

The Impact of Golf Courses on Soil Quality

Annual Report to USGA, November, 2000

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Objective: Our objective is to quantify indicators of soil quality and follow their change during the construction, establishment, and operation of a golf course on a natural grassland site. Baseline values for critical indicators of soil quality were established prior to construction. Then, those same criteria were monitored during the construction and the seeding/sodding grow-in, phase. In May 2000, the course opened for play and monitoring has continued. Changes in soil quality indicators will be described, quantified, and used to predict areas where future golf construction and/or management may require special attention.

Research Sampling and Analysis Timeline

I. Pre-construction period, 1997 and 1998.

Native soils sampling was completed during this time period and analyses of these samples is completed.



Fig. 1. Hole #13, pre-construction.

II. Construction, 1999.

Several changes were necessary in our sampling schedule and technique. Firstly, in several cases changes in the design of the course caused construction to encroach onto sites that the preliminary drawings showed would not be disturbed. This means we will need to re-locate our undisturbed sites and re-sample them to provide baseline information. This re-siting and re-sampling occurred in Fall, 1999 and Spring, 2000. A soil map of the Colbert Hills Golf Course was completed.



Extensive modification of the soil occurred in all fairways. Essentially a new and different soil profile was produced. A base layer typically consisting of unweathered or slightly-weathered shale and fractured limestone was put in place to shape each fairway according to architects specifications. In some areas the base layer consisted of subsoil materials quite high in silt and clay content.

Fig. 2. Hole #13, during construction.

Topsoil from on-site was stockpiled and additional topsoil was brought onto the course from several local sources. A 6-12 inch layer of topsoil was placed on the base layer and the fairways and roughs were sodded. Soil sampling sites were established on six fairway sites. Analyses of these samples is completed.

III. Sampling, 2000 and 2001

Two sampling periods are scheduled for 2000 and two more for 2001, occurring in May and October of each year. Sampling will follow earlier standards and techniques. Some analyses remains to be completed on the samples taken in May, 2000 and the October, 2000 samples were not yet collected as of this writing.



Fig. 3. Hole #13 prior to course opening.

IV. Using Data to Evaluate Soil Quality



Fig. 4. A team of scientists at Colbert Hills is monitoring many indicators and using specialized images to assess their environmental impact (see example to the left). Indices (purple dots) that lie within their target range (zone between the red lines) denote ecosystem indicators operating in a sustainable mode. Indices lying outside their target range represent an indicator in need of remediation.

A high quality ecosystem would show a nearly circular radar image (colored area outlined by purple dots) within the sustainable range. Degraded functions lying outside the sustainable range skew the radar image and alert the superintendent to begin remediation.

Outer arcs group indicators into management areas (soil, water, fauna, and flora quality).

(These data are representational and do not reflect current conditions at Colbert Hills.)

V. Data Sets Included

Raw data sets from May, 2000 samples are attached. They will be used to generate graphs such as the one shown in Figure 4.

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Executive Summary

This project is monitoring soil quality criteria necessary to assess the long-term impact and sustainability of golf courses on the soil environment. Research was initiated in 1997-1998 at a time the future golf course site was in a natural grassland, or pre-construction condition. These field observations and sample collections were made to establish base-line values for a host of critical indicators of soil quality. Mapping of the area identified seven soil series on the golf course site.

During late 1998 and for most of 1999 the course was in the "construction phase". Extensive modification of the original soil occurred in all fairways. Essentially a new and different soil profile was produced. A base layer typically consisting of unweathered or slightly-weathered shale and fractured limestone was put in place to shape each fairway according to architects specifications. In some areas the base layer consisted of subsoil materials quite high in silt and clay content. After topsoil was put in place, and before the fairways were sodded, another set of samples was collected. Sodding finished in late 1999 and the course opened for play in May, 2000.

During the next several years the same sites will be sampled each spring and fall. Our objective is to quantify indicators of soil quality and follow their change during the construction and establishment of a golf course on a natural grassland site. Changes in soil quality indicators will be described, quantified, and used to predict areas where future golf construction and/or management may require special attention. Plans are underway to computerize special imaging to assist in the evaluation of quality indicators.

