AN ABSTRACT OF THE THESIS OF

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Title: Organic Carbon, Bulk Density, and Microbial Biomass in Reseeded Kansas Farmland

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A study of organic carbon, soil bulk density, and microbial biomass in a native prairie and reseeded old fields was conducted from May 1988 through September 1989. All study sites were located on the Kenoma soil series in Lyon County, Kansas. Samples were taken from each site and analyzed for percent organic carbon using the procedure of Nelson and Sommers (1982). Microbial biomass was determined using the technique of Jenkinson and Powlson (1982). Soil bulk density was also determined following the procedure outlined by Burke et al. (1986).

Results from the organic carbon determinations revealed that the most recently reseeded site had the lowest carbon levels (1.8%), followed by the oldest reseeding (2.19%) and the native prairie (4.26%), which had considerably higher carbon levels. The total microbial biomass found in the prairie (8.21 mg/100g) was more than that found in either reseeding (oldest 3.41 mg/100g and youngest 5.24 mg/100g). There was no statistical difference between the reseedings. Soil bulk density was least in the prairie (1.07 g/cm^3), followed by the oldest reseeding (1.17 g/cm^3), with the

youngest reseeding (1.29 g/cm^3) showing the most compacted soil. The bulk density and organic carbon determinations suggest that the soils of the reseedings are moving toward a more native condition. However, microbial biomass did not show this trend.

ORGANIC CARBON, BULK DENSITY, AND MICROBIAL BIOMASS IN RESEEDED KANSAS FARMLAND SOILS

A Thesis

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by

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Introduction

With the advent of the plow came the demise of most of the native prairie ecosystem. Not all of the prairie was broken out for crops. Some of the prairie was preserved because it was not suitable for till agriculture. It was too stony, steep, or had shallow soils. But within these unsuitable areas, fields were still broken out to farm. Many of these fields eroded quickly and were reduced to unproductive tracts of land known as go-back. The practice of reseeding these tracts of highly erodible land to native grasses has become common, especially since the Conservation Reserve Program (CRP) was implemented by the Soil Conservation Service, a division of the United States Department of Agriculture. In this program the farmer is paid an agreed upon price per acre annually to take highly erodible land out of production for a period of ten years and restore it to suitable cover, usually grass.

Under conventional farm tillage systems, soil bulk density tends to increase, due to compaction caused by tillage equipment (Brady 1990). A soil that is high in organic matter will have a lower bulk density than those having a low organic matter content (Brady 1990). Another reason for a higher bulk density in cultivated soils is due to the rapid break-down of organic matter. This reduces the pore space which in turn allows the soil particles to become

more tightly compacted (Brady 1990). With lower organic matter levels less organic carbon is available for soil microbes. When a native prairie is broken-out, and tilled for a number of years, the organic carbon levels will decrease (Brady 1990). Lower organic carbon levels are associated with reduced fertility, this greatly impairs the nitrogen system of the soil, by altering the carbon to nitrogen ratio (Brady 1990). This in turn will limit the beneficial soil microbes that use both the organic carbon and nitrogen to complete their life cycles. Using indicators such as soil bulk density, organic carbon, and microbial biomass, reseeded old fields can be compared to an undisturbed native prairie to see if the reseeding of native grasses has restored prairie-like qualities to these soils. By using organic carbon levels, bulk density, and total microbial biomass as indicators of soil condition, it should be possible to determine the possible beneficial effects of reseeding these old fields to native grasses. The purpose of this study was to determine the bulk density, organic carbon, and total microbial biomass of reseedings of different ages, and compare these with a native prairie. Some comparisons with a cultivated field were undertaken. This was done to see if the soil of the reseedings was taking on any native-like traits, or if these are just old farm fields planted to native vegetation, that may never recover from till agriculture.

The objectives were as follows:

1. to determine soil bulk density, organic carbon, and total microbial biomass, in reseeded old fields of different ages fields and a native prairie, which were all originally the same soil type.
2. to study the possibility that these reseedings may be a significant long-term carbon sink.

METHODS AND MATERIALS

Site Locations and Reseeding

Four sites located in Lyon County, Kansas, were selected for this study. Two of the sites were reseeded old fields and one was a native tall-grass prairie pasture, and the last site was a cultivated field; added near the end of the study (Figure 1). The oldest reseeding (site R1) was located in the N 1/2 of the SW 1/4 of the NW 1/4 of Section 3, Township 18S, Range 11E, and was reseeded in 1969 (Figure 2). The other reseeding (site R2) was located in the E 1/2 of the NE 1/4 of the NW 1/4 of Section 27, Township 18S, Range 10E, and was reseeded in 1981 (Figure 3). The native pasture (site P) was located adjacent to site R2 in the E 1/2 of the NW 1/4 of the NE 1/4 of Section 27, Township 18S, Range 10E (Figure 4). The fourth site was a farmed field (site F) adjacent to the north of site R1 (Figure 5). Site F was studied less intensively than the other sites. All of the study sites are located on the Kenoma soil series (Neill, 1981), a silty clay loam with a one to three percent slope. Erosion had removed most of the A horizon from the reseeded sites (R1 and R2) (Pritchard, 1990).

Soil and Vegetation Properties

The following soil and vegetation information was gathered by Crandall (1987) who used the same sites for a soil nitrogen study. Soil pH was determined using a Beckman pH meter. Active and reserve acidity was measured as

Figure 1. Map of Lyon County, Kansas, showing study sites. Where P is the native prairie, R1 is the 21-year-old reseeding, R2 is the nine-year-old reseeding, and F is the cultivated field.

