ABSTRACT

Title of Document: REDOXIMORPHIC FEATURES INDUCED BY ORGANIC AMENDMENTS AND SIMULATED WETLAND HYDROLOGY

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During wetland construction, it is common to add organic amendments to the soil, although little research has evaluated the effects of organic additions on the development of redoximorphic features. The objective of this study was to evaluate the effects of adding different types of organic materials, using different methods of incorporation, on the formation of redoximorphic features under hydric soil conditions. Five types of organic materials were incorporated into soil cores lacking redoximorphic features, using three incorporation methods. Cores were established as mesocosms in a controlled greenhouse environment or transplanted into a natural wetland. Mesocosms were periodically dissected and examined for newly formed redoximorphic features. The method of incorporating organic materials had a significant influence on the development of redoximorphic features, but the type of organic material had no significant effect. Organic materials should be concentrated into deeper zones during wetland construction to maximize development of redoximorphic features.

REDOXIMORPHIC FEATURES INDUCED BY ORGANIC AMENDMENTS AND SIMULATED WETLAND HYDROLOGY

by

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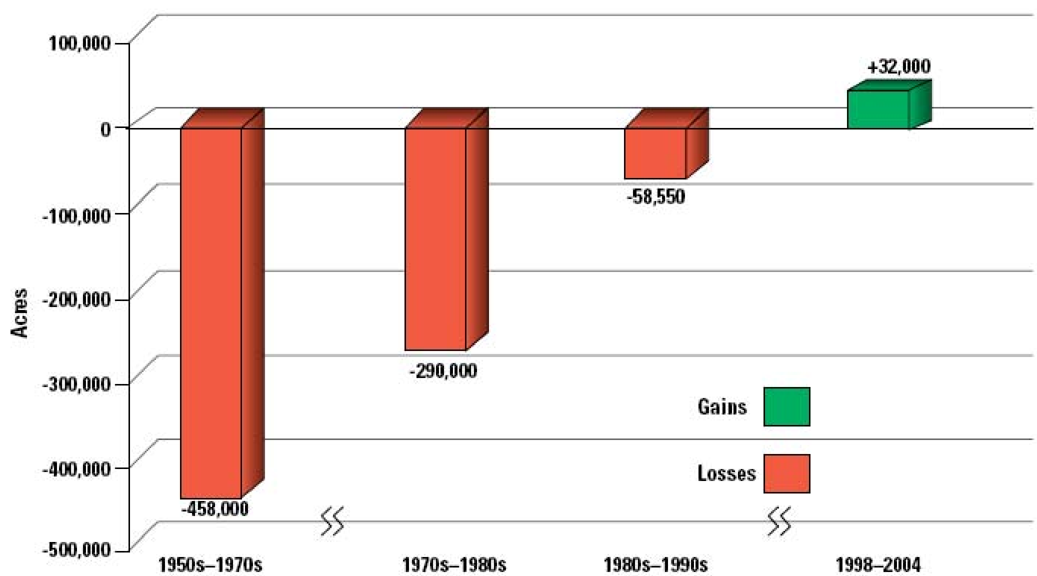
I. Introduction

The United States government defines wetlands as, "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal conditions do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (Federal Register, 1980). Rooted in this definition are the three fundamental characteristics of wetlands: hydrology, hydrophytic vegetation, and hydric soils (Cowardin et al, 1979). Hydrology is important in any landscape, but critical to wetland ecosystems (Mitsch and Gosselink, 1993). The term "wetland" even implies wet hydrology (Richardson et al, 2001), and can be thought of as water at or near soil surface for extended periods (Environmental Laboratory, 1987). However, hydrology alone is not enough to define a wetland. If that was the case, ponds, rivers, and lakes would be called wetlands. The plants that colonize wetlands and supporting soils must also be representative. Plants communities within wetlands are very unique, and are used to help identify wetlands (Environmental Laboratory, 1987). The indicative species within wetlands are called hydrophytic (water-plant) species and can be summarized as plant life that occurs in areas where soil saturation is of sufficient duration to exert a controlling influence on the plant species present (Environmental Laboratory, 1987).

Soils are the third recognized component of wetlands. Much like plants, soils within wetlands are very unique (USDA-NRCS, 2006), and are referred to as hydric soils. The concept of hydric soils was developed by observing the connections between wetland soils, hydrology, and vegetation (Mausbach and Parker 2001). The term "hydric soil" is defined as "a soil formed under conditions of saturation, ponding, or flooding long enough during the growing season to develop anaerobic conditions in the upper part" (Federal Register, 1995). Hydric soils have distinct morphological characteristics that are long-term indicators of wetland conditions (Cowardin et al, 1979). These morphological characteristics include gleying of the soil matrix, iron oxide concentrations and depletions (redoximorphic features), and organic matter accumulation. Under most natural wetland conditions, these morphological characteristics have been combined into hydric soil morphological indicators (USDA-NRCS, 2006). These indicators are characteristics that are sufficiently robust to provide "proof positive" evidence that a hydric soil is present and are used by trained wetland professionals to identify a hydric soil simply by making a few quick observations.

The three necessary components of wetlands (hydrology, hydrophytic vegetation, and hydric soils) constitute a very important ecosystem. Wetland ecosystems provide critical habitat for plants and animals, improve water quality, are reservoirs for flood waters, enhance erosion control, as well as many other important functions (Mitsch and Gosselink, 1993). Despite the importance of these functions, the value of wetlands was not always appreciated, and as a result, wetlands were not well protected in the United States. Non-tidal wetlands first became protected upon the introduction of section 404 (navigable water of the U.S.) of the Clean Water Act in 1977. The lack of federal protection before 1977 resulted in huge wetland loss (Figure 1.1). Most of these losses were the result of wetlands being converted to more profitable agricultural production or urban development (Shaw and Fredine, 1956). Despite federal protection, wetland areas continued to be lost in the 1980s and 1990s, although at a much slower rate. It was not until recently (1998-2004), that a net gain in wetland acreage was realized (Figure 1.1). The gain was attributed to small agricultural areas being converted to wetland ecosystems by wetland creation (construction of a wetland in an area where one did not previously exist) and restoration (re-establishment of natural wetland functions and characteristics to a historic wetland) efforts (Dahl, 2006).

Figure 1.1 Average annual net gain and loss estimates for the United States from 1954 to 2004 (Dahl, 2006). It shows that substantial wetland acres were lost in the past, but are recently accruing.



The goal of wetland creation and restoration is to replace the chemical, physical and biological functions of lost wetlands (Federal Register, 1995). However, it has been argued that created wetlands do not replace many key functions that occur in natural wetland systems (Kentula, 2000), and as a result, created wetlands are often scrutinized and compared to natural wetlands (Bishel-Machung et al, 1996; Stauffer and Brooks, 1997; Stolt et al, 2000; Campbell et al, 2002; Edwards and Proffitt, 2003, Bruland and

Richardson, 2004). These studies argue that some of the most significant differences between created and natural wetlands are soil properties. Soils in created wetlands often have lower organic matter content, higher bulk density, and far less development of redoximorphic morphology. These soil properties are significant because without suitable soil conditions, constructed wetlands may not function like natural wetlands (Bruland and Richardson, 2004), and therefore perhaps should not be considered adequate replacements.

The development and presence of redoximorphic features in created wetlands would indicate that they are progressing toward becoming more like a natural wetland. Redoximorphic features are a common type of hydric soil characteristic and are indicative of prolonged soil wetness. However, redoximorphic features and other hydric soil characteristics can be slow to form within created wetlands and thus are difficult to compare to natural wetland soils that have had many years to develop (Stolt et al, 2000; Campbell et al, 2002; Bruland and Richardson, 2004).

Organic matter has a critical role in the development of redoximorphic features in created and natural wetlands. Organic matter in wetlands is oxidized by microbial organisms to create a reducing biogeochemical environment (Craft, 2001) that allows for the redistribution of iron and manganese oxides that constitute redoximorphic features (Verpraskas, 2001). In an effort to increase the level of organic matter in created wetlands organic materials are often added to the soil during wetland construction (Hayes et al, 2000). These organic additions have the effect of decreasing bulk density, increasing water holding capacity, and serving as an energy source for respiring soil fauna and microbial populations (Craft, 2001). As a result, adding organic materials during wetland construction is thought to be essential.

Because organic matter is essential to the development and evolution of redoximorphic features in soils (Craft, 2001), it is thought that adding organic materials during wetland construction may affect the development redoximorphic features. However, very little research has focused on how these organic additions might affect the formation of redoximorphic features. As a result, it is unclear if the type of organic material (leaves or hay) used in constructed wetlands effects the development of redoximorphic features. The type of organic material added may affect the development of redoximorphic features because different organic materials have different properties (C:N ratio and lignin content) that cause them to be decomposed by microbial organisms at different rates (Vanlauwe et al. 1996; Nicolardot, 2001; de Neiff et al, 2006). The microbial activity associated with the decomposition of different organic materials can have different effects on wetland biogeochemistry (Beauchamp et al, 1989; Vera, 2001), and as a result, could affect the development of redoximorphic features.

Also, little research has focused on the best way to incorporate organic materials into constructed wetlands to maximize the formation and expression of redoximorphic features. The incorporation method (placing on the soil surface or plowing in) may be significant because it influences the physical location of the organic materials. Redoximorphic features have been shown to concentrate in localized areas near decomposing organic materials, most notably in soil horizons with higher organic carbon content and near decaying root matter left behind from plant senescence (Vepraskas, 1992). Thus the placement of the organic materials during wetland construction activities could have an effect on the development of redoximorphic features.

Based on the previous research and reasoning presented above, the following objectives and hypotheses have been developed.

Objectives

1. To evaluate the effect of adding different types of organic materials to soils, on the formation of redoximorphic features under induced hydric soil conditions over time.
2. To evaluate the effect of different methods of incorporating organic materials into the soil, on the formation of redoximorphic features under induced hydric soil conditions over time.
3. To evaluate the formation of redoximorphic features in a field wetland setting and to compare the results with results generated in a greenhouse setting.
4. To develop recommendations regarding types of organic materials to be used and methodology for incorporation during wetland creation/restoration efforts.

Hypotheses

It is hypothesized that; 1) Incorporating different types of organic materials, into a soil under induced hydric conditions, will result in different expressions (size, quantity, contrast) of redoximorphic features over time. 2) Using different physical arrangements when incorporating organic materials into soils that are subjected to induced hydric conditions, will result in different expressions (size, quantity, contrast) of redoximorphic features over time.

II. Background

Biogeochemistry in Wetland Soils

The chemistry of wetland soils has been extensively studied in the past (Ponnamperuma, 1972; Mcbride, 1994; Sparks, 1995; and Kirk, 2004). These studies show that the biological and chemical functions of wetlands are controlled by microbially mediated oxidation and reduction reactions. The chemistry within wetland soils is different from terrestrial soils because terrestrial soils have access to atmospheric oxygen. This is significant because oxygen is the preferred electron acceptor for heterotrophic microorganisms. In saturated wetland systems, oxygen is not easily available. When oxygen is depleted from the soil environment, such as in wetland soils, aerobic heterotrophic microorganisms can no longer proliferate. Under these oxygen limited environments, anaerobic heterotrophic microorganisms can use electron acceptors other than oxygen for respiration. Alternate electron acceptors for these anaerobic microorganisms are NO_3-, MnO_2, $Fe(OH)_3$, SO_4^{-2}, and CO_2 (Ponnamperuma, 1972). Figure 2.1 lists these electron acceptors in their corresponding reducing half reactions (oxidation half reaction always involves an organic substrate) (Vepraskas and Faulkner, 2001), and shows that the electron acceptors are used by microbes in a sequenced order (Mitsch and Gosselink, 1993). As one electron acceptor begins to become depleted, microbes begin to use the next on the list, if available. For example, once NO_3- is depleted from the soil, MnO_2 may be used as an electron acceptor. The potential for these reduction reactions to take place can be estimated or predicted using the concepts of Eh and pH. Eh is a voltage that can be used to predict the stability of types of reduced or oxidized species (when plotted against soil pH) in the soil solution (Vepraskas and Faulkner, 2001). Eh is typically measured as voltage difference between a platinum tipped electrode and a known reference electrode (Mansfeldt, 2003).

Figure 2.1 Sequence of reducing half reactions that occur in listed order within wetland soils. Modified from Vepraskas and Faulkner, 2001.

$$6O_2 + 24e^- + 24H^+ \rightarrow 12H_2O$$

$$\Downarrow$$

$$2NO_3- + 10e^- \ 12H^+ \rightarrow N_2 + 6H_20$$

$$\Downarrow$$

$$MnO_2 + 2e^- + 4H^+ \rightarrow Mn^{2+} + 2H_2O$$

$$\Downarrow$$

$$Fe(OH)_3 + e^- + 3H^+ \rightarrow Fe^{2+} + 12H_2O$$

$$\Downarrow$$

$$SO_4^{2-} + 8e^- + 10H^+ \rightarrow H_2S + 12H_2O$$

$$\Downarrow$$

$$CO_2 + 8e^- + 8H^+ \rightarrow CH_4 + 12H_2O$$

Figure 2.2 shows an example of an Eh/pH diagram. These lines were derived using equations of chemical equilibrium (Nernst equation), and are dependent on a number of assumptions such as activity of a particular chemical species, temperature, and partial pressure (Vepraskas and Faulkner, 2001). These theoretical lines are useful in comparing mineral stability and Eh changes with respect to pH. The lines represent the threshold at which a particular chemical or mineral phase changes from oxidized to reduced, which may also include phase changes from solid to soluble. For example, if the Eh/pH values plot above the line for a specific chemical or mineral phase shown in

Figure 2.2 Example of an Eh/pH diagram showing mineral stability thresholds. These threshold equations were derived from the Nernst equation and assumes an ion activity of 10-6. When Eh/pH values plot above the lines, the corresponding minerals are stable. However, when the values plot below the lines the minerals are not stable and their ions are available to soil solution. The technical standard is significant in this diagram because this is the threshold that determines anaerobic and aerobic conditions for hydric soil determination (Courtesy of M.C. Rabenhorst).

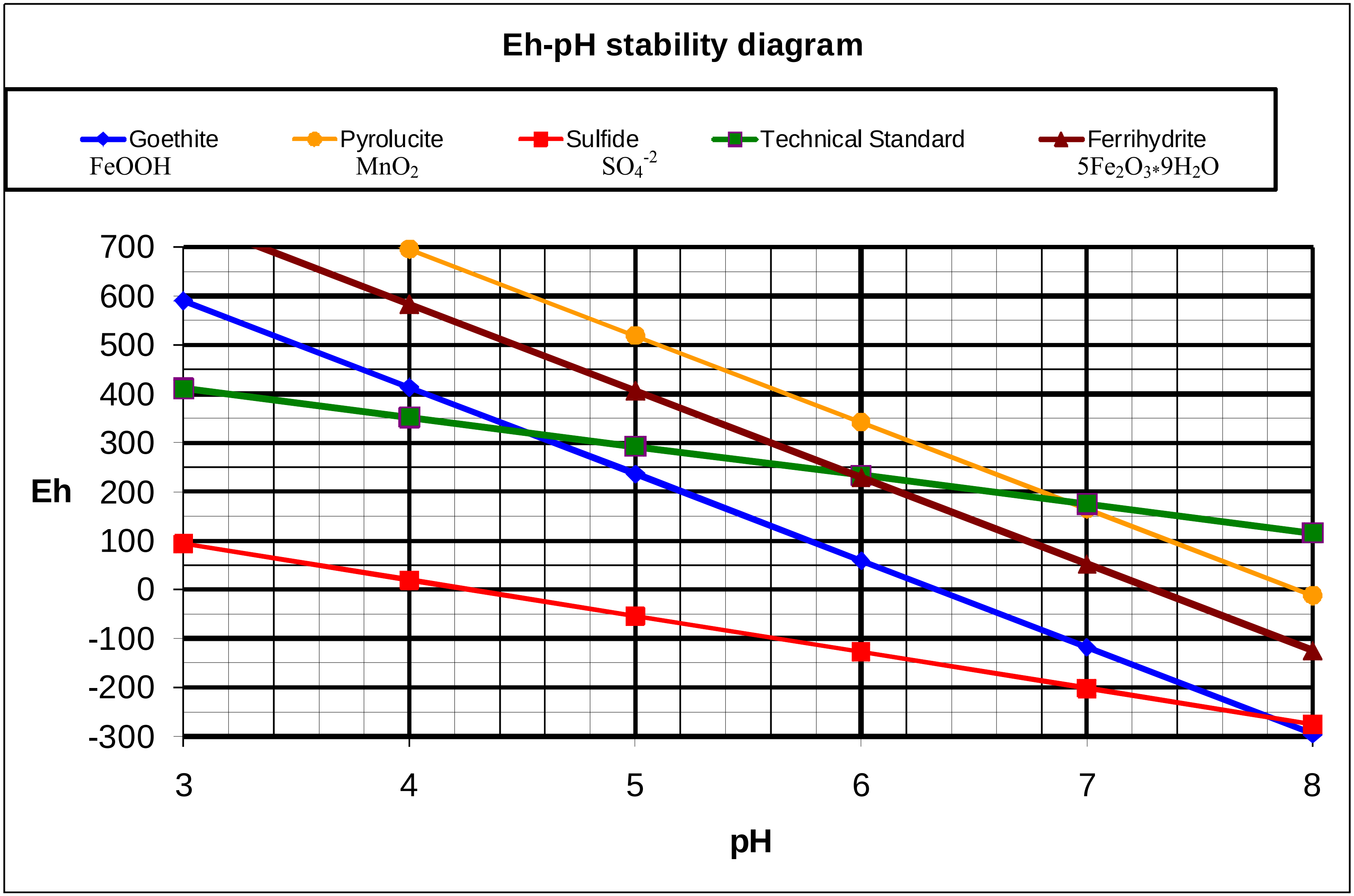


Figure 2.2, then the oxidized phase is predicted to be stable under those conditions. Alternately, if the values plot below the line, the mineral's phase is predicted to be reduced and in some cases, solid phases become soluble.

Much like a mineral stability line, the National Technical Committee on Hydric Soils (NTCHS) has developed a technical standard line (shown in Figure 2.2) that it is used to separate aerobic (oxidizing) and anaerobic (reducing) soil conditions for hydric soil determination (NTCHS, 2006). The technical standard line was developed by comparing field observations of reduced iron to Eh/pH measurements. According to the technical standard adopted by the NTCHS, in order for a soil to be considered hydric, it must simultaneously demonstrate reducing and saturated conditions in the upper part for 14 consecutive days, in most years (NTCHS, 2006).

Factors Affecting Reducing Conditions and Redoximorphic Features in Hydric Soils

There are many factors that affect the transition between aerobic and anaerobic conditions in soils. Vepraskas and Faulkner (2001) conclude that for a soil to become anaerobic it must have: 1) saturated hydrology, 2) oxidizable organic matter, and 3) an active microbial population.

Saturated Hydrology

Hydrology is recognized as one of the controlling components affecting reducing conditions in wetland soils. However, wetland hydrology can be dynamic and difficult to observe, and as a result, soil morphology is often used to show wetland hydrology (USDA-NRCS, 2006). The Army Corp of Engineers has developed hydrology indicators that can be used to identify “wetland hydrology” for wetland identification (Environmental Laboratory, 1987). These indicators include observation of inundation or soil saturation, water marks, drift lines, sediment deposits, and drainage patterns.

Hydrology for hydric soil determination is different. According to the technical standard adopted by the NTCHS, in order for a soil to be considered hydric, it must simultaneously demonstrate reducing and saturated conditions in the upper part for 14 consecutive days, in most years. (NTCHS, 2006). The technical standard was designed to capture the relationship between hydrology, the onset of reducing conditions, and the time required under normal conditions to exert a controlling influence on the soil environment. It was developed because there are many problem settings (Vepraskas and Sprecher eds., 1997), such as in newly constructed or restored wetlands (Campbell et al, 2002), sandy soils with low organic carbon and low in content of iron oxide minerals (Kuehl et al, 1997), or very dark soils subjected to seasonally saturated conditions (Bell and Richardson, 1997), where common hydric soil morphology (USDA-NRCS, 2006) is less easily used as an indicator of the saturated conditions.

In non-problem settings, it has been well documented in field studies that redoximorphic features are representative of hydrology (Rabenhorst et al, 1998). More recent research has attempted to relate the abundance of redoximorphic features to water table duration (Fielder and Sommer, 2004; D’Amore et. al, 2004; Morgan and Stolt, 2006). These studies reveal that in most soils there is good correlation between abundance of redoximorphic features and soil saturation time, but the specific saturation time required for soils to develop various redoximorphic features is dependent on many site specific conditions. It is generally understood that it takes less saturation time for redox concentrations to form than redox depletions. A summary of redoximorphic features and saturation time completed by Morgan and Stolt (2006) showed redox concentrations can form in finer texture soils that are saturated on average for just 2% of the year and in coarser textures soils 30% of year. The study also showed that redox depletions formed in finer textured soils that were saturated on average 19% of the year and coarser textured soils 32% of the year.

Soil Organic Matter

Soil organic matter refers to the sum of all organic substrates (Collins and Kuehl, 2001), and is comprised of plant and animal residues in various stages of decomposition. Organic matter has many important functions in soils which include reducing soil bulk density, increasing water holding capacity, releasing and retaining nutrients, increasing cation exchange capacity, and providing an energy source for respiring microorganisms (Tate, 1987).

In unsaturated soils, organic matter decomposition is dominantly regulated by temperature and moisture (Donnelly et al, 1990). Jenny (1950) showed that for each 10°C rise in mean annual temperature, soil organic matter content decreased 2 to 3 times. In wetland soils, organic matter content is similarly regulated by temperature and moisture (saturated conditions). However, soil organic matter accumulates in much greater quantities in wetland settings because anaerobic decomposition of plant residues is much slower (Collins and Kuehl, 2001).

During plant and root growth, small amounts of plant tissue are normally sloughed off in the soil, and are available for microbial and fungi consumption. Plant tissue residue has been divided into three components by Craft (2001): (1) sugars and amino acids, (2) cellulose and hemicellulose, and (3) lignin, which are listed in decreasing ease of decomposition. Therefore, the decay of plants residues can be linked to their relative proportions of soluble components, cellulose, hemicellulose, and lignin (Benner et al, 1985; Moran et al, 1989; Vanlauwe et al., 1996). It has been demonstrated that C:N ratio also has a significant effect on plant decomposition (Iritani and Arnold, 1960; Trinsoutrot et al., 2000; Nicolardot, 2001; Jensen et al, 2005). These studies show that as C:N ratio increases, the decomposition rate of plant residues decreases.

The addition of different types of plant tissues under anaerobic conditions has been linked with anaerobic biogeochemical activity. In a summary of organic matter's role in denitrification, Beauchamp et al.(1989) concluded that organic carbon availability during plant decomposition is one of the most important factors affecting denitrifying activity in soil. Vera (2001), showed that unrefined chitin, rather than corn crop residue or wood chips was the best electron donor to degrade Non-Aqueous Phase Liquids in anaerobic groundwater. Although this study was not completed under wetland conditions, the reduction/oxidation processes are similar between the two ecosystems. Thus, the ease with which microbes can extract energy from organic matter is often dependent on its chemical composition. As a result, organic matter with varying components could affect the development of anaerobic conditions in soils.

Microbial Ecology

It is recognized that microbial communities are an important component of soil ecology, are very diverse, and readily adapt to changes in environmental conditions. Microorganisms are also recognized as key agents that regulate organic matter decomposition and the development of hydric soil characteristics (Craft, 2001). Since wetland soils are dominantly anaerobic when they are saturated, anaerobic bacteria are mainly responsible for organic decomposition (Mitsch and Gosselink, 1993). Other organisms (most fungi and terrestrial bacteria) that decompose organic materials are aerobic and do not easily function in the absence of oxygen in wetlands. However, many wetlands are only seasonally saturated and allow aerobic organisms to populate the soil environment when they are not saturated.

Microbial ecology in constructed and restored wetlands has been shown to be very similar to that of natural wetlands (Duncan and Groffman, 1994). Recent research investigating microbial communities in bogs showed that very similar microbial communities existed in bogs with different soil properties (Morales et al., 2006). These studies show that despite variability in hydrologic conditions, soil properties, and physical location, similar active anaerobic microbial communities developed.

Soil saturation initiates the anaerobic process by segregating the soil from atmospheric oxygen (Richardson et al, 2001), but alone does not guarantee the development of anaerobic conditions. The development of anaerobic soil conditions once a soil is saturated is dependent on things such as microbial activity and available organic carbon (Craft,2001). As a result, the time it takes a soil to become anaerobic once it becomes saturated is variable (Vepraskas, 2001). For example, if a soil with adequate organic matter becomes saturated, but is subjected to low temperatures (<5° C), the microbial metabolic activity may be slowed (Rabenhorst, 2005) to the point that the development of anaerobic conditions may be impeded. In another case, soil may be saturated at a warmer temperature, but if there is very little available organic carbon to provide energy for microbial populations, the onset of anaerobic conditions may be very slow (Beauchamp et al, 1989).

Redoximorphic Features in Hydric Soils

In most upland soils (Figure 2.3) iron and manganese oxides form coatings on silicate grains that create homogeneous red, brown, or yellow surfaces (Schaetzl and Anderson, 2005). In wetland or hydric soils, some of the iron or manganese oxides are usually dissolved and redistributed by the anaerobic biogeochemistry (Vepraskas, 2001). The visual evidence of this redistribution is often referred to as redoximorphic features. Common redoximorphic features are redox concentrations (mainly composed of iron oxides and to a lesser degree manganese oxides) and/or redox depletions (of the oxides).

Redox concentrations (Figure 2.4) are defined as, "…bodies of apparent accumulation of Fe/Mn oxides that include soft masses, pore linings, nodules, and concentrations" (USDA-NRCS, 2006). Soft (crushable with fingers) iron masses are accumulations of iron oxide minerals (such as goethite, ferrihydrite, and lepidocrocite) occurring within the soil matrix in various shapes and sizes that are usually redder

Figure 2.3 The soil in this photograph exhibits morphological features common to upland soils. Notice the light color of the A horizon (low organic matter) and the uniform brown color (even distribution of iron oxide minerals) of the B horizon (down to 85 cm). (photo courtesy of M.C. Rabenhorst)

Figure 2.4 The soil in this photograph shows morphological features common to hydric soils.   Notice the dark color of the A horizon (accumulation of organic matter) and the concentrations (red areas) as soft masses surrounded by the depleted (gray area) matrix. (photo courtesy of M.C. Rabenhorst)

(redder Munsell hues or brighter chromas) than the surrounding soil material. Pore linings are accumulations of iron oxides in root channels or pores and only differ from soft masses in that they are found in a particular location. Nodules or concretions usually have a spherical shape, but are somewhat solidified because of a higher Fe/Mn oxide content that cause some degree of cementation.

Depletions are zones that have been stripped of Fe/Mn oxides (USDA-NRCS, 2006). Essentially, these are areas of exposed mineral grains (often gray) that occur in the soil matrix, pores, root channels, or ped faces. These areas often have lower Munsell chromas coupled with higher Munsell values that cause them to appear lighter than the surrounding soil material. A soil may have only a few small depletions or the entire matrix can be stripped of iron oxide minerals, as evident in Figure 2.4.

Although the redoximorphic features described above can be readily observed in most natural wetland soils, newly saturated soils in constructed wetlands often lack significant development of redoximorphic features and have a low organic carbon content (Bishel-Machung et al, 1996; Stauffer and Brooks, 1997; Stolt et al, 2000; Campbell et al, 2002; Edwards and Proffitt, 2003, Bruland and Richardson, 2004). The development of a significant quantity of redoximorphic features and increased organic carbon within the soils of constructed wetlands would likely indicate the wetlands' progression toward a more natural state. However, very little research has investigated or attempted to experimentally evaluate the development of redoximorphic features in these newly saturated soils.

Previous Work

Vepraskas and Bouma (1976) were the first to take an experimental pedological approach to redoximorphic feature formation in newly saturated soils. They manipulated the water table in 4 homogenized soil cores in an experimental setting. The setting was rather artificial as a glucose solution was used to provide a carbon source for the microbes. Also, the soil material was homogenized and artificial structure was introduced by creating macropores. The results showed that reducing conditions developed and that redoximorphic features (concentrations and depletions) were formed even with the contrived and abnormal conditions. However, the results achieved using the unnatural conditions have limited applicability to natural or constructed wetlands.

Dobos et al (1990) attempted to induce the formation of redox features in soil materials from the B-horizon of the Hagerstown soil (fine, mixed, mesic typic Hapludalf), which is derived from limestone residuum. Homogenized soil was mixed with three levels (0, 15, and 30 g/kg soil) of alfalfa hay and packed into PVC columns. The cores were saturated with water from the bottom up, with the atmospheric conditions surrounding the cores alternating weekly between nitrogen (anaerobic) and compressed air (aerobic). The study lasted for 35 weeks with four sampling periods. The process revealed <2% redoximorphic feature development in all cores. The study also documented a “yellowing” of the soil matrix. Although some minor features were observed, the homogenization process was quite artificial and did not closely represent a natural soil profile. In addition, weekly alteration between anaerobic and aerobic atmospheric conditions may not have been adequate to promote sufficiently reducing conditions to cause the redistribution of iron oxide minerals.

In a study by Stolt et al (1998) envelopes of soil materials (some amended with organic materials) were buried in various wetland settings. Half of the soil envelopes were removed after one year, with the final envelopes removed after two years. During the two-year study period, iron oxide concentrations and depletions were documented (type, quantity, contrast) in most soil materials. However, the study failed to relate saturation and carbon content to a percentage of redoximorphic features over time. This correlation is essential to determine the effects of saturation time and carbon content on feature formation. The experiment also used homogenized samples contained in bags. The homogenization process (similar to Dobos et al, 1990) destroyed the inherit soil structure and possibly disrupted natural hydrologic gradients.

Wheeler et al (1999) compared redoximorphic feature formation in a laboratory setting between soils derived from red parent materials (high hematite content) and Mollisols with very high organic carbon content. The study focused on these soils because the development of redoximorphic features within these types of soils is often limited. The restricted development of redoximorphic features in these soils is thought to result from the masking effects of hematite and organic matter (Verpraskas and Sprecher, 1997). In this study, homogenized soils were packed into PVC columns and permanently saturated to within 15 cm of the soil surface for the length of the experiment. The homogenized soil columns were dissected and examined for the presence of any redoximorphic features after 8, 12, and 16 weeks. The study revealed the development of only a few redoximorphic features. These features were classified as iron oxide concentrations associated with platinum electrode holes (inserted to document reducing conditions) and a textural discontinuity (resulted from the column filling method). The study could be criticized because the soils were only saturated and allowed to become reducing once (for periods up to 16 weeks) during the experiment. Conversely, in natural environments most soils undergo cycles of saturation/drainage that create reducing and oxidizing conditions that are favorable for redoximorphic feature formation. This particular study also used soils that were known to demonstrate difficulty in forming redoximorphic features. It was unlikely that these soils would develop redoximorphic features in just 16 weeks.

Vepraskas et al (1995 and 2006) documented the rapid formation of redoximorphic features along transects in two areas of a constructed floodplain wetland, one created of subsoil only and the other with topsoil over subsoil. The study demonstrated the formation of iron oxide concentrations and depletions in the constructed floodplain wetland after only one single 7 day inundation event. In the wettest areas of the constructed wetland, the surface horizon in areas amended with topsoil had 15 to 27% iron oxide depletions after nine soil inundation events ranging from 4 to 44 days over the three year study period. Vepraskas et al (2006) also noted that hydric soil indicators (USDA-NRCS, 2006), formed in many areas of the same constructed wetland after only three years. The rapid formation of redoximorphic features, most notably depletions, are contrary to the results presented by others (Stolt et al, 2000; Campbell et al, 2002) that show these types of redoximorphic features can be slow to form in constructed wetlands. These differing results suggest that under optimum conditions, redoximorphic features can form relatively quickly in constructed wetlands, but there are still many constructed wetlands that have difficulty developing significant redoximorphic features. Thus, more research is warranted into the factors controlling redoximorphic feature formation in constructed wetlands.

The previous studies have attempted to use experimental settings to document redoximorphic feature formation. They have used many variables under many different simulated and natural wetland conditions. However, none of the studies have used a natural soil profile. Many of the studies used homogenized or constructed soils which can disrupt natural hydrologic gradients and soil structure. This disruption is likely to have an effect on the development of redoximorphic features. Even though some of the studies added some type of organic carbon material, none of the studies evaluated the effect of adding different types of organic materials. Also, most of the studies failed to mimic natural hydrological cycling with alternating oxidizing and reducing conditions. Mimicing this cycling more closely could affect the development of redoximorphic features. Most of the studies have also failed to document how time relates to the abundance of redoximorphic feature formation. None of the studies have compared the formation of redoximorphic features in an experimental setting with a more natural field setting. A combination of ideas derived from these studies can be united in an experiment to better evaluate the factors affecting the formation of redoximorphic features in newly saturated soils.

III. Effect of Different Organic Material Amendments on Newly Formed Redoximorphic Features Under Simulated Wetland Hydrology

INTRODUCTION

Redoximophic features are morphological soil characteristics that are indicative of wetland conditions (Vepraskas, 1992). These morphological characteristics include accumulations of organic matter, redistribution of iron and manganese oxides in the form of concentrations or depletions, and gleying of the soil matrix. In most natural landscapes and settings, redoximorphic features can be used to identify hydric soils for jurisdictional wetland determination (Environmental Laboratory, 1987; USDA-NRCS, 2006).

However, there are problem soil settings where redoximorphic features are not typical of what would be expected under a given set of wetland conditions (Vepraskas and Sprecher eds, 1997). One such problem setting would be newly saturated soils constructed for wetland remediation. Often, these soils do not show the abundance or degree of expression of redoximorphic features expected for the given hydrological conditions. This is likely because soils have not had adequate time to develop significant redoximorphic features since they were created or their hydrology altered (Stolt et al, 2000; Campbell et al, 2002; Bruland and Richarson, 2004). The development of a significant amount of redoximorphic features in the constructed wetlands would likely indicate that proper wetland biogeochemical activity had developed, and thus are functioning like the natural wetlands they were designed to replace.

In order to stimulate wetland biogeochemical activity, reduce soil bulk density, and increase organic matter, organic materials are often added during wetland construction (Hayes et al, 2000). Since wetland biogeochemical activity regulates redoximorphic feature formation, stimulating this activity would likely have an effect on the formation of redoximorphic features. However, very little research has attempted to evaluate the type of organic materials that should be added in order to maximize wetland biogeochemical activity and redoximorphic feature formation. The type of organic material may affect the development of redoximorphic features because different organic materials have unique properties, such as C:N ratio and lignin content, that cause them to decompose at different rates (Vanlauwe et al., 1996; Nicolardot, 2001). This differential decomposition may have an effect on wetland biogeochemical activity and the development of redoximorphic features. Therefore, the objective of this study was to determine how different types of organic material amendments affect the formation and expression (size, quantity, contrast) of redoximorphic features under induced hydric soil conditions over time.

MATERIALS AND METHODS

Summary of Research Approach

Well-drained soil cores (lacking redoximorphic features) were extracted and transported to a greenhouse where they were established as mesocosms. The mesocosms were periodically saturated and drained to simulate wetland hydrology. A time series experiment was used so that mesocosms could periodically be opened and dissected and redoximorphic features described in detail. The experiment utilized six different organic matter type treatments over a period of six different reduction/oxidation cycles in a 6 X 6 replicated factorial treatment structure.

Soil Selection

The Downer soil series was chosen to be used in this experiment because of its broad extent on the Mid-Atlantic Coastal Plain and the high likelihood that it could be impacted by wetland construction activities. According to the Official Soil Series Description, this soil is well drained and very deep and is classified as a coarse loamy, semi-active, siliceous, mesic, Typic Hapludult. A sampling site was located on Wye Island on the Maryland Coastal Plain (38° 58' 50" N, 76° 28' 20" W). To ensure that this soil had no redoximorphic features, a detailed soil description was done and is shown in Table 3.1. Before soil extraction, the soils were examined at several points around the perimeter of the sampling area to ensure that all cores collected would be similar in properties.

Organic Material Selection

Five different organic materials were selected for the experiment, which included: oak leaves; maple leaves; timothy hay; wheat straw; and hardwood sawdust were selected for the experiment. These materials were chosen because they represent a wide range of C:N ratios and lignin contents (Table 3.2) both of which can impact the ease or rate of

Table 3.1 Description of Downer soil pedon located at Wye Island, Maryland. The soil was described on 9/25/2004 on a summit landscape position with corn stubble.

Horizon	Depth (cm)	Description
Ap	0-20	Brown, 10YR 4/3 sandy loam, 8% clay, weak medium subangular blocky structure, friable, abrupt smooth boundary. (0.50% carbon)
BE	20-24	Yellowish Brown, 10YR 5/4 sandy loam, 9% clay, weak medium subangular blocky structure, friable, clear irregular boundary. (0.15% carbon)
Bt1	24-49	Dark Yellowish Brown, 10YR 4/6 loam, 15% clay, moderate medium subangular blocky structure, clay films, friable, clear boundary. (0.10% carbon)
Bt2	49-70	Dark Yellowish Brown, 10YR4/6 loam sandy loam, 9% clay weak medium subangular blocky structure, clay films, weak lamella, friable, clear boundary
BC/	70-100+	Brownish Yellow, 10YR 6/6 sand, 3% clay, single grain loose, very friable
Bt		Dark Yellowish Brown, 10YR 4/6 loamy sand, lamella, 1-2 cm thick, with 6% clay, weak medium platy structure, friable

Table 3.2 Properties of organic materials used in this study. Generally, higher C/N ratios and Lignin contents indicate less easily degradable materials.

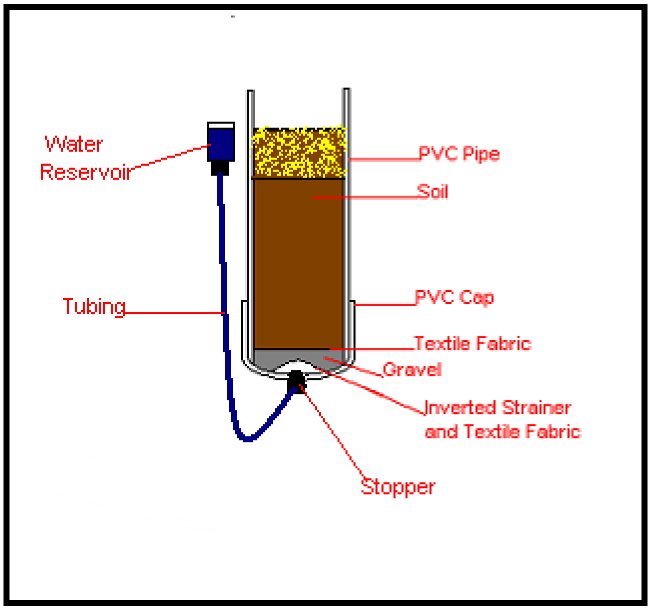
Organic Material Type	Total Carbon g/kg	*C/N Ratio*	*Lignin g/kg*
Oak Leaves	500	68	241
Maple Leaves	520	49	152
Wheat Straw	460	82	66
Timothy Hay	470	44	48
Sawdust	490	189	188

decomposition (Craft, 2001). These also represent readily available materials that could possibly be used during wetland construction projects. The materials were collected from local sources near College Park, MD and were considered to be representative of materials found in the Mid-Atlantic region. To eliminate decomposition bias caused by size and shape, the organic materials were ground to less than 2 mm using a plant grinder. The C:N ratio and total carbon were analyzed on each sample by total combustion at 900ºC using a LECO-CHN Analyzer (LECO Corp., St. Joseph, MI). Lignin content was determined by forage analysis using AOAC (Association of Official Agricultural Chemists) method 973.18 (Holmes Laboratory, Millersburg, OH). Forage Analysis laboratory reports are included in Appendix A.

Mesocosm Procedures

Sections of intact soil profiles (40cm column) were extracted from a site where the Downer soil series was identified (discussed previously). This was done by using 15cm diameter schedule 40 PVC pipe that had been cut into 50cm lengths and sharpened on one end. The pipe sections were carefully hammered 40cm into the ground and then excavated. Once extracted, the cores were taken to the greenhouse and prepared for the experiment. A cap with a 2.5cm hole was placed on the bottom of the mesocosm. Gravel had been placed in the base to assure that water could easily drain from the core. A layer of geotextile fabric and a plastic strainer were used to keep the soil from moving into the gravel and plugging the hole. A section of tygon tubing (3/8” inside diameter, 5/8” outside diameter) connected the mesocosm (through rubber stoppers) to a reservoir that was placed near the top of the core and was used to control water levels.   A schematic diagram of a mesocosm is illustrated in Figure 3.1.

Figure 3.1 Schematic representation of a constructed mesocosm. The parts used to construct each mesocosm are listed in red. The hatched area represents organic material that was uniformly mixed into the upper 10cm.



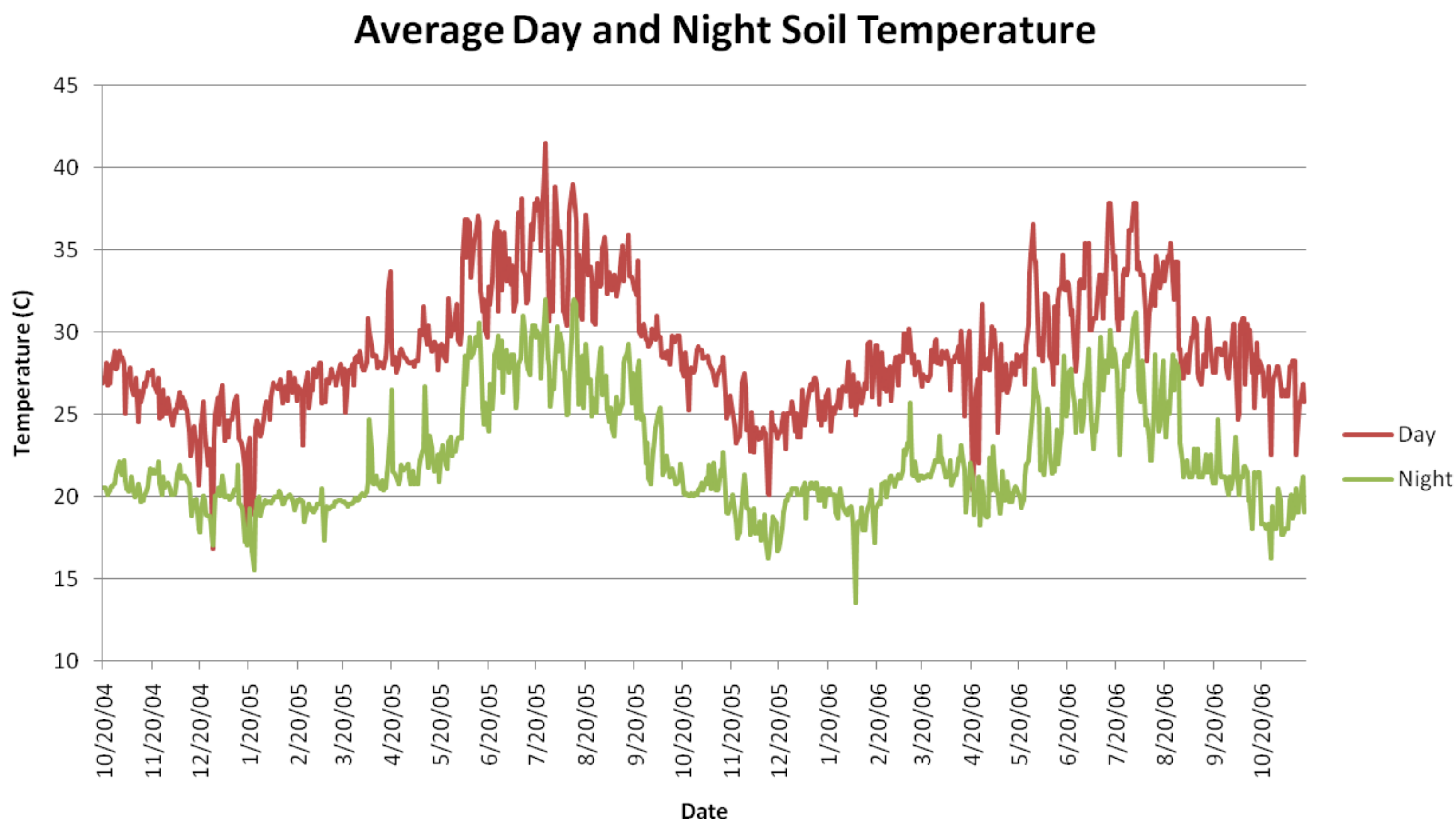
Prior to the start of the experiment, each core received an addition of 60g of organic material. The addition corresponded to approximately 25-30g carbon per core (7-10 g/kg carbon added in upper 10 cm) or 1.4-1.7 kg carbon added /m^2 which is approximately three times the average annual litter fall (500g/m^2) of eastern riparian wetlands (Mitch and Gosslink, 1993). The addition was accomplished by excavating, sieving (<2mm), and homogenizing the top 10cm of moist soil from each individual core. The 60g of organic material was uniformly mixed with the processed soil, and then returned to the core and hand packed in 3 to 4 cm increments. The control cores were subjected to the mixing process, but no organic materials were added. The uniform mixing was intended to represent a shallow plow layer that might possibly be used to incorporate organic materials during wetland construction. It is important to note that vegetation was not allowed to grow on mesocosms, thus eliminating the possibility of organic additions through plant growth and senescence.

It should be noted that although soil cores used for the organic treatments were collected in August, 2004, the cores used for the control treatment were collected in March, 2005. These cores were collected in the same field using the same methodology employed to collect the previous cores. However, since these cores were not randomly distributed throughout the other organic material treatments, there could be confounding effects.

To ensure that a wetland microbial community would be present in the mesocosms, each core was inoculated with 50ml of a suspension prepared from the upper 5 cm of a natural riparian wooded wetland soil.

All mesocosms were maintained in the same greenhouse room and exposed to twelve hours of "daylight" (natural or artificial light) at approximately 30 degrees C, followed by 12 hours of "night" with a temperature of approximately 20 degrees C. Soil temperature was monitored throughout the experiment by thermocouples placed in several mesocosms located in various parts of the greenhouse. Figure 3.2 shows the temperatures recorded throughout the experiment. In the spring and fall the greenhouse facility was able to keep temperatures in the desired range (20-30°C). However, during the summer and winter seasons, the facility was unable to maintain the temperature within the range during extreme warm and cold periods. Summer temperatures were

Figure 3.2 Greenhouse soil temperature trends over the length of the experiment. The day temperature shown below is the average soil temperature at 3 or 4pm. The night temperature shown below is the average soil temperature at 3 or 4 am. The experimental goal was to keep the soil temperatures between 20°C and 30°C. Generally, soil daytime and nighttime soil temperatures were about 7-8 degrees different and mostly fell within the 20-30 degree target range. However, temperature ranges were a little higher in the summer and lower during the winter.



generally 5 to 9°C warmer than desired. Winter temperatures were generally about 3 to 5°C cooler than desired. Nevertheless, extreme temperatures were observed on a limited basis and are not believed to have significantly impacted the results of this study.

