Soil Health of Mountaintop Removal Mines in Southern West Virginia

Revised Project Report

By

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Abstract

Minesoils are young soils developing in drastically disturbed earth materials. The health and quality of these soils will deviate from native soils. Although minesoil quality in some places may be worse than the native soil quality, research has shown that overburden materials may be manipulated to improve minesoil quality, especially soil physical and chemical properties. However, very little information about microbiological activity in minesoils is available. Therefore, this study was designed to evaluate physical, chemical and microbiological properties of minesoils developing on reclaimed mountaintop removal coal mines in southern West Virginia. Minesoils of different ages and the contiguous native soils were described and sampled on three mines. Routine physical and chemical properties were determined as well as microbial biomass C and N, potentially mineralizable N, and microbial respiration. All minesoils were weakly developed compared to the native soils, but most had a transition horizon (AC) or a weak B horizon (Bw) developing between the A horizon at the surface and the C horizons. The minesoils would be classified as Entisols, while most of the native soils were Inceptisols. Both native and minesoil biomass C and N, potentially mineralizable N, and microbial respiration were generally within ranges of other reported data. In general, there were more similarities between the properties of the oldest minesoils and the native soils than between the younger minesoils and the native soils. There is a trend of C accumulation as the minesoils become older, and it appears that the stable organic pool is increasing with age. This study indicates that the minesoils are approaching stable, developed soils and should become more like the native soils as they continue to develop.

Introduction

Soil quality or health can be broadly defined as the capacity of a living soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health (Doran et al., 1999). Minesoil health is important, not only for initial revegetation, but also for continued long-term productivity and environmental quality. Since minesoils are drastically disturbed soils, their initial properties will be different than the surrounding native soils. However, minesoils are subject to the same soil forming factors and processes that have developed the contiguous native soils. These processes will eventually develop minesoils with properties similar to the native soils. Therefore, studies of minesoil health should include some documentation of minesoil property changes or differences with time. The objective of this study was to document differences in selected minesoil properties, especially those related to microbial activity, on mountaintop removal coal mines of different ages, and to compare the minesoils to the major contiguous native soils.

Methods and Materials

Site Descriptions And Field Sampling

Minesoils and native soils were sampled at the Dal-Tex mine in the Spruce Fork watershed in Logan County, the Hobet-21 mine in the Mud River watershed of Boone County, and the Cannelton mine in the Twentymile Creek watershed in Fayette County. Two different ages of minesoils, with three sampling points each, were selected for sampling at the Hobet-21 (8 and 17 years old) and Cannelton sites (16 and 30 years old). All sampling points at these two mines were 250 m apart, and they were placed 50 m away from the nearest wildlife sampling point. Specific location of each sampling point is presented in Appendix Table 1.

At Hobet-21, the 8-year-old site had slopes ranging from 3 to 5% with a south-southwest aspect. The Hobet-21 17-year-old site had slopes ranging from 3 to 28% with a northwest aspect. Slope inclination at each sampling point is presented in Appendix Table 2. All Hobet-21 sampling points were located at mid slope. At Cannelton, all minesoil sampling points also were located at mid slope and had a south-southwest aspect. Slopes ranged from 5 to 10% on the 16-year-old site, and all slopes were 2% on the 30-year-old site. All minesoils on both of these sites had similar geology and topography, and they had been mined and reclaimed by similar methods.

Three sampling points also were located on the contiguous steeply sloping native soils at both mine sites. These sampling points were located at mid slope and had south-southwest aspects at both sites. Hobet-21 soils had 45 to 72% slopes, and Cannelton soils had 45 to 70% slopes.

Sampling sites at the Dal-Tex mine had been selected €or another study (Thomas et al., 2000), but also were used for this study. Four different ages (23, 11, 7, and 2 years old) of minesoils were sampled. Three gently sloping and three steeply sloping sampling points were located on each of the different aged sites. Two steeply sloping native soils were sampled. All minesoil and native soil sampling points had south-southwest aspects. Slope inclination at each sampling point is presented in Appendix Table 2. The distance between sampling points on this mine differed for each age. Each of the sampling points at the 2-year-old site was within a distance of 20 m from the next point. Sampling points on the native soils and on each of the other minesoil ages were more than 20 in apart. The longest distance between points was approximately 100 meters on the 23-year-old site.

Native soils mapped at the three locations are presented below. In general, they are very similar. They are moderately deep and acid with loamy textures.

a. Cannelton – Muskingum; fine-loamy, mixed, active, mesic Typic Dystrochrepts (Gorman and Espy, 1975)

b. Hobet-21 – Berks; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts Gilpin; fine-loamy, mixed, sciniactive, mesic Typic Hapludults (Wolf, 1994)

c. Dal-Tex - Berks; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts Matewan; loamy-skeletal, mixed, active, mesic Typic Dystrochrepts (Rob Pate, Natural Resources Conservation Service, personal communication)

All native soils at each of the sites were forested. Both minesoil sampling sites at Cannelton were predominantly vegetated with grasses and legumes. The 16-year-old site had scattered black locust (*Robinia pseudoacacia* L.) trees, but the 30-year-old site had more trees of a variety of species including black locust, maples (*Acer* sp.), pines (*Pinus* sp.), sweet gum (*Liquidambar styraciflua* L.) and sourwood (*Oxydendrum arboreum* L.). The 8-year-old site at Hobet-21 was covered with grasses and legumes. The major cover on the Hobet-21 17-year-old site was black locust with ground cover of grasses and legumes. At Dal-Tex, the 23-year-old site was predominantly forested with some grasses and legumes on the gently sloping sites. The 7-year-old site had predominantly grasses and legumes with some shrubs. The 11-year-old and the 2- year-old sites were covered with grasses and legumes with scattered trees at the 11-year-old site.

At each sampling point, a soil pit was dug to a depth of 40 cm or more to expose enough of the soil to determine the thickness of the surface mineral horizon and to observe one or more subsurface horizons. The soil was described to the exposed depth, and bulk samples were collected from the surface horizon for laboratory analyses. The average thickness of surface horizons for all soils is presented in Table 1. These samples were collected in early to mid June 2000. All samples were refrigerated at 4" C until they were analyzed. Bulk density of the surface horizon was determined in the field by a frame excavation technique developed by soil scientists at the National Soil Survey Laboratory in Lincoln, NE (Grossman, R.B., unpublished procedure).

