; noneffervescent; smooth abrupt boundary.

2BC- 30 to 50 cm; gravelly clay loam, (10YR 3/6) moist; slightly effervescent.

Sample ID: 517 **Soil Series:** Barnes **Site ID:** 1B17 **Crew:** MPB & RE

County: Barnes **DDD:** -98.435877, 46.797123 **Legal:** 138-61-6

Date: 7/28/2017 **Time:** 3:30 PM **Weather:** Sunny **Temperature (ºF):** 72 **PDOP:** 1.5

Depth of mollic colors: 35 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** strongly effervescent **Plow pan range:** 6 to 32 cm, firm

Site notes: Corn field; Carbonates at 51 cm

Ap- 0 to 13 cm; sandy clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; common parting to many very fine roots; few very fine pores; platy (mechanical) structure; eroded mixed cambic colors; roots matted against horizontal platy (mechanical) structural units; noneffervescent; smooth very abrupt boundary.

Bw1- 13 to 35 cm; (10YR 3/2) moist; moderate parting to strong medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; very fine pores lined with cutans; common faint discontinuous cutans on all sides of peds; bridged sand grains; excellently developed cambic borderline argillic; common medium pores partially filled with mollic earthworm casts; parts to platy (mechanical) at the top of prismatic structural units; noneffervescent; wavy abrupt boundary.

Bw2- 35 to 50 cm; (2.5Y 4/3) moist; moderate medium parting to coarse prismatic; friable parting to firm; moderately few very fine roots; many very fine pores; 15 percent faint patchy cutans on tops and sides of peds; noneffervescent.

Sample ID: 37 **Soil Series:** Barnes **Site ID:** 1B18 **Crew:** MPB & BM

County: Barnes **DDD:** -97.898057, 46.91859 **Legal:** 140-57-29

Date: 7/7/2016 **Time:** 10:45 AM **Weather:** Overcast **Temperature (ºF):** 70 **PDOP:** 1.5

Depth of mollic colors: 39 cm **Depth of mollic epipedon:** 39 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 15 to 20 cm, friable

Site notes: Moved 2 m NW to stay in sampling pixel.

Ap- 0 to 20 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to moderate fine parting to medium granular; friable; common very fine parting to fine roots; few very fine pores; platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

Bw1- 20 to 39 cm; (10YR 3/2.5) moist; moderate coarse prismatic; common very fine parting to fine roots; many very fine parting to fine pores; common medium tubular earthworm pores; strongly expressed cambic; still has mollic color and structure; noneffervescent; smooth abrupt boundary.

Bw2- 39 to 50 cm; (2.5Y 4/4) moist; friable; noneffervescent.

Sample ID: 249 **Soil Series:** Svea **Site ID:** 1B19 **Crew:** MPB & RE

County: Barnes **DDD:** -97.852671, 46.79845 **Legal:** 138-57-3

Date: 5/17/2017 **Time:** 9:14 AM **Weather:** Overcast **Temperature (ºF):** 49 **PDOP:** 2.1

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 42 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 9 to 23 cm

Site notes: Drainages nearby; may have been an old wetland at one time; feels very mellow; high organic matter.

Ap- 0 to 11 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate coarse granular; very friable; many medium roots; many fine pores; platy (mechanical) structure from 9 to 23 cm; common medium tubular earthworm pores; few to common earthworm casts; bleached sand grains; noneffervescent; smooth clear boundary.

A- 11 to 42 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; very friable; moderately few very fine roots; many very fine parting to fine pores; common medium tubular earthworm pores; noneffervescent; smooth clear boundary.

Bw- 42 to 50 cm; (10YR 3/1) moist; moderate medium prismatic; very friable; common fine roots; many fine pores; noneffervescent.

Sample ID: 616 **Soil Series:** Svea **Site ID:** 1B2 **Crew:** MPB, DS, & ST

County: Stutsman **DDD:** -98.504585, 46.818395 **Legal:** 139-62-33

Date: 8/30/2017 **Time:** 11:30 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.8

Depth of mollic colors: 47 cm **Depth of mollic epipedon:** 25 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 5 to 22 cm, firm

Site notes: Swale surrounded by 3 to 6 percent slopes; obvious bleached sand grains throughout the profile.

Ap- 0 to 15 cm; sandy clay loam, (10YR 2/1) moist; moderate fine subangular blocky parting to weak fine granular; friable; common very fine roots; common fine parting to medium pores; thin platy (mechanical) structure; common medium earthworm tubular pores; common fine earthworm casts; noneffervescent; smooth very abrupt boundary.

A- 15 to 25 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; few very fine roots; many very fine pores; platy (mechanical) structure; common medium tubular earthworm pores; noneffervescent; wavy abrupt boundary.

Bw1- 25 to 47 cm; (10YR 2/2) moist; moderate medium prismatic; few very fine roots; many very fine pores; common medium tubular earthworm pores; noneffervescent; broken abrupt boundary.

Bw2- 47 to 50 cm; (2.5Y 5/4) moist; many bleached sand grains; many very fine pores lined with cutans; few faint patchy cutans; noneffervescent.

Sample ID: 40 **Soil Series:** Svea **Site ID:** 1B20 **Crew:** MPB & BM

County: Barnes **DDD:** -97.913484, 47.014447 **Legal:** 141-57-21

Date: 7/27/2016 **Time:** 9:30 AM **Weather:** Partly cloudy **Temperature (ºF):** 64 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** > 50 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 13 to 25 cm, friable

Site notes: Entire profile parts to some form of platy structure; not sure if pedogenic or mechanical.

Ap- 0 to 25 cm; clay loam, (10YR 2/1) moist; weak medium parting to coarse subangular blocky parting to weak fine parting to medium granular; very friable; common very fine roots; common very fine pores; noneffervescent; smooth clear boundary.

A- 25 to 50 cm; (10YR 2.5/1) moist; moderate medium parting to coarse platy parting to moderate medium parting to coarse prismatic; friable; moderately few very fine roots; common very fine pores; primary platy structure; secondary prismatic; noneffervescent.

Sample ID: 561 **Soil Series:** Barnes **Site ID:** 1B3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.441374, 46.737963 **Legal:** 138-62-25

Date: 8/15/2017 **Time:** 1:00 PM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 1.7

Depth of mollic colors: 21 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** 46 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 7 to 29 cm, firm

Site notes: In a swale surrounded by broad 3 to 6 percent slopes.

Ap- 0 to 14 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky; very friable; common very fine parting to fine roots; common parting to many very fine pores; common fine parting to medium earthworm casts; noneffervescent; smooth very abrupt boundary.

Bw1- 14 to 21 cm; clay, (10YR 3/2) moist; moderate coarse prismatic; friable; common very fine parting to fine roots; many very fine pores; continuous distinct cutans on interstructural voids; patchy distinct cutans on all sides of peds; 20 percent mollic stains on sides and tops of peds; very fine pores lined with cutans on interstructural voids; noneffervescent; wavy clear boundary.

Bw2- 21 to 46 cm; (2.5Y 4/4) moist; moderate coarse prismatic; friable; moderately few very fine parting to fine roots; many very fine pores; 10YR 3/3 cutans on interstructural voids; strong cambic development; very fine pores lined with distinct cutans; common medium tubular earthworm pores; 5 percent organic stains on sides of peds; noneffervescent; wavy very abrupt boundary.

Bk- 46 to 50 cm; (2.5Y 6/4) moist; moderate medium prismatic; very friable; few very fine roots; many very fine pores; 30 percent fine carbonate masses; violently effervescent.

Sample ID: 584 **Soil Series:** Barnes **Site ID:** 1B4 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.601151, 46.881955 **Legal:** 139-63-2

Date: 8/17/2017 **Time:** 3:30 PM **Weather: Temperature (ºF): PDOP:** 1.7

Depth of mollic colors: 15 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 24 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 6 to 24 cm, firm

Site notes: 3 to 6 percent slope VV BS.

Ap- 0 to 15 cm; loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; moderately few fine pores; mixed eroded cambic material; common fine parting to medium earthworm pores; few filled with calcic and cambic; common fine earthworm casts; developed roots from mature soybean have ruptured the plow pan; noneffervescent; smooth very abrupt boundary.

Bw- 15 to 24 cm; (10YR 4/3) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; common fine pores; common fine parting to medium tubular earthworm pores filled with calcic and mollic material; noneffervescent; irregular abrupt boundary.

Bk- 24 to 50 cm; (2.5Y 5/3) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; 5 percent fine carbonate masses; few parting to common fine earthworm casts; few fine parting to medium earthworm tubular pores filled with cambic material; thin platy structure from 39 to 50 cm; violently effervescent.

Sample ID: 42 **Soil Series:** Balaton **Site ID:** 1B5 **Crew:** MPB & DGH

County: Cass **DDD:** -97.61892, 46.822789 **Legal:** 139-55-27

Date: 6/10/2016 **Time:** 10:48 AM **Weather:** Sunny **Temperature (ºF):** 77 **PDOP:** 2.3

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 5 to 34 cm

Site notes: Balaton type pedon.

Ap- 0 to 19 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate fine granular; friable parting to firm; moderately few very fine roots; very few very fine pores; slightly effervescent; smooth very abrupt boundary.

Bw- 19 to 27 cm; (10YR 2/2) moist; strong medium prismatic; common very fine roots; very few very fine pores; common very fine parting to fine roots matted against horizontal faces of platy structural units; few fine roots extending vertically; lower 6 cm has platy (mechanical) structure; strong cambic expression on ped faces; most roots are matted on ped faces; slightly effervescent;

Bk- 27 to 40 cm; (10YR 6/3) moist; strongly effervescent;

Bky- 40 to 50 cm; (2.5Y 5/3) moist; 20 to 30 percent common medium parting to coarse gypsum crystal nests; few faint redoximorphic features; slightly effervescent.

Sample ID: 46 **Soil Series:** Barnes **Site ID:** 1B6 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.524243, 46.898747 **Legal:** 140-54-32

Date: 6/8/2016 **Time:** 11:30 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 2

Depth of mollic colors: 35 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** 35 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Common fine gypsum crystal nests near 50 cm.

Ap- 0 to 22 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky; friable; common very fine parting to fine roots; few very fine pores; glossy sheen of plow pan at horizon boundary; thick platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw- 22 to 35 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; few very fine parting to fine roots; many very fine pores; noneffervescent; wavy abrupt boundary.

Bk- 35 to 50 cm; (10YR 6/3) moist; very few very fine roots; many very fine pores; strongly effervescent.

Sample ID: 49 **Soil Series:** Balaton **Site ID:** 1B7 **Crew:** MPB & DGH

County: Cass **DDD:** -97.638747, 46.884816 **Legal:** 139-55-4

Date: 6/9/2016 **Time:** 2:58 PM **Weather:** Sunny **Temperature (ºF):** 84 **PDOP:** 1.6

Depth of mollic colors: 19 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: 20 m west of artificial surface drain; Balaton type pedon.

Ap- 0 to 19 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to moderate fine granular; friable; common very fine parting to fine roots; moderately few very fine pores; slightly effervescent; smooth abrupt boundary.

Bk- 19 to 38 cm; (10YR 5/2) moist; weak coarse prismatic; few very fine parting to fine roots; many very fine pores; strongly effervescent; wavy clear boundary.

Bky- 38 to 50 cm; loam, (2.5Y 5/3) moist; weak coarse prismatic; very few very fine roots; many very fine pores; 15 to 20 percent medium parting to coarse gypsum crystal nests; strongly effervescent.

Sample ID: 52 **Soil Series:** Svea **Site ID:** 1B8 **Crew:** MPB & DGH

County: Cass **DDD:** -97.635756, 46.838154 **Legal:** 139-55-21

Date: 6/17/2016 **Time:** 2:58 PM **Weather:** Sunny **Temperature (ºF):** 73 **PDOP:** 1.6

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 32 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 20 cm, firm

Site notes: Svea type pedon; CC depression in corn field; knee high very healthy corn in between two lush shelterbelts at the BS.

Ap- 0 to 20 cm; clay, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky; friable; common fine roots; moderately few fine pores; thin platy (mechanical) structure; significant bioturbation; common medium tubular earthworm pores; noneffervescent; smooth very abrupt boundary.

A- 20 to 32 cm; (10YR 2/1) moist; moderate coarse prismatic; firm; moderately few very fine roots; common very fine pores; common medium tubular earthworm pores partially filled with casts; noneffervescent; smooth abrupt boundary.

Bw- 32 to 50 cm; (10YR 3/2) moist; moderate coarse prismatic; firm; few fine roots; many very fine pores; noneffervescent.

Sample ID: 55 **Soil Series:** Barnes **Site ID:** 1B9 **Crew:** MPB & BM

County: Barnes **DDD:** -97.9023, 46.914597 **Legal:** 140-57-29

Date: 7/8/2016 **Time:** 8:00 AM **Weather:** Sunny **Temperature (ºF):** 66 **PDOP:** 1.9

Depth of mollic colors: 19 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 19 cm, firm

Site notes: 5 percent weathered shale fragments at surface.

Ap- 0 to 19 cm; clay loam, (10YR 2/1) moist; weak medium subangular blocky parting to moderate medium granular; friable; common fine roots; few fine pores; platy (mechanical) structure; pit has clear wavy boundary; noneffervescent; smooth gradual boundary.

Bw- 19 to 50 cm; (2.5Y 5/4) moist; moderate coarse prismatic; friable; few fine roots; many fine pores; transitional zone (10YR 3/2) evidence of mixing and truncation of 2 former distinct cambic horizons; transitional zone has organic stains on tops and sides of peds; noneffervescent.

Sample ID: 558 **Soil Series:** Coarse Buse/Esmond **Site ID:** 1C1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.447237, 46.738802 **Legal:** 138-62-25

Date: 8/15/2017 **Time:** 11:00 AM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 1.3

Depth of mollic colors: 11 cm **Depth of mollic epipedon:** 11 cm **Depth to carbonates:** 17 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 3 to 28 cm, friable

Site notes: Silty at 48 cm; VC FS 5 percent complex slope; this FS acts like SH of slope below.

Ap- 0 to 11 cm; sandy clay loam, (10YR 2/2) moist; moderate fine parting to medium subangular blocky parting to weak fine granular; very friable; common fine roots; common very fine parting to fine pores; common medium tubular earthworm pores filled with cambic and calcic material; platy (mechanical) structure; noneffervescent; wavy very abrupt boundary.

2Bw- 11 to 19 cm; small gravelly sandy loam, (2.5Y 5/3) moist; weak fine parting to medium prismatic; very friable parting to friable; few very fine parting to fine roots; few very fine pores; platy (mechanical) structure; common medium tubular earthworm pores filled with calcic and mollic material; slightly effervescent; wavy clear boundary.

2Bk- 19 to 50 cm; small gravelly sandy loam, (2.5Y 5/4) moist; weak fine parting to medium prismatic; very friable; few very fine roots; many very fine pores; few large gravel sized pieces of shale; parts to platy (mechanical) structure at top of prismatic structural units; few medium faint redoximorphic depletions (5Y 5/1) lining old dendritic tubular pores from roots; strongly effervescent.

Sample ID: 57 **Soil Series:** Buse **Site ID:** 1C10 **Crew:** MPB, DGH, & CG

County: Barnes **DDD:** -98.155198, 46.904209 **Legal:** 140-59-32

Date: 10/11/2016 **Time:** 10:00 AM **Weather:** Overcast **Temperature (ºF):** 45 **PDOP:** 1.7

Depth of mollic colors: 15 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 15 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Cambic horizon has been flipped and mixed into calcic horizon.

Ap- 0 to 15 cm; loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky; friable parting to firm; common very fine roots; common fine pores; contains calcic material mixed by fauna; medium pores commonly filled with cambic material (10YR 3/3 and 4/3); discrete mixed inclusions of cambic material common throughout matrix; common medium tubular earthworm pores; noneffervescent; smooth very abrupt boundary.

Bk1- 15 to 38 cm; (10YR 6/3) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 30 to 40 percent 10YR 5/3 stains; slightly effervescent parting to strongly effervescent; wavy clear boundary.

Bk2- 38 to 50 cm; fine sandy loam, (10YR 5/3) moist; common very fine roots; common very fine pores; strongly effervescent.

Sample ID: 60 **Soil Series:** Thick Barnes **Site ID:** 1C11 **Crew:** MPB & BM

County: Barnes **DDD:** -97.831675, 46.793237 **Legal:** 138-57-2

Date: 7/25/2016 **Time:** 2:40 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.7

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 17 to 25 cm, firm

Site notes:

Ap- 0 to 22 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine parting to medium granular; friable; common very fine roots; common medium pores; common medium earthworm casts lining the medium pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 22 to 32 cm; (10YR 3/2) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; many discontinuous organic stains on all sides of peds; noneffervescent; smooth clear boundary.

Bw2- 32 to 50 cm; (2.5Y 3/2) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; few fine pores; few faint discontinuous cutans on sides and tops of peds; noneffervescent.

Sample ID: 63 **Soil Series:** Barnes **Site ID:** 1C12 **Crew:** MPB & BM

County: Barnes **DDD:** -97.898668, 46.854087 **Legal:** 139-57-17

Date: 7/20/2016 **Time:** 11:55 AM **Weather:** Overcast **Temperature (ºF): PDOP:** 1.7

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 22 cm, firm

Site notes: 2 krotovinas in pit.

Ap- 0 to 22 cm; clay, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine parting to medium granular; friable; common very fine parting to fine roots; common parting to many very fine pores; platy (mechanical) structure at plow pan; upper portion is weak fine granular; common medium tubular earthworm pores; noneffervescent; smooth very abrupt boundary.

Bw1- 22 to 29 cm; (2.5Y 4/3) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine parting to fine roots; many very fine pores; parts to platy (mechanical) structure from 22 to 27 cm, moist rupture resistance is firm; common faint discontinuous cutans on sides of peds; few faint discontinuous organic stains on sides of peds; noneffervescent; smooth clear boundary.

Bw2- 29 to 50 cm; (2.5Y 5/4) moist; moderate coarse prismatic; friable; few fine roots; few very faint discontinuous cutans on sides and tops of peds; noneffervescent.

Sample ID: 66 **Soil Series:** Barnes **Site ID:** 1C13 **Crew:** MPB & BM

County: Barnes **DDD:** -97.899204, 46.855914 **Legal:** 139-57-17

Date: 7/20/2016 **Time:** 10:50 AM **Weather:** Overcast **Temperature (ºF): PDOP:** 2.1

Depth of mollic colors: 30 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** 45 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 13 to 20 cm, firm

Site notes:

Ap- 0 to 20 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky; friable; moderately few parting to common very fine roots; moderately few fine pores; platy (mechanical) structure; bleached sand grains less than one percent noneffervescent; smooth very abrupt boundary.

A- 20 to 30 cm; (10YR 2/2) moist; moderate coarse prismatic; friable; common very fine roots; many very fine pores; common medium tubular earthworm pores; some pores are filled with cambic material; noneffervescent; irregular gradual boundary.

Bw- 30 to 45 cm; (2.5Y 4/3) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many fine pores; organic stains lining fine pores noneffervescent; smooth abrupt boundary.

Bk- 45 to 50 cm; (2.5Y 5/3) moist; 40 percent stained with colors from Bw on sides and bottoms of peds; strongly effervescent.

Sample ID: 70 **Soil Series:** Barnes **Site ID:** 1C14 **Crew:** MPB & BM

County: Barnes **DDD:** -97.862884, 46.990169 **Legal:** 141-57-35

Date: 7/8/2016 **Time:** 3:00 PM **Weather:** Sunny **Temperature (ºF):** 78 **PDOP:** 1.7

Depth of mollic colors: 41 cm **Depth of mollic epipedon:** 28 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 20 to 28 cm, firm

Site notes:

Ap- 0 to 28 cm; clay loam, (10YR 2/1) moist; strong very coarse subangular blocky parting to moderate medium granular; firm; common fine roots; common very fine pores; top 9 cm have a weak fine granular structure; lower 21 cm medium moderate subangular blocky structure; moderately few fine pores; bioturbation of cambic material noneffervescent; smooth abrupt boundary.

Bw1- 28 to 41 cm; (10YR 3/2) moist; moderate coarse parting to very coarse prismatic; friable; few very fine roots; many very fine pores; 5 percent coverage of 10YR 2/1 material from earthworm bioturbation; common faint discontinuous organic stains on tops and sides of peds; noneffervescent; smooth clear boundary.

Bw2- 41 to 50 cm; (2.5Y 5/4) moist; friable; common faint discontinuous cutans on side of peds; strong cambic expression; patchy organic stains on sides of peds; noneffervescent.

Sample ID: 73 **Soil Series:** Buse **Site ID:** 1C15 **Crew:** MPB, DGH, & CG

County: Barnes **DDD:** -98.13985, 46.832886 **Legal:** 139-59-28

Date: 10/11/2016 **Time:** 11:45 PM **Weather:** Overcast **Temperature (ºF):** 42 **PDOP:** 1.5

Depth of mollic colors: 14 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** 14 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 9 to 18 cm, firm

Site notes: Pit is variable; few remnants of cambic horizon on N side of pit; tapers from 10 cm in thickness down to 3 cm with depth; Brown for around 10-12 cm of depth.

Ap- 0 to 14 cm; loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; common very fine roots; very few very fine pores; remnant cambic colored (10YR 4/2) material; bioturbated calcic material within common medium tubular earthworm pores; noneffervescent; smooth very abrupt boundary.

Bk1- 14 to 35 cm; (10YR 5/2) moist; weak medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 50 percent (10YR 5/2); 50 percent fine carbonate masses (10YR 6/2); medium parting to coarse pores partially filled with mollic material; strongly effervescent; wavy clear boundary.

Bk2- 35 to 50 cm; (10YR 5/4) moist; weak coarse prismatic; very friable; common very fine parting to fine roots; many very fine pores; strongly effervescent.

Sample ID: 76 **Soil Series:** Barnes **Site ID:** 1C16 **Crew:** MPB & BM

County: Barnes **DDD:** -97.899849, 46.852577 **Legal:** 139-57-17

Date: 7/20/2016 **Time:** 12:45 PM **Weather:** Overcast **Temperature (ºF): PDOP:** 1.6

Depth of mollic colors: 15 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 25 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 10 to 15 cm, firm

Site notes: Moved location 3 to 5 m W of original site to avoid sampling from wrong pixel.

Ap- 0 to 15 cm; sandy clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak medium granular; friable; common fine roots; few very fine pores; platy (mechanical) structure; mixed eroded cambic discrete inclusions in mollic epipedon from tillage; bleached sand grains; light clay loam; moderately few fine roots; noneffervescent; smooth very abrupt boundary.

Bw- 15 to 25 cm; silty clay loam, (2.5Y 4/3) moist; moderate medium prismatic; friable; few fine roots; common parting to many very fine pores; platy (mechanical) structure from 0 to 5 cm; common medium tubular earthworm pores filled with mollic material; noneffervescent; smooth abrupt boundary.

Bk- 25 to 50 cm; (2.5Y 6/4) moist; very friable; strongly effervescent.

Sample ID: 368 **Soil Series:** Svea **Site ID:** 1C17 **Crew:** MPB & RE

County: Barnes **DDD:** -98.33545, 46.969014 **Legal:** 140-61-2

Date: 6/20/2017 **Time:** 3:20 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 25 cm, firm

Site notes: LL 3% BS next to enclosed depression; in a wheel track.

Ap- 0 to 10 cm; loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; few very fine roots; few very fine pores; platy (mechanical) structure; smeared; noneffervescent; smooth abrupt boundary.

A- 10 to 23 cm; (10YR 2/1) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; common earthworm casts; noneffervescent; smooth abrupt boundary.

Bw- 23 to 47 cm; (10YR 3/2) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; strong cambic development; very fine pores lined with cutans; common medium pores filled with earthworm casts; few faint discontinuous cutans; noneffervescent; smooth abrupt boundary.

