RELATING THE EXPRESSION OF SOIL REDOXIMORPHIC FEATURES TO SOIL TEXTURE, pH, AND CATION EXCHANGE CAPACITY

A Thesis

by

RYAN SCOTT MERSMANN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2009

Major Subject: Soil Science

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Approved by:

Chair of Committee,	C. Thomas Hallmark
Committee Members,	Lawrence P. Wilding
	J. Rick Giardino
Head of Department,	David D. Baltensperger

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ABSTRACT

Relating the Expression of Soil Redoximorphic Features to Soil Texture, pH, and Cation Exchange Capacity. (August 2009)

Ryan Scott Mersmann, B.S., Texas A&M University

Chair of Advisory Committee: Dr. C. Thomas Hallmark

Three laboratory studies were performed to elucidate the influence of soil texture, pH, and cation exchange capacity (CEC) on the concentration of ferrous Fe in soil solution and the resulting expression of soil redoximorphic features. The objectives were: 1) assess the buffering effects of CEC on ferrous Fe concentration in soil solution, 2) evaluate the effects of pH on the concentration of ferrous Fe in soil solution, and 3) observe the expression of redoximorphic features in soils with varying texture and CEC.

The studies concentrated on seasonally wet soils from the Texas Gulf Coast Prairie. Selected soils included Alfisols and Vertisols with characteristics ranging from coarse-loamy to very-fine in texture, strongly acidic to neutral in soil reaction, and siliceous, mixed, and smectitic in mineralogy. The soils included the Pledger clay microlow (acidic, fine-textured), Pledger clay microhigh (neutral, fine-textured), China clay (acidic, fine-textured), Cieno loam (acidic, fine-loamy), Orelia sandy clay loam (neutral, fine-loamy), Gessner fine sandy loam (acidic, coarse-loamy), and Orelia fine sandy loam (neutral, coarse-loamy).

The studies provided the following information: 1) fine-textured soils with higher CEC contained more ferrous Fe in solution, 2) ferrous Fe concentrations in the acidic fine-loamy and coarse-loamy soils were higher than the neutral soils for the same textural class, 3) acidic and neutral fine-textured soils contained more ferrous Fe in solution than the remaining soils, 4) the highest percentage of redox concentrations was observed in the acidic, fine-textured soil, 5) the acidic fine-loamy and coarse-loamy soils exhibited a greater percentage of Fe depletions, and 6) a higher percentage of redox features were observed by micromorphic analysis (i.e., point counts under a binocular stereoscopic microscope) than by macromorphic descriptions. This research showed that differing soil characteristics affect the reductive dissolution and translocation of Fe, and subsequent formation of redox features.

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Thanks to my parents, Michael and Sharon Mersmann, my sister, and the rest of the family (both mine and my wife's) for their encouragement and understanding. I can not imagine anyone with a more supportive family.

Finally, thank you to my wife and son. Amie, I would have never made it without your love, patience, and support. You have sacrificed so much by allowing me the time to achieve this goal. I am blessed to have you in my life. Derek, one day you will understand why daddy was at his desk so much during the last few months. I am ready to come out and play now.

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INTRODUCTION

Over the past several decades there has been a growing awareness of the environmental and economic significance of wetlands. The important functions of wetlands (e.g., waste treatment, water quality improvement, flood and erosion control, biotic habitat) and the impacts of land use (e.g., agricultural production, urban and industrial development) on wetlands have prompted a need for accurate delineation of these areas. In addition, wetland management and preservation remain an important priority for federal, state, and some local regulatory agencies.

Jurisdictional wetlands are defined and delineated by the presences of hydric soils, as well as wetland hydrology and hydrophytic vegetation, (Environmental Laboratory, 1987). Redoximorphic features are utilized to identify saturated, anaerobic conditions associated with hydric soils (Hurt et al., 2003; Vepraskas, 1992). Redoximorphic features are diagnostic indicators formed by the reductive dissolution, translocation, and subsequent oxidation of Fe and Mn resulting from several biogeochemical processes (Van Breemen, 1988b; Vepraskas, 2001). Understanding these biogeochemical processes can improve the quantification of hydric soils and the accuracy of wetland delineation. The presence of diagnostic redoximorphic features and the identification of hydric soils may be the most reliable indicators for wetland delineation. This is especially true in seasonally wet areas, where hydrology can fluctuate with wet and dry seasons and hydrophytic vegetation exhibits such a wide

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This thesis follows the style of the Soil Science Society of America Journal.

range of adaptability that only obligate hydrophytes are useful wetland indicators (Griffin et al., 1998).

Although hydric soils are a reliable indicator for wetland delineation, seasonally wet Vertisols pose a unique problem. Some Vertisols tend to exhibit poorly expressed redoximorphic features and hydric/non-hydric boundaries tend to be diffuse and difficult to define (Jacob et al., 1997). This problem was evident in a study of seasonally wet Vertisols in the Columbia Bottomlands in Brazoria and Matagorda Counties, Texas, on the Texas Gulf Coast Prairie Major Land Resource Area (MLRA). Portions of this depressional landscape are ponded for approximately 24% to 68% of the year and reducing conditions were verified by oxidation-reduction (redox) potential measurements coupled with pH readings, and by the presence of ferrous Fe in soil solution (Miller and Bragg, 2007). However, there does not appear to be a good relationship between the presence of free-water, ferrous Fe, and the expression of redoximorphic features in surface horizons (Owens, 2001). Published guidelines for hydric soil indicators (Hurt et al., 2003; Environmental Laboratory, 1987) specify that there must be at least 2% redoximorphic features present to consider this a hydric soil. Yet in many of the ponded areas, there were no readily observed redoximorphic features (i.e., 2% or more) based on soil transect data obtained during the study (Miller and Bragg, 2007). This was especially evident in soils with near neutral reaction which exhibited very few redox features or did not exhibit these features at all, even after long to very long periods of ponding and reduction. There was no indication of ferrous Fe in soil solution in some areas that were ponded (and obviously saturated), whereas ferrous Fe was present in soil solution only a few meters away. The identification of ferrous Fe was based on a positive reaction to α, ά-dipyridyl on freshly obtained soil cores (Childs, 1981).

A number of factors may be contributing to the poor expression of redoximorphic features in the aforementioned soil. Three possible explanations are: 1) The high cation exchange capacity (CEC) of the smectitic clay associated with Vertisols may be limiting the concentration and mobility of ferrous Fe in soil solution, 2) The CEC may increase upon reducing conditions if the smectites contain Fe in the octahedral sheet, and 3) The effect of pH on redox reactions within the microtopography of Vertisols may contribute to limited free Fe available for transport and subsequent segregation.

Several studies on the Texas Gulf Coast Prairie have evaluated the relationship between saturation and reduction in seasonally wet soils with varying textures, pH, and landscape position (Griffin, 1991; Griffin et al. 1996; Griffin et al., 1998; Jacob et al., 1997; Owens, 2001; Starowitz, 1994; Vepraskas and Wilding, 1983). These studies demonstrated a poor relationship between the period of saturation and a corresponding period of Fe reduction, especially in Vertisols. Jacob et al. (1997) compared the saturation and reduction of three Texas Gulf Coast Vertisols (League, China, and Laewest). Results indicated a period of 50 to 60% of the time in saturation, but a period of reduction less than 10% of the time. In fact, the Laewest soil was saturated for 40% of the year, but exhibited no evidence of reduction. Griffin et al. (1996) found a good correspondence between saturation and reduction in loamy and non-vertic soils. Soils saturated for 20% of the year experienced significant periods of reduction, while little reduction was found in soils saturated for less than 15% of the year. Some vertic soils were saturated almost 40% of the year, but were never reduced. Vepraskas and Wilding (1983) showed that the period of saturation in a Segno fine sandy loam (Plinthic

Paleudalf) and Splendora fine sandy loam (Fragic Glossaqualfs) was much greater than the occurrence of Fe reduction. The Segno and Splendora soils were saturated for 116 days and 160 days, respectively. Reduction of Fe was identified for only six days in the Segno soil and 96 days in the Splendora soil.

Objectives

The purpose of the following laboratory studies was to relate the influence of soil texture, pH, and CEC to the concentration of ferrous Fe in soil solution and the resulting expression of soil redoximorphic features. The objectives were: 1) assess the buffering effects of CEC on ferrous Fe concentration in soil solution, 2) evaluate the effects of pH on the concentration of ferrous Fe in soil solution, and 3) observe the expression of redoximorphic features in soils with varying texture and CEC.

The study concentrated on seasonally wet soils from the Texas Gulf Coast Prairie MLRA (Fig. 1). Selected soils include Alfisols and Vertisols with characteristics ranging from coarse-loamy to very-fine in texture, strongly acidic to neutral in soil reaction, and siliceous, mixed, and smectitic in mineralogy.

Hypotheses

Based on the research objectives, the following hypotheses were formed for testing:

1. High CEC and adsorptive surface area of Vertisols buffers the soil solution resulting in lower concentrations of ferrous Fe available for transport by diffusion or mass flow and subsequent segregation into redoximorphic features;
2. Soils with higher pH yield a lower concentration of ferrous Fe in solution resulting in a lower quantity of redoximorphic features; and

3. Coarser-textured soils develop a higher quantity of redoximorphic features than loamy- or fine-textured soil because of lower CEC and lower buffering capacity.

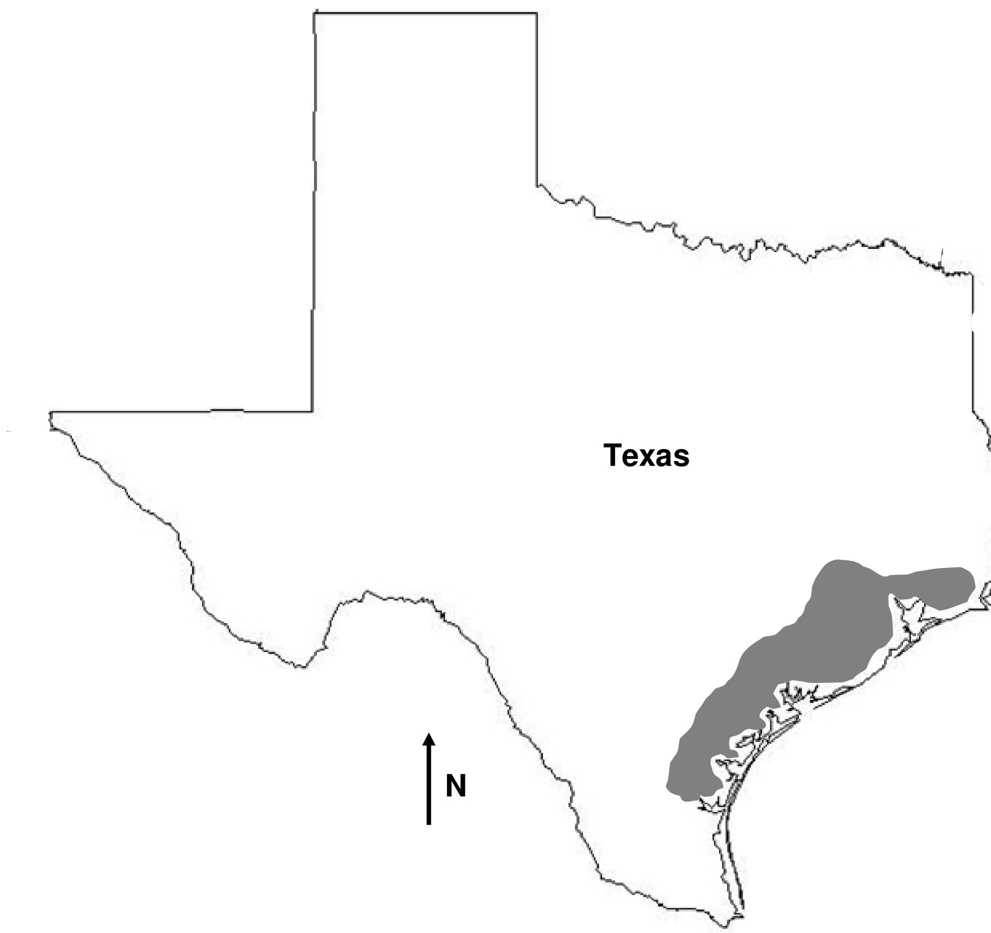

Figure 1. Texas Gulf Coast Prairie MLRA.

LITERATURE REVIEW

Hydric soils are formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil (Hurt et al., 2003). Hydric soils and the morphological indicators by which they are identified (e.g., redoximorphic features) are created by redox reactions that occur when the soil is saturated, anaerobic, and chemically reduced.

Redox Processes

Redox reactions are chemical reactions in which electrons are transferred from a donor to an acceptor, whereby the acceptor gains an electron and is chemically reduced (Ponnamperuma, 1972). In aerobic soils, O_2 is the major electron acceptor reduced by aerobic microorganisms while oxidizing organic matter. When a soil becomes waterlogged (i.e., saturated, flooded, or ponded), O_2 is consumed rapidly and other electron acceptors must be utilized by microorganisms, primarily bacteria, for anaerobic respiration (Faulkner and Patrick, 1992; Fiedler and Sommer, 2004). Oxygen remaining in the soil or present in interstitial water is consumed by microorganisms within a few hours (Ponnamperuma, 1972). Subsequent to saturation and in the absence of O_2, facultative and obligate anaerobic bacteria utilize NO_3^-, Mn oxides, ferric Fe oxyhydroxides, SO_4^{2-}, and CO_2 as alternative electron acceptors in the respiration process (Gambrell and Patrick, 1978; Gotoh and Patrick, 1974; Turner and Patrick, 1968). Theoretically, the electron acceptors are reduced in a thermodynamic sequence of redox reactions, beginning with NO_3^- and continuing in the order listed above once each prior compound is depleted (Vepraskas and Faulkner, 2001; Van Breemen, 1988a).

Redox reactions in soils can proceed only if the following conditions are met: 1) The soil must contain a sufficient amount of organic matter that can be used as an energy source by anaerobic microorganisms, 2) The soil must be devoid of O_2 or soil water must be stagnant enough to inhibit the diffusion of O_2, and 3) The soil must contain a viable population of anaerobic microorganisms (Bouma, 1983). If all three conditions are present and the soil contains a reducible source of ferric Fe, the formation of redoximorphic features occurs by:

1. Reduction of ferric Fe and subsequent mobilization of dissolved ferrous Fe;
2. Transportation of ferrous Fe by diffusion (along a concentration gradient) or by mass flow (under the influence of gravity or capillary action); and
3. Immobilization of ferrous Fe by oxidation to ferric oxyhydroxides in the presence of O_2, adsorption onto the soil exchange complex, or precipitation of ferrous Fe (favored by high pH, high concentration of sulfides, etc.).

The same processes are involved with the redistribution of Mn. However, ferric Fe is normally the dominant electron acceptor and is usually found in greater abundance in seasonally wet soils. According to Ponnamperuma (1972), the mean concentration of Fe is about 40 times greater than other oxidants in soil.

Redox Measurements

Redox reactions can be expressed thermodynamically using the concept of redox potential (Eh) (Vepraskas and Faulkner, 2001). Eh is a quantitative measurement of electron availability and indicates the tendency of soils to oxidize and reduce substances (Gambrell and Patrick, 1978; Faulkner and Patrick, 1992).

The relationship between the Eh and pH will affect the dissolution and transport of Fe in reduced soil environments (Reuter and Bell, 2001; Bohn, 1971). Eh/pH diagrams suggest that more intensive reducing conditions are necessary for Fe dissolution in alkaline soils than in acid soils (Wilding and Rehage, 1985; Collins and Boul, 1970; Lindsay, 1979). Under controlled conditions in a reaction vessel, Gotoh and Patrick (1974) showed that dissolution of reducible Fe to water-soluble and exchangeable Fe in a saturated Crowley silt loam ranged from no detectable Fe at pH 8 and Eh +300 mV to high concentrations in solution at pH 5 and Eh -250 mV. At pH 5 and Eh +300 mV, 316 ppm Fe was converted to the soluble form. At pH 6 and 7, the conversion of reducible Fe occurred between Eh +300 mV to +100 mV. At pH 8, an Eh of -100 mV was necessary before Fe was reduced. Ponnamperuma (1972) found that acid soil high in organic matter and Fe yielded ferrous Fe concentrations as high as 600 ppm within one to three weeks of saturation, and then decreased to levels of 50 to 100 ppm. In neutral and calcareous soils, the concentration of ferrous Fe rarely exceeded 20 ppm. The relationship between Eh, pH, and Fe reduction is shown in Fig. 2.

Soil reduction is typically determined in the field by measuring the Eh with Pt electrodes or by detecting the presence of reduced species with color indicators, such as α, ά-dipyridyl (Vepraskas and Sprecher, 1997; Faulkner et al., 1989).

Cation Exchange and Buffering

The soil CEC may significantly affect the redistribution of Fe in reduced soils by buffering the amount of ferrous Fe in soil solution available for transport. Under

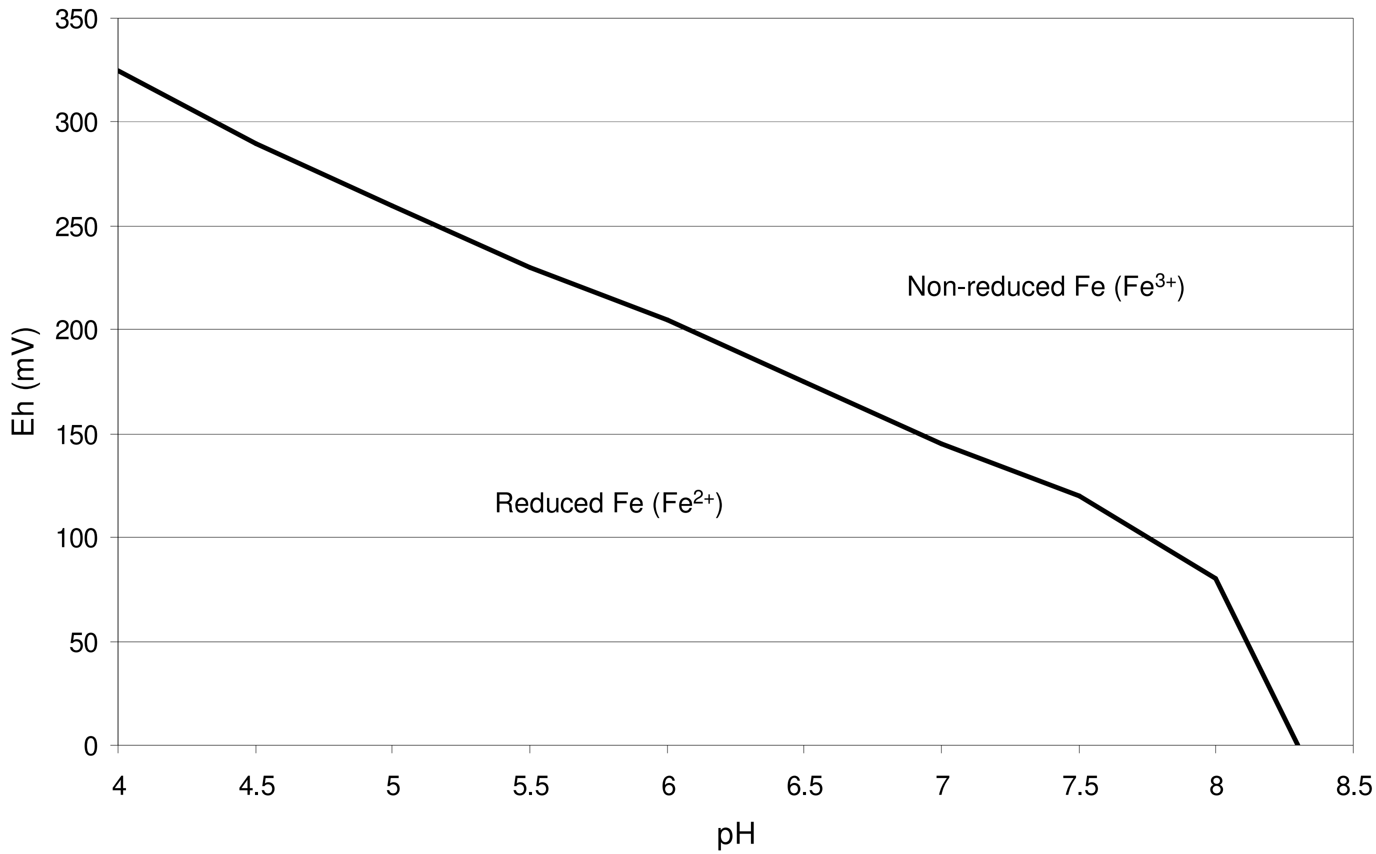

Figure 2. Relationship between Eh, pH, and Fe reduction, modified from Griffin (1991).

anaerobic conditions, a large portion of ferric Fe oxyhydroxides can be reduced to ferrous Fe. However, most of this portion may be in the exchangeable form with only a small fraction appearing in soil solution (Van Breemen, 1988a). Studies have shown that redox processes can influence the composition of the exchange complex. Favre et al. (2002) found that the CEC of a saturated, reduced Vertisol increased to twice that of the CEC in an unsaturated, oxidized state. The increase was attributed to the reduction of 19% of the structural Fe in smectites. Stucki et al. (1987), Gates et al. (1996), and Kostka et al. (1996) also indicated an increase in CEC of 51%, 19%, and 30%, respectively, upon biological reduction of structural Fe. In addition, reductive dissolution of ferric Fe oxyhydroxides coating clay surfaces may contribute to the increase of CEC (Favre et al., 2002; Kirk et al., 2003). Roth et al. (1969) noted an increase in CEC equal to the amount of positive charge associated with the oxyhydroxide.

Gotoh and Patrick (1974) found a relationship between soil pH and the proportion of reduced Fe on exchange sites. In a Crowley silt loam at pH 5 and Eh -250 mV, water-soluble Fe accounted for 76% of the soluble and exchangeable Fe fraction under reduced conditions. In that same soil, modified to pH 8 and Eh -250 mV, the water-soluble fraction of Fe was 4%, indicating that the proportion of exchangeable Fe in a reduced soil increases with increasing pH. Gotoh and Patrick (1974) and Van Breemen (1988a) suggested that the higher percentage of soluble Fe at low pH may be the result of H^+ and Al^{3+} ions displacing ferrous Fe from the exchange complex.

Many soils on the Texas Gulf Coast Prairie contain a significant amount of smectite. The large surface area of smectites (up to 800 m^2 g^{-1}) provides most of the adsorptive surface in these soils as a result of its small particle size (Borchardt, 1989; Langmuir, 1997). Clay contents in Vertisols range from 30% to as high as 90%, and are usually dominated by smectites (Coulombe et al., 1996). Soil CEC is generally 45 $cmol_c\ kg^{-1}$ or higher.

Organic Matter

The availability of organic carbon as an energy source for microbial respiration has an evident effect on the reduction of Fe. Bonner and Ralston (1968) showed that by adding organic substrate (5% sucrose) to a North Carolina forest soil, Eh values reached -676 mV after 25 days. Soil color changed dramatically in the sucrose-amended soil, from a well-oxidized yellow-red color to a gleyed color. Allison and Scarseth (1942) utilized a solution containing 7% sucrose to biologically reduce and remove approximately 24% of the free Fe oxides from the clay fraction of a Miami silt loam.

Redoximorphic Features

There are four basic groups of morphological features relating to soil reduction: 1) organic C-based features, 2) Mn-based features, 3) Fe-based features, and 4) S-based features. As stated previously, redoximorphic features are formed by the reduction, translocation, and oxidation of Fe and Mn compounds. Redoximorphic features are the most common morphological features associated with soil reduction and are used to indicate reduction in waterlogged soils. There are three major categories of redoximorphic features: 1) redox concentrations, 2) redox depletions, and 3) reduced matrix. The following discussion of these features draws from Vepraskas et al. (1994) and Vepraskas (2001).

Redox concentrations are zones of apparent concentrations of Fe and Mn oxyhydroxides. The three types of redox concentrations include:

- Pore linings – zones of accumulation along pores, either coating the pore surface or contained within the matrix adjacent to the pore;
- Masses – soft bodies within the soil matrix; and
- Nodules and concretions – firm, irregular-shaped bodies with diffuse or sharp boundaries.

Redox depletions are zones of low ($\leq$ 2) chroma where Fe-Mn oxyhydroxides have been removed or Fe-Mn oxyhydroxides and clay have been removed. Two types of redox depletions include:

- Fe depletions – zones which contain low amounts of Fe and Mn oxides, but have clay contents similar to the adjacent soil matrix; and
- Clay depletions – zones which contain low amounts of Fe, Mn, and clay. According to Vepraskas (2001), clay depletions have not been reported in the upper part of hydric soils and are less important than Fe depletions for hydric soil identification.

Reduced matrices are soil matrices that contain ferrous Fe. These matrices exhibit a low chroma *in situ*, but the hue and chroma increase when the soil is exposed to O_2. The color change is a result of Fe^{2+} oxidizing to Fe^{3+}.

STUDY SOILS AND THEIR ENVIRONMENTAL SETTINGS

Soil Selection

Seven soils were selected for laboratory studies to assess the influence of soil properties on the concentration of ferrous Fe in soil solution under reducing conditions, and the resulting expression of redoximorphic features. Selections were based on texture (sandy, loamy, or clayey), pH (acidic or neutral), CEC (low, moderate, or high), and the fact that each selected soil is considered a seasonally wet soil with hydromorphic characteristics. Classifications and general characteristics of the selected soils are included in Table 1. The soil names shown in parentheses will be used for the remainder of this document.

The study soils were selected from locations in Brazoria County (Pledger-low and Pledger-high), Harris County (Gessner), Jefferson County (China), San Patricio County (Orelia-loamy and Orelia-sandy), and Victoria County (Cieno) on the Texas Gulf Coast Prairie MLRA (Fig. 3). The soils from Brazoria, Harris, Jefferson, and Victoria Counties were used in previous soil hydromorphology studies (Griffin, 1991; Griffin et al. 1998; Starowitz, 1994; Owens, 2001; Miller and Bragg, 2007).

Pledger-low and Pledger-high

The Pledger site is located approximately 10 km north of Old Ocean, Texas, in Brazoria County. The Pledger soil is highly smectitic in the clay fraction of the soil surface, and parent material is recent calcareous alluvium of Holocene age deposited upon the Pleistocene-age Beaumont Formation. The surface topography varies with

Table 1. Classification and general characteristics of selected soils.

Soil Name	Classification †	General Characteristics	Geologic Formation
Pledger clay, microlow (Pledger-low) ‡	Very-fine, smectitic, hyperthermic Typic Epiaquerts	acidic, clayey, high CEC	Alluvium (Holocene)
Pledger clay, microhigh (Pledger-high) ‡	Very-fine, smectitic, hyperthermic Typic Epiaquerts	neutral, clayey, high CEC	Alluvium (Holocene)
China clay (China)	Fine, smectitic, hyperthermic Oxyaquic Dystruderts	acidic, clayey, high CEC	Beaumont
Cieno loam (Cieno)	Fine-loamy, siliceous, active, hyperthermic Typic Vermaqualfs	acidic, loamy, moderate CEC	Lissie
Orelia sandy clay loam (Orelia-loamy)	Fine-loamy, mixed, superactive, hyperthermic Aquic Haplustalfs	neutral, loamy, moderate CEC	Lissie
Gessner fine sandy loam (Gessner)	Fine-loamy, siliceous, active, hyperthermic Typic Vermaqualfs	acidic, sandy, low CEC	Lissie
Orelia fine sandy loam (Orelia-sandy)	Fine-loamy, mixed, active, hyperthermic Aquic Haplustalfs	neutral, sandy, low CEC	Lissie

† Soil Survey Staff, 2003.

‡ Classification for the depressional Pledger soil is based on a recent study. The proposed soil series name for the Pledger depression is Churnabog (Miller and Bragg, 2007).

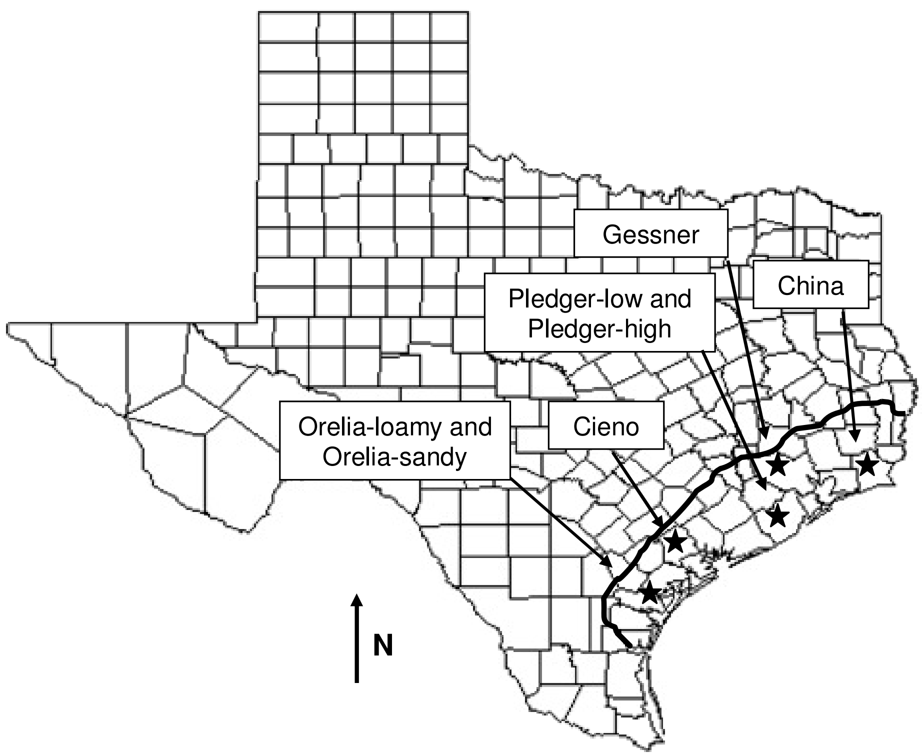

Figure 3. Locations of selected soils within the Texas Gulf Coast Prairie MLRA.

topographic position. Uplands have strongly expressed gilgia. The transitional area does not express gilgia on the surface, but does express diapir (i.e, subsurface chimneys) and bowl-shaped morphology commonly seen in Vertisols. The depressional area does not exhibit surface topography, and expresses subtle subsurface diapirs. The elevation difference between the upland and the depression is approximately 1 m. Inconsistencies between saturation, Fe reduction, and the expression of redoximorphic features are evident in portions of this soil. The Pledger-low and Pledger-high were sampled from the depressional area.

China

The China site is located approximately 0.25 km south of the Texas AgriLife Research Center headquarters, Beaumont, Texas, in Jefferson County. The China soil is found on nearly level, broad uplands on the Beaumont Formation deposited by a paleo-Trinity River. This soil is derived from clayey sediments of Pleistocene age.

Cieno

The Cieno site is located approximately 8 km east of Victoria, Texas, in Victoria County. The Cieno soil is part of the Nada-Cieno-Telferner complex located on the Lissie Formation. Cieno is in the depressional position of the complex approximately 0.5 to 1.0 m lower than the Nada intermounds, and approximately 1.5 to 2.5 m below the Telferner mounds.

Gessner

The Gessner site is near Cypress, Texas, in northwest Harris County. The Gessner soil is in the depressional position of the Gessner complex mapping unit. The soils are of Pleistocene age and were formed in the Lissie Formation. The Lissie Formation is composed of loamy sediments from fluvio-deltaic materials deposited approximately 120,000 years before present.

Orelia-loamy and Orelia-sandy

The Orelia sites are located on the Welder Wildlife Refuge near Sinton, Texas, in the north-central portion of San Patricio County. These soils are formed in marine sediments of Pleistocene age on nearly level coastal terraces in the Lissie Formation. The texture of the surface horizon of the Orelia series is fine sandy loam, clay loam, or sandy clay loam.

MATERIALS AND METHODS

Soil Sampling and Description

Each soil was sampled at a depth of approximately 15 cm below ground surface. This depth was chosen based on previous studies (Griffin, 1991; Griffin et al. 1998; Starowitz, 1994; Owens, 2001; Miller and Bragg, 2007) and soil survey data (Soil Survey Staff, 1979) indicating that texture, pH, and CEC should correspond to ranges necessary for the study. Sampling locations were selected in areas adjacent to field monitoring stations (i.e., ongoing field study instrumentation) at the Pledger-low, Pledger-high, Cieno, and Gessner sites. At the China site, the sampling location was adjacent to a previous field monitoring station.

At each sampling location, a spade was utilized to open several shallow pits to extract approximately 50 intact soil clods randomly from a 3-m by 3-m area. Prior to sampling, the soil was described at the anticipated depth of 15 cm and compared to prior descriptions and characterization data. Soil morphological descriptions and characterization data used for the comparison are included in Appendix A. Note that soil classifications indicated in Appendix A are from the previous studies and indicate the classification at that time. The classifications included in Table 1, excluding the Pledger-low and Pledger-high, are updated classifications from official soil series descriptions.

Each clod, approximately 7-cm in diameter, was marked for orientation and then preserved in Al foil for transport from the field to the laboratory. In addition, one bulk composite sample of about 1 kg was collected from each area for analyses of selected physical and chemical parameters. Bulk soil material was used in Study #1 (Ferrous Fe

Concentration in Unamended Bulk Soil). Intact soil clods were used in Study #2 (Redox Features in Amended/Equilibrated Natural Soil Clods) and Study #3 (Redox Features in Unamended/Equilibrated Natural Soil Clods).

Bulk Soil Characterization

Bulk samples from each soil were analyzed for selected physical and chemical parameters to ensure that the soils met the necessary ranges of texture, pH, and CEC, as well as to provide baseline characterization data. Each sample was submitted to the Soil Characterization Laboratory at Texas A&M University for the analyses shown in Table 2.

Table 2. Laboratory methods for selected soil physical and chemical analyses.

Parameter	Method †
Particle Size Analysis	3A1
Bulk Density (oven-dry and -1/3 bar)	4A1h, 4A1d
Coefficient of Linear Extensibility (COLE)	4D
-1/3 Bar Water Retention	4A1d
Organic C	6A2a
Citrate-Dithionite Extractable Fe	6C2b
Extractable Bases (Ca, Mg, Na, K)	5B5
KCl Extractable Al	6G9a
Cation Exchange Capacity	USDA Handbook 60 ‡
1:1 pH	8C1a
1:1 Electrical Conductivity	8I

† Soil Survey Staff, 1996.

‡ U.S. Salinity Laboratory Staff, 1954.

