The effects of mechanical treatment on the soils and vegetation of a Natrargid-Paleargid complex in Northern Montana
by Marie Margaret Boehm

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Soil Science
Montana State University
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Abstract:
Three Natrargid soils (Tealette, Elloam and Thoeny) and one Pale-argid soil (Phillips) in northern Blaine County, Montana were characterized and their vegetative productivity was measured with and without mechanical treatment (plowing or chiseling). Four treatments were studied: native vegetation, unplowed (control); native vegetation, plowed (cl930); crested wheatgrass vegetation, plowed (c!940); and native vegetation, chiseled (1972).

Plowing was found to be the most effective mechanical treatment. Grass, forb and total productivity increased significantly ($p = .01$), especially on Elloam and Thoeny, the most extensive soils in the landscape. Favorable response was attributed to increased infiltration of precipitation and spring snow melt due to clubmoss removal and fracturing of the impermeable B horizon, particularly on Elloam and shallow Thoeny soils.

The chiseled site showed an increase in total productivity, but the vegetative community was still in a serai stage of secondary succession as indicated by a large proportion of forbs, notably fringed sagewort. Measurements were made only 8 years after treatment with continuous grazing in the interim, so that little successionary progress would be expected.

The beneficial effects of plowing were still evident at least 50 years a ter treatment. A long residual effect is expected for these soils in which natric horizon development has ceased due to the dominance of a semiarid climate. The elimination of the prerequisite perched water table prevents the net upward movement of water and the reformation of columnar structure in the B horizon.

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by

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A thesis submitted in partial fulfillment
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ABSTRACT

Three Natrargid soils (Tealette, Elloam and Thoeny) and one Paleargid soil (Phillips) in northern Blaine County, Montana were characterized and their vegetative productivity was measured with and without mechanical treatment (plowing or chiseling). Four treatments were studied: native vegetation, unplowed (control); native vegetation, plowed (c1930); crested wheatgrass vegetation, plowed (c1940); and native vegetation, chiseled (1972).

Plowing was found to be the most effective mechanical treatment. Grass, forb and total productivity increased significantly ($p = .01$), especially on Elloam and Thoeny, the most extensive soils in the landscape. Favorable response was attributed to increased infiltration of precipitation and spring snow melt due to clubmoss removal and fracturing of the impermeable B horizon, particularly on Elloam and shallow Thoeny soils.

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INTRODUCTION

Natrargid soils with slow permeability induced by soil texture and columnar structure occur intermittently in dryland areas of the continental till plain in northern Montana. Dense clubmoss (Selaginella densa) cover is frequently associated with these soils on heavily grazed rangelands. It reduces effective infiltration of precipitation and competes with preferred species for the limited moisture supply.

Historically, management intensity on these soils has been low. Economic factors on private land and public interest in better management of publicly owned rangeland has promoted an assessment of their potential productivity and the feasibility of renovation practices to increase their production.

A study of these soils in northern Blaine County was undertaken in 1979 as part of Interagency Agreement No. MT950-IA9-1442 between the Bureau of Land Management and Montana Agricultural Experiment Station. The objectives of the study were to:

1. Characterize four major range soils - Phillips (Paleargid); and Thoeny, Elloam and Tealette (Natrargids).
2. Evaluate their potential for forage productivity.
3. Evaluate the effects of two mechanical treatments, plowing and chiseling, on vegetative composition and productivity.

LITERATURE REVIEW

Mechanical land renovation has been practiced on western rangelands for more than 40 years in efforts to increase soil water storage, reduce runoff, and increase production of desirable forage (Neff, 1973; Branson et al., 1966). Climate, soil, grazing management, vegetation types, implements, and their use interact to determine treatment success (Branson et al., 1966).

Reports indicate that the most favorable response to mechanical treatments occur in arid and semiarid rangelands (Wight et al., 1978) with medium- to fine-textured soils (Branson et al., 1966). Sites in which soils are saline or sodium dominated tend to respond especially favorably to treatments which reduce run-off, providing a longer time for infiltration (Neff and Wight, 1977).

Implements most commonly used to treat rangelands are the moldboard plow, disc plow, ripper, pitter, chisel and contour furrower. There is consensus in the literature that contour furrowing is the most effective general method of treatment and that plowing tends to have the least long-term effect (Branson et al., 1966; Allmaras et al., 1977; Neff, 1973). Chiseling was only beneficial for treatments which required the fracturing of a "hardpan" layer in the soil to increase water infiltration and storage (Branson et al., 1966).

Effect of Mechanical Treatment on Soil Hydraulic Properties

Studies on the influences of chiseling and moldboard plowing on hydraulic properties of soils with an impermeable subsurface layer have shown that shallow chiseling improves water intake, soil water storage, and reduces soil water erosion more effectively than moldboard plowing (Lindstrom et al., 1974; Burwell and Larson, 1969; Allmaras et al., 1977; Sommerfeldt and Chang, 1980; Johnson and Moldenhauer, 1979). Burwell and Larson (1969) found that before runoff occurred, up to 50 percent more water infiltrated on chiseled plots than on counterparts moldboard plowed to the same depth. During the runoff phase, intake was not affected by tillage treatment when there were no residues on the surface. Water storage increases associated with chiseling have been attributed to improved intake from snowmelt and prevention of runoff due to the rough, trashy surface and fractured impermeable layer (Allmaras et al., 1977; Burwell et al., 1968).

Improved infiltration due to chiseling reported by Burwell et al. (1968) was inferred either from an increased proportion of large pores and increased permeability of saturated soil cores taken from problem subsurface layers, or when rupture of the problem subsurface layer was verified, even if changes in surface roughness were not great enough to affect surface detention and water intake. According to Allmaras et al. (1977) and Lindstrom et al. (1974) those observations would be insuffi-

cient to indicate any improvement due to chiseling. They propose that increased water holding capacity and greater downward distribution of water due to chiseling cannot be expected if the surface layer remains unchanged or if changes in profile water relations are unaffected by changes in water relations of the treated layer.

Allmaras et al. (1977) suggested that the beneficial effects of chiseling are related to increased water intake and redistribution down through the profile due to changed soil hydraulic properties. Reduction in water content of the upper layer of chiseled treatments due to more rapid drainage and redistribution would decrease surface evaporation, which decreases with soil water content (water diffusity), thus enhancing effective soil water storage. Increased hydraulic conductivity at constant water content due to chiseling and increased turbulent drying as the soil porosity is increased are both nullifying influences that must be considered in any net soil water storage projections.

Few researchers have studied the effects of chiseling or plowing on the water relations of sodium dominated soils. Branson et al. (1962) compared contour furrowing, trenching, pitting, plowing and ripping (chiseling) on 20 sites, one of which was a clayey saline-upland range site. They found that storage capacities of mechanically treated soils decreased rapidly during the first 5 years after treatment. Contour furrowing was the only treatment that caused a decrease in salts in

the upper portion of the treated soil within that time. They postulated that although chiseling fractured the subsoil, it did not modify the soil surface sufficiently to allow maximum detention and storage of precipitation and snowmelt. Despite its relative inefficiency, chiseling produced to some degree all of the benefits of contour furrowing. For soils with a "hardpan" layer, they concluded that it may be the most mechanically efficient method of improving infiltration and subsurface drainage. Plowing did not significantly affect soil hydraulic properties at any of the sites for more than 3 years.

Several studies have examined the influence of contour furrowing on water relations of Natrargid soils of mixed prairie rangelands. Increased soil water was the major beneficial effect of all contour furrowing treatments (Branson et al., 1966; Soiseth et al., 1974; Wight et al., 1978; Neff and Wight, 1977). Overwinter recharge increased 157 and 162 percent, respectively (Neff and Wight, 1977), and available soil water, measured as cm-days, increased 36 and 107 percent, respectively (Wight et al., 1978) on treated saline-upland and panspot sites. Enhanced overwinter recharge increased spring available moisture which accounted ($r = 0.89$) for about 65 percent of increased herbage production in both studies. Branson et al. (1966) reported that even after treatment, panspot soils had lower infiltration rates and soil moisture percentages than saline-upland soils, although some soils that would have been classed as panspot soils before treatment

were improved to saline-upland by contour furrowing. However, the fact that many furrowed panspots remained almost barren indicates that they cannot be completely reclaimed by mechanical treatment alone (Branson et al., 1966).

Influence of Mechanical Treatment on Herbage Production

Branson et al. (1966), in review of the influence of mechanical treatments on herbage production, reported that for panspot and saline-upland sites, beneficial biological effects persist for many years after enhanced moisture storage capacities of the soil have decreased. Wight et al. (1978) interpreted Soiseth's et al. (1974) data to indicate that any beneficial effects of contour furrowing should be autocyclic. As more water enters the soil, salinity decreases and herbage production increases, resulting in increased infiltration and nutrient availability, which, in turn, favors increased herbage production. In reference to panspot (Solonetzic) range sites, White (1969) observed increased herbage production 11 years after treatment and Soiseth et al. (1974) showed that improved infiltration, reduced sodium hazard and increased herbage production lasted for at least 10 years.

Yield responses of panspot range sites to mechanical treatment have varied from 0 to 100 percent or more (Wight, 1976). Wight et al. (1978) reported increased average herbage production of 165 percent (527 kg/ha) with thickspike-western wheatgrass (Agropyron smithii)

accounting for 64 percent of the increase. Basal cover of all other species was decreased. Rasmussen et al. (1972) and Branson et al. (1966) suggest that yield increases were generally 2.5 times greater on treated than check sites. Significant increases in litter, associated with increased forage production, were reported for all mechanical treatments (Branson et al., 1966).

It is generally agreed that re-establishment of major forage species requires about 4 years. Thickspike-western wheatgrass, Nuttall alkaligrass (Distichlis stricta) and, initially, foxtail barley (Hordeum jubatum) responded favorably to treatment. Crested wheatgrass (Agropyron cristatum) was generally not affected. Blue grama grass (Bouteloua gracilis), needle-and-thread grass (Stipa comata), and buffalo grass (Buchloe dactyloides) decreased on all treatment sites. Clubmoss response varied, tending to decrease with increased intensity of mechanical treatment. Fringed sagewort (Artemesia frigida) and other annual and biennial forbs increased with treatment intensity, but did not exceed 2.5 percent of total vegetation on any of the ungrazed study sites (Dolan and Taylor, 1972; Wight et al., 1978).

Influence of Grazing on Treatment Success

Restocking mechanically treated areas before forage species have become re-established has been shown to significantly reduce the beneficial effects of treatment. Branson et al. (1966) reported that

infiltration rates on contour furrowed "slick and semi-slick soils" decreased with an increase in grazing intensity. They speculated that this was due to decreased mulch and increase in soil compaction due to trampling.

Branson et al. (1966) and Dormaar et al. (1977) found that blue grama grass dominated heavily grazed treatment sites whereas needle-and-thread grass eventually dominated ungrazed sites. Clubmoss increased with grazing intensity. Vegetation changes were accompanied by a change in dry matter of the root mass in the top 15 cm of the soil in each study site, which averaged 15 and 24 tons of dry matter on the ungrazed and heavily grazed sites, respectively (Dormaar et al., 1977). These findings concur with those of Smoliak et al. (1976) who also noted an increase in moss phlox (Phlox hoodii), prickly pear cactus (Opuntia spp.) and fringed sagewort on heavily grazed Stipa-Bouteloua mixed prairie rangelands.

Influence of Mechanical Treatment on Clubmoss

Dolan (1966) compiled a comprehensive literature review on the ecological role of clubmoss and its control by mechanical treatment. He concluded that despite its role as a stabilizer against water and wind erosion, "high clubmoss density is inimical to maximum range production." Because of its ability to intercept moisture which is then

subject to rapid evaporation, it competes with desirable forage species for moisture. Removal of clubmoss competition for water and an increase in available nitrogen resulting from the decomposition of uprooted and buried clubmoss are partially responsible for increased productivity of preferred forage species on mechanically renovated range sites.

Dolan and Taylor (1972) observed that although clubmoss was still evident 40 years after mechanical treatment, its basal cover was reduced in proportion to intensity of treatment. Yield and ground cover contributed by forage species increased, as clubmoss decreased. Since no detrimental effects to the sites were observed in 40 years, renovation would appear to be effective in controlling clubmoss in areas where it is a problem.

LANDSCAPE ECOLOGY

Glacial History and Paleoecology

During the Wisconsin age, several major climatic changes associated with six distinct glacial advances and recessions occurred over the Northern Great Plains. In Montana, only the first two advances extended as far south as the Missouri River, each retreat marked by a deposition of glacial till material (Alden, 1932; Lemke et al., 1965). Meltwaters associated with the recession of the final four glaciations, flowed south to the Milk and Missouri Rivers, presumably carrying away much of the till. In some areas only a veneer of drift remains to cover the underlying, poorly consolidated Cretaceous shales, siltstones, and sandstones (Alden, 1932; Lemke et al., 1965).

Ice-age climate ended around 10,800 years BP (Bryson, 1975). The subsequent temperature trend was one of extensive warming in the mid-latitudes which culminated in a plateau of maximum warmth around the seventh millenium BP. The thermal maximum was maintained until the fourth millenium BP, after which cooling trends dominated with minor glacial advances around 3000 and 200 years BP (Bray, 1971).

Morrison and Frye (1965) have correlated climatic fluctuations during the Quaternary with soil-forming intervals in mid-latitude regions. They indicate that the rate of soil development varied exponentially, probably through several orders of magnitude, attaining greatest intensity during stronger soil-forming intervals of relative

erosional stability and accelerated chemical weathering. Their research showed that intense soil-formation occurred during warm interglacial periods, with little pedogenesis during wetter and colder glacial intervals.

On the basis of climatic and soil data collected around 50°N latitudes, Bray (1971) concurs with their findings, but he contends that interglacial periods tended to be wetter, though drier in the summer, than during the glacial intervals. The researchers do agree that in the Northern Great Plains, a period favoring soil development was initiated by the humid environment associated with glacial melt and was intensified during the thermal maximum. It has been hypothesized (Morrison and Frye, 1965) that the rate of pedogenic development has been negligible over most of the Northern Great Plains during the past 4,000 years. This would infer that well-developed Natrargid/Paleargid soils in Wisconsin-age glacial till parent material can only be explained with reference to former paleoclimatic conditions.

Soils

Northern Blaine County is in a soil transition zone of Aridisols and Mollisols developed in glacial till under mixed prairie vegetation. The surface mantle is thin and the underlying Cretaceous Bearpaw Shale is often near the surface (Alden, 1932). Bearpaw Shale, of the Montana Group of soft grey-black shales, was deposited by marine regression over the Judith River Formation sandstones of the Claggett Sea regres-

sion. It is characteristically a steel or lead grey to black, fissile, clayey shale with numerous limestone and ferruginous concretions and bentonite seams. A few thin fine-grained sandstones may be found in the upper part. Bearpaw Shale is nonresistant forming a subdued topography on the landscape (Veseth and Montagne, 1980). Both the glacial till parent material and the shale are somewhat saline (Lemke et al., 1965).

Localized areas of naturally occurring salt-affected soils are common throughout the region. They have distinctive argillic or natric horizons which are low in soluble salts but contain significant exchangeable sodium. The lower horizons usually contain both appreciable soluble salts and exchangeable sodium and magnesium.

Within a typical salt-affected landscape, the degree of salinization and/or alkalinization of individual pedons varies significantly. The most severely affected soils are panspots, or soils from which the A horizon has been eroded, exposing the columns of the B horizon. They are very sparsely vegetated by halophytes due to unfavorable physical conditions and extremely low water infiltration rates caused by the high exchangeable sodium levels.

Panspot soils occur in complex patterns on the landscape with less severely sodium affected and partially leached soils. The presence of an A horizon on these associated soils sufficiently ameliorates unfavorable conditions so that mesophytic species can survive. The proportion of mesophytic plants and total vegetative productivity tend to increase

as depth to the impermeable B horizon increases. The partially leached soils, in which the columnar structure has to some extent degraded, do not as severely restrict infiltration or root and water penetration. They are the most productive soils on the landscape.

Present views on the genesis of salt-affected or "solonetzic" soils (natric great groups of Alfisols, Mollisols or Aridisols in Soil Taxonomy, 1975) are mainly based on the concepts of "colloidal-chemical exchange" originally outlined by two early Russian workers, Gedroits and Vil'yams (Tyurin, 1960). Briefly, they postulated that the evolution of a solonetzic soil involves cation exchange in which sodium eventually dominates the colloidal system. The soil colloids become highly dispersed and mobile under such conditions, and are carried downward with percolating water or upward from moist subsoil during a dry season. Upon drying, they form a dense, compact and intractable illuvial horizon, in which, after many wetting and drying cycles, columnar structures develop (Tyurin, 1960; Arshad and Pawluk, 1966; Birkeland, 1974).

Conditions necessary for the development of solonetzic soil include: 1) periods of temporary excessive moisture (Westin, 1953), or 2) "an arid or semiarid climate, 3) an impervious subsoil or hardpan layer, and 4) a temporary abundance of humidity interspersed with dry periods" (de Sigmond, 1938). In the Northern Great Plains, solonetzic

complexes are associated with thin glacial till parent material which is somewhat less calcareous than parent material of associated "unaffected" soils, and which is underlain by Cretaceous marine shales which are devoid of lime and which frequently contain appreciable amounts of salts (Kellogg, 1934; MacGregor and Wyatt, 1945; Bentley and Rost, 1947; Westin, 1953; Bowser et al., 1962; Arshad and Pawluk, 1966). The presence of relatively impermeable strata fairly close to the surface would likely have caused the formation of a perched water table, particularly in immediate post-glacial times, which provided appropriate conditions for the temporary infusion of salts by capillary moisture towards the surface during periods of low precipitation. The process would have been intensified by the significantly warmer climate that characterized the period of thermal maximum (Arshad and Pawluk, 1966).

There is general agreement in the literature that solonetz will only develop in situations where sodium ions moved upward in greater concentration than either magnesium or calcium ions. The sodium ions then competed favorably for positions on the exchange sites. Since salts of calcium and magnesium are generally of lower solubility, they tended to precipitate in the lower solum when the soil dries. Thus, the selective removal of salts resulting from water table influence maintained the exchangeable sodium status in the upper solum. Variation in the occurrence and fluctuation of temporary and permanent water tables, and variability in the differential removal of sodium ions,

produced soils with B horizons varying both chemically and morphologically (Kellogg, 1934; MacGregor and Wyatt, 1945; Bentley and Rost, 1947; Westin, 1953; Bowser et al., 1962; Arshad and Pawluk, 1966; Rasmussen et al., 1972). Canadian researchers have reported studies on morphological solonetz in which magnesium is the dominant cation on the B horizon exchange complex (Ellis and Caldwell, 1935; Bentley and Rost, 1947; Bowser et al., 1962).

Vegetation and Land Use

Vegetation in northern Blaine County is typical of the Stipa-Bouteloua faciation of the mixed prairie association (Coupland, 1961). Dominant species of potential climax communities would include needle-and-thread grass, blue grama grass, green needlegrass (Stipa viridula), western wheatgrass, blackroot sedge (Carex eleocharis), sandberg bluegrass (Poa secunda), clubmoss, and prickly pear cactus. Introduced species, notably crested wheatgrass (Agropyron cristatum), have become common members of the association.

Needle-and-thread grass and western wheatgrass tend to dominate ungrazed sites. As grazing intensity increases, blue grama grass, fringed sagewort, and clubmoss increase considerably (Dormaar et al., 1977).

Land use is primarily livestock grazing. Some of the rangeland has been improved by reseeding, fertilizer or mechanical treatments. Where

soil conditions are compatible, cereal grains are produced in a dryland crop-fallow rotation.

Attempts to homestead in northern Montana were often unsuccessful as many of the early settlers failed in their attempt to dryland farm wheat. Frequently their farmland was abandoned and allowed to revegetate naturally. The restoration of many such disturbed sites was monitored by ecologists who observed that secondary succession proceeded in distinct stages, reculminating in native grassland (Costello, 1944; Hironaka and Tisdale, 1963; Looman, 1963). Their studies indicated that three successional plant communities preceded the re-establishment of a climax community.

The initial stage was characterized by annual forbs, most notably Russian thistle (Salsola kali). Within 3 to 5 years, perennial forbs began to replace Russian thistle and western wheatgrass and blue grama grass were occasionally observed. Gradually, perennial "weeds" were replaced by a short-lived community of perennial grass, as foxtail barley, western wheatgrass and blue grama grass became dominant. Prickly pear cactus and clubmoss were usually established by the end of this stage. The subsequent transition to native mixed prairie was usually complete within 25 years, characterized by an increasing dominance of blue grama, buffalo, needle-and-thread, and western wheatgrass. Forb population was extremely variable by this stage (Costello, 1944; Hironaka and Tisdale, 1963; Looman, 1963).

Transition between stages was generally progressive, unless retarded by severe climatic stress or overgrazing. The frequency of mid-grasses varied with precipitation, being inconspicuous in dry years (Hironaka and Tisdale, 1963). Costello (1944) noted that excessive grazing may maintain the forb stage indefinitely and, further, that overgrazing of the climax community may re-establish the forb community.

Overgrazing has been a serious problem on rangelands throughout the Northern Great Plains. Excessive grazing pressure upon natural plant communities is marked by a significant loss of forage species, however, it is the degree of overall environmental deterioration which must be used to measure grazing impact (Daubenmire and Colwell, 1942). In northern Montana, many plant communities are associated with morphologically and/or chemically unpropitious soils and are frequently subjected to climatic stress. Their survival is ensured only by the maintenance of a fragile balance. Edaphic changes and reduced vegetative cover due to overgrazing at such sites may result in serious erosion and compaction problems that complicate maintenance or restoration of mixed prairie vegetation, thus perpetuating the retrogradational trend (Daubenmire and Colwell, 1942; Smoliak et al., 1972; USDA, 1975; Dormaar et al., 1980).

MATERIALS AND METHODS

Sites were located 57 km north of Chinook in Blaine County, Montana on land administered by the Bureau of Land Management and on the Russell Unruh ranch (Figure 1). The area is located on gently undulating glacial topography with typical northern mixed prairie vegetation (Coupland, 1961). Parent material is glacial till which varies in thickness from a veneer to greater than 1 m over a Cretaceous saline, marine shale. Elevation ranges from 807 to 825 m. Mean annual precipitation is about 30 cm with half falling during May, June, and July.

Four major soils, representing extensive acreages of rangelands in the state were selected for study. They were identified with the help of Dan Tippy, BLM soil scientist in the Havre Resource Area. Three of the soils were Borollic Natrargids: Tealette, Elloam and Thoeny. The fourth soil was Phillips, a Borollic Paleargid. All four soils are in fine-textured families. They were identified in the field on the basis of depth to the tops of the columnar structure characteristic of Natrargids with caps of Tealette being 0-3 cm, Elloam being 3-13 cm, and Thoeny being 13-23 cm below the surface. Phillips does not exhibit columnar structure. The photograph (Figure 2) of the Thoeny and Phillips soils shows the variation in depth to caps and the abrupt breakdown of columnar structure between Thoeny and Phillips.

Field work was undertaken in July 1979 and June 1980. During July 10-13, 1979, three pedons were sampled for each soil representing

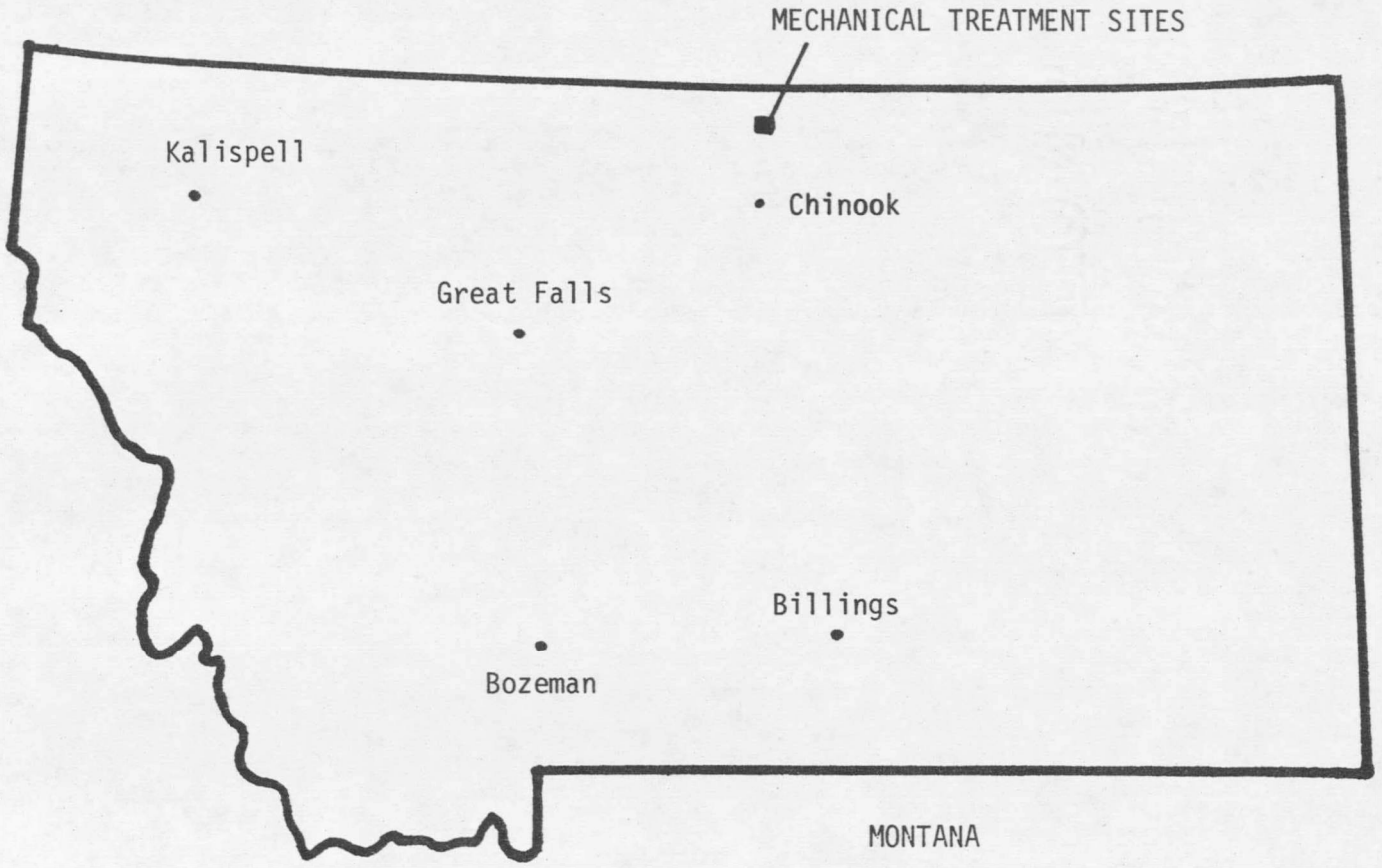


Figure 1. State map showing study site locations.