Bt- 47 to 50 cm; (10YR 3/2) moist; moderate medium prismatic parting to weak parting to moderate medium angular blocky; very friable parting to friable; very few very fine roots; many very fine pores; many distinct continuous cutans on all sides of peds; unexpectedly friable for an argillic horizon; noneffervescent.

Sample ID: 538 **Soil Series:** Clayey Barnes **Site ID:** 1C18 **Crew:** MPB & RE

County: Barnes **DDD:** -98.28086, 46.967298 **Legal:** 140-60-5

Date: 8/9/2017 **Time:** 9:05 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.6

Depth of mollic colors: 40 cm **Depth of mollic epipedon:** 21 cm **Depth to carbonates:** 48 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Nearly level flat; slightly lower area; wet conditions; unsure of plow pan because of moisture.

Ap- 0 to 21 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate medium granular; very friable; common very fine roots; moderately few fine pores; tight clay loam; many continuous distinct cutans on ped faces and lining root dendritic tubular pores; few bleached sand grains coating surface; organic stains on sides of peds; common medium vesicular earthworm pores filled with earthworm casts; common fine pores; noneffervescent; wavy abrupt boundary.

Bw1- 21 to 40 cm; (10YR 3/2) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; common faint to distinct patchy cutans on all sides of peds; borderline argillic; few peds with weak angular blocky structure; common peds with thin parting to medium platy structure; noneffervescent; wavy clear boundary.

Bw2- 40 to 48 cm; (10YR 5/3) moist; moderate medium prismatic; friable; moderately few fine roots; many very fine pores; common faint to distinct patchy cutans (10YR 4/2) on all sides of peds; strong cambic development; very fine pores lined with cutans; noneffervescent; wavy abrupt boundary.

Bk- 48 to 50 cm; (10YR 6/2) moist; strongly effervescent parting to violently effervescent.

Sample ID: 79 **Soil Series:** Buse/Thin Barnes **Site ID:** 1C19 **Crew:** MPB & BM

County: Barnes **DDD:** -97.936585, 46.812771 **Legal:** 139-58-36

Date: 7/21/2016 **Time:** 8:25 AM **Weather:** Overcast **Temperature (ºF): PDOP:** 2.4

Depth of mollic colors: 18 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 26 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 11 to 18 cm, firm

Site notes:

Ap- 0 to 18 cm; clay loam, (10YR 2/2) moist; moderate coarse subangular blocky parting to moderate medium granular; friable; common very fine parting to fine roots; few very fine pores; platy (mechanical) structure; bioturbated cambic; medium tubular earthworm pores; noneffervescent; smooth very abrupt boundary.

Bw- 18 to 26 cm; (10YR 4/3) moist; moderate medium parting to coarse prismatic; friable parting to firm; few very fine parting to fine roots; many very fine pores; looks highly eroded but is still leached; much mixing has occurred organic colors coat 40 to 50 percent of the peds; noneffervescent; smooth clear boundary.

Bk- 26 to 50 cm; (2.5Y 5/3) moist; moderate coarse prismatic; friable; common very fine roots; many very fine pores; few medium pores lined with earthworm casts; strongly effervescent.

Sample ID: 506 **Soil Series:** Barnes **Site ID:** 1C2 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.491539, 46.839896 **Legal:** 139-62-22

Date: 7/28/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 72 **PDOP:** 1.8

Depth of mollic colors: 32 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 10 to 30 cm, friable

Site notes: Gentle swale between 2 SU's; BS's are 3 to 6 percent slopes; looks like it has been under no-till for several years.

Ap- 0 to 16 cm; sandy clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to moderate medium granular; very friable parting to friable; common very fine roots; many fine parting to medium pores; high earthworm activity; many granules are casts; many medium tubular earthworm pores filled with cambic material; platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

Bw1- 16 to 32 cm; clay loam, (10YR 3/2) moist; moderate medium prismatic; friable parting to firm; moderately few very fine roots; many medium pores; tubular pores filled cambic and mollic material from earthworm casts; common organic stains on sides and tops of peds; many very fine pores; noneffervescent; wavy clear boundary.

2Bw2- 32 to 50 cm; silt loam, (2.5Y 4/3) moist; moderate medium prismatic; very friable parting to friable; few very fine roots; many very fine pores; noneffervescent.

Sample ID: 82 **Soil Series:** Buse **Site ID:** 1C20 **Crew:** MPB & BM

County: Barnes **DDD:** -97.901123, 46.738466 **Legal:** 138-57-29

Date: 7/21/2016 **Time:** 11:30 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 2.1

Depth of mollic colors: 16 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 13 to 18 cm, firm

Site notes:

Ap- 0 to 16 cm; clay loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak medium granular; common fine roots; few fine pores; platy (mechanical) structure; common medium tubular earthworm pores filled with Bk1 material; very slightly effervescent; smooth very abrupt boundary.

Bk1- 16 to 37 cm; (2.5Y 7/3) moist; moderate coarse prismatic; very friable; few fine roots; many very fine pores; common medium tubular earthworm pores with Ap material; strongly effervescent parting to violently effervescent; smooth clear boundary.

Bk2- 37 to 50 cm; (2.5Y 6/6) moist; strongly effervescent parting to violently effervescent.

Sample ID: 85 **Soil Series:** Svea **Site ID:** 1C3 **Crew:** MPB & BM

County: Cass **DDD:** -97.574013, 46.730071 **Legal:** 138-55-36

Date: 6/21/2016 **Time:** 1:49 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 30 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 20 to 30 cm, firm

Site notes: Wheat field.

Ap- 0 to 30 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky; friable; common very fine parting to fine roots; few very fine pores; thin platy (mechanical) structure; darkness of mollic exaggerates bleached quartz sand grains; few parting to common medium tubular earthworm pores; noneffervescent; smooth abrupt boundary.

Bw- 30 to 50 cm; (10YR 3/2) moist; moderate parting to strong coarse prismatic; friable; common very fine parting to fine roots; many very fine pores; common medium tubular earthworm pores; noneffervescent.

Sample ID: 87 **Soil Series:** Truncated Barnes **Site ID:** 1C4 **Crew:** MPB & BM

County: Cass **DDD:** -97.656445, 46.96165 **Legal:** 140-55-8

Date: 6/21/2016 **Time:** 9:31 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.7

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 27 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes:

Ap- 0 to 14 cm; silt loam, (10YR 2/1) moist; strong very coarse subangular blocky; very firm; few fine roots; few very fine pores; very firm massive and dry from 0 to 14 cm; still maintains some pedogenic structure; many earthworm casts; common parting to many medium pores; some limiting root restriction, but compacted area doesn't appear to impact earthworm burrows; noneffervescent; smooth abrupt boundary.

A- 14 to 19 cm; (10YR 2/1) moist; moderate coarse prismatic; friable; few fine roots; moderately few very fine parting to fine pores; common medium pores with earthworm casts; noneffervescent; smooth abrupt boundary.

Bw- 19 to 27 cm; (10YR 3/2) moist; moderate coarse prismatic; friable; common very fine pores; contains mixed inclusions of A and Bk1 horizon; truncated; noneffervescent;

Bk1- 27 to 37 cm; (2.5Y 6/3) moist; very friable; violently effervescent;

Bk2- 37 to 50 cm; (2.5Y 6/4) moist; violently effervescent.

Sample ID: 92 **Soil Series:** Truncated Barnes **Site ID:** 1C5 **Crew:** MPB & BM

County: Cass **DDD:** -97.62916, 46.8705 **Legal:** 139-55-9

Date: 7/6/2016 **Time:** 9:40 AM **Weather:** Sunny **Temperature (ºF):** 73 **PDOP:** 2.2

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:**

Site notes: Original point located by artificial surface drain; moved sampling location roughly 25 m SW.

Ap- 0 to 15 cm; clay, (10YR 2/2) moist; moderate coarse subangular blocky parting to moderate fine granular; firm; few fine roots; many very fine pores; platy (mechanical) structure; mixed calcic material from 13 to 15 cm; very slightly effervescent; smooth clear boundary.

Bw- 15 to 22 cm; (10YR 3/1) moist; strong coarse prismatic; moderately few very fine parting to fine roots; many very fine parting to fine pores; platy (mechanical) structure; mixed calcic material from 15 to 20 cm; slightly effervescent; broken gradual boundary.

Bk- 22 to 38 cm; (2.5Y 6/2) moist; moderate very coarse prismatic; mixed cambic colors (10YR 4/2); strongly effervescent; smooth abrupt boundary.

Bky- 38 to 50 cm; (2.5Y 6/4) moist; common medium gypsum crystal nests; strongly effervescent parting to violently effervescent.

Sample ID: 96 **Soil Series:** Thin Svea w/ disturbance **Site ID:** 1C6 **Crew:** MPB & DGH

County: Cass **DDD:** -97.566162, 46.823358 **Legal:** 139-55-25

Date: 6/17/2016 **Time:** 11:22 AM **Weather:** Partly cloudy **Temperature (ºF):** 77 **PDOP:** 1.6

Depth of mollic colors: 43 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 38 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 18 to 28 cm, firm

Site notes:

Ap- 0 to 13 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky; friable; common fine roots; very few very fine pores; 20 percent earthworm casts on sides of peds; noneffervescent; smooth abrupt boundary.

A- 13 to 30 cm; (10YR 2/1) moist; moderate coarse prismatic; friable; common very fine roots; common fine pores; common medium pores; noneffervescent; smooth very abrupt boundary.

Bw- 30 to 38 cm; (10YR 2/2) moist; moderate coarse prismatic; friable; noneffervescent; smooth gradual boundary.

Bk1- 38 to 43 cm; (10YR 3/1) moist; few inclusions of mixed upper horizons; strongly effervescent;

Bk2- 43 to 50 cm; (10YR 4/1) moist; few fine gypsum crystal nests; few fine carbonate masses; strongly effervescent.

Sample ID: 101 **Soil Series:** Truncated Barnes/Buse **Site ID:** 1C7 **Crew:** MPB & DGH

County: Cass **DDD:** -97.656933, 46.903423 **Legal:** 140-55-32

Date: 6/9/2016 **Time:** 10:09 AM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 2.1

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:**

Site notes: Eastern side of pit has mollic colors to 17 cm, cambic horizon extends to 5 cm below; cambic thickness around pit ranges from 3 to 6 cm; high variability within pit.

Ap- 0 to 17 cm; clay loam, (10YR 2/1) moist; strong coarse subangular blocky; firm parting to very firm; common very fine roots; very few very fine pores; very slightly effervescent; smooth very abrupt boundary.

Bw- 17 to 21 cm; (10YR 4/2) moist; moderate coarse prismatic parting to moderate medium subangular blocky; friable; common very fine roots; common very fine pores; high degree of earthworm bioturbation; tubular pores filled with calcic and mollic material; horizon boundary has platy (mechanical) structure; slightly effervescent; broken abrupt boundary.

Bk- 21 to 32 cm; (2.5Y 7/3) moist; strongly effervescent;

Bky- 32 to 50 cm; (2.5Y 5/3) moist; 25 to 30 percent medium and coarse gypsum crystal nests; strongly effervescent.

Sample ID: 252 **Soil Series:** Barnes **Site ID:** 1C8 **Crew:** MPB & RE

County: Barnes **DDD:** -97.889776, 46.727683 **Legal:** 138-57-33

Date: 5/17/2017 **Time:** 10:30 AM **Weather:** Overcast **Temperature (ºF):** 50 **PDOP:** 2

Depth of mollic colors: 30 cm **Depth of mollic epipedon:** 30 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 13 to 24 cm, firm

Site notes:

Ap- 0 to 19 cm; loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; many very fine parting to fine roots; moderately few fine pores; platy (mechanical) structure from 13 to 19 cm; few medium earthworm casts; bleached sand grains; noneffervescent; smooth clear boundary.

A- 19 to 30 cm; (10YR 2/2) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; faint continuous cutans on macropores; parts to platy (mechanical) structure at top of prismatic structural units; noneffervescent; irregular abrupt boundary.

Bw- 30 to 50 cm; (2.5Y 5/4) moist; moderate medium parting to coarse prismatic; friable; many fine roots; many very fine pores; common fine pores; discontinuous faint cutans coating fine pores; weak thin platy structure from 46 to 50 cm; noneffervescent.

Sample ID: 302 **Soil Series:** Forman **Site ID:** 1C9 **Crew:** MPB & RE

County: Barnes **DDD:** -97.843977, 46.780554 **Legal:** 138-57-11

Date: 5/25/2017 **Time:** 10:40 AM **Weather:** Sunny **Temperature (ºF):** 60 **PDOP:** 2.9

Depth of mollic colors: 20 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** 49 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 6 to 20 cm, firm

Site notes: 6 to 9 percent slope; upper interfluve of LV BS; 10 meters from shelterbelt; Bk at 49 cm; did not describe horizon.

Ap- 0 to 20 cm; clay loam, (10YR 2/1) moist; weak parting to moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common fine pores; platy (mechanical) structure; smeared; moderately few very fine pores; noneffervescent; smooth very abrupt boundary.

Bt1- 20 to 33 cm; clay, (10YR 3/4) moist; moderate parting to strong medium parting to coarse prismatic parting to moderate medium angular blocky; firm; common very fine parting to fine roots; many very fine pores; bridged sand grains; very fine pores lined with cutans; 60 to 70 percent distinct continuous cutans on all sides of peds; parts to subangular blocky; common organic stains on sides and tops of peds; noneffervescent; wavy clear boundary.

Bt2- 33 to 49 cm; clay loam, (2.5Y 4/4) moist; moderate parting to strong medium prismatic parting to moderate medium subangular blocky; firm; common very fine parting to fine roots; many very fine pores; 40 to 50 percent faint to distinct continuous cutans on sides and tops of peds; noneffervescent.

Sample ID: 392 **Soil Series:** Sioux **Site ID:** 2A1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.46811, 46.900723 **Legal:** 140-62-35

Date: 6/22/2017 **Time:** 10:30 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 1.4

Depth of mollic colors: 10 cm **Depth of mollic epipedon:** 10 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: Glaciofluvial outwash; 4 percent slope CC BS; like digging through concrete at 2C; pores tough to discern because of weak structure; could not determine plow pan.

Ap- 0 to 10 cm; loam, (10YR 3/2) moist; weak fine subangular blocky parting to weak fine granular; friable parting to firm; common fine parting to medium roots; eroded mixed Bk material; slightly effervescent; wavy very abrupt boundary.

Bw- 10 to 20 cm; gravelly sandy clay loam, (2.5Y 4/4) moist; friable parting to firm; common fine roots; slightly effervescent; wavy very abrupt boundary.

2C- 20 to 50 cm; loamy coarse sand, (2.5Y 3/4) moist; massive; very firm; very slightly effervescent.

Sample ID: 258 **Soil Series:** Buse **Site ID:** 2A10 **Crew:** MPB & RE

County: Barnes **DDD:** -97.718925, 46.736848 **Legal:** 138-56-26

Date: 5/17/2017 **Time:** 2:00 PM **Weather:** Overcast **Temperature (ºF):** 50 **PDOP:** 1.4

Depth of mollic colors: 21 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: Slightly level rise; 5 percent slope; 10 percent slope 100 meters NW; Buse type pedon; 30 percent surface gravels on highest knolls.

Ap- 0 to 14 cm; sandy clay loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine roots; very few very fine pores; very few fine to medium tubular earthworm pores; slightly effervescent; irregular abrupt boundary.

Ak- 14 to 21 cm; (10YR 2/2) moist; moderate medium subangular blocky; friable; common very fine roots; very few very fine pores; 20 to 30 percent mixed calcic material; medium tubular earthworm pores filled with remnant cambic material; mostly biotically mixed; some also mechanically mixed; slightly effervescent; smooth very abrupt boundary.

Bk1- 21 to 32 cm; (2.5Y 6/3) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; remnant truncated cambic colors (2.5Y 6/3) at boundary; common medium tubular earthworm pores filled with mollic; strongly effervescent; smooth clear boundary.

Bk2- 32 to 50 cm; (2.5Y 6/4) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; strongly effervescent.

Sample ID: 422 **Soil Series:** Barnes **Site ID:** 2A11 **Crew:** MPB & RE

County: Barnes **DDD:** -98.406367, 46.967083 **Legal:** 140-61-5

Date: 7/21/2017 **Time:** 1:40 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.9

Depth of mollic colors: 29 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 5 to 25 cm, firm

Site notes: 6 percent slope VV upper third of BS; 20 to 30 percent surface gravels; Bw is still leached; carbonates at surface are from slope wash colluvium and carbonates below Bw are from discharge.

Ap1- 0 to 10 cm; sandy clay loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine roots; few very fine pores; platy (mechanical) structure; slightly effervescent; wavy abrupt boundary.

2Ap2- 10 to 15 cm; small gravelly loam, (10YR 3/2) moist; moderate medium subangular blocky; friable parting to firm; common very fine parting to fine roots; few very fine pores; platy (mechanical) structure; slightly effervescent; wavy abrupt boundary.

Bw- 15 to 29 cm; (10YR 3/3) moist; moderate medium prismatic; friable parting to firm; moderately few very fine roots; many very fine pores; common coarse sand and small gravel sized bits of shale; parts to platy (mechanical) structure at the top of prismatic structural units; few mollic stains; biotic mixing; noneffervescent; wavy clear boundary.

Bk- 29 to 50 cm; (2.5Y 5/4) moist; moderate medium prismatic; very friable; moderately few very fine roots; many very fine pores; strongly effervescent.

Sample ID: 105 **Soil Series:** Barnes **Site ID:** 2A12 **Crew:** MPB & JS

County: Barnes **DDD:** -98.104519, 46.872102 **Legal:** 139-59-10

Date: 8/30/2016 **Time:** 10:45 AM **Weather:** Sunny **Temperature (ºF):** 68 **PDOP:** 2.1

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: Esker SW of sampling location; 20 percent surface gravels; sandy outwash; pedon contains smooth rounded medium gravels.

Ap- 0 to 13 cm; loam, (10YR 2/1) moist; weak fine granular parting to strong very coarse subangular blocky; friable; common very fine roots; very few very fine pores; top 4 cm has weak fine granular structure; dry conditions make it difficult to determine plow pan; few medium pores; noneffervescent; smooth abrupt boundary.

A- 13 to 27 cm; fine sandy loam, (10YR 2/1) moist; strong very coarse prismatic; friable parting to firm; common very fine roots; few fine pores; noneffervescent; wavy clear boundary.

Bw1- 27 to 38 cm; fine sandy loam, (10YR 3/2) moist; strong coarse prismatic; friable parting to firm; common medium roots; noneffervescent; wavy clear boundary.

2Bw2- 38 to 50 cm; small gravelly fine sandy loam, (10YR3/2) moist; common very coarse sands and small gravels; few medium gravels; noneffervescent.

Sample ID: 265 **Soil Series:** Buse **Site ID:** 2A13 **Crew:** MPB & RE

County: Barnes **DDD:** -98.085225, 46.87299 **Legal:** 139-59-11

Date: 5/18/2017 **Time:** 10:00 AM **Weather:** Sunny **Temperature (ºF):** 50 **PDOP:** 1.7

Depth of mollic colors: 20 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 20 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 6 to 12 cm, firm

Site notes: 5 percent slope LV SH.

Ap- 0 to 15 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky; friable; moderately few very fine roots; very few very fine pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw- 15 to 20 cm; (10YR 3/2) moist; moderate fine parting to medium prismatic; friable; common very fine roots; many very fine pores; many medium tubular earthworm pores with mollic material; 10 percent small to medium gravels; noneffervescent; smooth abrupt boundary.

Bk1- 20 to 30 cm; (10YR 5/3) moist; moderate medium parting to coarse prismatic; very friable; common very fine roots; many very fine pores; 10 percent small to medium gravels; slightly effervescent parting to strongly effervescent; smooth gradual boundary.

Bk2- 30 to 50 cm; (10YR 6/3) moist; moderate medium parting to coarse prismatic; very friable; common very fine roots; many very fine pores; 10 percent small to medium gravels; 20 percent fine carbonate masses; strongly effervescent.

Sample ID: 440 **Soil Series:** Buse **Site ID:** 2A14 **Crew:** MPB & RE

County: Barnes **DDD:** -98.281193, 46.879227 **Legal:** 139-60-5

Date: 7/24/2017 **Time:** 3:04 PM **Weather:** Overcast **Temperature (ºF):** 80 **PDOP:** 1.7

Depth of mollic colors: 23 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: Common coarse gravels while digging; corn field; no landscape information available; fragments range from coarse sands to cobbles, but are not well sorted; collapsed moraine sediments rather than glaciofluvial.

Ap- 0 to 23 cm; sandy clay loam, (10YR 2/2) moist; moderate coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common very fine parting to fine pores; 30 percent mixed eroded cambic material; few medium tubular earthworm pores partially filled with cambic and calcic material; slightly effervescent; smooth very abrupt boundary.

Bk- 23 to 50 cm; large gravelly sandy clay loam, (10YR 5/4) moist; moderate medium prismatic; friable; moderately few very fine parting to fine roots; many very fine pores; common medium tubular earthworm pores; 15 to 20 percent large gravels; strongly effervescent.

Sample ID: 282 **Soil Series:** Uncultivated Vallers **Site ID:** 2A15 **Crew:** MPB & RE

County: Barnes **DDD:** -97.768235, 46.756019 **Legal:** 138-56-20

Date: 5/22/2017 **Time:** 2:55 PM **Weather:** Overcast **Temperature (ºF):** 55 **PDOP:** 1.9

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 27 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:**

Site notes: Depression of an uncultivated area; near an eroded area with a 6 to 9 percent slope; Vallers type pedon; great contrast between dark mollic colors and extremely gray calcic colors; Vallers was mapped adjacent to this site; map unit delineations could be shifted based on field observations.

A1- 0 to 10 cm; clay loam, (10YR 2/1) moist; weak fine parting to medium granular; very friable; many very fine parting to fine roots; many fine pores; many medium pores; bleached sand grains present; slightly effervescent parting to strongly effervescent; smooth clear boundary.

A2- 10 to 27 cm; (10YR 2/1) moist; moderate medium subangular blocky parting to moderate medium parting to coarse granular; friable; many very fine roots; many very fine parting to fine pores; bleached sand grains; common medium pores; slightly effervescent parting to strongly effervescent; wavy parting to irregular abrupt boundary.

Bk- 27 to 50 cm; (2.5Y 6/1) moist; weak medium prismatic; very friable; many very fine parting to fine roots; many very fine parting to fine pores; common coarse prominent redoximorphic concentrations (10YR 6/4); strongly effervescent parting to violently effervescent.

Sample ID: 109 **Soil Series:** Forman **Site ID:** 2A16 **Crew:** MPB, DGH, & CG

County: Barnes **DDD:** -98.124267, 46.802508 **Legal:** 138-59-4

Date: 10/11/2016 **Time:** 2:30 PM **Weather:** Overcast **Temperature (ºF):** 45 **PDOP:** 1.5

Depth of mollic colors: 36 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 8 to 22 cm, firm

Site notes: 10 to 15 percent slope BS; 150m west of large wetland; Depth to carbonates is at least 57 cm; exceptional and unexpected Forman type pedon site.

Ap- 0 to 22 cm; loam, (10YR 2/1) moist; weak fine parting to medium subangular blocky parting to weak fine granular; very friable; common very fine roots; common fine pores; common medium earthworm casts; bleached sand grains; thin lens of fine sand at top of horizon from overland flow; 1 to 2 mm; noneffervescent; wavy clear boundary.

Bt1- 22 to 36 cm; clay loam, (10YR 3/2) moist; strong very coarse prismatic; friable; common fine roots; many very fine pores; tight clay loam; many continuous distinct cutans on ped faces and lining root dendritic tubular pores; few bleached sand grains coating surface; organic stains on sides of peds; common medium pockets of earthworm casts; common fine pores; noneffervescent; wavy clear boundary.

Bt2- 36 to 50 cm; clay loam, (10YR 4/3) moist; strong very coarse prismatic; friable; moderately few fine roots; many very fine parting to fine pores; many continuous distinct cutans on all sides of peds; tighter clay loam than Bt1; 20 percent organic stains on sides of peds; noneffervescent.

