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A Quantitative Analysis of Wetlands at the University of Notre Dame's Environmental Research Center

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Abstract

This study examined certain chemical and physical parameters in eight peatland sites at the University of Notre Dame Environmental Research Center (UNDERC) in Land O' Lakes, Wisconsin. In addition to comparison between each $100m^2$ site, certain parameters were used in soil classification. These sites were permanently marked for future experimentation. This study was performed in conjunction with a study determining floral composition in the marked sites. The studies together were used to classify the peatlands into bogs, fens, and cedar swamps. Five sites were determined to have fibric soil. These sites were: Sarah's Bog, Dan's Fen, Degobah, Ed's Bog, and Forest Service Bog. Of the other sites, Nih and Enchanted Forest were determined to be hemic, while Cedar Swamp was classified as sapric. In general, the sites with the higher pH's were determined to have higher conductivities and bulk densities, and lower percent moisture. Studies of certain parameters with respect to depth showed a trend of decreasing percent rubbed fiber with increasing depth. Peat core depths for each site were also determined. The deepest peat core depth was recorded for Ed's Bog, which could be cored down to 5.86 meters.

Introduction

Scientific analysis of wetlands has been actively undertaken since the early nineteenth century (Naismith 1807, Dau 1823). Because many early studies of wetlands revealed certain plant community gradients corresponding to underlying hydrological and chemical gradients, scientists have long attempted to classify wetlands primarily along these lines. Subsequent classifications which have arisen from these studies have been based on limited data and have ignored other important factors which influence the formation of these gradients (Bridgham et al. 1996). This data has portrayed a rather descriptional approach to the study of wetlands. Recently, wetland ecologists have attempted to redefine these relationships and terminologies by improving their understanding of the underlying science and by developing a universal terminology (Bridgham et al. 1996).

In the modern general sense, a wetland is defined as an ecotone, or transitional area between the terrestrial and aquatic systems in the topography of a region. Three descriptive criteria indicate the presence of a wetland. The most important of these is the presence of water at or near the surface of the soil for at least a portion of the year. Hydric, or reduced soils also denote wetlands. Because hydrophytic vegetation are adapted to life in water-logged conditions, these plants are the third criteria utilized to indicate a wetland.

Historically, wetlands have been subdivided into various categories consisting of swamps, bogs, fens, marshes, moors, and muskegs (Gore 1983). These terms have become problematic, owing to their subjective definitions by various scientists. In response to this dilemma, Gore (1983) and Bridgham (1996) suggest that the terms mire or peatland should be used when referring to a peat-forming wetland without prior knowledge of specific biotic and abiotic factors. Peatlands are present in the location of UNDERC, and will be the dominant focus of this study.

If some of the parameters of a peatland are known, the site may be further classified as a bog or fen. A bog refers to a peatland of low pH and alkalinity and features *Sphagnum* moss as a common plant species. A fen refers, conversely, to a peatland of greater pH and alkalinity, and contains more coniferous and deciduous trees (Bridgham et al. 1996). The most important factor in structuring a peatland is the underlying hydrology of the site (Bridgham et al. 1996). Peatlands may be either ombrotrophic or minerotrophic. Ombrotrophic peatlands, owing to their raised peat dome, receive water primarily through precipitation. This water is typically low in nutrients. Minerotrophic peatlands receive a geogenous water supply which commonly has a higher amount of nutrients. These two hydrologic terms, ombrotrophic and minerotrophic, are commonly thought to determine the division of peatlands into bogs and fens, respectively

(Gore 1983). This relationship is also controversial for many wetlands ecologists, including Bridgham (1996), who challenge this ontogenical relationship and find that bogs and fens do not necessarily follow this distinction.

There are many different variables that scientists consider when studying the properties of or classifying a specific wetland. Correlating factors such as pH, alkalinity, and mineral cation concentrations are often indicative of the presence of certain plant communities. For instance, it has been found that in northwestern European mires, sites with rich fen vegetation have a pH in water of over 5.5, while bog water shows a pH below 4.0 (Malmer 1986). In fact, one of the main distinctions today between bogs and fens is acid, mineral-poor soil conditions for the former, and less acid or alkaline mineral-rich conditions for the latter.

Correlating to pH concerns, mineral cation concentrations of such elements as nitrogen, calcium, sodium, and potassium can be studied to reveal how they control the growth of peatland plants. Ca^{2+} specifically is important in many ways in determining the species present in peatlands. Ca^{2+} associates with bicarbonate and forms a buffering system, thereby controlling the pH of many peatlands. In addition, high levels of Ca^{2+} at low pH have been shown to be toxic to several species of

Sphagna (Bridgham et al. 1996). Different species in a peatland can be tested in how they respond to cations like $Ca^{2+}$and other specific elements. This can be a valuable indicator as to how these minerals affect the peatland plants, and to what kind of species can be found in certain chemical environments.

In relation to these chemical considerations, hydrology of a peatland is often studied as a determinant in classification. Hydrology is accepted as an important force in controlling the structure and nature of wetlands. The source of water into a peatland regulates its soil and water chemistry. Thus, an increase in minerogenous waters generally corresponds to higher pH, higher cation concentration, higher nutrient availability and better productivity (Bridgham et al. 1996). The main separation between bogs and fens often lies in the origin and chemistry of their respective water supplies. The distinctions between ombrotrophic (rain-fed) bogs, and minerotrophic fens have been noted above. It has been recognized, however, that the distinction between bogs and fens is also often attributed to the presence or absence of certain “fen indicator plants” (Gorham 1990). Classifications which are based only on vegetative structure have limited value for wetland ecology (Gore 1983).

Since many different organic and environmental factors can vary independently, close relationships of species to single habitat factors are rather rare. In fact, most of the data that exists is correlational. There is some connection between mire vegetation and chemical factors. Chemical factors, however, are not always decisive in determining the composition of mire vegetation. Water level, water movement, aeration, peat texture, acidity, and various nutrients affect the success of different mire vegetation (Gorham 1950). All of these factors and their interrelations must be studied to gain a clear picture for classification. Because of this complex coordination of many variables, there are obvious difficulties in setting up strict boundaries for classification of different wetlands.

During the twentieth century there have been many attempts to classify peatlands using chemistry, hydrology, and plant communities as a basis. No strict classification has been achieved, and perhaps the most helpful studies have determined various factors governing plant distribution in specific sites (Gorham, 1950). Detailed and comprehensive research on environmental factors and plant distribution within small areas reveal a great deal more about the relations between plants, chemistry, and hydrology, than do studies based from a wide range of separated communities. UNDERC provides an ideal habitat for this kind of research. In this study, experiments will be performed to collect data on many different variables in certain well defined localities. Plant communities and peatland soils will be examined in detail, and relations between these variables will be understood in the framework of a single locality. This paper will focus specifically on the aspects of soil classification and certain soil analyses, such as bulk density, percent moisture, pH, and conductivity.