The water table was controlled in each core using a reservoir (connected to the bottom of the mesocosm by tubing) located on the side of each mesocosm (Figure 3.1). The soil was saturated from the bottom of the mesocosm and the water table was maintained at or near the surface for eight weeks to promote the development of anaerobic conditions. During this eight-week period the water table was lowered twice for one-week periods to a depth of 10cm in an attempt to more closely replicate natural variation in water table movement. Following the eight weeks of saturation, the mesocosms were drained for eight-weeks to promote aerobic conditions and oxidation. One wet period followed by one dry period (16 weeks total) was termed a cycle. A cycle was intended to simulate what might happen over the course of a year through the wet winter and spring, and the dry fall and summer. There were six cycles in the experiment.

Monitoring Procedures

To document the presence of reducing and oxidizing conditions, soil oxidation-reduction potentials (Eh) were measured periodically throughout the experiment. Redox potentials were measured in mesocosms at approximately one week intervals at 10 and 25 cm depths. This was done using three replicate platinum electrodes at each depth coupled with a calomel reference electrode (correction factor of 244 mV). To avoid data redundancy and the high cost of instrumenting all mesocosms, platinum electrodes were initially only placed in 1/3 of the mesocosms (cycles 1 and 2). After the first cycle was complete, electrodes were removed from the cores that were dissected, tested to ensure their accuracy and functionality, and installed into mesocosms of the next cycle. This testing and rotation process continued for the length of the experiment.

Soil pH (1:1 water) was measured every four weeks at the same depth (10 and 25 cm) where Eh measurements were made. This was done by collecting a 1cm micro-core from three randomly selected mesocosms. In order to minimize the effect of introducing macropores in the mesocosms, pH was measured on those mesocosms that were to be dissected following that particular cycle.

To document the changes in carbon over time, total soil carbon was analyzed using a LECO CHN-2000 analyzer (LECO Corp., St. Joseph, MI). The procedures were completed in duplicate on soil samples from experimental units before the initial experiment as well as on samples collected following the completion of cycles 1, 3, and 6.

Active carbon was measured on soils from all organic material treatments after the completion of cycles 1, 3, and 6 using the permanganate oxidation method of Weil et al. (2003). Active carbon can be thought of as the most labile fraction of soil carbon that is most easily available to microbial organisms. Active carbon was measured by mixing 2.5 g of soil with a dilute (0.02M) potassium permanganate solution and shaking for exactly 120 seconds. An aliquot of the shaken solution (0.5 ml) was diluted into 45.5 ml of distilled water. A spectrophotometer was then used to measure the absorbance at a wave length of 550 nm wavelength. Using a standard linear calculation presented by Weil et al (2003), the absorbance reading was transferred into active carbon (mg/Kg soil).

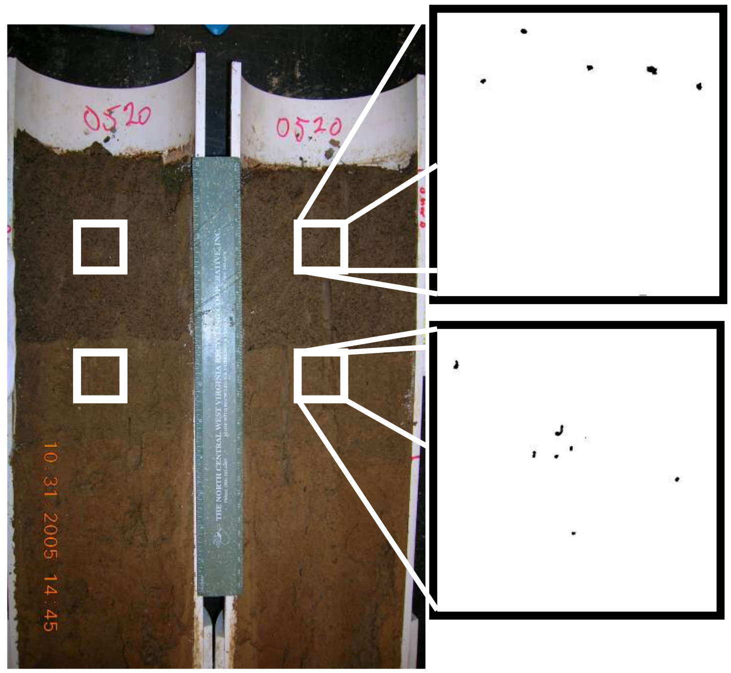
Documenting Morphology

After the completion of the first saturation-drying cycle, one set of mesocosms (termed "cycle 1") was dissected so that detailed soil morphological descriptions could be made. All remaining mesocosms continued through additional cycles. The mesocosms were dissected by using a circular saw to make two lengthwise cuts in the PVC directly across from each other. Once the PVC cuts were made, the mesocosms were split in half using a hand held rip-saw. The smeared surface of each mesocosm half was "picked" to reveal a fresh soil surface.

Initially, redoximorphic features were documented and quantified by making visual estimates comparing the observed features to a set of known charts (Stoops, 2003; Schoeneberger et al, 2002). It became clear that this approach would not provide adequate quantification of the features. A new method was developed to more accurately quantify the newly formed redoximorphic features. Redoximorphic features were traced onto a clear mylar sheet using a fine point marker. Duplicate 5cm square areas were traced for the top two (Ap1 and Ap2) horizons in each dissected core as shown in Figure 3.3. These were scanned (200 DPI) , cleaned using Adobe Photoshop Editor, and quantified using Image Tool 3.0 (UTHSCSA, 2002).

A digital colorimeter (Minolta Data Processor DP-301 coupled with a Chroma Meter-300 Series) was used to document possible soil color changes in the zone (upper 10cm) where organic materials were mixed. Five replicate (random) measurements were taken on the mixed horizon (Ap1) of every mesocosm following dissection.

Figure 3.3 Redoximorphic features within each of the two white 5 cm square areas in each horizon were traced using a very fine point permanent marker. The resulting areas (shown at the right) were then analyzed for % black area using Image Tool 3.0.



Statistical Analysis

Statistical analysis was performed using SAS Version 9.0 (SAS Institute Inc., 2007). All data were checked for normality. Analysis of variance was performed using the “proc mixed” procedure with the denominator degrees of freedom calculated using the Satterth method. Means were compared using least square difference. Alpha for all analyses was set at 0.05.

RESULTS AND DISCUSSION

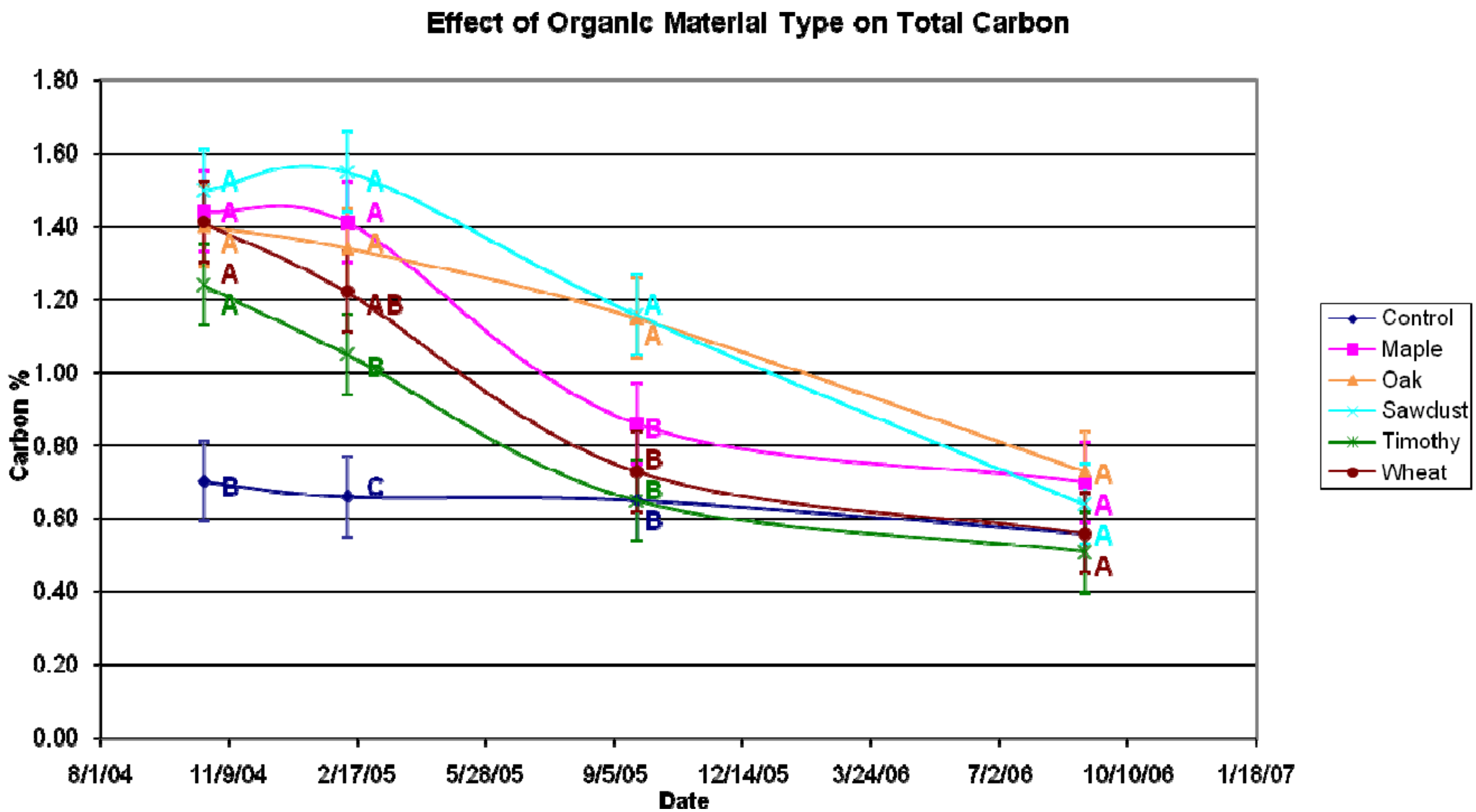
Total Soil Carbon

Figure 3.4 shows how total soil carbon changes over time in mesocosms amended with different organic materials. A complete total soil carbon data set is presented in Appendix B. Initially, the organic amended treatments had 1.25-1.50% total soil carbon. These values were significantly higher than the 0.75% total carbon found in the control mesocosms. This was expected because the control didn't have any organic materials added. The difference corresponds well with the calculated 0.75-1.0% increase in soil organic carbon that was added to each core through organic materials at the start of the experiment.

After cycle 1, the total soil carbon within timothy hay and wheat straw treatments began to fall and show a slight separation from the other organic type treatments. By the end of cycle 3, total soil carbon within mesocosms amended with maple leaves, timothy hay, and wheat straw dropped to levels similar to that of the control mesocosms. However, the total soil carbon observed (after cycle 3) in mesocosms amended with oak and sawdust was significantly higher than the other treatments.

Even though the total soil carbon percentages of soil cores amended with oak and sawdust treatments had been higher in Oct. 05 (after cycle 3), by the end of cycle 6 (conclusion of the experiment) the carbon contents were similarly low across all organic treatments. Based on these results, it was evident that soil organic carbon was steadily depleted over time, and by the end of cycle 6, there was no significant difference between any of the treatments and the control.

Figure 3.4 Plot of total carbon percentage for each organic treatment over time. Statisitical analysis revealed a significant interaction (p=0.0085, α=.05) between organic material type and time. Therefore, the main effect of time cannot be statistically compared using these data. The error bars on each treatment represent Standard Error of the Means (0.11). Means that share like letters within a specific time period are not significantly different (α= 0.05) from each other.



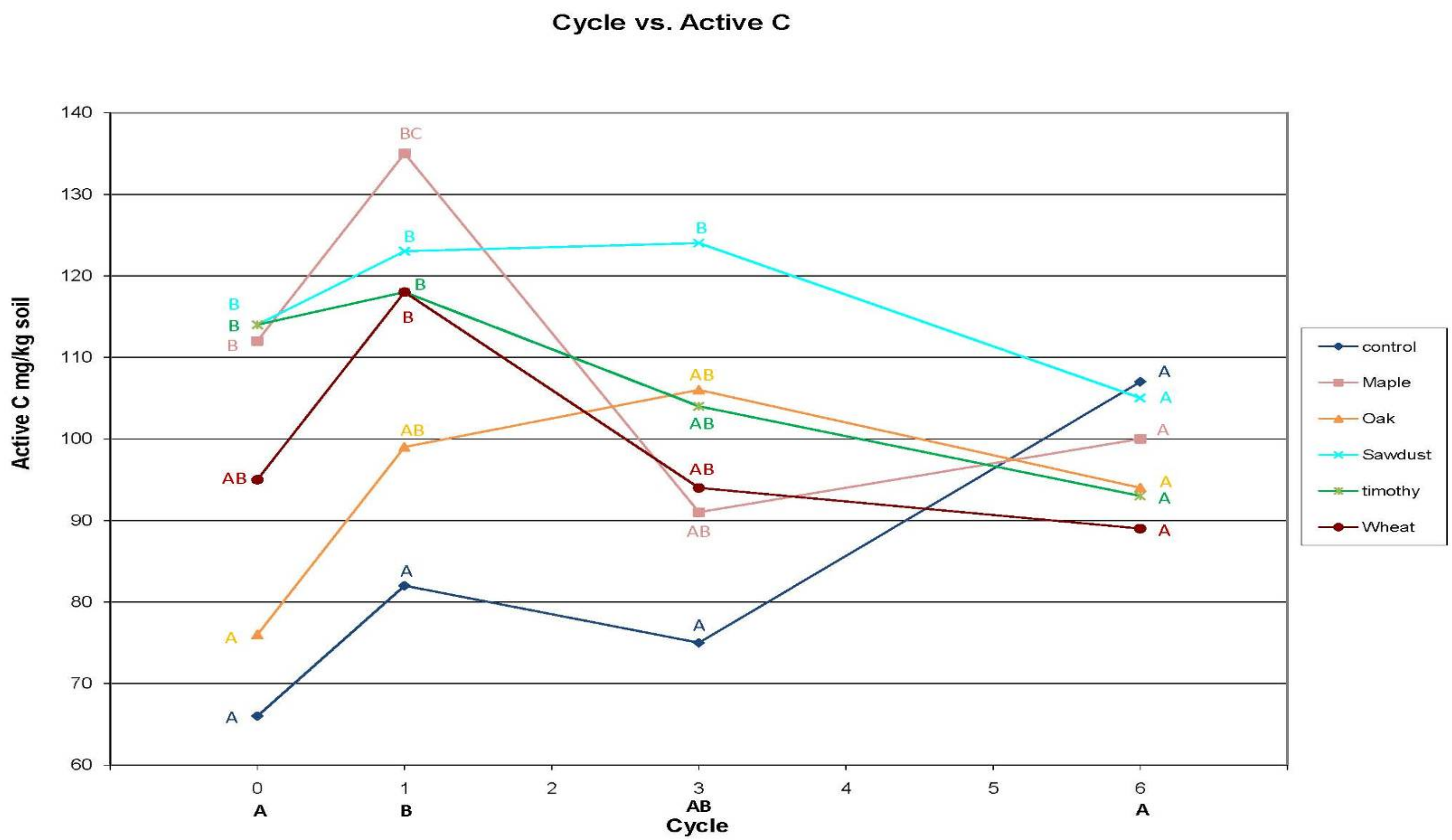
It is thought that the high lignin content and C:N ratio (Table 3.2) of sawdust and oak leaves caused these materials to decompose at a slower rate than the other organic materials. Evidence of this is shown in Figure 3.4 where the total soil carbon content of mesocosms amended with oak and sawdust remained higher for a longer period of time. Similar decomposition trends of fresh organic materials have been found by Vanlauwe et al. (1996) and Nicolardot (2001), who showed that materials with higher lignin contents and C:N ratios decompose more slowly.

The depletion of organic carbon is not usually observed in natural wetland soils. In fact, due to periodic additions of slowly decomposing plant material, most wetlands accumulate organic carbon (Collins and Kuehl, 2001). However, since there was only a single addition of organic materials at the onset of the experiment, the observed soils responded much differently. There was also no vegetation growing in the mesocosms, which eliminated the possibility of continued organic matter additions from plant material.

Active Carbon

Figure 3.5 displays active soil carbon in mesocosms before the start of the experiment and after the completion of cycles 1,3, and 6. A summary table of all active carbon data is shown in Appendix C. The data show no clear trends. Active carbon ranged between 65 and 115 mg/kg across all organic material type treatments during the length of experiment. Mesocosms in the control treatment had the lowest active carbon for most of the investigation. This was not surprising because no fresh organic material

Figure 3.5 Soil active carbon measured in mesocosms before the start of the experiment and after the completion of cycles 1,3, and 6. The data set shown below shows no clear overall trends. Means that share like letters within a specific cycle are not significantly different (α= 0.05) from each other.

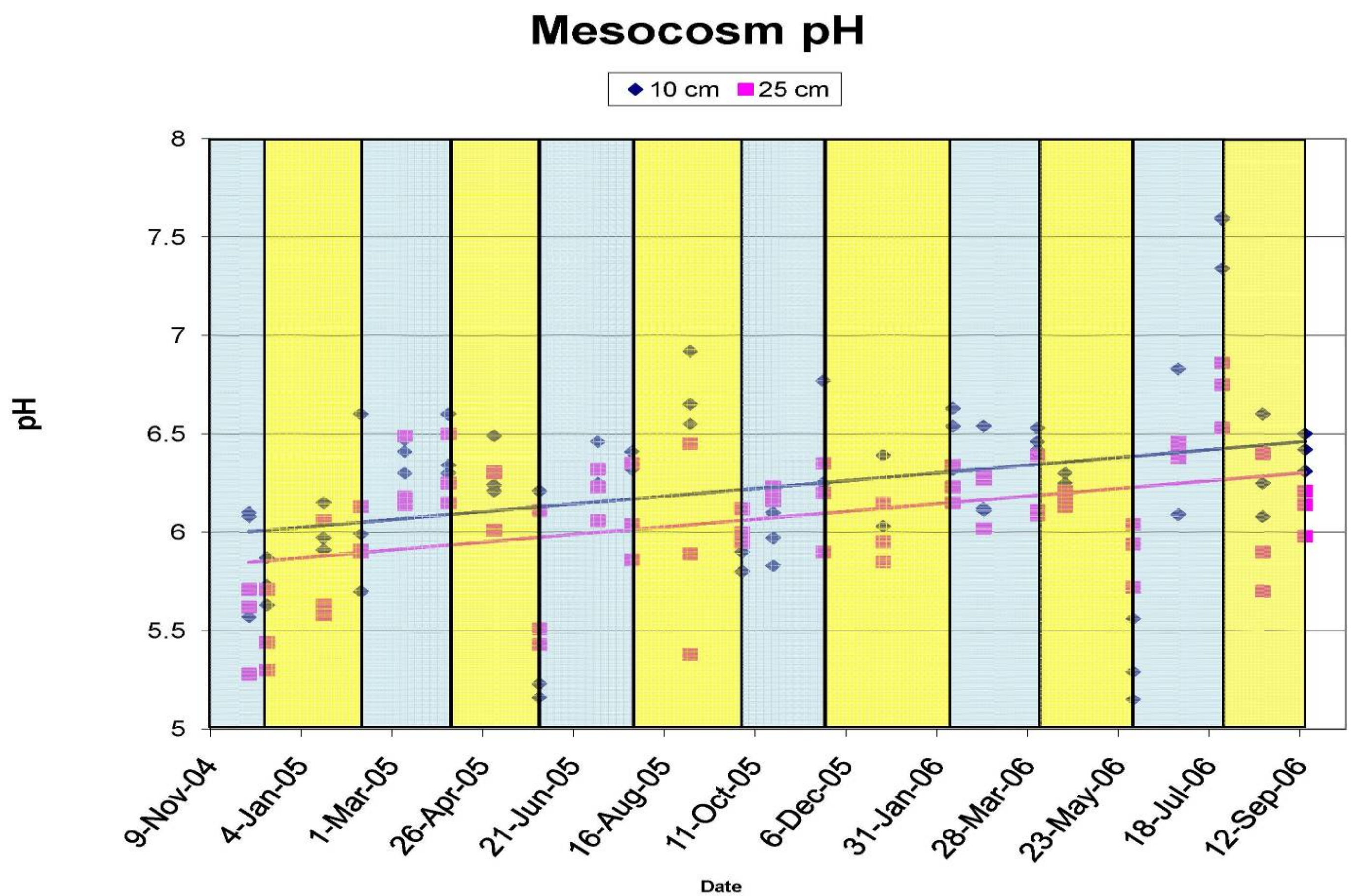


was added to these mesocosms. After the completion of cycle 1, there seemed to consistently be a 25-30 mg/kg active carbon increase in mesocosms across all organic material type treatments even when no carbon was added. This suggests that during the course of the 1st wet/dry cycle, some of the initially less labile C (perhaps relict root matter), was converted into more labile forms. It is interesting to note that active carbon in mesocosms amended with maple leaves, timothy hay, and wheat straw drop sharply by the time cycle 3 was completed, whereas active carbon in mesocosms amended with oak leaves and sawdust remained essentially the same at the completion of cycle 3. Perhaps the higher C:N ratio and lignin content of these organic materials (oak leaves and sawdust) which causes them to decompose more slowly, also results in the release a medium concentration of more easily degradable organic compounds.

Redox Potential and pH

Figure 3.6 shows the pH data (Appendix D) collected during the experiment. The blue and yellow areas represent times when the mesocosms were saturated or drained, respectively. The pH varied throughout the experiment, but most values were between 5.5 and 6.5. There was no consistent difference in measured pH between the two depths (10 and 25 cm). The regression lines show that the values were a little lower earlier in the experiment when compared to later. The rise is probably a result of anaerobic biogeochemistry that tends to shift wetland soil systems toward a neutral pH (Ponnamperuma, 1972). We postulated that the pH would rise and fall with corresponding saturated/drained periods. There is some slight evidence of this cyclical pattern at the end (in cycle 6) of experiment, but was not consistent. The inconsistency in

Figure 3.6 pH values over the 96 week experiment. pH was measured in three different cores at two depths every four weeks. The transparent light blue areas represent times when the mesocosms were saturated, whereas the yellow areas were unsaturated times. Regression lines have been inserted into the graph for each depth to view how pH changes over time.



the data is probably due to the measurement of a very small sample. Although, more replication may have been useful, additional sampling would have compromised the integrity of the mesocosms.

Figures 3.7 and 3.8 depict the mean Eh (calculated from four independent experimental units) of each treatment at the depths of 10 cm and 25 cm, respectively. The orange zone in each graph represents an approximation of the transition zone between oxidizing and reducing conditions. The zone was calculated using the technical standard of the NTCHS (Figure 2.2) and the measured pH range of 5.75-6.5 (Figure 3.6). The regular sinusoidal shape of the data corresponds very well to each saturated/drained cycle. When the cores were saturated, redox potentials moved into the reducing zone. Conversely, when the cores were drained, redox potentials were observed in the oxidizing zone.

Measurements taken at the 10 cm depth during the first cycle (12/04-2/05) are very similar despite different organic material type treatments (Figure 3.7). Redox potentials quickly fell deep into the reducing zone (-200 Eh) after saturation and then quickly climbed into the oxidizing zone after draining. During cycles two and three, the treatment Eh values again fell deep into the reducing zone with the control treatment approximately 100 mV higher. This was likely due to the difference in organic carbon percentage between the control and rest of the treatments observed in Figure 3.4. However, after cycle three, the redox potentials for the other treatments were not nearly as low. As a result, the difference between the control and the other reducing Eh potentials disappear. Figure 3.4 shows that after cycle 3, the total carbon becomes similarly low across treatments, which might explain why the redox potentials found in

Figure 3.7 Plot of treatment mean Eh values (SE of 58 mV) at a depth of 10cm between October 2004 and August 2006. The transparent orange area represents the diffuse boundary between oxidizing and reducing conditions taken from the technical standard in Figure 2.2 using a ph range of 5.75-6.5. Redox potentials clearly fall into the reducing zone during saturated periods and rise into the oxidizing zone when the mesocosms are drained.

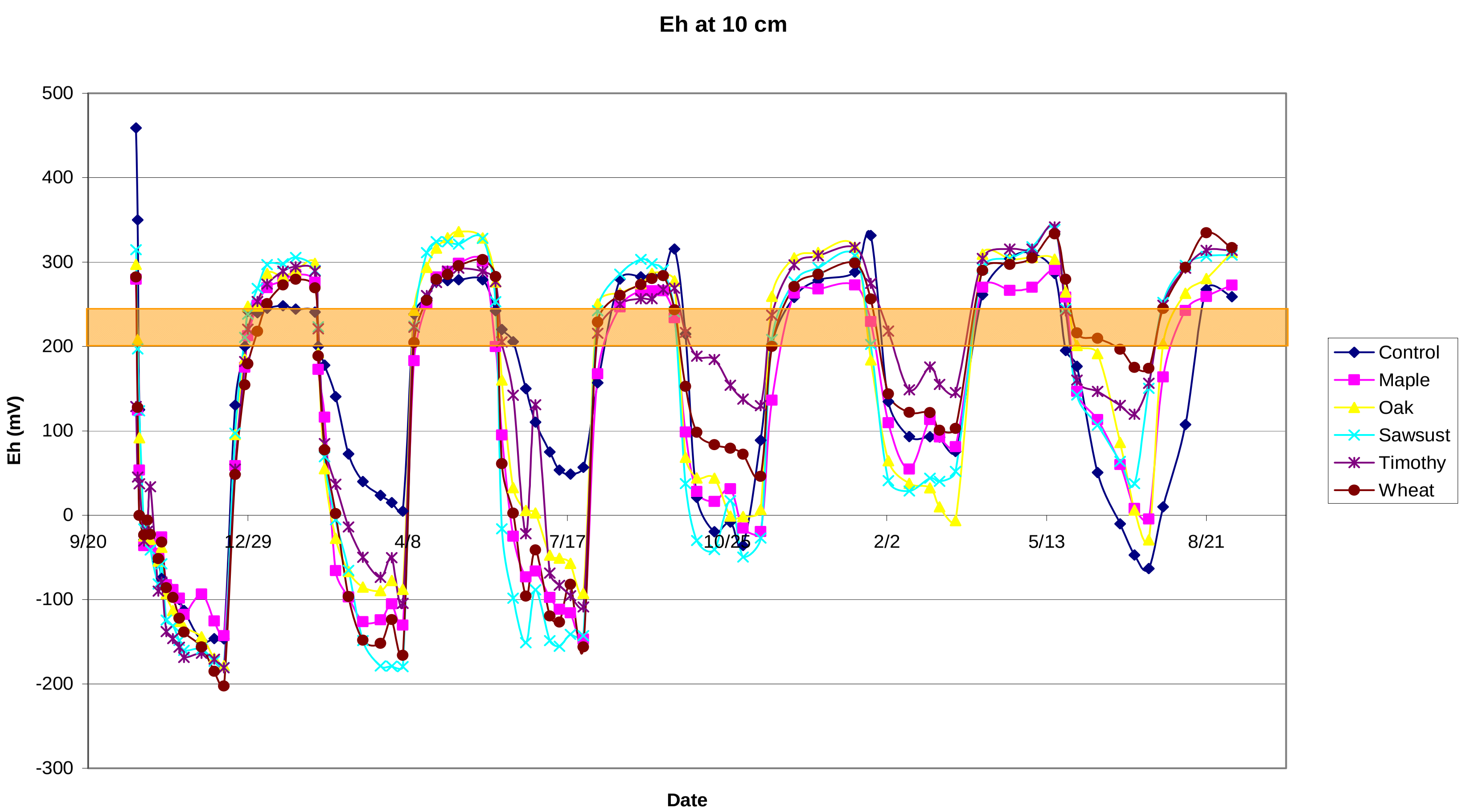


Figure 3.8 Plot of treatment mean Eh values (SE of 58 mV) at a depth of 25cm between October 2004 and August 2006. The transparent orange area represents the diffuse boundary between oxidizing and reducing conditions taken from the technical standard in Figure 2.2 using a ph range of 5.75-6.5. Redox potentials clearly fall into the reducing zone during saturated periods and rise into the oxidizing zone when the mesocosms are drained.

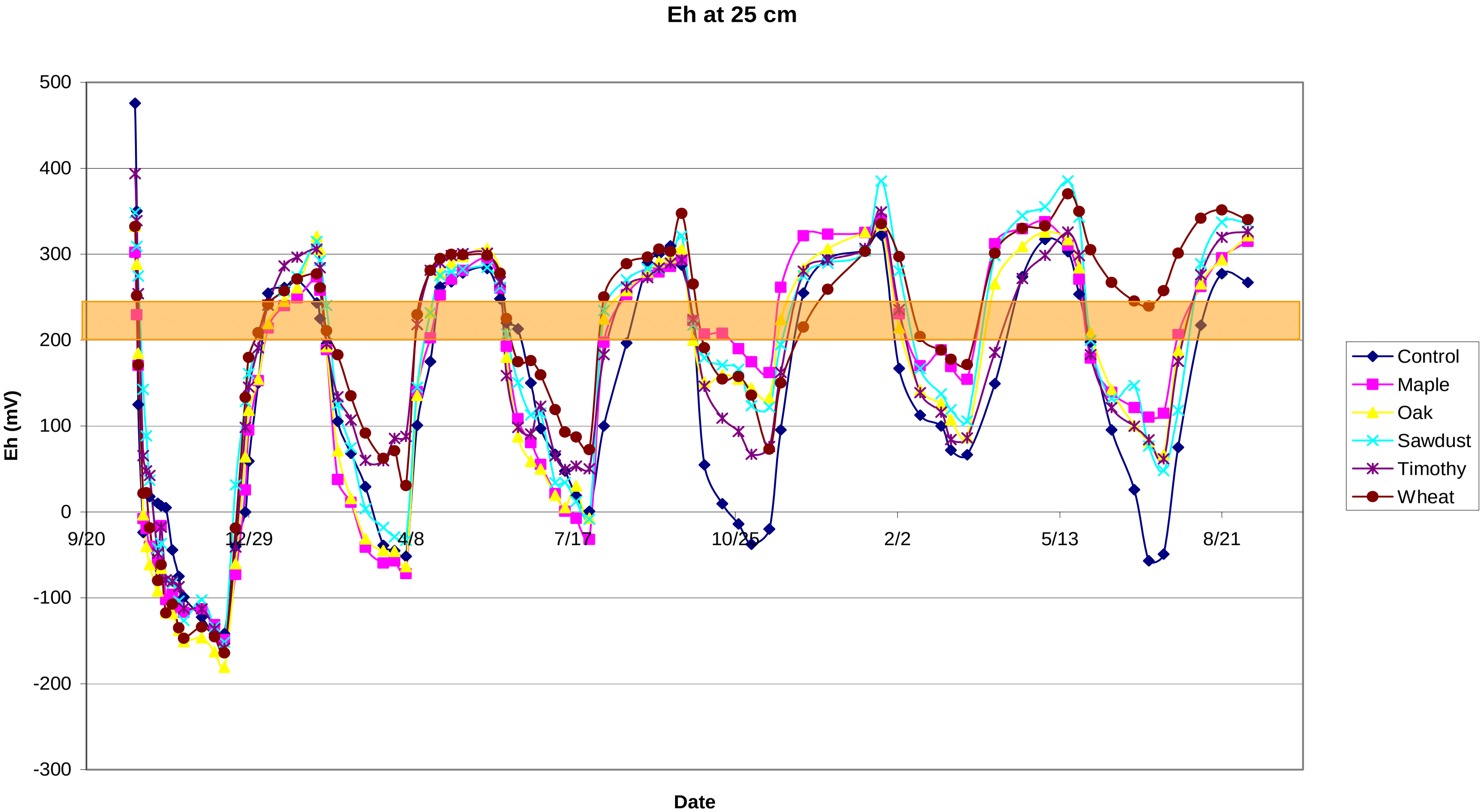


Figure 3.7 from cycle 3 on are not as reducing. It was also noteworthy that later in the experiment, redox values for maple, oak, and sawdust treatments were consistently found lower than timothy and wheat treatments. It is believed that these treatments are lower because they retain a higher total carbon percentage over time (Figure 3.4).

Initially (12/04-2/05), redox potentials at 25 cm were very similar to those at the 10 cm depth. However, after cycle 1, the values measured at the 25cm depth were consistently 75-100 mV higher than those at 10 cm. The difference was likely due to the fact that the Bt horizon had a much smaller total organic carbon content (0.15%) compared to the Ap horizon (0.5-1.0%) (Table 3.1). Thus, the Eh data measured at 25 cm (Figure 3.8) reveals that the addition of different organic material types, into the upper 10 cm, does not affect redox potentials at 25 cm. This trend is not surprising because organic materials were not added at this depth. Following a trend similar to that found at the 10 cm depth, the redox potentials at 25 cm become progressively less reducing during subsequent cycles. This reinforces the idea that organic carbon is being depleted over time and is becoming limiting to microbial activity.

Summary tables of redox potentials are presented in Appendix E. Overall, the redox potential measurements at both depths suggest that the soil environment was reducing with respect to iron and manganese oxides during saturated periods and then reoxidized during drained periods to conditions where oxidized forms of iron and manganese would be stable.

Changes in Soil Morphology

In the Downer soil pedon sampled at Wye Island, Maryland, three horizons were identified within a 40 cm depth (Table 3.1). However, due to the manipulation of the upper 10 cm during organic additions, a new horizon (Ap1) was created in all mesocosms. Soil morphological descriptions of all mesocosms can be found in Appendix F.

Soil Matrix Color

A complete soil color data set is presented in Appendix G. The surface horizon of the untreated Downer soil had an initial brown color of 10 YR 4/3 (colorimeter 10YR 3.7/2.9). Figures 3.9 and 3.10 show how matrix Munsell value and chroma differ as a result of organic material treatments and how they change across cycles. The nearly horizontal lines in Figure 3.9 show that different cycles have little effect on Munsell value. However, Figure 3.10 shows that addition of some types of organic materials result in significantly lower Munsell chroma that gradually increases through later cycles. It is thought that observed color changes are mostly due to the initial addition of the organic materials that gradually change overtime as the organic materials decompose.

It is also important to note that different organic materials had different effects on matrix Munsell value and chroma. Figures 3.9 and 3.10 show that mesocosms amended with oak and maple leaves have significantly lower Munsell value and chroma. This trend of lower value and chroma persists through cycle four, but tends to fade in cycles five and six. The difference in Munsell value and chroma between different organic type

Figure 3.9 Average Munsell value (SE= 0.05) of the Ap1 horizon after the completion of each cycle. Since there was no significant interaction (α= 0.05, p= 0.56) between cycle and organic type treatment, a best-fit line was placed through the means. The separation between lines represents the main effect of each organic type treatment. Lines that share a like letter are not significantly different (α= 0.05) from each other.

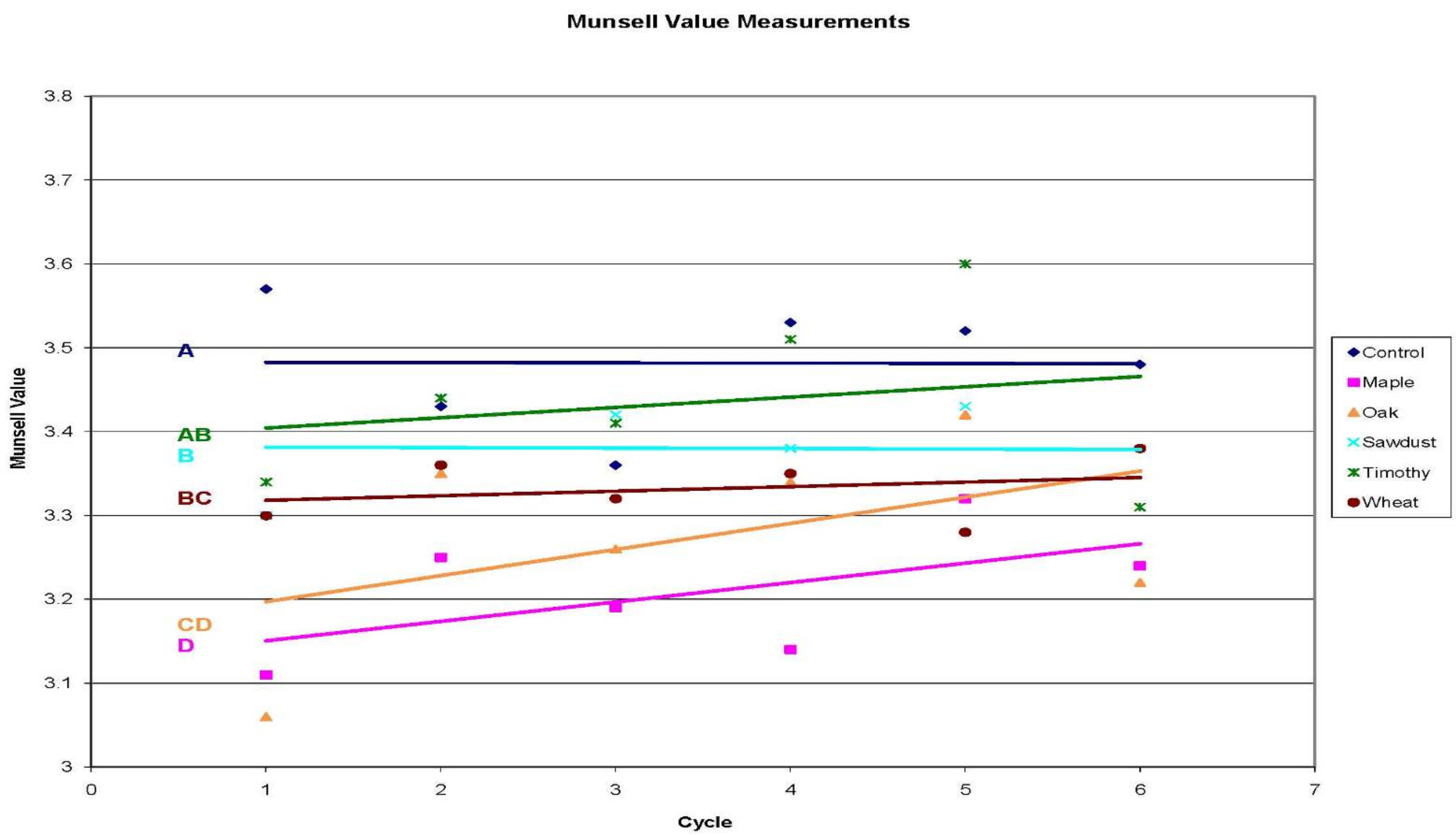
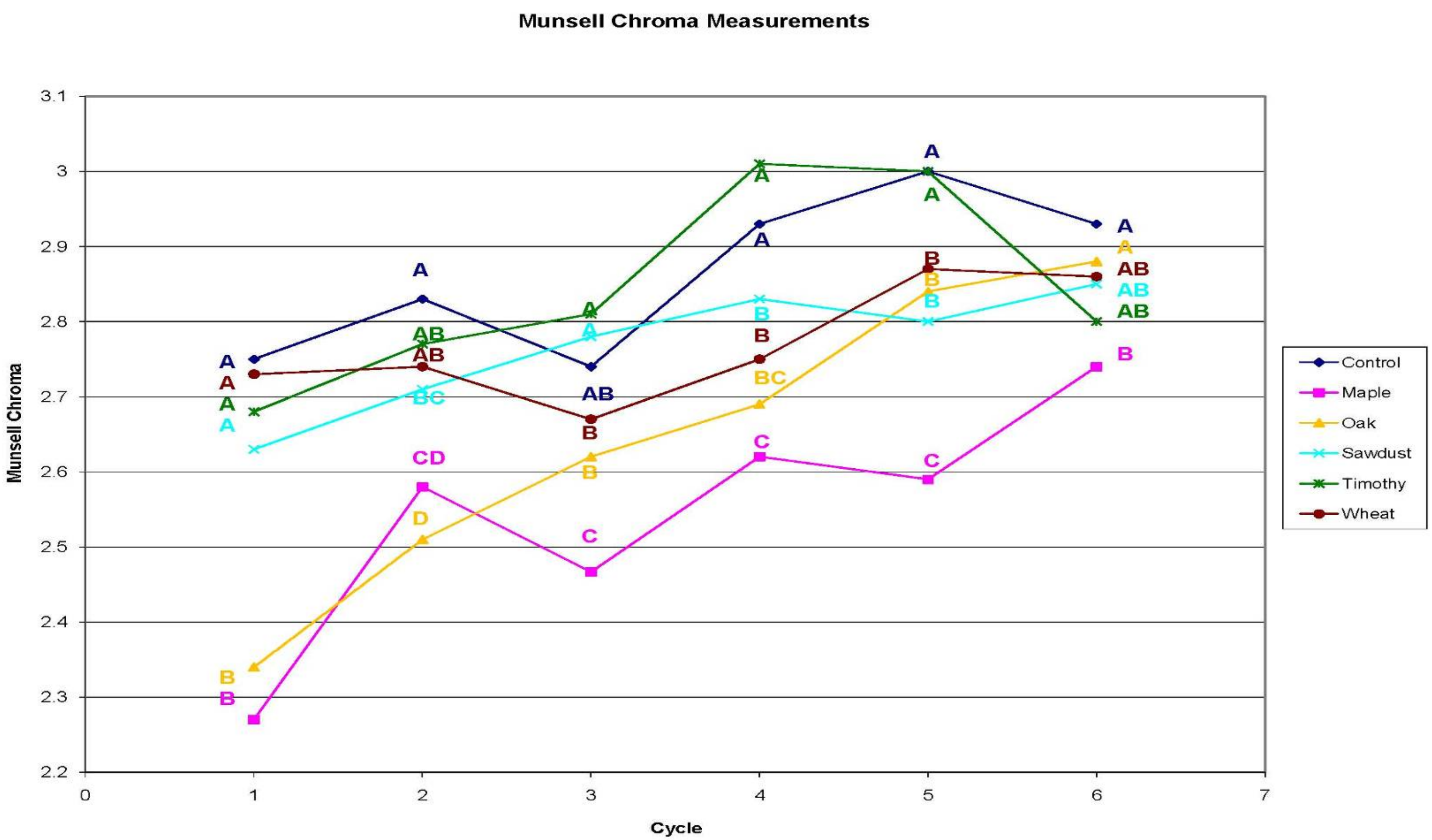


Figure 3.10 Average Munsell chroma of the Ap1 horizon after the completion of each cycle. There was a significant interaction (α= 0.05, p= 0.03) between cycle and organic type treatment. Means that share like letters within a specific cycle, are not significantly different (α= 0.05) from each other.



treatments may be subtle, but is also visually discernable using the naked eye. Figure 3.11 A/B illustrates the visible effect of adding maple leaves versus adding timothy hay to the soil. The darker shade is perhaps related to the wetland phenomena of "blackened" or water-stained leaves (USAEWES, 1993). It is also interesting to note that blackened leaves are a secondary indicator of wetland hydrology for jurisdictional wetland determination (environmental laboratory, 1987). It is thus recognized that leaves under ponded conditions often turn dark in color. It is possible that the observations here represent a similar phenomenon. There were no visually documented matrix color changes in the Ap2, BE, or Bt horizons. These results are similar to that found by Vepraskas and Bouma (1976) and Wheeler et al., (1999) that showed under experimental conditions, there was not a color change in the soil matrix. It is suspected that experiments of this nature lack the hydrological gradients and the time required to strip iron oxides from the soil matrix in significant quantities to observe a matrix color change.

Redox Concentrations

Redox concentrations were observed mostly in the Ap1 and Ap2 horizons. These were typically 7.5YR 4/4 or 4/6, fine (< 2mm) and very fine (< 1mm), faint (or occasionally distinct) iron oxide concentrations found as soft masses and pore linings (Figure 3.12a). A summary table of redoximorphic feature abundance in each mesocosm is shown in Appendix H.

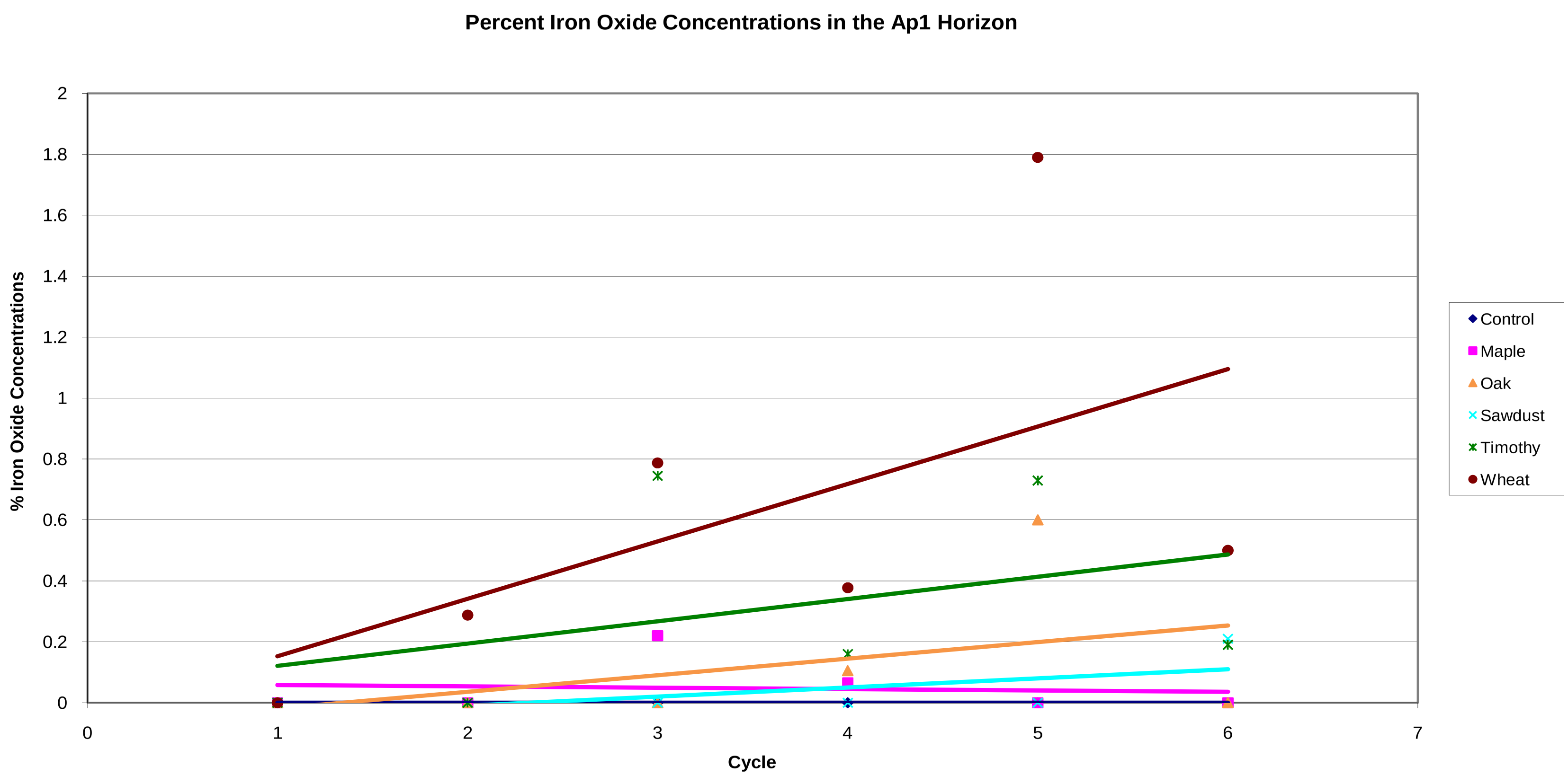
The Ap1 horizon (0-10cm) across all treatments and cycles had mostly between 0 and 1% iron oxide features (Figure 3.13). Based on the evaluation of organic carbon content (Figure 3.4) and Eh data (Figure 3.7), it was very surprising that such a small

Figure 3.11 A/B Images of two dissected mesocosms (after 3 wet-dry cycles) that had organic materials mixed throughout the upper 10cm. Ground maple leaves were added to core A, while ground timothy hay was added to core B. The surface horizon of core A had a color of 10YR 3.1/2.4, while core B was 10YR 3.4/2.8. While these differences may seem subtle, the different shades are easily discernable with the naked eye.

