

A CLASSIFICATION OF SOILS IN BUR OAK WOODLANDS IN THE FOOTHILLS OF THE BLACK HILLS, SOUTH DAKOTA

CAROLYN HULL SIEG¹

Soils were classified in riparian bur oak (*Quercus macrocarpa*) woodlands in the foothills of the Black Hills, South Dakota. The soils in these gallery forests represented a blending of grassland (Mollisol) soils and forested (Alfisol) soils. Four soil-landscape units were identified: (i) relatively young soils on steep slopes (usually Ustochrepts); (ii) soils adjacent to stream channels that were subject to episodic flooding and burial by new layers of alluvium or colluvium (Fluventic Mollisols); (iii) low relief, concave surfaces on stable floodplains away from stream channels (Cumulic Mollisols); (iv) Alfisols and Mollisols with argillic horizons on stable surfaces up off the floodplain. The actual taxonomic classification of similar pedons was often quite different, reflecting changes over time in the overstory and understory. In general, soil types and vegetative communities were poorly correlated. Soil pedons may provide a glimpse of history that helps us to understand past processes in formation, but this knowledge may not be very useful in understanding current plant distribution patterns.

In the Northern Great Plains, native deciduous woodlands constitute less than 1% of the land area, but they provide critical habitat for a number of wildlife species and greatly enhance the biotic diversity of the region. Unfortunately, research has suggested that these native woodlands are in jeopardy (Boltdt et al. 1978). The absence of regeneration of the trees, the decline in the numbers and diversity of shrubs, and the replacement of native grass species with a dense mat of Kentucky bluegrass (*Poa pratensis*) are evidence of the demise of these stands in many areas. A basic understanding of the ecology of these stands, including information on the classification of soils and plant-soil interactions, is necessary to develop methodology for regenerating decadent stands.

¹Rocky Mountain Forest and Range Experiment Station, Rapid City, SD 57701.

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Bur oak reaches its western limit in western North Dakota and South Dakota and the very northeastern portion of Wyoming (Johnson 1990). It occurs in dense stands in the Black Hills of South Dakota and the Killdeer Mountains in western North Dakota, but it also occurs in stream bottoms and along adjacent draws and upper slopes in the western part of its range. Little published information is available on the classification of soils in deciduous woodlands in the Black Hills area. Myers and VanDeusen (1960) and Radeke and Westin (1963) described soils under coniferous vegetation. Bennett (1984) examined pedons of six major soils in the upper Black Hills. White et al. (1969), White (1972), White and Gartner (1974), and White et al. (1974) studied prairie-forest transition soils in the Black Hills. Thilenius (1972) provided the only published information on soils associated with bur oak stands in the Black Hills.

Most of the information available on soil classification of deciduous riparian communities comes from studies conducted in North Dakota. Mack (1981), Butler (1983), and Girard (1985) studied deciduous woodlands in western North Dakota. Wikum and Wali (1974) provided soils information for gallery forests in northeastern North Dakota. Abrams (1985) provided chemical data for bur oak gallery forests in northeastern Kansas. Based on the assumption that vegetative communities are a function of soil taxonomy, soil chemical properties, and landscape position, this study sought to develop a soil-landscape model for bur oak woodlands in riparian or riparian-like areas in the foothills of the Black Hills. This paper reports on the taxonomy and associated chemical composition of associated soils; relationships between vegetative patterns and underlying soil gradients are addressed in a separate manuscript (Sieg 1991).

STUDY AREA AND METHODS

The study area is located in Meade County, South Dakota, in the Fort Meade Recreation Area, south of the town of Sturgis (Fig. 1). Elevation of the area ranges between 1030 and 1130 m, and the area receives an annual average

of 49 cm precipitation (NOAA 1986). The study area encompassed three physiographic areas: the Lower Limestone Plateau in the southwest end, the Red Valley to the northeast of the Limestone Plateau, and the Dakota Hogback that encircles the Black Hills (Darton and Paige 1925) (Fig. 1). The Red Valley formed from reddish-colored Triassic and Permian soft shale and sandstone. The Dakota Hogback is a narrow ridge formed from hard Mesozoic sandstone and shale. Vegetation on the Recreation Area consists of mixed-grass prairie dissected by intermittent streams and pine-covered outcrops. Soils range from Alfisols under pine canopies to Mollisols on level grasslands; Entisols are common on steep slopes (Ollila 1978).

Four study sites were established in 1986: sites 1 and 2 were located on intermittent streams with gradients of approximately 2%; sites 3 and 4 were located in draws with ephemeral streams (Fig. 1). Gradients on these two sites, from the head of the draw to the lower end, ranged from 4 to 8%. Bur oak dominated the overstory on all four sites; green ash (*Fraxinus pennsylvanica*),

box elder (*Acer negundo*), American elm (*Ulmus americana*), and ironwood (*Ostrya virginiana*) were also present in lesser abundance (Sieg 1991). Western snowberry (*Symphoricarpos occidentalis*) was the most common shrub, followed by chokecherry (*Prunus virginiana*), poison ivy (*Toxicodendron rydbergii*), and Missouri gooseberry (*Ribes missouriense*). Kentucky bluegrass, sedges (*Carex* spp.), Canada wildrye (*Elymus canadensis*), and smooth brome (*Bromus inermis*) were the dominant graminoids in the study area.

Soil samples were collected after digging four pits on each site to a depth of 152 cm to describe and classify the soil (Soil Survey Staff 1990); in addition, numerous cores were taken by hand coring to a depth of 70-90 cm to identify boundaries of soil types. The location of the pits was selected to represent the diversity of slopes, aspects, distances from the channel, and plant species composition (Figs. 2-6). Five hundred grams of material were collected from each horizon in each 152-cm pedon, air-dried, and analyzed. Analyses included particle size distribution (Day 1965), electrical conductivity (EC), cation exchange capacity (CEC) (USDA Salinity Laboratory Staff 1954), organic matter (OM) (Prince 1955), NO₃-nitrogen (N) (Keeney and Nelson 1982), total phosphorous (P) (Olsen and Sommers 1982), and pH (McLean 1982). Plant-available levels of potassium (K), zinc (Zn), iron (Fe), manganese (Mn), and copper (Cu) were estimated with the DTPA method (Baker and Amacher 1982). Cross sections of each site were developed by measuring the profile of the land along transects perpendicular to the draw bottom or creek channel. Depth and width of the channel, distance to soil pits and vegetation changes and percent slope were measured on each site with a clinometer, telescoping 30-m pole and a 100-m tape.

Weighted averages, based on horizon depth, were calculated for soil characteristics in pedons with more than one A, B, and/or C horizon. Average characteristics were analyzed separately for the A, B, and C horizons. Analysis of variance (Norusis 1988) was used to test the hypothesis that soil chemical properties did not differ among soil types. Means were separated with Fisher's protected least significant difference multiple comparison tests (Milliken and Johnson 1984). Homogeneity of variances was tested using Cochran's C test (Cochran 1941).

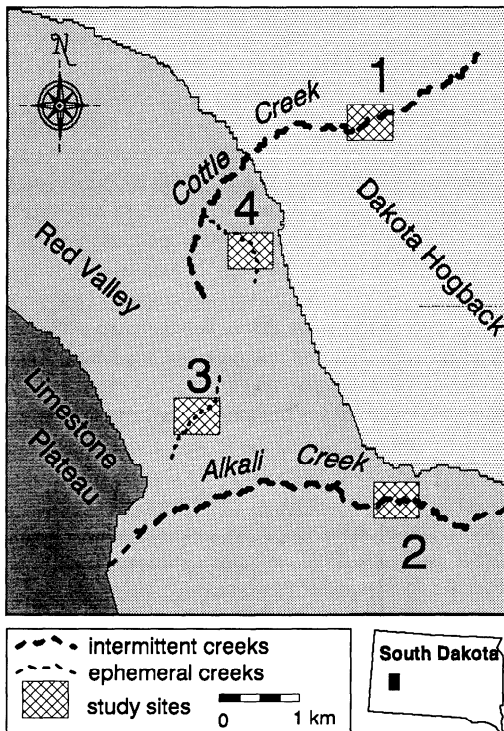


FIG. 1. Location of study area in the foothills of the Black Hills, South Dakota.

