1987

Impact of Ponderosa Pine Thinning and Slash Management on the Herbage Production of Selected Soils in Custer State Park

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IMPACT OF PONDEROSA PINE THINNING AND SLASH MANAGEMENT ON THE HERBAGE PRODUCTION OF SELECTED SOILS IN CUSTER STATE PARK.

BY

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A thesis submitted in partial fulfillment
of the requirements for the degree
Master of Science
Major in Agronomy

South Dakota State University
1987

IMPACT OF PONDEROSA PINE THINNING AND SLASH MANAGEMENT ON THE HERBAGE PRODUCTION OF SELECTED SOILS IN CUSTER STATE PARK.

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for the degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Gary D. Lemme Date
Thesis and Major Advisor

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ACKNOWLEDGMENT

A special thanks needs to be extended to my major adviser, Gary D. Lemme, for his guidance throughout this masters degree project. I would also like to thank Dr. Lemme and the rest of the thesis committee for their assistance in the preparation of this manuscript.

Students, Gary Ward and Midge Felton also deserve a special thanks for their help with the preparation of the data, tables, and figures.

A lot of friends and family gave me support that was greatly appreciated even when I didn't express my gratitude. This manuscript is dedicated to these people.

Finally, I would like to thank a lot of people I have never meet at Philip Morris Inc. Without their most generous financial support my academic career could not have reached this moment.

The Men That Don't Fit In.

Robert Service

There's a race of men that don't fit in,
        A race that can't stay still;
So they break the hearts of kith and kin,
        And they roam the world at will.
They range the field and they rove the flood,
        And they climb the mountain's crest;
Theirs is the curse of the gypsy blood,
        And they don't know how to rest.

If they just went straight they might go far;
        They are strong and brave and true;
But they're always tired of the things that are,
        And they want the strange and new.
They say: "Could I find my proper grove,
        What a deep mark I would make!"
So they chop and change, and each fresh move
        Is only a fresh mistake.

And each forgets, as he strips and runs
        With a brilliant, fitful pace,
It's the steady, quiet, plodding ones
        Who win in the lifelong race.
And each forgets that his youth has fled,
        Forgets that his prime is past,
Till he stands one day, with a hope that's dead,
        In the glare of the truth at last.

He has failed, he has failed; he has missed his chance;
        He has just done things by half.
Life's been a jolly good joke on him,
        And now is the time to laugh.
Ha, ha! He is one of the legion lost;
        He was never ment to win;
He's a rolling stone, and it's bred in the bone;
        He's a man who won't fit in.

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INTRODUCTION

Custer State Park's multiple-use management plan stresses compromise among resource users. The objective of integration of forest, wildlife and recreational resource management is to provide maximum benefits to all sectors of the management plan. Forest management techniques have a marked influence on the unique wildlife populations of Custer State Park.

To provide input for individuals making integrated management decisions, an approach was taken to combine forest stand and soil survey information, to assess understory herbage production for deer and elk grazing. Thinning pine stands will increase forage and browse production. Slash left from thinning and timber harvesting operations is suspected of limiting the response of understory vegetation. Overstory and understory production is dependent on soils which contain moisture and nutrient reserves.

This study was designed to accomplish the following three objectives:

(1) Characterize predominant soils of the Precambrian Crystalline core area of Custer State Park.

(2) Evaluate the understory production of these soils under varying forest conditions.

(3) Develop prediction models that resource managers can use to assess understory production in different forest environments.

Results from this study should enable resource managers to evaluate the effects of current and proposed forest management schemes on wildlife populations. Coupled with the recently completed soil survey of the Black Hills parts of Custer and Pennington counties, these results should be useful managerial tools for Custer State Park personnel.

LITERATURE REVIEW

Geology

The Black Hills of South Dakota and Wyoming were uplifted from an inland sea during the end of the Cretaceous period about 70 million years before the present (U.S. Dept. of. Interior 1967)(Fig. 1). This uplift was part of the Laramide Orogeny that formed the Rocky Mountain chain. During this orogeny, a massive core of Precambrian granite and schist was forced upward, deforming the younger Paleozoic and Mesozoic sedimentary rocks into an elliptical dome. Subsequent erosion has exposed the Precambrian core of this anticline and created a ridge and valley system of successively younger sedimentary rocks dipping away from the central core (Gries 1964). This ridge and valley system completely encircles the central core forming a radial drainage pattern. The creeks draining the southern part of the Hills empty into the Cheyenne river. In the northern Black Hills the creeks drain to the Belle Fourche River which empties into the Cheyenne in eastern Meade county (Feldman and Heimlich 1980).

Custer State Park is located in the southeastern quarter of the Black Hills of South Dakota (Fig. 2). The Park's approximate 29,000 ha stretch from the level open prairies in the southeast, to the rugged spires of granite, called the Needles, in the northwestern corner of the park.

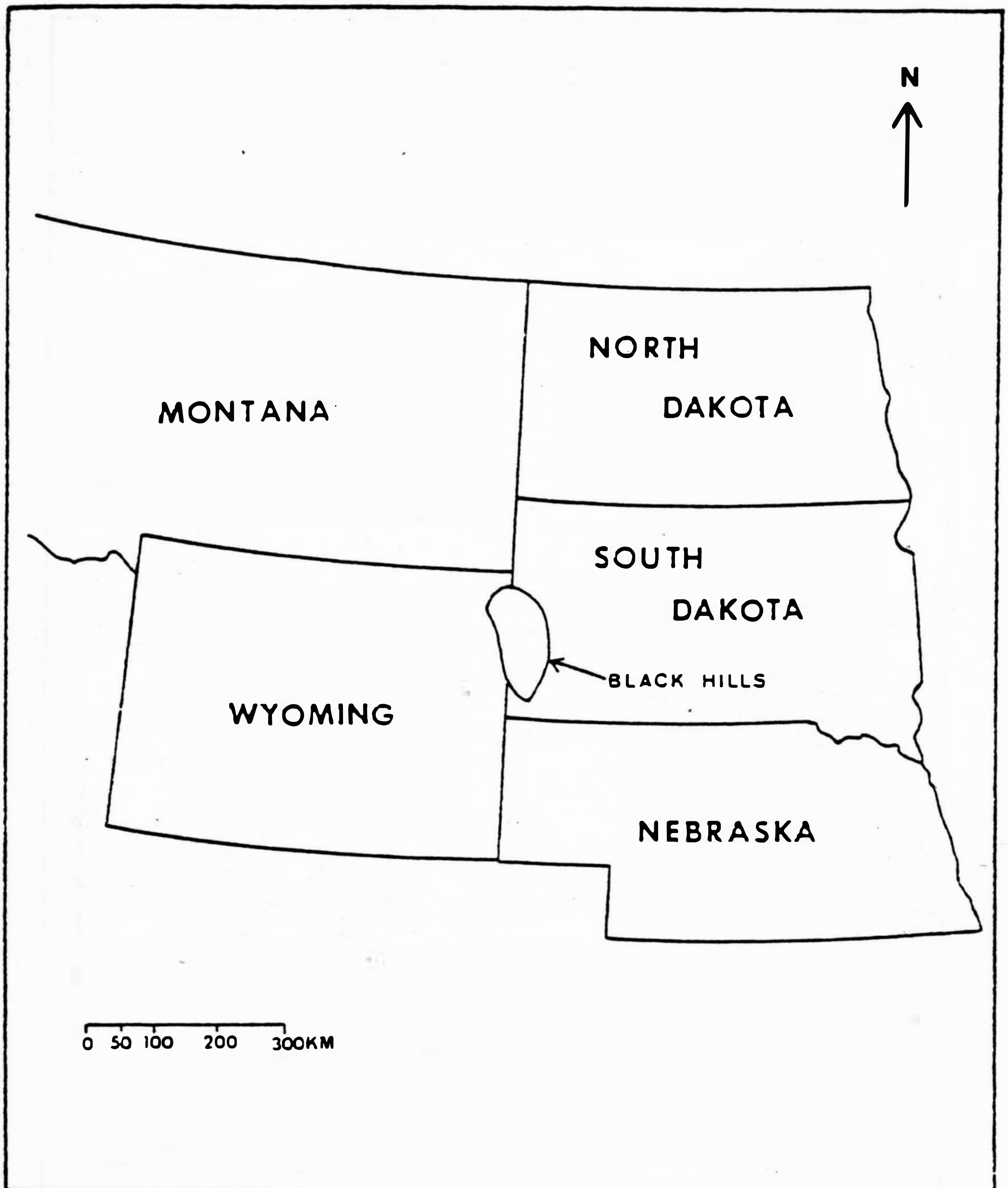

Fig. 1. Geographic setting of the Black Hills of South Dakota and Wyoming (Bennett 1984).

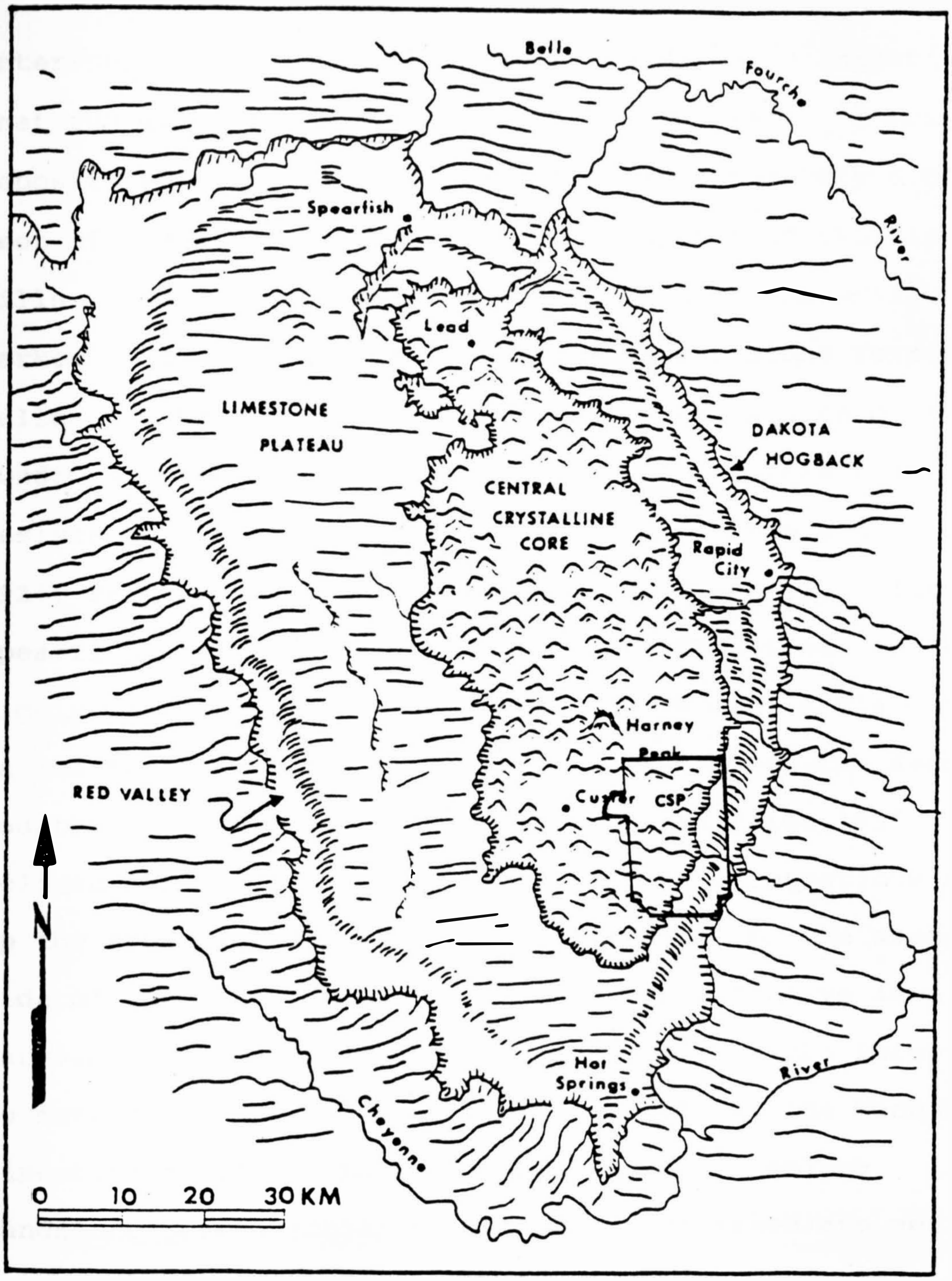

Fig. 2. Geographic regions of the Black Hills, including Custer State Park. Major rivers and towns are given for reference. (After Feldman and Heimlich 1980).

Tertiary sediments of the White River group occur interspersed within the Paleozoic and Mesozoic formations that run along the eastern boarder of the Park. These deposits were formed from erosion of approximately 6,000 feet of sedimentary strata after the uplift of the Black Hills. The boundary between the prairie and the Hills is marked by the sharp rise of the Dakota sandstone formation called the Dakota Hogback. Sandstones and shales of the Sundance, Lakota, and Fall River formations form this resistant outer rim of the Black Hills (Darton and Paige 1925, Feldman and Heimlich 1980) (Fig. 2 and 3). The Spearfish formation is the next oldest formation. This highly weatherable red sandy shale has formed a flat valley called the Red Valley or the Racetrack between the Hogback and the Paleozoic formations (Darton and Paige 1925, Feldman and Heimlich 1980). The Paleozoic formations make up the area called the Limestone Plateau. On the western side of the Black Hills, this covers an extensive area but narrows drastically on the eastern side. Of the Paleozoic formations comprising the Limestone Plateau, the Minnekahta limestone formation is the youngest, the Minnelusa sandstone (carbonaceous sandstone) is intermediate and the Pahasapa and Englewood limestone formations are the oldest (Feldman and Heimlich 1980). A thin band of the Deadwood formation (sandstone, shale, and conglomerate) is the final

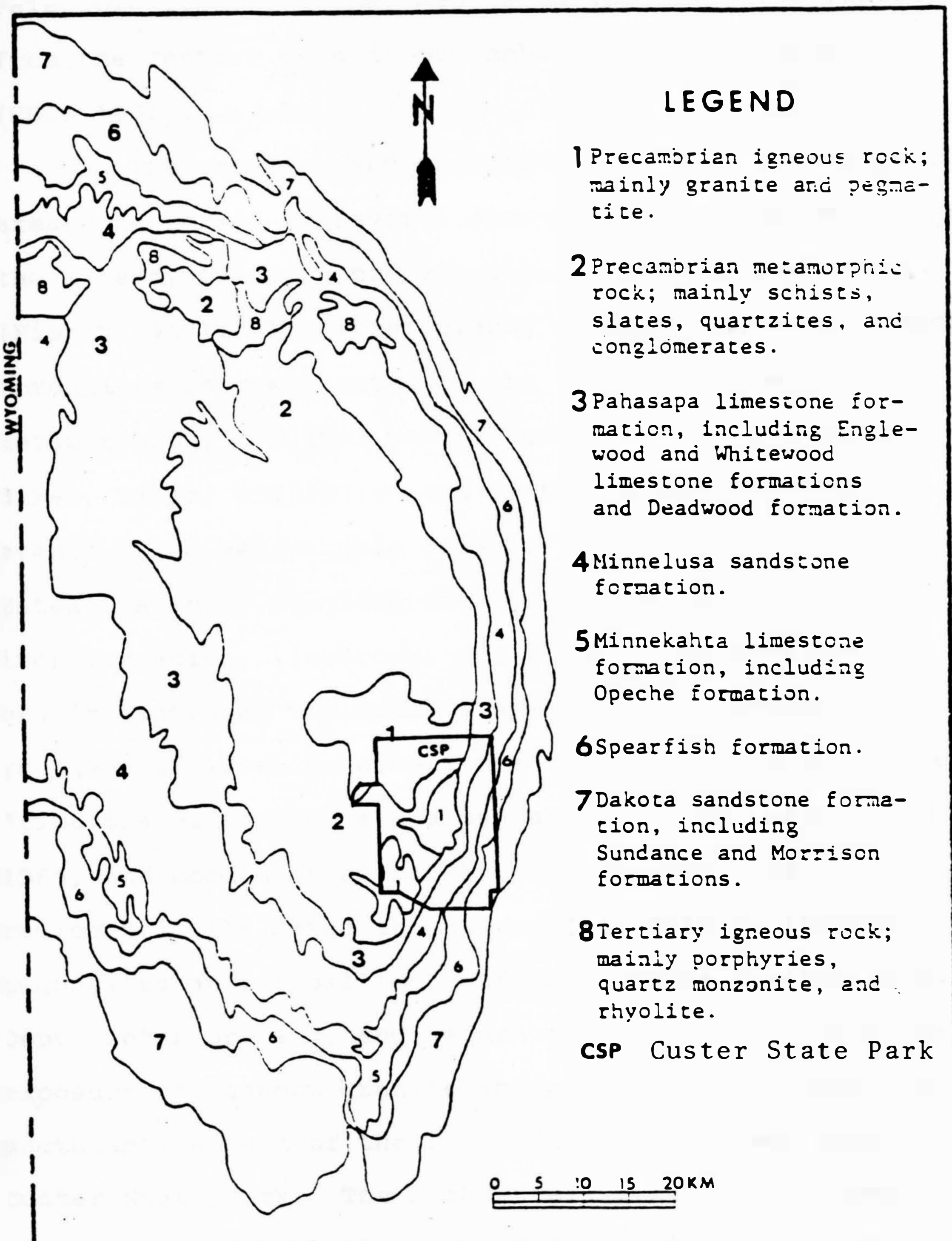

Fig. 3. Major geologic formations of the Black Hills and Custer State Park (After U.S. Geological Survey, Geological Map of the Black Hills).

Paleozoic formation that separates the Limestone Plateau from the central core of precambrian crystalline rocks (USGS 1951).

The granites and pegmatites in the crystalline core area were formed in several stages and were forced up into the already existing precambrian metamorphic sediments (Fisher 1942). The stratigraphy and correlation of these formations is complicated by the varying degrees of metamorphism, original parent rock, and the innumerable dikes, sills, and inclusions formed by many different events. The metamorphic core is thought to be part of the Estes system of conglomerate, quartzite, quartz schist, iron formation, limestone, and slate. The Game Lodge granite intrudes the Estes system east of Custer. The youngest of these precambrian sediments is the Harney Peak "fine grained" granite and pegmatite (Agnew and Tychsen 1965, and Redden et al. 1981). Geologists have radiometrically dated the Harney Peak granite and the pegmatites at 1.6 billion years before the present (U.S. Dept. Interior 1967, and Redden et al. 1981). The largest exposure of igneous granite and pegmatite is located in the southeastern part of the Black Hills, including much of Custer State Park. The highest elevation of the Black Hills (Harney Peak elevation 2,173 m) is found in the Granite core, just north of Custer State Park.

Climate

Because the elevation of the Black Hills is much higher than the surrounding prairie, the climate is subject to an orographic effect. Precipitation is formed as moist air masses rise over the Black Hills. The orographic effect caused by the rugged topography, is responsible for creating isolated short duration cloudbursts, resulting in a large variability in precipitation within an area. Mt. Rushmore and Custer, the closest weather stations to Custer State Park, annually receive 530 mm and 461 mm of precipitation respectively. Typically, the majority of this precipitation falls during the late spring and early summer months. Hermosa, Buffalo Gap and Hot Springs receive 412 mm, 438 mm, and 383 mm of annual precipitation respectively (U.S. Dept. of Commerce 1963-present). This is as much as 147 mm less than weather stations near the study area receive.

Summer temperatures in the Black Hills remain cool as a result of their elevation. Brief freezing may occur at any time during the summer at the higher elevations. Whereas during the winter, temperatures may be higher than on the surrounding plains because the dense cold arctic air masses may not extend to the higher elevations. Chinook winds commonly make the Black Hills the warmest part of the state during the winter (Van Bruggen 1985).

Native Vegetation

Along with the change in elevation and climate, the botanical composition of the Black Hills stands out from the surrounding plains. Ponderosa pine (*Pinus ponderosa*) dominate the overstory vegetation of the Black Hills. Exploitative cutting, mining, insect epidemics, fire, protection from fire, or a combination of these factors have disturbed the original vegetation to some extent (Orr 1968, and Thilenius 1971). Thus, today's forest stands of the Hills are considered secondary growth ponderosa pine. Timber stands are thick and vigorous in the Central Core area. The southern segments of the Limestone Plateau and the Hogback have less vigorous timber stands and have more open grass areas (Radeke and Westin 1963).

Although the overstory is essentially a monoculture, there is a great deal of variation in understory vegetation. Thilenius (1971) and Alexander (1986) both identified as many as six distinct subtypes or habitat types. Further variation is observed where habitat types intergrade. Elk and deer populations depend on this variation in habitat for food and cover.

The relationships between ponderosa pine forest parameters and understory production have been studied by numerous researchers. Canopy density and/or basal area have been shown to have a negative effect on herbage production in Washington (McConnell and Smith 1970), the Black Hills of South Dakota (Pase 1958, Bennett 1984), Texas (Halls and Schuster 1965), Arizona (Clary and Larson 1971), and in Oregon (Harris 1954). Hall and Schuster (1965) found that canopy density was a better predictor of understory yields than basal area, but suggested that basal area could be used because of the relative ease of obtaining accurate values. Jameson (1967) suggested that the loss of production was due to competition for light, water, and nutrients, and possible antagonistic chemical effects. Work in the Black Hills by Orr (1986) and Thompson et al. (1971) showed that thinning reduced the evapotranspiration demand. Soil moisture reserves become recharged, resulting in more available water for the remaining vegetation. The relationship between forest parameters and herbage production has been most successfully predicted using curvilinear equations (Halls and Schuster 1965, Pase and Hurd 1957, and Jameson 1967).

Research in this area has been concentrated mainly on canopy density and basal area parameters. Slash loading from harvesting or thinning operations is often prevented or ignored in research work. An example of this is the study done by McConnell and Smith (1965 and 1970), where the slash was removed from the study plots and burned. They further demonstrate that herbage yields have been studied outside the normal environmental condition when the authors conclude "Before thinning can make a practical contribution to the resource, however, more economical slash disposal methods must be developed". Pase (1958) showed that natural litter (0 to 48 t/ha) adversely affects herbage yields. Slash levels in Custer State Park however, have been measured as high as 170 t/ha (D. Sparks 1986, personal communication).

The conventional practice of slash management in Custer State Park is for fire protection. The practice of lop and scatter to 18 inches is employed except in fire break areas or where fuel loads would be dangerously high (R. Walker 1987, personal communication). The lop and scatter system cuts and scatters slash so that no fuel stands more than 18 inches above the ground surface. This reduced the chance of wildfire spreading to the forest canopy. In areas where slash must to be removed, the slash is piled to be burned during the following winter. The lop and scatter technique affects the vast majority of the hectares important for deer and elk grazing in the Park.

Understory herbage production has traditionally been reported as total production or broken into classes of graminoids, forbs and shrubs if not by species. Graminoids show the greatest response to overstory thinning, while shrubs show the least response (McConnell and Smith 1970, Pase and Hurd 1957, and Pase 1958). Often there is a lag period between harvesting or thinning and the full response of herbage production. McConnell and Smith (1965) reported this and continued their study for five additional years. It took up to four years to naturally reestablish the ground cover in Washington and Oregon after disturbance from logging (Reid 1964). To minimize this response lag time, some researchers suggest seeding the area with the desired seed stock (Bever 1952, Pase and Hurd 1957, and Reid 1964).

Wildlife Habitat

It has been shown that forest management practices can increase understory herbage yields. Whether this improves the deer and elk habitat depends not only on the quantity, but the type of forage available. Currie et al. (1977) reported that the diet of mule deer grazing in ponderosa pine forest in central Colorado was composed of 32% trees and shrubs, 48% forbs, 18% grasses, and 2% fungus (mushrooms). In the Black Hills, Schenck (1971) found Kinnikinnick (Arctostaphles Una-ursi) and Oregon grape (Berberis repens) to be the major food supply of mule and whitetail deer. During winter months, deer in the Black

Hills concentrate in the lower elevations in areas with less snow cover, good browse conditions, and high vegetation diversity. These are characteristics of the Vanocker-Sawdust-Paunsaugunt soil association (Vicuna 1987). The elk population is concentrated in and around Custer State Park. A good interspersion of rangeland and woody habitat areas is important to elk (Vicuna 1987). Elk in ponderosa pine forests of Arizona also prefer areas with low basal area and high shrub production (Clary and Larson 1971 and U.S. Forest Service 1967). Elk were found to use the open areas in a ponderosa pine forest in the southwestern United States more than deer (Reid 1964). Patton (1974 and 1976) agreed with this and reported that elk usage of a thinned area increased more than deer usage. Wildlife habitat improvement can be accomplished using thinning or some timber harvesting practices. To be successful, habitat improvement plans must not only consider the quantity of timber to remove in order to stimulate herbage production, but also must be concerned with how much vegetation to leave for cover (Patton 1974, Patton 1976, and McConnell and Smith 1970).

Soils

The first major study of the soils in the Black Hills was reported by Radeke and Westin (1963). This was a reconnaissance study to investigate the types of soils found in the region. Gray Wooded soils were commonly found in the Central Core area. Horizon thickness and the occasional presence of an A horizon were the main differences among the soils reported by Radeke and Westin. Thin profiles were also found to occur in thin mantles of unconsolidated material over hard bedrock. Later, soil mapping in the Black Hills supported Radeke and Westin's general conclusions. Soil taxonomy allowed for further differentiation of these soils. A general soils map of the park has been divided into six soil groups for the purpose of this study (Ensz 1987)(Fig. 4).

The southeastern edge of the park is dominated by Nevee, Gypnevee, and Rekop soil series (Ustic Torriorthents). These soils occupy the Red Valley and have developed in the Spearfish and related formations. The next soil group to the west is made of Vanocker (Typic Eutroboralfs), Sawdust (Typic Ustorthents), and Paunsaugunt (Lithic Haploborolls) soil series. These soils have developed from the Pahasapa limestone, the Minnelusa sandstone, and the Minnekahta limestone. The prairie-forest transition occurs on this limestone plateau in this part of the Black Hills. The bottomland soils in the granitic core are classified as Mollisols. Marshbrook soils (Haplaquolls) occur in the lowest positions, and

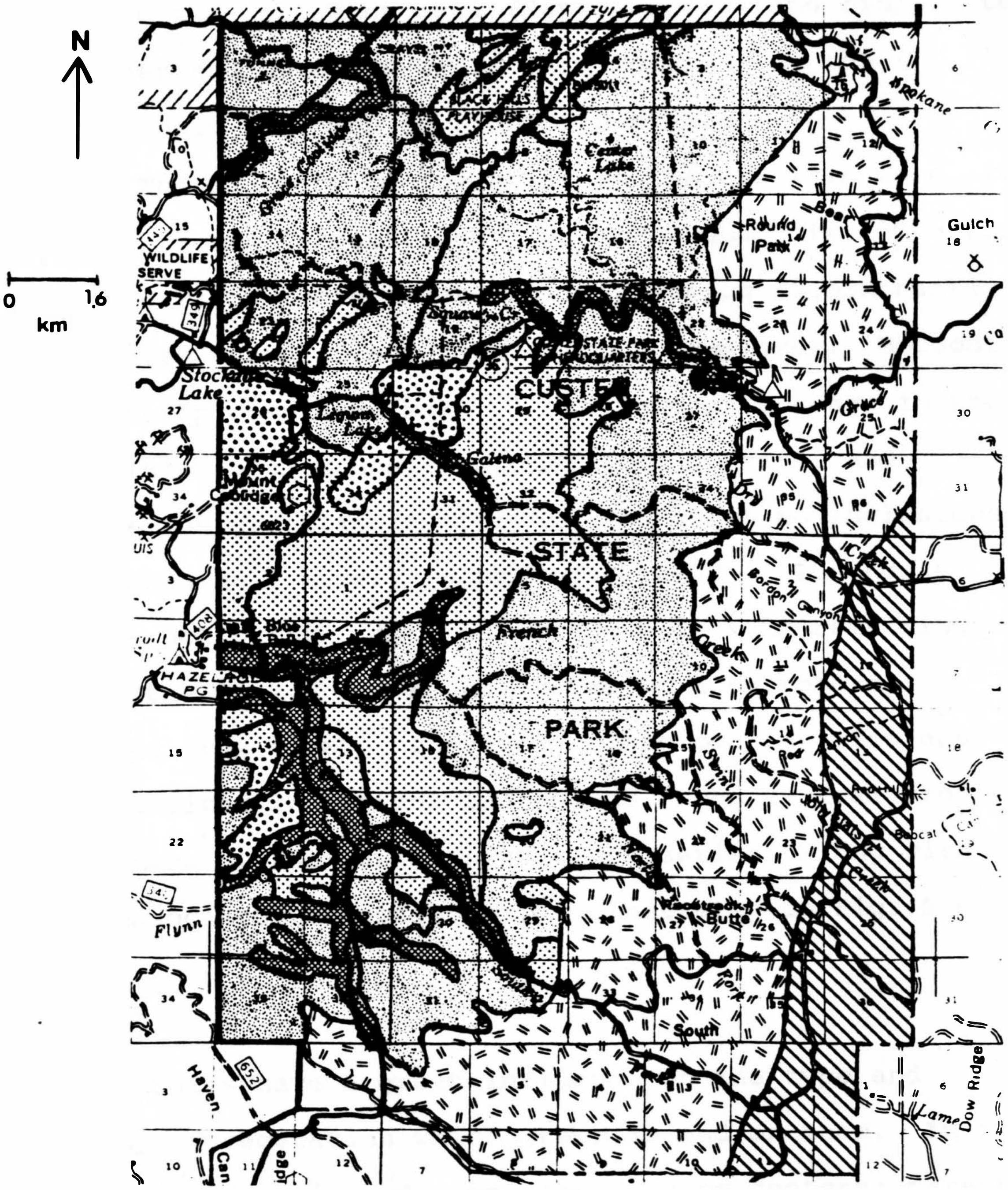

Fig. 4. General soils map of Custer State Park South Dakota. 1cm=1.3km.

- Vanocker-Sawdust-Paunsaugunt
- Cordeston-Hilger-Bullflat-Marchbrook
- Pactola-Virkula-Rock Outcrop
- Buska-Mocmont-Rock Outcrop
- Mocmont-Rock Outcrop
- Nevee-Gypnevee-Rekop

grades to the Cordeston soil (Haploborolls) and finally to the Hilger and Bullflat soils (Argiborolls) as the physiographic position becomes more stable.