Figure 2. Typical sampling pit showing Thoeny series (left of meter tape) and Phillips series (right of meter tape).

three treatments: unplowed, native vegetation (NU79); plowed, native vegetation (NP79), and plowed, crested wheatgrass vegetation (CP79). From June 25-29, 1980, three pedons for each soil were sampled on three new treatment sites: unplowed, native vegetation (NU80), plowed, native vegetation (NP80), and chiseled, native vegetation (CH80). This resulted in 24 sites total, including 8 native, unplowed (control) and 8 native, plowed sites if the 1979 and 1980 sites are combined. Figure 3 schematically illustrates the locations of the study sites.

Although exact site history is not documented, Russel Unruh (personal communication, 1979 and 1980), a local rancher who grazes cattle on the study area on BLM land in addition to his own ranch, provided some historical data. The plowed sites were farmed until the 1930's at which time the land reverted to federal ownership under the Bankstead-Jones Act. Some of the abandoned farmland was seeded to crested wheatgrass while the balance gradually revegetated to native species. Boundaries between the plowed and unplowed areas are visually apparent (Figure 4), grass species being both more abundant and vigorous on the plowed sites, probably due to a reduction in ground cover of clubmoss mats. Unruh noted that the plowed sites were weedy for about 10 to 15 years following abandonment. The chiseled treatments were located on the Unruh Ranch, immediately adjacent to the plowed native and unplowed native sites sampled in 1980. The chiseled sites were

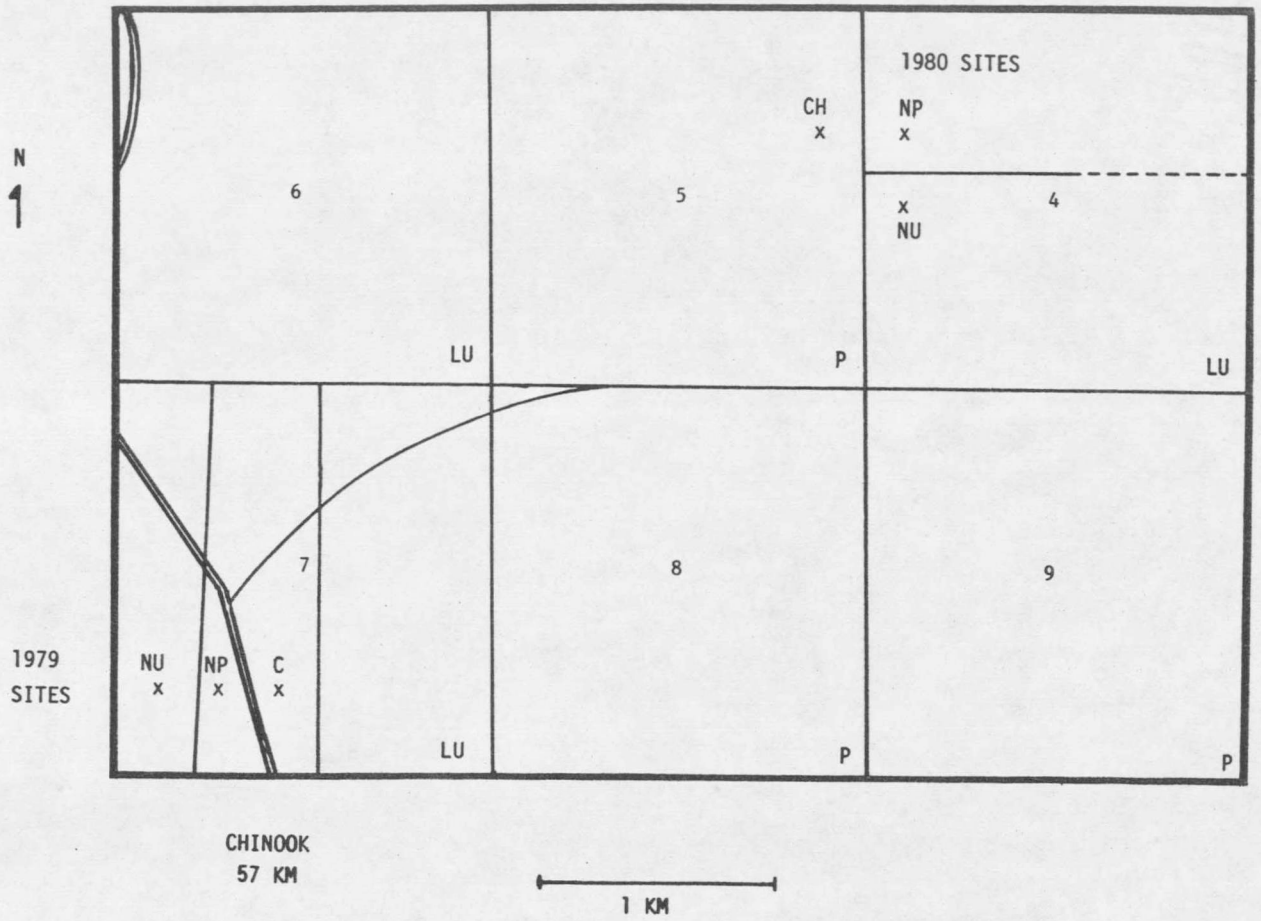


Figure 3. Schematic illustration of experimental design. Sections 4, 5, 6, 7, 8 and 9, T35N, R19E, MPM in Blaine County, Montana, USA. Treatments: NU = native vegetation, unplowed; NP = native vegetation, plowed; C = crested wheatgrass, plowed; CH = native vegetation, chiseled. Land ownership: LU = public land, administered by Bureau of Land Management; P = private land.



Figure 4. Photograph showing vegetation contrast between native vegetation, unplowed (left side) and native vegetation, plowed (right side) at the 1979 sampling location.

mechanically treated in 1972 by Unruh using a sheepsfoot chisel. These sites were not seeded after chiseling.

Soil sampling pits were selected to represent a pedon typical of each soil by digging exploratory pits in areas representative of the major topographical features. Grave-sized pits were dug to at least 100 cm or to relatively unaltered parent material. Because of the contiguous association of the four soils, some pits exposed pedons of two soils. In that case each pedon was sampled, one pit representing both soils.

Site and soil profile descriptions were recorded using standard field forms developed following Soil Survey Manual (Soil Survey Staff, 1951) guidelines, and processed using the Montana Automated Data Processing System (Decker et al., 1975). Coarse fragments, root and pore volumes were estimated visually. Bulk density was measured for each horizon using the saran-coated clod method (Soil Conservation Service, USDA, 1972). Before sampling, each soil profile, soil pit and associated vegetation, and landscape was photographed.

Four-liter soil samples were collected from all sides of the pit for each horizon. In the laboratory, samples were air dried, crushed in a flail-type mill and sieved to remove the greater than 2 mm fraction. The fine earth fractions were submitted to the Soil Testing Laboratory at Montana State University where they were subsampled and analyzed for soluble cation content, EC and pH of saturated paste (U. S. Salinity

Laboratory Staff, 1954), texture (Bouyoucos, 1939), extractable Ca, Mg, Na and K (Chapman, 1965a, 1965b), modified Bray P (Smith et al., 1957), organic matter (Sims and Haby, 1971), and Zn, Mn, Cu and Fe content of Al horizons (Chapman, 1965a, 1965b). Water retention characteristics were established from 1/3 bar and 15 bar extractions (Soil Conservation Service, USDA, 1972).

Soil water content at the beginning of the growing season was determined on 1979 location treatments by sampling each soil with a Giddings probe, incrementally to parent material. Samples were taken to the laboratory, weighed, oven dried and reweighed. Results are presented as percent moisture of a dry weight basis.

Vegetation was sampled using the BLM's point transect SVIM method (BLM Staff, 1978). Two 100-hit transects were randomly located on each treatment site. Plant species at each point was identified concurrently with soil series so that plant data for each soil were recorded separately. At every tenth hit along a transect, species within a 0.18 m^2 (1.92 ft^2) hoop were separated into the following categories: western wheatgrass, blackroot sedge, blue grama grass, fringed sagewort, crested wheatgrass, clubmoss, prickly pear cactus, lichen and miscellaneous grasses, forbs and shrubs. An estimated wet weight for each category was recorded. At 10 of the plots on each transect, vegetation was clipped at ground level, separated by category and weighed. These samples were later air dried and reweighed in the laboratory.

In addition to the SVIM transect, ten 0.18 m^2 (1.92 ft^2) hoops were randomly sampled around the pit by tossing the hoop and clipping where it landed until 10 hoops had been clipped on each soil. For these hoops, vegetation was separated into grasses, forbs and shrubs. Samples were air dried and weighed in the laboratory.

Data related to the effects of mechanical treatment and soil type on herbage production, vegetative composition, the effect of mechanical treatment on soil properties, and to differences between sites were analyzed statistically. The F-test was used to indicate significance of main effects, treatment and soil, at the $p = .01$ and $p = .05$ levels. Data were analyzed using the statistical package "Analysis of Variance and Covariance including Repeated Measures" (Jennrich and Sampson, 1979).

Vegetation measurements from both the SVIM transect and random clip plot samples were grouped by treatment and by soil. Two-way analysis of variance (ANOV) was used to determine the effect of both groups on productivity. This test was also used to show significance for productivity from data for which control site measurements were excluded.

Stepwise regression (Jennrich and Sampson, 1979) was used to model productivity. Independent variables tried in the regression are listed in Appendix 8. Results of the regression analysis are presented in Appendices 6 and 7 and Tables 13 and 14. Three regression analyses

were run. Initially, data from all sites were included. For the final two analyses, data from the control sites and from Tealette soils were excluded.

Cluster analysis (Jennrich and Sampson, 1979) was run to show groupings based on vegetative total productivity by soil and treatment. The distance matrix is given in Figure 7.

RESULTS

Soil Characteristics

Soil profile descriptions are given in Appendix 1, physical and chemical data for each soil by horizon are presented in Appendix 2 and 3, respectively. Figure 5 illustrates the relative horizonation and contiguous occurrence of the four soils in the landscape.

Several of the soils at the 1980 location could only be classified as Natrargids because of the Na + Mg > Ca rule. They would not otherwise have met the required criteria. At site 53, Phillips, chiseled, the clay increase between the A2 horizon and the B21t horizon was insufficient to meet the criteria for Paleargids. It was classified as a Haplargid. As well, chiseled sites 53 (Phillips) and 54 (Thoeny) are in the fine-loamy rather than fine family.

Predictable soil patterns were observed within the landscape, with Phillips found on small micro-knolls and Tealette in micro-depressions or panspots. Elloam and Thoeny occupied successively higher positions between Tealette and Phillips. Soils within the complex were distinguished on the basis of morphological features. Tealette, Elloam and Thoeny soils are differentiated on A2 horizon thickness over the columnar structured natric horizon. Phillips soils are identified by the presence of a prismatic structured argillic horizon overlain by a thick A horizon (15 to 30 cm). Transition between the soils occurs within a few centimeters (3-5) of horizontal distance.

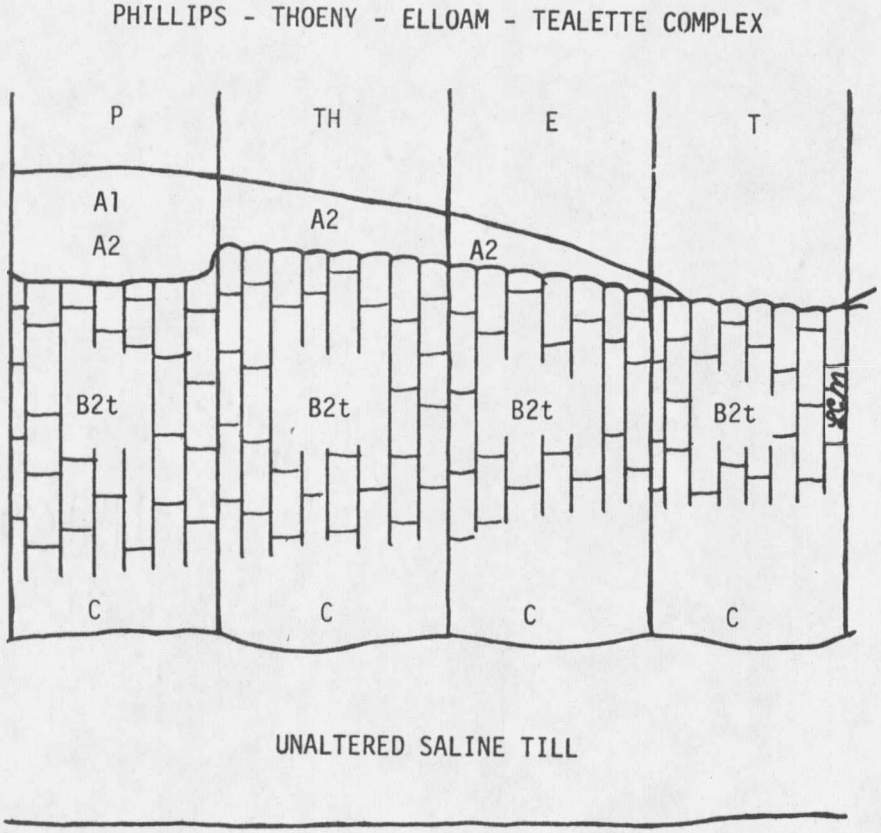


Figure 5. Schematic showing occurrence of Phillips, Thoeny, Elloam and Tealette soils on the landscape.

Subtle surface topography was paralleled by subdued undulation of the upper surface of the B horizon which rose abstrusely from Tealette through Thoeny. Between Thoeny and Phillips the columnar structure of the natric horizon changed very abruptly to the prismatic structure and argillic horizon of Phillips. This degradation lowered the B horizon surface to approximately the level of Elloam.

Surface micro-relief is exaggerated by variation in A horizon thickness. Tealette soils characteristically had either very thin (less than 3 cm) or no A horizon. A2 horizons of Elloam and Thoeny ranged in thickness from 3-13 and 13-23 cm, respectively. Phillips had both a darkened, organic enriched A1 horizon and an underlying eluviated A2 horizon, which were greater than 23 cm in thickness.

Solum thickness, depth to salts, and depth to calcium carbonates are given in Table 1. Depth to salts and carbonates tended to parallel solum thickness which generally increased from Tealette to Thoeny and Phillips.

Depth to unaltered saline till and the Bearpaw Shale from which it was derived did not vary as sharply as solum thickness. Contact depth changed considerably, however, over the 1.5 km separating 1979 and 1980 locations. Bearpaw Shale was generally observed at greater than 1.5 m and between 0.5 to 1.0 m for 1979 and 1980 locations, respectively. Shallowest solum development was observed for soils associated with the thinnest till deposits.

Table 1. General soil physical characteristics associated with treatment at 1979 and 1980 locations.

Treatment	Soil	Solum thickness		Textural class at 80 cm		Depth to salts		Depth to $CaCO_3$		Available water	
		1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
		cm				cm		cm		cm/80 cm	
Native, unplowed	Tealette	55	49	CL	C	13	24	13	24	47	41
	Elloam	53	32	CL	C	42	32	27	27	49	39
	Thoeny	62	44	SCL	C	26	41	26	32	32	35
	Phillips	62	53	SCL	C	55	45	28	21	38	29
Native, plowed	Tealette	35	12	CL	C	35	44	19	12	54	39
	Elloam	60	25	CL	C	60	40	19	16	59	32
	Thoeny	92	60	L	CL	90	44	33	53	39	40
	Phillips	74	54	SCL	CL	74	44	27	44	37	35
Crested, plowed	Tealette	62		L		62		24		62	
	Elloam	62		CL		62		23		60	
	Thoeny	67		CL		67		18		56	
	Phillips	72		CL		72		28		48	
Chiseled	Tealette		20		C		30		10		51
	Elloam		27		C		41		15		59
	Thoeny		63		CL		60		44		38
	Phillips		64		CL		64		30		44

Figure 6 shows the x-ray diffraction pattern for the clay size fraction of each horizon of site 46-Elloam and site 47-Phillips, both native, unplowed, 1980 treatments. The dominant mineral is smectite, with much smaller peaks for illite, kaolinite and quartz. The 18Å smectite peak increases markedly at the IIC contact for Elloam, but is almost nonexistent in the A horizons, especially in Phillips. The uniformity of diffraction patterns throughout the profile indicates that the till is largely shale derived.

Table 2 summarizes the results of ANOV of soil physical and chemical variables grouped according to 1979 and 1980 locations. Soils of the two sites varied significantly for both textural parameters and cation (soluble and extractable) content, despite the fact that they were mapped as the same soils. Sites sampled in 1979 contained more sand and less clay in C horizons than did 1980 location soils; sodium contents were significantly higher throughout the solum, generally by an order of magnitude; and magnesium content was significantly greater.

ANOV, with variables grouped by soil (Table 3) showed that sodium, magnesium, EC, and clay content in both B and C horizons tended to decrease from Tealette to Phillips. Bulk density of the B horizon was also significantly different ($p = .05$).

Extent of each soil by treatment site is given in Table 4. Elloam, and to a lesser degree Thoeny, were dominant soils on both landscapes. Tealette and Phillips comprised approximately one-third of the soil

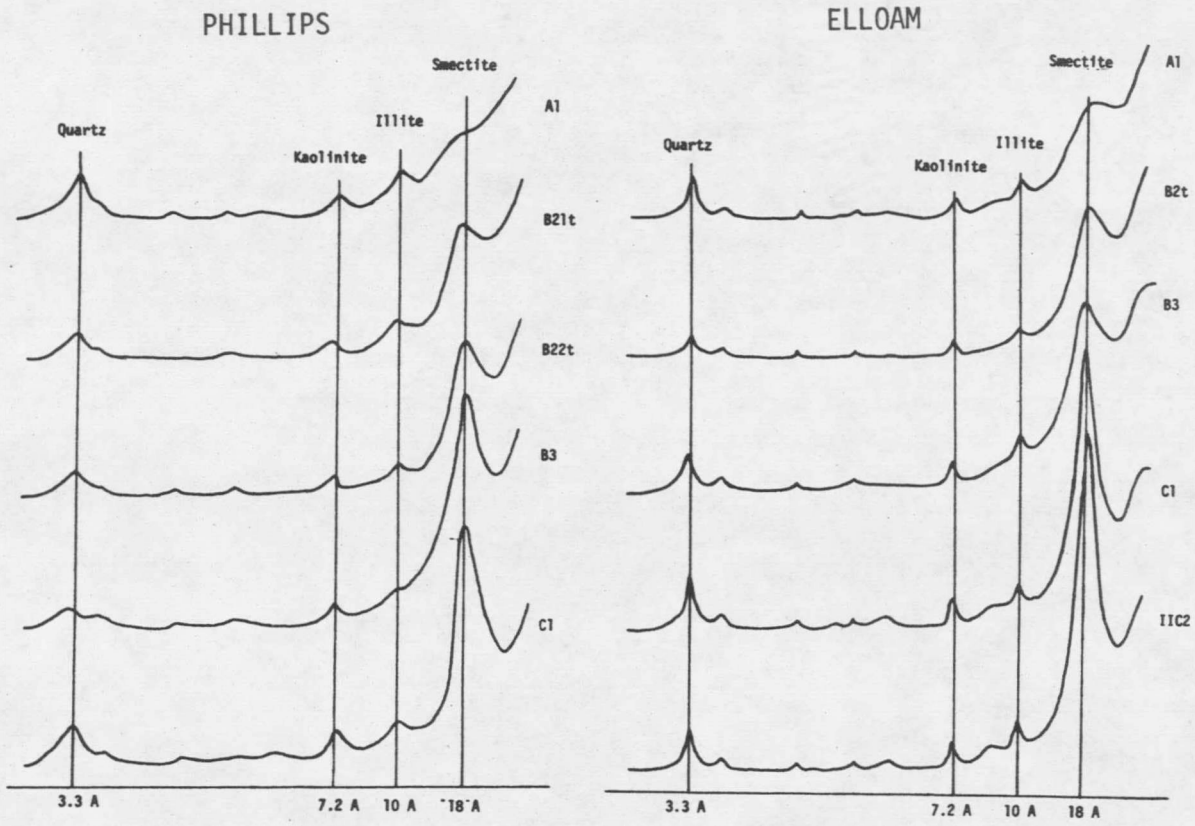


Figure 6. X-ray diffraction patterns for Elloam and Phillips, native vegetation, unplowed, 1980 location. Clay fraction (<2 μm) samples were Mg saturated, ethylene glycol solvated.

Table 2. Summary of analysis of variance showing significantly different variables between 1979 and 1980 locations.

Variable	Mean 1979	Mean 1980
A horizon:	---p = .01---	
Bulk density (g/cm^3)	1.68	0.92
Soluble K (me/100 g)	1.80	0.70
B horizon:		
Organic matter (%)	1.2	1.6
Extractable Mg (me/100 g)	11.6	7.7
Soluble K (me/100 g)	0.7	0.2
Soluble Mg (me/100 g)	3.0	1.1
Soluble Ca (me/100 g)	5.2	1.3
Silt (%)	23.0	28.0
Soluble Na (me/100 g)	28.2	6.6
15 bar water (%)	18.7	13.2
C horizon:		
Cation Exchange Capacity (me/100 g)	43.7	25.1
Soluble K (me/100 g)	2.5	0.2
Soluble Ca (me/100 g)	34.6	6.6
Sand (%)	44.0	32.0
Clay (%)	30.0	42.0
Soluble Na (me/100 g)	116.3	22.2
Sodium Adsorption Ratio	21.5	8.2
A horizon:	---p = .05---	
Organic matter (%)	1.8	2.9
Sodium Adsorption Ratio	8.7	2.7
B horizon:		
Electrical Conductivity (mmhos)	1.5	0.8
Cation Exchange Capacity (me/100 g)	31.7	23.9
Sodium Adsorption Ratio	14.9	6.9
C horizon:		
Organic matter (%)	0.6	1.0
Extractable P (me/100 g)	3.5	2.4
Soluble Mg (me/100 g)	26.7	10.2

Table 3. Summary of analysis of variance showing significantly different variables between soils.

Variable	Mean by soil type T†	E†	Th†	P†	p =
A horizon:					
Extractable Na (me/100 g)	11.0a‡	0.2b	0.2b	0.1b	.01
B horizon:					
Bulk density (g/cm^3)	1.62a	1.70b	1.72b	1.50c	.01
Extractable Mg (me/100 g)	10.1a	12.5b	9.1a	6.9c	.05
Extractable Na (me/100 g)	3.3a	2.5b	3.4a	0.7c	.01
Clay (%)	42.0a	43.0a	36.0b	34.0c	.01
C horizon:					
Electrical conductivity (mmhos)	5.5a	5.5a	3.6b	1.4c	.01
Extractable Mg (me/100 g)	12.3a	12.2a	8.2b	8.6b	.05

†T = Tealette, E = Elloam, Th = Thoeny, P = Phillips.

‡Numbers across rows not followed by the same letter are significantly different by the probability level given in the last column.

Table 4. Relative frequency of each soil by treatment.

Soil	Treatment					
	1979			1980		
	NU†	NP†	C†	NU†	NP†	CH†
	%					
T‡	23	15	13	15	12	23
E‡	28	58	41	43	39	27
Th‡	14	18	25	26	33	41
P‡	35	9	22	17	16	10

†NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass, plowed, CH = Native vegetation, chiseled.

‡T = Tealette, E = Elloam, Th = Thoeny, P = Phillips.

composition. The 1979 native, unplowed site contained significantly more Phillips than the plowed site, suggesting that it is a better drained landscape. It is located near an old drainage channel where more leaching could carry soluble salts through the profile, resulting in amelioration of the natric horizon. There was a reduction in the number of hits on Tealette on the plowed sites. On the chiseled site, the frequency of Phillips decreased, while Thoeny increased.

Effects of Mechanical Treatment on Soils

Results for ANOV of chemical properties, showing variables which differed significantly ($p = .05$) by treatment, are presented in Tables 5 and 6. Statistics presented in Table 5 represent analysis in which control and native, plowed treatments from 1979 and 1980 locations were combined; sites were considered individually for the analysis summarized in Table 6. Analysis combining duplicate treatments were run to show the effect of treatment on soil chemistry. Table 6 shows that most variables which differed significantly by treatment also varied by site location (1979, 1980) (Table 2). It appears that the differences are not entirely due to treatment, but are also a function of differences between locations. The only variable shown in Table 6 which is not attributable to differences between locations is A horizon total N.

Beginning of growing season moisture for sites at the 1979 location is given in Table 7. Tealette, Elloam and Thoeny all show greater

Table 5. Summary of analysis of variance showing significantly different variables between treatments.