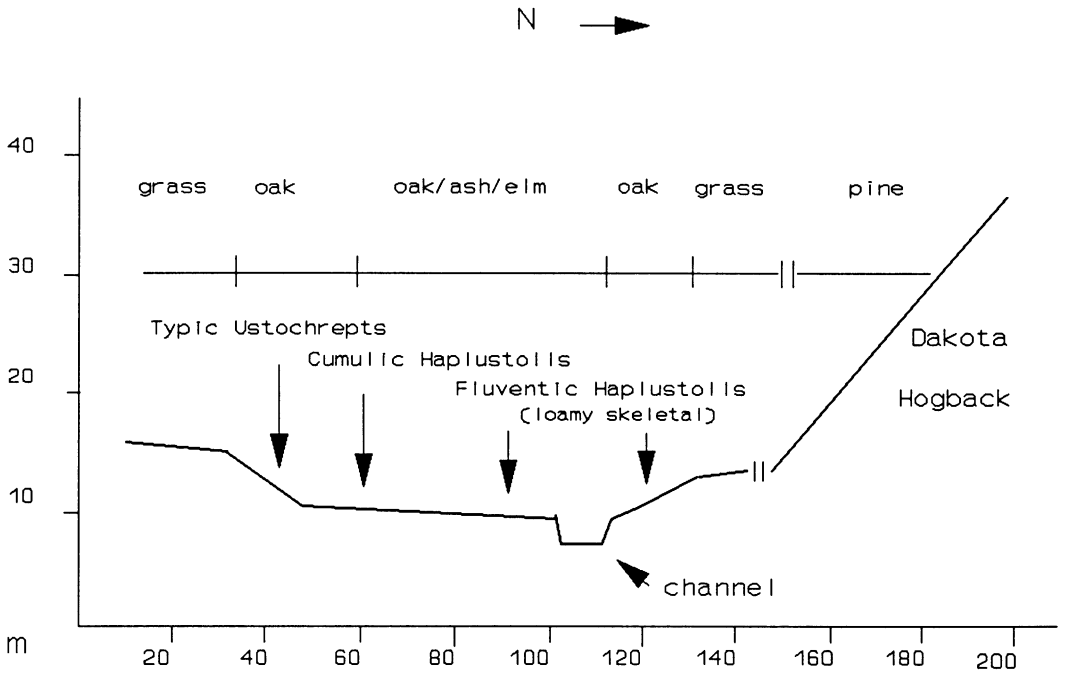


FIG. 2. Typical cross section of site 2, showing locations Typic Ustochrepts, plus Cumulic and Fluentic Haplustolls, on Alkali Creek, in the foothills of the Black Hills, South Dakota.

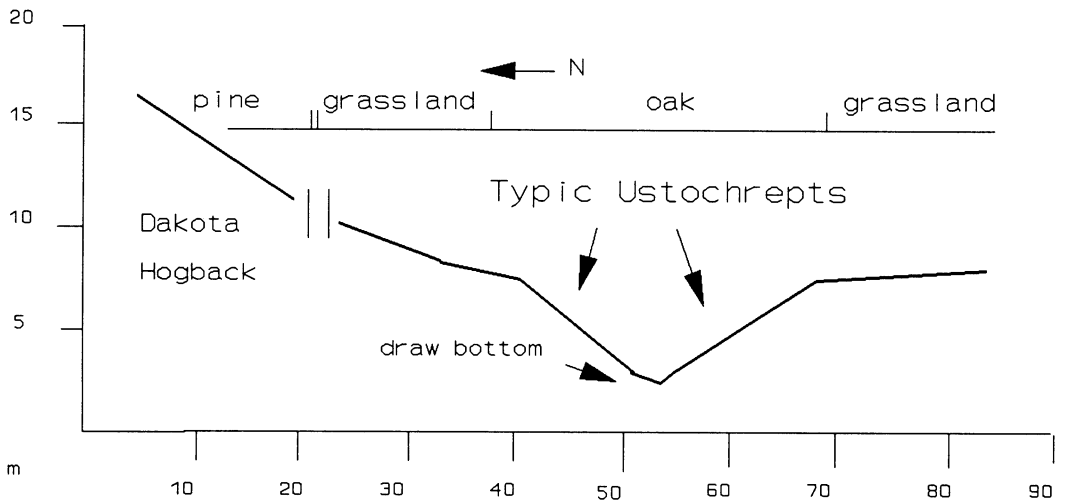


FIG. 3. Typical cross section of the upper end of site 4, showing locations of Typic Ustochrepts, in the foothills of the Black Hills, South Dakota.

Variables with heterogeneous variances were log transformed, which corrected for the heterogeneous variances. Statistical significance was interpreted as $P \leq 0.10$, unless otherwise stated. This significance level was chosen since the

tradition of setting $\alpha = 0.05$ developed in relatively controlled experimental circumstances compared with ecological field studies (Hinds 1984), and religious adherence (Salsburg 1985) to setting $\alpha = 0.05$ ignores information provided

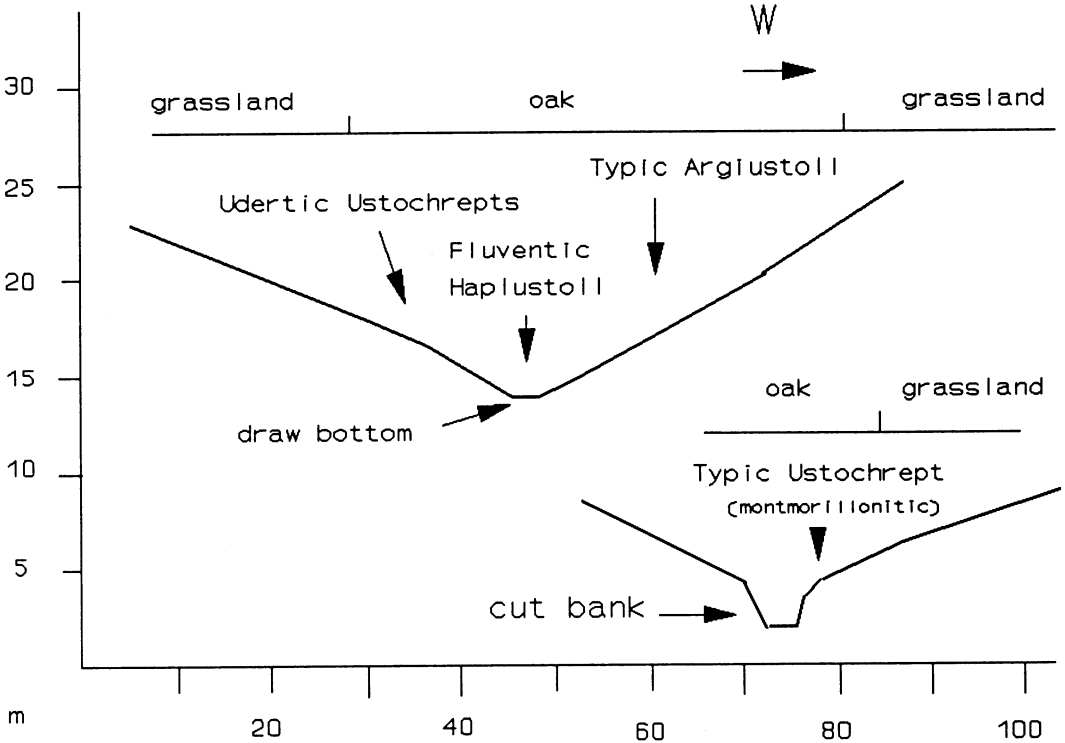
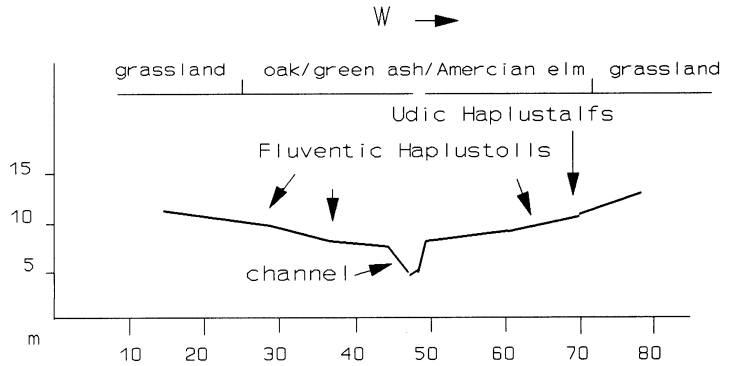