Bulk Density, Porosity
Water Content
Colbert Hills 6/28/00

Sample	Beaker	Wet	Dry	Net Weight	Net Dry Weight	BD	Por.	WC	ODW	Water Add
0-9, 49 Benfield 1	170.22	278.3	251.26	108.08	81.04	0.84	68.20	0.33	15.00	-1.25
0-9, 49 Benfield 2	179.68	308.39	277.71	128.71	98.03	1.02	61.53	0.31	15.23	-0.96
0-9, 49 Benfield 3	177.2	300.56	274.96	123.36	97.76	1.01	61.64	0.26	15.85	-0.19
Average						0.96	63.79	0.30	15.36	-0.80
STDEV						0.10	3.82	0.04	0.44	0.55
VAR						0.01	14.58	0.00	0.19	0.30
A1, 0-10, 48, Florence 1	176.5	304.56	288.37	128.06	111.87	1.16	56.10	0.14	17.47	1.84
A1, 0-10, 48, Florence 2	135.24	252.49	232.9	117.25	97.66	1.01	61.68	0.20	16.66	0.82
A1, 0-10, 48, Florence 3	177.6	324.96	287.93	147.36	110.33	1.14	56.71	0.34	14.97	-1.28
Average						1.10	58.16	0.23	16.37	0.46
STDEV						0.08	3.06	0.10	1.27	1.59
VAR						0.01	9.36	0.01	1.62	2.53
A1, 0-12, 31 Tully 1	179.21	295.48	279.27	116.27	100.06	1.04	60.74	0.16	17.21	1.51
A1, 0-12, 31 Tully 2	153.09	275.057	258.42	121.967	105.33	1.09	58.67	0.16	17.27	1.59
A1, 0-12, 31 Tully 3	177.14	300.73	275.46	123.59	98.32	1.02	61.42	0.26	15.91	-0.11
Average						1.05	60.27	0.19	16.80	1.00
STDEV						0.04	1.43	0.06	0.77	0.96
VAR						0.00	2.05	0.00	0.59	0.92
A1, 0-10, 35 Konza 1	179.28	308.06	301.03	128.78	121.75	1.26	52.22	0.06	18.91	3.64
A1, 0-10, 35 Konza 2	177.63	291.05	274.77	113.42	97.14	1.01	61.88	0.17	17.13	1.41
A1, 0-10, 35 Konza 3	156	297.4	271.84	141.4	115.84	1.20	54.54	0.22	16.38	0.48
Average						1.16	56.22	0.15	17.47	1.84
STDEV						0.13	5.04	0.08	1.30	1.62
VAR						0.02	25.41	0.01	1.68	2.63
A1, 0-11, 36, Cline 1	136.67	270.81	245.28	134.14	108.61	1.13	57.38	0.24	16.19	0.24
A1, 0-11, 36, Cline 2	134.56	247.91	236.94	113.35	102.38	1.06	59.83	0.11	18.06	2.58
A1, 0-11, 36, Cline 3	179.01	298.35	285.05	119.34	106.04	1.10	58.39	0.13	17.77	2.21
Average						1.09	58.53	0.16	17.34	1.68
STDEV						0.03	1.23	0.07	1.01	1.26
VAR						0.00	1.51	0.00	1.01	1.58

Bulk Density, Porosity
Water Content
Colbert Hills 6/28/00
Undisturbed Sites

Sample	Beaker	Wet	Dry	Net Wet	Net Dry	BD	Por.	WC	ODW	Water Add
47, Tuttle, Surface 1	175.84	269.85	255.99	94.01	80.15	0.83	68.55	0.17	17.05	1.31
47, Tuttle, Surface 2	139.01	249.75	235.65	110.74	96.64	1.00	62.08	0.15	17.45	1.82
47, Tuttle, Surface 3	200.94	325.4	314.27	124.46	113.33	1.17	55.53	0.10	18.21	2.76
Average						1.00	62.05	0.14	17.57	1.97
STDEV						0.17	6.51	0.04	0.59	0.74
VAR						0.03	42.38	0.00	0.35	0.54
33, Kahola, Surface 1	201.35	345.82	309.57	144.47	108.22	1.12	57.53	0.33	14.98	-1.27
33, Kahola, Surface 2	207.08	352.26	322.24	145.18	115.16	1.19	54.81	0.26	15.86	-0.17
33, Kahola, Surface 3	204.94	328.35	312.6	123.41	107.66	1.12	57.75	0.15	17.45	1.81
Average						1.14	56.70	0.25	16.10	0.12
STDEV						0.04	1.64	0.10	1.25	1.56
VAR						0.00	2.69	0.01	1.56	2.44