Laboratory Analyses

Texture, pH and electrical conductivity were determined by standard methods of the National Soil Survey Laboratory (Soil Survey Staff, 1996). **A** LECO CNS-2000 analyzer was used to determine total carbon, sulfur, and nitrogen. Microbial biomass C and N were determined by a chloroform-fumigation-extraction procedure (Rice et al., 1996). Twenty grams of sample at field moisture content were used for this extraction procedure. Nitrogen in extracts was determined by a Kjeldahl method, and C was determined by a Tekmar-Dohrman DC-190 automated carbon analyzer. Potentially mineralizable N was determined by an anaerobic incubation procedure (Drinkwater et al., 1996). Microbial respiration was determined by static soil incubation in closed bottles (Zibilske et al., 1994). Triplicate soil samples (25 g field moist) were placed in funnels lined with Whatman #1 filter paper. Soils were then completely saturated with 100 ml of distilled water and allowed to drain for 24 hr to normalize soil moisture. Wetted soil (20 g) was weighed into serum bottles (160 ml) and incubated uncovered in the dark for 24 hr. Each bottle was capped with a butyl rubber stopper, and initial headspace CO_2 levels were established by injecting 1 ml via a syringe into an infrared gas analyzer (IRGA) equipped with a gas recirculation loop. This process was repeated for each bottle at 24, 48, 72, and 96 hr. Microbial respiration rates were determined using linear regression analysis of CO_2 concentrations at each sampling time.

Results and Discussion

The GPS latitude and longitude for each of the minesoil and native soil sampling points are presented in Appendix Table 1. Detailed profile descriptions are presented in Appendix Table 2. All of the minesoils had developed A horizons and most of the profiles had some weak development in the subsoil, so AC or Bw horizons were described. Minesoils at the Dal-Tex 1976-01 and the Hobet-21 1992-01 sites have cambic horizons and would be classified as Inceptisols (Soil Survey Staff, 1998), while all other minesoils are Entisols. All native soils, except Hobet-21 native-01, are classified as Inceptisols. Hobet-21 native 01 has an argillic horizon and is classified as an Ultisol.

In general, A horizons of the strongly sloping minesoils at Dal-Tex were thicker than the **A** horizons of the gently sloping minesoils (Table 1). Thickness of **A** horizons directly relates to the depth of incorporation and accumulation of organic matter primarily from root gowth, but also from aboveground biomass. Since bulk densities of the gently sloping minesoils were generally greater than the bulk densities of the strongly sloping minesoils (Thomas et al., 2000), roots should have penetrated more deeply on the strongly sloping minesoils developing thicker **A** horizons. A review of Appendix Table 2 shows that A horizons had more roots than subsurface horizons.

Rock fragment content of minesoil subsoil horizons averaged greater than 35% by volume and was greater than the rock fragment content of **A** horizons (Appendix Table 2). Therefore, all minesoils were classified as skeletal (Soil Survey Staff, 1998). Some of the native soils had more than 35% and others had less than 35% rock fragments in the subsoil horizons (Appendix Table 2). The average A-horizon rock fragment content for all soils was less than 35% by volume (Table 1, Appendix Table 2).

Minesoil physical and chemical properties are presented in Table 2. Most of the minesoils and native soils had loamy textures, i.e. sandy loam, loam, silt loam, or silty clay loam. Electrical conductivity values were very low for all soils. Minesoil pH ranged from 4.1 on the 23-year-old Dal-Tex site to 7.0 on the 8-year-old Hobet-21 site. Native soil **pH** values generally ranged from 4.5 to 5.6, but one site at Dal-Tex had a pH of 3.7. Low total S values for all minesoils and native soils in this study were similar to values reported by Smith et al. (1976) for soils and overburdens in nearby Mingo County.

Our minesoil and native soil C and N values are similar to other minesoils with comparable vegetation (Li, 1991; Prince and Raney, 1961; unpublished soil survey data, National Soil Survey Laboratory, Lincoln, NE). However, except for Dal-Tex native-02, the native soil C and N values are on the low end of the range of the other native soils used for comparison. The Dal-Tex native-02 C value of 12.45% is higher than most soils in the region. Total N and C values tended to be lower for minesoils than for native soils on the Dal-Tex site. However, the older minesoils on the Cannelton and Hobet-21 sites, had higher C and N values than the native soils.

Both native soil and minesoil biomass C and N, potentially mineralizable N and microbial respiration (MR) (Table 3) are generally within ranges given for other soils (Myrold, 1987; Insam and Dornsch, 1988; Rice et al., 1996). The minesoil biomass C values are generally higher than values reported for soils from long-term cropping experiments, but minesoil biomass N and potentially mineralizable N are similar to values from these experiments (Bonde et al., 1988). The native soils at Dal-Tex and at Cannelton are similar to each other in all three parameters, but the Hobet native soil is lower for all three. The reasons for this difference are not understood at this time since soils and vegetation are similar for the three sites.

Rice et al. (1996) suggest that the ratio of microbial biomass to total soil organic carbon and nitrogen may provide a measure of soil organic matter dynamics and soil quality. These authors quote other studies for agricultural soils (Anderson and Domsch, 1989; Jenkinson, 1988; Sparling, 1992) indicating that microbial biomass C (MBC) normally comprises 1 to 4% of total organic C and microbial biomass N (MBN) comprises 2 to 6% of the total organic N. The biomass C to total C (TC) ratios for all of our minesoils and native soils are within this quoted range (Table 4). The biomass N to total N (TN) ratios of the native soils at Dal-Tex are within this range, but the ratios present in the native soils at the other two mines are generally higher than the reported range. The fact that these soils are forest soils may explain why the MBN:TN range is different than that reported for agricultural soils. Extremely high MBN:TN values for Dal-Tex 7-year-old and 11-year-old sites indicate that these soils have not developed a stable organic matter base.

As the organic carbon pool becomes more stable with time, ratios of MBC:TC, MBN:TN and potentially mineralizable nitrogen (PMN):TC should decrease. This relationship is apparent at the Dal-Tex site. No total N was detectable in the Dal-Tex 2-year-old site, so the ratios could not be calculated. This site is apparently so young that the C and N pools are very unstable. However, the MBN:TN and PMN:TN ratios generally decrease in the following order: 7 years > 11 years > 23 years > native soil. For the MBC:TC ratios, there is a decrease in the following order: 11 years > 7 years = 23 years > native soil. We do not understand at this time why the MBC:TC ratio for the 7-year-old minesoil is not higher than the 11 or 23-year-old minesoil. These same relationships of decreasing ratios with age are not readily apparent at the Cannelton and Hobet-21 sites. The total C values may not be an accurate estimate of organic C in some minesoils because of the presence of coal or high C rock fragments in the samples. Therefore, the N values and ratios are probably more reliable comparisons.

Soil respiration previously has been used to assess decomposition dynamics in West Virginia minesoils (Stroo and Jencks, 1985). Kennedy and Papendick (1995) suggested that a respiratory quotient such as the MR/MBC ratio relates both the size and activity of microbial biomass. A lowering of the ratio indicates a trend to a more stable and mature system (Insam and Domsch, 1988). The respiratory quotient for the Dal-Tex soils decreased in the following order: 7 years > 11 years > 23 years > native soil (Table 4). Again excluding the 2-year-old soil, this trend indicated a maturation of soils at the Dal-Tex site. **A** decreasing respiratory quotient with site age was not observed at the Cannelton and Hobet sites.