Variable	Mean by treatment NU†	NP†	C†	CH†
	----------p = .05----------			
A horizon:				
Total N (%)	0.6a‡	0.9b	0.3ab	1.6c
Sodium Adsorption Ratio	4.3a	3.2b	14.9c	4.0a
B horizon:				
Cation Exchange Capacity (me/100 g)	26.0a	27.2b	39.7b	20.8c
15 bar water (%)	17.7a	17.1b	17.0b	9.0b
C horizon:				
Sodium Adsorption Ratio	16.3a	12.4b	24.6c	6.0d

†NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass, plowed; CH = Native vegetation, chiseled.

‡Numbers across rows not followed by the same letter are significantly different at the p = .05 level.

Table. 6. Summary of analysis of variance showing significantly different variables between treatments and locations.

Variable	Mean by site and location					
	NU79†	NU80†	NP79†	NP80†	C79†	CH80†
	p = .05					
A horizon:						
Cation Exchange Capacity (me/100 g)	6.8a‡	18.1b	13.4b	7.3a	9.5ab	13.2b
Organic matter (%)	2.2a	2.9b	1.7c	2.0a	1.7c	3.8d
Extractable Ca (me/100 g)	4.0a	10.6b	7.8c	2.9d	7.0c	4.9a
Total N (%)	1.2a	0.6b	1.0a	0.9ab	0.8ab	1.6c
B horizon:						
Organic matter (%)	1.3ac	2.0b	0.9a	1.6c	1.3ac	1.4ac
Extractable Ca (me/100 g)	13.4a	20.5b	22.5b	8.5c	24.8d	6.8c
Soluble K (me/100 g)	1.1a	0.1b	0.5b	0.2b	0.6ab	0.2a
Soluble Mg (me/100 g)	3.9a	1.2b	2.6c	1.0b	2.5c	1.0b
Soluble Ca (me/100 g)	6.5a	2.1b	4.2c	1.0d	4.9c	0.9d
15 bar water (%)	21.5a	14.0b	17.6c	16.6c	17.0c	9.0d
C horizon:						
Organic matter (%)	0.5a	1.0b	0.8b	1.4c	0.7ab	0.7ab
Extractable P (me/100 g)	3.9a	2.4b	4.1a	3.0c	2.4b	2.0b
Soluble K (me/100 g)	2.8a	0.8b	2.1c	0.3d	2.7a	0.3d
Sand (%)	46.0a	24.0b	46.0a	35.0c	38.0c	37.0c
Clay (%)	29.0a	50.0b	27.0a	42.0c	33.0d	34.0d
Soluble Na (me/100 g)	117.8a	29.3b	97.4c	17.1d	133.8c	20.4d
Sodium Adsorption Ratio	24.0a	8.7b	15.8ab	9.0b	24.7a	7.0b

†NU79 = Native vegetation, unplowed, 1979 location; NP79 = Native vegetation, plowed, 1979 location; C79 = Crested wheatgrass, plowed, 1979 location; NU80 = Native vegetation, unplowed, 1980 location; NP80 = Native vegetation, plowed, 1980 location; CH80 = Native vegetation, chiseled, 1980 location.

‡Numbers across rows not followed by the same letter are significantly different at the p = .05 level.

Table 7. Beginning of growing season soil moisture (April 20, 1980) for treatments at the 1979 location.

Soil	Native, unplowed		Native, plowed		Crested, plowed	
	Depth	Water	Depth	Water	Depth	Water
	cm	%	cm	%	cm	%
Tealette	2-13	22	0-10	22	0-10	20
	13-26	12	10-19	22	11-24	19
			19-35	12	24-43	10
	36-55	7	35-68	10	43-62	8
Elloam	0-11	18	0-10	15	0-10	18
	11-27	17	10-19	15	10-23	20
	27-42	8	19-36	12	23-43	14
	42-53	10	36-68	9	43-62	9
	53-79	11	68-99	10		
	79-88	11				
Thoeny	0-11	16	0-13	16	0-10	18
	11-26	13	13-33	13	10-23	20
	26-36	9	33-61	9	23-43	14
	36-62	5	61-72	10	43-62	9
Phillips	0-11	22	0-11	18	0-10	17
	11-28	15	11-27	17	10-28	17
	28-55	10	27-53	10	28-53	11
	55-78	12	53-74	8	53-74	8
			74-115	10	74-92	9

moisture contents beneath the first measured increment on treated sites than on nontreated sites. Moisture contents for Phillips remained constant.

Composition of the Plant Community

Hits on each SVIM transect were recorded by soil type, providing composition data for each treatment by soil. Raw data from each transect is given in Appendix 4.

Frequency of major species is summarized in Table 8. Western wheatgrass was the dominant species on Tealette soils (except on the chiseled site where fringe sagewort was dominant) and tended to decrease in frequency on other soils. Treatment reduced western wheatgrass on Tealette, but had little effect on its frequency for other soils.

Blue grama grass tended to decrease with mechanical treatment. It was hit more often than any other species for all soils and treatments, except crested wheatgrass, plowed, 1979 location. Although frequency decreased at 1980 locations, it was still a dominant species on Elloam, Thoeny and Phillips.

Clubmoss was a major plant component on the control sites. It represented only 1% of hits on Tealette, but averaged 28% of hits on other soils. Frequency of hits on clubmoss was reduced to 5% on plowed sites, and 0% on crested wheatgrass and chiseled sites.

Table. 8. Frequency of major species,[†] bare ground, gravel, and litter as measured by the SVIM transect and recorded by soil and treatment.

Treatment[‡]	Soil[§]	Bare ground	Litter	Gravel	AGSM	BOGR	CAEL	ARFR	SEDE	Lichen	STCO	AGCR	OPPO	KOCR	Other
		%													
NU79	T	35	19	1	16	6	5	2	3	6	0	0	4	0	1
	E	1	18	1	5	33	9	3	26	3	0	0	1	0	1
	Th	0	2	0	0	51	6	0	36	4	0	0	0	0	0
	P	0	21	0	5	30	5	1	24	3	5	0	1	0	3
NP79	T	49	26	1	9	2	0	4	0	0	1	1	2	0	2
	E	9	33	1	5	34	0	5	1	2	4	1	2	1	0
	Th	4	28	0	5	41	0	5	1	0	4	0	5	0	6
	P	2	33	0	0	40	0	2	2	0	4	0	17	0	0
C79	T	23	48	0	11	0	5	1	0	0	0	11	2	0	0
	E	9	41	2	1	19	1	4	0	0	2	8	0	2	3
	Th	9	38	0	4	18	0	1	0	0	0	22	0	1	5
	P	12	30	1	0	20	0	2	0	0	8	22	0	3	2
NU80	T	38	24	5	12	1	6	4	0	1	0	0	3	0	5
	E	9	23	1	10	13	6	11	18	3	1	0	1	1	2
	Th	0	14	0	12	26	4	7	29	1	3	0	0	1	3
	P	2	13	1	6	25	6	6	37	3	3	0	0	1	2
NP80	T	58	29	0	8	0	0	6	0	0	0	0	0	0	0
	E	16	31	1	5	10	16	11	5	2	4	0	1	3	4
	Th	5	36	0	11	4	0	8	9	2	9	0	2	7	2
	P	1	41	1	10	8	0	7	9	3	10	0	2	3	4
CH80	T	10	38	0	12	13	3	16	0	0	4	0	0	3	3
	E	20	34	0	14	6	6	14	1	0	1	9	1	2	0
	Th	9	44	0	9	10	4	16	0	0	1	0	0	1	3
	P	37	37	2	9	0	3	5	0	0	0	0	0	0	4

[†]Vegetation codes given are after USDA and Soil Conservation Service (1976).

[‡]NU79 = Native vegetation, unplowed, 1979 location; NP79 = Native vegetation, plowed, 1979 location; C79 = Crested wheatgrass, plowed, 1979 location; NU80 = Native vegetation, unplowed, 1980 location; NP80 = Native vegetation, plowed, 1980 location; CH80 = Native vegetation, chiseled, 1980 location.

[§]T = Tealette, E = Elloam, Th = Thoeny, P = Phillips.

For all treatments except chiseled, fringe sagewort averaged 4, 6, 2 and 3% of hits on vegetation for Tealette, Elloam, Thoeny, and Phillips, respectively. It averaged 16, 14, 16, and 5% for the respective soils on the chiseled site. Excluding the chiseled site, it represented 3% of the hits at the 1979 location compared to 8% for the 1980 location.

Blackroot sedge tended to decrease, while needle-and-thread grass tended to increase with mechanical treatment. Blackroot sedge distribution was not affected by soil type; needle-and-thread grass was associated with only Elloam, Thoeny and Phillips.

Bare ground accounted for 35% of hits on Tealette, compared to only 6% on other soils. (Tealette averaged 40% vegetative cover relative to 80% of the other soils.) Frequency of bare ground increased with all treatments, especially chiseling. This was due to reduction in clubmoss, and to a lesser extent, blue grama grass cover.

Nonpersistent litter increased with treatment. This undoubtedly reflects the increase in total productivity of the treated sites and the corresponding reduction in blue grama grass and clubmoss cover.

Effects of Mechanical Treatment on Vegetative Productivity

Raw productivity data from the SVIM moist estimate and clip plots and the 10 random clip plots are given in Appendix 5. Since SVIM moist and dry weight data represented only two clip plots per treatment site,

moist estimate and random clip plot data (6 and 10 samples, respectively) were used in statistical analysis to attain the largest degrees of freedom. There was some concern that the moist estimate data would contain greater variability than dry weight data. However, ANOV showed that coefficients of variability for both productivity measurements were similar (Table 9). Productivity analysis by species was based on estimated data; analysis of total, grass, forb and shrub productivity was based on random clip plot data.

Table 10 presents the mean values for productivity of seven major plant species by soil and treatment. Only needle-and-thread grass, blue grama grass and clubmoss production were significantly different by soil. Western wheatgrass and blue grama grass were the most productive grasses in the plant community. Western wheatgrass production was greatest on the Tealette native, unplowed treatment. On Tealette and Elloam, its production decreased with treatment, whereas on Thoeny and Phillips, its productivity increased on the native, plowed and chiseled treatments.

Relative to Tealette, blue grama grass production was greater on the other three soils. Blue grama grass production generally increased on native, plowed sites, but tended to decrease on other treatments (except for the Phillips, chiseled site).

Needle-and-thread grass was most productive on Phillips and decreased with treatment. On other soils, it tended to increase with

Table 9. Average coefficients of variability by vegetation type and sampling method.

Vegetation class	Weight			Estimate	Average
	Random	Dry	Moist	moist	
n	10	2	2	6	
	%				
Grass	29	52	54	35	43
Forb	83	107	102	88	95
Shrub	143	413	453	185	299
Total	34	59	66	42	50

Table 10. Summary of analysis of variance showing significant difference in productivity of major vegetative species by soil and treatment.

Species‡	Tealette				Elloam				Thoeny				Phillips			
	NU†	NP†	C†	CH†	NU†	NP†	C†	CH†	NU†	NP†	C†	CH†	NU†	NP†	C†	CH†
	kg/h															
STCO	0a§	12a	0a	0a	0a	105b	41c	20d	0a	135b	0a	21c	110a	82b	93b	51c
AGSM	196a	79b	56b	0c	151a	112a	22b	157c	90a	157b	22c	73ac	112a	246b	11c	414d
BOGR	28	28	73	95	151	269	90	73	118	168	67	84	241	174	151	67
CAEL	57a	6b	0b	17c	73a	17b	0c	39d	76a	17b	0c	28b	50a	11b	11b	11b
ARFR	78a	92a	157a	95a	140a	230b	213ab	347c	34a	392b	34a	728c	179a	157a	39b	571c
OPPO	2766	0	0	0	790	6	0	0	0	22	0	0	358	157	0	0
	cm^2															
SEDE	0a	0a	0a	0a	955a	20b	0c	5c	1297a	286b	0c	0c	620a	206b	0c	0c

†NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass, plowed; CH = Native vegetation, chiseled.

‡Vegetation codes given are after USDA and Soil Conservation Service (1976).

§Numbers across rows not followed by the same letter are significantly different at the p = .01 level.

with treatment. Blackroot sedge production was similar on control sites for all soils, but decreased on all treatment sites. Fringed sagewort production increased with treatment, especially on chiseled sites. Its productivity was somewhat greater on Thoeny and Phillips than on the other soils.

No clubmoss was measured on Tealette. It was ubiquitous on the native, unplowed treatment of the other soils, but was reduced significantly by all treatments.

ANOV by treatment and soil was run with clubmoss as a covariate to determine the extent to which treatment effect was related to clubmoss removal. The p values for variables significantly different by treatment tended to increase in this analysis.

Table 11 presents an ANOV summary based on random clip plot data for grass, forb, shrub and total production by soil treatment. Grass production increased on plowed sites for all soils except Tealette. Chiseling increased grass production on Elloam, but decreased production or had little effect on other soils. Production increased from Tealette to Phillips for all treatments. Its production was lowest on crested wheatgrass treatments and control sites. Compared to control sites, it increased, usually by an order of magnitude on the chiseled treatment site. Shrub production was not significantly different by either soil or treatment.

Table 11. Summary of analysis of variance for grass, forb, shrub and total production and level of significance for soil and treatment.

Variable	Soil	Treatment mean NU†	NP†	C†	CH†	Soil	Treatment
		kg/ha				p	
Grass	Tealette	207a	169b	381c	207a	.01	.05
	Elloam	226a	338b	276c	419d		
	Thoeny	307a	370b	220c	250c		
	Phillips	376a	394a	441b	276c		
Forbs	Tealette	22a	84b	11c	90d	.05	.01
	Elloam	67a	90b	17c	291d		
	Thoeny	90a	95a	28b	241d		
	Phillips	78a	101b	0c	157d		
Shrubs	Tealette	2	22	7	11	ns	ns
	Elloam	7	7	17	34		
	Thoeny	0	11	22	0		
	Phillips	0	50	7	0		
Total	Tealette	231a	275a	399b	308c	.01	.01
	Elloam	300a	435b	310a	744c		
	Thoeny	397a	467b	270c	491d		
	Phillips	454a	545b	448c	433a		

†NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass, plowed; CH = Native vegetation, chiseled.

Total production generally increased with treatment. Tealette, Elloam and Thoeny total production was greatest on chiseled treatment; for Phillips it was greatest on the native, plowed treatment. A significant proportion of the increase on chiseled sites was due to forb and shrub production. Sixty-seven percent of production on chiseled soils was due to grass compared to 74% on native, plowed; 81% on native, unplowed; and 92% on crested wheatgrass sites (Table 12). However, 33% of the grass production on crested wheatgrass sites was crested wheatgrass, which has limited forage value except during early spring. Elloam and Thoeny responded most favorably to treatment. Seventy-nine percent of production on native, plowed sites on those soils was due to grass production.

Appendices 6 and 7 contain correlation matrices and stepwise regression equations for chemical and physical data, respectively, from stepwise regression analysis. Table 13 presents a summary of site characteristics correlated with grass, forb, shrub and total production. Removal of the control sites, to eliminate the effects of clubmoss on productivity, increased simple correlation values, but did not change the variables which were well correlated with productivity. Solum thickness, A and B horizon thickenss, organic matter content of the solum and organic matter content of the A horizon were significantly related to productivity. Excluding Tealette soils from

Table 12. Proportion of grass production relative to total production for all treatments and soils.

Soil	Treatment			
	NU†	NP†	C†	CH†
	----------%----------			
Tealette	90	61	95	67
Elloam	74	79	89	56
Thoeny	76	79	81	51
Phillips	83	72	98	64

†NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass, plowed; CH = Native vegetation, chiseled.

Table 13. Regression analysis summary for productivity on site data, comparing significant relationships and r values for analysis based on all sites, treated sites and with Tealette excluded.

Dependent variable	Independent variable	All sites	Treated sites	Tealette excluded
Random Clip Plot Data			r	
Grass	Organic matter (%) - A Horizon	.57	.60	.00
	A horizon thickness (cm)	.57	.59	.05
	Soil type			.52
Forbs	Aspect (°)	-.63	-.73	-.82
	Elevation (m)	-.60	-.73	-.80
	Coarse fragments (%) - C Horizon	-.57	-.69	-.69
	Total N (%)	.55	.70	-.67
Shrubs	Extractable phosphorus (ppm) - Solum	.61	.28	.21
Total	Organic matter (%) - A Horizon	.57	.60	.42
	A horizon thickness (cm)	.57	.59	.40
	Aspect (°)	-.15	-.21	.53
	Clubmoss cover (cm^2)	-.29	.31	-.70
SVIM Moist Estimate Data				
Grass	Organic matter (%) - Solum	.66	.69	.49
	Available water (cm) - Solum	.61	.58	.54
	Solum thickness (cm)	.55	.57	.26
		.44	.39	.52
Forbs	Total N (%) - Solum	.62	.65	.61
	Organic matter (%) - A Horizon	.60	.60	.55
	Clubmoss cover (cm^2)	-.35	-.05	-.54
Total	Solum thickness (cm)	.55	.76	.36
	B horizon thickness (cm)	.44	.68	.30
	Soluble K (me/100 g) - Solum	.48	.62	.31
	A horizon thickness (cm)	.43	.53	.17
	Clubmoss cover (cm^2)	-.28	.13	-.65

regression analysis tended to change the variables which were well correlated and increased clubmoss, Mg and Ca correlations with production.

Significant correlation of soil chemical properties to productivity are summarized in Table 14. Regressions were run with all sites and with control sites excluded, again to remove the effect of clubmoss on production. Simple correlations based on treated site data increased in value.

Results of a cluster analysis are shown in Figure 7. Tealette soils showed a strong tendency to group, as did native, unplowed and crested wheatgrass treatments.

Table 14. Regression analysis for laboratory data by all sites and by treated sites, comparing significant relationships and r values.

Dependent variable	Independent variable	All sites	Treated sites
Random Clip Plot Data		-----r-----	
Grass	% Sand - C horizon	.49	.81
	% Clay - C horizon	-.48	-.75
	Extractable Ca (me/100 g) - B horizon	.39	.64
	Extractable Mg (me/100 g) - C horizon	-.60	-.55
	Electrical Conductivity (mmhos) - C horizon	-.51	-.37
Forbs	pH - A horizon	-.43	-.73
	Soluble Ca (me/100 g) - B horizon	-.51	-.72
	Extractable Ca (me/100 g) - B horizon	-.34	-.68
	% Water at saturation - B horizon	-.48	-.67
	Cation Exchange Capacity (me/100 g) - B horizon	-.48	-.65
	Organic matter (%) - A horizon	.53	.65
	Total N (%) - B horizon	.56	.64
	Soluble K (me/100 g) - B horizon	-.43	-.64
	Soluble Mg (me/100 g) - B horizon	-.45	-.60
	Total N (%) - A horizon	.23	-.57
	Sodium Adsorption Ratio - C horizon	-.58	-.59
Shrubs	Soluble Mg (me/100 g) - C horizon	.59	.72
	Cation Exchange Capacity (me/100 g) - C horizon	.55	.68
	Soluble Ca (me/100 g) - C horizon	.60	.53
	% Silt - A horizon	-.01	-.59
	Extractable Na (me/100 g) - C horizon	.48	.57
	Soluble Na (me/100 g) - C horizon	.46	.54
Total	% Clay - B horizon	-.25	-.62
	% Sand - A horizon	.13	.54
	% Water at saturation	-.39	-.54

(table continued)

Table 14. continued

Dependent variable	Independent variable	All sites	Treated sites
SVIM Moist Estimate Data		-----r-----	
Grass	Extractable P (ppm) - C horizon	-.48	-.66
	% Silt - A horizon	-.48	-.53
	Bulk density (g/cm^3) - A horizon	.46	.53
Forbs	% Water at saturation - C horizon	-.71	-.73
	Extractable Na (me/100 g) - C horizon	-.57	-.69
	Extractable Mg (me/100 g) - C horizon	-.57	-.68
	Sodium Adsorption Ratio - C horizon	-.64	-.67
	B horizon thickness (cm)	.43	-.66
	Extractable Mg (me/100 g) - B horizon	-.46	-.66
	Cation Exchange Capacity (me/100 g) - C horizon	-.57	-.64
	% Clay - B horizon	-.42	-.62
	Soluble Na (me/100 g) - C horizon	-.53	-.60
	Extractable K (me/100 g) - C horizon	.52	.60
	Soluble Mg (me/100 g) - C horizon	-.44	-.59
	Extractable Mg (me/100 g) - A horizon	-.34	-.58
	Cation Exchange Capacity (me/100 g) - B horizon	-.42	-.56
Shrubs	% Sand - C horizon	.39	.76
	% Sand - B horizon	.35	.63
	% Silt - A horizon	-.47	-.61
	A horizon thickness (cm)	.32	.53
	pH - C horizon	-.41	-.52
	Organic matter (%) - B horizon	-.38	-.52
Total	% Clay - B horizon	-.54	-.76
	% Sand - B horizon	.43	.75
	% Sand - C horizon	.40	.71
	B horizon thickness (cm)	.49	.66
	Organic matter (%) - B horizon	-.44	-.63
	% Silt - A horizon	-.49	-.62
	Extractable Na (me/100 g) - A horizon	-.50	-.60
	% Clay - C horizon	-.41	-.56
	A horizon thickness (cm)	.47	.56

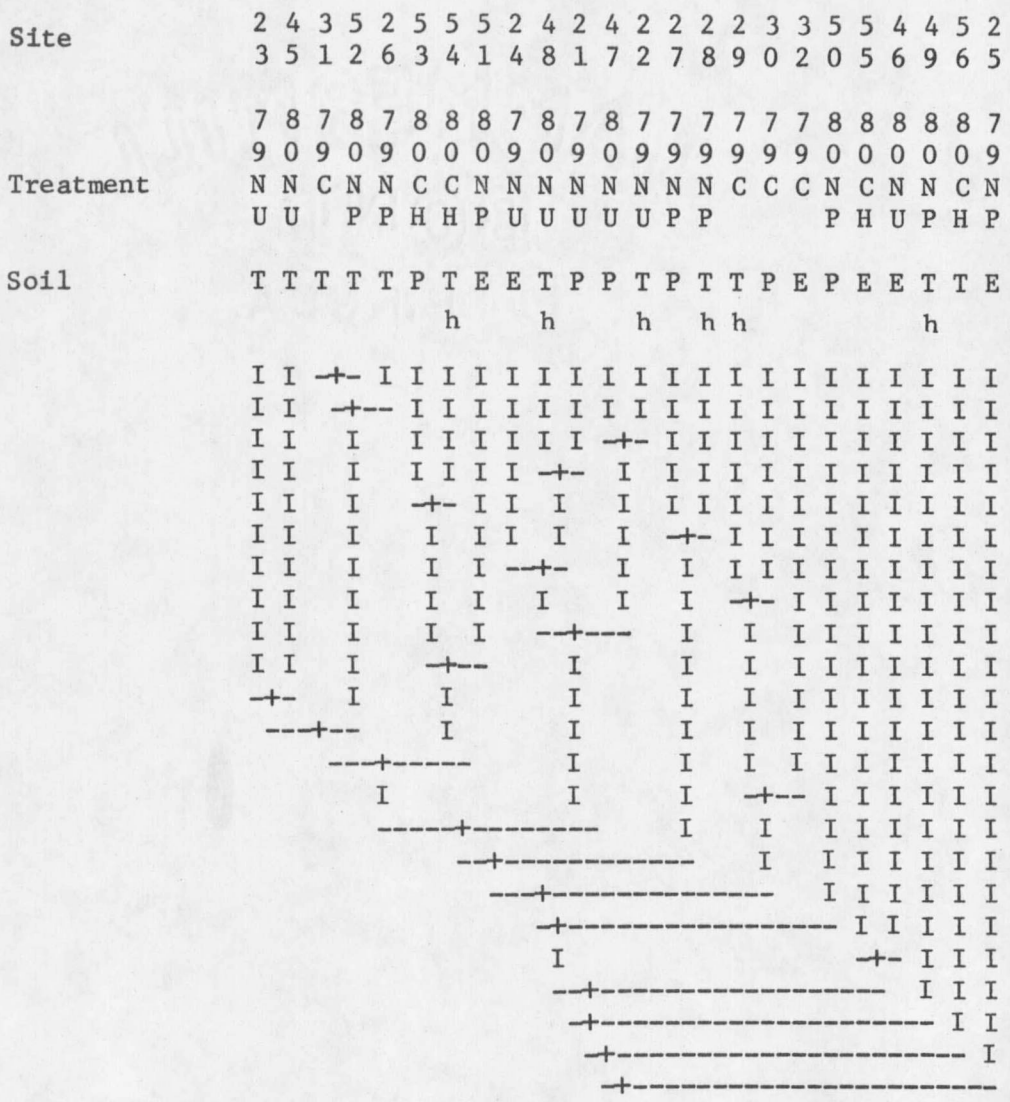


Figure 7. Cluster analysis distance matrix based on total vegetative productivity, random clipped plot data by soil and treatment. Soil: T = Tealette, E = Elloam, Th = Thoeny, P = Phillips. Treatment: NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass, plowed; CH = Native vegetation, chiseled.

DISCUSSION

Effect of Mechanical Treatment on Herbage Production

Herbage production generally increased on mechanically treated sites. This is attributed to the removal of clubmoss cover and ensuing increase in infiltration into the mineral soil (A2 horizon) and to the disruption of the columnar structure on Elloam and on Thoeny soils with thin A horizons. The influence of mechanical treatment was quantifiable 50 years later, indicating that it is a pragmatic means of increasing forage productivity on these semiarid rangelands. These findings concur with those of White (1969), Dolan and Taylor (1972), Soiseth et al. (1974) and Wight et al. (1978).

Plowing was the most beneficial treatment, improving both quantity and quality of forage production. Fifty years of secondary succession on plowed sites has resulted in a more stable, mature plant community relative to the chiseled sites which were sampled only 8 years after treatment.