The majority of the soils in the Granitic Core area of the Park are classified as Typic Eutroboralfs. The west central part of Custer State Park is mapped predominantly as Pactola, Virkula, and rock outcrop complexes. Mocmont-rock outcrop complexes make up the largest acreage in the Park. This complex has developed from granite, and includes the granitic Inceptisols mentioned as inclusions in the area soil survey report (Ensz 1987). The Buska-Mocmont-rock outcrop complex accounts for the remaining area of the Park. The Buska series is a Eutroboralf developed from micaceous schist. This complex also has schist derived Inceptisol inclusions. The typical profile development of the Buska and Mocmont series, along with their associated Inceptisols is illustrated in Fig. 5.

Pedology

Soils have a great influence on the type and quantity of vegetation which grows in and on them. In turn soils are a function of five soil forming factors; parent material, climate, topography, biotic factors, and time. How these factors affect the soil processes involved in soil genesis is the subject of pedology.

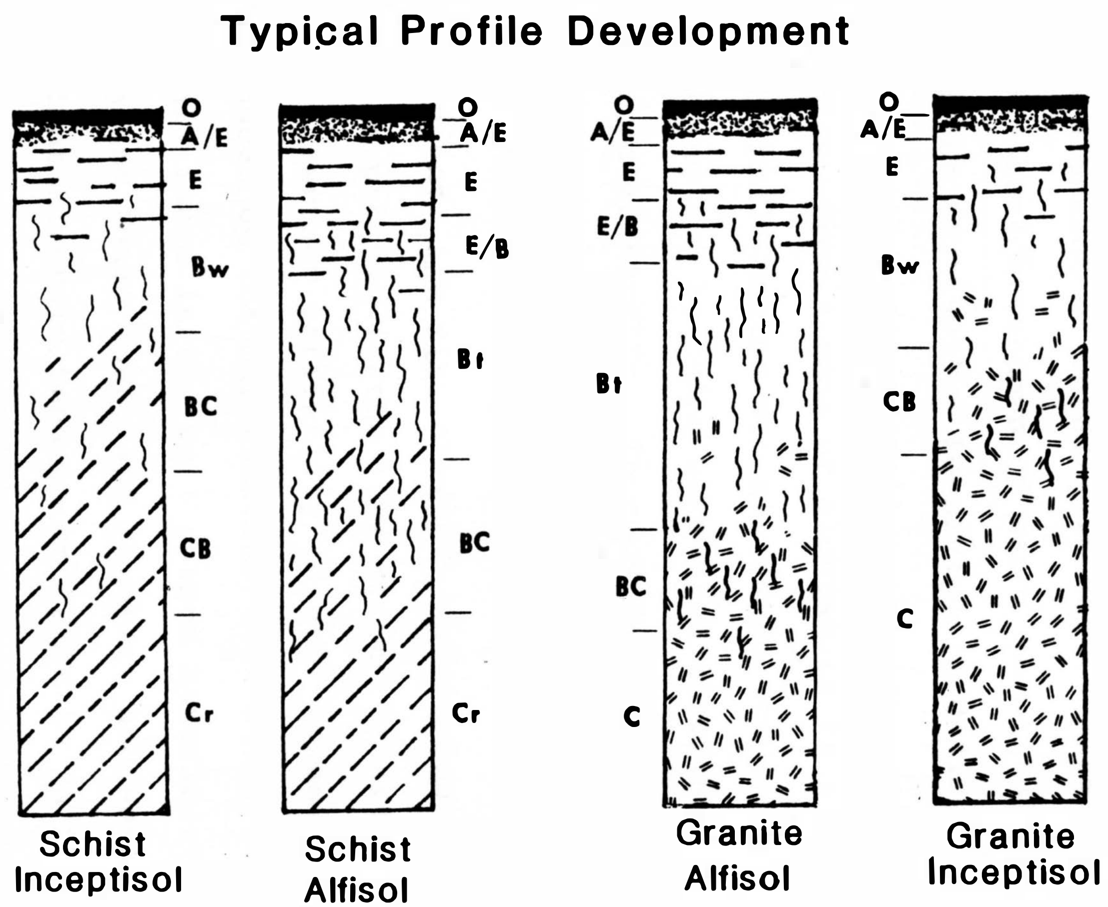

Fig. 5. Typical profile development of the micaceous schist Buska series, granitic Mocmont series, and the Inceptisols associated with both series.

Mechanical disintegration of soil minerals is maximized in the Ae (E) horizons of Gray Wooded soils (St. Arnoud and Whiteside 1963). This was attributed to the effects of frost action. The dominate processes acting on the development of Boralfs in east central Saskatchewan were physical breakdown of sands to silts, and lessivage (Santos et al. 1986). Lessivage is defined as the mechanical movement of soil particles, usually clay particles, from a zone of eluviation to a zone of illuviation. Santos et. al. (1986) concluded that chemical weathering and leaching were also important in the formation of Boralfs. In a chronosequence of Alfisols in Australia, Walker and Chittleborough (1986) showed that lessivage was most important in the early stages of profile development. *In situ* chemical weathering became the dominate process in the late stages of Alfisol genesis.

Further variability in soil genesis over time is introduced by the differential weathering rates of the minerals found in the soil parent material (Goldich 1938, Harris and Adams 1966, and Kronberg and Nesbitt 1981). Resistant minerals tend to concentrate in the soil as a result of more susceptible minerals being removed through chemical weathering. The secondary minerals that are formed are dependent on the original primary minerals and the climate. Tardy et al. (1973) outlined the secondary weathering products of the most common primary minerals found in granite rocks. In temperate climates, as the Black Hills, the typical weathering sequences are as shown in Table 1. These sequences generally agree with those reported by the USDA Soil Survey Staff (1980). Mica (muscovite and biotite) have also been reported to form vermiculite and some interlayered smectites (Fanning and Keramidas 1977). The dominate mineral in granite (quartz) is very resistant to chemical weathering (Goldich 1938), and thus does not have a secondary mineral product. Quartz, however, is broken down to finer particles by physical weathering (Santos et al. 1986). These weathering sequences hold true for other rocks in the same climate as evident by the dominance of kaolinite, with moderate quantities of montmorillonite and chlorite in the clay fraction reported for the Buska soil series (National Soil Survey Lab 1979).

Considering the relative weathering rates of the minerals, it would be expected that the rate of saprolite production would be dominated by the major constituent minerals of a rock. With this in mind, soil development should begin earlier in the micaceous schist, than the quartz dominated granite. Parsons and Herriman (1975) supported this by showing in a lithosequence of granite-schist-pyroclast, the granitic soils were less developed

Table 1. Typical weathering sequences of granitic minerals in temperate climate regions. (After Tardy et al. 1973).

Orthoclase-feldspar ===> Kaolinite

Biotite ===> (Chlorite) ===> Vermiculite

Plagioclase ===> (Montmorillonite) ===> Kaolinite

(Montmorillonite) is only a transitional stage in plagioclase weathering.
(Chlorite) only forms readily in the deeper zones of the "retrodiagenesis" of granite.

than the schist soils. These differences in soil development were shown to effect forest productivity by their influence on soil water holding capacity.

Of the soil factors related to forest productivity, plant available water holding capacity (PAWC) has been shown to be one of the most important (Pase and Thilenius 1968, and Parsons and Herriman 1975). The depth of the solum has also been shown to be an important predictor of productivity (Meyers and VanDeusen 1960). These two parameters are interrelated with soil development in that as the profile develops, it gets deeper, and finer textured, thus increasing the PAWC.

Plant available water holding capacity (PAWC) is the difference between the water held at field capacity (FC) and the permanent wilting point (PWP). The PWP is considered to be at a matrix potential of -1.5 MPa. This is true for both disturbed samples and undisturbed cores (R.Kohl 1987, personal communication), although some plants may be able to extract water at lower suction pressures.

At the other end, FC has been subject to much debate. Laboratory measurements of FC are influenced by soil texture, structure, and sample handling. Lund (1959) suggests that in sandy soils, the FC maybe at lower suction than 0.03 MPa. Under low pressures disturbed samples of medium and fine textured soils have been shown to have a higher mass water content than natural cores of the same soil (R. Kohl 1987, personal communication, Salter and Williams 1965, Sommerfeldt 1986, Lund 1959, Broadfoot 1954, and Elrick and Tanner 1955). Sieved coarse textured samples have been reported to both increase and decrease the moisture content at low pressures as compared to undisturbed soil cores (Broadfoot 1954 and Elrick and Tanner 1955). Logically, the natural cores samples would more realistically represent the actually conditions in the field. MacLean and Yager (1972) have shown that 0.01 MPa of pressure was a better measure of field capacity than 0.03 MPa on undisturbed cores. When disturbed samples must be used (as in this study), it must be realized that field capacity (FC) may not parallel measurements on undisturbed cores and actual field measurements (Kohl 1987, personal communication, Salter 1965, Sommerfeldt 1986, Lund 1959, Broadfoot 1954 and Elrick and Tanner 1955).

MATERIALS AND METHODS

Site Selection

Site selection was conducted to evaluate the interaction of canopy cover and slash levels on four soils in the northwest quarter of Custer State Park. Canopy cover and slash levels were estimated ocularly for site selection purposes. During 1984, 30 sites were initially chosen to cover a full range of possible canopy and slash levels encountered in Custer State Park. Twelve sites were added in 1985 to help balance the data set. Two sites were later dropped (CSP27 could not be relocated in 1985 and CSP14 produced atypical yields) leaving 40 sites in the study.

Sites were limited to four soil mapping units in the Custer and Pennington Counties-Black Hills parts soil survey report; Mocmont gravely loam 2 to 12% slopes, Mocmont-Rock outcrop complex 10 to 40% slopes, Rock outcrop-Mocmont complex 40 to 80% slopes, and Buska-Mocmont-Rock outcrop complex 10 to 40% slopes. The Buska series is a loamy-skeletal, micaceous Typic Eutroboralf derived from micaceous schist residuum (USDA-SSS 1985). The Mocmont series is a loamy-skeletal, mixed Typic Eutroboralf that has developed in residuum or colluvium weathered from igneous rock (granite)(USDA-SSS 1980). Both soils are found on uplands and mountain slopes. These soil mapping units can contain up to 15% inclusions of Inceptisols and other soils (E. Ensz 1987, personal communication). Some sites were established on these Eutrochrept soils to evaluate their productivity.

Site Measurements and Sampling

Soil pits were dug at each site to a depth considered to be the C or R horizon. The soils were then morphologically described in accordance with the Soil Survey Manual (Soil Survey Staff 1981), and bulk samples were collected from each horizon. Abundance and size of coarse fragments were estimated in all pedons. Bulk density samples could not be obtained due to the nature of the coarse fragments. Thus, soil bulk density was estimated from the SCS S-5 description sheets, particle size analysis, organic matter, and the paraffin clod method (Blake 1965). The slope was measured as a percent using a clinometer, and slope profile position was noted corresponding to Ruhe's slope component model (Ruhe 1969). United States Geological Survey topographic maps were used to estimate the elevation of each site.

A ten meter transect was established perpendicular to the slope at each site for measuring understory production. The ends of the transects were marked with wooden stakes for ease of relocation. Vegetation samples were collected within a two and a half day period during the middle of August each year. This minimized any differences due to growth during the sampling period, and allowed for sampling when vegetative growth had reached its maximum. Vegetation samples were comprised of the current year's growth from 0.2 m^2 plots at one meter intervals. Clippings were taken on alternating sides of the transect each year to minimize any residual effects from the preceding year's sampling. Vegetation from each clipping was separated into one of three classes (graminoids, forbs, or shrubs), and stored in paper bags. The samples were transported to Brookings, SD and dried at 83^{o}C to a constant weight. Understory production of each class was calculated from the mean weight of the ten plots harvested at each site (Eq.[1]).

Eq.[1] $kg/ha = (\bar{x}\ g/0.2\ m^2)(1\ kg/1{,}000\ g)(10{,}000\ m^2/ha)$

Where $\bar{x}$ is the mean weight (g) of the vegetation harvested from ten 0.2 m^2 plots. This equation was then simplified to Eq.[2]:

Eq.[2] $kg/ha = (\bar{x}\ g/plot)\ 53.8$

Total understory production was calculated as the sum of the understory production of each vegetation class at each site (Eq.[3]).

Eq.[3] kg/ha = graminoids + forbs + shrubs

The most common plant species were noted at each site, although no intensive flora inventory was made. The graminoid class included all grasses and grass-like vegetation. The major species observed were: prairie dropseed (Sporobolus heterolepis), sedges (Carex sp.), little bluestem (Andropogon scoparius), and roughleaf ricegrass (Oryzopsis asperifolia). The shrubs consisted of low to the ground perennials (seedling trees were not included). Kinnikinick (Arctostaphles una-ursi) was the most important species and juniper (Juniperus communis) was of minor importance. The herbaceous plants not included in the above classes were classified as forbs. American vetch (Vicia americana), thistles (Cirsium sp.), western snowberry (Symphoricarpos occidentalis), and western yarrow (Achillea lanulosa) were the most common species.

Slash levels (t/ha) were obtained using a slightly modified version of Brown's method for inventorying downed woody material (Brown 1974). Brown's transect method was modified to utilize the understory vegetation transect already established at each site. This allows investigation of the site specific interaction between slash levels and vegetation production. Percent canopy density was measured using a spherical densiometer (Lemmon

1956), and basal area was measured in ft^2/acre using a cruising prism with a basal area factor of ten.

The time since thinning of each site was obtained from Custer State Park thinning and harvesting records (Appendix I). Work area one (W1) is located in Norbeck Draw (see Appendix V for site locations). This area was thinned in June 1982. At the time of the study the canopy cover was open and slash levels ranged from 20 to 60 t/ha. This thinning operation removed predominately small diameter trees to increase the mean diameter at breast height (DBH) from 4.3 cm (1.7 in) to 16.0 cm (6.3 in). Two thinning operations split work area two (W2) along the logging road that runs through this work area. Sites to the south of the road were thinned in 1968 and to the north in 1969. This work area has moderate and dense canopy cover with the exception of one site. Slash levels are also moderate to heavy with the exception of two sites in this area. The thinning in 1969 also included work area three (W3) which has similar slash levels and thinner canopy covers. In 1983, work area four (W4) was harvested leaving 24.9 t/ha slash and 28% canopy cover. The mean DBH in W4 was 6.4 cm (2.5 in) and 10.9 cm (4.3 in) before and after harvesting respectively. Work area five (W5) was thinned in 1982 from a mean DBH of 3.0 cm (1.2 in) to a mean DBH of 14.2 cm (5.6 in). This operation opened the canopy to moderate and open levels and left from 4.4 to 174.4 t/ha slash. There was no record of thinning or harvesting operations in work areas six (W6) or seven (W7). Work area seven is an unthinned dog hair stand with extremely dense canopy cover. Slash levels are generally extremely high, however they may be low in areas where few trees have fallen to the ground. Area six is a mature stand with low to moderate canopy cover and slash levels. One site in W6 does have man made slash which attain high levels. The final work area (W8) was thinned in 1981. This is a large area and has an extremely large variation in canopy density and slash level.

Laboratory Procedures

Bulk soil samples from each horizon were air dried, crushed with a rolling pin, and passed through a 2 mm sieve to separate the coarse fragments from the fine earth fraction. Soil reaction (pH) was measured in a 1:1 soil water suspension (Maclean 1982 and USDA-SCS 1972). Organic matter content was measured as readily oxidizable organic matter using the modified Walkley-Black method (Carson and Gelderman 1980, Jackson 1958, and Walkley and Black 1934). Cation exchange capacity was measured on selected profiles using a NH_4OAc at pH 7.0, Buchner funnel and Kjeldahl procedure (USDA-SCS 1972).

Particle size analysis by the pipette method was used to measure three silt fractions, and the <0.002 mm clay. Five sand fractions were separated by dry sieving (USDA-SCS 1972). The sand fractions were saved to determine the non-colloidal mineralogy of the fine and coarse sand fractions. Using a petrographic microscope, frequency of the quartz, feldspar, mica, and miscellaneous minerals were made on a minimum of 500 sand grains per sample. Mineral count frequencies were calculated and used to determine the mineralogical class of the three-tier mineralogy control sections as proposed by Kittrick (1985). Moisture retention capacity was measured at 0.03 and 1.5 MPa on disturbed samples using the pressure plate method (Richards 1965). "Plant available" water holding capacity (PAWC) was considered to be the difference between the two moisture retention measurements. The PAWC was then multiplied by the soil bulk density to convert it from a mass basis to a volume basis. Finally the PAWC was adjusted downward for the coarse fragment content.

Data Analysis

Probabilities of the occurrence of the recorded precipitation were evaluated using cumulative frequency distributions. The cumulative frequency percentage is obtained by ranking monthly, critical, and annual precipitation records and using Eq.[4]:

Eq.[4] $F_i = (m/n+1) * 100$

Where the data has been ranked in ascending order, F_i= cumulative frequency percentage, m= rank of the i^{th} observation, and n= number of years in the record. The cumulative frequency percentage represents the percentage of years with rainfall equal to or less than that particular monthly, critical, or annual rainfall. It also represents an estimate of the events in the future that will have equal or less precipitation than a particular event (Dunne and Leopold 1978).

Understory production models for graminoid, forb, shrub, and total vegetation were generated from a data base containing as many as 17 forest and soil variables using a SAS PROC LEAPS procedure. The LEAPS procedure finds a set of models with the highest R^2 using leaps and bounds algorithms (P.E. Evenson 1986, personal communication). Biologically correct models with high R^2's were selected for further development. A SAS PROC REG procedure was used to force lower order terms into exponential models when appropriate. For statistical purposes this experiment is considered a completely random design (CRD). A SAS PROC GLM with a Duncan-Waller option was employed to separate the means of understory production classes by soil types.

Relationships between understory production and soil mineralogy were investigated using a PROC CORR procedure in SAS (Ray 1982). Correlation matrixes were calculated for each year's graminoid, forb, shrub, and total understory production by the percentages of quartz and mica in the surface, subsurface, and substratum control sections. Correlation coefficients (r) can range from -1, indicating a perfect negative relationship, through zero being independent or no relationship, to +1 indicating a direct positive relationship. The 0.1 probability level was used to separate significantly different correlation coefficients from zero.

RESULTS AND DISCUSSION

Rainfall Probabilities

Precipitation, or the lack of, is a critical factor governing the production of understory vegetation. A 38% reduction in total vegetative production was seen in 1985, when critical precipitation (April, May, and June) averaged 84 mm, as compared to 1986 when the mean critical precipitation was 260 mm (Table 2 and 3). Forb production was decreased by 59% on average, whereas mean shrub production had the smallest loss of production.

National Climatic Data Center precipitation records at Mt. Rushmore and Custer indicate the later part of 1983 received near or above normal precipitation (U.S. Dept. of Comm. 1963-1986). This trend continued through the first year of this study, until August 1984 (Fig. 6 and 7). During the 1984 critical rainfall period, 271 mm of precipitation fell as compared to the long term mean of 237 mm. The cumulative frequency percentage (F_i) of receiving this amount or more precipitation is 36%, where the mean F_i is equal to 50%.

A severe drought began in August of 1984. The Custer station reported the only above average precipitation (March 1985) until September of 1985 when both stations received above average precipitation. Only

Table 2. Recorded precipitation at Custer and Mt. Rushmore weather stations during the study period.

Station	Mean Precip[1] crit[2]	Mean Precip[1] ann[3]	1984 crit	1984 ann	1985 crit	1985 ann	1986 crit	1986 ann
	mm							
Custer	216	461	285	509	92	361	266	530
Mt. Rushmore	248	530	256	476	80	318	254	552
mean	237	496	271	492	84	342	260	541

[1]Mean Precip: precipitation based on a 23 year record
[2]crit: critical precipitation = April + May + June
[3]ann: annual precipitation

Table 3. Mean understory production by vegetation classes during 1985 and 1986.

Vegetation Class	Mean Understory Production 1986	Mean Understory Production 1985	Production Loss
	kg/ha	kg/ha	%
total	121.40	75.03	38
graminoids	62.73	36.96	41
forbs	8.60	3.49	59
shrubs	50.07	34.59	31

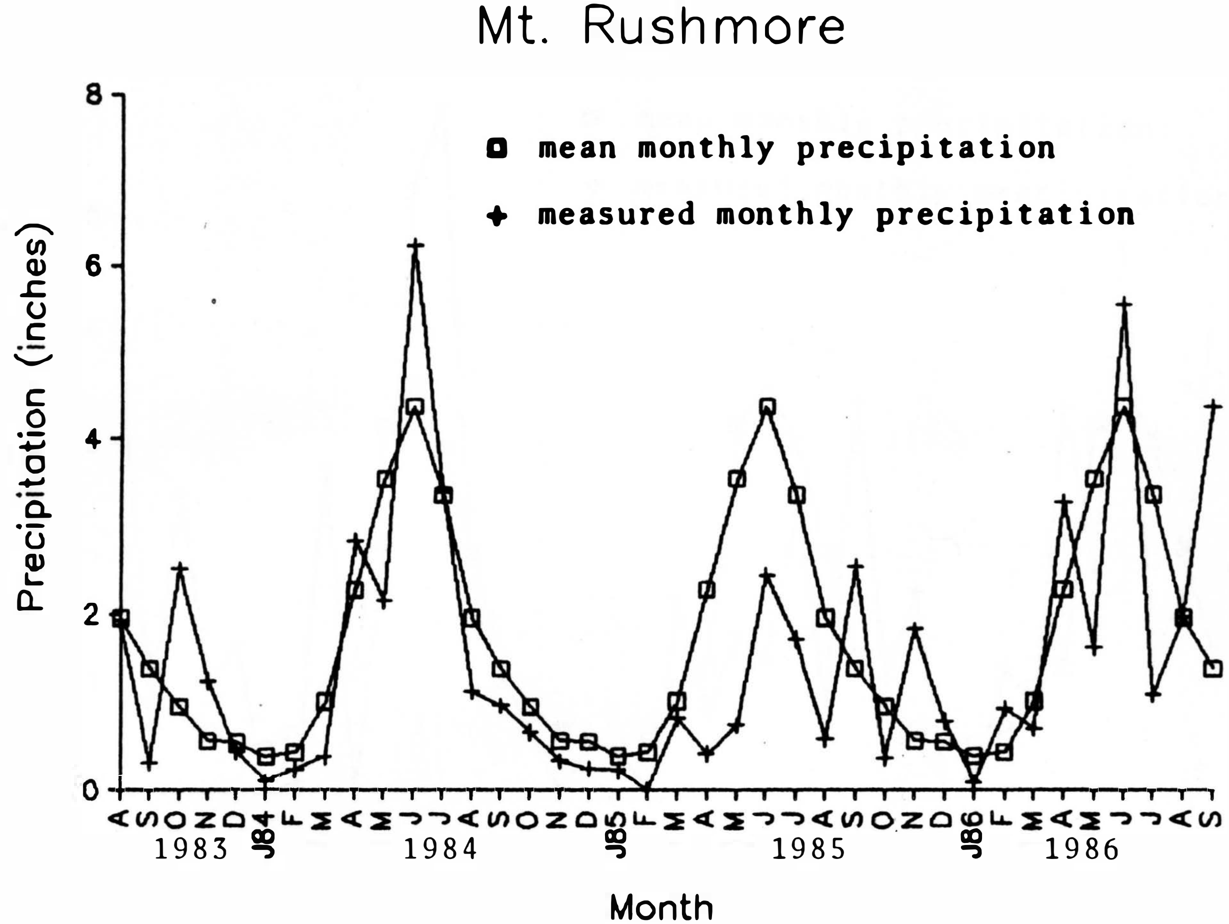

Fig. 6. Mean and actual recorded precipitation at Mt. Rushmore SD by months during the period August 1983 through September 1986.

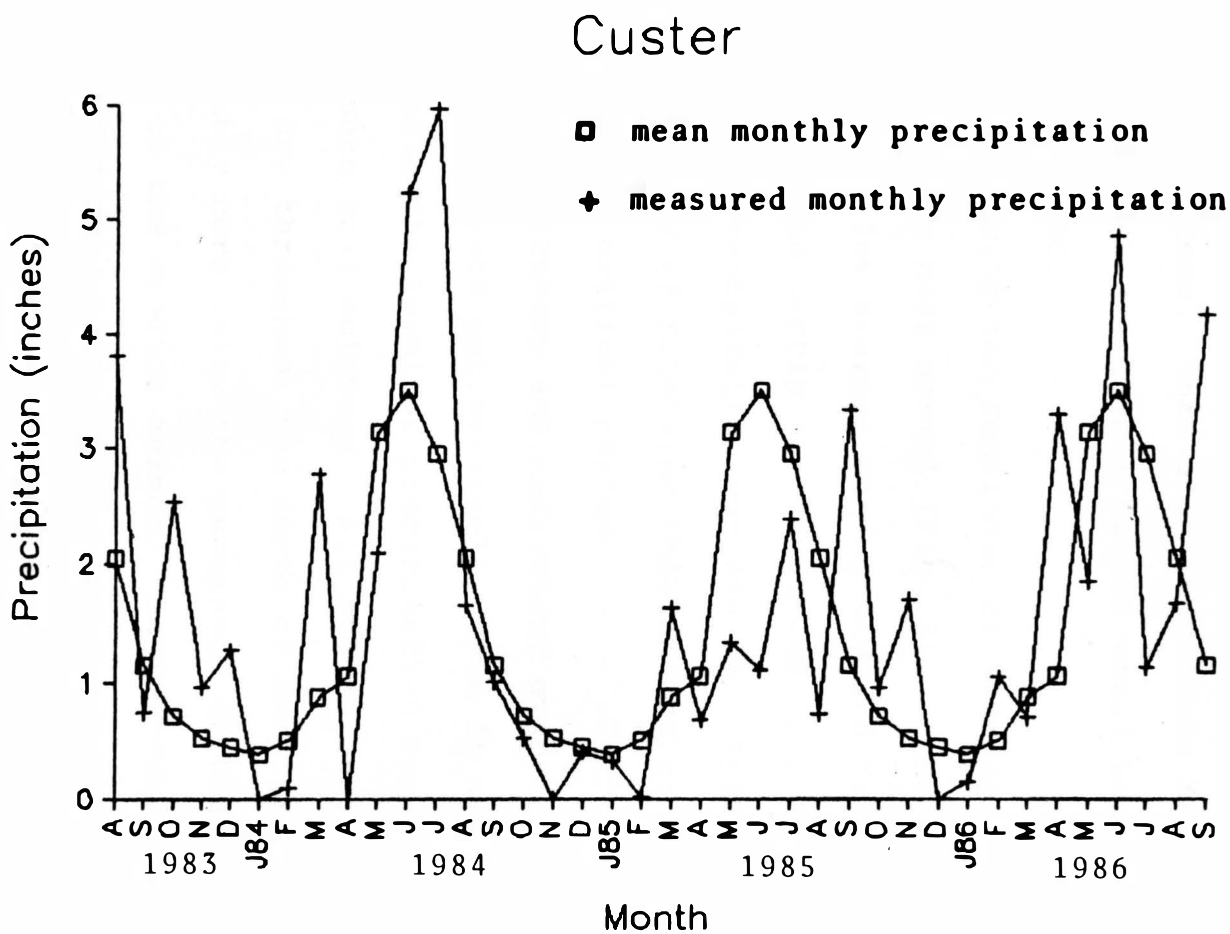

Fig. 7. Mean and actual recorded precipitation at Custer SD by months during the period August 1983 through September 1986.

84 mm of precipitation fell during the critical period, which corresponds to a 4% probability of receiving this amount or less. This also represents the percentage of years that the critical period would be as dry or drier than in 1985.

During the remainder of 1985 and 1986 precipitation returned to near normal (Fig. 8). Precipitation was only sharply below average during May and July of 1986. Although the precipitation during May was quite low, the critical precipitation was 260 mm. This relates to a 44% probability of receiving this amount or more precipitation during the critical period.

Overstory and understory evapotranspiration estimates were not available, thus it was not possible to estimate the level of precipitation required to provide adequate soil moisture. All pedons excavated during 1985 were dry throughout the depth of sampling. These sites probably were below the permanent wilting point (PWP) for much of the growing season. During June 1986, schist soils were observed to be moist throughout the pedons except in the surface. Granitic soils were observed to be dry throughout. This indicates that the granitic soils are less efficient in storing precipitation for plant use.

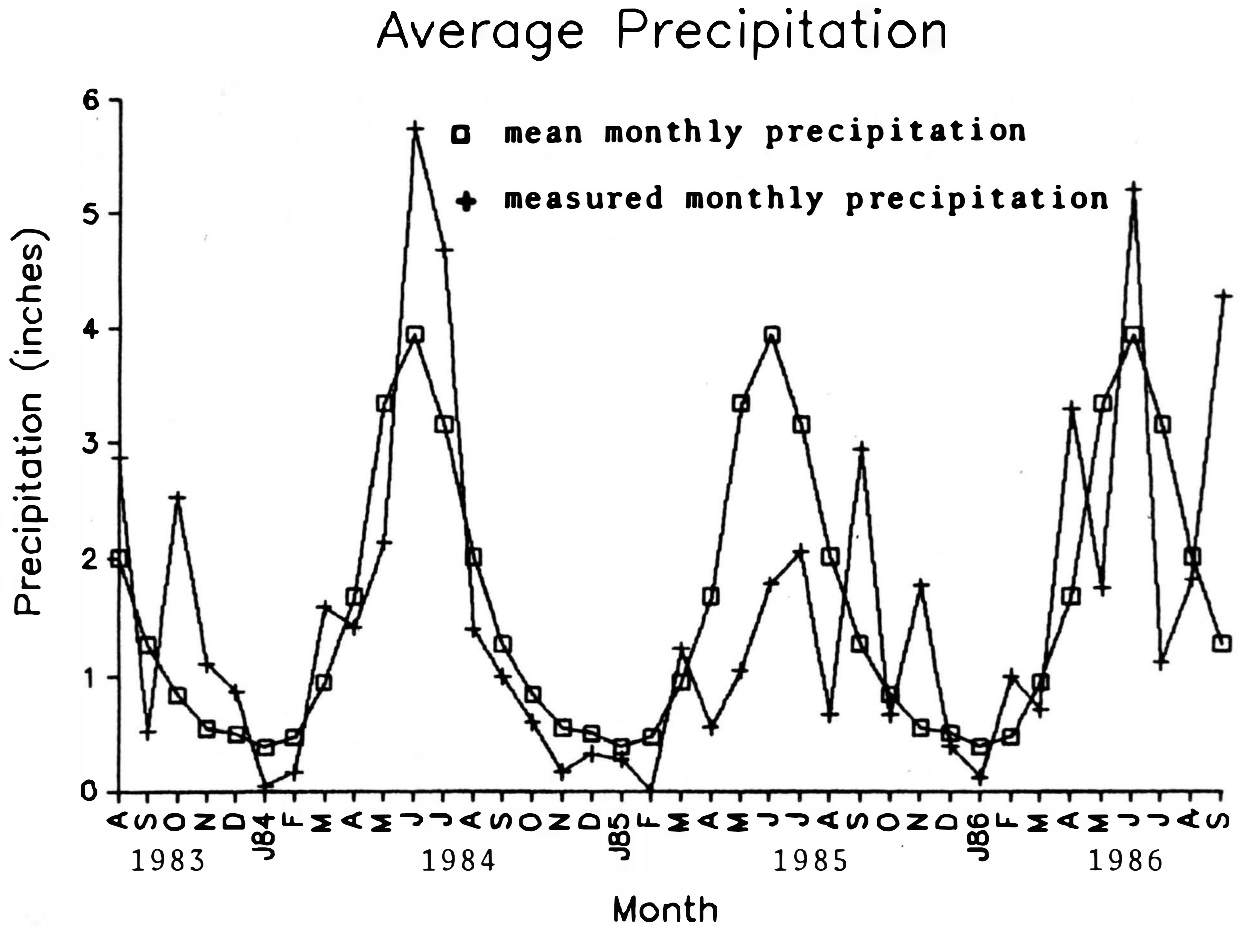

Fig. 8. Means of the recorded precipitation at Custer and Mt. Rushmore by months during the period August 1983 through September 1986.