Figure 3.12a Image of iron oxide concentrations as soft masses and pore linings. These feature were routinely observed in the Ap1 and Ap2 horizons.

Figure 3.12b Image of prominent iron oxide concentrations as pore linings observed in created macropores. Even though this the most prominent example, similar coatings were often observed in pH and redox electrode sampling holes within the upper 10cm. A very thin coating of iron oxide can also be seen lining the surface of this mesocosm.

Figure 3.13 Percent iron oxide concentrations in the Ap1 horizon after the completion of each cycle. These data depart severely from normality. There was no significant interaction ($\alpha=0.05$, $p=0.68$) between organic type treatment and cycle. Therefore, the differences between means were not analyzed.

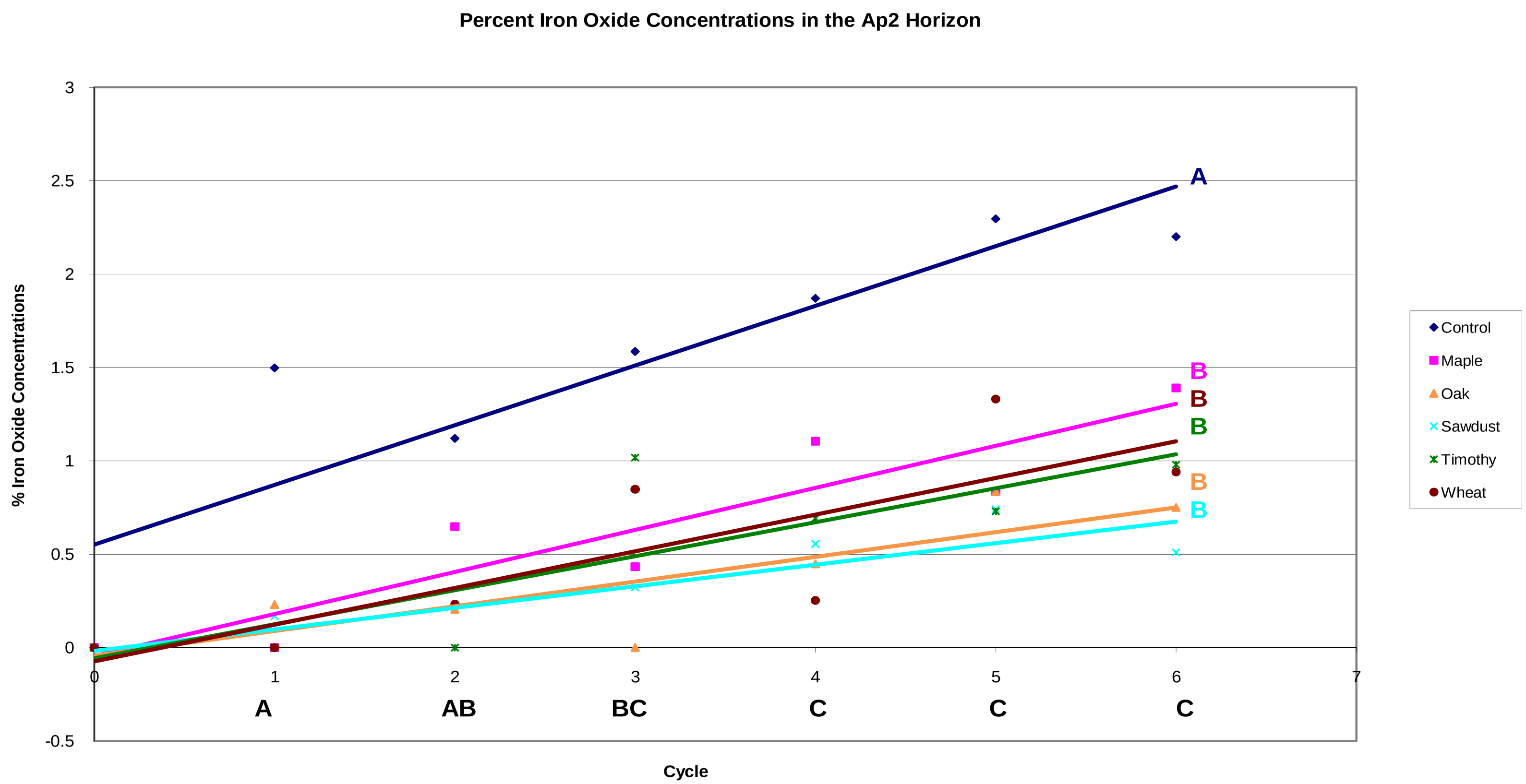


(0-1%) percentage of (and often no) features were found in the Ap1 horizon. The small percentage of redox features also made it very difficult to make comparisons (Figure 3.13) between different treatment combinations. It was hypothesized that different organic materials would affect the abundance of hydromorphic features. However, Figure 3.13 demonstrates that different organic materials affected the abundance in the Ap 1 horizon very little. The wheat straw treatment seemed to have the largest percentage of features, but is questionably inflated by one large value observed in cycle 5. There is some evidence in Figure 3.13 suggesting that the abundance of features increased over time. Albeit most of the slopes are positive, they increase so subtlety and are too statistically variable to be considered different from zero. The most distinct features found in the Ap1 horizon were iron oxide concentrations in artificial "macropores" that were created by pH sampling or platinum electrodes (Figure 3.12b). The features found in macropores were typically much larger (< 10mm) than the ones observed in natural soil pores. Comparable concentrations were also recognized in similar macropores by Vepraskas and Bouma (1976). They concluded that these enlarged pores drained first upon a moisture regime change, and as a result were avenues for oxygen to enter the soil system and create an oxidized environment. Vepraskas (1992) also explains the importance of soil structure and related macropores on the formation of redoximorphic features in natural settings. He explains that soil ped surfaces and larger pores (structure) are preferential areas for redoximorphic concentrations. They are preferred because as the soil drains, oxygen diffuses to these areas first creating an interface where dissolved iron and manganese can precipitate. As a result, soil structure is thought to be critical to the formation of redoximorphic features.

In this study soil structure was essentially destroyed in the Ap1 horizon during homogenization and organic material incorporation and is likely the reason why there was limited formation of redoximorphic features in most mesocosms. Thus any effect of using different organic materials through time was likely masked by the overriding effect of soil structure being absent.

The quantity of redox concentrations in the Ap2 horizon was generally greater than in the Ap1 horizon and ranged between 0-2.5 % across all treatments and cycles (Figure 3.14). Since organic materials were not mixed into the Ap2 horizon, it was initially thought that there would not be an organic treatment effect. However, Figure 3.14 shows that the control treatment formed significantly more iron oxide concentrations than the other treatments. This is very confounding because it was expected that control mesocosms would have fewer or equal features than the other treatments because there was not as much organic matter to create a reducing environment. It is believed that the development of a greater quantity of features in the control treatment was due to unforeseen factors during mesocosm collection. The control soil cores were collected in April, 2005 only a couple meters away from the other treatment soil cores collected in August, 2004. As result, it is thought that the difference between the control and the rest of the treatments was not due to the lack of organic matter addition, but rather unseen inherent soil properties that were different between the soil cores. Perhaps the agricultural field from which the all the soil cores were collected was fertilized with nitrogen or phosphorus just before collecting the control cores causing increased microbial activity when they were first saturated. It is also possible that soil structure was slightly different in the control cores affecting the microhydrologic gradients

Figure 3.14 Percent iron oxide concentrations in the Ap2 horizon after the completion of each cycle. These data are not normal, but were still analyzed because they do not depart severely from normality. There was no significant interaction (α=0.05, p=0.68) between organic type treatment and cycle. As a result, a best-fit line was placed through the means. The separation between lines represents the main effect of each organic type treatment. Lines that share a like letter are not significantly different (α= 0.05) from each other. Also, cycles (x-axis) that have like letters are not significantly different from each other.



differently. Despite the confounding effects of the control treatment in Figure 3.14, the effect of time was evident. The slope across all organic treatments had a positive slope ($\alpha = 0.05$) as a function of time which indicated that approximately 0.2% concentrations were formed per cycle.

Iron oxide concentrations were seldom observed in the BE or Bt horizons. This was surprising because during every cycle, redox potentials at those depths were documented to be reducing with respect to common iron oxide minerals (Figure 3.7 and 3.8). The lack of significant redoximorphic feature formation in these horizons is probably due to lower organic carbon content or masking of redistributed iron oxides. Organic carbon content in these horizons was significantly lower (Table 3.1) than the overlying (Ap1 and Ap2) horizons. The low levels of organic carbon may have been insufficient to sustain microbial activity necessary to mobilize large quantities of iron. Also, slight segregation of iron could have been masked by the redder hues or higher iron oxide content found the BE and Bt horizons. When the concentration of iron oxide minerals is high in the surrounding soil matrix, a greater degree of segregation is required for redoximorphic features to become visible (Vepraskas and Sprecher eds, 1997).

CONCLUSIONS

In summary, this laboratory greenhouse study was designed to determine the effect of different organic materials on the formation of redoximorphic features in newly saturated hydric soils. The study showed that a small percentage of iron oxide concentrations can form within soils relatively quickly, after only one saturated and dry period, and that the abundance of concentrations increase with the amount of time subjected to alternating saturated and dry conditions. These observations are not surprising and agree with the generally accepted concepts of redoximorphic feature formation.

The addition of the organic materials was adequate to sustain reducing biochemistry for approximately for the length of the experiment, but without periodic additions from plant senescence, the strength of the reducing conditions was less. The addition of different types of organic materials had no significant effects on the formation of redoximorphic features. It is suspected that the uniform mixing process used to incorporate the different organic materials had an overriding effect on feature formation.

These results lead to the conclusion that the type of organic material initially added to a newly saturated or constructed wetland soil, has little effect on quantity and nature of redoximorphic features found. Perhaps, different results would have been achieved had the experiment had a more natural hydrology, continued longer, or used a different set of organic materials. Although different organic materials had little effect on newly saturated soil morphology, it is still critical to add some source of organic carbon during wetland construction to stimulate anaerobic biogeochemical functions.

IV. Effect of Using Different Application Strategies for Adding Organic Material on Newly Formed Redoximorphic Features Under Simulated Wetland Hydrology

INTRODUCTION

Organic material has many ways in which it can impact wetland soils including decreasing bulk density, increasing water holding capacity, and serving as an energy source for respiring soil fauna and microbial populations (Craft, 2001). However, newly formed wetland soils, such as those found in constructed wetlands, often lack sufficient organic matter to function like the natural wetlands they were designed to replace (Bishel-Machung et al, 1996; Stauffer and Brooks, 1997; Stolt et al, 2000; Campbell et al, 2002; Edwards and Proffitt, 2003). Therefore, in an effort to increase the initial organic matter content in soil during wetland construction and remediation projects, it has been common practice to add organic material to soil (Hayes et al, 2000). This added organic material is thought to stimulate biogeochemical activity (Craft, 2001) and likely contributes to the development of redoximorphic features.

In newly constructed wetlands, little research has attempted to evaluate the influence of the organic material incorporation method on the development of redoximorphic features. The incorporation method (placing on the soil surface or plowing in) may be significant because it influences the physical location of the organic materials. Redoximorphic features have been shown to concentrate in localized areas near decomposing organic materials, most notably in soil horizons with higher organic carbon content and near decaying root matter left behind from plant senescence (Vepraskas, 1992). Thus the placement of the organic materials during wetland construction activities could have an effect on the development of redoximorphic features. Therefore the objective of this experiment was to evaluate the effect of using various techniques for incorporating fresh organic materials into newly formed wetland soils, particularly on the development of redoximorphic features.

MATERIALS AND METHODS

Research Approach

Soil cores were extracted from a well-drained soil and then established as mesocosms in a greenhouse. Before mesocosm establishment, ground organic materials were added to separate mesocosms in three different ways. The organic materials were 1) applied to the soil surface, 2) mixed uniformly throughout the upper 10 cm of soil, or 3) placed in zones within the upper 20 cm of the soil surface. The mesocosms were subjected to six cycles of saturation and drainage that simulated wetland hydrology in a time series experiment. The experiment used two different types of organic materials and three application strategies in a 2 x 3 x 6 replicated factorial treatment structure. At the completion of each cycle, the mesocosms were dissected so that a detailed morphological description could be completed.

Mesocosm Construction

Intact soil profiles were extracted from a representative Downer (coarse loamy, semi-active, siliceous, mesic, Typic Hapludult) soil series located at the Wye Research Institute on Wye Island (38° 58' 50" N, 76° 28' 20" W) in Maryland. Before extraction, a detailed soil morphological description (Table 3.1) was completed to ensure that there were no redoximorphic features in the soils. Additionally, the perimeter of the sampling site was investigated to a depth of 50 cm to ensure that similar soil characteristics encompassed the entire sampling area. Each soil core was collected using a 50cm long by 15 cm diameter schedule 40 PVC pipe that was sharpened on one end. The integrity of soil horizons was preserved by vertically inserting each pipe 40 cm into the soil. The cores were carefully extracted and transported to a staging area where they were prepared for the experiment.

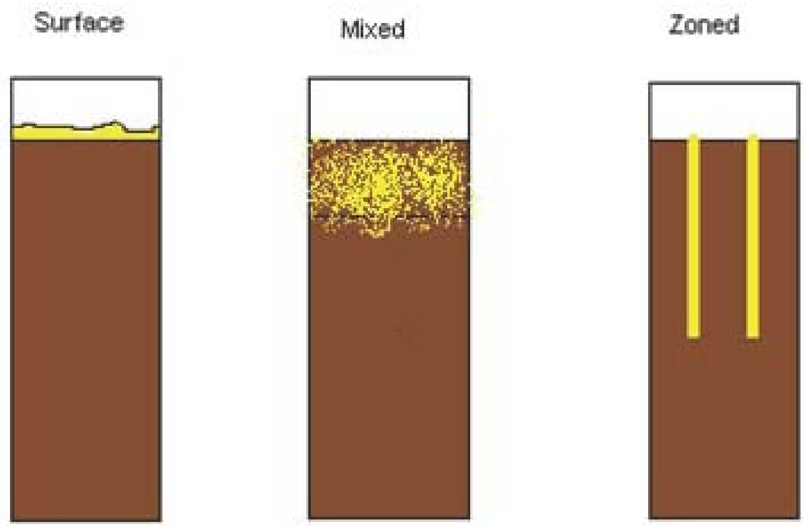
Once at the staging area, each core was capped on the bottom using a standard 15 cm PVC cap modified with a 2.5 cm hole in the base. Each cap included a plastic strainer (covering a drainage hole) and two layers of geotextile fabric sandwiching approximately 250 cm^3 of quartz gravel. A water reservoir was placed near the top of each core. The reservoir was connected to the core through the hole in the cap at the bottom by a length of 9.5 mm inside diameter tygon tubing and rubber stopper. A schematic of a constructed mesocosm is shown in Figure 3.1.

Prior to the beginning of the experiment, a single addition of 60g of either ground (< 2 mm) oak leaves or wheat straw was added to each mesocosm. Oak leaves and wheat straw were chosen because they were readily available materials that could easily be used during wetland remediation and construction practices. The materials were collected from sources near College Park, Maryland and are thought to be representative of materials found in the Mid-Atlantic region. Total carbon, C:N ratio, and lignin content were analyzed on both organic materials before they were added to the soil cores and are presented in Table 3.2.

Sixty grams of organic material was added to each core using one of three different incorporation strategies: mixing, surface application, or zoned additions (Figure 4.1). The mixing application was designed to replicate the addition of organic materials by uniform tillage. It was accomplished by excavating, sieving (<2mm), and homogenizing the top 10 cm of moist soil from an individual core and then adding and mixing the organic material with the soil before repacking each core by hand in 3 cm increments. The surface application was intended to represent a mulch layer that could be broadcast over the soil surface. The surface method was accomplished by placing 60 grams (1.7 kg C/m^2) of organic material uniformly over the soil surface. The zonal application was performed by drilling four 2 cm diameter holes, 20cm deep within the soil, and then packing 60g of organic material (oak leaves or wheat straw) into the vacated holes. The zoned method was intended to represent chisel plowing or disking that could insert the organic materials deeper into the soil profile.

Since the Downer soil cores were collected from an ecosystem that did not represent a natural wetland, it was possible that they did not contain microbial organisms that are present in wetland soils. Therefore, prior to the start of the experiment, each mesocosm was inoculated on the surface with a 50ml suspension derived from the fresh O and A horizons of a wooded wetland soil. This suspension was prepared by harvesting the upper 5cm of material (organic and soil) from approximately 1 ft^2 of a wooded wetland and mixing it with water from a nearby stream. The suspension was applied just prior to initial saturation.

Figure 4.1 Schematic mesocosm cross-section of each incorporation/application method. The brown area in each mesocosm represents soil while the yellow area symbolizes organic material. The organic material was laid on the surface of the soil (left), uniformly mixed throughout the upper 10 cm (middle), or placed in four 2cm diameter by 20cm deep vertical columns (right).



Mesocosm Environment

To replicate natural hydrologic variation that occurs in wetlands the mesocosms were subjected to a periodic pattern of saturated and drained conditions. The pattern consisted of 8 weeks during which the mesocosms were saturated where the water table was maintained at or near the soil surface, followed by an 8 week period where they were drained and allowed to dry. Also, to create additional hydrologic movement within the 8 week saturated period, the water level was periodically lowered to a depth of 10 cm below the soil surface for two one-week periods. A 16 week period, during which there were 8 weeks of saturated conditions followed by 8 weeks of drained conditions, was termed a “hydrologic cycle”. After each hydrologic cycle, a block of mesocosms was removed from the experiment and described. The mesocosms that remained in the experiment continued to be subjected to additional hydrologic cycles. There were a total of six hydrologic cycles in the experiment.

All mesocosms were contained in the same greenhouse setting. To replicate natural diurnal temperature variations, the greenhouse temperature was adjusted to approximately 30°C during the day and 20°C at night. The soil temperature in mesocosms was monitored using thermocouples inserted into four mesocosms strategically placed in different corners of the greenhouse. The daily high and low soil temperature monitored by the thermocouples can be seen in Figure 3.2 which shows that the soil temperatures occasionally extended beyond the desired temperature range (20-30°C). However, these temperatures were not extreme and are not believed to have had any detrimental effects on results.

Monitoring Procedures

To document the oxidation state in each mesocosm, soil reduction-oxidation (redox) potentials were periodically measured throughout the experiment. The redox potential (Eh) was measured at depths of 10 and 25 cm using three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of 244 mV). However, due to the high cost of platinum electrodes, they were initially only placed in 1/3 of the mesocosms and then rotated to the next block once the hydrologic cycle was complete. For example, at the start of the experiment only mesocosms scheduled to be removed and dissected after 1 and 2 hydrologic cycles were instrumented with electrodes.

The mesocosms scheduled to be dissected after 3, 4, 5 and 6 hydrologic cycles were not instrumented. Once the first hydrologic cycle was complete, electrodes were removed from the block of cores that were to be dissected, tested to ensure their accuracy and functionality, and installed into mesocosms to be dissected after the third cycle. This testing and rotation process continued for the length of the experiment. In the event that a platinum electrode was found to be faulty, it was replaced with a new one.

So that redox potentials could be used to predict mineral stability, soil pH (1:1 water) was also documented throughout the experiment. Soil pH was measured every four weeks at the same depths where platinum electrodes were placed. Soil pH was measured by collecting a 1cm micro-core from three randomly selected mesocosms. In order to minimize the effect of introducing macropores in the mesocosms, pH was measured on those mesocosms in the group that were to be dissected following that particular cycle.

Documenting Morphology

Upon the completion of each hydrologic cycle, a block of mesocosms was removed from the experiment so that detailed morphological descriptions could be made. To dissect each mesocosm the PVC cap attached to the bottom was first removed with a circular saw. Two length-wise cuts were then made directly opposite each other so that the mesocosm could be split in half. A hand-held wood saw was used to split each mesocosm in half. Fresh soil surfaces were exposed by picking away soil that had been disturbed by the sawing activity.

Once dissected and fresh soil surfaces were exposed, each mesocosm half was carefully described and inspected for redoximorphic features. If redoximorphic features were visually observed, the type and quantity of features were documented. The quantity of features in a particular horizon was evaluated using a computerized image analysis method to more accurately quantify the features. This was accomplished by placing a clear mylar sheet over a representative 5 cm square area and tracing the features using a fine point marker. The tracing was completed on two separate areas in each horizon as shown in Figure 3.3. The mylar sheets on which the features were traced were then scanned (200 DPI), cleaned using Adobe Photoshop Editor, and quantified using Image Tool 3.0 (UTHSCSA, 2002).

Micromorphology

In an effort to observe newly formed redoximorphic features on a microscopic level, soil thin sections were prepared from select mesocosms. The goal was to confirm and observe newly formed redoximorphic features in mesocosm soil microstructure. Soil micromorphology was observed by making 30µm thin sections from soils clods that had been impregnated with epoxy resin. Polished slides were viewed under a petrographic microscope under both plane and cross-polarized light. Slides were described using standard terminology (Stoops, 2003).

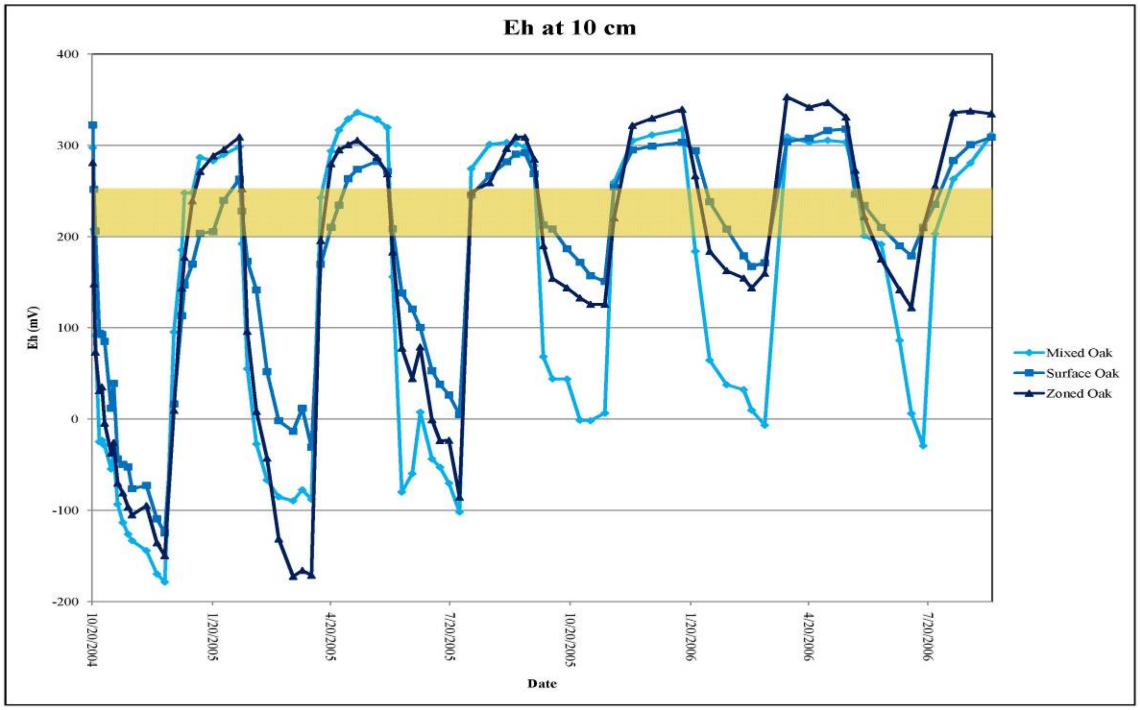
RESULTS AND DISCUSSION

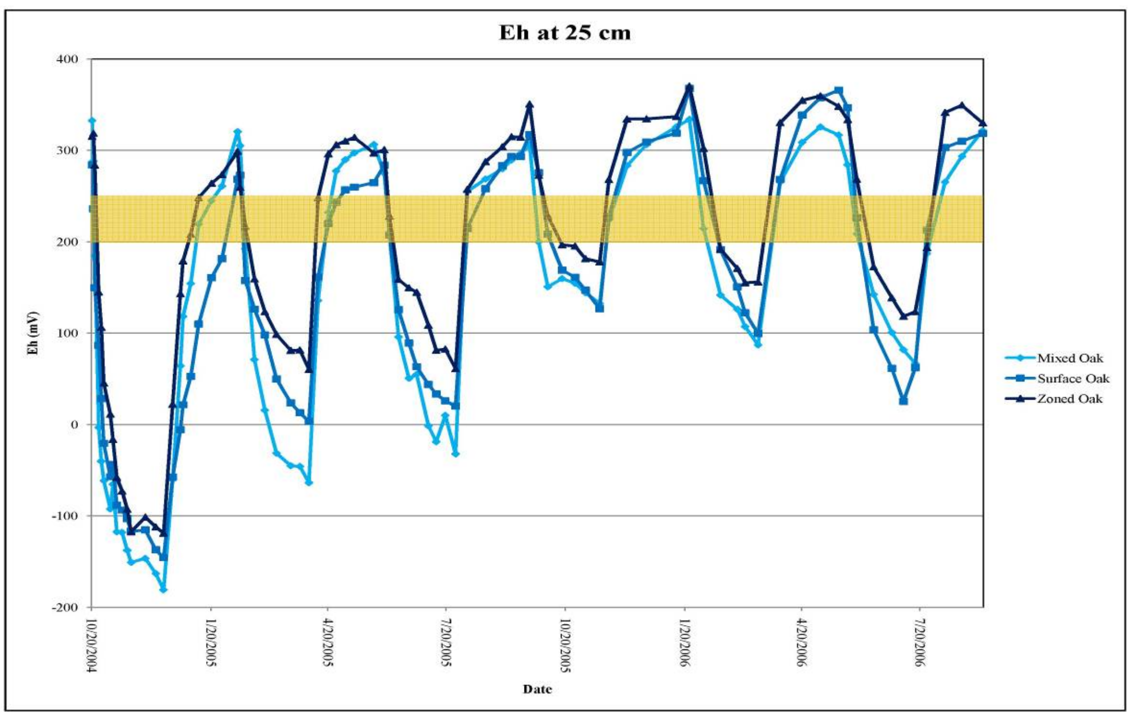
Soil Reduction and Oxidation Potentials

Figures 4.2 (oak leaves) and 4.3 (wheat straw) show the redox potentials at depths of 10 and 25 cm for each mesocosm treatment throughout the experiment. The values on each figure represent the mean of 12 replicate electrodes at a given depth and equally distributed among four mesocosms of a given treatment. The orange zone in Figure 4.2a/b and blue zone in Figure 4.3a/b represent the diffuse boundary between oxidizing and reducing conditions based upon the measured pH values (ranging between 5.7 and 6.5) and the technical standard for reducing conditions in hydric soils shown in Figure 2.2 (NTCHS, 2006).

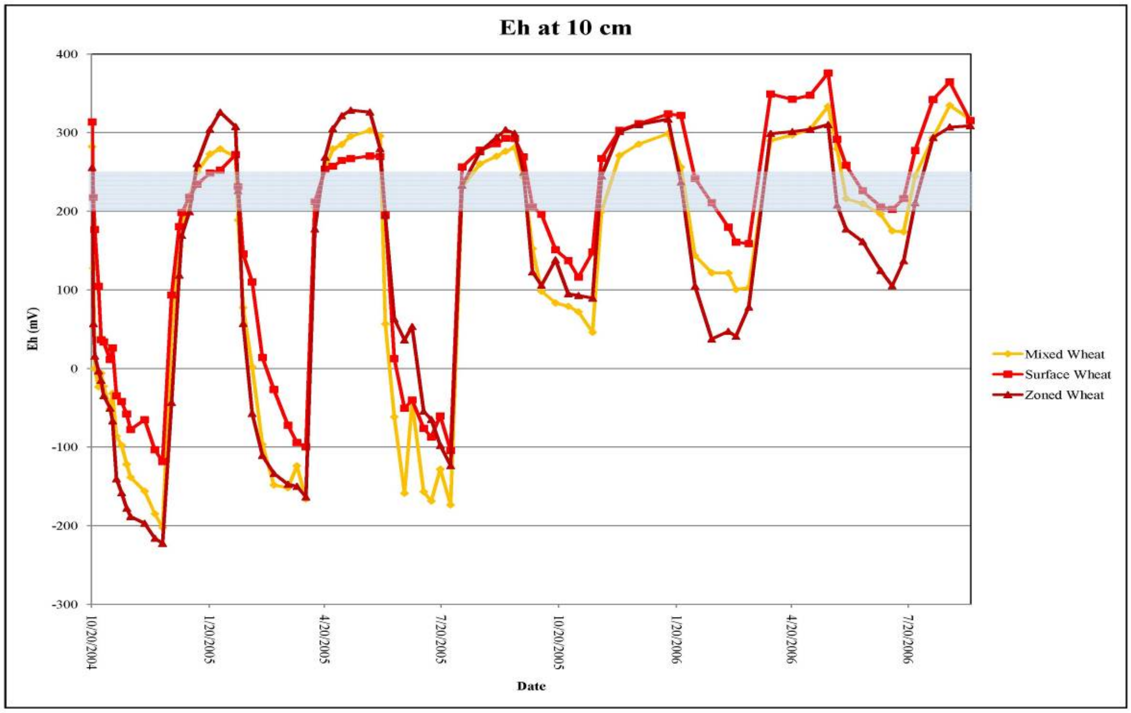
Figures 4.2 and 4.3 demonstrate that redox potentials correspond well with saturated and drained periods. Redox potentials fall into the reducing zone during saturated periods and rise into the oxidizing zone when drained. Also, regardless of organic treatment or application strategy, the redox potentials are not as reducing in later cycles as they were in earlier ones. As discussed in Chapter III, it is thought that the upward trend in redox potentials over time is a result of a decrease in organic carbon. This was likely caused because the experimental units were kept unvegetated, and as a result, supplementary organic carbon that would have been added thorough plant growth was prevented. Thus, it is thought under a more natural and vegetated setting, a more sustainable redox environment would probably be maintained.

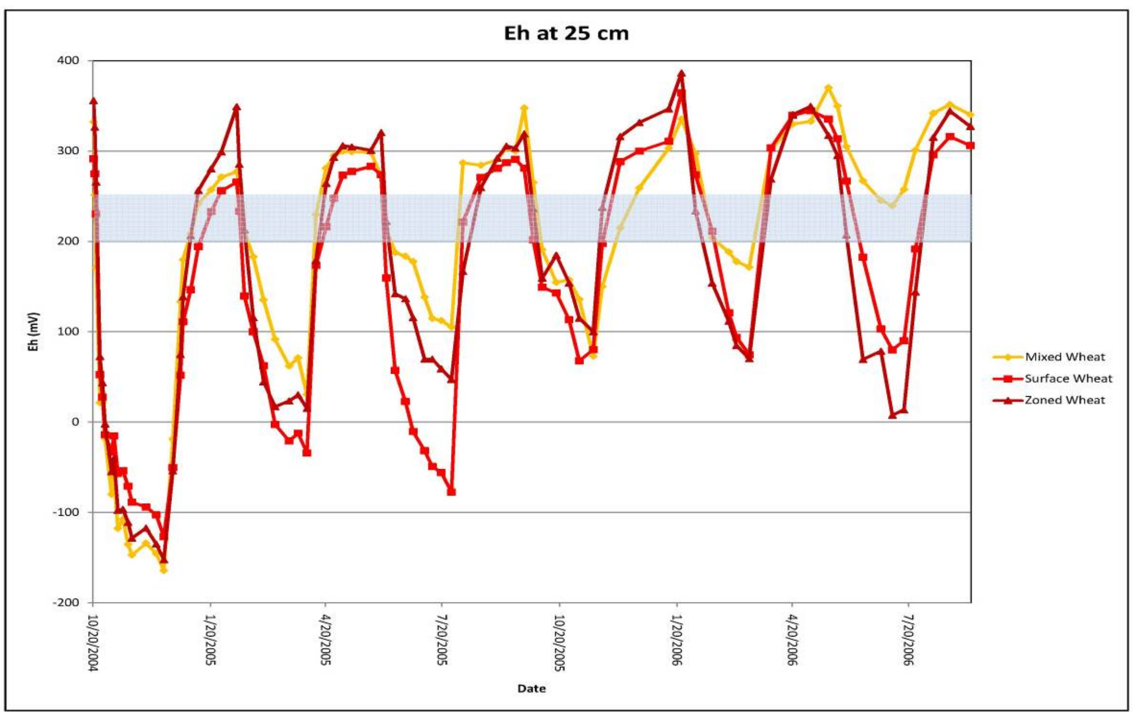
Figures 4.2a/b Mean Eh values measured in mesocosms treated with ground oak leaves at depths of 10(a) and 25(b) cm over the 6 cycles between October 2004 and August 2006. The shaded area represents the diffuse boundary between reduction and oxidation of iron oxides based on measured soil pH (5.7-6.5) and the technical standard of the NTCHS (Figure 2.2). Redox potentials fell into the reducing zone during saturated periods and rose into the oxidizing zone when the mesocosms were drained.





Figures 4.3a/b Mean Eh values measured in mesocosms treated with ground wheat straw at depths of 10(a) and 25(b) cm over the 6 cycles between October 2004 and August 2006. The shaded area represents the diffuse boundary between reduction and oxidation of iron oxides based on measured soil pH (5.7-6.5) and the technical standard of the NTCHS (Figure 2.2). Redox potentials fell into the reducing zone during saturated periods and rose into the oxidizing zone when the mesocosms were drained.





It was initially hypothesized that specific soil zones amended with organic materials would show lower redox potentials during saturated periods than other to areas that were not amended with organic materials. Thus, it was thought that mesocosms treated with the with organic material homogenized throughout the upper 10 cm (mixed) would have lower redox potentials during saturated periods than the other two treatments (at the upper 10 cm depth) because of the higher concentration of organic carbon in that area. However, illustrated in Figures 4.2a and 4.3a the mixed treatment mesocosms were not consistently more reducing at a depth of 10 cm during saturated periods than the other two application treatments. Similarly, it was postulated that zoned treatment mesocosms would be more reducing at 25 cm during saturated periods because of the close proximity of fresh organic materials. However, this expected trend was not observed at 25 cm with either oak leaves or straw (Figure 4.2b or 4.3b). Instead, redox potentials were generally similar throughout the mesocosm regardless of the location of the added organic materials. It is suspected that redox potentials were similar because dissolved organic compounds were dispersed by hydrological gradients throughout the soil mesocosm instead of only being localized to the area in which organic materials were added.

Summary tables of redox potentials are presented in Appendix E. Overall, the redox potential measurements at 10 and 25 cm suggest that the soil environment was reducing with respect to iron oxides (the primary component involved in forming redoximorphic features) during saturated periods and oxidizing during drained periods. The reduction and oxidation of iron oxide minerals are key to the development of redoximorphic features.

Redoximorphic Features

Iron oxide concentrations were the dominant, and often the only type of redoximorphic feature observed in the mesocosms. The iron oxide concentrations were mostly observed in the Ap1 and Ap2 horizons, with occasional features in the upper part of the BE/Bt horizon. The concentrations were typically faint in contrast, 7.5YR 4/4 to 4/6 in color, fine (< 2mm) to very fine (< 1mm) in size, and found as soft masses and pore linings (Figure 3.11). Examples of typical iron oxide concentrations observed in mesocosms subjected to each application strategy are shown in Figure 4.4. A summary table listing the abundance of iron oxide concentrations in each mesocosm is provided in Appendix H.

Figures 4.5 and 4.6 show the percentage of iron oxide concentrations in the Ap1 (Figure 4.5) and Ap2 (Figure 4.6) horizons for each organic material type and application strategy in each cycle. It was initially postulated that organic material type (wheat straw or oak leaves) would have an effect on the development of redoximorphic features. However, as shown in Figures 4.5 and 4.6, wheat straw and oak leaves did not have significantly different effects on the percentage of iron oxide concentrations in the either the Ap1 ($p=0.7451$) or Ap2 ($p=0.5446$) horizon. Similar results were also presented in Chapter III, where organic material type had little effect on the results. Since organic material type had no significant effects on the results, organic material type was removed as explanatory variable and data were combined across organic material type for the analyses that follow.

Figure 4.4 Pictures of iron oxide concentrations and organic material in each application strategy after mesocosm dissection. Black arrows point to iron oxide concentrations while white arrows indicate added organic material.

Zoned | Surface | Mixed

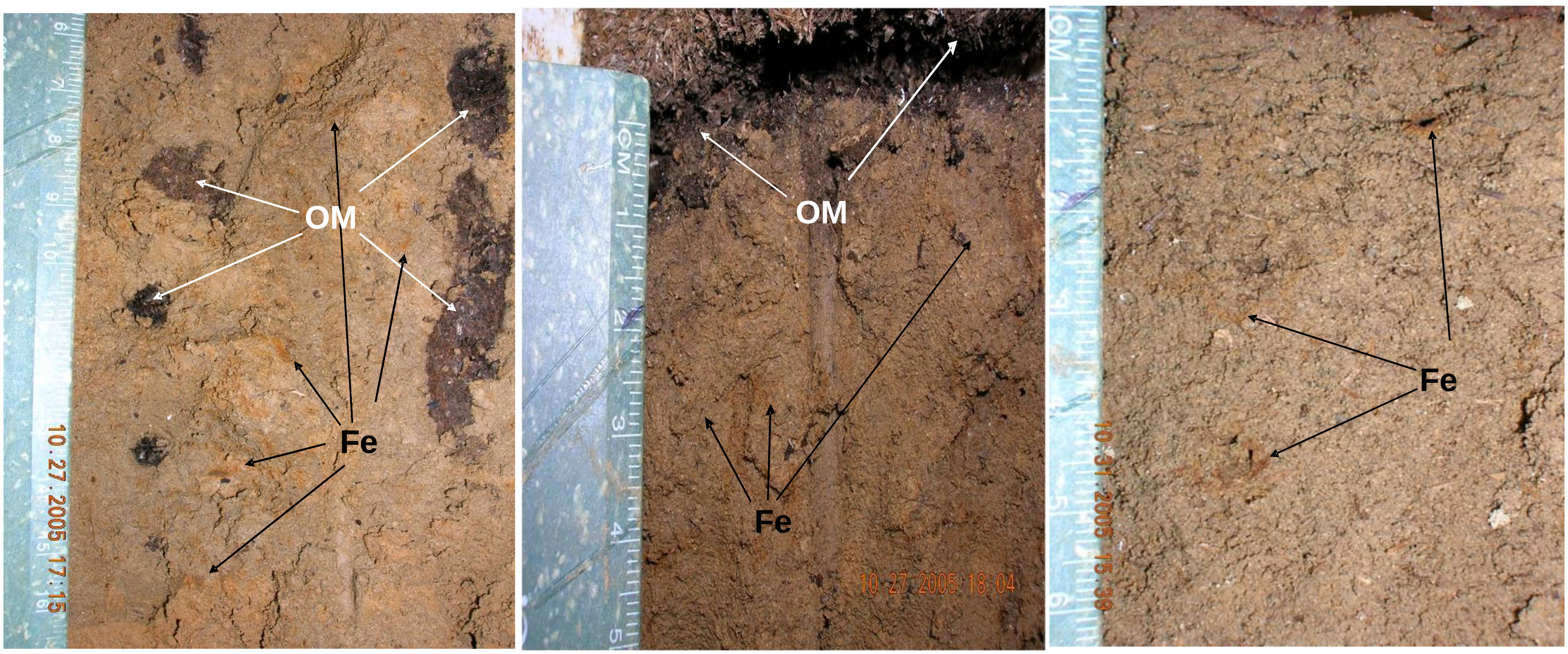


Figure 4.5 Percent iron oxide concentrations in the Ap1 horizon measured after the completion of each cycle. The mesocosms where organic material was applied in deep concentrated zones tended to have more iron oxide concentrations, while the mesocosms where organic material was mixed uniformly throughout the upper 10cm tended to have less.

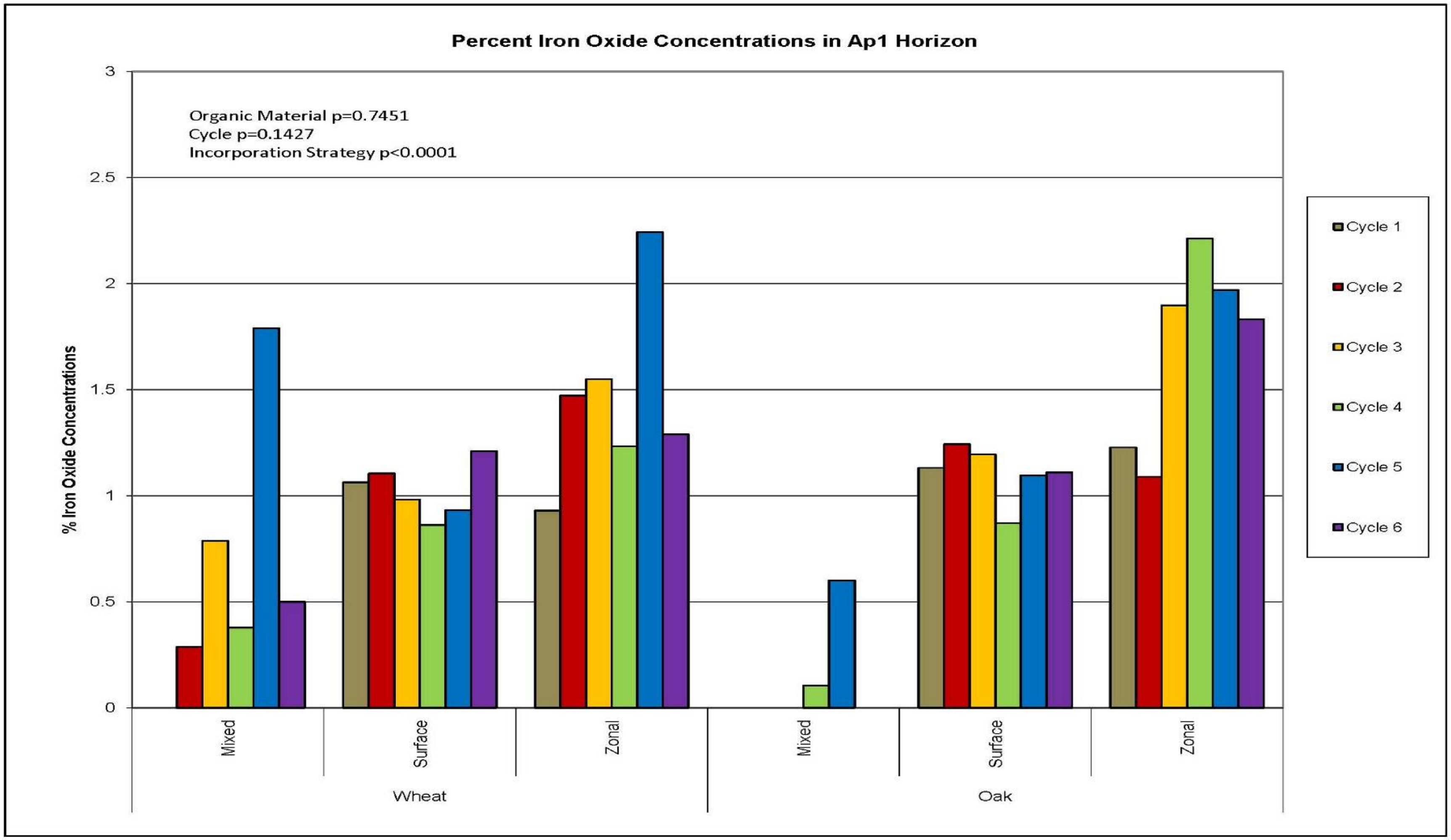
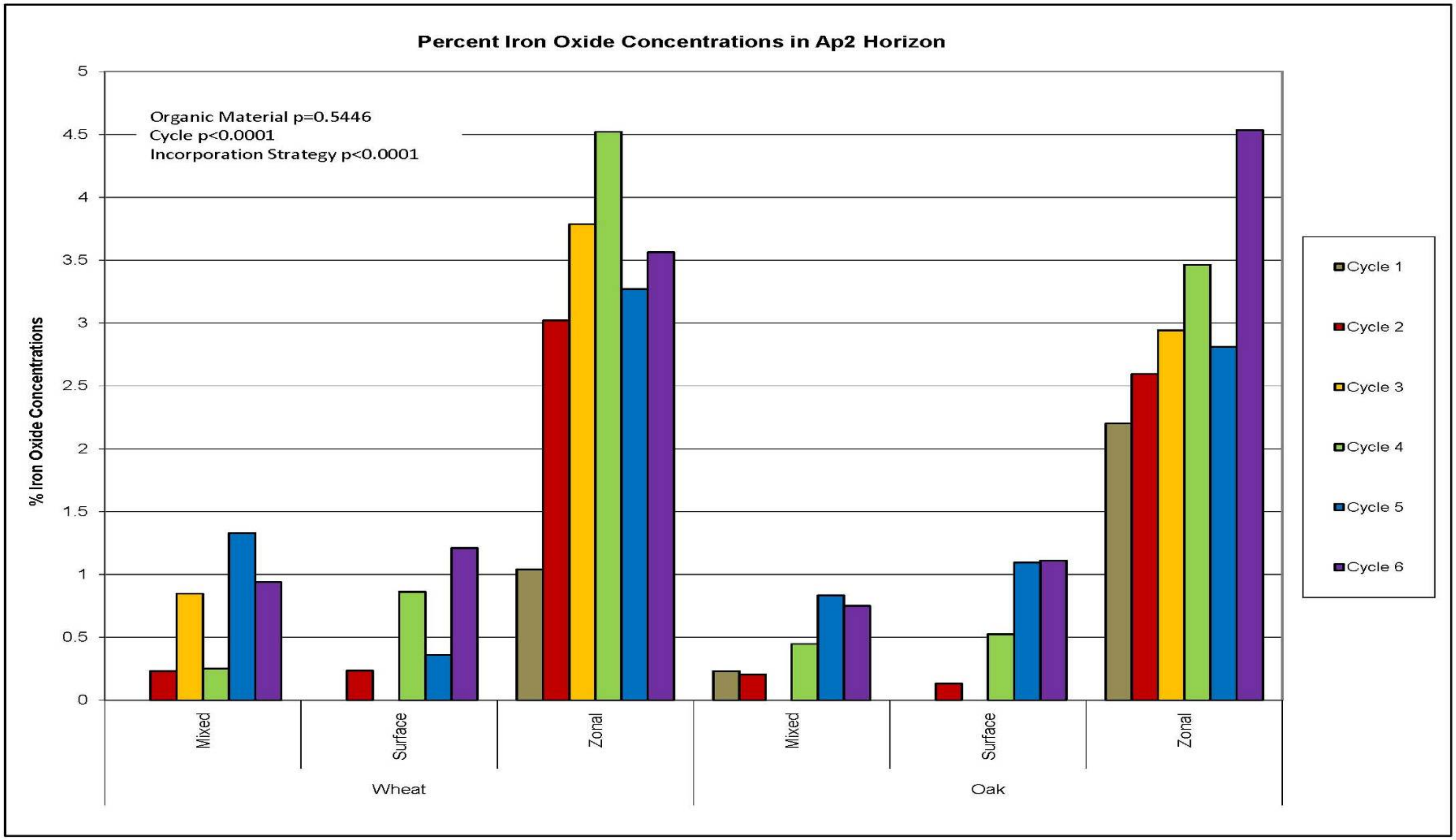


Figure 4.6 Percent iron oxide concentrations in the Ap2 horizon after the completion of each cycle. The mesocosms that were subjected to the zoned application treatment tended to have more iron oxide concentrations compared to the other two application treatments.