Sample ID: 112 **Soil Series:** Barnes **Site ID:** 2A17 **Crew:** MPB & BM

County: Barnes **DDD:** -97.822887, 46.737982 **Legal:** 138-57-25

Date: 7/25/2016 **Time:** 9:50 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.7

Depth of mollic colors: 26 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 42 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 10 to 21 cm, firm

Site notes: Moved site 2m south to stay in sampling pixel; gravelly outwash 40 m SW of site where corn growth was noticeably stunted.

Ap- 0 to 18 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine parting to medium granular; common fine roots; few very fine pores; many medium tubular earthworm pores; platy (mechanical) structure; common medium casts and medium pores filled with cambic material; noneffervescent; smooth very abrupt boundary.

Bw1- 18 to 26 cm; (10YR 3/3) moist; moderate coarse prismatic; friable parting to firm; common very fine roots; many very fine pores; few faint organic stains on sides and tops of peds; platy (mechanical) structure; few faint discontinuous cutans lining pores; noneffervescent; smooth clear boundary.

Bw2- 26 to 42 cm; (2.5Y 4/3.5) moist; moderate coarse prismatic; friable; few fine roots; many very fine pores; noneffervescent; smooth abrupt boundary.

Bk - 42 to 50 cm; (2.5Y 5/4) moist; very friable; strongly effervescent.

Sample ID: 116 **Soil Series:** Svea **Site ID:** 2A18 **Crew:** MPB & BM

County: Barnes **DDD:** -97.882402, 46.996677 **Legal:** 141-57-27

Date: 7/8/2016 **Time:** 11:50 AM **Weather:** Sunny **Temperature (ºF):** 74 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 37 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 18 cm, firm

Site notes: Moved site 10 m N out of drain; stunted soybean growth in drain.

Ap- 0 to 18 cm; clay loam, (10YR2/1) moist; moderate coarse subangular blocky parting to moderate medium granular; friable; common very fine roots; very few very fine pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

A- 18 to 37 cm; (10YR 2/2) moist; moderate coarse prismatic; friable; few very fine roots; many fine pores; noneffervescent; smooth abrupt boundary.

Bw- 37 to 50 cm; (10YR 3/2) moist; noneffervescent.

Sample ID: 542 **Soil Series:** Coarse Barnes/Heimdal **Site ID:** 2A19 **Crew:** MPB & RE

County: Barnes **DDD:** -98.398234, 46.996155 **Legal:** 141-61-27

Date: 8/9/2017 **Time:** 10:40 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.9

Depth of mollic colors: 26 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 6 to 23 cm, firm

Site notes: corn field; surface is gravelly.

Ap- 0 to 13 cm; loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common fine roots; moderately few fine pores; contains eroded calcic slope wash colluvium; light clay loam; few fine parting to medium tubular earthworm pores commonly filled with remnant mollic material; platy (mechanical) structure; slightly effervescent; wavy very abrupt boundary.

Bw- 13 to 26 cm; gravelly sandy clay loam, (2.5Y 3/3) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; faint to distinct patchy cutans on tops and sides of peds; common very fine pores lined with cutans; many organic stains on tops of peds; noneffervescent; wavy clear boundary.

Bk1- 26 to 37 cm; gravelly sandy clay loam, (2.5Y 4/3) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; few medium tubular earthworm pores filled with mollic material; strongly effervescent parting to violently effervescent; smooth abrupt boundary.

2Bk2- 37 to 43 cm; small gravelly sandy clay loam, (2.5Y 6/4) moist; moderate medium prismatic; friable; few fine roots; common very fine pores; common medium carbonate masses;

common small gravel size bits of shale; carbonate coats on bottoms of gravels; strongly effervescent parting to violently effervescent; smooth very abrupt boundary.

3Bk3- 43 to 50 cm; fine sandy loam, (2.5Y 6/4) moist; moderate medium prismatic; friable; common very fine parting to fine roots; many very fine pores; few coarse sand sized bits of shale; weak thin platy structure; violently effervescent.

Sample ID: 502 **Soil Series:** Thick Barnes **Site ID:** 2A2 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.525323, 46.876598 **Legal:** 139-62-8

Date: 7/28/2017 **Time:** 9:30 AM **Weather:** Sunny **Temperature (ºF):** 72 **PDOP:** 1.6

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 8 to 40 cm, friable

Site notes: 6 percent slope lower BS; no-till field; differentiated Ap1 from Ap2 based on the fact that all aggregates in Ap1 were earthworm casts.

Ap1- 0 to 7 cm; sandy loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak parting to moderate medium granular; friable; common very fine parting to fine roots; many fine parting to medium pores; high earthworm bioturbation; many earthworm casts; light loam; run on sands; noneffervescent; smooth very abrupt boundary.

Ap2- 7 to 16 cm; (10YR 2/1) moist; moderate medium subangular blocky; friable; common very fine parting to fine roots; common fine parting to medium pores; platy (mechanical) structure; many very fine pores; run on sands; common medium cambic earthworm casts; noneffervescent; smooth very abrupt boundary.

Bw1- 16 to 40 cm; loam, (10YR 3/2) moist; moderate medium prismatic; very friable; very few fine roots; many very fine pores; platy (mechanical) structure; common medium tubular earthworm pores; light loam to fine sandy loam; noneffervescent; wavy clear boundary.

Bw2- 40 to 50 cm; (10YR 3/2) moist; moderate medium prismatic; very friable; very few fine roots; many very fine pores; bridged sand grains; strong cambic development; very fine pores lined with cutans; faint common discontinuous cutans on sides of peds; noneffervescent.

Sample ID: 275 **Soil Series:** Forman **Site ID:** 2A20 **Crew:** MPB & RE

County: Barnes **DDD:** -97.746717, 46.740756 **Legal:** 138-56-28

Date: 5/18/2017 **Time:** 3:50 PM **Weather:** Sunny **Temperature (ºF):** 55 **PDOP:** 1.5

Depth of mollic colors: 26 cm **Depth of mollic epipedon:** 26 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 17 cm, firm

Site notes: Complex slope; CC BS between two summits.

Ap- 0 to 26 cm; clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine parting to medium granular; very friable; common very fine parting to fine roots; many very fine pores; platy (mechanical) structure; bleached sand grains; noneffervescent; smooth abrupt boundary.

Bt1- 26 to 34 cm; clay, (10YR 4/4) moist; strong coarse prismatic parting to strong medium parting to coarse angular blocky; firm; common very fine roots; many very fine pores; 20 percent organic stains on all sides of peds; very many continuous prominent cutans on all sides of peds; noneffervescent; wavy gradual boundary.

Bt2- 34 to 50 cm; clay, (10YR 4/3) moist; strong coarse prismatic parting to strong medium parting to coarse angular blocky; firm; moderately few very fine roots; many very fine pores; 10 percent organic stains on all sides of peds; very many continuous prominent cutans on all sides of peds; noneffervescent.

Sample ID: 395 **Soil Series:** Divide **Site ID:** 2A3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.468361, 46.900371 **Legal:** 140-62-35

Date: 6/22/2017 **Time:** 11:20 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 2.3

Depth of mollic colors: 30 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 4 to 20 cm, firm

Site notes: 6 percent slope CC FS; glaciofluvial coarse outwash interbedded with silty alluvium.

Ap- 0 to 15 cm; loam, (10YR 2/2) moist; weak fine parting to medium subangular blocky parting to weak fine granular; friable; few fine roots; few fine pores; common medium to coarse carbonate masses mixed from Bk1 in matrix; roots matted against horizontal platy (mechanical) structural units; 20 percent coarse sands; slightly effervescent; wavy very abrupt boundary.

Bk1- 15 to 24 cm; coarse sandy clay loam, (2.5Y 3/3) moist; moderate medium parting to coarse prismatic; firm; very few very fine roots; common very fine pores; 20 percent coarse sands; strongly effervescent; wavy abrupt boundary.

2Bk2- 24 to 30 cm; loamy sand, (2.5Y 3/3) moist; moderate fine parting to medium subangular blocky; friable; 20 percent coarse sand lens; 40 percent silt coats on tops of peds; slightly effervescent; wavy very abrupt boundary.

3C- 30 to 50 cm; silty clay loam, (2.5Y 4/3) moist; massive; friable; few very fine roots; common very fine pores; 5 mm bands of 2.5Y 5/4 material; dark organic stains on bottoms of peds; 30 percent coarse firm purplish-black clasts; few thin stratified higher silt content lenses; strongly effervescent.

Sample ID: 620 **Soil Series:** Thick Barnes **Site ID:** 2A4 **Crew:** MPB, DS, & ST

County: Stutsman **DDD:** -98.529842, 46.830435 **Legal:** 139-62-29

Date: 8/30/2017 **Time:** 1:35 PM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 1.7

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 12 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: 40 m NW of wetland; saline at the surface near wetland rim; 6 percent slope LL BS; soybeans are much yellower than those up slope; but I did not see any signs of salt accumulation.

Ap- 0 to 12 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine granular; friable; common very fine roots; common medium pores; parts to platy (mechanical) structure; common medium tubular earthworm pores; run on sands; common fine earthworm casts; clay loam (higher silt content); noneffervescent; smooth abrupt boundary.

Bw1- 12 to 18 cm; (10YR 3/2) moist; moderate medium prismatic; moderately few very fine roots; common very fine pores; common medium tubular earthworm pores filled with mollic material; 60 percent organic stains on side of peds; noneffervescent; wavy clear boundary.

Bw2- 18 to 50 cm; (10YR 3/3) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; faint to distinct and continuous cutans on interstructural voids; strong cambic development; very fine pores lined with cutans; very abrupt irregular boundary with Bk horizon at 50 cm; noneffervescent.

Sample ID: 414 **Soil Series:** Svea; buried by upslope cambic horizon **Site ID:** 2A5 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.500535, 46.902595 **Legal:** 140-62-34

Date: 7/21/2017 **Time:** 10:00 AM **Weather:** Overcast **Temperature (ºF):** 75 **PDOP:** 2.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 43 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 43 cm, friable

Site notes: CC FS between two large summits; moist soil; surface has eroded cambic colors from slope wash colluvium and was free of carbonates.

Bw- 0 to 4 cm; sandy loam, (10YR 3/2) moist; moderate medium granular parting to weak fine granular; friable; common very fine parting to fine roots; moderately few very fine pores; evidence of old cambic expression on some peds still intact; these peds have bridged sand grains and very fine pores lined with cutans; eroded, mixed and mechanically bulked from 0 to 4 cm; parts to platy (mechanical) structure below the bulked portion; roots are true for rows with plants; noneffervescent; smooth very abrupt boundary.

Apb- 4 to 22 cm; (10YR 2/2) moist; moderate medium prismatic; friable parting to firm; common very fine roots; common parting to many very fine pores; platy (mechanical) structure; noneffervescent; wavy clear boundary.

A- 22 to 43 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine parting to fine roots; many very fine pores; platy (mechanical) structure; noneffervescent; wavy very abrupt boundary.

Bw'- 43 to 50 cm; (10YR 3/2) moist; moderate medium prismatic; friable; very few very fine roots; many very fine parting to fine pores; noneffervescent.

Sample ID: 554 **Soil Series:** Barnes **Site ID:** 2A6 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.529748, 46.719669 **Legal:** 138-62-32

Date: 8/15/2017 **Time:** 9:30 AM **Weather:** Overcast **Temperature (ºF):** 60 **PDOP:** 1.7

Depth of mollic colors: 29 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 46 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 24 cm, friable

Site notes: Nearly level SU; feels like a light loam or sandy clay loam.

Ap- 0 to 15 cm; sandy clay loam, (10YR 2/2) moist; moderate fine parting to medium subangular blocky parting to moderate fine parting to medium granular; very friable; common very fine parting to fine roots; common fine pores; many coarse sand grains; common medium earthworm pores filled with Bw1; platy (mechanical) structure; noneffervescent; wavy very abrupt boundary.

Bw1- 15 to 29 cm; (10YR 3/3) moist; moderate medium parting to coarse prismatic; friable; few very fine parting to fine roots; many very fine pores; strong cambic development; very fine pores lined with cutans; parts to platy (mechanical) structure at the top of prismatic structural units; 20 percent organic stains on sides of peds; faint discontinuous cutans on interstructural voids; common fine tubular earthworm pores filled with mollic material; noneffervescent; wavy clear boundary.

Bw2- 29 to 46 cm; (2.5Y 4/4) moist; moderate medium parting to coarse prismatic; very friable; few very fine parting to fine roots; many very fine pores; noneffervescent; wavy abrupt boundary.

Bk- 46 to 50 cm; (2.5Y 5/4) moist; strongly effervescent.

Sample ID: 119 **Soil Series:** Langhei **Site ID:** 2A7 **Crew:** MPB & DGH

County: Cass **DDD:** -97.60836, 46.781476 **Legal:** 138-55-10

Date: 6/10/2016 **Time:** 2:50 PM **Weather:** Sunny **Temperature (ºF):** 77 **PDOP:** 1.5

Depth of mollic colors: 10 cm **Depth of mollic epipedon:** 10 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes:

Ap- 0 to 10 cm; clay loam, (10YR 3/1) moist; strong coarse subangular blocky parting to moderate fine granular; firm parting to very firm; moderately few very fine roots; moderately few very fine pores; few traces of carbon rich material, darker than the matrix, from faunal mixing of original mollic epipedon; strongly effervescent; smooth very abrupt boundary.

Cky- 10 to 50 cm; silty clay loam, (2.5Y 4/4) moist; massive; moderately few very fine roots; moderately few very fine pores; light silty clay loam; common medium prominent redoximorphic depletions (2.5Y 4.5/1); 30 to 60 percent coarse irregular gypsum crystal nests from 40 to 50 cm; violently effervescent.

Sample ID: 269 **Soil Series:** Buse **Site ID:** 2A8 **Crew:** MPB & RE

County: Barnes **DDD:** -98.133565, 46.796315 **Legal:** 138-59-4

Date: 5/18/2017 **Time:** 11:50 AM **Weather:** Sunny **Temperature (ºF):** 50 **PDOP:** 3.1

Depth of mollic colors: 11 cm **Depth of mollic epipedon:** 11 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 6 to 16 cm, firm

Site notes: 5 percent surface gravels; 6 percent slope LV lower BS; common coarse gravels while digging.

Ap- 0 to 11 cm; loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; moderately few very fine roots; very few very fine pores; platy (mechanical) structure; matrix is mixed with cambic material; common medium tubular earthworm pores filled with calcic material; very slightly effervescent; wavy abrupt boundary.

Bk- 11 to 50 cm; (2.5Y 5/4) moist; moderate coarse prismatic; friable; few very fine roots; many very fine pores; common fine carbonate masses; strongly effervescent.

Sample ID: 426 **Soil Series:** Hamerly **Site ID:** 2A9 **Crew:** MPB & RE

County: Barnes **DDD:** -98.413888, 46.967013 **Legal:** 140-61-5

Date: 7/21/2017 **Time:** 2:35 AM **Weather:** Partly cloudy **Temperature (ºF):** 90 **PDOP:** 1.5

Depth of mollic colors: 12 cm **Depth of mollic epipedon:** 12 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 6 to 26 cm, firm

Site notes: Moved site to Barnes like location 15 m SW; 3 to 6 percent slope LV BS; 15 m from wetland.

Ap- 0 to 12 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; moderately few very fine roots; very few very fine pores; roots matted against horizontal platy (mechanical) structural units; violently effervescent; smooth very abrupt boundary.

Bk1- 12 to 22 cm; silty clay (10YR 6/3) moist; moderate medium parting to coarse prismatic; friable parting to firm; common very fine roots; many very fine pores; few coarse sand sized bits of shale; common distinct redoximorphic concentrations and depletions; few fine pores filled with mollic material; strongly effervescent parting to violently effervescent; wavy clear boundary.

Bk2- 22 to 50 cm; silty clay (10YR 6/3) moist; moderate medium parting to coarse prismatic; very friable parting to friable; common very fine roots; many very fine pores; common coarse sand and small gravel sized bits of shale; common prominent fine to medium redoximorphic concentrations and depletions; parts to platy (mechanical) structure at the top of prismatic structural units; strongly effervescent parting to violently effervescent.

Sample ID: 523 **Soil Series:** Svea **Site ID:** 2B1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.48591, 47.028665 **Legal:** 141-62-13

Date: 8/1/2017 **Time:** 11:45 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.3

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** > 50 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 8 to 30 cm, firm

Site notes: Corn field.

Ap- 0 to 14 cm; clay loam, (10YR 2/1) moist; moderate fine subangular blocky parting to weak fine granular; friable; many very fine parting to fine roots; common very fine parting to fine pores; platy (mechanical) structure; many medium roots; common coarse roots; noneffervescent; wavy gradual boundary.

A/B- 14 to 50 cm; (10YR 2/1) moist; moderate medium prismatic parting to moderate fine parting to medium platy; friable; moderately few very fine parting to fine roots; many very fine pores; platy (mechanical) structure; common fine pores; matrix has 20 percent 10YR 2/2 colors; noneffervescent.

Sample ID: 372 **Soil Series:** Barnes **Site ID:** 2B10 **Crew:** MPB & RE

County: Barnes **DDD:** -98.433384, 46.95967 **Legal:** 140-61-7

Date: 6/21/2017 **Time:** 9:48 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 1.8

Depth of mollic colors: 34 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** 41 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 4 to 24 cm, firm

Site notes: 3 to 6 percent slope VC upper third of BS; sandy loam lens below 50 cm.

Ap- 0 to 13 cm; clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common very fine parting to fine pores; parts to platy (mechanical) structure; weakly smeared; noneffervescent; smooth very abrupt boundary.

A- 13 to 22 cm; (10YR 2/1) moist; moderate medium prismatic; firm; very few very fine roots; many very fine pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 22 to 34 cm; (10YR 3/2) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; 20 percent organic stains on sides and tops of peds; strong cambic development; very fine pores lined with cutans; common faint to distinct discontinuous cutans on sides and tops of peds; few bridged sand grains; noneffervescent; wavy abrupt boundary.

Bw2- 34 to 41 cm; (2.5Y 4/4) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; strong cambic development; very fine pores lined with cutans; few to common faint to distinct discontinuous cutans on sides and tops of peds; few bridged sand grains; noneffervescent;

2Bk- 41 to 50 cm; sandy loam, (2.5Y 5/4) moist; moderate medium prismatic; very friable parting to friable; common very fine parting to fine roots; many very fine parting to fine pores; few coarse sands to small gravels; slightly effervescent parting to strongly effervescent.

Sample ID: 121 **Soil Series:** Thick Barnes/Svea **Site ID:** 2B11 **Crew:** MPB & BM

County: Barnes **DDD:** -97.894269, 46.907896 **Legal:** 140-57-29

Date: 7/6/2016 **Time:** 1:56 PM **Weather:** Overcast **Temperature (ºF):** 77 **PDOP:** 1.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 10 to 19 cm, firm

Site notes: Thickness of Bw was uniform in all parts of pit.

Ap- 0 to 19 cm; clay loam, (10YR 2/1) moist; weak medium subangular blocky parting to moderate medium granular; friable; common fine roots; common very fine pores; platy (mechanical) structure; common medium earthworm casts; noneffervescent; smooth clear boundary.

Bw- 19 to 50 cm; sandy clay loam, (10YR 3/3) moist; strong coarse parting to very coarse prismatic; common fine roots; many very fine parting to fine pores; noneffervescent.

Sample ID: 123 **Soil Series:** Barnes **Site ID:** 2B12 **Crew:** MPB & BM

County: Barnes **DDD:** -97.883603, 47.039022 **Legal:** 141-57-10

Date: 7/12/2016 **Time:** 2:00 PM **Weather:** Sunny **Temperature (ºF):** 73 **PDOP:** 1.6

Depth of mollic colors: 32 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 32 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Uncultivated area near an old farmstead; tall grasses and weeds now dominate.

Ap- 0 to 19 cm; clay, (10YR 2/1) moist; weak fine parting to medium granular; very friable; many very fine parting to fine roots; many very fine parting to fine pores; noneffervescent; smooth clear boundary.

Bw- 19 to 32 cm; (10YR 3/3) moist; weak medium prismatic; very friable; common parting to many very fine roots; many fine pores; noneffervescent; broken clear boundary.

Bk- 32 to 50 cm; (2.5Y 6/3) moist; weak coarse prismatic; very friable; common parting to many fine roots; many very fine pores; strongly effervescent; smooth clear boundary.

Sample ID: 644 **Soil Series:** Buse **Site ID:** 2B13 **Crew:** MPB

County: Barnes **DDD:** -98.121705, 46.76786 **Legal:** 138-59-15

Date: 9/12/2017 **Time:** 12:00 PM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 1.5

Depth of mollic colors: 23 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 4 to 32 cm, very firm

Site notes: 3 percent slope gentle CC BS; soybeans are much greener in depressions, very yellow on upper VV BS, very brown and dry on SU and SH; degree of senescence during this time aligns with anticipated soil morphology at differing landscape positions.

Ap- 0 to 23 cm; loam, (10YR 2/2) moist; strong coarse subangular blocky parting to weak fine granular; firm; common very fine parting to fine roots; very few very fine pores; common medium tubular earthworm pores; parts to platy (mechanical) structure; primary structure parts to angular blocky; run on sands; mixed eroded cambic material; slightly effervescent parting to strongly effervescent; smooth very abrupt boundary.

Bk1- 23 to 35 cm; (10YR 4/1) moist; strong coarse prismatic; firm; few very fine parting to fine roots; moderately few very fine pores; mixed eroded remnant cambic material; 20 percent grayish calcic and cambic stains; parts to angular blocky structure; strongly effervescent parting to violently effervescent; smooth abrupt boundary.

Bk2- 35 to 50 cm; (10YR 5/3) moist; moderate parting to strong coarse prismatic; friable; very few very fine roots; many very fine pores; 5 percent coarse sand to small gravel size bits of shale; violently effervescent.

Sample ID: 347 **Soil Series:** Thick Barnes/Svea **Site ID:** 2B14 **Crew:** MPB, RE, & SC

County: Barnes **DDD:** -98.34079, 46.907984 **Legal:** 140-61-26

Date: 6/8/2017 **Time:** 2:05 PM **Weather:** Partly cloudy **Temperature (ºF):** 85 **PDOP:** 1.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 30 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 19 cm

Site notes: 6 to 9 percent CC FS; 50 to 70 percent surface gravels 30 m S; gravel pits across road to the E; Esker country; site is in a basin 80 m W of wetland/enclosed depression.

Ap- 0 to 19 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; few fine roots; few fine pores; platy (mechanical) structure; smeared; common earthworms present; noneffervescent; smooth very abrupt boundary.

A- 19 to 30 cm; (10YR 2/1) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; common fine to medium pores filled with earthworm casts; common earthworms present; noneffervescent; smooth clear boundary.

Bw1- 30 to 45 cm; (10YR 3/1) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; common fine to medium earthworm casts; noneffervescent; smooth clear boundary.

Bw2- 45 to 50 cm; (2.5Y 3/3) moist; noneffervescent.

Sample ID: 437 **Soil Series:** Buse **Site ID:** 2B15 **Crew:** MPB & RE

County: Barnes **DDD:** -98.260923, 46.818187 **Legal:** 139-60-33

Date: 7/24/2017 **Time:** 12:56 PM **Weather:** Overcast **Temperature (ºF):** 70 **PDOP:** 1.6

Depth of mollic colors: 11 cm **Depth of mollic epipedon:** 11 cm **Depth to carbonates:** 15 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 26 cm, very firm

Site notes: 10 to 12 percent slope VV SH; 5 m from a large rock pile; moved site 5 m S from rock pile; very difficult to dig through; extremely dry; soybeans still appear to be healthy.

Ap- 0 to 11 cm; sandy clay loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; many very fine pores; roots matted against horizontal platy (mechanical) structural units; remnant cambic colors mixed throughout matrix; discrete inclusions of calcic and cambic material; bioturbated; noneffervescent; smooth very abrupt boundary.