Soil Properties

As mentioned above, there may be differences between soils in ability to store water. Soil texture and to a lesser extent organic matter content control the plant available water holding capacity (PAWC) of these soils. Sandy loam and loamy sand textures dominate the studied pedons, and have a mean water holding capacity of 0.09 and 0.06 mm/mm respectively (Fig. 9).

Argillic horizons, being an accumulation zone of illuvial silicate clays, increase the PAWC of the Alfisol soils as compared to the Inceptisols. The granitic Alfisols and the schist Alfisols have a mean PAWC for the pedon of 78 mm and 96 mm respectively. The Inceptisols have a mean PAWC of 40 mm and 49 mm respectively for the granite and schist soils. The increase in PAWC from the Inceptisols to the Alfisols comes from the argillic horizon and the effects of weathering on the particle size distribution (see Particle Size Distribution section). Schist soils also have a slightly higher PAWC as compared to the related granitic soils. This is a result of the schist soils being dominated by fine sands (0.25 to 0.1 mm) and the granitic soils dominated by coarse sands (1 to 0.5 mm).

The daily precipitation record (U.S. Dept. of

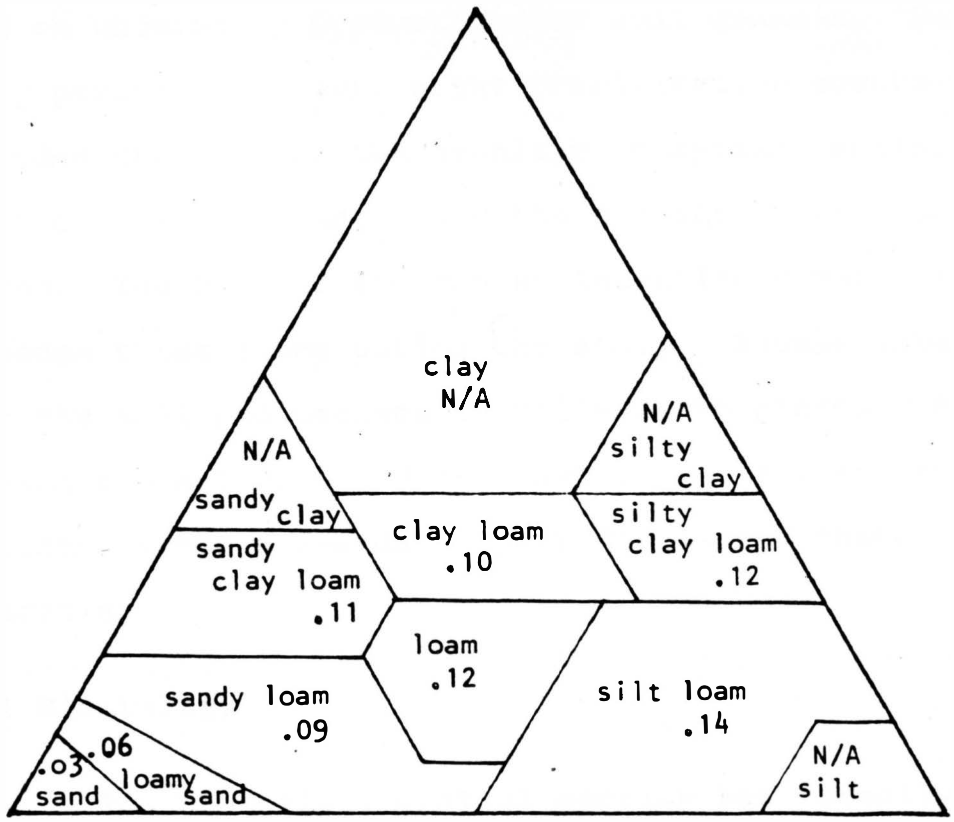

Fig. 9. Soil water holding capacity (mm/mm) by soil texture using 0.3 and1.5 MPa pressure on disturbed samples. Assumes a bulk density of 1.3 and corrected for organic matter content. silt loam, silty clay loam, and sandy clay loam texture classes had a limited number of observations in their mean.

Commerce 1963-present) exemplifies the influence of soil PAWC on understory production and soil genesis. During the study period there were eight precipitation events which exceeded the PAWC of the granitic Inceptisol soils. One of these events occurred during the droughty 1985 growing season. The PAWC of the schist Inceptisols was also exceeded three times during the study. Excess water drains from the soil and becomes unavailable to plants. Although no single event exceeded the PAWC of the Alfisol soils, separate events a few days apart did exceed these capacities.

Soil Mineralogy

The mineralogy control section has formally been the same as the control section used in particle-size class determination (Soil Survey Staff 1975). For the Buska and Mocmont soils this corresponded to the mineralogy of a selected size sand fraction from the argillic horizon. Present mineralogy classes for the Buska and Mocmont series are micaceous and mixed respectively. The mineralogy control section of the unnamed Inceptisol soils consists of the segment of soil from the base of the epipedon to a lithic contact or 1 m, whichever is shallower.

A three-tier mineralogy control section has been used in this study as proposed by Kittrick (Soil Sci Soc Am

1985). The surface control section consists of the segment of soil from the mineral surface to the base of the epipedon or a depth of 0.25 m, whichever is deeper. The subsoil control section starts at the base of the surface control section and extends to the depth of 1 m or a shallower lithic contact. This section most closely corresponds to the traditional mineralogy control section. Soil material below 1 m to a depth of 2 m or a shallower lithic contact is considered to be the substratum control section.

All of the control sections sampled in the Buska soils contained greater than 40% micaceous minerals. Using these new control sections, the Buska soil would continue to be classified in the micaceous mineralogy family. The percentage of mica increases in the finer particle size classes and with depth within a particle size class. This is considered to be evidence that physical breakdown of micaceous minerals is an important pedogenic process in these soils.

Mineral classification of the unnamed schist Inceptisols was also micaceous throughout the pedons. Mica percentages indicate the same trends within and across particle sizes as were evident in the Buska soils. Inceptisols however, had higher mica contents, particularly in the coarse sand fraction, indicating that physical weathering has not proceeded to the same extent. These unnamed soils are considered to be chronologically younger, precursors to the Buska series. This can not be proven using mineral weathering ratios because of the effects of physical weathering (St. Arnaud and Whiteside 1963).

Pedons of the Mocmont series had substantially more variation in mineralogy than the Buska series. It was originally classified as having mixed mineralogy. Pedon mineralogy in this study ranges from Siliceous (>90% Quartz) to Micaceous (>40% mica). The majority of the control sections classify as mixed mineralogy. Surface control sections often classify as micaceous as a result of physical weathering causing the fine sand fractions to dominate the particle size distribution. The micaceous minerals quickly break down and concentrate in the finer sand fractions. An inherently high mica content throughout the profile is also a possibility. Siliceous mineralogy classes are associated with the most strongly developed Mocmont pedons. This suggests that physical and chemical weathering is responsible for removing the mica and other less resistant minerals. As a result of the physical disintegration of mica in the coarse sand fractions quartz is concentrated near the surface. Deeper in the profile, quartz decreases relative to mica in the absence of intensive weathering processes. The fine sand fractions near the surface are diluted by the accumulation of mica. The most strongly developed profiles follow these trends, but further weathering has also removed the mica from the fine sand fraction near the surface.

Mixed mineralogy classes dominate the unnamed granitic Inceptisols. The coarse sand quartz percentage generally decreases from the surface to the C horizon. Other trends in the mineralogy are not clear. This is a result of the variability in the parent material.

Kittrick's proposed subclasses for the mixed mineralogy class were also used in this study. This converts the mixed mineralogy class from a catch-all term to a logical sequence of mineralogy classes. In reality, there exists a continuum between the micaceous, mixed, and siliceous mineral classes. The mixed-micaceous (20 to 40% mica), mixed-moderate quartz (40 to 80% quartz), and mixed-high quartz (80 to 90% quartz) subclasses better describe the variability of the granitic soils than the traditional mineralogy classification. These sub-classes are justified because the ratio of mica to quartz can have a substantial influence on soil properties. Mineralogy did not consistently relate to understory production (see Mineralogy and Understory Production section), however its influence on pedogenesis has been shown above. Engineering characteristics of coarse textured soils have also been shown to be influenced by the physical properties of mica (Gilroy 1928, Johnson et al. 1969, and Moore 1971). The mineral percentages and classification of individual pedons are reported in appendix II.

Particle Size Distribution

Within the granitic Inceptisols, C horizons are unimodal with the maximum in the coarse sand fraction (1 to 0.5 mm) or the very coarse sand fraction (2 to 1 mm) (Fig. 10). Some thin pedons show evidence of a second weak peak with its maximum in the coarse silt fraction (0.05 to 0.02 mm). The effects of intense weathering processes which occur near the surface influence the C horizon in these soils.

Cambic horizons are generally bimodal. The coarse population (maximum 2 to 0.5 mm) dominates with a finer population (maximum 0.05 to 0.02 mm) expressed to differing degrees (Fig. 10). The strength of the finer population is an expression of the degree of physical weathering. This is also reflected in the epipedon.

Bimodal distributions are strongly expressed in the A and E horizons of these granitic Inceptisols. In the less developed pedons (CSP17 and CSP22) the particle size distribution is dominated by a population with its mode in the very coarse sand fraction. The finer peak becomes

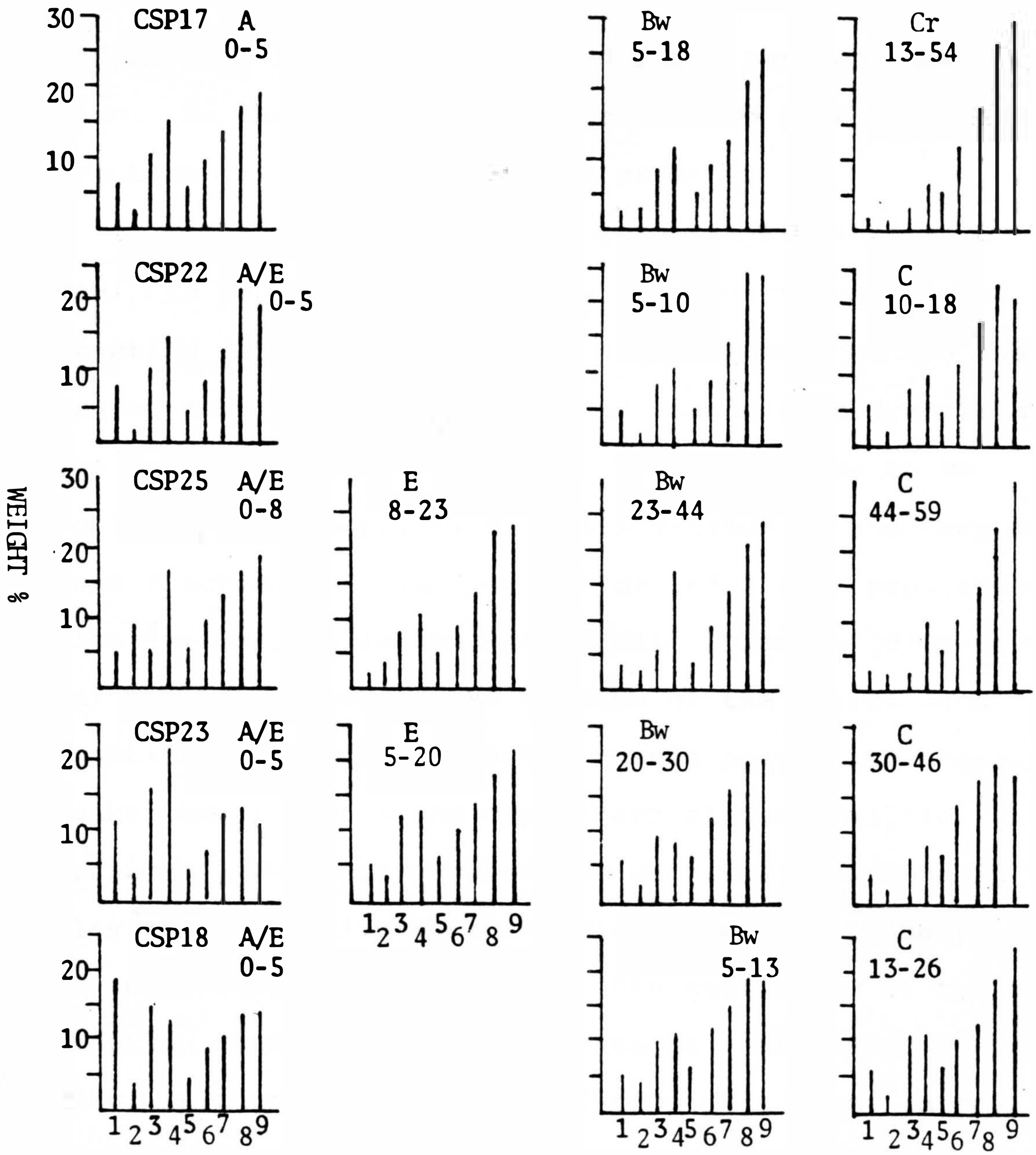

Fig. 10. Particle size distribution histograms of key horizons in Inceptisol soils developed in granite parent material. 1 clay (<0.002mm), 2 fine silt (0.005 to 0.002mm), 3 medium silt (0.02 to 0.005mm), 4 coarse silt (0.05 to 0.02mm), 5 very fine sand (0.1 to 0.05mm), 6 fine sand (0.25 to 0.1mm), 7 medium sand (0.5 to 0.25mm), 8 coarse sand (1 to 0.5mm), and 9 very coarse sand (2 to 1mm).

codominant as in pedon CSP25, and eventually dominate as in pedons CSP23, and CSP18 with advanced physical disintegration. In the latter two pedons a third peak in the clay fraction (< 0.002 mm) also is present.

The C horizons in the granitic Alfisols also have a dominate population in the coarse or very coarse sand fraction (Fig. 11). There is also evidence of two weak apexes developed in the clay and coarse silt fractions. The argillic horizon of pedon CSP11 continues to be dominated by a population with a maximum in the very coarse sand fraction. A clay population and a weak population with its maximum in the medium silt fraction (0.02 to 0.005 mm) have developed at the expense of the coarse sand fraction. In pedon CSP28 the coarse population becomes weaker and finer in the upper part of the argillic horizons. Two weak populations with their maximum in the clay and the medium silt fractions are also present. In advanced stages of weathering, the coarse end of the sand fraction continues to deteriorate as represented in pedon CSP8. Although a coarse population is present in the Bt2 horizon, it is suppressed to an increasing degree in the Bt1 and B/E horizons. The clay and coarse silt apexes of pedon CSP8 replace the coarse population in these upper argillic horizons.

The A and E horizons of pedons CSP11 and CSP28

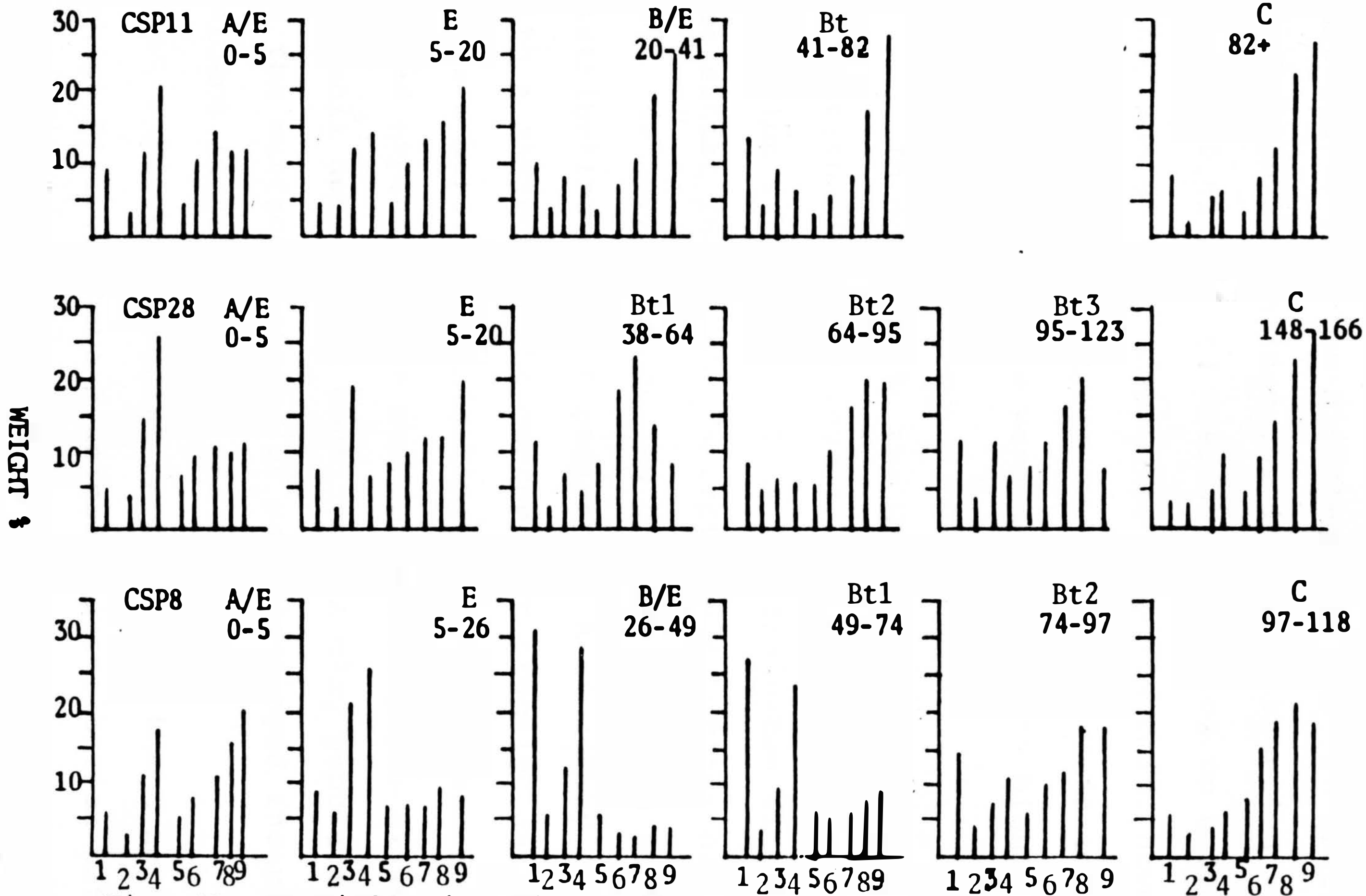

Fig. 11. Particle size distribution histograms of key horizons in Alfisol soils developed in granite parent material. 1 clay (<0.002mm), 2 fine silt (0.005 to 0.002mm), 3 medium silt (0.02 to 0.005mm), 4 coarse silt (0.05 to 0.02mm), 5 very fine sand (0.1 to 0.05mm), 6 fine sand (0.25 to 0.1mm), 7 medium sand (0.5 to 0.25mm), 8 coarse sand (1 to 0.5mm), and 9 very coarse sand (2 to 1mm).

continue to show the disintegration of the coarse population and an increase in a silt fraction (CSP8 maximum 0.05 to 0.02 mm, and CSP28 maximum 0.02 to 0.005 mm). The E horizon of pedon CSP8 also supports this, however, the A/E horizon has a strong coarse mode. This is a result of cumulization of slope wash material from higher landscape positions.

In contrast to the granitic Inceptisols, a coarse population with a maximum in the fine sand (0.25 to 0.1mm) or medium sand (0.5 to 0.25 mm) dominates all horizons of the schist Inceptisols except the A horizon of CSP13 (Fig. 12). Bw horizons show few changes from the particle size distribution of the C horizons. A secondary population with a maximum in the coarse silt fraction develops in the A and E horizons. This finer population becomes stronger at the expense of the coarse mode as physical weathering and soil development continue. A clay population is formed in the surface horizons of well developed Inceptisols as evident in pedons CSP30 and CSP13.

Micaceous schist saprolite in the C horizons of the schist Alfisols have a unimodal distribution with a maximum in the medium sand fraction (Fig. 13). A very weak clay population exists in the transitional BC horizons along with the coarse mode similar to that in the C horizons.

Pedons CSP42 and CSP16 show a marked reduction in

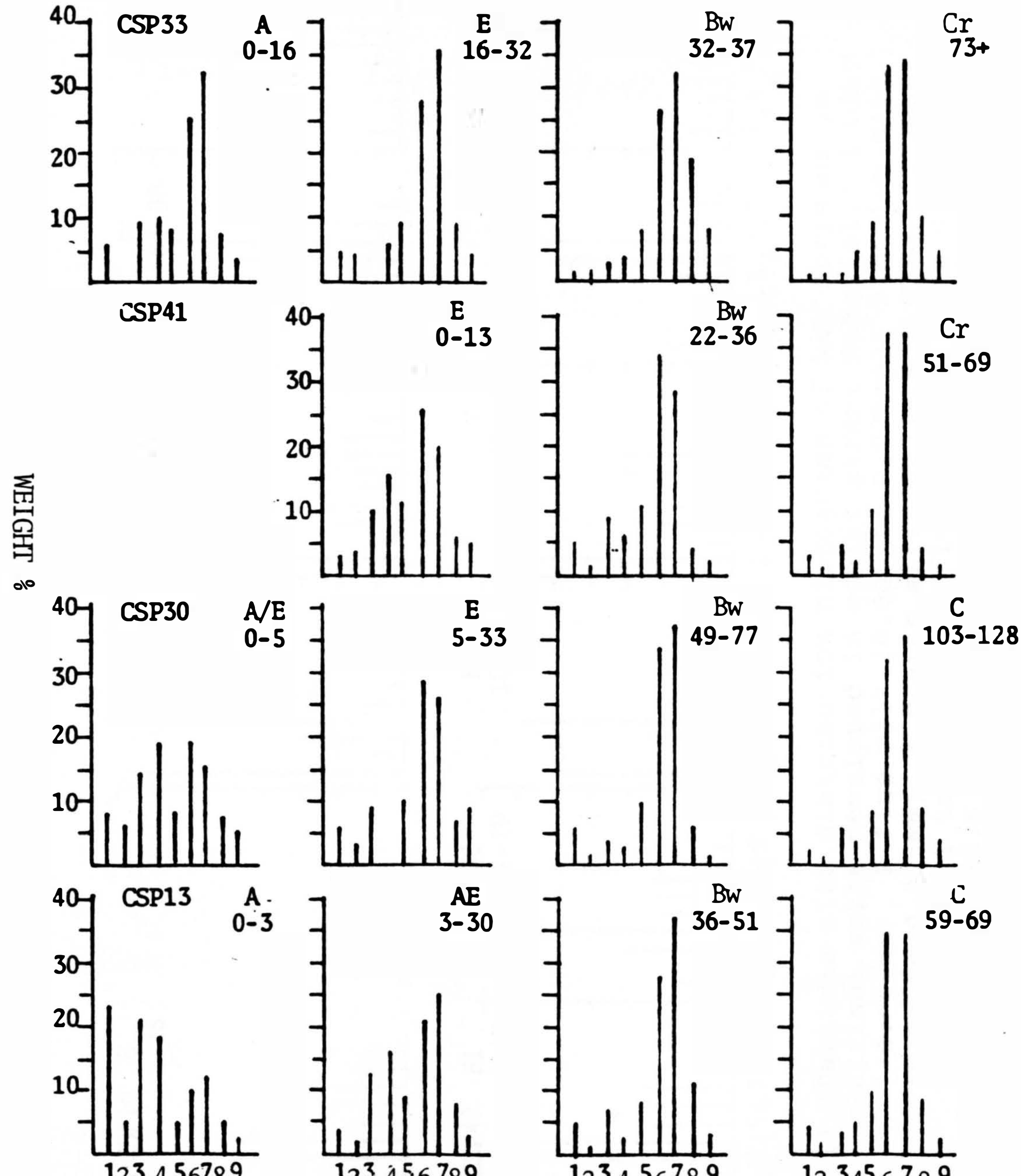

Fig. 12. Particle size distribution histograms of key horizons in Inceptisol soils developed in schist parent material. 1 clay (<0.002mm), 2 fine silt (0.005 to 0.002mm), 3 medium silt (0.02 to 0.005mm), 4 coarse silt (0.05 to 0.02mm), 5 very fine sand (0.1 to 0.05mm), 6 fine sand (0.25 to 0.1mm), 7 medium sand (0.5 to 0.25mm), 8 coarse sand (1 to 0.5mm), and 9 very coarse sand (2 to 1mm).

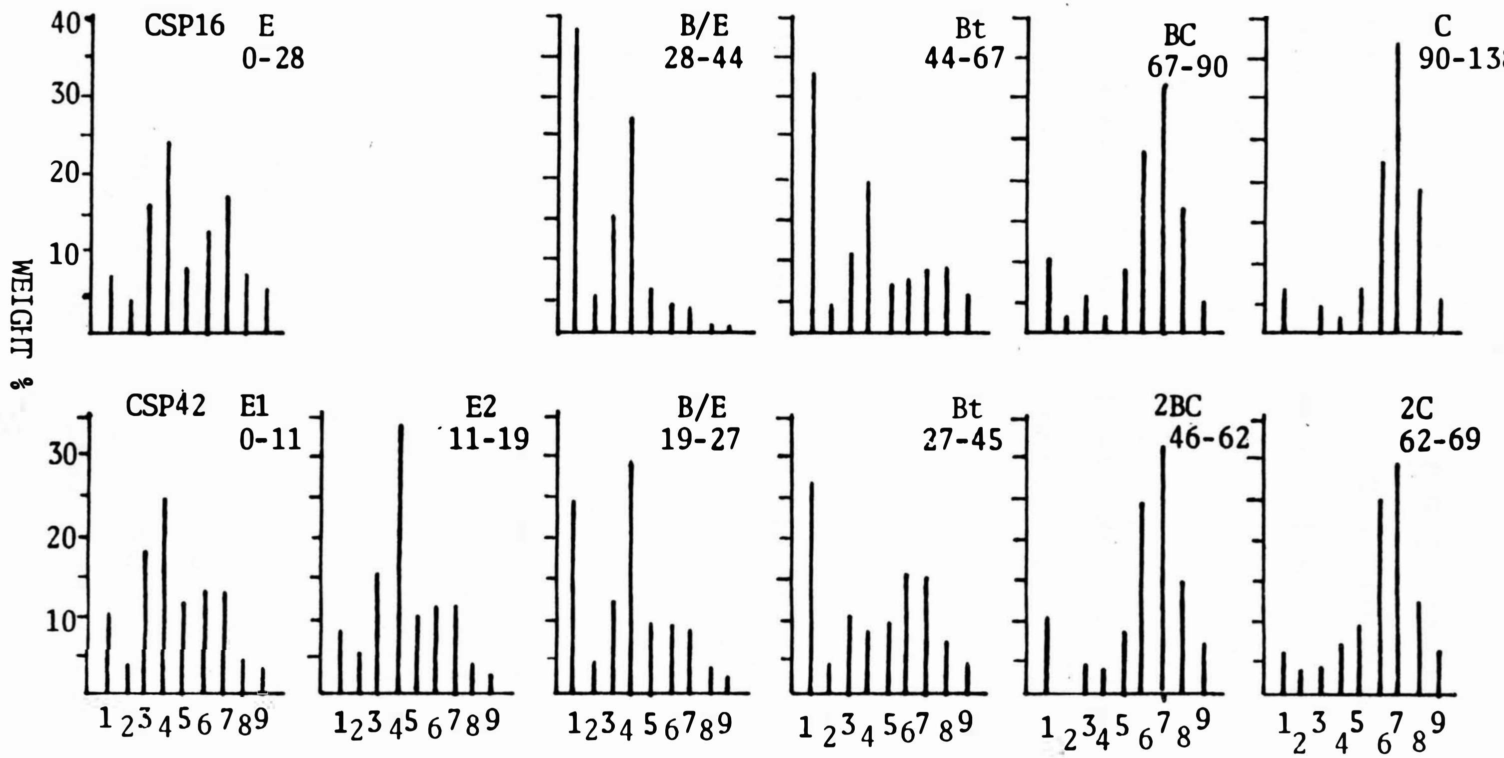

Fig. 13. Particle size distribution histograms of key horizons in Alfisol soils developed in schist parent material. 1 clay (<0.002mm), 2 fine silt (0.005 to 0.002mm), 3 medium silt (0.02 to 0.005mm), 4 coarse silt (0.05 to 0.02mm), 5 very fine sand (0.1 to 0.05mm), 6 fine sand (0.25 to 0.1mm), 7 medium sand (0.5 to 0.25mm), 8 coarse sand (1 to 0.5mm), and 9 very coarse sand (2 to 1mm).

the sand content of the Bt horizons. Pedon CSP42 has a substantially smaller coarse population (maximum 0.5 to 0.25 mm), a weak fine population (maximum 0.02 to 0.005 mm), and a strong clay population (< 0.002 mm). The coarse population is totally replaced in the Bt horizon of pedon CSP16 by the clay and coarse silt fractions.

A population with its maximum in the coarse silt fraction dominates the E horizons of the schist Alfisols. Pedogenic clay has been eluviated out of these horizons and thus the medium sand fraction peak becomes prominent again. This coarse population is now secondary and is substantially weaker than it had been in the saprolite material.

Soil Genesis

The shifts in particle size distribution from the C horizons to the surface, and from the Inceptisols to the Alfisols indicate that the sand fractions are not inert to weathering processes. Physical weathering is the dominate force that acts to reduce the coarse sand population to form the silt size population. Kittrick (1985) reported this for micaceous soils, and Santos et al. (1986) reported it for Boralfs in east central Saskatchewan.