Bulk Density, Porosity
Water Content
Colbert Hills 5/26/00

Sample	Beaker	Wet	Dry	Net Wet	Net Dry	BD	Por.	WC	ODW	Water Add
10-A	108.62	261.86	231.84	153.24	123.22	1.28	51.65	0.24	16.08	0.10
10-B	99.35	256.74	230.17	157.39	130.82	1.36	48.67	0.20	16.62	0.78
10-C	102.76	261.59	231.82	158.83	129.06	1.34	49.36	0.23	16.25	0.31
Average						1.32	49.89	0.23	16.32	0.40
STDEV						0.04	1.56	0.02	0.28	0.35
VAR						0.00	2.44	0.00	0.08	0.12
12a-A	95.3	229.12	205.47	133.82	110.17	1.14	56.77	0.21	16.47	0.58
12a-B	101.8	248.27	221.27	146.47	119.47	1.24	53.12	0.23	16.31	0.39
12a-C	99.93	256.79	229.88	156.86	129.95	1.35	49.01	0.21	16.57	0.71
Average						1.24	52.97	0.22	16.45	0.56
STDEV						0.10	3.88	0.01	0.13	0.16
VAR						0.01	15.08	0.00	0.02	0.03
12b-A	101.26	242.61	209.44	141.35	108.18	1.12	57.55	0.31	15.31	-0.87
12b-B	102.51	231.42	201.28	128.91	98.77	1.02	61.24	0.31	15.32	-0.85
12b-C	100.15	255.76	218.8	155.61	118.65	1.23	53.44	0.31	15.25	-0.94
Average						1.12	57.41	0.31	15.29	-0.88
STDEV						0.10	3.90	0.00	0.04	0.05
VAR						0.01	15.23	0.00	0.00	0.00
13-A	103.16	254.93	231.18	151.77	128.02	1.33	49.76	0.19	16.87	1.09
13-B	103.3	241.4	216.58	138.1	113.28	1.17	55.55	0.22	16.41	0.51
13-C	123.96	255.2	234.53	131.24	110.57	1.15	56.61	0.19	16.85	1.06
Average						1.22	53.97	0.20	16.71	0.89
STDEV						0.10	3.68	0.02	0.26	0.33
VAR						0.01	13.58	0.00	0.07	0.11
14-A	100.07	243.04	223.22	142.97	123.15	1.28	51.68	0.16	17.23	1.53
14-B	107.08	265.58	242.83	158.5	135.75	1.41	46.73	0.17	17.13	1.41
14-C	103.71	251.92	231.61	148.21	127.9	1.32	49.81	0.16	17.26	1.57
Average						1.34	49.41	0.16	17.21	1.51
STDEV						0.07	2.50	0.00	0.07	0.08
VAR						0.00	6.23	0.00	0.00	0.01

Bulk Density, Porosity

Water Content

Colbert Hills 5/26/00

Sample	Beaker	Wet	Dry	Net Wet	Net Dry	BD	Por.	WC	ODW	Water Add
15-A	105.46	268.63	240.71	163.17	135.25	1.40	46.93	0.21	16.58	0.72
15-B	98.4	239.4	209.65	141	111.25	1.15	56.35	0.27	15.78	-0.27
15-C	100.57	255.75	227.55	155.18	126.98	1.32	50.17	0.22	16.37	0.46
Average						1.29	51.15	0.23	16.24	0.30
STDEV						0.13	4.78	0.03	0.41	0.52
VAR						0.02	22.89	0.00	0.17	0.27

18-A	102.01	268.61	240.97	166.6	138.96	1.44	45.47	0.20	16.68	0.85
18-B	100.01	252.24	226.83	152.23	126.82	1.31	50.24	0.20	16.66	0.83
18-C	66.81	250.47	225.16	183.66	158.35	1.64	37.86	0.16	17.24	1.55
Average						1.46	44.52	0.19	16.86	1.08
STDEV						0.16	6.24	0.02	0.33	0.41
VAR						0.03	38.94	0.00	0.11	0.17

Soil pH

Sample: 30-Oct

CaCl2 2:1	1	2	3	Avg	Std	Var
CH-10	5.84	6.5	6.61	6.32	0.42	0.17
CH-12A	6.69	7.02	7.05	6.92	0.20	0.04
CH-12B	7.25	7.3	7.32	7.29	0.04	0.00
CH-13	7.19	7.17	7.14	7.17	0.03	0.00
CH-14	6.42	6.47	6.43	6.44	0.03	0.00
CH-15	6.51	6.57	6.58	6.55	0.04	0.00
CH-18	7.45	7.53	7.54	7.51	0.05	0.00

H2O 1:1	1	2	3	Avg	Std	Var
CH-10	6.73	6.82	6.84	6.80	0.06	0.00
CH-12A	7.11	7.07	7.19	7.12	0.06	0.00
CH-12B	7.44	7.43	7.47	7.45	0.02	0.00
CH-13	7.28	7.31	7.3	7.30	0.02	0.00
CH-14	6.81	6.74	6.79	6.78	0.04	0.00
CH-15	6.82	6.82	6.82	6.82	0.00	0.00
CH-18	7.79	7.89	7.89	7.86	0.06	0.00