Bw- 11 to 15 cm; loam, (10YR 4/3) moist; strong medium subangular blocky; firm parting to very firm; many fine roots; many very fine pores; common gravel sized bits of shale; roots matted against horizontal platy (mechanical) structural units; noneffervescent; smooth very abrupt boundary.

2Bk- 15 to 50 cm; gravelly sandy loam, (10YR 5/3) moist; strong medium prismatic; friable; moderately few very fine parting to fine roots; many very fine pores; common fine carbonate masses; common coarse sand and small gravel sized bits of shale; dry conditions; strongly effervescent parting to violently effervescent.

Sample ID: 126 **Soil Series:** Buse **Site ID:** 2B16 **Crew:** MPB & BM

County: Barnes **DDD:** -97.86452, 47.013794 **Legal:** 141-57-23

Date: 7/12/2016 **Time:** 8:45 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.2

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 9 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: Moved site 2 m W to stay in sampling pixel.

Ap- 0 to 17 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to moderate medium granular; friable; common fine roots; very few very fine pores; contains mixed calcic material; difficult to determine plow pan and rupture resistance due to moisture; slightly effervescent; smooth abrupt boundary.

Bk1- 17 to 33 cm; (2.5Y 5/3) moist; moderate coarse prismatic; very friable; few very fine parting to fine roots; many fine pores; few medium masses of carbonates; strongly effervescent; smooth clear boundary.

Bk2- 33 to 50 cm; (2.5Y 6/3) moist; very friable; common medium masses of carbonates; violently effervescent.

Sample ID: 129 **Soil Series:** Forman; grayish argillic **Site ID:** 2B17 **Crew:** MPB & BM

County: Barnes **DDD:** -97.802754, 46.73966 **Legal:** 138-56-30

Date: 7/25/2016 **Time:** 11:20 AM **Weather:** Sunny **Temperature (ºF):** 86 **PDOP:** 2.3

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 12 to 26 cm, firm

Site notes: Corn field; in a depression near a shelterbelt; very rare grayish Typic Argiudoll.

Ap- 0 to 23 cm; clay loam, (10YR 2.5/1) moist; strong coarse subangular blocky parting to moderate medium granular; friable; common fine roots; few very fine pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw- 23 to 38 cm; fine sandy loam, (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; moderately few fine roots; many very fine pores; 40 percent organic stains on sides of peds; very strong cambic expression throughout horizon; faint continuous cutans covering 60 to 70 percent of peds; noneffervescent; smooth clear boundary.

Bt- 38 to 50 cm; clay loam, (2.5Y 4/2) moist; strong medium prismatic parting to strong medium angular blocky; firm; distinct continuous cutans on all sides of peds; noneffervescent.

Sample ID: 498 **Soil Series:** Forman w/ LD **Site ID:** 2B18 **Crew:** MPB & RE

County: Barnes **DDD:** -98.313523, 46.927718 **Legal:** 140-61-24

Date: 7/26/2017 **Time:** 2:00 PM **Weather:** Sunny **Temperature (ºF):** 78 **PDOP:** 1.7

Depth of mollic colors: 45 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 45 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: 6 to 9 percent CV FS; healthy soybeans; moved site N to stay in sampling pixel

Ap- 0 to 18 cm; sandy clay loam, (10YR 2/1) moist; moderate parting to strong medium subangular blocky parting to weak fine granular; friable; common very fine roots; common parting to many very fine pores; noneffervescent; wavy very abrupt boundary.

Bt1- 18 to 32 cm; clay loam, (10YR 3/2) moist; moderate parting to strong medium prismatic; friable parting to firm; moderately few very fine roots; many very fine pores; very fine pores lined with cutans; parts to platy (mechanical) structure at top of prismatic structural units; common continuous distinct cutans on all sides of peds; noneffervescent; wavy abrupt boundary.

2Bt2- 32 to 45 cm; gravelly clay loam, (10YR 3/3) moist; moderate medium prismatic; firm; moderately few very fine roots; many very fine pores; 30 percent gravel; common continuous distinct cutans on all sides of peds; noneffervescent; smooth abrupt boundary.

Bk- 45 to 50 cm; (2.5Y 4/3) moist; strongly effervescent.

Sample ID: 278 **Soil Series:** Svea **Site ID:** 2B19 **Crew:** MPB & RE

County: Barnes **DDD:** -98.097866, 46.799574 **Legal:** 138-59-2

Date: 5/22/2017 **Time:** 12:30 PM **Weather:** Sunny **Temperature (ºF):** 60 **PDOP:** 1.7

Depth of mollic colors: 42 cm **Depth of mollic epipedon:** 28 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: 6 percent slope LV; uncultivated old shelterbelt; in a natural drain; many earthworms found while digging.

A1- 0 to 12 cm; clay loam, (10YR 2/1) moist; weak medium granular; very friable; many fine roots; many fine pores; many medium roots many medium and many very fine pores; noneffervescent; smooth clear boundary.

A2- 12 to 28 cm; (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to moderate medium granular; friable; many fine roots; many fine pores; many medium tubular earthworm pores; noneffervescent; smooth clear boundary.

Bw1- 28 to 42 cm; fine sandy loam, (10YR 2/2) moist; moderate medium parting to coarse prismatic; very friable; many fine roots; many very fine parting to fine pores; many very fine roots; lighter texture; noneffervescent; smooth abrupt boundary.

Bw2- 42 to 50 cm; fine sandy loam, (10YR 4/3) moist; moderate medium parting to coarse prismatic; very friable; common very fine roots; many very fine pores; common medium parting to coarse, faint parting to distinct, discontinuous cutans on sides and tops of peds; irregular matrix with many bleached sand grains and many bridged sand grains; may be and E/Bt, but does not have higher value colors associated with an eluvial horizon; noneffervescent.

Sample ID: 513 **Soil Series:** Wet Barnes/Balaton **Site ID:** 2B2 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.446248, 46.840976 **Legal:** 139-62-24

Date: 7/28/2017 **Time:** 2:00 PM **Weather:** Sunny **Temperature (ºF):** 72 **PDOP:** 1.5

Depth of mollic colors: 31 cm **Depth of mollic epipedon:** 25 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: On a nearly level rise in relatively large low area in the field; matrix was too high in clay content to determine plow pan.

Apz- 0 to 25 cm; clay loam, (10YR 2/1) moist; strong coarse subangular blocky parting to weak fine granular; firm parting to very firm; moderately few very fine roots; common very fine pores; platy (mechanical) structure; slightly effervescent parting to strongly effervescent; smooth very abrupt boundary.

Bwz- 25 to 31 cm; silty clay (10YR 3/2) moist; strong coarse prismatic; firm; very few very fine roots; many very fine pores; 20 percent organic stains on all sides of peds; noneffervescent; wavy abrupt boundary.

Bkz- 31 to 39 cm; silty clay (10YR 4/1) moist; moderate medium parting to coarse prismatic; friable; very few fine roots; many very fine pores; 10 percent organic stains on sides and tops of peds; violently effervescent; wavy clear boundary.

Bk- 39 to 50 cm; silty clay (10YR 5/2) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; common medium distinct redoximorphic concentrations (2.5Y 6/6); few fine iron nodules; violently effervescent.

Sample ID: 132 **Soil Series:** Barnes **Site ID:** 2B20 **Crew:** MPB & JS

County: Barnes **DDD:** -98.116962, 46.872385 **Legal:** 139-59-10

Date: 8/30/2016 **Time:** 1:00 PM **Weather:** Sunny **Temperature (ºF):** 77 **PDOP:** 1.7

Depth of mollic colors: 23 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** strongly effervescent **Plow pan range:** 4 to 13 cm

Site notes: Esker type environment or collapsed end moraine surrounding sampling location.

Ap- 0 to 13 cm; clay loam, (10YR 2/1) moist; weak fine granular parting to moderate coarse subangular blocky; friable; common very fine parting to fine roots; many medium pores; parts to platy (mechanical) structure; parts to weak fine granular structure from 0 to 3 cm; highly bioturbated (earthworms); noneffervescent; irregular abrupt boundary.

A- 13 to 23 cm; (10YR 2/1) moist; moderate coarse prismatic; very friable; common very fine roots; many very fine pores; platy (mechanical) structure varies throughout pit; profile in the pit has a partially compacted lower A horizon; some parts have natural prismatic structure; noneffervescent; wavy clear boundary.

Bw- 23 to 50 cm; (2.5Y 4/3) moist; moderate coarse prismatic; moderately few very fine roots; many very fine pores; common organic stains on tops and sides of peds; noneffervescent.

Sample ID: 576 **Soil Series:** Buse **Site ID:** 2B3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.591714, 46.932014 **Legal:** 140-63-23

Date: 8/17/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.3

Depth of mollic colors: 15 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 5 to 28 cm, firm

Site notes: Corn field.

Ap- 0 to 15 cm; loam, (10YR 3/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; moderately few fine pores; many fine earthworm casts; common medium tubular earthworm pores filled with calcic material; slightly effervescent; smooth very abrupt boundary.

Bk- 15 to 50 cm; (2.5Y 5/3) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine parting to fine roots; many very fine pores; from 32 to 50 cm, thin platy (mechanical) structure; uncommon at this depth; perhaps due to deep tillage; 20 percent fine and medium carbonate masses; parts to platy (mechanical) structure at the top of prismatic structural units; common medium tubular earthworm pores filled with mollic material; violently effervescent.

Sample ID: 596 **Soil Series:** Svea **Site ID:** 2B4 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.444921, 46.961953 **Legal:** 140-62-12

Date: 8/18/2017 **Time:** 1:00 PM **Weather:** Overcast **Temperature (ºF):** 75 **PDOP:** 2

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 29 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 8 to 34 cm, firm

Site notes: 6 to 9 percent LV FS; wetland 50 m W; carbonates at 52 cm.

Ap- 0 to 10 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak medium granular; very friable; common very fine parting to fine roots; common fine pores; many fine and medium earthworm casts; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

A- 10 to 29 cm; (10YR 2/1) moist; moderate medium prismatic; very friable; very few parting to moderately few very fine parting to fine roots; many very fine pores; platy (mechanical) structure; common fine tubular earthworm pores; noneffervescent; wavy abrupt boundary.

Bw- 29 to 50 cm; (10YR 3/2) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent.

Sample ID: 534 **Soil Series:** Barnes **Site ID:** 2B5 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.539548, 46.947678 **Legal:** 140-62-17

Date: 8/1/2017 **Time:** 5:00 PM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 1.7

Depth of mollic colors: 20 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 45 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: 8 percent slope LV BS; 50 m^2 area of stunted soybean growth; few cobbles at surface where soybeans are stunted; common cobbles when digging; too dry to determine plow pan.

Ap- 0 to 15 cm; sandy clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; few very fine roots; common very fine parting to fine pores; bleached sand grains; common fine to medium tubular earthworm pores filled with cambic material; noneffervescent; irregular abrupt boundary.

Bw1- 15 to 20 cm; sandy clay loam, (10YR 2/2) moist; moderate fine prismatic; friable; few very fine roots; many very fine pores; many medium tubular earthworm pores filled with mollic material; common fine pores; noneffervescent; irregular abrupt boundary.

Bw2- 20 to 45 cm; sandy clay loam, (2.5Y 4/3) moist; moderate medium prismatic; very friable parting to friable; common very fine roots; many very fine pores; common distinct patchy cutans on sides of peds; common fine and medium pores; very fine pores lined with cutans; slightly coarser texture; 10 percent coarse sands; noneffervescent; wavy very abrupt boundary.

Bk- 45 to 50 cm; (2.5Y 4/4) moist; slightly effervescent.

Sample ID: 135 **Soil Series:** Buse **Site ID:** 2B6 **Crew:** MPB & DGH

County: Cass **DDD:** -97.608779, 46.776918 **Legal:** 138-55-10

Date: 6/10/2016 **Time:** 1:34 PM **Weather:** Sunny **Temperature (ºF):** 77 **PDOP:** 1.7

Depth of mollic colors: 18 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:**

Site notes: Buse type pedon; south facing SH slope.

Ap- 0 to 18 cm; sandy clay loam, (10YR 3/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; many very fine roots; moderately few very fine pores; slightly effervescent; wavy very abrupt boundary.

Bk1- 18 to 29 cm; (10YR 6/3) moist; moderate coarse prismatic parting to moderate coarse subangular blocky; friable; common very fine parting to fine roots; many very fine pores; strongly effervescent; smooth abrupt boundary.

Bk2- 29 to 50 cm; (2.5Y 5/4) moist; strongly effervescent.

Sample ID: 381 **Soil Series:** Truncated Barnes/Buse **Site ID:** 2B7 **Crew:** MPB & RE

County: Barnes **DDD:** -98.455722, 46.998044 **Legal:** 141-61-30

Date: 6/21/2017 **Time:** 12:40 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.4

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** 17 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 4 to 30 cm, firm

Site notes: 10 percent slope lower BS CV; Kame or esker 20 m S with 10 to 20 percent surface coarse gravels and cobbles; site is in a tire track.

Ap1- 0 to 16 cm; clay, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine granular; firm; common very fine roots; many medium pores; many medium tubular earthworm pores filled with cambic and calcic material; smeared; roots matted against horizontal platy (mechanical) structural units; high earthworm activity; noneffervescent; irregular very abrupt boundary.

Ap2- 16 to 22 cm; (10YR 3/2) moist; moderate medium subangular blocky; friable parting to firm; few very fine roots; many very fine pores; parts to platy (mechanical) structure; mixed matrix contains remnant Ap(20% percent 10YR 2/1) Bw(60 percent 10YR 3/2) and Bk(20 percent 2.5Y 5/6); common earthworm casts; common medium tubular earthworm pores; slightly effervescent; wavy parting to irregular very abrupt boundary.

Bk1- 22 to 29 cm; (2.5Y 5/6) moist; moderate medium parting to coarse prismatic; very friable; moderately few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; 50 percent mixed mollic material; many medium tubular earthworm pores 20 to 30 percent remnant cambic colors; strongly effervescent; irregular very abrupt boundary.

Bk2- 29 to 50 cm; (2.5Y 5/6) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; few fine faint redoximorphic concentrations (7.5YR 5/6); violently effervescent.

Sample ID: 138 **Soil Series:** Svea **Site ID:** 2B8 **Crew:** MPB & BM

County: Barnes **DDD:** -97.89546, 46.960962 **Legal:** 140-57-8

Date: 7/6/2016 **Time:** 11:15 AM **Weather:** Sunny **Temperature (ºF):** 79 **PDOP:** 2

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 24 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 20 cm, firm

Site notes:

Ap- 0 to 18 cm; clay, (10YR 2/1) moist; moderate coarse parting to very coarse subangular blocky parting to weak fine parting to medium granular; friable parting to firm; common very fine roots; common very fine pores; medium platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

A- 18 to 24 cm; (10YR 2/1) moist; moderate coarse parting to very coarse prismatic; friable; common very fine parting to fine roots; many very fine parting to fine pores; noneffervescent; smooth clear boundary.

Bw- 24 to 50 cm; (10YR 2/2) moist; friable; common very fine roots; many very fine parting to fine pores; noneffervescent.

Sample ID: 141 **Soil Series:** Buse **Site ID:** 2B9 **Crew:** MPB & BM

County: Barnes **DDD:** -97.84753, 47.05511 **Legal:** 141-57-1

Date: 7/12/2016 **Time:** 12:00 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2

Depth of mollic colors: 13 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 24 to 31 cm, friable

Site notes: Moisture conditions make plow pan difficult to determine.

Ap- 0 to 13 cm; loam, (10YR 2.5/2) moist; moderate coarse subangular blocky; friable; common very fine roots; common faunal mixed calcic material in fine parting to medium pores; slightly effervescent parting to strongly effervescent; smooth abrupt boundary.

Bk1- 13 to 30 cm; (2.5Y 6/3) moist; moderate parting to strong coarse subangular blocky; friable; moderately few fine roots; common very fine pores; many fine parting to medium pores filled with mollic material; parts to firm in some areas; few fine pores; few fine carbonate filaments strongly effervescent parting to violently effervescent; smooth gradual boundary.

Bk2- 30 to 50 cm; (2.5Y 4/3) moist; moderate medium parting to coarse prismatic; few fine carbonate filaments; strongly effervescent.

Sample ID: 581 **Soil Series:** Barnes/Forman **Site ID:** 2C1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.576612, 46.932503 **Legal:** 140-63-24

Date: 8/17/2017 **Time:** 1:30 PM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.1

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 35 cm, firm

Site notes: Moved site 5 m S to remain in sampling pixel; 10 m away from shelter belt; corn field.

Ap- 0 to 22 cm; loam, (10YR 2/2) moist; strong medium parting to coarse subangular blocky parting to moderate fine granular; friable; common very fine parting to fine roots; few very fine parting to fine pores; corn roots matted against horizontal platy (mechanical) structural units; somewhat smeared; common medium tubular earthworm pores filled with Bw1; noneffervescent; wavy very abrupt boundary.

Bt1- 22 to 34 cm; sandy clay loam, (10YR 3/4) moist; moderate medium prismatic; friable; few very fine parting to fine roots; many very fine pores; 40 percent distinct cutans on all sides of peds; common medium tubular earthworm pores filled with mollic material; few fine tubular earthworm casts; borderline argillic; parts to platy (mechanical) structure at the top of prismatic structural units; very fine pores lined with cutans; noneffervescent; wavy clear boundary.

Bt2- 34 to 50 cm; sandy clay loam, (2.5Y 4/3) moist; moderate medium prismatic; very friable parting to friable; few very fine parting to fine roots; many very fine pores; 5 percent less clay content than Bt1; few distinct continuous cutans on interstructural voids; noneffervescent.

Sample ID: 144 **Soil Series:** Svea **Site ID:** 2C10 **Crew:** MPB & BM

County: Barnes **DDD:** -97.89933, 46.736285 **Legal:** 138-57-29

Date: 7/21/2016 **Time:** 10:45 AM **Weather: Temperature (ºF): PDOP:** 1.5

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** > 50 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 16 to 29 cm, firm

Site notes: NW corner of sampling pixel; moved site SW; in an area of accumulation; calcic materials have been transported from 3 distinct eroded knolls to the N, E, and S; first Pachic Hapludoll observed with calcic slope wash colluvium.

Ap- 0 to 23 cm; loam, (10YR 2/1) moist; strong coarse subangular blocky parting to moderate medium granular; friable; common very fine roots; moderately few medium pores; very few very fine pores; few fine masses of carbonates; slightly effervescent parting to strongly effervescent; smooth very abrupt boundary.

A- 23 to 50 cm; (10YR 2/1) moist; moderate coarse prismatic; friable; few very fine parting to fine roots; many very fine pores; platy (mechanical) structure; very slightly effervescent.

Sample ID: 146 **Soil Series:** Svea **Site ID:** 2C11 **Crew:** MPB & BM

County: Barnes **DDD:** -97.896914, 46.737031 **Legal:** 138-57-29

Date: 7/21/2016 **Time:** 9:45 AM **Weather:** Sunny **Temperature (ºF): PDOP:** 1.5

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 42 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 16 to 26 cm, friable

Site notes: 7 m W of drain

Ap- 0 to 26 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to moderate medium granular; friable; common fine roots; common very fine pores; many medium tubular earthworm pores; common casts ranging from fine to coarse; bleached sand grains; noneffervescent; smooth very abrupt boundary.

A- 26 to 42 cm; (10YR 2/1) moist; strong coarse prismatic; friable; moderately few very fine parting to fine roots; common very fine parting to fine pores; common medium tubular earthworm pores; noneffervescent; smooth abrupt boundary.

Bw- 42 to 50 cm; (10YR 3/1.5) moist; noneffervescent.

Sample ID: 442 **Soil Series:** Barnes **Site ID:** 2C12 **Crew:** MPB & RE

County: Barnes **DDD:** -98.277461, 46.890455 **Legal:** 139-60-5

Date: 7/26/2017 **Time:** 10:00 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.5

Depth of mollic colors: 30 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** 41 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 8 to 29 cm, friable

Site notes: Nearly level LV SH on a broad flat; soybeans healthy; 5 percent coarse and very coarse sands.

Ap- 0 to 20 cm; sandy clay loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; very friable; common very fine roots; common very fine pores; mixed eroded cambic material; parts to platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 20 to 30 cm; (2.5Y 3/3) moist; moderate medium prismatic; friable; common parting to many very fine roots; many very fine pores; 30 percent organic stains on sides and tops of peds; parts to platy (mechanical) structure at the top of prismatic structural units; common patchy distinct cutans on all sides of peds; continuous prominent cutans on interstructural voids; strong cambic development; very fine pores lined with cutans; noneffervescent; wavy clear boundary.

Bw2- 30 to 40 cm; (2.5Y 4/3) moist; moderate medium prismatic; friable; common very fine roots; many very fine pores; noneffervescent; wavy clear boundary.

2Bk- 40 to 50 cm; small gravelly clay loam, (2.5Y 5/3) moist; moderate medium prismatic; very friable; common very fine roots; many very fine pores; 15 percent very coarse sand and small gravel; few gravel sized pieces of shale; strongly effervescent.

Sample ID: 319 **Soil Series:** Thin Psammentic Argiudoll **Site ID:** 2C13 **Crew:** MPB & RE

County: Barnes **DDD:** -98.206382, 46.750736 **Legal:** 138-60-24

Date: 6/1/2017 **Time:** 1:00 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.5

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 33 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 7 to 20 cm, firm

Site notes: 3 to 5 percent CC FS; common worms when digging; argillic horizon under a thin loamy sand lithologic discontinuity; appears as if subsurface sand lens tapers off towards the lower third of this slope.

Ap- 0 to 16 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate medium granular; friable; common very fine roots; common fine parting to medium pores; bleached sand grains; platy (mechanical) structure; noneffervescent;

A- 16 to 33 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; common parting to many very fine pores; bleached sand grains; platy (mechanical) structure; noneffervescent; smooth clear boundary.

Bw1- 33 to 42 cm; (2.5Y 4/3) moist; moderate medium prismatic; friable; common very fine roots; many very fine pores; noneffervescent; wavy abrupt boundary.

2Bw2- 42 to 45 cm; loamy sand, (10YR 3/3) moist; noneffervescent;

Bt- 45 to 50 cm; clay, (2.5Y 3/3) moist; strong medium parting to coarse prismatic parting to strong medium angular blocky; firm; common very fine roots; many very fine pores; prominent continuous cutans on all sides of peds; noneffervescent.

Sample ID: 305 **Soil Series:** Barnes; buried by slope wash **Site ID:** 2C14 **Crew:** MPB & RE

County: Barnes **DDD:** -97.944213, 46.768312 **Legal:** 138-58-13

Date: 5/25/2017 **Time:** 12:20 PM **Weather:** Overcast **Temperature (ºF):** 60 **PDOP:** 1.8

Depth of mollic colors: 36 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 3 to 36 cm

Site notes: 10 to 12 percent slope LV BS; moved point 5 m SE to stay in sampling pixel; shelterbelt 80 m SE; buried Barnes type pedon; ephemeral drainage 20 m S; 10 percent surface gravels.

Ap(Bk)- 0 to 10 cm; loam, (10YR 4/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; very few very fine parting to fine roots; very few very fine pores; slope wash and colluvium; platy (mechanical) structure; violently effervescent; smooth abrupt boundary.

Apb- 10 to 17 cm; (10YR 2/1) moist; massive; firm parting to very firm; common very fine roots; many very fine pores; roots matted against horizontal platy (mechanical) structural units; discrete inclusions of mixed cambic material from plowing; noneffervescent; broken abrupt boundary.

Bwb- 17 to 36 cm; (10YR 3/2) moist; massive; firm parting to very firm; moderately few very fine roots; many very fine pores; noneffervescent; smooth abrupt boundary.

2Bkb- 36 to 50 cm; small gravelly loam, (2.5Y 4/4) moist; massive; friable parting to firm; common very fine parting to fine roots; many very fine pores; 20 percent coarse sands to small gravels; strongly effervescent.