Materials and Methods

Samples from the field were taken at eight different peatland sites. The eight different sites included (in order of visit): Degobah Fen, 0.3 miles west of Tenderfoot Creek on the northern side off the loop road, Ed's Bog, on the eastern half of the property, Forest Service Bog, off the southeast corner of the property, Sarah's Bog, on the north side of the south gate entrance road between Forest Service Bog and the Wetlab, Cedar Swamp, on the Tenderfoot Creek side of the loop road on the eastern half of the property, Enchanted Forest, at the intersection of the loop road and the road to Cranberry Lake on the north side, Nih, at the intersection of the loop road and the road to the gravel pit, and Dan's Fen, along the road to Cranberry Lake. At each site square plots were set up that were 10 meters by 10 meters. The peat samples were taken within those plot sites. The samples were acquired using a hand saw and a cylindrical PVC tube 30 cm in length and 10 cm in diameter. The tube was marked with a black permanent marker at 5 cm and 15 cm, and was placed at each site in an area where there seemed to be no large plantlife, and thus little or no roots below the surface. Where the tube was placed, the live sphagnum was removed so that 0 cm began with dead sphagnum. The peat saw was used to cut around the border of the PVC tube, until the tube could be pushed into the ground to the 5 cm mark. A hole on the outside of the tube was cut so that a hand could be inserted into the hole and underneath the PVC tube. The tube and its contents were then pulled up, with the hand directly under the tube, not allowing any of the surface peat to fall out. The peat was then place in a zip-lock bag marked with the depth increment (0-5 cm), the location, and the replication number. The peat saw was then used in the exact same manner until the tube could be pushed down to the 15 cm mark. A depth increment sample from 5 to 15 cm was then taken as described above. The whole process was repeated again by pushing the PVC tube completely into the peat, to get a sample from 15 to 30 cm. Replicate number one was followed by the taking of another three samples, so that two sets were taken at each site. The second replicate was acquired anywhere within the plot irrespective of where the first was taken. In total, there were six bags of peat collected at each site, two replicates of three depth increments each.

The last data which was acquired in the field was the peat core depth at each site. A MacCauley corer was taken around to each site on one day after all of the other surface peat had been sampled. This was done to avoid too much handling of the expensive corer. The peat corer was pushed into the ground, and attachments were added as needed. These attachment were secured on with a special tool designed for that purpose. When something solid seemed to be struck by the peat corer, a peat sample was taken to assure that the material was sand or clay, and thus the real bottom. If the sample showed that peat was still being collected, the peat core was inserted somewhere else on the plot. When the peat core was at its full depth in the ground, the attachment was marked with a marker. As the peat core was taken up, each attachment was taken off as it appeared wholly above ground. This was done to avoid bending of the corer. All of the pieces were placed together on the ground at the end, and the depth was measured to the mark. This peat core depth was recorded in a field notebook. Proper training on the MacCauley corer was required before use.

The second part of the experiment involved the soil analysis. Bulk density, percent moisture, pH, conductivity, rubbed fiber content, and pyrophosphate-soluble organic matter index were all determined for each peat depth increment. Before any of this could be done, each bag of peat had to be sorted through. Roots, undecomposed wood, and stones were removed from each sample. The bulk density was determined by first calculating the volume of each depth increment from the dimensions of the PVC tube. Then, each depth increment was weighed to the nearest .01 g.

The percent moisture was determined by taking a subsample of approximately 10 g of peat from each bag. The weight was determined to the nearest .01g. The samples were dried at approximately 105°C in crucibles. Each crucible was marked with pencil with the location, replication number, and depth increment of the peat sample. After at least 24 hours, or until the sample obtained a constant dry weight, the samples were removed from the oven, and the dry weight was determined to the nearest .01 g. The material was saved for later usage. The formula used for calculating the bulk density was:

$$\text{bulk density} = \frac{\left(\frac{\text{wet weight of increment x dry}}{\text{wet weight ratio}}\right)}{\text{volume (in cm}^3\text{)}} \quad ,$$

where the dry/wet weight ratio = dry weight/wet weight. The formula for percent moisture was:

((wet weight-dry weight)/dry weight) X100.

The soil pH and conductivity were determined by taking approximately 10 g of a wet sample from each bag, and placing it in 50 mL plastic sample cups. About 10 mL of distilled water was then added and the mixture was stirred vigorously for about 30 seconds. After letting the mixture sit for about 30 minutes, the electrical conductivity and the pH were determined for each sample. The pH meter was calibrated beforehand, and the conductivity meter was used first to create a calibration curve. It was calibrated against three known solutions having conductivities of 0, 8.64, and 100 uS/cm. Calibration curves were set up, with the experimental data placed along the x axis, and the known conductivities along the y axis. This was done, so that the measured conductivity could be corrected later. The conductivities were taken in units of uS/cm. The electrical conductivity was eventually corrected by using the calibration curve, considering the contribution of H^+ ions, and adjusting for temperature (Figure 10). The measured temperature was determined to be 20 ^oC.

Next, the rubbed fiber content of each sample was determined. 10 grams of each sample were weighed out to the nearest .01 g and placed into a large plastic cup. 200 mL of water were added along with approximately 2 g of Calgon detergent. The solution was shaken briefly to dissolve the detergent, and then capped. After standing overnight, the solution was shaken again by hand for approximately 1 minute and then poured through a 100 mesh sieve. The peat was washed onto the sieve screen under a gentle stream of tap water while the sample was rubbed lightly between the fingers. This was done until the water passing through the sieve was clear, and the peat no longer felt slimy. All of the remaining residue was placed in a labeled crucible, and dried at 105°C to a constant weight. The dried material was weighted to the nearest .01 g. The remaining peat represented the fibrous material over .15 mm in size. The rubbed fiber content as a percentage of total dry mass was calculated by:

%rubbed fiber = dry mass of residue on screen/ (wet weight of sample*dry/wet weight ratio)

Next, the pyrophosphate-soluble organic matter index was determined for each sample. This procedure used a pyrophosphate color extract compared to a Munsell Soil Color Chart as an index of the amount of soluble organic matter. This estimated the degree of humification of the organic soils. A small sample of moist peat of several cm^3 volume was placed in a scintillation vial. Approximately 1 g of granular sodium pyrophosphate was added along with 4 mL of distilled water. The mixture was shaken briefly and let set overnight. The next day, the mixture was shaken again briefly, and one end of a strip of chromatographic paper about 5 cm long was inserted into the suspension with tweezers. The paper strip was left in until it was wetted to the top. The strip was blotted on paper towel, and compared to the colors on the Munsell chart. The color on the strip was compared where the suspension had actually been touching the paper, not where the wetness at the top was. The soil was then classified according to the numbers obtained from the Munsell chart. The soil was classified as fibric if the fiber content was 40% or more and the pyrophosphate color extract on the Munsell Soil Color Chart yielded a value and chroma of 7/1, 7/2, 8/1, 8/2, or 8/3. The soil was classified as sapric if the fiber content was less than 17% and a pyrophosphate color extract on a Munsell Soil Color Chart was below or to the right of a line drawn to exclude blocks of value and chroma of 5/1, 6/2, and 7/3. Soil classified as hemic was an intermediate between fibric and sapric (Figure 11).