It was indicated above that the Inceptisol pedons in advanced stages of weathering (CSP13, CSP23, and CSP18) show clay development in the surface horizons. The Alfisols show a reduction of clay population in the surface and a substantial increase in the subsurface. The clay depth function (Fig. 14 and 15) indicate an accumulation of clay in the Bt horizons of the Alfisol soils. Field observation of clay skins and bridges confirm clay has been translocated from the epipedon. This indicates that the process of lessivage is an important factor in the pedogenesis of the Mocmont and Buska series.

Melanization and leucinization are two processes important in determining the morphology of the epipedon. Melanization is responsible for darkening of mineral material to form A or A/E horizons in 75% of the pedons studied. E horizons were found at the surface of the remaining pedons. The presence, absence, or thickness of an A horizon was not related to soil order, parent material, or slope position. Surface erosion may have truncated the A horizon on some pedons. The presence of O horizons directly above E horizons and A horizons on shoulder positions, suggest that erosion is not the only explanation. Epipedons with moderately well developed A horizons may be remnants of chernozem soils (Mollisols) developed under past climatic and vegetation regimes (Radeke and Westin 1963). This hypothesis suggests that the A horizons are being degraded by the leucinization

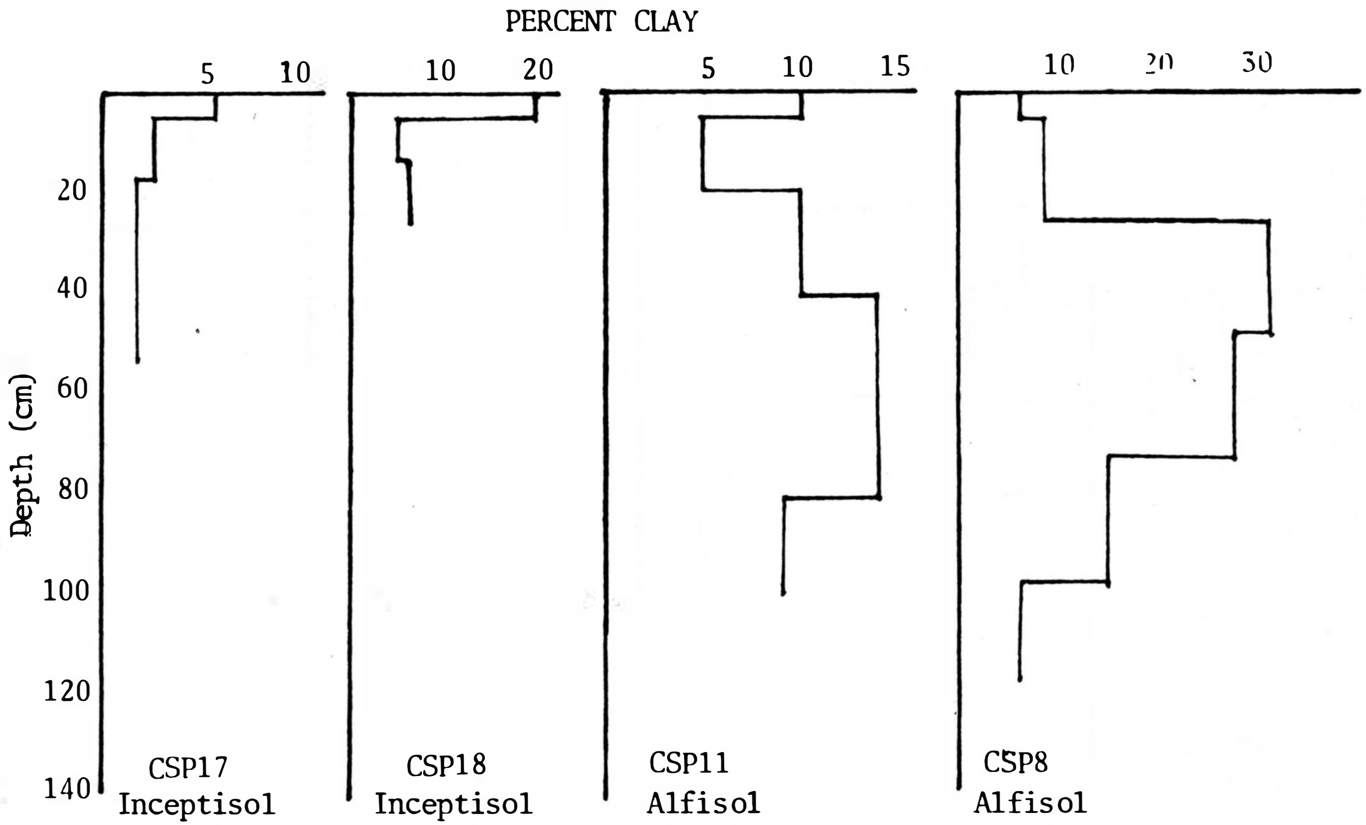

Fig. 14. Clay-depth functions of selected granitic Inceptisols and Alfisols.

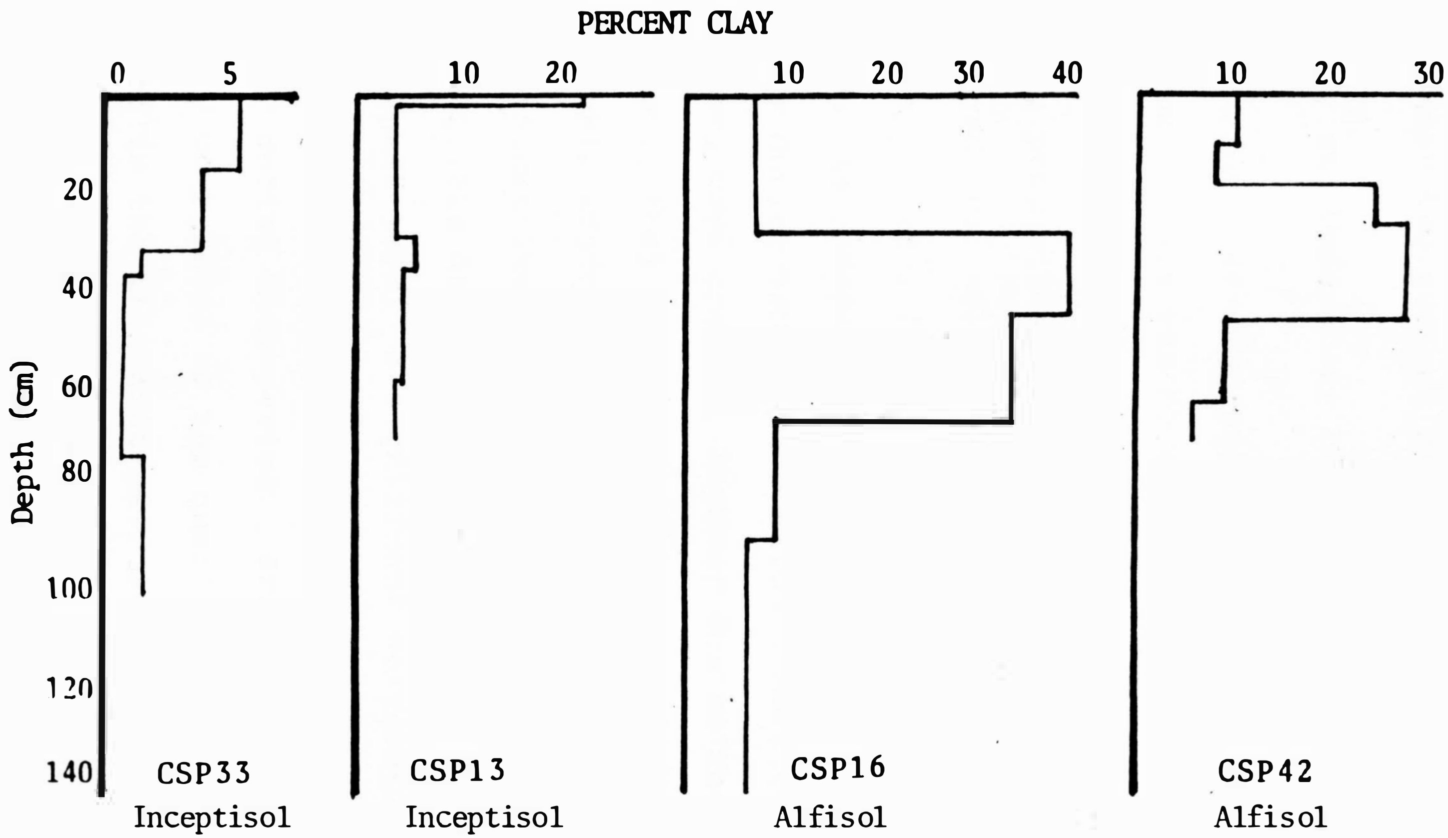

Fig. 15. Clay-depth functions of selected schist Inceptisols and Alfisols.

process under the present climate and vegetation regime.

Mineralogy and Understory Production

During 1984 when precipitation was only slightly below normal, there was no significant correlation between mineralogy of any of the mineral control sections and understory production. Correlation coefficients for the solum ranged from -0.08 to 0.09. Because these values are very close to zero, it was concluded that understory production was independent of surface and subsurface mineralogy during 1984. Substratum mineralogy correlation coefficients were greater, however due to the low number of observations, they were not significant during any of the years of this study. Mineralogy-understory production correlation matrixes are reported in Appendix III.

A severe drought began in August 1984 and continued through August 1985. A significant correlation was found between graminoid and shrub production and surface mineralogy during this period. Graminoid production was negatively correlated to the quartz content, and positively correlated to the mica content. Increased production as mica content increases is related to the finer texture which in turn increases the PAWC. The relationships between shrub production and surface mineralogy were opposite of those between graminoid production and surface mineralogy. One explanation of the negative correlation with mica is that shrubs (predominately Kinnickinick) may be more drought tolerant than the other vegetation classes. Graminoids can not get established on the droughty high quartz soils. Shrub production may be greater on these high quartz soils than on soils with higher PAWC's due to a lack of competition from graminoids. The negative correlation with mica content is not believed to be related to an increase in nutrient bearing mineral. The reason being that the relationship with quartz is equally as strong in the opposite (+) direction. The only significant correlation in the subsoil was between shrub production and quartz content. This again may be a reflection of the edaphic adaptations of the shrubs. Because correlation does not necessarily indicate a causal relationship, the correlation between shrub production and mineralogy may also be a coincidence. Correlation coefficients for total vegetation and forb production were again very close to zero and indicate independence between production and mineralogy.

Precipitation levels returned to near normal in 1986. Total production and forb production were again shown to be independent of surface or subsurface mineralogy. The relationships between shrub production and mineralogy returned to non-significant levels. Shrub production responds positively to the increased available water on the low and medium quartz soils even though there is competition from graminoids. Water remains as the limiting factor on the high quartz soils. The non-significant correlation is a result of this variability. Graminoid production and surface mineralogy (+ mica, and - quartz) was the only significant correlation remaining. Although precipitation was near normal, there was a strong deficit in May and July. Considering the possible residual water depletion from 1985, there does not seem to be a direct relationship between understory production and soil mineralogy. Instead, mineralogy influences particle size distribution, which in turn affects PAWC.

Site-Understory Relationships

Canopy cover categories were arbitrarily set at 0 to 25%, 25 to 50%, and >50%, for the open, moderate, and dense canopies respectively. Actual measurements of canopy cover ranged from a low of 2% to a high of 98% in a dog hair stand (Appendix I). Each category included sites representative of each soil type. The mean canopy cover of the schist soils (52%) is greater than that for the granitic soils (33%). Excluding the three sites in a dog hair stand, the schist soils would have very similar ranges in canopy cover to the granitic soils.

Basal area is a measure of the standing timber in a forest stand. This measurement is quick and easy, and has been highly correlated with canopy cover. Canopy cover can be replaced by basal area to model understory production (Halls and Schuster 1965, Jameson 1969, and Bennett 1984). This also became evident in our data during the modeling process. Bennett (1984) regressed canopy cover against basal area in ponderosa pine stands in the Black Hills. The resulting model (Eq.[5]) converts basal area measurements to canopy cover and vice-versa.

Eq.[5] canopy cover = 0.51(basal area) - 1.94

Measured basal area ranges from 10 to 280 ft^2/acre in Custer State Park. Dog hair stands had the highest basal areas. These extremely high basal areas misrepresent the overstory production due to the low percentage of merchantable timber. Understory production however, is accurately portrayed under these conditions.

The standard slash management practice employed in Custer State Park is to lop and scatter to 0.45 m (18 in). This is for fire protection purposes alone, and slash is only piled and burned when slash levels reach dangerously high energy levels or in fire break areas. Areas with heavy slash would logically be expected to adversely effect the understory growth as long as the slash remains on the surface. Stumps which are partly buried and slash that is in contact with the soil on northern and eastern aspect slopes, partly decomposes in three to five years. Summer sun dries and cures the slash on the southern slopes slowing the decomposition process. Slash cover categories were set at 0 to 25, 25 to 50, and >50 t/ha, for the low, medium, and high slash levels respectively. Slash levels ranged from near zero to well over 100 t/ha on both granitic and schist soils. In the Black Hills, levels greater than 75 t/ha are considered to be extremely high (D. Spark 1986, personal communication).

The negative affect of canopy density on understory production is well illustrated in Table 4. Within any column the total understory production decreases as canopy cover increases. This is in agreement with research by many authors throughout the western United States (Clary and Larson 1971, Harris 1954, McConnell and Smith 1970, and Pase 1958). This suggests that forest stand thinning produces a release response in the understory vegetation. Table 4 also indicates that slash levels effect understory production. As slash levels increase within a canopy cover class, a loss of total understory production is recognized. These trends imply that slash left from thinning and timber harvest operations suppresses the understory response to forest stand thinning. The influence of canopy density and

Table 4. Mean total understory production by slash cover and canopy cover categories over three years.

		Slash cover (t/ha) 0 - 25	25 - 50	> 50
		kg/ha		
Canopy cover %	0 - 25	177.50 (9)	146.35 (6)	131.36 (21)
	25 - 50	113.94 (16)	97.25 (17)	83.07 (19)
	> 50	1.67 (3)	69.94 (7)	6.20 (11)

number of observations in each mean is shown in parenthesis
observations = sites * years

Table 5. Mean graminoid understory production by slash cover and canopy cover categories over three years.

		Slash cover (t/ha) 0 - 25	25 - 50	> 50
		kg/ha		
Canopy cover %	0 - 25	40.20 (9)	9.56 (6)	52.34 (21)
	25 - 50	78.22 (16)	65.80 (17)	59.23 (19)
	> 50	1.67 (3)	10.82 (7)	6.18 (11)

number of observations in each mean is shown in parenthesis
observations = sites * years

slash levels compound each other as both independent variables increase. The yield under low slash and dense canopy cover fails to follow these trends. This is a result of the difficulty in finding adequate numbers of sites to represent each canopy-slash class. When final site measurements were made, only one site classified into the low slash-dense canopy class. This site was an unthinned dog hair stand. These sites have extremely dense canopies and typically have higher slash levels and almost no understory vegetation. Thus dog hair stands do not accurately represent the production conditions under a dense canopy with a low slash level. Understory production of individual sites is reported in Appendix IV.

These same trends can be identified in the individual vegetation classes (Table 5, 6, and 7). These trends are not consistent due to small sample sizes which misrepresent the understory production of some cells. Due to the vast number of independent forest and soil variables, it was not possible to sample enough sites to account for all the variation.

Some of the inconsistencies in these tables are caused by one or more categories being dominated by only a few site factors. Table 8 shows the understory production of the four vegetation classes by slope aspect. In general the northern and eastern aspects tend to out-produce the

Table 6. Mean forb understory production by slash cover and canopy cover categories over three years.

Canopy cover %	Slash cover (t/ha) 0 - 25	25 - 50	> 50
	kg/ha		
0 - 25	8.83 (9)	22.78 (6)	20.59 (21)
25 - 50	6.21 (16)	2.14 (17)	2.12 (19)
> 50	0.00 (3)	0.00 (7)	0.02 (11)

number of observations in each mean is shown in parenthesis
observations = sites * years

Table 7. Mean shrub understory production by slash cover and canopy cover categories over three years.

Canopy cover %	Slash cover (t/ha) 0 - 25	25 - 50	> 50
	kg/ha		
0 - 25	128.46 (9)	114.01 (6)	58.43 (21)
25 - 50	29.50 (16)	29.30 (17)	21.69 (19)
> 50	0.00 (3)	59.12 (7)	0.00 (11)

number of observations in each mean is shown in parenthesis
observations = sites * years

Table 8. Mean and range of vegetation yields by slope aspect over three years.

aspect	total	graminoids	forbs	shrubs
	kg/ha			
North (23)	119.2	59.8	6.0	53.4
	0-449	0-428	0-67	0-273
East (51)	122.2	49.9	12.0	60.3
	0-611	0-570	0-41	0-293
South (20)	26.5	17.8	2.0	6.7
	0-138	0-116	0-16	0-41
West (4)	110.6	7.1	0.0	103.5
	7-220	1-18	0	0-220

number of observations in each mean is shown in parenthesis more droughty southern aspects on these sandy soils. The data for the western aspect is skewed by one site which produced shrub vegetation atypical of other sites with western aspects or other granitic Inceptisols.

Soil order and parent material also influence the quantity and type of vegetation that is produced. Due to the large variation in production caused by the range in canopy density and slash levels within soil types, there were few significant differences among soils (Table 9). Alfisol soils significantly out-produce the Inceptisols in the forb understory class. The total vegetation class follows this same trend with much greater production by the Alfisols than the Inceptisols. Weaker separations occur in the graminoid and shrub classes. These classes segregate more by parent material than by soil order.

Overstory growth shows a marked response to thinning. Canopy cover and basal area were not measured at the time of thinning, however average tree height and age has been measured in cut areas since 1981. Sites thinned in 1981 were left with a mean height of 8.5 m (28 ft) and a mean age of 50 years. These trees had a growth rate of 0.18 m/yr (0.59 ft/yr) after accounting for ten years to reach breast height (4.5 ft). During 1985, site indexes were measured at selected sites. As an example, two trees from different sites within the area cut in 1981. At site

Table 9. Mean understory vegetation yields by soil type over three years.

soil	total	graminoids	forbs	shrubs
	kg/ha			
GA (48)	120.81a	51.60a	12.56a	56.65a
GI (30)	76.84a	18.02a	1.68b	57.14a
SA (11)	138.14a	89.73a	12.06a	36.35ab
SI (19)	64.55a	60.87a	2.08b	1.60 b

Yields in the same column with the same letter were not significantly different in a Duncan-Waller means separation at the 0.1 level.

GA - granitic Alfisols - Mocmont pedons
GI - granitic Inceptisols - unnamed
SA - schist Alfisols - Buska pedons
SI - schist Inceptisols - unnamed

number of observations in each mean is shown in parenthesis

CSP2 a tree was 13.3 m (44 ft) tall at 60 years, and at site CSP31 a tree was 14.9 m (49 ft) tall at 64 years of age. If these trees grew at the mean growth rate (0.18 m/yr) their heights would have been 9.5 m and 10.4 m in 1981 for CSP2 and CSP31 respectively. This leaves 3.8 m and 4.5 m of growth in the four years between thinning in 1981 and site index measurements in 1985. This corresponds to a mean growth rate of 1.04 m/yr after thinning. Other sites showed similar responses in tree growth to thinning. Overstory response to thinning was also noted by the thickening of the annual growth rings in incremental bores taken for the site index measurements (G.M. Simonds 1985, personal communication).

Understory response to thinning was not directly measured because understory yields prior to thinning were not available. This response was discussed under site-understory relationships as the production under varying canopy densities. Like McConnell and Smith (1965), there was insufficient data to draw conclusions on understory response to thinning over time. The data collected thus far is complicated by extremes in precipitation. Responses of individual sites with similar soils and environmental conditions vary greatly not only in quantity but also in composition. Other authors have attributed this to differences in or lack of an available natural seed source

(Bever 1952, Pase and Hurd 1957, and Reid 1964). Broadcasting seeds of desired understory species on thinned, low productive sites may greatly improve the response where a natural seed source is not available.

Understory Production Modeling

Understory herbage production models would be of use in making forestry decisions that may effect wildlife habitats and populations. The relationships discussed above were evaluated for such purposes. Earlier it was shown that vegetation yields vary greatly along with precipitation. Since soil and forest variables are relatively static in the short run, a precipitation term is needed in each model to account for annual variations in production. The best understory prediction models are reported in Table 10. Slash (SL), either basal area (BA) or canopy cover (CC), and a variety of soil variables consistently make up the models.

By inputting the mean critical precipitation, and means of the soil factors, an estimate of the long term productivity under varying basal areas for each soil can be generated (Fig. 16). Although this model can be useful, remember that it generalizes over slash levels. The means of the slash levels used in developing this model were 68, 46, 79, and 58 t/ha respectively for the Buska, Mocmont,

Table 10. Understory vegetation yield prediction models on an individual soil bases.

$$Total = 121.20 - 1.26(BA) - 1.09(SD) - 7.87(CL) + 29.06(WC) - 0.24(P)$$
R^2=.4102

$$Graminoid = 106.48 - 0.27(SL) + 0.75(CC) - 0.20(CC^2) - 0.72(SD) + 74.03(PM) - 58.23(O) + 0.04(P)$$
R^2=.1685

$$Forb = 4.13 + 0.10(SL) - 0.23(BA) + 0.0004(BA^2) - 0.13(SD) + 0.47(SS) - 22.19(O) + 0.04(P)$$
R^2=.4698

$$Shrub = 314.65 + 0.26(SL) - 0.003(SL^2) - 1.03(BA) + 0.002(BA^2) - 2.49(SS) - 9.33(CL) + 0.10(P)$$
R^2=.3290

BA= basal area (ft^2/a), CC= canopy cover (%), O= soil order (alf=0, ept=1), PM= parent material (granite=0, schist=1), SL= slash (t/ha), SS= surface sand content (%), CL= surface clay content (%), SD= solum depth (cm), WC= plant available water holding capacity (cm), P=precipitation (mm).

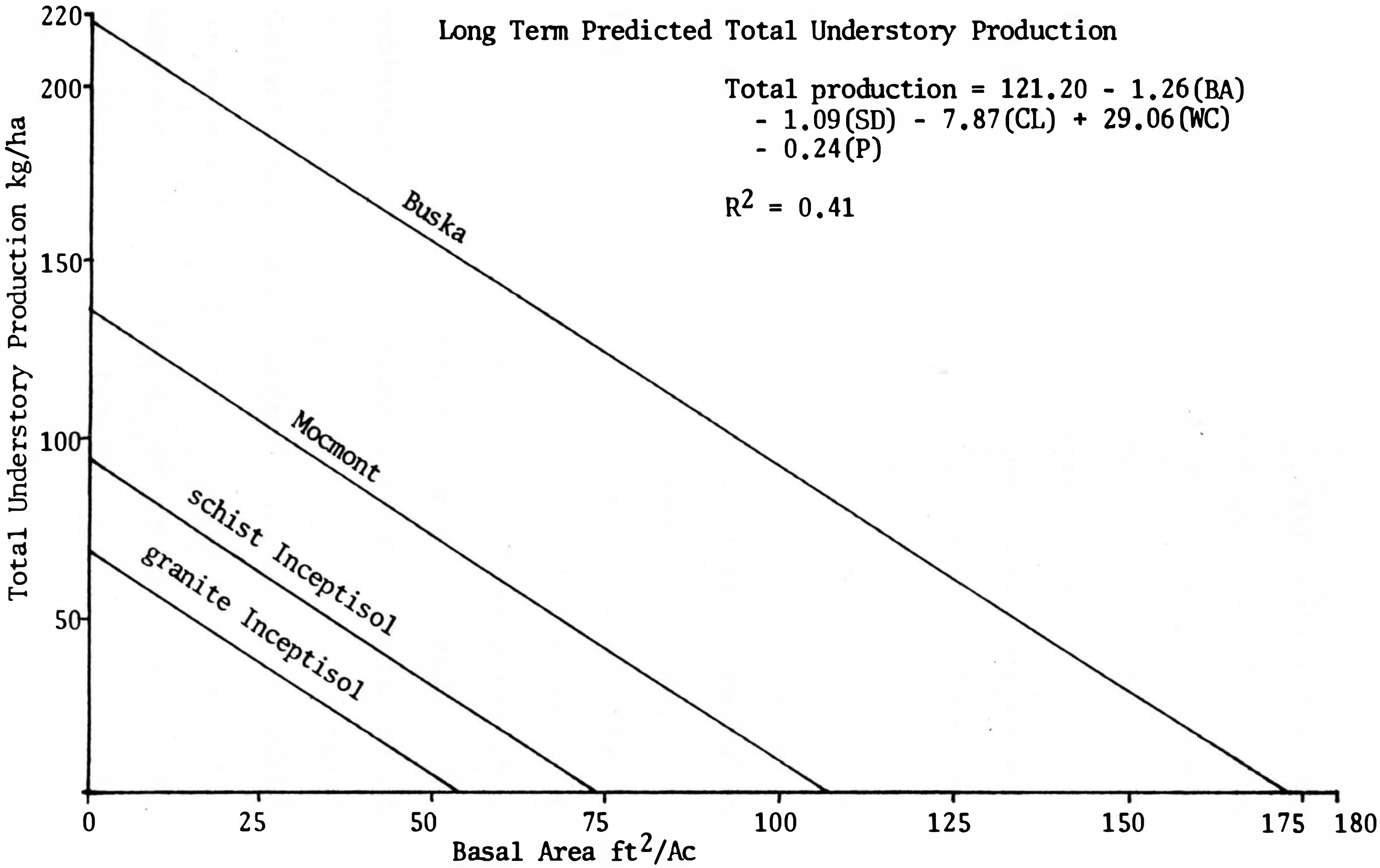

Fig. 16. Predicted understory vegetation production by soil types under varying overstory basal areas.

schist Inceptisol, and granitic Inceptisol soils. It was shown earlier that slash levels have a negative effect on understory production. A reduction in the slash levels would create an upward shift in the predicted production line. This is also illustrated by the models for the individual vegetation classes (Table 10). In these models, slash was found to be an important predictor.

Some degree of collinearity exists among many of the variables in these models, thus the true influence of the variable is not always reflected in its coefficient. In all cases collinearity was not excessive, and the model R^2 was substantially reduced by the elimination of a variable. An increase in basal area (BA), canopy cover (CC), and slash (SL), along with their polynomial components has a large negative influence on the predicted production of all the models. Precipitation is positively related to production, as expected, except in the total production model. Plant available water holding capacity interacts with the precipitation term in this model. This reflects that soils with larger water holding capacities are more efficient at preventing deep percolation. Thus, more water is available and the dependence of large quantities of precipitation to regularly recharge the profile is decreased. Parent material (PM) and/or soil order (O) are used as dummy variables in the graminoid and forb production models. The coefficients are positive for schist parent material and negative for Inceptisols. This follows the trends in understory vegetation production by soil types (Table 9). The physical soil factors, solum depth (SD), surface clay content (CL), and surface sand content (SS) are collinear and their direct influence is not directly evident.

It would be impractical to adjust forest management practices to individual soils because these soils are intertwined at such a small scale. Adapting the models to soils map units would provide adequately large areas for managerial purposes. Models based on soil mapping units can be integrated into the multiple-use management plans of Custer State Park. Foresters and resource managers would be able to identify these soil map units in the soil survey report and by topographic relationships in the field.

Table 11 presents the Buska and Mocmont map units and the composition of individual soils within them. The composition of a map unit varies within the limits set for it. Soil factors used to predict understory production should be flexible enough to reflect the variability of the map unit. New values for the soil factors were calculated using the means of the variable for individual soils. The new value was weighted by the percentage of the map unit

Table 11. Buska and Mocmont soil map units and percentage composition by individual soils (Ensz 1987).

Mapping symbol	Mapping unit and composition	
BuE	Buska-Rock outcrop complex	
	Buska	55 to 60 %
	Rock outcrop	35 to 45 %
	Inceptisols	0 to 20 %
BtE	Buska-Mocmont-Rock outcrop complex	
	Buska	35 to 40 %
	Mocmont	20 to 30 %
	Rock outcrop	20 to 30 %
	Inceptisols	0 to 15 %
MsC	Mocmont gravely loam	
	Mocmont	85 to 95 %
	Rock outcrop	0 to 5 %
	Inceptisols	0 to 15 %
MtE	Mocmont-Rock outcrop complex	
	Mocmont	50 to 65 %
	Rock outcrop	30 to 40 %
	Inceptisols	0 to 20 %
RgG	Rock outcrop-Buska complex	
	Rock outcrop	40 to 50 %
	Buska	35 to 45 %
	Inceptisols	0 to 15 %
RkG	Rock outcrop-Mocmont complex	
	Rock outcrop	40 to 50 %
	Mocmont	35 to 45 %
	Inceptisols	0 to 20 %

each soil occupies. Minimum and maximum values were calculated using the extremes in the map unit composition (Table 12, 13, 14, and 15).

When additional information about a management area is available, the soil factors can be adjusted accordingly. Specifically, a more accurate estimate of the percentage of rock outcrop in a management area guides the adjustments. The logic and direction of adjustment is as follows: as the percent rock outcrop increases, the percentage of Inceptisols increase proportionally, and thus their influence on production increases. This influence is expressed by a decrease in solum depth (SD) and plant available water holding capacity (WC) factors, and an increase in the surface sand (SS) and soil order (O) factors. Surface clay content (CL) is reported only as the weighted mean because map unit composition did not create a measurable difference in the minimum and maximum values.

Modeling Example

Seasonal variation in the diets of deer and elk would determine which model, or set of models is/are appropriate for predicting available forage. Elk consume large quantities of graminoids, although shrubs are important especially for winter forage. For demonstration purposes it is assumed that deer forage dominantly on

Table 12. Soil factors for use in total understory production models based on soil map units.

Mapping Symbol	Solum Depth (SD)	Surface Clay (CL)	Plant Available Water Capacity (WC)	Percent Rock-Outcrop (R)
	-- cm --	-- % ---	--- mm/mm -----	
BuE	48-60	7.8	8.64-9.57	.20-.30
BtE	66-73	7.6	7.98-8.80	.20-.30
MsC	84-91	7.2	7.20-7.77	0-.5
MtE	81-91	7.3	7.01-7.77	.30-.40
RgG	59-60	7.8	8.88-9.57	.40-.50
RkG	81-91	7.3	7.01-7.77	.40-.50

Table 13. Soil factors for use in graminoid understory production models based on soil map units.