FIG. 4. Typical cross section of site 3, upper (top) and lower (bottom) portions, showing locations of Typic Argiustolls, Fluentic Haplustolls, and Udertic and Typic Ustochrepts, in the foothills of the Black Hills, South Dakota.

FIG. 5. Typical cross section of site 1, showing locations of Udic Haplustalfs and Fluentic Haplustolls, on Cottle Creek in the foothills of the Black Hills, South Dakota.



by test statistics when $P \geq 0.05$ (Toft and Shea 1983) and fails to recognize the inverse relationship between α and the test's power level.

RESULTS

Soil Classification

Four soil-landscape units were identified on the study area: (i) steep slopes; (ii) unstable

floodplains; (iii) stable floodplains; and (iv) stable uplands. Soils classified on steep slope units were generally Inceptisols (Table 1), of which fine-loamy, mixed, mesic Typic Ustochrepts were the most common (Figs. 2 and 3). These soils were mapped on areas of >35% slope, had both cambic and calcic horizons, and were calcareous to the surface or within 23 cm of the soil surface (Table 2). Textures in a typical

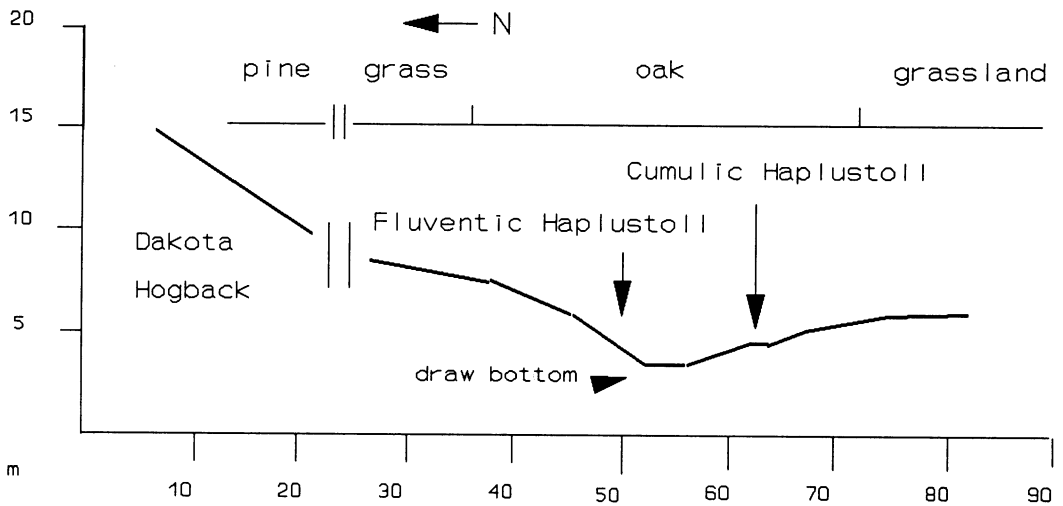


FIG. 6. Typical cross section of the lower end of site 4, showing locations of Fluventic and Cumulic Haplustolls, in the foothills of the Black Hills, South Dakota.

TABLE 1

Taxonomy, depth to free carbonates, thickness of mollic epipedon, aspect, and slope of sampled pedons at four soil-landscape units in the foothills of the Black Hills, South Dakota

Landscape soil unit	Taxonomy	Depth to free CaCO ₃ (cm)	Thickness of mollic epipedon (cm)	Aspect	Slope (%)
Steep slopes	Fine-loamy, mixed, mesic, Typic Ustochrept	0-23		N, S	35-46
	Fine, montmorillonitic, mesic, Typic Ustochrept	18	18	E	45
	Fine, mixed, mesic Uderitic Ustochrept	23		W	8
Unstable floodplains	Fine-loamy, mixed, mesic, Fluventic Haplustoll	0-23	18-28	N, S, E, W	1-15
	Loamy-skeletal, mixed, mesic Fluventic Haplustoll	13	18	S	20
Stable floodplains	Fine-loamy, mixed, mesic Cumulic Haplustoll	91-132	81-107	N, W	1
Stable uplands	Clayey-skeletal, mixed, Typic Argiustoll	89	31	E	28
	Fine-loamy, mixed, mesic Udic Haplustalf			E	4

pedon were gravelly loam, gravelly sandy loam, gravelly sandy clay loam, or gravelly clay loam. The clay content in the control sections ranged from 19% to >30%. The pH was neutral to alkaline throughout these pedons. In some pedons, rock fragments made up about 20% of the profile. Vegetation in areas dominated by Typic Ustochrepts consisted of an overstory of bur oak,

bur oak and box elder, or bur oak and ironwood, with an understory of snowberry and Kentucky bluegrass, False spikenard (*Smilacina stellata*), or poison ivy and bluegrass.

The other type of Typic Ustochrepts mapped on the study area was classified as fine, montmorillonitic, mesic Typic Ustochrept. A typical pedon, described on site 3, occurred on an east-

TABLE 2

Profile description of a fine-loamy, mixed, mesic Typic Ustochrept on site 1 on Alkali Creek alluvium on the inner face of the Dakota Hogback 4.5 m above the floodplain, 46% north-facing slope

Horizon	Depth (cm)	Description
Oi	1-0	Slightly decomposed forest litter; abrupt smooth boundary.
A	0-5	Dark grayish brown (10YR4/2) gravelly sandy loam, very dark brown (10YR2/2) moist; moderate fine and medium granular structure; slightly hard; friable; gradual wavy boundary; pH 7.8; O.M. 6.0%.
Bw1	5-23	Very pale brown (10YR7/4) gravelly sandy loam, light yellowish brown (10YR6/4) moist; soft, friable; moderate medium subangular blocky structure; gradual wavy boundary; pH 7.5; O.M. 3.7%.
Bw2	23-48	Very pale brown (10YR7/4) gravelly sandy clay loam, yellowish brown (10YR5/4) moist; slightly hard; moderate medium subangular blocky structure; slight effervescence; gradual wavy boundary; pH 7.4%; O.M. 1.8%.
Bk	48-71	Very pale brown (10YR7/4) gravelly sandy loam, yellowish brown (10YR5/4) moist; very weak platy structure; numerous threads and seams of calcium carbonate; strong effervescence; gradual wavy boundary; pH 8.0; O.M. 1.0%.
C	71-152	Very pale brown (10YR7/4) gravelly sandy loam, yellowish brown (10YR5/4) moist; loose structure; violent effervescence; pH 8.0; O.M. 0.9%.

facing, 45% slope above a cut bank (Fig. 4). In addition to an 18-cm-thick mollic epipedon, this pedon was calcareous at a depth of 18 cm, and the pH was acidic in the top 18 cm and alkaline below that depth (Table 3). Textures were clay, clay loam, or gravelly clay throughout. Vegetation consisted of an overstory of bur oak and hawthorn and an understory dominated by poison ivy and chokecherry.