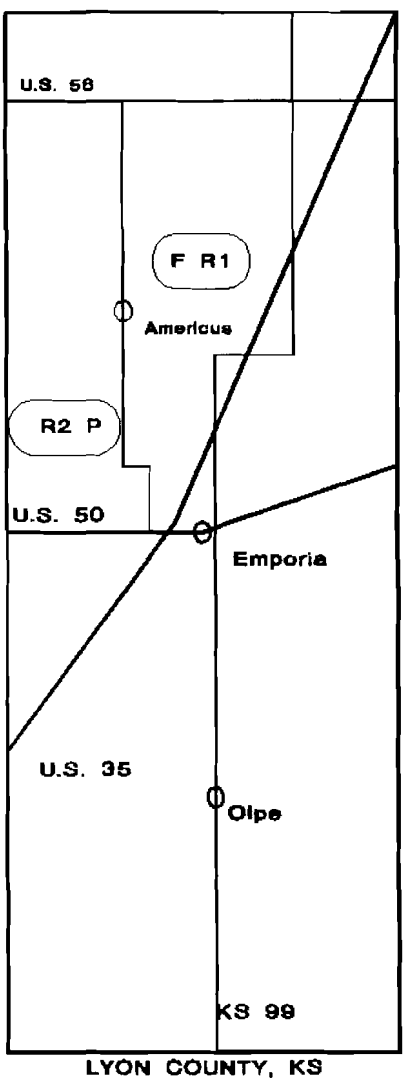

U.S. 56
F R1
Americus
R2 P
U.S. 50
Emporia
U.S. 35
Olpe
KS 99
LYON COUNTY, KS

Figure 2. Photograph of Site R1, 21-year-old reseeding.

Figure 3. Photograph of Site R2, nine-year-old reseeding.

Figure 4. Photograph of Site P, native prairie.

Figure 5. Photograph of Site F, cultivated field.

described by Dahnke (1980). Soil texture was determined using the Bouyoucos (1936) hydrometer method (Table 1). Vegetation composition was determined using the step-loop method described by Wilk (1984) (Table 2). Leroy Pritchard (1986) of the Soil Conservation Service provided the details on the composition and amount of pure live seed used in the reseedings (Table 3).

Soil Bulk Density Determination

Soil bulk density was determined using the method of Burke et al. (1986). Random soil samples were taken from sites P, R1, and R2 using the following technique. Using an insertion tool that was designed and made by Larry Prather (Buhler High School, Buhler, Kansas), 100 cc volumetric stainless steel Sauze soil rings were driven with an equal number of blows (to reduce disturbance) until the soil ring was slightly below the soil surface. The soil rings were then carefully removed using a spade and excess soil at either end of the ring was removed using a sharp knife. The rings which then contained a 100 cc soil sample were emptied into a standard soil tin. Multiple samples (n=30) were taken at each site. The soil samples were then taken back to the lab and placed (with the soil tin open) in a drying oven at 105 C and dried to a constant weight. The soil samples were then weighed and the bulk density was determined by dividing the weight (g) by the sample volume (100 cc). Thus bulk density was recorded as g/cm^3.

Table 1. Physical and Chemical characteristics of soils from the study sites.

Characteristic	P[3]	R1[4]	R2[5]
Soil Type	Silty Clay	Silty Clay	Silty Clay
% Sand	7.0	5.0	3.0
% Silt	48.0	46.0	52.0
% Clay	45.0	49.0	53.0
pH[1]	6.0	5.4	5.5
pH[2]	4.4	4.4	4.5

[1]pH determined in water

[2]pH determined in 0.01 M calcium chloride

[3]P native prairie

[4]R1 reseeded in 1969

[5]R2 reseeded in 1981

Table 2. Vegetation composition based on the step loop method of Wilk (1984). Percentage of hits on major species as reported by Crandall (1987).

Species	P	R1	R2
Andropogon gerardi	50		7
Andropogon scoparius	14	7	8
Panicum virgatum	3	43	3
Sorghastrum nutans	5	32	41
Carex spp.	6	3	
Agrostis spp.	17		
Schedonnardus paniculatus		6	
Bromus spp.		4	7
Sporobolus asper			5

Table 3. Amount of pure live seed planted at sites R1 and R2. Given as pounds of pure live seed planted per acre (Pritchard, 1986).

Site	*Andropogon gerardi*	*Andropogon scoparius*	*Sorghastrum nutans*	*Panicum virgatum*	*Bouteloua curtipendula*
P	___	___	___	___	___
R1	1.2	1.0	1.2	1.0	0.6
R2	1.1	1.1	1.2	0.5	1.1

Organic Carbon Determination

Soil organic carbon was determined by the modified Mebius method described by Nelson and Sommers (1982). Using a mortar and pestle, a freshly-dried soil sample was ground and sifted through a 100-mesh soil screen. A mortar and pestle was used, because a soil grinder would contaminate the samples with iron, which can interfere with the results. A sub sample of approximately 0.250 g of the sieved soil was weighed on a Mettler H54AR analytical balance to the nearest 0.01 mg. The sample was then placed into a 250 ml Erlenmeyer flask (with 24/40 ground glass joints) along with 10 ml of 0.5N potassium dichromate solution and 15 ml of concentrated H_2SO_4. The flask was then attached to a condenser (with 24/40 ground glass joints) using high vacuum grease (non-carbon base) and boiled very gently (refluxed) for thirty minutes. The samples were allowed to cool for 15 minutes, and approximately 50 ml of deionized water was poured through the condenser to wash down any dichromate that might have splashed during boiling. They were then titrated with 0.5N ferrous ammonium sulfate hexhydrate (FASH) using N-anthranilic acid (0.1 g/100ml) plus sodium carbonate (0.107 g/100ml) as the indicator. The initial color was a deep violet, which turned momentarily to gray and then to the end point color which was a deep green. Because of the slow oxidation of FASH in storage, the solution had to be standardized daily. A boiled and

unboiled blank was titrated and used as a correction factor to account for the artifact of heating. The formula for the correction factor (CF) is given in eq. 1:

Correction Factor=(mlBB-mlSAM)*((mlUB-mlBB/mlUB))+ (mlBB-mlSAM). eq. 1

Where: BB= boiled blank UB= unboiled blank SAM= Sample
Once the correction factor (CF) was calculated it was entered into the following equation to obtain the percent of organic carbon (% OC):

% OC=(CF)(Normality of FASH)(0.003)(100)/ (weight of soil g). eq. 2

Where CF is the correction factor (eq. 1), normality of FASH is the normality of the titrating solution, 0.003 and 100 are both constants, and the weight of soil in grams is that of the original sub sample placed into the dichromate solution. By following this formula, the percent organic carbon present in the sample was determined (Nelson and Sommers, 1982). Percent organic matter can be determined by multiplying the %OC by 1.8 (Nelson and Sommers, 1982).