Sample ID: 599 **Soil Series:** Buse **Site ID:** 2C15 **Crew:** MPB & RE

County: Barnes **DDD:** -98.360612, 46.953748 **Legal:** 140-61-10

Date: 8/18/2017 **Time:** 2:00 PM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 2.1

Depth of mollic colors: 11 cm **Depth of mollic epipedon:** 6 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Moved 3 m W to stay in sampling pixel; corn field; common coarse gravels and cobbles while digging.

Ap- 0 to 6 cm; sandy clay loam, (10YR 2/2) moist; weak medium subangular blocky parting to weak fine granular; very friable; common very fine parting to fine roots; very few very fine pores; mixed eroded cambic material; platy (mechanical) structure; strongly effervescent; smooth very abrupt boundary.

Bw- 6 to 11 cm; sandy loam, (10YR 3/2) moist; moderate medium subangular blocky; very firm; moderately few very fine roots; common very fine pores; roots matted against horizontal platy (mechanical) structural units; strongly effervescent; irregular very abrupt boundary.

Bk1- 11 to 32 cm; sandy loam, (10YR 6/4) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; violently effervescent; wavy abrupt boundary.

Bk2- 32 to 50 cm; sandy loam, (2.5Y 5/6) moist; moderate medium prismatic; very friable; few fine roots; common fine pores; violently effervescent.

Sample ID: 149 **Soil Series:** Barnes **Site ID:** 2C16 **Crew:** MPB & BM

County: Barnes **DDD:** -97.876768, 46.991235 **Legal:** 141-57-34

Date: 7/8/2016 **Time:** 10:49 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 2

Depth of mollic colors: 19 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 30 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 10 to 19 cm, firm

Site notes: Had to move sampling location 5 m SE; too close to corner of sampling pixel.

Ap- 0 to 19 cm; clay, (10YR 2/1) moist; weak medium parting to coarse subangular blocky parting to moderate fine parting to medium granular; few fine pores; mixed eroded cambic inclusions from plowing at 16 cm; platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

Bw- 19 to 30 cm; (2.5Y 4/4) moist; moderate coarse prismatic; friable; few very fine roots; many very fine pores; few faint discontinuous cutans on sides of peds; common faint discontinuous organic stains on sides and tops of peds; noneffervescent; smooth clear boundary.

Bk- 30 to 50 cm; (2.5Y 5.5/4) moist; very friable; few parting to common fine masses of carbonates; strongly effervescent.

Sample ID: 152 **Soil Series:** Buse/Langhei **Site ID:** 2C17 **Crew:** MPB & BM

County: Barnes **DDD:** -97.823083, 46.791102 **Legal:** 138-57-1

Date: 7/25/2016 **Time:** 1:15 PM **Weather:** Sunny **Temperature (ºF):** 86 **PDOP:** 1.6

Depth of mollic colors: 15 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 8 to 23 cm, very firm

Site notes:

Apk- 0 to 15 cm; loam, (10YR 3/1) moist; strong coarse subangular blocky; firm parting to very firm; many very fine roots; common very fine parting to fine pores; 5 to 10 percent calcic colors intermingled throughout; few medium pores filled with remnants of cambic material; common fine masses of carbonates; platy (mechanical) structure; strongly effervescent; smooth very abrupt boundary.

Bk- 15 to 50 cm; (10YR 5/4) moist; strong medium prismatic; very firm; few fine roots; many very fine pores; common fine masses of carbonates; structure was difficult to determine due to firmness and low moisture; 5 percent carbonate filaments from 38 to 50 cm; platy (mechanical) structure; strongly effervescent.

Sample ID: 315 **Soil Series:** Truncated Barnes/Buse **Site ID:** 2C18 **Crew:** MPB & RE

County: Barnes **DDD:** -98.027815, 46.725684 **Legal:** 138-58-32

Date: 6/1/2017 **Time:** 10:45 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 2.3

Depth of mollic colors: 20 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 20 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 7 to 16 cm, friable

Site notes: 6 to 9 percent slope LC; common coarse surface gravels on SH position of hillslope 50 m NE of site; ephemeral drainage 100 m SW.

Ap- 0 to 13 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; moderately few very fine roots; common parting to many very fine pores; platy (mechanical) structure; common medium tubular earthworm pores filled with cambic material; noneffervescent; wavy abrupt boundary.

Bw- 13 to 20 cm; (10YR 3/2) moist; moderate medium prismatic; friable; common very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; common fine to medium tubular earthworm pores filled with mollic and calcic material; few faint patchy cutans on sides of peds; strong cambic development; 10 percent of very fine pores lined with cutans; noneffervescent; wavy clear boundary.

Bk1- 20 to 31 cm; (10YR 5/3) moist; moderate medium prismatic; friable; common very fine roots; many very fine pores; moderately few medium tubular earthworm pores; slightly effervescent parting to strongly effervescent; wavy clear boundary.

Bk2- 31 to 50 cm; (10YR 5/3) moist; weak parting to moderate medium prismatic; friable; common very fine roots; many very fine pores; 5 to 10 percent medium carbonate masses; strongly effervescent.

Sample ID: 154 **Soil Series:** Thick Barnes/Svea **Site ID:** 2C19 **Crew:** MPB & BM

County: Barnes **DDD:** -97.901057, 46.879794 **Legal:** 139-57-5

Date: 7/20/2016 **Time:** 8:50 AM **Weather:** Overcast **Temperature (ºF):** 75 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 35 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 13 to 23 cm, friable

Site notes:

Ap- 0 to 23 cm; loam, (10YR 2/1) moist; weak fine granular parting to moderate parting to strong coarse subangular blocky; common very fine roots; common medium pores; very few very fine pores; moderately few medium earthworm casts; thin platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

A- 23 to 35 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many fine pores; few medium pores with mollic earthworm casts; noneffervescent; smooth clear boundary.

Bw- 35 to 50 cm; (10YR 3/2) moist; moderate coarse prismatic; friable; common very fine roots; many very fine pores; few medium earthworm casts; noneffervescent.

Sample ID: 613 **Soil Series:** Eroded Egeland, slope wash capped **Site ID:** 2C2 **Crew:** MPB, DS, & ST

County: Stutsman **DDD:** -98.445391, 46.840165 **Legal:** 139-62-24

Date: 8/30/2017 **Time:** 9:32 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 1.5

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 0 cm **Depth to carbonates:** > 50 cm

Carbonate effervescence: noneffervescent **Plow pan range:** 4 to 27 cm, friable

Site notes: Complex 6 to 9 percent slope CC lower third of BS; many bleached sand grains throughout profile; incorporated from sandy cambic horizon below.

Ap- 0 to 18 cm; sandy loam, (10YR 3/2) moist; moderate very fine subangular blocky parting to weak fine granular; very friable; moderately few very fine roots; very few very fine pores; cambic slope wash colluvium; platy (mechanical) structure; noneffervescent; wavy abrupt boundary.

A/B- 18 to 27 cm; (10YR 2/2) moist; moderate medium parting to coarse subangular blocky; friable parting to firm; few very fine roots; very few very fine pores; A horizon is cambic slope wash colluvium; 40 percent Bw2 material (2.5Y 4/3); noneffervescent; broken very abrupt boundary.

2Bw- 27 to 50 cm; loamy fine sand, (2.5Y 4/3) moist; weak medium parting to coarse prismatic; very friable; very few very fine roots; common very fine pores; noneffervescent.

Sample ID: 157 **Soil Series:** Buse **Site ID:** 2C20 **Crew:** MPB & BM

County: Barnes **DDD:** -97.887292, 46.908195 **Legal:** 140-57-28

Date: 7/6/2016 **Time:** 3:00 PM **Weather:** Overcast **Temperature (ºF):** 77 **PDOP:** 1.9

Depth of mollic colors: 24 cm **Depth of mollic epipedon:** 24 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 10 to 17 cm, friable

Site notes: Moved site 2 m S to stay in sampling pixel; boundary of Bk is irregular in pit wall.

Ap- 0 to 15 cm; clay, (10YR 2/1) moist; moderate coarse subangular blocky; friable; common fine roots; few fine pores; few parting to common medium pores; slightly effervescent; smooth abrupt boundary.

A- 15 to 24 cm; (10YR 2/1) moist; weak fine parting to medium granular; common very fine roots; many very fine pores; strongly effervescent; wavy clear boundary.

Bk1- 24 to 40 cm; (10YR 6/2) moist; very friable; strongly effervescent parting to violently effervescent; smooth clear boundary.

Bk2- 40 to 50 cm; (2.5Y 6/4) moist; very friable; violently effervescent.

Sample ID: 161 **Soil Series:** Buse **Site ID:** 2C21 **Crew:** MPB & BM

County: Barnes **DDD:** -97.839833, 46.805918 **Legal:** 139-57-35

Date: 7/27/2016 **Time:** 2:30 PM **Weather:** Sunny **Temperature (ºF): PDOP:** 1.6

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 17 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 12 to 17 cm, firm

Site notes: Moved 3 m S to stay in sampling pixel; gravelly sand lens beyond 50 cm; gravelly outwash observed at the surface SW of site on nearest highest knoll.

Ap- 0 to 17 cm; clay loam, (10YR 3/1) moist; moderate medium subangular blocky parting to weak fine granular; friable parting to firm; common very fine parting to fine roots; few very fine pores; platy (mechanical) structure; moderately few medium tubular earthworm pores; weak fine granular structure from 0 to 3 cm; noneffervescent; wavy very abrupt boundary.

Bk1- 17 to 23 cm; sandy clay loam, (2.5Y 5/3) moist; strong medium parting to coarse prismatic; firm; common very fine parting to fine roots; common very fine pores; transitional zone with remnant cambic stains; common carbonate masses; common organic stains on sides and tops of peds; entire horizon has platy (mechanical) structure; few medium earthworm pores lined with 10YR 2/1 casts; strongly effervescent; smooth clear boundary.

Bk2- 23 to 50 cm; sandy clay loam, (2.5Y 6/4) moist; few very fine roots; many very fine pores; platy (mechanical) structure from 23 to 33 cm and is firm; 15 to 20 percent carbonate masses; strongly effervescent.

Sample ID: 399 **Soil Series:** Renshaw **Site ID:** 2C3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.461664, 46.894169 **Legal:** 140-62-35

Date: 6/22/2017 **Time:** 1:10 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.4

Depth of mollic colors: 21 cm **Depth of mollic epipedon:** 21 cm **Depth to carbonates:** 21 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 7 to 27 cm, very firm

Site notes: 3 to 6 percent CC FS; few coarse gravels and cobbles while digging; wheat field.

Ap1- 0 to 13 cm; clay, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable parting to firm; many very fine parting to fine roots; few fine pores; parts to platy (mechanical) structure; parts to mechanically bulked; noneffervescent; wavy very abrupt boundary.

Ap2- 13 to 22 cm; (10YR 2/2) moist; strong coarse subangular blocky; very firm; common fine roots; few fine pores; cambic material (10YR 3/2) truncated and mixed into matrix; roots matted against horizontal platy (mechanical) structural units; noneffervescent; wavy very abrupt boundary.

Bk1- 22 to 42 cm; (10YR 7/2) moist; strong coarse prismatic; firm; moderately few very fine roots; common very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; strongly effervescent; wavy abrupt boundary.

2Bk2- 42 to 50 cm; sandy loam, (10YR 5/3) moist; moderate coarse prismatic; friable; few very fine roots; many very fine pores; strongly effervescent.

Sample ID: 164 **Soil Series:** Barnes **Site ID:** 2C4 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.550003, 46.998888 **Legal:** 141-54-29

Date: 6/16/2016 **Time:** 1:01 PM **Weather:** Sunny **Temperature (ºF):** 82 **PDOP:** 1.6

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 36 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Barnes type pedon; Initial dig shows high degree of faunal activity; Bw2 horizon boundary is broken in pit.

Ap- 0 to 16 cm; sandy clay loam, (10YR 2/2) moist; strong coarse parting to very coarse subangular blocky; firm; many fine roots; moderately few fine pores; noneffervescent;

Bw1- 16 to 27 cm; (10YR 2/2) moist; moderate parting to strong coarse prismatic; firm; common fine roots; common very fine parting to fine pores; tubular earthworms pores filled with 10YR 2/1 material; noneffervescent;

Bw2 - 27 to 36 cm; (10YR 4/3) moist; firm; few fine roots; many fine pores; noneffervescent;

Bk - 36 to 50 cm; (2.5Y 5/4) moist; friable; many fine pores; strongly effervescent.

Sample ID: 168 **Soil Series:** Barnes **Site ID:** 2C5 **Crew:** MPB & BM

County: Cass **DDD:** -97.573957, 46.74232 **Legal:** 138-55-25

Date: 6/29/2016 **Time:** 8:27 AM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 2.2

Depth of mollic colors: 19 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** very slightly effervescent **Plow pan range:** 11 to 19 cm, firm

Site notes: Leached of carbonates to 50 cm; had typical calcic horizon colors, but pedon was leached of carbonates.

Ap- 0 to 19 cm; sandy clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate fine parting to medium granular; firm; common very fine roots; very few very fine pores; common medium corn roots; noneffervescent; smooth abrupt boundary.

Bw1- 19 to 29 cm; (10YR 4/3) moist; moderate parting to strong coarse prismatic; firm; few fine roots; many fine pores; common organic stains on all ped sides (10YR 2/2); noneffervescent; smooth clear boundary.

Bw2- 29 to 50 cm; (2.5Y 5/3) moist; moderate medium prismatic; friable; common fine roots; many fine pores; few faint patchy cutans on sides of peds; few discontinuous distinct cutans on some sides of peds; noneffervescent.

Sample ID: 634 **Soil Series:** Gravelly Barnes **Site ID:** 2C6 **Crew:** MPB, DGH, & MR

County: Barnes **DDD:** -97.804652, 46.743155 **Legal:** 138-56-30

Date: 9/8/2017 **Time:** 9:20 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.1

Depth of mollic colors: 23 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 23 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:**

Site notes: 20 m W of shelterbelt; FS of a higher SU.

Ap- 0 to 13 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to moderate medium granular; friable; common very fine roots; common fine pores; 10 percent gravel; common casts; parts to platy (mechanical) structure; noneffervescent; wavy very abrupt boundary.

Bw- 13 to 23 cm; gravelly clay loam, (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; discrete horizontal bands of mixed mollic material; few faint discontinuous cutans; common fine pores; parts to platy (mechanical) structure; very slightly effervescent; wavy clear boundary.

2Bk1- 23 to 43 cm; very gravelly clay loam, (10YR 4/3) moist; weak coarse prismatic; friable; few very fine roots; many very fine pores; very slightly effervescent; wavy abrupt boundary.

Bk2- 43 to 50 cm; clay loam, (2.5Y 5/6) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; strongly effervescent.

Sample ID: 171 **Soil Series:** Barnes **Site ID:** 2C7 **Crew:** MPB & BM

County: Barnes **DDD:** -97.890337, 46.981329 **Legal:** 141-57-34

Date: 7/8/2016 **Time:** 9:30 AM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 1.5

Depth of mollic colors: 29 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 5 to 18 cm, friable

Site notes: Moved 1 m N of original site to stay in sampling pixel; wetland 50 m to the NW; Both cambic horizons are strongly expressed; Noticed few faint discontinuous clay skins.

Ap- 0 to 18 cm; sandy clay loam, (10YR 2/1) moist; weak coarse subangular blocky parting to weak parting to moderate medium granular; friable; few very fine roots; few very fine parting to fine pores; noneffervescent; smooth abrupt boundary.

Bw1- 18 to 29 cm; (10YR 3/2) moist; moderate coarse prismatic; few fine roots; many very fine pores; common fine pores; common discontinuous organic stains all sides of peds; noneffervescent; smooth clear boundary.

Bw2- 29 to 50 cm; (10YR 4/3) moist; moderate very coarse prismatic; friable; noneffervescent.

Sample ID: 312 **Soil Series:** Barnes **Site ID:** 2C8 **Crew:** MPB & RE

County: Barnes **DDD:** -98.194741, 46.738934 **Legal:** 138-60-25

Date: 5/25/2017 **Time:** 2:30 PM **Weather:** Sunny **Temperature (ºF):** 60 **PDOP:** 1.6

Depth of mollic colors: 39 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 7 to 23 cm, friable

Site notes: LC upper interfluve of a broad nearly level flat.

Ap- 0 to 20 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; very friable; moderately few very fine roots; common very fine pores; noneffervescent; smooth very abrupt boundary.

Bw1- 20 to 39 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; few earthworm casts; krotovina filled with Bw2; strong cambic development; very fine pores lined with cutans; faint to distinct cutans coating interstructural voids; noneffervescent; smooth abrupt boundary.

Bw2- 39 to 50 cm; (2.5Y 4/4) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; faint to distinct cutans coating interstructural voids; noneffervescent.

Sample ID: 242 **Soil Series:** Truncated Forman LD **Site ID:** 2C9 **Crew:** MPB & RE

County: Barnes **DDD:** -97.856141, 46.740502 **Legal:** 138-57-27

Date: 5/15/2017 **Time:** 1:45 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 38 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 10 to 17 cm

Site notes: Stone line at 33 cm.

Ap- 0 to 17 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky; friable; moderately few fine roots; very few very fine pores; common bleached sand grains; platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

Bw1- 17 to 27 cm; (2.5Y 3/3) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 30 to 50 percent organic stains on all sides of peds; discontinuous distinct cutans on sides of peds; truncated argillic; noneffervescent; smooth gradual boundary.

Bw2- 27 to 38 cm; (2.5Y 5/4) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 10 to 15 percent coarse sand to small gravel; slightly lighter in texture; strong cambic development; very fine pores lined with cutans; abnormally below an argillic horizon; slightly effervescent; smooth gradual boundary.

2Bk- 38 to 50 cm; gravelly loam, (10YR 4/3) moist; friable; moderately few very fine roots; common very fine parting to fine pores; slightly effervescent parting to strongly effervescent.

Sample ID: 418 **Soil Series:** Forman w/ LD **Site ID:** 3A1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.512277, 46.925052 **Legal:** 140-62-21

Date: 7/21/2017 **Time:** 11:14 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.9

Depth of mollic colors: 26 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** 48 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 4 to 21 cm, firm

Site notes: Moved 3 m SE to stay in sampling pixel; 3 to 6 percent slope LV upper third of BS.

Ap- 0 to 14 cm; loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; common parting to many very fine roots; many very fine parting to fine pores; many bleached sand grains; many medium tubular earthworm pores partially filled with argillic and cambic material; noneffervescent; smooth very abrupt boundary.

Bt1- 14 to 26 cm; clay, (10YR 3/3) moist; strong medium parting to coarse prismatic; firm; few very fine roots; many very fine parting to fine pores; 70 percent organic stains on tops of peds; common medium tubular earthworm pores filled with mollic material; prominent continuous cutans on interstructural voids; distinct discontinuous cutans on all sides of peds 60 to 70 percent; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; wavy clear boundary.

2Bt2- 26 to 48 cm; sandy clay loam, (2.5Y 4/3) moist; strong coarse prismatic; friable; very few very fine roots; many very fine pores; prominent continuous cutans on interstructural voids; distinct patchy cutans on all sides of peds; 50 percent common medium tubular earthworm pores; noneffervescent; wavy abrupt boundary.

2Btk- 48 to 50 cm; sandy clay loam, (2.5Y 4/4) moist; strong coarse prismatic; friable; very few very fine roots; many very fine pores; common fine and medium carbonate masses; strongly effervescent.

Sample ID: 291 **Soil Series:** Barnes **Site ID:** 3A10 **Crew:** MPB & RE

County: Barnes **DDD:** -98.040166, 47.040543 **Legal:** 141-58-9

Date: 5/24/2017 **Time:** 12:23 PM **Weather:** Partly cloudy **Temperature (ºF):** 60 **PDOP:** 1.6

Depth of mollic colors: 34 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 34 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 24 cm, firm

Site notes:

Ap- 0 to 16 cm; sandy clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine parting to medium granular; very friable; common very fine roots; common very fine parting to fine pores; broken 4 cm wedge of cambic mixed into horizon (10YR 3/2); common earthworm casts; noneffervescent; broken very abrupt boundary.

Bw- 16 to 34 cm; (10YR 3/3) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; strong cambic development; very fine pores lined with cutans; noneffervescent; irregular abrupt boundary.

Bk1- 34 to 42 cm; (10YR 6/3) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; 70 percent cambic colors (10YR 4/2) staining ped faces; parts to platy (mechanical) structure from 31 to 38 cm; strongly effervescent; wavy clear boundary.

Bk2- 42 to 50 cm; (2.5Y 6/4) moist; moderate medium prismatic; very friable; very few very fine roots; many very fine pores; strongly effervescent parting to violently effervescent.

Sample ID: 262 **Soil Series:** Buse/Barnes **Site ID:** 3A11 **Crew:** MPB & RE

County: Barnes **DDD:** -98.104644, 46.901408 **Legal:** 140-59-34

Date: 5/18/2017 **Time:** 8:50 AM **Weather:** Sunny **Temperature (ºF):** 45 **PDOP:** 1.7

Depth of mollic colors: 26 cm **Depth of mollic epipedon:** 10 cm **Depth to carbonates:** 26 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 4 to 12 cm, firm

Site notes: 1 percent slope SU.

Ap- 0 to 10 cm; loam, (10YR 2/2) moist; weak medium subangular blocky; friable; common very fine roots; very few very fine pores; platy (mechanical) structure; mechanically bulked surface; noneffervescent; smooth clear boundary.

Bw- 10 to 26 cm; (10YR 3/3) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; noneffervescent; smooth clear boundary.

Bk- 26 to 50 cm; (10YR 5/4) moist; moderate medium parting to coarse prismatic; friable; moderately few fine roots; many fine pores; 30 percent remnant cambic colors on sides of peds; 5 percent carbonate masses; slightly effervescent parting to strongly effervescent.

Sample ID: 331 **Soil Series:** Truncated Forman **Site ID:** 3A12 **Crew:** MPB & RE

County: Barnes **DDD:** -98.309452, 46.799338 **Legal:** 138-60-6

Date: 6/1/2017 **Time:** 4:40 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.5

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 38 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 4 to 18 cm, firm

Site notes: Surface is clayey; mixed from Bt; 3 to 6 percent slope LV FS; unusual for a cambic horizon to exist below an argillic horizon; the cambic horizon is lighter textured; not an actual discontinuity from sedimentation but different degrees of pedogenic development in the pedon.

Ap- 0 to 18 cm; clay loam, (10YR 2/1) moist; strong medium parting to coarse subangular blocky; friable parting to firm; many very fine parting to fine roots; common very fine pores; smeared; noneffervescent; smooth very abrupt boundary.

Bt- 18 to 31 cm; clay, (10YR 3/2) moist; strong medium parting to coarse prismatic parting to strong medium subangular blocky; firm; common very fine parting to fine roots; many very fine pores; distinct continuous cutans on all sides of peds; 10 to 20 percent organic stains on sides of peds; noneffervescent; wavy abrupt boundary.

Bw- 31 to 38 cm; loam, (2.5Y 3/3) moist; moderate medium prismatic; friable; common very fine roots; many very fine pores; 10 to 20 percent faint to distinct discontinuous cutans on sides of peds; few carbonate filaments; noneffervescent parting to very slightly effervescent; smooth very abrupt boundary.

Bk- 38 to 47 cm; (2.5Y 5/4) moist; very friable; strongly effervescent; wavy clear boundary.

Bky- 47 to 50 cm; (2.5Y 5/4) moist; very friable; 50 percent fine gypsum crystal nests; strongly effervescent parting to violently effervescent.

Sample ID: 327 **Soil Series:** Svea **Site ID:** 3A13 **Crew:** MPB & RE

County: Barnes **DDD:** -98.308516, 46.800899 **Legal:** 138-60-6

Date: 6/1/2017 **Time:** 4:00 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.3

Depth of mollic colors: 42 cm **Depth of mollic epipedon:** 32 cm **Depth to carbonates:** 42 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 4 to 16 cm, firm

Site notes: Nearly level LV FS on a broad flat; 6 percent slopes 80 meters to the S.