Map Symbol	Solum Depth (SD)	Parent Material (PM)	Soil Order (O)	Percent Rock-Outcrop (R)
	-- cm --			
BuE	48-60	1	0-0.20	.20-.30
BtE	66-73	.57	0-0.15	.20-.30
MsC	84-91	0	0-0.15	0-.5
MtE	81-91	0	0-0.20	.30-.40
RgG	59-60	1	0-0.15	.40-.50
RkG	81-91	0	0-0.20	.40-.50

Table 14. Soil factors for use in forb understory production models based on soil map units.

Map Symbol	Solum Depth (SD)	Surface Sand (SS)	Soil Order (O)	Percent Rock-Outcrop (R)
	-- cm --	---- % ----		
BuE	48-60	49-53	0-0.20	.20-.30
BtE	66-73	51-53	0-0.15	.20-.30
MsC	84-91	54	0-0.15	0-.5
MtE	81-91	54	0-0.20	.30-.40
RgG	59-60	49-52	0-0.15	.40-.50
RkG	81-91	54	0-0.20	.40-.50

Table 15. Soil factors for use in shrub understory production models based on soil map units.

Map Symbol	Surface Sand (SS)	Surface Clay (CL)	Percent Rock-Outcrop (R)
BuE	49-53	7.8	.20-.30
BtE	51-53	7.6	.20-.30
MsC	54	7.2	0-.5
MtE	54	7.3	.30-.40
RgG	49-52	7.8	.40-.50
RkG	54	7.3	.40-.50

shrubs and forbs although graminoids make up a significant component of their diet (Currie et al. 1977). The total understory production model would be most appropriate (table 10) for predicting forage production for deer.

A hypothetical, 325 ha forest management area containing the following soil map units (200 ha BtE, 75 ha BuE, and 50 ha RkG) will be used in this example. The composition of each map unit is outlined in Table 11. "Field observations" suggest that the Buska-Mocmont-Rock outcrop complex (BtE) has fewer rock outcrops than are typical for this map unit. Areas of the Buska-Rock outcrop complex (BuE) and the Rock outcrop-Mocmont complex (RkG) contain a greater number of rock outcrops than these map units in other areas. These observations were used to adjust the soil factors used in the prediction model. Solum depth and plant available water holding capacity are adjusted upwards when the Rock outcrops percent is low, and downwards as the Rock outcrops percent increases.

The critical precipitation (April + May + June) was assumed to be 290mm (53mm above average). It is likely that forest stand densities would be similar within soil map units. Mean canopy covers are assumed to have been measured to be 40%, 60%, and 20% for the BtE, BuE, and RkG map units respectively. Bennett's (1984) canopy cover-basal area model (Eq.[5]) converts the canopy cover measurements to basal areas of 74, 114, and 35 ft^2/acre respectively for the BtE, BuE, and RkG map units.

Using the parameters set up for the management area above, total understory production can be predicted for each map unit (Table 16). The total understory production model is modified to account for the percentage of Rock outcrops by reason that the outcrops do not produce understory vegetation. The mean total understory production of the management area is calculated as mean production of the map units weighted by the hectares of each soil map unit. By working through this model, it is found that the hypotetical management area has a mean understory production of 48 kg/ha. Forest stand thinning could then be planned if it is desired to improve the understory production in this area.

Table 16. Work sheet for predicting total understory production of a hypothetical forest management area.

Total =[121.20 - 1.26(BA) - 1.09(SD) - 7.87(CL) + 29.06(WC) - 0.24(P)] (1 - R)

<u>BtE map unit</u>

=[121.20 - 1.26(74) - 1.09(72) - 7.87(7.6) + 29.06 (8.75) - 0.24(290)] (1 - 0.21)

= **58 kg/ha**

<u>BuE map unit</u>

=[121.20 - 1.26(114) - 1.09(50) - 7.87(7.8) + 29.06 (8.70) - 0.24(290)] (1 - 0.28)

= **32 kg/ha**

<u>RkG map unit</u>

=[121.20 - 1.26(35) - 1.09(81) - 7.87(7.3) + 29.06 (7.01) - 0.24(290)] (1 - 0.50)

= **32 kg/ha**

<u>Mean total understory production for the management area</u>

=[(BtE)ha + (BuE)ha + (RkG)ha] / 325 ha

=[(58)200 ha + (32)75 ha + (33)50 ha] / 325 ha

= **48 kg/ha**

BA =basal area (ft^2/a), SD =solum depth (cm), CL =surface clay content (%), WC =profile water holding capacity (cm), P =critical precipitation (mm), R =percentage of Rock outcrops in a map unit.

BtE = Buska-Mocmont-Rock outcrop soil map unit
BuE = Buska-Rock outcrop complex soil map unit
RkG = Rock outcrop-Mocmont complex soil map unit

SUMMARY AND CONCLUSIONS

Soil characterization and understory production of major forest soils in the Precambrian crystalline core area of Custer State Park were studied over three years. The soils investigated were the Buska and Mocmont series which developed from micaceous schist and granite parent materials respectively. Eutrochrept inclusion developed in both parent materials were also investigated.

Physical weathering is the dominate force that acts on these soils. Disintegration of the sand fractions form a strong silt size population in the particle size distribution. With advanced pedogenesis, clay is formed and illuviated to subsoil horizons where it accumulates as an argillic horizon.

Pedon mineralogy of the Buska series and its associated Inceptisols were classified as Micaceous throughout the profile. The Mocmont series and its associated Inceptisols generally had Mixed mineralogy, but it did range from Micaceous to Siliceous. The quartz rich granitic soils are more coarse textured than the micaceous schist derived soils.

Soil water holding capacity, which is greatly influenced by soil texture, has a marked influence on understory production. Soil mineralogy was indirectly related to understory productivity. Alfisols out-produce their associated Inceptisols in every vegetation category. Graminoid production is greatest on the schist derived soils, whereas shrub production is greatest on the granitic derived soils.

Canopy density was found to have a negative influence on understory production. This suggests that forest stand thinning produces a release affect for understory vegetation, much like it does for overstory growth. Slash left behind from thinning and timber harvesting operations, suppresses the understory response to forest stand thinning.

Multiple regression models for predicting understory production were developed using forest, climatic, and soil variables. These models were adapted to several soil map units in the study area. Being based on soil map units, these models are suited for integration into the multiple-use management plans of Custer State Park. Caution should be used when extrapolating the models to areas outside the park where different forest management techniques have traditionally been implemented or where divergent climatic conditions exist.

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APPENDIX I

Table 17. Site measurements of topographic and forest overstory factors.

Sites	Soil Types	Aspect Degrees	Elevation (m)	Slope	Canopy Density (%)	Basal Area sqft/a	slash t/ha	Date of Thinning
CSP1	GA	340	1631	12%	40	120	43.11	1981
CSP2	GA	55	1631	14%	32	100	163.14	1981
CSP3	GA	85	1542	12%	20	20	49.94	1982
CSP4	GA	83	1548	14%	24	50	56.27	1982
CSP5	GA	110	1545	17%	40	120	56.35	1969
CSP6	SA	75	1551	22%	52	150	35.61	1969
CSP7	GA	40	1585	28%	24	150	11.85	U/T
CSP8	GA	42	1585	30%	36	90	12.68	U/T
CSP9	GA	40	1600	27%	24	80	12.63	U/T
CSP10	GA	145	1542	18%	28	90	24.86	1983
CSP11	GA	120	1600	14%	30	80	33.32	1982
CSP12	GI	135	1603	8%	32	90	174.39	1982
CSP13	SI	28	1646	11%	11	20	114.28	1981
CSP15	SI	45	1640	13%	36	140	82.24	1981
CSP16	SA	190	1640	7%	98	280	114	U/T
CSP17	GI	60	1597	23%	20	50	43.11	U/T
CSP18	GI	80	1597	32%	24	90	96.92	U/T
CSP19	GA	85	1542	19%	12	30	106.87	1982
CSP20	SA	50	1542	24%	16	60	90.32	1982
CSP21	GA	110	1548	16%	36	130	17.95	1969
CSP22	GI	145	1545	30%	32	100	64.66	1968
CSP23	GI	180	1579	31%	36	90	.18	1969
CSP24	GA	180	1572	27%	15	50	57.35	1969
CSP25	GI	180	1572	30%	32	130	34.93	1969
CSP26	GI	115	1603	15%	2	10	4.44	1982
CSP28	GA	70	1548	26%	32	110	44.95	1969
CSP29	GI	79	1551	26%	28	70	40.45	1969
CSP30	SI	79	1545	20%	8	30	145.61	1969
CSP31	GA	30	1634	10%	40	60	14.51	1981
CSP32	SI	160	1622	11%	73	130	68.15	1981
CSP33	SI	135	1618	24%	63	120	82.46	1981
CSP34	GI	300	1622	6%	71	130	42.61	1981
CSP35	GA	85	1548	33%	41	80	9.64	1969
CSP36	GA	105	1548	33%	61	110	63.7	1969
CSP37	GI	300	1548	2%	52	100	46.3	1968
CSP38	GI	15	1548	2%	27	20	92.8	1968
CSP39	SI	335	1664	2%	86	100	2.21	U/T
CSP40	SI	345	1664	15%	93	190	76.36	U/T
CSP41	SI	45	1664	13%	28	30	60.11	1981
CSP42	SA	75	1634	11%	49	130	31.39	1981

U/T unthinned forest stands

APPENDIX II

Table 18. Weighted average mineralogy, grain count percentages, and classification.

Site#	PM-Order	Series	Qz	Fs	Mi	Ot	Class
CSP1	GA	Mocmont					
surface			38	0	61	2	micaceous
subsurf			41	0	57	3	micaceous
substrat			x				
CSP2	GA	Mocmont					
surface			25	0	74	1	micaceous
subsurf			35	1	64	0	micaceous
substrat			x				
CSP3	GA	Mocmont					
surface			90	3	7	0	siliceous
subsurf			88	3	8	0	mixed-HQz
substrat			x				
CSP4	GA	Mocmont					
surface			93	4	4	0	siliceous
subsurf			92	3	5	1	siliceous
substrat			93	2	4	1	siliceous
CSP5	GA	Mocmont					
surface			51	3	44	2	micaceous
subsurf			50	3	47	0	micaceous
substrat			88	5	6	0	mixed-HQz
CSP6	SA	Buska					
surface			55	4	41	1	micaceous
subsurf			44	2	53	1	micaceous
substrat			18	0	82	0	micaceous
CSP7	GA	Mocmont					
surface			77	7	4	12	mixed-MQz
subsurf			76	5	6	13	mixed-MQz
substrat			74	3	18	6	mixed-MQz
CSP8	GA	Mocmont					
surface			93	2	4	1	siliceous
subsurf			91	2	6	1	siliceous
substrat			96	2	3	0	siliceous
CSP9	GA	Mocmont					
surface			45	3	51	2	micaceous
subsurf			35	1	64	0	micaceous
substrat			x				
CSP10	GA	Mocmont					
surface			86	10	2	1	mixed-HQz
subsurf			81	8	9	2	mixed-HQz
substrat			82	8	9	1	mixed-HQz
CSP11	GA	Mocmont					
surface			87	7	3	3	mixed-HQz
subsurf			89	7	3	1	mixed-HQz
substrat			x				

Table 18. continued.

Site#	PM-Order	Series	Qz	Fs	Mi	Ot	Class
CSP12	GI						
surface			90	7	2	1	mixed-HQz
subsurf			90	8	2	0	mixed-HQz
substrat			x				
CSP13	SI						
surface			14	1	85	0	micaceous
subsurf			10	0	90	0	micaceous
substrat			x				
CSP15	SI						
surface			10	0	90	0	micaceous
subsurf			7	0	93	0	micaceous
substrat			x				
CSP16	SA	Buska					
surface			3	0	97	0	micaceous
subsurf			27	1	71	0	micaceous
substrat			10	0	90	0	micaceous
CSP17	GI						
surface			77	9	13	1	mixed-MQz
subsurf			60	8	32	0	mixed-mica
substrat			x				
CSP18	GI						
surface			76	10	13	1	mixed-MQz
subsurf			78	12	9	1	mixed-MQz
substrat			x				
CSP19	GA	Mocmont					
surface			53	1	46	1	micaceous
subsurf			52	3	45	0	micaceous
substrat			x				
CSP20	SA	Buska					
surface			23	0	76	1	micaceous
subsurf			12	0	88	0	micaceous
substrat			x				
CSP21	GA	Mocmont					
surface			43	2	55	0	micaceous
subsurf			74	10	15	1	mixed-MQz
substrat			61	2	37	0	mixed-mica
CSP22	GI						
surface			95	2	3	0	siliceous
subsurf			x				
substrat			x				

Table 18. continued.

Site#	PM-Order	Series	Qz	Fs	Mi	Ot	Class
CSP23	GI						
surface			82	12	6	0	mixed-HQz
subsurf			83	10	7	0	mixed-HQz
substrat			x				
CSP24	GA	Mocmont					
surface			87	10	3	0	mixed-HQz
subsurf			85	12	4	0	mixed-HQz
substrat			86	9	5	0	mixed-HQz
CSP25	GI						
surface			85	10	4	1	mixed-HQz
subsurf			78	15	7	0	mixed-MQz
substrat			x				
CSP26	GI						
surface			79	9	11	0	mixed-MQz
subsurf			77	9	13	1	mixed-MQz
substrat			x				
CSP28	GA	Mocmont					
surface			85	6	7	2	mixed-HQz
subsurf			79	6	14	1	mixed-MQz
substrat			86	9	4	1	mixed-HQz
CSP29	GI						
surface			88	6	6	0	mixed-HQz
subsurf			45	2	53	0	micaceous
substrat			x				
CSP30	SI						
surface			13	0	86	0	micaceous
subsurf			29	1	70	0	micaceous
substrat			46	2	52	1	micaceous
CSP31	GA	Mocmont					
surface			33	0	67	0	micaceous
subsurf			95	1	4	0	siliceous
substrat			x				
CSP32	SI						
surface			43	1	55	1	micaceous
subsurf			22	1	77	0	micaceous
substrat			x				
CSP33	SI						
surface			43	1	55	1	micaceous
subsurf			22	1	77	0	micaceous
substrat			x				
CSP34	GI						
surface			58	0	41	0	micaceous
subsurf			41	0	58	0	micaceous
substrat			x				

Table 18. continued.

Site#	PM-Order	Series	Qz	Fs	Mi	Ot	Class
CSP35	GA	Mocmont					
surface			24	1	75	0	micaceous
subsurf			65	2	33	0	mixed-mica
substrat			x				
CSP36	GA	Mocmont					
surface			24	1	75	0	micaceous
subsurf			65	2	33	0	mixed-mica
substrat			x				
CSP37	GI						
surface			88	7	4	0	mixed-HQZ
subsurf			83	6	10	0	mixed-HQz
substrat			x				
CSP38	GI						
surface			88	7	4	0	mixed-HQz
subsurf			83	6	10	0	mixed-HQz
substrat			x				
CSP39	SI						
surface			43	1	55	1	micaceous
subsurf			31	0	69	0	micaceous
substrat			x				
CSP40	SI						
surface			43	1	55	1	micaceous
subsurf			31	0	69	0	micaceous
substrat			x				
CSP41	SI						
surface			23	1	76	0	micaceous
subsurf			7	0	93	0	micaceous
substrat			x				
CSP42	SA	Buska					
surface			27	0	71	1	micaceous
subsurf			18	1	80	0	micaceous
substrat			x				

APPENDIX III

Table 19. 1984 understory production-soil mineralogy correlation matrixes.

Mineral-ology	Statistic	Total	Grami-noid	Forb	Shrub
	r	0.03876	-0.06056	0.09020	0.07320
AQz	P>r	0.8448	0.7595	0.6481	0.7112
	n	28	28	28	28
	r	-0.02467	0.06053	-0.05823	-0.06069
AMi	P>r	0.9008	0.7596	0.7685	0.7590
	n	28	28	28	28
	r	-0.05089	-0.03257	0.07470	-0.07911
BQz	P>r	0.8010	0.8719	0.7111	0.6949
	n	27	27	27	27
	r	0.07199	0.04411	-0.04241	0.09480
BMi	P>r	0.7212	0.8271	0.8336	0.6381
	n	27	27	27	27
	r	0.40860	0.19070	0.37438	0.40356
CQz	P>r	0.2121	0.5743	0.2566	0.2184
	n	11	11	11	11
	r	-0.41196	-0.19320	-0.35520	-0.41442
CMi	P>r	0.2080	0.5692	0.2837	0.2051
	n	11	11	11	11

AQz, AMi = surface quartz and mica percentages respectively
BQz, BMi = subsurface quartz and mica percentages respectively
CQz, CMi = substratum quartz and mica percentages respectively

r = correlation coefficient, P>r = probability of a greater /r/, n = number of observations

* indicate the level of significants

Table 20. 1985 understory production-soil mineralogy correlation matrixes.

Mineral-ology	Statistic	Total	Grami-noid	Forb	Shrub
	r	-0.07629	-0.28898	-0.06943	0.30349
AQz	P>r	0.6399	0.0765*	0.6703	0.0569*
	n	40	40	40	40
	r	0.08461	0.29555	0.07555	-0.30006
AMi	P>r	0.6037	0.0641*	0.6431	0.0599*
	n	40	40	40	40
	r	0.05842	-0.11752	-0.01523	0.27101
BQz	P>r	0.7239	0.4761	0.9267	0.0952*
	n	39	39	39	39
	r	-0.02813	0.14138	0.01688	-0.25529
BMi	P>r	0.8650	0.3906	0.9188	0.1168
	n	39	39	39	39
	r	0.36435	0.18197	0.26777	0.37438
CQz	P>r	0.2706	0.5923	0.4260	0.2567
	n	11	11	11	11
	r	-0.35950	-0.17792	-0.26666	-0.36958
CMi	P>r	0.2775	0.6007	0.4280	0.2633
	n	11	11	11	11

AQz, AMi = surface quartz and mica percentages respectively
BQz, BMi = subsurface quartz and mica percentages respectively
CQz, CMi = substratum quartz and mica percentages respectively

r = correlation coefficient, P>r = probability of a greater /r/, n = number of observations

* indicate the level of significants

Table 21. 1986 understory production-soil mineralogy correlation matrixes.

Mineral-ology	Statistic	Total	Grami-noid	Forb	Shrub
	r	-0.13126	-0.30028	0.00019	0.22662
AQz	P>r	0.4195	0.0597*	0.9991	0.1597
	n	40	40	40	40
	r	0.14395	0.30995	0.02423	-0.22254
AMi	P>r	0.3755	0.0516*	0.8820	0.1675
	n	40	40	40	40
	r	0.01902	-0.12302	0.10203	0.21185
BQz	P>r	0.9085	0.4556	0.5365	0.1954
	n	39	39	39	39
	r	0.01470	0.14913	-0.07402	-0.19449
BMi	P>r	0.9292	0.3649	0.6543	0.2355
	n	39	39	39	39
	r	0.36809	0.26941	0.44451	0.38150
CQz	P>r	0.2654	0.4231	0.1707	0.2470
	n	11	11	11	11
	r	-0.35521	-0.25046	-0.42777	-0.37311
CMi	P>r	0.2837	0.4576	0.1894	0.2584
	n	11	11	11	11

AQz, AMi = surface quartz and mica percentages respectively
BQz, BMi = subsurface quartz and mica percentages respectively
CQz, CMi = substratum quartz and mica percentages respectively

r = correlation coefficient, P>r = probability of a greater /r/, n = number of observations

* indicate the level of significants

APPENDIX IV

Table 22. 1984 mean understory production (kg/ha) by vegetation classes.

site #	graminoids	forbs	shrubs	total
CSP1	91.51	8.72	0	100.23
CSP2	39.45	0	6.83	46.28
CSP3	9.63	54.68	110.49	174.8
CSP4	103.81	64.2	131.69	299.7
CSP5	15.88	0	0	15.88
CSP6	20.13	0	0	20.13
CSP7	26.59	26.21	94.64	147.44
CSP8	17.92	3.23	6.57	27.72
CSP9	8.77	7.64	177.28	193.69
CSP10	116.03	15.88	6.35	138.26
CSP11	31.54	2.26	0	33.8
CSP12	0	0	0	0
CSP13	46.23	0	0	46.23
CSP15	23.63	0	0	23.63
CSP16	0	0	0	0
CSP17	30.57	10.55	118.18	159.3
CSP18	0	0	0	0
CSP19	79.38	67.33	206.5	353.21
CSP20	56.4	60.06	236.37	352.83
CSP21	5.49	3.39	0	8.88
CSP22	30.41	4.68	26.91	62
CSP23	6.73	0	12.32	19.05
CSP24	43	2.15	0	45.15
CSP25	0	0	0	0
CSP26	200.69	8.88	148.7	358.27
CSP28	20.77	2.05	107.42	130.24
CSP29	16.31	0	87.08	103.39
CSP30	132.61	0	0	132.61
CSP31				
CSP32				
CSP33				
CSP34				
CSP35				
CSP36				
CSP37				
CSP38				
CSP39				
CSP40				
CSP41				
CSP42				

Table 23. 1985 mean understory production (kg/ha) by vegetation classes.

site #	graminoids	forbs	shrubs	total
CSP1	65.12	2.91	0	68.03
CSP2	42.52	.38	0	42.9
CSP3	3.77	.38	85.03	89.18
CSP4	33.37	10.23	116.79	160.39
CSP5	0	1.88	0	1.88
CSP6	7	0	0	7
CSP7	3.23	15.61	55.43	74.27
CSP8	.05	1.08	1.13	2.26
CSP9	.48	.16	139.39	140.03
CSP10	26.91	1.61	5.92	34.44
CSP11	40.9	0	0	40.9
CSP12	4.31	0	174.39	178.7
CSP13	8.07	0	0	8.07
CSP15	5.22	0	0	5.22
CSP16	0	0	0	0
CSP17	4.9	1.51	89.88	96.29
CSP18	0	0	0	0
CSP19	40.9	57.59	13.35	111.84
CSP20	40.36	10.23	57.59	108.18
CSP21	2.05	3.23	0	5.28
CSP22	4.57	0	16.68	21.25
CSP23	0	0	0	0
CSP24	7	0	0	7
CSP25	0	0	0	0
CSP26	33.91	1.88	111.4	147.19
CSP28	4.04	.16	53.82	58.02
CSP29	5.92	.16	103.33	109.41
CSP30	22.07	1.78	10.87	34.72
CSP31	387.49	11.84	0	399.33
CSP32	18.78	0	0	18.78
CSP33	0	0	0	0
CSP34	18.67	0	0	18.67
CSP35	5.38	.38	166.3	172.06
CSP36	1.94	0	0	1.94
CSP37	.91	0	219.58	220.49
CSP38	15.61	0	128.63	144.24
CSP39	.38	0	0	.38
CSP40	7.32	0	0	7.32
CSP41	280.39	11.84	8.29	300.52
CSP42	334.75	4.57	0	339.32

Table 24. 1986 mean understory production (kg/ha) by vegetation classes.

site #	graminoide	forbs	shrubs	total
CSP1	45.42	0	0	45.42
CSP2	95.26	0	0	95.26
CSP3	6.24	53.87	118.13	178.24
CSP4	144.45	31.81	272.59	448.85
CSP5	3.98	0	0	3.98
CSP6	20.07	0	0	20.07
CSP7	11.03	13.72	133.68	158.43
CSP8	2.85	4.04	3.28	10.17
CSP9	0	2.48	292.82	295.3
CSP10	70.18	5.92	41.33	117.43
CSP11	19.64	0	0	19.64
CSP12	0	0	0	0
CSP13	23.95	0	0	23.95
CSP15	50.05	2.53	0	52.58
CSP16	1.51	0	0	1.51
CSP17	2.26	15.66	162.37	180.29
CSP18	19.75	3.12	0	22.87
CSP19	175.12	65.82	70.18	311.12
CSP20	78.95	45.37	105.86	230.18
CSP21	2.26	1.72	2.96	6.94
CSP22	9.26	0	24.65	33.91
CSP23	2.69	1.02	0	3.71
CSP24	9.96	9.04	0	19
CSP25	0	0	0	0
CSP26	77.12	2.91	2.81	82.84
CSP28	9.04	3.18	73.3	85.52
CSP29	5.76	0	73.19	78.95
CSP30	33.74	3.77	5.22	42.73
CSP31	569.93	40.69	0	610.62
CSP32	8.56	.22	0	8.78
CSP33	29.06	0	0	29.06
CSP34	7.21	0	0	7.21
CSP35	35.63	5.38	225.87	266.88
CSP36	.81	0	0	.81
CSP37	1.78	0	194.23	196.01
CSP38	41.39	0	194.23	235.62
CSP39	2.96	0	0	2.96
CSP40	0	0	0	0
CSP41	463.53	19.37	5.97	488.87
CSP42	427.85	12.43	0	440.28

APPENDIX V

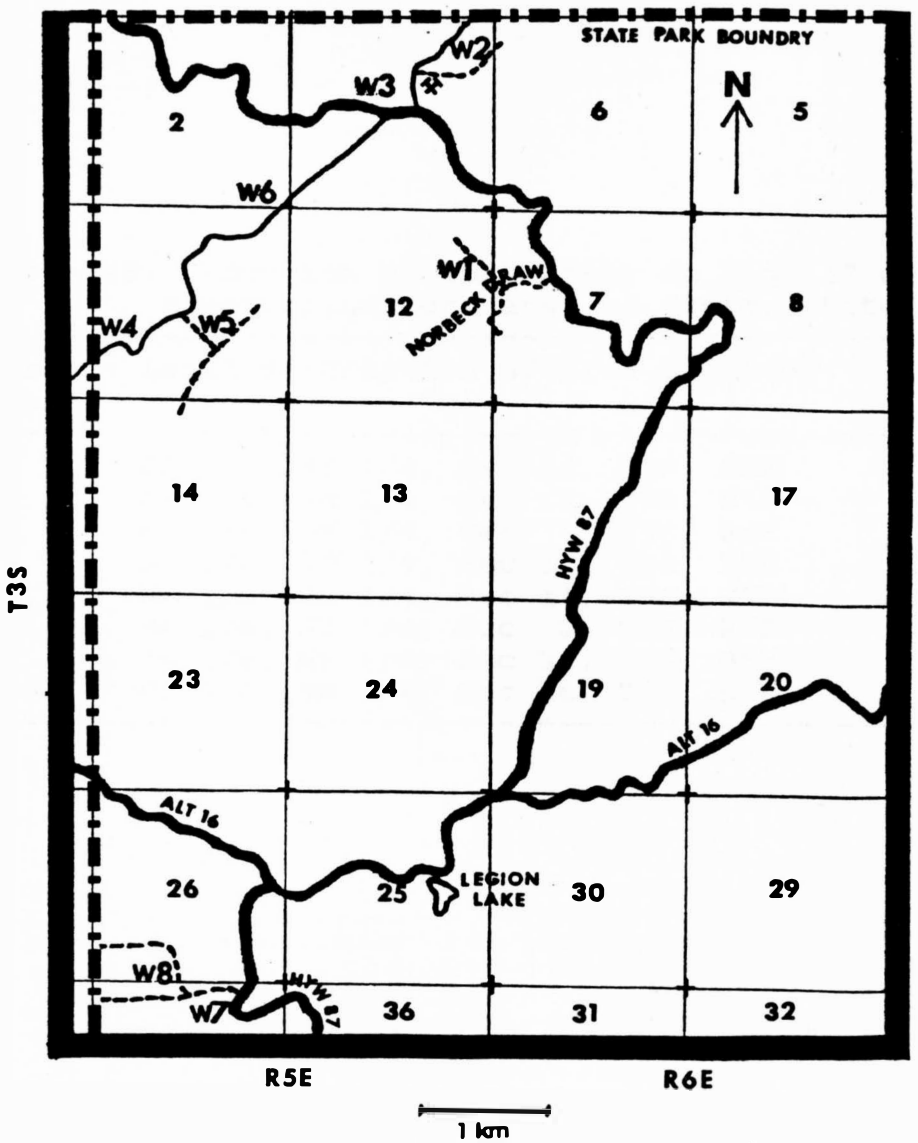

Fig. 17. General map of the work area (W#) locations in the Precambrian core area of Custer State Park.

Table 25. Location of work areas on Fig. 17 of the precambrian core area of Custer State Park.

Work area	Legal description of area location
W1	SE 1/4, NE 1/4, Sec 12, T3S, R5E
W2	NE 1/4, NE 1/4, Sec 1, T3S, R5E
W3	SE 1/4, NW 1/4, Sec 1, T3S, R5E
W4	NW 1/4, SW 1/4, Sec 11, T3S, R5E
W5	NW 1/4, SE 1/4, Sec 11, T3S, R5E
W6	SE 1/4, SE 1/4, Sec 2, T3S, R5E
W7	NW 1/4, NE 1/4, Sec 35, T3S, R5E
W8	SE 1/4, SW 1/4, Sec 26, T3S, R5E

Work area and site location directions

Trees or other objects that serve as beginning markers for a work area are marked on the maps with circles or squares. In the field these are marked with orange paint, and/or orange and lime green nylon tape. Sites are marked on the maps with a cross and identified by CSP followed by a number. Sites are actually transects that run along the slope contour. In the field transects are marked with orange or red wood stake. The top of each stake is marked with an arrow that points to the other end of the transect. Sites within a work area are located sequentially. The compass bearing from one site to the next is marked on the map nearest the site the direction is being shot from. Distances were paced off, and thus are only approximate.

Directions to work areas are presented sequentially from W1 to W8. The starting point is the intersection where ALT 16 (west) and HWY 87 (north) separate in the SW 1/4, SW 1/4, Sec. 19, T3S, R6E.

W1. Work area one is in Norbeck Draw, 4.1 miles north on HWY 87 from the starting point. Turn left (SW) on the logging trail (which is not well marked) into Norbeck Draw. Proceed 0.3 miles on this trail to the fork in the intermittent stream that this trail follows. Refer to Fig. 18 for individual site locations.

W2. Return to HWY 87. Continue north 1.3 miles to the intersection marked for Camp Remington and Iron Creek. Turn right (N), 0.1 miles to the gravel pit on the right. Head east through gravel pit, 0.6 miles on the logging trail. Refer to Fig. 19 for individual site locations.

W3. Return to HWY 87. Continue north (to the right) 0.1 to the next left (SW). This location is across the road to the north. The starting point is the stop sign at this intersection (Fig. 20).

W4. Proceed SE on this gravel road 1.9 miles to W4. The beginning point for this area is a tree right on the edge of the road marked with orange and lime green flagging (Fig. 21).

W5. Turn around and go 0.7 miles back toward HWY 87. Take the steep logging trail to the right (E) (vegetation may have overgrown it near the gravel road) 0.3 miles to where it intersects another logging trail. See Fig. 22 for individual site locations.

W6. Return to the gravel road and continue towards HWY 87 0.9 miles. Work area six is in the Draw to the left (W). The beginning of W6 is a small culvert that runs under the road. See Fig. 23 for individual site locations.