Sample: 30-May

CaCl2 2:1	1	2	3	Avg	Std	Var
CH-10-T	7.16	7.21	7.23	7.20	0.04	0.00
CH-10-B	6.41	6.5	6.52	6.48	0.06	0.00
CH-12A-T	7.3	7.3	7.33	7.31	0.02	0.00
CH-12A-B	7.04	7.08	7.12	7.08	0.04	0.00
CH-12B-T	7.2	7.1	7.15	7.15	0.05	0.00
CH-12B-B	7.15	7.13	7.1	7.13	0.03	0.00
CH-13-T	7.18	7.18	7.24	7.20	0.03	0.00
CH-13-B	6.32	6.41	6.37	6.37	0.05	0.00
CH-14-T	6.47	6.45	6.47	6.46	0.01	0.00
CH-14-B	6.27	6.31	6.3	6.29	0.02	0.00
CH-15-T	6.92	6.95	6.89	6.92	0.03	0.00
CH-15-B	7.13	7.17	7.21	7.17	0.04	0.00
CH-18-T	7.43	7.46	7.43	7.44	0.02	0.00
CH-18-B	7.21	7.25	7.27	7.24	0.03	0.00

H2O 1:1	1	2	3	Avg	Std	Var
CH-10-T	6.97	7.45	7.5	7.31	0.29	0.09
CH-10-B	7.17	7.18	7.1	7.15	0.04	0.00
CH-12A-T	7.61	7.62	7.64	7.62	0.02	0.00
CH-12A-B	7.68	7.6	7.64	7.64	0.04	0.00
CH-12B-T	7.44	7.43	7.37	7.41	0.04	0.00
CH-12B-B	7.49	7.55	7.54	7.53	0.03	0.00
CH-13-T	7.47	7.48	7.48	7.48	0.01	0.00
CH-13-B	6.99	6.96	6.94	6.96	0.03	0.00
CH-14-T	6.82	6.8	6.8	6.81	0.01	0.00
CH-14-B	6.86	6.83	6.84	6.84	0.02	0.00
CH-15-T	7.02	7.25	7.27	7.18	0.14	0.02

CH-15-B	7.85	7.78	7.86	7.83	0.04	0.00
CH-18-T	7.776	7.78	7.79	7.78	0.01	0.00
CH-18-B	7.82	7.84	7.82	7.83	0.01	0.00

Colbert Hills
Microbial Biomass
May 2000 Samples

#	Sample	MC	ODW	BD
1	CH-10-T	0.23	16.32	1.32
2	CH-10-B	0.23	16.32	
3	CH-12A-T	0.22	16.45	1.24
4	CH-12A-B	0.22	16.45	
5	CH-12B-T	0.31	15.29	1.12
6	CH-12B-B	0.31	15.29	
7	CH-13-T	0.2	16.71	1.22
8	CH-13-B	0.2	16.71	
9	CH-14-T	0.16	17.21	1.34
10	CH-14-B	0.16	17.21	
11	CH-15-T	0.23	16.24	1.29
12	CH-15-B	0.23	16.24	
13	CH-18-T	0.19	16.86	1.46
14	CH-18-B	0.19	16.86	

Analysis								
#	Sample	Peak UNF	Peak F	ug C/ml UNF	ugC/ml F	ug C/g UNF	ug C/g F	MBM C
1	CH-10-T	202710	213390	4.91	5.17	282.33	297.40	36.76
2	CH-10-B	81396	149780	1.94	3.61	111.14	207.64	235.37
3	CH-12A-T	110770	134110	2.66	3.23	151.38	184.06	79.70
4	CH-12A-B	107390	20937	2.57	0.45	146.65	25.61	-295.21
5	CH-12B-T	139350	282250	3.36	6.86	205.94	421.18	524.97
6	CH-12B-B	64298	162330	1.52	3.92	92.90	240.55	360.14
7	CH-13-T	169120	209370	4.09	5.07	229.44	284.91	135.30
8	CH-13-B	126120	167200	3.03	4.04	170.17	226.79	138.09
9	CH-14-T	181910	311500	4.40	7.57	239.88	413.29	422.96
10	CH-14-B	120470	220270	2.89	5.34	157.66	291.21	325.73
11	CH-15-T	146460	213690	3.53	5.18	203.95	299.29	232.53
12	CH-15-B	58069	81600	1.36	1.94	78.61	111.98	81.39
13	CH-18-T	129770	174530	3.12	4.22	173.64	234.78	149.12
14	CH-18-B	103370	114350	2.47	2.74	137.58	152.58	36.58

Lab Air	14086	0.29
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#	Sample	Min C
1	CH-10-T	266.00
2	CH-10-B	94.81
3	CH-12A-T	135.19
4	CH-12A-B	130.45
5	CH-12B-T	188.49
6	CH-12B-B	75.44
7	CH-13-T	213.50
8	CH-13-B	154.24
9	CH-14-T	224.41
10	CH-14-B	142.20
11	CH-15-T	187.55
12	CH-15-B	62.20
13	CH-18-T	157.85
14	CH-18-B	121.79