Chiseling may have produced better results if grazing had been deferred until a sustainable, diverse plant community had developed. Costello (1944) reported that overgrazing disturbed ranges maintains the forb stage of secondary succession indefinitely. Results in Table 11 show a 30% increase in forb production on the chiseled site, which accounts for a considerable portion of the increase in total production over control sites. Except on Elloam, grass production decreased on chiseled sites.

Reseeding to crested wheatgrass after plowing increased both total and grass production more than any other treatment, but the palatability of the forage (33% of the grass was crested wheatgrass) detracts from overall success.

Plowing increased grass production on all soils except Tealette. Similar findings were reported by Branson et al. (1966), Rasmussen et al. (1972) and Wight et al. (1978). It is suspected that reduction on Tealette is a measurement rather than a treatment effect. Horse-drawn plows would likely have pulled out of the ground and over panspots rather than through them, dragging surface material collected from the other three soils over the panspots, and depositing an "A horizon" near their periphery. These peripheral areas, which were the most productive portions of Tealette (relative to the center of the panspot), would, with the benefit of added A horizon material, increase in productivity. Vegetative measurements on these areas would likely have been recorded as Elloam, reducing the proportion of productive Tealette relative to the unpropitious center so that the data would indicate a decrease in grass production on Tealette after treatment.

Response of grass productivity to plowing on the other three soils was variable. Relative to control sites, Elloam showed that greatest increase (50%) compared to Thoeny (21%) or Phillips (5%). (Tealette decreased 18%.) That the dominant soils in the landscape--Elloam and Thoeny--showed the most favorable response lends further justification

to the use of mechanical treatment for improvement of range productivity.

Plowing also reduced the disparity in productivity between the Natrargids and the Paleargid soil. On the control sites, grass production increased 9% from Tealette to Elloam, 36% from Elloam to Thoeny and 22% from Thoeny to Phillips. On plowed sites, grass production increased 100% from Tealette to Elloam, 9% from Elloam to Thoeny, and 6% from Thoeny to Phillips.

This suggests that Elloam and Thoeny have nearly the same productive potential after treatment as Phillips. Plant production on Phillips is probably optimum for current climatic conditions given the limitations imposed by inherent chemical and physical properties of the soil. Clubmoss removal was beneficial on the Paleargid, but the effect of disturbance had a larger impact than on the Natrargid soils where the beneficial effect of increased infiltration outweighed the detrimental effects of disturbance.

Response to plowing varied between the three Natrargids. Fracturing and mixing of the columnar structure occurred only on Elloam, and Thoeny soils with thin A2 horizons. However, fracturing is not as necessary on Thoeny, given the thicker A horizon already present. The removal of clubmoss and increased infiltration into the A horizon alone caused a considerable increase in productivity.

Data from both SVIM and random clip plot measurements were used to model productivity. SVIM moist estimate data represents 20 samples for each treatment in which no attempt was made to equitably sample each soil. Since Elloam and Thoeny are the most extensive soils on the landscape, they were sampled more often than Tealette or Phillips. Results from SVIM data best represent productivity characteristic of each landscape. Random clip plot data are based on 10 samples for each soil on each treatment, so it shows productivity relative to soil type.

Since the measured extent of Tealette decreased from control to plowed sites, exclusion of control sites from analysis reduced the relative representation of Tealette soils for the SVIM data. If it can be assumed that the decrease is due to an actual reduction in the extent of Tealette as indicated by transect measurement, results will reflect actual post-treatment conditions. It is possible, however, that the proportion of Tealette varied between sites independent of treatment, in which case results of analysis would underestimate the negative relationship between soil chemistry and productivity.

Forb, and especially shrub, data are based on a smaller sample size than grass production, since they were not represented in each clip plot due to their clustered distribution and relative scarcity. Results of regression analysis for these groups may therefore be somewhat biased.

Results of regression analysis with site data (Table 13) show that if all sites are included, production is related to variables which change significantly ($p = .05$) between locations or soils rather than between treatments. For example, grass and total production were related to thickness and organic matter content of the A horizon (random clip plot data) and of the solum (SVIM data)--variables which vary as a function of soil and location.

Excluding the control sites from analysis to eliminate the effect of clubmoss increased partial correlation values, especially for variables significantly ($p = .05$) different by soil. It appears that after treatment has removed clubmoss cover and improved infiltration, production is a function of soil type.

Tealette data were excluded from analysis because its productivity is not limited by clubmoss cover but by chemical and physical soil properties. This resulted in a highly negative correlation of clubmoss to production, indicating that clubmoss is a major limiting factor to production on Elloam, Thoeny and Phillips. Again, this suggests that any treatment which removes clubmoss cover will enhance productivity despite only slight changes in soil chemical or physical properties, and that changes in soil properties are confounded with clubmoss removal.

Regression analysis of laboratory data (Table 14) reinforces findings of regression on site data (Table 13). As above, correlations

are strongest for variables which were significantly different between soils or locations. Exclusion of control site data increased correlation values of productivity to most significant ($p = .05$) variables. Random clip plot grass production was highly correlated to sand and clay content of the C horizon for treated sites from which clubmoss had been removed. Since both sand content and productivity were greatest at the 1979 location, results show that productivity is correlating to variables associated with the 1979 site. Since correlation values for Mg and electrical conductivity in the C horizon were highest when control sites were included in analysis there may be a relationship between clubmoss removal and leaching of soluble salts. Possibly, removal of clubmoss and fracturing of the columns in the B horizon increased infiltration sufficiently to leach soluble salts through the solum. Table 1 shows that depth to soluble salts is deeper on treated sites which is supported by chemical data in Appendix 1.

To summarize, herbage production is adversely affected by chemical and physical properties inherent in sodium and magnesium dominated systems from which natric horizon development (as exemplified by Tealette) ensues. Secondly, production is limited by clubmoss cover which reduces infiltration and competes successfully for the limited moisture supply in the semiarid environment. Treatment did not

completely ameliorate inherent limitations of the soil system to plant growth. However effects of treatment (e.g., clubmoss removal) which secondarily improve infiltration at least into the A horizon, will increase productivity, and hence stabilize the landscape. Wight et al. (1978) indicated that these effects tend to be autocyclic. Note that grass and total productivity are correlated to organic matter content of the A horizon.

Effects of Mechanical Treatment on Plant Composition

Removal of clubmoss is the most pronounced change in species composition on treated sites. Blue grama grass and blackroot sedge were also reduced; western wheatgrass was reduced on Tealette, but relatively unaffected on other soils. Fringed sagewort frequency increased significantly ($p = .01$) after treatment on most sites, especially on the chiseled site. On the chiseled site, it never exceeded 2% of total SVIM transect hits, but represented 40% of hits on vegetation. Dolan and Taylor (1972) and Wight et al. (1978) reported similar increases in fringed sagewort on ungrazed treatment sites. Since the chiseled site was grazed after treatment, some increase in forbs would be expected. With careful grazing management, it could probably be replaced by more favorable forage species. Overall, treatment had beneficial effects on species composition.

Effect of Mechanical Treatment on Soils

Changes in soil chemistry due to treatment were difficult to assess. Chemistry at the two locations was different, masking changes due to treatment.

The Sodium Adsorption Ratio (SAR) in the A and C horizon decreased significantly ($p = .05$) on treated sites (Table 5) as did soluble calcium in the B horizon and soluble sodium in the C horizon (Table 6). This indicates that salts are being leached out of the solum. Whether this is related to clubmoss removal or a fracturing of the impermeable B horizon is somewhat unclear, but it is probably a combination of both factors and depends largely on soil type. Percent organic matter increased in the A horizons of treated sites. It appears that treatment did not dramatically affect soil chemical properties, but increased organic matter indicates that treatment effect was substantial enough to influence herbage production.

Clay Mineralogy

X-ray diffraction patterns (Figure 6) show smectite as the dominant mineral in all horizons of the Elloam and Phillips pedons studied. It appears to become less prevalent with soil formation, as evidenced by the smaller, diffuse peaks for the A and B horizons. This concurs with findings of Klages and Southard (1968) for Thoeny and Phillips soils developed in Bearpaw Shale-derived till. They

proposed that changes occur in clay mineralogy during the formation of a natric horizon. Whittig (1959) and St. Arnaud and Mortland (1963) suggest that highly alkaline conditions during solonization would be conducive to solubilization of silica and alumina. These soluble constituents leaching down into zones of higher electrolyte content may have combined with soluble bases to form mixed layer minerals containing smectite and illite.

Whittig (1959) and Klages and Southard (1968) found that the 18Å peak was virtually absent in the A horizon. Klages and Southard (1968) suggest that it was replaced by a mineral so disordered in the C-axis that no basal reflections resulted. As Figure 6 illustrates, there is a subdued 18Å peak for the A horizon of the Elloam selected for study. The 18Å peak for the Phillips Al was obscure. The nature of the 18Å peaks in the A horizons corresponds to the relative degree of weathering associated with each soil. In Phillips, the diffuse A horizon 18Å peak is in agreement with the presence of skeletans coating B horizon prisms, and the total lack of columnar structure

Genesis of Natrargids

Intense pedogenesis was probably initiated 8,000 to 9,000 years ago following the end of Ice Age climate during a subsequent period of higher temperature and humidity than dominate today (Morrison and

Frye, 1965). Because several minor erosional phases have since occurred, it is only possible to speculate about surface conditions during immediate post-glacial times. Meltwaters from the final four glacial advances, flowing south to the Missouri River likely carried away much of earlier till deposits so depth to Bearpaw Shale was probably not markedly different than at present.

The author hypothesizes that the shallow impermeable shale and humid environment resulted in a perched water table. Because of high salt content in the shale and shale-derived till, the ground water contained appreciable soluble salts. Following the influx of meltwater, the environment became increasingly arid, and capillary rise of water toward the soil surface resulted in the precipitation of soluble salts at the upper boundary of the capillary fringe. This accumulation of salts initiated the development of a natric horizon as the cation exchange complex was dominated by sodium and magnesium. Natrargid development followed a pathway similar to that described by Gedroits and Vil'yams in Tyurin et al. (1960) under similar environmental conditions.

Morrison and Frye (1965) postulate that post-glacial climate ended 4,000 years ago as semiarid conditions became prevalent. As precipitation decreased and evapotranspiration increased, the perched water table was no longer present, preventing further "solonization." Net downward movement of water would affect the equilibrium between

solution and adsorbed cations. Ca and Mg (divalent cations) would gradually replace Na on the B horizon exchange complex and the natric horizon would begin to degrade. It is suspected that the effects of mechanical treatment on such relict Natrargids are essentially irreversible and accelerate degradational processes which would otherwise require considerable time.

Why predictable patterns of four contiguous, but distinct, soils have developed on a relatively homogeneous landscape (in terms of parent material) is difficult to understand. Although the number of profiles examined was too small to make a definitive statement about this phenomenon, it was observed that solum thickness (which is generally proportional to depth to Bearpaw Shale) is deepest under Phillips and shallowest under Tealette (Table 1). Further, texture at an arbitrarily selected depth of 80 cm tends to be heavier under Tealette and Elloam than Thoeny or Phillips (Table 1). I speculate that Phillips and Thoeny are developed on slightly higher and better drained micro-positions than Elloam and Tealette.

Again, although too few soils were examined to map the topography of the shale contact depth, the boundary is not level, but is irregular (undulating) and I suspect that Tealette and Elloam developed on slight rises and Thoeny and Phillips developed over slight troughs. Thus, shale surface topography would be the opposite of surface topography.

If Tealette and Elloam developed in shallower till deposits, development of the natric horizon may have been more intense since the water table would have been nearer to the surface. Development of the natric horizon of Thoeny and the argillic horizon of Phillips provided a slowly permeable subsurface layer so that infiltrating water would flow laterally onto the B horizon surface of Elloam and Tealette where it would accumulate and evaporate, leaving precipitated soluble salts behind. Net salt transport would be out of Thoeny-Phillips and into the Elloam-Tealette system. Removal of salts would improve conditions for plant growth on Phillips and Thoeny. As a thicker plant community became established, a stable, organically enriched A horizon would develop. Conversely, continual infusion of salts into Elloam, and particularly Tealette, would perpetuate poor conditions for plant growth. These soils would be subject to erosion (wind and water) which further exaggerates the surface topography, culminating in panspot soils (Tealette). Addition of wind-blown material to the entire landscape should also be considered. Vegetation established on Phillips and Thoeny would tend to hold these soils in place whereas Elloam and Tealette would not receive major additions of surface material.

Mechanical treatments which improve drainage on the other soils and reduce the amount of lateral flow onto the panspots may accelerate the degradation of the Tealette natric horizon, but under present climatic conditions, I postulate that Tealette will require extensive

periods of time or mechanical treatment which causes the addition of A horizon material from the surrounding landscape and fractures the impermeable B horizon to significantly alter existing propitious conditions.

Although soils of the 1979 study location are deeper to shale contact they contain significantly more sodium and magnesium than soils at the 1980 location. This is likely due to an inherent difference in the initial content of the shale at respective sites. However, high soluble salt content of the solum could also be related to the thickness of respective till deposits. Till, being unconsolidated, would expose more surface area to soil water than shale and hence release more soluble salts. Given the same moisture regime (i.e., water table perched at the shale contact) and rate of upward capillary flow at the two locations, fewer soluble salts in shallow till deposits would be concentrated at the capillary fringe than in deeper till deposits, simply due to absolute differences in salt content. Capillary infusion of salts on shallow till deposits would eventually decrease while remaining at the initial rate on the deeper till soils. In the amount of time expired since the development of the Natrargids has ceased and their degradation begun, assuming that the volume of percolating water has been similar on both sites, more salts would remain in soils on the 1979 than 1980 sites. Further, the 1980 sites occupy a slightly lower

landscape position (807 m compared to 825 m) so that the volume of spring meltwater may be greater resulting in a greater leaching potential.

Discussion of the genesis of these soils so far has been in line with the classical theory of Gedroits and Vil'yams as described by Tyurin et al. (1960) for the formation of solonetz and solodized solonetz. The data suggest an alternative hypothesis--that soil formation is ongoing under present climatic conditions in the absence of a water table or capillary fringe.

The apparently random occurrence of the "panspots" (Tealette) on the landscape and the difference in clay and sodium contents of the Tealette and Elloam soils as compared to Thoeny and Phillips soils (Table 3) suggest that these soils are not in fact "relict" soils, but are actively differentiating under the present climate. I hypothesize that the B horizon clay and sodium contents of the Tealette and Elloam soils are increasing as a result of lateral movement of water into the panspot soils from the surrounding soils. This water movement occurs due to a matric potential gradient resulting from reduced infiltration into the pans and the fact that the more clay rich and silty panspot soils are "drier" at the same water percentage.

The hypothetical genesis process is outlined as follows:

Initial condition: An undulating till plain; the till is saline and of relatively uniform texture.

Stage I: Under evapotranspirative demand the soils dry, and salty spots appear because of topography or slight differences in clay or salt contents. In the salty spots, vegetative productivity is limited and clay formation is accelerated in the higher pH, sodium-rich environment.

Stage II: The salty spots suffer wind erosion as a result of their lesser vegetative cover, some of this windblown material is caught by the thicker vegetation on the less salty soils. This, plus leaching, initiates the formation of A horizons on the less salty spots.

Stage III: The processes begun in earlier stages become autocyclic. Increased organic matter and A horizon thickness increases infiltration on the less salty spots. The B horizons of these soils are wetter than those of the salty soils and water, carrying silica and sodium, moves from these soils into the developing panspot soils. In the B horizons of the panspots, clay formation in place is enhanced due to the relatively high pH and sodium contents. With reduced infiltration due to puddling of the surface of the panspots, the panspots receive more water from lateral movement as a result of matric and osmotic potential gradients than from downward infiltration.

Stage IV: As we view the landscape today, the Phillips soils are developing in the direction of thicker A horizons, increased organic matter and lower salt contents. The panspot (Tealette) soils are developing in the direction of increased sodium, increased clay content (interstratified smectites), high bulk density, and higher electrical conductivity.

The x-ray diffraction patterns (Figure 6) support the concept of increased clay formation in place in the Tealette B2t horizons (Klages and Southard, 1968). The Phillips soils were at one point saline but were probably never solonetz. The Thoeny may ultimately become solodized-solonetz while the Elloam and Tealette soils are developing greater solonetz properties under present conditions.

CONCLUSIONS

A Natrargid-Paleargid soil complex was characterized in northern Blaine County, Montana. Three Natrargid (Tealette, Elloam and Thoeny) soils and one Paleargid (Phillips) soil were examined. Herbage production was measured for each soil with and without mechanical treatment: plowing or chiseling. Findings of the study showed that:

1. Mechanical treatment increased grass, forb and total productivity, particularly on Elloam and Thoeny soils.
2. Mechanical treatment had a long residual effect. Increases in productivity were still significant ($p = .01$) at least 50 years after treatment.
3. The significant reduction ($p = .01$) in clubmoss cover by mechanical treatment was highly correlated to herbage production on treated sites.
4. The productivity of undesirable forbs, particularly fringed sagewort, increased on treated sites, especially the chiseled site. This is an effect associated with disturbance due to mechanical treatment which can become a problem unless careful grazing management is practiced.

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APPENDICES

APPENDIX 1: SOIL PROFILE DESCRIPTIONS

SURVEY SAMPLE NO.: S79MT 21
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC PALEARGID, FINE MONTMONILLONITIC

SITE NO.: 79 21 COUNTY: BLAINE ELEVATION: 0807 METERS MONTH SAMPLED: JULY
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: SOUTH
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: AC WATER TABLE
PRECIPITATION: 030 CM. CONTROL SECTION LIMITS -- UPPER: 000 CM LOWER: 006 CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED UNCONSOLIDATED MINERAL SEDIMENTS
CALCAREOUS SHALE

PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY

HORIZON	PROFILE DESCRIPTION
A 1	0 - 6 CM. (0 - 2 IN.) BROWN (10YR 5/3) EXTERIOR ; SANDY CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; WEAK VERY FINE GRANULAR STRUCTURE ; LOOSE , LOOSE , NONSTICKY , NONPLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
A 2	6 - 11 CM. (2 - 4 IN.) BROWN (10YR 5/3) EXTERIOR ; SANDY CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; MODERATE FINE PLATY STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE & MEDIUM IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; COMMON DISTINCT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	11 - 28 CM. (4 - 11 IN.) BROWN (10YR 4/3) EXTERIOR ; CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; MODERATE TO STRONG MEDIUM PRISMATIC STRUCTURE ; VERY HARD , FRIABLE , STICKY , PLASTIC ; MANY FINE ROOTS BETWEEN PEDS ; COMMON FINE & MEDIUM VOID INTERSTITIAL PORES , MANY FINE IRREGULAR AND TUBULAR PORES ; MANY PROMINENT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22T CA	28 - 55 CM. (11 - 22 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE MEDIUM PRISMATIC STRUCTURE ; SOFT , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; MANY FINE ROOTS BETWEEN PEDS ; MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON FAINT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; COMMON MIXED SEDIMENTARY FRAGMENTS >2 MM ; FEW TO COMMON SOFT FINE SALT CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CACS	55 - 91 CM. (22 - 36 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; FEW FINE PROMINENT YELLOWISH BROWN (10YR 5/6) EXTERIOR MOTTLES ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FRIABLE , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; FEW FAINT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; COMMON MIXED SEDIMENTARY FRAGMENTS >2 MM ; COMMON TO MANY SOFT FINE & MEDIUM SALT CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CA	91 - 134 CM. (36 - 53 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; SANDY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; FEW TO COMMON FINE DISTINCT YELLOWISH BROWN (10YR 5/6) EXTERIOR MOTTLES ; WEAK MEDIUM SUBANGULAR BLOCKY STRUCTURE ; SOFT , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR PORES ; FEW FAINT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; FEW MIXED SEDIMENTARY FRAGMENTS >2 MM ; FEW SOFT FINE GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; ABRUPT SMOOTH BOUNDARY .
C 2CACS	91 - 134 CM. (36 - 53 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MASSIVE ; HARD , VERY FRIABLE , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR PORES ; FEW SOFT VERY FINE GYPSUM CRYSTALS ; NONCALCAREOUS ; NOT REACHED BOUNDARY .

REMARKS: UNPLOWED,NATIVE VEGETATION

SOIL SERIES: THOENY

SURVEY SAMPLE NO.: S79MT 22
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE, MONTMORILLONITIC

SITE NO.: 79 22 | COUNTY: BLAINE | ELEVATION: 0807 METERS | MONTH SAMPLED: JULY
SLOPE: 1% | CLASS: | KIND: | ASPECT: NORTHWEST
AIR TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: 70 DEGREES F
SOIL TEMPERATURE | ANNUAL: DEGREES F | SUMMER: 65 DEGREES F | WINTER: DEGREES F
WATER TABLE: | DEPTH: CM. | MONTH: | KIND: NO WATER TABLE
PRECIPITATION: 030 CM. | CONTROL SECTION LIMITS -- | UPPER: CM LOWER: CM
PERMEABILITY: | DRAINAGE CLASS: | STONINESS: CLASS
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY

PARENT MATERIAL: HIGHLY WEATHERED UNCONSOLIDATED MINERAL SEDIMENTS
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 2	0 - 11 CM. (0 - 4 IN.) YELLOWISH BROWN (10YR 5/4) EXTERIOR ; LOAM ; DK. YELLOWISH BROWN (10YR 3/4) EXTERIOR MOIST ; FEW TO COMMON FINE PROMINENT BROWNISH YELLOW (10YR 6/8) EXTERIOR MOTTLES ; MODERATE TO STRONG FINE PLATY STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 MM ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	11 - 26 CM. (4 - 10 IN.) BROWN (10YR 4/3) EXTERIOR ; SANDY CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; MODERATE TO STRONG MEDIUM COLUMNAR STRUCTURE ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES ; MANY PROMINENT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22T CA	26 - 36 CM. (10 - 14 IN.) BROWN (10YR 4/3) EXTERIOR ; SANDY CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; MANY PROMINENT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; FEW SOFT FINE SALT CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CACS	36 - 62 CM. (14 - 24 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; SANDY CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; WEAK COARSE SUBANGULAR BLOCKY STRUCTURE ; SLIGHTLY HARD , LOOSE , NONSTICKY , NONPLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; FEW TO COMMON SOFT FINE SALT CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR WAVY BOUNDARY .
C 1CACS	62 - 92 CM. (24 - 36 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; SANDY CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; WEAK MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR AND TUBULAR PORES ; MANY FINE VESICULAR PORES ; COMMON FINE & MEDIUM SALT CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
IIC 2CS	92 - 155 CM. (36 - 61 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; COMMON FINE PROMINENT YELLOWISH BROWN (10YR 5/8) EXTERIOR MOTTLES ; MODERATE FINE SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , VERY FRIABLE , STICKY , PLASTIC ; FEW ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR PORES ; FEW MIXED LITHOLOGY FRAGMENTS >2 CM ; FEW TO COMMON SOFT FINE SALT CRYSTALS , FEW TO COMMON SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: UNPLOWED, NATIVE VEGETATION

ISOIL SERIES: TEALETTE

SURVEY SAMPLE NO.: S79MT 23
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE MONTMORILLONITIC

SITE NO.: 79 23 | COUNTY: BLAINE | ELEVATION: 0807 METERS | MONTH SAMPLED: JULY
SLOPE: 01% | CLASS: | KIND: | ASPECT: NORTHWEST
AIR TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: DEGREES F
SOIL TEMPERATURE | ANNUAL: DEGREES F | SUMMER: 73 DEGREES F | WINTER: DEGREES F
WATER TABLE: | DEPTH: CM. | MONTH: | KIND: AC WATER TABLE
PRECIPITATION: 330 CM. | CONTROL SECTION LIMITS -- | UPPER: CM LOWER: CM
PERMEABILITY: | DRAINAGE CLASS: |
PHYSIOGRAPHY: | | STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY AND CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 2	1 - 2 CM. (0 - 1 IN.) LIGHT GRAY (5Y7/2) EXTERIOR ; LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; MASSIVE ; SOFT , VERY FRIABLE , STICKY , SLIGHTLY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; FEW MIXED LITHOLOGY FRAGMENTS >2 CM ; NONCALCAREOUS (HCL) CONTINUOUS .
B 21T	2 - 13 CM. (1 - 5 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE TO STRONG FINE SUBANGULAR BLOCKY STRUCTURE ; HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; COMMON FAINT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22	13 - 36 CM. (5 - 14 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; COMMON FINE DISTINCT BROWNISH YELLOW (10YR 6/6) EXTERIOR MOTTLES ; MODERATE FINE PRISMATIC STRUCTURE AND MODERATE FINE SUBANGULAR BLOCKY ; HARD , FRIABLE , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; FEW FAINT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; COMMON SOFT FINE GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3	36 - 55 CM. (14 - 22 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; FEW TO COMMON FINE DISTINCT LT. YELLOWISH BROWN (10YR 6/4) EXTERIOR MOTTLES ; WEAK MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FIRM , STICKY , PLASTIC ; FEW TO COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; COMMON FAINT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; COMMON SOFT FINE GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1	55 - 84 CM. (22 - 33 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; FEW TO COMMON FINE DISTINCT BROWNISH YELLOW (10YR 6/6) EXTERIOR MOTTLES ; WEAK MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 2	84 - 115 CM. (25 - 45 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BRWN (2.5Y 3/2) EXTERIOR MOIST ; FEW TO COMMON FINE DISTINCT BROWNISH YELLOW (10YR 6/8) EXTERIOR MOTTLES ; MODERATE FINE SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON TO MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , MANY FINE VESICULAR PORES ; COMMON SOFT FINE & MEDIUM GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: UNPLOWED,NATIVE VEGETATION