Ap- 0 to 15 cm; clay loam, (10YR 2/1) moist; moderate parting to strong medium parting to coarse subangular blocky; firm; common very fine roots; few very fine parting to fine pores; platy (mechanical) structure; smeared; few fine to medium tubular earthworm pores filled with cambic material; noneffervescent; smooth abrupt boundary.

A- 15 to 32 cm; (10YR 2/1) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; noneffervescent; wavy clear boundary.

Bw- 32 to 42 cm; (10YR 3/2) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; 30 percent organic stains on sides of peds; noneffervescent; wavy abrupt boundary.

2Bk- 42 to 50 cm; sandy loam, (2.5Y 6/2) moist; 30 percent cambic stains; strongly effervescent.

Sample ID: 354 **Soil Series:** Saline Buse/Truncated Barnes **Site ID:** 3A14 **Crew:** MPB & RE

County: Barnes **DDD:** -98.263012, 46.947765 **Legal:** 140-60-16

Date: 6/20/2017 **Time:** 10:00 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.1

Depth of mollic colors: 23 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 23 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 3 to 27 cm, firm

Site notes: On a slight (1 percent) rise of a CC FS depression; 60 m S of wetland.

Ap- 0 to 18 cm; clay, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to moderate fine parting to medium granular; firm; common very fine roots; very few very fine pores; rain drop impact crusting on mechanically bulked surface; smeared; roots matted against horizontal platy (mechanical) structural units; noneffervescent; smooth abrupt boundary.

Bw- 18 to 23 cm; silty clay (10YR 3/1) moist; moderate medium prismatic; firm; moderately few very fine roots; common very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; few medium carbonate masses; few carbonate filaments; noneffervescent; wavy clear boundary.

Bk1- 23 to 34 cm; silty clay (10YR 4/1) moist; weak parting to moderate medium prismatic; friable; common very fine roots; common very fine parting to fine pores; 50 percent organic stains on all sides off peds; 5 percent fine to medium carbonate masses; mixed eroded cambic remnants; strongly effervescent; wavy abrupt boundary.

Bk2- 34 to 44 cm; silty clay (2.5Y 6/2) moist; weak medium prismatic; very friable; common very fine roots; common parting to many very fine pores; 40 percent 10YR 5/1 stains from 34 to 38 cm; strongly effervescent parting to violently effervescent; wavy abrupt boundary.

Bky- 44 to 50 cm; (10YR 5/3) moist; weak medium prismatic; very friable; common medium gypsum crystal nests; slightly effervescent parting to strongly effervescent.

Sample ID: 446 **Soil Series:** Buse **Site ID:** 3A15 **Crew:** MPB & RE

County: Barnes **DDD:** -98.250502, 46.886309 **Legal:** 139-60-4

Date: 7/26/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 78 **PDOP:** 2.3

Depth of mollic colors: 9 cm **Depth of mollic epipedon:** 9 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 4 to 35 cm, firm

Site notes: SU of a nearly level rise; lower landscape portion of field.

Ap- 0 to 9 cm; clay loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; many very fine pores; mixed eroded cambic material; slightly effervescent; smooth very abrupt boundary.

Bk1- 9 to 24 cm; (10YR 4/2) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; organic and cambic stains on 50 percent of the sides of peds; violently effervescent; wavy clear boundary.

Bk2- 24 to 50 cm; (2.5Y 4/4) moist; moderate medium prismatic; friable; common very fine parting to fine roots; many very fine parting to fine pores; few coarse sand sized bits of shale; violently effervescent.

Sample ID: 641 **Soil Series:** Highly Developed Barnes/Truncated Forman **Site ID:** 3A16 **Crew:** MPB, DGH, & MR

County: Barnes **DDD:** -98.214835, 46.845607 **Legal:** 139-60-23

Date: 9/8/2017 **Time:** 2:09 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 9 to 25 cm, firm

Site notes: Common cobbles at surface; on an esker.

Ap- 0 to 16 cm; sandy clay loam, (10YR 3/1) moist; moderate coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; very few very fine pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 16 to 35 cm; sandy clay loam, (10YR 3/2) moist; moderate coarse prismatic; friable; few very fine roots; many very fine pores; faint discontinuous cutans on ped faces; borderline argillic horizon; noneffervescent; wavy clear boundary.

2Bw2- 35 to 50 cm; clay loam, (2.5Y 3/3) moist; moderate coarse prismatic; friable; few very fine roots; many very fine pores; common faint patchy cutans on all side of peds; distinct continuous cutans on interstructural voids; noneffervescent.

Sample ID: 385 **Soil Series:** Wet Barnes/Balaton **Site ID:** 3A17 **Crew:** MPB & RE

County: Barnes **DDD:** -98.369682, 46.985581 **Legal:** 141-61-35

Date: 6/21/2017 **Time:** 2:40 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.4

Depth of mollic colors: 25 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** 25 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 4 to 18 cm, firm

Site notes: Near water table intersection with surface; LV 0 to 2 percent slope at the middle third of BS; hilled corn field.

Ap- 0 to 14 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate medium granular; friable; few very fine roots; moderately few medium pores; smeared; parts to platy (mechanical) structure; many medium tubular earthworm pores; commonly filled with calcic material; noneffervescent; smooth very abrupt boundary.

Bw- 14 to 25 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 10 percent common medium tubular earthworm pores filled with calcic; organic staining on tops and sides of peds; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; wavy abrupt boundary.

Bk1- 25 to 43 cm; (10YR 6/2) moist; moderate medium prismatic; very friable; common very fine roots; many very fine pores; cambic stains on interstructural voids; violently effervescent; wavy clear boundary.

Bk2- 43 to 50 cm; (2.5Y 5/3) moist; moderate medium parting to coarse prismatic; very friable; few very fine roots; many very fine pores; strongly effervescent parting to violently effervescent.

Sample ID: 174 **Soil Series:** Truncated Buse **Site ID:** 3A18 **Crew:** MPB & BM

County: Barnes **DDD:** -97.856321, 47.027711 **Legal:** 141-57-14

Date: 7/12/2016 **Time:** 10:11 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.2

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 17 to 26 cm, very firm

Site notes:

Ap- 0 to 17 cm; clay loam, (10YR 3/1) moist; moderate coarse subangular blocky parting to moderate medium granular; common very fine parting to fine roots; few fine pores; few medium pores; strongly effervescent; smooth very abrupt boundary.

Ak- 17 to 26 cm; (10YR 4/1) moist; moderate parting to strong medium parting to coarse prismatic; firm; few very fine parting to fine roots; few very fine pores; stratified discrete inclusions of calcic material from 0 to 4 cm (2.5Y 5/2); strongly effervescent; smooth very abrupt boundary.

Bk- 26 to 36 cm; (10YR 4/2) moist; moderate medium prismatic; friable; strongly effervescent; smooth very abrupt boundary.

Bky- 36 to 50 cm; (2.5Y 4/4) moist; wet conditions; common medium gypsum crystal nests; few fine iron oxide nodules; common fine faint redoximorphic concentrations and depletions; slightly effervescent.

Sample ID: 525 **Soil Series:** Saline Buse **Site ID:** 3A19 **Crew:** MPB & RE

County: Barnes **DDD:** -98.424654, 47.042438 **Legal:** 141-61-9

Date: 8/1/2017 **Time:** 1:30 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2

Depth of mollic colors: 33 cm **Depth of mollic epipedon:** 24 cm **Depth to carbonates:** 24 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 26 cm, firm

Site notes: Accumulation of surface salts more soluble than gypsum; corn field.

Apz1- 0 to 6 cm; clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to moderate fine parting to medium granular; friable parting to firm; common very fine roots; common very fine parting to fine pores; common fine and medium earthworm casts; high degree of earthworm activity; noneffervescent; smooth very abrupt boundary.

Apz2- 6 to 24 cm; silty clay (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to moderate fine parting to medium granular; firm; few very fine parting to fine roots; moderately few very fine parting to fine pores; somewhat smeared; few mixed inclusions of remnant cambic colors (10YR 4/2) and calcic colors (10YR 6/3); lower degree of biotic mixing than Apz1; platy (mechanical) structure; noneffervescent; wavy clear boundary.

Bk1- 24 to 33 cm; silty clay (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) at the top of prismatic structural units; strongly effervescent; wavy abrupt boundary.

2Bk2- 33 to 42 cm; gravelly coarse sandy clay loam, (2.5Y 5/3) moist; weak medium prismatic; very friable; moderately few very fine parting to fine roots; many very fine pores; few fine parting to medium carbonate masses; few fine distinct redoximorphic concentrations (10YR 5/4); strongly effervescent parting to violently effervescent; wavy very abrupt boundary.

Bk3- 42 to 50 cm; silty clay (2.5Y 5/3) moist; weak medium prismatic; very friable; moderately few very fine parting to fine roots; many very fine pores; few fine to medium carbonate masses; few fine distinct redoximorphic concentrations (10YR 5/4); violently effervescent.

Sample ID: 377 **Soil Series:** Buse **Site ID:** 3A2 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.455269, 46.970197 **Legal:** 140-62-1

Date: 6/21/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.3

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 12 cm **Depth to carbonates:** 12 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 10 to 32 cm, firm

Site notes: Hilly more complex slopes; VC SH of relatively lower hillslope; wetland 60 m SW.

Ap- 0 to 12 cm; clay, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; very friable; many very fine parting to fine roots; common very fine parting to fine pores; many medium corn roots mechanically bulked; noneffervescent; wavy abrupt boundary.

Bw- 12 to 22 cm; (10YR 3/2) moist; moderate fine parting to medium prismatic; friable parting to firm; moderately few very fine roots; many very fine pores; mixed eroded remnant cambic colors; platy (mechanical) structure; slightly effervescent parting to strongly effervescent; smooth abrupt boundary.

Bk1- 22 to 35 cm; (10YR 4/2) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; mixed eroded remnant cambic colors; strongly effervescent; wavy clear boundary.

Bk2- 35 to 50 cm; (2.5Y 5/3) moist; weak parting to moderate medium prismatic; very friable parting to friable; common very fine roots; many very fine pores; few fine carbonate masses; strongly effervescent.

Sample ID: 339 **Soil Series:** Svea **Site ID:** 3A20 **Crew:** MPB, RE, & SC

County: Barnes **DDD:** -98.150179, 46.956063 **Legal:** 140-59-8

Date: 6/8/2017 **Time:** 11:22 AM **Weather:** Partly cloudy **Temperature (ºF):** 65 **PDOP:** 1.9

Depth of mollic colors: 50 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** 27 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 17 to 30 cm, friable

Site notes: 3 percent slope broad LV upper third BS; Bk at 50 cm; moldboard plowed; organic farmer; many worms, casts, and pores; high biotic activity.

Ap- 0 to 12 cm; clay loam, (10YR 2/1) moist; weak medium subangular blocky parting to weak fine granular; very friable; common very fine parting to fine roots; many very fine parting to fine pores; common earthworms while digging; noneffervescent; wavy clear boundary.

A- 12 to 23 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; very friable parting to friable; common very fine roots; many very fine pores; common medium earthworm casts in vesicular earthworm pores; common fine pores filled with cambic material; noneffervescent; wavy clear boundary.

Bw1- 23 to 27 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; very friable parting to friable; moderately few very fine roots; many very fine pores; few fine pores filled with mollic material; strong cambic development; very fine pores lined with cutans; noneffervescent; wavy clear boundary.

Bw2- 27 to 50 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; very friable; moderately few very fine roots; many very fine pores; 10 to 15 percent fine carbonate masses; very slightly effervescent parting to slightly effervescent.

Sample ID: 587 **Soil Series:** Vallers; saline **Site ID:** 3A3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.498574, 47.060102 **Legal:** 141-62-2

Date: 8/18/2017 **Time:** 10:30 AM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 1.4

Depth of mollic colors: 32 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** 32 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Moved site about 15 M N to get out of wetland; 3 to 6 percent slope CC FS; too wet to determine plow pan.

Apz- 0 to 9 cm; clay, (10YR 2/1) moist; strong coarse subangular blocky; friable; common very fine parting to fine roots; very few very fine pores; accumulations of salts more soluble than gypsum; noneffervescent; smooth very abrupt boundary.

Az- 9 to 18 cm; silty clay loam, (10YR 2/1) moist; moderate parting to strong coarse prismatic; friable; common very fine parting to fine roots; common very fine parting to fine pores; accumulations of salts more soluble than gypsum; noneffervescent; smooth very abrupt boundary.

Bwz- 18 to 32 cm; silty clay loam, (10YR 2/2) moist; strong coarse prismatic; friable; few very fine roots; common very fine pores; noneffervescent; wavy clear boundary.

Bky- 32 to 42 cm; clay loam, (10YR 4/1) moist; moderate coarse prismatic; friable; few very fine roots; many very fine pores; 15 percent irregular gypsum crystal nests; strongly effervescent; irregular very abrupt boundary.

Bk- 42 to 50 cm; (10YR 8/1) moist; weak medium prismatic; very friable; few very fine roots; many very fine pores; 50 percent 10YR 4/1 stains on sides of peds; violently effervescent.

Sample ID: 178 **Soil Series:** Barnes **Site ID:** 3A4 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.461458, 46.937969 **Legal:** 140-54-14

Date: 6/16/2016 **Time:** 9:09 AM **Weather:** Sunny **Temperature (ºF): PDOP:** 1.6

Depth of mollic colors: 41 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 41 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Barnes type pedon; 14 meters west of drain; redoximorphic features below 50 cm; fine iron oxide nodules; common faint iron depletions grade to prominent with depth.

Ap- 0 to 16 cm; sandy loam, (10YR 2/1) moist; moderate coarse subangular blocky; firm; very few very fine roots; very few very fine pores; noneffervescent; smooth clear boundary.

Bw- 16 to 41 cm; (10YR 3/2) moist; strong coarse prismatic parting to strong coarse subangular blocky; friable; moderately few very fine roots; many very fine pores; noneffervescent;

Bk- 41 to 50 cm; (10YR 6/3) moist; noneffervescent.

Sample ID: 181 **Soil Series:** Buse **Site ID:** 3A5 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.478794, 46.952231 **Legal:** 140-54-10

Date: 6/16/2016 **Time:** 10:40 AM **Weather:** Sunny **Temperature (ºF):** 82 **PDOP:** 2.3

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 12 to 35 cm, firm to very firm

Site notes: Buse type pedon.

Ap- 0 to 17 cm; sandy clay loam, (10YR 3/1) moist; strong coarse subangular blocky; firm; few very fine roots; few very fine pores; platy (mechanical) structure; strongly effervescent; smooth very abrupt boundary.

Bk1- 17 to 35 cm; (10YR 6/3) moist; weak coarse parting to very coarse prismatic; firm; common very fine parting to fine roots; many very fine parting to fine pores; platy (mechanical) structure; many medium tubular earthworm pores; plow pan is firm to very firm; violently effervescent; wavy abrupt boundary.

Bk2- 35 to 50 cm; (2.5Y 6/3) moist; weak coarse prismatic; friable; few medium gypsum crystal nests; violently effervescent.

Sample ID: 184 **Soil Series:** Barnes **Site ID:** 3A6 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.495376, 46.96061 **Legal:** 140-54-9

Date: 6/8/2016 **Time:** 10:00 AM **Weather:** Sunny **Temperature (ºF):** 66 **PDOP:** 2

Depth of mollic colors: 32 cm **Depth of mollic epipedon:** 21 cm **Depth to carbonates:** 32 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Somewhat poorly drained Barnes type pedon; 14 meters west of drain; redoximorphic features below 50 cm; fine iron oxide nodules; common faint iron depletions grade to prominent with depth.

Ap- 0 to 21 cm; clay loam, (10YR 2/1) moist; few very fine parting to fine roots; very few very fine pores; noneffervescent; smooth very abrupt boundary.

Bw- 21 to 32 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; noneffervescent; wavy clear boundary.

Bk- 32 to 38 cm; (10YR 6/3) moist; weak medium prismatic; very friable; few very fine roots; many very fine pores; strongly effervescent; wavy clear boundary.

Bky- 38 to 50 cm; (10YR 6/4) moist; weak medium prismatic; very friable; few very fine roots; many very fine pores; many medium and coarse gypsum crystal nests; strongly effervescent.

Sample ID: 429 **Soil Series:** Svea/Darnen **Site ID:** 3A7 **Crew:** MPB & RE

County: Barnes **DDD:** -97.860348, 46.960728 **Legal:** 140-57-10

Date: 7/24/2017 **Time:** 10:31 AM **Weather:** Partly cloudy **Temperature (ºF):** 70 **PDOP:** 2.3

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 35 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 4 to 18 cm, friable to firm

Site notes: Artificially cut surface drain leading to wetland; soybeans are yellow and stunted at outer perimeter of drain, soybeans at site are healthy; 5 cm lens of mixed eroded cambic and calcic (2.5Y 4/3) material from 30 to 35 cm; either drug up into solum by deep tillage or perhaps slop from an old drainage cut.

Apz- 0 to 23 cm; clay loam, (10YR 2/1) moist; strong coarse subangular blocky parting to weak fine granular; friable parting to firm; common very fine roots; common very fine parting to fine pores; highly smeared; salts more soluble than gypsum observed with 10x hand lens; platy (mechanical) structure; very slightly effervescent; smooth very abrupt boundary.

A/B- 23 to 35 cm; silty clay (10YR 2/2) moist; moderate parting to strong medium parting to coarse subangular blocky; friable parting to firm; moderately few very fine roots; common very fine pores; 3 cm thick discrete Bw lens mixed into matrix from tillage; platy (mechanical) structure; very slightly effervescent; smooth very abrupt boundary.

Bw- 35 to 47 cm; silty clay (10YR 3/1) moist; moderate fine parting to medium prismatic; very friable parting to friable; moderately few very fine roots; common very fine pores; noneffervescent; smooth very abrupt boundary.

Ab- 47 to 50 cm; silty clay (10YR 2/1) moist; moderate medium prismatic; very friable; moderately few very fine roots; many very fine pores; noneffervescent.

Sample ID: 343 **Soil Series:** Barnes **Site ID:** 3A8 **Crew:** MPB, RE, & SC

County: Barnes **DDD:** -98.18281, 46.966886 **Legal:** 140-59-6

Date: 6/8/2017 **Time:** 12:40 PM **Weather:** Partly cloudy **Temperature (ºF):** 80 **PDOP:** 1.4

Depth of mollic colors: 33 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** 33 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 3 to 26 cm, firm

Site notes: 2 percent slope FS VL; uncultivated area east 10 m E; moved site 3 m N to stay in sampling pixel.

Ap- 0 to 22 cm; clay loam, (10YR 2/1) moist; moderate parting to strong medium parting to coarse subangular blocky parting to moderate fine parting to medium granular; friable parting to firm; moderately few very fine roots; moderately few very fine pores; platy (mechanical) structure; common fine to medium tubular earthworm pores; smeared; noneffervescent; smooth abrupt boundary.

Bw- 22 to 33 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; few fine to medium pores filled with calcic and mollic material; noneffervescent; smooth clear boundary.

Bk1- 33 to 42 cm; (10YR 4/2) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; few fine to medium carbonate masses; slightly effervescent parting to strongly effervescent; smooth clear boundary.

Bk2- 42 to 50 cm; (10YR 6/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; few medium casts; violently effervescent.

Sample ID: 592 **Soil Series:** Wet Barnes/Balaton **Site ID:** 3A9 **Crew:** MPB & RE

County: Barnes **DDD:** -98.414297, 47.011942 **Legal:** 141-61-21

Date: 8/18/2017 **Time:** 12:00 PM **Weather: Temperature (ºF): PDOP:** 1.4

Depth of mollic colors: 39 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** 39 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: CC FS; saturated, salt, and/or water affected; poorly drained.

Ap- 0 to 10 cm; silty clay loam, (10YR 2/1) moist; weak medium subangular blocky parting to weak fine granular; very friable; common very fine roots; few very fine pores; noneffervescent; smooth very abrupt boundary.

A- 10 to 23 cm; silty clay (10YR 2/1) moist; strong medium parting to coarse prismatic; firm; common fine roots; common very fine pores; noneffervescent; wavy abrupt boundary.

Bw- 23 to 39 cm; silty clay loam, (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 20 percent organic stains on sides of peds; very fine pores 30 percent lined with cutans; faint to distinct patchy cutans on all sides of peds; noneffervescent; wavy abrupt boundary.

Bk- 39 to 50 cm; silty clay loam, (2.5Y 5/4) moist; weak medium prismatic; very friable; very few very fine roots; many very fine pores; 10 percent organic stains on sides of peds; few fine carbonate masses; strongly effervescent.

Sample ID: 578 **Soil Series:** Vallers; saline **Site ID:** 3B1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.581261, 46.931119 **Legal:** 140-63-24

Date: 8/17/2017 **Time:** 12:00 PM **Weather: Temperature (ºF): PDOP:** 1.8

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** 23 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 3 to 33 cm, firm

Site notes:

Apz- 0 to 23 cm; clay loam, (10YR 2/1) moist; strong coarse subangular blocky parting to moderate fine granular; very friable; common very fine parting to fine roots; few very fine parting to fine pores; 5 percent accumulations of salts more soluble than gypsum; common medium tubular earthworm pores; common fine casts; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bkz- 23 to 38 cm; silty clay (10YR 3/1) moist; moderate parting to strong coarse prismatic; friable parting to firm; moderately few very fine parting to fine roots; moderately few very fine parting to fine pores; few accumulations of salts more soluble than gypsum; parts to platy (mechanical) structure at the top of prismatic structural units; common medium redoximorphic concentrations (2.5Y 4/4); strongly effervescent; wavy clear boundary.

Bk- 38 to 50 cm; silty clay (2.5Y 5/2) moist; weak medium prismatic; very friable; very few very fine roots; many very fine pores; 30 percent redoximorphic concentrations on all sides of peds (2.5Y 5/4); violently effervescent.

Sample ID: 638 **Soil Series:** Svea/Tonka **Site ID:** 3B10 **Crew:** MPB, DGH, & MR

County: Barnes **DDD:** -97.926431, 46.814238 **Legal:** 139-57-31

Date: 9/8/2017 **Time:** 11:14 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 2.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 33 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 32 cm, very friable

Site notes: In a swale downslope from a vast upslope contributing area.

Ap- 0 to 13 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; very friable; common very fine roots; common fine pores; noneffervescent; smooth abrupt boundary.

A- 13 to 33 cm; loam, (10YR 2/1) moist; moderate medium prismatic parting to moderate coarse platy; very friable; few very fine roots; many very fine pores; platy (mechanical) structure; common fine and medium to coarse pores; noneffervescent; smooth clear boundary.

AE- 33 to 50 cm; silt loam, (10YR 3/1) moist; weak medium prismatic; very friable; few very fine roots; many very fine pores; 5 cm inclusion many fine salt nests more soluble than gypsum; noneffervescent.

Sample ID: 295 **Soil Series:** Forman **Site ID:** 3B11 **Crew:** MPB & RE

County: Barnes **DDD:** -98.05169, 47.045541 **Legal:** 141-58-8

Date: 5/24/2017 **Time:** 2:00 PM **Weather:** Partly cloudy **Temperature (ºF):** 60 **PDOP:** 1.8

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 25 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 5 to 25 cm, firm

Site notes: 3 percent slope LC SH/BS position

Ap- 0 to 15 cm; sandy clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; moderately few very fine roots; common very fine parting to fine pores; platy (mechanical) structure; smeared; few medium earthworm casts; noneffervescent; smooth abrupt boundary.

A- 15 to 25 cm; (10YR 2/1) moist; moderate medium prismatic; friable parting to firm; common very fine roots; many very fine pores; common fine tubular earthworm pores filled with cambic material; noneffervescent; smooth very abrupt boundary.