W7. Return to HWY 87 and turn right (S). Head back to starting point. Continue 2.2 miles past the starting point (past Legion Lake) to where HWY 87 (south) and ALT 16 (west) separate. Continue on HWY 87 (south) 0.75 miles. Take the logging road right just before the switch back on HWY 87. The steep trail has been replaced by a new road that follows the slope contour a better. See Fig. 24 for individual site locations.

W8. Continue along the logging road to where it intersects two other roads. Take the road to the right and see Fig. 25 for site locations.

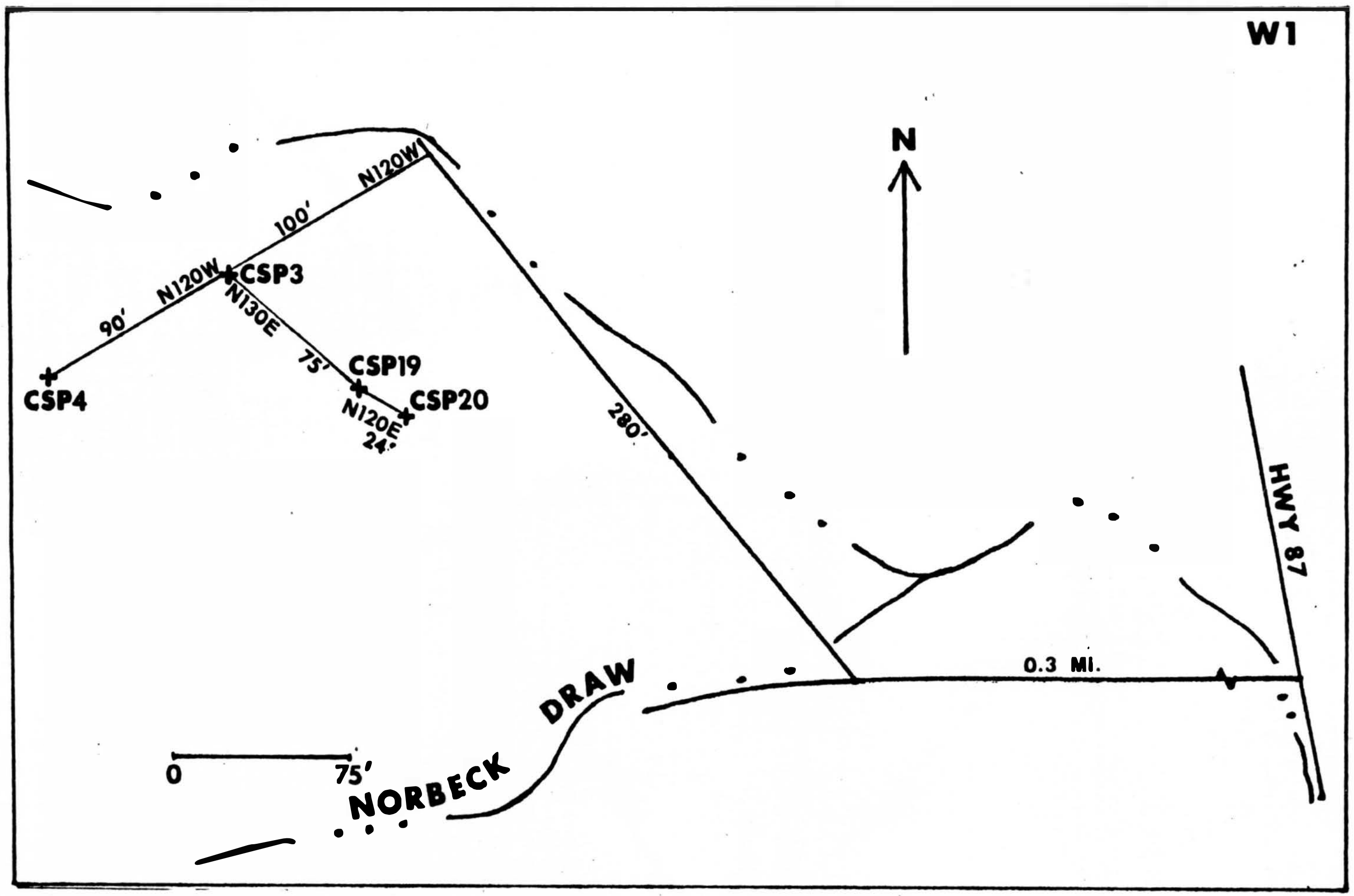

Fig. 18. Site location map for work area one (W1)

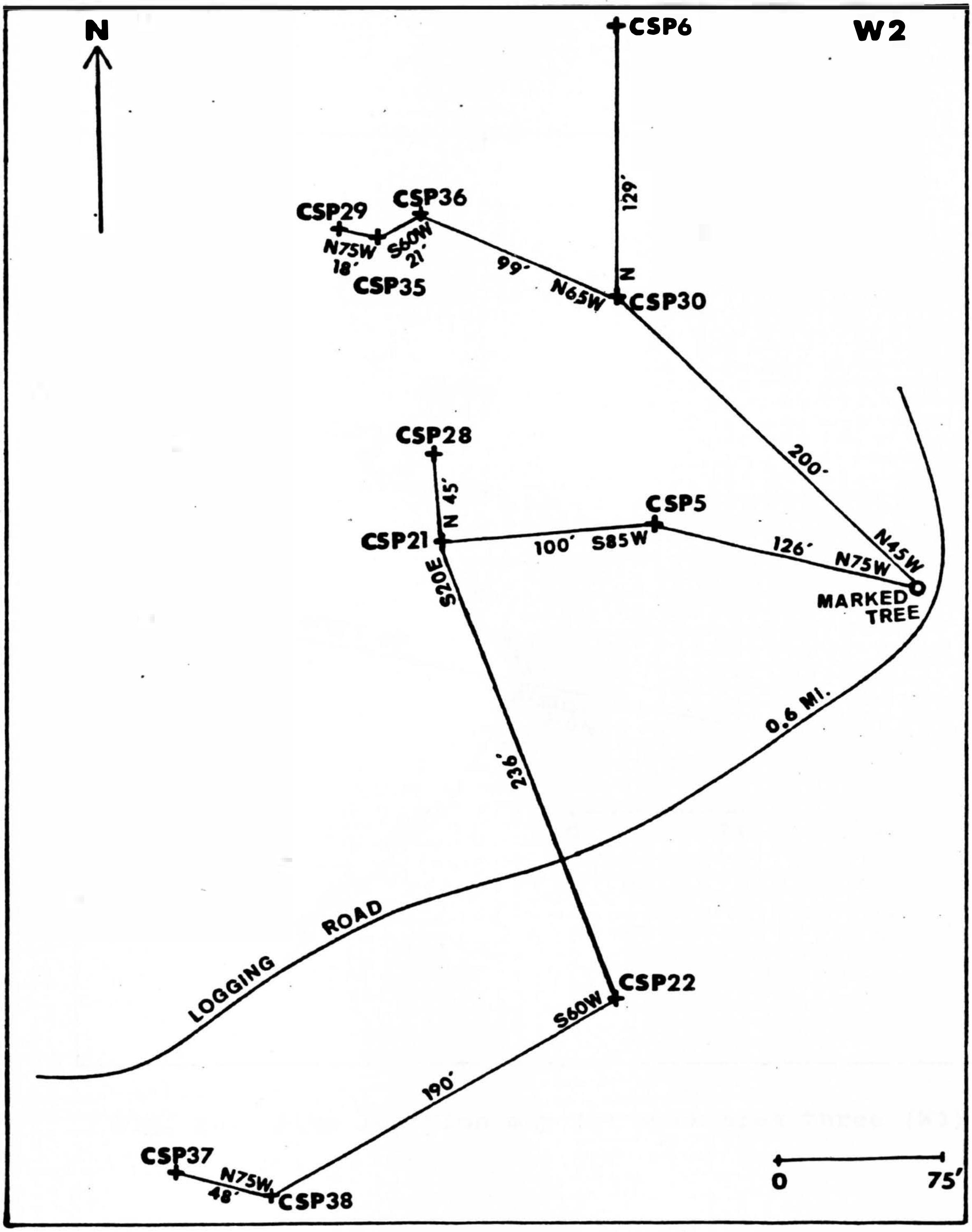

Fig. 19. Site location map for work are two (W2)

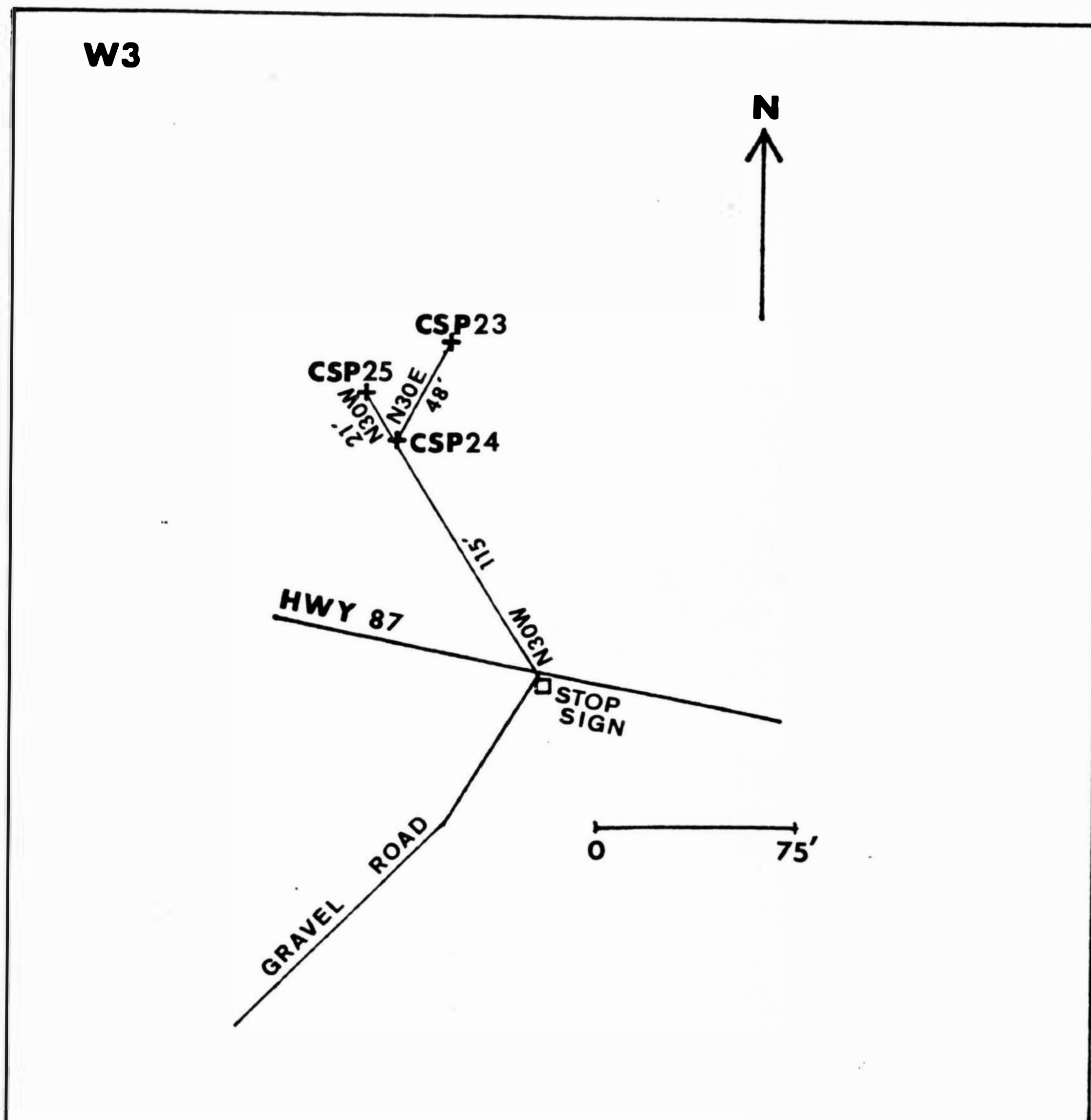

Fig. 20. Site location map for work area three (W3)

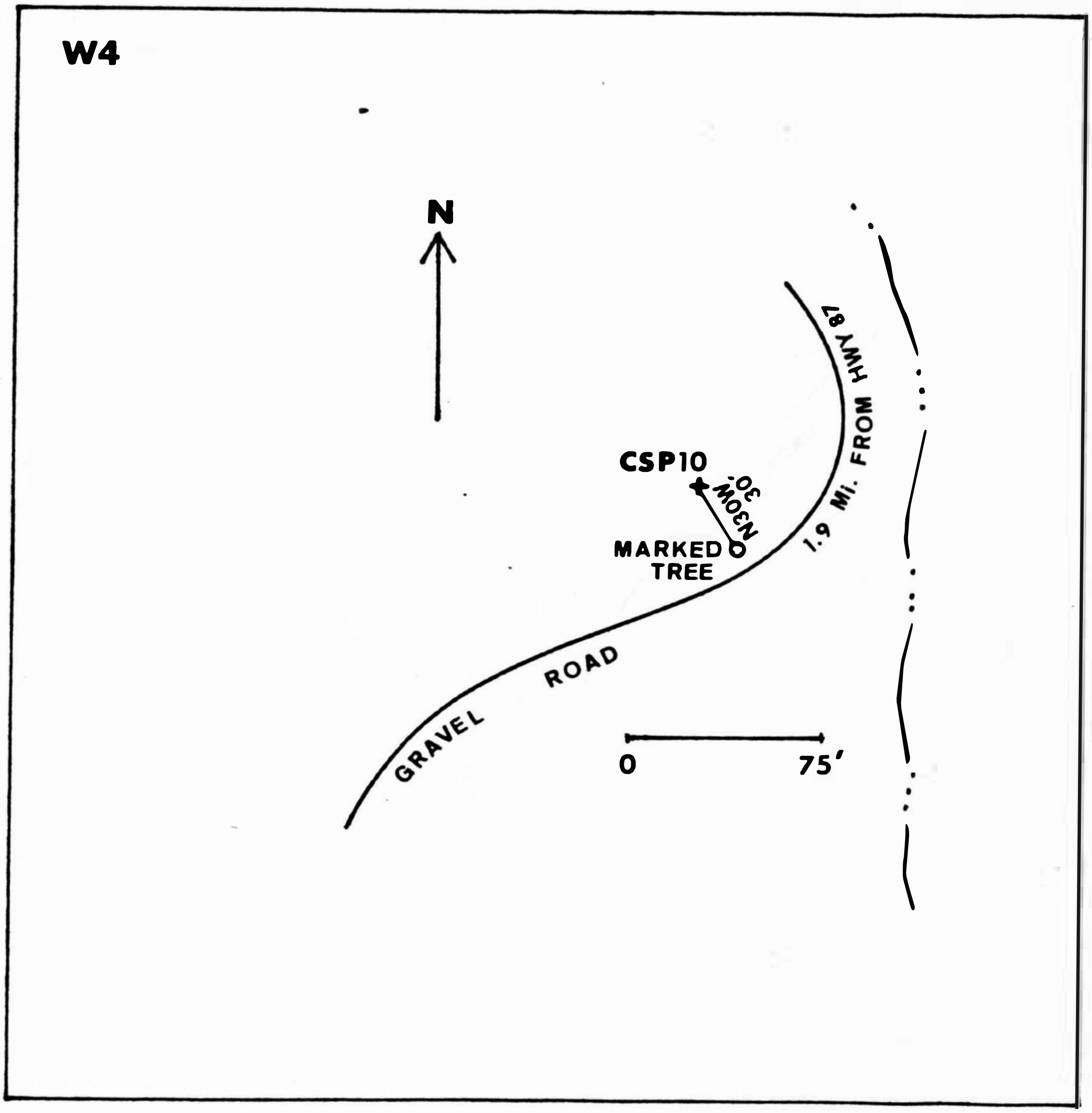

Fig. 21. Site location map for work area four (W4)

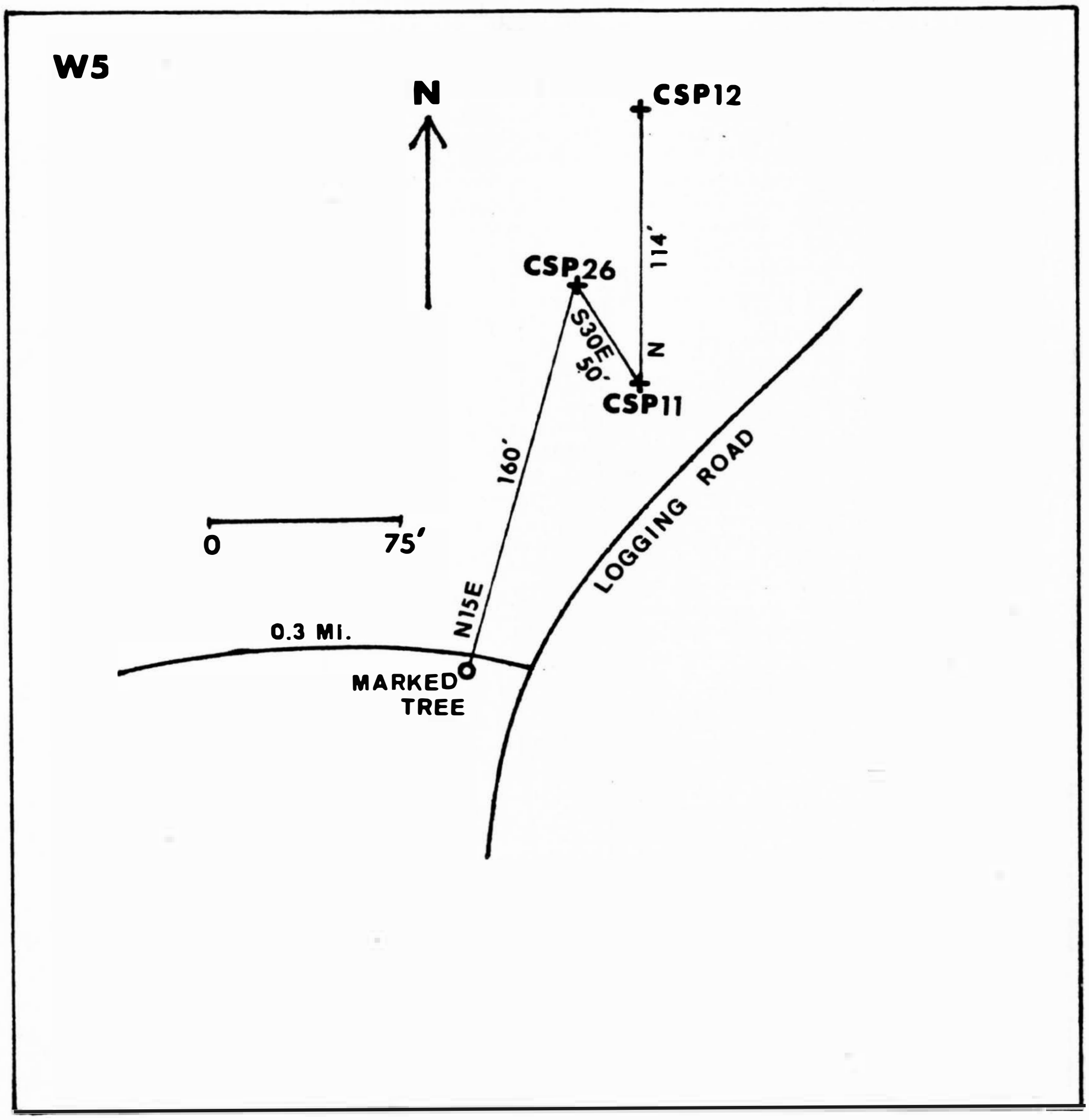

Fig. 22. Site location map for work area five (W5)

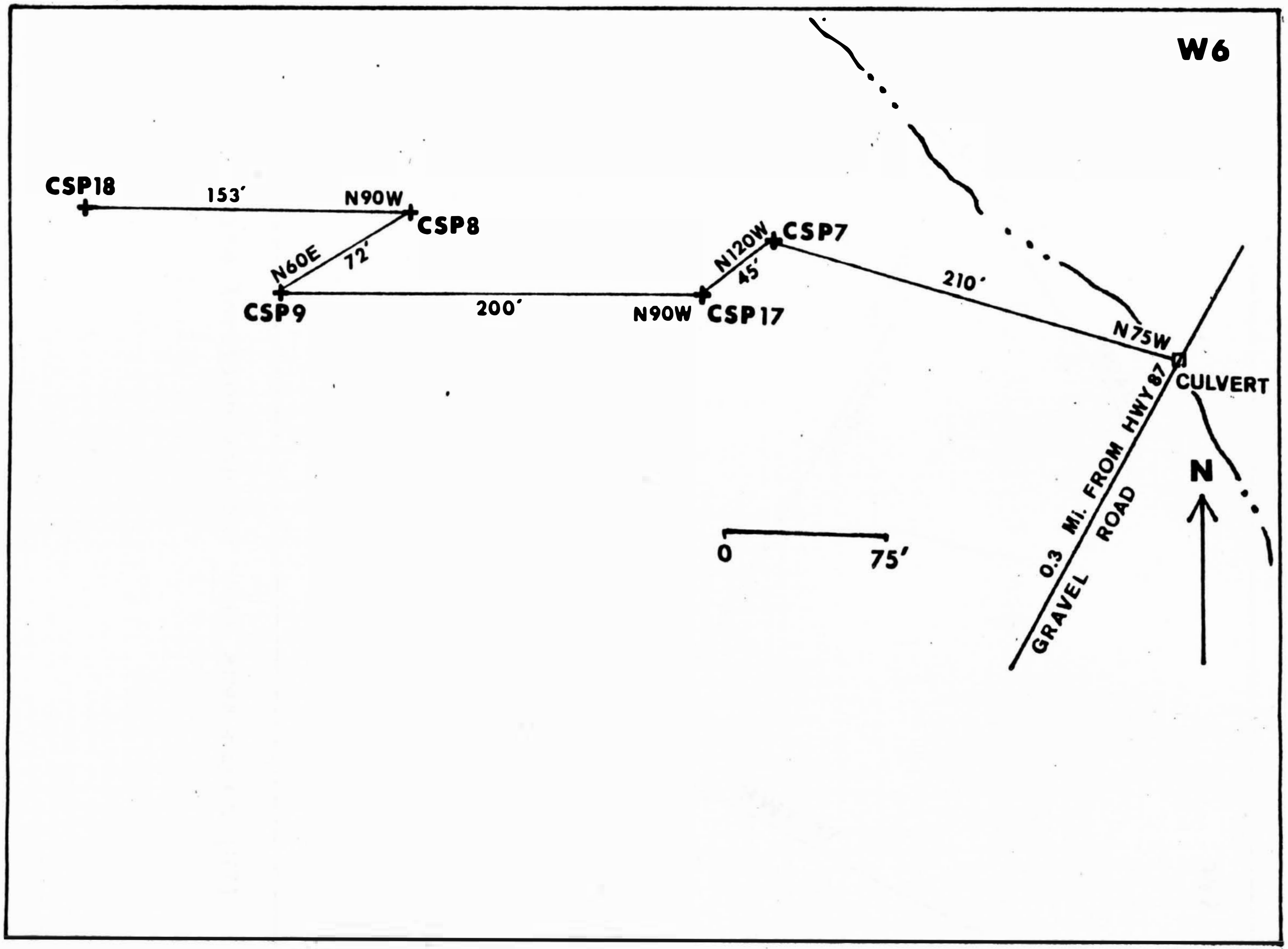

Fig. 23. Site location map for work area six (W6)

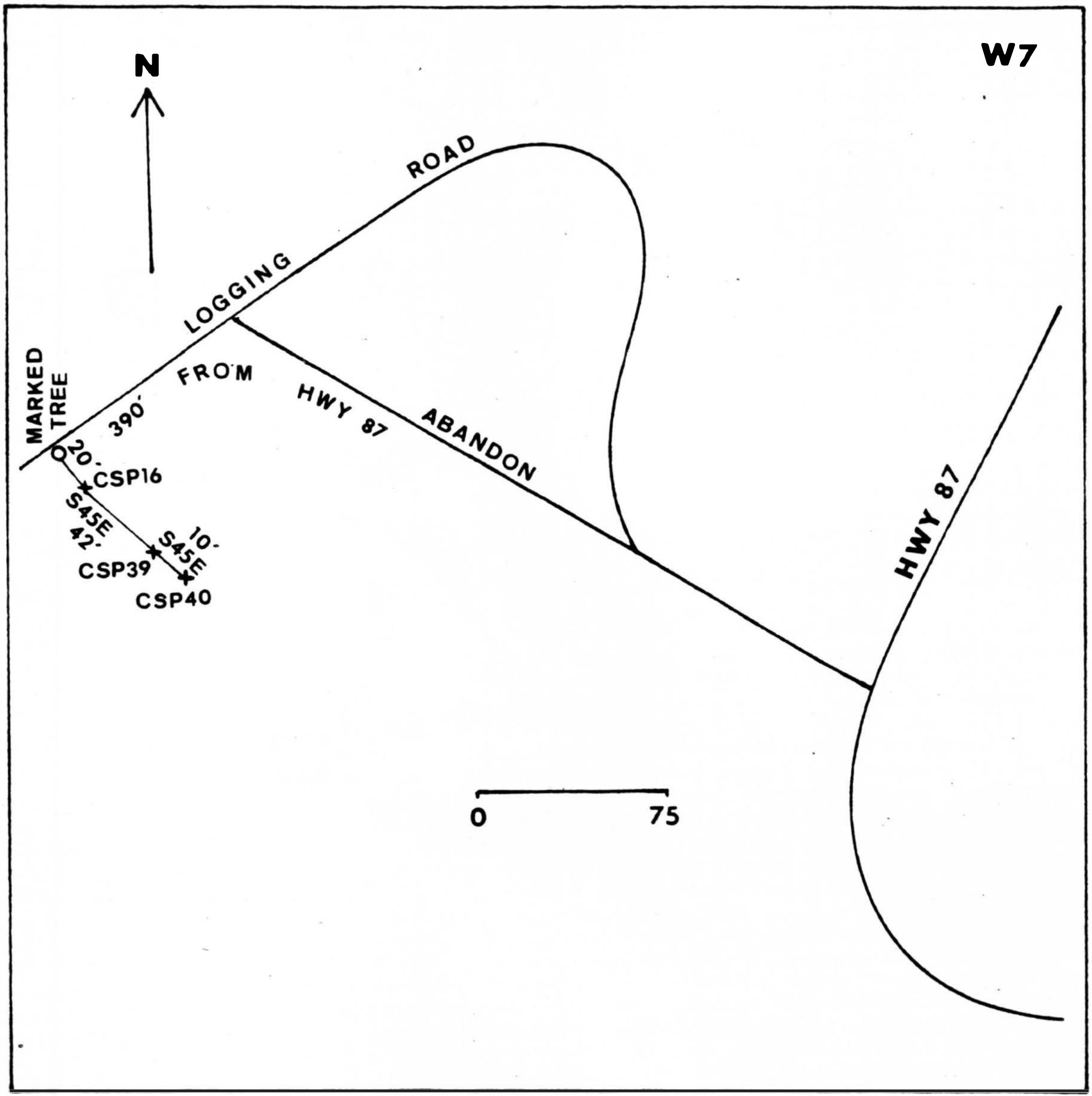

Fig. 24. Site location map for work area seven (W7)

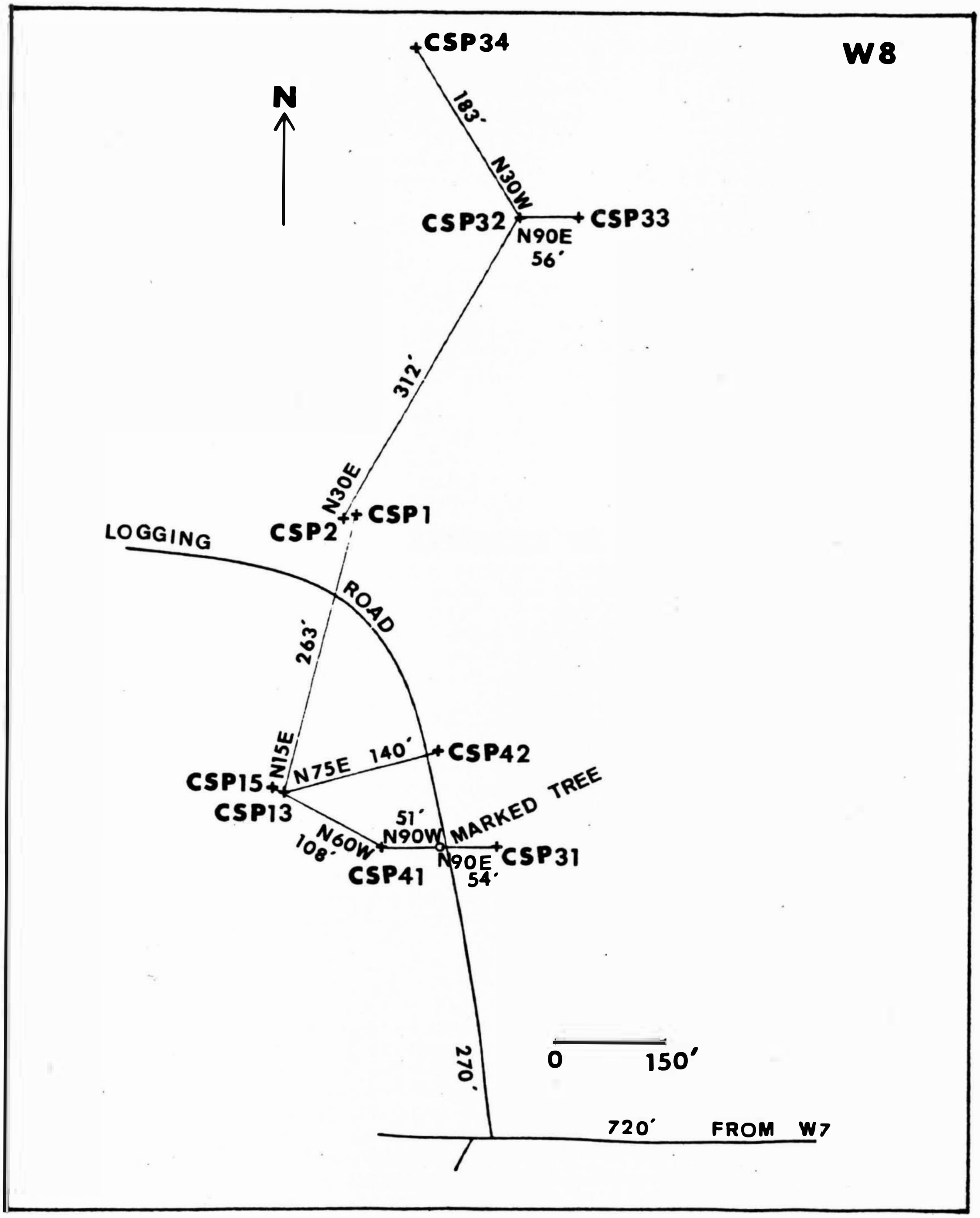

Fig. 25. Site location map for work area eight (W8)

APPENDIX VI

Table 26. Selected chemical and physical properties.