The data was analyzed in many ways. The variables of pH, corrected conductivity, conductivity, bulk density, and percent moisture were all compared with regard to the eight different sites. The average weighted variable for three depths was determined by the formula:

$$\frac{[(0-5\text{ cm})1)+(5-15\text{ cm})2+(15-30\text{ cm})3]}{6}$$

The number obtained was averaged with the number for the second replicate, and standard deviations were obtained. Next, a table analyzing the same variables with respect to depth was made. The two replicates for each depth were averaged, and the standard deviation was calculated. Finally, a table was made to determine soil classification on the basis of the Munsell chart and the percent rubbed fiber (as described above).

Results

The table analyzing the different variables with respect to depth showed varied results (Figure 1). The data comparing pH at different depths revealed little meaning. Including standard deviation error plus the error for the instrument (± .1), the pH showed little change with respect to the top 30 cm of peat. The data comparing percent moisture with depth also displayed very little change. Dan's Fen and Enchanted Forest showed modest decrease in percent moisture with depth, while Forest Service Bog revealed the opposite. The comparison of bulk density with depth showed decreasing bulk density with depth for Enchanted Forest. The other sites did not yield meaningful data. Data comparing percent rubbed fiber with depth showed a common trend. In all but one case the percent rubbed fiber became smaller with increasing depth. Finally, the corrected conductivity and conductivity data showed little change with respect to depth in the surface 30 cm. Cedar Swamp may have shown slightly higher conductivity at higher depths.

Comparison between sites were also performed (Figures 2-7). The sites with the lowest pH were Sarah's Bog and Forest Service Bog with pH's of 4.15, and 4.4 respectively. Ed's Bog (4.4), Degobah (4.5), Nih (4.9), and Dan's Fen (5.1), showed increasing pH's relatively. Cedar Swamp and Enchanted Forest displayed the highest pH's of 5.5 and 5.8 respectively.

The conductivity and corrected conductivity were also compared by site. Cedar Swamp showed the highest conductivity and corrected conductivity of all sites at 37.6 umhos/cm and 38.3 umhos/cm respectively (Figures 3 and 4). Enchanted Forest and Nih had the next highest conductivity, varying slightly with corrections for H^+ ions. After corrections, Sarah's Bog revealed the lowest conductivity. Forest Service Bog, Ed's Bog, and Degobah showed similar corrected conductivities. The bulk density comparison showed similar data to that of the corrected conductivity. Cedar Swamp showed the greatest bulk density at .091 g/cm^3, with Nih and Enchanted Forest next largest at .053 g/cm^3 and .052 g/cm^3 respectively. All other sites showed bulk density's closer to .02 g/cm^3 (Figure 5). Finally, percent moisture was compared by site. Cedar Swamp, Enchanted Forest, and Nih showed the smallest percent moistures, while Forest Service Bog revealed the largest at 2663%. Ed's Bog and Dan's Fen yielded the next largest with 2153% and 1986% respectively (Figure 6).

Next, the soils were classified by percent rubbed fiber, and the Munsell Chart (Figure 8). The criteria for classification were met in most cases. For four depths the criteria were not congruent, and no classification was made. The data showed conclusively that the sites of Sarah's Bog, Forest Service Bog, Ed's Bog, Degobah, and Dan's Fen could be classified as fibric. (Dan's Fen did show one depth reading to be hemic, but the other five were fibric.) Cedar Swamp revealed all six samples to be sapric. Two of the samples from Enchanted Forest could not be classified, however, three were hemic, and one was fibric. The same classifications occurred at site Nih.

Finally, the peat core depth for each site was determined. These depths can be found in Figure 9.

Discussion

This study attempted to examine certain physical and chemical parameters of peatlands at eight different sites on the University of Notre Dame Environmental Research Center's property in Land O' Lakes, Wisconsin. The sites under evaluation were clearly and permanently marked for future analysis. This study was limited to a small number of various elements, and did not take into account all correlational factors. To gain a clear picture of each peatland habitat, water level, water movement, peat texture, vegetation, and mineral cation concentrations would also need to be investigated. The data presented here represents a small portion of parameters used in peatland classification and examination. The parameters were examined by comparing between sites, and by comparing three depths at the surface of each individual peatland.

Finally, the soil at each site was classified as either fibric, hemic, or sapric.

The data showing varying parameters at different depths was for the most part, unremarkable. Data comparing percent rubbed fiber with depth did show a trend of decreasing percent rubbed fiber with increasing depth. This trend is expected because of the less decomposed peat at the surface. The less decomposed peat holds less water, and should subsequently reveal a lower percent moisture at the surface. Forest Service Bog data was consonant with this trend. (The extremely high percentages of moisture reveal the outstanding absorbance qualities of the peat at every site.) The higher amount of fiber at the surface should also mean that bulk density increases with depth. This was not substantiated by any of the data. The pH and conductivities of different depths revealed little change within the first 30 cm. More accurate trends with respect to depth would require analysis of many more depth increments. Also, some error considerations are discussed below.

Data compared between different sites yielded more interesting results. Those sites with the highest pH's, showed the largest bulk densities, the largest corrected conductivities, and the smallest percent moistures. This data shows the correlation of certain parameters with peatland classifications. The sites have previously been grouped into bogs, fens, and cedar swamps, based on vegetation, pH, and conductivity (Druckenbrod 1996). Cedar Swamp and Enchanted Forest were grouped as cedar swamps, Sarah's Bog and Forest Service Bog were identified as bogs, and the rest were grouped as fens. Theses classifications seem to hold true to the certain physical and chemical parameters examined. One interesting discrepancy seems to be the placement of Nih with respect to Dan's Fen. The bulk density, percent moisture, and corrected conductivity of Nih seem closer to that of the cedar swamps than Dan's Fen. However, the pH of Dan's Fen places it directly next to the cedar swamps.

The comparison of conductivity with corrected conductivity shows that the correction of conductivity for protons affects the more acidic sites the most, as is expected. The sites with largest conductivities, and thus, the most biological activity, are also the sites with the highest pH's.

The soil classifications correlate nicely with the examined parameters. The sites grouped as cedar swamps and the singular fen, Nih, are the only sites not classified as fibric. Those classified as fibric contain peat that is generally less decomposed. Enchanted Forest and Nih are classified as hemic, and Cedar Swamp, with its very dark soil, is classified as sapric. It is perhaps not surprising that Enchanted Forest and Nih are classified similarly. They both have extremely similar bulk densities, percent moistures, and corrected conductivities.

There are many special error considerations which should be made with respect to the above methods and data. For instance, some sites were more challenging than others in the collection of peat samples. The peat samples taken at Degobah fen were taken where there was too much water at the surface. This made it difficult to get good solid peat samples at the correct increments. The peat samples taken at Cedar Swamp and Enchanted Forest were difficult also. These samples had to be taken where there were trees all around, and thus many roots in the peat. It was extremely difficult to find a place where it was possible to core down 30 cm without hitting a root that couldn't be sawed through. This also made getting a hand under the peat core for collection nearly impossible. It is doubtful that completely accurate depth increments at those sites were obtained. Forest Service Bog also may have some inaccuracies in depth increments. At that site, the dead sphagnum seemed to start deeper than usual. It is possible that the 0-5 cm increment contained some live sample.