Study #1 – Ferrous Fe Concentration in Unamended Bulk Soil

The presence of ferrous Fe (and/or reduced Mn) in soil solution is a prerequisite for the formation of redoximorphic features. As discussed previously, soil pH and CEC can have a profound effect on the concentration of ferrous Fe in solution. The purpose of this study was to evaluate the maximum concentration of ferrous Fe released from a near neutral Vertisol under anaerobic conditions after a period of approximately 30 days of continuous ponding. The 30-day ponding period was based on the measured duration of ponding needed before ferrous Fe was identified in soil solution in some portions of the depressional Pledger soil at the Columbia Bottomland Hardwood study site (Miller and Bragg, 2007). Additional objectives were: 1) to compare the relationship between Eh, ferrous Fe concentration, and reduced Mn concentration in inundated soils over the period of continuous ponding, 2) to observe the effect of pH and CEC on the amount of time required after soil inundation for ferrous Fe to appear in soil solution, and 3) to calculate the percent reduction of free Fe oxyhydroxides and corresponding concentration of ferrous Fe. The concentrations of ferrous Fe determined by this study should represent the easily reducible Fe found in the selected soils under inundated, anaerobic conditions in the field.

The soils selected for this study include Pledger-high, Cieno, and Gessner. These soils were selected to represent strongly acid to neutral soils with soil textures ranging from coarse-loamy to very-fine and CEC values ranging from approximately 5 to 60 $cmol_c\ kg^{-1}$. To better represent field conditions, soils were not amended with additional organic matter or nutrients.

The three selected soils were placed in separate reaction vessels to promote anaerobic conditions. Each soil was replicated three times (i.e., three reaction vessels per soil). Reaction vessels were constructed from 1-L glass jars with lids. Four-hundred (400) mL of distilled water and 500 g of bulk soil were sealed in the reaction vessel. Water was constantly ponded over the soil at a depth of approximately 2 cm. Three Pt Eh electrodes were inserted into each jar through the lid. An additional opening was drilled through the lid for insertion of a Corning Model 476406 Calomel reference electrode with saturated KCl solution. This opening was sealed with a rubber stopper (#1 size) and removed only when recording Eh readings from the reaction vessel. A fifth opening was required for a solution extraction device. This device consisted of a 0.3-cm diameter PVC tube inserted into a 2.5-cm PVC cap. This cap was filled with glass wool to ensure that only soil solution entered the extraction chamber. The extraction chamber was buried approximately 5 cm below the soil surface. Each hole in the lid was sealed with waterproof epoxy to prevent the passage of O_2 into the system. A schematic of a reaction vessel is shown in Fig. 4. A photograph of the reaction vessel is included as Fig. 5.

Platinum Eh electrodes were constructed as follows (Owens, 2001): 1) 1-mm diameter (18 gauge) Pt wire was cut into 1.3-cm segments, 2) the segments were soaked in a 1:1 mixture of nitric and hydrochloric acids for approximately 4 h to remove contamination of other metals from the surface, 3) the segments were soaked in distilled water overnight, 4) 3 mm of the Pt wire segments were inserted into the end of a drilled 2.6-mm diameter (10 gauge) solid Cu wire, 5) the Cu wire was crimped to make an electrical connection and to secure the Pt wire segment, 6) the exposed Cu wire was covered with a waterproof epoxy (EPO-950 Epoxy Weld Part A and Part B, Advanced Epoxy Systems, Inc., 5103 Third St., Katy, Texas) to ensure that the Pt wire was the only metal exposed to the reaction, and 7) the electrode was viewed under a

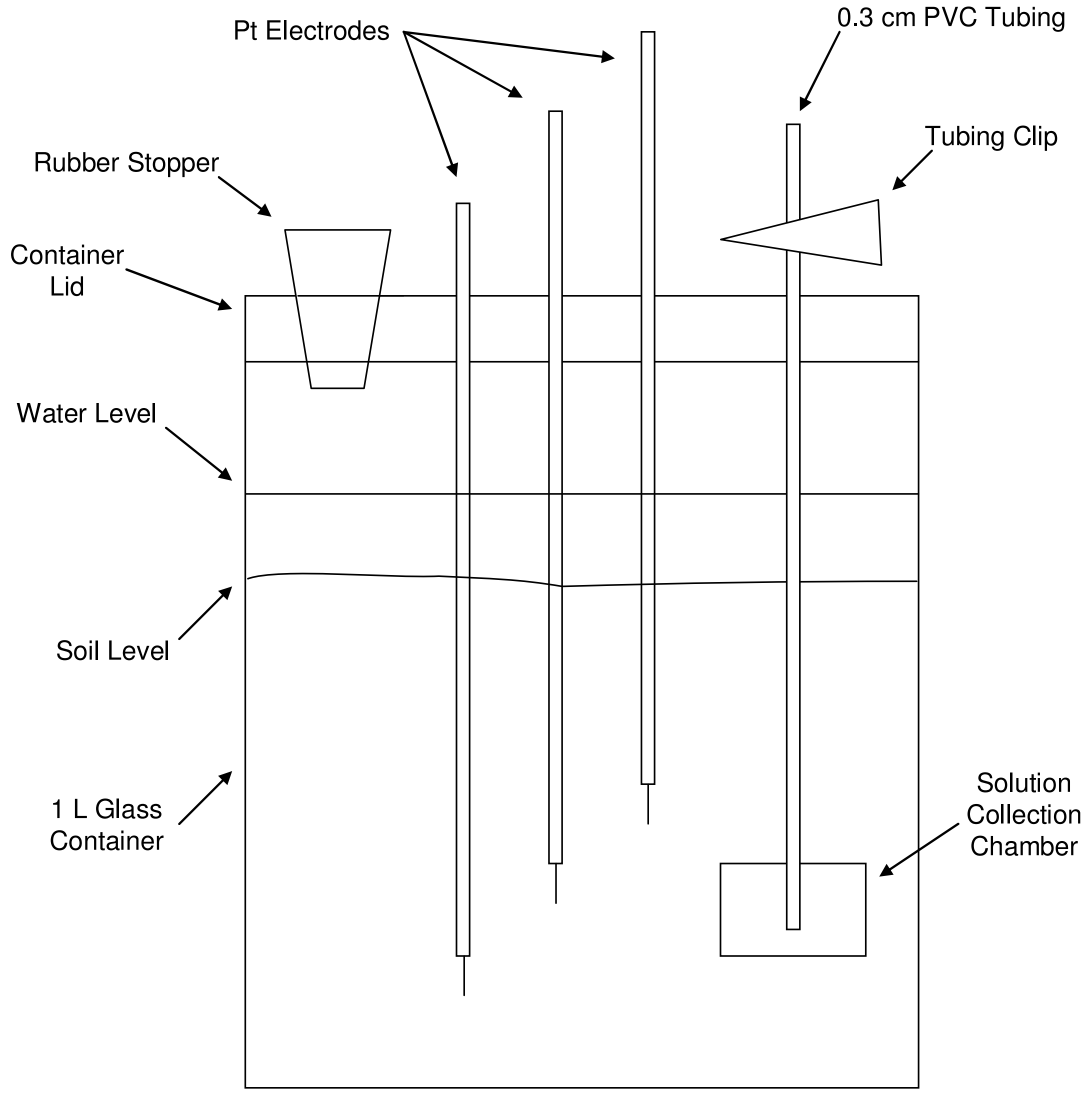

Figure 4. Schematic of a reaction vessel used in Study #1 (not to scale).

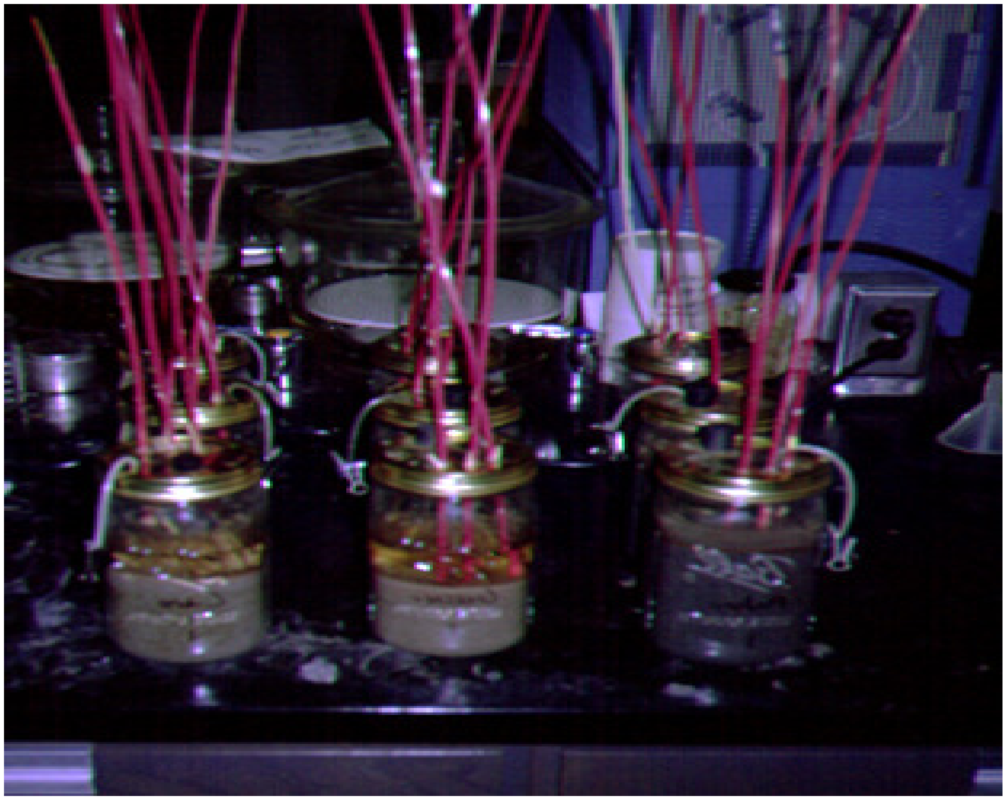

Figure 5. Photograph of reaction vessels used in Study #1.

stereoscopic microscope to observe the complete seal with epoxy. If the seal was not complete (i.e., holes in the epoxy), electrodes were re-sealed and checked again. Each Pt electrode was calibrated in a ferric-ferrous sulfate solution at a redox potential of +430 mV (Light, 1972). A Fisher Model 13-620-82 combination meter was used to measure Eh. A schematic of a Pt electrode is shown in Fig. 6.

Eh readings were recorded 24 h after inundation, then every 12 h until elapsed time reached 72 h after inundation. After 72 h, Eh readings were recorded every 24 h until elapsed time reached 192 h, then every 48 h until elapsed time reached 288 h, and finally every 96 h until elapsed time reached 768 h. Soil solution for analysis of ferrous Fe and reduced Mn was extracted from each reaction vessel at 48 h, 96 h, 168 h, 288 h, 384 h, 480 h, 576 h, 672 h, and 768 h. Upon extraction, soil solution samples were preserved in ferrozine reagent (Stookey, 1970), then analyzed for total soluble Fe by atomic absorption spectroscopy (Loeppert and Inskeep, 1996) and total soluble Mn by atomic absorption spectroscopy (Gambrell, 1996). After determining the concentration of ferrous Fe and reduced Mn in solution, concentrations were expressed on a soil basis (i.e., mg kg^{-1}) using the known volume of solution equilibrating the known weight of soil.

Redox potentials, ferrous Fe concentrations, and reduced Mn concentrations were plotted on a time sequence to evaluate the maximum concentration of ferrous Fe and reduced Mn in soil solution, and the corresponding Eh reading. Mean and standard deviation were calculated for redox potential, ferrous Fe, and reduced Mn replicants for each treatment (soil type). A one-way analysis of variance was performed for redox potential, ferrous Fe, and reduced Mn at 48 h, 168 h, 384 h, 576 h, and 768 h to evaluate treatment differences at a 95% confidence level. If the samples were

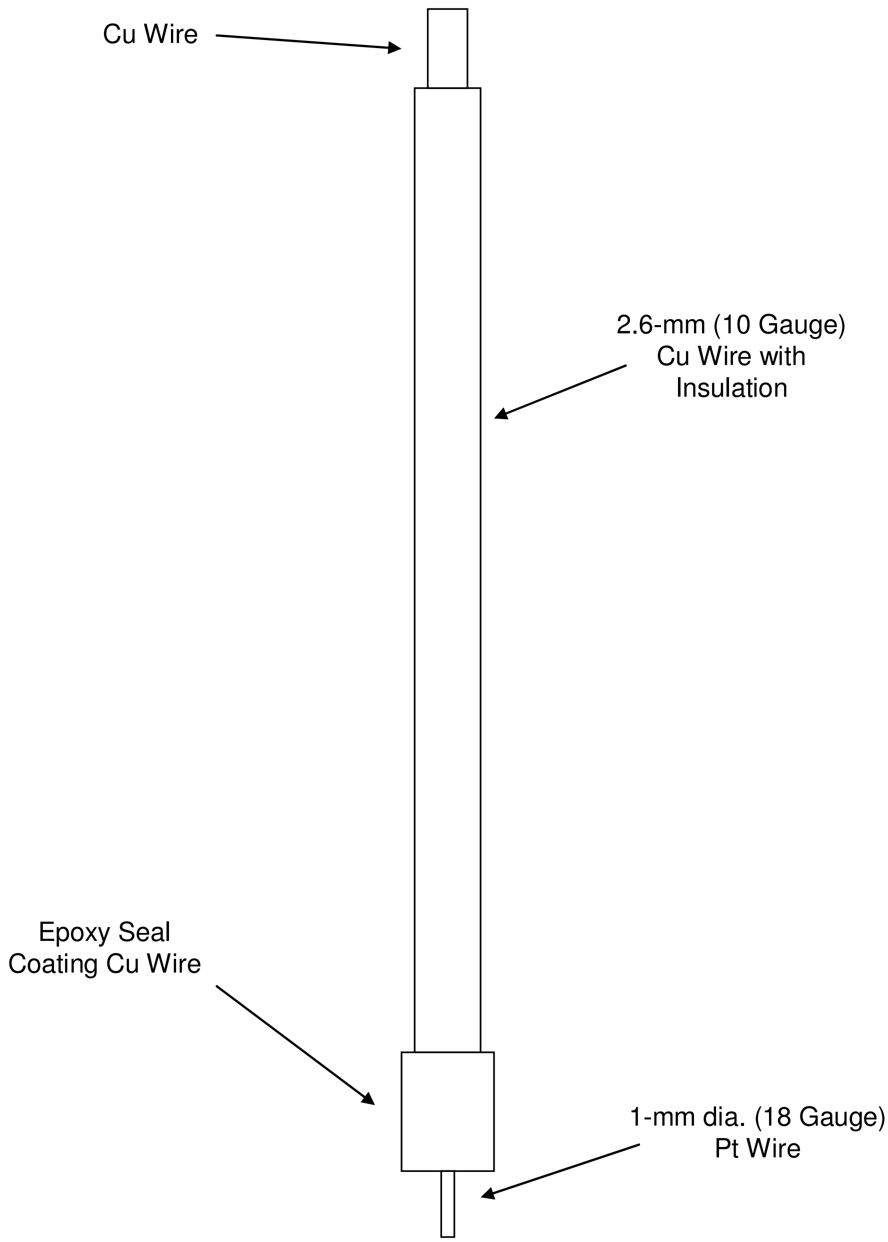

Figure 6. Schematic of a Pt electrode used in Study #1, Study #2, and Study #3 (not to scale).

significantly different at a treatment interval, a Fisher's least significant difference (LSD) was calculated to compare the means between soils.

Study #2 – Redox Features in Amended/Equilibrated Natural Soil Clods

This study was conducted to observe and quantify the redoximorphic features formed in soils that have been stripped of easily reducible Fe oxyhyroxides then equilibrated with varying amounts of ferrous Fe. The objective was to determine if high CEC will buffer the redistribution of ferrous Fe and affect the expression of redoximorphic features. Soils selected for this study included the Gessner, Cieno, China, and Pledger-low representing strongly to moderately acidic soil, as well as the Orleia-sandy, Orelia-loamy, and Pledger-high representing neutral soils. Both groups have textures ranging from coarse-loamy to very-fine, and CEC ranging from approximately 5 to 60 $cmol_c\ kg^{-1}$.

Eighteen natural clods for each soil type (126 total soil clods), approximately 7-cm in diameter, were coated with Saran by dipping the clods in Saran dissolved in acetone. The weight of each clod was measured prior to coating with Saran. Upon drying, each Saran coat was perforated with a 1-mm diameter stainless steel rod, and a 2-cm diameter section of Saran was removed from the top and bottom of each clod. The 1-mm stainless steel rod was inserted through each clod five times to form continuous cylindrical pores and allow solution to enter and flow through the clod. Two Pt electrodes were inserted into each clod to a depth of approximately 3 cm and 7 cm below the Saran coating. Clods were enclosed in 0.95-L high-density polyethylene (HDPE) reaction vessels, and the vessels were sealed with silicone. Openings were drilled through each lid for the Pt electrodes, a reference electrode (during Eh and pH measurements), a solution extraction device, and an inlet and outlet for nitrogen gas. A rubber stopper (#1 size) was inserted into the reference electrode opening to prevent O_2 from entering the reaction vessel. The solution extraction device was constructed of 0.64-cm I.D. x 0.95-cm O.D. PVC tubing. The tubing was closed with a common 1.9-cm wide paper binding clip to prevent O_2 from entering the reaction vessel. Nitrogen gas inlets/outlets consisted of 0.95-cm nozzles with hose bards and were connected with PVC tubing (0.64-cm I.D. x 0.95-cm O.D.) in series for each soil type (i.e., 18 reaction vessels containing the same soil type were connected in series). A schematic of a reaction vessel is shown in Fig. 7. Photographs of the reaction vessel setup are included in Fig. 8.

A manifold was constructed from two 2-m sections of 5-cm diameter PVC pipe to act as a reservoir for N_2 gas. The manifold was connected to a compressed N_2 gas cylinder via a gas regulator and to the first HDPE reaction vessel of each series/soil type. Air-flow meters were installed between the manifold to the first sample vessel of each series. The air-flow meters were utilized to build pressure inside the manifold and allow nitrogen gas to purge O_2 from each series of reaction vessels at a constant rate, thus creating an anaerobic environment.

To enhance the available labile energy source for microorganisms to reduce the indigenous reducible ferric Fe in the soils, samples were amended with a 5% by weight sucrose solution (Allison and Scarseth, 1942). Clods were submersed in sucrose solution for 168 h (7 days) under the influence of N_2 gas, and then the solution was removed through the solution extraction device. Fresh sucrose solution was added, and the clods were allowed to equilibrate for an additional 336 h (14 days). Again the

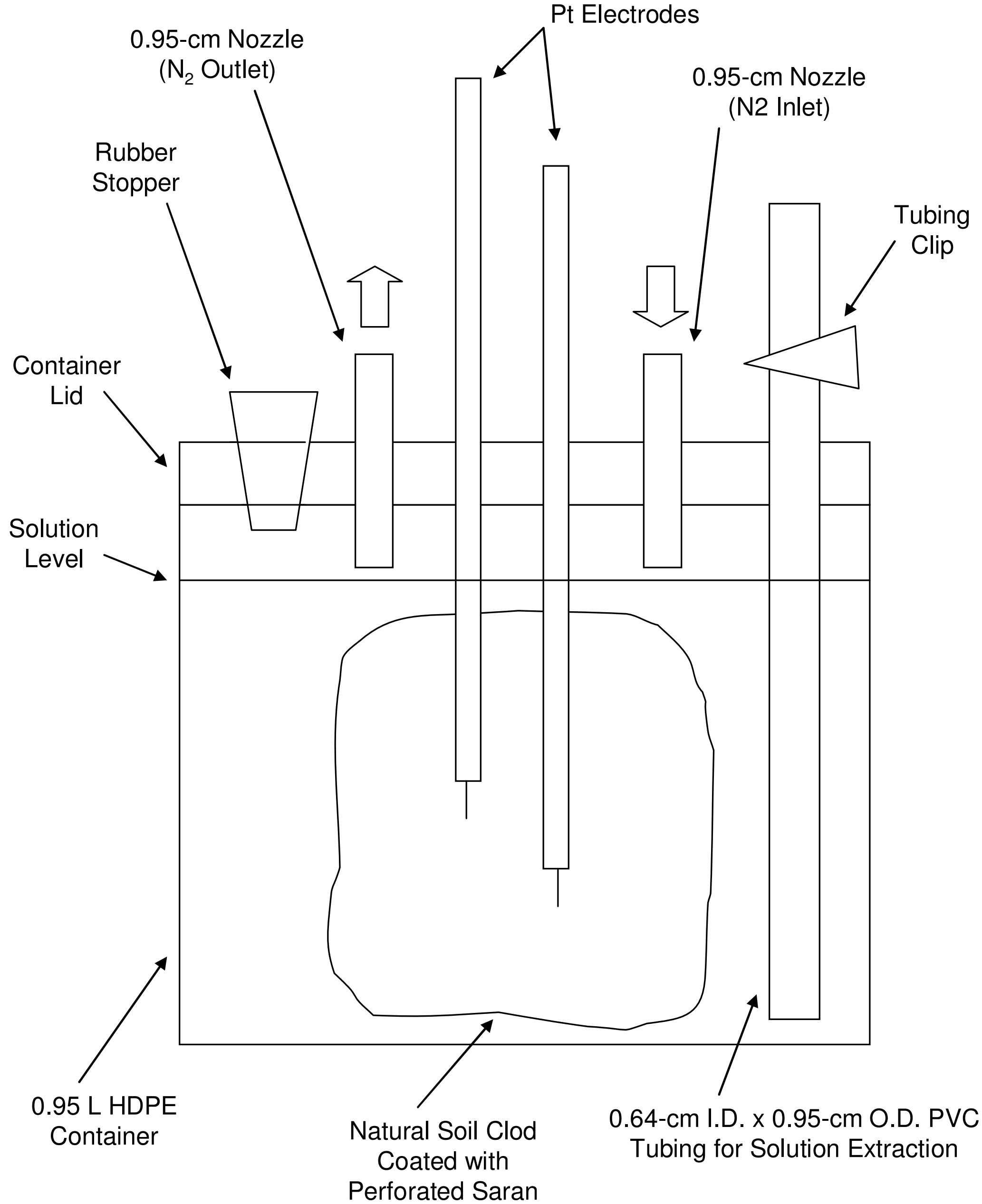

Figure 7. Schematic of a reaction vessel used in Study #2 and Study #3 (not to scale).

Figure 8. Photographs of reaction vessels (top) and air flow regulators (bottom) used in Study #2 and Study #3.

sucrose solution was removed and replaced with distilled water. Clods were submersed in distilled water under N_2 gas for an additional 168 h (7 days) to remove residual sucrose solution from the system. The distilled water was then extracted from each reaction vessel after a total of 672 h (28 days).

Eh and ferrous Fe concentrations in soil solution were monitored throughout the sucrose amendment process. Eh readings were recorded at 24 h, 48 h, 96 h, 168 h, 192 h, 216 h, 288 h, 360 h, 432 h, 504 h, 528 h, 600 h, and 672 h. Ferrous Fe concentrations were measured each time sucrose solution or distilled water was removed (i.e., 168 h, 504 h, and 672 h). Soil pH measurements were recorded after 672 h. In addition, α, ά-dipyridyl was used to verify the presence of ferrous Fe in solution each time sucrose solution or distilled water was removed from the reaction vessels and for random periodic tests.

After the sucrose amendment, the clods were equilibrated under reducing conditions in solutions containing varying concentrations of ferrous Fe (derived from ferrous chloride) for 14 days. The concentrations were determined by the maximum amount of ferrous Fe recovered from the neutral Vertisol in Study #1. Treatments consisted of the following: 1) Control #1 (natural clods; no sucrose or ferrous Fe additions), 2) Control #2 (sucrose but no ferrous Fe additions), 3) low ferrous Fe addition (10 mg L^{-1}), 4) moderate ferrous Fe addition (30 mg L^{-1}), 5) ferrous Fe addition approximately equal to maximum amount in Study #1 (60 mg L^{-1}), and 6) high ferrous Fe addition (100 mg L^{-1}). Each treatment was replicated three times for each soil type (i.e., 126 total clods). The clods for Control #1 were not included in the first portion of Study #2 (Fe removal with sucrose). Instead, three additional clods were included for soil pH measurements at the completion of the sucrose additions (i.e., following Fe removal). The natural soil clods for Control #1 were added to each series during the Fe addition portion of Study #2.

Eh was monitored throughout the Fe equilibration process. Eh readings were recorded at 24 h, 48 h, 96 h, 144 h, 240 h, 288 h, and 336 h. Ferrous Fe concentrations in soil solution were measured at the conclusion of the study (i.e., at 336 h).

Following 14 days of equilibration with ferrous Fe, lids were removed from each reaction vessel and samples were allowed to dry for 14 days. After the drying period, Saran was removed. Each clod was carefully divided in half to expose the interior of the sample. Visual descriptions were made for matrix color, Fe depletions, and Fe concentrations. Each clod was then viewed under a binocular stereoscopic microscope at a magnification of 15X to determine the amount of Fe accumulation. A scaled grid eyepiece was utilized to perform 50 point-counts per sample at a microscopic level.

Upon completion of macromorphic and micromorphic descriptions, selected samples from each treatment were analyzed for citrate-dithionite extractable Fe to determine the final concentration of reducible Fe. Each soil was also analyzed for pH to determine the effects of the biological reduction method, and subsequent addition of ferrous Fe, on soil reaction.

Redox potentials and ferrous Fe concentrations in soil solution were plotted on a time sequence to evaluate their relationship. Mean and standard deviation were calculated for each soil type and treatment to evaluate redox potentials, ferrous Fe concentrations in soil solution, and the percentage of redoximorphic features. A one-way analysis of variance was utilized to evaluate data at a 95% confidence level. If the soil means were significantly different at a sampling interval, Fisher's least significant difference (LSD) was calculated to assess the differences in means within each soil and within each treatment.

Due to limitations in laboratory space, Study #2 was performed in two separate phases. The first phase consisted on the Pledger-low, China, Cieno, Orelia-loamy, Gessner, and Orelia-sandy soils. The second phase consisted of the Pledger-high. Schematics of the reaction vessel layouts in each phase are shown in Figs. 9 and 10.

Study #3 – Redox Features in Unamended/Equilibrated Natural Soil Clods

This study was performed to determine if the expression and amount of redoximorphic features will increase by loading the soil solution with varying concentrations of ferrous Fe in addition to the indigenous easily reducible Fe in the natural soil. The goal was to determine if additional ferrous Fe in solution would result in diagnostic redoximorphic features in the Pledger-high (see discussion in Introduction). Soils used in this study included the Gessner, Cieno, and Pledger-low representing strongly to moderately acidic soil, as well as the Orleia-sandy, Orelia-loamy, and Pledger-high representing neutral soils. Both groups have textures ranging from coarse-loamy to very-fine, and CEC ranging from approximately 5 to 60 $cmol_c$ kg^{-1}.

Clod preparation, reaction vessel setup, and the N_2 gas system for Study #3 were identical to the procedures outlined in Study #2. However, to simulate field conditions, the clods used in Study #3 were not amended with sucrose solution prior to equilibration with ferrous Fe. The clods were equilibrated under reducing conditions in solutions containing varying concentrations of ferrous Fe (derived from ferrous chloride) for 14 days. Treatments consisted of the following: 1) control (natural clods; no ferrous Fe additions), 2) addition of 30 mg L^{-1} ferrous Fe, 3) addition of 60 mg L^{-1} ferrous Fe,

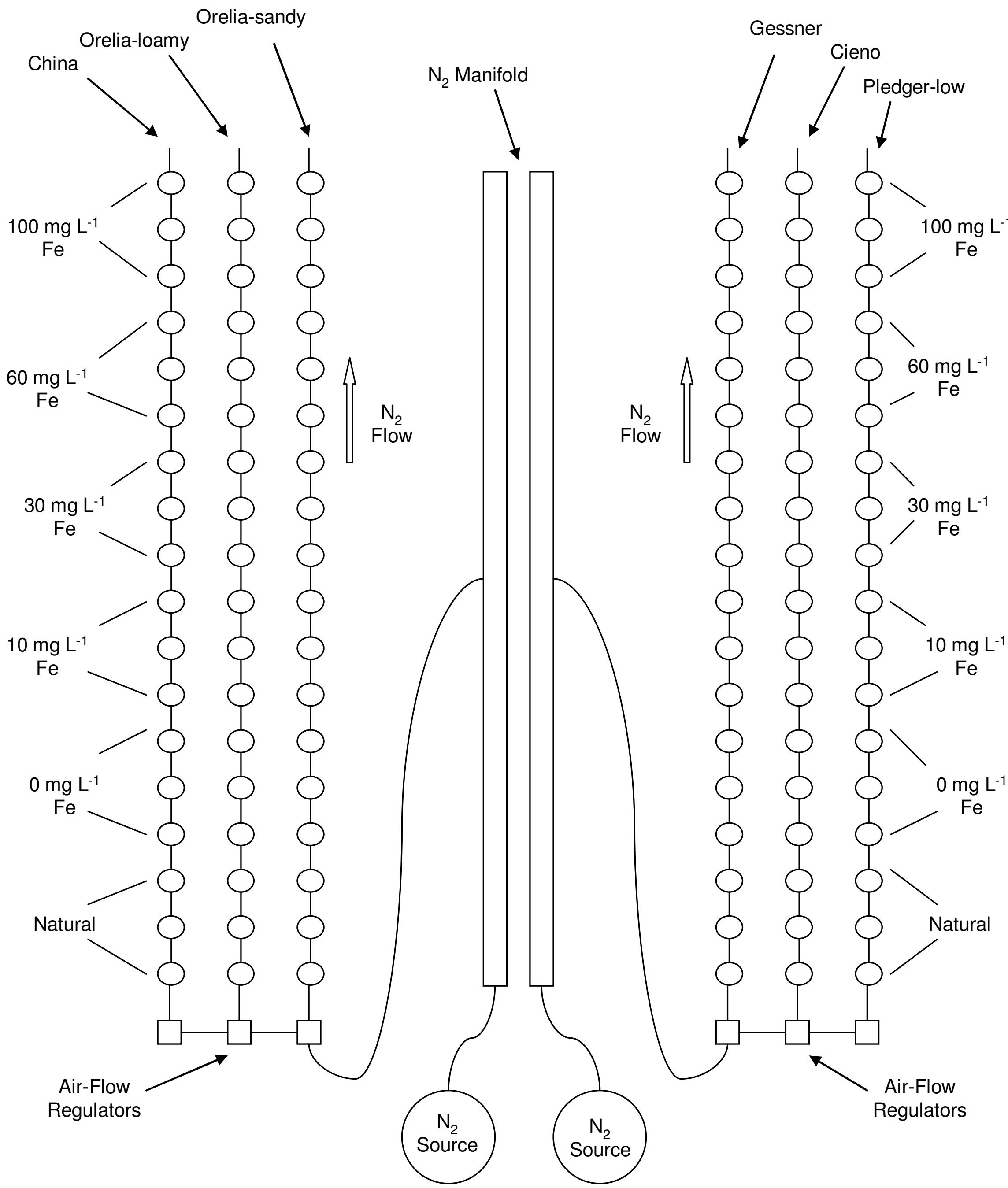

Figure 9. Schematic of the reaction vessel layout for Study #2 (Pledger-low, China, Cieno, Orelia-loamy, Gessner, and Orelia-sandy).

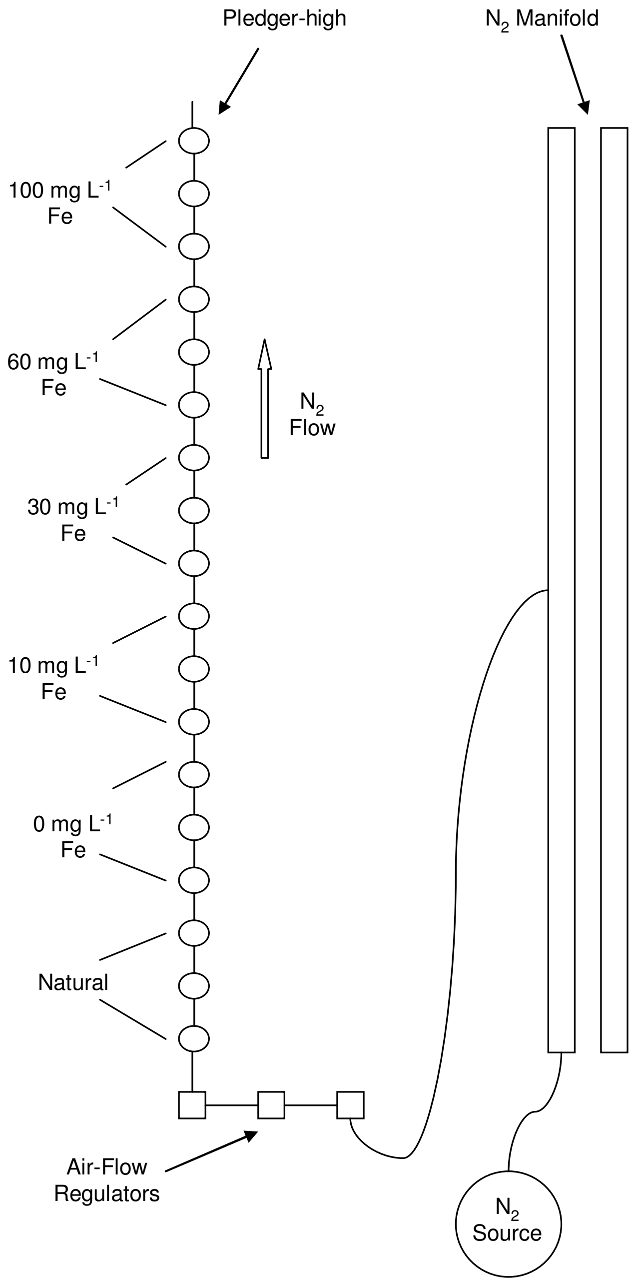

Figure 10. Schematic of the reaction vessel layout for Study #2 (Pledger-high).

and 4) addition of 100 mg L^{-1} ferrous Fe. Each treatment was replicated three times for each soil type (i.e., 72 total clods). A schematic of the reaction vessel layout is shown in Fig. 11. After 14 days, final measurements were collected for Eh and ferrous Fe in soil solution. Lids were removed from the reaction vessels to allow clods to dry for 14 days.

After the drying period, Saran was removed, and each clod was divided in half to expose the interior of the sample. Visual descriptions were made for matrix color, Fe depletions, and Fe concentrations. Each clod was viewed under a binocular stereoscopic microscope at a magnification of 15X to determine the amount of Fe accumulation. A scaled grid eyepiece was utilized to perform 50 point-counts per sample at a microscopic level. Upon completion of macromorphic and micromorphic descriptions, selected samples from each treatment were analyzed for dithionite-citrate extractable Fe and pH.

Mean and standard deviation were calculated for each soil type and treatment to evaluate redox potentials, ferrous Fe concentrations in soil solution, and the percentage of redoximorphic features. A one-way analysis of variance was utilized to evaluate data at a 95% confidence level. If treatment means for a sampling interval were significantly different, Fisher's least significant difference (LSD) was calculated to assess the differences in means within each soil and within each treatment.