Figures 4.5 and 4.6 demonstrate that the method in which organic material was incorporated into the mesocosms significantly ($p<0.0001$) affected the abundance of iron oxide concentrations observed in the mesocosms overtime. These trends can be seen more clearly for the Ap1 horizon in Figure 4.7 where data were combined across organic material type. Mesocosms in which organic material was uniformly mixed in the upper 10 cm tended to have the lowest percentage of iron oxide concentrations in Ap1. As was discussed more thoroughly in Chapter III, it is thought that these mesocosms have the fewest features because the inherent soil structure was destroyed during the mixing process. Competent soil structure provides distinct soil surfaces and accompanying fine-scale moisture gradients that are very important for the formation of redoximorphic features (Verpraskas, 1992).

Mesocosms in which organic material was inserted into deeper zones tended to have more iron oxide concentrations in the Ap1 horizon than mesocosms in which organic material was laid on the soil surface. It is thought that vertical distribution of the organic materials in columns effectively influenced more naturally intact soil in the upper 10 cm when compared to the surface application. It influenced more naturally intact soil because the zonal arrangement (4 vertical 2 cm diameter columns) had a greater volume of soil in close proximity to the organic material (approximately 250 cm^2 vs. 175 cm^2 in the upper 10 cm). More soil close to the organic material likely caused enhanced microbial activity to occur in a greater volume of soil which resulted in dissolution of more iron oxide minerals and created more iron oxide concentrations throughout the Ap1 horizon.

Figure 4.7 Mean percent iron oxide concentrations in the Ap1(a) horizon for each application strategy during each cycle regardless of organic material type. Organic material type was ignored because it was shown not to be signicant in Figure 4.5. Thus, the value for each point represents the mean of 4 mesocosms (2 for each OM types x 2 OM types). The error bars show the distribution (standard error of the means) for each set of 4 means. An ANOVA was completed on the data and regression lines placed through each application strategy data set. Regression lines that share like letters were not significantly different ($\alpha = 0.05$).

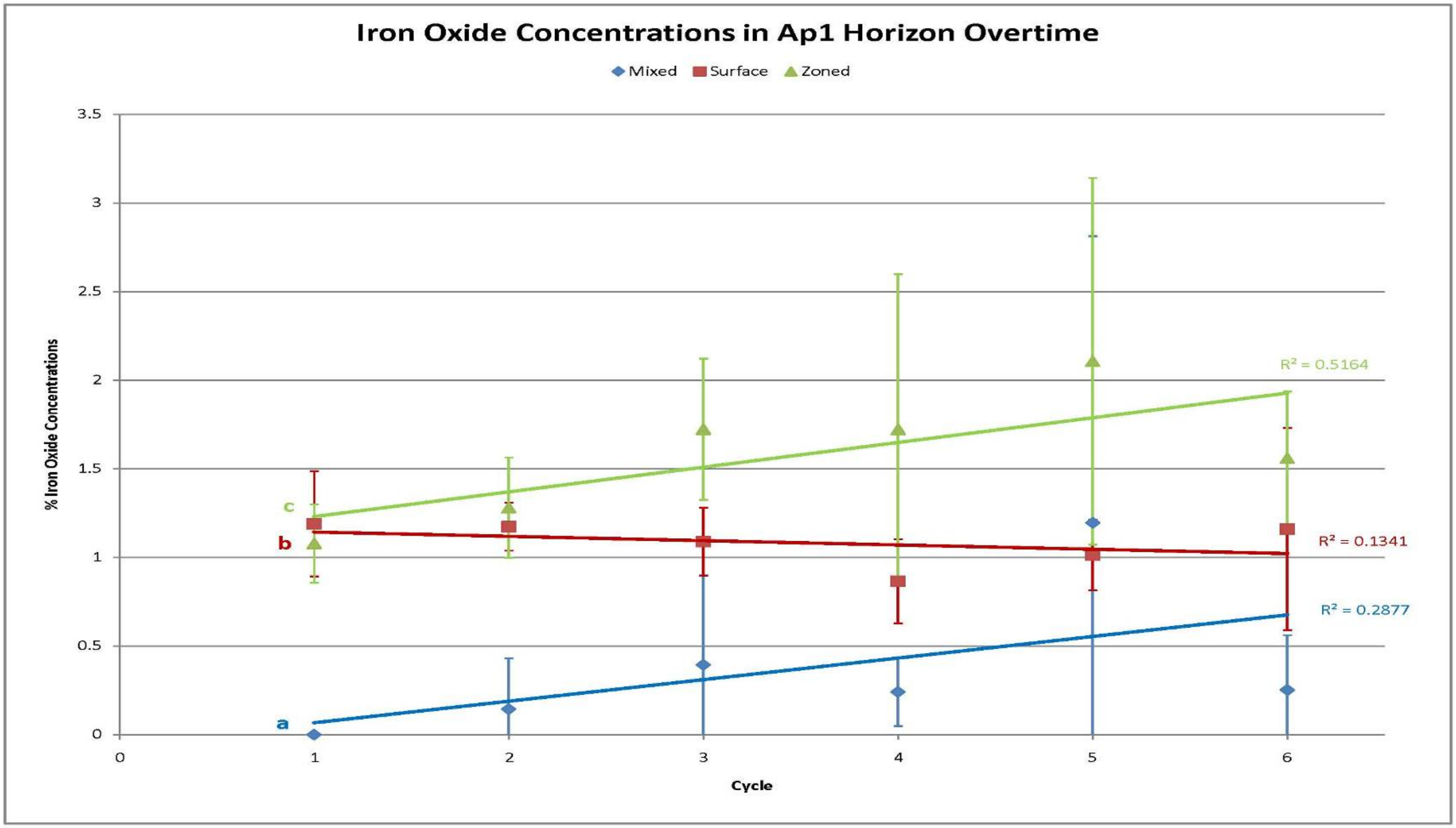
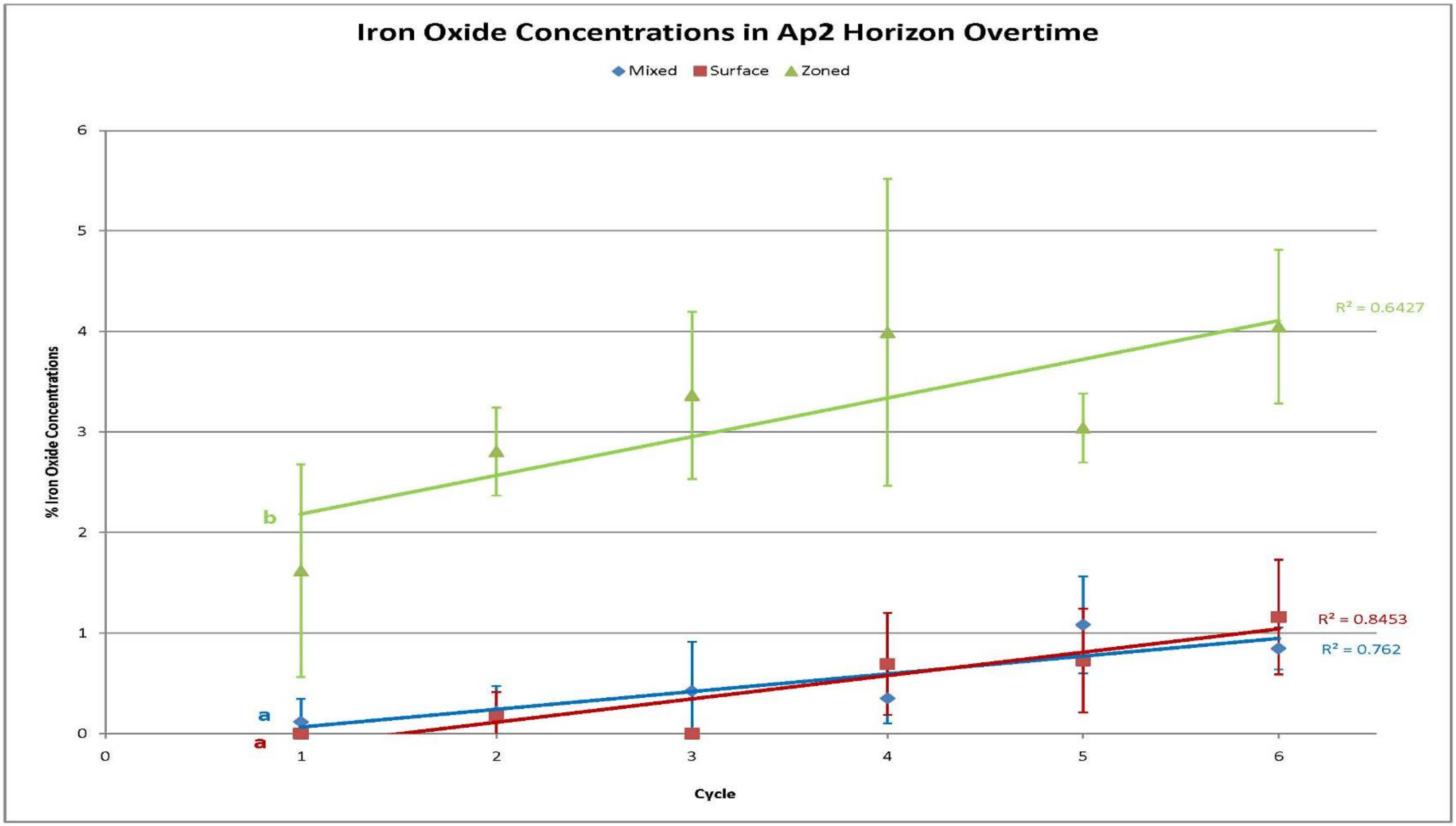


Figure 4.8 shows the percentage of iron oxide concentrations observed in the Ap2 horizon, regardless of organic material type. The figure shows that there was no difference between the percentages observed in the Ap2 horizon of mesocosms with mixed and surface applied organic materials. However, mesocosms with the zoned application had a significantly higher percentage of iron oxide concentrations than either of the other two strategies. This observation is not surprising because the zoned application inserted organic material directly into the Ap2 horizon, while the other did not.

Figures 4.7 (Ap1) and 4.8 (Ap2) also show the effect of 6 cycles of alternating saturated and dry conditions on the development of iron oxide concentrations. The figures show that the percentage of iron oxide concentrations in most treatments increased with time and number of alternating cycles. This trend was expected as it is generally accepted that the expression of wetland soil characteristics in newly saturated soils becomes stronger the longer it's subjected to wetland biogeochemical conditions. Mesocosms with organic material placed on the soil surface tended not to have an increase in iron oxide concentrations in the Ap1 horizon (Figure 4.7) as cycles and time increased. This could have been a result of the organic material acting as a mulch layer and withholding soil moisture in the Ap1 horizon upon mesocosm draining. Delayed drying in the Ap1 horizon could have caused a lag in the onset of soil oxidizing conditions and thus limiting the formation of iron oxide concentrations.

Figure 4.8 Mean percent iron oxide concentrations in the Ap2 horizons of mesocosms for each organic material application strategy. Organic material type was ignored because it was shown not to be signicant in Figure 4.6. Thus, the value for each point represents the mean of 4 mesocosms (2 for each OM type x 2 OM types). The error bars show the distribution (standard error of the means) for each set of 4 means. An ANOVA was completed on the data and regression lines placed through each application strategy data set. Regression lines that share like letters were not significantly different (α = 0.05).



Micromorphology

Micromorpholigcal descriptions were made from thin sections of the untreated Downer Ap and Bt horizons using the methods and terminology presented in Stoops, 2003. Both the Ap and Bt horizons had vughy microstructures with a quartzite mineralogy in the coarse fraction. The particles were arranged in a stippled speckled b-fabric with a single spaced porphyric related distribution. The pores were a little larger and more abundant in the Ap than in the Bt horizon. In thin section, the Ap horizon showed spherical excrement features probably from earthworms and a few areas where materials from the B horizon had been incorporated into the A horizon matrix. The Bt horizon had about 1% clay films. No redoximorphic features were observed in the thin sections taken from the untreated downer mesocosms. Select photos taken from the Downer thin sections are shown in Figure 4.9.

Figure 4.10 A&B show an iron oxide concentration that formed after three cycles around a pair of macropores (approximately 0.1mm) in the Ap2 horizon of a mesocosm treated with oak leaves and the zoned application. The feature likely formed when the mesocosm was transitioning from the reducing wet period(s) into the more oxidizing dry period(s). Dissolved iron in solution moved toward the center of the macropores where more oxidizing conditions resulted in precipitation of iron oxides. The gradation in color from light area on the outside to dark area on the inside of the iron oxide concentration likely represents an increasing concentration in iron oxides toward the interior of the feature adjacent to the pores and possibly also, enrichment in manganese oxides. The photomicrograph shown in Figure 4.10 C&D was from the Ap1 horizon of a mesocosm where oak materials were mixed throughout. The micrographs show organic material

Figure 4.9 Photomicrographs of Ap (A+B) and Bt (C+D) horizons from the untreated Downer soil. The photos on the left were taken under plane light and photos on the right taken under cross-polarized light. Frame width is 3.5 mm for upper set and 800 µm for the lower set. The upper set of photos are from the Ap horizon and show a stippled speckled b-fabric arranged in a single spaced porphyric related distribution. The lower photos show a typical pore lined with a clay film in the Downer Bt horizon. There were no redoximorphic features observed in the untreated soil.

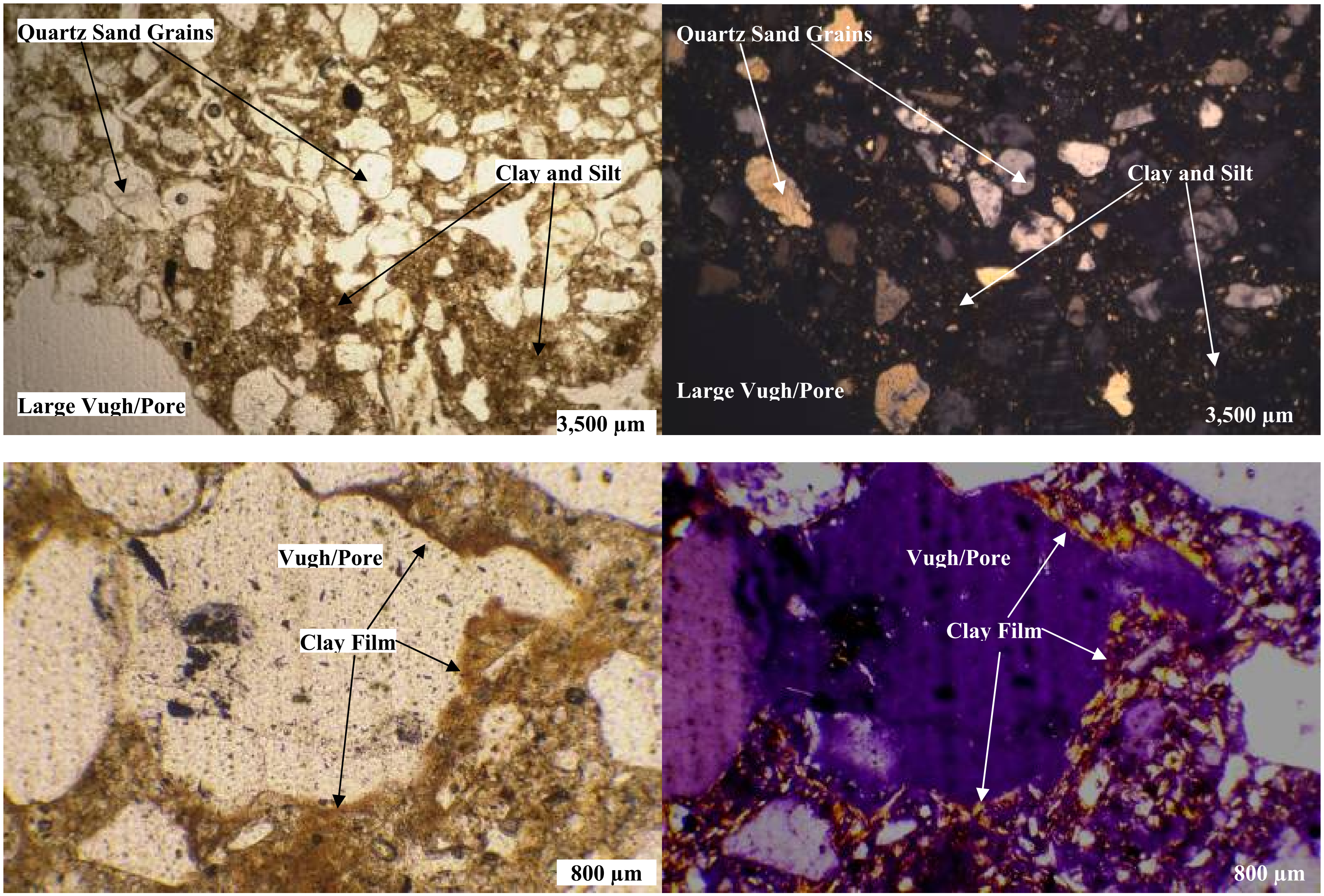
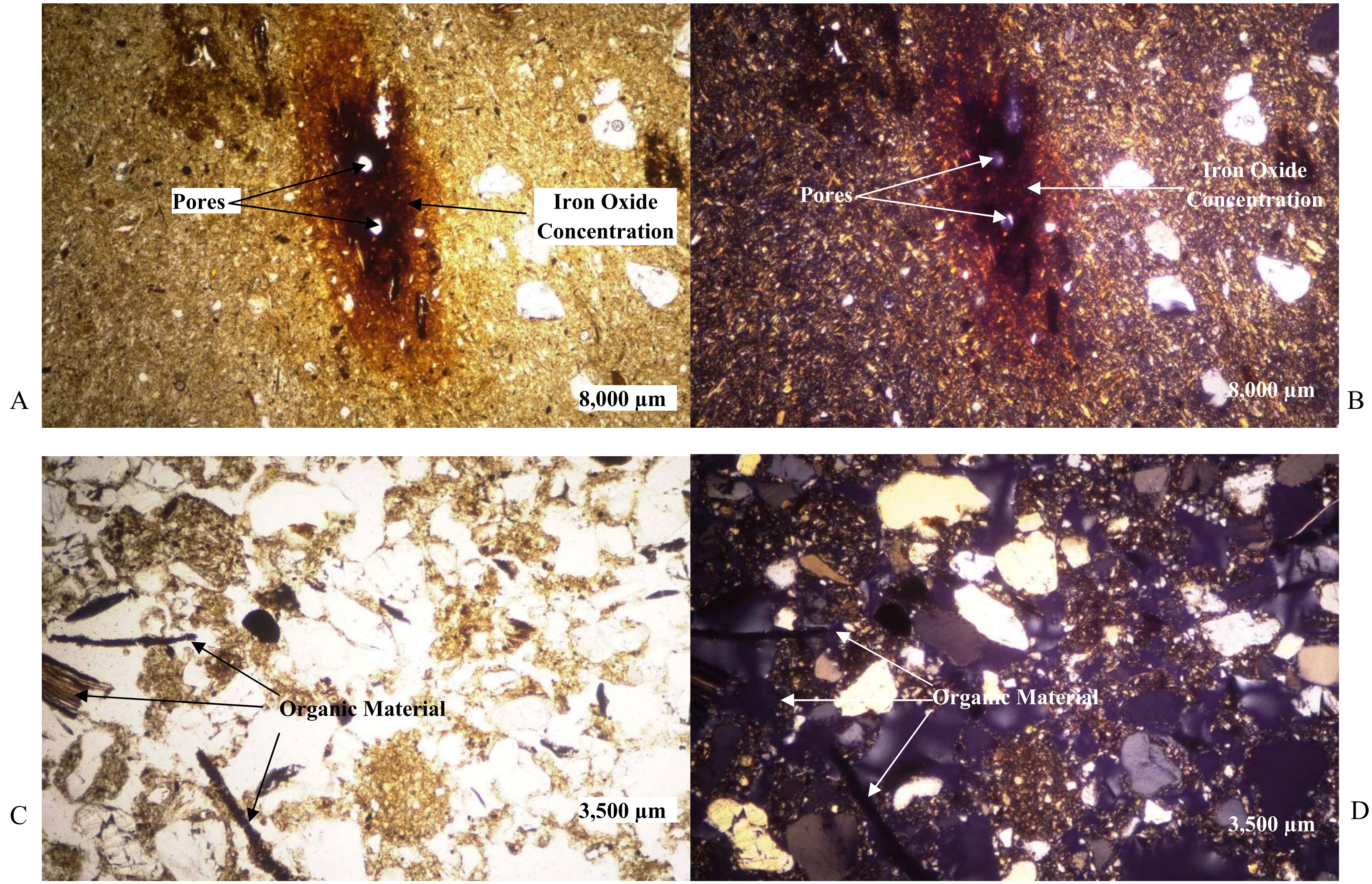


Figure 4.10 Photomicrographs taken from mesocosms treated with organic material and simulated wetland hydrology. The photos on the left were taken under plane light and photos on right under cross-polarized light. The upper set of photos (A+B) shows an iron oxide concentration in the Ap2 horizon of a mesocosm treated with oak leaves and the zoned application after three cycles. The iron oxide feature is darker in the middle and lighter around the edge, indicating higher iron concentration in the middle. The lower photos (C+D) shows organic material (wheat) uniformly mixed throughout the Ap1 soil matrix after three cycles. It is important to note the high microporosity induced by the uniform mixing of organic material into the soil.



uniformly distributed through homogenized soil material that has a high porosity, a single spaced porphyric related distribution, and a spongy microstructure. The spongy microstructure and high porosity were a consequence of the mixing process implemented during the addition of ground organic materials. No soil macrostructure was observed in the thin sections taken from the uniformly mixed horizon (Ap1). As presented previously in Chapter III and above in the previous section, it is thought that the destruction of soil macrostructure in mesocosms that had been mixed, has adversely affected the abundance of iron oxide features formed in the Ap1 horizon.

CONCLUSIONS

The addition of organic material to newly constructed or remediated wetlands is recognized as an integral part of creating a sustainable and naturally functioning wetland. The addition of these organic materials is thought to have positive effect on the development of wetland soil characteristics, most notably redoximorphic features.

The data show that regardless of method by which organic materials were incorporated into the soil, reducing conditions developed when the soil was saturated, and that oxidizing conditions developed after the soil was drained. The measured Eh and pH of the systems indicate that iron oxide minerals, the primary component of most redoximorphic features, were predicted to be mobilized during reducing periods and could have moved along moisture gradients where they could accumulate during oxidizing periods as iron oxide concentrations.

The method of organic material incorporation greatly influenced the abundance and location of the iron oxide concentrations. Concentrating organic material in zones within the soil resulted in a greater abundance of iron oxide concentrations throughout the Ap soil horizons when compared to the other two methods of application. The abundance of iron oxide concentrations generally increased with time and wet/dry cycles in most treatments. This trend agrees with the general consensus that soil will have a stronger expression of hydric soil properties the longer it's subjected to wetland biogeochemical conditions.

This study confirms that the method used to incorporate organic material into newly saturated soils, such as during wetland remediation or construction, does effect the development of redoximorphic features. This research indicates that the development of redoximorphic features will be maximized by concentrating organic amendments into deeper zones, rather than mixing uniformly or surface applying.

V. Development of Redoximorphic Features in an Upland Soil Transplanted within a Natural Riparian Wetland

INTRODUCTION

Wetlands are often constructed in upland landscapes. However, the soils within these constructed wetlands often do not have the soil characteristics typically found in natural wetlands (Bruland, 2004). It has been argued that the soil characteristics in the constructed wetlands must become like natural wetland soils for the ecosystem to function properly (Bishel-Machung et al, 1996; Stauffer and Brooks, 1997; Stolt et al, 2000; Campbell et al, 2002; Edwards and Proffitt, 2003). However, little research has attempted to experimentally evaluate the development of wetland soil characteristics in newly formed wetland soils over time in a natural setting.

In a study by Stolt et al (1998), envelopes of soil material (some amended with organic materials) were buried in various wetland settings. Half of the soil envelopes were removed after one year, with the final envelopes removed after two years. During the two-year period, iron oxide concentrations and depletions were formed in most soil materials. One of the objectives of the study was to investigate the time necessary for the formation of redoximorphic features in a wetland environment. Although they did document that redoximorphic features formed, the study failed to relate the specific percentage of redoximorphic features to soil properties such as time of saturation and carbon content. A better understanding of the effects of time of saturation and carbon content on the abundance of redoximorphic features would provide insight into how newly constructed wetland soils become like natural wetland soils.

Verpraskas et al (1995) documented the rapid formation of redoximorphic features (iron oxide concentrations and depletions) in a constructed floodplain wetland after only a single 7 day inundation event. Verpraskas et al (2006) concluded that at least one Hydric soil indicator (USDA-NRCS, 2006) was met in many areas throughout this constructed wetland after only three years. These results show that under optimum conditions significant redoximorphic features can form within constructed wetlands rather quickly. However, there are still many constructed wetlands where redoximorphic features are slow to develop. Also, Verpraskas et al did not address the potential effects of adding fresh organic materials (a common practice) during wetland construction on formation of redoximorphic features, and thus additional research is warranted.

As part of her Master's thesis research at the University of Maryland, Roslyand Orr implemented a sister study to the experiment presented herein (Orr, 2010). She transplanted three different well-drained intact soil types (one of which was the same Downer soil used in this experiment) into the same wetland and removed experimental units after one and two years. The percentage of iron oxide concentrations formed in the Downer soil cores from her study is presented in Table 5.1. She concluded that most iron oxide features in the A horizons formed during the first year, with a small increase in the percentage of features during the second year. The objectives of this study were to: (i) evaluate the potential effects of incorporating different quantities of organic carbon into newly saturated soils on the formation of redoximorphic features over time in a field setting; and (ii) compare the abundance of newly formed redoximorphic features formed in a field setting with the results from the greenhouse experiment presented in Chapter III.

Table 5.1 Summary of percent iron oxide concentrations formed in intact Downer soil cores that were transplanted into the same natural riparian wetland and removed after one and two years. Results are from Roslyand Orr's Master Thesis research completed at the University of Maryland (Orr, 2010).

Horizon	Approximate Percentage of Iron Oxide Concentrations	
	One Year	Two Years
A	7.0	8.5
Ap	4.0	4.1
B1	0.3	1.8
B2	0.0	1.5

MATERIALS AND METHODS

Research Approach

To further evaluate how an upland soil develops wetland soil characteristics under natural hydrologic wetland conditions, intact soil profiles were transplanted into a natural wetland field site. Before the soil profiles were transplanted into the wetland, timothy hay was uniformly mixed throughout the upper 10 cm at two different concentrations. Half of the transplanted soil profiles were removed after one year and detailed morphological descriptions were completed. The remaining experimental units were allowed to remain in the wetland for an additional year before being removed and descriptions completed.

Soil Profile Collection and Organic Addition

The upland soil used in this experiment was from the Downer soil series located at the Wye Research Institute on Wye Island (Coastal Plain) in Maryland, which is classified as a coarse loamy, semi-active, siliceous, mesic, Typic Hapludult. Prior to implementing the experiment, a detailed soil morphological description (Table 3.1) was completed to ensure that there was no morphological evidence of extended saturation (redoximorphic features). To ensure that similar soil characteristics encompassed the sampling area, the perimeter of the sampling site was investigated to a depth of 50 cm. Twelve intact soil profiles were harvested from the sampling area using 50cm long sections of 15 cm diameter schedule 40 PVC pipe that was sharpened on one end. The horizon integrity was preserved by vertically inserting each PVC casing 40 cm deep into the soil. The cores were carefully extracted and transported to a staging area where they were prepared for the experiment.

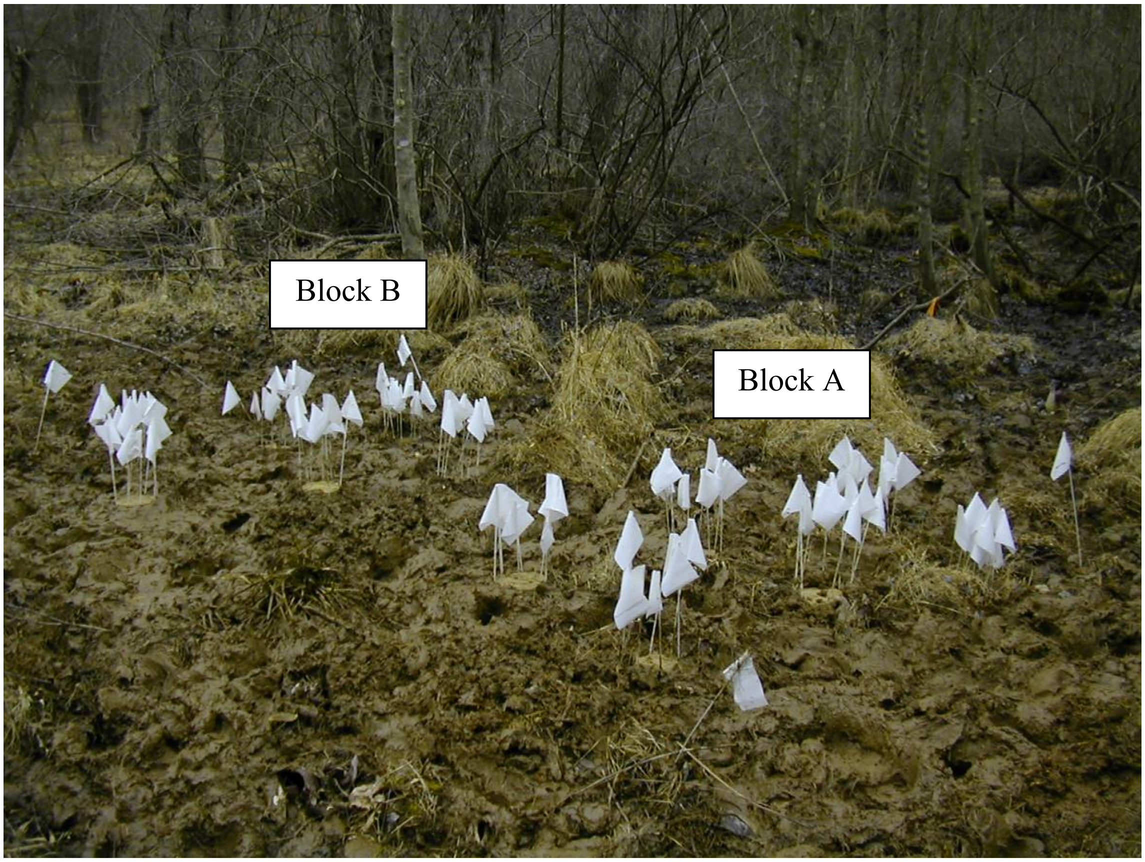
Once at the staging area, 60 grams (28 grams of carbon) of ground and homogenized timothy hay was uniformly mixed throughout the upper 10 cm of soil (Figure 4.1) in half (six) of the soil profiles. The addition corresponds to approximately 1.5 kg carbon added per square meter of soil which is approximately three times the average annual litter fall (500 g/m^2) of eastern riparian wetlands (Mitch and Gosslink, 1993) and was equivalent to adding approximately 12 g/kg of organic carbon to the 10 cm Ap1 horizon. The remaining 6 soil profiles were amended with 180 grams of timothy hay or 4.5 kg carbon/m^2 soil (approximately 36 g/kg added to the 10 cm thick Ap1 horizon). The addition of timothy hay was implemented by excavating, sieving (<2mm), and homogenizing the upper 10 cm of soil from an individual experimental unit. The 60g or 180g of timothy hay was uniformly mixed with the processed soil and then hand packed back into the PVC temporary casing in 3 or 4 cm equal increments. To solidify the upper 10 cm of soil, approximately 500 to 1,000 mL of water was added to the soil several times and allowed to dry for 2-3 weeks.

Transplantation and Extraction

Once prepared, the experimental units were inserted into a natural riparian wetland. The wetland used in the experiment was along the North Branch of Rock Creek (39° 07' 25" N, 77° 06' 05" W) near Olney, Maryland. The site was chosen because of the well documented wetland hydrology and reducing biogeochemistry in the wetland area from the work done between 2001 and 2003 as part of Karen Castenson's Master's thesis research at the University of Maryland which focused on the hydromorphology of piedmont floodplain soils (Castenson, 2004). Castenson's research indicated that during a year with normal rainfall the water table at the site (Rock Creek Low) was within 20 cm of the soil surface and reducing with respect to iron oxide minerals for most of the year. To confirm the wetland hydrology during this experiment, water table levels were automatically recorded twice daily in a nearby well. A soil description presented in Appendix A of Castenson's thesis classified the Hydric soil as a Fine loamy, mixed, mesic, Typic Fluvaquent within the Hatboro Soil Series. Notable observations from the soil description include a 2.5 cm thick mucky Oe horizon at the soil surface followed by a Bg hozion from 2.5 cm to 66 cm with 10% prominent (7.5YR 4/6) iron oxide concentrations in a depleted matrix (2.5Y 4/2), which met hydric soil field indicator F3 (depleted matrix).

Before each amended core was inserted into the wetland, an open a 15cm diameter hole 40cm deep was created in the wetland using a 15cm diameter hand auger. The PVC casing containing the soil core was placed vertically directly over the open hole and the soil core was carefully extruded from the PVC casing into the open hole, taking care to preserve the soil horizonation. The perimeter of each soil core was marked with flags to identify the exact location so that it could be recovered upon returning to the wetland at a later date (Figure 5.1). A total of 12 cores were inserted into the wetland in two blocks of six in March 2005. One block of soil cores (3 high timothy and 3 low timothy) was removed after one year in March 2006 and other six removed after two years in March 2007. Each soil core was removed from the wetland by carefully inserting a PVC casing to a depth of 40-50 cm back over the exact location of each core using the flags as a guide. Each PVC casing and soil were carefully excavated from the wetland and transported to a staging area where the soil was allowed to drain and partially dry until moist.

Figure 5.1 Photo of 12 upland soil cores amended with timothy hay transplanted into a riparian wetland soil along the North Branch of Rock Creek near Olney, Maryland in March 2005. The white flags mark the perimeter of each soil core so it can be found at a later date. Block A was removed after 1 year and block B removed after 2 years.



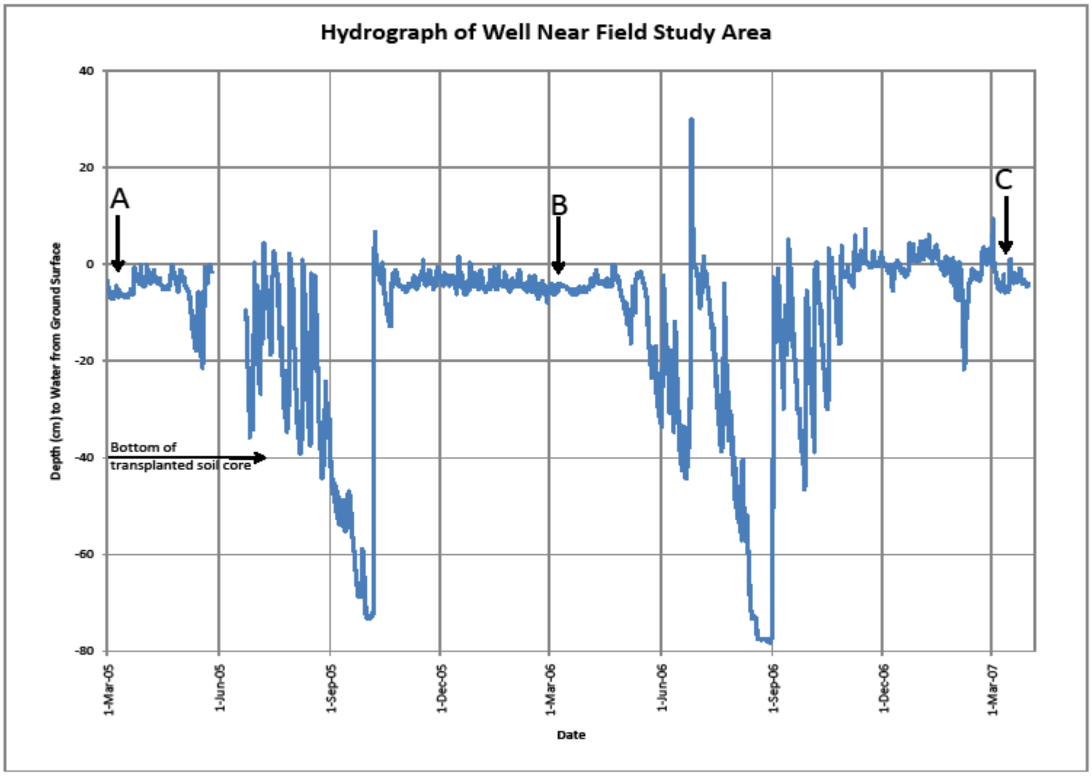
Documenting Morphology

Each moist soil core was cut in half lengthwise by making two lengthwise cuts through the PVC casing directly across from each other using a circular saw. A handheld wood saw was then used to cut the soil core in half. The smeared surface of each core half was dressed with a knife and spatula so that fresh soil surfaces could be observed. A detailed morphological description was completed on each core with special attention paid to any redoximorphic features. The abundance of redoximorphic features were quantified in each core using computerized image analysis. This was accomplished by placing a clear mylar sheet on representative 5 cm square areas and tracing all redoximorphic features using a fine point marker. The tracing was completed on two separate areas in each horizon as shown in Figure 3.4. The tracings on the mylar sheets were then scanned (200 DPI), cleaned using Adobe Photoshop Editor, and quantified using Image Tool 3.0 (UTHSCSA, 2002).

RESULTS AND DISCUSSION

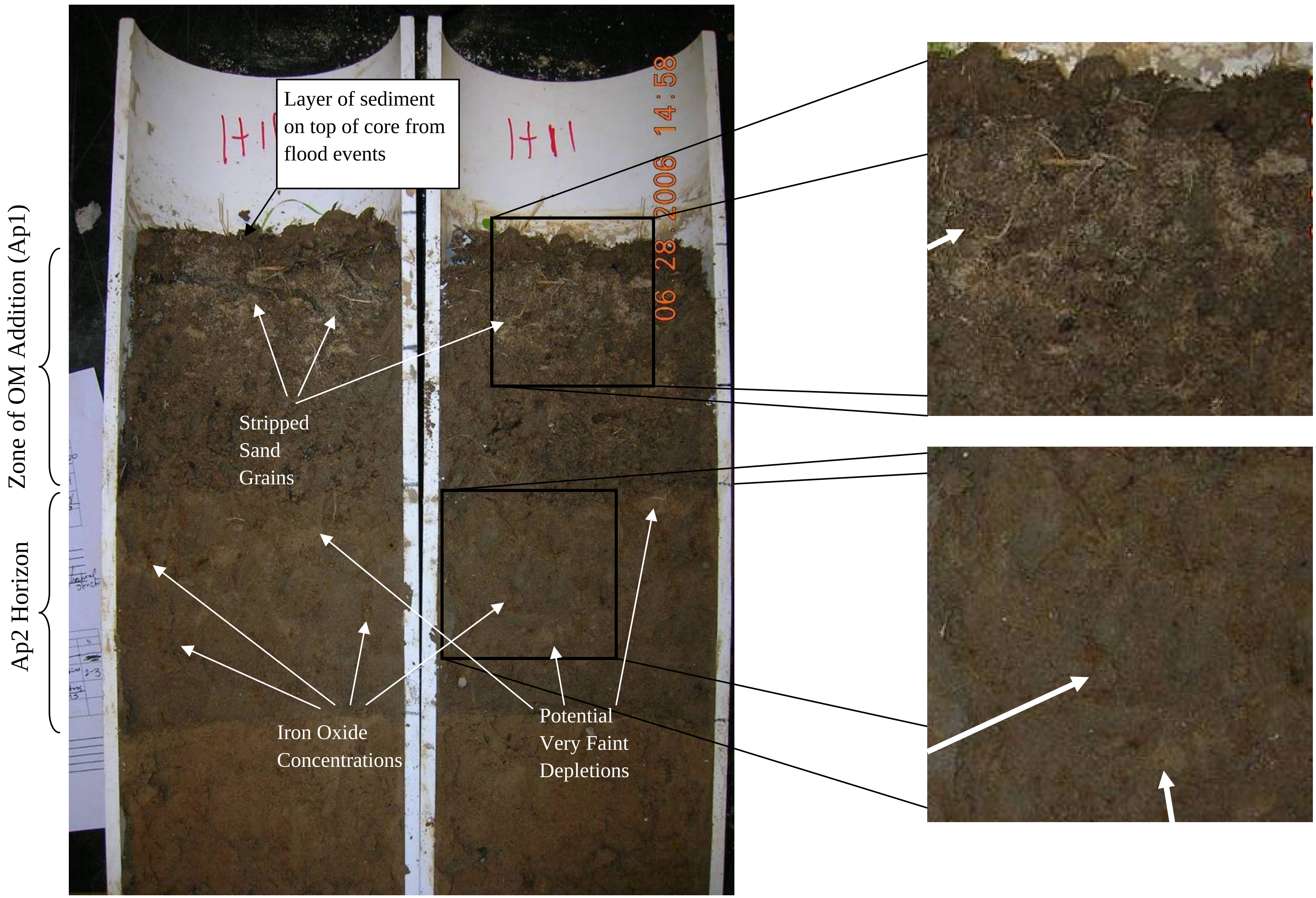
Water table data collected from a well adjacent to the study area over the two year experimental period is presented in Figure 5.2. These data show that during the winter and spring months, the water table was generally at or near the soil surface. Not surprisingly, during the dryer summer and fall months the water table tended to migrate away from the soil surface. Although the water table did drop in the summer and more substantially in the fall months, the zone in which the soil core was transplanted was saturated for most of the year. Similar hydrologic data from previous years at this site were presented in Castenson's (2004) thesis. Based on Eh measurements and the use of IRIS (Indicator of Reduction in Soil) tubes, she concluded that the site was reducing with respect to iron oxide minerals within 20 cm of the soil surface for much of the year. Given the similar hydrologic data during this study, it can be assumed that the zone in which the soil cores were transplanted experienced reducing conditions with respect to iron oxide minerals for much of the year, which favored the formation of redoximorphic features in the transplanted soil cores.

Figure 5.2 Water table data collected from a well adjacent to the study area over the two year period of the experiment. The depth value 0 is ground surface. Where indicated, A) the cores were inserted into the wetland; B) Half of the cores were removed from the wetland; C) Remaining cores removed from wetland.



The soil descriptions for each core are presented in Appendix F. The soil descriptions show that most redoximorphic features formed in cores tended to be faint to distinct iron oxide concentrations occurring as soft masses and pore-linings that were 7.5YR 4/4 and4/6 in color, and medium (3 to 5 mm) to very fine (< 1 mm) in size. Occasional very faint depletions that were 0.5 to 1 chroma lower than the matrix color were observed in some cores in the Ap1 and Ap2 horizons. Stripped sand grains were also observed in various cores in the Ap1 horizon. A photo of a soil core removed from the wetland after one year is presented in Figure 5.3 and highlights the redoximorphic features. Very few redoximorphic features (<1%) formed in the Bt horizon of most cores. If features were observed in the Bt horizon, they were typically within a couple centimeters of the

Figure 5.3 Photo of soil core amended with the high concentration of timothy hay and removed from the wetland after 1 year. Redoximorphic features are shown below.



overlying Ap2 horizon or adjacent to small pieces of wetland soil material that were captured along the edge of the core during extraction from the wetland.

Figure 5.4 shows the average percent iron oxide concentrations (quantified using image analysis) in the Ap1 and Ap2 horizons after 1 and 2 years in the wetland. A summary data table is presented in Appendix I. The data show that oxide concentrations were highest (8-10%) in the Ap2 horizon with relatively fewer (2-5%) in the Ap1 horizons. Contrary to expectation, statistical analysis demonstrated that there was no significant difference (p 0.73) in the quantity of iron oxide concentrations found in the same horizons of cores amended with high and low levels of timothy hay. This was probably because a substantial amount of organic carbon (1.5 kg/m^2 or approximately 12 g/kg within the Ap1 horizon) was added with just the low level treatment and thus organic carbon was not limiting to the formation of redoximorphic features. Because there was no significant treatment affect due to the amount of organic material added in the Ap1 horizon, these data could be combined for analysis. When this was done (Figure 5.5) the data show that significantly more iron oxide concentrations formed in the Ap2 horizon than the Ap1 horizon, but that there was no significant difference (p 0.21) between years 1 and 2. These results were contrary to the initial hypotheses. Due to the addition of organic material in the Ap1 horizon, it was initially postulated that more redoximorphic features would form in the Ap1 than Ap2. As noted in Chapters III and IV, it is thought that more features formed in the Ap2 than the Ap1 due to the homogenization process that was used to mix the organic material into the upper 10 cm which effectively destroyed the natural structural units. It is also possible that more redoximorphic features

Figure 5.4 Graph of average percent iron oxide concentrations (based on image analysis) in the Ap1 and Ap2 horizons of cores after being implanted in the wetland for one and two years. Error bars shown on top of bars represent Standard Error of the Means. Bars that share like letters are not significantly different from each other (α=0.05).