Based upon these data, we conclude that there is a trend toward the accumulation of C as these minesoils age. Also, it appears that the stable organic pool is increasing. The older minesoils, especially the 23-year-old minesoils at Dal-Tes and the 30-year-old minesoils at Cannelton, have properties similar to the native soils. These data and other data (Thomas et al., 2000) indicate that the minesoils sampled in this study are approaching stable, developed soils.

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Appendix Table 1. GPS Coordinates of Minesoils and Native Soils at Three Sites.

Site	Latitude	Longitude
Dal-Tex		
Gently Sloping		
23 yr old		
1976-01	N 37 deg 53 min 48 sec	W 81 deg 51 min 20 sec
1976-03	N 37 deg 53 min 30 sec	W 81 deg 51 min 32 sec
1976-05	N 37 deg 53 min 30 sec	W 81 deg 51 min 33 sec
11 yr old		
1988-01	N 37 deg 54 min 56 sec	W 81 deg 51 min 21 sec
1988-03	N 37 deg 54 min 58 sec	W 81 deg 51 min 11 sec
1988-05	N 37 deg 54 min 52 sec	W 81 deg 50 min 58 sec
7 yr old		
1992-01	N 37 deg 55 min 22 sec	W 81 deg 50 min 17 sec
1992-03	N 37 deg 55 min 21 sec	W 81 deg 50 min 20 sec
1992-05	N 37 deg 55 min 20 sec	W 81 deg 50 min 25 sec
2 yr old		
1997-01	N 37 deg 56 min 11 sec	W 81 deg 51 min 16 sec
1997-03	N 37 deg 56 min 11 sec	W 81 deg 51 min 14 sec
1997-05	N 37 deg 56 min 10 sec	W 81 deg 51 min 12 sec
Strongly Sloping		
23 yr old		
1976-02	N 37 deg 53 min 42 sec	W 81 deg 51 min 27 sec
1976-04	N 37 deg 53 min 41 sec	W 81 deg 51 min 33 sec
1976-06	N 37 deg 53 min 41 sec	W 81 deg 51 min 34 sec
11 yr old		
1988-02	N 37 deg 54 min 56 sec	W 81 deg 51 min 21 sec
1988-04	N 37 deg 54 min 57 sec	W 81 deg 51 min 11 sec
1988-06	N 37 deg 54 min 53 sec	W 81 deg 50 min 58 sec
7 yr old		
1992-02	N 37 deg 55 min 23 sec	W 81 deg 50 min 19 sec
1992-04	N 37 deg 55 min 22 sec	W 81 deg 50 min 22 sec
1992-06	N 37 deg 55 min 21 sec	W 81 deg 50 min 25 sec
2 yr old		
1997-02	N 37 deg 56 min 10 sec	W 81 deg 51 min 16 sec
1997-04	N 37 deg 56 min 10 sec	W 81 deg 51 min 14 sec
1997-06	N 37 deg 56 min 10 sec	W 81 deg 51 min 13 sec
Natives		
Native-01	N 37 deg 56 min 24 sec	W 81 deg 51 min 17 sec
Native-02	N 37 deg 56 min 25 sec	W 81 deg 51 min 14 sec

Cannelton

Minesoil

30 yr old

1970-01	N 38 deg 12 min 39.5 sec	W 81 deg 16 min 45.9 sec
1970-02	N 38 deg 12 min 34.7 sec	W 81 deg 17 min 01.4 sec
1970-03	N 38 deg 12 min 35.0 sec	W 81 deg 16 min 56.0 sec

16 yr old

1984-01	N 38 deg 14 min 17.9 sec	W 81 deg 16 min 46.6 sec
1984-02	N 38 deg 14 min 40.7 sec	W 81 deg 16 min 32.3 sec
1984-03	N 38 deg 14 min 42.4 sec	W 81 deg 16 min 09.4 sec

Natives

Native-01	N 38 deg 14 min 58.2 sec	W 81 deg 15 min 25.2 sec
Native-02	N 38 deg 14 min 59.1 sec	W 81 deg 15 min 18.3 sec
Native-03	N 38 deg 15 min 02.5 sec	W 81 deg 15 min 10.6 sec

Hobet 21

Minesoil

17 yr old

1983-01	N 38 deg 07 min 13.2 sec	W 81 deg 53 min 01.5 sec
1983-02	N 38 deg 06 min 58.7 sec	W 81 deg 52 min 56.6 sec
1983-03	N 38 deg 06 min 50.3 sec	W 81 deg 52 min 46.2 sec

8 yr old

1992-01	N 38 deg 04 min 46.3 sec	W 81 deg 55 min 42.3 sec
1992-02	N 38 deg 04 min 41.0 sec	W 81 deg 55 min 58.8 sec
1992-03	N 38 deg 04 min 48.9 sec	W 81 deg 56 min 03.8 sec

Natives

Native-01	N 38 deg 07 min 03.4 sec	W 81 deg 52 min 35.3 sec
Native-02	N 38 deg 07 min 01.9 sec	W 81 deg 52 min 36.2 sec
Native-03	N 38 deg 06 min 59.9 sec	W 81 deg 52 min 38.9 sec

Appendix Table 2. Profile Descriptions for the Dal-Tex, Cannelton, and Hobet -21 Mine Sites

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Dal-Tex											
1976-01	Oi	0--2									
23-years-old	Oe	2--3							aw		
(2% slope)	A	3--7		2.5Y 5/3	SIL	2, f, sbk breaking to 2, f-m, gr	fr		cw	many, vf-c	20% SS
	AC	7--22		2.5Y 5/3, 10YR 5/6, 10YR 6/2, N 2.5/0	SICL	1, m-c, sbk	fr		cw	com, vf-c	30% SS, MS, C
	C	22--65		7.5YR 5/8, 10YR 5/6, 2.5Y 7/4, 10YR 6/2 N 2.5/0	SICL	0, ma	fr		aw	few, vf-f	35% SS, MS, C
	2Cr	65--79			Gray shale and mudstone				aw		
	2R	79+			Sandstone						
1976-02	Oi	0--3									
23-years-old	Oe	3--6							aw		
(30% slope)	A	6--13		10YR 4/2, 10YR 5/3	L	1, m, sbk breaking to 1, f-m, gr	fr		cw	many, vf-m	4% SS, MS, C
	AC	13--31		10YR 4/2	L	1, m-c, sbk	fr		cw	few, vf-m	50% SS, MS, C
	C/B	31--75		2.5Y 5/3	LS	80% 0, ma 20% 1, f, sbk	vfr		gw	com, vf-m	65% SS, MS, C
	C	75--105+		2.5Y 5/2	LS	0, ma	vfr		aw	few vf-m	75% SS
	2R	79+			Sandstone						