Microbial Biomass Determination

Microbial biomass was determined using a fumigation method described by Jenkinson and Powlson (1982). Soil

samples were sieved through a 6.35 mm mesh to remove stones and roots. Two soil sub samples were taken from each sample and placed into a 400 ml beaker. Three replicates were taken at each site. One of the two samples was placed into a vacuum desiccator with 50 ml alcohol-free chloroform, evacuated, and placed in the dark at 25 C for 18 to 24 hours. A paired sample was also placed in a vacuum desiccator, but was not fumigated. Both the fumigated and non-fumigated desiccators were lined with moist paper to prevent drying of the sample. After fumigation was complete, each fumigated sample was inoculated with 1 g (fresh-weight) of unfumigated soil. Then both the fumigated and non-fumigated samples were brought to 55 percent-moisture holding capacity by the addition of water. Each sample was then placed in a 7.75 L airtight glass container (respirometer) along with 100 ml 1N NaOH in a 250 ml beaker and incubated at 25 C for 10 days. Controls consisted of 100 ml NaOH in a 250 ml beaker sealed in a 7.75 L container and placed with the other respirometers in the incubator. After incubation, each NaOH-CO_2 absorbent container was brought up to 250 ml with distilled water. A 25 ml aliquot of the NaOH, plus 25 ml of distilled water, and four drops of carbonic anhydrase (10 mg pure enzyme per 10 ml distilled water) was placed in a 150 ml beaker for titration. Using a pH meter, the sample was adjusted to pH=10 using 1N HCl. After this was accomplished, the pH was

further reduced to 8.3 using 0.05N HCl. The sample was then titrated to an end-point of pH=3.7 using 0.05N HCl. This was performed on all samples (fumigated, non-fumigated, and controls). Both the HCl and NaOH were standardized using the KHP standardization method of Pierce (1958). Total microbial biomass determination was determined by the following method. One ml 0.05N HCL is equivalent to 0.6 mg of CO_2-C in the NaOH solution. Using this as a conversion factor, mg of CO_2-C was calculated from the ml of HCl used in the titration by equation 3.

TMB= CO_2-C fumigated - CO_2-C nonfumigated/(k). eq. 3

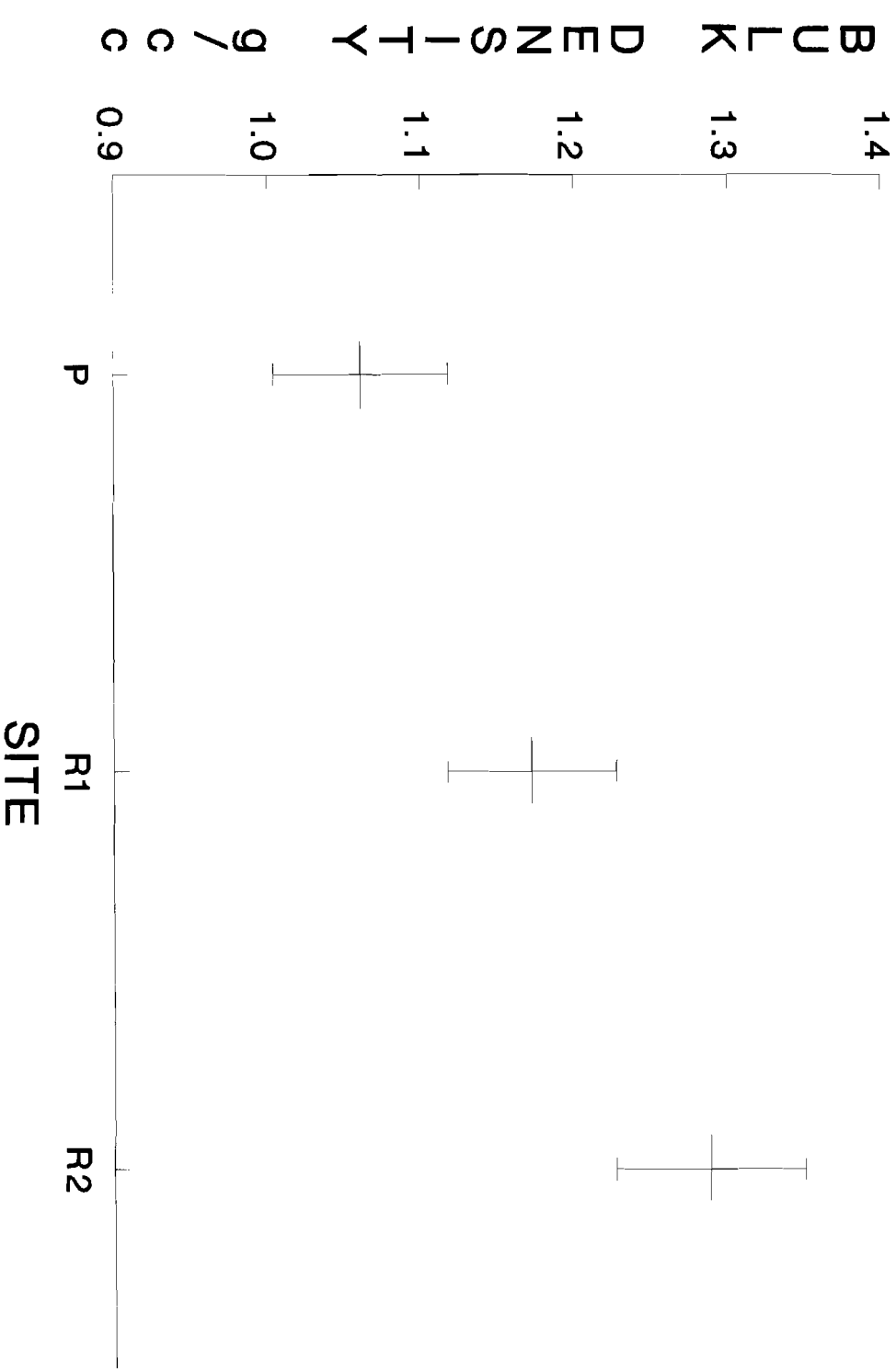
Here total microbial biomass (TMB) was calculated by subtracting the CO_2-C evolved in the nonfumigated sample from that of the CO_2-C evolved by the fumigated sample. This was then divided by the fraction of biomass C mineralized to CO_2 over the 10-day incubation period (k). A value of 0.45 was used for k as derived by Jenkinson and Ladd (1982).