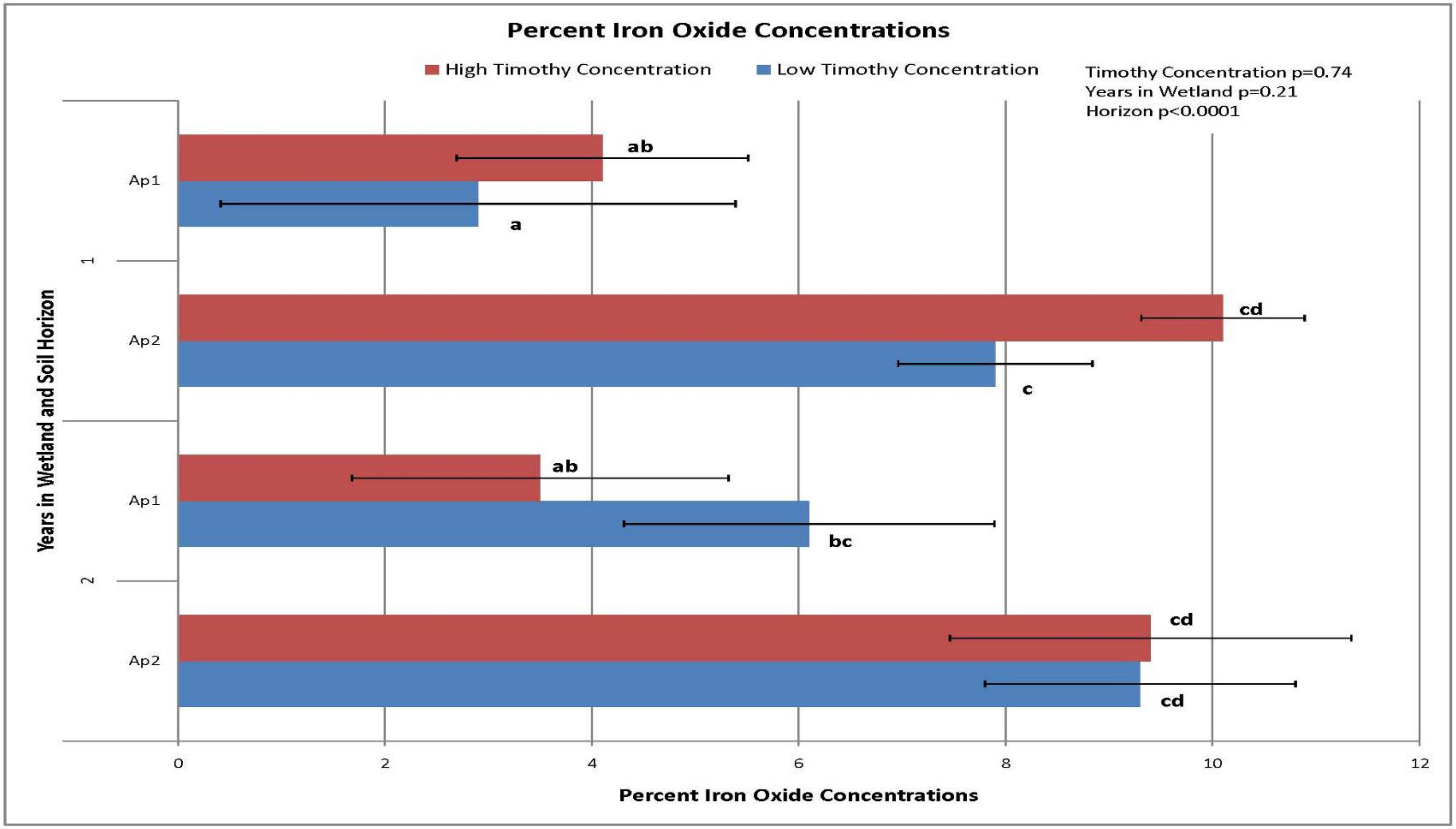
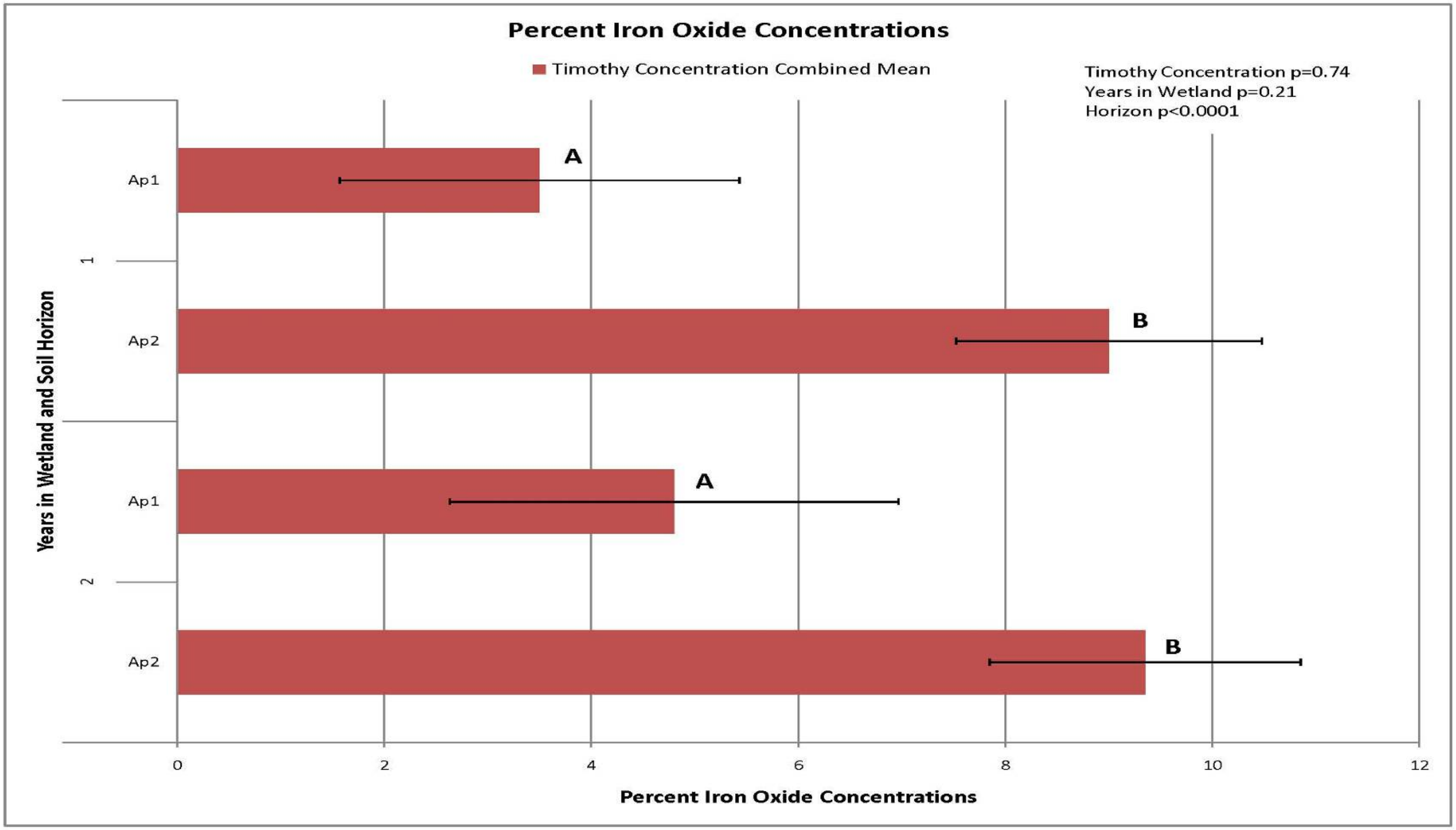


Figure 5.5 Graph of average percent iron oxide concentrations (image analysis) in the Ap1 and Ap2 horizons of cores after being removed from the wetland after one and two years regardless of amount of organic material added. Data were combined across added organic material because it was not significant in Figure 5.4. Error bars represent Standard Error of the Means. Bars that share like letters are not significantly different from each other (α=0.05).



formed in the Ap2 because the horizon was deeper in the soil profile, and as a result, was saturated and thus reducing more frequently.

It was also surprising that more features did not form in cores that remained in the wetland during the second year because it is generally understood that saturation time and abundance of redoximorphic features are positively correlated (Fielder and Sommer, 2004; D'Amore et. al, 2004; Morgan and Stolt, 2006). Results of this study, however, indicate that most iron oxide concentrations formed during the first year, and little during the second year. Perhaps if the experiment were allowed to continue for a longer period, a significant effect of time would be observed. It would also be interesting to have additional data during the first year to see when most of the iron oxide concentrations developed.

The sister study completed as part of Rosyland Orr's Master's thesis research (Orr, 2010), showed that 4-9% iron oxide concentrations formed over two years, with most features induced during the first year and little additional in year two (Table 5.1). Contrary to this experiment, her study showed that more features formed in the upper A horizon (7-8.5%) than the lower Ap horizon (4%) of Downer soil cores with natural structure transplanted in the same wetland between 2004 and 2006. The lesser quantity of iron oxide concentrations in the upper A horizon of this experiment was likely due to the homogenization (mixing) process that destroyed the natural soil structure and interrupted the mircohydrologic gradients that contribute to the formation of redoximorphic features. These same soil structural effects were also observed in the greenhouse experiment and discussed in Chapter III and IV. It is also noteworthy that approximately twice as many features (8-10%) formed in the lower Ap2 horizon of this experiment as formed in of the lower Ap horizon (4%) in Orr's (2010) experiment. Perhaps this was because the iron oxide minerals mobilized by the reducing conditions were unable to precipitate in oxidizing areas of the homogenized zone (Ap1) because of the impacts to soil structure. The soluble iron could have migrated through hydrologic gradients to the immediately adjacent intact Ap2 horizon with stronger soil structure where it was precipitated from solution and formed iron oxide concentrations. Some of the differences between the experiments could be attributed to 1) the cores being collected on different years, 2) the cores were located in slightly different areas within the wetland, and 3) they were implanted during different years.

In Table 5.2, data are presented for greenhouse and field mesocosms that received the same amount (1.5 kg/m^2) of timothy hay mixed uniformly mixed throughout the upper 10 cm. Three simulated hydrologic cycles spanned approximately 1 year and thus could perhaps be compared to 1 year in field, and similarly the 6^{th} greenhouse cycle might be comparable to the 2^{nd} year in the field. However, the field study values and the greenhouse values (Table 5.2) are very different. Generally speaking, the mesocosms placed in the natural wetland showed 4 to 10 times more iron oxide concentrations those saturated in the greenhouse. These results indicate that the natural and greenhouse environments were not equivalent. This difference may have been due to the much more dynamic hydrology in the wetland (Figure 5.2). The natural and more dynamic hydrology likely created many more alternating reducing and oxidizing cycles than the greenhouse simulated hydrology and thus resulted in the development of more redoximorphic features. Alternatively, the effects of the surrounding wetland soil (which was high in soil organic matter) or the effect of vegetation could have contributed to the substantial difference in the quantity of iron oxide concentrations formed.

Table 5.2 Comparison of percent iron oxide concentrations in mesocosms amended with 1.5 kg of timothy hay in the greenhouse (Chapter III) and natural wetland environments.

Cycle	Percent Iron Oxide Concentrations Greenhouse Component		Year	Percent Iron Oxide Concentrations Field Component	
	Ap1	Ap2		Ap1	Ap2
1	0.0	0.0		-	-
2	0.0	0.0		-	-
3	0.7	1.0	1.0	2.9	7.9
4	0.2	0.7		-	-
5	0.7	0.7		-	-
6	0.2	1.0	2.0	6.1	9.3

CONCLUSIONS

Few attempts have been made to quantify the development of redoximorphic features in newly saturated soils under natural wetland conditions over time. This small scale field study investigated the development of redoximorphic features in an upland soil profile amended with organic material and transplanted in a wetland over a two year period.

The research shows that a well-drained soil subjected to natural wetland conditions can develop significant redoximorphic features relatively quickly (less than one year). Most of the redoximorphic features formed were iron oxide concentrations that accumulated quickly during the first year and developed at a much slower rate during the second. The data indicated that the amount of organic material, either low or high, mixed uniformly into the soil had little effect on the development of redoximorphic features during the two year length of the experiment. It is thought that organic carbon, added at the lower level (1.5 kg) was adequate to remove this as a limiting factor to redoximorphic feature formation and thus further additions had no additional effect.

It was apparent that there was stronger expression of redoximorphic features in cores transplanted in the wetland when compared to similar mesocosms from the greenhouse study. It is likely that the hydrology in the wetland was much more dynamic than that of the greenhouse mesocosms causing a greater abundance of redoximorphic features. The surrounding soil, which was high in organic matter and had an active vegetation stand, could have also contributed to the increased formation of redoximorphic features in the natural wetland.

VI. Thesis Summary and Conclusions

In summary, this project was undertaken to determine the effect of adding organic material on the formation of redoximorphic features in newly saturated soils in constructed wetlands. A total of three studies were run that included two in a greenhouse setting where intact soil profiles were subjected to various organic material types that were added to the soil in various ways. They were then subjected to simulated wetland conditions over a two year period. A third study involved placing mesocosms into a natural wetland.

In each of the experiments, redoximorphic features formed relatively quickly. Most of the features observed were iron oxide concentrations that were typically faint to distinct in contrast, 7.5YR 4/4 to 4/6 in color, fine to very fine in size, and found as soft masses and pore linings. Iron oxide concentrations generally increased with the length of time they were subjected to wetland hydrology. Depletions, which are characteristic of longer saturated conditions, were rarely observed. These trends were expected and agree with the general consensus that soils will develop stronger expressions of redoximorphic features with time.

The results of this study indicate that the type of organic material used during wetland construction has little effect on the quantity and nature of redoximorphic feature formation. However, different organic materials did decompose at different rates and seemed to affect the redox potentials measured in the soils. Materials that were high in lignin content and had a high C:N ratio, such as sawdust and oak leaves, sustained lower redox potentials toward the end of the experiment. It is thought that these materials decomposed more slowly over the length of the experiment and were gradually releasing easily oxidizable organic compounds instead of decomposing more rapidly in the beginning. Although the organic additions (1.5 kg carbon/m^{2}) were adequate to sustain reducing biogeochemistry over the length of the experiment, the strength of reducing conditions was progressively less because there were no periodic additions of organic material from plant growth. This suggests that organic materials added to newly constructed wetlands support reducing conditions during the first couple of years, but quickly become more dependent on organic carbon contributions from natural plant and root decay.

The method in which organic material was incorporated into the soil greatly affected the development of redoximorphic features. Concentrating organic material into zones deeper within the soil profile resulted in a greater abundance of redoximorphic features compared to applying the organic materials to the soil surface or uniformly mixing the organic material in the upper part. The mixing process (completed on the upper 10 cm) negatively impacted the formation of redoximorphic features by destroying natural soil structure and therefore impacting microhydrologic gradients. The zoned application preserved the natural soil structure in the soil material surrounding the organic columns and had a greater influence on the soil profile than just laying the organic materials on the soil surface.

Cores with organic material mixed into the upper part and transplanted into a natural wetland developed significantly more redoximorphic features than their greenhouse counterparts. This was likely a result of a more natural hydrologic condition that was much more dynamic than that of the cores in the greenhouse setting, high organic matter content in soil surrounding the implanted mesocosms, and an active vegetation stand. These results make it difficult to compare and extrapolate the results in the greenhouse setting to a more natural setting. However, even though the absolute value of observed redoximorphic features may be different between the greenhouse and field setting, it is expected that a similar relative relationship exists between the treatments used in the greenhouse and field component. Thus, it is thought that the relationships documented in the greenhouse remain valid for a field setting.

Based on the findings of this project, it is recommended that, during the construction of wetlands, organic material be concentrated into deeper zones to maximize the development of redoximorphic features. Uniform mixing via plowing and disking should be avoided due to the negative effects resulting from impacted soil structure.

Appendix A: Forage Analysis Laboratory Reports

Maple Leaves.txt

HOLMES LABORATORY, INC.
3559 U.S. 62
Millersburg, Ohio 44654
Phone:(330)893-2933
holmeslabinfo@hughes.net

[A Vital Key to Todays Agriculture]

FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-352
SAMPLE I.D.:
Maple Leaves

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	9.16	
Dry Matter		%	90.84	
Crude Protein		%	5.16	5.68
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	15.17	16.70
Acid Detergent Fiber		%	41.09	45.23
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	1.93	2.13
Phosphorus	(P)	%	.09	.10
Magnesium	(Mg)	%	.31	.34
Potassium	(K)	%	.25	.27
Sulfur	(S)	%		
Sodium	(Na)	%	.002	.002
Chloride	(Cl)	%		
Copper	(Cu)	ppm	5	6
Manganese	(Mn)	ppm	243	268
Zinc	(Zn)	ppm	35	39
Iron	(Fe)	ppm	134	147
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

National Forage Testing Association Certified

Page 1

Oak Leaves 1.txt

HOLMES LABORATORY, INC.
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[A Vital Key to Todays Agriculture]

FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-348
SAMPLE I.D.:
Oak Leaves 1

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	10.08	
Dry Matter		%	89.92	
Crude Protein		%	3.70	4.12
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	23.86	26.54
Acid Detergent Fiber		%	43.49	48.37
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	.88	.98
Phosphorus	(P)	%	.14	.16
Magnesium	(Mg)	%	.11	.12
Potassium	(K)	%	.19	.21
Sulfur	(S)	%		
Sodium	(Na)	%	.007	.008
Chloride	(Cl)	%		
Copper	(Cu)	ppm	4	5
Manganese	(Mn)	ppm	693	771
Zinc	(Zn)	ppm	30	33
Iron	(Fe)	ppm	68	76
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

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Oak Leaves 2.txt

HOLMES LABORATORY, INC.
3559 U.S. 62
Millersburg, Ohio 44654
Phone:(330)893-2933
holmeslabinfo@hughes.net

[A Vital Key to Todays Agriculture]

FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-349
SAMPLE I.D.:
Oak Leaves 2

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	8.92	
Dry Matter		%	91.08	
Crude Protein		%	4.05	4.45
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	25.78	28.31
Acid Detergent Fiber		%	45.87	50.36
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	.87	.96
Phosphorus	(P)	%	.12	.13
Magnesium	(Mg)	%	.10	.11
Potassium	(K)	%	.15	.16
Sulfur	(S)	%		
Sodium	(Na)	%	.006	.007
Chloride	(Cl)	%		
Copper	(Cu)	ppm	5	6
Manganese	(Mn)	ppm	722	793
Zinc	(Zn)	ppm	30	33
Iron	(Fe)	ppm	76	83
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

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Sawdust.txt

HOLMES LABORATORY, INC.
3559 U.S. 62
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[A Vital Key to Todays Agriculture]

FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-354
SAMPLE I.D.:
Sawdust

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	8.76	
Dry Matter		%	91.24	
Crude Protein		%	1.24	1.36
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	18.78	20.58
Acid Detergent Fiber		%	71.73	78.62
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	.24	.26
Phosphorus	(P)	%	.02	.02
Magnesium	(Mg)	%	.03	.03
Potassium	(K)	%	.17	.19
Sulfur	(S)	%		
Sodium	(Na)	%	.009	.010
Chloride	(Cl)	%		
Copper	(Cu)	ppm	3	3
Manganese	(Mn)	ppm	145	159
Zinc	(Zn)	ppm	6	7
Iron	(Fe)	ppm	13	14
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

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Timothy Hay.txt

HOLMES LABORATORY, INC.
3559 U.S. 62
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FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-353
SAMPLE I.D.: Timothy Hay

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	9.00	
Dry Matter		%	91.00	
Crude Protein		%	5.97	6.56
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	4.82	5.30
Acid Detergent Fiber		%	39.38	43.27
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	.26	.29
Phosphorus	(P)	%	.18	.20
Magnesium	(Mg)	%	.12	.13
Potassium	(K)	%	1.95	2.14
Sulfur	(S)	%		
Sodium	(Na)	%	.021	.023
Chloride	(Cl)	%		
Copper	(Cu)	ppm	4	4
Manganese	(Mn)	ppm	58	64
Zinc	(Zn)	ppm	15	16
Iron	(Fe)	ppm	76	83
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

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FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-350
SAMPLE I.D.: Wheat Straw 1

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	8.06	
Dry Matter		%	91.94	
Crude Protein		%	3.11	3.38
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	7.11	7.73
Acid Detergent Fiber		%	52.29	56.87
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	.25	.27
Phosphorus	(P)	%	.09	.10
Magnesium	(Mg)	%	.06	.06
Potassium	(K)	%	1.58	1.72
Sulfur	(S)	%		
Sodium	(Na)	%	.016	.017
Chloride	(Cl)	%		
Copper	(Cu)	ppm	3	3
Manganese	(Mn)	ppm	30	33
Zinc	(Zn)	ppm	5	5
Iron	(Fe)	ppm	120	131
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

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Wheat Straw 2.txt

HOLMES LABORATORY, INC.
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[A Vital Key to Todays Agriculture]

University of Maryland
1109 HJ Patterson Hall
College Park, MD 20742

FORAGE/FEEDSTUFF
ANALYSIS REPORT
Web site: www.holmeslab.com
Date Reported: 01/19/2007
Submitted by : Adam Gray
Customer: Adam Gray
Lab Number: 07-351
SAMPLE I.D.:
Wheat Straw 2

Item		Units	As Sampled Basis	Dry Matter Basis
Moisture		%	7.75	
Dry Matter		%	92.25	
Crude Protein		%	3.04	3.29
Available Protein		%		
Adjusted Crude Protein		%		
A.D.F. Protein		%		
N.D.F. Protein		%		
Soluble Protein		%		
Degraded Protein		%		
Protein Solubility		%		
Protein Degradability		%		
Lignin		%	6.17	6.69
Acid Detergent Fiber		%	52.13	56.51
Neutral Detergent Fiber		%		
N.D.F.(Protein Free)		%		
NFC (Non-Fiber Carbohydrate)		%		
Sugar		%		
Starch		%		
Crude Fat		%		
TDN		%		
NEl		Mcal/lb.		
NEm		Mcal/lb.		
NEg		Mcal/lb.		
Ash		%		
Lignin Insoluble Ash		%		
Calcium	(Ca)	%	.21	.23
Phosphorus	(P)	%	.08	.09
Magnesium	(Mg)	%	.06	.06
Potassium	(K)	%	1.54	1.67
Sulfur	(S)	%		
Sodium	(Na)	%	.019	.021
Chloride	(Cl)	%		
Copper	(Cu)	ppm	3	3
Manganese	(Mn)	ppm	40	43
Zinc	(Zn)	ppm	6	6
Iron	(Fe)	ppm	92	100
Molybdenum	(Mo)	ppm		
Aluminum	(Al)	ppm		
Nitrate	(NO3)	%		Negative
pH				
RFV (Relative Feed Value)				
Horse	DE	Mcal/lb.		
Horse	TDN	%		
Crude Fiber		%		
DCAD		meq./100g DM		
DCAD		meq./1 lb.DM		

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Appendix B: Total Soil Carbon Data

UNIVERSITY OF MARYLAND
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
DEPT. ENST, ANALYTICAL LAB
H. J. PATTERSON HALL, ROOM 0225

Dr. Rabenhorst mrabenho@umd.edu
H. J. Patterson Hall, Dept. ENST

On 4/5/07, 84 samples of soil placed in tin capsules were submitted for CHN analysis by Adam Gray, agray1@umd.edu

Samples (Analytical Lab No. 3329-3414) completed on 5/3/07 using LECO CHN-2000 instrumentation and drift calibration with Leco soil (0.91% C, 0.43% H, 0.016% N).

Analytical Lab No.	I.D.	Organic Treatment	Incorporation Method	Cycle	Weight (g)	% C	% H	% N
3329"	40102	Sawdust	Mixed	Cycle 6	0.1317	0.58	0.32	0.02
3330"	1A1	Control	Mixed	Cycle 1	0.1152	0.64	0.31	0.02
3331"	5073	Oak	Mixed	Cycle 3	0.1210	1.09	0.36	0.03
3332"	177	Timothy Hay	Mixed	Cycle 3	0.1390	0.59	0.27	0.02
3333"	3702	Maple	Mixed	Cycle 1	0.1252	1.47	0.43	0.03
3334"	42A	Control	Mixed	Cycle 6	0.1407	0.85	0.35	0.03
3335"	11B	Control	Mixed	Cycle 6	0.1351	0.99	0.35	0.03
3336"	1750	Timothy Hay	Mixed	Cycle 6	0.1352	0.50	0.26	0.02
3337"	4346	Oak	Mixed	Cycle 6	0.1281	0.73	0.30	0.02
3338"	Timothy	Control	Mixed	Cycle 0	0.1270	1.27	0.36	0.02
3339"	4455	Oak	Mixed	Cycle 1	0.1087	1.36	0.41	0.02
3340"	44B	Control	Mixed	Cycle 1	0.1111	0.63	0.29	0.02
3341"	16101	Maple	Mixed	Cycle 6	0.1187	0.71	0.31	0.02
3342"	Downer	Control	Mixed	Cycle 0	0.1610	0.66	0.28	0.02
3343"	520	Maple	Mixed	Cycle 3	0.1377	0.90	0.33	0.03
3344"	304	Wheat Straw	Mixed	Cycle 1	0.1058	1.51	0.41	0.03
3345"	2119	Oak	Mixed	Cycle 3	0.1727	1.06	0.33	0.03
3346"	Sawdust	Control	Mixed	Cycle 0	0.1874	1.49	0.38	0.03
3347"	1222	Wheat Straw	Mixed	Cycle 3	0.1357	0.68	0.29	0.03
3348"	3174	Maple	Mixed	Cycle 3	0.1179	0.80	0.32	0.02
3349"	1159	Timothy Hay	Mixed	Cycle 1	0.1560	0.92	0.31	0.02
3350"	1301	Oak	Mixed	Cycle 1	0.1255	1.34	0.39	0.03
3351"	36100	Oak	Mixed	Cycle 6	0.1144	0.72	0.31	0.02
3352"	103	Sawdust	Mixed	Cycle 1	0.1533	1.56	0.37	0.02
3353"	2749	Wheat Straw	Mixed	Cycle 6	0.1631	0.56	0.25	0.02
3354"	4505	Timothy Hay	Mixed	Cycle 1	0.1212	1.14	0.36	0.03
3355"	Oak	Control	Mixed	Cycle 0	0.1701	1.44	0.37	0.03
3356"	557	Sawdust	Mixed	Cycle 1	0.1083	1.49	0.41	0.02
3357"	3A	Control	Mixed	Cycle 3	0.1512	0.66	0.30	0.02
3358"	3823	Timothy Hay	Mixed	Cycle 3	0.1161	0.65	0.29	0.03
3359"	258	Wheat Straw	Mixed	Cycle 1	0.1088	0.97	0.36	0.02
3360"	821	Sawdust	Mixed	Cycle 3	0.1499	1.32	0.40	0.03
3361"	375	Sawdust	Mixed	Cycle 3	0.1193	0.77	0.32	0.03
3362"	52103	Wheat Straw	Mixed	Cycle 6	0.1772	0.57	0.28	0.02
3363"	3347	Maple	Mixed	Cycle 6	0.1680	0.69	0.28	0.02
3364"	2776	Wheat Straw	Mixed	Cycle 3	0.1101	0.72	0.30	0.02
3365"	45B	Control	Mixed	Cycle 3	0.1261	0.62	0.30	0.02
3366"	Maple	Control	Mixed	Cycle 0	0.1369	1.49	0.39	0.02
3367"	Wheat	Control	Mixed	Cycle 0	0.1579	1.50	0.39	0.02
3368"	4748	Sawdust	Mixed	Cycle 6	0.1036	0.67	0.30	0.02
3369"	29104	Timothy Hay	Mixed	Cycle 6	0.1417	0.51	0.27	0.01
3370"	1556	Maple	Mixed	Cycle 1	0.1627	1.36	0.36	0.03

UNIVERSITY OF MARYLAND
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Dr. Rabenhorst mrabenho@umd.edu
H. J. Patterson Hall, Dept. ENST

On 4/5/07, 84 samples of soil placed in tin capsules
were submitted for CHN analysis by Adam Gray, agray1@umd.edu

Samples (Analytical Lab No. 3320-3414) completed on 5/3/07
using LECO CHN-2000 instrumentation
and drift calibration with Leco soil (0.91% C, 0.43% H, 0.016% N).

Analytical Lab No.	I.D.	Organic Treatment	Incorporation Method	Cycle	Weight (g)	% C	% H	% N
3372*	4455	Oak	Mixed	Cycle 1	0.1118	1.36	0.41	0.02
3373*	52103	Wheat Straw	Mixed	Cycle 6	0.1194	0.55	0.27	0.02
3374*	2749	Wheat Straw	Mixed	Cycle 6	0.1388	0.56	0.26	0.02
3375*	1A1	Control	Mixed	Cycle 1	0.1144	0.63	0.28	0.02
3376*	29104	Timothy Hay	Mixed	Cycle 6	0.1373	0.51	0.27	0.01
3377*	3174	Maple	Mixed	Cycle 3	0.1057	0.77	0.30	0.02
3378*	2776	Wheat Straw	Mixed	Cycle 3	0.1181	0.78	0.31	0.03
3379*	40102	Sawdust	Mixed	Cycle 6	0.1091	0.59	0.31	0.02
3380*	103	Sawdust	Mixed	Cycle 1	0.1315	1.65	0.40	0.02
3381*	1301	Oak	Mixed	Cycle 1	0.1231	1.33	0.38	0.02
3382*	Oak	Control	Mixed	Cycle 0	0.1567	1.35	0.35	0.02
3383*	16101	Maple	Mixed	Cycle 6	0.1252	0.73	0.31	0.02
3384*	3823	Timothy Hay	Mixed	Cycle 3	0.1080	0.72	0.31	0.03
3385*	4346	Oak	Mixed	Cycle 6	0.1234	0.68	0.29	0.02
3386*	557	Sawdust	Mixed	Cycle 1	0.1224	1.48	0.38	0.02
3387*	Timothy	Control	Mixed	Cycle 0	0.1199	1.22	0.35	0.02
3388*	45B	Control	Mixed	Cycle 3	0.1208	0.64	0.30	0.02
3389*	Wheat	Control	Mixed	Cycle 0	0.1353	1.31	0.38	0.02
3390*	2119	Oak	Mixed	Cycle 3	0.1030	1.28	0.40	0.03
3391*	4505	Timothy Hay	Mixed	Cycle 1	0.1206	1.24	0.40	0.02
3392*	1556	Maple	Mixed	Cycle 1	0.1370	1.34	0.39	0.03
3393*	375	Sawdust	Mixed	Cycle 3	0.1561	0.87	0.33	0.02
3394*	3A	Control	Mixed	Cycle 3	0.1122	0.69	0.31	0.02
3395*	1159	Timothy Hay	Mixed	Cycle 1	0.1327	0.90	0.32	0.02
3396*	42A	Control	Mixed	Cycle 6	0.1353	0.90	0.37	0.02
3397*	3347	Maple	Mixed	Cycle 6	0.1302	0.69	0.29	0.02
3398*	520	Maple	Mixed	Cycle 3	0.1253	0.97	0.37	0.03
3399*	11B	Control	Mixed	Cycle 6	0.1479	0.92	0.35	0.02
3400*	1750	Timothy Hay	Mixed	Cycle 6	0.1334	0.51	0.27	0.01
3401*	36100	Oak	Mixed	Cycle 6	0.1145	0.78	0.31	0.03
3402*	Downer	Control	Mixed	Cycle 0	0.1500	0.70	0.27	0.03
3403*	3702	Maple	Mixed	Cycle 1	0.1720	1.49	0.39	0.04
3404*	821	Sawdust	Mixed	Cycle 3	0.1174	1.68	0.45	0.04
3405*	258	Wheat Straw	Mixed	Cycle 1	0.1238	1.03	0.33	0.03
3406*	Sawdust	Control	Mixed	Cycle 0	0.1244	1.51	0.36	0.03
3407*	4748	Sawdust	Mixed	Cycle 6	0.1280	0.74	0.30	0.02
3408*	304	Wheat Straw	Mixed	Cycle 1	0.1167	1.37	0.36	0.03
3409*	44B	Control	Mixed	Cycle 1	0.1405	0.73	0.31	0.02
3410*	1222	Wheat Straw	Mixed	Cycle 3	0.1204	0.75	0.29	0.03
3411*	Maple	Control	Mixed	Cycle 0	0.1140	1.40	0.35	0.02
3412*	5073	Oak	Mixed	Cycle 3	0.1144	1.17	0.34	0.03
3413*	177	Timothy Hay	Mixed	Cycle 3	0.1185	0.65	0.26	0.02

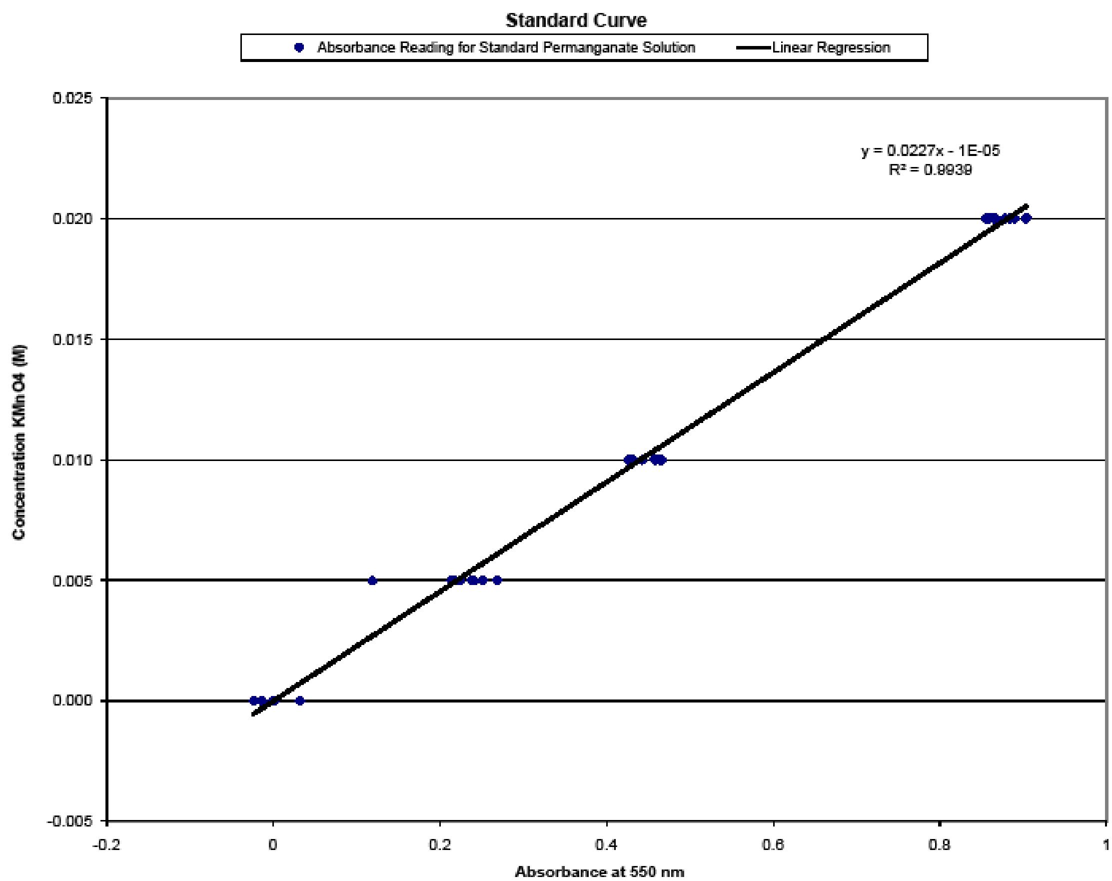
Appendix C: Active Soil Carbon Data

Core ID	DATE	Replicate	Treatment	Cycle	Absorbance Reading (550 nm)	Active C (mg/Kg soil)
DOWNER	3/5/2007	A	control	0	0.811	57
DOWNER	3/5/2007	B	control	0	0.785	78
RDOWNER	3/5/2007	A	control	0	0.795	70
RDOWNER	3/5/2007	B	control	0	0.809	59
MAPLE	3/5/2007	A	maple	0	0.733	121
MAPLE	3/5/2007	B	maple	0	0.754	104
OAK	3/5/2007	A	oak	0	0.810	58
OAK	3/5/2007	B	oak	0	0.765	95
SAWDUST	3/5/2007	A	sawdust	0	0.745	111
SAWDUST	3/5/2007	B	sawdust	0	0.737	118
TIMOTHY	3/5/2007	A	timothy	0	0.749	108
TIMOTHY	3/5/2007	B	timothy	0	0.734	120
WHEAT	3/5/2007	A	wheat	0	0.748	109
WHEAT	3/5/2007	B	wheat	0	0.782	81
1A	2/26/2007	A	control	1	0.766	94
1A	2/26/2007	B	control	1	0.826	45
44B	2/22/2007	A	control	1	0.771	90
44B	2/22/2007	B	control	1	0.758	101
1556	2/22/2007	A	maple	1	0.731	123
1556	2/22/2007	B	maple	1	0.727	126
3702	2/22/2007	A	maple	1	0.704	145
3702	2/22/2007	B	maple	1	0.700	148
1301	2/22/2007	A	oak	1	0.773	88
1301	2/22/2007	B	oak	1	0.728	125
4455	2/22/2007	A	oak	1	0.781	82
4455	2/22/2007	B	oak	1	0.760	99
103	3/5/2007	A	sawdust	1	0.700	148
103	2/22/2007	B	sawdust	1	0.674	169
557	2/22/2007	A	sawdust	1	0.810	58
557	2/22/2007	B	sawdust	1	0.740	115
1159	2/22/2007	A	timothy	1	0.738	117
1159	2/22/2007	B	timothy	1	0.724	128
4505	2/26/2007	A	timothy	1	0.750	107
4505	2/26/2007	B	timothy	1	0.735	119
258	2/22/2007	A	wheat	1	0.763	96
258	2/26/2007	B	wheat	1	0.691	155
304	3/5/2007	A	wheat	1	0.778	84
304	2/22/2007	B	wheat	1	0.715	136
3A	3/5/2007	A	control	3	0.825	46
3A	3/5/2007	B	control	3	0.766	94
45B	2/26/2007	A	control	3	0.764	96
45B	3/5/2007	B	control	3	0.802	65

520	2/26/2007	A	maple	3	0.712	138
520	2/22/2007	B	maple	3	0.766	94
3174	2/22/2007	A	maple	3	0.759	100
3174	2/26/2007	B	maple	3	0.800	66
2119	2/26/2007	A	oak	3	0.737	118
2119	2/22/2007	B	oak	3	0.784	79
5073	2/22/2007	A	oak	3	0.743	113
5073	2/22/2007	B	oak	3	0.743	113
375	2/26/2007	A	sawdust	3	0.806	61
375	2/22/2007	B	sawdust	3	0.744	112
821	2/22/2007	A	sawdust	3	0.676	168
821	2/22/2007	B	sawdust	3	0.692	154
177	2/22/2007	A	timothy	3	0.766	94
177	2/26/2007	B	timothy	3	0.782	81
3823	2/22/2007	A	timothy	3	0.729	124
3823	2/22/2007	B	timothy	3	0.738	117
1222	2/22/2007	A	wheat	3	0.736	119
1222	3/5/2007	B	wheat	3	0.782	81
2776	2/22/2007	A	wheat	3	0.809	59
2776	2/22/2007	B	wheat	3	0.738	117
11B	2/22/2007	A	control	6	0.731	123
11B	3/5/2007	B	control	6	0.753	105
42A	3/5/2007	A	control	6	0.780	83
42A	2/22/2007	B	control	6	0.737	118
3347	2/22/2007	A	maple	6	0.774	87
3347	2/26/2007	B	maple	6	0.770	91
16101	2/22/2007	A	maple	6	0.768	92
16101	2/22/2007	B	maple	6	0.768	92
4346	2/26/2007	A	oak	6	0.746	110
4346	3/5/2007	B	oak	6	0.784	79
36100	2/22/2007	A	oak	6	0.745	111
36100	2/22/2007	B	oak	6	0.788	76
4748	2/22/2007	A	sawdust	6	0.755	103
4748	2/22/2007	B	sawdust	6	0.765	95
40102	2/22/2007	A	sawdust	6	0.763	96
40102	2/22/2007	B	sawdust	6	0.730	123
1750	2/26/2007	A	timothy	6	0.768	92
1750	2/26/2007	B	timothy	6	0.788	76
29104	3/5/2007	A	timothy	6	0.770	91
29104	2/22/2007	B	timothy	6	0.744	112
2749	2/22/2007	A	wheat	6	0.736	119
2749	2/22/2007	B	wheat	6	0.739	116
52103	2/22/2007	A	wheat	6	0.802	65
52103	3/5/2007	B	wheat	6	0.814	55

Notes:
Method used: Weil et al (2003)
Active C (mg/kg) = [0.02 mol/L - (a+b * absorbance)] * (9,000 mg C/mol) * (0.21 solution/0.005 kg soil)

Where
0.02 mol/L = initial solution concentration
a = intercept of standard curve
b = slope of standard curve
9,000 = mg C (0.75 mol) oxidized by 1 mol of MnO_4 changing from Mn^{7+} to Mn^{4+}
0.21 = volume of $KMnO_4$ reacted
0.005 = kg of soil used



Appendix D: pH Data

Date	pH at 10cm	pH at 25cm	Cycle	Moisture Regime	Date	pH at 10cm	pH at 25cm	Cycle	Moisture Regime
3-Dec-04	6.1	5.71	1	Wet	22-Oct-05	6.1	6.16	4	Wet
3-Dec-04	5.57	5.28	1	Wet	22-Oct-05	5.83	6.18	4	Wet
3-Dec-04	6.08	5.62	1	Wet	22-Oct-05	5.97	6.23	4	Wet
14-Dec-	5.63	5.3	1	Wet	22-Nov-05	5.9	5.9	4	Wet
14-Dec-	5.87	5.44	1	Wet	22-Nov-05	6.25	6.2	4	Wet
14-Dec-	5.73	5.71	1	Wet	22-Nov-05	6.77	6.35	4	Wet
18-Jan-05	6.15	6.06	1	Dry	29-Dec-05	6.39	6.15	4	Dry
18-Jan-05	5.97	5.63	1	Dry	29-Dec-05	6.03	5.85	4	Dry
18-Jan-05	5.91	5.58	1	Dry	29-Dec-05	5.95	5.95	4	Dry
10-Feb-	5.7	5.91	1	Dry	10-Feb-06	6.32	6.23	4	Dry
10-Feb-	5.99	5.9	1	Dry	10-Feb-06	6.54	6.15	4	Dry
10-Feb-	6.6	6.13	1	Dry	10-Feb-06	6.63	6.34	4	Dry
9-Mar-05	6.47	6.14	2	Wet	1-Mar-06	6.11	6.02	5	Wet
9-Mar-05	6.3	6.49	2	Wet	1-Mar-06	6.54	6.29	5	Wet
9-Mar-05	6.41	6.18	2	Wet	1-Mar-06	6.12	6.27	5	Wet
5-Apr-05	6.6	6.5	2	Wet	3-Apr-06	6.53	6.11	5	Wet
5-Apr-05	6.3	6.25	2	Wet	3-Apr-06	6.42	6.39	5	Wet
5-Apr-05	6.34	6.15	2	Wet	3-Apr-06	6.46	6.09	5	Wet
3-May-05	6.21	6.01	2	Dry	20-Apr-06	6.3	6.13	5	Dry
3-May-05	6.24	6.31	2	Dry	20-Apr-06	6.25	6.21	5	Dry
3-May-05	6.49	6.3	2	Dry	20-Apr-06	6.15	6.15	5	Dry
31-May-	5.16	5.51	2	Dry	1-Jun-06	5.15	6.04	5	Dry
31-May-	5.23	5.43	2	Dry	1-Jun-06	5.29	5.94	5	Dry
31-May-	6.21	6.11	2	Dry	1-Jun-06	5.56	5.72	5	Dry
6-Jul-05	6.46	6.32	3	Wet	29-Jun-06	6.45	6.46	6	Wet
6-Jul-05	6.25	6.23	3	Wet	29-Jun-06	6.83	6.38	6	Wet
6-Jul-05	6.23	6.06	3	Wet	29-Jun-06	6.09	6.44	6	Wet
27-Jul-05	6.32	5.86	3	Wet	26-Jul-06	7.6	6.75	6	Wet
27-Jul-05	6.41	6.35	3	Wet	26-Jul-06	7.59	6.53	6	Wet
27-Jul-05	6.04	6.04	3	Wet	26-Jul-06	7.34	6.86	6	Wet
1-Sep-05	6.92	6.45	3	Dry	20-Aug-06	6.25	6.4	6	Dry
1-Sep-05	6.55	5.38	3	Dry	20-Aug-06	6.08	5.7	6	Dry
1-Sep-05	6.65	5.89	3	Dry	20-Aug-06	6.6	5.9	6	Dry
3-Oct-05	5.93	6	3	Dry	15-Sep-06	6.31	6.14	6	Dry
3-Oct-05	5.8	6.12	3	Dry	15-Sep-06	6.5	5.98	6	Dry
3-Oct-05	5.9	5.95	3	Dry	15-Sep-06	6.42	6.21	6	Dry

Appendix E: Summary of Redox Potentials (Eh)