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary'	Roots[7]	Rock' Fragments
1976-03	Oi	0--1			Leaf and stem litter						
23-years-old	Oe	1--5			Partially decomposed leaf and stem litter						
(6% slope)	A	5–12		10YR 4/2	SL	2, f, sbk breaking to 2, f-m, gr	fr	6.5	cw	many, vf-m	35% SS, MS, C
	AC	12–30		IOYR 3/2	SL	1, c, sbk breaking to 1, m, sbk	fr	6.0	cw	com, vf-m	50% SS, MS, C
	C1	30--87	com, f IOYR 5/8	N 310	SL	0, ma	fr	4.0	cw	few, vf-f	80% SS, MS, C
	C2	87--115+	many, f, 7.5YR 4/6 10YR 5/8, N 2.510 10YR 7/4	IOYR 413	L	0, ma	fr				40% SS, MS, C
1976-04	Oi	0--1			Leaf and stem litter						
23-years-old	Oe	1--4			Partially decomposed leaf and stem litter				aw		
(42% slope)	A	4--12		10YR 5/4	SL	2, f-m, gr	vfr		aw	many, vf-vc	30% SS, MS
	AC	12--38	Discontinuous layers 1OYR 2/1	10YR 5/4, 10YR 516	SL	1,m-c, sbk	fr		gw	com, vf-vc	60% SS, MS, C
	C	38--69		1OYR 5/4, 10YR 5/6	LS	0, ma	fr	5.0	gw	few, vf-c	45% SS, MS, C
	C/B	69--150+	Discontinuous layers 10YR 4/1	IOYR 5/4, 10YR 5/6, IOYR 4/4	L SL/L	75% 0, ma 25% f-m, sbk	fr	6.0		com, vf-c	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling'	Moist Color'	Texture'	Structure[4]	Moist' Consistence	pH	Boundary[6]	Roots'	Rock[8] Fragments

1976-05 23-years-old (4% slope)	Oe	0--3			Partially decomposed litter				aw		
	A	3--8		10YR 3/3	LS	2, f, gr	vfr	6.2	cw	many, vf-m	30% SS, C
	AC	8--26		10YR 4/1, 10YR 4/2	SL	1, m, sbk breaking to 1, m, gr	fr	6.0	cw	many, vf-m	50% SS, C
	C1	26–61	few, f-m IOYR 518	10YR 4/2	SL	0, ma	fr	8.0	gw	few, vf-f	80% SS, C
	C2	61+			Fragmental--large sandstone boulders with large voids						
1976-06 23-years-old (23% slope)	Oi	0--2			Leaf and stem litter						
	Oe	2--5			Partially decomposed litter				aw		
	A	5--11		2.5Y 5/3	L	1, f-m, sbk breaking to 1, m, gr	fr		cw	many, vf-m	30% SS, CO, MS
	Bw	11–26	com, f-m, IOYR 518, .10YR 3/1	1OYR 514	L	1, m-c, sbk	fr		cw	corn, vf-c	40% SS, CO, MS, C
	C	26--120+	coni, f-m, IOYR 516, 10YR 3/1, 7.5YR 5/6	10YR 4/3	L	0, ma	fr			few, f-m	60% SS, MS, C
1988-01 11-years-old (1% slope)	Oe	0--3		10YR 4/2	Root Mat		fr		as	many, vf-f	
	A	3--11		2.5Y 513	SL	1, m, sbk breaking to 2, m, gr	fr		aw	many, vf-f	26% SS, C
	AC	11--37		2.5Y 5/1	L	1, m, sbk	fr		cw	corn, vf-f	40% SS, C, MS
	C1	37-49		IOYR 513	SL/LS	0, ma	fr		gw	few, vf-f	70% SS, C
	C2	89--160+		2.5Y 513	SL	0, ma	fr			vfew, vf-f	70% SS, MS, C
1988-02 11-years-old	Oi	0--3	Root mat	lOYR 313					as	many, vf-f	
	A	3--12		lOYR 416	L	1, m, sbk	fr		cw	com, vf-m	30%

(44% slope)						breaking to				SS
						2, m, gr				
	AC	12--41		10YR 4/6	SL	1, f-m, sbk	fr	aw	few, vf-m	35%
										SS, C
	C1	41--75		10YR 4/2	SL	90% 0, ma	vfr	gw	com, vf-m	70%
						10% 2, f, sbk				SS, MS, C
	c2	75--125+		10YR 4/2	SL	0, ma	vfr		few, vf-f	70%
										SS, MS, C
1988-03	A	0--3		10YR 4/2	SL	1-2, m, sbk	vfr	aw	many, vf-f	20%
11-years-old										SS
(7% **slope)**	AC	3--16		10YR 4/1	SL	1, m, sbk	fr	cw	com, vf-f	50%
										SS, C
	C1	16--49		2.5Y 4/1	SL	0, ma	fr	aw	few, vf	GO%
										SS, C
	c2	49--91		10YR 4/3	SL	0, ma	fr	cw	few, vf	50%
										SS, C
	c 3	91--125+	com, f, 10YR 5/6	10YR 4/4	CL		fr		vfcw, vf	SO%
										SS, C

1988-04	Oe	0--2			Root mat-partially decomposed leaves and roots			aw	many, vf-m	30%
11-years-old										SS
(34% slope)	A	2--10		10YR 4/3	SL	2, f-m, gr	vfr	cw	many, vf-m	50%
										SS

Site ID & Soil Age	Horizon	Depth	Mottling	Moist Color	Texture	Structure	Moist Consistence	pH	Boundary	Roots	Rock Fragments
	C1	10--24		10YR 5/4	SL/LS	95% 0, ma 5% 1, m, sbk breaking to 1, m, gr	fr		cw	corn. vf-m	60% SS, C
	C2	24--59		10YR 5/4, 10YR 5/8	SL/SCL	95% 0, ma 5% 1, m, sbk	fr		cw	few, vf-m	SS, C
	C3	59--114		10YR 4/6, 10YR 5/6	L	0, ma	fi in place fr in hand		aw	vfew, vf-m	SS, C SS, C
	C4	114--125+	com, f, 10YR 5/6	1OYR 4/1	L/CL	0, ma	fr				60% SS, C
1988-05 11-years-old (8% slope)	A	0--9		1OYR 313	SL	1, m, sbk breaking to 1, f, gr	vfr		cw	many, vf-f	30% SS
	C1	9--22		10YR 4/1	SL	0, ma	fr		cw	com, vf-f	55% SS, MS, C
	C2	22--45		2.5Y 412	SL	0, ma	fr		gw	few, f-vf	70%
	C3	45--79		2.5Y 4/1	LS	0, ma	fr		gw	few, vf-f	55% SS, MS, C
	C4	79--135+		2.5Y 4/1	SL	0, ma	fr			vfew, vf	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth	Mottling[1]	Moist Color[2]	Texture'	Structure[4]	Moist' Consistence	pH	Boundary[6]	Roots'	Rock' Fragments
1988-06 11-years-old (48% slope)	A	0--7		10YR 3/3, 10YR 4/3	L	2, f-m, gr	vfr		cw	many, vf-f	30% SS
	AC	7--36		10YR 413	L	1-2, m-c, sbk	fr		gw	corn, vf-f	60% SS, C
	CB	36--72	few, m-c, 7.5YR 5/6	10YR 4/3	SL	1, c, sbk	fr		cw	few, vf-f	75% SS, C
	C	72--150+		2.5Y 5/3	SL	0, ma	fi in place		gw	vfew, vf-f	50%