Results and Discussion

Bulk Density

The surface (top 10 cm) soil bulk density found in the native prairie was considerably less than that of either reseeding (Figure 6). The average bulk density for the prairie site averaged 1.07 g/cm^3, compared with that of site R1, with a bulk density of 1.17 g/cm^3 and site R2 at 1.29 g/cm^3 (Figure 6). Using a two sample t-test, it was determined that all sites were significantly ($p<0.01$) different from each other (Table 4 pg. 40). These results are similar to those of Bauer and Black (1981) in a North Dakota study in which grassland soils in a native state had an average surface bulk density of 0.98 g/cm^3 and cropland had a bulk density of 1.12 g/cm^3. Although the soil series in the North Dakota study is different from the one in this study, a difference in bulk density between the native grassland and cropland soils was found. When comparing sites R1 and R2, there is a noticeable decrease in the bulk density from the nine-year-old reseeding (R2) and the 21-year-old reseeding (R1). Curtis and Post (1964) found that bulk density varies with organic matter content. Site R1 had a significantly higher surface organic carbon than that of site R2; this point will be further addressed later in this paper. The lower bulk density in the older reseeding (R1), suggests that the soil is recovering from cultivation, returning to a more native-like condition.

Figure 6. Surface (top 10 cm) soil bulk densities of native and reseeded sites. Where P is the native prairie, R1 is the 21-year-old reseeding, and R2 is the nine-year-old reseeding. Error bars indicate one standard deviation.


BULK DENSITY g/cc
0.9
1.0
1.1
1.2
1.3
1.4
P
R1
R2
SITE

It has been shown that cultivation can increase bulk density of surface soils by up to 100% (Martel and Deschenes, 1976; Davidson et al., 1967; De Haan, 1977; as cited in Tiessen et al., 1982). Dormaar and Smoliak (1985) found that a field in southern Alberta, Canada, abandoned in 1925, and allowed to revegetate naturally, had a lower bulk density (1.29 g/cm^3) than that of a field abandoned in 1950 (1.35 g/cm^3) that recovered in the same manner. Bulk density is important because of the relationship between root penetration and the degree of compaction. Viehmeyer and Hendrickson (1948), using sunflowers, found that bulk densities of 1.9 g/cm^3 or greater totally inhibited root growth, and a bulk density of 1.7 g/cm^3 - 1.8 g/cm^3 allowed very little root penetration. They suggest that the effect of bulk density upon root penetration is not the decrease in O_2 that accompanies high bulk densities, but instead the small pore size in the tightly packed soil aggregates (Viehmeyer and Hendrickson, 1948). The small pore size caused by compaction will not allow root penetration. It will also decrease the infiltration rate of water making it difficult for the soil to absorb water. Without root penetration, it would be very difficult to revegetate these soils. Addition of some kind of organic matter (cost effective) that would decrease the bulk density would be necessary, for sites with such great compaction. This probably accounts for the yield reductions that led to

abandonment of these fields.

Thompson and Troeh (1978) state that organic matter decreases bulk density in two ways. The first is by replacing some of the mineral soil components in a certain volume. Because organic matter is lighter (weight) than the mineral components of soil, its increase will reduce the bulk density. The second and more important way is by increased aggregate stability. This creates more pore space and allows greater O_2 and H_2O penetration, thus alleviating the effects of compaction.

Gas exchange is another important factor to consider when working with compacted soils. Salter (1940) found that if the pore space in the top two inches of a puddled soil is reduced from 25% to 5%, CO_2 concentrations below this layer increased to four times that of a non-compacted soil. This is important because, as shown by Kramer (1949) sunflower and tomato plants that have their roots exposed at saturated CO_2 exhibit a 34-52% reduction in transpiration. There was a significant reduction in the amount of exudation from cut stems as well. This is important because the reduced transpiration rate can be directly linked to the amount of gas exchange (for photosynthesis) that is occurring in the leaf. These results suggest that high bulk densities can even affect the plant by reducing stomatal aperture and indirectly photosynthesis.