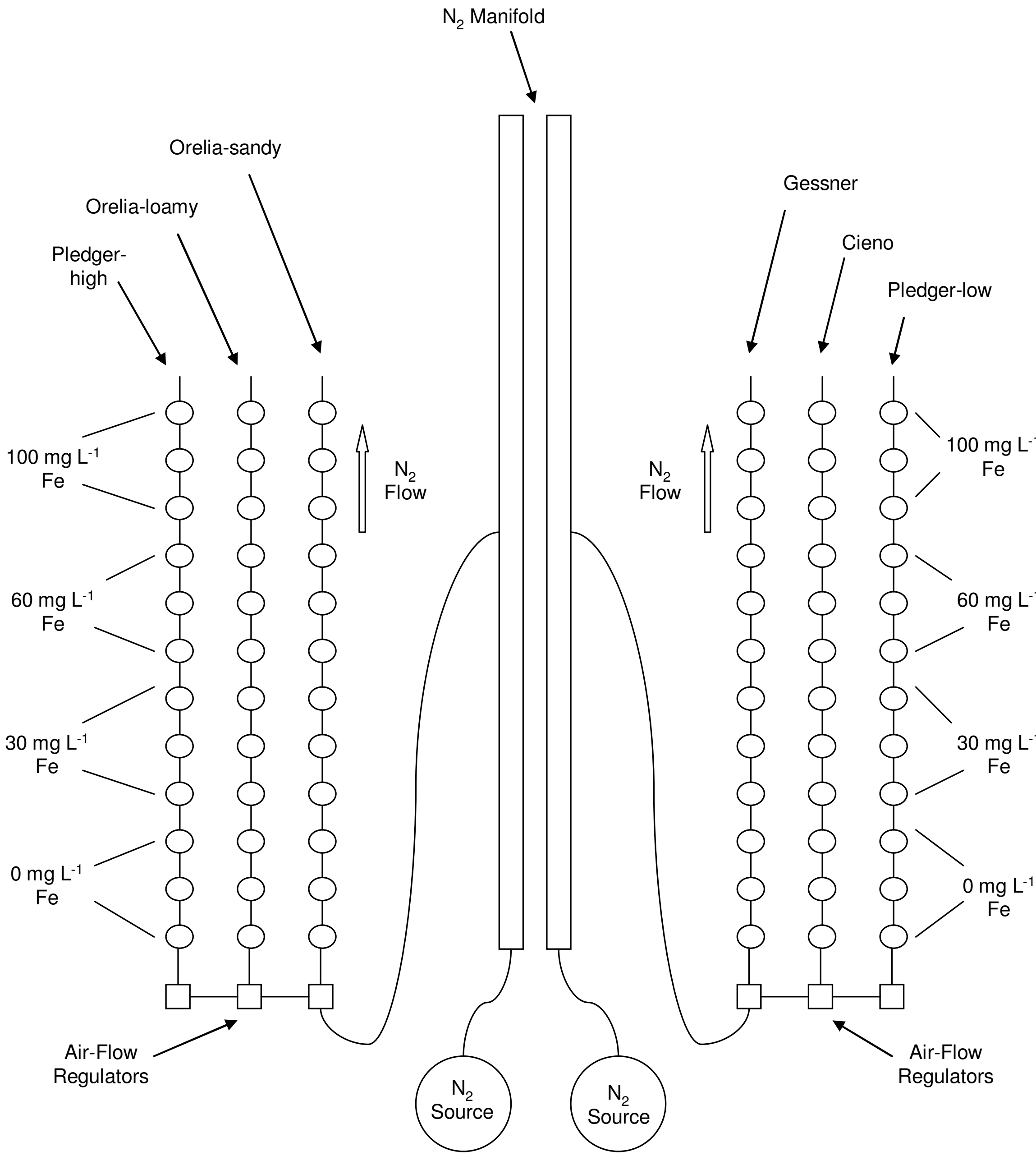

Figure 11. Schematic of the reaction vessel layout for Study #3 (Pledger-low, Pledger-high, Cieno, Orelia-loamy, Gessner, and Orelia-sandy).

RESULTS AND DISCUSSION

Bulk Soil Characterization

Table 3 provides physical and chemical characteristics showing that the selected soils meet the ranges of texture, pH, and CEC intended for the studies. Complete physical and chemical analytical results are included in Appendix B.

Table 3. Selected physical and chemical characteristics.

Soil	Total Sand	Total Silt	Total Clay	Textural Class	pH (H_2O) 1:1	CEC	Org. C	CD Fe
	--------------%-----------					cmol$_c$ kg^{-1}	-------%------	
Pledger-low	3.9	32.8	63.3	C	5.5	47.4	1.79	0.88
China	5.6	29.6	64.8	C	5.1	50.1	2.04	1.20
Pledger-high	2.9	28.0	69.1	C	6.8	57.2	3.27	1.03
Cieno	53.5	22.7	23.8	SCL	5.3	9.3	0.84	0.083
Orelia-loamy	59.9	18.2	21.9	SCL	7.0	17.2	0.82	0.078
Gessner	65.9	22.7	11.4	FSL	4.9	5.5	0.58	0.040
Orelia-sandy	79.0	8.7	12.3	FSL	6.6	11.5	0.93	0.055

Study #1 – Ferrous Fe Concentration in Unamended Bulk Soil

Results from Study #1 are presented in Fig. 12 through Fig. 18 and Table 4 through Table 6. Additional Study #1 data are included in Appendix C.

Pledger-high

Figure 12 shows redox potentials (Eh), ferrous Fe concentrations, and reduced Mn concentrations for the Pledger-high soil over 768 h of continuous ponding. Redox potentials (Eh) ranged from +345 mV within 24 h after inundation to -13 mV at 768 h. Theoretically, the reduction of ferric Fe to ferrous Fe from amorphous Fe oxyhydroxides would occur around an Eh of +150 mV at a pH of 6.8 (Fig. 2). The Pledger-high reached that Eh value between 144 h and 168 h after initial inundation. However, a ferrous Fe concentration of 6.4 mg kg^{-1} was detected after only 48 h (in the initial soil solution extraction) at an Eh of +259 mV. The ferrous Fe concentration at 168 h was 3.5 mg kg^{-1} indicating a decrease from the concentration at 48 h. It should be noted that at 168 h the water level in each Pledger-high reaction vessel was at the soil surface and an additional 50 mL of distilled water was added. No additional distilled water was needed after that point, and the water remained ponded approximately 2 cm above the soil surface for the duration of the study indicating that the soil was satiated. Also, the Eh continued to decrease prior to complete satiation. After 168 h of continuous ponding, a significant increase in Fe reduction was recorded. Between 168 h and 288 h, ferrous Fe concentrations increase from 3.5 mg kg^{-1} to 13.6 mg kg^{-1}, and continued to increase until reaching a maximum concentration of 69.3 mg kg^{-1} at 768 h.

The initial presence of reduced Mn in soil solution was detected at 168 h with a concentration of 2.1 mg kg^{-1} at an Eh of +136 mV. The maximum concentration was 5.6 mg kg^{-1} at 768 h and an Eh of -13 mV. The reduced Mn concentration in the Pledger-high was low and does not appear to be a factor in poising the redox system. In fact, ferrous Fe appeared in solution at least 48 h before Mn.

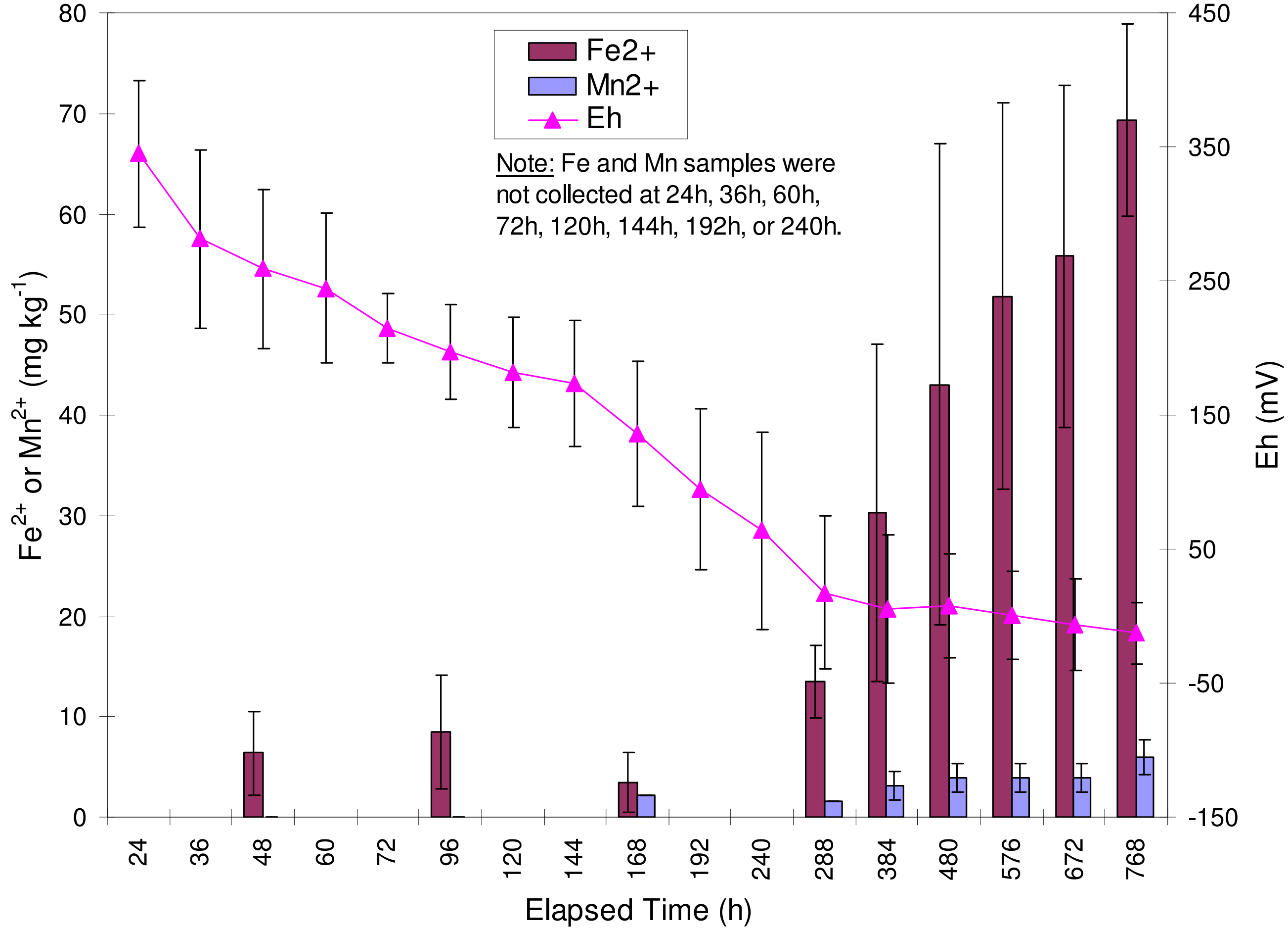

Figure 12. Redox potentials (Eh), ferrous Fe concentrations, and reduced Mn concentrations over time for the Pledger-high soil from Study #1. Values are means of three replicants and error bars represent +/- one standard deviation.

Cieno

Figure 13 shows the redox potentials (Eh), ferrous Fe concentration, and reduced Mn concentration for the Cieno soil over 768 h of continuous ponding. The redox potential (Eh) was +292 mV at 24 h after initial inundation and continuously declined to -98 mV at 768 h. Theoretically, the reduction of ferric Fe to ferrous Fe from amorphous Fe oxyhydroxides would occur around an Eh of +240 mV at a pH of 5.3 (Fig. 2). The Cieno reached that Eh value around 48 h after initial inundation. However, the initial concentration of ferrous Fe detected in solution was 3.5 mg kg^{-1} at 168 h. The ferrous Fe concentration decreased slightly at 288 h and was followed by a continued increase until reaching a maximum concentration of 44.4 mg kg^{-1} at 768 h. An initial reduced Mn concentration of 2.8 mg kg^{-1} was detected after 288 h of ponding at an Eh of +46 mV. Similar to the Pledger-high, ferrous Fe in the Cieno appeared in solution before reduced Mn. The Mn concentration of the Cieno soil was low, but may be a factor in the delayed presence of ferrous Fe in solution after 168 h and at an Eh of +117 mV.

Gessner

Figure 14 shows the redox potentials (Eh), ferrous Fe concentration, and reduced Mn concentration for the Gessner soil over 768 h of continuous ponding. The redox potential (Eh) was +280 mV at 24 h after initial inundation and continuously declined to -106 mV at 768 h. Theoretically, the reduction of ferric Fe to ferrous Fe from amorphous Fe oxyhydroxides would occur around an Eh of +260 mV at a pH of 4.9 (Fig. 2). The Gessner reached that Eh value between 24 h and 36 h after initial inundation, and an initial ferrous Fe concentration of 0.7 mg kg^{-1} was detected in

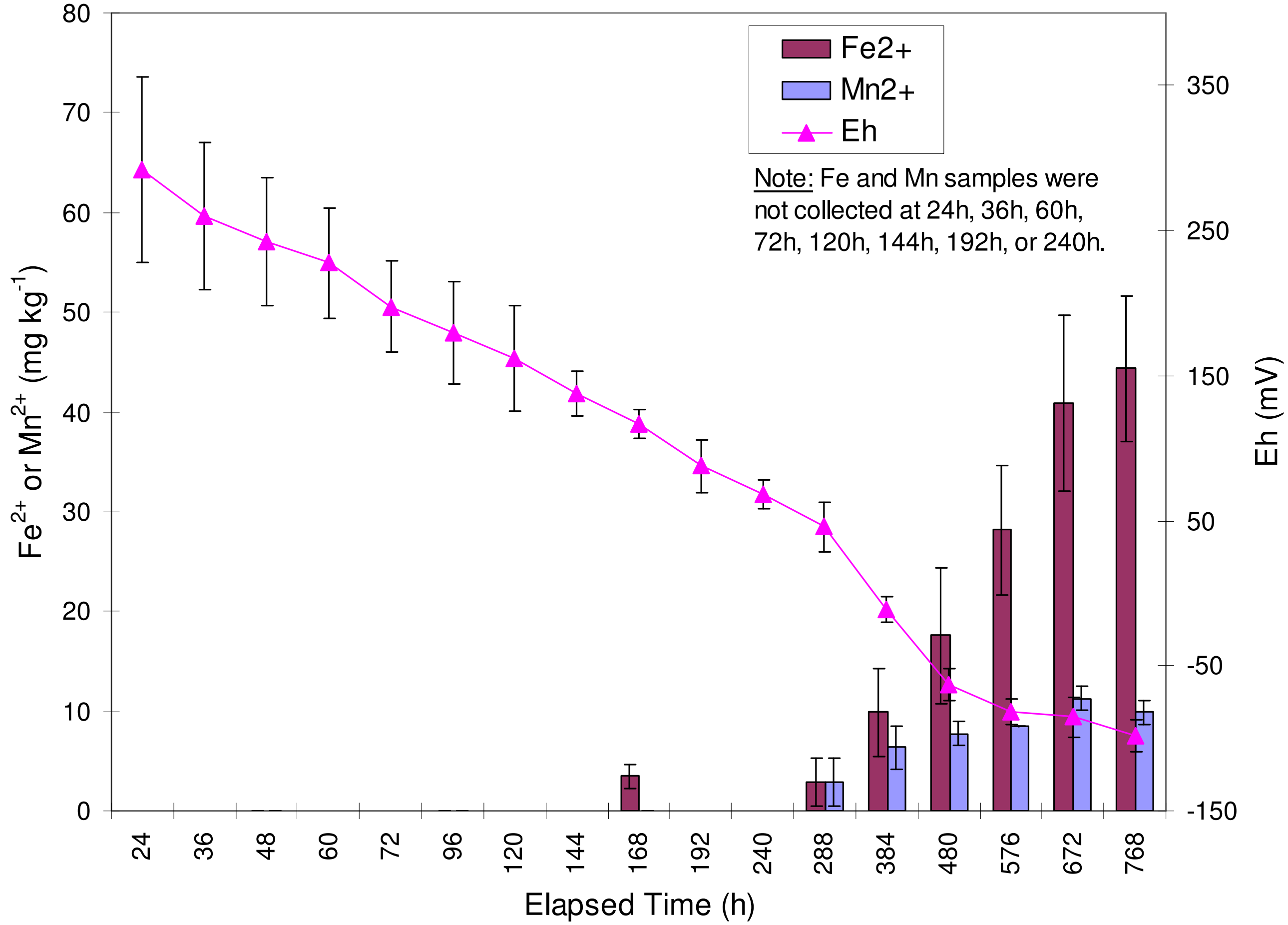

Figure 13. Redox potentials (Eh), ferrous Fe concentrations, and reduced Mn concentrations over time for the Cieno soil from Study #1. Values are means of three replicants and error bars represent +/- one standard deviation.

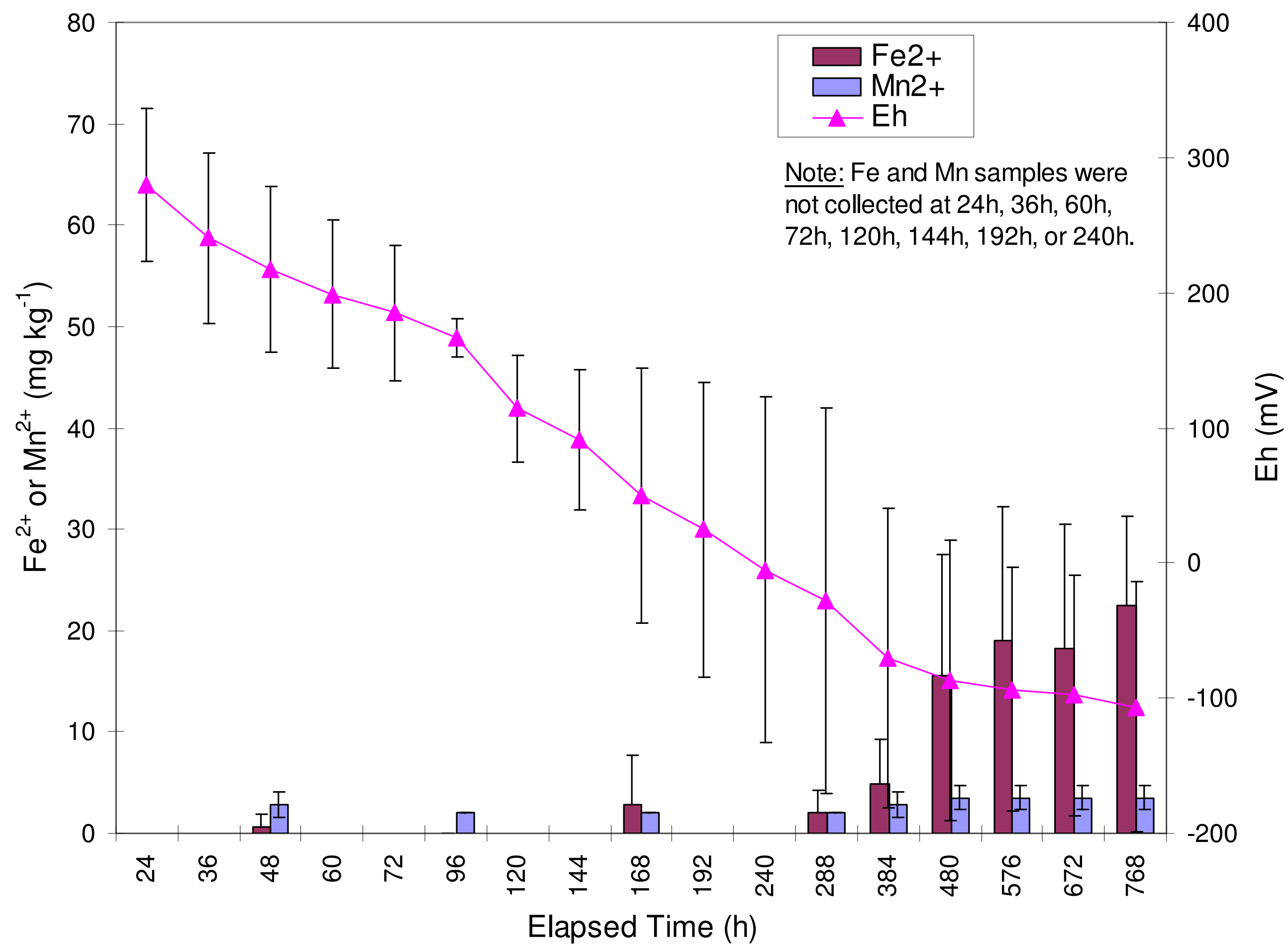

Figure 14. Redox potentials (Eh), ferrous Fe concentrations, and reduced Mn concentrations over time for the Gessner soil from Study #1. Values are means of three replicants and error bars represent +/- one standard deviation.

solution at 48 h (from the initial soil solution extraction). Ferrous Fe was not detected in soil solution at 96 h, but appeared again at 168 h and increased to a maximum concentration of 22.5 mg kg^{-1} at 768 h. The initial reduced Mn concentration was 2.8 mg kg^{-1} after 48 h of ponding at an Eh of +46 mV. Reduced Mn remained in solution throughout the ponding period and increased slightly to a maximum concentration of 3.5 mg kg^{-1} at 768 h.

Comparison of the Pledger-high, Cieno, and Gessner Soils

The Eh value for each soil after 48 h of inundation was +259 mV, +242 mV, and +217 mV for the Pledger-high, Cieno, and Gessner, respectively (Fig. 15). An analysis of the means indicated no significant difference between the Eh values at a 95% confidence level (Table 4). In addition, there was no significant difference in the final Eh values at 768 h between the Pledger-high (Eh at -13 mV), Cieno (Eh at -98 mV), or Gessner (Eh at -106 mV). The only significant difference found over the entire 768 h of inundation occurred at 168 h between the Pledger-high (Eh at 136 mV) and the Gessner (Eh at 50 mV).

The first appearance of ferrous Fe in soil solution for the Pledger-high, Cieno, and Gessner was at 48 h, 168 h, and 48 h, respectively (Fig. 16). As discussed previously, ferrous Fe was detected in the Cieno soil at an Eh of +117 mV. There was a substantial difference between the Eh at initial Fe reduction in the Cieno and the appearance of ferrous Fe in the Pledger-high at an Eh of +259 mV and the Gessner at an Eh of +217 mV.

Table 5 shows the means and standard deviations for ferrous Fe concentrations obtained in Study #1, as well as a comparison of means at the 95% confidence level for selected sample intervals. The final concentration of ferrous Fe in soil solution was

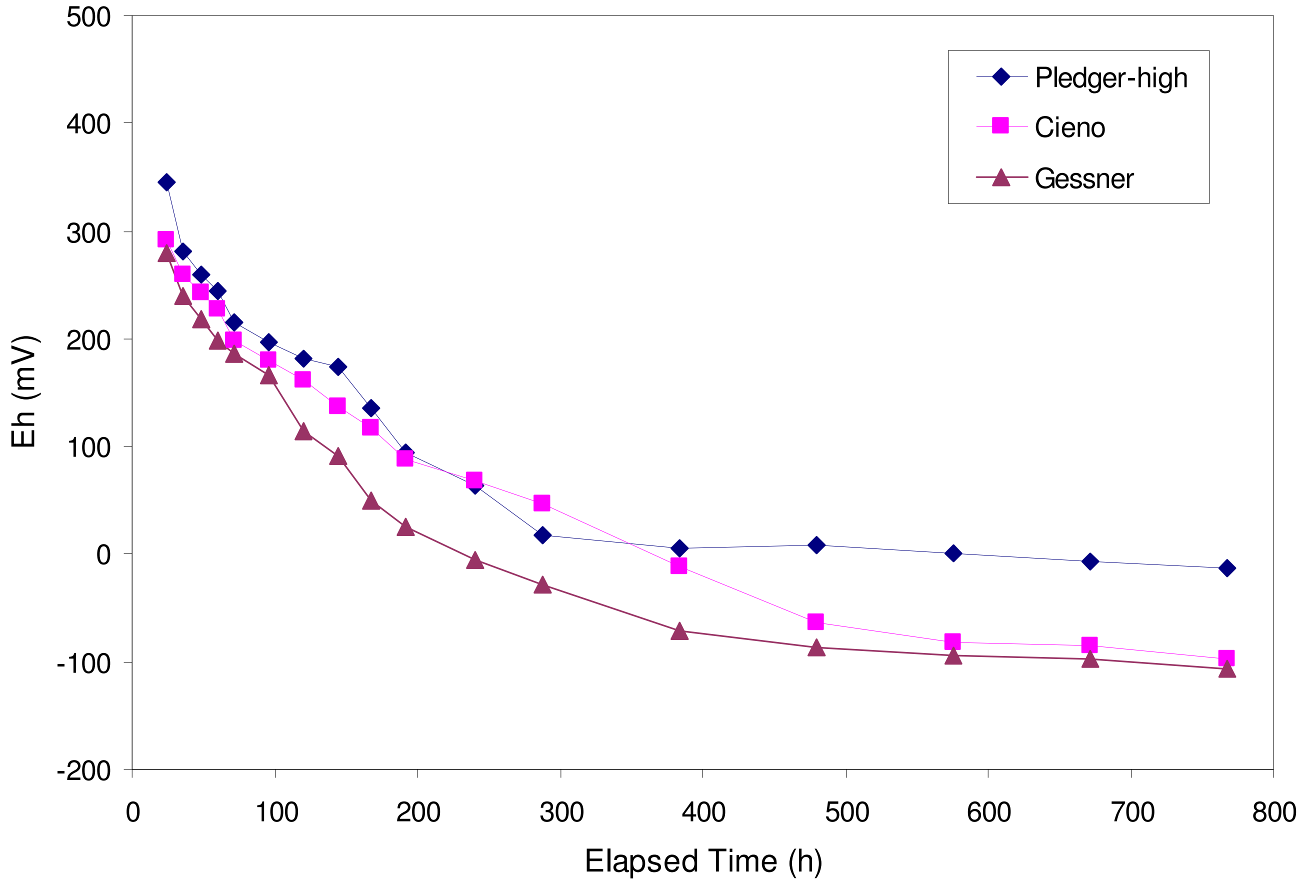

Figure 15. Mean redox potential (Eh) over time for the Pledger-high, Cieno, and Gessner soils from Study #1.

Table 4. Mean and standard deviation (SD) for redox potential (Eh) values from Study #1.

Elapsed Time	Soil	Mean Eh †	SD
h		mV	
24	Pledger-high	345	55
	Cieno	292	64
	Gessner	280	57
36	Pledger-high	281	66
	Cieno	260	51
	Gessner	240	63
48	Pledger-high	259 a	59
	Cieno	242 a	44
	Gessner	217 a	61
60	Pledger-high	244	56
	Cieno	228	38
	Gessner	199	55
72	Pledger-high	215	26
	Cieno	198	31
	Gessner	185	50
96	Pledger-high	197	35
	Cieno	179	35
	Gessner	167	14
120	Pledger-high	182	41
	Cieno	162	36
	Gessner	114	39
144	Pledger-high	174	47
	Cieno	138	15
	Gessner	91	52
168	Pledger-high	136 a	54
	Cieno	117 ab	10
	Gessner	50 b	94
192	Pledger-high	94	60
	Cieno	88	18
	Gessner	25	109

Table 4 Continued.

Elapsed Time	Soil	Mean Eh †	SD
h		mV	
240	Pledger-high	64	73
	Cieno	68	10
	Gessner	-5	128
288	Pledger-high	17	57
	Cieno	46	17
	Gessner	-28	143
384	Pledger-high	5 a	55
	Cieno	-11 a	9
	Gessner	-71 a	111
480	Pledger-high	8	39
	Cieno	-63	11
	Gessner	-87	104
576	Pledger-high	0 a	33
	Cieno	-82 a	9
	Gessner	-94 a	90
672	Pledger-high	-7	34
	Cieno	-85	14
	Gessner	-98	89
768	Pledger-high	-13 a	23
	Cieno	-98 a	11
	Gessner	-106 a	92

† Means within a sampling interval with different letters are significantly different at the 95% confidence level.

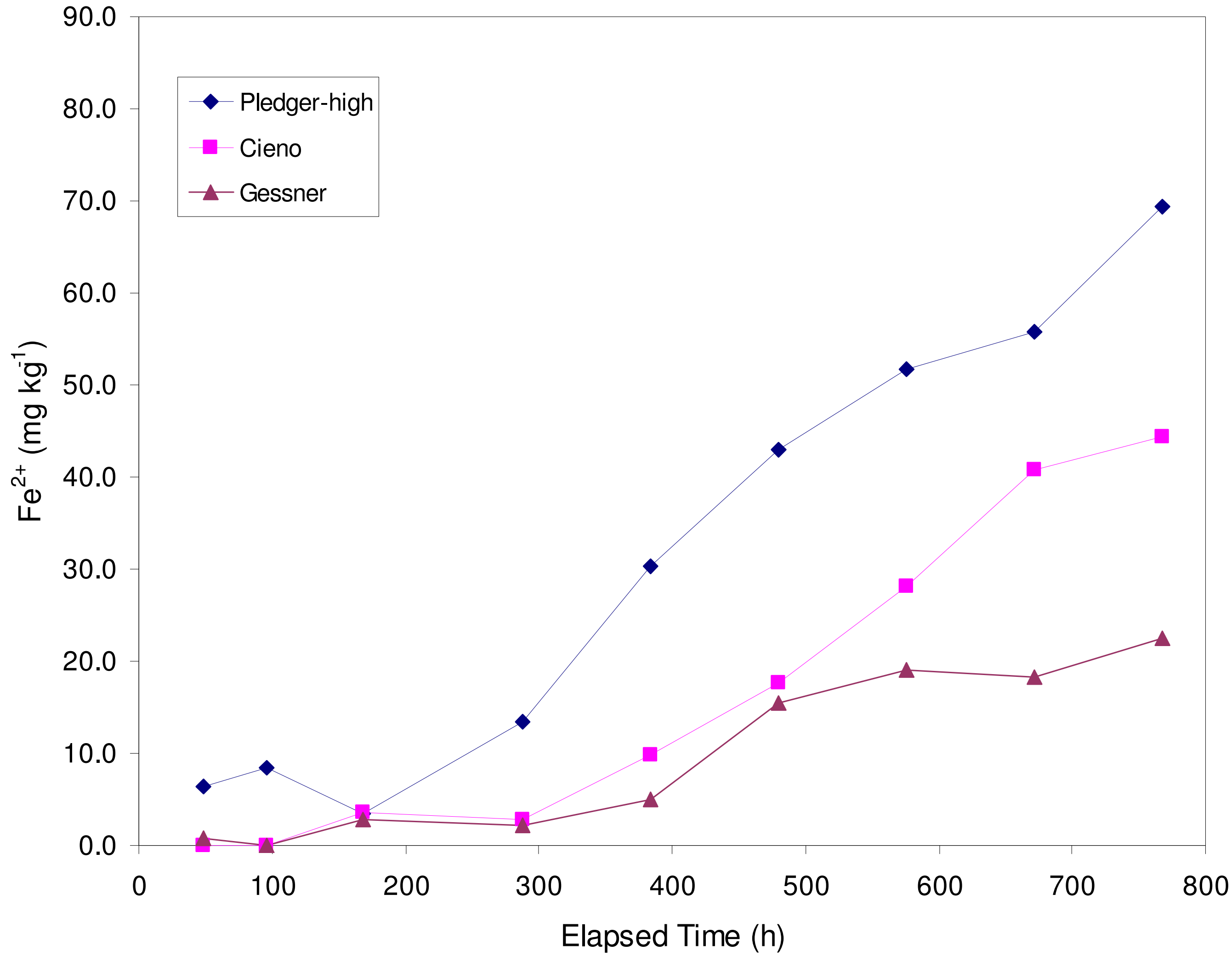

Figure 16. Mean ferrous Fe concentration in soil solution over time for the Pledger-high, Cieno, and Gessner soils from Study #1.

Table 5. Mean and standard deviation (SD) for ferrous Fe concentrations from Study #1.

Elapsed Time	Soil	Mean Fe^{2+} †	SD
h		mg kg^{-1}	
48	Pledger-high	6.4 a	4.2
	Cieno	0.0 b	0.0
	Gessner	0.7 b	1.2
96	Pledger-high	8.5	5.6
	Cieno	0.0	0.0
	Gessner	0.0	0.0
168	Pledger-high	3.5 a	3.0
	Cieno	3.5 a	1.2
	Gessner	2.8 a	4.9
288	Pledger-high	13.5	3.6
	Cieno	2.8	2.4
	Gessner	2.1	2.1
384	Pledger-high	30.3 a	16.8
	Cieno	9.9 a	4.4
	Gessner	4.9 a	4.4
480	Pledger-high	43.0	23.9
	Cieno	17.6	6.8
	Gessner	15.5	12.0
576	Pledger-high	51.8 a	19.2
	Cieno	28.2 a	6.5
	Gessner	19.0 a	13.2
672	Pledger-high	55.8	17.0
	Cieno	40.9	8.8
	Gessner	18.3	12.2
768	Pledger-high	69.3 a	9.6
	Cieno	44.4 b	7.3
	Gessner	22.5 c	8.8

† Means within a sampling interval with different letters are significantly different at the 95% confidence level.

significantly different between the Pleger-high (69.3 mg kg^{-1}), Cieno (44.4 mg kg^{-1}), and Gessner (22.5 mg kg^{-1}).

The first appearance of reduced Mn in soil solution for the Pledger-high, Cieno, and Gessner was at 168 h, 288 h, and 48 h, respectively (Fig. 17). There was a substantial difference in Eh at initial Mn reduction between all three soils (Pledger-high at an Eh of +136 mV, Cieno at an Eh of +46 mV, and Gessner at an Eh of +217 mV).

The final reduced Mn concentration in the Cieno (9.9 mg kg^{-1}) was significantly different from the Pledger-high (5.6 mg kg^{-1}) and the Gessner (3.5 mg kg^{-1}). Table 6 shows the means and standard deviations calculated for reduced Mn concentrations obtained in Study #1, as well as a comparison of means at the 95% confidence level for selected sample intervals.

Reduction of Free Fe Oxyhydroxides

The concentration of Fe from potential "free" Fe oxyhydroxides available for reduction in the study soils was determined by analysis of citrate-dithionite extractable Fe. The results ranged from 8,800 mg kg^{-1} Fe in the Pledger-high to 830 mg kg^{-1} and 400 mg kg^{-1} in the Cieno and Gessner, respectively. Using the concentration of ferrous Fe in soil solution after 768 h of ponding, a comparison was made to show the relative quantity of Fe from free Fe oxyhydroxides found in soil solution. Results of this comparison are found on Fig. 18. Although the Pledger-high contained 8,800 mg kg^{-1} citrate-dithionite extractable Fe, only 69.3 mg kg^{-1} ferrous Fe was found in solution indicating a 0.79% reduction of citrate-dithionite extractable Fe. Approximately 5.35% reduction was found in the Cieno and 5.63% reduction in the Gessner.