Fine, mixed, mesic Udertic Ustochrepts also occurred in the steep slope unit. A typical pedon, described on site 3, occurred on a west-facing, 8% backslope (Fig. 4) and had both cambic and calcic horizons (Table 4). Average clay content was between 44 and 52% in the Bw horizons. Textures ranged from loam in the surface to sand in the C horizon, with gravelly sandy clay loam, sandy loam, or clay in the A2 and B horizons. Vegetation on sites where Udertic Ustochrepts were mapped was characterized by an overstory of bur oak and hawthorn; understory plants included sedges and poison ivy.

The second soil-landscape unit, unstable floodplains, was characterized by Fluventic Haplustolls. Most of these pedons were calcareous at or near the surface, were located on the floodplain or on other depositional positions (Figs. 4, 5, and 6), and often had organic matter

contents that decreased irregularly with increasing depth (Table 5). All these pedons had mollic epipedons; their thicknesses ranged from 18 to 28 cm. The pH was alkaline in nearly all pedons, but it was slightly acidic (6.6-6.9) between 5 and 58 cm in one pedon. Textures ranged from sandy clay loam to loam or clay loam in the control sections of these pedons. Plant overstory composition on areas where these soils were mapped was dominated by bur oak, or by a combination of bur oak and green ash, common buckthorn (*Rhamnus cathartica*) and/or northern hawthorn (*Crataegus rotundifolia*). The understory was dominated by a combination of chokecherry and/or Kentucky bluegrass, and/or snowberry; in one area the understory was dominated by sedges.

The unstable floodplain unit also had Fluventic Haplustolls, with a large percentage of channers in some locations and cobbles in the others; hence, these were placed in the loam-skeletal textural family. These soils were mapped on site 2, on backslopes at the base of the Dakota Hogback, or in old stream channels (Fig. 2.). These soils lacked B horizons and were calcareous within 13 cm of the soil surface (Table 6). The solum in backslope landscape positions was shallow to shale and the profile contained

TABLE 3

Profile description of a fine, montmorillonitic, mesic Typic Ustochrept, on site 3, on the lower slopes of the Lower Limestone Plateau, 4.4 m above an actively cutting channel, on a 45% east-facing slope

Horizon	Depth (cm)	Description
Oi	2-0	Partially decomposed forest litter; abrupt smooth boundary.
A	0-13	Dark gray (10YR4/1) clay, black (10YR2/1) moist; moderate fine and medium granular structure; slightly hard; gradual wavy boundary; pH 6.5; O.M. 6.5%.
Bt	13-18	Grayish brown (10YR5/2) clay loam, dark grayish brown (10YR4/2) moist; moderate medium subangular blocky structure; slightly hard; numerous clay films on surfaces of peds; clear smooth boundary; pH 5.4; O.M. 3.2%.
B/C	18-51	Matrix of grayish brown (10YR5/2) clay, dark grayish brown (10YR4/2) moist [B]; and spots of brownish yellow (10YR6/6) clay, light yellowish brown (10YR6/5) moist [C]; weak coarse and very coarse prismatic structure; hard; strong effervescence; clear smooth boundary; pH 7.3; O.M. 1.2%.
C1	51-102	Matrix of white (10Y8/2) gravelly clay, light gray (10YR7/2) moist, yellow (10YR8/6) gravelly clay, brownish yellow (10YR6/6) moist, and light gray (5Y7/2) clay, olive gray (5Y5/2) moist; massive structure; very hard; strong effervescence; gradual wavy boundary; pH 7.4; O.M. 0.4%.
C2	102-152	Matrix of light gray (5Y7/2) gravelly clay, olive gray (5Y5/2) moist, white (5Y8/1) gravelly clay, white (5Y8/2) moist, and pale yellow (5Y8/4) gravelly clay, pale olive (5Y6/4) moist; massive structure; hard; strong effervescence; pH 7.8; O.M. 0.5%.

ing amounts of shale fragments throughout the profile. Textures in a typical pedon switched from sandy clay loam in the upper portion of the pedon to gravelly silty clay loam in the lower horizons. The overstory on these sites was dominated by bur oak and ironwood; snowberry and Kentucky bluegrass were the predominant understory species.

The third soil-landscape unit, stable floodplains, consisted of Cumulic Haplustolls, which occurred on old, nearly level floodplains and on some toeslopes (Figs. 2 and 6). These soils were characterized by thick mollic epipedons, buried horizons, and organic matter percentages that decreased irregularly with increasing depth (Table 7). Textures were loam in the upper horizons, sandy clay loam in the subjacent horizons, and varied among loam, gravelly sandy loam, and gravelly clay loam in the lower horizons. The floodplain sites where these soils occurred were dominated by green ash in the overstory and had an understory of snowberry and chokecherry. The toeslope site where these soils oc-

curred was characterized by an overstory of bur oak and an understory of Kentucky bluegrass and smooth brome.

The fourth soil-landscape unit occurred on stable uplands; Argiustolls and Haplustolls characterized these sites. A typical Argiustoll, described on site 3, occurred on an east-facing slope of 28% (Fig. 4). This pedon was calcareous at a depth of 89 cm and had a mollic epipedon 31 cm thick and an argillic horizon 48 cm thick (Table 8). Textures were loam, clay loam, or gravelly clay loam, except for the silty clay C horizon. The lower Bt horizon contained over 40% gravel. The pH was acidic (4.9-6.8) in the upper 89 cm, but alkaline in the C horizon. The vegetation at sites where these soils occurred was dominated by bur oak in the overstory and chokecherry and Kentucky bluegrass in the understory.

Alfisols constituted the other major soil type on stable uplands. These soils occurred in only a small portion of the study area on site 1, above the floodplain on an east-facing backslope (Fig.

TABLE 4

Profile description of a fine, mixed, mesic Udertic Ustochrept, in a draw on site 3, on the lower slope of the Lower Limestone Plateau, 8 m above the ephemeral stream, on an 8% west-facing slope

Horizon	Depth (cm)	Description
Oi	2-0	Slightly decomposed forest litter; abrupt smooth boundary.
A1	0-10	Dark grayish brown (10YR4/2) loam, black (10YR2/2) moist; moderate fine granular structure; slightly hard, friable; gradual smooth boundary; pH 7.0; O.M. 6.5%.
A2	10-23	Light yellowish brown (10YR6/4) gravelly sandy clay loam, dark yellowish brown (10YR4/4) moist; moderate fine and medium granular structure; slightly hard; wavy clear boundary; pH 6.8; O.M. 2.8%.
Bt1	23-33	Light gray (2.5Y7/2) clay, grayish brown (2.5Y5/2) moist; moderate medium prismatic parting to moderate fine and medium subangular blocky structure; hard; slight effervescence; pH 7.4; O.M. 2.0%.
Bt2	33-84	Light gray (2.5Y7/2) clay, grayish brown (2.5Y5/2) moist; weak coarse and very coarse prismatic structure; very hard; strong effervescence; large (1-cm) cracks running down side of pit; pH 7.7; O.M. 1.1%.
2Bk	84-114	Light gray (2.5Y7/2) sandy loam, grayish brown (2.5Y5/2) moist; massive structure; soft; segregations of lime common; strong effervescence; pH 7.6; O.M. 0.7%.
2C	114-152	Light gray (2.5Y7/2) clay, grayish brown (2.5Y5/2) moist with tongues of pale yellow (2.5Y6/4) sand, light yellowish brown (2.5Y6/4) moist; massive structure; slightly hard; strong effervescence; pH 7.7; O.M. 0.9%.

5). A typical alfisol pedon, described on site 1, was noncalcareous throughout and had an ochric epipedon and albic and argillic horizons (Table 9). The textures ranged from loam in the A horizons to sandy loam or gravelly sandy loam in the E horizons to clay loam in the Bt and C horizons. Vegetation at this site consisted of a green ash/chokecherry overstory with an understory of smooth brome.