Bt1- 25 to 38 cm; clay loam, (10YR 3/2) moist; moderate medium prismatic parting to moderate fine parting to medium angular blocky; firm; moderately few very fine roots; many very fine pores; 90 percent distinct continuous cutans on all sides of peds; noneffervescent; smooth clear boundary.

2Bt2- 38 to 50 cm; fine sandy clay loam, (2.5Y 4/4) moist; moderate medium prismatic parting to moderate medium subangular blocky; friable parting to firm; moderately few very fine roots; many very fine pores; 60 to 70 percent, patchy parting to discontinuous, faint to distinct cutans on sides and tops of peds; bridged sand grains; noneffervescent.

Sample ID: 188 **Soil Series:** Svea **Site ID:** 3B12 **Crew:** MPB & BM

County: Barnes **DDD:** -97.880792, 46.881357 **Legal:** 139-57-4

Date: 7/19/2016 **Time:** 2:20 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** > 50 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 13 to 38 cm, firm

Site notes:

Ap- 0 to 25 cm; clay loam, (10YR 2/1) moist; weak fine parting to medium granular parting to weak medium subangular blocky; friable; common fine roots; very few very fine pores; platy (mechanical) structure; bleached sand grains; common fine to medium tubular earthworm pores; few fine earthworm casts; noneffervescent; smooth very abrupt boundary.

A- 25 to 50 cm; clay loam, (10YR 2/1) moist; moderate medium parting to coarse prismatic; friable; common fine roots; common parting to many very fine pores; platy mechanical structure; bleached sand grains; tubular earthworm pores filled with casts; rubbed color 10YR 3/2; noneffervescent.

Sample ID: 190 **Soil Series:** Barnes **Site ID:** 3B13 **Crew:** MPB & BM

County: Barnes **DDD:** -97.884981, 46.881619 **Legal:** 139-57-4

Date: 7/19/2016 **Time:** 3:22 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.8

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 11 to 20 cm, very firm

Site notes: Moved site 3 m east to stay in sampling pixel; Bk horizon observed below 50 cm.

Ap- 0 to 20 cm; clay loam, (10YR 2/2) moist; moderate parting to strong coarse subangular blocky; firm; common fine roots; few very fine pores; noneffervescent; smooth very abrupt boundary.

Bw1- 20 to 32 cm; (10YR 3/3) moist; moderate coarse prismatic; friable; common very fine parting to fine roots; many very fine pores; common distinct continuous organic stains of all sides of peds; few faint discontinuous cutans on sides and bottoms of peds; few fine and medium pores; noneffervescent; smooth gradual boundary.

Bw2- 32 to 50 cm; (10YR 3/1) moist; few faint discontinuous cutans on sides and bottoms of peds; few fine and medium pores; noneffervescent.

Sample ID: 193 **Soil Series:** Barnes **Site ID:** 3B14 **Crew:** MPB & BM

County: Barnes **DDD:** -97.772299, 46.850182 **Legal:** 139-56-17

Date: 7/19/2016 **Time:** 10:50 AM **Weather:** Sunny **Temperature (ºF):** 84 **PDOP:** 1.5

Depth of mollic colors: 19 cm **Depth of mollic epipedon:** 19 cm **Depth to carbonates:** 30 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 10 to 18 cm, firm

Site notes: Moved 2 m south to stay in sampling pixel; krotovina filled with mollic material on the side of pit wall; common medium tubular earthworm pores in all horizons; few are either void, filled with mollic, or filled with calcic material.

Ap- 0 to 19 cm; sandy loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak medium granular; friable; many very fine roots; few very fine parting to fine pores; medium platy (mechanical) structure; common medium roots; noneffervescent; smooth abrupt boundary.

Bw- 19 to 30 cm; (2.5Y 4/4) moist; moderate medium prismatic; friable; common very fine roots; common very fine pores; common discontinuous distinct organic stains on sides and tops of peds; noneffervescent; smooth clear boundary.

Bk- 30 to 50 cm; (2.5Y 6/4) moist; very friable; 30 percent tonguing of cambic colors (2.5Y 5/3); violently effervescent.

Sample ID: 196 **Soil Series:** Truncated Forman/Buse **Site ID:** 3B15 **Crew:** MPB & BM

County: Barnes **DDD:** -97.818607, 46.823957 **Legal:** 139-57-25

Date: 7/27/2016 **Time:** 11:05 AM **Weather:** Sunny **Temperature (ºF): PDOP:** 1.7

Depth of mollic colors: 24 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 4 to 13 cm

Site notes: Moved 3 m W to stay in sampling pixel.

Ap- 0 to 13 cm; clay, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky parting to weak fine parting to medium granular; firm parting to very firm; common very fine parting to fine roots; few very fine pores; irregular horizon boundary; weak fine granular structure from 0 to 4 cm; platy (mechanical) structure; very slightly effervescent; wavy very abrupt boundary.

Bt- 13 to 24 cm; (10YR 3/2) moist; moderate medium prismatic parting to strong medium angular blocky; firm; few fine roots; many very fine pores; faint parting to distinct cutans on all sides of peds; cutans become faint with depth; moderately few medium pores filled with calcic material; few pores lined with mollic and or remnant cambic material; mixed mollic and calcic colors; dominant cambic color 10YR 4/2; slightly effervescent parting to strongly effervescent; smooth gradual boundary.

Bk1- 24 to 42 cm; (2.5Y 6/3) moist; moderate medium prismatic; friable parting to firm; few very fine roots; many very fine pores; faint discontinuous cutans from 24 to 31 cm; 10 to 15 percent remnant cambic colors (2.5Y 4/3); strongly effervescent; smooth gradual boundary.

Bk2- 42 to 50 cm; (2.5Y 5/4) moist; matrix colors are much more mixed than Bk1; strongly effervescent.

Sample ID: 647 **Soil Series:** Barnes **Site ID:** 3B16 **Crew:** MPB

County: Barnes **DDD:** -98.372042, 46.814394 **Legal:** 139-61-34

Date: 9/12/2017 **Time:** 2:08 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 1.4

Depth of mollic colors: 24 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 24 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 26 cm, firm

Site notes: 4 percent slope VL; enclosed depression 40 m NE of site.

Ap- 0 to 15 cm; loam, (10YR 3/1) moist; moderate coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; few very fine pores; platy (mechanical) structure; mixed eroded cambic material; noneffervescent; smooth very abrupt boundary.

Bw- 15 to 24 cm; (10YR 3/2) moist; moderate medium prismatic; friable parting to firm; moderately few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; few medium tubular earthworm pores filled with remnant mollic material; distinct and faint patchy cutans on sides and tops of peds; 20 percent very fine pores lined with cutans; noneffervescent; wavy abrupt boundary.

Bk- 24 to 50 cm; (10YR 5/3) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; strongly effervescent.

Sample ID: 365 **Soil Series:** Buse **Site ID:** 3B17 **Crew:** MPB & RE

County: Barnes **DDD:** -98.287678, 46.988677 **Legal:** 141-60-33

Date: 6/20/2017 **Time:** 2 PM **Weather:** Sunny **Temperature (ºF):** 70 **PDOP:** 1.4

Depth of mollic colors: 16 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** 7 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 7 to 24 cm, friable

Site notes: 3 to 6 percent CL upper third of BS; 30 percent surface gravels on surrounding SU's.

Ap- 0 to 16 cm; loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; very friable parting to friable; common very fine parting to fine roots; moderately few very fine pores; few fine pores filled with remnant cambic and calcic material; platy (mechanical) structure; slightly effervescent; wavy very abrupt boundary.

Bk1- 16 to 44 cm; (2.5Y 5/3) moist; moderate medium prismatic; very friable parting to friable; common very fine roots; many very fine pores; 30 percent cambic stains (2.5Y 4/3) on sides of peds; 5 percent coarse sand sized shale; parts to platy (mechanical) structure at the top of prismatic structural units; common cambic stains on all sides of peds; moderately few fine pores filled with mollic material; strongly effervescent; smooth clear boundary.

Bk2- 44 to 50 cm; (2.5Y 5/5) moist; moderate medium prismatic; very friable; moderately few very fine roots; many very fine pores; few coarse sand sized shale fragments; violently effervescent.

Sample ID: 627 **Soil Series:** Balaton **Site ID:** 3B18 **Crew:** MPB & DGH

County: Barnes **DDD:** -98.386269, 46.976121 **Legal:** 140-61-4

Date: 9/1/2017 **Time:** 12:36 PM **Weather:** Overcast **Temperature (ºF):** 70 **PDOP:** 2.2

Depth of mollic colors: 33 cm **Depth of mollic epipedon:** 21 cm **Depth to carbonates:** 21 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Corn field; high earthworm activity; surface is firm.

Ap- 0 to 21 cm; loam, (10YR 2/2) moist; moderate parting to strong medium parting to coarse subangular blocky parting to moderate medium granular; firm; moderately few very fine parting to fine roots; common parting to many medium pores; mixed eroded cambic material; common parting to many medium tubular earthworm pores; parts to thin platy (mechanical) structure; highly smeared; noneffervescent; smooth very abrupt boundary.

Bk1- 21 to 33 cm; (10YR 3/1) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; remnant cambic colors; 40 percent faint patchy cutans on tops of peds; strongly effervescent; irregular abrupt boundary.

Bk2- 33 to 50 cm; (10YR 4/1) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; 30 percent 10YR 6/3; strongly effervescent parting to violently effervescent.

Sample ID: 630 **Soil Series:** Truncated Barnes/Buse **Site ID:** 3B19 **Crew:** MPB & DGH

County: Barnes **DDD:** -98.399094, 46.87133 **Legal:** 139-61-8

Date: 9/1/2017 **Time:** 3:00 PM **Weather:** Overcast **Temperature (ºF):** 70 **PDOP:** 1.8

Depth of mollic colors: 13 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 21 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 5 to 30 cm, firm

Site notes: VV upper third of BS/SH; soybean field; highly bioturbated.

Ap- 0 to 13 cm; loam, (10YR 2/2) moist; moderate coarse subangular blocky; friable; common very fine roots; common very fine pores; common medium tubular earthworm pores, commonly filled with cambic and calcic material; few fine pores; mixed eroded cambic material; parts to platy (mechanical) structure near horizon boundary; noneffervescent; smooth very abrupt boundary.

Bw- 13 to 21 cm; clay loam, (2.5Y 4/4) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; mixed inclusions of peds with patchy to discontinuous distinct cutans (10YR 3/2) from a truncated argillic (no longer present); clay loam (siltier); common organic stains on sides and tops of peds; common medium tubular earthworm pores commonly filled with mollic and calcic material; parts to platy (mechanical) structure; noneffervescent; wavy abrupt boundary.

Bk1- 21 to 37 cm; silt loam, (2.5Y 6/4) moist; moderate medium parting to coarse prismatic; very friable; very few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; strongly effervescent; wavy clear boundary.

Bk2- 37 to 50 cm; (2.5Y 5/4) moist; moderate medium parting to coarse prismatic; very friable; very few very fine roots; many very fine pores; many weathered shale fragments and stains from 42 to 50 cm; violently effervescent.

Sample ID: 530 **Soil Series:** Svea **Site ID:** 3B2 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.494279, 46.942323 **Legal:** 140-62-15

Date: 8/1/2017 **Time:** 4:00 PM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 1.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 23 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 6 to 29 cm, firm

Site notes: CC nearly level depression; very dry area; soybeans appear to tolerate drought better in these landscape positions.

Ap- 0 to 12 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; very few very fine pores; platy (mechanical) structure; somewhat smeared; common fine to medium tubular earthworm pores; noneffervescent; smooth clear boundary.

A- 12 to 23 cm; (10YR 2/1) moist; moderate medium prismatic; firm; few very fine roots; many very fine pores; platy (mechanical) structure; common fine pores; noneffervescent; smooth clear boundary.

Bw1- 23 to 47 cm; (10YR 2/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; common fine pores; strong cambic development; very fine pores lined with cutans; noneffervescent;

Bw2- 47 to 50 cm; (2.5Y 3/2) moist.

Sample ID: 351 **Soil Series:** Barnes **Site ID:** 3B20 **Crew:** MPB, RE, & SC

County: Barnes **DDD:** -98.302465, 46.833426 **Legal:** 139-60-30

Date: 6/8/2017 **Time:** 3:20 PM **Weather:** Partly cloudy **Temperature (ºF):** 80 **PDOP:** 1.6

Depth of mollic colors: 38 cm **Depth of mollic epipedon:** 22 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 7 to 25 cm, firm

Site notes: Site is in a CC swale between two 6 percent slope SH's.

Ap- 0 to 22 cm; clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; moderately few very fine roots; moderately few very fine parting to fine pores; platy (mechanical) structure; smeared; roots matted against horizontal platy (mechanical) structural units; noneffervescent; abrupt boundary.

Bw1- 22 to 38 cm; (10YR 3/3) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; common fine to medium pores filled with mollic material; faint to distinct discontinuous to continuous cutans on interstructural voids; noneffervescent; smooth clear boundary.

2Bw2- 38 to 50 cm; sandy clay loam, (2.5Y 4/3) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine parting to fine pores; faint to distinct cutans on interstructural voids; noneffervescent.

Sample ID: 509 **Soil Series:** Svea **Site ID:** 3B3 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.456557, 46.821788 **Legal:** 139-62-25

Date: 7/28/2017 **Time:** 9:30 AM **Weather:** Sunny **Temperature (ºF):** 72 **PDOP:** 1.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 27 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: Nearly level FS; moved site SW to stay in sampling pixel; extremely dry; bleached sand grains; platy structure throughout entire profile; most likely a Tonka type pedon if further investigated.

Ap- 0 to 20 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; very friable parting to friable; common parting to many very fine roots; many very fine pores; thin platy (mechanical) structure from 12 to 18 cm; high earthworm activity; many fine and medium pores filled with earthworm casts; noneffervescent; smooth abrupt boundary.

A- 20 to 27 cm; (10YR 2/1) moist; moderate medium prismatic; very friable; moderately few very fine roots; many very fine pores; platy (mechanical) structure; common fine to medium pores; noneffervescent; wavy clear boundary.

Bw- 27 to 45 cm; (10YR 3/1) moist; moderate medium prismatic; very friable; few very fine roots; many very fine pores; platy (mechanical) structure; common fine to medium pores; noneffervescent; wavy abrupt boundary.

E/Bt- 45 to 50 cm; (10YR 3/1) moist; moderate medium prismatic parting to weak medium platy; friable; moderately few very fine roots; many very fine pores; platy (pedogenic) structure; many bleached sand grains; common faint to distinct discontinuous cutans; noneffervescent.

Sample ID: 200 **Soil Series:** Buse **Site ID:** 3B4 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.529279, 46.887217 **Legal:** 139-54-5

Date: 6/14/2016 **Time:** 11:30 AM **Weather:** Rainy **Temperature (ºF):** 66 **PDOP:** 1.5

Depth of mollic colors: 0 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 14 to 20 cm, firm

Site notes:

Ap- 0 to 17 cm; clay loam, (10YR 4/2) moist; moderate medium subangular blocky parting to moderate medium granular; friable; few very fine roots; very few very fine pores; platy (mechanical) structure at boundary; common medium tubular earthworm pores; few carbonate masses; strongly effervescent; irregular clear boundary.

Bk- 17 to 50 cm; (2.5Y 5/3) moist; weak coarse prismatic; very friable; few fine roots; many fine pores; common medium tubular earthworm pores; few carbonate masses; strongly effervescent.

Sample ID: 202 **Soil Series:** Svea **Site ID:** 3B5 **Crew:** MPB & DGH

County: Cass **DDD:** -97.559292, 46.816446 **Legal:** 139-55-36

Date: 6/17/2016 **Time:** 9:52 AM **Weather:** Overcast **Temperature (ºF):** 77 **PDOP:** 1.6

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 28 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: Svea type pedon; in a swale; broad contributing slopes from N W and S 40 to 50 m from site; leached of carbonates beyond 69 cm.

Ap- 0 to 18 cm; loam, (10YR 2/1) moist; moderate coarse parting to very coarse subangular blocky; friable; common very fine roots; mechanically bulked to weak fine granular structure; high degree of faunal activity; common medium tubular earthworm pores; many medium pores; noneffervescent; smooth abrupt boundary.

A- 18 to 28 cm; (10YR 2/1) moist; moderate very coarse prismatic; firm; common very fine roots; many very fine parting to fine pores; common medium tubular earthworm pores; mostly filled with casts; noneffervescent; smooth abrupt boundary.

Bw- 28 to 50 cm; (10YR 2/2) moist; friable; strong expression of cambic development around pores; noneffervescent.

Sample ID: 205 **Soil Series:** Hamerly **Site ID:** 3B6 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.501131, 46.868021 **Legal:** 139-54-9

Date: 6/8/2016 **Time:** 2:30 PM **Weather:** Sunny **Temperature (ºF):** 84 **PDOP:** 2.7

Depth of mollic colors: 0 cm **Depth of mollic epipedon:** 32 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: somewhat poorly drained area; Hamerly type pedon;

Ap- 0 to 18 cm; loam, (10YR 4/1) moist; strong coarse prismatic parting to strong coarse subangular blocky; firm; common very fine parting to fine roots; few very fine pores; common fine salt (more soluble than gypsum) crystal nests; strongly effervescent; irregular very abrupt boundary.

Az- 18 to 32 cm; (10YR 4/1) moist; moderate coarse subangular blocky parting to strong medium granular; firm; common very fine parting to fine roots; few very fine pores; common faint redoximorphic features strongly effervescent; irregular abrupt boundary.

Bk- 32 to 50 cm; (2.5Y 5/4) moist; grades toward common prominent redoximorphic features with depth; violently effervescent.

Sample ID: 362 **Soil Series:** Svea **Site ID:** 3B7 **Crew:** MPB & RE

County: Barnes **DDD:** -98.282039, 46.999035 **Legal:** 141-60-28

Date: 6/20/2017 **Time:** 1:00 PM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.4

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 37 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 6 to 26 cm, firm

Site notes: 2 percent slope CC; lower cambic horizon likely mixed into the surface from a chisel plow.

Ap- 0 to 22 cm; silty clay loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine granular; friable; many very fine roots; few very fine pores; smeared; parts to platy (mechanical) structure; common fine pores partially filled with earthworm casts; noneffervescent; smooth clear boundary.

A- 22 to 37 cm; (10YR 3/1) moist; moderate medium prismatic; friable; common very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; common fine to medium pores partially filled with mollic material; few faint continuous cutans on interstructural voids; noneffervescent; wavy clear boundary.

Bw- 37 to 50 cm; clay loam, (10YR 3/2) moist; moderate medium prismatic; friable; moderately few very fine roots; many very fine pores; few medium pores partially filled with cambic material from below 50 cm (2.5Y 5/3); lower cambic material has also been mechanically mixed into this horizon; very fine pores lined with cutans; noneffervescent.

Sample ID: 208 **Soil Series:** Truncated Barnes **Site ID:** 3B8 **Crew:** MPB & BM

County: Barnes **DDD:** -97.77189, 47.011665 **Legal:** 141-56-21

Date: 6/29/2016 **Time:** 11:54 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.6

Depth of mollic colors: 28 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** 15 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 8 to 11 cm, very firm

Site notes:

Ap- 0 to 15 cm; loam, (10YR 2/2) moist; moderate parting to strong coarse subangular blocky; firm parting to very firm; common fine roots; very few very fine pores; common medium tubular earthworm pores; noneffervescent; wavy abrupt boundary.

Bw- 15 to 28 cm; (10YR 2/2) moist; moderate coarse prismatic; friable; moderately few fine roots; many very fine parting to fine pores; truncated; irregularly distributed finely disseminated carbonates (violently effervescent); depth to carbonates is highly variable slightly effervescent; broken clear boundary.

Bk- 28 to 42 cm; (2.5Y 6/3) moist; very friable; strongly effervescent parting to violently effervescent;

Bky- 42 to 50 cm; (2.5Y 6/4) moist; very friable; many coarse gypsum crystal nests near 50 cm; strongly effervescent parting to violently effervescent.

Sample ID: 212 **Soil Series:** Truncated Forman **Site ID:** 3B9 **Crew:** MPB & BM

County: Barnes **DDD:** -97.771714, 46.849426 **Legal:** 139-56-17

Date: 7/19/2016 **Time:** 9:45 AM **Weather:** Sunny **Temperature (ºF):** 84 **PDOP:** 1.6

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 13 cm **Depth to carbonates:** 27 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 6 to 13 cm, firm

Site notes: Irregular abrupt boundary in pit between Bt and Bk; undulates in profile from 15 to 27 cm.

Ap- 0 to 13 cm; loam, (10YR 2/2) moist; strong coarse subangular blocky; firm parting to very firm; few very fine roots; very few very fine pores; dry conditions; common medium tubular earthworm pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bt- 13 to 27 cm; (10YR 3/3) moist; strong medium parting to coarse prismatic; moderately few fine roots; many fine pores; many distinct continuous cutans on peds; common organic stains on sides of peds; noneffervescent; irregular abrupt boundary.

Bk1- 27 to 40 cm; (2.5Y 6/3) moist; very friable; strongly effervescent; smooth clear boundary.

Bk2- 40 to 50 cm; (2.5Y 5/4) moist; very friable; strongly effervescent; smooth clear boundary.

Sample ID: 573 **Soil Series:** Barnes **Site ID:** 3C1 **Crew:** MPB & RE

County: Stutsman **DDD:** -98.60562, 46.932227 **Legal:** 140-63-23

Date: 8/17/2017 **Time:** 10:00 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.1

Depth of mollic colors: 28 cm **Depth of mollic epipedon:** 18 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:**

Site notes: Carbonates at 51 cm; 5 percent coarse gravels at surface.

Ap- 0 to 18 cm; clay loam, (10YR 2/2) moist; moderate fine parting to medium subangular blocky parting to weak fine granular; very friable; common very fine parting to fine roots; common very fine parting to fine pores; mixed eroded cambic material; platy (mechanical) structure; common fine earthworm casts; few fine and medium tubular earthworm pores; noneffervescent; wavy abrupt boundary.

Bw1- 18 to 28 cm; (10YR 3/3) moist; moderate medium prismatic; friable parting to firm; few very fine parting to fine roots; many very fine pores; distinct continuous cutans on interstructural voids in plow pan; 10 percent common fine earthworm casts; many organic stains on sides and tops of peds; few fine and medium tubular earthworm pores; strong cambic development; very fine pores lined with cutans; noneffervescent; wavy clear boundary.

Bw2- 28 to 50 cm; (10YR 4/3) moist; moderate medium parting to coarse prismatic; friable parting to firm; few very fine parting to fine roots; many very fine pores; common 10YR 3/3 stains on interstructural voids; few fine to medium tubular earthworm pores; few patchy faint to distinct cutans on tops of peds; strong cambic development; very fine pores lined with cutans; noneffervescent.

Sample ID: 239 **Soil Series:** Esmond/Coarse Buse **Site ID:** 3C10 **Crew:** MPB & RE

County: Barnes **DDD:** -97.731794, 46.766017 **Legal:** 138-56-15

Date: 5/15/2017 **Time:** 11:38 AM **Weather:** Sunny **Temperature (ºF):** 65 **PDOP:** 2.1

Depth of mollic colors: 0 cm **Depth of mollic epipedon:** 9 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: 10 percent slope VL SH; many surface gravels and cobbles; medium to coarse gravels throughout pedon.

Ap- 0 to 9 cm; sandy clay loam, (10YR 4/2) moist; weak medium subangular blocky parting to weak fine parting to medium granular; friable parting to firm; very few very fine roots; very few very fine pores; many mixed inclusions of violently effervescent material; remnant cambic colors (2.5Y 5/4); strongly effervescent; broken clear boundary.

Bk1- 9 to 29 cm; (2.5Y 5/4) moist; moderate medium parting to coarse prismatic; friable; very few very fine roots; many very fine pores; 20 percent mixed mollic material; few fine carbonate masses; violently effervescent; smooth gradual boundary.

Bk2- 29 to 50 cm; (2.5Y 4/4) moist; moderate medium parting to coarse prismatic; friable; very few very fine roots; many very fine pores; common fine carbonate accumulations; many bits of shale; violently effervescent.