Site #	Depth (cm)	Horizon	Texture	pH (1:1)	(%) Organic Carbon	Water Content ¦---- mm ----¦ .03MPa	1.5MPa
CSP1	0 T 8	A/E	SL/L	5.2	8.30	.18	.07
CSP1	8 T 31	E	SL	4.8	.80	.1	.02
CSP1	31 T 61	Bt	SL	4.8	.43	.11	.03
CSP1	61 T 79	C	S	4.8	.11	.03	.01
CSP2	0 T 5	A	SiL	5	6.81	.25	.09
CSP2	5 T 36	E	L	5.3	.74	.15	.02
CSP2	36 T 56	B/E	L/SiL	4.8	.59	.19	.07
CSP2	56 T 74	Bt	L/CL	4.8	.59	.15	.07
CSP2	74 T 100	C	L	4.8	.21	.14	.07
CSP3	0 T 8	A/E	SL	5	6.60	.17	.07
CSP3	8 T 33	E	SiL	4.5	.80	.11	.02
CSP3	33 T 46	Bt1	CL	4.5	.59	.15	.07
CSP3	46 T 54	Bt2	SCL	4.5	.53	.12	.06
CSP3	54 T 67	C	SL	4.6	1.28	.08	.04
CSP4	0 T 5	A/E	L	5.4	11.49	.25	.11
CSP4	5 T 30	E	SL	5.2	.37	.09	.02
CSP4	30 T 56	B/E	L	4.5	.48	.14	.07
CSP4	56 T 77	Bt1	SiCL	4.5	.48	.19	.1
CSP4	77 T 95	Bt2	CL	4.5	.48	.17	.09
CSP4	95 T 123	C	L	4.6	.59	.14	.07
CSP5	0 T 5	A/E	L	5.1	8.51	.22	.08
CSP5	5 T 33	E	SL	5.2	1.70	.11	.03
CSP5	33 T 49	B/E	CL	5.3	1.01	.16	.09
CSP5	49 T 90	Bt1	L/CL	6.2	.37	.14	.07
CSP5	90 T 118	Bt2	L	5.5	.21	.13	.07
CSP5	118 T 141	C	S	6	.05	.02	.01
CSP6	0 T 5	A/E	L	5	6.81	.21	.08
CSP6	5 T 28	E	SiL	5.2	.90	.14	.05
CSP6	28 T 41	B/E	CL	5.2	.85	.19	.11
CSP6	41 T 59	Bt1	CL	5.2	.43	.17	.09
CSP6	59 T 74	Bt2	L	5.2	.37	.14	.08
CSP6	74 T 154	2C	S	5.6	.05	.04	.02
CSP7	0 T 5	A/E	L	4.6	14.04	.17	.09
CSP7	5 T 20	E/B	SiL	5.6	1.44	.14	.06
CSP7	20 T 44	B/E	SL	5.6	.90	.16	.09
CSP7	44 T 74	Bt1	CL	5.4	.96	.16	.09
CSP7	74 T 102	Bt2	SiCL/CL	5.6	1.06	.15	.09
CSP7	102 T 148	C	SL	5.8	.21	.09	.05

Table 26. Continued.

Site #	Depth (cm)	Horizon	Texture	pH (1:1)	(%) Organic Carbon	Water Content ¦---- mm -----¦ .03mPa	1.5mPa
CSP8	0 T 5	A/E	SL	4.7	2.98	.12	.04
CSP8	5 T 26	E	SiL	4.9	1.65	.13	.04
CSP8	26 T 49	B/E	CL/SiCL	5	1.38	.19	.08
CSP8	49 T 74	Bt1	CL/L	5.3	.48	.12	.07
CSP8	74 T 97	Bt2	SL	5.5	.27	.08	.03
CSP8	97 T 118	C	LS	6	.27	.03	.01
CSP9	0 T 5	A/E	SL	4.8	10.64	.21	.11
CSP9	5 T 28	E	SL	5.2	1.17	.13	.03
CSP9	28 T 44	Bt1	LS	5.1	.74	.09	.03
CSP9	44 T 51	Bt2	LS	5.2	.48	.09	.05
CSP9	51 T 79	CB	LS	5.4	.53	.09	.04
CSP9	79 T 92	C	LS/S	5.4	.21	.08	.04
CSP10	0 T 8	A	SL	5.1	4.26	.11	.05
CSP10	8 T 30	E	SL/SiL	5.3	0	.09	.03
CSP10	30 T 56	E/B	SiCL	5.3	.85	.17	.09
CSP10	56 T 100	Bt1	CL/L	5.4	.43	.16	.07
CSP10	100 T 133	Bt2	L	5.6	.32	.13	.06
CSP10	133 T 148	BC	L	5.8	.21	.09	.05
CSP10	148 T 166	C	L	5.8	.05	.08	.06
CSP11	0 T 5	A/E	SL	5.4	13.62	.22	.12
CSP11	5 T 20	E	SL	5.1	1.65	.09	.03
CSP11	20 T 41	B/E	SL	4.7	.74	.08	.04
CSP11	41 T 82	Bt	SL	4.7	.48	.09	.05
CSP11	82 T	C	SL	5	.43	.05	.03
CSP12	0 T 5	A/E	L	4.6	14.47	.31	.18
CSP12	5 T 23	E	SL	4.9	1.22	.1	.03
CSP12	23 T 36	B/E	LS	5	.64	.06	.03
CSP12	36 T 67	Bw	LS	5.2	.21	.04	.02
CSP12	67 T 74	C	S	5.2	.37	.04	.01
CSP13	0 T 3	A	L	5.1	20.43	.42	.22
CSP13	3 T 30	A/E	SL	4.8	.37	.11	.02
CSP13	30 T 36	BE	SL/LS	4.7	.43	.12	.02
CSP13	36 T 51	Bw	LS	4.7	.32	.06	.02
CSP13	51 T 59	BC	LS	4.6	.27	.05	.02
CSP13	59 T 69	C	LS/S	4.8	.11	.03	.01
CSP15	0 T 30	A/E	SL	4.9	.74	.11	.02
CSP15	30 T 49	E	LS	5.2	.11	.07	.02
CSP15	49 T 67	Bw	LS	5.3	.05	.06	.03
CSP15	67 T 74	BC	S	5.5	0	.04	.02
CSP15	74 T 90	C	S	6.9	.21	.02	.01

Table 26. Continued.

Site #	Depth (cm)	Horizon	Texture	pH (1:1)	(%) Organic Carbon	Water Content mm .03mPa	1.5mPa
CSP16	0 T 28	E	L/SL	5.7	.80	.16	.03
CSP16	28 T 44	B/E	SiCL	5	.80	.23	.11
CSP16	44 T 67	Bt	CL	4.6	.32	.16	.07
CSP16	67 T 90	BC	LS	5	.05	.06	.03
CSP16	90 T 138	C	S/LS	5	.05	.05	.02
CSP17	0 T 5	A	SL	4.7	5.32	.11	.04
CSP17	5 T 18	Bw	SL/LS	4.4	1.38	.06	.01
CSP17	18 T 54	Cr	S	4.4	.48	.02	.01
CSP18	0 T 5	A/E	L	4.3	26.39	.22	.17
CSP18	5 T 13	Bw	SL	5	1.49	.06	.02
CSP18	13 T 26	C	SL	5.1	1.44	.04	.01
CSP19	0 T 5	A/E	L	4.8	14.04	.2	.09
CSP19	5 T33	E	L/SL	4.9	.48	.12	.02
CSP19	33 T 49	B/E	CL/L	4.5	.32	.14	.07
CSP19	49 T 61	Bt	CL/L	4.5	.48	.13	.08
CSP19	61 T 72	BC	SL	4.8	.11	.06	.03
CSP19	72 T 87	C	LS	5	.05	.01	.01
CSP20	0 T 18	A/E	SL	4.9	1.28	.11	.04
CSP20	18 T 41	Bt1	SL	4.7	.74	.11	.04
CSP20	41 T 63	Bt2	SL	4.5	.09	.06	.02
CSP21	0 T 5	A/E	SL	4.4	10.85	.13	.07
CSP21	5 T 28	E	SL	4.4	.64	.08	.02
CSP21	28 T 44	B/E	SL	4.8	.21	.08	.04
CSP21	44 T 84	Bt	SL	4.8	.32	.1	.05
CSP21	84 T 115	BC	SL	4.9	.85	.07	.03
CSP21	115 T 141	C	LS	5.1	0	.05	.02
CSP22	0 T 5	A/E	SL	4.8	4.47	.12	.04
CSP22	5 T 10	Bw	LS/SL	4.6	1.44	.06	.02
CSP22	10 T 18	C	LS/SL	4.5	.74	.04	.01
CSP23	0 T 5	A/E	L	4.6	16.60	.35	.15
CSP23	5 T 20	E	SL	4.6	3.94	.12	.04
CSP23	20 T 30	Bw	LS	4.9	.43	.08	.03
CSP23	30 T 46	C	LS	5	.32	.05	.02
CSP24	0 T 8	A/E	L	4.6	12.77	.28	.15
CSP24	8 T 28	E	L	4.8	.85	.12	.03
CSP24	28 T 38	B/E	SL	4.9	.80	.11	.05
CSP24	38 T 61	Bw1	SL/LS	5.2	.32	.07	.03
CSP24	61 T 87	Bw2	SL	5.3	.11	.09	.04
CSP24	87 T 138	BC	SL	5.5	.05	.09	.03
CSP24	138 T 161	C	SL	5.7	.05	.07	.03

Table 26. Continued.

Site #	Depth (cm)	Horizon	Texture	pH (1:1)	(%) Organic Carbon	Water Content mm .03mPa	1.5mPa
CSP25	0 T 8	A/E	SL	4.8	4.04	.14	.05
CSP25	8 T 23	E	LS	4.7	1.22	.08	.03
CSP25	23 T 44	Bw	SL	4.8	.37	.06	.02
CSP25	44 T 59	C	LS	5	.05	.05	.02
CSP26	0 T 5	A/E	SL	5.2	6.81	.16	.06
CSP26	5 T 20	E	SL	4.8	.59	.54	.02
CSP26	20 T 41	Bw	LS	4.7	.05	.04	.02
CSP26	41 T 54	C	LS	4.7	.43	.02	.01
CSP28	0 T 5	A/E	SL	4.5	8.09	.18	.09
CSP28	5 T 20	E	SL	4.7	.80	.09	.03
CSP28	20 T 38	B/E	SL	4.9	.43	.1	.05
CSP28	38 T 64	Bt1	SL	4.8	.05	.07	.04
CSP28	64 T 95	Bt2	SL	5.1	.11	.08	.04
CSP28	95 T 123	Bt3	SL	5.5	.32	.1	.04
CSP28	123 T 148	BC	SL	5.5	.16	.05	.02
CSP28	148 T 166	C	LS	5.9	.05	.04	.02
CSP29	0 T 5	A/E	SL	5.2	10.43	.19	.1
CSP29	5 T 20	E	SL	5.1	1.81	.11	.02
CSP29	20 T 44	B/E	SL	5	.96	.07	.02
CSP29	44 T 72	Bw	SL/LS	5	.53	.05	.02
CSP29	72 T 90	C	LS	5.2	.27	.04	.02
CSP30	0 T 5	A/E	SL	4.8	11.12	.2	.07
CSP30	5 T 33	E	LS	5.2	1.28	.1	.02
CSP30	33 T 49	B/E	LS	5.1	.16	.06	.02
CSP30	49 T 77	Bw	LS	5.3	.05	.04	.02
CSP30	77 T 87	BC	LS	4.8	.05	.03	.01
CSP30	87 T 108	CB	S	5.1	.05	.03	.01
CSP30	108 T 128	C	S	5.1	.05	.03	.01
CSP31	0 T 6	A	SL	5	2.13	.12	.04
CSP31	6 T 28	E1	LS	4.6	.74	.07	.02
CSP31	28 T 43	E2	LS	4.7	1.17	.07	.02
CSP31	43 T 66	Bt	LS	4.9	.43	.05	.02
CSP32	0 T 16	A	SL	4.9	1.60	.09	.03
CSP32	16 T 32	E	LS	4.9	.80	.05	.02
CSP32	32 T 37	Bw	S	5	.64	.04	.01
CSP32	37 T 51	C1	S	5.2	.32	.03	.01
CSP32	51 T 73	C2	S	5.3	.21	.02	.01
CSP32	73 T	Cr	S	5.1	.64	.06	.03
CSP33	0 T 16	A	SL	4.9	1.60	.09	.03
CSP33	16 T 32	E	LS	4.9	.80	.05	.02
CSP33	32 T 37	Bw	S	5	.64	.04	.01
CSP33	37 T 51	C1	S	5.2	.32	.03	.01
CSP33	51 T 73	C2	S	5.3	.21	.02	.01
CSP33	73 T	Cr	S	5.1	.64	.06	.03

Table 26. Continued.

Site #	Depth (cm)	Horizon	Texture	pH (1:1)	(%) Organic Carbon	Water Content .03mPa	mm 1.5mPa
CSP34	0 T 19	E1	SL	4.6	1.44	.13	.03
CSP34	19 T 34	E2	LS	4.7	.59	.09	.03
CSP34	34 T 56	Bw	LS	4.7	.53	.07	.02
CSP35	0 T 6	E1	SL	4.7	4.58	.18	.04
CSP35	6 T 22	E2	SL	4.9	.16	.12	.03
CSP35	22 T 33	2EB	SL	5	.53	.11	.05
CSP35	33 T 42	2Bt1	SL	4.9	.16	.13	.06
CSP35	42 T 55	2Bt2	SL	5.4	0	.13	.06
CSP36	0 T 6	E1	SL	4.7	4.58	.18	.04
CSP36	6 T 22	E2	SL	4.9	.16	.12	.03
CSP36	22 T 33	2EB	SL	5	.53	.11	.05
CSP36	33 T 42	2Bt1	SL	4.9	.16	.13	.06
CSP36	42 T 55	2Bt2	SL	5.4	0	.13	.06
CSP37	0 T 18	E	SL	4.1	1.38	.11	.03
CSP37	18 T 31	E/B	LS/SL	4.5	.05	.09	.02
CSP37	31 T 42	Bw	LS	4.5	.59	.05	.01
CSP37	42 T 51	Cr	S	4.6	0	.03	.01
CSP38	0 T 18	E	SL	4.1	1.38	.11	.03
CSP38	18 T 31	E/B	LS/SL	4.5	.05	.09	.02
CSP38	31 T 42	Bw	LS	4.5	.59	.05	.01
CSP38	42 T 51	Cr	S	4.6	0	.03	.01
CSP39	0 T 20	E	SL/LS	4.6	0	.1	.02
CSP39	20 T 34	E/B	S/LS	4.9	0	.05	.01
CSP39	34 T 49	Bw	S	5.2	0	.03	.01
CSP39	49 T 65	B/C	LS	4.8	0	.09	.03
CSP39	65 T 92	Cr	S	5	0	.05	.02
CSP40	0 T 20	E	SL/LS	4.6	0	.1	.02
CSP40	20 T 34	E/B	S/LS	4.9	0	.05	.01
CSP40	34 T 49	Bw	S	5.2	0	.03	.01
CSP40	49 T 65	B/C	LS	4.8	0	.09	.03
CSP40	65 T 92	Cr	S	5	0	.05	.02
CSP41	0 T 13	E	SL	4.6	.85	.09	.02
CSP41	13 T 23	B/E	SL	4.6	.64	.1	.02
CSP41	23 T 36	Bw	LS	4.7	.53	.07	.02
CSP41	36 T 51	BC	LS	4.8	.59	.04	.02
CSP41	51 T 69	Cr	S	4.8	.43	.02	.01
CSP42	0 T 11	E1	L	5	1.06	.2	.04
CSP42	11 T 19	E2	SiL	4.8	1.92	.19	.04
CSP42	19 T 27	E/B	L	4.8	.21	.2	.08
CSP42	27 T 45	Bt1	SCL	4.9	0	.19	.09
CSP42	45 T 62	2BC	LS	5.2	0	.11	.04
CSP42	62 T 69	2C	LS	5.3	0	.12	.05

APPENDIX VII

Table 27. Particle size distribution of 40 soil sites in Custer State Park.

SITE #	Parent Order	Depth (cm)	Horizon	Clay	FSi	Silt MSi	CSi	VFS	FS	Sand MS	CS	VCS	(%) coarse frag	Texture
				PARTICAL SIZE (% OF TOTAL)										
CSP1	6A	0 TO 8	A/E	6.4	4.2	13.5	23.2	6.8	11.7	13.7	10.4	10	.2	SL/L
CSP1	6A	8 to 31	E	3.6	3.9	15.4	23.4	7.5	12	12.9	9.2	12.3	.25	SL
CSP1	6A	31 to 61	Bt	11.1	1.7	3.7	5.5	7.9	27.9	30.8	7.9	3.4	.35	SL
CSP1	6A	61 to 79	C	1.7	1	1.7	3.6	8.6	36.5	38.8	5.9	2.2	.4	S
CSP2	6A	0 T 5	A	12.8	6.2	25	32.4	7.6	5.8	5.6	2.7	1.9	.15	SiL
CSP2	6A	5 T 36	E	8.9	5.9	16.7	21.9	8.4	20	9.9	4.5	3.7	.2	L
CSP2	6A	36 T 56	B/E	27	5.1	14.6	29	8.3	7.5	5.5	1.6	1.5	.25	L/SiL/CL
CSP2	6A	56 T 74	Bt	27.7	4.6	10.2	24	8.5	10.3	8.7	3.2	2.7	.35	L/CL
CSP2	6A	74 T 100	C	23	5.4	8.8	16.5	9.6	15.9	14.4	4.2	2.2	.35	L
CSP3	6A	0 T 8	A/E	4.2	3.8	10.1	15.9	6.4	13.3	16	15.9	14.3	.2	SL
CSP3	6A	8 T 33	E	5.2	4.5	14.7	31.3	7.9	8.4	9.5	9.3	9.2	.25	SiL
CSP3	6A	33 T 46	Bt1	31.9	5	9	17.3	6.4	7.1	8.2	9	6.2	.35	CL
CSP3	6A	46 T 54	Bt2	24.1	4.1	7.5	14.4	6.7	8.9	11	11.8	11.6	.4	SCL
CSP3	6A	54 T 67	C	15.8	3.3	7.9	13.5	6.5	10.1	13.1	15.3	14.3	.45	SL
CSP4	6A	0 T 5	A/E	9.2	4.9	17.3	20.8	4.5	6.9	9.9	13.6	12.8	.2	L
CSP4	6A	5 T 30	E	2.9	2.5	10.1	15.2	5.2	8.4	13.5	21	21.1	.25	SL
CSP4	6A	30 T 56	B/E	23.3	5.3	14.5	21	5.7	5.1	7	9.5	8.7	.35	L
CSP4	6A	56 T 77	Bt1	30.9	5.2	14.9	30.9	7.2	2.4	2.8	3.2	2.6	.35	SiCL
CSP4	6A	77 T 95	Bt2	30.5	6.1	14.7	26.9	6.9	2.5	3.2	4.3	4.8	.4	CL
CSP4	6A	95 T 123	C	26.6	4	12.5	24	7.2	4.6	6	8.2	7	.45	L
CSP5	6A	0 T 5	A/E	8.4	5	15.2	28	7	10.2	11.8	8.5	6.1	.15	L
CSP5	6A	5 T 33	E	4.3	4.3	11.1	22.4	8.1	12.4	14.8	11.5	11	.2	SL
CSP5	6A	33 T 49	B/E	30.8	5.1	9.6	19.3	6.5	9.3	8.6	6	4.7	.3	CL
CSP5	6A	49 T 90	Bt1	27.8	5.4	8	22.1	6.4	8	7.8	8.3	6.1	.4	L/CL
CSP5	6A	90 T 118	Bt2	24.1	2.9	10.8	22.6	7.3	7.5	8.1	8.5	8.1	.4	L
CSP5	6A	118 T 141	C	4.5	.7	1.7	3.7	5.1	13.7	21.3	31.5	17.9	.5	S

Table 27. Continued.

SITE #	Parent Order	Depth (cm)	Horizon	PARTICAL SIZE (% OF TOTAL) Clay	Silt FSi	Silt MSi	Silt CSi	Sand VFS	Sand FS	Sand MS	Sand CS	Sand VCS	(%) coarse frag	Texture
CSP6	SA	0 T 5	A/E	8.4	4.4	18.8	24.5	6.3	8.5	10.8	9.4	9	.1	L
CSP6	SA	5 T 28	E	10.8	5.9	13.9	34.6	8.7	7.6	7.6	5.7	5.3	.15	SiL
CSP6	SA	28 T 41	B/E	35.5	5.6	10	27.5	8	4.2	3.7	2.8	2.7	.25	CL
CSP6	SA	41 T 59	Bt1	32.8	5.1	12	24.9	7.1	6.2	5.8	2.9	3.2	.35	CL
CSP6	SA	59 T 74	Bt2	25.3	3.9	9.9	33	5.5	6.5	6.4	4	5.6	.4	L
CSP6	SA	74 T 154	2C	2.6	1	4.6	4.1	10.2	35.1	31.9	7	3.5	.45	S
CSP7	6A	0 T 5	A/E	7.9	2.5	13.3	25.1	6.1	6.4	8.7	13.2	16.6	.2	L
CSP7	6A	5 T 20	E/B	17.6	5	14.8	31.8	7.5	3.3	4	6.4	9.6	.25	SiL
CSP7	6A	20 T 44	B/E	15.7	4.5	9.4	9.1	7.4	11.3	13.2	15	14.3	.3	SL
CSP7	6A	44 T 74	Bt	29.2	6.5	12	25.3	5.7	3.4	4.1	6.2	7.7	.35	CL
CSP7	6A	74 T 102	Bt	32.8	5.4	15.2	27.3	5.7	2.4	2.5	3.5	5.1	.4	SiCL/CL
CSP7	6A	102 T 148	C	13.9	3.5	9.8	8.9	8.5	15.1	19.2	14	7.1	.45	SL
CSP8	6A	0 T 5	A/E	5.7	2.7	11.4	18.1	5.7	7.8	11.1	16.8	20.7	.2	SL
CSP8	6A	5 T 26	E	8.9	6.3	21.2	25.4	7	5.7	6.6	9.8	9	.2	SiL
CSP8	6A	26 T 49	B/E	32.3	5.8	12.9	29	6.4	3.1	3.2	3.8	3.6	.25	CL/SiCL
CSP8	6A	49 T 74	Bt1	27.9	3.6	10.4	23.6	6.3	4.9	6.1	7.8	9.4	.35	CL/L
CSP8	6A	74 T 97	Bt2	15.3	3.5	7	10.7	5.8	9.5	11.7	17.1	19.4	.45	SL
CSP8	6A	97 T 118	C	6.3	2.5	4.4	6.2	7.5	15.2	18.5	21.7	17.6	.5	LS
CSP9	6A	0 T 5	A/E	4	3.3	13.3	19.5	5.5	10.5	15.5	16.6	11.8	.05	SL
CSP9	6A	5 T 28	E	4.5	4.5	10.8	13.4	7.6	14.5	17.2	14	13.7	.1	SL
CSP9	6A	28 T 44	Bt1	8.4	1.5	5.3	4	5.7	12.9	18.2	21.9	22.2	.05	LS
CSP9	6A	44 T 51	Bt2	8.6	.7	3.6	2.8	7.7	22.8	29.9	17	7	.05	LS
CSP9	6A	51 T 79	CB	7.2	1.1	3.8	2.2	8.8	28.3	31	14.4	3.3	.05	LS
CSP9	6A	79 T 92	C	4.5	1.3	3.5	3.2	7.4	23.2	31	19.3	6.6	.05	LS/S

Table 27. Continued.

				PARTICAL SIZE (% OF TOTAL)									(%)	
					Silt			Sand					coarse	
SITE #	Parent Order	Depth (cm)	Horizon	Clay	FSi	MSi	CSi	VFS	FS	MS	CS	VCS	frag	Texture
CSP10	6A	0 T 8	A	5.9	2	8.9	15.6	5.6	9.3	13.4	19.4	19.8	.2	SL
CSP10	6A	8 T 30	E	5.2	3.8	12.2	31.8	11.9	6.8	8.2	10	10	.3	SL/SiL
CSP10	6A	30 T 56	E/B	32.6	4.4	13.9	30.5	8.3	2.7	2.8	3	1.9	.35	SiCL
CSP10	6A	56 T 100	Bt1	28.4	6.8	10.9	28.2	7.2	3.5	4.2	4.6	6.2	.4	CL/L
CSP10	6A	100 T 133	Bt2	22.9	4.8	12.6	20.8	7.1	7.2	7.3	8.2	9.1	.45	L
CSP10	6A	133 T 148	BC	20.5	3.5	10.7	16.4	6.6	7.8	8.8	11.9	13.9	.55	L
CSP10	6A	148 T 166	C	22.6	2.9	11.8	17.7	7.1	7.8	8.6	10.5	10.9	.6	L
CSP11	6A	0 T 5	A/E	9.5	3.7	12.3	20.5	4.6	11	15.1	11.7	11.7	.2	SL
CSP11	6A	5 T 20	E	5.1	3.6	11.7	14.6	4.9	9.6	13.7	15.5	21.3	.25	SL
CSP11	6A	20 T 41	B/E	10.2	4.1	8.8	7.1	3.8	7.9	11.9	20.2	25.9	.35	SL
CSP11	6A	41 T 82	Bt	14.2	4	9.6	6.9	3.4	6.2	9.3	18.1	28.4	.4	SL
CSP11	6A	82 T	C	8.9	1.5	6.2	6.9	4.3	9.2	12.9	23	27	.45	SL
CSP12	6I	0 T 5	A/E	12	4	17.9	21	4.9	9.7	12.5	11.6	6.4	.06	L
CSP12	6I	5 T 23	E	4.7	3.2	12.1	20.3	6.4	12.7	14.8	13.7	12.1	.2	SL
CSP12	6I	23 T 36	B/E	5.7	3	3.8	6.6	4.7	10.2	14.4	26.8	24.8	.35	LS
CSP12	6I	36 T 67	Bw	6.3	.9	3.7	3.1	3.9	8.9	14.5	29.6	29.1	.35	LS
CSP12	6I	67 T 74	C	3.1	2.1	2.1	2.7	3.9	9	14.7	28.2	34	.4	S
CSP13	SI	0 T 3	A	22.7	5	21	18	5.4	9.8	11.9	4.6	1.5	.1	L
CSP13	SI	3 T 30	A/E	4.2	1.8	13.1	15.6	9.4	20.5	24.6	7.7	3.1	.15	SL
CSP13	SI	30 T 36	BE	5.5	2.8	8.7	7.7	9.2	25.5	28.5	8.9	3.3	.2	SL/LS
CSP13	SI	36 T 51	Bw	4.5	.8	7.3	1.7	8.1	26.7	36.5	11	3.4	.4	LS
CSP13	SI	51 T 59	BC	5	.4	6.9	2.1	8.3	27.4	34.3	11.3	4.2	.5	LS
CSP13	SI	59 T 69	C	4.2	0	4.2	4.5	9.9	33.7	33.8	7.8	1.9	.6	LS/S
CSP15	SI	0 T 30	A/E	5.9	3.3	10.3	17.3	11.5	24.4	18.5	4.8	4	.2	SL
CSP15	SI	30 T 49	E	7	5	0	1.7	10.2	39.3	29.8	4.9	2	.3	LS
CSP15	SI	49 T 67	Bw	8.6	2.6	0	2.6	9.7	37.7	34.4	3.6	.7	.4	LS
CSP15	SI	67 T 74	BC	6.2	.4	4.8	0	8.9	36.2	35	6.7	1.8	.5	S
CSP15	SI	74 T 90	C	5	.6	3.4	1.2	8.3	36.4	37.7	6.5	!	.65	S

Table 27. Continued.

				PARTICAL SIZE (% OF TOTAL)									(%)	
	Parent	Depth			Silt			Sand					coarse	
SITE #	Order	(cm)	Horizon	Clay	FSi	MSi	CSi	VFS	FS	MS	CS	VCS	frag	Texture
CSP16	SA	0 T 28	E	7.2	3.6	15.9	24.2	7.7	12.8	16.5	7.4	4.6	.15	L/SL
CSP16	SA	28 T 44	B/E	37.9	4.9	15.2	26.8	6.2	3.7	3.3	1.3	.8	.2	SiCL
CSP16	SA	44 T 67	Bt	32.8	3.7	11.4	18.6	6	6.5	7.8	7.8	5.4	.4	CL
CSP16	SA	67 T 90	BC	8.6	1.8	4.6	2.4	7.9	22.5	31.8	16.3	4	.4	LS
CSP16	SA	90 T 138	C	5.8	.4	3.6	2.1	6.3	22.1	37.2	18.8	3.7	.45	S/LS
CSP17	GI	0 T 5	A	6	2	10.3	14.7	5.9	10.2	13.5	18.2	19.2	.25	SL
CSP17	GI	5 T 18	Bw	3.2	3.4	8.6	11.5	5	8.8	12.9	20.5	26.2	.4	SL/LS
CSP17	GI	18 T 54	Cr	2.4	.7	2.8	5.9	5.1	11.3	16.9	24.8	30	.6	S
CSP18	GI	0 T 5	A/E	19.2	2.9	14.7	13.4	4.2	8.1	9.7	13.5	14.3	.35	L
CSP18	GI	5 T 13	Bw	4.5	4.1	10	11.4	6.3	10.9	14.8	19	19.1	.45	SL
CSP18	GI	13 T 26	C	6.4	2.2	10.9	10.5	5.7	10.2	13.1	18.5	22.5	.65	SL
CSP19	GA	0 T 5	A/E	8.3	2.9	13.2	23.9	6.7	10.7	14	11.8	8.4	.2	L
CSP19	GA	5 T33	E	7.1	4.4	14.8	23.7	8.1	11.5	13.2	10.2	7	.25	L/SL
CSP19	GA	33 T 49	B/E	24.5	6	10.5	25.4	8	7.7	7.8	5.1	5.1	.35	CL/L
CSP19	GA	49 T 61	Bt	28.2	4.4	10.4	25.4	7.5	7.1	7.2	6	3.9	.4	CL/L
CSP19	GA	61 T 72	BC	10.3	1.7	4.2	10.2	5.6	10.8	16.3	21.7	19.2	.4	SL
CSP19	GA	72 T 87	C	5.1	.8	2.5	6.1	4.9	11.2	18.4	29.5	21.5	.65	LS
CSP20	SA	0 T 18	A/E	5.1	6.4	10.9	16.5	6.7	14.7	19.5	11.6	8.4	.2	SL
CSP20	SA	18 T 41	Bt1	9.9	2.6	14	19.1	8.4	14.1	18.4	10.1	3.5	.2	SL
CSP20	SA	41 T 63	Bt2	9.6	1.8	11	7.9	7.9	19.6	26.1	12.2	3.9	.55	SL

Table 27. Continued.