Colbert Hills
Microbial Biomass
May 2000 Samples

Initial N				
#	Sample	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	1.25	0.27	2.07
2	CH-10-B	0.97	2.72	16.17
3	CH-12A-T	1.95	0.81	9.60
4	CH-12A-B	0.66	9.64	38.68
5	CH-12B-T	0.75	0.25	1.23
6	CH-12B-B	0.06	0.1	0.04
7	CH-13-T	1.22	0.26	1.90
8	CH-13-B	1.23	0.35	2.58
9	CH-14-T	0.02	0.08	0.01
10	CH-14-B	0.47	1.59	4.34
11	CH-15-T	1	0.24	1.48
12	CH-15-B	0.33	0.16	0.33
13	CH-18-T	0.03	0.11	0.02
14	CH-18-B	0.07	0.24	0.10

#	Sample	Fum			UNF		
		NO3-N ppm	NH4-N ppm	ug N/g soil	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	1.65	7	53.00245	1.86	0.14	12.25
2	CH-10-B	3.35	4.74	49.57108	4.04	0.18	25.86
3	CH-12A-T	2.5	4.99	45.53191	3.12	0.15	19.88
4	CH-12A-B	7.5	7	88.1459	11.4	0.18	70.40
5	CH-12B-T	1.06	9.3	67.7567	1.92	0.15	13.54
6	CH-12B-B	0.1	6.2	41.2034	0.19	0.16	2.29
7	CH-13-T	2.26	8.5	64.39258	4.06	0.16	25.25
8	CH-13-B	1.94	5.6	45.12268	2.88	0.2	18.43
9	CH-14-T	0.1	8.5	49.97095	1.45	0.18	9.47
10	CH-14-B	1.9	7.5	54.61941	4	0.2	24.40
11	CH-15-T	1.47	8	58.31281	1.59	0.34	11.88
12	CH-15-B	0.58	2.43	18.53448	0.61	0.09	4.31
13	CH-18-T	0.05	4.85	29.06287	0.38	0.12	2.97
14	CH-18-B	0.14	3.7	22.7758	0.43	0.13	3.32

#	Sample	MBM N	Min N
1	CH-10-T	67.91	10.19
2	CH-10-B	39.52	9.69
3	CH-12A-T	42.76	10.28
4	CH-12A-B	29.58	31.72
5	CH-12B-T	90.36	12.31
6	CH-12B-B	64.86	2.25
7	CH-13-T	65.23	23.36
8	CH-13-B	44.48	15.86
9	CH-14-T	67.50	9.46
10	CH-14-B	50.36	20.06
11	CH-15-T	77.38	10.41
12	CH-15-B	23.71	3.99
13	CH-18-T	43.50	2.95
14	CH-18-B	32.42	3.22

Colbert Hills
Microbial Biomass
May 2000 Samples
Rep. #1

#	Sample	MC	ODW	BD
1	CH-10-T	0.23	16.32	1.32
2	CH-10-B	0.23	16.32	
3	CH-12A-T	0.22	16.45	1.24
4	CH-12A-B	0.22	16.45	
5	CH-12B-T	0.31	15.29	1.12
6	CH-12B-B	0.31	15.29	
7	CH-13-T	0.2	16.71	1.22
8	CH-13-B	0.2	16.71	
9	CH-14-T	0.16	17.21	1.34
10	CH-14-B	0.16	17.21	
11	CH-15-T	0.23	16.24	1.29
12	CH-15-B	0.23	16.24	
13	CH-18-T	0.19	16.86	1.46
14	CH-18-B	0.19	16.86	

Analysis								
#	Sample	Peak UNF	Peak F	ug C/ml UNF	ugC/ml F	ug C/g UNF	ug C/g F	MBM C
1	CH-10-T	202710	213390	4.91	5.17	282.33	297.40	36.76
2	CH-10-B	81396	149780	1.94	3.61	111.14	207.64	235.37
3	CH-12A-T	110770	134110	2.66	3.23	151.38	184.06	79.70
4	CH-12A-B	107390	20937	2.57	0.45	146.65	25.61	-295.21
5	CH-12B-T	139350	282250	3.36	6.86	205.94	421.18	524.97
6	CH-12B-B	64298	162330	1.52	3.92	92.90	240.55	360.14
7	CH-13-T	169120	209370	4.09	5.07	229.44	284.91	135.30
8	CH-13-B	126120	167200	3.03	4.04	170.17	226.79	138.09
9	CH-14-T	181910	311500	4.40	7.57	239.88	413.29	422.96
10	CH-14-B	120470	220270	2.89	5.34	157.66	291.21	325.73
11	CH-15-T	146460	213690	3.53	5.18	203.95	299.29	232.53
12	CH-15-B	58069	81600	1.36	1.94	78.61	111.98	81.39
13	CH-18-T	129770	174530	3.12	4.22	173.64	234.78	149.12
14	CH-18-B	103370	114350	2.47	2.74	137.58	152.58	36.58