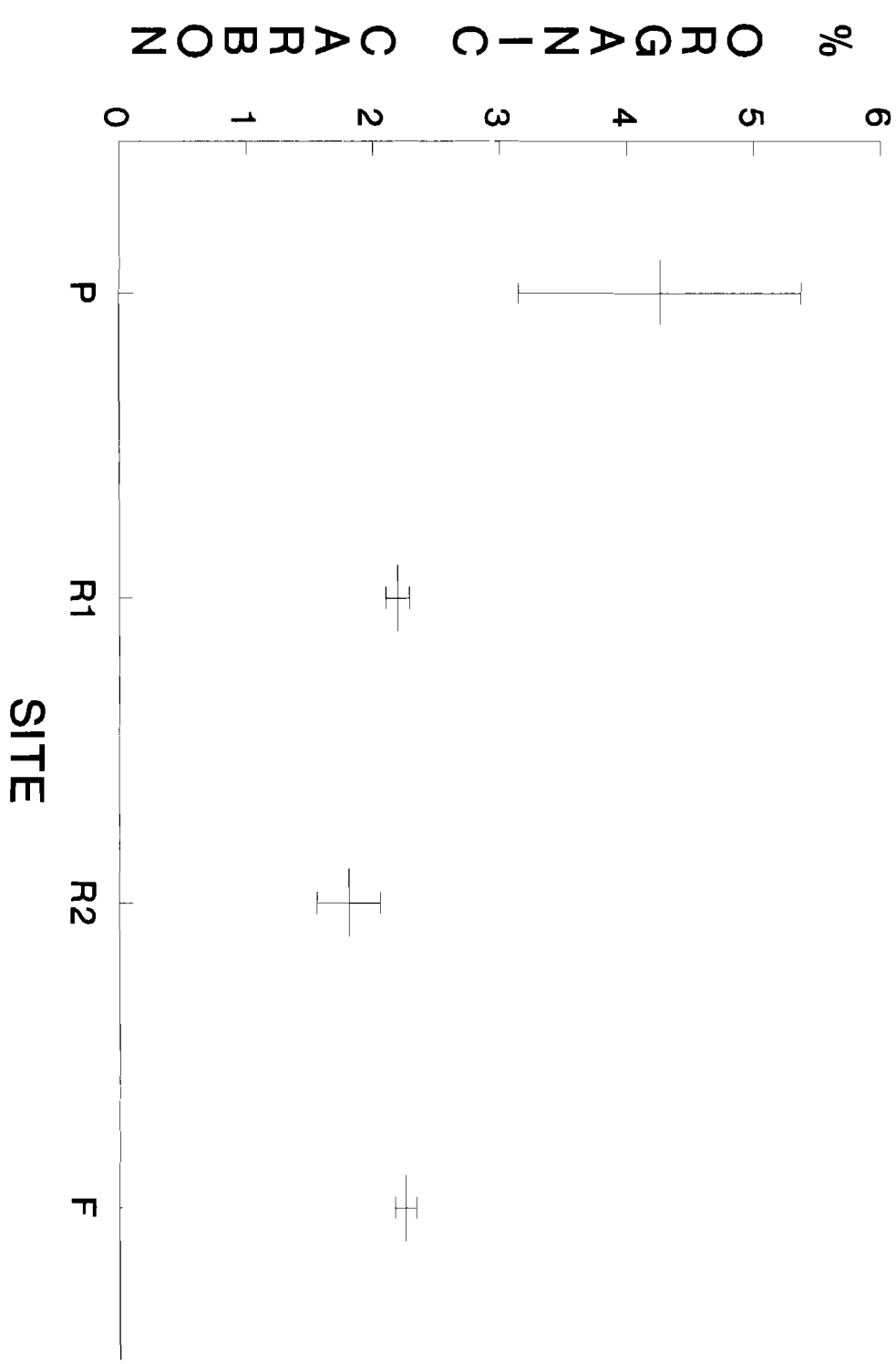
Water infiltration is also another important consideration when working with soils with a high bulk density. It is obvious that if the pore space is reduced, water will infiltrate at a slower rate than in the same soil with a lower bulk density (more pore space). This was noted at site R2 and P (adjacent sites) 24 hours after a heavy rain. Water was standing in the reseeded site (R2) whereas the adjacent native prairie site (P) had absorbed most of the rainfall. Knowing that a compacted soil has less pore space and a slower infiltration rate, it can be assumed that there will be less water for plant growth, and less plant growth means less production. One might expect lower plant water potentials in plants growing on compacted soil (Mayo, 1990). If this is true, then there will be less turnover of organic matter because of the overall decrease in production and plant biomass, which will in turn increase the time it takes the soil to recover to a more native-like state. Thus, the degree of compaction is important in the recovery process, and bulk density is a good indicator of that process.

Organic Carbon

The native prairie had the highest organic carbon content with an average of 4.26% in the top 15 cm of the soil. In the reseedings, the 21 year-old site (R1) had the highest organic carbon content with an average of 2.19% in the top 15 cm of the soil. This was followed by the nine-

year-old reseeding (R2) which had an average organic carbon of 1.8% in the top 15 cm of soil (Table 4 pg. 40). In the top 15 cm of the cultivated field an organic carbon content of 2.25 % was found (Figure 7). These organic carbon results, can be converted to percent organic matter content by multiplying percent organic carbon content by 1.8 (Nelson and Sommers, 1982.). It was difficult to find other studies that used just a straight percent organic carbon or percent organic matter values. However, a study done in Ohio revealed the % organic carbon in a native prairie soil of 2.71%, and that of an adjacent field that had been cultivated for 100 to 150 years at 1.13% organic carbon (Tomoko and Hall 1986). These values are lower than those found in the Kansas prairie and that of the cultivated field. This is not surprising, considering that different methods for organic carbon extraction were used in the studies. Other values for % organic carbon were converted (%Organic C * 1.8=% Organic Matter, Nelson and Sommers, 1982) from values listed by Donahue et al. (1983) for a cultivated mollisol in Iowa. For a loam the %OC was 1.6%, and for a silty clay was 2.7%, these values are similar to the values I obtained for site F, the cultivated field. An uncultivated loam mollisol in Santa Barbara, CA, had a %OC of 4.4%, Which is similar to that of the native (site P) soil of this study. Although these soils are located long distances from each other, they are