Sample ID: 389 **Soil Series:** Svea **Site ID:** 3C11 **Crew:** MPB & RE

County: Barnes **DDD:** -98.34903, 47.001409 **Legal:** 141-61-25

Date: 6/21/2017 **Time:** 4:00 PM **Weather:** Sunny **Temperature (ºF):** 85 **PDOP:** 3

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 39 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 3 to 20 cm, friable

Site notes: In a gentle swale of a broad flat; 100 m from 3 to 6 percent slopes to the NW; wetland 100 m to the SE; moved site 3 m N to remain in sampling pixel.

Ap- 0 to 13 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; many fine pores; minimal smearing; matted roots on sides of ped faces; common medium tubular earthworm pores; common fine parting to medium earthworm casts; noneffervescent; smooth very abrupt boundary.

A- 13 to 39 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; friable; moderately few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; smooth clear boundary.

Bw- 39 to 50 cm; (10YR 2/2) moist; moderate medium prismatic; friable; few very fine roots; common very fine pores; strong cambic development; very fine pores lined with cutans; 20 percent faint discontinuous cutans on sides and tops of peds; noneffervescent.

Sample ID: 609 **Soil Series:** Thick Barnes **Site ID:** 3C12 **Crew:** MPB, DGH, & MR

County: Barnes **DDD:** -98.325227, 46.828116 **Legal:** 139-61-25

Date: 8/25/2017 **Time:** 1:46 PM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 2.1

Depth of mollic colors: 50 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 4 to 29 cm, firm

Site notes:

Ap- 0 to 10 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; few fine pores; parts to platy (mechanical) structure; mixed eroded cambic material; heavy clay loam; noneffervescent; smooth very abrupt boundary.

A- 10 to 20 cm; clay loam, (10YR 2/1) moist; moderate medium parting to coarse prismatic; firm; moderately few very fine parting to fine roots; common very fine pores; mixed eroded cambic material; heavy clay loam; parts to platy (mechanical) structure; common medium tubular earthworm pores; noneffervescent; smooth very abrupt boundary.

Bw1- 20 to 35 cm; clay loam, (10YR 3/3) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; strong cambic development; heavy clay loam; very fine pores lined with cutans; faint to distinct patchy and discontinuous cutans; noneffervescent; wavy clear boundary.

Bw2- 35 to 50 cm; silty clay loam, (10YR 3/2) moist; moderate medium parting to coarse prismatic; friable; few very fine roots; many very fine pores; distinct continuous cutans on interstructural voids; bleached sand grains; noneffervescent.

Sample ID: 551 **Soil Series:** Truncated Forman LD **Site ID:** 3C13 **Crew:** MPB & RE

County: Barnes **DDD:** -98.411432, 46.895016 **Legal:** 140-61-32

Date: 8/9/2017 **Time:** 3:05 PM **Weather:** Overcast **Temperature (ºF):** 75 **PDOP:** 2.3

Depth of mollic colors: 50 cm **Depth of mollic epipedon:** 10 cm **Depth to carbonates:** 28 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 5 to 31 cm, firm

Site notes: Complex 3 to 6 percent slopes VV SU which acts as the FS of a higher hillslope system; Supercell thunderstorm was approaching and had to describe quickly; drought stressed soybeans; specific portions of the field have non-wilting plants; looks like it might be in locations where that argillic horizon is more fully developed; drainages and other low spots have no signs of drought stress.

Ap- 0 to 10 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; moderately few very fine pores; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bt- 10 to 28 cm; (10YR 3/2) moist; strong medium prismatic parting to strong fine subangular blocky; firm; moderately few very fine roots; many very fine pores; platy (mechanical) structure; 80 percent distinct continuous cutans on all sides of peds; parts to angular blocky structure; noneffervescent; irregular very abrupt boundary.

2Bk- 28 to 50 cm; gravelly clay loam, (2.5Y 3/3) moist; moderate medium prismatic; friable; few very fine roots; many very fine pores; parts to platy (mechanical) structure at top of prismatic structural units; coarse sand sized pieces of shale; violently effervescent.

Sample ID: 216 **Soil Series:** Svea **Site ID:** 3C14 **Crew:** MPB & BM

County: Barnes **DDD:** -97.76421, 46.863462 **Legal:** 139-56-9

Date: 7/19/2016 **Time:** 12:30 PM **Weather:** Sunny **Temperature (ºF):** 88 **PDOP:** 1.9

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 43 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 13 to 24 cm, friable

Site notes: Moved site 1 m S to stay in sampling pixel.

Ap- 0 to 24 cm; loam, (10YR 2/1) moist; moderate coarse subangular blocky; friable; common fine roots; common parting to many very fine pores; common fine parting to medium tubular earthworm pores; few fine earthworm casts; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

A- 24 to 43 cm; (10YR 2/1) moist; moderate medium parting to coarse prismatic; friable; moderately few fine roots; many very fine pores; noneffervescent; smooth abrupt boundary.

Bw- 43 to 50 cm; (10YR 3/1) moist; moderate coarse prismatic; friable; very thick platy (mechanical) structure; parts to prismatic structure; 10YR 3/2 rubbed; noneffervescent.

Sample ID: 324 **Soil Series:** Balaton **Site ID:** 3C15 **Crew:** MPB & RE

County: Barnes **DDD:** -98.268431, 46.779677 **Legal:** 138-60-9

Date: 6/1/2017 **Time:** 2:35 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.7

Depth of mollic colors: 45 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** 45 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 7 to 23 cm, firm

Site notes: CC FS next to a swale; very dark mollic colored Ap and Bw horizons over a Bk horizon; similar to a Balaton type pedon, but did not have a natural A horizon.

Ap- 0 to 20 cm; clay, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable parting to firm; common very fine parting to fine roots; moderately few very fine pores; platy (mechanical) structure; smeared; common medium tubular earthworm pores; bleached sand grains; noneffervescent; smooth very abrupt boundary.

Bw- 20 to 45 cm; (10YR 2/2) moist; moderate medium prismatic; friable; common very fine parting to fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; strong cambic development; very fine pores lined with cutans on sides of peds; noneffervescent; wavy abrupt boundary.

Bk- 45 to 50 cm; (10YR 4/1) moist; very friable; medium to coarse redoximorphic concentrations (2.5Y 4/4); strongly effervescent.

Sample ID: 547 **Soil Series:** Forman **Site ID:** 3C16 **Crew:** MPB & RE

County: Barnes **DDD:** -98.364083, 47.060011 **Legal:** 141-61-2

Date: 8/9/2017 **Time:** 12:45 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.8

Depth of mollic colors: 32 cm **Depth of mollic epipedon:** 14 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 8 to 28 cm, firm

Site notes: Nearly level SU; dry conditions.

Ap- 0 to 14 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common very fine pores; parts to platy (mechanical) structure; noneffervescent; wavy very abrupt boundary.

E/Bt- 14 to 22 cm; loam, (10YR 3/1) moist; moderate fine subangular blocky parting to weak fine platy; very friable; common very fine roots; many very fine pores; many bleached sand grains; many discontinuous distinct cutans on all sides of peds; bridged sand grains; dry color 10YR 5/2; noneffervescent; irregular abrupt boundary.

Bt1- 22 to 32 cm; clay, (10YR 3/2) moist; strong medium prismatic parting to strong medium angular blocky; firm; common very fine roots; many very fine pores; 90 percent distinct continuous cutans on interstructural voids with bleached sand grains lining the macropores; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; irregular abrupt boundary.

Bt2- 32 to 50 cm; clay loam, (2.5Y 4/3) moist; strong medium prismatic parting to strong medium subangular blocky; firm; moderately few very fine parting to fine roots; many very fine parting to fine pores; 50 percent distinct discontinuous cutans on sides and tops of peds; noneffervescent.

Sample ID: 235 **Soil Series:** Wyard **Site ID:** 3C17 **Crew:** MPB & RE

County: Barnes **DDD:** -97.755269, 46.792127 **Legal:** 138-56-4

Date: 5/15/2017 **Time:** 10:00 AM **Weather:** Overcast **Temperature (ºF):** 61 **PDOP:** 1.7

Depth of mollic colors: 50 cm **Depth of mollic epipedon:** 30 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: very slightly effervescent **Plow pan range:** 10 to 27 cm

Site notes: Somewhat poorly drained Barnes/Wyard type pedon; 3 percent slope lower third of FS slope; 15 m from an enclosed depression; contains calcic slope wash colluvium at surface; the rest of the pedon is leached of carbonates.

Ap- 0 to 10 cm; clay loam, (10YR 2/1) moist; weak fine parting to medium granular; very friable; moderately few fine roots; very few very fine pores; noneffervescent; smooth abrupt boundary.

A- 10 to 30 cm; (10YR 2/1) moist; strong coarse subangular blocky; friable parting to firm; moderately few very fine roots; many very fine parting to fine pores; 5 percent tubular earthworm pores filled with cambic material; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 30 to 42 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic parting to weak fine platy; friable; very few very fine roots; many fine pores; 5 percent fine faint redoximorphic concentrations and depletions; noneffervescent; smooth clear boundary.

Bw2- 42 to 50 cm; (10YR 3/1) moist; moderate medium prismatic parting to weak fine platy; friable parting to firm; very few very fine roots; many very fine parting to fine pores; few distinct redoximorphic concentrations and depletions; common faint discontinuous cutans on all sides of peds; noneffervescent.

Sample ID: 219 **Soil Series:** Svea **Site ID:** 3C18 **Crew:** MPB & BM

County: Barnes **DDD:** -97.793661, 46.942995 **Legal:** 140-56-18

Date: 6/29/2016 **Time:** 10:27 AM **Weather:** Sunny **Temperature (ºF):** 80 **PDOP:** 1.6

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 35 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 15 to 23 cm, firm

Site notes: Moderate degree of faunal activity.

Ap- 0 to 20 cm; loam, (10YR 2/1) moist; moderate medium subangular blocky parting to moderate fine granular; friable parting to firm; common fine roots; few very fine pores; very thick platy (mechanical) structure; noneffervescent; smooth abrupt boundary.

A- 20 to 35 cm; (10YR 2/1) moist; moderate coarse parting to very coarse prismatic; firm; common fine roots; many fine pores; common medium tubular earthworm pores; noneffervescent; smooth clear boundary.

Bw- 35 to 50 cm; (10YR 2/2) moist; moderate medium parting to coarse prismatic; friable; common fine roots; many fine pores; noneffervescent.

Sample ID: 495 **Soil Series:** Buse **Site ID:** 3C19 **Crew:** MPB & RE

County: Barnes **DDD:** -98.296783, 46.913584 **Legal:** 140-60-30

Date: 7/26/2017 **Time:** 11:00 AM **Weather:** Sunny **Temperature (ºF):** 78 **PDOP:** 1.7

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: slightly effervescent **Plow pan range:** 6 to 25 cm, friable

Site notes: Nearly level SU; very healthy soybean field.

Ap- 0 to 17 cm; loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common fine pores; mixed eroded cambic and calcic material; common medium earthworm casts; common medium pores; platy (mechanical) structure; slightly effervescent parting to strongly effervescent; wavy very abrupt boundary.

Bk1- 17 to 24 cm; (2.5Y 5/3) moist; moderate medium prismatic; firm; common very fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; common faint organic stains on sides of peds; strongly effervescent parting to violently effervescent; wavy clear boundary.

Bk2- 24 to 50 cm; (2.5Y 5/4) moist; moderate medium prismatic; very friable; common very fine parting to fine roots; many very fine pores; common coarse sand sized bits of shale; violently effervescent.

Sample ID: 222 **Soil Series:** Truncated Forman **Site ID:** 3C2 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.664955, 46.938532 **Legal:** 140-55-18

Date: 6/13/2016 **Time:** 10:30 AM **Weather:** Sunny **Temperature (ºF):** 72 **PDOP:** 1.9

Depth of mollic colors: 27 cm **Depth of mollic epipedon:** 27 cm **Depth to carbonates:** 27 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: 20 m W of an artificially cut surface drain; Original site was too close to drain and the top soil was excavated from elsewhere; chose to move site 17 m W within sampling pixel.

Ap- 0 to 27 cm; clay loam, (10YR 2/1) moist; moderate coarse subangular blocky parting to moderate fine parting to medium granular; friable; few fine roots; few very fine pores; argillic horizon has been truncated and mixed into this horizon; weakly expressed prisms and peds with higher clay content from 16 to 27 cm, pedogenic transitional zone, but no color change; noneffervescent; smooth very abrupt boundary.

Bt- 27 to 33 cm; silty clay loam, (10YR 4/1) moist; strong coarse prismatic; friable; common fine roots; many fine pores; very many continuous prominent cutans on all sides of peds; organic stains on sides of peds; few faint redoximorphic concentrations near bottom of horizon; strongly effervescent; smooth abrupt boundary.

Bk- 33 to 50 cm; (2.5Y 6/2) moist.

Sample ID: 606 **Soil Series:** Buse **Site ID:** 3C20 **Crew:** MPB, DGH, & MR

County: Barnes **DDD:** -98.285392, 46.896498 **Legal:** 140-60-32

Date: 8/25/2017 **Time:** 11:22 AM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 1.9

Depth of mollic colors: 17 cm **Depth of mollic epipedon:** 17 cm **Depth to carbonates:** 17 cm

Carbonate effervescence: violently effervescent **Plow pan range:** 4 to 23 cm, firm

Site notes: Complex 3 to 6 percent slopes; on a nearly level SU that acts as the FS of a higher hillslope system; enclosed depression to the SE.

Ap- 0 to 17 cm; loam, (10YR 2/2) moist; moderate medium parting to coarse subangular blocky; friable; common very fine parting to fine roots; few fine pores; parts to platy (mechanical) structure; roots matted against horizontal faces of platy structural units; common medium tubular earthworm pores; few medium pores filled with calcic material; noneffervescent; smooth very abrupt boundary.

Bk1- 17 to 34 cm; clay loam, (10YR 6/3) moist; moderate medium parting to coarse prismatic; very friable; few very fine roots; many very fine pores; 80 percent organic stains from 0 to 4 cm; few tubular earthworm pores commonly filled with mollic material; few very coarse sand and small gravel sized pieces of shale; violently effervescent; wavy clear boundary.

Bk2- 34 to 50 cm; (2.5Y 6/4) moist; moderate medium parting to coarse prismatic; very friable; very few very fine roots; many very fine pores; 10 percent small gravels; few fine carbonate masses; few very coarse sand to small gravel size bits of shale; violently effervescent.

Sample ID: 225 **Soil Series:** Buse **Site ID:** 3C3 **Crew:** MPB, DGH, & BM

County: Cass **DDD:** -97.530932, 46.888795 **Legal:** 139-54-5

Date: 6/14/2016 **Time:** 10:35 AM **Weather:** Overcast **Temperature (ºF):** 60 **PDOP:** 2.1

Depth of mollic colors: 26 cm **Depth of mollic epipedon:** 26 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes:

Ap- 0 to 26 cm; clay loam, (10YR 3/1) moist; moderate coarse parting to very coarse subangular blocky; friable; common very fine roots; common very fine parting to fine pores; irregular 10YR 4/2 mixed cambic material; many medium tubular earthworm pores; strongly effervescent; smooth abrupt boundary.

Bk- 26 to 50 cm; (2.5Y 5/4) moist; weak coarse prismatic; very friable; moderately few very fine roots; common very fine pores; common fine gypsum crystal nests strongly effervescent parting to violently effervescent.

Sample ID: 227 **Soil Series:** Buse **Site ID:** 3C4 **Crew:** MPB & BM

County: Cass **DDD:** -97.673525, 46.991651 **Legal:** 141-55-32

Date: 6/21/2016 **Time:** 11:39 AM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.2

Depth of mollic colors: 20 cm **Depth of mollic epipedon:** 20 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Several krotovinas in soil pit.

Ap- 0 to 20 cm; clay loam, (10YR 2/1) moist; strong very coarse subangular blocky; firm; common very fine parting to fine roots; common medium pores; faunal and mechanically mixed calcic material 2.5Y 6/3; evidence of old cambic earthworm casts; strongly effervescent; smooth very abrupt boundary.

Bk- 20 to 50 cm; (2.5Y 6/3) moist; moderate coarse prismatic; friable; common very fine parting to fine roots; many fine pores; common organic stains on all sides of peds; strongly effervescent parting to violently effervescent.

Sample ID: 229 **Soil Series:** Hamerly/near surficial drainage cut **Site ID:** 3C5 **Crew:** MPB & DGH

County: Cass **DDD:** -97.614913, 46.878561 **Legal:** 139-55-3

Date: 6/9/2016 **Time:** 12:20 PM **Weather:** Sunny **Temperature (ºF):** 82 **PDOP:** 1.7

Depth of mollic colors: 21 cm **Depth of mollic epipedon:** 21 cm **Depth to carbonates:** 0 cm

Carbonate effervescence: strongly effervescent **Plow pan range:**

Site notes: Anthropogenically altered non-typical site; Introduced directed sampling based on site coordinates after this site; SU of slope next to a surface drain; high degree of mechanical mixing of surface and subsurface horizons.

Ap- 0 to 21 cm; clay loam, (10YR 2/2) moist; strong coarse subangular blocky; firm; mixed 10YR 3/2 material; faint redoximorphic concentrations and depletions; few fine iron oxide nodules; faint iron depletions grading to common prominent with depth; strongly effervescent; broken abrupt boundary.

Ak- 21 to 31 cm; (10YR 4/2) moist; strongly effervescent; broken abrupt boundary.

Bk- 31 to 50 cm; (10YR 6/2) moist.

Sample ID: 570 **Soil Series:** Truncated Barnes **Site ID:** 3C6 **Crew:** MPB & RE

County: Barnes **DDD:** -98.373685, 46.85112 **Legal:** 139-61-15

Date: 8/15/2017 **Time:** 4:00 PM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 2.1

Depth of mollic colors: 22 cm **Depth of mollic epipedon:** 11 cm **Depth to carbonates:** 22 cm

Carbonate effervescence: strongly effervescent **Plow pan range:** 4 to 33 cm, friable

Site notes: Moved S 3 m to stay in sampling pixel; middle third of BS of a long broad 3 to 6 percent slope hillslope.

Ap- 0 to 11 cm; clay loam, (10YR 2/1) moist; moderate medium subangular blocky parting to weak fine granular; very friable; many very fine roots; very few very fine pores; platy (mechanical) structure; 10 percent fine earthworm casts; noneffervescent; smooth very abrupt boundary.

Bw- 11 to 22 cm; (10YR 3/3) moist; moderate medium parting to coarse prismatic; friable; common very fine roots; many very fine pores; 10 percent mollic stains on interstructural voids; distinct continuous cutans on interstructural voids; strong cambic development; very fine pores lined with cutans; platy (mechanical) structure; noneffervescent; wavy abrupt boundary.

Bk- 22 to 50 cm; (2.5Y 6/3) moist; moderate medium prismatic; very friable; few very fine roots; many very fine pores; cambic stains on interstructural voids; parts to platy (mechanical) structure at the top of prismatic structural units; strongly effervescent; wavy clear boundary.

Sample ID: 433 **Soil Series:** Thick Barnes/Svea **Site ID:** 3C7 **Crew:** MPB & RE

County: Barnes **DDD:** -98.20957, 46.854603 **Legal:** 139-60-14

Date: 7/24/2017 **Time:** 12:13 PM **Weather:** Sunny **Temperature (ºF):** 75 **PDOP:** 1.4

Depth of mollic colors: 33 cm **Depth of mollic epipedon:** 15 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 3 to 25 cm, firm

Site notes: Nearly level FS between two 3 percent slope hillslope systems.

Ap- 0 to 15 cm; loam, (10YR 2/2) moist; moderate medium subangular blocky parting to weak fine granular; friable; common very fine parting to fine roots; common parting to many very fine parting to fine pores; somewhat smeared; 20 percent mixed cambic material; many bleached sand grains; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw1- 15 to 33 cm; (10YR 3/2) moist; moderate medium prismatic; friable; few very fine parting to fine roots; many very fine pores; common organic stains on sides and tops of peds; common medium tubular earthworm pores; noneffervescent; wavy clear boundary.

Bw2- 33 to 40 cm; (2.5Y 4/3) moist; moderate medium prismatic; friable; very few very fine roots; many very fine pores; common Bw1 stains on interstructural voids; noneffervescent; wavy clear boundary.

Bw3- 40 to 50 cm; (2.5Y 5/4) moist; moderate medium prismatic; very friable parting to friable; very few very fine roots; many very fine pores; common medium tubular earthworm pores; noneffervescent.

Sample ID: 232 **Soil Series:** Svea **Site ID:** 3C8 **Crew:** MPB & BM

County: Barnes **DDD:** -97.898946, 46.956428 **Legal:** 140-57-8

Date: 7/6/2016 **Time:** 12:04 PM **Weather:** Sunny **Temperature (ºF):** 79 **PDOP:** 2.5

Depth of mollic colors: > 50 cm **Depth of mollic epipedon:** 27 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 10 to 16 cm, firm

Site notes: Wheat field.

Ap- 0 to 18 cm; loam, (10YR 2/1) moist; moderate medium parting to coarse subangular blocky parting to weak fine parting to medium granular; friable parting to firm; common very fine parting to fine roots; common medium pores; few medium tubular earthworm pores; mixed 10YR 3/2 material 20 to 30 percent; noneffervescent; smooth abrupt boundary.

A- 18 to 27 cm; sandy clay loam, (10YR 2/1) moist; strong coarse prismatic; common very fine pores; wavy 2 cm sand lens from 25 to 27 cm; few medium tubular earthworm pores; noneffervescent; smooth clear boundary.

Bw- 27 to 50 cm; (10YR 2/2) moist; moderate coarse parting to very coarse prismatic; moderately few fine roots; many very fine pores; noneffervescent.

Sample ID: 565 **Soil Series:** Bisequal Tonka **Site ID:** 3C9 **Crew:** MPB & RE

County: Barnes **DDD:** -98.427745, 46.734139 **Legal:** 138-61-30

Date: 8/15/2017 **Time:** 2:00 PM **Weather:** Overcast **Temperature (ºF):** 65 **PDOP:** 1.9

Depth of mollic colors: 30 cm **Depth of mollic epipedon:** 16 cm **Depth to carbonates:** > 50 cm **Carbonate effervescence:** noneffervescent **Plow pan range:** 7 to 24 cm, firm

Site notes: Corn field; platy pedogenic structure was not apparent in eluvial horizons.

Ap- 0 to 16 cm; loam, (10YR 2/1) moist; moderate parting to strong coarse subangular blocky; firm; common very fine parting to fine roots; many very fine pores; many quartz sand grains; platy (mechanical) structure; noneffervescent; smooth very abrupt boundary.

Bw- 16 to 24 cm; (10YR 3/2) moist; moderate medium parting to coarse prismatic; very friable; few very fine parting to fine roots; many very fine pores; parts to platy (mechanical) structure at the top of prismatic structural units; noneffervescent; wavy abrupt boundary.

EB- 24 to 30 cm; (10YR 2/2) moist; moderate medium parting to coarse prismatic; very friable; few very fine parting to fine roots; many very fine pores; many organic stains on all sides of peds; higher sand content; noneffervescent; wavy clear boundary.

E- 30 to 37 cm; (10YR 5/2) moist; weak fine prismatic parting to weak fine subangular blocky; very friable; very few very fine parting to fine roots; many very fine pores; common organic stains; bleached sand grains; few faint patchy cutans on bottoms of peds; noneffervescent; smooth abrupt boundary.

Bt- 37 to 50 cm; (10YR 5/3) moist; strong coarse prismatic parting to strong medium angular blocky; extremely firm; few very fine parting to fine roots; many very fine pores; 100 percent prominent continuous cutans on all sides of peds; roots matted against ped faces on interstructural voids; 40 percent cutans (10YR 4/2); from 42 to 50 cm, 10 percent redoximorphic concentrations (5YR 4/6) in shape of fine root dendritic tubular pores; noneffervescent.