Lab Air	14086	0.29
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#	Sample	Min C
1	CH-10-T	266.00
2	CH-10-B	94.81
3	CH-12A-T	135.19
4	CH-12A-B	130.45
5	CH-12B-T	188.49
6	CH-12B-B	75.44
7	CH-13-T	213.50
8	CH-13-B	154.24
9	CH-14-T	224.41
10	CH-14-B	142.20
11	CH-15-T	187.55
12	CH-15-B	62.20
13	CH-18-T	157.85
14	CH-18-B	121.79

Colbert Hills
Microbial Biomass
May 2000 Samples
Rep. #1

Initial N				
#	Sample	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	1.25	0.27	2.07
2	CH-10-B	0.97	2.72	16.17
3	CH-12A-T	1.95	0.81	9.60
4	CH-12A-B	0.66	9.64	38.68
5	CH-12B-T	0.75	0.25	1.23
6	CH-12B-B	0.06	0.1	0.04
7	CH-13-T	1.22	0.26	1.90
8	CH-13-B	1.23	0.35	2.58
9	CH-14-T	0.02	0.08	0.01
10	CH-14-B	0.47	1.59	4.34
11	CH-15-T	1	0.24	1.48
12	CH-15-B	0.33	0.16	0.33
13	CH-18-T	0.03	0.11	0.02
14	CH-18-B	0.07	0.24	0.10

#	Sample	Fum			UNF		
		NO3-N ppm	NH4-N ppm	ug N/g soil	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	1.65	7	53.00245	1.86	0.14	12.25
2	CH-10-B	3.35	4.74	49.57108	4.04	0.18	25.86
3	CH-12A-T	2.5	4.99	45.53191	3.12	0.15	19.88
4	CH-12A-B	7.5	7	88.1459	11.4	0.18	70.40
5	CH-12B-T	1.06	9.3	67.7567	1.92	0.15	13.54
6	CH-12B-B	0.1	6.2	41.2034	0.19	0.16	2.29
7	CH-13-T	2.26	8.5	64.39258	4.06	0.16	25.25
8	CH-13-B	1.94	5.6	45.12268	2.88	0.2	18.43
9	CH-14-T	0.1	8.5	49.97095	1.45	0.18	9.47
10	CH-14-B	1.9	7.5	54.61941	4	0.2	24.40
11	CH-15-T	1.47	8	58.31281	1.59	0.34	11.88
12	CH-15-B	0.58	2.43	18.53448	0.61	0.09	4.31
13	CH-18-T	0.05	4.85	29.06287	0.38	0.12	2.97
14	CH-18-B	0.14	3.7	22.7758	0.43	0.13	3.32

#	Sample	MBM N	Min N
1	CH-10-T	67.91	10.19
2	CH-10-B	39.52	9.69
3	CH-12A-T	42.76	10.28
4	CH-12A-B	29.58	31.72
5	CH-12B-T	90.36	12.31
6	CH-12B-B	64.86	2.25
7	CH-13-T	65.23	23.36
8	CH-13-B	44.48	15.86
9	CH-14-T	67.50	9.46
10	CH-14-B	50.36	20.06
11	CH-15-T	77.38	10.41
12	CH-15-B	23.71	3.99
13	CH-18-T	43.50	2.95
14	CH-18-B	32.42	3.22

Colbert Hills
Microbial Biomass
May 2000 Samples
Rep #2

#	Sample	MC	ODW	BD
1	CH-10-T	0.23	16.32	1.32
2	CH-10-B	0.23	16.32	
3	CH-12A-T	0.22	16.45	1.24
4	CH-12A-B	0.22	16.45	
5	CH-12B-T	0.31	15.29	1.12
6	CH-12B-B	0.31	15.29	
7	CH-13-T	0.2	16.71	1.22
8	CH-13-B	0.2	16.71	
9	CH-14-T	0.16	17.21	1.34
10	CH-14-B	0.16	17.21	
11	CH-15-T	0.23	16.24	1.29
12	CH-15-B	0.23	16.24	
13	CH-18-T	0.19	16.86	1.46
14	CH-18-B	0.19	16.86	