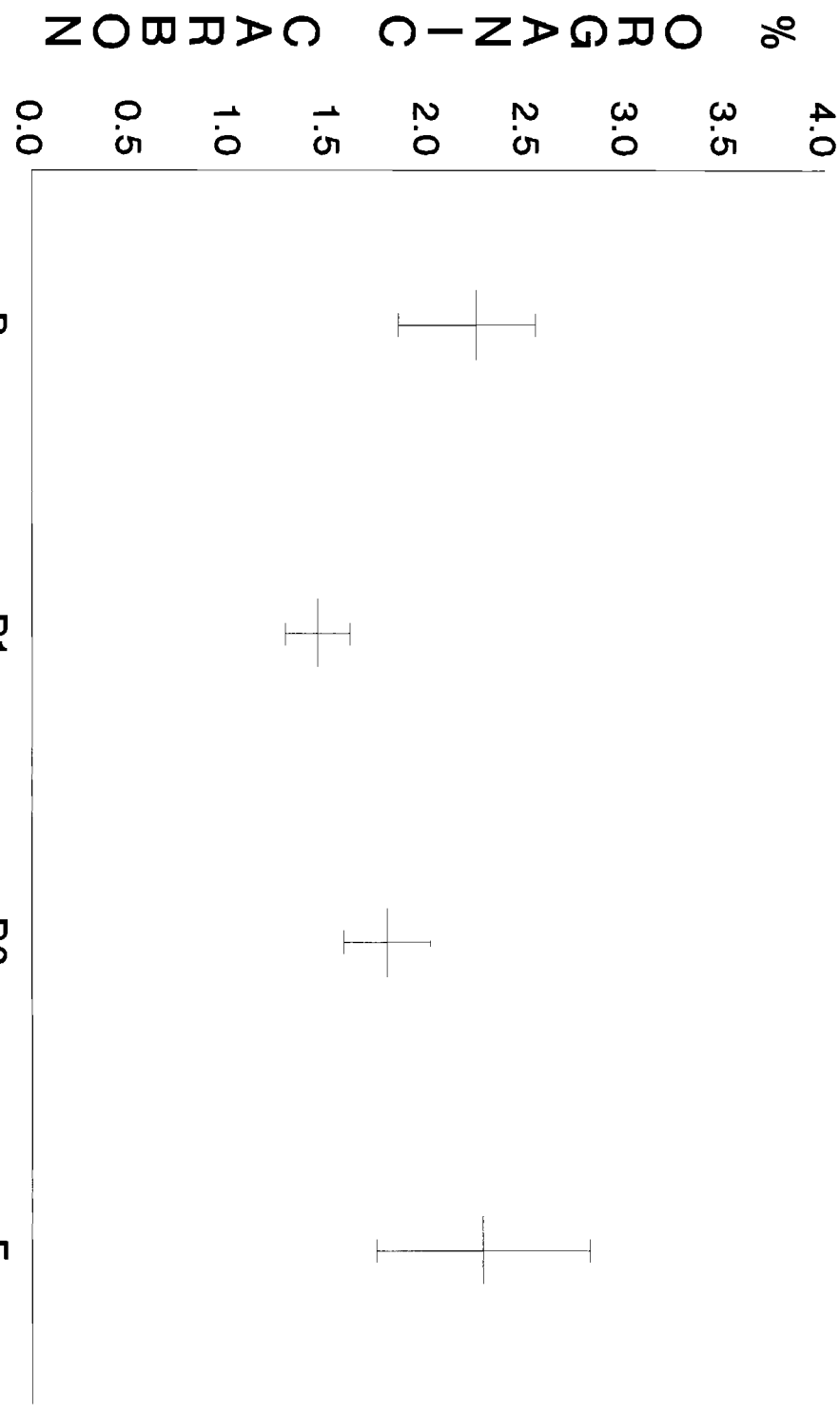
Figure 7. Organic Carbon percentages in the top 15 cm of soil in the native, reseeded, and cultivated sites. Where P is the native prairie, R1 is the 21-year-old reseeding, R2 is the nine-year-old reseeding, and F is the cultivated field. Error bars represent one standard deviation.


% ORGANO-CARBON
0
1
2
3
4
5
6
P
R1
R2
F
SITE

classified as mollisols or grassland soils and should have similar characteristics with each other.

Organic carbon was determined at a depth of 30-35 cm. The native prairie had an average organic carbon content of 2.24%,followed by the oldest reseeding with 1.44%, and the nine-year-old reseeding with an average of 1.79% (Figure 8 & Table 4 pg. 40). The cultivated soil had an average organic carbon at depth of 2.27% (Figure 8). In the Ohio study an organic carbon content in the BA horizon of the native prairie was 0.75%, and that of the cultivated field was 1.01% (Tomoko and Hall 1986). Again, the Ohio study organic carbon percentages are lower than those found in this study, probably due to extraction method, and also the soil types found under these prairies, that are located hundreds of miles from each other. When looking at the organic carbon percentages of the cultivated field, (Figures 7 & 8) it is evident that both the surface and depth samples are about the same. This is probably explained by the fact that the surface and subsurface soil horizons are blended with tillage equipment. This same thing can be seen in the youngest reseeding with a surface %OC of 1.8% and at depth an %OC of 1.79%. This would indicate that during the first nine years after reseeding, not much carbon has been added to the soil by reseeding. But, if this same comparison is made with the 21-year-old reseeding which had a surface %OC of 2.19% and a depth %OC 1.44% ($p=0.01$), it appears that the

Figure 8. Percent of Organic Carbon found at 30-35 cm in the native, reseeded, and cultivated sites. Where P is the native prairie, R1 is the 21-year-old reseeding, R2 is the nine - year-old reseeding, and F is the cultivated field. Error bars indicate one standard deviation.


% ORGANO-CARBONO
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
P
R1
R2
F
SITE

upper layer of soil has gained a significant amount of carbon. Since the nine-year-old reseeding has a significantly ($p=0.01$) higher organic carbon level at depth than that of the 21-year-old reseeding at depth, it may be assumed that the older reseeding was more eroded or different tillage practices were used prior to abandonment, and this may account for the lower organic carbon content at depth. Due to the artifact of tillage, the organic carbon content at surface and depth was approximately equal at the time of reseeding. The addition of carbon at depth, since cultivation, has changed very little due to the fact that there was not sufficient root penetration to add a significant amount of carbon at depth. Although it was not tested experimentally, it appeared that the root mass found at 30 cm in the reseedings, was, in every case, considerably less than that seen at the same depth in the native prairie. This would account for the lack of addition of carbon at these depths in the reseedings.