Iron is less soluble under reducing conditions in neutral or alkaline soils. The Eh at 768 h was considerably higher (i.e., less reduction) in the Pledger-high (-13 mV)

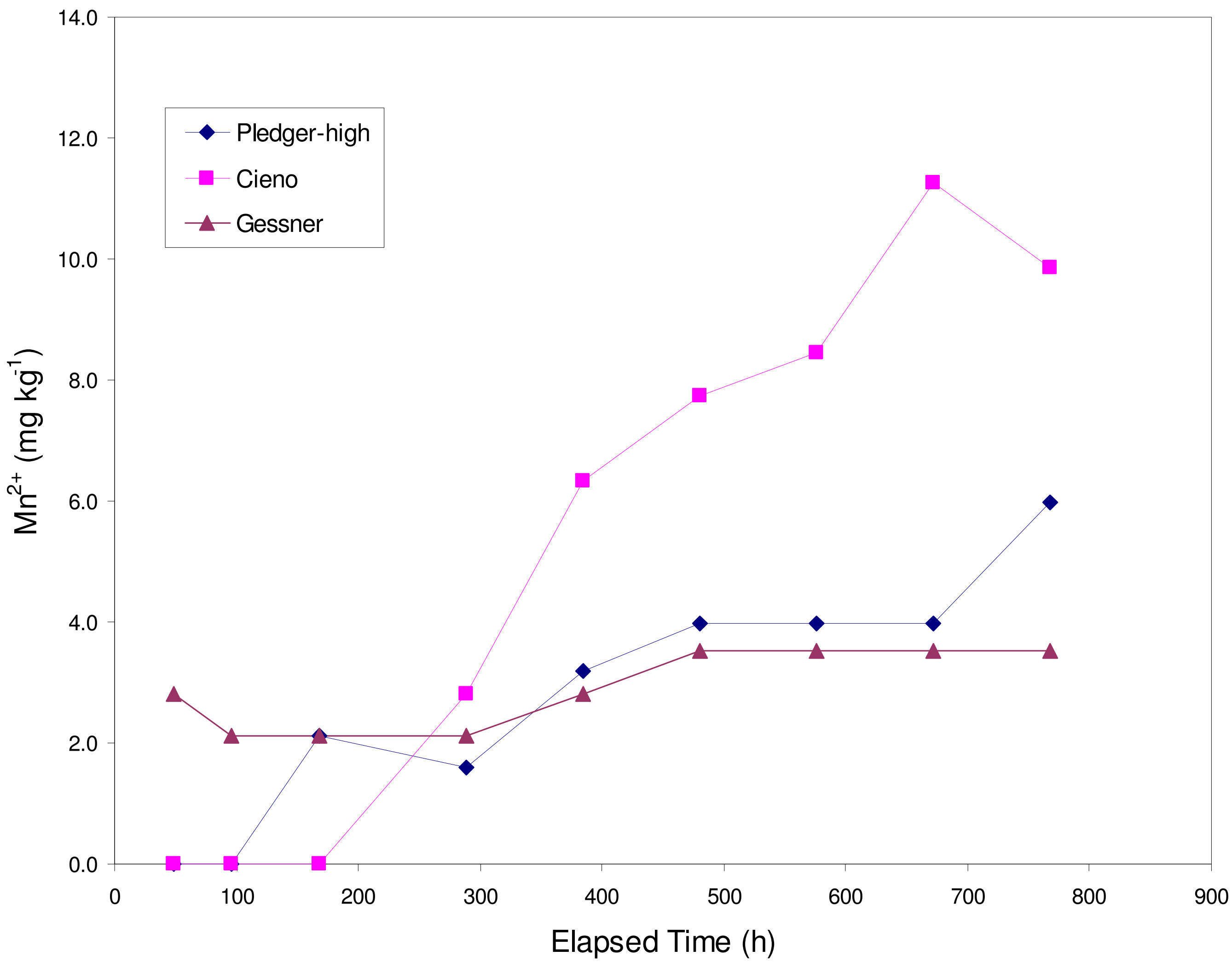

Figure 17. Mean reduced Mn concentration in soil solution over time for the Pledger-high, Cieno, and Gessner soils from Study #1.

Table 6. Mean and standard deviation (SD) for reduced Mn concentrations from Study #1.

Elapsed Time	Soil	Mean Mn^{2+} †	SD
h		mg kg^{-1}	
48	Pledger-high	0.0 a	0.0
	Cieno	0.0 a	0.0
	Gessner	2.8 b	1.2
96	Pledger-high	0.0	0.0
	Cieno	0.0	0.0
	Gessner	2.1	0.0
168	Pledger-high	2.1 a	0.0
	Cieno	0.0 b	0.0
	Gessner	2.1 a	0.0
288	Pledger-high	2.4	0.0
	Cieno	2.8	2.4
	Gessner	2.1	0.0
384	Pledger-high	3.2 a	1.4
	Cieno	6.3 a	2.1
	Gessner	2.8 a	1.2
480	Pledger-high	4.0	1.4
	Cieno	7.7	1.2
	Gessner	3.5	1.2
576	Pledger-high	4.0 a	1.4
	Cieno	8.5 b	0.0
	Gessner	3.5 a	1.2
672	Pledger-high	4.0	1.4
	Cieno	11.3	1.2
	Gessner	3.5	1.2
768	Pledger-high	5.6 a	1.7
	Cieno	9.9 b	1.2
	Gessner	3.5 a	1.2

† Means within a sampling interval with different letters are significantly different at the 95% confidence level.

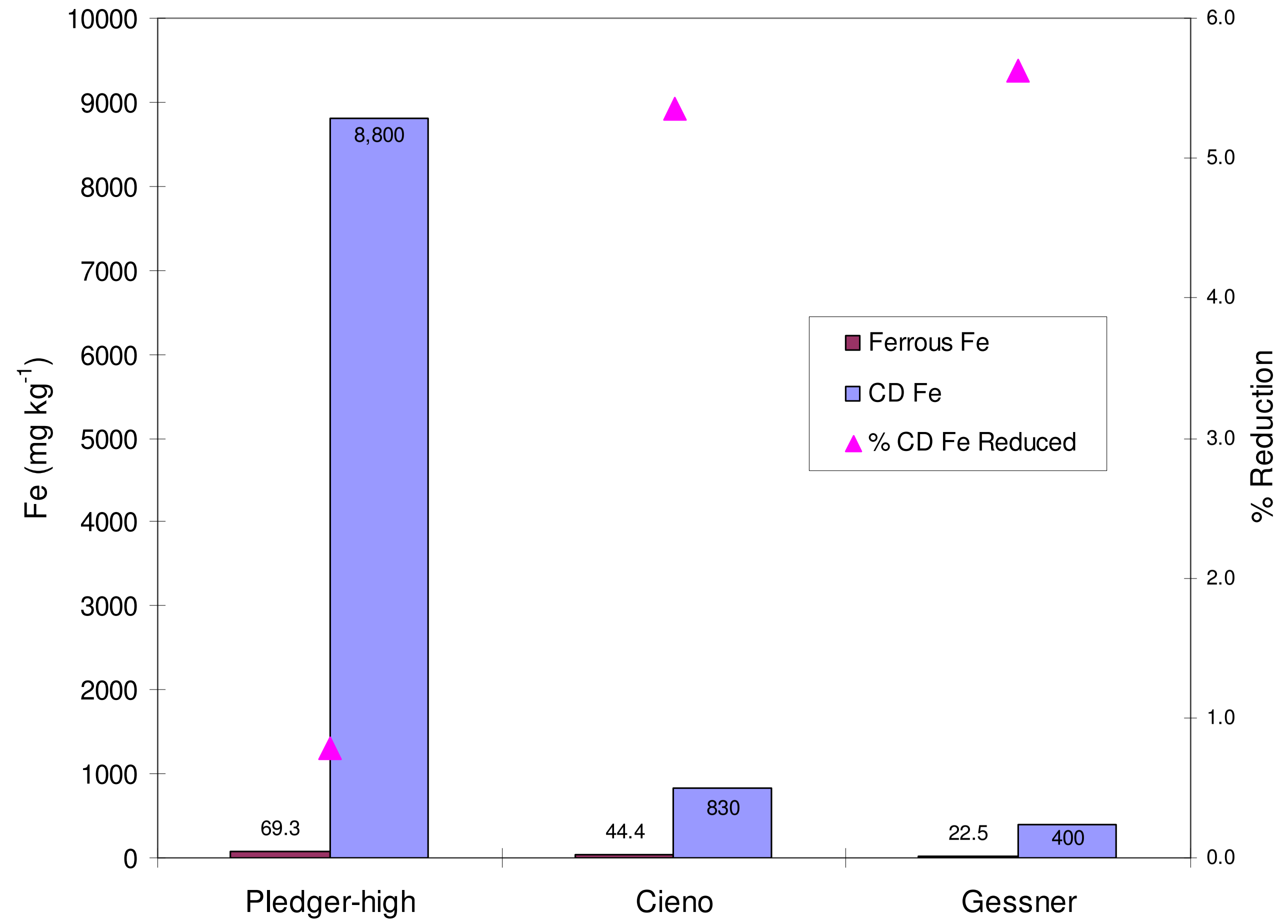

Figure 18. Concentration of ferrous Fe (at elapsed time of 768 h), citrate-dithionite extractable Fe, and percentage of citrate-dithionite extractable Fe reduced (at elapsed time of 768 h) from Study #1.

when compared to the Cieno (-98 mV) and the Gessner (-107 mV). This may indicate that because of the higher pH in the Pledger-high soil, the redox potential did not reach a level low enough to allow for the reduction of a large quantity of free Fe oxyhydroxides (amorphous Fe oxyhydroxides as well as more crystalline Fe oxyhydroxides). The kinetics of Fe reduction is much slower at a higher pH and more time under reducing conditions may be necessary for additional Fe reduction. The Cieno and Gessner soils are more acidic and, therefore, reduction of amorphous Fe oxyhydroxides as well as more crystalline Fe oxyhydroxides was possible and may account for the large difference in quantity of Fe reduced. In addition, the greater quantity of Fe oxyhydroxides in the Pledger-high would require more time to reduce and become soluble due to buffering effects, whereas the reducing reaction in the Cieno and Gessner would occur at a faster rate due to the lower quantity of Fe oxyhydroxides.

Cation exchange capacity may affect the concentration of ferrous Fe in soil solution. The Pledger-high has a high CEC (57.2 $cmol_c\ kg^{-1}$) which may have adsorbed some of the ferrous Fe from soil solution. If approximately 5% of the citrate-dithionite extractable Fe were reduced in the Pledger-high similarly to the Cieno and Gessner, then 440 mg kg^{-1} ferrous Fe would have been present in soil solution. The difference of 370 mg kg^{-1} Fe, which equals to 1.33 $cmol_c$ Fe, could have been adsorbed to the exchange complex of the Pledger-high.

Study #2 – Redox Features in Amended/Equilibrated Natural Soil Clods

Study #2 was conducted in two parts: sucrose amendment and Fe equilibration. The purpose of the sucrose amendment was to reduce the indigenous reducible ferric Fe in the soils and remove the ferrous Fe fraction from solution following reduction. The assumption was that removal of the reducible Fe fraction from each soil would render the soils equal before equilibration with varying amounts of ferrous Fe. Redox potential (Eh), pH, and ferrous Fe concentrations were observed during both parts of this study. Diagnostic redox features were observed following equilibration with ferrous Fe.

Results from Study #2 are included in the figures on pages 56 through 80, as well as Table 7 and Table 8. Additional data are included in Appendix D.

Redox Potential

The redox potential (Eh) trend during sucrose amendment is depicted on Fig. 19. A dramatic decrease in Eh was observed after addition of the initial sucrose amendment until approximately 96 h of elapsed time. The Eh values remained relatively steady from 96 h until the first removal of sucrose solution at 168 h. The Eh values at 168 h ranged from -208 mV in the Pledger-high to -308 mV in Orelia-loamy. An analysis of the means indicated a significant difference in Eh at a 95% confidence level between the neutral fine-textured soil (i.e., Pledger-high) and the acidic fine-textured soils (i.e., Pledger-low and China) after 168 h of sucrose amendment. In addition, the Eh of the neutral fine-loamy soil (Orelia-loamy) was significantly lower than the acidic fine-loamy soil (Cieno), as well as the neutral and acidic coarse-loamy soils (Orelia-sandy and Gessner).

The Eh values in each soil began a steady increase after the addition of the second sucrose amendment at 168 h and the addition of distilled water (i.e., fresh water flush) at 504 h through the conclusion of Fe removal at 672 h. The Eh increase ranged from 71 mV in the Orelia-sandy to 264 mV in the Pledger-high and 388 mV in the Pledger-low. The mean Eh values for the Pledger-low and the Pledger-high were significantly higher than the Eh values for the remaining soils at 672 h. The mean Eh

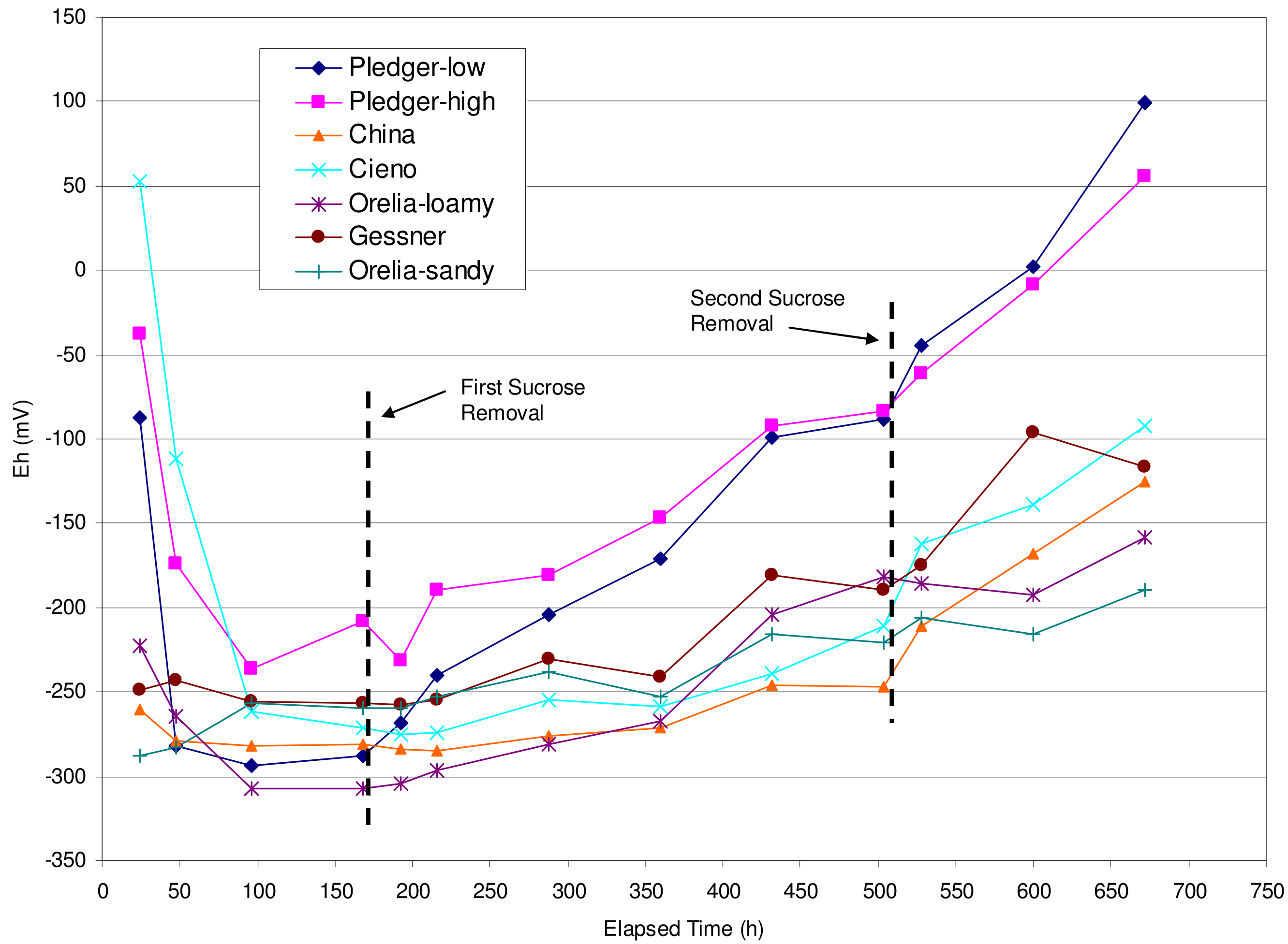

Figure 19. Redox potential (Eh) over time during Fe removal (sucrose amendment) from Study #2.

values at 672 h for the Pledger-low and Pledger-high were 100 mV and 56 mV, respectively, while the Eh values in the remaining soils ranged from -93 mV to -189 mV. Statistical data for Eh values at each solution removal are included in Table 7. Mean and standard deviation were calculated for each recording of Eh values during sucrose amendment and are included as Table D-2 in Appendix D. Table D-3 in Appendix D shows analysis of variance and Fisher's LSD calculations for Eh values at each solution removal.

Redox potential (Eh) values during 336 h of equilibration with varying concentration of ferrous Fe are shown on Fig. 20 through Fig. 26. An additional treatment was added to each series of soil as a control following sucrose amendment. The control consisted of natural clods which were not amendment with sucrose (i.e., indigenous Fe was not removed) and no additional ferrous Fe was added. Redox potentials (Eh) after 24 h of Fe equilibration in treatments previously amended with sucrose were generally similar to the final Eh value at the conclusion of sucrose amendment. The Eh values for these treatments remained relatively stable over the 336 h of equilibration with a general increasing trend. However, Eh values for the control samples (i.e., natural soil clods) for the fine-textured soils (excluding the China soil), acid fine-loamy soil, and neutral coarse-loamy soil were significantly different than the previously amended samples. The control samples for the neutral fine-loamy and acid coarse-loamy soils were significantly different than at least three of the remaining treatments. Statistical data for Eh values after 336 h of equilibration are included in Table 8. Mean and standard deviation for each recording of Eh during equilibration is included as Table D-4 in Appendix D. Table D-5 in Appendix D shows analysis of variance and Fisher's LSD calculations for Eh values after 336 h of equilibration.

Table 7. Mean and standard deviation (SD) for redox potential (Eh) during Fe removal (sucrose amendment) from Study #2.

Elapsed Time	Soil	Mean Eh †	SD
h		mV	
168	Pledger-low	-288 a	14
	Pledger-high	-208 b	52
	China	-281 a	10
	Cieno	-271 ac	13
	Orelia-loamy	-307 d	38
	Gessner	-257 c	14
	Orelia-sandy	-260 c	67
504	Pledger-low	-88 a	165
	Pledger-high	-84 a	109
	China	-247 b	46
	Cieno	-211 bc	98
	Orelia-loamy	-182 c	137
	Gessner	-190 c	70
	Orelia-sandy	-220 bc	39
672	Pledger-low	100 a	141
	Pledger-high	56 a	82
	China	-126 bc	147
	Cieno	-93 c	138
	Orelia-loamy	-158 bd	135
	Gessner	-116 bc	102
	Orelia-sandy	-189 d	62

† Mean Eh values followed by different letters indicate significant differences at the 95% confidence level.

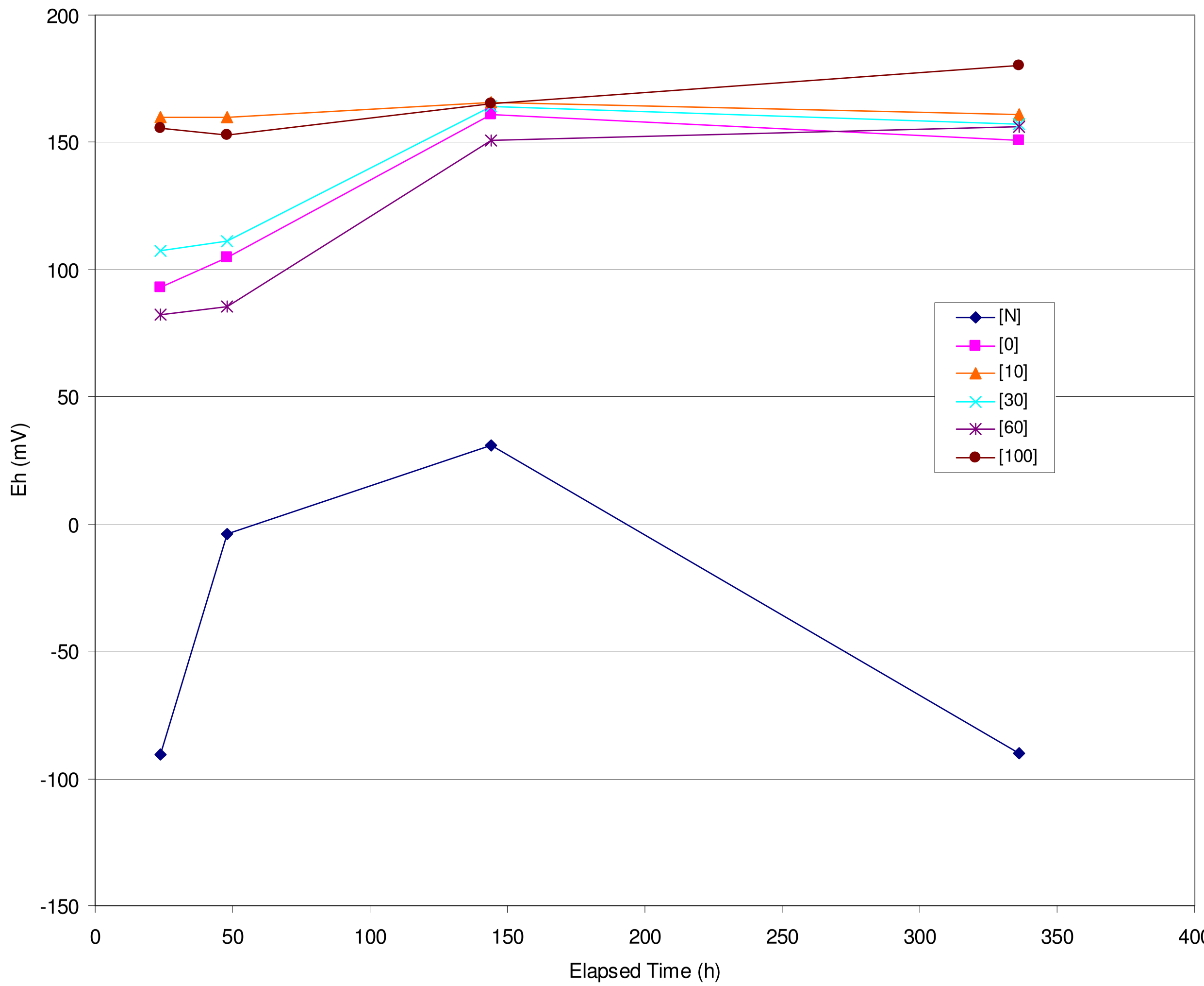

Figure 20. Redox potential (Eh) over time during Fe equilibration for Pledger-low from Study #2.

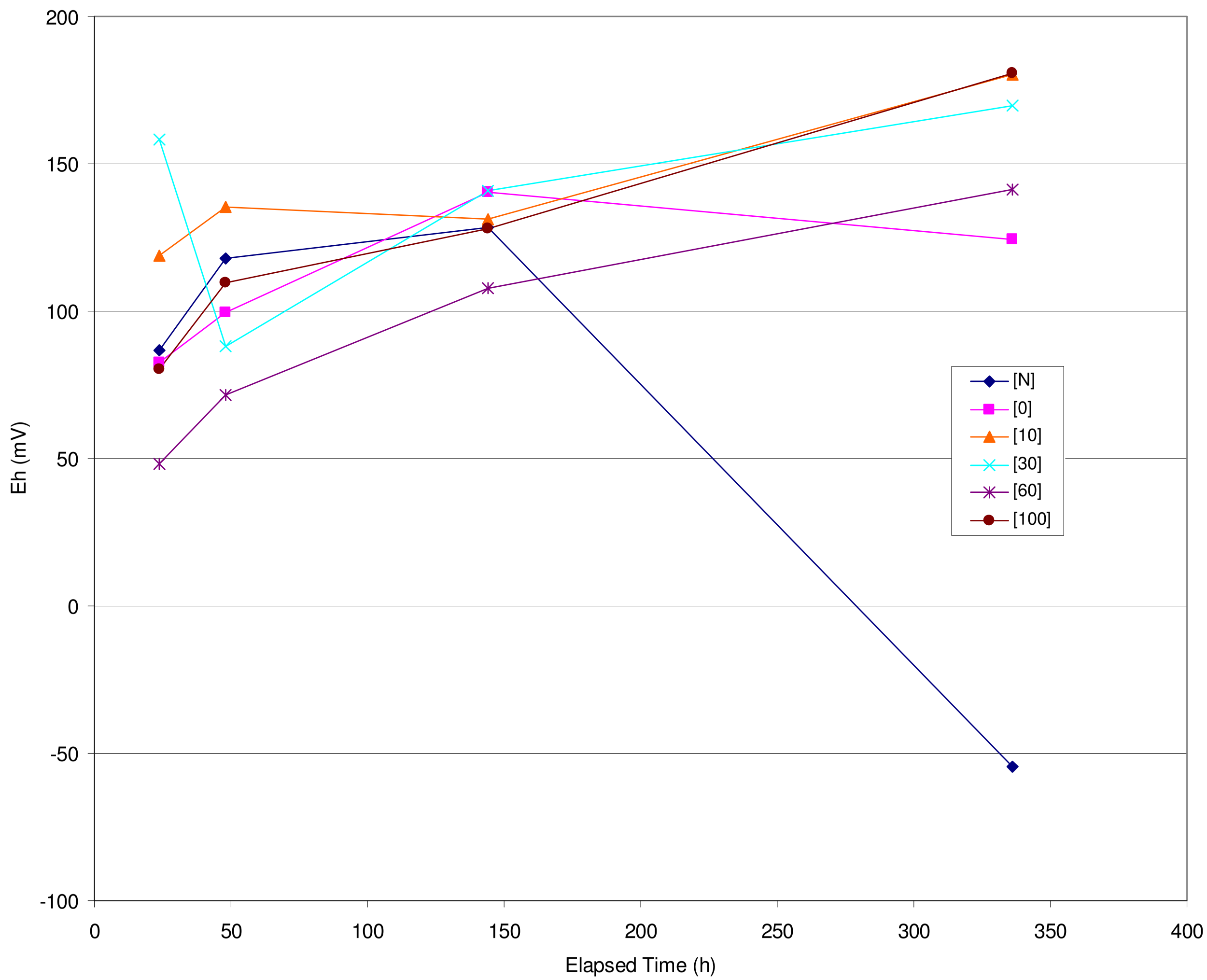

Figure 21. Redox potential (Eh) over time during Fe equilibration for Pledger-high from Study #2.

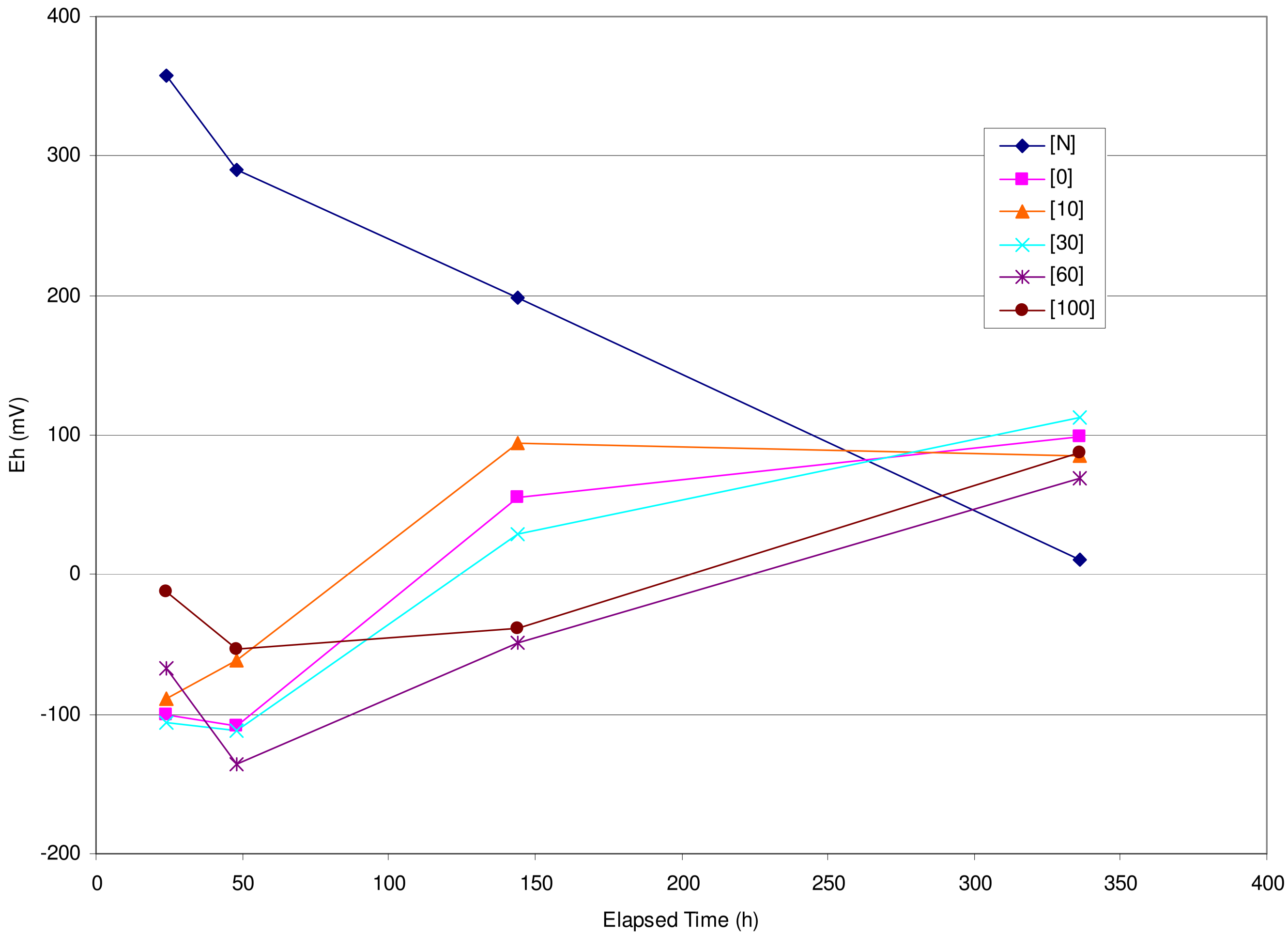

Figure 22. Redox potential (Eh) over time during Fe equilibration for China from Study #2.

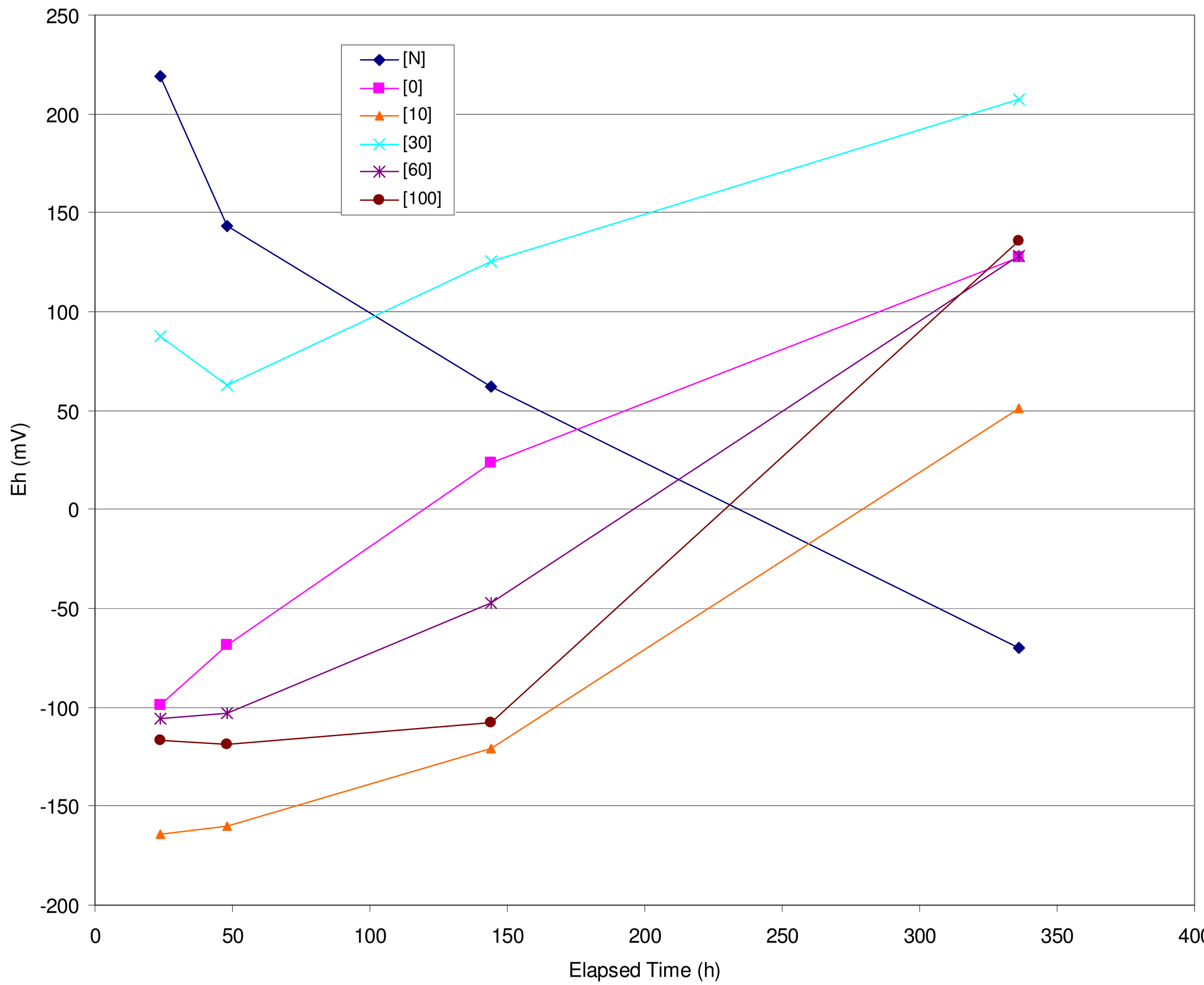

Figure 23. Redox potential (Eh) over time during Fe equilibration for Cieno from Study #2.