1SOIL SERIES: ELLOAM

SURVEY SAMPLE NO.: S79MT 24
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE, MONTMORILLONITIC

SITE NO.: 79 24 COUNTY: BLAINE ELEVATION: 0807 METERS MONTH SAMPLED: JULY
SLOPE: 01% CLASS: KIND: ASPECT: NORTHWEST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 68 DEGREES F WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: 030 CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY AND CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A <2	0 - 11 CM. (0 - 4 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE FINE PLATY STRUCTURE ; LOOSE , LOOSE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	11 - 27 CM. (4 - 11 IN.) DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; CLAY ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE TO STRONG MEDIUM COLUMNAR STRUCTURE ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; MANY FINE VESICULAR PORES ; MANY VERY PROMINENT V DK GRAYISH BROWN (2.5Y 3/2) MOIST CLAY SKINS ON PED FACES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22T CA	27 - 42 CM. (11 - 17 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE TO STRONG MEDIUM PRISMATIC STRUCTURE AND MODERATE TO STRONG MEDIUM SUBANGULAR BLOCKY ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; MANY FINE VESICULAR PORES ; MANY PROMINENT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CACS	42 - 53 CM. (17 - 21 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE MEDIUM PRISMATIC STRUCTURE AND MODERATE MEDIUM SUBANGULAR BLOCKY ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; MANY FINE VESICULAR PORES ; MANY PROMINENT V DK GRAYISH BROWN (2.5Y 3/2) MOIST CLAY SKINS ON PED FACES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CACS	53 - 79 CM. (21 - 31 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE FINE & MEDIUM SUBANGULAR BLOCKY STRUCTURE ; HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES ; MANY SOFT FINE & MEDIUM GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; GRADUAL WAVY BOUNDARY .
C 2CACS	79 - 135 CM. (31 - 53 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; WEAK FINE & MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES ; FEW TO COMMON SOFT FINE GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: UNPLOWED,NATIVE VEGETATION

SOIL SERIES: ELLOAM

SURVEY SAMPLE NO.: S79MT 25
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE, MONTMORILLONITIC

SITE NO.: 79 25 COUNTY: BLAINE ELEVATION: 0807 METERS MONTH SAMPLED: JULY
SLOPE: 01% CLASS: KIND: ASPECT: NORTHWEST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: 030 CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER:
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY AND CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 10 CM. (0 - 4 IN.) BROWN (10YR 4/3) EXTERIOR ; CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; MODERATE FINE PLATY STRUCTURE ; SOFT , LOOSE , STICKY , PLASTIC ; COMMON TO MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	10 - 19 CM. (4 - 7 IN.) BROWN (10YR 4/3) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) EXTERIOR MOIST ; MODERATE FINE SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; MANY DISTINCT DARK GRAYISH BROWN (10YR 4/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22T	19 - 36 CM. (7 - 14 IN.) BROWN (10YR 4/3) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) EXTERIOR MOIST ; MODERATE FINE PRISMATIC STRUCTURE AND MODERATE FINE SUBANGULAR BLOCKY ; HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; FEW TO COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW FAINT DARK GRAYISH BROWN (10YR 4/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CA	0 - CM. (0 - IN.) DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE FINE & MEDIUM SUBANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON SOFT VERY FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CACS	0 - CM. (0 - IN.) DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; HARD , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 CM ; COMMON SOFT FINE GYPSUM CRYSTALS , COMMON SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 2CACS	0 - CM. (0 - IN.) V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR ; CLAY LOAM AND SANDY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; COMMON FINE PROMINENT YELLOWISH BROWN (10YR 5/6) EXTERIOR MOTTLES ; COMMON FINE DISTINCT YELLOWISH BROWN (10YR 5/8) EXTERIOR MOTTLES ; MODERATE MEDIUM ANGULAR BLOCKY STRUCTURE ; VERY HARD , VERY FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; FEW TO COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON TO MANY SOFT FINE GYPSUM CRYSTALS , COMMON SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: PLOWED. NATIVE VEGETATION

SOIL SERIES: TEALETTE

SURVEY SAMPLE NO.: S79MT 26
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE, MONTMORILLONITIC

SITE NO.: 73 26 | COUNTY: BLAINE | ELEVATION: 0807 METERS | MONTH SAMPLED: JULY
SLOPE: 1% | CLASS: | KIND: | ASPECT: NORTHWEST
AIR TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: DEGREES F
SOIL TEMPERATURE | ANNUAL: DEGREES F | SUMMER: 71 DEGREES F | WINTER: DEGREES F
WATER TABLE: | DEPTH: CM. | MONTH: | KIND: NO WATER TABLE
PRECIPITATION: 30 CM. | CONTROL SECTION LIMITS -- | UPPER: CM LOWER: CM
PERMEABILITY: | DRAINAGE CLASS: | STONINESS: CLASS
PHYSIOGRAPHY:
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY AND CALCAREOUS SHALE

HORIZON — PROFILE DESCRIPTION

A 1P — 0 - 10 CM. (0 - 4 IN.)
BROWN (10YR 4/3) EXTERIOR ; CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE AND WEAK FINE PLATY ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .

B 21T — 10 - 19 CM. (4 - 7 IN.)
BROWN (10YR 4/3) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) EXTERIOR MOIST ; MODERATE TO STRONG FINE & MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY DISTINCT DARK GRAYISH BROWN (10YR 4/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .

B 22T CA — 19 - 35 CM. (7 - 14 IN.)
BROWN (10YR 4/3) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON DISTINCT MOIST CLAY SKINS THROUGHOUT THE SOIL ; NONCALCAREOUS (HCL) ; CLEAR SMOOTH BOUNDARY .

C 1CA — 35 - 68 CM. (14 - 27 IN.)
DARK GRAYISH BROWN (10YR 4/2) EXTERIOR ; CLAY ; V DK GRAYISH BROWN (10YR 3/2) EXTERIOR MOIST ; MODERATE MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW TO COMMON SOFT VERY FINE GYPSUM CRYSTALS ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .

C 2CSS — 68 - 109 CM. (27 - 43 IN.)
DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; FEW TO COMMON DISTINCT YELLOWISH BROWN (10YR 5/8) EXTERIOR MOTTLES ; MODERATE VERY FINE & FINE ANGULAR BLOCKY STRUCTURE ; SLIGHTLY HARD , VERY FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 CM ; COMMON TO MANY SOFT FINE GYPSUM CRYSTALS ; NONCALCAREOUS (HCL) ; CLEAR SMOOTH BOUNDARY .

C 3CACS — 109 - 140 CM. (43 - 55 IN.)
V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; FEW FINE DISTINCT YELLOWISH BROWN (10YR 5/6) EXTERIOR MOTTLES ; MODERATE FINE & MEDIUM ANGULAR BLOCKY STRUCTURE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON TO MANY SOFT VERY FINE GYPSUM CRYSTALS ; NONCALCAREOUS (HCL) ; NOT REACHED BOUNDARY .

REMARKS: PLOWED. NATIVE VEGETATION

SOIL SERIES: PHILLIPS

SURVEY SAMPLE NO.: S79MT 27
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC PALEARGID, FINE, MONTMORILLONITIC

SITE NO.: 79 27 | COUNTY: BLAINE | ELEVATION: 0807 METERS | MONTH SAMPLED: JULY
SLOPE: 01% | CLASS: | KIND: | ASPECT: NORTHWEST
AIR TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: DEGREES F
SOIL TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: DEGREES F
WATER TABLE: | DEPTH: CM. | MONTH: | KIND: NO WATER TABLE
PRECIPITATION: 030 CM. | CONTROL SECTION LIMITS -- | UPPER: CM LOWER: CM
PERMEABILITY: | DRAINAGE CLASS:
PHYSIOGRAPHY: | STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 11 CM. (0 - 4 IN.) BROWN (10YR 5/3) EXTERIOR ; SANDY LOAM ; V DK GRAYISH BROWN (10YR 3/2) EXTERIOR MOIST ; WEAK FINE GRANULAR STRUCTURE AND WEAK FINE PLATY ; SLIGHTLY HARD , LOOSE , NONSTICKY , NONPLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	11 - 27 CM. (4 - 11 IN.) BROWN (10YR 4/3) EXTERIOR ; SANDY CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; STRONG FINE PRISMATIC STRUCTURE ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY PROMINENT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; FEW MIXED LITHOLOGY FRAGMENTS >2 CM ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22CA	27 - 53 CM. (11 - 21 IN.) CLAY LOAM ; MODERATE MEDIUM PRISMATIC STRUCTURE ; HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON PROMINENT V DK GRAYISH BROWN (10YR 3/2) MOIST CLAY SKINS ON PED FACES ; MANY SOFT FINE & MEDIUM MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR WAVY BOUNDARY .
B 3CA	53 - 74 CM. (21 - 29 IN.) GRAYISH BROWN (10YR 5/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (10YR 3/2) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; VERY HARD , FRIABLE , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; FEW FAINT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; COMMON SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CACS	74 - 115 CM. (29 - 45 IN.) DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; SANDY CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; STRONG MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON TO MANY SOFT VERY FINE GYPSUM CRYSTALS , COMMON SOFT FINE MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 2CACS	115 - 150 CM. (45 - 59 IN.) V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR ; SANDY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; COMMON MEDIUM PROMINENT YELLOWISH BROWN (10YR 5/8) EXTERIOR MOIST MOTTLES ; MODERATE FINE & MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , LOOSE , STICKY , PLASTIC ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; COMMON SOFT FINE GYPSUM CRYSTALS , FEW SOFT VERY FINE OXIDES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: PLOWED NATIVE VEGETATION

SOIL SERIES: THOENY

SURVEY SAMPLE NO.: S79MT 28
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE, MONTMORILLONITIC

SITE NO.: 79 28 | COUNTY: BLAINE | ELEVATION: 0807 METERS | MONTH SAMPLED: JULY
SLOPE: 01% | CLASS: | KIND: | ASPECT: NORTHWEST
AIR TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: DEGREES F
SOIL TEMPERATURE | ANNUAL: DEGREES F | SUMMER: 61 DEGREES F | WINTER: DEGREES F
WATER TABLE: | DEPTH: CM. | MONTH: | KIND: NO WATER TABLE
PRECIPITATION: 039 CM. | CONTROL SECTION LIMITS -- | UPPER: CM LOWER: CM
PERMEABILITY: | DRAINAGE CLASS:
PHYSIOGRAPHY: | STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY AND CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 13 CM. (0 - 5 IN.) BROWN (10YR 5/3) EXTERIOR ; SANDY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; WEAK FINE GRANULAR STRUCTURE AND WEAK FINE PLATY ; LOOSE , LOOSE , NONSTICKY , NONPLASTIC ; FEW TO COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 2LT	13 - 33 CM. (5 - 13 IN.) BROWN (10YR 4/3) EXTERIOR ; CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; STRONG MEDIUM COLUMNAR STRUCTURE ; VERY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY VERY PROMINENT DARK BROWN (10YR 3/3) MOIST CLAY SKINS THROUGHOUT THE SOIL ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 2LT CA	33 - 61 CM. (13 - 24 IN.) BROWN (10YR 4/3) EXTERIOR ; CLAY LOAM ; DARK BROWN (10YR 3/3) EXTERIOR MOIST ; STRONG MEDIUM PRISMATIC STRUCTURE ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE & MEDIUM IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON DISTINCT DARK BROWN (10YR 3/3) MOIST CLAY SKINS ON PED FACES ; MANY SOFT MEDIUM MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CA	61 - 92 CM. (24 - 36 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE MEDIUM PRISMATIC STRUCTURE ; VERY HARD , FRIABLE , STICKY , PLASTIC ; FEW TO COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; COMMON SOFT FINE MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CACS	92 - 125 CM. (36 - 49 IN.) V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR ; LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE MEDIUM ANGULAR BLOCKY STRUCTURE ; SLIGHTLY HARD , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; FEW TO COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW MIXED LITHOLOGY FRAGMENTS >2 CM ; COMMON SOFT FINE GYPSUM CRYSTALS , COMMON SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; GRADUAL SMOOTH BOUNDARY .
C 2CACS	125 - 160 CM. (49 - 63 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE FINE & MEDIUM ANGULAR BLOCKY STRUCTURE ; SOFT , LOOSE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY MIXED LITHOLOGY FRAGMENTS >2 MM ; COMMON SOFT VERY FINE GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: PLOWED NATIVE VEGETATION

SOIL SERIES: THOENY

SURVEY SAMPLE NO.: S79MT 29
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC NATRARGID, FINE, MONTMORILLONITIC

SITE NO.: 79 29 | COUNTY: BLAINE | ELEVATION: 0807 METERS | MONTH SAMPLED:
SLOPE: 1% | CLASS: | KIND: | ASPECT: NORTHWEST
AIR TEMPERATURE | ANNUAL: DEGREES F | SUMMER: DEGREES F | WINTER: DEGREES F
SOIL TEMPERATURE | ANNUAL: DEGREES F | SUMMER: 64 DEGREES F | WINTER: DEGREES F
WATER TABLE: | DEPTH: CM. | MONTH: | KIND: NO WATER TABLE
PRECIPITATION: 13 CM. | CONTROL SECTION LIMITS -- | UPPER: CP LOWER: CP
PERMEABILITY: | DRAINAGE CLASS:
PHYSIOGRAPHY:
VEGETATION: GRASSES AND FORBS AND SHRUBS | STONINESS: CLASS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 10 CM. (0 - 4 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; WEAK MEDIUM SUBANGULAR BLOCKY STRUCTURE AND WEAK VERY FINE PLATY ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; ABRUPT SMOOTH BOUNDARY .
B 21T	10 - 18 CM. (4 - 7 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; OLIVE GRAY (5Y4/2) EXTERIOR MOIST ; STRONG MEDIUM COLUMNAR STRUCTURE ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; MANY FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY PROMINENT OLIVE GRAY (5Y4/2) MOIST CLAY SKINS ON PED FACES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 22T CA	18 - 45 CM. (7 - 18 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; OLIVE GRAY (5Y4/2) EXTERIOR MOIST ; STRONG MEDIUM PRISMATIC STRUCTURE ; HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON DISTINCT OLIVE GRAY (5Y4/2) MOIST CLAY SKINS ON PED FACES ; COMMON SILTSTONE FRAGMENTS >2 MM ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 2CA	45 - 67 CM. (18 - 26 IN.) CLAY LOAM ; MODERATE MEDIUM PRISMATIC STRUCTURE ; HARD , FIRM , STICKY , PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CACS	67 - 135 CM. (26 - 41 IN.) CLAY ; MODERATE MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; COMMON SOFT VERY FINE GYPSUM CRYSTALS ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 2CSCS	135 - 139 CM. (41 - 51 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; MODERATE FINE & MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 MM ; COMMON SOFT VERY FINE GYPSUM CRYSTALS ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; ACT REACHED BOUNDARY .

REMARKS: PLOWED. CRESTED WHEATGRASS

SOIL SERIES:		PHILLIPS	
SURVEY SAMPLE NO.:		S79MT 30	
LOCATION:	S34-T35N-R19E		
CLASSIFICATION:	BOROLLIC PALEARGID, FINE, MONTMORILLONITIC		
SITE NO.: 79 30	COUNTY: BLAINE	ELEVATION: 0807 METERS	MONTH SAMPLED: JULY
SLOPE: 01%	CLASS:	KIND:	ASPECT: NORTHWEST
AIR TEMPERATURE	ANNUAL: DEGREES F	SUMMER: DEGREES F	WINTER: DEGREES F
SOIL TEMPERATURE	ANNUAL: DEGREES F	SUMMER: 55 DEGREES F	WINTER: DEGREES F
WATER TABLE:	DEPTH: CM.	MONTH:	KIND: NO WATER TABLE
PRECIPITATION:	030 CM.	CONTROL SECTION LIMITS --	UPPER: CM LOWER: CM
PERMEABILITY:		DRAINAGE CLASS:	
PHYSIOGRAPHY:			STONINESS: CLASS
VEGETATION:	GRASSES AND FORBS AND SHRUBS		
PARENT MATERIAL:	HIGHLY WEATHERED GLACIAL TILL MIXED LITHOLOGY		

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 10 CM. (0 - 4 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; SANDY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE FINE GRANULAR STRUCTURE AND MODERATE VERY FINE PLATY ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
A 2	10 - 16 CM. (4 - 6 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; SANDY CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE MEDIUM PRISMATIC STRUCTURE AND MODERATE FINE PLATY ; LOOSE , LOOSE , STICKY , PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 MM ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	16 - 28 CM. (6 - 11 IN.) DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; CLAY LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; STRONG FINE & MEDIUM PRISMATIC STRUCTURE ; VERY HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; MANY FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY VERY PROMINENT V DK GRAYISH BROWN (2.5Y 3/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; COMMON MIXED LITHOLOGY FRAGMENTS >2 MM ; NONCALCAREOUS (HCL) ; CLEAR SMOOTH BOUNDARY .
B 22T C1	28 - 53 CM. (11 - 21 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR ; STRONG FINE & MEDIUM PRISMATIC STRUCTURE ; HARD , FRIABLE , VERY STICKY , VERY STICKY ; COMMON TO MANY FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON DISTINCT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; COMMON TO MANY SOFT FINE & MEDIUM MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3C1	53 - 72 CM. (21 - 28 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; SANDY CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; MODERATE MEDIUM PRISMATIC STRUCTURE ; HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW MIXED LITHOLOGY FRAGMENTS >2 MM ; FEW TO COMMON SOFT FINE MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CSCS	72 - 123 CM. (28 - 48 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; OLIVE GRAY (5Y4/2) EXTERIOR MOIST ; FEW FINE DISTINCT OLIVE YELLOW (2.5Y 6/8) EXTERIOR MOIST MOTTLES ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; SOFT , VERY FRIABLE , VERY STICKY , VERY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW MIXED LITHOLOGY FRAGMENTS

SOIL SERIES: TEALETTE

SURVEY SAMPLE NO.: S79PT 31
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC HAPLARGID; FINE

SITE NO.: 79 31 COUNTY: BLAINE ELEVATION: 0807 METERS MONTH SAMPLED: JULY
SLOPE: 01% CLASS: KIND: ASPECT: NORTHWEST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 64 DEGREES F WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: 33 CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
MIXED LITHOLOGY

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 10 CM. (0 - 4 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE AND WEAK VERY FINE PLATY ; HARD , VERY FRIABLE , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW MIXED LITHOLOGY FRAGMENTS >2 CM ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	10 - 24 CM. (4 - 9 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE FINE PRISMATIC STRUCTURE AND MODERATE FINE SUBANGULAR BLOCKY ; VERY HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON FINE VESICULAR PORES ; MANY PROMINENT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 22T CA	24 - 43 CM. (9 - 17 IN.) OLIVE GRAY (5Y5/2) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; FEW FINE FAINT YELLOWISH BROWN (10YR 5/6) EXTERIOR MOTTLES ; MODERATE MEDIUM PRISMATIC STRUCTURE ; VERY HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON DISTINCT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; MIXED LITHOLOGY FRAGMENTS >2 MM ; FEW TO COMMON SOFT FINE MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CA	43 - 62 CM. (17 - 24 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE MEDIUM PRISMATIC STRUCTURE ; EXTREMELY HARD , VERY FIRM , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; FEW DISTINCT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS ON PED FACES ; FEW MIXED LITHOLOGY FRAGMENTS >2 MM ; COMMON SOFT FINE MASSES OF LIME , FEW SOFT VERY FINE OXIDES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR WAVY BOUNDARY .
C 1CACS	62 - 95 CM. (24 - 37 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; LOAM ; V DK GRAYISH BROWN (2.5Y 3/2) EXTERIOR MOIST ; MODERATE MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS , CLEAR SMOOTH BOUNDARY .
C 2CACS	95 - 125 CM. (37 - 49 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; SANDY CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST , MODERATE MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY SOFT FINE GYPSUM CRYSTALS , FEW SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: PLOWED. CRESTED WHEATGRASS

SOIL SERIES: ELLOAN

SURVEY SAMPLE NO.: S79MT 32
LOCATION: S34-T35N-R19E
CLASSIFICATION: BOROLLIC HAPLARGID; FINE

SITE NO.: 79 32 COUNTY: BLAINE ELEVATION: 0807 METERS MONTH SAMPLED: JULY
SLOPE: 01% CLASS: KIND: ASPECT: NORTHWEST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 63 DEGREES F WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: 030 CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: STONINESS: CLASS
VEGETATION:
PARENT MATERIAL: HIGHLY WEATHERED GLACIAL TILL
CALCAREOUS SHALE AND CALCAREOUS SANDSTONE

HORIZON	PROFILE DESCRIPTION
A 1P	0 - 10 CM. (0 - 4 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; LOOSE , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) ; ABRUPT SMOOTH BOUNDARY .
B 21T	10 - 23 CM. (4 - 9 IN.) GRAYISH BROWN (2.5Y 5/2) EXTERIOR ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) EXTERIOR MOIST ; WEAK FINE PRISMATIC STRUCTURE AND MODERATE MEDIUM SUBANGULAR BLOCKY ; VERY HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; MANY PROMINENT DARK GRAYISH BROWN (2.5Y 4/2) MOIST CLAY SKINS THROUGHOUT THE SOIL ; NONCALCAREOUS (HCL) , ABRUPT SMOOTH BOUNDARY .
B 22T CA	23 - 43 CM. (9 - 17 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; MODERATE MEDIUM SUBANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON DISTINCT GRAYISH BROWN (2.5Y 5/2) MOIST CLAY SKINS ON PED FACES ; COMMON SOFT FINE MASSES OF LIME ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
B 3CA	43 - 62 CM. (17 - 24 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; WEAK FINE PRISMATIC STRUCTURE AND MODERATE MEDIUM SUBANGULAR BLOCKY ; VERY HARD , FRIABLE , STICKY , PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 MM ; COMMON SOFT FINE MASSES OF LIME , COMMON SOFT VERY FINE OXIDES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 1CACS	62 - 112 CM. (24 - 44 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; COMMON FINE FAINT OLIVE YELLOW (2.5Y 6/6) EXTERIOR MOTTLES ; MODERATE FINE & MEDIUM ANGULAR BLOCKY STRUCTURE ; VERY HARD , FRIABLE , VERY STICKY , VERY PLASTIC ; FEW TO COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON SOFT VERY FINE GYPSUM CRYSTALS , COMMON SOFT FINE & MEDIUM MASSES OF LIME ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; CLEAR SMOOTH BOUNDARY .
C 2CACS	112 - 135 CM. (44 - 53 IN.) LIGHT BROWNISH GRAY (2.5Y 6/2) EXTERIOR ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) EXTERIOR MOIST ; COMMON TO MANY FINE & MEDIUM PROMINENT BROWNISH YELLOW (10YR 6/8) EXTERIOR MOTTLES ; MODERATE FINE & MEDIUM ANGULAR BLOCKY STRUCTURE ; HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE IRREGULAR AND TUBULAR PORES , COMMON TO MANY FINE VESICULAR PORES ; COMMON MIXED LITHOLOGY FRAGMENTS >2 MM , COMMON MIXED LITHOLOGY FRAGMENTS >2 CM ; COMMON SOFT FINE & MEDIUM MASSES OF LIME , FEW TO COMMON SOFT VERY FINE OXIDES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; NOT REACHED BOUNDARY .

REMARKS: PLOWED. CRESTED WHEATGRASS

SOIL SERIES: TEALETTE

SURVEY SAMPLE NO.: S80MT 45
LOCATION: SW-S33-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS: FINE

SITE NO.: 80 45 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: SOUTH
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 18 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 2	0 - 4 CM. (0 - 2 IN.) PALE BROWN (10YR 6/3) CRUSHED ; CLAY LOAM ; LIGHT GRAY (2.5Y 7/2) CRUSHED DRY ; WEAK FINE PLATY MOIST STRUCTURE PARTING TO STRONG VERY FINE GRANULAR MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 6.9 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 21T	4 - 24 CM. (2 - 9 IN.) DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO MODERATE TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON TO MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VOID INTERSTITIAL PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.1 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 3CA	24 - 49 CM. (9 - 19 IN.) YELLOWISH BROWN (10YR 5/4) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MODERATE MEDIUM ANGULAR BLOCKY MOIST STRUCTURE PARTING TO MODERATE FINE ANGULAR BLOCKY MOIST ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VOID INTERSTITIAL PORES , COMMON FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.4 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 1CA	49 - 76 CM. (19 - 30 IN.) BROWN (10YR 5/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; VERY WEAK MEDIUM SUBANGULAR BLOCKY MOIST STRUCTURE PARTING TO MASSIVE ; HARD , VERY FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.3 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 2CA	76 - 104 CM. (30 - 41 IN.) YELLOWISH BROWN (10YR 5/6) CRUSHED ; CLAY ; LIGHT BROWNISH GRAY (2.5Y 6/2) CRUSHED DRY ; MASSIVE MOIST ; HARD , VERY FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.6 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: NATIVE UNPLOWED 1980
Columnar caps were evident near the surface beneath a very shallow A_2 horizon. Small pieces of coal and iron nodules and stains were observed in the C horizons. The C_2 horizon was a mixture of glacial till and the underlying shale.