Soil Chemistry

Average soil chemical characteristics for the 16 A horizons, 11 B horizons, and 14 C horizons are given in Table 10. There were few significant differences in soil chemical characteristics among soil types. (Soil pH ($P = 0.08$), total phosphorus ($P = 0.05$), and DTPA-extractable iron differed ($P < 0.01$) among types in the A horizons (Table 11); pH ($P < 0.01$), organic matter ($P = 0.01$), Fe ($P < 0.01$), and Mn ($P = 0.03$) differed among soil types in the B horizons (Table 12); Cu differed ($P < 0.01$) among types in the C horizons (Table 13). Other soil characteristics were similar among soil types.

Average pH values were slightly acidic to al-

kaline in the A, B, and C horizons (Table 10). Average pH differed ($P < 0.01$) among series in the A and B horizons, with lowest levels occurring in Argiustolls, followed by the fine, montmorillonitic, mesic Ustochrepts; highest levels occurred in the other Inceptisols (Tables 11 and 12). Organic matter averaged 5.8% in the A horizons, 1.8% in the B horizons, and 1.2% in the C horizons. Organic matter in the B horizons was generally higher in the montmorillonitic Inceptisols and Cumulic Haplustolls. Electrical conductivity ranged from 0.3 to 1.6 mmhos/cm in the A horizon and averaged 0.8 mmhos/cm. Average EC in the B and C horizons was 0.4 mmhos/cm and 0.5 mmhos/cm, respectively. CEC values averaged 32.9 meq/100g in the A horizon, 22.4 meq/100g in the B horizon, and 21.9 meq/100g in the C horizon.

Soil NO₃-N in the A horizons ranged from 1-17 ppm, and averaged 5 ppm; in the B and C horizons NO₃-N averaged < 2 ppm (Table 10). Phosphorus levels ranged from <1 to 17 ppm and averaged 9 ppm in the A horizons. Highest P values occurred in fine-loamy, mixed, mesic Typic Ustochrepts and in the Fluventic

TABLE 5

Profile description of a fine-loamy, mixed, mesic Fluventic Haplustoll, on site 1, on Cottle Creek alluvium, 13 m from the creek channel, on a 2%, west-facing slope

Horizon	Depth (cm)	Description
A1	0-8	Dark grayish brown (10YR4/2) loam, very dark grayish brown (10YR3/2) moist; medium fine granular structure; soft, very friable; clear smooth boundary; slight effervescence; pH 7.4; O.M. 6.2%.
A2	8-25	Grayish brown (10YR5/2) loam, very dark grayish brown (10YR3/2) moist; weak medium and fine granular structure; slightly hard, friable; slight effervescence; clear smooth boundary; pH 7.7; O.M. 3.7%.
C	25-51	Pale brown (10YR6/3) sandy clay loam, brown (10YR5/3) moist; very weak coarse prismatic grading to massive structure; hard, friable; slight effervescence; clear smooth boundary; pH 7.9; O.M. 3.7%.
Ab	51-61	Grayish brown (10YR5/2) loam, very dark grayish brown (10YR3/2) moist; weak coarse prismatic parting to very weak to weak moderate subangular blocky structure; slightly hard, friable; slight effervescence; gradual wavy boundary; pH 7.8; O.M. 3.8%.
Cb	61-86	Pale brown (10YR6/3) loam, dark yellowish brown (10YR4/4) moist; massive structure; hard, friable; slight effervescence; clear smooth boundary; pH 8.0; O.M. 2.0%.
A1b	86-108	Dark gray (10YR4/1) loam, very dark gray (10YR3/1) moist; moderate medium subangular blocky parting to medium to coarse granular structure; slightly hard, friable; 30% seams and threads of calcium carbonate; gradual smooth boundary; pH 8.0; O.M. 3.4%.
A2b	108-140	Dark gray (10YR4/1) loam, very dark gray (10YR3/1) moist; moderate medium subangular blocky parting to medium granular structure; hard, friable; 30% seams and threads of calcium carbonate; clear smooth boundary; pH 8.0; O.M. 4.9%.
Cb'	140-163	Brown (10YR5/3) sandy clay loam, dark brown (10YR3/3) moist; massive structure; some tonguing of A into C (possibly krotovina); slightly hard, friable; slight effervescence; pH 8.0; O.M. 1.3%.

tolls. Average P levels were 2 ppm or less in the B and C horizons (Table 10). Potassium levels ranged from 228 to 728 ppm in the A horizon, and averaged 417 ppm in the A horizons, 251 ppm in the B horizons, and 227 ppm in the C horizons.

Zinc levels averaged 5.3 ppm in the A horizons, 0.8 in the B horizons, and 1.2 in the C horizons. Iron levels were highly variable, ranging from 12 to 138 ppm in the A horizons, 10 to 121 ppm in the B horizons, and 8 to 27 ppm in the C horizons. Iron levels were significantly higher ($P < 0.01$) in the montmorillonitic Inceptisols and Argiustolls in the A and B horizons (Tables 11 and 12). Manganese levels ranged from 5.1 to 42.4 ppm in the A horizons. Man-

ganese averaged 5.8 and 4.3 ppm in the B and C horizons, respectively. Manganese levels in B horizons were higher in Cumulic Haplustolls than in most other pedons but generally similar among remaining series. Copper levels ranged from 1 to 3.1 ppm, 0.9 to 2.2 ppm, and 0.7 to 23.4 ppm in the A, B, and C horizons, respectively; Cu levels differed ($P < 0.01$) among series in the C horizons, with the highest levels occurring in the loamy-skeletal Fluventic Haplustolls.

DISCUSSION

Soil Classification

The soils in riparian bur oak woodlands represented a blending of grassland (Mollisol) soils

TABLE 6

Profile description of a loamy-skeletal, mixed, mesic Fluventic Haplustoll, on Alkali Creek on the inner face of the Dakota Hogback 11 m above the creek channel, on a 20%, south-facing slope

Horizon	Depth (cm)	Description
Oi	2-0	Slightly decomposed forest litter; abrupt smooth boundary.
A1	0-5	Dark grayish brown (10YR4/2) sandy clay loam, very dark brown (10YR2/2) moist; weak fine granular structure; slightly hard; wavy clear boundary pH 7.3; O.M. 5.8%.
A2	5-13	Brown (10YR5/7) sandy clay loam, dark brown (10YR3/3) moist; hard, friable; moderate medium granular structure; clear wavy boundary; pH 7.1; O.M. 5.8%.
AC	13-30	Light gray (10YR7/2) gravelly clay loam, grayish brown (10YR5/2) moist; weak medium prismatic structure; hard; slight effervescence; gradual wavy boundary pH 7.0; O.M. 2.4%.
C1	30-41	White (10YR8/2) silty clay loam, light brownish gray (10YR6/2) moist; massive structure; hard; strong effervescence; gradual wavy boundary pH 7.5; O.M. 1.2%.
C2	41-102	Light gray (10YR7/2) gravelly silty clay loam, grayish brown (10YR5/2) moist; hard; massive structure; strong effervescence; clear smooth boundary pH 7.6; O.M. 1.8%.
Cr	102-152	Light gray (10YR7/2) loam, grayish brown (10YR5/2) moist; slightly hard; bedded shale pH 7.8; O.M. 0.1%.