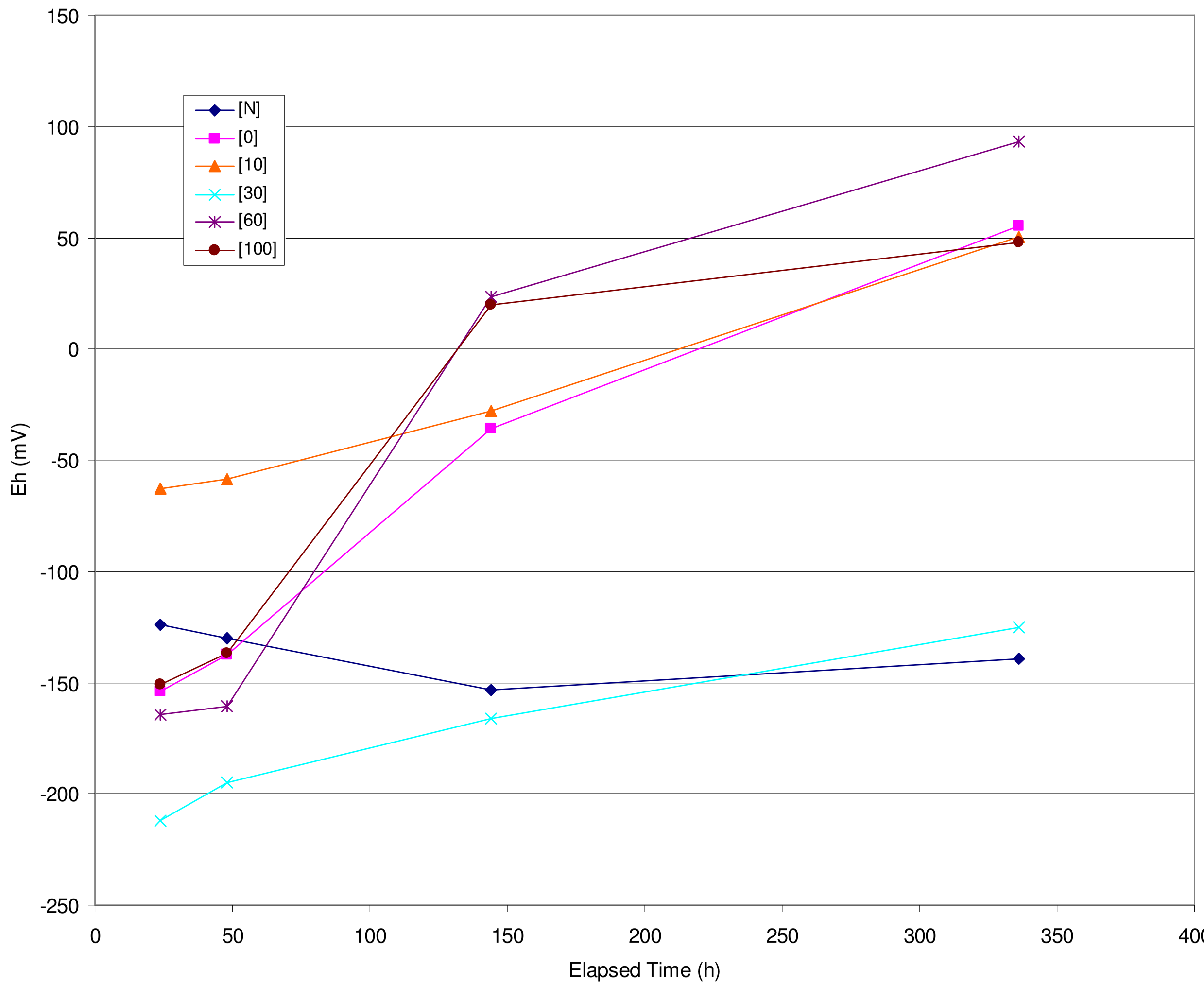

Figure 24. Redox potential (Eh) over time during Fe equilibration for Orelia-loamy from Study #2.

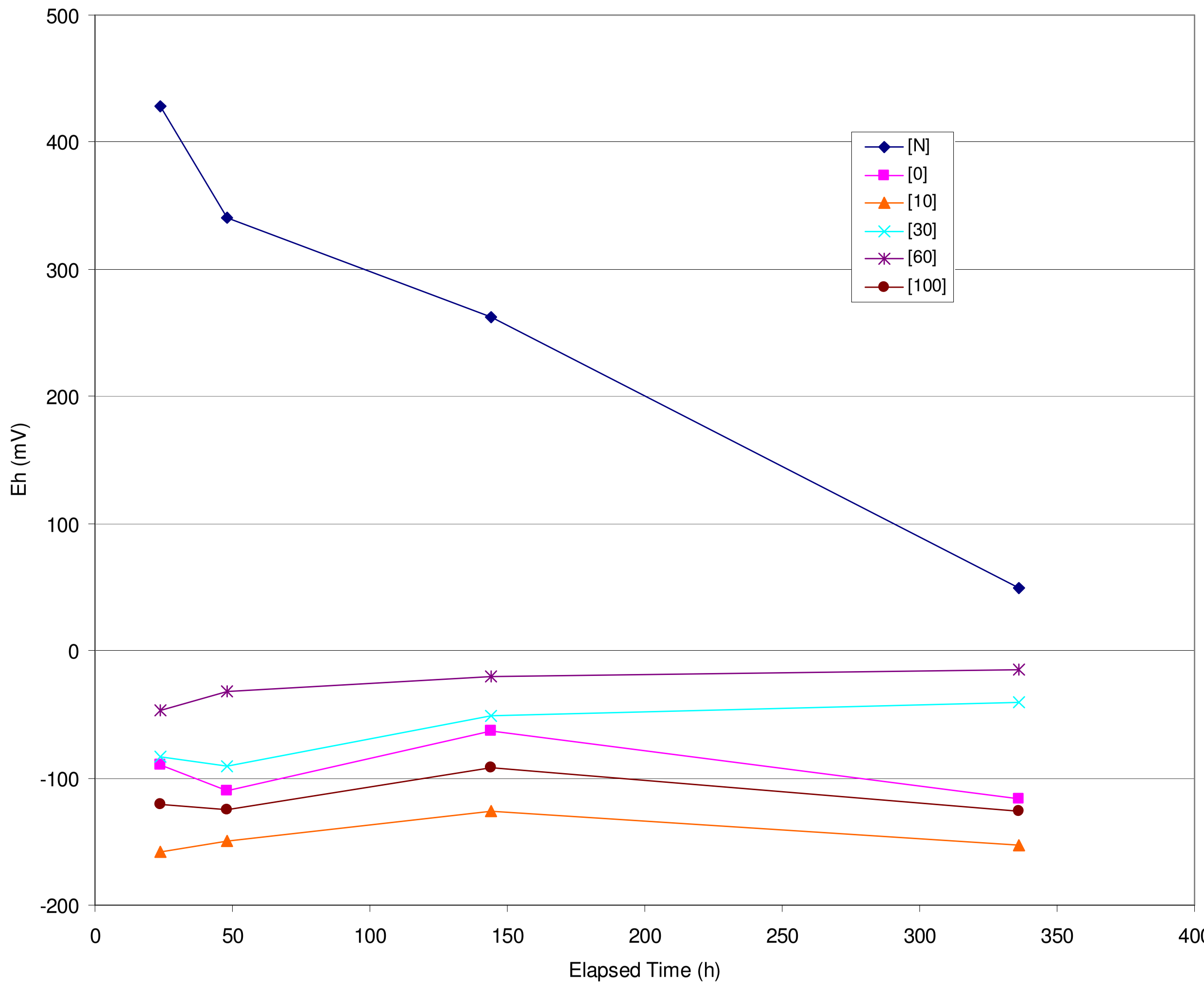

Figure 25. Redox potential (Eh) over time during Fe equilibration for Gessner from Study #2.

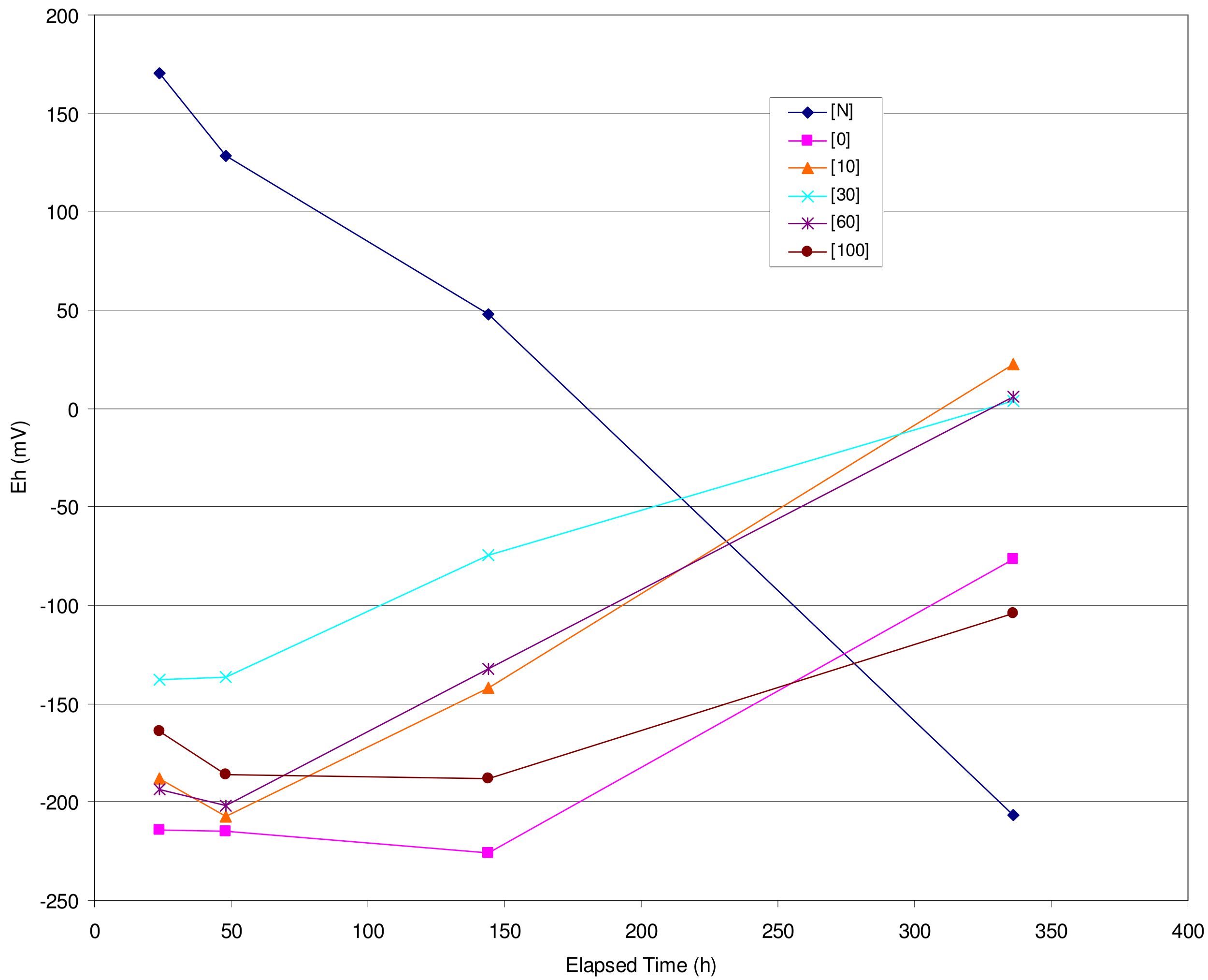

Figure 26. Redox potential (Eh) over time during Fe equilibration for Orelia-sandy from Study #2.

Table 8. Mean and standard deviation (SD) for redox potential (Eh) after 336 h of equilibration from Study #2.

Soil	Treatment	Mean Eh †	SD
	mg Fe^{2+} L^{-1}	mV	
Pledger-low	[N]	-90 a	51
	[0]	151 b	37
	[10]	161 b	22
	[30]	157 b	70
	[60]	156 b	59
	[100]	180 b	19
Pledger-high	[N]	-55 a	25
	[0]	124 b	25
	[10]	181 c	48
	[30]	170 bc	54
	[60]	141 bc	40
	[100]	181 c	58
China	[N]	10 a	64
	[0]	99 a	33
	[10]	86 a	95
	[30]	112 a	86
	[60]	69 a	163
	[100]	88 a	114
Cieno	[N]	-70 a	68
	[0]	128 bd	82
	[10]	51 b	72
	[30]	207 c	38
	[60]	128 bd	54
	[100]	136 cd	74
Orelia-loamy	[N]	-140 a	45
	[0]	55 b	90
	[10]	50 b	43
	[30]	-125 a	166
	[60]	93 b	50
	[100]	48 b	175

Table 8 Continued.

Soil	Treatment	Mean Eh †	SD
	mg Fe^{2+} L^{-1}	mV	
Gessner	[N]	49 a	113
	[0]	-116 bc	106
	[10]	-153 c	61
	[30]	-40 ab	80
	[60]	-15 ab	116
	[100]	-126 bc	80
Orelia-sandy	[N]	-206 a	13
	[0]	-76 bc	36
	[10]	22 b	90
	[30]	4 b	94
	[60]	6 b	73
	[100]	-104 c	143

† Mean Eh values followed by different letters indicate significant differences at the 95% confidence level.

Redox potential (Eh) for the Pledger-low control reached -91 mV at 24 h and then increased to 31 mV at 144 h before decreasing to -90 mV at 336 h (Fig. 20). By comparison, the Pledger-low 30 ppm treatment increased from 110 mV at 24 h to 155 mV at 336 h which was similar to the trend in the remaining treatments (i.e, 0 ppm, 10 ppm, 60 ppm, and 100 ppm). The Eh trend for the Pledger-high control was similar to the Pledger-low control. The Pledger-high control reached 87 mV at 24 h and then increased to 128 mV at 144 h before decreasing to -55 mV at 336 h (Fig. 21). The Eh values at 336 h in both control treatments for the Pledger-low and Pledger-high were significantly different from all remaining treatments.

Redox potential (Eh) for the control treatment in the China, Cieno, Gessner, and Orelia-sandy resulted in similar decreasing trends from 24 h to 336 h (Fig. 22, 23, 25, and 26, respectively). However, the Eh values at 24 h in each of these soils were considerably higher than the Pledger-low and Pledger-high. In addition, the Eh values in the China, Cieno, Gessner, and Orelia-sandy continued to decrease substantially from 24 h to 336 h unlike the the Pledger-low and Pledger-high. For example, the Eh value at 24 h in the China soil (acidic, fine-textured) was 358 mV and decreased sharply to 10 mV at 336h. By comparison, the Eh value in the Pledger-low (also acidic and fine-textured) reached -91 mV at 24 h and then increase to 31 mV at 144 h before decreasing to -90 mV at 336 h.

The Eh trend in the Orelia-loamy control behaved differently than all other soils during the 336 h of equilibration (Fig. 24). The Eh at 24 h reached -124 mV and then remained stable over 336 h with a final Eh value of -140 mV.

Soil Reaction (pH)

Results for changes in pH during Study #2 are depicted on Fig. 27 and included as Table D-6 in Appendix D. Changes in pH for each soil were observed and comparisons were made for native samples (not included during sucrose amendment or during Fe equilibration), amended treatments (amended with sucrose but not included during Fe equilibration), control treatments (amended with sucrose and included during Fe equilibration, but no Fe added), and equilibrated treatments (amended with sucrose and then equilibrated with Fe addition).

The amended samples were compared to pH values of native soil following the sucrose amendment procedure. Soil reaction (pH) in the amended samples decreased for all seven study soils. The decrease in pH ranged from 0.5 standard units (s.u.) in the Pledger-high to 1.1 s.u. in the Gessner. The control and equilibrated samples were compared to native samples following the equilibration procedure. The pH values for six of the seven soils were lower in the control samples by 0.1 to 0.5 s.u. Only the Gessner soil remained unchanged. The pH values for all seven soils decreased in the equilibrated samples by 0.2 to 1.8 s.u. A similar trend when the equilibrated samples were compared to the control samples. The pH values in the equilibrated samples for all seven soils decreased by 0.2 to 1.6 s.u.

The amended samples were then compared to equilibrated samples. The pH of the naturally acidic soils (i.e., Pledger-low, China, Cieno, and Gessner) increased in the equilibrated samples by 0.1 to 0.9 s.u. The pH of the naturally neutral soils (i.e., Pledger-high, Orelia-loamy, and Orelia-sandy) continued to decrease by 0.3 to 1.0 s.u.

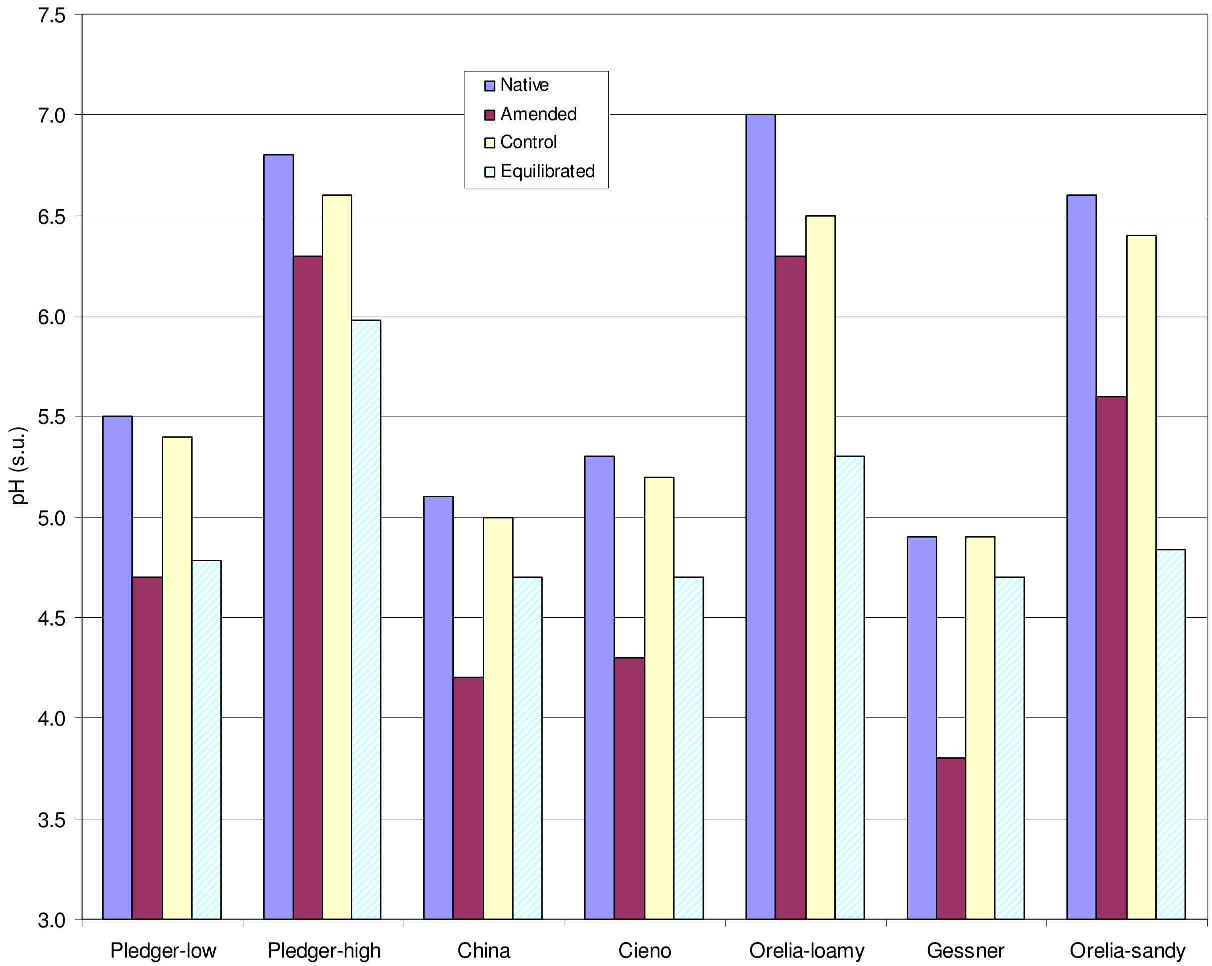

Figure 27. Mean soil reaction (pH) values during sucrose amendment and Fe equilibration from Study #2.

The biological reduction procedure with sucrose affected the normal trend of pH changes in saturated and reduced soils. Normally, soil undergoing reduction will proceed toward a pH of 7. The pH of alkaline soils generally decrease as a result of CO_2 produced by biological activity while the pH of acid soils increases due to the consumption of H^+ by reduction reactions (Ponnamperuma, 1972). The increase in CO_2 produced by biological activity with the addition of labile organic matter (i.e., sucrose amendment) may have contributed to the downward trend in pH for all soils. In addition, a large amount of ferrous Fe in solution during the sucrose amendment procedure was available to replace exchangeable bases. These replaced bases may have been removed during extraction of the sucrose solution.

Ferrous Fe and Redox Features

The amount of ferrous Fe removed by biological reduction and the corresponding percent reduction of CD extractable Fe during the sucrose amendment procedure is presented in Fig. 28. The amount of ferrous Fe removed by sucrose amendment ranged from 64 mg kg^{-1} in the loamy, neutral Orelia-loamy soil to 2,207 mg kg^{-1} in the clayey, acidic China soil. The reduction of CD extractable Fe ranged from 5% in the clayey, neutral Pledger-high soil to 41% in the sandy, acidic Gessner soil. A large difference in CD extractable Fe reduction between acidic and neutral soils was noted in each textural class. A 22% reduction was observed in the fine-loamy, acidic Cieno compared to 8% in the neutral Orelia-loamy. A 41% reduction was recorded in the Gessner compared to 17% in the Orelia-sandy. A 18% reduction was observed in the fine-textured, acidic China (18% reduction) compared to 5% in the neutral Pledger-high. However, the reduction of CD extractable Fe was similar in the Pledger-low (fine-

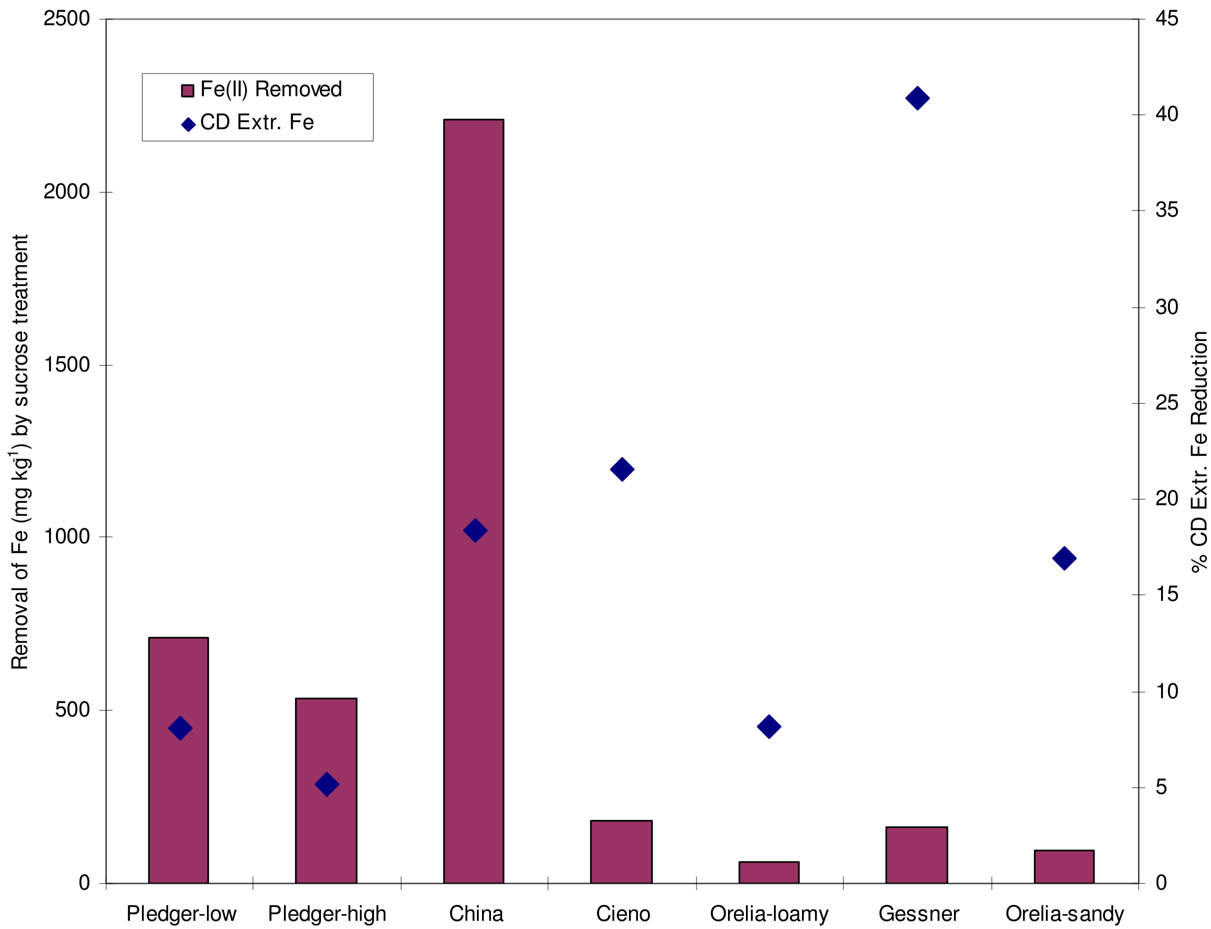

Figure 28. Amount of ferrous Fe removed during sucrose amendment and percent reduction of CD extractable Fe from each soil during Study #2. Values are the means of all clods of each soil receiving sucrose treatment.

textured, acidic) and Pledger-high (fine-textured, neutral) with results of 8% and 5%, respectively. The calculated values for ferrous Fe removal and CD extractable Fe reduction are included in Table D-7 of Appendix D. Overall, the biological reduction method with 5% sucrose proved more effective in removing free iron oxides from coarse-loamy and fine-loamy soils, with the exception of the Orelia-loamy soil, and less effective in removing free iron oxides from fine-textured soils, with the exception of the China soil. Also, the method was more effective in removing free iron oxides from acidic soils then near neutral soils of similar texture.

The results of the Fe equilibration portion of Study #2 are included in Fig. 29 through Fig. 35. Ferrous Fe in solution following equilibration and the corresponding redox concentrations were recorded for each soil. The sucrose amendment procedure had a profound effect on the ferrous Fe in solution available for transport and subsequent segregation into redox features. The results indicate that the amounts of ferrous Fe added to the soil after removal of free iron oxides by biological reduction were insufficient to cause significant changes in concentrations of ferrous Fe in solution. Any ferrous Fe in solution was likely adsorbed on exchange sites to replace iron removed during the sucrose amendment. This is evident in the coarse-loamy soils (Gessner and Orelia-sandy) and fine-loamy soils (Cieno and Orelia-loamy) where no redox concentrations were identified upon oxidation. Redox concentrations were observed in the fine-textured soils upon oxidation almost exclusively as pore linings. This shows a difficulty in diffusion through finer pores and a tendency to retard the translocation of Fe. In addition, the higher CEC in the Pledger-low, Pledger-high, and China could have hindered the removal of Fe during the sucrose amendment procedure.

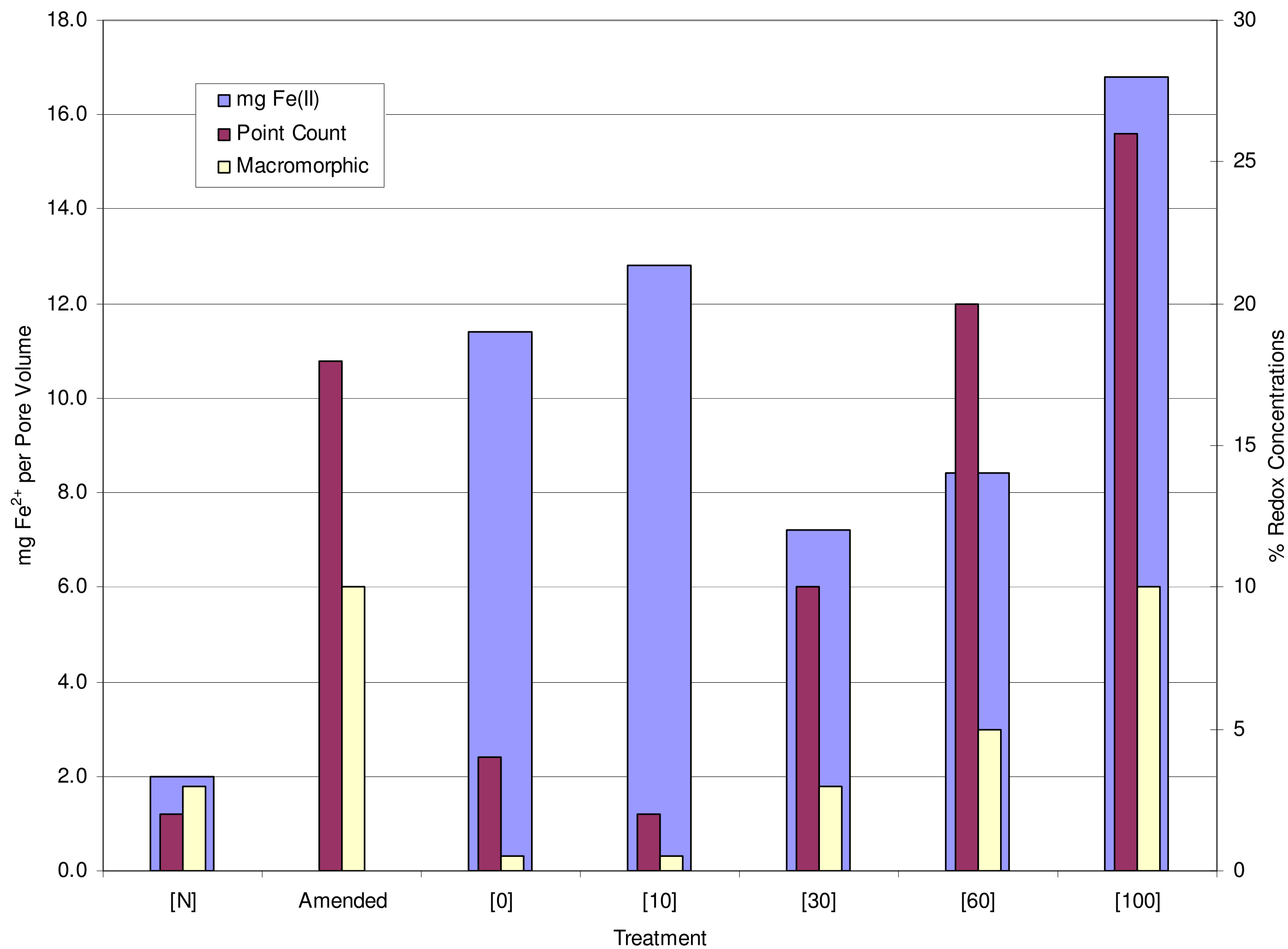

Figure 29. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the Pledger-low soil from Study #2.

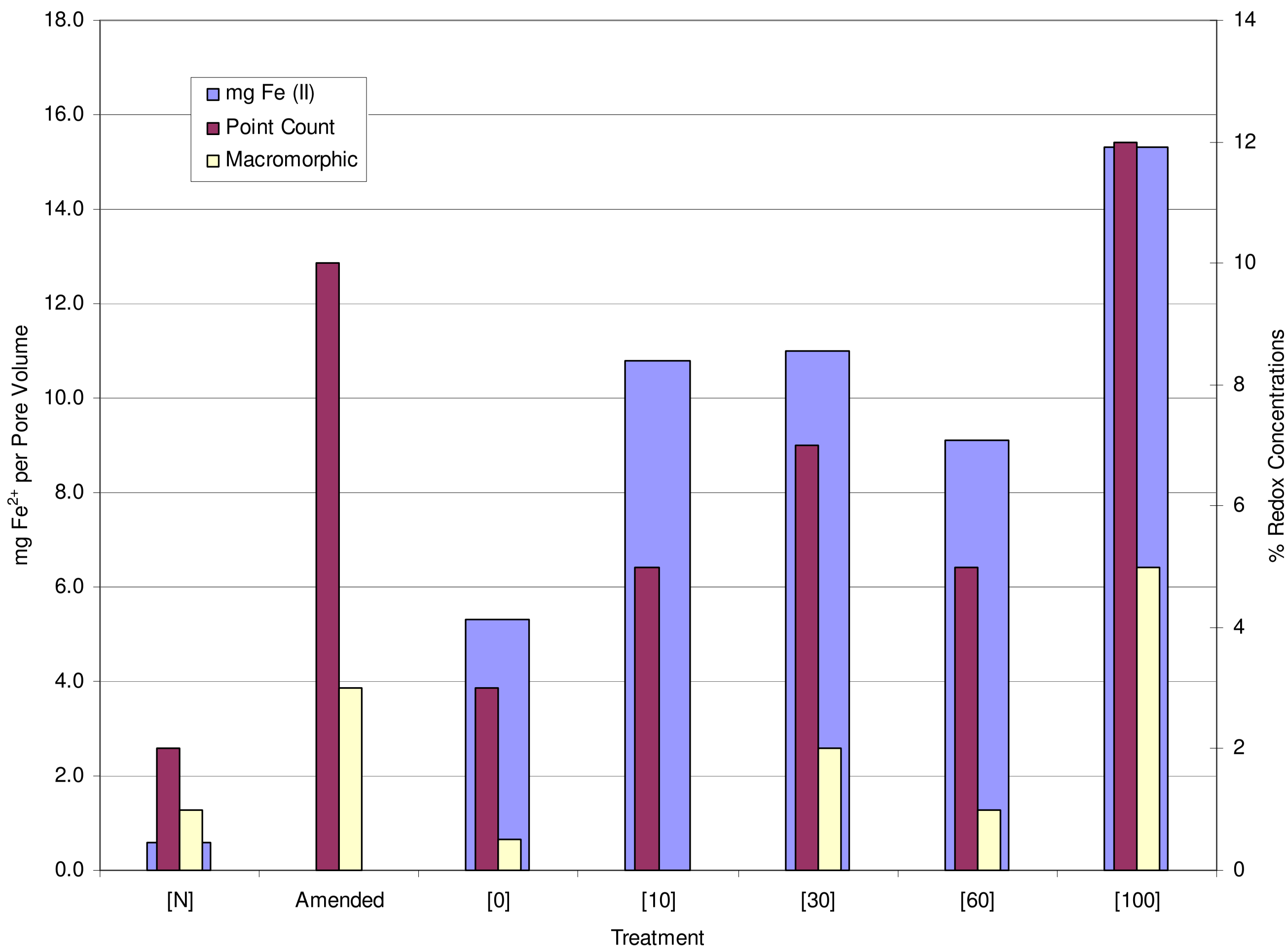

Figure 30. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the Pledger-high soil from Study #2.