SITE #	Parent Order	Depth (cm)	Horizon	PARTICAL SIZE (% OF TOTAL) Clay	Silt FSi	Silt MSi	Silt CSi	Sand VFS	Sand FS	Sand MS	Sand CS	Sand VCS	(%) coarse frag	Texture
CSP21	6A	0 T 5	A/E	6.9	2.9	8.2	12.8	6.7	13.1	15.5	17.4	16.7	.25	SL
CSP21	6A	5 T 28	E	4.2	3.8	8.4	11.6	6.7	21	20.7	14.3	9.2	.3	SL
CSP21	6A	28 T 44	B/E	11.4	1.8	4.9	7	7.7	18.7	22	18.1	8.3	.35	SL
CSP21	6A	44 T 84	Bt	16.9	2.4	6.6	7.6	6.1	10.7	14	18.7	16.9	.45	SL
CSP21	6A	84 T 115	BC	9.9	2.8	5.9	6.2	5.9	12.8	18.8	22.7	15.2	.5	SL
CSP21	6A	115 T 141	C	7.5	1.2	7.2	4.4	7	19.1	25.5	18.1	10.1	.5	LS
CSP22	6I	0 T 5	A/E	6.6	2	9.9	15.1	4.3	8.9	12.6	21.8	18.8	.35	SL
CSP22	6I	5 T 10	Bw	4	1.4	9.2	11.4	4.8	8.9	13.8	23.9	22.5	.45	LS/SL
CSP22	6I	10 T 18	C	4.6	1.8	8.3	10.3	5.1	10.9	16.5	22.6	19.8	.6	LS/SL
CSP23	6I	0 T 5	A/E	11	4.1	15.9	20.7	4.2	8	11.5	13.8	10.8	.2	L
CSP23	6I	5 T 20	E	4.5	3.3	12	11.7	6.1	10.2	13.7	17.8	20.7	.35	SL
CSP23	6I	20 T 30	Bw	5	2.2	8.7	8.3	6.7	11.7	15.6	21.3	20.7	.45	LS
CSP23	6I	30 T 46	C	3.8	1.2	5.8	8.4	7.3	14.1	18.7	22.4	18.3	.55	LS
CSP24	6A	0 T 8	A/E	10.3	4.7	17.1	23.4	4.6	7.3	9.8	12.5	10.4	.2	L
CSP24	6A	8 T 28	E	8.9	5.3	15.8	24	5.6	6	7.9	11.6	14.9	.3	L
CSP24	6A	28 T 38	B/E	15.4	3.7	8.3	14.3	4.6	7.2	11.5	18	17	.35	SL
CSP24	6A	38 T 61	Bw1	8.7	2	5.9	5.2	4.9	9.3	14.7	25	24.3	.4	SL/LS
CSP24	6A	61 T 87	Bw2	11.6	3	9.7	5.5	5.6	10.5	14.2	20.8	19.1	.45	SL
CSP24	6A	87 T 138	BC	7.3	2.9	9.9	8.9	6.1	11	14.5	19.9	19.7	.5	SL
CSP24	6A	138 T 161	C	6.6	2.4	9.6	7.8	7	12.9	16.7	20.3	16.7	.6	SL
CSP25	6I	0 T 8	A/E	5.3	8.6	4.9	17.3	5.7	10.2	12.9	16.5	18.6	.25	SL
CSP25	6I	8 T 23	E	2	4.3	7.6	10.9	4.9	9.4	14.4	22.5	24.1	.35	LS
CSP25	6I	23 T 44	Bw	3	2.2	5.5	16.6	4.4	9.3	13.8	20.8	24.3	.5	SL
CSP25	6I	44 T 59	C	3.2	2.2	2.2	10.2	4.7	9.9	15	23	29.6	.6	LS

Table 27. Continued.

	Parent	Depth		PARTICAL SIZE (% OF TOTAL)									(%)	
					Silt			Sand					coarse	
SITE #	Order	(cm)	Horizon	Clay	FSi	MSi	CSi	VFS	FS	MS	CS	VCS	frag	Texture
CSP26	GI	0 T 5	A/E	4.9	2.6	9.4	16.7	6.3	16.6	23.7	12.4	7.5	.2	SL
CSP26	GI	5 T 20	E	3.8	3.1	10.1	12.7	5.9	13.4	18.7	16.4	15.8	.35	SL
CSP26	GI	20 T 41	Bw	3	1.3	5.3	6.5	6.9	14.4	20.7	24.5	17.5	.45	LS
CSP26	GI	41 T 54	C	2.4	1	4.4	7	6.1	14.7	21.2	24.4	18.9	.65	LS
CSP28	GA	0 T 5	A/E	5.9	4.2	15.4	25.6	6.6	9.7	11.2	10.4	11.1	.2	SL
CSP28	GA	5 T 20	E	7.6	3.2	18.7	6.8	8.5	9.9	12.7	13.3	19.5	.25	SL
CSP28	GA	20 T 38	B/E	12.7	3	10.7	12.3	6.6	10.6	13.7	14.1	16.2	.25	SL
CSP28	GA	38 T 64	Bt1	11.8	2.2	7	5.2	8.5	18.5	24	13.9	8.9	.35	SL
CSP28	GA	64 T 95	Bt2	8.9	5.3	6.9	5.8	6.1	11.4	16.7	20.2	18.8	.35	SL
CSP28	GA	95 T 123	Bt3	12.4	4.3	11.7	6.5	7.6	12.1	16.2	20.7	8.3	.4	SL
CSP28	GA	123 T 148	BC	8.3	2.5	8	6	5.1	10.1	15.9	21.7	22.4	.6	SL
CSP28	GA	148 T 166	C	3.9	3.3	4.6	10.3	4.5	8.9	14.8	22.8	26.8	.6	LS
CSP29	GI	0 T 5	A/E	9.5	3.2	12.7	20.4	4.6	7.9	9.2	13.3	19.2	.2	SL
CSP29	GI	5 T 20	E	6.6	6.2	14.5	16.9	7	10.1	12.4	18.1	8.2	.3	SL
CSP29	GI	20 T 44	B/E	8.2	5	13.2	7.5	8.2	15.4	16.8	18.6	7.1	.4	SL
CSP29	GI	44 T 72	Bw	8.1	1.8	7.4	5.7	7.9	22.5	25.3	13.1	8.2	.45	SL/LS
CSP29	GI	72 T 90	C	4.8	3.1	4.8	7.1	8.1	22.4	26.5	13.7	9.4	.45	LS
CSP30	SI	0 T 5	A/E	7.8	5.7	13.5	19.1	7.6	18.9	14.8	7.4	5.3	.2	SL
CSP30	SI	5 T 33	E	5.6	3.3	9.2	.4	9.9	28.9	26.2	7	9.4	.25	LS
CSP30	SI	33 T 49	B/E	7.6	2	4	5.2	10.3	39.9	25	4	2	.3	LS
CSP30	SI	49 T 77	Bw	6.1	.6	4.1	3.4	9.7	32.7	36.8	6.1	.5	.35	LS
CSP30	SI	77 T 87	BC	6.2	.6	3.7	3.1	7.5	32.3	38.3	6.5	1.6	.45	LS
CSP30	SI	87 T 108	CB	3.5	1.3	2.5	3.2	8	30.3	35.3	10.8	5.2	.45	S
CSP30	SI	108 T 128	C	2.3	.7	5.6	3	7.7	31.7	36	9.3	3.7	.45	S

Table 27. Continued.

SITE #	Parent Order	Depth (cm)	Horizon	Clay	FSi	Silt MSi	CSi	VFS	FS	Sand MS	CS	VCS	(%) coarse frag	Texture
				PARTICAL SIZE (% OF TOTAL)										
CSP31	GA	0 T 6	A	6	3.2	10.4	11.4	8.9	20.4	26.6	10	3.1	.02	SL
CSP31	GA	6 T 28	E1	0	1.7	3.3	12.1	7.8	22	34.2	14.9	4.1	.02	LS
CSP31	GA	28 T 43	E2	0	2.2	3.1	13.1	7.7	21.8	33.7	13	5.4	.02	LS
CSP31	GA	43 T 66	Bt	6.4	.8	2.5	3	6.8	17.6	22.2	23.7	16.8	0	LS
CSP32	SI	0 T 16	A	6	0	9.1	9.9	8.3	25	31.9	7.2	2.7	.1	SL
CSP32	SI	16 T 32	E	4.3	3.7	0	6.1	9.1	28	36.1	9.2	3.5	.1	LS
CSP32	SI	32 T 37	Bw	1.3	1	2.6	4.1	8.1	25.6	31.6	18.3	7.5	.2	S
CSP32	SI	37 T 51	C1	.3	3.4	0	6.9	10.1	34.7	34	7.4	3.2	.5	S
CSP32	SI	51 T 73	C2	0	1	0	7.3	8.3	28.9	35.5	12.2	6.9	.5	S
CSP32	SI	73 T	Cr	1.3	1.3	1.3	5.2	8.8	33.4	33.6	10.3	4.6	.1	S
CSP33	SI	0 T 16	A	6	0	9.1	9.9	8.3	25	31.9	7.2	2.7	.1	SL
CSP33	SI	16 T 32	E	4.3	3.7	0	6.1	9.1	28	36.1	9.2	3.5	.1	LS
CSP33	SI	32 T 37	Bw	1.3	1	2.6	4.1	8.1	25.6	31.6	18.3	7.5	.2	S
CSP33	SI	37 T 51	C1	.3	3.4	0	6.9	10.1	34.7	34	7.4	3.2	.5	S
CSP33	SI	51 T 73	C2	0	1	0	7.3	8.3	28.9	35.5	12.2	6.9	.5	S
CSP33	SI	73 T	Cr	1.3	1.3	1.3	5.2	8.8	33.4	33.6	10.3	4.6	.1	S
CSP34	GI	0 T 19	E1	7.2	3.6	11.7	11.3	4.5	4.5	23.5	24.7	9	.05	SL
CSP34	GI	19 T 34	E2	4.6	2.6	7.6	8.6	11	32.8	26.1	3.9	2.7	.1	LS
CSP34	GI	34 T 56	Bw	5.1	1.4	5.8	7	11	35	26.8	5.2	2.8	.2	LS

Table 27. Continued.

				PARTICAL SIZE (% OF TOTAL)									(%)	
	Parent	Depth			Silt			Sand					coarse	
SITE #	Order	(cm)	Horizon	Clay	FSi	MSi	CSi	VFS	FS	MS	CS	VCS	frag	Texture
CSP35	6A	0 T 6	E1	4.6	4.2	16	24	9.4	13.3	12.4	7.3	8.7	.08	SL
CSP35	6A	6 T 22	E2	4.3	5	12.7	29.8	9.2	13	13.2	6.2	6.6	.25	SL
CSP35	6A	22 T 33	2EB	17	2.8	11.4	12.7	7.5	14.7	17.9	8.4	7.5	.2	SL
CSP35	6A	33 T 42	2Bt1	17.8	2.3	9.7	5.8	6.4	14.3	20.3	12	11.4	.15	SL
CSP35	6A	42 T 55	2Bt2	17.2	5.5	9.3	3.3	8.2	15.2	21.1	11	9.1	.15	SL
CSP36	6A	0 T 6	E1	4.6	4.2	16	24	9.4	13.3	12.4	7.3	8.7	.08	SL
CSP36	6A	6 T 22	E2	4.3	5	12.7	29.8	9.2	13	13.2	6.2	6.6	.25	SL
CSP36	6A	22 T 33	2EB	17	2.8	11.4	12.7	7.5	14.7	17.9	8.4	7.5	.2	SL
CSP36	6A	33 T 42	2Bt1	17.8	2.3	9.7	5.8	6.4	14.3	20.3	12	11.4	.15	SL
CSP36	6A	42 T 55	2Bt2	17.2	5.5	9.3	3.3	8.2	15.2	21.1	11	9.1	.15	SL
CSP37	6I	0 T 18	E	6.1	2.8	18	24.5	5.6	6.4	8.1	13.7	14.7	.23	SL
CSP37	6I	18 T 31	E/B	2.9	3.5	11.3	7.6	5.7	9.2	12.6	18.3	29	.23	LS/SL
CSP37	6I	31 T 42	Bw	2.8	2.5	6.8	6.9	6.1	10.6	13.9	22.2	28.3	.4	LS
CSP37	6I	42 T 51	Cr	.3	.3	3.3	8.3	6.9	11.1	15.6	22.2	32.1	.6	S
CSP38	6I	0 T 18	E	6.1	2.8	18	24.5	5.6	6.4	8.1	13.7	14.7	.23	SL
CSP38	6I	18 T 31	E/B	2.9	3.5	11.3	7.6	5.7	9.2	12.6	18.3	29	.23	LS/SL
CSP38	6I	31 T 42	Bw	2.8	2.5	6.8	6.9	6.1	10.6	13.9	22.2	28.3	.4	LS
CSP38	6I	42 T 51	Cr	.3	.3	3.3	8.3	6.9	11.1	15.6	22.2	32.1	.6	S

Table 27. Continued.

				PARTICAL SIZE (% OF TOTAL)									(%)	
	Parent	Depth			Silt				Sand				coarse	
SITE #	Order	(cm)	Horizon	Clay	FSi	MSi	CSi	VFS	FS	MS	CS	VCS	frag	Texture
CSP39	SI	0 T 20	E	3	3.3	10.3	10.1	7.5	22.9	30.4	8.6	3.9	.1	SL/LS
CSP39	SI	20 T 34	E/B	1.8	2.1	2.4	7	8.2	30.1	36.5	9.1	3	.1	S/LS
CSP39	SI	34 T 49	Bw	3.7	.3	.6	4.4	5.5	22.8	39.5	20.1	3.2	.15	S
CSP39	SI	49 T 65	B/C	3.8	1.7	3.8	7.1	11.1	34.2	31.4	5.8	1.2	.05	LS
CSP39	SI	65 T 92	Cr	3.6	1	0	5.7	7.6	31.1	39.3	9.2	2.5	.05	S
CSP40	SI	0 T 20	E	3	3.3	10.3	10.1	7.5	22.9	30.4	8.6	3.9	.1	SL/LS
CSP40	SI	20 T 34	E/B	1.8	2.1	2.4	7	8.2	30.1	36.5	9.1	3	.1	S/LS
CSP40	SI	34 T 49	Bw	3.7	.3	.6	4.4	5.5	22.8	39.5	20.1	3.2	.15	S
CSP40	SI	49 T 65	B/C	3.8	1.7	3.8	7.1	11.1	34.2	31.4	5.8	1.2	.05	LS
CSP40	SI	65 T 92	Cr	3.6	1	0	5.7	7.6	31.1	39.3	9.2	2.5	.05	S
CSP41	SI	0 T 13	E	3.2	3.5	9.6	15	11.3	26.1	20.2	5.7	5.4	.25	SL
CSP41	SI	13 T 23	B/E	5.1	2.1	11.7	12.9	10.5	29	21.5	4.7	2.5	.25	SL
CSP41	SI	23 T 36	Bw	4.9	.7	9.4	6.2	10.7	34	28.1	4.2	1.8	.35	LS
CSP41	SI	36 T 51	BC	3.9	.3	6.5	3.1	11	38.9	28.7	5.4	2.1	.45	LS
CSP41	SI	51 T 69	Cr	2.5	1	5.4	1.6	9.9	36.5	37.4	4.3	1.3	.65	S
CSP42	SA	0 T 11	E1	10.3	4.2	18.1	24.1	10.6	12.6	12.9	4.2	3	.03	L
CSP42	SA	11 T 19	E2	8.1	5	14.8	32.9	10	11.4	11.2	3.6	3	.03	SiL
CSP42	SA	19 T 27	E/B	23.8	4.1	11.9	28.5	8.7	8.8	8.3	3.4	2.4	.06	L
CSP42	SA	27 T 45	Bt1	26.9	4.4	10.2	7.7	9.4	14.9	15.4	6.9	4.2	.12	SCL
CSP42	SA	45 T 62	2BC	9.3	0	3.8	2.7	8	23.9	31	14.4	6.9	.02	LS
CSP42	SA	62 T 69	2C	6.2	3.1	3.8	7.1	8.8	24.6	29.2	11.7	5.5	0	LS

APPENDIX VIII

Table 28. Summary of the morphological pedon descriptions.

Hor	Depth (cm)	Moist color	Texture	Structure	Consistence	Boundary	Coarse frag. (%)
	CSP1 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf						
Oi	3-0						
A/E	0-8	10YR 2/2	SL/L	1fgr	mvfr	as	20
E	8-30	10YR 5/3	SL	1tpl	mfr	cs	25
Bt	30-60	10YR 5/4	SL	2msbk	mfr	gw	35
C	60-79	10YR 6/6	S		mfr	-	40
	CSP2 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf						
A	0-5	10YR 2/1	SiL	1fgr	mvfr	as	15
E	5-36	10YR 5/4	L	1tpl	mvfr	cs	20
B/E	36-56	/	L/SiL/CL	1msbk	mfi	cw	25
Bt	56-74	10YR 4/4	L/CL	2msbk	mfi	gw	35
C	74-99+	10YR 6/6	L	0 sg	ml	-	35
	CSP3 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf						
Oi	5-0						
A/E	0-8	10YR 3/2	SL	2 gr	mfr	as	20
E	8-33	10YR 5/3	SiL	2 gr	mfr	cs	25
Bt1	33-46	10YR 5/4	CL	2 sbk	mfi	gw	35
Bt2	46-53	10YR 5/4	SCL	1 sbk	mfi	gs	40
C	53-66+	10YR 6/6	SL	0 m		-	45
	CSP4 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf						
Oi	5-0						
A/E	0-5	10YR 3/2	L	2 gr	mvfr	cs	20
E	5-30	10YR 5/3	SL	2 gr	mfr	cs	25
B/E	30-56	/	L	2 sbk	mfr	cs	35
Bt1	56-77	10YR 5/4	SiCL	2 sbk	mfi	gs	35
Bt2	77-95	10YR 5/4	CL	1 sbk	mfi	gw	40
C	95-123+	10YR 5/4	L	0 m	mfi	-	45
	CSP5 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf						
Oi	3-0						
A/E	0-5	10YR 2/2	L	2 gr	mvfr	cs	15
E	5-33	10YR 4/2	SL	2 gr	mfr	cs	20
B/E	33-49	/	CL	2 sbk	mfi	gc	30
Bt1	49-90	10YR 5/4	L/CL	2 sbk	mfi	gc	40
Bt2	90-118	10YR 6/4	L	1 sbk	mfi	gw	40
C	118-141+	10YR 6/4	S	0 m		-	50

Table 28. Continued.

Hor	Depth (cm)	Moist color	Texture	Structure	Consistence	Boundary	Coarse frag. (%)
CSP6 Buska series, Loamy-skeletal, micaceous Typic Eutroboralf							
Oi	3-0						
A/E	0-5	10YR 2/2	L	2 gr	mvfr	cs	10
E	5-28	10YR 5/3	SiL	2 gr	mfr	cs	15
B/E	28-41	/	CL	2 sbk	mfi	gs	25
Bt1	41-59	10YR 5/4	CL	2 sbk	mfi	gw	35
Bt2	59-74	10YR 5/4	L	1 sbk	mfi	gw	40
2C	74-154+	10YR 4/3	S	0 m		-	45
CSP7 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf							
A/E	0-5	10YR 3/2	L	2 gr	mvfr	as	20
E/B	5-20	10YR 5/3	SiL	2 gr	mfr	cs	25
B/E	20-44	/	SL	2 sbk	mfi	cw	30
Bt1	44-74	10YR 5/4	CL	2 sbk	mfi	gw	35
Bt2	74-102	10YR 5/4	SiCL	1 sbk	mfi	gw	40
C	102-148+	10YR 5/4	SL	0 m	mfi	-	45
CSP8 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf							
A/E	0-5	10YR 3/2	SL	1 pl	mvfr	cs	20
E	5-26	10YR 4/3	SiL	2 gr	mfr	cs	20
B/E	26-49	/	CL/L	2 gr	mfi	cs	25
Bt1	49-74	10YR 5/4	CL/L	2 sbk	mfi	gw	35
Bt2	74-97	10YR 5/4	SL	1 sbk	mfi	gw	45
C	97-118+	10YR 5/4	LS	0 m		-	50
CSP9 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf							
A/E	0-5	10YR 3/3	SL	2 gr			5
E	5-28	10YR 4/4	SL	2 gr			10
Bt1	28-44	10YR 5/4	LS	2 sbk			5
Bt2	44-51	10YR 5/4	LS	1 sbk			5
CB	51-79	10YR 4/4	LS	0 m			5
C	79-92	10YR 4/4	LS/S	0 m			5
CSP10 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf							
Oi	5-0						
A/E	0-8	10YR 2/2	SL	2 gr			20
E	8-30	10YR 5/4	L/SL	1 sbk			30
B/E	30-56	/	SiCL	2 sbk			35
Bt1	56-100	10YR 6/3	CL/L	2 sbk			40
Bt2	100-133	10YR 6/3	L	2 sbk			45
BC	133-148	10YR 6/4	L	1 sbk			55
C	148-166+	10YR 6/4	L	0 m			60

Table 28. Continued.

Hor	Depth (cm)	Moist color	Texture	Structure	Consistence	Boundary	Coarse frag. (%)
			CSP24 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf				
A/E	0-8	10YR 2/2	L	2 gr	mfr	as	20
E	8-28	10YR 5/4	L	2 gr	mfr	cs	30
B/E	28-38	10YR 5/4	SL	2 sbk	mfr	cs	35
Bw1	38-61	10YR 5/4	SL/LS	2 sbk	mfi	gs	40
Bw2	61-87	10YR 5/4	SL	2 sbk	mfi	gs	45
BC	87-138	10YR 6/4	SL	2 sbk	mfi	dw	50
C	138-161+	10YR 6/4	SL	1 sbk	mfi	-	60
			CSP25 unnamed, mixed Typic Eutrochrept				
A/E	0-8	10YR 3/3	SL	2 gr	mfr	cs	25
E	8-23	10YR 5/4	LS	2 gr	mfr	gs	35
Bw	23-44	10YR 5/4	SL	1 sbk	mfr	gs	50
C	44-59+	10YR 6/4	LS	0 m	mfr	-	60
			CSP26 unnamed, mixed Typic Eutrochrept				
A/E	0-5	10YR 3/2	SL	2 gr	mvfr	cs	20
E	5-20	10YR 4/3	SL	2 gr	mfr	gs	35
Bw	20-41	10YR 5/4	LS	1 sbk	mfr	gw	45
C	41-54+	10YR 5/4	LS	0 m	mfr	-	65
			CSP28 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf				
A/E	0-5	10YR 2/1	SL	2 gr	mfr	cs	20
E	5-20	10YR 6/4	SL	2 gr	mfr	cs	25
B/E	20-38	/	SL	2 sbk	mfr	cs	25
Bt1	38-64	10YR 4/4	SL	2 sbk	mfi	cs	35
Bt2	64-95	10YR 5/4	SL	2 sbk	mfi	gs	35
Bt3	95-123	10YR 5/4	SL	1 sbk	mfi	gs	40
BC	123-148	10YR 6/4	SL	0 m	mfr	ds	60
C	148-166+	10YR 6/4	LS	0 m	mfr	-	60
			CSP29 unnamed, mixed Typic Eutrochrept				
A/E	0-5	10YR 2/2	SL	2 gr	mfr	cs	20
E	5-20	10YR 5/4	SL	2 gr	mfr	gs	30
B/E	20-44	/	SL	1 sbk	mfi	gs	40
Bw	44-72	10YR 5/4	SL/LS	1 sbk	mfi	gw	45
C	72-90+	10YR 4/5	LS	0 m	mfr	-	45

Table 28. Continued.

Hor	Depth (cm)	Moist color	Texture	Struc-ture	Consist-ence	Bound-ary	Coarse frag. (%)
			CSP30 unnamed, micaceous Typic Eutrochrept				
A/E	0-5	10YR 2/2	SL	2 gr	mfr	cs	20
E	5-33	10YR 5/3	LS	2 gr	mfr	cs	25
B/E	33-49	/	LS	2 sbk	mfr	gs	30
Bw	49-77	10YR 4/3	LS	2 sbk	mfi	gw	35
BC	77-87	10YR 5/3	LS	2 sbk	mfi	gs	45
CB	87-108	10YR 5/3	S	1 sbk	mfr	gs	45
C	108-128+	10YR 5/3	S	0 m	mfr	-	45
		CSP31 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf					
A	0-6	10YR 2/2	SL	1fsbk	mvfr	cs	2
E1	6-28	10YR 6/3	LS	1msbk	mvfr	cw	2
E2	28-43	10YR 6/4	LS	1msbk	mfr	cw	2
Bt	43-66	7.5YR 5/4	LS	2msbk	mfi	gw	0
			CSP32 unnamed, micaceous Typic Eutrochrept				
Oi	5-0						
A	0-16	10YR 3/2	SL	1fsbk	mfr	gw	10
E	16-32	10YR 5/3	LS	1msbk	mfr	gw	10
Bw	32-37	10YR 5/3	S	0 sg	ml	gw	20
C1	37-51	10YR 5/4	S	2msbk	mfr	gw	50
C2	51-73	10YR 5/5	S	0 m	mfr	gw	50
Cr	73+		S	3cpl	mfi	-	10
			CSP33 unnamed, micaceous Typic Eutrochrept				
Oi	5-0						
A	0-16	10YR 3/2	SL	1fsbk	mfr	gw	10
E	16-32	10YR 5/3	LS	1msbk	mfr	gw	10
Bw	32-37	10YR 5/3	S	0 sg	ml	gw	20
C1	37-51	10YR 5/4	S	2msbk	mfr	gw	50
C2	51-73	10YR 5/5	S	0 m	mfr	gw	50
Cr	73+		S	3cpl	mfi	-	10
			CSP34 unnamed, mixed Typic Eutrochrept				
Oi	3-0						
E1	0-19	10YR 5/2	SL	2msbk	mfr	gw	5
E2	19-34	10YR 5/3	LS	2msbk	mfr	gw	10
Bw	34-56	10YR 5/4	LS	2msbk	mfr	-	20

Table 28. Continued.

Hor	Depth (cm)	Moist color	Texture	Structure	Consistence	Boundary	Coarse frag. (%)
			CSP35 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf				
Oi	8-0						
E1	0-6	10YR 5/3	SL	1tpl	mvfr	cs	8
E2	6-22	10YR 6/3	SL	1tpl	mvfr	cs	25
2EB	22-33	/	SL	1msbk	mfr	cw	20
2Bt1	33-42	10YR 5/4	SL	2msbk	mfi	cw	15
2Bt2	42-64	10YR 5/4	SL	2msbk	mfi	cw	15
2Cr	64+						
			CSP36 Mocmont series, Loamy-skeletal, mixed Typic Eutroboralf				
Oi	8-0						
E1	0-6	10YR 5/3	SL	1tpl	mvfr	cs	8
E2	6-22	10YR 6/3	SL	1tpl	mvfr	cs	25
2EB	22-33	/	SL	1msbk	mfr	cw	20
2Bt1	33-42	10YR 5/4	SL	2msbk	mfi	cw	15
2Bt2	42-64	10YR 5/4	SL	2msbk	mfi	cw	15
2Cr	64+						
			CSP37 unnamed, mixed Typic Eutrochrept				
Oi	1-0						
E	0-18	10YR 4/4	SL	2fgr	mvfr	gw	23
E/B	18-28	/	LS/SL	1fsbk	mfr	gb	23
Bw	28-42	2.5YR 4/6	LS	1fsbk	mvfi	cb	40
Cr	42-51+	2.5YR 4/6	S	1fsbk	mefi	-	60
			CSP38 unnamed, mixed Typic Eutrochrept				
Oi	1-0						
E	0-18	10YR 4/4	SL	2fgr	mvfr	gw	23
E/B	18-28	/	LS/SL	1fsbk	mfr	gb	23
Bw	28-42	2.5YR 4/6	LS	1fsbk	mvfi	cb	40
Cr	42-51+	2.5YR 4/6	S	1fsbk	mefi	-	60
			CSP39 unnamed, micaceous Typic Eutrochrept				
Oi	6-0						
E	0-20	10YR 6/4	SL/LS	1cpl	mfr	cs	10
E/B	20-34	/	S/LS	1fsbk	mfr	cw	10
Bw	34-49	10YR 6/6	S	1fsbk	mfr	gw	15
BC	49-65	10YR 4/6	LS	2msbk	mfi	gw	5
Cr	65-92+	10YR 3/4	S	2cpl	mfi	-	5

Table 28. Continued.

Hor	Depth (cm)	Moist color	Texture	Structure	Consistence	Boundary	Coarse frag. (%)
			CSP40 unnamed, micaceous Typic Eutrochrept				
Oi	6-0						
E	0-20	10YR 6/4	SL/LS	1cpl	mfr	cs	10
E/B	20-34	/	S/LS	1fsbk	mfr	cw	10
Bw	34-49	10YR 6/6	S	1fsbk	mfr	gw	15
BC	49-65	10YR 4/6	LS	2msbk	mfi	gw	5
Cr	65-92+	10YR 3/4	S	2cpl	mfi	-	5
			CSP41 unnamed, micaceous Typic Eutrochrept				
E	0-13	10YR 3/2	SL	1fpl	mvfr	cs	25
B/E	13-23	/	SL	1msbk	mfr	cs	25
Bw	23-36	10YR 4/4	LS	1msbk	mfr	gw	35
BC	36-51	10YR 6/4	LS	1msbk	mfr	gw	45
Cr	51-69+	10YR 4/4	S	0 m	mfr	-	65
			CSP42 Buska series, Loamy-skeletal, micaceous Typic Eutroboralf				
Oi	5-0						
E1	0-11	10YR 4/2	L	2cpl	mfr	cs	3
E2	11-19	10YR 5/2	SiL	2msbk	mfr	gw	3
B/E	19-27	/	L	2msbk	mfi	gw	6
Bt	27-45	10YR 5/3	SCL	3msbk	mfi	gw	12
2BC	45-62	10YR 5/4	LS	2msbk	mfr	gw	2
2C	62-69+	10YR 5/4	LS	1msbk	mfr	-	0