The errors above are specific to different sites. General considerations also are important. Perhaps the largest error in the collection process came from the difficulty in getting a hand directly under the tube while collecting no extra peat from the lower depth increment. It often seemed that the 5-15 cm increment was not as large as it should have been, while the 0-5 cm increment was too large. Error in taking the peat core depth also was possible. In some sites the depth was sampled several times without ever obtaining a clay or sand core. This occurred at Cedar Swamp, Enchanted Forest, and Forest Service Bog. At those sites the peat core depth is uncertain and needs further testing.

There are some important considerations in the experimental portion of the analysis also. Many of the experiments involved use of the oven. Unfortunately, the oven provided did not have a working thermometer, and the setting for the heat had to be estimated. When a thermometer was found, and the temperature of the oven taken, it was found that the majority of the samples had been dried at 121oC. In addition to this problem, there were difficulties taking the conductivity of each depth increment. The sample may have been too small to get accurate readings. The reading for one sample appeared to vary as much as 20 uS/cm.

The majority of the time spent for the project was spent separating the peat into a useable mass. It was found that for maximum efficiency and time management, four sites could be analyzed at one time. Therefore, 24 peat bags were sorted through for each round of experiments. There were two rounds of experiments done during the summer.

In conclusion, the parameters examined in this study offer a starting point for future evaluation. A comparison of the physical and chemical factors along with the plant communities (Druckenbrod 1996) at each site provided sufficient data to make preliminary classifications of the peatlands. Future studies including hydrological factors and nutrient determinations could substantiate those classifications.

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SITE$	DEPTH$	AveragepH	StDevpH	AvePERMOIST	StDevPERMOIS
cedr	cm0-5	5.4	0.14142136	778.123773	89.0922335
cedr	cm5-15	5.4	0.14142136	858.662531	134.27352
cedr	cm15-30	5.5	0	835.88591	247.464258
dan	cm0-5	4.9	0	2435.32051	127.732494
dan	cm5-15	5.05	0.07071068	2241.13636	196.382838
dan	cm15-30	5.1	0	1666.24242	378.666395
dego	cm0-5	4.65	0.21213203	2244.41392	45.9748915
dego	cm5-15	4.45	0.35355339	1629.66389	529.752277
dego	cm15-30	4.5	0.28284271	1836.66667	164.991582
edbg	cm0-5	4.35	0.07071068	2073.75763	1323.59046
edbg	cm5-15	4.5	0.28284271	2227.29508	1135.19618
edbg	cm15-30	4.35	0.07071068	2129.7956	511.762974
ench	cm0-5	5.1	1.13137085	1284.45946	8.59994734
ench	cm5-15	5.75	0.49497475	1123.6128	297.282871
ench	cm15-30	6.05	0.21213203	1102.16912	44.6621121
fsbg	cm0-5	4.4	0.14142136	2267.69941	99.1907205
fsbg	cm5-15	4.3	0	2707.01122	383.412788
fsbg	cm15-30	4.4	0.14142136	2764.50893	151.838554
nih	cm0-5	4.8	0	1628.80435	641.776263
nih	cm5-15	4.8	0.14142136	1005.55952	288.179685
nih	cm15-30	4.9	0	1098.33333	266.343554
sarh	cm0-5	4	0.14142136	1784.01387	504.726065
sarh	cm5-15	4.15	0.07071068	1758.33656	203.351327
sarh	cm15-30	4.2	0.14142136	1870.19191	63.2177652

Figure 1: Table comparing depth increments with variables of pH, percent moisture, bulk density, percent rubbed fiber, corrected conductivity, and conductivity. Bulk density is measured in g/cm and conductivities are given in umhos/cm.

Figure 1

SITE$	DEPTH$	AveBULKDEN	StDevBULKDEN	AvePERRUB	StDevPERRUB
cedr	cm0-5	0.11821282	0.03026389	15.9987847	2.25406389
cedr	cm5-15	0.07655593	0.01642304	14.7826262	3.47386334
cedr	cm15-30	0.09121977	0.02055942	6.89795267	0.11709966
dan	cm0-5	0.03042811	0.004452	64.4382487	9.12741775
dan	cm5-15	0.02066045	0.00047286	53.5152932	10.4735159
dan	cm15-30	0.02313303	0.00328867	32.8877939	7.97986246
dego	cm0-5	0.03096978	0.00793493	58.459365	6.72710391
dego	cm5-15	0.02416561	0.02070124	64.8863096	1.85776936
dego	cm15-30	0.01605885	0.00774438	66.0996847	10.183617
edbg	cm0-5	0.02504929	0.00106607	65.3363419	4.26831879
edbg	cm5-15	0.0150521	0.0058422	64.5543971	14.518769
edbg	cm15-30	0.02253409	0.00995941	44.9040503	2.86737344
ench	cm0-5	0.08183881	0.0033167	36.2407598	17.9545028
ench	cm5-15	0.0458914	0.0206753	23.1606188	9.10076379
ench	cm15-30	0.04498226	0.01204053	15.4053683	7.61030974
fsbg	cm0-5	0.0363234	0.00804383	80.429406	2.53070093
fsbg	cm5-15	0.02188159	0.00746665	69.5457966	10.3668249
fsbg	cm15-30	0.02503265	0.00653087	54.1302089	15.0866301
nih	cm0-5	0.05110898	0.01526401	39.5731184	16.2564419
nih	cm5-15	0.0656002	0.02221402	19.7259191	1.49442435
nih	cm15-30	0.04464724	0.01114499	19.0089233	0.8099333
sarh	cm0-5	0.03321327	0.00913101	64.8573459	4.31192323
sarh	cm5-15	0.01925527	0.00283265	60.7014863	1.23303045
sarh	cm15-30	0.02812486	0.0092549	47.9384741	0.59251689

Figure 1: Table comparing depth increments with variables of pH, percent moisture, bulk density, percent rubbed fiber, corrected conductivity, and conductivity. Bulk density is measured in g/cm and conductivities are given in umhos/cm.

Figure 1

SITE$	DEPTH$	AveCORRCOND	StDevCORRCON	AverageK	StDevK
cedr	cm0-5	43.9607	6.1644155	42.7	5.51543289
cedr	cm5-15	38.8194333	0.15806194	38.1	0.14142136
cedr	cm15-30	36.08115	1.34352645	35.65	1.20208153
dan	cm0-5	18.1015	5.37410582	23.5	4.80832611
dan	cm5-15	20.9162333	2.39171798	24.9	1.69705627
dan	cm15-30	15.9573167	3.39833162	20.15	3.04055916
dego	cm0-5	10.1279	9.89544086	19.9	5.37401154
dego	cm5-15	6.49853333	2.93227754	22.2	6.92964646
dego	cm15-30	5.5573	8.53105475	19.3	0.98994949
edbg	cm0-5	9.03683333	14.2421677	25.5	10.4651804
edbg	cm5-15	10.6985667	19.7534522	23.9	11.0308658
edbg	cm15-30	5.125	9.02612378	22	5.79827561
ench	cm0-5	15.7832744	9.23725172	26.3	2.96984848
ench	cm5-15	30.9240239	2.91303717	32.35	2.75771645
ench	cm15-30	34.304255	9.03788454	35.55	8.55599205
fsbg	cm0-5	3.78970889	5.57118905	20.2	0.98994949
fsbg	cm5-15	14.902875	21.8851254	33.75	20.7182287
fsbg	cm15-30	5.69108889	7.21444078	22	2.54558441
nih	cm0-5	24.5845983	0.22407978	31.65	0.21213203
nih	cm5-15	24.6958628	0.71807872	31.85	1.06066017
nih	cm15-30	31.7000028	6.6477002	37.25	6.29325035
sarh	cm0-5	0	0	21.55	1.06066017
sarh	cm5-15	22.1357539		47.65	32.5976226
sarh	cm15-30	0	0	22.7	0.28284271

Figure 1: Table comparing depth increments with variables of pH, percent moisture, bulk density, percent rubbed fiber, corrected conductivity, and conductivity. Bulk density is measured in g/cm and conductivities are given in umhos/cm.