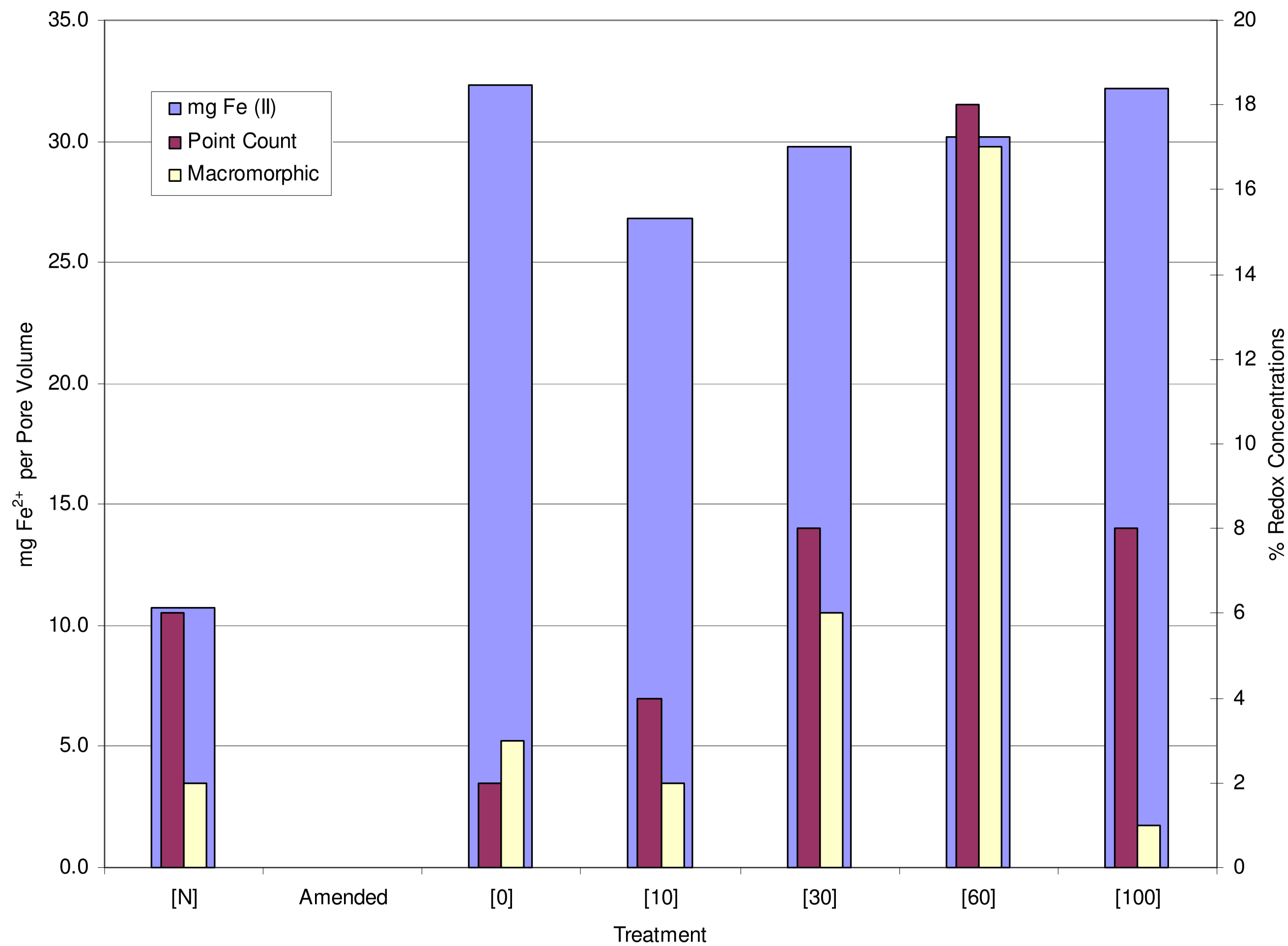

Figure 31. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the China soil from Study #2.

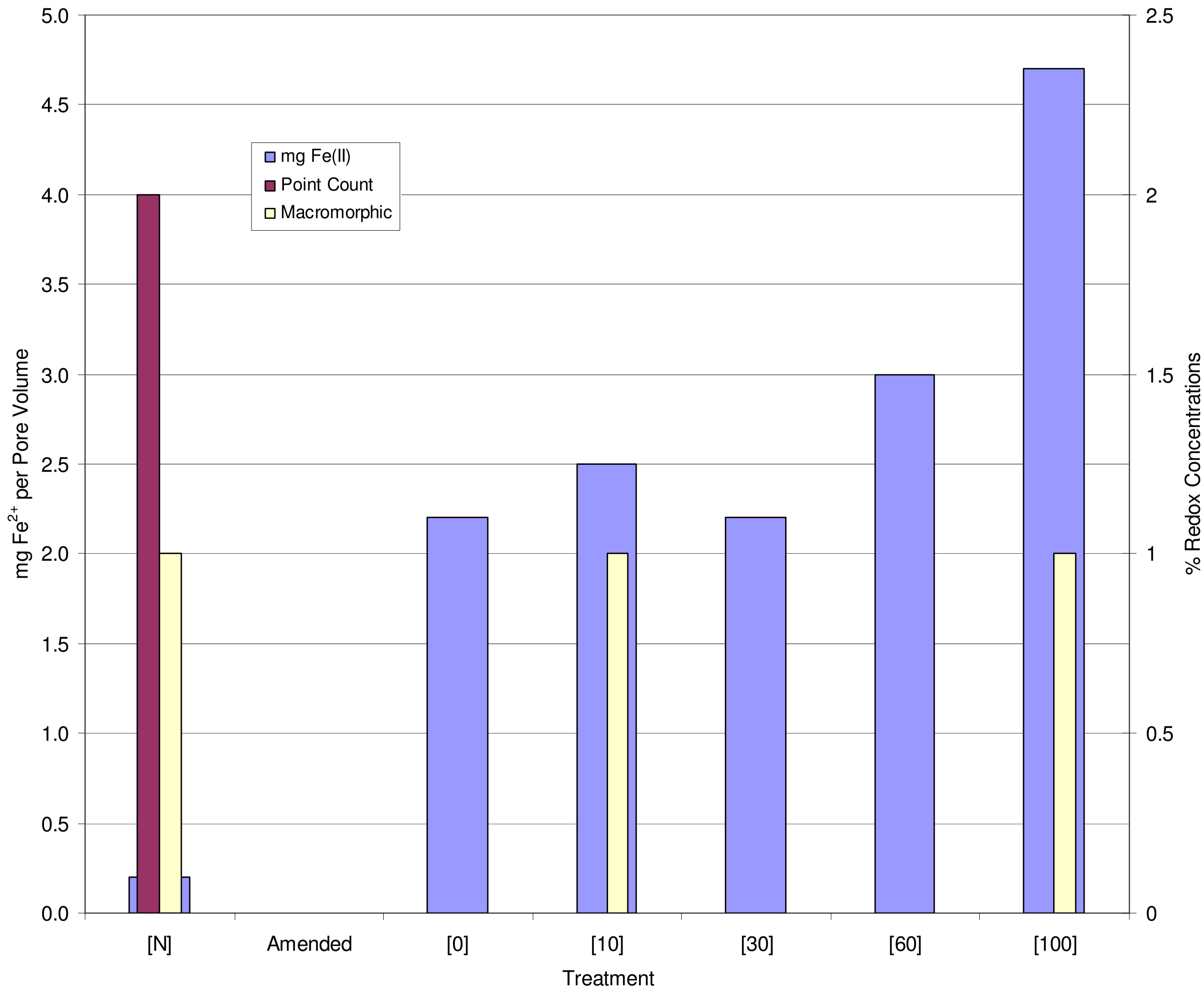

Figure 32. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the Cieno soil from Study #2.

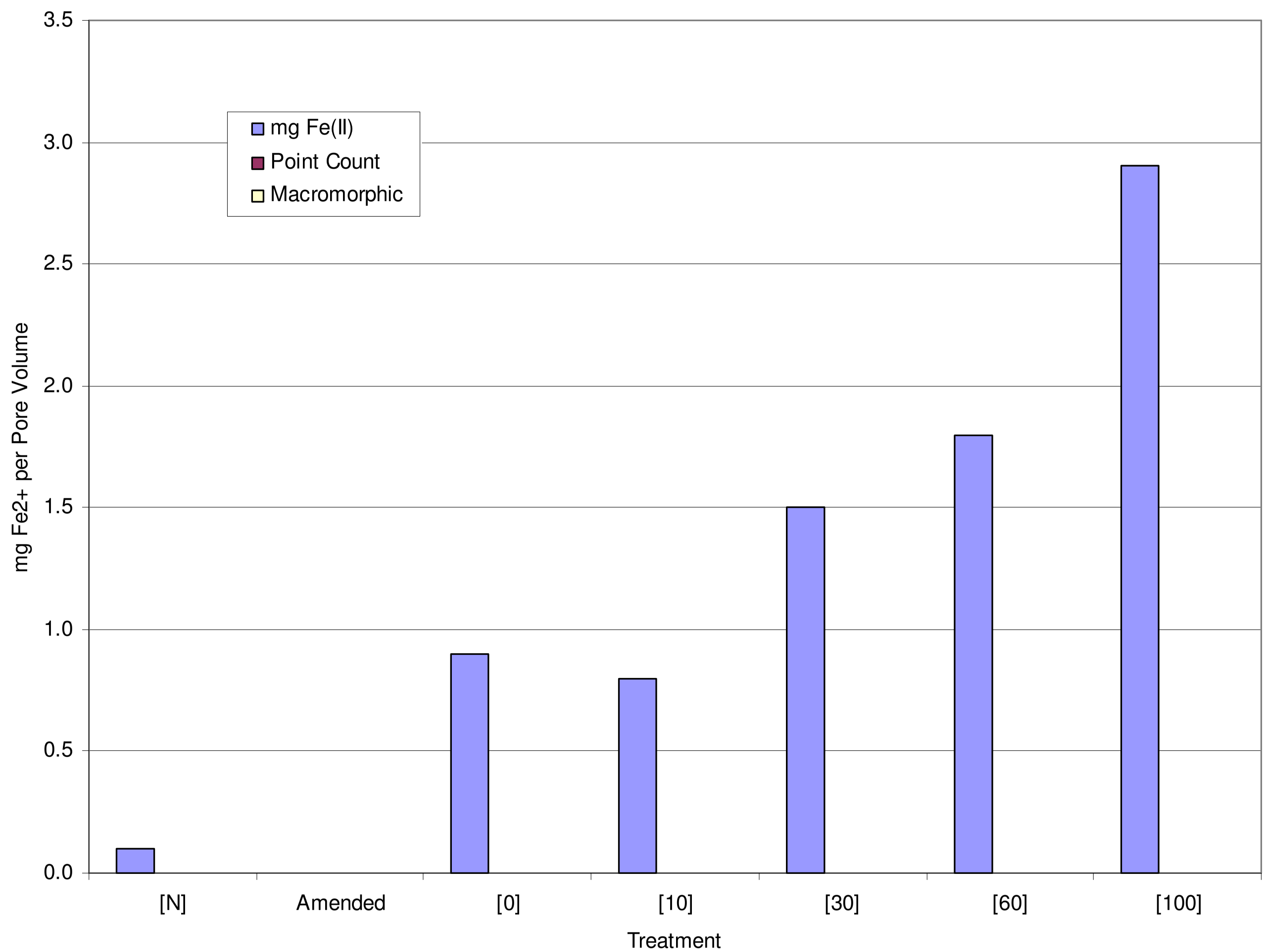

Figure 33. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the Orelia-loamy soil from Study #2.

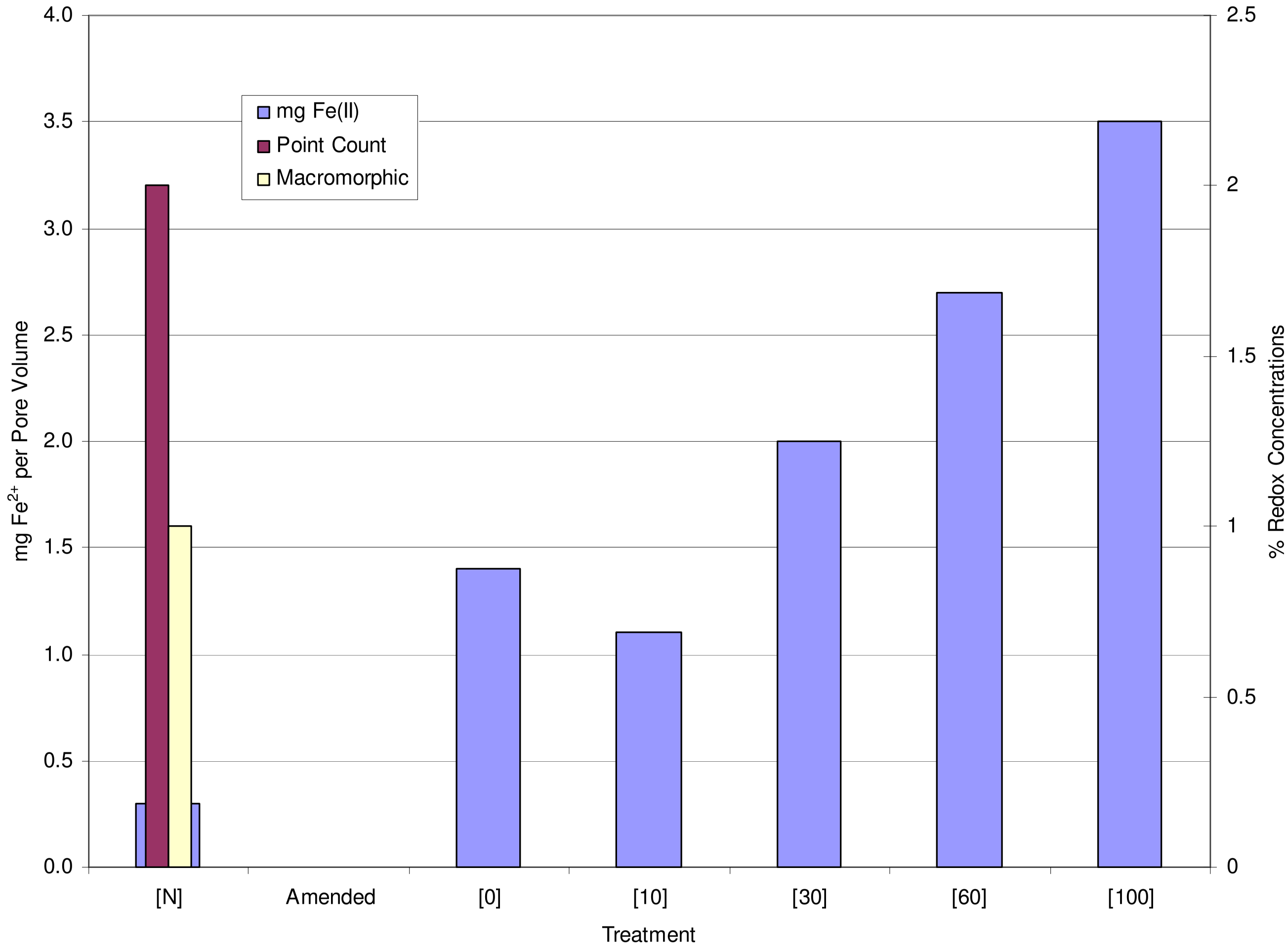

Figure 34. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the Gessner soil from Study #2.

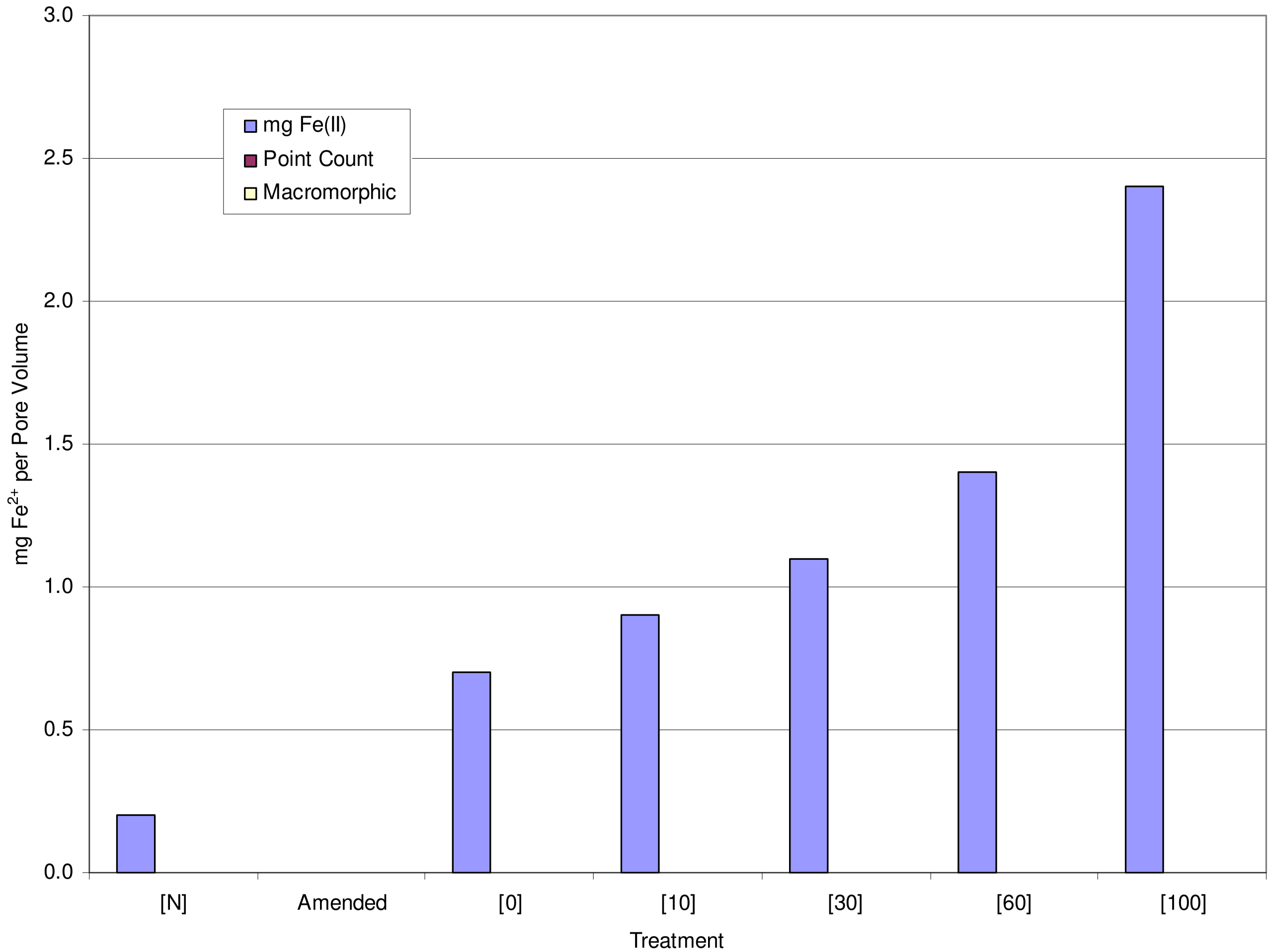

Figure 35. Ferrous Fe in solution per pore volume after Fe equilibration and corresponding percent redox concentration for the Orelia-sandy soil from Study #2.

Table D-8 in Appendix D shows a comparison of the milliequivalents of Fe in solution and the total milliequivalents of the soil exchange capacity. The results indicate that the Fe in solution would occupy no more than 1% of the exchange capacity.

Due to the issues described above, the method used was not effective in achieving the objectives and testing the hypotheses of this study. The purpose of utilizing biological reduction with sucrose was to remove easily reducible Fe oxyhyroxides and equalize each soil before adding various ferrous Fe concentrations. However, the methods should be adjusted to compensate for CEC, as well as total Fe and free Fe oxides removed by biological reduction with sucrose, before determining the concentration of Fe necessary for the formation of redoximorphic features.

Study #3 – Redox Features in Unamended/Equilibrated Natural Soil Clods

Results for Study #3 are presented for redox potential (Eh), ferrous Fe in solution, and amount of ferrous Fe adsorbed after 336 h of equilibration with varying concentration of ferrous Fe treatment. In addition, the expression of diagnostic redox features present following equilibration and subsequent oxidation were observed and quantified.

Redox Potential

Redox potential (Eh) values recorded after 336 h of equilibration with ferrous Fe are presented in Fig. 36 and Table 9. The Eh values for each ferrous Fe treatment within each soil were analyzed to determine differences resulting from the varying concentration of ferrous Fe added to the soil system. There were no significant differences in Eh values between ferrous Fe treatments for the Pledger-low, Pledger-high, Cieno, Orelia-loamy, Gessner, or Orelia-sandy soils.

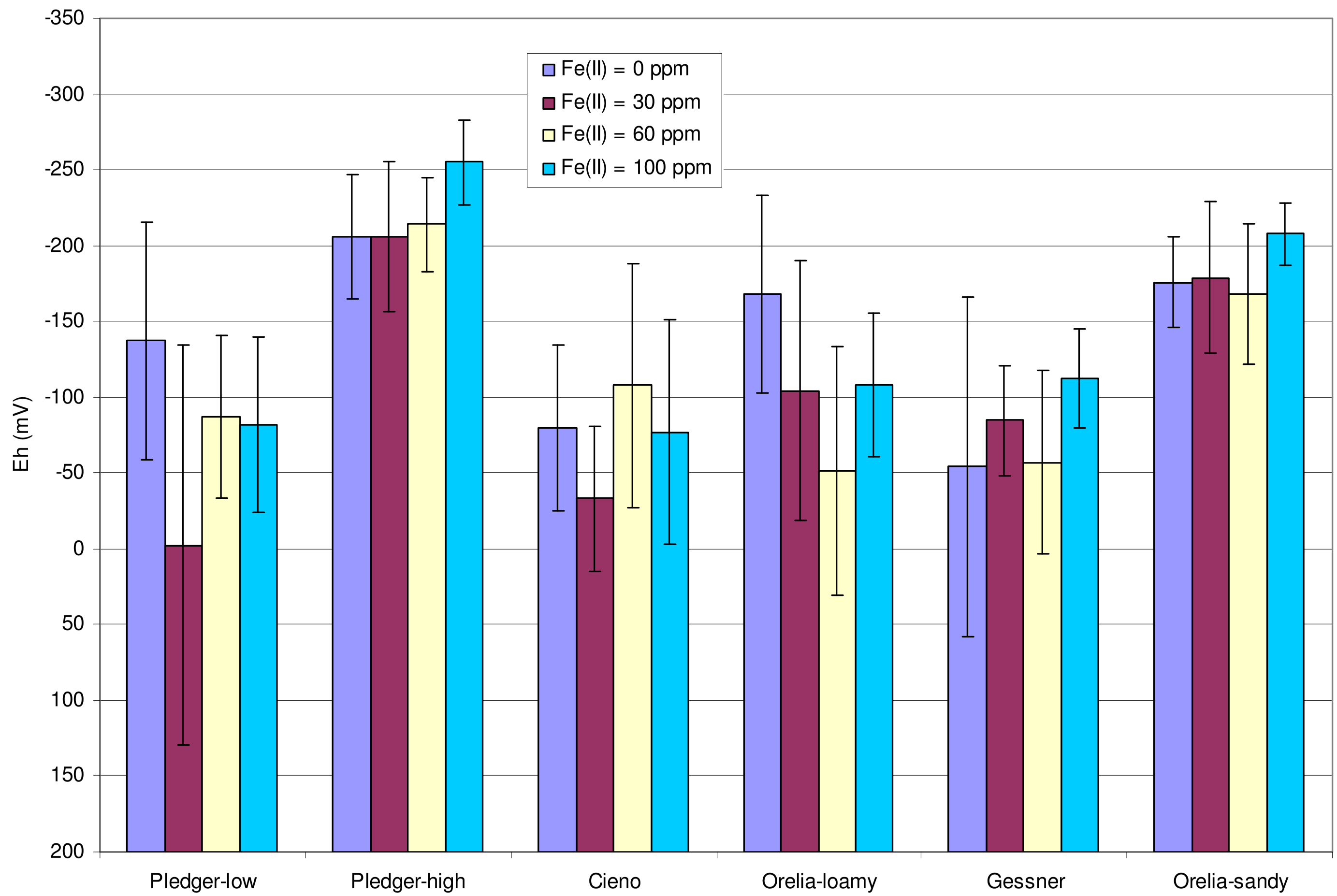

Figure 36. Redox potential (Eh) for each ferrous Fe treatment after 336 h of equilibration from Study #3. Values are means of three replicants and error bars represent +/- one standard deviation.

Table 9. Mean and standard deviation (SD) for redox potential (Eh) after 336 h of equilibration from Study #3.

Soil	Treatment	Mean Eh	SD	Treatments within Soil †	Soils within Treatment ‡
	mg Fe^{2+} L^{-1}	mV			
Pledger-low	0	-137	78	a	ac
	30	-2	132	a	a
	60	-87	54	a	a
	100	-82	58	a	a
Pledger-high	0	-206	41	a	a
	30	-206	49	a	b
	60	-214	31	a	b
	100	-255	28	a	b
Cieno	0	-80	55	a	bc
	30	-33	48	a	ac
	60	-108	80	a	ac
	100	-77	74	a	a
Orelia-loamy	0	-168	65	a	a
	30	-104	86	a	cde
	60	-52	82	a	a
	100	-108	48	a	a
Gessner	0	-54	112	a	b
	30	-85	36	a	ad
	60	-57	60	a	a
	100	-113	32	a	a
Orelia-sandy	0	-176	30	a	a
	30	-179	50	a	be
	60	-168	46	a	bc
	100	-208	21	a	b

† Comparison of mean Eh values for treatments within the indicated soil. Mean Eh values followed by different letters indicate significant differences at the 95% confidence level.

‡ Comparison of mean Eh values for soils within the indicated treatment. Mean Eh values followed by different letters indicate significant differences at the 95% confidence level.

A comparison of soils within each ferrous Fe treatment revealed significant differences in Eh Values (e.g., Pledger-low versus Pledger-high for the 30 ppm treatment). The Eh values in the Pledger-low (fine-textured, acidic) ranged from -2 mV for the 30 ppm treatment to -137 mV for the 0 ppm treatment (i.e., control treatment). The Eh values in the Pledger-high (fine-textured, neutral) ranged from -206 mV for the 0 ppm and 30 ppm treatments to -255 mV for the 100 ppm treatment. The Eh values in the Pledger-high for the 30 ppm, 60 ppm, and 100 ppm treatments were significantly lower than the Pledger-low for the same treatment. In addition, the Eh value for the Pledger-high was significantly lower than all soils for the 30 ppm, 60 ppm, and 100 ppm treatments except the Orelia-sandy. The Eh values for the Pledger-low were also significantly higher than the Orelia-loamy for the 30 ppm treatment, as well as the Orelia-sandy for the 30 ppm, 60 ppm, and 100 ppm treatments.

The Eh difference in the Pledger-low and Pledger-high soils was similar to the general trend for the other textural classes. Generally, Eh values in the neutral soils were lower than those in the acid soils, although not all differences were significant at a 95% confidence level. Also, the 60 ppm treatment for the fine-loamy soils did not follow this trend. Mean and standard deviation calculations for Eh values after 336 h of equilibration are included as Table E-1 in Appendix E. Analysis of variance and Fisher's LSD calculations for Eh values within each soil and within each treatment are included as Table E-2 in Appendix E.

Ferrous Fe

Ferrous Fe concentration in solution per pore volume after 336 h of equilibration are depicted on Fig. 37 through Fig. 42, and presented in Table 10. The ferrous Fe results for each equilibration treatment within each soil were assessed

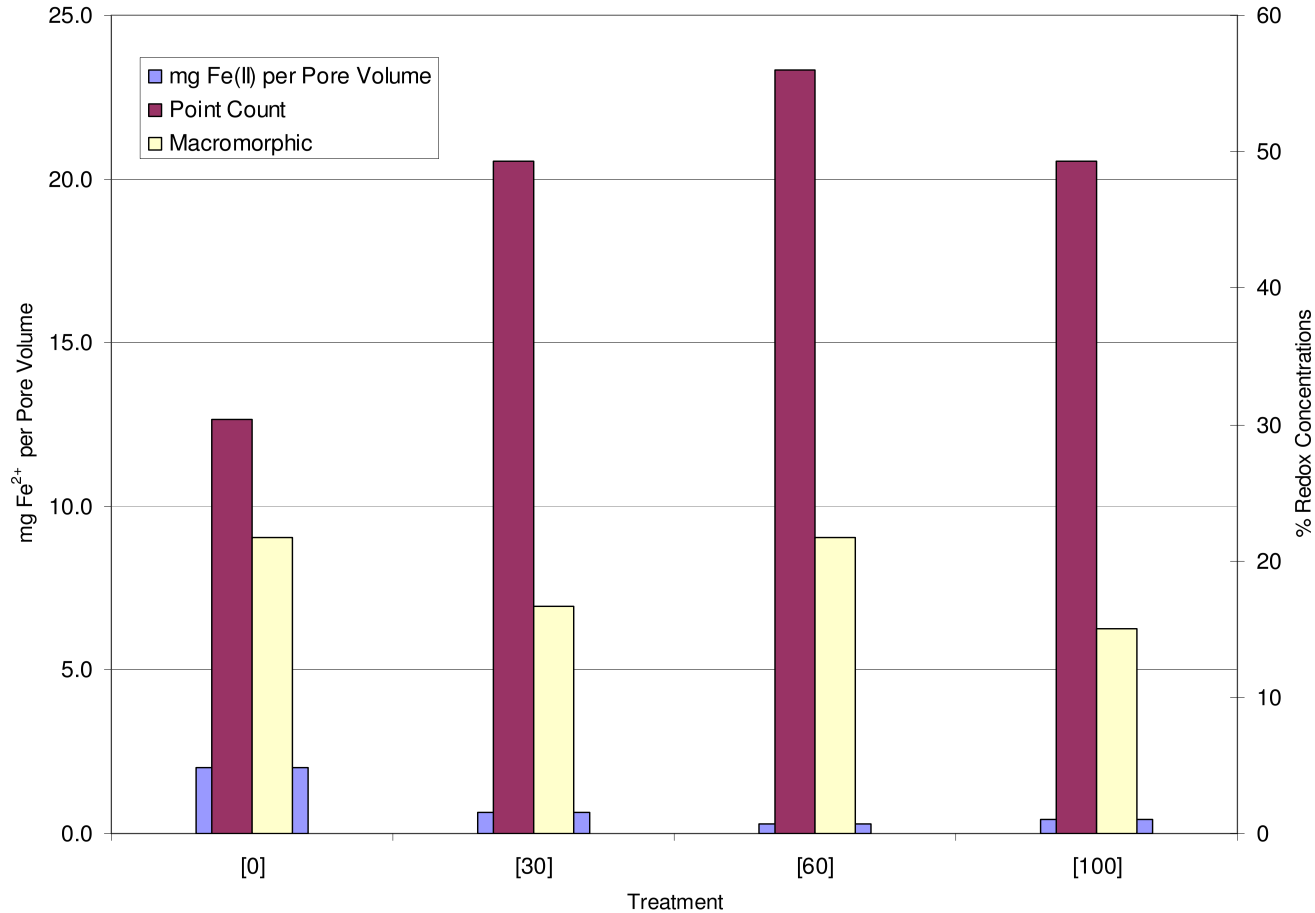

Figure 37. Ferrous Fe in solution per pore volume and percent redox concentration for the Pledger-low soil from Study #3.

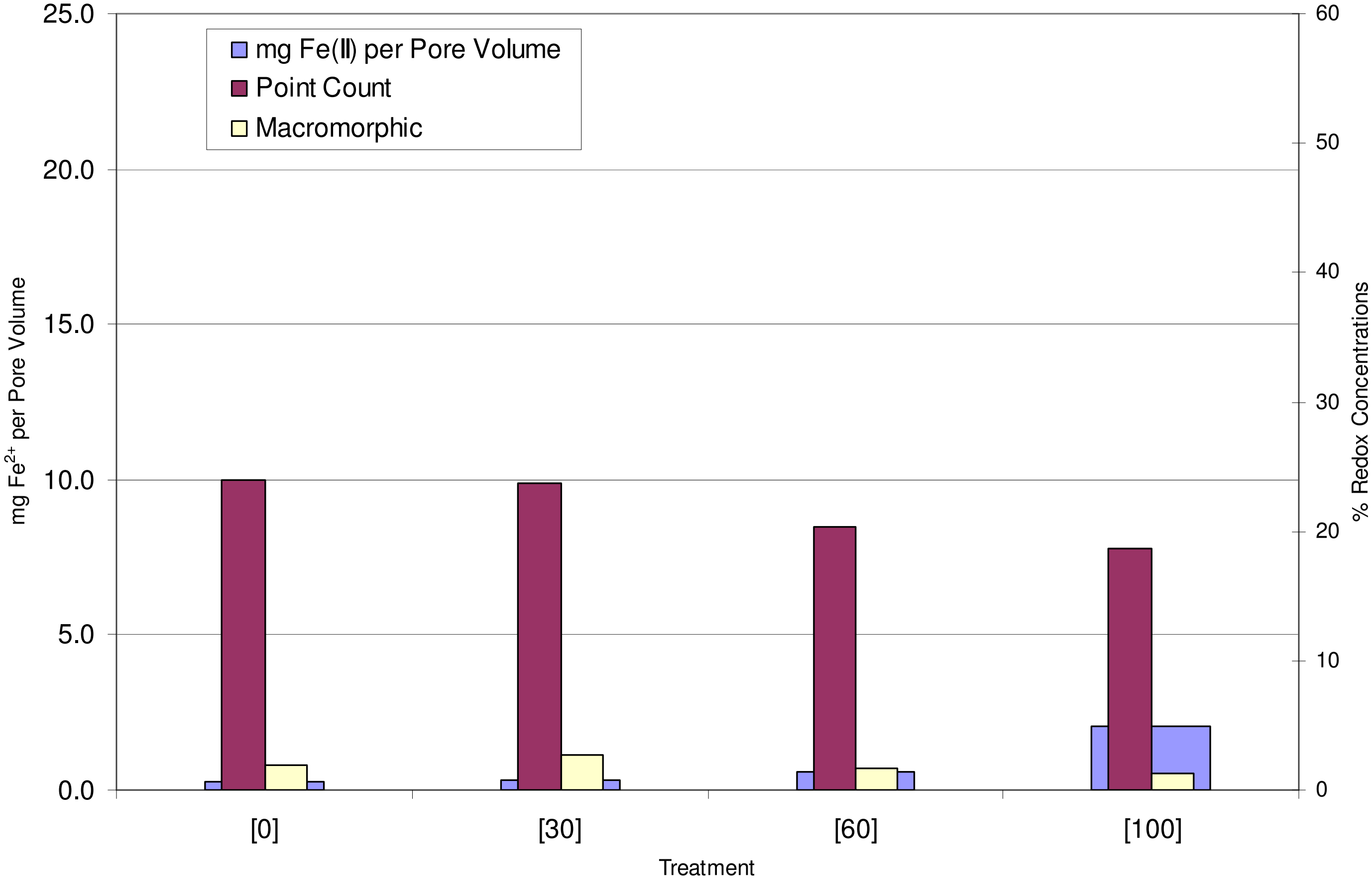

Figure 38. Ferrous Fe in solution per pore volume and percent redox concentration for the Pledger-high soil from Study #3.