Analysis								
#	Sample	Peak UNF	Peak F	ug C/ml UNF	ug C/ml F	ug C/g UNF	ug C/g F	MBM C
1	CH-10-T	100410	185630	2.40	4.49	137.97	258.23	293.31
2	CH-10-B	50353	129600	1.18	3.12	67.33	179.16	272.76
3	CH-12A-T	53542	127120	1.25	3.06	71.26	174.27	251.24
4	CH-12A-B	67573	121220	1.60	2.91	90.90	166.01	183.18
5	CH-12B-T	97577	255610	2.33	6.20	143.02	381.05	580.56
6	CH-12B-B	53010	175450	1.24	4.24	75.89	260.31	449.81
7	CH-13-T	73405	230670	1.74	5.59	97.52	314.27	528.65
8	CH-13-B	52996	123460	1.24	2.97	69.39	166.51	236.87
9	CH-14-T	40120	235850	0.92	5.72	50.14	312.06	638.83
10	CH-14-B	47761	180080	1.11	4.35	60.36	237.43	431.87
11	CH-15-T	73082	216000	1.73	5.23	99.90	302.57	494.32
12	CH-15-B	32955	26147	0.75	0.58	42.99	33.34	-23.55
13	CH-18-T	109630	187060	2.63	4.52	146.13	251.90	257.97
14	CH-18-B	94768	116280	2.26	2.79	125.83	155.22	71.67

Lab Air	18613	0.40
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#	Sample	Min C
1	CH-10-T	121.64
2	CH-10-B	51.00
3	CH-12A-T	55.07
4	CH-12A-B	74.71
5	CH-12B-T	125.57
6	CH-12B-B	58.44
7	CH-13-T	81.58
8	CH-13-B	53.46
9	CH-14-T	34.67
10	CH-14-B	44.90
11	CH-15-T	83.49
12	CH-15-B	26.58
13	CH-18-T	130.34
14	CH-18-B	110.04

Colbert Hills
Microbial Biomass
May 2000 Samples
Rep #2

Initial N				
#	Sample	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	1.25	0.27	2.07
2	CH-10-B	0.97	2.72	16.17
3	CH-12A-T	1.95	0.81	9.60
4	CH-12A-B	0.66	9.64	38.68
5	CH-12B-T	0.75	0.25	1.23
6	CH-12B-B	0.06	0.1	0.04
7	CH-13-T	1.22	0.26	1.90
8	CH-13-B	1.23	0.35	2.58
9	CH-14-T	0.02	0.08	0.01
10	CH-14-B	0.47	1.59	4.34
11	CH-15-T	1	0.24	1.48
12	CH-15-B	0.33	0.16	0.33
13	CH-18-T	0.03	0.11	0.02
14	CH-18-B	0.07	0.24	0.10

Fum					UNF		
#	Sample	NO3-N ppm	NH4-N ppm	ug N/g soil	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	2.6	6.5	55.7598	2.78	0.12	17.77
2	CH-10-B	4.29	4.62	54.59559	5	0.16	31.62
3	CH-12A-T	3.5	5.3	53.49544	3.92	0.16	24.80
4	CH-12A-B	10.1	5.5	94.83283	12.2	0.95	79.94
5	CH-12B-T	1.85	9.3	72.92348	2.8	0.14	19.23
6	CH-12B-B	0.15	5.8	38.91432	0.73	0.23	6.28
7	CH-13-T	2.69	8.5	66.96589	2.34	0.18	15.08
8	CH-13-B	2.45	6	50.56852	3.06	0.29	20.05
9	CH-14-T	0.15	5	29.92446	0.4	0.3	4.07
10	CH-14-B	1.68	7.1	51.01685	2.3	1.22	20.45
11	CH-15-T	1.64	8	59.35961	2.69	0.36	18.78
12	CH-15-B	0.75	2.15	17.85714	0.8	0.11	5.60
13	CH-18-T	0.1	5	30.24911	0.34	0.12	2.73
14	CH-18-B	0.31	4.29	27.28351	0.61	0.12	4.33

#	Sample	MBM N	Min N
1	CH-10-T	63.32	15.70
2	CH-10-B	38.30	15.45
3	CH-12A-T	47.82	15.20
4	CH-12A-B	24.82	41.26
5	CH-12B-T	89.49	18.00
6	CH-12B-B	54.39	6.24
7	CH-13-T	86.48	13.18
8	CH-13-B	50.87	17.47
9	CH-14-T	43.10	4.06
10	CH-14-B	50.94	16.11
11	CH-15-T	67.63	17.30
12	CH-15-B	20.42	5.28
13	CH-18-T	45.87	2.71
14	CH-18-B	38.26	4.23

Colbert Hills
Microbial Biomass
May 2000 Samples
Rep #3

#	Sample	MC	ODW	BD
1	CH-10-T	0.23	16.32	1.32
2	CH-10-B	0.23	16.32	
3	CH-12A-T	0.22	16.45	1.24
4	CH-12A-B	0.22	16.45	
5	CH-12B-T	0.31	15.29	1.12
6	CH-12B-B	0.31	15.29	
7	CH-13-T	0.2	16.71	1.22
8	CH-13-B	0.2	16.71	
9	CH-14-T	0.16	17.21	1.34
10	CH-14-B	0.16	17.21	
11	CH-15-T	0.23	16.24	1.29
12	CH-15-B	0.23	16.24	
13	CH-18-T	0.19	16.86	1.46
14	CH-18-B	0.19	16.86	