OM TYPE	TREATMENT	Depth	10/20/2004	10/21/2004	10/22/2004	10/25/2004	10/27/2004	10/29/2004	11/3/2004	11/5/2004	11/8/2004	11/12/2004	11/16/2004
Days into experiment			1	2	3	6	8	10	15	17	20	24	28
Cycle			1	1	1	1	1	1	1	1	1	1	1
Maple	Mixed	10	387	171	64	-27	-18	-26	-91	-72	-117	-112	-128
Maple	Mixed	10	213	67	0	-48	-32	-47	-39	0	-56	-57	-71
Maple	Mixed	10	405	214	139	-26	-5	-19	-47	-53	-117	-141	-132
Maple	Mixed	10	114	47	12	-43	-39	-46	-6	21	-40	-42	-62
Oak	Mixed	10	314	254	120	-41	-25	-14	-7	25	-28	-34	-40
Oak	Mixed	10	288	198	73	0	-14	-24	-104	-96	-157	-204	-206
Oak	Mixed	10	309	155	4	-65	-43	-56	-70	-59	-114	-121	-141
Oak	Mixed	10	278	226	170	6	-10	-21	-37	-22	-74	-93	-117
Sawdust	Mixed	10	325	253	171	32	1	-37	-83	-59	-113	-114	-149
Sawdust	Mixed	10	257	175	93	-45	-29	-50	-79	-50	-143	-142	-155
Sawdust	Mixed	10	272	188	134	0	-2	-7	-40	-16	-77	-98	-105
Sawdust	Mixed	10	405	173	97	-52	-46	-71	-124	-105	-163	-170	-184
Timothy	Mixed	10	11	-14	-12	-45	-33	223	-102	-97	-170	-179	-189
Timothy	Mixed	10	190	127	131	-30	-22	-50	-93	-73	-119	-125	-144
Timothy	Mixed	10	165	45	10	-25	-21	-46	-159	-159	-209	-221	-210
Timothy	Mixed	10	149	23	20	-23	-1	7	-5	11	-53	-61	-83
Wheat	Mixed	10	218	16	-19	-30	-9	-33	-54	-37	-90	-93	-121
Wheat	Mixed	10	297	171	79	1	31	7	-41	-31	-102	-136	-165
Wheat	Mixed	10	233	113	-29	-39	-19	-21	-32	-5	-54	-67	-94
Wheat	Mixed	10	381	212	-32	-26	-27	-45	-78	-55	-99	-94	-108
Oak	Surface	10	420	265	180	116	98	54	-21	-3	-105	-114	-125
Oak	Surface	10	288	236	215	-22	10	124	26	36	-24	-27	-62
Oak	Surface	10	282	238	211	134	143	93	31	98	-8	-1	-8
Oak	Surface	10	299	269	218	148	120	70	11	24	-38	-58	-15
Wheat	Surface	10	298	178	109	102	63	-8	-60	-41	-99	-103	-117
Wheat	Surface	10	319	215	163	-6	-101	-1	-16	7	-39	-35	-43
Wheat	Surface	10	327	255	213	161	149	119	63	59	-39	-64	-89
Wheat	Surface	10	310	222	222	161	36	25	58	80	37	34	18
Oak	Zoned	10	364	119	1	16	25	1	-19	2	-59	-74	-93
Oak	Zoned	10	385	239	175	122	102	60	-17	-21	-76	-92	-106
Oak	Zoned	10	92	33	15	-29	-25	-41	-62	-50	-82	-97	-111
Oak	Zoned	10	283	201	104	15	39	-38	-51	-34	-63	-60	-74
Wheat	Zoned	10	138	100	59	-1	-14	-33	-53	-31	-92	-118	-164
Wheat	Zoned	10	243	34	20	-1	-11	-30	-64	-52	-126	-140	-142
Wheat	Zoned	10	237	27	10	-34	-20	-49	-68	-60	-152	-163	-183
Wheat	Zoned	10	405	67	-26	24	-15	-27	-17	-125	-191	-212	-222
Maple	Mixed	25	154	111	96	-39	-20	-40	-51	-14	-86	-74	-98
Maple	Mixed	25	400	355	357	83	24	-26	-75	-51	-130	-124	-132
Maple	Mixed	25	331	243	147	-79	-91	-84	-68	24	-106	-99	-118
Maple	Mixed	25	325	208	81	3	9	-11	-40	-22	-87	-87	-96
Oak	Mixed	25	364	265	97	-165	-173	-154	-140	-123	-140	-129	-149
Oak	Mixed	25	396	363	245	47	28	-26	-90	-76	-128	-136	-159
Oak	Mixed	25	370	337	253	106	-18	-52	-109	-43	-142	-131	-148
Oak	Mixed	25	200	189	143	-1	2	-14	-30	-20	-60	-76	-95

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	10/20/2004	10/21/2004	10/22/2004	10/25/2004	10/27/2004	10/29/2004	11/3/2004	11/5/2004	11/8/2004	11/12/2004	11/16/2004
Days into experiment			1	2	3	6	8	10	15	17	20	24	28
Cycle			1	1	1	1	1	1	1	1	1	1	1
Sawdust	Mixed	25	285	243	257	193	141	96	9	4	-73	-102	-147
Sawdust	Mixed	25	243	222	170	44	-2	-69	-167	-171	-192	-194	-184
Sawdust	Mixed	25	433	386	321	125	51	1	-80	-64	-76	-59	-87
Sawdust	Mixed	25	431	385	350	208	163	120	70	85	25	25	3
Timothy	Mixed	25	300	278	235	113	83	228	-103	-64	-82	-94	-60
Timothy	Mixed	25	455	361	152	-107	-58	-55	-70	-43	-123	-123	-130
Timothy	Mixed	25	363	347	308	161	96	20	18	57	-46	-39	-70
Timothy	Mixed	25	457	371	320	94	70	-23	-37	-20	-65	-66	-89
Wheat	Mixed	25	262	147	-19	-71	-37	-52	-127	-107	-161	-164	-182
Wheat	Mixed	25	355	260	128	-62	-12	-50	-105	-86	-154	-121	-174
Wheat	Mixed	25	306	311	277	99	73	-2	-66	-52	-104	-104	-123
Wheat	Mixed	25	406	287	299	120	66	31	-21	0	-51	-41	-62
Control	Mixed	10	408	-	-	-7	-	24	-	-	-17	-43	-
Control	Mixed	10	450	-	-	-31	-	-39	-	-	-102	-104	-
Control	Mixed	10	451	-	-	-15	-	-39	-	-	-103	-116	-
Control	Mixed	10	528	-	-	-64	-	-78	-	-	-105	-114	-
Oak	Surface	25	256	225	162	127	131	86	19	36	-16	-15	-31
Oak	Surface	25	263	220	139	48	46	23	2	14	-35	-41	-69
Oak	Surface	25	225	135	53	99	-95	-118	-145	-132	-171	-165	-173
Oak	Surface	25	394	364	245	72	32	-73	-105	-94	-131	-154	-138
Wheat	Surface	25	247	228	194	55	12	-11	-74	-63	-70	-71	-95
Wheat	Surface	25	365	343	283	-78	-82	-142	-78	-49	-87	-74	-93
Wheat	Surface	25	360	356	345	254	207	157	103	118	46	44	25
Wheat	Surface	25	194	173	99	-21	-26	-59	-84	-69	-116	-113	-121
Oak	Zoned	25	312	291	263	157	105	25	-25	5	-27	-30	-65
Oak	Zoned	25	317	288	255	157	130	58	-8	5	-48	-57	-82
Oak	Zoned	25	90	168	122	64	79	56	102	-59	-78	-121	-133
Oak	Zoned	25	542	527	496	202	112	42	-24	-16	-79	-83	-90
Wheat	Zoned	25	275	237	157	-11	-10	-41	-67	-56	-86	-89	-105
Wheat	Zoned	25	332	312	292	63	21	-49	-52	-24	-75	-71	-74
Wheat	Zoned	25	422	388	351	228	138	89	-9	-6	-81	-82	-105
Wheat	Zoned	25	394	368	262	10	24	-7	-91	-74	-147	-144	-160

OM TYPE	TREATMENT	Depth	11/19/2004	11/30/2004	12/8/2004	12/14/2004	12/21/2004	12/27/2004	12/29/2004	1/4/2005	1/10/2005	1/20/2005	1/28/2005
	Days into experiment		31	42	54	56	63	69	71	77	83	93	101
	Cycle		1	1	1	1	1	1	1	1	1	1	1
Maple	Mixed	10	-142	-132	-181	-197	64	194	213	281	282	273	286
Maple	Mixed	10	-119	-65	-111	-139	23	146	208	267	282	290	285
Maple	Mixed	10	-125	-128	-142	-146	65	137	173	193	241	253	262
Maple	Mixed	10	-84	-49	-66	-89	82	224	257	254	274	294	307
Oak	Mixed	10	-53	-55	-99	-121	163	212	215	263	294	286	294
Oak	Mixed	10	-203	-221	-228	-232	36	137	180	243	289	292	289
Oak	Mixed	10	-154	-135	-171	-175	52	146	163	223	266	280	298
Oak	Mixed	10	-122	-165	-181	-187	131	245	433	262	298	275	279
Sawdust	Mixed	10	-171	-186	-198	-203	193	276	286	307	334	302	306
Sawdust	Mixed	10	-166	-182	-197	-218	35	126	173	238	288	308	317
Sawdust	Mixed	10	-107	-74	-94	-84	135	228	259	274	268	273	276
Sawdust	Mixed	10	-196	-192	-204	-218	26	213	236	256	298	310	324
Timothy	Mixed	10	-188	-128	-148	-155	14	197	235	285	302	302	312
Timothy	Mixed	10	-155	-166	-150	-153	129	229	250	279	285	285	292
Timothy	Mixed	10	-209	-233	-246	-255	-12	130	171	210	234	286	290
Timothy	Mixed	10	-121	-128	-138	-161	87	172	225	239	276	284	283
Wheat	Mixed	10	-127	-110	-147	-189	91	209	221	268	275	300	289
Wheat	Mixed	10	-190	-228	-261	-267	22	85	120	161	223	257	277
Wheat	Mixed	10	-114	-140	-147	-162	71	171	181	190	231	245	255
Wheat	Mixed	10	-123	-147	-184	-192	8	153	196	252	273	290	297
Oak	Surface	10	-133	-136	-159	-182	124	184	196	200	203	200	235
Oak	Surface	10	-96	-104	-139	-146	-61	44	93	160	224	185	229
Oak	Surface	10	-25	-21	-50	-69	4	85	129	145	197	236	256
Oak	Surface	10	-50	-30	-89	-101	-1	139	169	175	189	201	239
Wheat	Surface	10	-123	-124	-179	-184	113	178	188	217	228	239	245
Wheat	Surface	10	-57	-41	-65	-83	126	188	206	231	246	263	257
Wheat	Surface	10	-137	-108	-156	-169	132	236	228	233	246	249	260
Wheat	Surface	10	5	12	-14	-37	2	121	171	192	216	243	246
Oak	Zoned	10	-96	-88	-135	-139	13	92	114	200	250	264	286
Oak	Zoned	10	-121	-132	-168	-180	-93	73	137	241	266	290	285
Oak	Zoned	10	-116	-95	-138	-154	11	170	208	255	293	304	316
Oak	Zoned	10	-87	-65	-100	-125	106	240	249	260	276	295	295
Wheat	Zoned	10	-181	-187	-208	-214	-72	38	125	128	197	290	338
Wheat	Zoned	10	-157	-158	-191	-216	-135	23	80	106	219	292	296
Wheat	Zoned	10	-190	-218	-234	-238	-12	174	213	264	306	316	325
Wheat	Zoned	10	-225	-225	-232	-222	47	240	259	300	321	319	345
Maple	Mixed	25	-119	-136	-154	-159	-80	29	96	148	201	235	247
Maple	Mixed	25	-138	-133	-159	-177	-128	1	71	105	196	234	243
Maple	Mixed	25	-109	-139	-154	-167	-57	54	131	204	257	279	282
Maple	Mixed	25	-101	-44	-58	-92	-27	18	82	154	203	212	224
Oak	Mixed	25	-160	-156	-178	-199	47	243	249	264	280	275	285
Oak	Mixed	25	-171	-163	-156	-171	-83	45	135	167	239	260	265
Oak	Mixed	25	-160	-165	-176	-176	-146	-106	-31	31	116	189	238
Oak	Mixed	25	-113	-101	-143	-177	-60	75	120	155	242	256	255

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	11/19/2004	11/30/2004	12/8/2004	12/14/2004	12/21/2004	12/27/2004	12/29/2004	1/4/2005	1/10/2005	1/20/2005	1/28/2005
	Days into experiment		31	42	54	56	63	69	71	77	83	93	101
	Cycle		1	1	1	1	1	1	1	1	1	1	1
Sawdust	Mixed	25	-186	-174	-176	-181	-7	191	228	271	329	314	322
Sawdust	Mixed	25	-187	-71	-133	-179	90	213	249	250	262	291	306
Sawdust	Mixed	25	-112	-135	-168	-174	97	52	107	159	223	252	260
Sawdust	Mixed	25	-21	-29	-58	-73	-53	57	61	84	147	173	207
Timothy	Mixed	25	-89	-90	-90	-115	48	169	226	209	238	313	331
Timothy	Mixed	25	-145	-140	-166	-179	-150	79	139	188	270	292	303
Timothy	Mixed	25	-106	-106	-138	-173	-40	85	97	161	245	280	288
Timothy	Mixed	25	-108	-115	-150	-167	-22	61	119	207	211	260	263
Wheat	Mixed	25	-193	-182	-190	-202	-40	161	173	195	234	232	245
Wheat	Mixed	25	-185	-182	-184	-202	-42	92	152	184	226	258	277
Wheat	Mixed	25	-131	-88	-99	-117	61	180	221	243	260	271	283
Wheat	Mixed	25	-79	-83	-108	-137	-53	100	173	212	248	268	279
Control	Mixed	10	-59	-128	-122	-164	198	-	259	-	259	256	256
Control	Mixed	10	-117	-132	-141	-126	203	-	228	-	234	240	236
Control	Mixed	10	-143	-161	-146	-131	148	-	225	-	227	233	226
Control	Mixed	10	-133	-174	-175	-166	-26	-	255	-	262	264	259
Oak	Surface	25	-55	-82	-126	-145	-93	-54	-38	-46	-27	21	54
Oak	Surface	25	-88	-103	-131	-135	-96	-115	-43	-42	51	119	161
Oak	Surface	25	-180	-155	-148	-145	-23	7	34	108	185	252	254
Oak	Surface	25	-145	-121	-143	-158	-19	140	133	191	231	250	257
Wheat	Surface	25	-103	-87	-89	-102	-2	78	135	176	228	261	280
Wheat	Surface	25	-126	-144	-160	-170	-126	-35	54	90	156	205	265
Wheat	Surface	25	4	-43	-55	-89	-3	100	143	190	227	249	254
Wheat	Surface	25	-130	-102	-106	-147	-71	64	112	130	165	218	225
Oak	Zoned	25	-100	-54	-54	-67	74	180	209	231	264	268	283
Oak	Zoned	25	-106	-109	-125	-134	-34	91	138	167	209	243	247
Oak	Zoned	25	-159	-149	-156	-156	44	112	149	195	265	276	288
Oak	Zoned	25	-105	-92	-113	-119	4	189	221	239	256	270	276
Wheat	Zoned	25	-121	-102	-88	-114	17	136	169	206	254	271	319
Wheat	Zoned	25	-93	-58	-111	-136	-34	94	162	200	242	286	309
Wheat	Zoned	25	-125	-134	-158	-167	-61	86	155	214	255	277	292
Wheat	Zoned	25	-174	-174	-183	-191	-139	-16	68	206	274	287	277

OM TYPE	TREATMENT	Depth	2/9/2005	2/11/2005	2/15/2005	2/22/2005	3/2/2005	3/11/2005	3/22/2005	3/29/2005	4/5/2005	4/12/2005	4/20/2005
Days into experiment			113	115	119	126	134	143	154	161	168	175	183
Cycle			2	2	2	2	2	2	2	2	2	2	2
Maple	Mixed	10	312	216	56	-33	-99	-138	-95	-85	-102	251	283
Maple	Mixed	10	295	254	131	67	45	-26	-45	3	-46	261	281
Maple	Mixed	10	315	261	68	-147	-161	-156	-165	-158	-174	213	250
Maple	Mixed	10	183	-40	209	-148	-172	-184	-192	-179	-199	6	189
Oak	Mixed	10	288	150	33	-26	-91	-112	-115	-93	-101	246	285
Oak	Mixed	10	294	245	84	-106	-170	-177	-175	-173	-164	217	257
Oak	Mixed	10	302	94	-137	-175	-176	-173	-159	-169	-174	261	345
Oak	Mixed	10	311	279	241	198	171	122	92	125	88	248	288
Sawdust	Mixed	10	282	273	188	73	-73	-168	-182	-178	-172	276	288
Sawdust	Mixed	10	268	289	181	72	38	-100	-194	-198	-200	251	316
Sawdust	Mixed	10	271	174	44	11	-40	-137	-148	-153	-145	117	309
Sawdust	Mixed	10	339	156	-136	-177	-187	-190	-192	-187	-201	253	331
Timothy	Mixed	10	295	301	237	201	180	133	95	133	50	225	263
Timothy	Mixed	10	301	140	-71	-173	-202	-207	-209	-215	-209	245	272
Timothy	Mixed	10	266	175	75	-16	-140	-187	-136	-110	-149	204	237
Timothy	Mixed	10	295	268	99	136	107	62	-44	-10	-110	217	270
Wheat	Mixed	10	262	228	161	85	42	-21	-46	-59	-64	269	269
Wheat	Mixed	10	299	283	179	132	-36	-172	-174	-106	-177	194	287
Wheat	Mixed	10	265	120	-92	-205	-215	-210	-215	-181	-231	164	207
Wheat	Mixed	10	251	124	61	-4	-178	-190	-174	-150	-192	191	255
Oak	Surface	10	241	226	156	143	100	60	39	53	25	203	247
Oak	Surface	10	249	218	195	188	108	50	17	16	12	124	177
Oak	Surface	10	295	256	210	118	-58	-119	-87	24	-108	186	200
Oak	Surface	10	267	212	131	117	59	2	-22	-46	-51	166	217
Wheat	Surface	10	276	195	109	94	96	59	-5	-35	-32	224	265
Wheat	Surface	10	328	290	169	136	-33	-107	-127	-132	-135	205	256
Wheat	Surface	10	240	211	107	88	75	48	21	-24	-43	150	224
Wheat	Surface	10	244	229	197	123	-83	-108	-179	-186	-189	269	269
Oak	Zoned	10	311	209	10	-121	-183	-196	-202	-202	-203	243	293
Oak	Zoned	10	347	244	20	-41	-55	-163	-176	-179	-164	177	274
Oak	Zoned	10	285	275	151	30	-18	-115	-174	-178	-172	174	280
Oak	Zoned	10	294	281	203	165	85	-51	-137	-105	-144	188	273
Wheat	Zoned	10	237	227	110	-71	-96	-99	-103	-113	-122	117	254
Wheat	Zoned	10	335	227	84	-66	-173	-203	-209	-203	-217	215	281
Wheat	Zoned	10	343	301	159	33	-56	-85	-98	-86	-118	289	315
Wheat	Zoned	10	316	149	-124	-125	-118	-148	-179	-197	-197	88	225
Maple	Mixed	25	319	296	122	12	-56	-63	-56	-55	-43	137	213
Maple	Mixed	25	253	245	210	74	81	-42	-90	-91	-125	227	276
Maple	Mixed	25	245	241	199	147	106	48	16	35	-11	247	286
Maple	Mixed	25	277	249	225	-83	-88	-108	-107	-118	-108	-50	35
Oak	Mixed	25	399	319	68	-116	-113	-137	-142	-159	-156	-64	137
Oak	Mixed	25	284	310	261	163	135	99	87	95	59	242	287
Oak	Mixed	25	338	324	221	106	-51	-148	-166	-175	-177	157	239
Oak	Mixed	25	262	267	220	131	92	61	41	56	20	208	266

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	2/9/2005	2/11/2005	2/15/2005	2/22/2005	3/2/2005	3/11/2005	3/22/2005	3/29/2005	4/5/2005	4/12/2005	4/20/2005
Days into experiment			113	115	119	126	134	143	154	161	168	175	183
Cycle			2	2	2	2	2	2	2	2	2	2	2
Sawdust	Mixed	25	274	261	215	44	-23	-77	-92	-98	-113	203	264
Sawdust	Mixed	25	245	210	160	112	100	85	76	72	56	159	239
Sawdust	Mixed	25	442	433	383	193	112	31	3	-11	9	48	139
Sawdust	Mixed	25	298	267	204	149	111	-24	-59	-79	-85	171	286
Timothy	Mixed	25	327	319	158	115	87	38	32	94	-10	245	314
Timothy	Mixed	25	326	292	94	101	100	78	137	151	98	215	286
Timothy	Mixed	25	272	253	218	196	172	96	72	60	280	184	247
Timothy	Mixed	25	299	272	311	123	69	28	-2	37	-15	228	278
Wheat	Mixed	25	294	267	229	232	173	108	63	112	37	294	310
Wheat	Mixed	25	279	260	223	187	147	120	87	87	53	236	289
Wheat	Mixed	25	267	261	198	185	156	112	112	113	81	215	249
Wheat	Mixed	25	268	257	194	127	65	26	-14	-27	-48	174	276
Control	Mixed	10	275	-	211	187	212	202	194	-	137	257	-
Control	Mixed	10	225	-	222	132	90	-52	-54	-	-66	218	-
Control	Mixed	10	244	-	161	125	87	63	50	-	27	199	-
Control	Mixed	10	219	-	118	119	-99	-53	-95	-	-78	280	-
Oak	Surface	25	180	248	108	60	43	30	26	20	14	113	167
Oak	Surface	25	301	287	160	98	80	-48	-100	-133	-127	129	223
Oak	Surface	25	327	310	134	148	126	107	76	92	72	180	212
Oak	Surface	25	265	246	228	199	143	111	93	73	56	224	278
Wheat	Surface	25	280	265	237	152	110	42	-18	-46	-47	203	237
Wheat	Surface	25	299	259	63	20	-26	-78	-54	-42	-60	166	188
Wheat	Surface	25	231	200	159	142	114	50	24	39	4	160	202
Wheat	Surface	25	252	210	99	86	51	-24	-35	-1	-34	165	238
Oak	Zoned	25	323	267	123	90	38	-8	-30	-35	-61	237	300
Oak	Zoned	25	327	316	305	172	143	124	113	134	98	238	284
Oak	Zoned	25	281	205	236	207	171	155	133	126	111	288	322
Oak	Zoned	25	265	250	205	168	142	124	108	101	92	229	279
Wheat	Zoned	25	320	278	238	156	95	81	89	140	126	239	302
Wheat	Zoned	25	320	253	171	112	95	89	72	68	41	231	293
Wheat	Zoned	25	327	275	163	62	-11	-67	-86	-87	-113	184	284
Wheat	Zoned	25	429	334	263	132	-1	-35	19	0	8	63	178

OM TYPE	TREATMENT	Depth	4/26/2005	5/3/2005	5/10/2005	5/25/2005	6/2/2005	6/6/2005	6/13/2005	6/21/2005	6/27/2005	7/6/2005	7/12/2005
	Days into experiment		189	196	203	218	225	229	236	244	250	259	265
	Cycle		2	2	2	2	3	3	3	3	3	3	3
Maple	Mixed	10	310	317	310	294	215	12	-112	-185	-145	-191	-201
Maple	Mixed	10	304	310	330	361	302	255	222	202	184	132	74
Maple	Mixed	10	282	274	274	268	265	239	-59	-206	-201	-203	-210
Maple	Mixed	10	233	254	281	281	17	-131	-151	-104	-103	-128	-109
Oak	Mixed	10	308	330	334	342	294	60	-114	-109	-82	-65	-50
Oak	Mixed	10	273	277	285	285	340	230	-142	-97	-3	-98	-103
Oak	Mixed	10	379	394	401	374	295	145	91	76	88	45	23
Oak	Mixed	10	306	314	325	314	349	190	-154	-109	28	-56	-81
Sawdust	Mixed	10	292	284	275	276	351	66	41	-172	-91	-197	-193
Sawdust	Mixed	10	306	297	299	286	394	140	-203	-199	-95	-140	-162
Sawdust	Mixed	10	329	336	334	351	126	-155	-125	-110	-66	-95	-103
Sawdust	Mixed	10	370	380	378	399	141	-115	-107	-124	-103	-163	-163
Timothy	Mixed	10	290	304	312	311	268	186	19	-135	202	-186	-187
Timothy	Mixed	10	289	311	304	287	290	115	240	-113	-98	-130	-155
Timothy	Mixed	10	247	261	269	276	277	286	142	17	247	67	54
Timothy	Mixed	10	278	282	286	282	272	234	168	144	172	-25	-44
Wheat	Mixed	10	268	271	270	287	291	94	-130	-199	-59	-214	-198
Wheat	Mixed	10	296	299	318	310	315	210	-45	-53	204	-48	-86
Wheat	Mixed	10	232	249	265	298	292	39	-168	-192	-119	-166	-183
Wheat	Mixed	10	322	322	329	317	285	-115	96	-192	-199	-200	-208
Oak	Surface	10	267	282	280	292	275	223	214	214	223	181	168
Oak	Surface	10	190	251	263	270	277	252	217	160	91	59	36
Oak	Surface	10	237	261	281	286	239	163	-21	-35	-58	-117	-103
Oak	Surface	10	244	259	271	282	294	195	143	144	146	90	51
Wheat	Surface	10	263	277	285	274	288	202	51	111	73	-18	-33
Wheat	Surface	10	261	267	268	281	268	197	52	-175	-141	-124	-124
Wheat	Surface	10	240	248	246	259	277	228	105	44	89	21	-3
Wheat	Surface	10	265	265	269	268	246	154	-145	-182	-182	-184	-188
Oak	Zoned	10	298	302	310	293	202	150	90	55	30	-10	-36
Oak	Zoned	10	296	297	302	280	292	225	85	85	196	113	86
Oak	Zoned	10	291	304	312	287	294	165	49	6	59	-66	-86
Oak	Zoned	10	295	299	298	288	286	193	88	33	31	-40	-58
Wheat	Zoned	10	299	302	290	294	239	69	-17	-65	13	-126	-112
Wheat	Zoned	10	300	313	320	309	289	231	117	155	115	-10	-39
Wheat	Zoned	10	314	339	373	353	328	251	-58	-144	-127	-183	-191
Wheat	Zoned	10	308	331	333	349	263	227	211	199	212	101	82
Maple	Mixed	25	299	309	303	305	231	158	115	98	74	27	-2
Maple	Mixed	25	284	289	297	318	306	245	154	115	64	40	11
Maple	Mixed	25	298	302	302	301	259	167	10	10	17	-26	-49
Maple	Mixed	25	129	184	223	256	246	200	154	100	66	44	43
Oak	Mixed	25	236	267	272	312	241	105	25	-6	-38	-61	-79
Oak	Mixed	25	306	306	315	317	316	287	5	-80	-59	-122	-134
Oak	Mixed	25	291	291	299	289	250	189	175	111	76	35	21
Oak	Mixed	25	278	295	303	307	294	256	178	178	241	142	117

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	4/26/2005	5/3/2005	5/10/2005	5/25/2005	6/2/2005	6/6/2005	6/13/2005	6/21/2005	6/27/2005	7/6/2005	7/12/2005
Days into experiment			189	196	203	218	225	229	236	244	250	259	265
Cycle			2	2	2	2	3	3	3	3	3	3	3
Sawdust	Mixed	25	297	292	286	297	275	243	105	58	-13	-69	-89
Sawdust	Mixed	25	263	268	280	277	278	192	154	110	80	47	38
Sawdust	Mixed	25	248	265	266	276	241	192	173	150	193	98	81
Sawdust	Mixed	25	293	293	298	288	252	202	170	134	200	60	107
Timothy	Mixed	25	320	334	341	339	298	254	176	141	232	111	82
Timothy	Mixed	25	298	308	304	292	288	-17	-39	-25	-51	-52	-56
Timothy	Mixed	25	258	262	260	271	216	179	93	103	172	99	84
Timothy	Mixed	25	284	289	298	302	270	218	164	144	139	102	87
Wheat	Mixed	25	312	323	314	321	276	220	199	193	187	162	147
Wheat	Mixed	25	295	296	297	291	301	218	173	161	163	126	108
Wheat	Mixed	25	275	275	276	276	251	213	190	198	199	131	75
Wheat	Mixed	25	298	306	310	306	265	201	190	183	161	134	129
Control	Mixed	10	266	-	-	264	254	-	243	-	240	-	234
Control	Mixed	10	283	-	-	271	186	-	100	-	-64	-	-93
Control	Mixed	10	254	-	-	264	249	-	234	-	182	-	138
Control	Mixed	10	303	-	-	317	281	-	246	-	83	-	-65
Oak	Surface	25	192	208	211	237	268	181	119	56	6	-26	-36
Oak	Surface	25	255	262	264	261	350	247	147	114	73	70	63
Oak	Surface	25	242	273	275	280	235	175	109	64	50	20	6
Oak	Surface	25	285	285	289	281	283	227	128	123	124	111	101
Wheat	Surface	25	286	298	303	312	270	205	55	-56	-84	-84	-95
Wheat	Surface	25	204	256	263	266	235	17	-62	-96	-143	-183	-188
Wheat	Surface	25	240	259	261	278	278	189	122	103	80	63	55
Wheat	Surface	25	261	281	283	277	312	226	114	140	105	77	32
Oak	Zoned	25	296	293	295	285	308	216	169	167	147	114	84
Oak	Zoned	25	307	311	316	309	294	224	191	174	121	95	79
Oak	Zoned	25	321	329	335	295	291	194	69	63	115	49	29
Oak	Zoned	25	301	308	311	299	310	278	207	195	195	177	133
Wheat	Zoned	25	308	302	287	294	361	180	154	130	124	90	87
Wheat	Zoned	25	294	305	303	291	290	260	237	242	244	160	218
Wheat	Zoned	25	294	301	309	301	312	184	57	44	4	-20	-46
Wheat	Zoned	25	277	316	319	317	319	266	120	130	90	49	20

OM TYPE	TREATMENT	Depth	7/19/2005	7/27/2005	8/5/2005	8/19/2005	9/1/2005	9/8/2005	9/15/2005	9/22/2005	9/29/2005	10/6/2005	10/17/2005
	Days into experiment		272	280	289	303	316	323	330	337	344	351	362
	Cycle		3	3	3	3	3	3	3	4	4	4	4
Maple	Mixed	10	-184	-206	152	225	256	245	248	227	-9	-88	-150
Maple	Mixed	10	-16	-76	241	300	315	309	306	275	208	93	123
Maple	Mixed	10	-214	-211	183	238	233	244	241	255	213	165	159
Maple	Mixed	10	-48	-94	94	225	259	266	269	179	-19	-57	-67
Oak	Mixed	10	-45	-122	274	282	288	294	290	237	-127	-174	-117
Oak	Mixed	10	-109	-145	228	272	273	262	272	336	244	233	185
Oak	Mixed	10	20	4	298	294	298	293	302	222	-117	-141	-206
Oak	Mixed	10	-146	-143	297	356	353	356	330	317	274	258	313
Sawdust	Mixed	10	-166	-179	235	263	282	277	289	292	179	119	98
Sawdust	Mixed	10	-117	-135	239	307	360	353	330	287	169	38	39
Sawdust	Mixed	10	-120	-112	263	275	270	273	267	206	-78	-115	-145
Sawdust	Mixed	10	-161	-145	233	299	300	290	278	178	-121	-162	-155
Timothy	Mixed	10	-180	-185	231	255	261	265	267	282	189	149	146
Timothy	Mixed	10	-145	-126	169	216	217	219	235	251	200	200	197
Timothy	Mixed	10	-32	-28	228	275	280	272	282	238	212	219	213
Timothy	Mixed	10	-25	-96	234	254	268	270	285	305	266	186	182
Wheat	Mixed	10	-64	-203	240	250	262	272	273	318	220	177	172
Wheat	Mixed	10	-141	-76	261	297	303	307	308	300	190	162	167
Wheat	Mixed	10	-122	-202	207	253	271	277	281	141	8	-54	-120
Wheat	Mixed	10	-186	-214	215	242	245	249	262	215	192	108	114
Oak	Surface	10	164	145	265	275	291	307	296	316	256	272	306
Oak	Surface	10	20	-21	277	288	294	317	313	255	201	227	142
Oak	Surface	10	-92	-79	169	204	242	248	251	262	227	190	164
Oak	Surface	10	15	-25	271	299	301	289	307	247	182	160	159
Wheat	Surface	10	-49	-81	250	285	302	308	303	282	242	237	200
Wheat	Surface	10	-45	-41	271	274	276	277	276	231	175	173	52
Wheat	Surface	10	28	-112	276	292	297	313	304	302	175	144	129
Wheat	Surface	10	-176	-184	228	259	269	274	288	263	231	217	200
Oak	Zoned	10	-47	-108	187	177	305	314	314	253	101	75	61
Oak	Zoned	10	149	45	239	291	309	320	315	240	193	179	145
Oak	Zoned	10	-111	-148	281	279	274	287	294	308	192	127	114
Oak	Zoned	10	-83	-132	287	289	297	317	313	323	251	229	266
Wheat	Zoned	10	-149	-175	219	277	282	288	287	238	41	2	-22
Wheat	Zoned	10	-91	-111	259	273	283	289	280	304	207	189	182
Wheat	Zoned	10	-195	-203	200	256	296	314	310	331	257	241	232
Wheat	Zoned	10	44	-6	254	297	316	324	319	132	-19	-18	170
Maple	Mixed	25	-2	-38	224	273	288	289	294	271	195	193	228
Maple	Mixed	25	0	-49	240	267	292	282	285	298	247	219	221
Maple	Mixed	25	-67	-69	106	178	220	236	252	308	252	241	227
Maple	Mixed	25	39	27	218	293	301	311	311	299	197	176	155
Oak	Mixed	25	18	-82	227	251	254	271	283	318	195	146	143
Oak	Mixed	25	-136	-140	233	264	294	304	308	278	214	173	156
Oak	Mixed	25	61	12	266	274	280	289	298	319	136	68	44
Oak	Mixed	25	97	81	294	285	290	294	296	308	255	215	295

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	7/19/2005	7/27/2005	8/5/2005	8/19/2005	9/1/2005	9/8/2005	9/15/2005	9/22/2005	9/29/2005	10/6/2005	10/17/2005
Days into experiment			272	280	289	303	316	323	330	337	344	351	362
Cycle			3	3	3	3	3	3	3	4	4	4	4
Sawdust	Mixed	25	-103	-115	66	190	245	257	280	319	266	254	246
Sawdust	Mixed	25	38	21	282	290	286	287	283	318	250	256	266
Sawdust	Mixed	25	80	62	292	285	285	282	289	325	170	129	130
Sawdust	Mixed	25	34	-2	298	315	317	306	306	323	184	78	43
Timothy	Mixed	25	77	59	195	267	276	281	277	310	208	116	83
Timothy	Mixed	25	-37	-24	108	264	273	316	329	287	213	195	130
Timothy	Mixed	25	87	74	159	249	261	251	261	319	242	104	104
Timothy	Mixed	25	88	91	270	267	280	288	291	258	232	170	120
Wheat	Mixed	25	160	137	277	277	280	286	287	319	265	248	245
Wheat	Mixed	25	99	102	318	287	291	307	299	313	247	244	188
Wheat	Mixed	25	69	42	288	277	295	317	305	447	371	162	145
Wheat	Mixed	25	122	140	265	295	296	304	309	311	178	109	41
Control	Mixed	10	224	213	-	293	283	-	295	419	157	3	3
Control	Mixed	10	-81	-64	-	261	281	-	285	283	231	-106	-153
Control	Mixed	10	130	152	-	283	287	-	279	283	205	-45	-123
Control	Mixed	10	-79	-74	-	282	279	-	277	277	265	233	195
Oak	Surface	25	-39	-36	281	276	281	296	290	304	270	235	198
Oak	Surface	25	54	48	158	231	285	298	302	377	311	198	170
Oak	Surface	25	3	-3	218	273	295	299	302	299	291	221	195
Oak	Surface	25	85	72	202	252	273	280	280	289	231	179	113
Wheat	Surface	25	-100	-111	172	258	277	280	288	274	167	73	123
Wheat	Surface	25	-191	-199	256	262	271	278	278	265	194	130	82
Wheat	Surface	25	58	56	290	293	298	311	308	279	246	207	172
Wheat	Surface	25	10	-56	167	270	276	278	289	305	201	187	194
Oak	Zoned	25	81	53	139	298	338	347	351	394	301	212	182
Oak	Zoned	25	75	72	277	279	295	299	296	362	262	228	183
Oak	Zoned	25	45	8	296	275	283	297	296	341	282	246	213
Oak	Zoned	25	129	111	318	299	300	317	315	306	247	227	209
Wheat	Zoned	25	76	88	187	260	298	318	318	300	194	114	110
Wheat	Zoned	25	214	196	334	304	312	313	300	334	270	231	196
Wheat	Zoned	25	-51	-65	-25	170	245	274	282	323	280	236	138
Wheat	Zoned	25	-2	-30	171	305	315	316	312	319	200	57	296

OM TYPE	TREATMENT	Depth	10/27/2005	11/4/2005	11/15/2005	11/22/2005	12/6/2005	12/21/2006	1/13/2006	1/23/2006	2/3/2006	2/16/2006	3/1/2006
Days into experiment			372	380	391	398	412	427	448	449	460	473	486
Cycle			4	4	4	4	4	4	4	5	5	5	5
Maple	Mixed	10	-107	-129	-101	75	257	262	266	230	118	66	167
Maple	Mixed	10	75	57	46	149	258	266	274	256	144	147	154
Maple	Mixed	10	205	82	46	172	267	272	276	274	144	-10	84
Maple	Mixed	10	-47	-70	-68	149	270	273	275	159	32	15	48
Oak	Mixed	10	-129	-159	-150	217	290	292	287	88	-85	-69	-113
Oak	Mixed	10	98	67	24	291	299	314	330	271	170	167	155
Oak	Mixed	10	-177	-169	-100	226	306	310	318	75	-53	-149	-95
Oak	Mixed	10	204	255	252	304	324	330	336	302	226	202	182
Sawdust	Mixed	10	60	24	36	269	295	307	315	273	155	122	110
Sawdust	Mixed	10	45	32	43	207	266	279	288	267	171	125	101
Sawdust	Mixed	10	83	-119	-89	159	268	290	311	110	-64	-56	-14
Sawdust	Mixed	10	-119	-136	-99	200	278	297	317	160	-98	-76	-22
Timothy	Mixed	10	143	140	139	234	252	275	297	324	246	238	238
Timothy	Mixed	10	141	99	104	179	304	308	304	259	203	205	198
Timothy	Mixed	10	188	147	112	256	292	288	291	238	204	-68	50
Timothy	Mixed	10	143	164	164	279	339	358	377	279	219	219	218
Wheat	Mixed	10	156	147	60	232	268	275	283	278	175	156	131
Wheat	Mixed	10	170	159	122	230	269	297	324	226	136	84	98
Wheat	Mixed	10	-103	-83	-69	146	270	288	306	262	225	215	211
Wheat	Mixed	10	93	66	72	192	278	282	283	259	39	33	45
Oak	Surface	10	262	265	259	305	314	318	321	309	245	225	220
Oak	Surface	10	141	113	106	278	316	316	316	258	235	162	114
Oak	Surface	10	177	173	157	234	286	290	295	328	242	227	218
Oak	Surface	10	136	110	117	207	263	272	281	282	231	218	163
Wheat	Surface	10	183	187	180	283	304	315	331	259	185	116	41
Wheat	Surface	10	26	-42	85	249	292	291	294	358	254	222	197
Wheat	Surface	10	128	119	124	255	309	314	325	308	265	259	256
Wheat	Surface	10	194	185	180	243	321	337	352	362	276	265	249
Oak	Zoned	10	70	57	70	179	316	323	330	290	185	156	118
Oak	Zoned	10	139	121	122	234	332	356	380	141	49	14	35
Oak	Zoned	10	119	101	105	190	299	315	341	302	220	208	196
Oak	Zoned	10	215	238	218	299	329	326	319	331	267	257	254
Wheat	Zoned	10	-21	-37	-28	122	252	276	290	245	238	116	132
Wheat	Zoned	10	167	157	144	272	307	312	317	259	38	18	-15
Wheat	Zoned	10	210	208	199	286	323	329	334	187	40	-2	30
Wheat	Zoned	10	16	38	36	310	319	313	307	232	59	-44	-11
Maple	Mixed	25	198	198	193	301	326	328	330	349	312	206	268
Maple	Mixed	25	198	185	185	271	296	302	307	319	293	263	249
Maple	Mixed	25	217	208	208	283	322	321	319	338	290	218	203
Maple	Mixed	25	146	107	63	190	342	343	344	356	28	-7	34
Oak	Mixed	25	155	142	127	224	296	314	326	389	368	282	205
Oak	Mixed	25	152	168	138	267	308	311	315	307	297	178	170
Oak	Mixed	25	67	44	67	136	220	285	340	334	44	37	46
Oak	Mixed	25	244	223	197	268	309	315	321	306	149	69	84

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	10/27/2005	11/4/2005	11/15/2005	11/22/2005	12/6/2005	12/21/2006	1/13/2006	1/23/2006	2/3/2006	2/16/2006	3/1/2006
	Days into experiment		372	380	391	398	412	427	448	449	460	473	486
	Cycle		4	4	4	4	4	4	4	5	5	5	5
Sawdust	Mixed	25	228	96	78	135	254	288	321	335	280	237	229
Sawdust	Mixed	25	242	234	231	307	307	310	312	295	226	100	41
Sawdust	Mixed	25	144	145	150	263	321	319	315	482	260	110	91
Sawdust	Mixed	25	50	19	28	74	217	242	267	429	355	221	189
Timothy	Mixed	25	97	66	81	172	313	316	318	300	223	138	102
Timothy	Mixed	25	62	52	57	152	232	269	309	387	122	33	23
Timothy	Mixed	25	86	54	53	183	337	332	326	377	310	192	186
Timothy	Mixed	25	130	96	113	143	239	256	273	334	288	193	153
Wheat	Mixed	25	236	225	41	263	277	285	292	335	384	218	209
Wheat	Mixed	25	173	138	79	118	154	233	313	246	107	26	26
Wheat	Mixed	25	155	146	140	193	285	311	337	387	321	276	264
Wheat	Mixed	25	66	35	32	26	144	208	272	373	377	297	255
Control	Mixed	10	-26	-53	26	215	275	291	294	443	69	-35	-
Control	Mixed	10	-153	-120	186	249	291	292	301	268	201	227	-
Control	Mixed	10	-35	-126	22	173	244	250	268	266	202	183	-
Control	Mixed	10	182	154	122	174	224	281	290	348	67	-1	-
Oak	Surface	25	198	184	180	230	304	305	306	271	211	130	112
Oak	Surface	25	153	132	92	138	224	252	280	403	366	205	98
Oak	Surface	25	196	187	150	312	356	355	355	448	154	129	136
Oak	Surface	25	99	86	85	232	307	325	335	349	337	302	257
Wheat	Surface	25	55	35	10	268	315	318	317	252	100	115	-104
Wheat	Surface	25	64	-20	91	27	224	259	294	450	299	157	126
Wheat	Surface	25	150	96	105	200	281	288	293	328	294	264	242
Wheat	Surface	25	184	161	114	295	332	334	339	427	402	308	219
Oak	Zoned	25	187	161	153	219	312	313	323	399	233	39	25
Oak	Zoned	25	181	174	176	311	359	362	366	400	379	281	263
Oak	Zoned	25	210	197	188	233	324	334	344	322	286	170	155
Oak	Zoned	25	202	195	195	309	343	329	316	360	310	278	241
Wheat	Zoned	25	78	59	62	176	248	300	351	459	344	122	34
Wheat	Zoned	25	203	160	115	212	302	308	313	321	233	171	144
Wheat	Zoned	25	138	122	90	178	314	321	325	376	261	268	212
Wheat	Zoned	25	197	119	129	385	400	398	397	389	96	54	58

OM TYPE	TREATMENT	Depth	3/7/2006	3/17/2006	4/3/2006	4/20/2006	5/4/2006	5/18/2006	5/25/2006	6/1/2006	6/14/2006	6/28/2006	7/7/2006
	Days into experiment		492	502	519	536	550	561	567	575	588	602	611
	Cycle		5	5	5	5	5	6	6	6	6	6	6
Maple	Mixed	10	143	127	276	270	282	-	-	-	-	-	-
Maple	Mixed	10	117	103	268	261	259	317	264	203	181	135	66
Maple	Mixed	10	66	56	279	276	278	265	253	91	46	-15	-50
Maple	Mixed	10	44	39	257	259	262	-	-	-	-	-	-
Oak	Mixed	10	-154	-152	302	288	276	-	-	-	-	-	-
Oak	Mixed	10	148	145	315	294	299	285	261	202	201	80	-7
Oak	Mixed	10	-117	-110	311	329	339	-	-	-	-	-	-
Oak	Mixed	10	162	90	310	301	308	322	268	200	182	93	19
Sawdust	Mixed	10	97	99	270	278	280	325	288	161	134	116	69
Sawdust	Mixed	10	81	60	301	304	342	353	201	124	79	12	6
Sawdust	Mixed	10	-1	61	294	309	309	-	-	-	-	-	-
Sawdust	Mixed	10	-16	-13	305	325	341	-	-	-	-	-	-
Timothy	Mixed	10	227	227	335	336	336	350	279	225	220	205	195
Timothy	Mixed	10	181	176	309	306	311	-	-	-	-	-	-
Timothy	Mixed	10	10	-27	267	304	307	-	-	-	-	-	-
Timothy	Mixed	10	202	206	307	317	308	334	205	95	73	55	44
Wheat	Mixed	10	101	95	255	267	274	352	292	233	239	224	198
Wheat	Mixed	10	63	60	289	282	293	315	267	199	180	169	152
Wheat	Mixed	10	196	200	318	343	349	-	-	-	-	-	-
Wheat	Mixed	10	42	57	298	297	303	-	-	-	-	-	-
Oak	Surface	10	205	203	346	338	345	296	239	228	203	177	157
Oak	Surface	10	104	92	244	264	276	-	-	-	-	-	-
Oak	Surface	10	211	227	322	327	331	-	-	-	-	-	-
Oak	Surface	10	149	163	304	303	313	340	254	241	217	203	201
Wheat	Surface	10	5	2	316	304	316	369	287	270	198	182	178
Wheat	Surface	10	189	181	350	349	364	-	-	-	-	-	-
Wheat	Surface	10	243	249	360	362	352	382	296	247	254	230	226
Wheat	Surface	10	232	227	382	365	358	-	-	-	-	-	-
Oak	Zoned	10	108	102	356	341	374	-	-	-	-	-	-
Oak	Zoned	10	17	57	348	330	332	-	-	-	-	-	-
Oak	Zoned	10	188	208	337	336	330	330	281	248	199	182	170
Oak	Zoned	10	246	258	363	352	351	332	265	195	152	101	74
Wheat	Zoned	10	139	147	317	328	337	-	-	-	-	-	-
Wheat	Zoned	10	-19	1	297	303	304	332	227	182	179	178	171
Wheat	Zoned	10	13	135	308	284	290	288	188	172	144	72	39
Wheat	Zoned	10	-18	-8	254	272	271	-	-	-	-	-	-
Maple	Mixed	25	235	228	338	337	343	-	-	-	-	-	-
Maple	Mixed	25	239	235	344	353	359	341	325	272	236	223	213
Maple	Mixed	25	166	131	372	364	366	280	217	86	42	20	7
Maple	Mixed	25	36	23	194	264	282	-	-	-	-	-	-
Oak	Mixed	25	161	99	334	337	335	-	-	-	-	-	-
Oak	Mixed	25	167	156	298	328	349	334	318	275	191	135	104
Oak	Mixed	25	43	53	154	271	297	-	-	-	-	-	-
Oak	Mixed	25	58	40	275	299	321	300	251	142	93	67	60

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	3/7/2006	3/17/2006	4/3/2006	4/20/2006	5/4/2006	5/18/2006	5/25/2006	6/1/2006	6/14/2006	6/28/2006	7/7/2006
	Days into experiment		492	502	519	536	550	561	567	575	588	602	611
	Cycle		5	5	5	5	5	6	6	6	6	6	6
Sawdust	Mixed	25	220	220	362	352	361	396	364	143	92	64	49
Sawdust	Mixed	25	25	14	296	313	322	375	322	256	171	230	105
Sawdust	Mixed	25	72	53	254	357	383	-	-	-	-	-	-
Sawdust	Mixed	25	160	138	282	357	354	-	-	-	-	-	-
Timothy	Mixed	25	56	42	144	254	280	302	270	120	50	27	6
Timothy	Mixed	25	4	-3	55	236	301	-	-	-	-	-	-
Timothy	Mixed	25	179	171	305	326	343	-	-	-	-	-	-
Timothy	Mixed	25	97	134	238	271	269	350	327	246	193	172	162
Wheat	Mixed	25	198	194	260	328	335	367	347	301	267	256	253
Wheat	Mixed	25	10	-5	206	271	279	373	353	309	267	235	226
Wheat	Mixed	25	258	257	374	367	362	-	-	-	-	-	-
Wheat	Mixed	25	245	240	364	353	355	-	-	-	-	-	-
Control	Mixed	10	-7	-65	242	295	298	-	-	-	-	-	-
Control	Mixed	10	228	206	316	351	336	-	-	-	-	-	-
Control	Mixed	10	182	178	252	298	321	286	200	177	-4	-62	-100
Control	Mixed	10	-34	-18	236	272	287	288	190	176	105	41	6
Oak	Surface	25	104	97	209	268	309	333	329	253	105	16	-20
Oak	Surface	25	24	5	309	333	335	-	-	-	-	-	-
Oak	Surface	25	119	89	183	375	400	-	-	-	-	-	-
Oak	Surface	25	242	208	371	378	387	399	365	200	103	107	70
Wheat	Surface	25	-128	-148	284	339	346	319	295	228	107	3	-31
Wheat	Surface	25	75	36	194	302	329	-	-	-	-	-	-
Wheat	Surface	25	227	222	362	352	348	352	332	305	258	203	191
Wheat	Surface	25	201	188	374	364	356	-	-	-	-	-	-
Oak	Zoned	25	-2	20	230	298	327	-	-	-	-	-	-
Oak	Zoned	25	242	230	391	387	378	-	-	-	-	-	-
Oak	Zoned	25	142	139	323	357	347	314	304	222	60	14	-14
Oak	Zoned	25	238	235	377	377	387	382	363	315	285	263	251
Wheat	Zoned	25	6	-10	171	332	338	-	-	-	-	-	-
Wheat	Zoned	25	130	125	344	376	376	333	329	243	47	-6	-38
Wheat	Zoned	25	184	167	416	392	390	302	261	171	92	163	54
Wheat	Zoned	25	19	0	145	261	294	-	-	-	-	-	-

OM TYPE	TREATMENT	Depth	7/16/2006	7/25/2006	8/8/2006	8/21/2006	9/6/2006
	Days into experiment		620	629	643	656	672
	Cycle		6	6	6	6	6
Maple	Mixed	10	-	-	-	-	-
Maple	Mixed	10	51	208	261	273	285
Maple	Mixed	10	-60	120	224	245	260
Maple	Mixed	10	-	-	-	-	-
Oak	Mixed	10	-	-	-	-	-
Oak	Mixed	10	-22	206	258	275	300
Oak	Mixed	10	-	-	-	-	-
Oak	Mixed	10	-36	200	268	286	323
Sawdust	Mixed	10	153	248	296	309	312
Sawdust	Mixed	10	148	257	296	305	304
Sawdust	Mixed	10	-	-	-	-	-
Sawdust	Mixed	10	-	-	-	-	-
Timothy	Mixed	10	232	273	308	328	319
Timothy	Mixed	10	-	-	-	-	-
Timothy	Mixed	10	-	-	-	-	-
Timothy	Mixed	10	81	225	278	300	308
Wheat	Mixed	10	207	273	307	327	324
Wheat	Mixed	10	141	217	280	343	310
Wheat	Mixed	10	-	-	-	-	-
Wheat	Mixed	10	-	-	-	-	-
Oak	Surface	10	178	211	262	292	295
Oak	Surface	10	-	-	-	-	-
Oak	Surface	10	-	-	-	-	-
Oak	Surface	10	242	260	305	310	322
Wheat	Surface	10	189	267	322	367	340
Wheat	Surface	10	-	-	-	-	-
Wheat	Surface	10	243	288	362	362	290
Wheat	Surface	10	-	-	-	-	-
Oak	Zoned	10	-	-	-	-	-
Oak	Zoned	10	-	-	-	-	-
Oak	Zoned	10	202	273	333	347	337
Oak	Zoned	10	217	236	338	328	332
Wheat	Zoned	10	-	-	-	-	-
Wheat	Zoned	10	201	239	313	330	344
Wheat	Zoned	10	73	183	275	284	274
Wheat	Zoned	10	-	-	-	-	-
Maple	Mixed	25	-	-	-	-	-
Maple	Mixed	25	201	272	311	322	333
Maple	Mixed	25	29	141	214	269	297
Maple	Mixed	25	-	-	-	-	-
Oak	Mixed	25	-	-	-	-	-
Oak	Mixed	25	72	223	273	293	312
Oak	Mixed	25	-	-	-	-	-
Oak	Mixed	25	62	151	258	294	331

Notes: Each Eh Value is from three replicate platinum electrodes coupled with a calomel reference electrode (correction factor of +244 mv). Eh measurements for the control cores were taken on a different date and have been adjusted to match.