SOIL SERIES: ELLOAM

SURVEY SAMPLE NO.: SBOMT 46
LOCATION: SW-S33-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS: FINE

SITE NO.: 80 46 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 18 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON		PROFILE DESCRIPTION
A	1	0 - 7 CM. (0 - 3 IN.) BROWN (10YR 5/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; WEAK FINE GRANULAR MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.5 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A	2	7 - 11 CM. (3 - 4 IN.) LIGHT BROWNISH GRAY (10YR 6/2) CRUSHED ; ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; WEAK ' FINE PLATY MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; ABRUPT SMOOTH BOUNDARY .
B	2T	11 - 27 CM. (4 - 11 IN.) DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO MODERATE MEDIUM ANGULAR BLOCKY MOIST ; HARD , FIRM , STICKY , PLASTIC ; MANY FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES , COMMON TO MANY FINE VOID INTERSTITIAL PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.5 (PH METER) ; CLEAR SMOOTH BOUNDARY .
B	3CA	27 - 32 CM. (11 - 13 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; STRONG MEDIUM ANGULAR BLOCKY MOIST STRUCTURE PARTING TO STRONG FINE ANGULAR BLOCKY MOIST ; HARD , VERY FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; FEW TO COMMON FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.6 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C	1CA	32 - 65 CM. (13 - 26 IN.) YELLOWISH BROWN (10YR 5/4) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MASSIVE MOIST ; HARD , FIRM , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.4 (PH METER) ; CLEAR SMOOTH BOUNDARY .
IIC	2CA	65 - 112 CM. (26 - 44 IN.) OLIVE (5Y4/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.5 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: NATIVE UNPLOWED 1980

Very strong profile development with very abrupt boundary between the A_2 and B_{2t} horizon. Threadlike nodules of $CaCO_3$ and $CaSO_4$ were observed in the P.M., as well iron staining, especially in voids associated with small CF. The II C_2 horizon is a mixture of glacial till and shale material.

SOIL SERIES: PHILLIPS

SURVEY SAMPLE NO.: S80MT 47
LOCATION: SW-SEC33-T36N-R19E
CLASSIFICATION: BOROLLIC HAPLARGIDS; FINE

SITE NO.: 80 47 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 19 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON — PROFILE DESCRIPTION

A 1 — 0 - 11 CM. (0 - 4 IN.)
YELLOWISH BROWN (10YR 5/4) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO STRONG FINE GRANULAR MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.0 (PH METER) ; ABRUPT SMOOTH BOUNDARY .

B 21T — 11 - 21 CM. (4 - 8 IN.)
DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; CLAY LOAM ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; WEAK MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.0 (PH METER) ; ABRUPT SMOOTH BOUNDARY .

B 22CA — 21 - 45 CM. (8 - 18 IN.)
BROWN (10YR 4/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; STRONG MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE TO COARSE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 7.9 (PH METER) ; ABRUPT SMOOTH BOUNDARY .

B 3CA — 45 - 53 CM. (18 - 21 IN.)
OLIVE GRAY (5Y4/2) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; STRONG MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE TO COARSE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.1 (PH METER) ; CLEAR SMOOTH BOUNDARY .

C 1 — 53 - 97 CM. (21 - 38 IN.)
DARK OLIVE GRAY (5Y3/2) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; WEAK MEDIUM SUBANGULAR BLOCKY MOIST STRUCTURE PARTING TO MASSIVE MOIST ; VERY HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.2 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: NATIVE UNPLOWED 1980
Best structural development and argillans were observed between 21 and 45 cm in the B22tca. It was difficult to discern the contact between the glacial till material and the underlying shale, but it appeared that the C1 horizon, and possibly the B3ca horizon, contained some shale. Remanents of columns were observed on the B21t horizon. Salt nodules and iron mottles were evident in the C_1ca horizon. Soft coal fragments were observed in the B3ca and C1ca horizons.

SOIL SERIES: THOENY

SURVEY SAMPLE NO.: S80MT 48
LOCATION: SW-SEC33-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE

SITE NO.: 80 48 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 19 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 6 CM. (0 - 2 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; MODERATE MEDIUM PLATY MOIST STRUCTURE PARTING TO STRONG FINE GRANULAR MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 6.6 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	6 - 18 CM. (2 - 7 IN.) BROWN (10YR 5/3) CRUSHED ; CLAY LOAM ; PALE BROWN (10YR 6/3) CRUSHED DRY ; MODERATE TO STRONG MEDIUM PLATY MOIST STRUCTURE PARTING TO WEAK TO MODERATE FINE GRANULAR MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; FEW TO COMMON FINE ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES , FEW TO COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; ABRUPT SMOOTH BOUNDARY .
B 21T	18 - 32 CM. (7 - 13 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; STRONG MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; HARD , FIRM , STICKY , PLASTIC ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.4 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 3CAT	32 - 44 CM. (13 - 17 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; STRONG MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; VERY HARD , FIRM , VERY STICKY , VERY PLASTIC ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.1 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 1CA	44 - 97 CM. (17 - 38 IN.) V DK GRAYISH BROWN (10YR 3/2) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.0 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: NATIVE PLOWED 1980

Columnar structure is very strongly expressed. Very thin (0.5cm) but distinct natric horizon above caps. Root penetration below 32 cm was prohibited by extremely hard consistance. Salt nodules, coal and shale fragments were observed in the C1ca horizon.

SOIL SERIES: THOENY

SURVEY SAMPLE NO.: S80MT 49
LOCATION: SW-SEC33-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE

SITE NO.: 80 49 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 18 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 7 CM. (0 - 3 IN.) DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; SANDY CLAY LOAM ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO MODERATE FINE GRANULAR MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.3 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	7 - 23 CM. (3 - 9 IN.) PALE BROWN (10YR 6/3) CRUSHED ; ; VERY PALE BROWN (10YR 7/3) CRUSHED ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO WEAK TO MODERATE FINE PLATY ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.5 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 21T	23 - 44 CM. (9 - 17 IN.) DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; CLAY LOAM ; BROWN (10YR 5/3) CRUSHED DRY ; MODERATE MEDIUM COLUMNAR MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES , COMMON TO MANY FINE VOID INTERSTITIAL PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.6 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 22T	44 - 53 CM. (17 - 21 IN.) DK. YELLOWISH BROWN (10YR 3/4) CRUSHED ; CLAY ; DARK BROWN (10YR 3/3) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY ; HARD , FIRM , VERY STICKY , VERY PLASTIC ; FEW COARSE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE VOID INTERSTITIAL PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.3 (PH METER) ; CLEAR SMOOTH BOUNDARY .
B 3CA	53 - 60 CM. (21 - 24 IN.) V DK GRAYISH BROWN (10YR 3/2) CRUSHED ; CLAY LOAM ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MODERATE MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; FEW COARSE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE VOID INTERSTITIAL PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.5 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 1CA	60 - 98 CM. (24 - 39 IN.) DARK GRAYISH BROWN (10YR 4/2) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MASSIVE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; MANY FINE TUBULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.6 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: PLOWED NATIVE 1980

Very strongly expressed columnar and prismatic structures developed under a prominent, thick A2 horizon in which fine vesicular structure was observed. A few fine salt nodules were present in the B22t horizon, increasing to common and medium/fine in the B3ca and C1ca horizons. Roots are distributed throughout the soil, but most common between peds. Soft coal fragments were common in the C1ca horizon.

SOIL SERIES: PHILLIPS

SURVEY SAMPLE NO.: S80MT 50
LOCATION: SW-S33-T36N-R19E
CLASSIFICATION: BOROLLIC HAPLARGIDS; FINE .

SITE NO.: 80 50 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 19 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 15 CM. (0 - 6 IN.) YELLOWISH BROWN (10YR 5/4) CRUSHED ; SANDY LOAM ; BROWN (10YR 5/3) CRUSHED DRY ; WEAK TO MODERATE FINE GRANULAR MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.4 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	15 - 25 CM. (6 - 10 IN.) BROWN (10YR 5/3) CRUSHED ; SANDY CLAY LOAM ; PALE BROWN (10YR 6/3) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO MODERATE TO STRONG FINE PLATY ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.1 (PH METER) ; ABRUPT WAVY BOUNDARY .
B 2T	25 - 44 CM. (10 - 17 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY LOAM ; BROWN (10YR 4/3) CRUSHED DRY ; STRONG FINE & MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO MODERATE FINE ANGULAR BLOCKY ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE VOID INTERSTITIAL PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.7 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 3CA	44 - 54 CM. (17 - 21 IN.) V DK GRAYISH BROWN (10YR 3/2) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; MODERATE MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; HARD , FRIABLE , STICKY , PLASTIC ; FEW COARSE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , MANY FINE VOID INTERSTITIAL PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.5 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 1CA	54 - 104 CM. (21 - 41 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY LOAM ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; MASSIVE MOIST ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; FEW MEDIUM & COARSE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.3 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: PLOWED NATIVE 1980
A2 is thick and shows platy structure. There was very little evidence of even degraded columnar structure, but prismatic development was strong. Salt nodules were common in the B3 horizon, and present in the C1 horizon. Coal fragments were also obvious in the C1ca.

SOIL SERIES: ELLOAM

SURVEY SAMPLE NO.: SBOMT 51
LOCATION: SW-SEC33-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE

SITE NO.: 80 51 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 18 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 5 CM. (0 - 2 IN.) YELLOWISH BROWN (10YR 5/4) CRUSHED ; SANDY LOAM ; LIGHT BROWNISH GRAY (2.5Y 6/2) CRUSHED DRY ; WEAK FINE GRANULAR MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.3 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	5 - 7 CM. (2 - 3 IN.) LIGHT GRAY (10YR 7/2) CRUSHED ; SANDY LOAM ; LIGHT GRAY (2.5Y 7/2) CRUSHED DRY ; WEAK FINE & MEDIUM PLATY MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE. TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.4 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 2T	7 - 16 CM. (3 - 6 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; STRONG MEDIUM COLUMNAR MOIST STRUCTURE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS BETWEEN PEDS ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.8 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 3CA	16 - 25 CM. (6 - 10 IN.) YELLOWISH BROWN (10YR 5/4) CLAY ; BROWN (10YR 4/3) CRUSHED DRY ; STRONG MEDIUM ANGULAR BLOCKY MOIST STRUCTURE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.4 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 1CA	25 - 57 CM. (10 - 22 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MASSIVE MOIST ; HARD , FIRM , STICKY , PLASTIC ; FEW MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.3 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 2CA	57 - 102 CM. (22 - 40 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , MANY FINE VOID INTERSTITIAL PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.8 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: PLOWED NATIVE 1980
Caps on columnar structure are not as hard in dry consistance as the unplowed site; they are distinct, however. A distinct band of accumulated salts at 57 cm may indicate the top of the capillary fringe.

SOIL SERIES: TEALETTE

SURVEY SAMPLE NO.: S80MT 52
LOCATION: SW-SEC33-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE

SITE NO.: 80 52 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 18 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 2	0 - 4 CM. (0 - 2 IN.) LIGHT GRAY (10YR 7/2) CRUSHED ; LOAM ; LIGHT GRAY (2.5Y 7/2) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO WEAK FINE PLATY MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.5 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 2T	4 - 12 CM. (2 - 5 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; STRONG MEDIUM COLUMNAR MOIST STRUCTURE ; HARD , FIRM , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS BETWEEN PEDS ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.5 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 1CA	12 - 57 CM. (5 - 22 IN.) BROWN (10YR 5/3) CRUSHED ; CLAY ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE TUBULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.2 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 2CA	57 - 97 CM. (22 - 38 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY ; DARK GRAYISH BROWN (2.5Y 4/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; COMMON FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE TUBULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MILDLY ALKALINE PH- 7.7 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: Plowing has damaged, but not destroyed the caps and upper portion of the columns in the B2t. Many, very fine threadlike nodules characterize the C2ca horizon. No coal fragments or iron staining was observed.

SOIL SERIES: PHILLIPS

SURVEY SAMPLE NO.: S80MY 53
LOCATION: SW-SEC32-T36N-R19E
CLASSIFICATION: BOROLLIC HAPLARGIDS: FINE-LOAMY

SITE NO.: 80 53 COUNTY: SEE REMARKS ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 17 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 8 CM. (0 - 3 IN.) DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; LOAM ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO WEAK FINE GRANULAR MOIST ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.3 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	8 - 15 CM. (3 - 6 IN.) DK. YELLOWISH BROWN (10YR 4/4) CRUSHED ; LOAM ; BROWN (10YR 5/3) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO WEAK FINE PLATY ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.3 (PH METER) ; ABRUPT WAVY BOUNDARY .
B 2T	15 - 30 CM. (6 - 12 IN.) DK. YELLOWISH BROWN (10YR 3/4) CRUSHED ; CLAY LOAM ; BROWN (10YR 4/3) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; HARD , FIRM , STICKY , PLASTIC ; COMMON FINE ROOTS BETWEEN PEDS ; COMMON FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 6.9 (PH METER) ; CLEAR SMOOTH BOUNDARY .
B 3CA	30 - 64 CM. (12 - 25 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; WEAK FINE & MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO MODERATE MEDIUM ANGULAR BLOCKY ; HARD , FIRM , STICKY , PLASTIC ; FEW MEDIUM & COARSE ROOTS THROUGHOUT HORIZON ; FEW TO COMMON FINE VOID INTERSTITIAL PORES , FEW TO COMMON FINE VESICULAR PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.3 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 1CA	64 - 96 CM. (25 - 38 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY LOAM ; LIGHT BROWNISH GRAY (2.5Y 6/2) CRUSHED DRY ; WEAK VERY FINE & FINE ANGULAR BLOCKY MOIST STRUCTURE PARTING TO MASSIVE ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.7 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: CHISLED 1980
Chiseling created a microtopography with 10 cm of relief between ridges and furrows. This caused variation in the thickness of the A1 horizon((1e) ridge 0-8cm, furrow 0-6 cm). There were very few, very fine salt nodules in the C1ca in contrast to the accumulation at other sites.

SOIL SERIES: THOENY

SURVEY SAMPLE NO.: S80MT 54
LOCATION: SE-SEC32-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE-LOAMY

SITE NO.: 80 54 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 17 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 7 CM. (0 - 3 IN.) DK. YELLOWISH BROWN (10YR 3/4) CRUSHED ; LOAM ; BROWN (10YR 5/3) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO MODERATE MEDIUM GRANULAR ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON COMMON TO MANY FINE VESICULAR PORES , FEW FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 6.6 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	7 - 20 CM. (3 - 8 IN.) PALE BROWN (10YR 6/3) CRUSHED ; LOAM ; LIGHT BROWNISH GRAY (10YR 6/2) CRUSHED DRY ; WEAK COARSE PLATY MOIST STRUCTURE PARTING TO WEAK FINE PLATY MOIST ; SOFT , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; MANY FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.3 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 21T	20 - 44 CM. (8 - 17 IN.) DK. YELLOWISH BROWN (10YR 3/4) CRUSHED ; CLAY LOAM ; BROWN (10YR 4/3) CRUSHED DRY ; STRONG MEDIUM COLUMNAR MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; HARD , FIRM , STICKY , PLASTIC ; COMMON FINE & MEDIUM ROOTS BETWEEN PEDS ; FEW TO COMMON FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 7.9 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 22T	44 - 63 CM. (17 - 25 IN.) YELLOWISH BROWN (10YR 5/5) CRUSHED ; CLAY LOAM ; BROWN (10YR 5/3) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO MODERATE MEDIUM ANGULAR BLOCKY MOIST ; VERY HARD , FIRM , STICKY , PLASTIC ; COMMON FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; MILDLY EFFERVESCENT (HCL) DISCONTINUOUS ; STRONGLY ALKALINE PH- 8.7 (PH METER) ; CLEAR SMOOTH BOUNDARY .
C 1CA	63 - 103 CM. (25 - 41 IN.) BROWN (10YR 5/3) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW FINE ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.4 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: CHISLED

Chiseling has created micro relief which varies the thickness of the A1 and A2 horizons. Ridge: A1 is 0-10cm, A2 is 10-32 cm. Furrow: A1 is 0-7 cm, A2 is 7-20 cm. The expression of strong columnar structure has not been affected by chiseling. There is a change along the pit as the Thoeny soil meets Phillips and the columns abruptly degrade to prismatic structure. Salt nodules are common below 60 cm, although they are not evident in the adjacent Phillips profile. At 85 cm, many fine platy shale fragments were observed, although the contact with underlying shale was not reached.

SOIL SERIES: ELLOAM

SURVEY SAMPLE NO.: S80MT 55
LOCATION: SE-SEC32-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE

SITE NO.: 80 55
SLOPE: 01%
AIR TEMPERATURE
SOIL TEMPERATURE
WATER TABLE:
PRECIPITATION:
PERMEABILITY:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

COUNTY: BLAINE
CLASS: NEARLY LEVEL
ANNUAL: DEGREES F
ANNUAL: DEGREES F
DEPTH: CM.
CM.

ELEVATION: 807 METERS
KIND: PLANE
SUMMER: DEGREES F
SUMMER: 17 DEGREES C
MONTH:
CONTROL SECTION LIMITS --
DRAINAGE CLASS:

MONTH SAMPLED: JUNE
ASPECT: EAST
WINTER: DEGREES F
WINTER: DEGREES F
KIND: NO WATER TABLE
UPPER: CM LOWER: CM

STONINESS: CLASS

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 1	0 - 6 CM. (0 - 2 IN.) BROWN (10YR 4/3) CRUSHED ; SANDY LOAM ; PALE BROWN (10YR 6/3) CRUSHED DRY ; WEAK FINE GRANULAR MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON FINE VESICULAR PORES , COMMON TO MANY FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; STRONGLY ACID PH- 5.1 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
A 2	6 - 10 CM. (2 - 4 IN.) DARK BROWN (10YR 3/3) CRUSHED ; LOAM ; PALE BROWN (10YR 6/3) CRUSHED DRY ; WEAK FINE PLATY MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , FEW TO COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; MEDIUM ACID PH- 5.6 (PH METER) ; ABRUPT WAVY BOUNDARY .
B 2T	10 - 15 CM. (4 - 6 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY LOAM ; BROWN (10YR 5/3) CRUSHED DRY ; MODERATE MEDIUM COLUMNAR MOIST STRUCTURE ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , COMMON FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.0 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 3CA	15 - 27 CM. (6 - 11 IN.) YELLOWISH BROWN (10YR 5/4) CRUSHED ; CLAY LOAM ; DARK GRAYISH BROWN (10YR 4/2) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; HARD , FIRM , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.4 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 1CA	27 - 54 CM. (11 - 21 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; WEAK FINE ANGULAR BLOCKY MOIST STRUCTURE AND MASSIVE ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.4 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 2CA	55 - 88 CM. (22 - 35 IN.) BROWN (10YR 5/3) CRUSHED ; CLAY ; GRAYISH BROWN (10YR 5/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , FIRM , STICKY , PLASTIC ; FEW FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.9 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: CHISLED
The microrelief created by chiseling caused the thickness of the A1 horizon to vary, being thickest under the ridges. Columnar structure is intact, not affected by the treatment although the underlying prisms were not as strongly expressed as at the other treatment sites.

SOIL SERIES: TEALETTE

SURVEY SAMPLE NO.: S80MT 56
LOCATION: SE-SEC32-T36N-R19E
CLASSIFICATION: BOROLLIC NATRARGIDS; FINE

SITE NO.: 80 56 COUNTY: BLAINE ELEVATION: 807 METERS MONTH SAMPLED: JUNE
SLOPE: 01% CLASS: NEARLY LEVEL KIND: PLANE ASPECT: EAST
AIR TEMPERATURE ANNUAL: DEGREES F SUMMER: DEGREES F WINTER: DEGREES F
SOIL TEMPERATURE ANNUAL: DEGREES F SUMMER: 17 DEGREES C WINTER: DEGREES F
WATER TABLE: DEPTH: CM. MONTH: KIND: NO WATER TABLE
PRECIPITATION: CM. CONTROL SECTION LIMITS -- UPPER: CM LOWER: CM
PERMEABILITY: DRAINAGE CLASS:
PHYSIOGRAPHY: LEVEL OR UNDULATING UPLANDS STONINESS: CLASS
MICRORELIEF: ON SLOPE
VEGETATION: GRASSES AND FORBS AND SHRUBS
PARENT MATERIAL: PARTLY WEATHERED GLACIAL TILL
IGNEOUS, METAMORPHIC AND SEDIMENTARY

PARENT MATERIAL: PARTLY WEATHERED MARINE
CALCAREOUS SHALE

HORIZON	PROFILE DESCRIPTION
A 2	0 - 4 CM. (0 - 2 IN.) BROWN (10YR 5/3) CRUSHED ; LOAM ; LIGHT BROWNISH GRAY (10YR 6/2) CRUSHED DRY ; WEAK FINE PLATY MOIST STRUCTURE ; SOFT , VERY FRIABLE , SLIGHTLY STICKY , SLIGHTLY PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES , COMMON FINE TUBULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; SLIGHTLY ACID PH- 6.5 (PH METER) .
B 2T	4 - 10 CM. (2 - 4 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY LOAM ; BROWN (10YR 4/3) CRUSHED DRY ; STRONG MEDIUM COLUMNAR MOIST STRUCTURE PARTING TO MODERATE MEDIUM PRISMATIC ; SLIGHTLY HARD , FRIABLE , STICKY , PLASTIC ; COMMON TO MANY FINE & MEDIUM ROOTS BETWEEN PEDS ; FEW TO COMMON FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; NONCALCAREOUS (HCL) CONTINUOUS ; NEUTRAL PH- 7.1 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
B 3CA	10 - 20 CM. (4 - 8 IN.) YELLOWISH BROWN (10YR 5/4) CRUSHED ; CLAY ; PALE BROWN (10YR 6/3) CRUSHED DRY ; MODERATE MEDIUM PRISMATIC MOIST STRUCTURE PARTING TO STRONG MEDIUM ANGULAR BLOCKY MOIST ; HARD , FIRM , STICKY , PLASTIC ; MANY FINE & MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VOID INTERSTITIAL PORES , COMMON TO MANY FINE VESICULAR PORES ; MILDLY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.5 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 1CA	20 - 57 CM. (8 - 22 IN.) BROWN (10YR 4/3) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; WEAK FINE ANGULAR BLOCKY MOIST STRUCTURE PARTING TO MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; VIOLENTLY EFFERVESCENT (HCL) CONTINUOUS ; MODERATELY ALKALINE PH- 8.3 (PH METER) ; ABRUPT SMOOTH BOUNDARY .
C 2CA	57 - 90 CM. (22 - 35 IN.) DARK BROWN (10YR 3/3) CRUSHED ; CLAY LOAM ; GRAYISH BROWN (2.5Y 5/2) CRUSHED DRY ; MASSIVE MOIST ; VERY HARD , VERY FIRM , STICKY , PLASTIC ; FEW MEDIUM ROOTS THROUGHOUT HORIZON ; COMMON TO MANY FINE VESICULAR PORES ; MODERATELY EFFERVESCENT (HCL) CONTINUOUS ; STRONGLY ALKALINE PH- 8.5 (PH METER) ; NOT REACHED BOUNDARY .

REMARKS: CHILSED

Columns and underlying prismatic structure appear to be partially destroyed by the treatment. Chiseling mixed sufficient OM into the A2 and upper B2t that the B horizon is darker than any of the other Tealettes have been. The zone of salt accumulation begins at 30 cm, and nodules are common below that depth.