TABLE 7

Profile description of a fine-loamy, mixed, mesic Cumulic Haplustoll on site 2, on Alkali Creek alluvium on the inner face of the Dakota Hogback, 41 m from the channel, on a 1% slope

Horizon	Depth (cm)	Description
Oi	2-0	Slightly decomposed forest litter; abrupt smooth boundary.
A1	0-5	Very dark gray (10YR3) loam, black (10YR2/1) moist; moderate fine granular structure; slightly hard, friable; gradual smooth boundary pH 7.7; O.M. 6.3%.
A2	5-20	Very dark gray (10YR3/1) loam, black (10YR2/1) moist; moderate fine granular structure; slightly hard, friable; gradual smooth boundary pH 7.3; O.M. 6.2%.
AB	20-30	Dark grayish brown (10YR4/2) sandy clay loam, very dark gray (10YR3/1) moist; weak medium prismatic structure; soft, friable; gradual smooth boundary; pH 7.1; O.M. 2.8%.
Bw	30-51	Very dark gray (10YR3/1) sandy clay loam, very dark grayish brown (10YR3/2) moist; moderate medium subangular blocky structure; slightly hard, friable; abrupt clear boundary pH 7.3; O.M. 3.4%.
Ab	51-81	Very dark gray (10YR3/1) gravelly sandy clay loam, black (10YR2/1) moist; slightly hard; weak medium prismatic structure; clear smooth boundary; pH 7.1; O.M. 5.3%.
Cb1	81-91	Dark gray (7.5YR4/4) loam, dark brown (7.5YR3/4) moist; massive structure; slightly hard; gradual smooth boundary pH 7.7; O.M. 2.2%.
Cb2	91-137	Dark gray (7.5YR4/4) gravelly sandy loam, dark brown (7.5YR3/4) moist; single grained structure; loose; slight effervescence; gradual smooth boundary; pH 8.0; O.M. 1.8%.
Ab'	137-152	Very dark grayish brown (10YR3/2) gravelly clay loam, black (10YR2/1) moist; slightly hard to hard; weak medium prismatic structure; slight effervescence pH 7.8; O.M. 5.1%.

TABLE 8

Profile description of a clayey-skeletal, mixed Typic Argiustoll, on site 3, on the lower slope of the Lower Limestone Plateau, on a 28%, east-facing slope

Horizon	Depth (cm)	Description
Oi	2-0	Slightly decomposed forest litter; abrupt smooth boundary.
A1	0-10	Dark grayish brown (10YR4/2) loam, black (10YR4/2) moist; weak fine granular structure; hard, friable; gradual wavy boundary; pH 6.8; O.M. 6.3%.
A2	10-31	Dark grayish brown (10YR4/2) loam, black (10YR4/2) moist; weak moderate granular structure; hard, friable; gradual wavy boundary; pH 5.8; O.M. 5.7%.
AB	31-41	Yellowish brown (10YR5/4) loam, dark brown (10YR3/4) moist; weak thin platy structure; slightly hard; gradual wavy boundary; pH 5.1; O.M. 2.5%.
Bt1	41-51	Pale brown (10YR6/3) clay loam, brown (10YR4/3) moist; weak to moderate coarse subangular blocky structure; hard, friable; numerous clay films on surfaces of peds; gradual wavy boundary; pH 5.0; O.M. 1.9%.
2Bt2	51-89	Light yellowish brown (10YR6/4) gravelly clay loam, dark gray (10YR4/4) moist; moderate medium subangular blocky structure; hard, friable; many clay films on surfaces of peds; pH 4.9; O.M. 1.6%.
2C	89-152	White (2.5Y8/2) silty clay, light brownish gray (2.5Y6/2) moist; massive, hard, friable; slight effervescence; pH 7.5; O.M. 1.4%.

TABLE 9

Profile description of a fine-loamy, mixed, mesic Udic Haplustalf, on site 1 on Cottle Creek alluvium, 26 m from creek, on a 4%, east-facing slope

Horizon	Depth (cm)	Description
Oi	2-0	Partly decomposed forest litter; abrupt smooth boundary.
A1	0-3	Gray (10YR5/1) loam, very dark gray (10YR3/1) moist; moderate very fine granular structure; soft, very friable; clear wavy boundary; pH 7.3; O.M. 6.7%.
A2	3-20	Gray (10YR5/1) loam, very dark gray (10YR3/1) moist; moderate fine granular structure; soft, very friable; gradual wavy boundary; pH 6.8; O.M. 4.5%.
E1	20-35	Pinkish gray (7.5YR6/2) sandy loam, dark brown (7.5YR4/2) moist; weak fine granular structure; slightly hard, very friable; clear wavy boundary; pH 6.5; O.M. 1.4%.
E2	35-48	Light brown (7.5YR6/4) gravelly sandy loam, dark brown (7.5YR4/4) moist; weak fine granular structure; slightly hard, very friable; clear wavy boundary; pH 6.5; O.M. 0.7%.
Bt1	48-78	Yellowish brown (10YR5/4) clay loam; dark yellowish brown (10YR3/4) moist; moderate coarse prismatic breaking to angular blocky structure; hard, friable; thin clay films on faces of peds; clear wavy boundary; pH 6.1; O.M. 1.0%.
Bt2	78-109	Pale brown (10YR6/3) clay loam, brown (10YR4/3) moist; moderate coarse prismatic parting to weak medium subangular blocky structure; thin clay films on faces of peds; clear wavy boundary; pH 6.2; O.M. 0.9%.
C	109-149	Pale brown (10YR6/3) clay loam, brown (10YR4/3) moist; massive structure; hard, friable; pH 6.5; O.M. 0.9%.

TABLE 10

Average soil characteristics of A, B, and C horizons described in the foothills of the Black Hills, South Dakota. Weighted averages were calculated for pedons with more than one A, B, or C horizon

Variable	A horizon (n = 16)				B horizon (n = 11)				C horizon (n = 14)			
	\bar{x}	SE	Min.	Max.	\bar{x}	SE	Min.	Max.	\bar{x}	SE	Min.	Max.
Thickness (cm)	17.2	2.3	5.0	38.0	53.4	8.6	5.0	91.0	53.9	6.1	20.0	81.8
pH	7.1	0.1	6.1	7.8	6.9	0.3	4.9	7.6	7.5	0.1	6.5	8.0
EC (mmhos/cm)	0.8	0.1	0.3	1.6	0.4	0.1	0.2	0.6	0.5	0.1	0.3	1.5
OM (%)	5.8	0.2	4.4	6.5	1.8	0.3	0.9	3.2	1.2	0.2	0.4	3.8
CEC (meq/100 g)	32.9	1.6	21.0	41.7	22.4	1.4	16.0	32.8	21.9	1.9	13.6	34.0
NO ₃ -N (ppm)	5.4	1.6	1.0	17.0	1.6	0.2	1.0	3.0	1.9	0.3	1.0	4.0
P (ppm)	8.8	1.4	0.5	17.2	1.8	0.8	0.1	7.6	2.0	0.8	0.1	9.2
K (ppm)	417.4	28.6	228.0	728.0	251.4	17.2	155.0	332.0	227.1	18.1	136.0	356.0
Zn (ppm)	5.3	1.0	0.7	13.1	0.8	0.2	0.2	2.9	1.2	0.5	0.2	8.0
Fe (ppm)	37.4	9.3	11.8	138.0	28.8	9.9	9.6	121.0	15.8	1.4	8.2	27.0
Mn (ppm)	21.7	2.4	5.1	42.4	5.8	1.1	2.1	14.1	4.3	0.8	1.0	11.2
Cu (ppm)	2.1	0.1	1.0	3.1	1.5	0.1	0.9	2.2	2.9	1.6	0.7	23.4
Sand (%)	45.1	1.3	35.0	56.0	41.6	3.1	27.0	58.0	39.1	5.1	14.0	73.0
Silt (%)	31.1	1.3	23.0	40.0	26.5	1.6	18.0	36.0	31.1	3.4	10.0	55.0
Clay (%)	23.8	0.9	18.0	30.0	31.6	2.3	20.0	43.0	29.7	2.7	17.0	50.0

TABLE 11

A horizon characteristics, averaged by pedon classification, in bur oak stands near the Black Hills, South Dakota