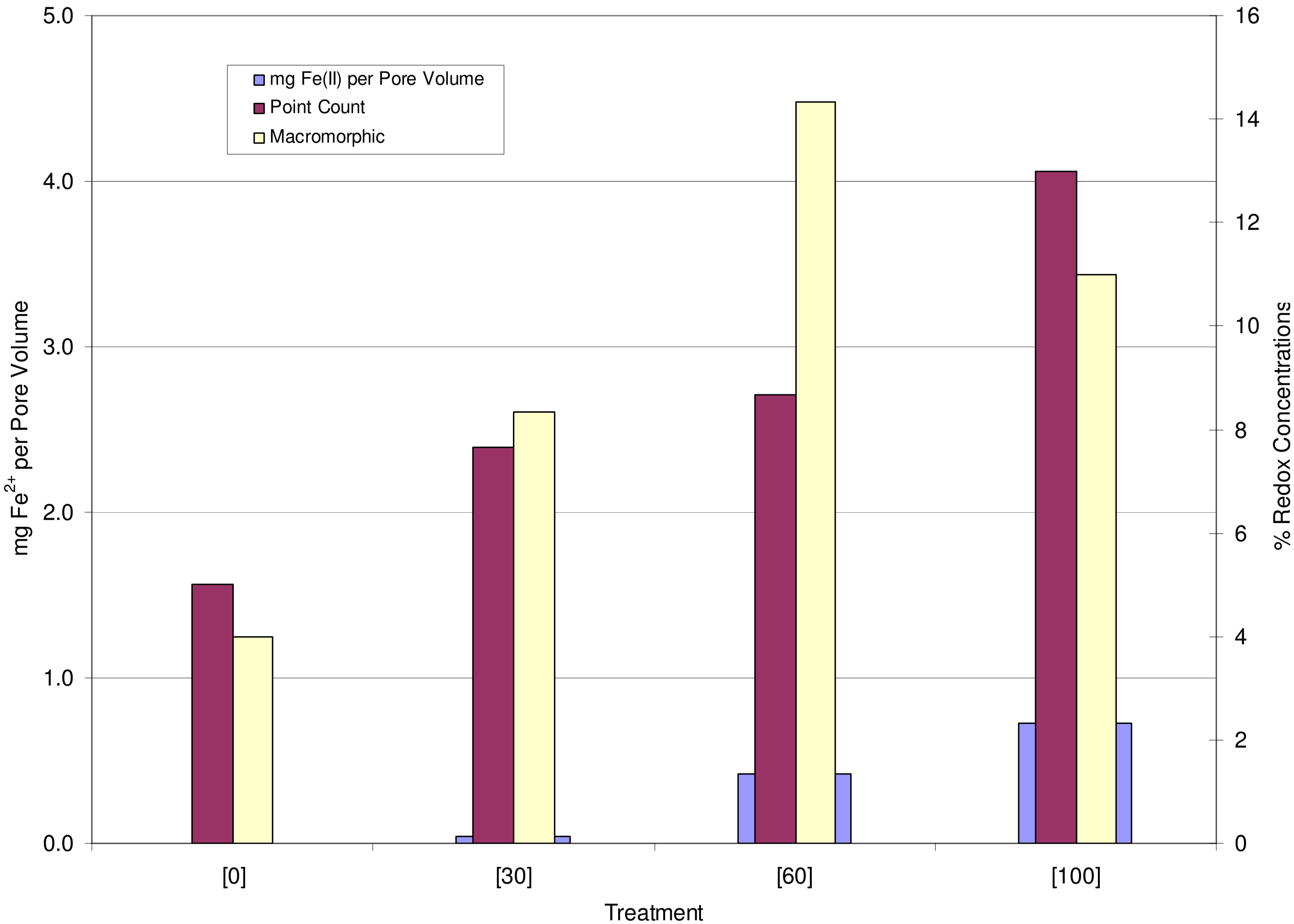

Figure 39. Ferrous Fe in solution per pore volume and percent redox concentration for the Cieno soil from Study #3.

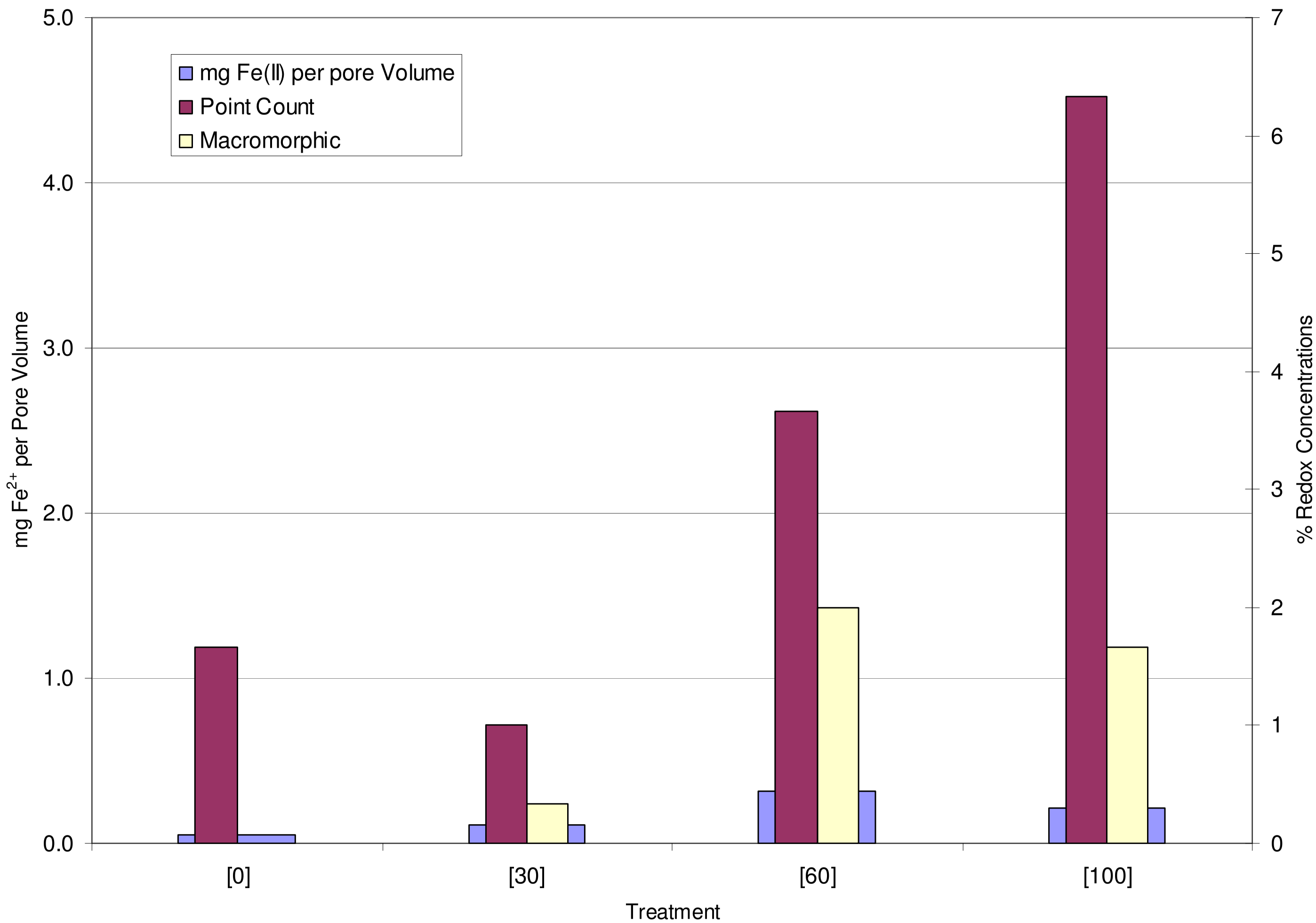

Figure 40. Ferrous Fe in solution per pore volume and percent redox concentration for the Orelia-loamy soil from Study #3.

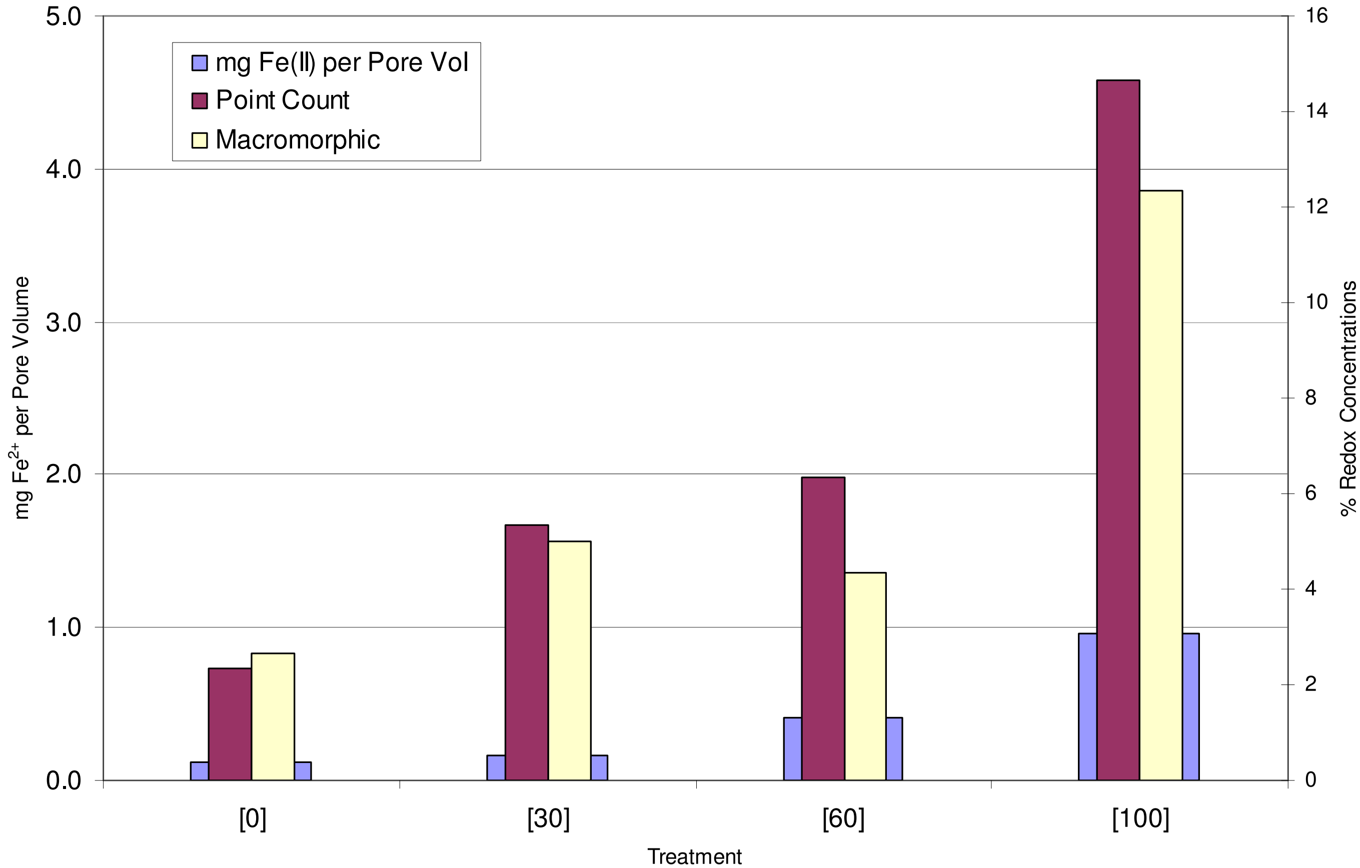

Figure 41. Ferrous Fe in solution per pore volume and percent redox concentration for the Gessner soil from Study #3.

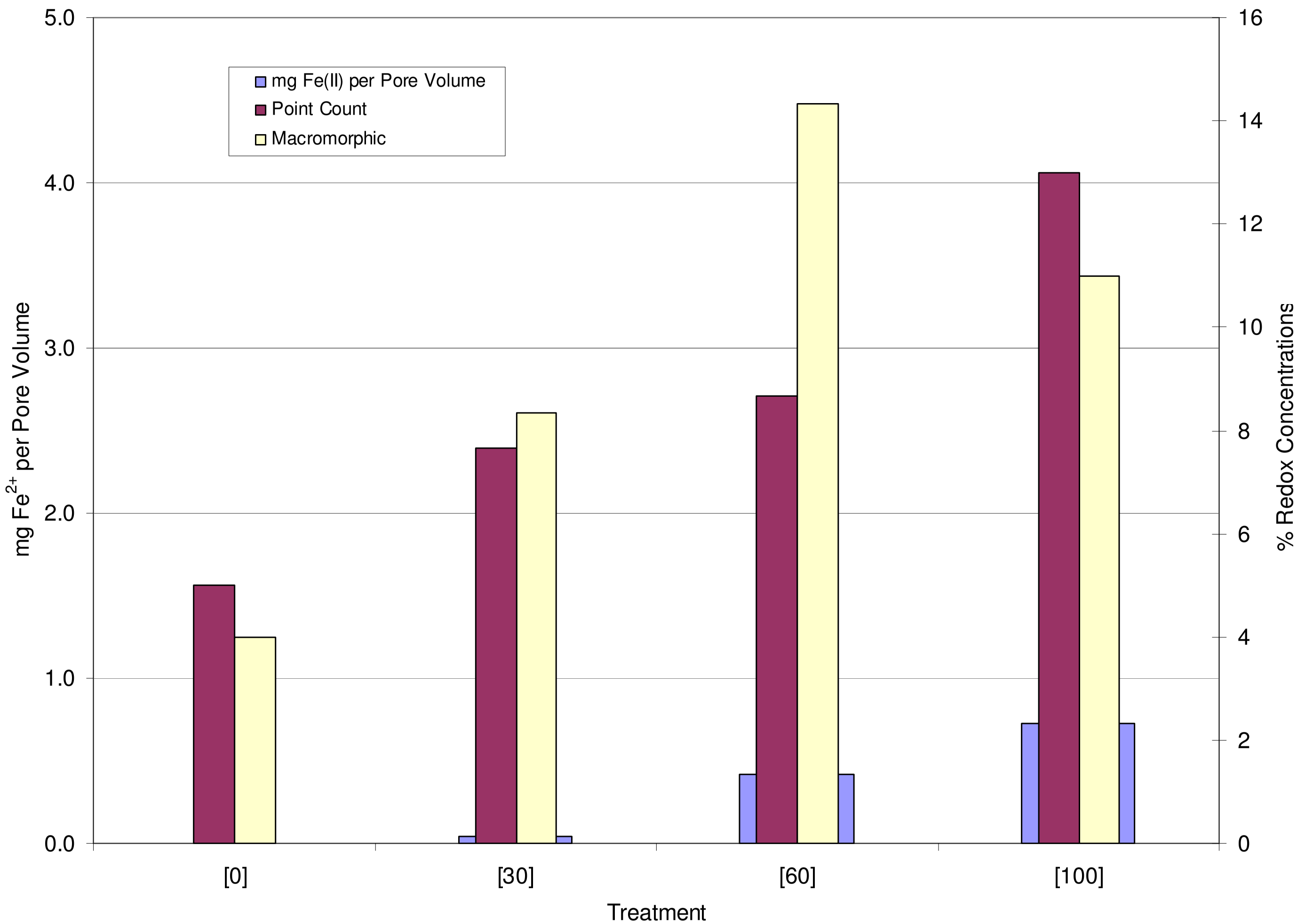

Figure 42. Ferrous Fe in solution per pore volume and percent redox concentration for the Orelia-sandy soil from Study #3.

Table 10. Mean and standard deviation (SD) for ferrous Fe in solution per pore volume after 336 h of equilibration from Study #3.

Soil	Treatment	Mean Fe^{2+}	SD	Treatments within Soil †	Soils within Treatment ‡
	mg Fe^{2+} L^{-1}	mg			
Pledger-low	0	2.00	1.56	a	a
	30	0.63	0.33	a	a
	60	0.31	0.01	a	ad
	100	0.41	0.18	a	a
Pledger-high	0	0.28	0.28	a	b
	30	0.32	0.01	a	c
	60	0.57	0.24	a	b
	100	2.05	2.17	a	a
Cieno	0	0.00	0.00	a	b
	30	0.05	0.08	a	b
	60	0.42	0.18	b	ab
	100	0.73	0.06	c	a
Orelia-loamy	0	0.05	0.09	a	b
	30	0.12	0.11	a	bc
	60	0.32	0.03	b	ac
	100	0.21	0.11	ab	a
Gessner	0	0.12	0.00	a	b
	30	0.17	0.07	a	bc
	60	0.41	0.09	a	ab
	100	0.96	0.12	a	a
Orelia-sandy	0	0.18	0.18	a	b
	30	0.00	0.00	a	b
	60	0.10	0.09	a	cd
	100	0.15	0.02	a	a

† Comparison of mean ferrous Fe for treatments within the indicated soil. Mean Eh values followed by different letters indicate significant differences at the 95% confidence level.

‡ Comparison of mean ferrous Fe for soils within the indicated treatment. Mean Eh values followed by different letters indicate significant differences at the 95% confidence level.

to determine differences resulting from the varying concentrations of ferrous Fe added to the soil system. There were no significant differences between ferrous Fe treatments for the Pledger-low, Pledger-high, Gessner, and Orelia-sandy. Ferrous Fe concentrations for the Pledger-low ranged from 0.31 mg Fe^{2+} per pore volume for the 60 ppm treatment to 2.0 mg Fe^{2+} for the 0 ppm treatment (i.e., control treatment). Ferrous Fe concentrations for the Pledger-high ranged from 0.28 mg Fe^{2+} for the 0 ppm treatment to 2.05 mg Fe^{2+} for the 100 ppm treatment. The acidic fine-loamy soil (Cieno) exhibited a similar trend to the neutral fine-loamy soil (Orelia-loamy) with respect to differences in ferrous Fe in solution resulting from the different equilibration treatments. The 0 ppm and 30 ppm treatments were significantly different than the 60 ppm and 100 ppm treatments in the Cieno soil. Also, the 60 ppm treatment was significantly different than the 100 ppm in the Cieno. The 60 ppm treatment in the Orelia-loamy was significantly different than the remaining treatments.

A comparison of ferrous Fe concentration in solution between soils within each ferrous Fe treatment showed several differences after 336 h of equilibration. The ferrous Fe concentration in the Pledger-low was significantly higher than all remaining soils for the 0 ppm and 30 ppm treatments. The ferrous Fe concentration in the Pledger-high was significantly higher than all soil except for the Gessner for at least one ferrous Fe treatment. Although not significantly different in all cases, the ferrous Fe concentrations in the fine-textured soils were higher than the remaining soils for each ferrous Fe treatment (with the exception of the 60 ppm treatment for the Pledger-low). This indicates that the higher CEC and adsorptive surface area of the fine-textured soils did not result in a lower amount of ferrous Fe in solution in most cases when compared to the fine-loamy and coarse-loamy soils. However, the concentration of free iron oxides (i.e., CD extractable Fe) in the fine-textured soils is approximately 10 times greater than the fine-loamy soils and approximately 20 times greater than the coarse-loamy soils. Reduction of less than 1% of the free iron oxides in the fine-textured soils would result in more ferrous Fe in solution than the final ferrous Fe concentration for any treatment in the fine-loamy and coarse-loamy soils.

The ferrous Fe concentrations in the acidic fine-loamy and coarse-loamy soils were higher than the neutral soils for the same textural class for over 60% of the ferrous Fe treatments. The Cieno contained a higher concentration than the Orelia-loamy for the 60 ppm and 100 ppm treatments. The ferrous Fe concentration in the Gessner was higher than the Orelia-sandy for the 30 ppm, 60 ppm , and 100 ppm treatments. However, the only significant difference at the 95% confidence level occurred for the 60 ppm treatment. The ferrous Fe concentrations in the Cieno and Gessner soils were significantly higher than the Orelia-sandy soil. Statistical analyses for ferrous Fe concentrations in solution are included as Table E-3 and E-4 in Appendix E.

Table 11 shows the decrease of ferrous Fe in solution per pore volume after 336 h of equilibration with the 30 ppm to 100 ppm ferrous Fe treatments. Greater than 75% of the ferrous Fe added to solution by the various treatments was removed from each soil. This amount of decrease in ferrous Fe was independent of pH and texture, and may indicate that the CEC for each textural class is sufficient to buffer Fe at the equilibration concentrations.

Redoximorphic Features

The percentage of redox concentrations formed after 336 h of equilibration are depicted on Fig. 37 through Fig. 42. Statistical analyses of percent redox

Table 11. Percent decrease of ferrous Fe in solution per pore volume after 336 h of equilibration from Study #3.

Soil	Treatment	Added	Final	Difference	Decrease
	ppm Fe^{2+}	--------mg Fe^{2+} per Pore Volume--------			%
Pledger-low	0	0.00	2.00	2.00	-
	30	3.81	0.63	-3.18	83
	60	7.39	0.31	-7.08	96
	100	12.31	0.41	-11.90	97
Pledger-high	0	0.00	0.28	0.28	-
	30	3.85	0.32	-3.53	92
	60	7.03	0.57	-6.46	92
	100	12.77	2.05	-10.73	84
Cieno	0	0.00	0.00	0.00	-
	30	1.61	0.05	-1.56	97
	60	3.05	0.42	-2.63	86
	100	5.15	0.73	-4.42	86
Orelia-loamy	0	0.00	0.05	0.05	-
	30	1.96	0.12	-1.85	94
	60	3.80	0.32	-3.48	92
	100	6.18	0.21	-5.97	97
Gessner	0	0.00	0.12	0.12	-
	30	1.50	0.17	-1.34	89
	60	2.94	0.41	-2.53	86
	100	4.44	0.96	-3.48	78
Orelia-sandy	0	0.00	0.18	0.18	-
	30	1.83	0.00	-1.83	100
	60	3.51	0.10	-3.41	97
	100	5.95	0.15	-5.80	98

concentrations observed by macromorphic description and micromorphic point counts are presented on Table E-5 and Table E-6, respectively, in Appendix E.

The percentage of redox concentrations for each equilibration treatment within each soil were assessed to determine differences resulting from the varying concentrations of ferrous Fe added to the soil system. Macromorphic analysis revealed no significant differences between ferrous Fe treatments within the Pledger-low, Pledger-high, Cieno, Orelia-loamy, and Orelia-sandy. The percentage of redox concentrations was significantly higher for the 100 ppm treatment in the Gessner when compared to the 0 ppm, 30 ppm, and 60 ppm treatments. Micromorphic analysis (i.e., point counts) showed a significant difference in Orelia-sandy between the 0 ppm treatment and the remaining treatments.

Significant differences in the formation of redox concentrations varied greatly between soils within each ferrous Fe treatment and by observation method (macromorphic and micromorphic). The acidic, fine-textured Pledger-low showed significantly greater redox concentrations than the coarser-textured soils at the 0 ppm, 30 ppm, and 60 ppm treatments by macromorphic descriptions and for all ferrous Fe treatments by micromorphic point counts. For the 100 ppm treatment by macromoprhic description, concentrations in the Pledger-low were not significantly different than the acidic fine-loamy and coarse-loamy soils (although the Pledger-low contained more concentrations), but were significantly greater than all neutral soils. The neutral, fine-textured Pledger-high contained significantly fewer redox concentrations than the Pledger-low for all treatments by macromorphic analysis, and for the 60 ppm and 100 ppm treatments by micromorphic analysis. Although not significantly different, fewer concentrations were observed by micromorphic analysis in the Pledger-high when compared to the Pledger-low for the 0 ppm and 30 ppm treatments.

A higher percentage of redox concentrations were observed by micromorphic analysis for each soil and at times conflicted with the results obtained from macromorphic analysis. For example, the Pledger-high contained fewer redox concentrations (although not significantly different) than the Cieno for the 0 ppm and 30 ppm treatments using macromorphic analysis. However, the amount of redox concentrations in the Pledger-high was significantly greater than the Cieno for those same treatments using micromorphic analysis. In addition, the percentage of redox concentrations observed between methods varied substantially in most cases. The percentage of redox concentrations in the Pledger-low ranged from 15 to 22% by macromorphic description and 30 to 56% by micromorphic point counts. The Pledger-high contained percentages ranging from 1 to 3% by macromorphic description and 19 to 24% by micromorphic point counts. A similar trend was observed for the fine-loamy and coarse-loamy soils.

Overall, the fine-textured soils contained more redox concentrations than the coarser-textured soils by the macromorphic description method. The acidic, fine-textured soil exhibited more redox concentrations than all remaining soils regardless of observation method. The neutral soils (Pledger-high, Orelia-loamy, and Orelia-sandy) contained fewer redox concentrations than their acidic counterparts (Pledger-low, Cieno, and Gessner, respectively).

The percentages of Fe depletions were recorded by macromorphic observations. The amounts of Fe depletions were similar within each soil as no noticeable changes were observed between treatments. The 0 ppm treatment (similar to natural soil conditions) exhibited amounts of Fe depletions comparable to the other treatments. Depletions were substantially higher in the acidic fine-loamy (Cieno) and coarse-loamy (Gessner) than the fine-textured soils as well as the neutral coarser-textured soils. Macromorphic observations showed approximately 50% Fe depletions in both the Cieno and Gessner. By comparison, the percentage of Fe depletions ranged from 0 to 5% in the remaining soils. Macromorphic descriptions for matrix color, redox concentrations, and redox depletions are presented in Table E-7 in Appendix E.

SUMMARY AND CONCLUSIONS

Three laboratory studies were performed to elucidate the influence of soil texture, pH, and CEC on the concentration of ferrous Fe in soil solution and the resulting expression of soil redoximorphic features. The objectives were: 1) assess the buffering effects of CEC on ferrous Fe concentration in soil solution, 2) evaluate the effects of pH on the concentration of ferrous Fe in soil solution, and 3) observe the expression of redoximorphic features in soils with varying texture and CEC.

The studies concentrated on seasonally wet soils from the Texas Gulf Coast Prairie MLRA. Selected soils included Alfisols and Vertisols with characteristics ranging from coarse-loamy to very-fine in texture, strongly acidic to neutral in soil reaction, and siliceous, mixed, and smectitic in mineralogy. The soils included the Pledger-low (acidic, fine-textured), Pledger-high (neutral, fine-textured), China (acidic, fine-textured), Cieno (acidic, fine-loamy), Orelia-loamy (neutral, fine-loamy), Gessner (acidic, coarse-loamy), and Orelia-sandy (neutral, coarse-loamy).

Based on the research objectives, the following hypotheses were formed for testing:

1. High CEC and adsorptive surface area of Vertisols buffers the soil solution resulting in lower concentrations of ferrous Fe available for transport by diffusion or mass flow and subsequent segregation into redoximorphic features;
2. Soils with higher pH yield a lower concentration of ferrous Fe in solution resulting in a lower quantity of redoximorphic features; and
3. Coarser-textured soils develop a higher quantity of redoximorphic features than loamy- or fine-textured soil because of lower CEC and lower buffering capacity.

Study #1 – Ferrous Fe Concentration in Unamended Bulk Soil

The purpose of Study #1 was to evaluate the maximum concentration of ferrous Fe released from a near neutral fine-textured soil (Pledger-high) under anaerobic conditions after a period of approximately 768 h of continuous ponding then compare the relationship between Eh, ferrous Fe concentration, and reduced Mn concentration in the Pledger-high to the acidic fine-loamy Cieno and the acidic coarse-loamy Gessner soils. Additional objectives were to observe the effect of pH and CEC on the amount of time required after soil inundation for ferrous Fe to appear in soil solution, and to assess the amount of free Fe oxyhydroxides reduced in each soil under ponded conditions after a period of 30 d. All objectives of this study were accomplished and the selected ferrous Fe equilibration concentrations utilized in Study #2 and Study #3 were based on ferrous Fe concentrations obtained in this study.

The Eh value at 768 h of -13 mV was substantially higher for the Pledger-high when compared to the Cieno (-98 mV) and Gessner(-107 mV). Corresponding ferrous Fe and reduced Mn for each soil were as follows: 69.3 mg kg^{-1} Fe and 5.6 mg kg^{-1} Mn for the Pledger-high, 44.4 mg kg^{-1} Fe and 9.9 mg kg^{-1} Mn for the Cieno, and 22.5 mg kg^{-1} Fe and 3.5 mg kg^{-1} Mn for the Gessner. The first appearance of ferrous Fe in solution for the Pledger-high, Cieno, and Gessner was at 48 h, 168 h, and 48 h, respectively after initial inundation. The corresponding Eh values at the initial detection of ferrous Fe was +259 mV for the Pledger-high, +117 mV for the Cieno, and +217 mV for the Gessner.

A reduction of 0.79%, 5.35%, and 5.63% of the citrate-dithionite extractable Fe was obtained for the Pledger-high, Cieno, and Gessner soils, respectively. The higher Eh at 768 h along with the neutral pH of Pledger-high may have contributed to the lower reduction in free Fe oxyhydroxides. The kinetics of Fe reduction are much slower at a higher pH. The greater quantity of Fe oxyhydroxides in the Pledger-high would require more time to reduce and become soluble due to buffering effects, whereas the reducing reaction in the acidic Cieno and Gessner would occur at a faster rate due to the lower quantity of Fe oxyhydroxides. In addition, the higher CEC of the Pledger-high likely adsorbed ferrous Fe from soil solution and may account for the difference in citrate-dithionite extractable Fe reduction.

Study #2 – Redox Features in Amended/Equilibrated Natural Soil Clods

This study was conducted to observe and quantify the percentage of redoximorphic features formed in soils that have been stripped of easily reducible Fe oxyhyroxides then equilibrated with varying amounts of ferrous Fe. The objective was to determine if high CEC will buffer the redistribution of ferrous Fe and affect the expression of redoximorphic features. Soils selected for this study included the Gessner, Cieno, China, and Pledger-low representing strongly to moderately acidic soil, as well as the Orleia-sandy, Orelia-loamy, and Pledger-high representing neutral soils. Both groups had textures ranging from coarse-loamy to very-fine, and CEC ranging from approximately 5 to 60 $cmol_c\ kg^{-1}$.

A dramatic decrease in Eh was observed after addition of the initial sucrose amendment until approximately 96 h of elapsed time. The Eh values remained relatively steady from 96 h until the removal of the first sucrose solution at 168 h. The Eh values at 168 h ranged from -208 mV in the Pledger-high to -308 mV in the Orelia-loamy. The Eh values in each soil began a steady increase after the addition of the second sucrose amendment at 168 h and the addition of distilled water (i.e., fresh water flush) at 504 h through the conclusion of Fe removal at 672 h. The mean Eh values at 672 h from the Pledger-low and Pledger-high were 100 mV and 56 mV, respectively, while the mean Eh values in the remaining soils ranged from -93 mV to -189 mV.

Redox potentials (Eh) after 24 h of Fe equilibration in treatments previously amended with sucrose were generally similar to the final Eh value at the conclusion of sucrose amendment. The Eh values for these treatments remained relatively stable over the 336 h of equilibration with a general increasing trend. However, Eh values for the control samples (i.e., natural soil clods) for each soil were significantly different than the previously sucrose amended samples. In addition, there was a high degree in variance among Eh readings during the sucrose amendment procedure and during Fe equilibration.

The biological reduction procedure with sucrose affected the normal trend of pH changes in saturated and reduced soils. Normally, soil undergoing reduction will proceed toward a pH of 7. The increase in CO_2 produced by biological activity with the addition of labile organic matter (i.e., sucrose amendment) may have contributed to the downward trend in pH for all soils. In addition, a portion of ferrous Fe in solution during the sucrose amendment procedure was available to replace exchangeable bases, and replaced bases may have been removed during extraction of the sucrose solution.

The amount of ferrous Fe removed by sucrose amendment ranged from 64 mg kg^{-1} in the loamy, neutral Orelia-loamy soil to 2,207 mg kg^{-1} in the clayey, acidic China soil. The reduction of CD extractable Fe ranged from 5% in the clayey, neutral Pledger-high soil to 41% in the sandy, acidic Gessner soil. A large difference in CD extractable Fe reduction between acidic and neutral soils was noted in each textural class. Overall, the biological reduction method with 5% sucrose proved more effective in removing free

Fe oxides from coarse-loamy and fine-loamy soils, with the exception of the Orelia-loamy soil, and less effective in removing free Fe oxides from fine-textured soils, with the exception of the China soil. In addition, the sucrose treatment proved to be more effective in removing Fe from the acidic soils than the neutral soils regardless of texture.

The sucrose amendment procedure had a profound effect on the available ferrous Fe in solution available for transport and subsequent segregation into redox features. The results indicate that the concentrations of ferrous Fe added to the soil after removal of free iron oxides by biological reduction were insufficient to cause significant changes in concentrations of ferrous Fe in solution. Likely, ferrous Fe in solution quickly reached a new equilibrium with the exchange sites. A comparison of the milliequivalents of Fe in solution and the total milliequivalents of the soil exchange capacity indicated that the Fe in solution would occupy no more than 1% of the exchange capacity.

Due to the issues described above, the method used was not effective in achieving the objective of this study. The purpose of utilizing biological reduction with sucrose was to remove easily reducible Fe oxyhyroxides and equalize each soil before adding various ferrous Fe concentrations. Varying amounts of Fe oxyhydroxides remained after sucrose treatment, and all soil CEC was sufficiently high to adsorb the ferrous Fe that was added. The method should be adjusted to compensate for CEC, as well as total Fe and free Fe oxides removed by biological reduction with sucrose, before determining the concentration of Fe necessary for the formation of redoximorphic features.

Study #3 – Redox Features in Unamended/Equilibrated Natural Soil Clods

The purpose of Study #3 was to determine if the expression and amount of redox features would change after equilibration for 336 h with varying concentration of ferrous Fe added to the soil system to supplement the indigenous easily reducible Fe in the natural soil. Soils used in this study included acidic and neutral fine-textured (Pledger-low and Pledger-high), fine-loamy (Cieno and Orelia-loamy), and coarse-loamy (Gessner and Orelia-sandy) soils with CEC values ranging from 5 to 60 $cmol_c$ kg^{-1}. Since the Pledger-high soil (neutral, fine-textured) generally lacks diagnostic redox features even with long to very long periods of reduction, additional emphasis was placed on the analysis of this soil.