APPENDIX 2: PHYSICAL DATA FOR EACH SOIL BY HORIZON

1979 DATA

SOIL	TREAT-MENT	HOR-IZON	WATER AT SAT.†	WILT†	FIELD†	TEXTURE SAND	SILT	CLAY	COARSE FRAGMENTS	BULK DENSITY	THICKNESS
			(..... % .....)			(..... % .....)			(%)	(g/cm^3)	(cm)
P‡	NU§	A1	44.3	8.7	18.8	50	16	34	.0	1.29	6
		A2	43.7	8.5	25.6	50	28	22	.0	1.54	5
		B21	45.4	16.6	18.6	40	24	36	1.0	1.57	17
		B22	54.8	15.5	23.7	38	26	36	1.0	1.61	27
		B3	44.6	12.2	22.8	40	28	32	1.0	1.68	36
		C1	43.6	6.6	16.9	52	32	16	1.0	1.68	43
		C2	56.1	15.1	25.7	36	28	36	1.0	1.62	13
TH‡	NU	A2	32.7	4.5	12.2	50	34	16	.0	1.49	11
		B21	44.4	19.9	25.3	52	18	30	.0	1.82	15
		B22	34.4	13.0	19.9	60	12	28	.0	1.56	10
		B3	43.7	9.4	18.7	62	16	22	.0	1.78	26
		C1	44.2	9.6	20.6	58	18	24	.0	1.75	30
		C2	45.9	18.6	27.3	36	22	42	.0	1.88	63
T‡	NU	A2	32.7	6.5	17.6	45	41	14	.0	1.63	2
		B21	45.5	22.8	30.5	32	26	42	.0	1.61	11
		B22	45.5	20.0	30.3	30	26	44	.0	1.67	23
		B3	54.8	15.4	24.3	35	28	37	.0	1.76	19
		C1	54.9	16.3	25.2	37	26	37	.0	1.60	29
		C2	44.7	16.0	25.4	35	28	37	.0	1.69	31
E‡	NU	A2	33.1	6.6	22.0	47	34	19	.0	1.57	11
		B21	45.7	26.4	35.8	37	22	41	1.0	1.74	16
		B22	45.0	15.5	27.9	33	28	39	1.0	1.61	15
		B3	45.3	14.4	27.6	35	28	37	1.0	1.78	11
		C1	54.9	14.2	25.1	37	26	37	1.0	1.75	26
		C2	54.5	13.8	27.0	35	30	35	1.0	1.55	56
E	NP§	A1	34.8	15.3	29.4	35	28	37	1.0	1.67	10
		B21	45.2	17.2	31.9	31	24	45	.0	1.73	9
		B22	45.1	16.1	33.9	29	30	41	.0	1.66	17
		B3	55.1	15.0	29.5	37	24	39	.0	1.64	11
		C1	54.1	10.9	24.1	42	29	29	2.0	1.75	44
		C21	44.0	9.9	19.7	44	29	27	2.0	2.82	29
		C22	43.3	13.3	14.9	66	18	16	2.0	1.88	25

SOIL	TREAT-MENT	HOR-IZON	WATER AT SAT	WILT	FIELD	TEXTURE SAND	SILT	CLAY	COARSE FRAGMENTS	BULK DENSITY	THICKNESS
			(..... % .....)			(..... % .....)			(%)	(g/cm^3)	(cm)
T	NP	A1	44.2	19.5	27.4	38	28	34	.0	1.68	10
		B21	45.5	17.6	34.9	33	24	43	.0	1.63	9
		B22	55.3	16.0	32.6	28	28	44	.0	1.57	16
		C1	55.2	8.3	28.4	32	26	42	.0	1.68	33
		C2	54.5	17.0	25.6	43	21	36	.0	1.68	41
		C3	45.0	18.1	26.6	37	27	36	.0	1.62	31
P	NP	A1	43.4	9.9	19.8	50	13	37	.0	1.39	11
		B21	54.4	17.9	26.6	48	20	32	1.0	1.55	16
		B22	54.7	18.7	27.9	38	22	40	2.0	1.69	26
		B3	45.4	19.8	--	40	26	34	2.0	1.68	21
		C1	45.0	17.3	--	57	19	24	2.0	1.70	41
		C2	55.3	19.4	--	61	23	16	2.0	1.67	35
TH	NP	A1	32.7	5.6	--	54	32	14	2.0	1.64	13
		B21	44.3	19.3	--	42	26	32	.0	1.75	20
		B22	55.0	17.6	--	44	22	34	1.0	1.66	28
		B3	56.0	21.8	--	37	29	34	1.0	1.77	31
		C1	46.9	21.4	27.3	34	32	34	1.0	1.60	33
		C2	55.3	11.4	24.1	36	26	38	1.0	1.58	35
TH	C[§]	A1	44.9	13.2	30.9	38	26	36	.0	1.72	10
		B21	55.6	17.1	33.4	36	22	42	.0	1.71	8
		B22	45.6	15.4	28.1	38	22	40	.0	1.83	27
		B3	56.8	15.3	31.2	36	24	40	1.0	1.82	22
		C1	67.1	16.4	30.9	32	26	42	1.0	1.79	38
		C2	55.7	14.2	27.0	43	22	35	1.0	1.74	25
P	C	A1	33.5	7.0	20.0	52	30	18	.0	1.45	10
		A2	33.7	11.1	24.6	46	26	28	.0	1.48	6
		B21	45.0	16.5	30.6	40	22	38	.0	1.62	12
		B22	54.6	13.2	25.9	40	26	34	3.0	1.64	25
		B3	44.0	10.2	24.6	48	26	26	4.0	1.60	19
		C1	44.3	11.5	23.5	42	24	34	4.0	2.58	51
		C2	55.2	11.6	28.5	40	28	32	5.0	1.58	37

SOIL	TREAT-MENT	HOR-IZON	WATER AT SAT	WILT	FIELD	TEXTURE SAND	SILT	CLAY	COARSE FRAGMENTS (%)	BULK DENSITY (g/cm^3)	THICKNESS (cm)
			(..... % .....)			(..... % .....)					
T	C	A1	44.9	14.5	31.4	40	30	30	.0	1.56	10
		B21	46.2	21.4	35.8	32	22	46	3.0	1.63	14
		B22	56.4	18.1	32.7	38	22	40	3.0	1.77	19
		B3	54.9	18.6	37.3	37	22	41	4.0	1.84	19
		C1	44.2	6.3	22.1	43	36	21	5.0	1.50	33
		C2	55.2	8.1	24.2	45	26	29	5.0	1.70	30
E	C	A1	32.8	3.7	10.7	51	34	15	1.0	1.50	10
		B21	45.6	13.7	34.4	35	26	39	3.0	1.69	13
		B22	45.6	13.6	32.0	33	30	37	3.0	1.63	20
		B3	54.4	12.1	24.7	33	34	33	3.0	1.68	19
		C1	54.9	12.4	26.4	36	31	33	3.0	1.67	50
		C2	55.8	13.7	27.3	35	32	33	3.0	1.68	23
					1980 DATA						
T	NU	A2	40.0	6.7	18.9	37	37	26	.0	1.46	4
		B21	40.7	11.5	24.3	33	30	37	.0	1.60	20
		B3	53.8	15.6	29.5	29	25	46	.0	1.52	25
		C1	53.8	16.3	28.4	23	25	52	.0	1.73	27
		C2	52.6	24.6	29.4	25	29	46	.0	1.69	32
E	NU	A1	52.3	14.2	26.5	25	33	42	.0	1.29	7
		B2	54.0	17.1	31.2	25	27	46	.0	1.69	16
		B3	50.9	15.1	28.3	23	33	44	.0	1.58	5
		C1	49.4	12.6	24.3	25	31	44	.0	1.60	33
		C2	51.1	13.1	24.9	29	24	47	.0	1.46	50
P	NU	A1	33.9	8.9	18.6	37	35	28	.0	1.40	11
		B21	41.8	11.1	21.3	33	31	36	.0	1.44	10
		B22	48.9	15.9	27.7	27	25	48	.0	1.54	24
		B3	52.4	28.2	25.9	25	25	50	.0	1.56	8
		C1	56.0	19.7	26.8	21	25	54	.0	1.52	57

SOIL	TREAT-MENT	HOR-IZON	WATER AT SAT	WILT	FIELD	TEXTURE SAND	SILT	CLAY	COARSE FRAGMENTS (%)	BULK DENSITY (gm/cm^3)	THICKNESS (cm)
			(..... % .....)			(..... % .....)					
TH	NU	A1	46.9	15.2	23.9	29	27	44	.0	1.42	6
		B21	50.5	16.4	24.3	29	27	44	.0	1.69	14
		B22	50.0	17.1	25.6	21	29	50	.0	1.67	12
		C1	57.0	19.9	28.4	21	24	55	.0	1.64	53
TH	NP	A1	34.4	6.1	12.8	51	28	21	.0	1.43	7
		A2	26.0	5.0	9.9	53	44	35	.0	1.71	21
		B21	41.5	13.0	21.6	21	44	35	.0	1.71	21
		B22	51.5	19.3	29.1	33	24	43	.0	1.66	9
		B3	48.6	18.7	26.7	37	24	39	.0	1.68	7
		C1	46.2	14.9	25.3	43	22	35	.0	1.65	30
P	NP	A1	33.2	5.7	12.0	53	28	19	.0	.99	15
		A2	24.3	.59	11.5	53	26	21	.0	1.59	10
		B2	35.2	12.8	23.0	45	24	31	.0	1.71	19
		B3	43.5	16.8	30.2	37	26	37	.0	1.69	10
		C1	47.8	16.2	26.8	41	20	39	.0	1.71	36
E	NP	B2	61.3	20.4	33.5	27	24	49	.0	1.71	9
		B3	61.2	21.7	32.7	25	26	49	.0	1.55	9
		C1	49.2	15.7	27.3	27	28	45	.0	1.72	32
		C2	47.6	16.1	26.1	29	28	43	.0	1.72	33
T	NP	A2	27.4	8.0	20.8	35	42	23	.0	1.46	4
		B2	55.2	20.2	33.6	29	24	47	.0	1.70	8
		C1	51.1	18.4	29.3	29	24	47	.0	1.69	45
		C2	74.3	15.8	25.8	31	26	43	.0	1.73	33
P	CH[5]	A1	43.0	11.5	24.2	31	26	43	.0	1.41	6
		A2	27.6	6.7	16.9	48	30	22	.0	1.41	9
		B2	34.5	10.3	20.2	42	27	31	.0	1.61	15
		B3	32.2	9.3	19.9	40	31	29	.0	1.60	34
		C1	34.3	9.4	20.7	40	31	29	.0	1.53	54

SOIL	TREAT-MENT	HOR-IZON	WATER AT SAT	WILT	FIELD	TEXTURE SAND	SILT	CLAY	COARSE FRAGMENTS (%)	BULK DENSITY (gm/cm^3)	THICKNESS (cm)
			(..... % .....)			(..... % .....)					
TH	CH	A1	28.4	5.8	15.6	49	30	21	.0	1.51	10
		A2	21.3	4.5	12.5	47	34	19	.0	1.59	22
		B21	37.6	11.6	23.8	43	26	31	.0	1.77	24
		B22	46.5	13.9	28.8	42	23	35	.0	1.62	19
		C1	34.8	9.8	19.3	41	26	33	.0	1.57	27
E	CH	A1	35.9	7.8	20.5	51	30	19	.0	1.41	6
		A2	28.3	6.5	18.6	43	36	21	.0	1.46	4
		B2	41.0	14.1	27.6	35	26	39	.0	1.75	5
		B3	50.8	16.9	27.3	37	24	39	.0	1.65	12
		C1	47.1	13.4	23.3	31	30	39	.0	1.83	28
		C2	54.3	--	--	29	28	43	.0	1.80	63

† SAT = Saturation, WILT = Wilting point, FIELD = Field capacity

‡ P = Phillips, TH = Thoeny, T = Tealette, E = Elloam

§ NU = Native vegetation, unplowed; NP = Native vegetation, plowed; C = Crested wheatgrass vegetation, plowed, CH = Native vegetation, chiseled

APPENDIX 3: CHEMICAL DATA FOR EACH SOIL BY HORIZON

1979 DATA

SOIL	TREATMENT	HORIZON	SAR	CEC	EXTRACTABLE CA	EXTRACTABLE NA	EXTRACTABLE MG	EXTRACTABLE K	SOLUBLE CA	SOLUBLE MG	SOLUBLE NA	SOLUBLE K	BRAY P	TOTAL N	ORGANIC MATTER	pH	EC
				(.....me/100g.....)									ppm	ppm	(%)		mmhos/cm
E†	NP‡	A1	1.0		10.4	11.2	.3	1.2	.0	.0	.0	.0	43	120	2.2	7.4	5.0
		B21	1.0		16.6	15.1	.4	.8	.0	.0	.0	.0	10	0	.9	7.7	6.5
		B22	2.0		31.4	11.8	.6	.7	.0	.0	.0	.0	48	0	.7	6.5	
		B3	4.0		35.8	11.8	1.2	.6	.0	.0	.0	.0	51	0	.5	8.3	8.5
		C1	7.0		32.4	8.2	1.4	.4	.0	.0	.0	.0	39	0	.6	8.2	2.0
		C21	5.0		36.4	7.9	2.8	.6	.1	.1	.1	.0	22	0	.4	8.0	1.0
		C22	13.0		24.6	3.3	2.4	.3	.0	.0	.1	.0	22	0	.1	8.5	5.0
T†	NP	A1	6.0		7.2	9.2	2.1	.9	.0	.0	.0	.0	36	90	1.5	7.3	4.0
		B21	8.0		13.8	15.1	4.3	.7	.0	.0	.1	.0	12	0	1.3	8.1	1.2
		B22	14.0		32.0	16.7	6.0	.6	.0	.0	.2	.0	64	0	.9	8.3	3.5
		C1	11.0		52.0	15.1	6.4	.5	.2	.2	.4	.0	51	0	.6	8.3	4.0
		C2	13.0		80.0	10.5	5.7	.4	.2	.2	.4	.0	31	0	.7	7.9	5.0
		C3	11.0		44.0	20.7	8.3	.5	.1	.1	.3	.0	26	0	.4	7.9	6.0
P†	NP	A1	1.0		8.4	5.3	.0	.7	.0	.0	.0	.0	40	110	1.5	6.8	1.0
		B21	2.0		25.4	11.5	.6	.7	.0	.0	.0	.0	10	0	1.1	7.6	6.5
		B22	9.0		35.8	11.2	1.4	.4	.0	.0	.1	.0	0	0	.8	8.3	8.0
		B3	12.0		27.4	14.4	3.8	.5	.0	.0	.1	.0	48	0	.5	8.2	3.0
		C1	14.0		68.0	16.1	8.8	.5	.1	.3	.4	.0	33	0	.4	8.1	3.5
		C2	18.0		90.0	13.5	8.1	.7	.2	.3	.6	.0	40	0	1.4	8.0	5.0
TH†	NP	A1	2.0		5.2	1.6	.2	.7	.0	.0	.0	.0	40	80	1.5	6.4	6.5
		B21	15.0		5.3	6.0	.6	.0	.0	.0	.1	.0	8	0	.9	7.6	4.0
		B22	23.0		34.2	9.8	6.2	.5	.0	.0	.1	.0	13	0	.4	8.4	2.0
		B3	30.0		29.4	13.5	7.2	.5	.0	.0	.3	.0	6	0	.3	8.7	5.0
		C1	24.0		25.0	13.8	6.5	.6	.0	.1	.5	.0	57	0	.3	8.6	5.0
		C2	15.0		62.0	16.7	2.9	.5	.1	.2	.4	.0	57	0	.3	8.3	8.0

SOIL	TREAT-MENT	HOR-IZON	SAR	CEC	EXTRACTABLE				SOLUBLE				BRAY P	TOTAL N	ORGANIC MATTER	pH	EC
					CA	NA	MG	K	CA	MG	NA	K					
				(.....me/100g.....)									ppm	ppm	(%)		mmhos/cm
P	NU‡	A1	6.0	6.2	2.0	.0	.7	.0	.0	.0	.0	30	170	3.5	6.6	8.0
		A2	7.1	6.8	3.3	.1	.8	.0	.0	.0	.0	10	0	1.5	6.4	7.0
		B21	10.9	16.2	6.9	.5	1.0	.0	.0	.0	.0	13	0	1.2	7.0	9.0
		B22	10.9	33.0	9.8	.5	.6	.0	.0	.0	.0	0	0	.8	7.8	5.5
		B3	11.1	33.6	9.2	1.6	.5	.0	.0	.0	.0	24	0	.5	8.1	.0
		C1	10.0	17.4	5.3	1.7	.4	.0	.0	.1	.0	33	0	.3	8.2	7.5
		C2	18.0	22.8	9.5	6.9	.6	.2	.0	.5	.0	68	0	.5	7.9	5.0
TH	NU	A2	4.0	2.4	1.6	.3	.5	.0	.0	.0	.0	36	90	1.6	5.6	7.5
		B21	15.0	3.8	11.8	4.8	1.1	.0	.0	.1	.0	17	0	.9	7.4	6.0
		B22	23.0	27.4	14.8	4.0	.7	.0	.1	.4	.0	27	0	.8	8.5	5.0
		B3	21.0	27.4	11.8	5.0	.5	.0	.1	.3	.0	37	0	.4	8.6	5.0
		C1	18.0	27.4	11.2	4.0	.5	.0	.0	.2	.0	36	0	.3	8.5	5.0
		C2	15.0	30.4	16.4	6.2	.8	.2	.2	.5	.0	26	0	.6	8.2	7.5
T	NU	A2	9.0	3.0	4.6	.8	.6	.0	.0	.0	.0	40	90	1.5	6.4	9.0
		B21	8.0	13.0	10.2	4.6	.9	.0	.0	.1	.0	23	0	1.5	7.6	7.5
		B22	9.0	38.8	11.5	4.6	.9	.0	.1	.2	.0	87	0	1.3	8.3	7.5
		B3	8.0	37.6	12.5	3.4	.7	.1	.1	.2	.0	56	0	.5	8.0	7.0
		C1	10.0	38.8	12.8	5.7	.7	.2	.2	.3	.0	43	0	.5	8.0	8.0
		C2	13.0	74.0	10.2	4.1	.7	.2	.2	.4	.0	33	0	.5	7.9	8.0
E	NU	A2	2.0	4.4	2.6	.2	.5	.0	.0	.0	.0	39	110	2.2	6.4	5.0
		B21	9.0	20.6	12.8	2.6	.9	.0	.0	.1	.0	9	0	1.5	7.3	4.5
		B22	11.0	40.0	12.8	3.8	.6	.0	.0	.1	.0	15	0	1.1	8.2	7.5
		B3	13.0	34.6	12.1	4.6	.7	.0	.0	.2	.0	30	0	.8	8.4	5.0
		C1	13.0	37.0	13.8	5.3	.6	.2	.2	.4	.0	45	0	.7	8.1	5.0
		C2	13.0	78.0	12.5	6.2	.6	.1	.2	.4	.0	37	0	.7	8.1	5.0

SOIL	TREATMENT	HORIZON	SAR	CEC	EXTRACTABLE CA	EXTRACTABLE NA	EXTRACTABLE MG	EXTRACTABLE K	SOLUBLE CA	SOLUBLE MG	SOLUBLE NA	SOLUBLE K	BRAY P	TOTAL N	ORGANIC MATTER	pH	EC
				(.....me/100g.....)									ppm	ppm	(%)		mmhos/cm
TH	C‡	A1	1.0		8.0	9.5	.4	1.2	.0	.0	.0	.0	51	80	1.7	6.8	9.5
		B21	5.0		11.4	13.5	1.2	.8	.0	.0	.0	.0	24	0	.9	7.5	9.5
		B22	11.0		30.8	13.1	2.9	.5	.0	.0	.1	.0	41	0	.4	8.2	8.0
		B3	28.0		31.4	11.8	5.3	.6	.0	.0	.4	.0	28	0	4.0	8.5	5.0
		C1	15.0		28.4	12.1	7.7	.7	.1	.1	.4	.0	22	0	.5	8.0	5.0
		C2	16.0		56.0	9.8	6.5	.5	.2	.2	.5	.0	24	0	.5	8.0	4.5
P	C	A1	14.0		6.2	3.3	.0	.9	.1	.1	.0	.0	36	100	1.7	7.1	8.0
		A2	2.0		9.4	5.6	.3	.9	.0	.0	.0	.0	19	0	1.5	6.6	3.5
		B21	2.0		30.8	10.5	.8	.9	.0	.0	.0	.0	12	0	1.6	7.8	5.5
		B22	3.0		30.4	8.2	.9	.6	.0	.0	.0	.0	5	0	1.4	8.0	6.5
		B3	8.0		21.4	4.9	2.4	.6	.1	.1	.1	.0	61	0	.7	8.0	5.0
		C1	9.0		32.0	8.2	1.6	.6	.0	.0	.0	.0	33	0	.9	8.1	4.0
		C2	12.0		27.8	5.9	2.9	.8	.0	.0	.1	.0	74	0	.9	8.5	2.5
T	C	A1	7.0		9.6	5.3	1.6	.9	.0	.0	.0	.0	37	110	1.7	7.3	1.0
		B21	12.0		35.2	7.9	4.0	.7	.0	.0	.1	.0	15	0	1.4	8.0	5.0
		B22	15.0		37.0	12.1	6.2	.6	.0	.0	.1	.0	27	0	1.0	8.3	4.0
		B3	16.0		29.8	11.8	8.6	.6	.0	.0	.1	.0	25	0	.7	8.4	5.0
		C1	16.0		29.4	8.9	6.2	.4	.1	.1	.3	.0	27	0	.9	8.1	5.0
		C2	16.0		35.8	7.2	6.2	.4	.1	.1	.4	.0	18	0	.7	8.0	4.5
E	C	A1	11.0		4.0	3.0	.5	.5	.0	.0	.0	.0	41	10	1.5	6.7	1.0
		B21	11.0		21.8	13.5	3.6	.6	.0	.0	.1	.0	19	0	1.3	8.0	8.0
		B22	13.0		31.0	12.1	4.8	.5	.0	.1	.2	.0	21	0	1.1	8.1	5.0
		B3	14.0		31.0	9.8	4.0	.4	.1	.2	.4	.0	13	0	.7	8.2	5.0
		C1	15.0		31.0	11.5	5.3	.4	.1	.2	.4	.0	12	0	.5	8.3	5.0
		C2	18.0		40.0	8.9	5.9	.5	.2	.2	.6	.0	13	0	.5	8.3	5.0

1980 DATA

SOIL	TREAT-MENT	HOR-IZON	SAR	CEC	EXTRACTABLE CA	EXTRACTABLE NA	EXTRACTABLE MG	EXTRACTABLE K	SOLUBLE CA	SOLUBLE MG	SOLUBLE NA	SOLUBLE K	BRAY P ppm	TOTAL N ppm	ORGANIC MATTER (%)	pH	EC mmhos/cm
				(.....me/100g.....)													
T	NU	A2	1.0	11.3	7.2	3.1	.9	.6	.1	.1	.4	.0	61	900	2.2	6.9	1.0
		B21	4.3	23.9	6.0	5.6	1.9	.4	.0	.0	.3	.0	29	800	1.6	7.1	1.0
		B3	5.6	29.1	24.0	10.2	3.8	.6	.2	.2	1.1	.0	44	800	1.5	8.4	2.1
		C1	10.5	32.2	44.0	11.1	5.9	.6	.5	.5	1.8	.0	25	500	.9	8.3	4.3
		C2	10.9	26.5	40.0	9.2	5.9	.5	.3	.3	1.6	.0	41	400	.8	8.6	2.8
E	NU	A1	0.5	22.2	16.0	6.2	.1	1.5	.2	.1	.1	.0	61	1600	3.6	7.5	.4
		B2	5.9	26.5	40.0	12.5	2.6	.5	.0	.1	.3	.0	33	900	1.6	8.5	1.0
		B3	9.1	24.8	42.0	11.8	3.5	.4	.1	.2	.8	.0	39	700	1.0	8.6	2.1
		C1	13.2	23.0	52.0	12.1	6.6	.4	1.1	1.8	3.6	.0	31	400	.8	8.4	7.9
		C2	21.4	30.0	30.0	13.8	1.0	.4	1.3	3.5	1.0	.0	30	400	.9	8.5	7.3
P	NU	A1	.4	17.0	7.2	3.1	.1	1.0	.1	.0	.0	.0	51	1400	2.9	7.0	.5
		B21	.8	20.0	12.0	3.6	.2	.7	.2	.1	.1	.0	17	1100	2.4	7.0	.3
		B22	1.3	29.6	46.0	6.6	.6	.7	.1	.0	.1	.0	19	800	1.5	7.9	.8
		B3	3.1	30.4	56.0	7.5	.4	.5	.1	.0	.1	.0	25	600	1.0	8.1	.8
		C1	5.2	36.1	40.0	6.6	1.9	.5	.1	.0	.4	.0	22	500	1.1	8.2	1.0
TH	NU	A1	.7	24.8	12.0	5.6	.3	1.5	.1	.0	.0	.0	25	1400	2.9	6.6	.5
		B21	2.9	33.5	24.0	6.2	.8	.9	.1	.1	.2	.0	12	1200	2.3	7.4	.9
		B22	4.1	28.7	52.0	7.9	1.5	.6	.1	.0	.2	.0	12	700	1.3	8.1	.9
		C1	6.9	36.5	44.0	9.2	2.4	.6	.2	.0	.4	.0	13	600	1.1	8.0	1.0
TH	NP	A1	.7	10.4	4.0	2.6	.1	.8	.1	.1	.1	.0	28	1300	3.3	6.3	.7
		A2	1.6	11.3	3.2	2.4	.2	.5	.0	.0	.0	.0	10	700	1.5	6.5	.2
		B21	9.8	20.9	6.6	7.5	3.1	.9	.0	.0	.3	.0	6	800	1.5	7.6	.8
		B22	9.8	29.1	10.0	10.5	4.3	1.2	.1	.1	.6	.0	7	1000	1.5	8.3	1.5
		B3	8.7	26.5	13.0	9.5	4.3	1.0	.1	.1	.5	.0	11	800	1.5	8.5	2.3
		C1	11.9	27.4	22.0	9.2	4.3	.9	.1	.1	.9	.0	17	800	1.7	8.6	2.4

SOIL	TREAT-MENT	HOR-IZON	SAR	CEC	EXTRACTABLE				SOLUBLE				BRAY P	TOTAL N	ORGANIC MATTER	pH	EC
					CA	NA	MG	K	CA	MG	NA	K					mmhos/cm
				(.....me/100g.....)									ppm	ppm	(%)		
P	NP	A1	1.4	9.6	4.0	2.1	.1	.8	.0	.0	.0	.0	27	1300	2.9	6.4	.5
		A2	2.9	11.3	4.0	2.6	.4	.6	.0	.0	.1	.0	9	800	1.0	7.1	.2
		B2	6.7	19.6	7.4	4.6	1.7	.8	.0	.0	.2	.0	7	800	1.2	7.7	.6
		B3	10.2	26.5	15.0	7.2	2.8	1.1	.1	.0	.5	.0	13	900	1.3	8.5	1.4
		C1	10.4	24.8	34.0	7.2	3.0	.8	.1	.0	.5	.0	14	800	1.8	8.3	1.6
E	NP	B2	6.7	30.9	10.0	11.5	3.0	.7	.1	.1	.4	.0	11	900	1.9	7.8	1.0
		B3	6.3	30.9	32.0	14.4	3.5	.8	.1	.2	.6	.0	27	1000	1.9	8.4	2.4
		C1	7.1	23.5	40.0	13.8	3.7	.6	.2	.5	.9	.0	44	400	.9	8.3	3.7
		C2	8.2	22.6	64.0	12.5	4.2	.4	1.1	1.2	1.9	.0	37	400	.7	7.8	9.0
T	NP	A2	3.6	9.1	3.6	3.6	.6	.5	.1	.1	.2	.0	39	900	1.8	6.5	1.1
		B2	7.5	28.3	10.0	11.5	2.6	.7	.1	.1	.4	.0	15	900	1.6	7.5	1.0
		C1	6.6	26.5	40.0	14.4	3.8	.6	.3	.5	.9	.0	43	600	1.1	8.2	3.4
		C2	7.7	72.4	15.0	11.1	9.4	1.3	1.7	2.4	2.8	.5	33	400	.7	8.7	4.9
P	CH ‡	A1	.2	13.0	5.6	2.5	.1	1.9	.1	.1	.2	.1	37	2100	3.5	6.3	1.6
		A2	.5	10.9	3.8	1.9	.1	1.7	.0	.0	.0	.1	20	900	1.8	6.3	.4
		B2	1.7	17.4	8.0	4.3	.4	1.5	.0	.0	.1	.0	20	800	1.3	6.9	.3
		B3	5.1	17.8	30.0	5.9	.9	1.0	.0	.0	.1	.0	22	700	1.0	8.3	.7
		C1	7.4	16.1	32.0	7.2	1.7	.9	.0	.0	.2	.0	13	500	.7	8.7	1.0
TH	CH	A1	1.1	19.1	4.0	2.2	.1	.8	.0	.0	.0	.0	19	1000	2.3	6.6	.4
		A2	10.6	18.3	2.8	1.9	1.0	.5	.0	.0	.2	.0	15	500	.9	7.3	.4
		B21	14.5	18.7	5.0	5.6	4.4	1.0	.0	.1	.6	.0	12	700	1.1	7.9	1.8
		B22	21.7	26.1	10.2	8.5	7.1	1.2	.1	.2	2.0	.0	17	700	.9	8.7	4.3
		C1	3.9	18.7	38.0	5.6	.8	.9	.0	.0	.1	.0	17	600	,8	8.4	.8