							fr in hand				SS, C
1992-01 7-years-old (0.5% slope:	A	0--8		10YR 3/3	SL	1, m, sbk breaking to 2, vf-f, gr	vfr	7.5	cw	many, vf-f	25% SS
	C1/B	8--30		2.5Y 413	LS	75%, 0, ma 25% ,1,f-m, sbk	fr	8.0	gw	com, vf-f	60% SS, MS, C
	C2/B	30--77		1OYR 412	LS	90%, 0, ma 10%, 1, f, sbk	fr	8.0	cw	few, vf-f	70% SS, MS, C
	C	77--125+	com, f, 10YR 618	10YR 514	LS	0, ma	vfr	8		few, vf-f	75% SS, MS, C
1992-02 7-years-old (27% slope)	Oi	0--2			Leaf and stem litter						
	A	2--8		10YR 4/1	SL	2, f-ni, gr	vfr		cw	many, vf-f	25% SS
	AC	8–24		10YR 4/1	SL	1, m, sbk	fr		ci	com, vf-f	40% SS, MS, C
	C1/B	24–60		10YR 4/2, 10YR 4/3	SL	90% 0, ma 10% 1, m, sbk	fi in place fr in hand		gw	com, vf-f	50% SS, C
	C2/B	60--107		10YR 4/2	SL/LS	90% 0, ma 10% 1, m, sbk	fi in place fr in hand		gw	few, vf-f	50% SS, MS, C
	C	107-207+		10YR 4/2	SL/LS	95% 0, ma 5% 1, m, sbk (roots continue past 207 cm)	vfr			few, vf-f	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure'	Moist' Consistence	pH	Boundary[6]	Roots'	Rock[8] Fragments
1992-03 7-years-old (1% slope)	Oe	0--2			Partially decomposed organic matter				aw		
	A	2--6		10YR 4/1	L	2, f, sbk breaking to 1, f-m, sbk	vfr		cw	many, vf-f	30% SS, MS
	AC	6--24	few, c, 7.5 YR 5/6	10YR 3/1	L	I, c, sbk 2, m, sbk-- around roots	fr		aw	com, vf-f	25% MS, SS
	C/B	24-48		2.5Y 5/3	SL	60% 0, ma 40%, 2, f-m, sbk	fr		gw	com, vf-f	71% SS, C

	C1	48--66		10YR 5/3	SL	95%, 0, ma 5%, 1, m, sbk	fi in place fr in hand		gw	few, vf-f	75% SS, MS, C
	C2	66--97		10YR 5/3	SL	0, ma	fr		gw	few, vf-m	75% SS, MS, C
	C3	97--160+		10YR 5/3	SL	0, ma	fr		gw	vfew, f-m	90% SS, MS
1992-04 7-years-old (33% slope)	A	0--7		10YR 3/1	SL/L	2, m, gr	vfr	4.2	cw	many, vf-m	15% SS
	Bw	7--21	coni, f, 10YR 5/6	10YR 4/2, 10YR 5/3	SL	1, m, sbk	fr	4.2		com, vf-m	30% SS
	C1	21--42		2.5Y 5/3	SL/LS	0, ma	fi in place fr in hand	4.2	gw	few, vf-m	45% SS, MS, C
	C2	42--101		2.5Y 5/3	SL/LS	0, ma	fi in place fr in hand	4.2	cw	none	45% SS, MS, C
	C3	101--160+		2.5Y 5/3	SL/LS	0, ma	fr			none	56% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist Consistence[5]	pH	Boundary[6]	Roots[7]	Rock Fragments[8]
1992-05 7-years-old	Oe	0--2				Partially decomposed leaf and stem litter			aw		35% SS
	A	2--6		2.5Y 3/2	SL	1, f-m, gr	vfr	6.0	cw	many, vf-m	35% SS
	AC	6--24		2.5Y 4/1, 2.5Y 3/1	SL	1-2, f-m, sbk	fr	6.5	cw	com, vf-m	50% SS, MS, C
	C1/B	24-48		2.5Y 3/1	L	60%, 0, ma 40%, 1, f, sbk breaking to 1, f, gr	fr	7.0	gw	com, vf-m	60% SS, MS, C
	C2/B	48--66		2.5Y 3/1	L	85%, 0, ma	vfr/l	6.5		few, vf-m	70%

						15%, 1, f, sbk breaking to 1, f, gr					SS, MS, C
(Roots continue past lowest horizon described)											
1992-06 7-years-old (39% slope)	A1	0--10		10YR 312, 10YR 412	SL	2, f-m, gr	vfr	4.2	cw	many, vf-m	30% SS, C
	A2	10--19		10YR 513	SL	1, m, gr	vfr		cw	many, vf-m	35% SS
	AC	19--32		1OYR 6/4	SL	1, m, sbk breaking to 1, m, gr	fr	4.2	cw	com, vf-m	40% SS
	C1	32--73		1OYR 514	LS/SL	75%, 0, ma 25%, 1, m, sbk	vfr	4.2	gw	few, vf-m	50% SS
	C2	73--110+		10YR 5/4	SL	0, ma	vfr	4.5		vfew, vf-f	50%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist Consistence[5]	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-01 2-years-old (15% slope)	Oi	0--1			Grass stems						
	A	1--4		1OYR 4/3	SL	1, f, gr	vfr		cw	many, vf-f	40% SS, MS, C
	AC	4--10		10YR 4/3	SL	1, m, sbk	fr		cw	corn, vr-f	40% SS, MS, C
	C1	10--41	com, f-m, 2.5Y 6/6, N 2.510	2.5Y 412	USL	0, ma	vfr		gw	few, vf-f	50% SS, C, MS
	c2	10--92	com, m, N 2.510, 1OYR 5/6, 7.5YR 518 2.5YR 5/8, 2.5Y 616 1OYR 616	2.5Y 413	SL	0, ma	fr		aw	few, vf-f	60% SS, C, MS
	c3	92--150+	few, f, 2.5Y 7/1	7.5YR 518	LS	0, ma	fi in place fr in hand				90% SS