Analysis								
#	Sample	Peak UNF	Peak F	ug C/ml UNF	ugC/ml F	ug C/g UNF	ug C/g F	MBM C
1	CH-10-T	190720	234540	4.36	5.37	250.94	308.74	140.97
2	CH-10-B	37701	130660	0.86	2.99	49.11	171.72	299.05
3	CH-12A-T	93094	154490	2.13	3.53	121.20	201.54	195.95
4	CH-12A-B	73148	118850	1.67	2.72	95.10	154.91	145.86
5	CH-12B-T	113240	273830	2.59	6.27	158.79	384.87	551.43
6	CH-12B-B	67902	151900	1.55	3.47	94.96	213.22	288.43
7	CH-13-T	82684	229670	1.89	5.26	105.90	295.25	461.83
8	CH-13-B	87771	156150	2.01	3.57	112.45	200.54	214.85
9	CH-14-T	79841	257200	1.82	5.89	99.26	321.09	541.07
10	CH-14-B	61389	216770	1.40	4.96	76.18	270.52	474.02
11	CH-15-T	99204	214980	2.27	4.92	130.87	284.33	374.29
12	CH-15-B	50554	12000	1.15	0.27	66.39	15.28	-124.64
13	CH-18-T	71190	167340	1.63	3.83	90.28	213.04	299.41
14	CH-18-B	63156	99487	1.44	2.27	80.02	126.41	113.14

Lab Air 21106.75 0.46

#	Sample	Min C
1	CH-10-T	234.61
2	CH-10-B	32.78
3	CH-12A-T	105.01
4	CH-12A-B	78.91
5	CH-12B-T	141.34
6	CH-12B-B	77.51
7	CH-13-T	89.96
8	CH-13-B	96.52
9	CH-14-T	83.79
10	CH-14-B	60.71
11	CH-15-T	114.46
12	CH-15-B	49.98
13	CH-18-T	74.49
14	CH-18-B	64.23

Colbert Hills
Microbial Biomass
May 2000 Samples
Rep #3

Initial N				
#	Sample	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	1.25	0.27	2.07
2	CH-10-B	0.97	2.72	16.17
3	CH-12A-T	1.95	0.81	9.60
4	CH-12A-B	0.66	9.64	38.68
5	CH-12B-T	0.75	0.25	1.23
6	CH-12B-B	0.06	0.1	0.04
7	CH-13-T	1.22	0.26	1.90
8	CH-13-B	1.23	0.35	2.58
9	CH-14-T	0.02	0.08	0.01
10	CH-14-B	0.47	1.59	4.34
11	CH-15-T	1	0.24	1.48
12	CH-15-B	0.33	0.16	0.33
13	CH-18-T	0.03	0.11	0.02
14	CH-18-B	0.07	0.24	0.10

Fum					UNF		
#	Sample	NO3-N ppm	NH4-N ppm	ug N/g soil	NO3-N ppm	NH4-N ppm	ug N/g soil
1	CH-10-T	2.59	7.1	59.375	3	0.17	19.42
2	CH-10-B	4.58	4.29	54.35049	4.9	0.13	30.82
3	CH-12A-T	3.44	4.5	48.26748	3.79	0.12	23.77
4	CH-12A-B	11	4.77	95.86626	14.72	0.16	90.46
5	CH-12B-T	1.87	9.1	71.74624	2.74	0.15	18.90
6	CH-12B-B	0.2	5	34.00916	0.22	0.14	2.35
7	CH-13-T	2.81	8.5	67.68402	3.39	0.2	21.48
8	CH-13-B	2.4	5.3	46.08019	3.22	0.15	20.17
9	CH-14-T	0.1	5.7	33.70134	0.65	0.16	4.71
10	CH-14-B	1.66	8.2	57.29227	3.14	0.89	23.42
11	CH-15-T	1.71	8	59.79064	2.15	0.15	14.16
12	CH-15-B	0.76	2.35	19.15025	0.87	0.1	5.97
13	CH-18-T	0.05	4.45	26.69039	0.71	0.1	4.80
14	CH-18-B	0.4	3.6	23.72479	0.16	0.11	1.60

#	Sample	MBM N	Min N
1	CH-10-T	66.58	17.36
2	CH-10-B	39.22	14.65
3	CH-12A-T	40.83	14.17
4	CH-12A-B	9.02	51.78
5	CH-12B-T	88.07	17.67
6	CH-12B-B	52.76	2.32
7	CH-13-T	77.00	19.59
8	CH-13-B	43.19	17.59
9	CH-14-T	48.32	4.70
10	CH-14-B	56.46	19.07
11	CH-15-T	76.05	12.68
12	CH-15-B	21.96	5.65
13	CH-18-T	36.48	4.78
14	CH-18-B	36.87	1.50