The Organic carbon gain for the oldest reseeding (R1), can be calculated using the hectare-furrow slice (HFS), and the percent organic carbon found at the surface and at depth. Assuming that the %OC of present at 30cm represents the overall %OC at the time of reseeding (surface and depth), the total gain of organic C can be calculated as described below. By subtracting the depth %OC from the surface %OC, a rough estimate of OC gain in the surface

layer (top 15 cm) during the period of reseeding. If this is then incorporated into a HFS, which weighs 2.2 million pounds-per-acre, the total organic carbon gain over the 20 year period for site R1, is roughly 16,544 kg/ha or 827 kg/ha/yr. When considering all of the acreage that has been put into the Conservation Reserve Program (CRP), implemented by the USDA Soil Conservation Service, a large carbon sink has been created. This is important, not only because of the resting and reconditioning of soil, but also the fact that soil erosion is drastically reduced. With the destruction of the rain forests of South America, there is speculation about the "greenhouse effect". This is where an increase of CO_2 in the atmosphere retains heat, causing detrimental global warming. The carbon sink that these reseedings can provide has been ignored by most scientists, but has been mentioned as a possibility by McConnell and Nielsen (1989) in a letter to the editor of the Journal of Soil and Water Conservation. Consider that roughly 827 kg/ha/yr is added over a 20 year period, this can become quite substantial when considering that approximately 650,000 acres of tall grass prairie has been bid for reestablishment in the eastern half of Kansas alone (Egbarts, 1990). Reseeding of old fields in the tall grass prairie belt of the great plains and midwest will increase this carbon sink. In other words approximately 16,540 kg/ha would by added to the soil in 20 years of being reseeded to

grass throughout this area. Then consider that nation wide between 30 and 40 million acres have been bid for CRP restoration, this represents a massive long term carbon sink.

Microbial Biomass

Microbial biomass is an important factor to consider when looking at soils which have been highly impacted. In this particular study the soil was impacted by crop agriculture. Microbial biomass can indicate whether or not a soil has hidden factors that are affecting it. Soil microbes do a number of things in the soil, such as, fix nitrogen, break down unusable minerals and nutrients into usable forms and also break down detritus into smaller organic compounds more suited for other soil microbes and invertebrates (Brady, 1990). Humus is the result of microbial activities

Total microbial biomass (TMC) was calculated for the native and reseeded sites. The average TMC of the prairie site P1 was found to be 82.1 ugC/g of soil (Figure 9). This was followed by the youngest reseeding (site R2), which had a TMC of 52.4 ugC/g of soil. TMC for the oldest reseeding (R1), was the lowest at 34.1 ugC/g of soil (Table 4). This was not expected because of the higher %OC found at this site, but is probably do to the fact that this reseeding (R1) was more highly impacted and abused than that of the other reseeding. These results differ from those found by

Figure 9. Total microbial biomass in samples taken in the top 15 cm of the native (P) and reseeded (R1 and R2) sites. Where P is the native prairie, R1 is the 21-year-old reseeding, and R2 is the nine-year-old reseeding. Error bars indicate one standard deviation.