1997-02 2-years-old (**43%** slope)	**Oi**	0--2			Grass and legume stems						
	A	2--6		2.5Y 312	**SL**	1, f-m, **gr**	vfr		**cw**	com, vf-m	30% SS, MS, C
	C1	6–51	com, f-m, 10YR 5/6, N 2.5/0, 10YR 4/4	2.5Y 312	**SL**	**90%,** 0, ma **10%,** 1, f, **sbk**	fr		gi	few, vf-m	50% SS, MS, **C**
	C2	51--104	com, f, N 2.5/0, 10YR 5/6	10YR 512	L/SL	0, ma	fi in place		ci	few, vf-f	75% SS, MS, C
	C3	104--140+	few, m, N *2.510*	10YR 3/2, 10YR 4/2	**SL**	0, ma	fr			vfew, vf-f	40% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-03 2-years-old (10% slope)	Oi	0--1			**Grass and** legume stem litter						
	A	1--7		2.5Y 3/2	L	1, m, sbk breaking to **2, m, gr**	fr		cw	many, vf-m	20% SS, MS, C
	AC	7–13		2.5Y 312	L	I, **m,** sbk	fr		gw	com, vf-m	20% SS, MS, C
	C1	13–56	few, m-c, 10YR 516	2.5Y 3/1	L	0, ma	**fi**		**aw**	few, vf-f	35% MS, SS, C
	c2	56--82	many, f-m, 2.5Y **6/6,** N 2.5/0, 7.5YR 516, 10YR **6/3**	10YR 6/6	L	0, ma	fr		**aw**	few, vf-f	30% SS, **MS,** *C*
	2Cr	82--92+			**Soft** grey mudstone						
1997-04 2-years-old	**Oi**	**0--1**			Grass and legume **stems**						
	A	1--7		2.5Y 312	**SL**	1-2, f, **gr**	vfr		cw	many, vf-f	25%

(44% slope)											SS, MS, C
	C1	7--37	com, f, IOYR 6/1, 10YR 6/6	2.5Y 3/2, 2.5Y 4/2	CL	90% 0, ma, with pockects of 1, pl 10% 1, f, sbk	fi		gw	many, vf-m	45% SS, MS, C
	C2	37--120	few, m, N 2.5/0	2.5Y 3/2, 2.5Y 5/3	CL	0, ma	fi		cw	few, vf-m at rock faces	75% SS, MS, C
	C3	120--152+	com, f, 10YR 4/1, 10YR 3/1	IOYR 5/6, 2.5Y 5/4	SL	0, ma	fr			vfew, vf	50% SS, MS, C

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1997-05 2-years-old (1% slope)	Oi	0--1			Grass and legume stem litter						
	A	1--5		10YR 3/2	SL	1, m, sbk and 1, m, gr	fr		cw	many, vf-f	25% SS, MS, C
	AC	5--22	few, f-m, N 2.5/0, 2.5 614	2.5Y 4/2	SL	1, f-m, sbk	fi		cw	com, vf-f	35% MS, SS, C
	C	22-44	many, f-m, 2.5Y 6/4, 7.5YR 5/6, N 2.5/0	2.5Y 4/3, 2.5Y 4/1	CL	0, ma	fi		aw	few, vf-m	40% SS, MS, C
	2Cr	64--91+			Soft grey mudstone						
1997-06 2-years-old (53% slope)	Oi	0--2			Grass and legume stem litter						
	A	2--8		10YR 3/3	SL	1, f, gr	fr		cw	many, vf-f	30% SS, MS, C
		8–14		10YR4/2, IOYR 5/6	SL/L	1, f-m, sbk	fr		aw	many, vf-f	30% SS, MS, C
		14–29	com, c, IOYR 516	2.5Y 4/3	SL	75% 0, ma	fr		gw	many, vf-m	70%

						25% 1, f, **sbk**					SS, MS, **C**
	C	29--120+	few, m, N 2.510	2.5Y 513, 10YR 6/1	SL	0, ma	fi			few, vf-m	**70%**
											SS, MS, *C*
Native-0 1	**Oi**	4--0			Leaf and twig **litter**						
(31% slope)	**A**	0--9		10YR 2/2	SIL	**2,** f, gr	vfr		cw	many, vf-c	**5%**
											SS
	BA	9–18		10YR 4/2	SIL	**1, m,** sbk breaking to 1, m, **gr**	vfr		cw	niany, f-c	10%
											SS
	Bw1	18-43		10YR 614	SIL	2, m-c, sbk	fr		gw	corn, f-m	25%
											SH
	Bw2	43--67		lOYR 516	SIL	2, **f-m,** sbk	**fr**		ab	**few, f-m**	40%
											SS
	R	67--104+			Shale						
Soil Age		**(cm)**					**Consistence**				**Fragments**
Native-02	**Oi**	5--0			Leaf and twig litter						
(58% slope)	OA	0--2			Decomposed oraganic matter						
	A/E	2--5		10YR 3/1, 10YR 4/2	SL	**1,** f, gr	vfr		aw	many, vf-m	20%
											SS
	BA	5--23		10YR 5/6	SL/LS	1, f, sbk and **1, f,** gr	vfr/l		cw	many, vf-c	40%
											SS
	Bw	23–59		lOYR 6/6	**SL/LS**	**1,** in, sbk	fr		**gw**	corn, f-vc	45%
											SS
	BC	59-48		lOYR **6/6**	SL/LS	1, m-c, sbk	**fr**		aw	com, f-vc	55
											SS
	R	88-107+			Fractured sandstone, with few **roots** in fractures						
Cannelton											
1970-01	***Oi***	0--1									
30-years-old	**A**	**1--4**		lOYR *313*	SIL	2, f, **gr**	vfr	5.3	**aw**	many, vf-m	**1%**
(2% slope)	**AC**	4–13		lOYR 6/3, 7.5YR *516*	SICL	1, m, sbk	fr	4.7	cw	com, f-m	10%
				10YR 6/1, N 210							MS, *SS*, C
	C	13--43+		7.5 YR ***GIG***, 7.5YR 7/1	SICL	0, ma	**fi**	5.0		few, vf-f	25%

				10YR 6/1, N 210 10YR 6/3		and 1, t, pl					MS, SS, C
1970-02 30-years-old (2% slope)	Oi	0--1									
	A	1--4		10YR 4/3	L	2, f-c, gr	vfr	6.5	aw	many, vf-m	1%
	AC	4--16		2Y 5/3, 10YR 5/6, N 2/0, 7.5YR 4/6	L	1, f-m, sbk	fr	7.0	cw	com, vf-m	20%
	C	16--40+		2Y 513, 10YR 5/6, N 2/0, 7.5YR 4/6	SL	0, ma		8.0		vfew, m	85%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
1970-03 30-years-old (2% slope)	Oi	0--1									
	A	1--3		10YR 3/2	L	2, f-m, gr	vfr	6.5	cw	many, vf-m	5%
	AC	3--15		N 2/0, 7.5YR 4/6, 10YR 512, 10YR 6/1, 7.5YR 6/8	SICL	2, m, sbk breaking to 2, f-c, gr	fr	7.0	gw	com, vf-m	25%
	C	15--45+		N 2/0, 7.5YR 4/6, 10YR 5/6, 10YR 5/8, 10YR 5/2		0, ma	fi	8.0		few, f-m	50%
1984-01 16-years-old (10% slope)	Oi	0--3									
	A	3--7		10YR 412	SL	1, f, gr	vfr	7.5	cw	com, vf-f	0
	AC	7--14		2.5Y 5/2	LS	1, f, sbk	vfr	8.0	cw	few, vf-f	60% SS, C, MS
	C	14--50+		2.5Y 5.2	LS	0, ma	1	8.0		vfew, vf	70% SS, C, MS
1984-02 16-years-old (5% slope)	Oi	0--2									
	A	2--8		2.5Y 4/2	SICL	2, m-c, gr breaking to 2, m, sbk	fr	7.0	cw	many, vf-m	35%
	AC	8--18		2.5YR 5/2, 10YR 516	SICL	1--2, c, gr	fi	8.0	cw	com, f-m	50%