Figure 2

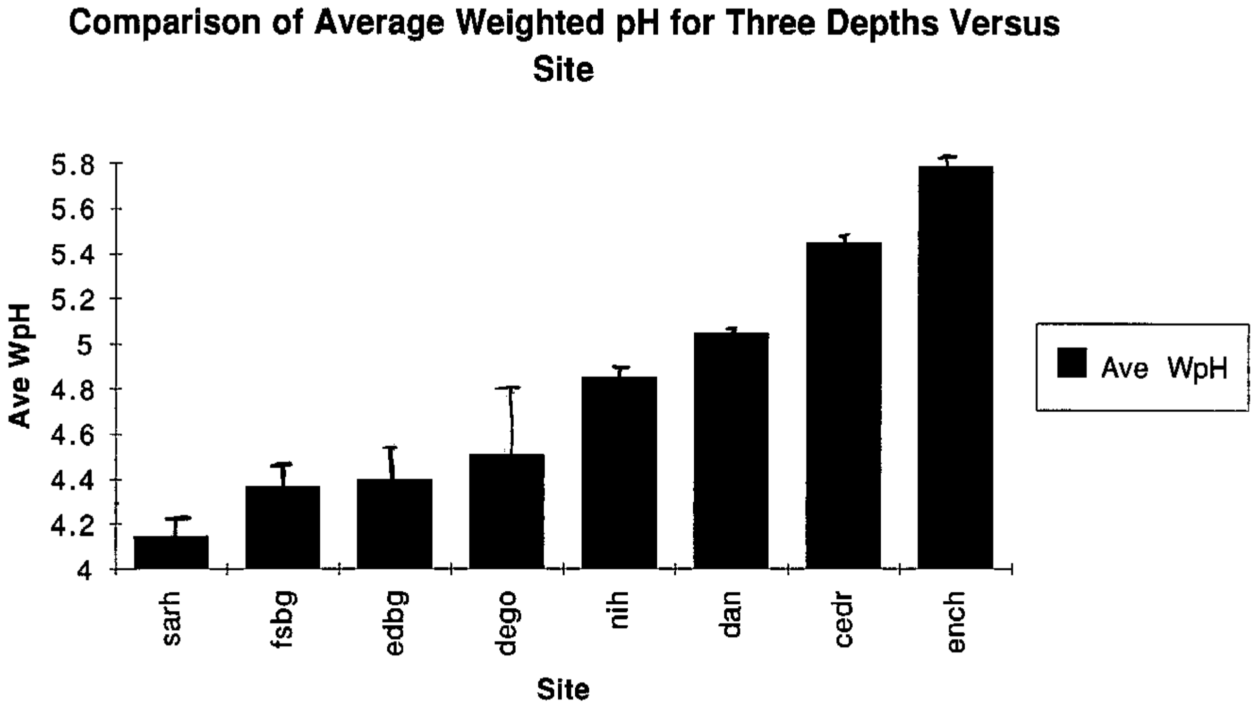

Figure 2: Chart comparing pH by site.

Figure 3

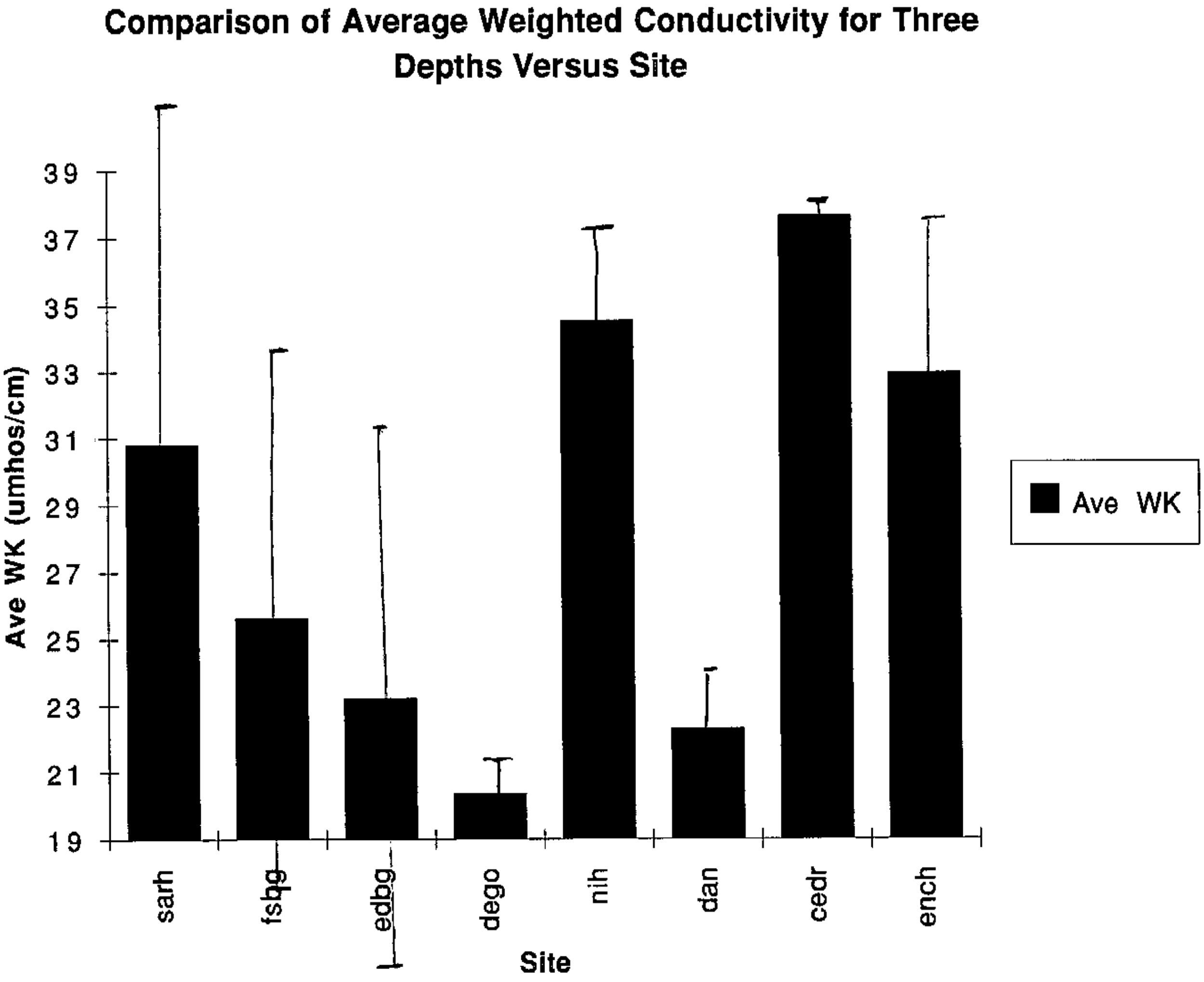

Figure 3: Chart comparing conductivity by site.