OM TYPE	TREATMENT	Depth	7/16/2006	7/25/2006	8/8/2006	8/21/2006	9/6/2006
Days into experiment			620	629	643	656	672
Cycle			6	6	6	6	6
Sawdust	Mixed	25	-1	100	295	326	333
Sawdust	Mixed	25	97	137	282	349	340
Sawdust	Mixed	25	-	-	-	-	-
Sawdust	Mixed	25	-	-	-	-	-
Timothy	Mixed	25	5	127	238	305	313
Timothy	Mixed	25	-	-	-	-	-
Timothy	Mixed	25	-	-	-	-	-
Timothy	Mixed	25	118	223	314	334	340
Wheat	Mixed	25	267	293	342	347	351
Wheat	Mixed	25	248	309	341	356	329
Wheat	Mixed	25	-	-	-	-	-
Wheat	Mixed	25	-	-	-	-	-
Control	Mixed	10	-	-	-	-	-
Control	Mixed	10	-	-	-	-	-
Control	Mixed	10	-99	-	94	266	249
Control	Mixed	10	-28	-	121	269	269
Oak	Surface	25	10	150	265	285	308
Oak	Surface	25	-	-	-	-	-
Oak	Surface	25	-	-	-	-	-
Oak	Surface	25	114	276	341	335	329
Wheat	Surface	25	-73	84	247	289	304
Wheat	Surface	25	-	-	-	-	-
Wheat	Surface	25	253	299	344	343	308
Wheat	Surface	25	-	-	-	-	-
Oak	Zoned	25	-	-	-	-	-
Oak	Zoned	25	-	-	-	-	-
Oak	Zoned	25	-10	88	289	323	312
Oak	Zoned	25	257	299	394	376	348
Wheat	Zoned	25	-	-	-	-	-
Wheat	Zoned	25	-28	84	287	344	334
Wheat	Zoned	25	55	204	343	345	320
Wheat	Zoned	25	-	-	-	-	-

Appendix F: Soil Morphological Descriptions

Date: 10/31/05		Incorporation: Mixed			
Core ID: 44B		Organic Material: Control			
		Cycle: 1			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-11	10YR 4/4	-	-	-
Ap2	11-18	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, masses and pore linings,	2-4
Bt	18+	10YR 5/6	7.5YR 4/4	Faint, very fine to fine, 18-24cm in old root channels	1-3

Date: 10/31/05		Incorporation: Mixed			
Core ID: 1A		Organic Material: Control			
		Cycle: 1			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-11	10YR 4/4	-	-	-
Ap2	11-22	10YR 4/4	7.5YR 4/4	faint, very fine, throughout old root channels, masses and pore linings,	4-6
Bt	22+	10YR 5/6	7.5YR 4/4	Faint, very fine to fine, 22-25cm in old root channels	1-3

Date: 3/8/05		Incorporation: Mixed			
Core ID: 3702		Organic Material: Maple			
		Cycle: 1			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-14	10YR 3/3	-	Potential feature around macropore	-
Ap2	14-24	10YR 4/3	-	Very few, faint iron oxide concentrations	-
Bt	24+	10YR 5/6	-	-	-

Notes: No significant iron coating on top of core

Date: 3/8/05		**Incorporation: Mixed**			
Core ID: 1556		**Organic Material: Maple**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 3/3	-	-	-
Ap2	13-20	10YR 4/4	-	-	-
BE	20-25	10YR 5/4	-	-	-
Bt	25+	10YR 5/6	-	-	-

Notes: No surface coating on top of core, iron staining/concentrations from 1-3cm in macropores.

Date: 3/8/05		**Incorporation: Mixed**			
Core ID: 4455		**Organic Material: Oak**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-15	10YR 3/2	-	-	-
Ap2	15-22	10YR 4/3	-	-	-
Bt	22+	10YR 5/6	-	-	-

Notes: No iron surface crust, iron staining/concentrations from 2-5cm in pH sampling macrocore.

Date: 3/8/05		**Incorporation: Mixed**			
Core ID: 1301		**Organic Material: Oak**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-15	10YR 3/3	-	-	-
Ap2	15-21	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, masses and pore linings	< 0.5
BE	21-25	10YR 5/4	-	-	-
Bt	25+	10YR 5/6	-	-	-

Notes: Light iron surface coating on top of core, iron staining/concentrations from 4-6cm in redox probe hole.

Date: 4/8/05		**Incorporation: Surface**			
Core ID: 5309		**Organic Material: Oak**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/3	7.5YR 5/6	faint to distinct, very fine, throughout, soft masses and pore linings	3
Ap2	10-20	10YR 4/3	-	-	-
BE	20-24	10YR 5/4	-	-	-
Bt	24+	10YR 5/6	-	-	-

Date: 4/8/05		**Incorporation: Surface**			
Core ID: 2063		**Organic Material: Oak**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/3	7.5YR 4/4	distinct, very fine, throughout soft masses and pore linings	2
Ap2	10-17	10YR 4/3	-	-	-
BE	17-20	10YR 5/4	-	-	-
Bt	20+	10YR 5/6	-	-	-

Date: 4/8/05		**Incorporation: Zoned**			
Core ID: 4962		**Organic Material: Oak**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-19	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, masses and pore linings	<2
Bt	19+	10YR 5/6	-	-	-

Date: 4/8/05	**Incorporation: Zoned**
Core ID: 4208	**Organic Material: Oak**
	Cycle: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap	0-20	10YR 4/3	7.5YR 5/6	mostly faint, very fine, throughout, masses and pore linings, large distinct or prominent concentration at 14cm	<2
Bt	20+	10YR 5/6	-	-	-

Notes: Potential depletion (1.5 cm diameter) observed at 14 cm, 10YR 6/4.

Date: 3/8/05	**Incorporation: Mixed**
Core ID: 0557	**Organic Material: Sawdust**
	Cycle: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-14	10YR 3/3	-	-	-
Ap2	14-18	10YR 4/3	-	-	-
Bt	18+	10YR 5/6	-	-	-

Notes: No iron surface crust, iron staining/concentrations from 2-4cm in pH sampling macropore.

Date: 3/8/05	**Incorporation: Mixed**
Core ID: 0103	**Organic Material: Sawdust**
	Cycle: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-12	10YR 3/3	-	-	-
Ap2	12-19	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<0.5
BE	19-25	10YR 5/4	-	-	-
Bt	25+	10YR 5/6	-	-	-

Notes: No surface coating on top of core, iron staining/concentrations from 2-5cm in redox probe macropore.

Date: 3/8/05	**Incorporation: Mixed**				
Core ID: 1159	**Organic Material: Timothy**				
	Cycle: 1				

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-20	10YR 4/3	-	-	-
BE	20-25	10YR 5/5	-	-	-
Bt	25+	10YR 5/6	-	-	-

Notes: Iron coating on top of core.

Date: 3/8/05	**Incorporation: Mixed**
Core ID: 4505	**Organic Material: Timothy**
	Cycle: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-22	10YR 4/3	-	-	-
Bt	22+	10YR 5/6	-	-	-

Notes: Light iron coating on top of core.

Date: 3/8/05	**Incorporation: Mixed**
Core ID: 0304	**Organic Material: Wheat**
	Cycle: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	-	Potential iron oxide concentration around macropore	-
Ap2	13-18	10YR 4/3	-	-	-
BE	18-23	10YR 5/5	-	-	-
Bt	23+	10YR 5/6	-	-	-

Notes: Light iron coating on top of core.

Date: 3/8/05	**Incorporation: Mixed**				
Core ID: 0258	**Organic Material: Wheat**				
	Cycle: 1				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-15	10YR 4/3	-	-	-
Ap2	15-27	10YR 4/3	-	-	-
Bt	27+	10YR 5/6	-	-	-

Notes: Splotty iron surface crust. Zones of Bt is bottom of Ap2

Date: 4/8/05	**Incorporation: Surface**				
Core ID: 0661	**Organic Material: Wheat**				
	Cycle: 1				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-5	10YR 4/3	7.5YR 4/4	faint, very fine, 0-5 cm, masses and pore linings	<2
Ap2	5-19	10YR 4/3	-	-	-
Bt	19+	10YR 5/6	-	-	-

Date: 4/8/05	**Incorporation: Surface**				
Core ID: 3907	**Organic Material: Wheat**				
	Cycle: 1				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/3	7.5YR 4/4	faint, very fine, 0-10cm, masses and pore linings	<2
Ap2	10-18	10YR 4/3	-	-	-
Bt	18+	10YR 5/6	-	-	-

Date: 4/8/05		**Incorporation: Zoned**			
Core ID: 5006		**Organic Material: Wheat**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-22	10YR 4/3	7.5YR 4/4	faint, very fine, throughout and around roots	<2
Bt	22+	10YR 5/6	-	-	-

Notes: Organic matter is lighter in color

Date: 4/8/05		**Incorporation: Zoned**			
Core ID: 4560		**Organic Material: Wheat**			
		Cycle: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-18	10YR 4/3	7.5YR 4/4	faint, very fine, throughout upper 10cm, soft masses and pore linings	2
BE	18-22	10YR 5/4	-	-	-
Bt	22+	10YR 5/6	-	-	-

Date: 3/16/06		**Incorporation: Mixed**			
Core ID: 2B		**Organic Material: Control**			
		Cycle: 2			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-11.5	10YR 4/3	-	-	-
Ap2	11.5-22	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1
Bt	20+	10YR 5/6	7.5YR 4/4	faint, very fine, 20-25 cm, soft masses and pore linings	2

Date: 3/16/06		**Incorporation: Mixed**			
Core ID: 37A		**Organic Material: Control**			
		Cycle: 2			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-11	10YR 4/4	-	-	-
Ap2	11-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1
Bt	19+	10YR 4/6	7.5YR 4/6	faint, very fine, 19-24 cm, soft masses and pore linings	1

Date: 6/21/05	**Incorporation: Mixed**				
Core ID: 0711	**Organic Material: Maple**				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-12	10YR 4/3	-	-	-
Ap2	12-20	10YR 4/4	7.5 YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	20+	10YR 5/6	-	-	-

Notes: Light iron staining in macropore within 1cm, no staining on soil surface, brittle in bottom 5cm of core.

Date: 6/21/05	**Incorporation: Mixed**				
Core ID: 5465	**Organic Material: Maple**				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-21	10YR 4/4	7.5YR 4/4	faint, very fine, 13-16cm, soft masses and pore linings	1-2
Bt	21+	10YR 5/6	-	-	-

Notes: iron oxide features at base of Ap1

Date: 6/23/05	**Incorporation: Mixed**				
Core ID: 2864	**Organic Material: Oak**				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-22	10YR 4/4	7.5 YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	22+	10YR 5/6	-	-	-

Notes: faint staining in macropores.

Date: 6/21/05	**Incorporation: Mixed**				
Core ID: 0410	**Organic Material: Oak**				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-26	10YR 4/4	-	-	-
Bt	26+	10YR 5/6	-	-	-

Notes: Little iron staining on soil surface, distinct staining in redox probe macropores in upper 5cm, lots of miscellaneous colors in bottom of Ap2 that's not redox.

Date: 6/23/05	**Incorporation: Surface**				
Core ID: 2272	**Organic Material: Oak**				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-5	10YR 4/3	5YR 4/6	distinct, very fine, throughout, soft masses and pore linings	3
Ap2	5-21	10YR 4/4	5YR 4/6	distinct, very fine, throughout, soft masses and pore linings	1
Bt	21+	10YR 5/6	-	-	-

Date: 6/23/05	**Incorporation: Surface**				
Core ID: 5218	**Organic Material: Oak**				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1-3
Ap2	10-22	10YR 4/4	-	-	-
Bt	22+	10YR 5/6	-	-	-

Notes: Bt material mixed into bottom of Ap2 horizon.

Date: 6/23/05	Incorporation: Zoned				
Core ID: 2171	Organic Material: Oak				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-23	10YR 4/3	5YR 4/6	distinct, very fine, throughout, soft masses and pore linings	5
Bt	23+	10YR 5/6	-	-	-

Date: 6/23/05	Incorporation: Zoned				
Core ID: 3517	Organic Material: Oak				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-18	10YR 4/3	5YR 4/6	distinct, very fine, throughout, soft masses and pore linings	3
BE	18-21	10YR 5/4	5YR 4/6	-	-
Bt	21+	10YR 5/6	-	-	-

Notes: potential depleted halo around organic material.

Date: 6/21/05	Incorporation: Mixed				
Core ID: 0766	Organic Material: Sawdust				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-22	10YR 4/3	-	-	-
Bt	22+	10YR 5/6	-	-	-

Notes: Little iron staining on soil surface, faint staining in redox macropores within 1 cm of soil surface.

Date: 6/23/05	**Incorporation: Mixed**				
Core ID: 2212	**Organic Material: Sawdust**				
	Cycle: 2				

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-11	10YR 4/3	-	-	-
Ap2	11-20	10YR 4/4	-	-	-
Bt	20+	10YR 5/6	-	-	-

Notes: faint staining in macropores.

Date: 6/21/05	**Incorporation: Mixed**
Core ID: 4414	**Organic Material: Timothy**
	Cycle: 2

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-18	10YR 4/3	-	-	-
Bt	18+	10YR 5/6	-	-	-

Notes: Significant iron staining on soil surface, light staining in macrocpores within 5 cm of soil surface.

Date: 6/21/05	**Incorporation: Mixed**
Core ID: 4368	**Organic Material: Timothy**
	Cycle: 2

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-14	10YR 4/3	-	-	-
Ap2	14-25	10YR 4/3	-	-	-
Bt	25+	10YR 5/6	-	-	-

Notes: Significant iron staining on soil surface. Staining in redox probe holes within 5cm of soil surface.

Date: 6/21/05	**Incorporation: Mixed**
Core ID: 0967	**Organic Material: Wheat**
	Cycle: 2

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-15	10YR 4/3	7.5YR 4/4	faint, very fine, throughout upper 5 cm, soft masses and pore linings	<1
Ap2	15-22	10YR 4/4	7.5YR 4/4	faint, very fine, throughout	<1
Bt	22+	10YR 5/6	-	-	-

Notes: Heavy iron staining on soil surface, little staining in macropores.

Date: 6/23/05	**Incorporation: Mixed**
Core ID: 3013	**Organic Material: Wheat**
	Cycle: 2

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-12	10YR 4/3	-	-	-
Ap2	12-22	10YR 4/4	-	-	-
Bt	22+	10YR 5/6	-	-	-

Notes: faint iron staining in macropores in upper 2 cm.

Date: 6/23/05	**Incorporation: Surface**
Core ID: 0916	**Organic Material: Wheat**
	Cycle: 2

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-5	10YR 4/3	5YR 4/6	faint, very fine, throughout soft masses and pore linings	3-4
Ap2	5-21	10YR 4/3	5YR 4/6	faint, fine, throughout soft masses and pore linings	1
Bt	21+	10YR 5/6	-	-	-

Date: 6/23/05	Incorporation: Surface				
Core ID: 4870	Organic Material: Wheat				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-5	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<2
Ap2	5-21.5	10YR 4/4	-	-	-
Bt	21.5+	10YR 5/6	-	-	-

Date: 6/23/05	Incorporation: Zoned				
Core ID: 2569	Organic Material: Wheat				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap	0-23	10YR 4/3	5YR 4/6	faint, very fine, throughout soft masses and pore linings	4
Bt	23+	10YR 5/6	-	-	-

Date: 6/23/05	Incorporation: Zoned				
Core ID: 5115	Organic Material: Wheat				
	Cycle: 2				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-12	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	2
Ap2	12-21	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	4-6
Bt	21+	10YR 5/6	-	-	-

Date: 6/20/06		**Incorporation: Mixed**			
Core ID: 3A		**Organic Material: Control**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-11	10YR 4/4	-	-	-
Ap2	11-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, masses and pore linings,	1-3
Bt	22+	10YR 5/6	7.5YR 4/6	faint, very fine to fine, 22-23cm	-

Date: 6/26/06		**Incorporation: Mixed**			
Core ID: 45B		**Organic Material: Control**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/4	-	-	-
Ap2	10-20	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, masses and pore linings,	3
Bt	20+	10YR 5/6	7.5YR 4/6	faint, very fine to fine, 20-22cm	<1

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 3174		**Organic Material: Maple**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-14	10YR 4/3	-	-	-
Ap2	14-21	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Notes: iron oxide staining/concentrations in macropores from 0-5cm.

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 0520		**Organic Material: Maple**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	7.5YR 4/4	faint, very fine, upper 5cm, soft masses and pore linings	<1
Ap2	13-21	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Notes: iron oxide staining/concentrations in macropores from 0-5cm.

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 5073		**Organic Material: Oak**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/4	-	-	-
Ap2	13-22.5	10YR 4/4	-	-	-
Bt	22.5+	10YR 5/6	-	-	-

Notes: iron oxide staining/concentrations (7.5YR 4/4) 0-5cm in macropores.

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 2119		**Organic Material: Oak**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-14	10YR 4/3	-	-	-
Ap2	13-20	10YR 4/4	-	-	-
Bt	20+	10YR 5/6	-	-	-

Date: 10/31/05	Incorporation: Surface
Core ID: 4027	Organic Material: Oak
	Cycle: 3

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-5	10YR 4/3-4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1
Ap2	5-16.5	10YR 4/4	-	-	-
Bt	18.5+	10YR 5/6	-	-	-

Date: 10/27/05	Incorporation: Surface
Core ID: 3281	Organic Material: Oak
	Cycle: 3

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-5	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1-3
Ap2	5-20	10YR 4/3	-	-	-
Bt	20+	10YR 5/6	-	-	-

Date: 10/27/05	Incorporation: Zoned
Core ID: 3980	Organic Material: Oak
	Cycle: 3

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-22.5	10YR 4/3	7.5YR 4/6	distinct, very fine, throughout, soft masses and pore linings	7-9
Bt	22.5+	10YR 5/6	-	-	-

Date: 10/31/05	**Incorporation: Zoned**
Core ID: 0626	**Organic Material: Oak**
	Cycle: 3

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap	0-22.5	10YR 4/3	7.5YR 4/4	faint to distinct, very fine, throughout, soft masses and pore linings	3-5
Bt	22.5+	10YR 5/6	-	-	-

Date: 10/31/05	**Incorporation: Mixed**
Core ID: 0821	**Organic Material: Sawdust**
	Cycle: 3

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-23	10YR 4/3-4	-	-	-
Bt	23+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations (7.5YR 4/4) from 0-5cm in macropores.

Date: 10/31/05	**Incorporation: Mixed**
Core ID: 0375	**Organic Material: Sawdust**
	Cycle: 3

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-21	10YR 4/3-4	7.5YR 4/4	-	<1
Bt	21+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations (7.5YR 4/4) from 0-8cm in macropores.

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 3823		**Organic Material: Timothy**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-12	10YR 4/3	7.5YR 4/4	faint, very fine, throughout upper 5 cm, soft masses and pore linings	<1
Ap2	12-20	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	20+	10YR 5/6	-	-	-

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 0177		**Organic Material: Timothy**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/4	7.5YR 4/4	faint, very fine, throughout upper 5 cm, soft masses and pore linings	<1
Ap2	13-22.5	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<0.5
Bt	20+	10YR 5/6	-	-	-

Date: 10/31/05		**Incorporation: Mixed**			
Core ID: 1222		**Organic Material: Wheat**			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1-3
Ap2	13-22	10YR 4/3-4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	3-5
Bt	22+	10YR 5/6	-	-	-

Notes: very large iron oxide feature in macropore (8cm long x 2 cm wide, 5YR 3/4)

Date: 10/31/05		Incorporation: Mixed			
Core ID: 2776		Organic Material: Wheat			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-13	10YR 4/3	7.5YR 4/4	faint, very fine, throughout upper 5cm, soft masses and pore linings	<1
Ap2	13-23	10YR 4/3-4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	2-4
Bt	23+	10YR 5/6	-	-	-

Date: 10/27/05		Incorporation: Surface			
Core ID: 5179		Organic Material: Wheat			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-5	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	5-18	10YR 4/4	-	-	-
Bt	20+	10YR 5/6	-	-	-

Date: 10/31/05		Incorporation: Surface			
Core ID: 5425		Organic Material: Wheat			
		Cycle: 3			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-5	10YR 4/3	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1-2
Ap2	5-18.5	10YR 4/3	-	-	-
Bt	18.5+	10YR 4-5/6	-	-	-

Date: 10/27/05	Incorporation: Zoned				
Core ID: 3124	Organic Material: Wheat				
	Cycle: 3				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/3	7.5YR 4/4	faint and distinct, very fine, throughout, soft masses and pore linings	4-5
Ap2	10-23	10YR 4/3	7.5YR 4/4	faint and distinct, very fine, throughout, soft masses and pore linings	8-10
Bt	23+	10YR 5/6	-	-	-

Date: 10/27/05	Incorporation: Zoned				
Core ID: 3078	Organic Material: Wheat				
	Cycle: 3				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/3	7.5YR 4/4	faint and distinct, very fine, throughout, soft masses and pore linings	2-4
Ap2	10-19	10YR 4/3	7.5YR 4/4	faint and distinct, very fine, throughout, soft masses and pore linings	7-9
Bt	19+	10YR 5/6	-	-	-

Notes: Line of features at Ap/Bt contact, potential features in top 5cm of Bt.

Date: 11/1/06	Incorporation: Mixed				
Core ID: 49B	Organic Material: Control				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/4	-	-	-
Ap2	10-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	2-3
Bt	21+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Mixed				
Core ID: 15B	Organic Material: Control				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/4	-	-	-
Ap2	10-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	2
Bt	21+	10YR 5/6	-	Very few iron oxide concentrations in very top of horizon, not enough to map	-

Date: 3/16/06	Incorporation: Mixed				
Core ID: 2029	Organic Material: Maple				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-12.5	10YR 4/3	7.5YR 4/4	faint, very fine, throughout the upper 3 cm.	<1
Ap2	12.5-23	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	2
Bt	23+	10YR 5/5	-	-	-

Date: 3/16/06	Incorporation: Mixed				
Core ID: 3383	Organic Material: Maple				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	12.5-23	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	23+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations from 0-1 cm in macropores.

Date: 3/16/06	Incorporation: Mixed				
Core ID: 2328	Organic Material: Oak				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-14	10YR 4/4	-	-	-
Ap2	14-19	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	19+	10YR 4/6	-	-	-

Notes: Iron oxide staining/concentrations from 0-4 cm in macropores.

Date: 3/16/06	Incorporation: Mixed				
Core ID: 2482	Organic Material: Oak				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-15	10YR 4/3	7.5YR 4/4	faint, very fine, throughout the upper 3 cm.	<1
Ap2	15-24	10YR 4/3	7.5YR 4/4	faint, very fine, throughout	2
Bt	24+	10YR 5/6	-	-	-

Date: 6/20/06	Incorporation: Surface				
Core ID: 1790	Organic Material: Oak				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-5	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	5-14	10YR 4/4	-	-	-
Bt	14+	10YR 5/6	-	-	-

Date: 6/23/06	Incorporation: Surface				
Core ID: 3636	Organic Material: Oak				
	Cycle: 4				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap	0-17	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Bt	17+	10YR 5/6	-	-	-

Date: 6/23/06	**Incorporation: Zoned**
Core ID: 1989	**Organic Material: Oak**
	Cycle: 4

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap	0-22	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	1-2
Bt	22+	10YR 5/6	-	-	-

Notes: Small depleted halo around organic material and a few very fine depletions in Ap2

Date: 6/23/06	**Incorporation: Zoned**
Core ID: 1935	**Organic Material: Oak**
	Cycle: 4

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-11	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1-2
Ap2	11-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	6
			10YR 4/3	Faint, fine, throughout	3
Bt	22+	10YR 5/6	-	-	-

Notes: Small depleted halo around organic material approx 5-7mm thick.

Date: 3/16/06	**Incorporation: Mixed**
Core ID: 0232	**Organic Material: Timothy**
	Cycle: 4

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/3	7.5YR 4/4	faint, very fine, throughout the upper 3 cm.	<1
Ap2	13-20	10YR 4/3	7.5YR 4/4	faint, very fine, throughout	2
Bt	20+	10YR 5/6	-	-	-

Date: 3/16/06		**Incorporation: Mixed**			
Core ID: 4786		**Organic Material: Timothy**			
		Cycle: 4			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-12	10YR 4/4	-	-	-
Ap2	12-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	22+	10YR 5/6	-	-	-

Date: 3/16/06		**Incorporation: Mixed**			
Core ID: 2930		**Organic Material: Sawdust**			
		Cycle: 4			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-23	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	23+	10YR 4/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores 0-2cm.

Date: 3/16/06		**Incorporation: Mixed**			
Core ID: 4184		**Organic Material: Sawdust**			
		Cycle: 4			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/4	-	-	-
Ap2	13-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	0.5
Bt	21+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores and creases of Ap1.

Date: 3/16/06	Incorporation: Mixed
Core ID: 2431	Organic Material: Wheat
	Cycle: 4

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-13.5	10YR 4/3	7.5YR 5/6	faint, very fine, throughout upper 3cm, soft masses and pore linings	<1
Ap2	13.5-24	10YR 4/3	7.5YR 5/6	faint, very fine, throughout, soft masses and pore linings	2
Bt	24+	10YR 5/6	-	-	-

Date: 3/16/06	Incorporation: Mixed
Core ID: 1285	Organic Material: Wheat
	Cycle: 4

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-13	10YR 4/3	7.5YR 4/4	Faint, Very Fine, throughout the upper 3 cm.	<2
Ap2	13-23	10YR 4/3.5	7.5YR 4/4	Faint, very fine, throughout	2
Bt	23+	10YR 5/6	-	-	-

Date: 6/23/06	Incorporation: Surface
Core ID: 1434	Organic Material: Wheat
	Cycle: 4

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-17	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	17+	10YR 4/6	-	-	-

Date: 6/23/06	Incorporation: Surface
Core ID: 1888	Organic Material: Wheat
	Cycle: 4

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-20	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	20+	10YR 4/6	-	-	-

Date: 6/20/06	Incorporation: Zoned
Core ID: 1833	Organic Material: Wheat
	Cycle: 4

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-9	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	9-18	10YR 4/4	7.5YR 4/6	faint to distinct, fine to very fine, throughout, soft masses and pore linings	6-8
Bt	23+	10YR 5/6	-	faint, very fine, 18-21cm, soft masses and pore linings	<1

Notes: Potential depletion 10YR 5/4 in Ap2.

Date: 6/23/06	Incorporation: Zoned
Core ID: 1487	Organic Material: Wheat
	Cycle: 4

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-10	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	2
Ap2	10-24	10YR 4/4	7.5YR 4/6	faint to distinct, fine to very fine, throughout, soft masses and pore linings	6
			10YR 4/3	Faint, fine, chroma 3 depletions throughout Ap2	2
Bt	24+	10YR 5/6	-	faint, very fine, 18-21cm, soft masses and pore linings	<1

Notes: Potential depleted halo around organic matter approximately 5mm wide.

Date: 6/25/07	Incorporation: Mixed
Core ID: 50A	Organic Material: Control
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/3	-	-	-
Ap2	12-20	10YR 4/3	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
BE	20-24	10YR 5/4	-	-	-
Bt	24+	10YR 5/6	-	-	-

Date: 6/25/07		Incorporation: Mixed			
Core ID: 13A		Organic Material: Control			
		Cycle: 5			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-10	10YR 4/3	-	-	-
Ap2	10-19	10YR 4/3	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1-2
BE	19-23	10YR 5/4	-	-	-
Bt	23+	10YR 5/6	-	-	-

Date: 6/26/06		Incorporation: Mixed			
Core ID: 3438		Organic Material: Maple			
		Cycle: 5			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/3	-	-	-
Ap2	12-24	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	24+	10YR 4/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores from 0-3cm.

Date: 6/26/06		Incorporation: Mixed			
Core ID: 1392		Organic Material: Maple			
		Cycle: 5			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/4	-	-	-
Ap2	12-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	19+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores from 0-3cm.

Date: 6/20/06	Incorporation: Mixed
Core ID: 1537	Organic Material: Oak
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-14	10YR 4/4	7.5YR 4/6	faint, very fine, throughout upper 5cm, soft masses and pore linings	<1
Ap2	14-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	22+	10YR 5/6	-	-	-

Date: 6/20/06	Incorporation: Mixed
Core ID: 0491	Organic Material: Oak
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-11	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	11-18	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	18+	10YR 4/6	-	-	-

Date: 6/23/06	Incorporation: Surface
Core ID: 1099	Organic Material: Oak
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-16	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	18+	10YR 4/6	-	-	-

Date: 6/23/06	Incorporation: Surface
Core ID: 4145	Organic Material: Oak
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-16	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	16+	10YR 4/6	-	-	-

Date: 6/23/06	**Incorporation: Zoned**				
Core ID: 4298	**Organic Material: Oak**				
	Cycle: 5				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-20	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<2
Bt	20+	10YR 4/6	-	-	-

Notes: Depleted halos around organic columns, 10YR 4/3, approximately 5mm thick.

Date: 6/23/06	**Incorporation: Zoned**				
Core ID: 2644	**Organic Material: Oak**				
	Cycle: 5				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-10	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1
Ap2	10-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	3
Bt	22+	10YR 4/6	-	-	-

Notes: Depleted halo approx. 2-5 cm thick and 1 or 2 fine 3 chroma depletions in Ap2.

Date: 6/20/06	**Incorporation: Mixed**				
Core ID: 1039	**Organic Material: Sawdust**				
	Cycle: 5				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/4	-	-	-
Ap2	13-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	22+	10YR 4/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores from 0-3cm.

Date: 6/26/06	Incorporation: Mixed
Core ID: 3593	Organic Material: Sawdust
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/3	-	-	-
Ap2	12-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	0.5
Bt	21+	10YR 4/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores.

Date: 6/29/06	Incorporation: Mixed
Core ID: 4695	Organic Material: Timothy
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-10	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	10-18	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	18+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores.

Date: 6/29/06	Incorporation: Mixed
Core ID: 4941	Organic Material: Timothy
	Cycle: 5

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	0.5
Ap2	12-25	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	25+	10YR 5/6	-	-	-

Date: 6/29/06	**Incorporation: Mixed**
Core ID: 4840	**Organic Material: Wheat**
	Cycle: 5

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-12	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	12-20	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1
Bt	20+	10YR 5/6	-	-	-

Notes: Large macropores throughout Ap1, iron oxide concentrations in macropores, macropores may be from worms/insects.

Date: 6/26/06	**Incorporation: Mixed**
Core ID: 3894	**Organic Material: Wheat**
	Cycle: 5

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-13	10YR 4/4	-	-	-
Ap2	13-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 4/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores from 0-3cm.

Date: 6/20/06	**Incorporation: Surface**
Core ID: 0897	**Organic Material: Wheat**
	Cycle: 5

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-8	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	8-18	10YR 4/4	-	-	-
Bt	18+	10YR 4/6	-	-	-

Date: 6/23/06		**Incorporation: Surface**			
Core ID: 2543		**Organic Material: Wheat**			
		Cycle: 5			
Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap	0-20	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	20+	10YR 4/6	-	-	-

Date: 6/23/06		**Incorporation: Zoned**			
Core ID: 3796		**Organic Material: Wheat**			
		Cycle: 5			
Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap	0-17	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<3
			10YR 4/3	Faint, fine, throughout, 3 chroma depletions	<1
Bt	17+	10YR 5/6	-	-	-

Notes: Depleted halos around organic columns, 10YR 4/3, approximately 7mm thick.

Date: 6/20/06		**Incorporation: Zoned**			
Core ID: 4642		**Organic Material: Wheat**			
		Cycle: 5			
Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-10	10YR 4/4	7.5YR 4/4	faint, very fine, throughout, soft masses and pore linings	2
Ap2	10-20	10YR 4/4	7.5YR 4/4	faint to distinct, throughout, soft masses and pore linings	5
Bt	20+	10YR 4/6	-	-	-

Notes: Depleted halos around organic columns, 10YR 4/3, approximately 5mm thick.

Date: 6/25/07		**Incorporation: Mixed**			
Core ID: 11B		**Organic Material: Control**			
		Cycle: 6			
Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-10	10YR 4/3	-	-	-
Ap2	10-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 4/6	-	-	-

Date: 6/25/07		**Incorporation: Mixed**			
Core ID: 42A		**Organic Material: Control**			
		Cycle: 6			
Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-10	10YR 4/4	-	-	-
Ap2	10-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	2
BE	21-25	10YR 5/4	-	-	-
Bt	25+	10YR 5/6	-	-	-

Date: 10/31/06		**Incorporation: Mixed**			
Core ID: 16101		**Organic Material: Maple**			
		Cycle: 6			
Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-12	10YR 4/4	-	-	-
Ap2	12-24	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	24+	10YR 5/6	-	-	-

Notes: Iron oxide staining/concentrations in macropores in upper part of Ap1.

Date: 11/1/06	Incorporation: Mixed
Core ID: 3347	Organic Material: Maple
	Cycle: 6

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/4	-	-	-
Ap2	12-20	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	20+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Mixed
Core ID: 40102	Organic Material: Sawdust
	Cycle: 6

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-13	10YR 4/4	7.5YR 4/6	faint, very fine, throughout upper 5cm, soft masses and pore linings	<1
Ap2	13-23	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	23+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Mixed
Core ID: 4748	Organic Material: Sawdust
	Cycle: 6

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/4	-	-	-
Ap2	12-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Mixed				
Core ID: 36100	Organic Material: Oak				
	Cycle: 6				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-12	10YR 4/4	-	-	-
Ap2	12-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Mixed				
Core ID: 4346	Organic Material: Oak				
	Cycle: 6				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-13	10YR 4/4	-	-	-
Ap2	13-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Surface				
Core ID: 2854	Organic Material: Oak				
	Cycle: 6				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap	0-17	10YR 4/4	7.5YR 4/6	faint, very fine, throughout soft masses and pore linings	1-2
Bt	17+	10YR 5/6	-	-	-

Date: 10/31/06		Incorporation: Surface			
Core ID: 26108		Organic Material: Oak			
		Cycle: 6			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap	0-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout soft masses and pore linings	<1
Bt	19+	10YR 5/6	-	-	-

Date: 10/31/06		Incorporation: Zoned			
Core ID: 1653		Organic Material: Oak			
		Cycle: 6			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-9	10YR 4/3	7.5YR 4/6	faint, very fine, throughout soft masses and pore linings	2-3
Ap2	9-19	10YR 4/3	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	4-6
Bt	19+	10YR 5/6	-	faint, very fine, 1cm into Bt	-

Notes: Depleted halos around organic columns, 10YR 4/3, approximately 5mm thick.

Date: 11/1/06		Incorporation: Zoned			
Core ID: 34107		Organic Material: Oak			
		Cycle: 6			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-9	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	9-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	2-3
Bt	19+	10YR 5/6	-	-	-

Notes: Depleted halos around organic columns, 10YR 4/3, approximately 5mm thick.

Date: 10/31/06		Incorporation: Mixed			
Core ID: 1750		Organic Material: Timothy			
		Cycle: 6			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-13	10YR 4/3	-	-	-
Ap2	13-20	10YR 4/3	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	20+	10YR 5/6	-	-	-

Date: 11/1/06		Incorporation: Mixed			
Core ID: 29104		Organic Material: Timothy			
		Cycle: 6			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-13	10YR 4/4	7.5YR 4/6	faint, very fine, throughout upper 5cm, soft masses and pore linings	<1
Ap2	13-21	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Date: 10/31/06		Incorporation: Mixed			
Core ID: 2749		Organic Material: Wheat			
		Cycle: 6			
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/4	7.5YR 4/6	faint, very fine, throughout upper 5cm, soft masses and pore linings	<0.5
Ap2	12-19	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	19+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Mixed				
Core ID: 52103	Organic Material: Wheat				
	Cycle: 6				
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-12	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Ap2	12-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	22	10YR 5/6	-	-	-

Date: 10/31/06	Incorporation: Surface				
Core ID: 1152	Organic Material: Wheat				
	Cycle: 6				
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-17	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	<1
Bt	21+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Surface				
Core ID: 53106	Organic Material: Wheat				
	Cycle: 6				
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap	0-15	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1-2
Bt	15+	10YR 5/6	-	-	-

Date: 11/1/06	Incorporation: Zoned				
Core ID: 3251	Organic Material: Wheat				
	Cycle: 6				
Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-11	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	1-2
Ap2	11-22	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	3
Bt	22+	10YR 5/6	-	-	-

Date: 10/31/06		**Incorporation: Zoned**			
Core ID: 23105		**Organic Material: Wheat**			
		Cycle: 6			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-9	10YR 4/4	7.5YR 4/6	faint, very fine, throughout soft masses and pore linings	1-3
Ap2	9-18	10YR 4/4	7.5YR 4/6	faint, very fine, throughout, soft masses and pore linings	3-5
Bt	18+	10YR 5/6	-	-	-

Notes: Depleted halos around organic columns, 10YR 4/3, approximately 5mm thick.

Date: 6/28/06		**Incorporation: Mixed**			
Core ID: L11		**Organic Material: Low Timothy**			
		Field Year: 1			
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-4	10YR 4/3	10YR 6/3-4	Depleted zones/stripped sand grains	20
Ap2	4-9	10YR 4/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	3-4
Ap3	9-21	10YR 4/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	6-8
			10YR 5/3	faint depletions, fine, throughout	2-3
Bt	21+	10YR 5/6	-	-	-

Notes: Most features surround macropores, root channels, and other natural structure.

Date: 6/28/06	**Incorporation: Mixed**
Core ID: L12	**Organic Material: Low Timothy**
	Field Year: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-3	10YR 4/3	10YR 5/3	Depleted zones/stripped sand grains	30
Ap2	3-9	10YR 4/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	2
Ap3	9-20	10YR 4/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	5
			10YR 4/3	faint depletions, fine, throughout	2-5
Bt	20+	10YR 5/6	-	-	-

Notes: Most features surround macropores, root channels, and other natural structure.

Date: 6/28/06	**Incorporation: Mixed**
Core ID: L13	**Organic Material: Low Timothy**
	Field Year: 1

Horizon	**Depth (cm)**	**Matrix Color**	**Redoximorphic Features (visually quantified)**		
			Color	**Location**	**%**
Ap1	0-7	10YR 4/4	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	<1
			10YR 5/3	Depleted zones/stripped sand grains	5
Ap2	7-16	10YR 4/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	2-3
			10YR 5/3	faint depletions, fine, throughout	1-3
Bt	16+	10YR 5/6	-	-	-

Notes: Most features surround macropores, root channels, and other natural structure.

Date: 6/28/06	Incorporation: Mixed				
Core ID: H11	Organic Material: High Timothy				
	Field Year: 1				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-7	10YR 3/3	10YR 5/3	Faint depletions, fine, throughout	15-20
Ap2	7-14	10YR 3/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	2-3
Ap3	14-25	10YR 4/4	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	6
			10YR 5/3	faint depletions, fine, throughout	2-3
Bt	25+	10YR 5/6	-	-	-

Notes: Most features surround macropores, root channels, and other natural structure.

Date: 6/28/06	Incorporation: Mixed				
Core ID: H12	Organic Material: High Timothy				
	Field Year: 1				
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-9	10YR 3/3	10YR 6/3	Faint depletions, fine, throughout	2
			7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	1
Ap2	14-25	10YR 4/4	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	5
			10YR 5/3	faint depletions, fine, throughout	1
Bt	25+	10YR 5/6	-	-	-

Notes: Most features surround macropores, root channels, and other natural structure.

Date: 6/28/06	Incorporation: Mixed				
Core ID: H13	Organic Material: High Timothy				
	Field Year: 1				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-9	10YR 3/3	10YR 6/3	Faint depletions, fine, throughout	3
			7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	1
Ap2	9-20	10YR 4/3	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	5
			10YR 5/3	faint depletions, fine, throughout	2
Bt	20+	10YR 5/6	-	-	-

Notes: Most features surround macropores, root channels, and other natural structure.

Date: 4/6/07	Incorporation: Mixed				
Core ID: L12	Organic Material: Low Timothy				
	Field Year: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-9	10YR 4/4	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	5
Ap2	9-18	10YR 4/3	5YR 4/4	distinct and prominent concentrations, very fine to fine, throughout, soft masses and pore linings	8-10
Bt	18+	10YR 5/6	5YR 4/4	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	<1

Notes: Few depletions throughout (10YR 5/3). Most features surround macropores, root channels, and other natural structure.

Date: 4/6/07	**Incorporation: Mixed**				
Core ID: L22	**Organic Material: Low Timothy**				
	Field Year: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-5	10YR 4/4	7.5YR 4/4	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	5
Ap2	5-16	10YR 4/3	7.5YR 4/6	distinct and prominent concentrations, very fine to fine, throughout, soft masses and pore linings	8-10
Bt	16+	10YR 5/6	-	-	-

Notes: Few depletions throughout (10YR 5/3). Most features surround macropores, root channels, and other natural structure.

Date: 4/6/07	**Incorporation: Mixed**				
Core ID: L23	**Organic Material: Low Timothy**				
	Field Year: 2				
			Redoximorphic Features (visually quantified)		
Horizon	**Depth (cm)**	**Matrix Color**	**Color**	**Location**	**%**
Ap1	0-5	10YR 3/3		5cm of wetland soil material deposited from flooding	
Ap2	5-16	10YR 4/4	7.5YR 4/6	faint to distinct concentrations, very fine to fine, throughout, soft masses and pore linings	8
Ap3	16-28	10YR 4/4	5YR 4/4	Distinct to prominent concentrations, very fine to fine, throughout, soft masses and pore linings	12-15
Bt	28+	10YR 5/6	-	-	-

Notes: Few depletions throughout (10YR 5/3). Most features surround macropores, root channels, and other natural structure.

Date: 4/5/07		Incorporation: Mixed			
Core ID: H21		Organic Material: High Timothy			
		Field Year: 2			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-10	10YR 4/4	7.5YR 4/6	faint and distinct concentrations, very fine to fine, throughout, soft masses and pore linings	3-4
Ap2	10-21	10YR 4/3	5YR 4/6	distinct and prominent concentrations, very fine to fine, throughout, soft masses and pore linings	12-15
Bt	21+	10YR 5/6	7.5YR 4/6	faint concentrations, very fine, 21-24cm, soft masses and pore linings	<1

Notes: Few depletions throughout (10YR 5/3). Most features surround macropores, root channels, and other natural structure.