						breaking to					SS, SH
						2, f, sbk					
	C	18--45+		2Y 512, 1OYR 516	CL	0, ma		8.0		vfew, f	75%
											SS, SH
1984-03	Oi	0--2									
16-years-old	A	2--7		2.5Y 412	SIL	2, f-m, gr	fr	7.0	cw	many, f-m	35%
(5% slope)	AC	7–17		2.5Y 4/1, 7.5YR 518, N 210	L	1, f-m, sbk	fi	8.0	aw	few, f-m	65%
	C	17--40+		10YR 4/1, N 2/0	SL	1		8.0		vfew, f-m	85%

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist Consistence[5]	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-01	Oi	0--5									
(70% slope)	A	5–17		10YR 4/3	SIL	2, f-m, gr	vfr	5.5		many, f-m	5%
	Bw1	17–33		10YR 4/4	SIL	1, m, sbk breaking to 2, f-c, gr	fr	5.0		many, Ill-c	15%
	Bw2	33–50+		10YR 5/6	SIL	1, m, sbk breaking to 2, f-c, gr	fr	5.0		few, m-c	30%
Native-02	Oe	0--4									
(45% slope)	A	4--12		10YR 3/3	SIL	2, f-m, gr	fr	5.5	aw	many, vf-f	5%
	AB	12--18		10YR 3/4	SIL	1, f, sbk breaking to 2, f-c, gr	fr	5.5	cw	com, vf-f	5%
	Bw1	18--31		10YR 3/4	SIL	2, m, sbk breaking to 2, f-c, gr	fr	5.5	cw	com, vf-c	10%
	Bw2	31--45+		10YR 4/4	SIL	2, m-c, sbk breaking to 2, f-c, gr	fr	5.5		few, m-c	10%
				(Very few discontinuous clay films in Bwl and few discontinuous clay films in Bw1)							
Native-03	Oi	0--3									

(67% slope)	A	3--16		lOYR 412	SIL	1, f-m, sbk breaking to 2, f-m, gr	fr	5.5	aw	many, vf-c	25%
	Bw1	16–29		lOYR 5/4	SIL	2, f-m, sbk	fr	5.5	cw	few, f-c	40%
	Bw2	29--45+		10YR 5/6	SIL	2, m, sbk	fr	5.5		vfew, f-m	60%
				(few discontinuous clay films in lower horizons)							

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock' Fragments
Hobet-21											
1983-01	Oi	0--2		Leaf and twig litter							
17-years-old (12% slope)	A	2--4		2.5Y 312	SIL/L	1, f, sbk breaking to 2, m, gr	fr		cw	many, vf-c	20% SS
	AC	4--16		2.5Y 5/2	L	1, f, sbk	fr		cw	many, vf-m	50% SS,C
	C	16--45+		5Y 3/1	SL	0, ma	fi			few, vf-f	80% SS, C
1983-02	Oi	0--2									
17-years-old (28% slope)	A	2--5		7.5YR 3/1	SL	2, c, gr	vfr		cw	many, vf-m	20% SS,SH
	AC	5--19		2.5Y 312	CL	1, f, sbk	fr		cw	com, vf-c	45% SS, SH, C
	C	19--45+		2.5Y 3/2		0, ma	fi			few, vf-f	75% SS, C
1983-03	Oi	0--1									
17-years-old (3% slope)	A	1--5		10YR 3/3	SIL/L	2, f-m, gr	vfr		aw	many, vf-m	15% SS, SH
	AC	5–18		lOYR 5/8, lOYR 5/1	CL	1, f, sbk	fr		cw	many, vf-m	50% SS, SH, C
	C	18--45+		2.5Y 312	L	0, ma	fi, in place, fr in hand			few, vf-f	80% SS, C

1992-01	Oi	0--2		Ground moss						
8-years-old	A	2--5	10YR 3/2, 10YR 4/2	SL	2, vf-f, gr	vfr		aw	many, vf-m	
(3% slope)	Bw	5--26	10YR 4/3, 10YR 6/4, N 210	CL	2, f-m, sbk	fr		cw	many, vf-m	45% SS, C
	C	26--50+	2.5Y 3/2	SCL	0, ma	fi			com, vf-f	55% SS, C

Soil Age		(cm)				Consistence				Fragments
1992-02	Oi	0--2		Mat of moss and mots						
8-years-old	A	2--6	2.5Y 3/3	L	1, f-m, gr	vfr		aw	many, vf-m	20% SS
(5% slope)	AC	6--28	2.5Y 5/3, 10YR 6/6 N 210	SL	1, f-m, sbk	fr		cw	many, vf-m	65% SS
	C	28--45+	2.5Y 5/3, 7.5YR 5/6, N 210	SL	0, ma	fi			few, vf-f	65% SS
1992-03	Oi	0--1		Leaf litter from forages						
8-years-old	A	1--5	2.5Y 4/2	L	1, f-m, gr	vfr		cw	many, vf-m	25% SS
(5% slope)	AC	5--11	2.5Y 4/2	SL	1, f, sbk breaking to 2, m, gr	vfr		cw	many, vf-m	25% SS
	C	11-45+	2.5Y [illegible]	SL	0, ma	fr			few, vf-f	80% SS
Native-01	Oi	0--3		Leaf and twig litter						
(45% slope)	Oe	3--4								
	A	4--13	10YR 4/2	SL	2, f-m, gr	vfr	5.5	aw	com, vf-m	5% SS
	E	13--27	10YR 6/4	SL	1, m, sbk	fr	5.5	cw	com, vf-c	5% SS
	Bt1	27-44	10YR 5/6	SCL	2, m, sbk	fr	5.5	gw	few, vf-c	5%
	Bt2	44--57+	10YR 5/6	CL	2, m, sbk	fr	4.8		few, vf-c	10% SS

(few patchy clay films on ped faces and in pores in the Bt1 and common patchy clay films on ped faces an in pores on Bt2)