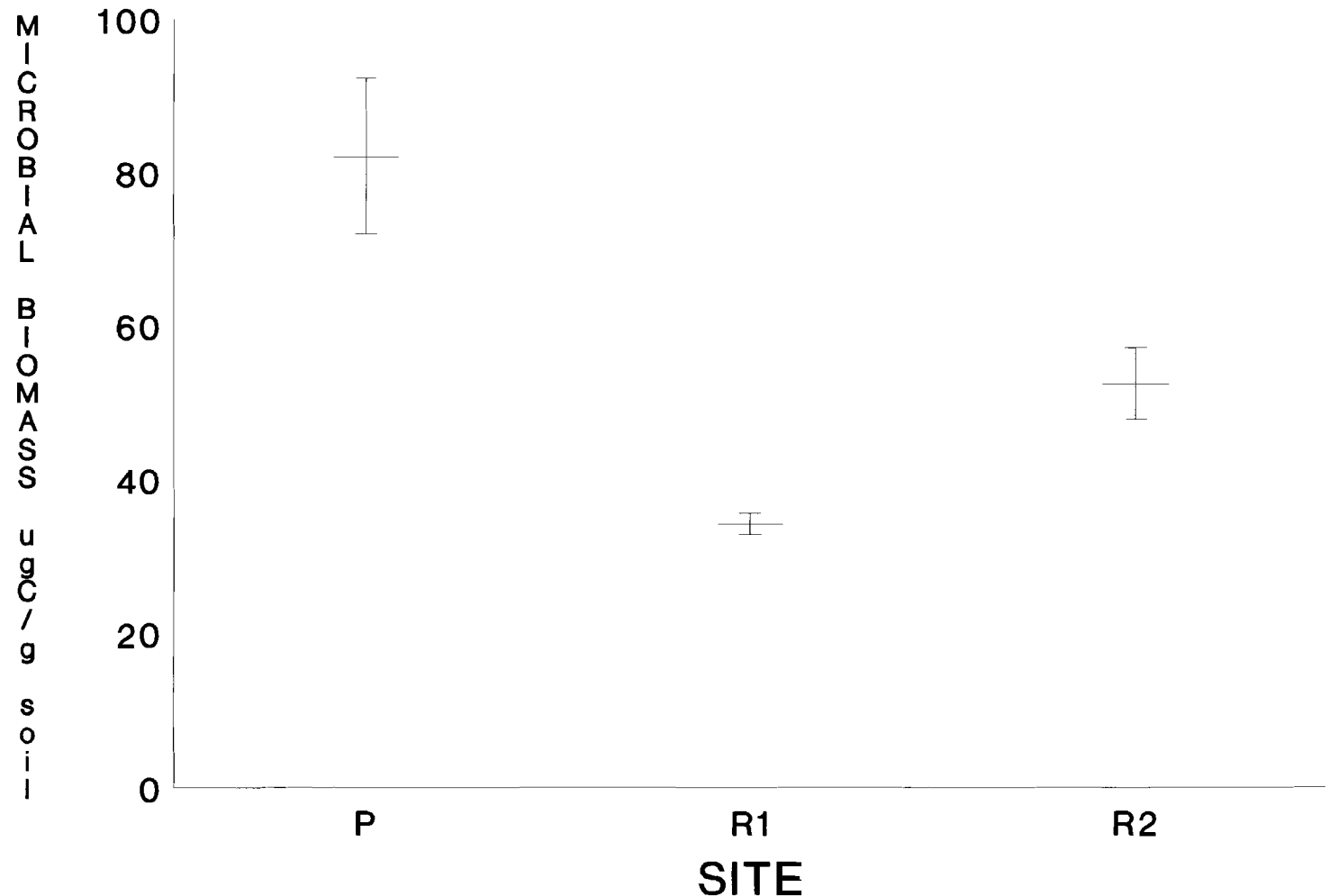

MICROBIAL BIOMASS ugC/g soil
100
80
60
40
20
0
P
R1
R2
SITE

Table 4. Bulk density, organic carbon, and microbial biomass by site.

SITE	Bulk Density g/cm^3	%Organic Carbon 0-15cm	%Organic Carbon 15-30cm	Microbial Biomass ugC/g soil
P	1.07*	4.26*	2.24*	82.1*
R1	1.17*	2.19*	1.44*	34.1
R2	1.29*	1.80*	1.79*	52.4
F	----	2.25	2.27	----

* indicates statistical significance of 0.05 or better.

Insam (1989), who calculated TMC as 298.7 ugC/g in a field located near Emporia, Kansas that has been in cultivation for 90 years, and has been in the same crop type for the last 20 years. Since the cultivated field in this study was not utilized for TMC determinations, the nearest comparison would be that of the reseeded old fields. The reseeded old fields had considerably less TMC than that of the cultivated fields that were sampled by Insam (1989). This may seem hard to believe since reseeding is supposed to be improving the condition of the soil. But, this could be explained by the fact that these fields are in cultivation, fertilized, and organic crop residues are incorporated thus providing a continuous source of food to support these microbes. This theory makes even more sense when you consider that these abandoned old fields lay dormant for long periods of time, without fertilizer, or the incorporation of crop residues. Crandall (1987), studying these same sites, found that the nitrogen levels in both of the reseedings was less than one ppm. This in turn with the weedy fauna associated with the succession of these old fields, would create a nitrogen poor environment for soil microbes. A low %OC may have also contributed to the low TMC determinations. The TMC for the native prairie (P) was also low when compared to the TMC (793.4 ug/g soil) reported to Mayo (1990) by Insam in a native prairie hay meadow. This may seem strange that the two native prairies showed so much difference. This

difference could be attributed to the method used to determine TMC, which could cause a difference in values found by either study. But it was revealed by Mayo (1990) that the native prairie in this study was sprayed for "weeds". This spraying in turn killed the weeds and also those unsightly nasty legumes, which fix nitrogen, and add to the total nitrogen pool of the soil. This might explain why TMC was lower in this "native" ecosystem. Though this site has been tainted by herbicides, it did suggest that the legumes contribute a major portion to the nitrogen pool, and that an innocent act such as killing weeds can have a detrimental effect on such a fragile ecosystem. As far as this study is concerned, TMC as an indicator of condition was useful, in the fact that it indicated that there was a problem, which could be traced back to the nitrogen sufficient condition.

SUMMARY

A study of soil bulk density, organic carbon, and total microbial biomass was carried out on a native prairie, reseeded old fields of different age classes, and a cultivated field. All of the study sites were located on the Kenoma soil series. Samples were taken during the spring and summer of 1988 and 1989 and analyzed for organic carbon (Nelson and Sommers, 1982), total microbial biomass (Jenkinson and Powlson, 1982), and bulk density (Burke et al., 1986).

Results from the organic carbon analysis show that the youngest reseeding has the lowest %OC (1.8%). This is followed by the oldest reseeding which had a higher %OC (2.19%) level. There is a statistically significant rise in %OC with age. This combined with the lower bulk density (1.17 g/cm^3) of the older reseeded site (compared with the youngest reseeding 1.29g/cm^3) would indicate that the older reseeding is recovering from the impact of cultivation agriculture. The %OC (4.26%) of the native prairie was the highest of all, which is not surprising due to the lack of cultivation agriculture. The native prairie site also had the lowest (1.07g/cm^3) bulk density. All %OC determinations were statistically significant from each other. Total microbial biomass was highest in the prairie (82.1 ugC/g soil), followed by the youngest reseeding (52.4 ugC/g soil), and finally the oldest reseeding (34.1 ugC/g soil). There

was no statistical different between the reseeded sites, but both were statistically significant from the native prairie site. A trend was seen in the bulk densities, and %OC levels of the reseedings, that suggest that the soil is recovering from the effects of cultivation. Exactly how long, if ever, a complete recovery will be obtained is uncertain, but reseedings as a long term carbon sink may be the more important factor. This especially true when microbial biomass is factored into the picture. There is no trend in microbial biomass associated with age of reseeding. Thus there is no evidence, in microbial biomass, of recovery.

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NOV. 16, 1990
Date

Jacki Tolbert
Signature of Graduate Office Staff Member

November 20, 1990
Date Received

OLD FIELD

"I feel all worn out"

RESEEDED OLD FIELD

"I did; but I'm much better now"

NATIVE PRAIRIE

"Wow, I'm glad I had the rocks to hold my ground!