Classification	pH	OM (%)	EC (mmhos/cm)	CEC (meq/100 g)	N	P	K	Zn (ppm)	Fe	Mn	Cu
Steep slopes											
Typic Ustochrepts											
Fine-loamy mixed mesic	7.5 ^{bc}	6.1	0.7	35.0	2.3	15.6 ^c	403	1.9	21.5 ^a	17.3	2.1
Fine, mont., mesic	6.5 ^a	6.5	1.6	40.7	5.0	5.3 ^a	503	7.1	138.0 ^b	29.6	2.8
Udertic Ustochrepts	6.9 ^{ab}	4.4	0.8	25.0	1.0	0.5 ^a	389	0.7	20.5 ^a	12.4	1.0
Unstable floodplains											
Fluventic Haplustolls											
Fine-loamy mixed mesic	7.2 ^b	5.8	0.9	31.5	5.2	10.7 ^{bc}	401	2.3	20.7 ^a	5.1	2.3
Loamy-skel. mixed mesic	7.2 ^b	5.8	0.6	35.1	5.0	10.4 ^{abc}	462	3.4	16.3 ^a	14.2	2.3
Stable floodplains											
Cumulic Haplustolls	7.2 ^b	5.4	0.6	30.5	15.5	6.7 ^{ab}	490	2.5	32.2 ^a	33.8	1.8
Stable uplands											
Typic Argiustolls	6.1 ^a	5.9	0.3	36.6	4.0	1.9 ^{ab}	358	6.2	121.5 ^b	25.6	2.5
Udic Haplustalfs	6.9 ^{ab}	4.8	0.4	21.0	2.0	3.4 ^{ab}	356	1.6	37.7 ^a	11.6	1.3

^a Values within a single column followed by different letters are significantly different ($P \leq 0.1$).

and forested (Alfisol) soils, with areas of Inceptisols interspersed. The preponderance of Mollisols in these stringer woodlands is consistent with other studies of wooded draws in the northern Great Plains. Mollisols constituted the largest portions of soils mapped in draws in western North Dakota dominated by bur oak (Girard 1985) and in those dominated by green ash (Mack 1981; Butler 1983). The domination of these sites by Mollisols was attributed to deposition of dark soil material from upland grasslands and to the contribution of organic matter from the dense herbaceous understory in some areas. However, factors such as slope, aspect,

landscape position, and parent materials also likely played some role in the ability of Mollisols to persist in these woodlands. For example, in Illinois, grassland soils with mollic epipedons persisted after forest invasion of poorly drained sites; Alfisols were more likely to occur on well drained uplands (Geis et al. 1970).

The basic soil-landscape units recognized on the study area included: (i) steep slopes; (ii) unstable floodplains; (iii) stable floodplains; and (iv) stable uplands. The steep slope soil-landscape unit was characterized by the presence of Inceptisols; this was the most common soil type on the study area. Both Udertic and Typic In-

TABLE 12

B horizon characteristics, averaged by pedon classification, in bur oak stands near the Black Hills, South Dakota

Classification	pH	OM (%)	EC (mmhos/cm)	CEC (meq/100 g)	N	P	K	Zn (ppm)	Fe	Mn	Cu
Steep slopes											
Typic Ustochrepts											
Fine-loamy mixed mesic	7.6 ^{de}	1.4 ^a	0.5	21.4	1.5	3.9	267	1.1	14.8 ^{ab}	4.3 ^a	0.7
Fine, mont., mesic	5.4 ^{ab}	3.2 ^b	0.4	25.1	3.0	0.8	308	1.4	121.0 ^d	7.7 ^{ab}	1.4
Udertic Ustochrepts	7.7 ^{de}	1.0 ^a	0.4	23.0	1.5	0.1	301	0.6	17.3 ^{ab}	3.5 ^a	0.5
Unstable floodplains											
Fluventic Haplustolls											
Fine-loamy mixed mesic	7.3 ^{cd}	1.8 ^{ab}	0.4	17.3	1.0	0.1	280	0.4	11.7 ^a	3.4 ^a	1.1
Stable floodplains											
Cumulic Haplustolls	7.0 ^{bc}	2.6 ^b	0.4	20.6	2.8	3.9	224	1.6	18.3 ^b	11.6 ^b	0.9
Stable uplands											
Typic Argiustolls	4.9 ^a	1.7 ^{ab}	0.2	22.5	1.0	0.6	155	0.2	54.8 ^c	4.0 ^a	1.7
Udic Haplustalfs	6.2 ^b	0.9 ^a	0.2	15.8	1.0	0.3	199	0.2	15.1 ^{ab}	4.9 ^{ab}	1.5

^a Values within a single column followed by different letters are significantly different ($P \leq 0.05$).

TABLE 13

C horizon characteristics, averaged by pedon classification, in bur oak stands near the Black Hills, South Dakota

Classification	pH	OM (%)	EC (mmhos/cm)	CEC (meq/100 g)	N	P	K	Zn (ppm)	Fe	Mn	Cu
Steep slopes											
Typic Ustochrepts											
Fine-loamy mixed mesic	7.9	0.8	0.4	18.0	2.5	5.2	236	0.3	12.0	4.4	1.2 ^{ab}
Fine, mont., mesic	7.6	0.4	0.4	34.0	1.0	0.2	309	0.9	19.5	1.0	2.2 ^c
Udertic Ustochrepts	7.7	0.9	0.6	29.2	1.0	0.3	356	1.7	10.6	2.2	0.7 ^a
Unstable floodplains											
Fluventic Haplustolls											
Fine-loamy mixed mesic	7.5	1.7	0.7	19.0	1.6	0.7	229	2.2	17.6	5.1	1.3 ^b
Loamy-skel. mixed mesic	7.6	1.7	0.3	32.9	3.0	8.3	266	0.5	16.5	2.2	23.4 ^d
Stable floodplains											
Cumulic Haplustolls	7.7	0.9	0.6	19.5	2.0	2.5	163	0.3	16.1	6.3	1.7 ^{bc}
Stable uplands											
Typic Argiustolls	7.5	1.4	0.4	27.4	1.0	0.7	190	0.2	16.7	2.4	1.1 ^{ab}
Udic Haplustalfs	6.5	0.9	0.3	19.6	4.0	1.5	143	0.2	16.2	7.8	2.0 ^{bc}

^a Values within a single column followed by different letters are significantly different ($P \leq 0.1$).

ceptisols were mapped in the study area, mainly on backslopes of draws and stream terraces. Erosion because of the steep slopes, and reduced infiltration prevented development of either a mollic epipedon or an argillic horizon. Most were calcareous at or near the surface, and their steepness impeded water percolation and, hence, movement of materials through the profile.

The second soil-landscape unit recognized on the study area was unstable floodplains, where Fluventic Haplustolls were common. Fine-loamy Fluventic Haplustolls occurred in a variety of landscape positions, ranging from footslopes and backslopes, to draw bottoms. The

slope was generally less than 15%. Buried horizons, free carbonates at or near the surface, and the absence of B horizons were evidence of the young age of these soils. This limited soil development was attributable to recent flooding events that buried the organic-matter-rich sola. The loamy-skeletal Fluventic Haplustolls occurred on backslopes at the base of the Dakota Hogback where colluvium was deposited. They also occurred in the old stream channel along Alkali Creek. Mack (1981) mapped Haploborolls on the backslopes and footslopes of deciduous woodlands in North Dakota. Backslope Haploborolls had thin surface horizons and soil from

these steep slopes continue to erode; hence, they were classified as Entic Haploborolls. Butler (1983) mapped Entic Haploborolls on the foot-slopes and Fluvaquentic Haploborolls on toeslopes in green ash woodlands in western North Dakota.

The third soil-landscape unit, stable floodplains, was characterized by Cumulic Haplustolls. These soils had mollic epipedons > 50 cm thick, which were partially attributed to their location either on footslope positions or on old, stable floodplains with poor drainage. Although these soils had overthickened epipedons, subsoils are usually only moderately developed. Footslope Haploborolls in North Dakota woodlands were classified as Typic Haploborolls because they had a thicker A horizon compared to Entic Haploborolls (Mack 1981).