SOIL	TREAT-MENT	HOR-IZON	SAR	CEC	EXTRACTABLE CA	EXTRACTABLE NA	EXTRACTABLE MG	EXTRACTABLE K	SOLUBLE CA	SOLUBLE MG	SOLUBLE NA	SOLUBLE K	BRAY P ppm	TOTAL N ppm	ORGANIC MATTER (%)	pH	EC mmhos/cm
				(.....me/100g.....)													
E	CH	A1	1.6	17.8	3.2	2.6	.3	.4	.1	.1	.1	.0	99	1900	4.2	5.1	.9
		A2	3.7	10.4	3.0	3.0	.4	.5	.0	.1	.1	.0	62	1100	2.3	5.6	.7
		B2	7.4	23.0	6.8	9.8	3.0	.2	.0	.0	.2	.0	18	800	1.4	7.0	.6
		B3	6.8	28.7	30.0	11.8	3.7	.4	.1	.2	.7	.0	25	900	1.6	8.4	2.8
		C1	8.6	21.7	36.0	13.8	3.7	.4	.4	.9	1.5	.0	19	400	.5	8.4	4.6
		C2	10.8	24.4	30.0	15.1	4.3	.4	.1	.3	1.2	.0	30	400	.5	8.9	3.4
T	CH	A2	2.7	13.0	6.8	3.9	.5	.6	.2	.2	.2	.0	86	1400	3.0	6.5	1.2
		B2	7.3	23.9	7.2	10.2	2.1	.5	.0	.1	.3	.0	42	1100	1.8	7.1	1.2
		B3	13.5	27.8	30.0	15.4	3.5	.5	.2	.4	1.7	.0	36	1100	1.7	8.5	2.2
		C1	7.9	20.0	52.0	11.5	3.3	.4	.9	1.4	1.7	.0	30	500	.6	8.3	6.4
		C2	17.4	21.3	34.0	13.1	4.0	.4	.4	.8	3.0	.0	29	500	.6	8.5	3.7

† E = Elloam, T = Tealette, P = Phillips, TH = Thoeny

‡ NP = Native vegetation, plowed, NU = Native vegetation, unplowed, C = Crested wheatgrass vegetation, plowed
CH = Native vegetation, chiseled

APPENDIX 4: COMPOSITION DATA FROM SVIM TRANSECTS BY SOIL AND TREATMENT

SOIL	TREATMENT	BARE GROUND	PERSISTANT LITTER	NONPERSISTANT LITTER	GRAVEL	OTHER	AGSM†	BOGR†	CAEL†	ARFR†	SEDE†	LICHEN	STCO†	AGCR†	OPPO†	KOCR†	PHHO†	SCPA†	POSE†	CAST†	CAMO†	CAFI†
		(..... % .....)																				
T§	NU79‡	33	3	15	1	1	15	6	5	2	3	6			4			1				
E§		1	1	21	1	1	6	40	11	3	32	4			1				1			
TH§				1				24	3		17	2										
P§			1	35		5	9	49	9	1	40	5	9		1					2	1	1
T	NP79‡	38		20	1	2	7	2		3			1	1	2							
E		23	3	83	3		13	88		12	4	6	11	2	5	2						
TH		3	1	21		6	4	32		4	1		3		4				3			
P		1		16				20		1	1		2		8							
T	C79‡	13		27				6		3	1			6	1							
E		18	2	79	4	6	2	37	1	7			3	35		4						
TH		13		52		7	6	25		2				31		2						
P		13		34	1	2		23		2			8	25		3						
T	NU80‡	28	3	15	4	4	9	1	4	3		1			2			1				
E		20	2	48	3	5	22	28	12	23	40	6	3		3	2	1					
TH		3	2	17	1	2	8	36	10	9	44	4	5			2						
P				12		2	10	22	3	6	24	1	3			1	1					
T	NP80‡	29	1	14			4			3												
E		1	5	30	1	2	9	7		6	5	3	9		2	6						
TH		8	3	57		4	18	14	7	14	15	2	15			12	2	1				
P		24	3	43	2	6	7	15	9	16	7	3	6		1	5	2	3	1			
T	CH80‡	16		16	1	2	4	1	2													
E		44	1	74	1		31	12	14	30	2	1	2		1	4						
TH		15	2	69		5	14	16	6	26	1		2		1	2			3			
P		13		50		4	16	17	3	21			5			3			2			

†Four letter plant symbols are given in U.S. Department of Agriculture, Soil Conservation Service (1976).

‡NU79 = Native vegetation, unplowed, 1979 location; NP79 = Native vegetation, plowed. 1979 location; C79 = Crested wheatgrass vegetation, 1979 location; NU80 = Native vegetation, unplowed, 1980 location; NP80 = Native vegetation, plowed, 1980 location; CH80 = Native vegetation, chiseled, 1980 location

§T = Tealette, E = Elloam, TH = Thoeny, P = Phillips

APPENDIX 5: PRODUCTIVITY DATA FROM SVIM ESTIMATE AND CLIP PLOTS AND FROM RANDOM CLIP PLOTS

Key to Appendix 5

[†] Four letter plant symbols given in U. S. Department of Agriculture, Soil Conservation Service (1976).

[‡] T = Tealette, E = Elloam, TH = Thoney, P = Phillips

[§] NU79 = Native vegetation, unplowed, 1979 location
NP79 = Native vegetation, plowed, 1979 location
C79 = Crested wheatgrass vegetation, 1979 location
NU80 = Native vegetation, unplowed, 1980 location
NP80 = Native vegetation, plowed, 1980 location
CH80 = Native vegetation, chiseled, 1980 location

MOIST ESTIMATE DATA (SVIM)

SOIL	TREATMENT	GRASS†	FORB†	SHRUB†	AGSM†	AGSP†	BOGR†	CAEL†	ARFR†	SEDE†	LICHEN†	OPPO†	MISC. GRASS	MISC. FORB	MISC. SHRUB	AGCR†
		(..... g/m² .....)								(..... cm² ...)			(..... g/m² .....)			
T‡	NU79§	7	3		5		1	1	3		1					
		5			3			2			5	41				1
		12	2	3	10			1	2			350	2			2
		9	2		5		1	1	2		9					2
E‡	NU79	6					3	1		260	4		2			
		9			8		1			200	10	80				
		16	3		3		4	4	3	50	25	40	5			
		7	2				5	1	2	210	2		1			
TH‡	NU79	11					7	2		230	5		2			
		6			1		2	3		260						
		8			3		2	1		230	4		2			
		4		2	3			1		260	5				2	
P‡	NU79	21					2	1		140	1		18			
		10			3		5	1		100	2		1			
		11	4	16	2		1	1	3	240	5	70	7	1	16	
		11					6	2		140	6		3			
		6					5	1		160	5					
		9		1	5		2		1	140	1		2			
T	NP79§	4			4											
		6			2		1					1	3			
		2	2	4	2				2		4				4	
		5	1				3						1	1		1
		6			4		1						1			
E	NP79	8	6		1		4		6				2			1
		7	6		5		1		6				1			
		12			1		10				3		1			
		16		1			14			35	2	1	2			
		12	5		3		9		5		2		1			
		6					5				3		1			
		5	11				1		10				4	1		
TH	NP79	11		30			9			20	3		2		30	
		2	40	2	2				40						2	
		6					6									
		12	1	1	5		6		1		1		1		1	
P	NP79	12	6	50	8		2		6				2		50	
		20	2	2	10		5		2	2			5		2	
		8					4				2		4			
		8	2				8		2							
T	C79§	12	1		1				1							11
		8	6		2		1		6				2			3
		9					2									7
		11	4		1		2		4				2			6
E	C79	12	1						1				2			10
		24					3						3			18
		12	15		1				15							11
		26	1		1		15		1				3			7
		2											2			
TH	C79	21			1								5			15
		18					2						1			15
		13	2						2				1			12
		14	1				4		1				3			7
		13		9	1								3		9	9
P	C79	24	1						1				4			20
		7	1				3		1							4
		10					4		1				4			2
		11	13				9						2	13		
		16	1	1	1				1				3		1	12
		2						1					1			

SOIL	TREATMENT	GRASS	FORB	SHRUB	AGSM	AGSP	BOGR	CAEL	ARFR	SEDE	LICHEN	OPPO	MISC. GRASS	MISC. FORB	MISC. SHRUB	AGCR
		(..... g/m^2 .....)								(.... cm^2 ....)			(..... g/m^2 .....)			
T	NU80[§]	3	1					1	1				2			
		8		1			1	1	3		1		5			
		9					1	1					7			
		8		9	4						2	4	4			5
E	NU80	1	3					1	3	240	3					
		12	5		9			2	5	24	5		1			
		5	7	50	1				6	20	50	4	1			
		15	6		8		4	2	5	4		1	1			
		7	1				5		1	210	4		2			
		4	3				2	2	3	260	1					
		9	5		3		1	5		80	3		2			
P	NU80	5	12		4		1		12	40						
		12	8		4		5		7				4	1		
		15	7		2		13		6					1		
		11	4				6	2	3	100	2		3	1		
		7	4		2		1	2	3				2	1		
TH	NU80	8	3		2		3	1	3	250	5		2			
		3	1				2		1	140	1		1			
		2	1					1					1	1		
		9	1		4		1	1	1	240			3			
TH	NP80[§]	6	11		2				11	240	5	2	4			
		9	1		2		5		1		3		2			
		9	9		3			1	6	140		5	3			
		14	4	2	6				2		3	2	8	2		
		8	2		5		1	2	2							
P	NP80	7	5	22	1		1		2	210		22	5	3		
		12	2		4		1	1		2	20		7	1		
		16	5	3	2		8		5	70		3	6			
		9	5		4				3				5	2		
		7		11				1	4				9	3		
E	NP80	11	5		2			1	4		3		8	1		
		10	3		3			2	3				5			
		10	10		1		3		9				6	1		
		10	1		4		6		1		2					
		11	5		4		5		5	2	3		2			
T	NP80	4	4		1				4				3			
			10						10							
		2	1						1		1		2	1		
		3	2					1	1		9		2	1		
P	CH80[§]	6	22		4				21				2	2		
		18	5		8		1		4				9	1		
		25	6		16				6				9			
		10	12		8		1		9				1	3		
		8	11		1		4	1	11				2			
TH	CH80	4	5				1		5				3			
		5	14		1		2	1	14		3		1			
		16	12		1		2	1	12				12			
		6	21		3		1		21				2			
E	CH80	8	4		2			1	4				5			
		5	4				1	1	4				3			
		12	1		8		1	1	1				4			
		9	15		2		3	1	15	5	2		3			
		8	11		4		2		11				2			
		13	2		1		2		2		2	10				
T	CH80	7	2				1	2					6			
		7					5						2			
		1	3				3						1			

DRY WEIGHED DATA (SVIM)

SOIL	TREAT-MENT	GRASS	FORB	SHRUB	AGSM	AGSP	BOGR	CAEL	ARFR	SEDE	LICHEN	OPPO	MISC. GRASS	MISC. FORB	MISC. SHRUB	AGCR
		(.....			g/m^2	.....				)	(.... cm^2	....)	(..... g/m^2	.....		)
T	NU79	8			6			1								1
		2	2		2				2							
E	NU79	3	4										4			
		3											3			
		4			3								1			
TH	NU79	3											3			
		3			3											
P	NU79	5						1					4			
		6	1		3				1				3			
T	NP79	3			3											
E	NP79	5	3		4				3				1			
		5	3		1				3				4			
TH	NP79	1	15	13	1				15			13				
		7			3								4			
P	NP79	6	3	28					3			28	2			
		8											8			
T	C79	5											1			4
		4	3		1				3				1			2
E	C79	9											1			8
		7														7
TH	C79	12											3			9
		12														12
P	C79	11											1			10
		14											11			3
T	NU80	3	2						2				3			
		3	2					1					3			
E	NU80	6	2		3		2	1	2							
		3	4		1		2		4							
P	NU80	6	3		3		2		3				1			
		5	1				4	1	1							
TH	NU80	2	2				1		2				1			
		6	1		2		2	1	1				1			
TH	NP80	6			1		5									
		7	1		3				1				4			
P	NP80	10			3								7			
		7	2		4				1				3	1		
E	NP80	7	1		1		6		1							
		5	2		2		3		2							
T	NP80		5						5							
			5						5							
P	CH80	8	3		3				3				5			
		5	5		4				5				1			
TH	CH80	4	4		3		3		4				1			
		6	7				1		7				5			
E	CH80	4	1		1				1				3			
		3	2						2				3			
T	CH80	3					2						1			
			3						3							

MOIST WEIGHED DATA (SVIM)

SOIL	TREAT-MENT	GRASS	FORB	SHRUB	AGSM	AGSP	BOGR	CAEL	ARFR	SEDE	LICHEN	OPPO	MISC. GRASS	MISC. FORB	MISC. SHRUB	AGCR
		(..... g/m^2 .....)								(.... cm^2 ....)			(..... g/m^2 .....)			
T	NU79	6	4		6				4							
		14	2		12			1	2							1
E	NU79	5				4							1			
		7				6		1								
			2						2							
TH	NU79	8				6		2								
		3						3								
		5		1	4			1						1		
P	NU79	9											9			
		3			3											
		8											8			
		7				7										
		9	1		6		2		1				1			
T	NP79	6			6											
		2					2									
E	NP79	6	5				4		5				2			
		8	7		8				7							
TH	NP79	2	28		2				28							
		13			6		7									
P	NP79	14	8	68	9		5		8						68	
		11					6						5			
T	C79	12														12
		7	6		2		1		6							4
		11					2									9
		11					2									9
E	C79	12														12
		19					2									17
		16														16
TH	C79	22											6			16
		23														23
P	C79	5	21										5	21		
		14					4						6			6
		20					10									10
T	NU80	12	7		6				7				6			
		4	3						3				4			
		6						1					5			
E	NU80	12	4		5		4	2	4				1			
		9	4		3		3	1	4				2			
P	NU80	12	7		4		5		7				3			
		7	2				5	1	2				1			
TH	NU80	5	5				3		5				2			
		11	2		4		3	2	2				2			
TH	NP80	11			3		8									
		12	7		5				2				7			
				8											8	
P	NP80	14			5								9			
		14					9						5			
		15	6		9				3				6	3		
E	NP80	13	1		3		10		1							
		8	4		3		5		4							
T	NP80		10						10							
			11						11							
P	CH80	4	10				5		8				1	3		
		5	9				4		8					1		
TH	CH80	3	11				2		10					1		
		5	19						19							
E	CH80	4	22				3		18				1	3		
		5	17		2		2		15				1	2		
T	CH80	2	12		2				12							
		4	11		3		1		8					3		

RANDOM CLIP PLOT DATA

SOIL	TREATMENT	GRASS	FORB	SHRUB
		(.....	g/m^2	.....)
T	NU79	4		6
		3	1	
		4		
		3		
		4	1	2
		4		
		5		
		2		
		2	1	9
		4		
		5	1	
E	NU79	4		
		3		
		5	1	1
		5	2	
		4		
		2	1	
		5	1	
		4		
		4		
		4	1	
TH	NU79	5		
		4		
		3		
		7		
		4		
		4		
		4		
		4		
		3		
P	NU79	4		
		6		
		6	1	
		4		
		8	1	
		5	2	
		7	1	
		4		
		7	2	
		7		
T	NP79	2	8	1
		2		
		2	3	1
		3	2	6
		4	2	
		2	2	
		3	1	
		3		1
		3	1	
		3	1	
E	NP79	9		
		5	2	
		5	3	
		6		
		6		
		7		
		9		2
		4	2	
		6	1	
		6		

SOIL	TREATMENT	GRASS	FORB	SHRUB
		(.....	g/m^2	.....)
TH	NP79	7		
		5		
		6	1	
		8		
		9	1	
		8	3	
		2		
		5		
		5		3
		9	6	1
P	NP79	8		8
		8		
		7		
		3	1	
		1		
		5	7	2
		6		1
		9		
		4		
		8		
T	C79	4		
		7		1
		8		
		9		
		4		
		7		
		6	1	
		6		
		9		
		1	1	
E	C79	1		
		1		
		9		
		1		2
		6	1	
		9		
		1		1
		3		
		8	1	
		6	1	
TH	C79	1		
		1		
		7	3	
		3		
		2		
		1		
		9		
		7		4
			1	
		7	1	
P	C79	8		
		8		
		9		
		3		1
		3		
		7		
		5		
		6		
		8		
		8		

SOIL	TREATMENT	GRASS	FORB	SHRUB
		(.....	g/m^2	.....)
T	NU80	5	2	1
		2		
		3	1	1
		2		2
		3		
		3	1	
		2		
		4		
		1		
		3	1	
E	NU80	3	2	
		3	2	
		3	3	1
		2	3	
		2		
		4	2	
		3	2	
		3	2	
		3	3	
		5		
P	NU80	6	2	
		5	3	
		4	7	
		5		
		6		
		5	2	
		8	1	
		7	2	
		9	2	
		7	2	
TH	NU80	6	2	
		8	2	
		3	4	
		5	1	
		6	3	
		5	2	
		6	5	
		7	2	
		5		
		4	1	
TH	NP80	4	1	
		7	3	
		6	2	
		6	3	
		9	2	
		4	1	
		3	7	
		4		
		5	1	
		6	3	
P	NP80	3	3	5
		8	1	
		8	3	
		7	1	
		3	3	
		6	2	
			3	
		7	2	
		9	6	
		3		
E	NP80	5	6	
		6	2	
		6	1	
		4		
		3	4	
		4		
		5	1	
		5	3	
		2	4	
		5	2	

SOIL	TREATMENT	GRASS	FORB	SHRUB
		(.....	g/m^2	.....)
E	NP80	5	6	
		6	2	
		6	1	
		4		
		3	4	
		4		
		5	1	
		5	3	
		2	4	
		5	2	
T	NP80	1	1	
		2	2	
		3	3	
		1		
		2		
		6	1	
		2	1	
			3	
		2		
		3	1	
P	CH80	4	6	
		6	1	
		9	2	
		4		
		1	3	
		1	3	
		6		
		7	3	
		3	5	
		3	5	
TH	CH80	6	1	
		1	4	
		4	6	
		6	5	
		4	3	
		7	3	
		5	3	
			9	
		4	2	
		3	7	
E	CH80	2	4	
		4	9	
		3	4	
		4	5	5
		5	2	
		3	6	
		5	6	
		5	8	1
		3	2	
		4	6	
T	CH80	5		
		4		
		4	4	
		6	2	2
		3	3	
		1		
		4	4	
		3	1	
			2	
		4		
		1	1	1

APPENDIX 6: STEPWISE REGRESSION EQUATIONS FOR SOIL CHEMICAL DATA ON PRODUCTIVITY

Dependent Variable Productivity (P)	Equation	Multiple R^2	F
g/m^2	**Data with All Sites Included**		
Total[†]	P = 14.34 - .18(C horizon available water (%)) - .67(C horizon extractable P (me/100g)) + .18(C horizon 15 bar water)	.76	8.45
Grass[†]	P = 5.15 - .94(A horizon extractable Na (me/100g)) + .19(A horizon extractable P (me/100g)) + .05(B horizon cation exchange capacity (me/100g)) - .45(C horizon extractable Mg (me/100g))	.92	18.90
Total[‡]	P = 59.32 - 3.49(B horizon electrical conductivity (mmhos/cm)) - 6.69(B horizon organic matter (%)) + .35(B horizon extractable Ca (me/100g)) - 4.48(B horizon soluble K (me/100g)) - .90(B horizon clay (%))	.90	15.36
Grass[‡]	P = 19.34 - 3.26(B horizon organic matter (%)) - 1.06(B horizon extractable Na (me/100g)) - 1.90(C horizon extractable P (me/100g)) + 1.28(C horizon soluble K (me/100g)) + .10 (A horizon Sodium Adsorption Ratio)	.92	17.58
	Data with Control Sites Excluded		
Total[†]	P = 6.10 + .31(A horizon cation exchange capacity (me/100g)) - .70(A horizon extractable Na (me/100g)) + .10(A horizon sand (%)) - .22(B horizon clay (%)) + .10(B horizon 15 bar water)	.98	36.56
Grass[†]	P = -1.07 + .14(C horizon sand (%))	.81	24.10

Dependent Variable Productivity (P)	Equation	Multiple R^2	F
Total‡	P = 124.65 - .79(A horizon extactable Ca (me/100g)) - 7.36 (B horizon pH) + .45(B horizon cation exchange capacity (me/100g)) - 17.84(B horizon organic matter (%)) - .98 (B horizon clay (%))	.99	77.67
Grass‡	P = 20.07 - 1.03(B horizon extractable Na (me/100g)) - 6.76 (B horizon total N (ppm)) - 2.95(C horizon extractable P (me/100g)) + .60(C horizon total N (ppm) + .08(C horizon clay (%))	.99	89.61

†Random clip plot data

‡SVIM moist estimate data

APPENDIX 7: STEPWISE REGRESSION EQUATIONS FOR SOIL PHYSICAL DATA ON PRODUCTIVITY

Dependent Variable Productivity (P)	Equation	Multiple R^2	F
g/m^2	**Data with All Sites Included**		
Total†	P = 4.70 + .00(A horizon organic matter (%))	.57	10.78
Grass†	P = 2.4 + .04 (solum thickness (cm))	.63	14.39
Total‡	P = 248.46 - .03(clubmoss cover (cm^2)) - .03(elevation (m)) + .26(solum thickness (cm))	.74	8.47
Grass‡	P = 2.25 + .00(organic matter (%) in solum) + .09(C/N in solum)	.79	17.43
	Data with Tealette Soils Excluded		
Total†	P = 8.80 - .01(aspect) - .01(clubmoss cover (cm^2))	.70	7.26
Grass†	P = 2.45 + .90(soil type) + 1.74(A horizon coarse fragment content (%)) + .00(solum extractable Na (me/100g))	.82	9.88
Total‡	P = 12.82 - .06(clubmoss cover (cm^2)) + .15(solum thickness (cm)) - 1.71(C horizon coarse fragment content (%))	.80	8.52
Grass‡	P = 6.53 + .00(solum extractable Na me/100g)) + .49(available water (%) in solum)	.66	5.92
	Data with Control Sites Excluded		
Total†	P = 5.02 + .00(A horizon organic matter (%))	.60	8.07
Grass†	P = 2.44 + .04(solum thickness (cm))	.69	12.86
Total‡	P = 5.78 - .03(aspect) + .30(solum thickness (cm))	.84	15.65
Grass‡	P = 2.60 - .00(organic matter (%) in solum) + .08(C/N in solum)	.79	10.63

†Random clip plot data

‡SVIM moist estimate data

APPENDIX 8: INDEPENDENT VARIABLES TRIED IN STEPWISE REGRESSION ANALYSIS

PHYSICAL VARIABLES

Aspect
Slope (%)
Elevation (m)
A horizon thickness (cm)
B horizon thickness (cm)
Solum thickness (cm)
Coarse fragments in A horizon (%)
Coarse fragments in B horizon (%)
Coarse fragments in C horizon (%)
Calcium in the solum (me/100g)
Magnesium in the solum (me.100g)
Sodium in the solum (me/100g)
Potassium in the solum (me/100g)
Nitrogen in the solum (me/100g)
Phosphorus in the solum (me/100g)
Organic matter content of A horizon (%)
Organic matter content of the solum (%)
Available water in the solum (cm)

CHEMICAL VARIABLES

For one A,B and C horizon for each soil:

Electical conductivity (mmhos/cm)
pH
Cation Exchange Capacity (me/100g)
Bulk density (g/cm^3)
Organic matter (%)
Water at saturation (%)
Extractable calcium (me/100g)
Extractable magnesium (me/100g)
Extractable potassium (me/100g)
Extractable sodium (me/100g)
Bray phosphorus (ppm)
Soluble potassium (me/100g)
Soluble magnesium (me/100g)
Soluble calcium (me/100g)
Total nitrogen (ppm)
Sand (%)
Silt (%)
Clay (%)
Water content at 15 bars
Water content at 1/3 bar
Horizon thickness (cm)
Sodium Adsorption Ratio

APPENDIX 9: LINNEAN AND COMMON PLANT NAMES

Agropyron cristatum	Crested wheatgrass
Agropyron smithii	Thickspike western wheatgrass
Artemesia frigida	Fringed sagewort
Bouteloua gracilis	Blue grama grass
Buchloe dactyloides	Buffalo grass
Carex eleocharis	Blackroot sedge
Distichlis stricta	Nuttal alkaligrass
Hordeum jubotum	Foxtail barley
Oppuntia spp.	Prickly pear cactus
Phlox hoodii	Moss phlox
Poa secunda	Sandberg bluegrass
Salsola kali	Russian thistle
Selaginella densa	Clubmoss
Stipa comata	Needle-and-thread grass
Stipa viridula	Green needlegrass

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