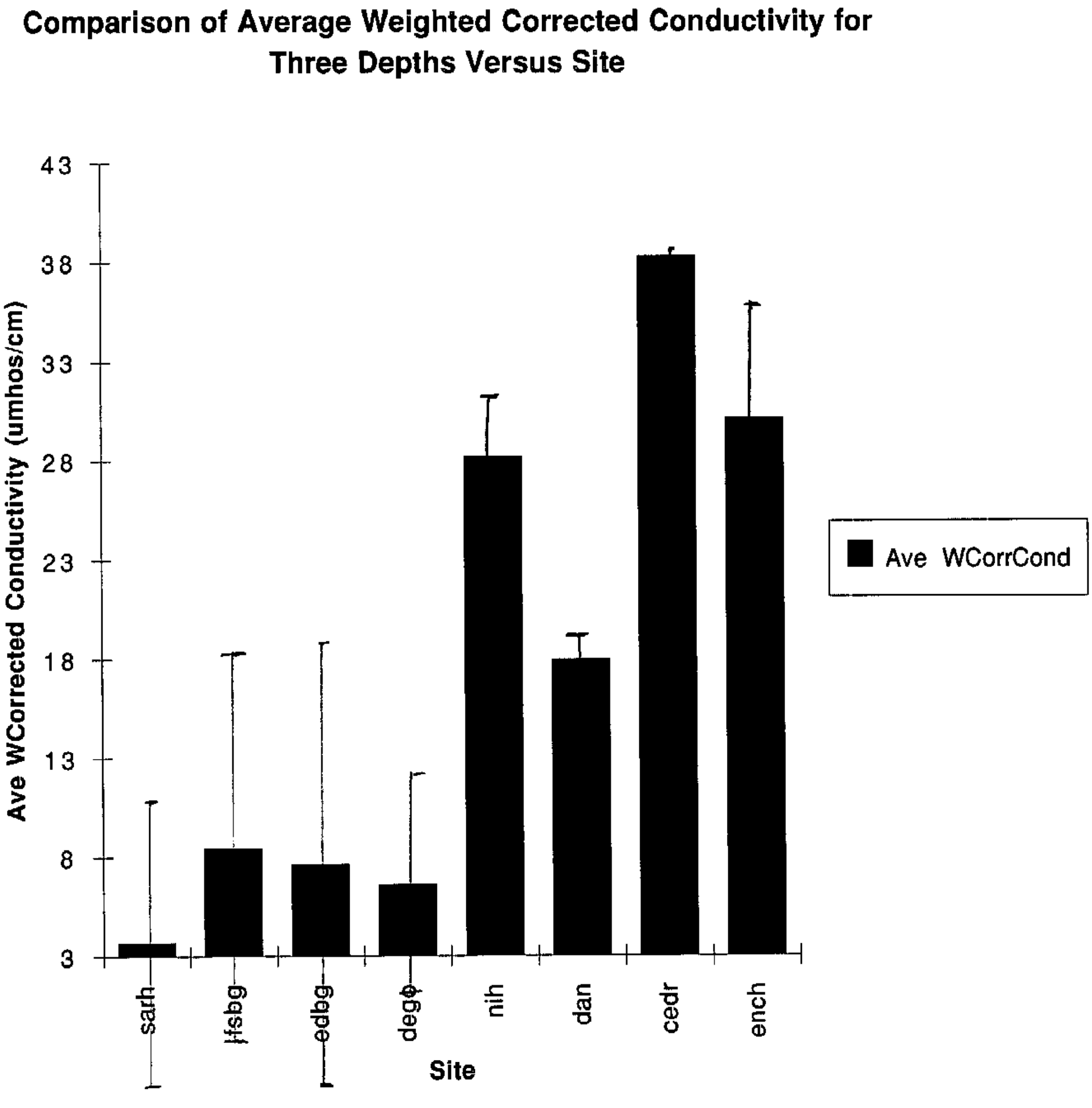

Figure 4: Chart comparing corrected conductivity by site.

Figure 5

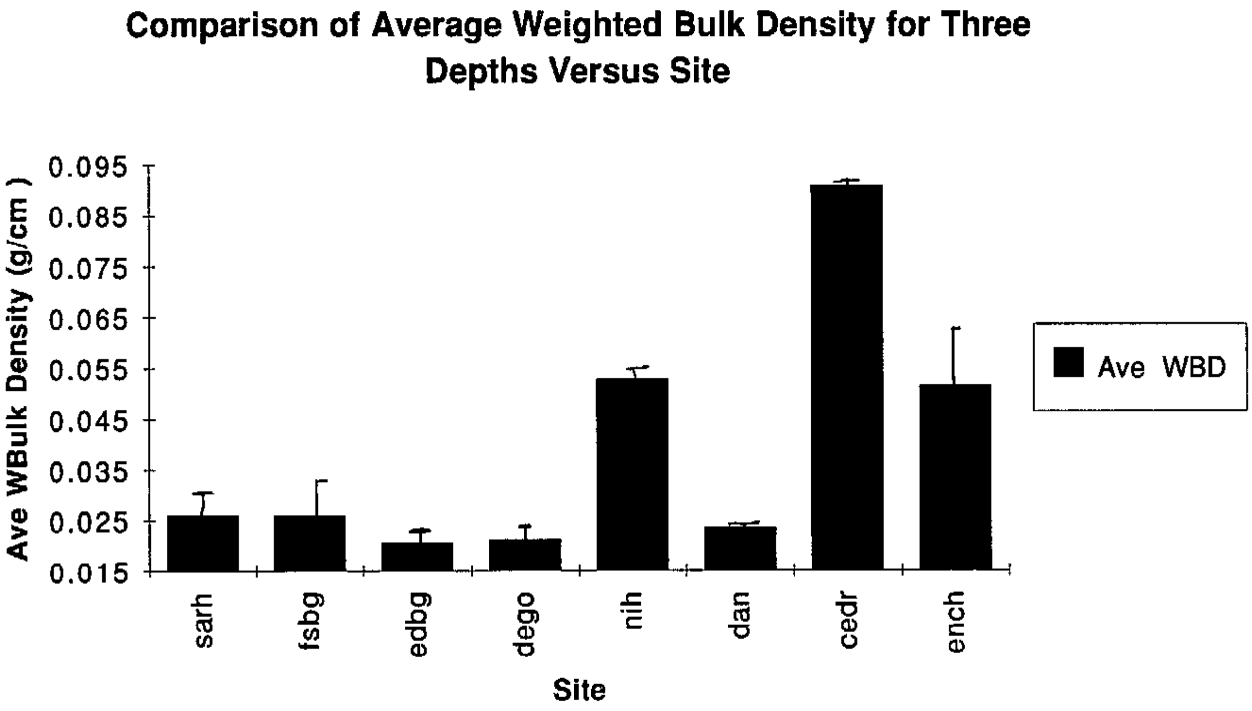

Figure 5: Chart comparing bulk density by site.