The fourth soil-landscape unit occurred on relatively stable upland sites and included Mollisols with argillic horizons and Alfisols. The formation of argillic horizons in Argiustolls was indicative that sufficient time had elapsed for the accumulation of clay in the Bt horizon. Mack (1981) described similar soils on the toeslopes in draws in North Dakota. He attributed the formation of an argillic horizon in the Argiborolls to frequent wetting and drying of the soil from intermittent streams. The accumulation of clay to form thicker argillic horizons in down-slope positions relative to summit positions was also reported by Honeycutt et al. (1990), and was attributed to increased effective precipitation in the lower landscape positions compared with upland positions.

Alfisols were also present on stable uplands. These were likely the oldest pedons in the study area, as evidenced by the development of an albic horizon. The profiles were entirely leached of free carbonates, the pH was acidic, and sufficient time had elapsed for the eluviation of clay from albic horizons and its accumulation below in argillic horizons. Alfisols are common in the Black Hills area, although they are more predominant in pine stands, as a result of the more acidic litter of conifers. However, Alfisols also occur in deciduous woodlands. Mack (1981) described a Mollic Ochraqualf in draws dominated by green ash in North Dakota. Girard (1985) mapped small areas of Alfisols among the predominant Mollisols on sites in western North Dakota dominated by bur oak and hazlenut (*Corylus* spp.). In my study, the gentle slope,

proximity of the pedon to the forest-grassland ecotone, and eastern aspect likely contributed to the development of albic and argillic horizons.

Vegetation was generally a poor predictor of soil type, as was soil type a poor predictor of vegetative composition. In another phase of this study, vegetative composition was analyzed by a combination of cluster and discriminant analyses (Sieg 1991). Three main vegetation types were identified. Green ash and box elder were characteristic species of floodplains; ironwood, bittersweet (*Celastrus scandens*), and poison ivy were common on steep slopes; bur oak and hawthorn were common species on backslopes. These vegetation types were poorly correlated with soil types. Vegetation types encompassed up to three different soil types, and many spanned a combination of both calcareous and noncalcareous pedons. Other plant community studies have reported similar results. In Wikum and Wali's (1974) study, the floodplain community was the only one of five types that was restricted to a particular soil series; other community types encompassed as many as four soil series. Both soil types and geologic formations differed within vegetation types described by Thilenius (1972). This disparity suggests that other factors, such as water table levels, may be more important in determining plant distribution. Soil pedons may provide a glimpse of history that helps us to understand the past processes in soil formation, but this knowledge may or may not be very useful in understanding current plant distribution patterns.

Soil Chemistry

The chemical characteristics of the soils described in the study area varied from those described for bur oak and green ash stands in other areas. The generally alkaline pH values in this study differed from acidic profiles described by Wali et al. (1980) in the Killdeer Mountains of North Dakota, but were similar to the alkaline pH values observed in bur oak gallery forests in northeast Kansas (Abrams 1985). Thilenius (1972) documented bur oak growing on both acidic, noncalcareous soils and alkaline soils developed from limestone in the Black Hills.

Differences in pH among soil types observed in this study were attributed to a combination of differences in parent materials, slope, and age. The Argiustolls and fine, montmorillonitic Typic Ustochrepts had the lowest pH values in

the B horizon. Both were located on the lower slopes of the Limestone Plateau. Soils derived from limestone tend to have larger base saturation values than soils formed from sandstone (Pritchett 1979). Further, extensive leaching in Alfisols resulted in lower pH values than most other pedons. High pH values in some Inceptisols were attributed to the relatively young age of these soils.

Organic matter percentages (4.4-6.5%) in the A horizons were similar to ranges reported for gallery forests in Kansas (Abrams 1985). Low percentages of organic matter in the B horizons of the Alfisols were attributed to high rates of leaching; however, organic matter content in soils is also influenced by faunalurbation, above-ground organic matter production, and microbial activity. Several Inceptisols also had very low levels of organic matter in the B horizon, probably due to the steep slopes on these sites which resulted in low rates of organic matter accumulation and potentially higher rates of erosion. The average range of EC values in profiles in the study area (0.4-0.8 mmhos/cm) was higher than that observed in North Dakota. Electrical conductivity values averaged 0.3 mmhos/cm in the A horizons of green ash stands and 0.11 mmhos/cm in bur oak stands in North Dakota; EC values of the B and C horizons were all less than 0.2 mmhos/cm (Wali et al. 1980). Based on low EC values, Wali et al. (1980) speculated that amounts of water-soluble Ca and Mg were lower in bur oak stands than in other woodlands sampled.

Soils on the study area were higher in NO₃-N, ranging from 1 to 17 ppm in the A horizon, than soils sampled in Kansas (range 1-4.4 ppm) by Abrams (1985). The highest N values in this study were generally associated with relatively level and stable sites that tended to collect organic materials from higher landscape positions. Average P values in soil pedons described in this study were lower than those observed by Wali et al. (1980) in the upper 100 cm in bur oak sands (\bar{x} = 34.5), but were within the range for green ash stands of Wali et al. (1980) (0-18.3 g/m³). In general, soils with high P were those with relatively alkaline pH's. Acidic soils are often characterized by low phosphorus availability (Pritchett 1979). Potassium levels in this study were more variable (228-728 ppm) in the A horizon than levels that Abrams (1985) reported (441-688 ppm). However, all values re-

ported in this study appear to be adequate for growth. Levels between 20 and 100 ppm are adequate for growth of most trees (Pritchett 1979).

Zinc and iron levels reported in this study were higher than those observed in Kansas. Abrams (1985) reported a range of 2.0-3.5 ppm for Zn and 11-34.8 ppm for Fe in the upper 15 cm. In this study, ranges were 0.7-13.1 ppm and 11.8-138 ppm, for Zn and Fe, respectively. Manganese and copper levels in this study were also more variable (5.1-42.4 ppm for Mn; 1.0-3.1 ppm for Cu) than those reported in Kansas. Levels of Mn ranged from 12.3 to 34.4 ppm, and levels of Cu ranged from 0.8-1.2 ppm in gallery forests in Kansas (Abrams 1985). The contributions of alluvium, colluvium, and residuum from three physiographic areas in the development of the soils on the study area make it difficult to determine the origin of high Fe, Cu, and Mn in some soils.

CONCLUSIONS

Although deciduous forests constitute only a small percentage of the land area in the northern Great Plains, they contribute significantly to the biological diversity of the region. The soils in bur oak gallery forests represented a diversity best described as a blending of grassland (Mollisol) soils and forested (Alfisol) soils. The actual taxonomic classification of similar pedons was often quite different, reflecting changes over time in the understory and overstory communities. The dominance of Mollisols was attributed to deposition of sediment eroded from upland grassland soils and accumulation of organic materials in dense herbaceous understories on some sites.

Four landscape soil units were recognized: i) steep slopes, ii) unstable floodplains, iii) stable floodplains, and iv) stable uplands. Limited water infiltration and loss of soil material from erosion contributed to the development of Inceptisols common on steep slopes. Fluventic Mollisols, characterized by buried soil horizons, were common on less stable floodplains. Cu-

Mollisols occurred in concave locations away from stream channels and received additions of A horizon material from soils in higher landscape positions. Alfisols and Argiustolls occurred in stable landscape positions farther from stream channels.

The chemical composition also reflected a

blending of grassland and forest soils plus variability in parent materials, landscape position, and age. The alkaline pH values of the Inceptisols reflected calcareous parent materials and limited leaching due to steep slopes. The oldest pedon in the area was a product of excessive leaching that led to acidic conditions. Both the classification and chemical composition of these soils was confounded by the contribution of alluvium, colluvium, and residuum from three physiographic regions. In general, soil types and vegetative communities were poorly correlated. Soil pedons may provide a glimpse of history that helps us to understand past processes in soil formation, but this knowledge may not be very useful in understanding current plant distribution patterns.

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