Date: 4/5/07		Incorporation: Mixed			
Core ID: H22		Organic Material: High Timothy			
		Field Year: 2			
			Redoximorphic Features (visually quantified)		
Horizon	Depth (cm)	Matrix Color	Color	Location	%
Ap1	0-4	10YR 3/3	7.5YR 4/6	5cm of wetland soil material deposited from flooding	5-7
Ap2	4-13	10YR 3/3	7.5YR 4/6	faint to distinct concentrations, very fine to fine, throughout, soft masses and pore linings	10-12
Ap3	13-23	10YR 4/3	5YR 4/6	Distinct to prominent concentrations, very fine to fine, throughout, soft masses and pore linings	10-12
Bt	28+	10YR 5/6	7.5YR 4/6	few, faint concentrations	<1

Notes: Depletions evident throughout (10YR 5/3). Most features surround macropores, root channels, and other natural structure.

Date: 4/6/07	Incorporation: Mixed
Core ID: L33	Organic Material: High Timothy
	Field Year: 2

Horizon	Depth (cm)	Matrix Color	Redoximorphic Features (visually quantified)		
			Color	Location	%
Ap1	0-9	10YR 4/4	7.5YR 4/6	faint to distinct concentrations, very fine to fine, throughout, soft masses and pore linings	2
Ap2	9-18	10YR 4/3	5YR 4/4	Distinct to prominent concentrations, very fine to fine, throughout, soft masses and pore linings	8-10
Bt	18+	10YR 5/6	5YR 4/4	Iron oxide concentrations along (<3cm) wetland material	<1

Notes: Few depletions throughout (10YR 5/3). Most features surround macropores, root channels, and other natural structure. Evidence of sedimentation on top of core.

Appendix G: Soil Color Data

Core ID	OM Type	Cycle	Replicate	Hue		Value		Chroma	
				Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1A	control	1	A	0.1Y	0.0	3.7	0.2	2.7	0.0
44B	control	1	B	0.1Y	0.0	3.5	0.1	2.8	0.0
37A	control	2	B	0.1Y	0.0	3.5	0.1	2.9	0.1
3A	control	3	A	0.1Y	0.0	3.5	0.3	2.8	0.1
49B	control	3	B	0.1Y	0.0	3.2	0.2	2.7	0.1
15B	control	4	A	0.1Y	0.0	3.6	0.1	3.0	0.1
50A	control	5	A	0.1Y	0.0	3.6	0.1	3.1	0.0
13A	control	5	B	0.1Y	0.0	3.5	0.1	2.9	0.0
11B	control	6	A	0.1Y	0.0	3.4	0.1	2.9	0.0
42A	control	6	B	0.1Y	0.0	3.6	0.1	2.9	0.1
3702	maple	1	A	0.1Y	0.0	3.1	0.2	2.3	0.1
711	maple	2	A	0.1Y	0.1	3.3	0.1	2.6	0.1
5465	maple	2	B	0.1Y	0.0	3.2	0.1	2.6	0.0
520	maple	3	A	0.1Y	0.0	3.3	0.0	2.5	0.1
3174	maple	3	B	0.1Y	0.0	3.1	0.3	2.4	0.1
3383	maple	4	B	9.9YR	0.2	3.2	0.1	2.6	0.1
3438	maple	5	A	0.1Y	0.0	3.4	0.1	2.6	0.1
1392	maple	5	B	0.1Y	0.0	3.3	0.1	2.6	0.1
3347	maple	6	A	9.9YR	0.2	3.2	0.1	2.8	0.2
1556	maple	1	B	0.1Y	0.0	3.1	0.2	2.3	0.1
16101	maple	6	B	0.1Y	0.0	3.3	0.1	2.7	0.1
1301	oak	1	A	0.1Y	0.0	3.1	0.2	2.3	0.1
4455	oak	1	B	0.1Y	0.0	3.0	0.3	2.4	0.1
410	oak	2	A	0.1Y	0.0	3.3	0.2	2.5	0.2
2864	oak	2	B	0.1Y	0.0	3.4	0.1	2.5	0.2
2119	oak	3	A	0.1Y	0.0	3.0	0.1	2.5	0.0
5073	oak	3	B	10YR	0.1	3.5	0.1	2.8	0.1
2328	oak	4	A	10YR	0.1	3.4	0.2	2.7	0.1
1537	oak	5	A	10YR	0.1	3.4	0.1	2.9	0.1
491	oak	5	B	10YR	0.2	3.4	0.1	2.8	0.2
4346	oak	6	A	10YR	0.0	3.3	0.1	2.9	0.1
36100	oak	6	B	9.8YR	0.2	3.1	0.2	2.9	0.2
103	sawdust	1	A	0.1Y	0.0	3.1	0.2	2.5	0.1
557	sawdust	1	B	0.1Y	0.0	3.5	0.1	2.8	0.2
766	sawdust	2	A	0.1Y	0.0	3.5	0.1	2.7	0.1
2212	sawdust	2	A	0.1Y	0.0	3.4	0.2	2.7	0.1
821	sawdust	3	A	10YR	0.1	3.4	0.1	2.9	0.2
375	sawdust	3	B	10YR	0.1	3.4	0.1	2.7	0.1
2930	sawdust	4	A	9.9YR	0.2	3.5	0.2	2.9	0.1
4184	sawdust	4	B	10YR	0.2	3.2	0.2	2.7	0.1
3593	sawdust	5	B	9.8YR	0.2	3.5	0.2	2.8	0.1
4748	sawdust	6	A	9.9YR	0.2	3.3	0.2	2.9	0.1
40102	sawdust	6	B	10YR	0.2	3.3	0.1	2.8	0.1
4505	timothy	1	A	0.1Y	0.0	3.3	0.2	2.7	0.1
1159	timothy	1	B	0.1Y	0.0	3.3	0.2	2.7	0.1
4414	timothy	2	A	0.1Y	0.0	3.4	0.1	2.7	0.1
4368	timothy	2	B	0.1Y	0.0	3.5	0.1	2.8	0.1
3823	timothy	3	A	0.1Y	0.0	3.4	0.1	2.8	0.1
177	timothy	3	B	10YR	0.1	3.4	0.1	2.8	0.1
4786	timothy	4	B	0.1Y	0.1	3.5	0.1	3.0	0.1
4941	timothy	5	A	10YR	0.1	3.6	0.1	3.0	0.1
4695	timothy	5	B	0.1Y	0.0	3.6	0.1	3.0	0.0
1750	timothy	6	A	9.9YR	0.2	3.3	0.1	2.7	0.1
29104	timothy	6	B	0.1Y	0.1	3.3	0.2	2.9	0.1
304	wheat	1	A	0.1Y	0.0	3.2	0.1	2.6	0.1
258	wheat	1	B	10YR	0.2	3.4	0.1	2.8	0.1

Core ID	OM Type	Cycle	Replicate	Hue		Value		Chroma	
				Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
3013	wheat	2	A	0.1Y	0.0	3.4	0.1	2.8	0.1
967	wheat	2	B	0.1Y	0.0	3.3	0.1	2.7	0.0
1222	wheat	3	A	10YR	0.1	3.4	0.1	2.7	0.1
2776	wheat	3	B	9.8YR	0.1	3.2	0.1	2.6	0.0
4840	wheat	5	A	10YR	0.1	3.2	0.1	2.9	0.1
3894	wheat	5	B	10YR	0.2	3.3	0.1	2.8	0.1
2749	wheat	6	A	0.1Y	0.1	3.3	0.1	2.8	0.0
52103	wheat	6	B	0.1Y	0.0	3.4	0.0	2.9	0.1

Notes:
Each mean consists of five measurements from a Minolta Data Processor DP-301 coupled with a Chroma Meter-300 Series.

Appendix H: Percent Iron Oxide Concentrations in Greenhouse Mesocosms Quantified Using Image Analysis

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
1A	Ap1	Control	Mixed	1	0.0	0.0	0.0	0.0	0.0
1A	Ap1	Control	Mixed	1	0.0				
44B	Ap1	Control	Mixed	1	0.0	0.0	0.0		
44B	Ap1	Control	Mixed	1	0.0				
1556	Ap1	Maple	Mixed	1	0.0	0.0	0.0	0.0	0.0
1556	Ap1	Maple	Mixed	1	0.0				
3702	Ap1	Maple	Mixed	1	0.0	0.0	0.0		
3702	Ap1	Maple	Mixed	1	0.0				
1301	Ap1	Oak	Mixed	1	0.0	0.0	0.0	0.0	0.0
1301	Ap1	Oak	Mixed	1	0.0				
4455	Ap1	Oak	Mixed	1	0.0	0.0	0.0		
4455	Ap1	Oak	Mixed	1	0.0				
103	Ap1	Sawdust	Mixed	1	0.0	0.0	0.0	0.0	0.0
103	Ap1	Sawdust	Mixed	1	0.0				
557	Ap1	Sawdust	Mixed	1	0.0	0.0	0.0		
557	Ap1	Sawdust	Mixed	1	0.0				
1159	Ap1	Timothy Hay	Mixed	1	0.0	0.0	0.0	0.0	0.0
1159	Ap1	Timothy Hay	Mixed	1	0.0				
4505	Ap1	Timothy Hay	Mixed	1	0.0	0.0	0.0		
4505	Ap1	Timothy Hay	Mixed	1	0.0				
258	Ap1	Wheat Straw	Mixed	1	0.0	0.0	0.0	0.0	0.0
258	Ap1	Wheat Straw	Mixed	1	0.0				
304	Ap1	Wheat Straw	Mixed	1	0.0	0.0	0.0		
304	Ap1	Wheat Straw	Mixed	1	0.0				
2B	Ap1	Control	Mixed	2	0.0	0.0	0.0	0.0	0.0
2B	Ap1	Control	Mixed	2	0.0				
37A	Ap1	Control	Mixed	2	0.0	0.0	0.0		
37A	Ap1	Control	Mixed	2	0.0				
711	Ap1	Maple	Mixed	2	0.0	0.0	0.0	0.0	0.0
711	Ap1	Maple	Mixed	2	0.0				
5465	Ap1	Maple	Mixed	2	0.0	0.0	0.0		
5465	Ap1	Maple	Mixed	2	0.0				
2864	Ap1	Oak	Mixed	2	0.0	0.0	0.0	0.0	0.0
2864	Ap1	Oak	Mixed	2	0.0				
410	Ap1	Oak	Mixed	2	0.0	0.0	0.0		
410	Ap1	Oak	Mixed	2	0.0				
2212	Ap1	Sawdust	Mixed	2	0.0	0.0	0.0	0.0	0.0
2212	Ap1	Sawdust	Mixed	2	0.0				
766	Ap1	Sawdust	Mixed	2	0.0	0.0	0.0		
766	Ap1	Sawdust	Mixed	2	0.0				
4414	Ap1	Timothy Hay	Mixed	2	0.0	0.0	0.0	0.0	0.0
4414	Ap1	Timothy Hay	Mixed	2	0.0				
4368	Ap1	Timothy Hay	Mixed	2	0.0	0.0	0.0		
4368	Ap1	Timothy Hay	Mixed	2	0.0				
967	Ap1	Wheat Straw	Mixed	2	0.6	0.6	0.0	0.3	0.4
967	Ap1	Wheat Straw	Mixed	2	0.6				
3013	Ap1	Wheat Straw	Mixed	2	0.0	0.0	0.0		
3013	Ap1	Wheat Straw	Mixed	2	0.0				
3A	Ap1	Control	Mixed	3	0.0	0.0	0.0	0.0	0.0
3A	Ap1	Control	Mixed	3	0.0				
45B	Ap1	Control	Mixed	3	0.0	0.0	0.0		
45B	Ap1	Control	Mixed	3	0.0				
520	Ap1	Maple	Mixed	3	0.3	0.4	0.2	0.2	0.3
520	Ap1	Maple	Mixed	3	0.6				
3174	Ap1	Maple	Mixed	3	0.0	0.0	0.0		
3174	Ap1	Maple	Mixed	3	0.0				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
2119	Ap1	Oak	Mixed	3	0.0	0.0	0.0	0.0	0.0
2119	Ap1	Oak	Mixed	3	0.0				
5073	Ap1	Oak	Mixed	3	0.0	0.0	0.0		
5073	Ap1	Oak	Mixed	3	0.0				
375	Ap1	Sawdust	Mixed	3	0.0	0.0	0.0	0.0	0.0
375	Ap1	Sawdust	Mixed	3	0.0				
821	Ap1	Sawdust	Mixed	3	0.0	0.0	0.0		
821	Ap1	Sawdust	Mixed	3	0.0				
177	Ap1	Timothy Hay	Mixed	3	0.6	0.7	0.1	0.7	0.1
177	Ap1	Timothy Hay	Mixed	3	0.7				
3823	Ap1	Timothy Hay	Mixed	3	1.1	0.8	0.3		
3823	Ap1	Timothy Hay	Mixed	3	0.6				
1222	Ap1	Wheat Straw	Mixed	3	1.2	1.1	0.1	0.8	0.4
1222	Ap1	Wheat Straw	Mixed	3	1.0				
2776	Ap1	Wheat Straw	Mixed	3	0.4	0.5	0.2		
2776	Ap1	Wheat Straw	Mixed	3	0.7				
15B	Ap1	Control	Mixed	4	0.0	0.0	0.0	0.0	0.0
15B	Ap1	Control	Mixed	4	0.0				
49B	Ap1	Control	Mixed	4	0.0	0.0	0.0		
49B	Ap1	Control	Mixed	4	0.0				
2029	Ap1	Maple	Mixed	4	0.1	0.1	0.1	0.1	0.1
2029	Ap1	Maple	Mixed	4	0.2				
3383	Ap1	Maple	Mixed	4	0.0	0.0	0.0		
3383	Ap1	Maple	Mixed	4	0.0				
2328	Ap1	Oak	Mixed	4	0.0	0.0	0.0	0.1	0.1
2328	Ap1	Oak	Mixed	4	0.0				
2482	Ap1	Oak	Mixed	4	0.2	0.2	0.0		
2482	Ap1	Oak	Mixed	4	0.2				
2930	Ap1	Sawdust	Mixed	4	0.0	0.0	0.0	0.0	0.0
2930	Ap1	Sawdust	Mixed	4	0.0				
4184	Ap1	Sawdust	Mixed	4	0.0	0.0	0.0		
4184	Ap1	Sawdust	Mixed	4	0.0				
232	Ap1	Timothy Hay	Mixed	4	0.4	0.3	0.1	0.2	0.2
232	Ap1	Timothy Hay	Mixed	4	0.3				
4786	Ap1	Timothy Hay	Mixed	4	0.0	0.0	0.0		
4786	Ap1	Timothy Hay	Mixed	4	0.0				
1285	Ap1	Wheat Straw	Mixed	4	0.4	0.3	0.1	0.4	0.1
1285	Ap1	Wheat Straw	Mixed	4	0.2				
2431	Ap1	Wheat Straw	Mixed	4	0.5	0.5	0.1		
2431	Ap1	Wheat Straw	Mixed	4	0.4				
13A	Ap1	Control	Mixed	5	0.0	0.0	0.0	0.0	0.0
13A	Ap1	Control	Mixed	5	0.0				
50A	Ap1	Control	Mixed	5	0.0	0.0	0.0		
50A	Ap1	Control	Mixed	5	0.0				
1392	Ap1	Maple	Mixed	5	0.0	0.0	0.0	0.0	0.0
1392	Ap1	Maple	Mixed	5	0.0				
3438	Ap1	Maple	Mixed	5	0.0	0.0	0.0		
3438	Ap1	Maple	Mixed	5	0.0				
491	Ap1	Oak	Mixed	5	0.5	0.5	0.0	0.6	0.2
491	Ap1	Oak	Mixed	5	0.5				
1537	Ap1	Oak	Mixed	5	0.6	0.7	0.1		
1537	Ap1	Oak	Mixed	5	0.8				
1039	Ap1	Sawdust	Mixed	5	0.0	0.0	0.0	0.0	0.0
1039	Ap1	Sawdust	Mixed	5	0.0				
3593	Ap1	Sawdust	Mixed	5	0.0	0.0	0.0		
3593	Ap1	Sawdust	Mixed	5	0.0				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
4695	Ap1	Timothy Hay	Mixed	5	0.5	0.8	0.4	0.7	0.0
4695	Ap1	Timothy Hay	Mixed	5	1.1				
4941	Ap1	Timothy Hay	Mixed	5	0.5	0.7	0.2		
4941	Ap1	Timothy Hay	Mixed	5	0.9				
3894	Ap1	Wheat Straw	Mixed	5	0.0	0.0	0.0	1.8	2.5
3894	Ap1	Wheat Straw	Mixed	5	0.0				
4840	Ap1	Wheat Straw	Mixed	5	3.3	3.6	0.4		
4840	Ap1	Wheat Straw	Mixed	5	3.9				
11B	Ap1	Control	Mixed	6	0.0	0.0	0.0	0.0	0.0
11B	Ap1	Control	Mixed	6	0.0				
42A	Ap1	Control	Mixed	6	0.0	0.0	0.0		
42A	Ap1	Control	Mixed	6	0.0				
3347	Ap1	Maple	Mixed	6	0.0	0.0	0.0	0.0	0.0
3347	Ap1	Maple	Mixed	6	0.0				
16101	Ap1	Maple	Mixed	6	0.0	0.0	0.0		
16101	Ap1	Maple	Mixed	6	0.0				
4346	Ap1	Oak	Mixed	6	0.0	0.0	0.0	0.0	0.0
4346	Ap1	Oak	Mixed	6	0.0				
36100	Ap1	Oak	Mixed	6	0.0	0.0	0.0		
36100	Ap1	Oak	Mixed	6	0.0				
4748	Ap1	Sawdust	Mixed	6	0.0	0.0	0.0	0.2	0.3
4748	Ap1	Sawdust	Mixed	6	0.0				
40102	Ap1	Sawdust	Mixed	6	0.3	0.4	0.1		
40102	Ap1	Sawdust	Mixed	6	0.5				
1750	Ap1	Timothy Hay	Mixed	6	0.0	0.0	0.0	0.2	0.3
1750	Ap1	Timothy Hay	Mixed	6	0.0				
29104	Ap1	Timothy Hay	Mixed	6	0.4	0.4	0.1		
29104	Ap1	Timothy Hay	Mixed	6	0.3				
2749	Ap1	Wheat Straw	Mixed	6	0.2	0.4	0.2	0.5	0.2
2749	Ap1	Wheat Straw	Mixed	6	0.5				
52103	Ap1	Wheat Straw	Mixed	6	0.6	0.6	0.1		
52103	Ap1	Wheat Straw	Mixed	6	0.7				
1A	Ap2	Control	Mixed	1	1.7	2.1	0.6	1.5	0.8
1A	Ap2	Control	Mixed	1	2.5				
44B	Ap2	Control	Mixed	1	1.1	0.9	0.3		
44B	Ap2	Control	Mixed	1	0.7				
1556	Ap2	Maple	Mixed	1	0.0	0.0	0.0	0.0	0.0
1556	Ap2	Maple	Mixed	1	0.0				
3702	Ap2	Maple	Mixed	1	0.0	0.0	0.0		
3702	Ap2	Maple	Mixed	1	0.0				
1301	Ap2	Oak	Mixed	1	0.3	0.5	0.3	0.2	0.3
1301	Ap2	Oak	Mixed	1	0.7				
4455	Ap2	Oak	Mixed	1	0.0	0.0	0.0		
4455	Ap2	Oak	Mixed	1	0.0				
103	Ap2	Sawdust	Mixed	1	0.4	0.3	0.1	0.2	0.2
103	Ap2	Sawdust	Mixed	1	0.3				
557	Ap2	Sawdust	Mixed	1	0.0	0.0	0.0		
557	Ap2	Sawdust	Mixed	1	0.0				
1159	Ap2	Timothy Hay	Mixed	1	0.0	0.0	0.0	0.0	0.0
1159	Ap2	Timothy Hay	Mixed	1	0.0				
4505	Ap2	Timothy Hay	Mixed	1	0.0	0.0	0.0		
4505	Ap2	Timothy Hay	Mixed	1	0.0				
258	Ap2	Wheat Straw	Mixed	1	0.0	0.0	0.0	0.0	0.0
258	Ap2	Wheat Straw	Mixed	1	0.0				
304	Ap2	Wheat Straw	Mixed	1	0.0	0.0	0.0		
304	Ap2	Wheat Straw	Mixed	1	0.0				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
2B	Ap2	Control	Mixed	2	0.6	0.8	0.3	1.1	0.5
2B	Ap2	Control	Mixed	2	1.0				
37A	Ap2	Control	Mixed	2	1.4	1.5	0.0		
37A	Ap2	Control	Mixed	2	1.5				
711	Ap2	Maple	Mixed	2	0.6	0.7	0.1	0.6	0.0
711	Ap2	Maple	Mixed	2	0.8				
5465	Ap2	Maple	Mixed	2	0.7	0.6	0.1		
5465	Ap2	Maple	Mixed	2	0.6				
410	Ap2	Oak	Mixed	2	0.0	0.0	0.0	0.2	0.3
410	Ap2	Oak	Mixed	2	0.0				
2864	Ap2	Oak	Mixed	2	0.5	0.4	0.2		
2864	Ap2	Oak	Mixed	2	0.3				
766	Ap2	Sawdust	Mixed	2	0.0	0.0	0.0	0.0	0.0
766	Ap2	Sawdust	Mixed	2	0.0				
2212	Ap2	Sawdust	Mixed	2	0.0	0.0	0.0		
2212	Ap2	Sawdust	Mixed	2	0.0				
4414	Ap2	Timothy Hay	Mixed	2	0.0	0.0	0.0	0.0	0.0
4414	Ap2	Timothy Hay	Mixed	2	0.0				
4368	Ap2	Timothy Hay	Mixed	2	0.0	0.0	0.0		
4368	Ap2	Timothy Hay	Mixed	2	0.0				
967	Ap2	Wheat Straw	Mixed	2	0.6	0.5	0.2	0.2	0.3
967	Ap2	Wheat Straw	Mixed	2	0.4				
3013	Ap2	Wheat Straw	Mixed	2	0.0	0.0	0.0		
3013	Ap2	Wheat Straw	Mixed	2	0.0				
3A	Ap2	Control	Mixed	3	1.3	1.2	0.1	1.6	0.5
3A	Ap2	Control	Mixed	3	1.2				
45B	Ap2	Control	Mixed	3	2.0	1.9	0.1		
45B	Ap2	Control	Mixed	3	1.9				
520	Ap2	Maple	Mixed	3	0.6	0.5	0.2	0.4	0.0
520	Ap2	Maple	Mixed	3	0.3				
3174	Ap2	Maple	Mixed	3	0.3	0.4	0.2		
3174	Ap2	Maple	Mixed	3	0.6				
2119	Ap2	Oak	Mixed	3	0.0	0.0	0.0	0.0	0.0
2119	Ap2	Oak	Mixed	3	0.0				
5073	Ap2	Oak	Mixed	3	0.0	0.0	0.0		
5073	Ap2	Oak	Mixed	3	0.0				
375	Ap2	Sawdust	Mixed	3	0.5	0.6	0.2	0.3	0.5
375	Ap2	Sawdust	Mixed	3	0.8				
821	Ap2	Sawdust	Mixed	3	0.0	0.0	0.0		
821	Ap2	Sawdust	Mixed	3	0.0				
177	Ap2	Timothy Hay	Mixed	3	1.7	1.7	0.1	1.0	0.9
177	Ap2	Timothy Hay	Mixed	3	1.6				
3823	Ap2	Timothy Hay	Mixed	3	0.3	0.4	0.1		
3823	Ap2	Timothy Hay	Mixed	3	0.4				
1222	Ap2	Wheat Straw	Mixed	3	0.5	0.9	0.5	0.8	0.0
1222	Ap2	Wheat Straw	Mixed	3	1.2				
2776	Ap2	Wheat Straw	Mixed	3	0.8	0.8	0.0		
2776	Ap2	Wheat Straw	Mixed	3	0.8				
15B	Ap2	Control	Mixed	4	1.5	1.6	0.2	1.9	0.4
15B	Ap2	Control	Mixed	4	1.7				
49B	Ap2	Control	Mixed	4	2.0	2.1	0.2		
49B	Ap2	Control	Mixed	4	2.3				
2029	Ap2	Maple	Mixed	4	0.4	0.3	0.0	1.1	1.1
2029	Ap2	Maple	Mixed	4	0.3				
3383	Ap2	Maple	Mixed	4	1.8	1.9	0.2		
3383	Ap2	Maple	Mixed	4	2.0				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
2328	Ap2	Oak	Mixed	4	0.6	0.5	0.0	0.4	0.1
2328	Ap2	Oak	Mixed	4	0.5				
2482	Ap2	Oak	Mixed	4	0.3	0.4	0.0		
2482	Ap2	Oak	Mixed	4	0.4				
2930	Ap2	Sawdust	Mixed	4	0.5	0.5	0.1	0.6	0.1
2930	Ap2	Sawdust	Mixed	4	0.6				
4184	Ap2	Sawdust	Mixed	4	0.8	0.6	0.2		
4184	Ap2	Sawdust	Mixed	4	0.5				
232	Ap2	Timothy Hay	Mixed	4	0.2	0.2	0.0	0.7	0.7
232	Ap2	Timothy Hay	Mixed	4	0.2				
4786	Ap2	Timothy Hay	Mixed	4	1.3	1.2	0.1		
4786	Ap2	Timothy Hay	Mixed	4	1.1				
1285	Ap2	Wheat Straw	Mixed	4	0.0	0.0	0.0	0.3	0.4
1285	Ap2	Wheat Straw	Mixed	4	0.0				
2431	Ap2	Wheat Straw	Mixed	4	0.6	0.5	0.2		
2431	Ap2	Wheat Straw	Mixed	4	0.4				
13A	Ap2	Control	Mixed	5	2.7	2.7	0.1	2.3	0.6
13A	Ap2	Control	Mixed	5	2.8				
50A	Ap2	Control	Mixed	5	2.1	1.9	0.4		
50A	Ap2	Control	Mixed	5	1.6				
1392	Ap2	Maple	Mixed	5	1.4	1.1	0.4	0.8	0.3
1392	Ap2	Maple	Mixed	5	0.8				
3438	Ap2	Maple	Mixed	5	0.4	0.6	0.3		
3438	Ap2	Maple	Mixed	5	0.8				
491	Ap2	Oak	Mixed	5	0.7	0.9	0.2	0.8	0.0
491	Ap2	Oak	Mixed	5	1.0				
1537	Ap2	Oak	Mixed	5	0.4	0.8	0.6		
1537	Ap2	Oak	Mixed	5	1.2				
1039	Ap2	Sawdust	Mixed	5	0.6	0.8	0.3	0.7	0.0
1039	Ap2	Sawdust	Mixed	5	1.0				
3593	Ap2	Sawdust	Mixed	5	0.8	0.7	0.0		
3593	Ap2	Sawdust	Mixed	5	0.7				
4695	Ap2	Timothy Hay	Mixed	5	0.5	0.8	0.4	0.7	0.0
4695	Ap2	Timothy Hay	Mixed	5	1.1				
4941	Ap2	Timothy Hay	Mixed	5	0.5	0.7	0.2		
4941	Ap2	Timothy Hay	Mixed	5	0.9				
3894	Ap2	Wheat Straw	Mixed	5	0.7	0.9	0.3	1.3	0.7
3894	Ap2	Wheat Straw	Mixed	5	1.1				
4840	Ap2	Wheat Straw	Mixed	5	2.3	1.8	0.7		
4840	Ap2	Wheat Straw	Mixed	5	1.3				
11B	Ap2	Control	Mixed	6	0.8	1.0	0.3	2.2	1.7
11B	Ap2	Control	Mixed	6	1.2				
42A	Ap2	Control	Mixed	6	3.3	3.4	0.2		
42A	Ap2	Control	Mixed	6	3.6				
3347	Ap2	Maple	Mixed	6	2.1	1.8	0.4	1.4	0.6
3347	Ap2	Maple	Mixed	6	1.6				
16101	Ap2	Maple	Mixed	6	1.2	0.9	0.4		
16101	Ap2	Maple	Mixed	6	0.7				
4346	Ap2	Oak	Mixed	6	1.2	1.0	0.4	0.8	0.3
4346	Ap2	Oak	Mixed	6	0.7				
36100	Ap2	Oak	Mixed	6	0.4	0.5	0.2		
36100	Ap2	Oak	Mixed	6	0.7				
4748	Ap2	Sawdust	Mixed	6	0.9	0.7	0.2	0.5	0.3
4748	Ap2	Sawdust	Mixed	6	0.6				
40102	Ap2	Sawdust	Mixed	6	0.3	0.3	0.0		
40102	Ap2	Sawdust	Mixed	6	0.3				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
1750	Ap2	Timothy Hay	Mixed	6	1.2	1.0	0.3	1.0	0.0
1750	Ap2	Timothy Hay	Mixed	6	0.8				
29104	Ap2	Timothy Hay	Mixed	6	0.7	1.0	0.4		
29104	Ap2	Timothy Hay	Mixed	6	1.3				
2749	Ap2	Wheat Straw	Mixed	6	0.9	1.0	0.1	0.9	0.1
2749	Ap2	Wheat Straw	Mixed	6	1.1				
52103	Ap2	Wheat Straw	Mixed	6	0.9	0.9	0.1		
52103	Ap2	Wheat Straw	Mixed	6	0.9				
2063	Ap1	Oak	Surface	1	0.7	1.2	0.7	1.3	0.2
2063	Ap1	Oak	Surface	1	1.7				
5309	Ap1	Oak	Surface	1	1.0	1.5	0.7		
5309	Ap1	Oak	Surface	1	1.9				
661	Ap1	Wheat Straw	Surface	1	1.5	1.3	0.2	1.1	0.4
661	Ap1	Wheat Straw	Surface	1	1.2				
3907	Ap1	Wheat Straw	Surface	1	0.9	0.8	0.2		
3907	Ap1	Wheat Straw	Surface	1	0.7				
2272	Ap1	Oak	Surface	2	0.9	1.2	0.4	1.2	0.0
2272	Ap1	Oak	Surface	2	1.5				
5218	Ap1	Oak	Surface	2	1.1	1.3	0.2		
5218	Ap1	Oak	Surface	2	1.4				
916	Ap1	Wheat Straw	Surface	2	1.2	1.0	0.3	1.1	0.2
916	Ap1	Wheat Straw	Surface	2	0.8				
4870	Ap1	Wheat Straw	Surface	2	1.1	1.2	0.2		
4870	Ap1	Wheat Straw	Surface	2	1.4				
3281	Ap1	Oak	Surface	3	1.4	1.4	0.0	1.2	0.2
3281	Ap1	Oak	Surface	3	1.3				
4027	Ap1	Oak	Surface	3	1.5	1.0	0.7		
4027	Ap1	Oak	Surface	3	0.6				
5179	Ap1	Wheat Straw	Surface	3	0.8	0.9	0.2	1.0	0.1
5179	Ap1	Wheat Straw	Surface	3	1.1				
5425	Ap1	Wheat Straw	Surface	3	1.5	1.0	0.6		
5425	Ap1	Wheat Straw	Surface	3	0.6				
1790	Ap1	Oak	Surface	4	0.7	0.7	0.0	0.9	0.3
1790	Ap1	Oak	Surface	4	0.7				
3636	Ap1	Oak	Surface	4	1.1	1.1	0.1		
3636	Ap1	Oak	Surface	4	1.0				
1434	Ap1	Wheat Straw	Surface	4	0.6	0.6	0.0	0.9	0.3
1434	Ap1	Wheat Straw	Surface	4	0.7				
1888	Ap1	Wheat Straw	Surface	4	1.2	1.1	0.2		
1888	Ap1	Wheat Straw	Surface	4	1.0				
1099	Ap1	Oak	Surface	5	1.0	1.1	0.2	1.1	0.0
1099	Ap1	Oak	Surface	5	1.3				
4145	Ap1	Oak	Surface	5	1.0	1.1	0.0		
4145	Ap1	Oak	Surface	5	1.1				
897	Ap1	Wheat Straw	Surface	5	1.3	1.1	0.2	0.9	0.3
897	Ap1	Wheat Straw	Surface	5	1.0				
2543	Ap1	Wheat Straw	Surface	5	0.6	0.7	0.2		
2543	Ap1	Wheat Straw	Surface	5	0.9				
2854	Ap1	Oak	Surface	6	1.7	1.5	0.2	1.1	0.6
2854	Ap1	Oak	Surface	6	1.4				
26108	Ap1	Oak	Surface	6	0.9	0.7	0.3		
26108	Ap1	Oak	Surface	6	0.5				
1152	Ap1	Wheat Straw	Surface	6	0.7	0.7	0.0	1.2	0.8
1152	Ap1	Wheat Straw	Surface	6	0.7				
53106	Ap1	Wheat Straw	Surface	6	2.3	1.8	0.7		
53106	Ap1	Wheat Straw	Surface	6	1.2				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
2063	Ap2	Oak	Surface	1	0.0	0.0	0.0	0.0	0.0
2063	Ap2	Oak	Surface	1	0.0				
5309	Ap2	Oak	Surface	1	0.0	0.0	0.0		
5309	Ap2	Oak	Surface	1	0.0				
661	Ap2	Wheat Straw	Surface	1	0.0	0.0	0.0	0.0	0.0
661	Ap2	Wheat Straw	Surface	1	0.0				
3907	Ap2	Wheat Straw	Surface	1	0.0	0.0	0.0		
3907	Ap2	Wheat Straw	Surface	1	0.0				
2272	Ap2	Oak	Surface	2	0.2	0.3	0.1	0.1	0.2
2272	Ap2	Oak	Surface	2	0.3				
5218	Ap2	Oak	Surface	2	0.0	0.0	0.0		
5218	Ap2	Oak	Surface	2	0.0				
916	Ap2	Wheat Straw	Surface	2	0.3	0.5	0.3	0.2	0.3
916	Ap2	Wheat Straw	Surface	2	0.7				
4870	Ap2	Wheat Straw	Surface	2	0.0	0.0	0.0		
4870	Ap2	Wheat Straw	Surface	2	0.0				
3281	Ap2	Oak	Surface	3	0.0	0.0	0.0	0.0	0.0
3281	Ap2	Oak	Surface	3	0.0				
4027	Ap2	Oak	Surface	3	0.0	0.0	0.0		
4027	Ap2	Oak	Surface	3	0.0				
5179	Ap2	Wheat Straw	Surface	3	0.0	0.0	0.0	0.0	0.0
5179	Ap2	Wheat Straw	Surface	3	0.0				
5425	Ap2	Wheat Straw	Surface	3	0.0	0.0	0.0		
5425	Ap2	Wheat Straw	Surface	3	0.0				
1790	Ap2	Oak	Surface	4	0.0	0.0	0.0	0.5	0.7
1790	Ap2	Oak	Surface	4	0.0				
3636	Ap2	Oak	Surface	4	1.1	1.1	0.1		
3636	Ap2	Oak	Surface	4	1.0				
1434	Ap2	Wheat Straw	Surface	4	0.6	0.6	0.0	0.9	0.3
1434	Ap2	Wheat Straw	Surface	4	0.7				
1888	Ap2	Wheat Straw	Surface	4	1.2	1.1	0.2		
1888	Ap2	Wheat Straw	Surface	4	1.0				
1099	Ap2	Oak	Surface	5	1.0	1.1	0.2	1.1	0.0
1099	Ap2	Oak	Surface	5	1.3				
4145	Ap2	Oak	Surface	5	1.0	1.1	0.0		
4145	Ap2	Oak	Surface	5	1.1				
897	Ap2	Wheat Straw	Surface	5	0.0	0.0	0.0	0.4	0.5
897	Ap2	Wheat Straw	Surface	5	0.0				
2543	Ap2	Wheat Straw	Surface	5	0.6	0.7	0.2		
2543	Ap2	Wheat Straw	Surface	5	0.9				
2854	Ap2	Oak	Surface	6	1.7	1.5	0.2	1.1	0.6
2854	Ap2	Oak	Surface	6	1.4				
26108	Ap2	Oak	Surface	6	0.9	0.7	0.3		
26108	Ap2	Oak	Surface	6	0.5				
1152	Ap2	Wheat Straw	Surface	6	0.7	0.7	0.0	1.2	0.8
1152	Ap2	Wheat Straw	Surface	6	0.7				
53106	Ap2	Wheat Straw	Surface	6	2.3	1.8	0.7		
53106	Ap2	Wheat Straw	Surface	6	1.2				
4208	Ap1	Oak	Zoned	1	1.3	1.3	0.1	1.2	0.0
4208	Ap1	Oak	Zoned	1	1.2				
4962	Ap1	Oak	Zoned	1	1.1	1.2	0.1		
4962	Ap1	Oak	Zoned	1	1.3				
4560	Ap1	Wheat Straw	Zoned	1	0.4	0.8	0.5	0.9	0.2
4560	Ap1	Wheat Straw	Zoned	1	1.1				
5006	Ap1	Wheat Straw	Zoned	1	1.0	1.1	0.2		
5006	Ap1	Wheat Straw	Zoned	1	1.2				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
2171	Ap1	Oak	Zoned	2	1.5	1.2	0.4	1.1	0.2
2171	Ap1	Oak	Zoned	2	1.0				
3517	Ap1	Oak	Zoned	2	1.1	0.9	0.2		
3517	Ap1	Oak	Zoned	2	0.8				
2569	Ap1	Wheat Straw	Zoned	2	1.4	1.3	0.1	1.5	0.2
2569	Ap1	Wheat Straw	Zoned	2	1.3				
5115	Ap1	Wheat Straw	Zoned	2	1.6	1.6	0.0		
5115	Ap1	Wheat Straw	Zoned	2	1.6				
626	Ap1	Oak	Zoned	3	2.3	2.2	0.0	1.9	0.5
626	Ap1	Oak	Zoned	3	2.2				
3980	Ap1	Oak	Zoned	3	1.4	1.6	0.2		
3980	Ap1	Oak	Zoned	3	1.7				
3078	Ap1	Wheat Straw	Zoned	3	1.1	1.3	0.3	1.6	0.3
3078	Ap1	Wheat Straw	Zoned	3	1.5				
3124	Ap1	Wheat Straw	Zoned	3	2.1	1.8	0.5		
3124	Ap1	Wheat Straw	Zoned	3	1.5				
1935	Ap1	Oak	Zoned	4	3.3	2.7	0.8	2.2	0.7
1935	Ap1	Oak	Zoned	4	2.1				
1989	Ap1	Oak	Zoned	4	1.8	1.8	0.0		
1989	Ap1	Oak	Zoned	4	1.7				
1487	Ap1	Wheat Straw	Zoned	4	2.2	1.9	0.4	1.2	1.0
1487	Ap1	Wheat Straw	Zoned	4	1.6				
1833	Ap1	Wheat Straw	Zoned	4	0.4	0.6	0.2		
1833	Ap1	Wheat Straw	Zoned	4	0.7				
2644	Ap1	Oak	Zoned	5	1.4	1.4	0.0	2.0	0.8
2644	Ap1	Oak	Zoned	5	1.4				
4298	Ap1	Oak	Zoned	5	2.9	2.6	0.4		
4298	Ap1	Oak	Zoned	5	2.3				
3796	Ap1	Wheat Straw	Zoned	5	3.3	3.4	0.1	2.2	1.6
3796	Ap1	Wheat Straw	Zoned	5	3.5				
4642	Ap1	Wheat Straw	Zoned	5	1.4	1.1	0.3		
4642	Ap1	Wheat Straw	Zoned	5	0.9				
1653	Ap1	Oak	Zoned	6	2.1	1.8	0.4	1.8	0.0
1653	Ap1	Oak	Zoned	6	1.6				
34107	Ap1	Oak	Zoned	6	1.7	1.9	0.3		
34107	Ap1	Oak	Zoned	6	2.0				
3251	Ap1	Wheat Straw	Zoned	6	0.8	1.0	0.3	1.3	0.4
3251	Ap1	Wheat Straw	Zoned	6	1.3				
23105	Ap1	Wheat Straw	Zoned	6	1.9	1.5	0.5		
23105	Ap1	Wheat Straw	Zoned	6	1.2				
4208	Ap2	Oak	Zoned	1	3.5	3.2	0.5	2.2	1.4
4208	Ap2	Oak	Zoned	1	2.9				
4962	Ap2	Oak	Zoned	1	1.1	1.2	0.1		
4962	Ap2	Oak	Zoned	1	1.3				
4560	Ap2	Wheat Straw	Zoned	1	1.1	1.0	0.2	1.0	0.1
4560	Ap2	Wheat Straw	Zoned	1	0.8				
5006	Ap2	Wheat Straw	Zoned	1	0.8	1.1	0.5		
5006	Ap2	Wheat Straw	Zoned	1	1.4				
2171	Ap2	Oak	Zoned	2	3.6	3.0	0.9	2.6	0.6
2171	Ap2	Oak	Zoned	2	2.4				
3517	Ap2	Oak	Zoned	2	2.3	2.2	0.1		
3517	Ap2	Oak	Zoned	2	2.1				
2569	Ap2	Wheat Straw	Zoned	2	3.8	3.2	0.8	3.0	0.3
2569	Ap2	Wheat Straw	Zoned	2	2.7				
5115	Ap2	Wheat Straw	Zoned	2	3.5	2.8	1.0		
5115	Ap2	Wheat Straw	Zoned	2	2.1				

Core ID	Horizon	Organic Treatment	Incorporation Method	Cycle	% Redox Concentrations	Mesocosm Mean	Standard Deviation	Treatment Mean	Standard Error of Means
626	Ap2	Oak	Zoned	3	2.3	2.2	0.0	2.9	1.0
626	Ap2	Oak	Zoned	3	2.2				
3980	Ap2	Oak	Zoned	3	3.7	3.6	0.0		
3980	Ap2	Oak	Zoned	3	3.6				
3078	Ap2	Wheat Straw	Zoned	3	3.8	3.4	0.6	3.8	0.6
3078	Ap2	Wheat Straw	Zoned	3	2.9				
3124	Ap2	Wheat Straw	Zoned	3	3.1	4.2	1.6		
3124	Ap2	Wheat Straw	Zoned	3	5.4				
1935	Ap2	Oak	Zoned	4	4.7	5.2	0.7	3.5	2.4
1935	Ap2	Oak	Zoned	4	5.7				
1989	Ap2	Oak	Zoned	4	1.8	1.8	0.0		
1989	Ap2	Oak	Zoned	4	1.7				
1487	Ap2	Wheat Straw	Zoned	4	5.4	4.6	1.1	4.5	0.1
1487	Ap2	Wheat Straw	Zoned	4	3.8				
1833	Ap2	Wheat Straw	Zoned	4	5.1	4.5	0.9		
1833	Ap2	Wheat Straw	Zoned	4	3.8				
2644	Ap2	Oak	Zoned	5	3.4	3.1	0.5	2.8	0.4
2644	Ap2	Oak	Zoned	5	2.7				
4298	Ap2	Oak	Zoned	5	2.9	2.6	0.4		
4298	Ap2	Oak	Zoned	5	2.3				
3796	Ap2	Wheat Straw	Zoned	5	3.3	3.4	0.1	3.3	0.1
3796	Ap2	Wheat Straw	Zoned	5	3.5				
4642	Ap2	Wheat Straw	Zoned	5	3.7	3.2	0.8		
4642	Ap2	Wheat Straw	Zoned	5	2.6				
1653	Ap2	Oak	Zoned	6	6.0	4.8	1.7	4.5	0.4
1653	Ap2	Oak	Zoned	6	3.6				
34107	Ap2	Oak	Zoned	6	5.0	4.2	1.1		
34107	Ap2	Oak	Zoned	6	3.5				
3251	Ap2	Wheat Straw	Zoned	6	5.2	4.1	1.5	3.6	0.8
3251	Ap2	Wheat Straw	Zoned	6	3.0				
23105	Ap2	Wheat Straw	Zoned	6	3.0	3.0	0.1		
23105	Ap2	Wheat Straw	Zoned	6	3.0				

Appendix I: Percent Iron Oxide Concentrations in Field Study Cores Quantified Using Image Analysis

Core ID	Timothy Concentration	Years in Wetland	Horizon	% Iron Oxide Concentrations	Core Mean	Standard Deviation	Treatment Mean	Standard Error of Means
H11	High	1	Ap1	4.9	5.4	0.6	4.1	0.7
H11	High	1	Ap1	5.8				
H12	High	1	Ap1	2.7	2.6	0.2		
H12	High	1	Ap1	2.5				
H13	High	1	Ap1	5.4	4.3	1.6		
H13	High	1	Ap1	3.2				
H11	High	1	Ap2	10.4	10.8	0.7	10.1	0.3
H11	High	1	Ap2	11.3				
H12	High	1	Ap2	10.0	9.3	1.0		
H12	High	1	Ap2	8.6				
H13	High	1	Ap2	11.1	10.2	1.2		
H13	High	1	Ap2	9.4				
L11	Low	1	Ap1	5.0	4.4	0.9	2.9	0.5
L11	Low	1	Ap1	3.8				
L12	Low	1	Ap1	4.7	4.2	0.6		
L12	Low	1	Ap1	3.8				
L13	Low	1	Ap1	0.0	0.0	0.0		
L13	Low	1	Ap1	0.0				
L11	Low	1	Ap2	6.4	7.5	1.6	7.8	0.5
L11	Low	1	Ap2	8.7				
L12	Low	1	Ap2	9.7	8.9	1.1		
L12	Low	1	Ap2	8.1				
L13	Low	1	Ap2	8.5	7.1	2.0		
L13	Low	1	Ap2	5.6				
H21	High	2	Ap1	3.7	3.2	0.7	3.5	0.4
H21	High	2	Ap1	2.7				
H22	High	2	Ap1	4.7	5.5	1.1		
H22	High	2	Ap1	6.2				
H23	High	2	Ap1	1.6	1.8	0.4		
H23	High	2	Ap1	2.1				
H21	High	2	Ap2	13.2	11.6	2.3	9.4	0.7
H21	High	2	Ap2	10.0				
H22	High	2	Ap2	8.4	7.8	0.8		
H22	High	2	Ap2	7.3				
H23	High	2	Ap2	8.0	8.9	1.3		
H23	High	2	Ap2	9.8				
L21	Low	2	Ap1	5.9	6.1	0.2	6.1	0.1
L21	Low	2	Ap1	6.2				
L22	Low	2	Ap1	4.1	4.4	0.3		
L22	Low	2	Ap1	4.6				
L23	Low	2	Ap1	8.1	8.0	0.1		
L23	Low	2	Ap1	7.9				
L21	Low	2	Ap2	11.7	10.7	1.4	9.4	0.7
L21	Low	2	Ap2	9.8				
L22	Low	2	Ap2	9.3	7.8	2.2		
L22	Low	2	Ap2	6.2				
L23	Low	2	Ap2	7.6	9.6	2.8		
L23	Low	2	Ap2	11.6				

Notes:
Low timothy concentration was 60 grams per core or 1.5 kg Carbon/m^2
High timothy concentration was 180 grams per core or 4.5 kg Carbon/m^2

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