Figure 6

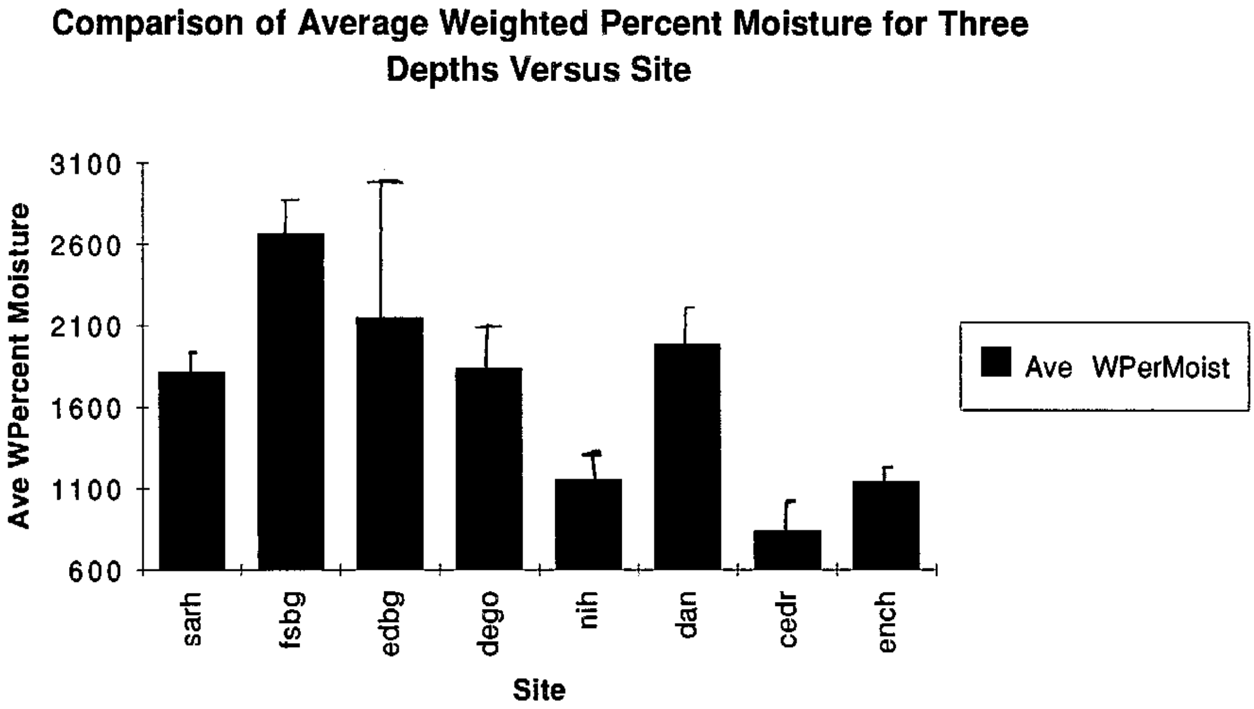

Figure 6: Chart comparing percent moisture by site.

Figure 7

SITE$	Ave WpH	StDev WpH	Ave WK	StDev WK	Ave WPerMois	StDev WPerMo
sarh	4.15	0.07071068	30.825	10.9012295	1818.54378	120.295904
fsbg	4.366667	0.0942809	25.6166667	8.34386002	2662.54144	187.191753
edbg	4.4	0.14142136	23.2166667	8.32028979	2152.95576	854.878624
dego	4.508333	0.29462783	20.3666667	0.91923882	1835.62362	251.417402
nih	4.85	0.04714045	34.5166667	2.82842712	1155.82057	144.074593
dan	5.05	0.02357023	22.2916667	1.75598184	1986.05342	233.505394
cedr	5.45	0.02357023	37.6416667	0.2710576	833.851094	153.641263
ench	5.791667	0.45961941	32.9416667	4.70226009	1139.69873	78.1965587
SITE$	Ave WBD	StDev WBD	Ave WCorrCor	StDev WCorrCond		
sarh	0.026016	0.00404983	3.6881325	8.43929652		
fsbg	0.025864	0.00709495	8.44478759	11.8307937		
edbg	0.020459	0.00285462	7.63482778	13.4712406		
dego	0.021246	0.00170573	6.63281111	6.89219337		
nih	0.052709	0.01552117	28.1793887	3.6005563		
dan	0.023525	0.00074471	17.9676528	1.79761079		
cedr	0.090831	0.00023862	38.3071694	0.30295204		
ench	0.051428	0.01346482	30.0906812	7.02949661		

Figure 7: Table showing comparison of different parameters with site. Conductivity is recorded in umhos/cm and bulk density is g/cm .

SITE$	REP	DEPTH$	MUNSELL$	PERRUB	SOIL$
cedr	1	cm0-5	s7/4	14.4049208	Sapric
cedr	1	cm5-15	s6/4	12.3262338	Sapric
cedr	1	cm15-30	s6/4	6.98075464	Sapric
cedr	2	cm0-5	s7/4	17.5926486	Sapric
cedr	2	cm5-15	s6/4	17.2390185	Sapric
cedr	2	cm15-30	s6/4	6.81515071	Sapric
dan	1	cm0-5	s8/1	70.8923077	Fibric
dan	1	cm5-15	s8/2	46.1093991	Fibric
dan	1	cm15-30	s7/3	27.2451791	Hemic
dan	2	cm0-5	s8/3	57.9841897	Fibric
dan	2	cm5-15	s8/1	60.9211873	Fibric
dan	2	cm15-30	s8/3	38.5304088	~Fibric
dego	1	cm0-5	s8/2	63.2161458	Fibric
dego	1	cm5-15	s8/2	63.5726683	Fibric
dego	1	cm15-30	s7/2	58.8987801	Fibric
dego	2	cm0-5	s8/1	53.7025843	Fibric
dego	2	cm5-15	s8/2	66.1999509	Fibric
dego	2	cm15-30	s8/3	73.3005894	Fibric
edbg	1	cm0-5	s8/1	62.3181848	Fibric
edbg	1	cm5-15	s8/1	74.8207171	Fibric
edbg	1	cm15-30	s8/2	46.9315895	Fibric
edbg	2	cm0-5	s8/2	68.3544991	Fibric
edbg	2	cm5-15	s8/3	54.2880771	Fibric
edbg	2	cm15-30	s8/3	42.8765111	Fibric
ench	1	cm0-5	s8/3	48.9365105	Fibric
ench	1	cm5-15	s7/3	29.5958306	Hemic
ench	1	cm15-30	s7/3	20.78667	Hemic
ench	2	cm0-5	s8/2	23.5450092	
ench	2	cm5-15	s7/3	16.725407	~Hemic
ench	2	cm15-30	s7/3	10.0240667	
fsbg	1	cm0-5	s8/1	82.2188818	Fibric
fsbg	1	cm5-15	s8/2	76.8762488	Fibric
fsbg	1	cm15-30	s8/2	64.7980674	Fibric
fsbg	2	cm0-5	s8/1	78.6399303	Fibric
fsbg	2	cm5-15	s8/2	62.2153444	Fibric
fsbg	2	cm15-30	s8/2	43.4623505	Fibric
nih	1	cm0-5	s8/2	51.0681587	Fibric
nih	1	cm5-15	s8/3	20.7826367	
nih	1	cm15-30	s7/3	18.436214	Hemic
nih	2	cm0-5	s7/3	28.0780781	Hemic
nih	2	cm5-15	s7/3	18.6692015	Hemic
nih	2	cm15-30	s7/4	19.5816327	
sarh	1	cm0-5	s8/2	61.8083558	Fibric
sarh	1	cm5-15	s8/3	59.8296021	Fibric
sarh	1	cm15-30	s8/2	48.3574468	Fibric