Appendix Table 2. Continued

Site ID & Soil Age	Horizon	Depth (cm)	Mottling[1]	Moist Color[2]	Texture[3]	Structure[4]	Moist[5] Consistence	pH	Boundary[6]	Roots[7]	Rock[8] Fragments
Native-02	Oi	0--5			Leaf and twig litter						
(70% slope)	A	5--11		10YR 3/3	SL	2, f, gr	vfr	5.5	cw	many, vf-c	15 SS% SS
	BA	11--26		10YR 4/4	SL	1, f, sbk breaking to 1, f-m, gr	vfr	5.2	cw	many, vf-vc	20% SS
	Bw1	26-38		10YR 5/4	SL	1, m, sbk	fr	5.2	gw	com, f-vc	20% SS
	Bw2	38--60+		10YR 5/4	SL	1, m, sbk	fr	4.7		com, f-vc	25% SS
Native-03	Oi	0--5			Leaf litter						
(72% slope)	Oe/Oa	5--9									
	A	9--17		10YR 3/2	SL	2, f-m, gr	vfr	4.7	cw	many, vf-m	20% SS
	AB	17--35		10YR 3/4, 10YR 5/6	SL	2, f-m, gr	vfr	5.0	cw	many, vf-vc	35% SS
	Bw1	35--51		10YR 5/6	SL	1, m, sbk	fr	5.0	gw	many, vf-c	35% SS
	Bw2	51--81+		7.5YR 4/6	SL	1, m, sbk	fr	4.5		com, vf-c	45% SS

-f=fine, m=medium, c= coarse, com=common

2-Colors derived with Munsel color book

3-CL=clay loam, L=loam, LS= loamy sand, SCL=sandy clay loam, SICL=silty clay loam, SIL=silt loam, SL=sandy loam

4-0=stuctureless, 1=weak, 2=moderate
vf=very fine, f=fine, m=medium, c=coarse, t=thick
gr=granualr, ma=massive, pl=platy, sbk=subangular blocky

5-fr=friable, fi=firm, L=loose, vfr=very friable

[6]-aw=abrupt wavy, cw=clear wavy, gw=gradual wavy, ab=abrupt broken, ci=clear irregular, gi=gradual irregular, as=abrupt smooth

[7]-com=common, vfew=very few, vf=very fine, f=fine, m=medium, c=coarse, vc=very coarse

[8]-C=carbolithic material, CO=conglomerate, MS=mudstone, SH=shale, SS=sandstone

Table 3. Minesoil microbial biomass carbon and nitrogen, potentially mineralizable nitrogen, and microbial respiration

[illegible]	Microbial Biomass Carbon mg/kg	Microbial Respiration ug-CO_2-C/kg/hr	Microbial Biomass Nitrogen mg/kg	Potentially Mineralizable Nitrogen mg/kg
Dal-Tex				
Gently Sloping				
23 yrs old				
1976-01	1080	1452	55	83
1976-03	659	780	76	79
1976-05	1111	1163	100	119
mean	950	**1132**	**77**	**94**
11 yrs old				
1988-01	989	2025	84	156
1988-03	786	1791	27	180
1988-05	1061	1098	102	95
mean	**945**	**1638**	**71**	**144**
7 yrs old				
1992-01	907	2288	62	172
1992-03	1506	2055	148	180
1992-05	1014	3971	78	248
mean	**1142**	**2772**	**96**	**200**
2 yrs old				
1997-01	219	104	13	27
1997-03	362	260	17	42
1997-05	216	133	20	34
mean	**266**	**166**	**17**	**68**
Strongly Sloping				
23 yrs old				
1976-02	618	1347	19	94
1976-04	387	261	22	55
1976-06	**567**	784	36	55
mean	**524**	**798**	**26**	**68**

Table 3. Continued

	Carbon mg/kg	ug-CO_2-C/kg/hr	Nitrogen mg/kg	Nitrogen mg/kg
11 yrs old				
1988-02	698	1632	*50*	103
1988-04	451	728	27	75
1988-06	669	1237	48	94
mean	616	**1199**	**42**	**90**
7 yrs old				
1992-02	739	1986	65	135
1992-04	*573*	592	62	30
1992-06	106	255	15	13
mean	**489**	**944**	47	**59**
2 yrs old				
1997-02	1236	2792	93	238
1997-04	799	467	49	156
1997-06	1031	676	68	115
mean	**1022**	1312	**70**	170
Natives				
Native-01	1171	988	90.0	70.8
Native-02	1885	1839	138.0	43.3
mean	1528	1411	114	68
Cannelton				
Gently Sloping				
30 yrs old				
1970-01	4893	6119	505	400
1970-02	2261	2810	203	269
1970-03	2898	3481	273	256
mean	3351	4137	329	**308**

Table 3. Continued

	Microbial Biomass Carbon	Microbial Respiration	Microbial Biomass Nitrogen	Potentially Mineralizable Nitrogen
		ug-CO_2-C/kg/hr	mg/kg	mg/kg

16 yrs old				
1984-01	307	193	35	26
1984-02	220	271	12	39
1984-03	314	377	31	45
mean	280	**247**	**26**	**37**
Strongly Sloping				
Natives				
Native-01	883	526	91	57
Native-02	1120	100s	145	77
Native-03	1085	853	123	70
mean	**1029**	**796**	**119**	**68**
Holbet 21				
17 yrs old				
Gently Sloping				
1983-01	1822	1477	170	134
1983-02	1078	1050	98	102
1983-03	2885	2931	302	221
	1928	1819	190	152
8 yrs old				
1992-01	1435	1014	154	110
1992-02	675	79s	5s	103
1992-03	12C4	686	112	111
	1166	833	108	111
Strongly Sloping				
Natives				
Native-01	1011	G39	G5	48
Native-02	834	658	73	G0
Native-03	804	479	69	51
	883	592	69	53

Table 4. Ratios of microbial biomass C (MBC) to total C (TC), microbial biomsss N (MBN) to total N (TN), potentially mineralizable N (PMN) to TN, and microbial respiration (MR) to MBC on native soils and minesoils at the Dal-Tex site, Smithers site, and the Holbet 21 site.

Soil ID	Slope Class[#]	MBC/TC %	MR/MBC CO_2-C/hr x10^{-4}	MBN/TN %	PMN/TN %
Dal-Tex					
Native	SS	1.7	9.2	4.1	2.4
23-year-old	GS	2.4	12.0	4.9	5.8
	SS	2.2	15.6	7.7	16.8
11-year-old	GS	3.6	17.5	19.6	35.9
	SS	3.8	19.6	41.7	90.4
7-year-old	GS	2.5	23.9	24.1	50.0
	SS	1.3	19.3	59.0	84.7
2-y ear-old	GS	0.9	6.1	--	--
	SS	2.2	12.1	13.4	33.9
Cannelton					
Native	SS	2.5	7.7	7.4	4.2
30-year-old	GS	3.3	12.3	6.1	5.7
16-year-old	GS	1.2	8.8	13.1	18.3
Hobet 21					
Native	SS	2.7	6.7	11.4	8.8
17-year-old	GS	2.0	9.4	4.2	**3.4**
8-year-old	GS	2.2	7.1	**7.7**	**7.9**

#- GS=Gently Sloping; SS=Strongly Sloping