Figure 8: Table showing the classification of soils based on percent rubbed fiber and the Munsell Chart

Corrections and Reporting

(1) If conductivity is measured at a temperature other than 25°C, correct the measured value to 25°C with the following formula:

$$L_{25} = \frac{L_t}{1 + .02\ \Delta t}$$

where L_{25} = conductivity at 25°C;

L_t = conductivity at measured temperature;

and Δ_t = difference between measured temperature and 25°C.

If L_t above 25°C, then Δt is + .

If L_t below 25°C, then Δt is - .

(2) If the pH of the supernatant or expressed water is 5.1 or lower, correct L_{25} by subtracting conductivity owing to hydrogen ions, as follows:

pH	H^+ (µmhos/cm at 25°C)
2.5	1106.7
2.6	879.2
2.7	698.2
2.8	554.8
2.9	440.3
3.0	350.0
3.1	278.0
3.2	220.8

Figure 10

pH	H⁺ (μmhos/cm at 25°C)
3.3	175.5
3.4	139.3
3.5	110.7
3.6	87.9
3.7	69.8
3.8	55.5
3.9	44.0
4.0	35.0
4.1	27.8
4.2	22.1
4.3	17.5
4.4	13.9
4.5	11.1
4.6	8.8
4.7	7.0
4.8	5.6
4.9	4.4
5.0	3.5
5.1	2.8

Report as L_{25}, H^+ corr. if these corrections are applied to any of the values in a set of values.

(3) Report conductivity either in micromhos/cm (μmhos/cm) at 25°C, or millimhos/cm (mmhos/cm) at 25°C.*

e.g. 1.620 mmhos/cm = 1,620 μmhos/cm; and
335 μmhos/cm = 0.335 mmhos/cm

Indicate with results whether air-dry or field-moist peat samples were used.

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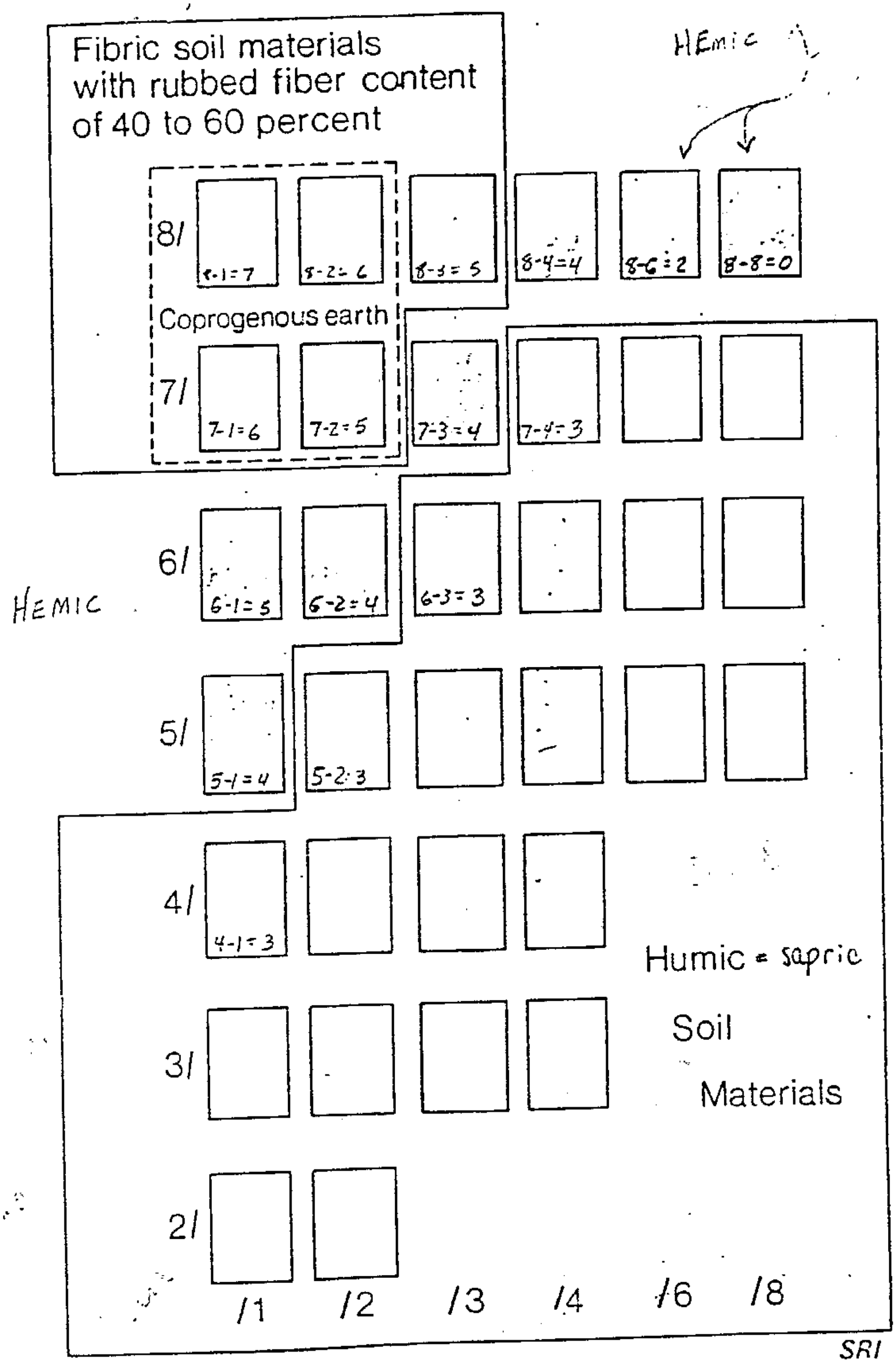
* In the metric system, 'mhos' are termed 'siemens', (S). Hence, μmhos/cm = μS/cm, and mmhos/cm = mS/cm.

Fig - 10



SKETCH OF 10 YR MUNSELL COLOUR CHART SHOWING THE SODIUM PYROPHOSPHATE EXTRACT COLOUR SEPARATIONS (FOR FIBRIC, MESIC, AND HUMIC MATERIALS) (Anonymous, 1974).

Figure 11