The neutral, fine-textured Pledger-high experienced greater reduction than the acidic, fine-textured Pledger-low. The Eh values in the Pledger-high (fine-textured, neutral) ranged from -206 mV for the 0 ppm and 30 ppm Fe treatments to -255 mV for the 100 ppm treatment. The Eh values in the Pledger-high for the 60 ppm and 100 ppm Fe treatments were significantly lower than the Pledger-low for the same treatment. In addition, the Eh values for the Pledger-high were significantly lower than all soils independent of pH and texture (with the exception of the Orelia-sandy) for three of the four treatments. The Eh difference in the Pledger-low and Pledger-high soils was similar to the general trend for the other textural classes. Generally, Eh values in the neutral soils were lower than those in the acid soils, although not all differences were significant at a 95% confidence level. Also, similar to Study #2, there was a high degree in variance among Eh readings during Study #3.

Although not significantly different in all cases, the ferrous Fe concentrations in the fine-textured soils were higher than the remaining soils for each ferrous Fe treatment (with the exception of the 60 ppm treatment for the Pledger-low). This indicates that the higher CEC and adsorptive surface area of the fine-textured soils did not result in a lower amount of ferrous Fe in solution in most cases when compared to the fine-loamy and coarse-loamy soils. However, the concentration of free iron oxides (i.e., CD extractable Fe) in the fine-textured soils is approximately 10 times greater than the fine-loamy soils and approximately 20 times greater than the coarse-loamy soils. Reduction of less than 1% of the free Fe oxides in the fine-textured soils would result in more ferrous Fe in solution than the final ferrous Fe concentration for any treatment in the fine-loamy and coarse-loamy soils. The ferrous Fe concentrations in the acidic fine-loamy and coarse-loamy soils were higher than the neutral soils for the same textural class for over 60% of the ferrous Fe treatments.

More than 75% of the ferrous Fe added in solution by the various treatments was removed from each soil. This decrease in ferrous Fe was independent of pH and texture, and may indicate that the CEC for each textural class is sufficient to buffer Fe at the equilibration concentrations.

Formation of redox concentrations varied greatly between soils within each treatment and by observation method (macromorphic and micromorphic). Overall, the fine-textured soils contained more redox concentrations than the coarser-textured soils by the macromorphic description method. The acidic, fine-textured soil exhibited more redox concentrations than the other soils regardless of observation method. The neutral soils (Pledger-high, Orelia-loamy, and Orelia-sandy) contained fewer redox concentrations than their acidic counterparts (Pledger-low, Cieno, and Gessner, respectively). A higher percentage of redox concentrations were observed by micromorphic analysis for each soil and at times conflicted with the results obtained from macromorphic analysis.

The amounts of Fe depletions were similar within each soil as no noticeable changes were observed between treatments. The 0 ppm treatment (similar to natural soil conditions) exhibited amounts of Fe depletions comparable to the other treatments. Depletions were substantially higher in the acidic fine-loamy (Cieno) and coarse-loamy (Gessner) than the fine-textured soils as well as the neutral coarser-textured soils. Approximately 50% Fe depletions were observed in the acidic fine-loamy and coarse-loamy soil compared to 5% or less in the remaining soils.

In conclusion, this study provided the following information for each hypothesis:

- Hypothesis #1 (higher CEC, lower ferrous Fe in solution) – As the fine-textured soils with higher CEC contained more ferrous Fe in solution, hypothesis #1 is rejected.
- Hypothesis #2 (higher pH, lower ferrous Fe in solution) – Ferrous Fe concentrations in the acidic fine-loamy and coarse-loamy soils were higher than the neutral soils for the same textural class. However, the acidic and neutral fine-textured soils contained more ferrous Fe in solution than the remaining soils. Therefore, hypothesis #2 is neither accepted nor rejected.
- Hypothesis #3 (coarser-texture, more redox features) – The highest percentage of redox concentrations was observed in the acidic, fine-textured soil. The acidic fine-loamy and coarse-loamy soils exhibited a greater percentage of Fe depletions. Macromorphic and micromorphic analyses revealed conflicting results for some soils. Based on this study, the results are inconclusive so the hypothesis cannot be rejected or accepted.

This research showed that differing soil characteristics affect the reductive dissolution and translocation of Fe, and subsequent formation of redox features. However, these studies also indicated the need for additional research. Both Study #2 and Study #3 showed a substantial amount of ferrous Fe removed from soil solution during equilibration under reducing conditions. Additional research should be conducted to consider the final disposition of Fe following periods of reduction to account for differences in readily observable redox features. A high degree in variance among Eh readings was observed during Study #2 and Study #3. Additional research should assess the microsite variability in Eh readings and the reliability of utilizing Pt electrodes for Eh readings during field studies to determine periods of reduction.

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APPENDIX A

SOIL MORPHOLOGICAL DESCRIPTIONS AND CHARACTERIZATION DATA

Table A-1. United States Department of Agriculture Natural Resources Conservation Service reference numbers for each of the study soils to access soil morphological descriptions and characterization data.

Soil Name	Soil Survey Number	Lab Pedon Number †
Pledger clay, microlow (Pledger-low) ‡	S98-TX-039-005	98P0584
Pledger clay, microhigh (Pledger-high) ‡	S98-TX-039-004A	98P0583
China clay (China)	S88-TX-245-001	89P0038
Cieno loam (Cieno)	S88-TX-469-004	89P0035
Orelia sandy clay loam (Orelia-loamy)	S56-TX-409-002	40A4435
Gessner fine sandy loam (Gessner)	S92-TX-201-001	93P0347
Orelia fine sandy loam (Orelia-sandy)	S56-TX-409-002	40A4435

† Access the National Soil Survey Center (NSSC) Soil Survey Laboratory Research Database website at http://ssldata.nrcs.usda.gov/querypage.asp. Utilize the lab pedon number to search for morphological descriptions and characterization data.

APPENDIX B

BULK SOIL CHARACTERIZATION DATA

Table B-1. Bulk soil characterization. [†]

Soil	Depth (cm)	Sand VC (2.0-1.0)	Sand C (1.0-0.5)	Sand M (0.5-0.25)	Sand F (0.25-0.10)	Sand VF (0.10-0.05)	Sand Total (2.0-0.05)	Silt Fine (0.02-0.002)	Silt Total (0.05-0.002)	Clay Fine (< 0.0002)	Clay Total (< 0.002)	Texture Class	Coarse Fragments
		%	%	%	%	%	%	%	%	%	%		%
Pledger-low	10-20	0.1	0.1	0.4	1.0	2.3	3.9	26.6	32.8	43.3	63.3	C	
China	10-20	0.2	0.3	0.2	1.3	3.6	5.6	26.5	29.6	41.7	64.8	C	
Pledger-high	10-20	0.4	0.4	0.3	0.5	1.3	2.9	22.4	28.0	45.0	69.1	C	1
Cieno	10-20	0.0	1.5	9.5	27.5	15.0	53.5	16.8	22.7	9.6	23.8	SCL	
Orelia-loamy	10-20	0.0	0.2	2.2	32.1	25.4	59.9	9.1	18.2	16.0	21.9	SCL	
Gessner	10-20	0.0	0.3	2.3	39.6	23.7	65.9	12.7	22.7	5.3	11.4	FSL	
Orelia-sandy	10-20	0.0	0.3	1.4	57.9	19.4	79.0	5.4	8.7	8.1	12.3	FSL	

Soil	Orgn C	pH (H2O)	NH4OAC Extr Bases CA	MG	NA	K	TOTAL	KCL AL	NaOAc CEC	ECEC	Base Sat	ESP	SAR	Cal-cite	Dolo-mite	CaCO3 Eq	Gyp-sum
	%	1:1	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%	%		%	%	%	%
Pledger-low	1.79	5.5	34.5	5.6	0.2	1.4	41.7	0.0	47.4	41.7	88	0	0	-	-	-	-
China	2.04	5.1	31.3	7.3	0.5	0.6	39.7	0.2	50.1	39.9	79	1	1	-	-	-	-
Pledger-high	3.27	6.8	68.2	5.6	0.2	1.8	75.8	-	57.2	-	100	0	-	1.3	0.3	1.6	-
Cieno	0.84	5.3	4.3	1.8	0.1	0.1	6.3	0.1	9.3	6.4	68	1	-	-	-	-	-
Orelia-loamy	0.82	7.0	11.2	3.7	0.8	0.3	16.0	-	17.2	-	93	5	-	-	-	-	-
Gessner	0.58	4.9	2.0	0.8	0.1	0.1	3.0	0.4	5.5	3.4	55	2	-	-	-	-	-
Orelia-sandy	0.93	6.6	9.2	1.1	0.1	0.7	11.1	-	11.5	-	97	1	-	-	-	-	-

Table B-1 Continued.

Soil	Elec Cond	H2O Cont	CA	MG	NA	K	CO3	HCO3	CL	SO4	Bulk Density 0.33 Bar	Bulk Density Oven Dry	COLE	Water Content 0.10 BAR	Water Content 0.33 BAR	Water Content 15 BAR	CD Fe
	Saturated Paste Extract																
	dS/m	%	meq/L								g/cc		cm/cm	wt%			%
Pledger-low	0.2	95	1.4	0.3	0.4	0.2	-	-	-	-	1.14	1.93	0.192	-	47.6	-	0.9
China	0.3	72	1.1	0.4	1.1	0.1	-	-	-	-	1.11	1.83	0.181	-	-	-	1.2
Pledger-high	-	-	-	-	-	-	-	-	-	-	1.04	1.87	0.216	-	56.8	-	1.1
Cieno	-	-	-	-	-	-	-	-	-	-	1.68	1.78	0.019	-	19.7	-	0.1
Orelia-loamy	-	-	-	-	-	-	-	-	-	-	1.50	1.71	0.045	-	24.1	-	0.1
Gessner	-	-	-	-	-	-	-	-	-	-	1.68	1.74	0.012	-	18.2	-	0.0
Orelia-sandy	-	-	-	-	-	-	-	-	-	-	1.44	1.56	0.027	-	22.8	-	0.1

Soil	Sand VCS	Sand C	Sand M	Sand F	Sand VF	Sand Total	Silt C	Silt F	Silt Total	S/ SI	Ratio FSI/ CSI	Ratio VFS/ FS	Ratio FC/ TC	CEC/ Clay	Mean PSD (Phi)	Mean PSD (mm)
	Particle Size Distribution (Clay-Free Basis)															
	%															
Pledger-low	0.3	0.3	1.1	2.7	6.3	10.6	16.9	72.5	89.4	0.1	4.3	2.3	0.7	0.75	10.12	0.0009
China	0.6	0.9	0.6	3.7	10.2	15.9	8.8	75.3	84.1	0.2	8.6	2.8	0.6	0.77	10.14	0.0009
Pledger-high	1.3	1.3	1.0	1.6	4.2	9.4	18.1	72.5	90.6	0.1	0.4	2.6	0.7	0.83		
Cieno	0.0	2.0	12.5	36.1	19.7	70.2	7.8	22.0	29.8	2.4	2.8	0.5	0.4	0.39	5.72	0.0190
Orelia-loamy	0.0	0.3	2.8	41.1	32.5	76.7	11.6	11.7	23.3	3.3	1.0	0.8	0.7	0.79	5.66	0.0198
Gessner	0.0	0.3	2.6	44.7	26.8	74.4	11.3	14.3	25.6	2.9	1.3	0.6	0.5	0.48	4.73	0.0377
Orelia-sandy	0.0	0.3	1.6	66.0	22.1	90.1	3.7	6.2	9.9	9.1	1.7	0.3	0.7	0.93	4.34	0.0494

† The appendix contains physical and chemical characterization data for bulk soil samples from the interval used for the research studies. Analyses were performed by the Texas AgriLife-Research Soil Characterization Laboratory, College Station, TX.

APPENDIX C

ADDITIONAL STUDY #1 DATA

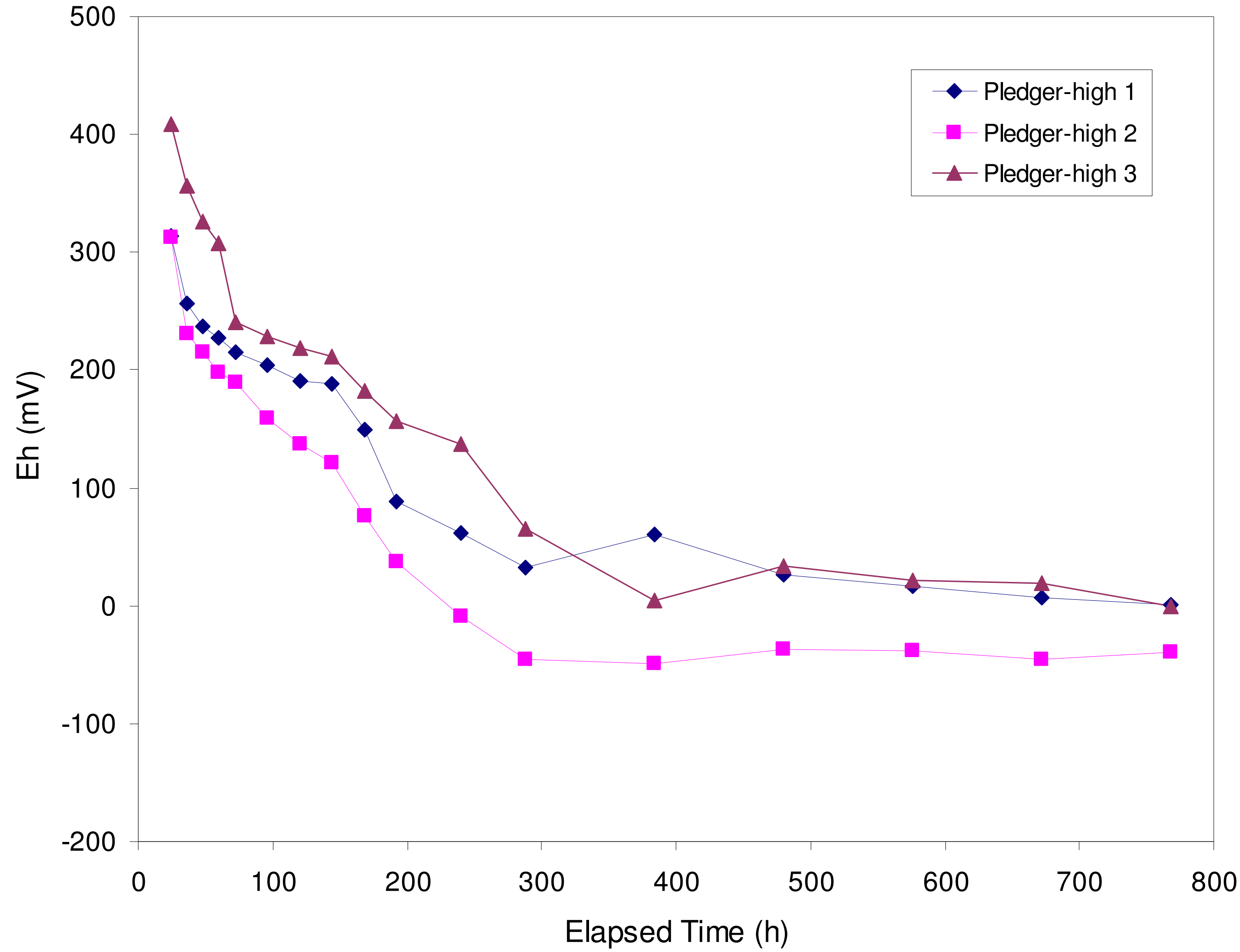

Figure C-1. Eh readings over time for the Pledger-high soil.

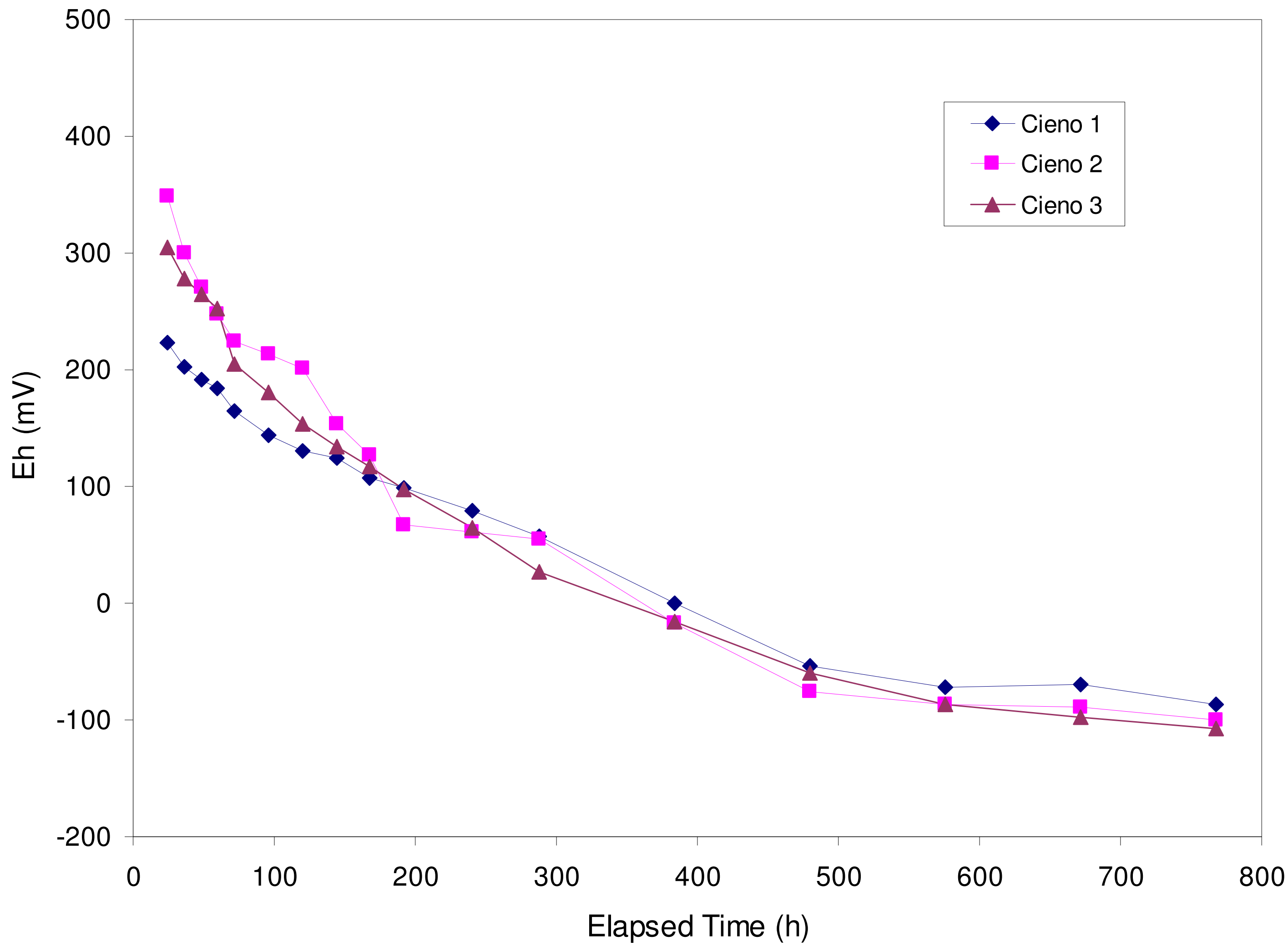

Figure C-2. Eh readings over time for the Cieno soil.

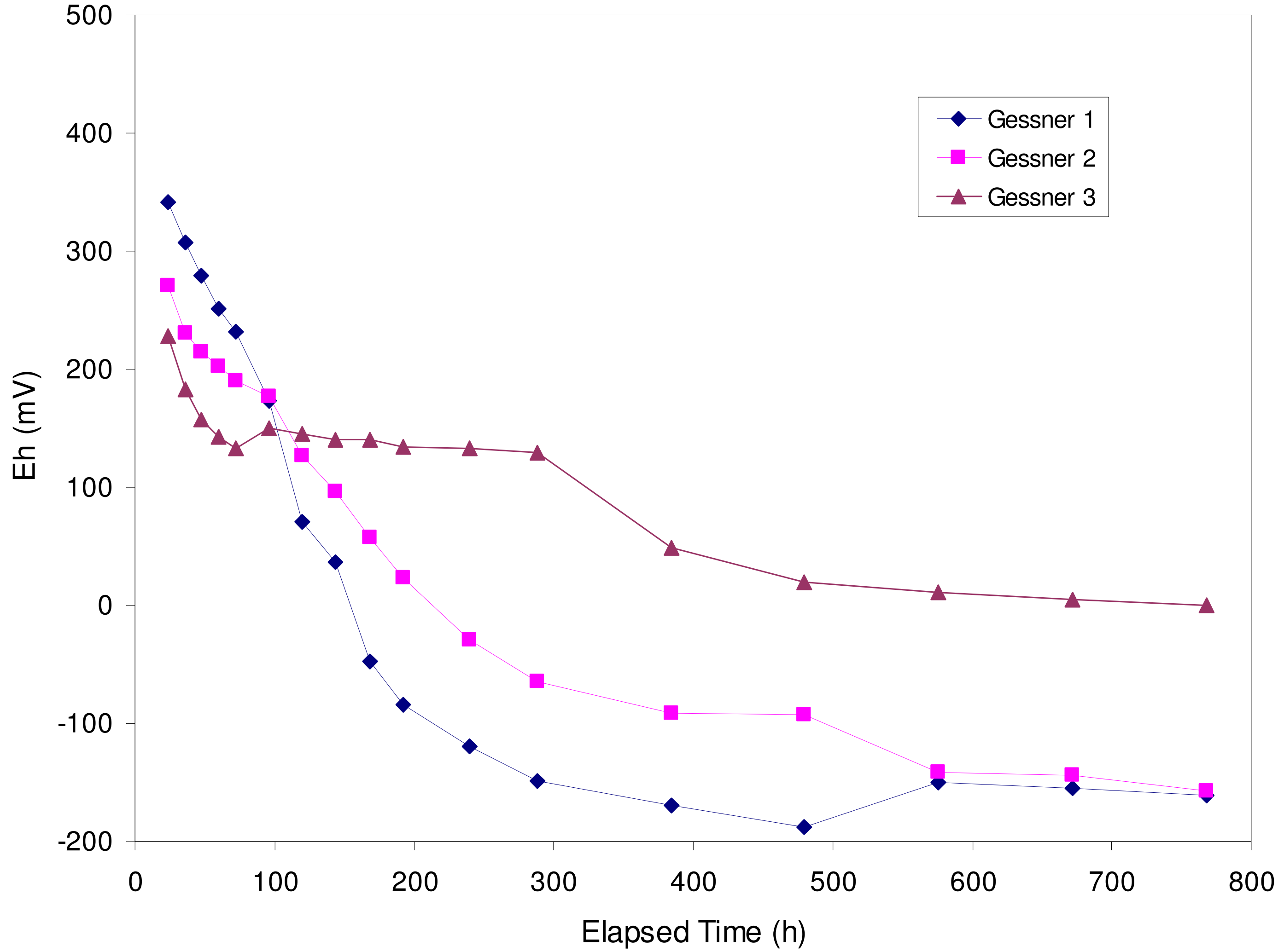

Figure C-3. Eh readings over time for the Gessner soil.

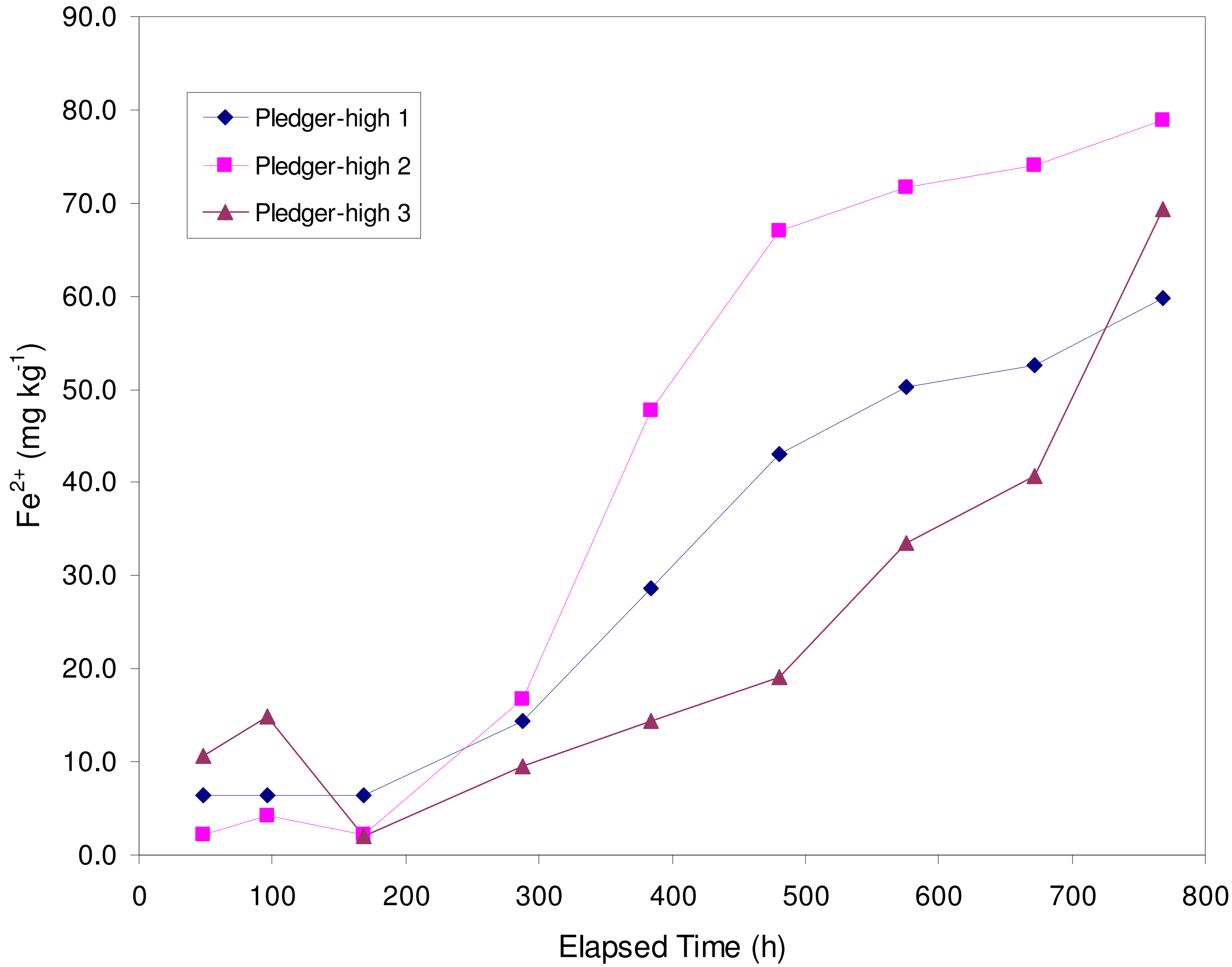

Figure C-4. Ferrous Fe concentration in soil solution over time in the Pledger-high soil.

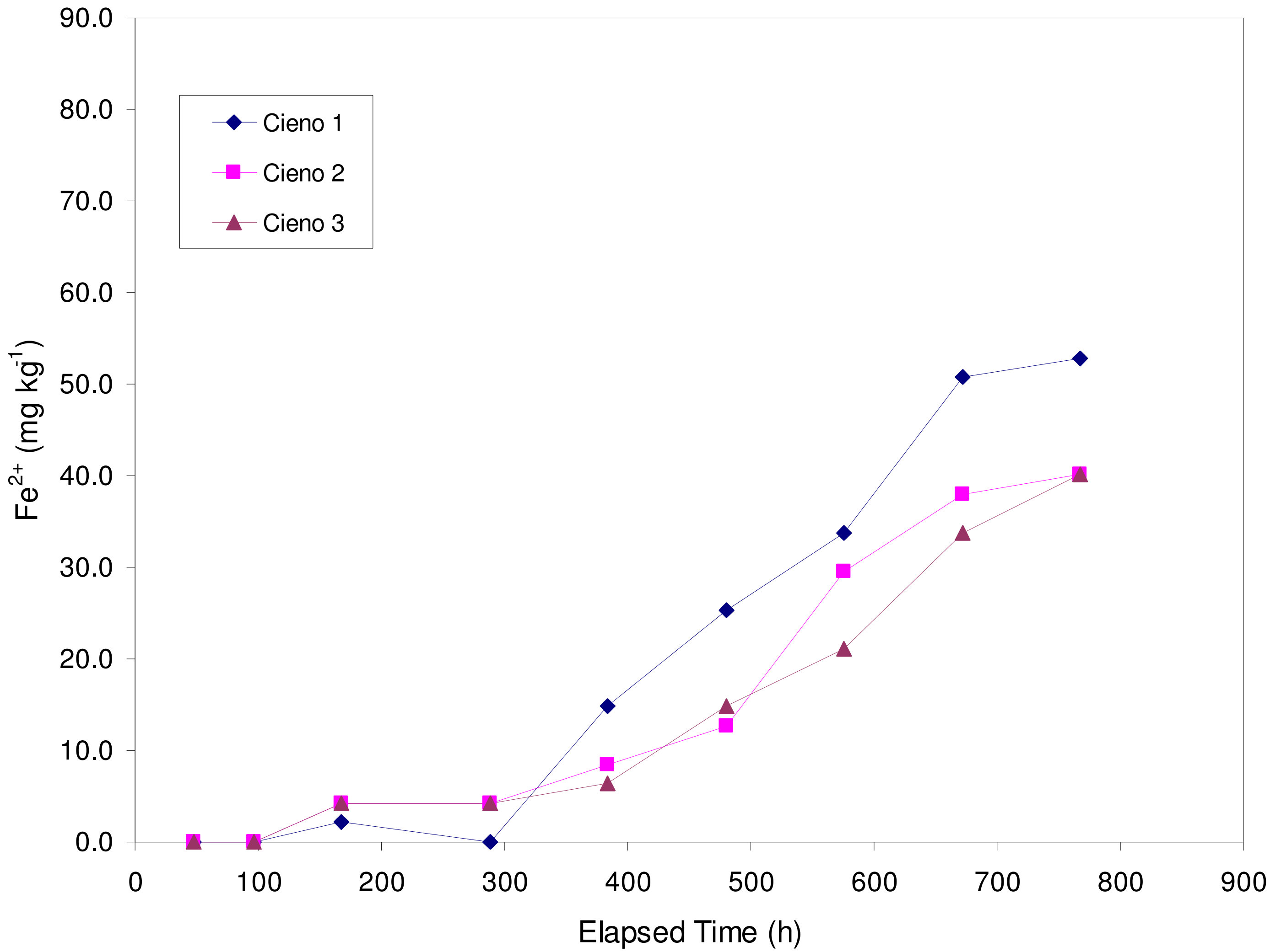

Figure C-5. Ferrous Fe concentration in soil solution over time in the Cieno soil.

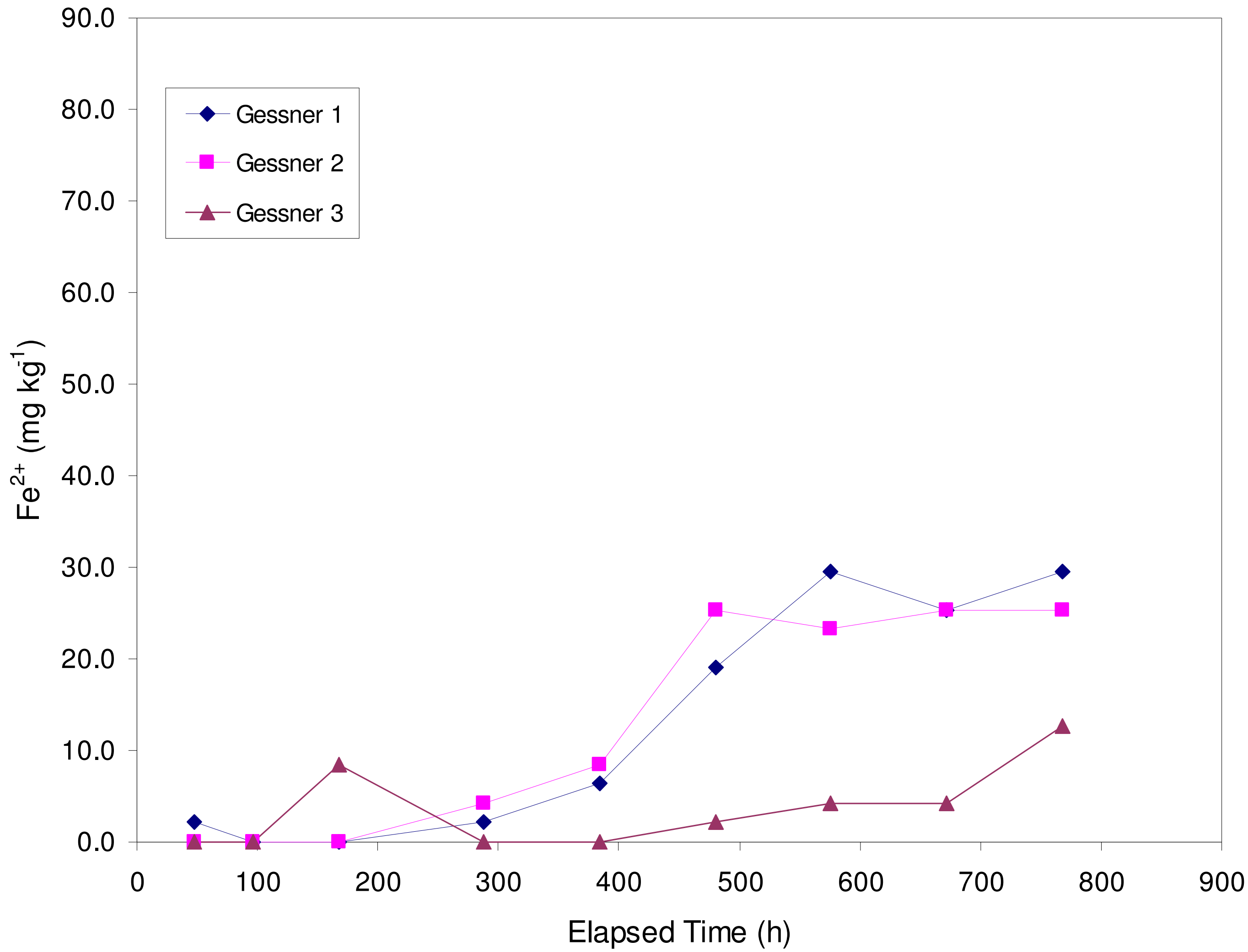

Figure C-6. Ferrous Fe concentration in soil solution over time in the Gessner soil.

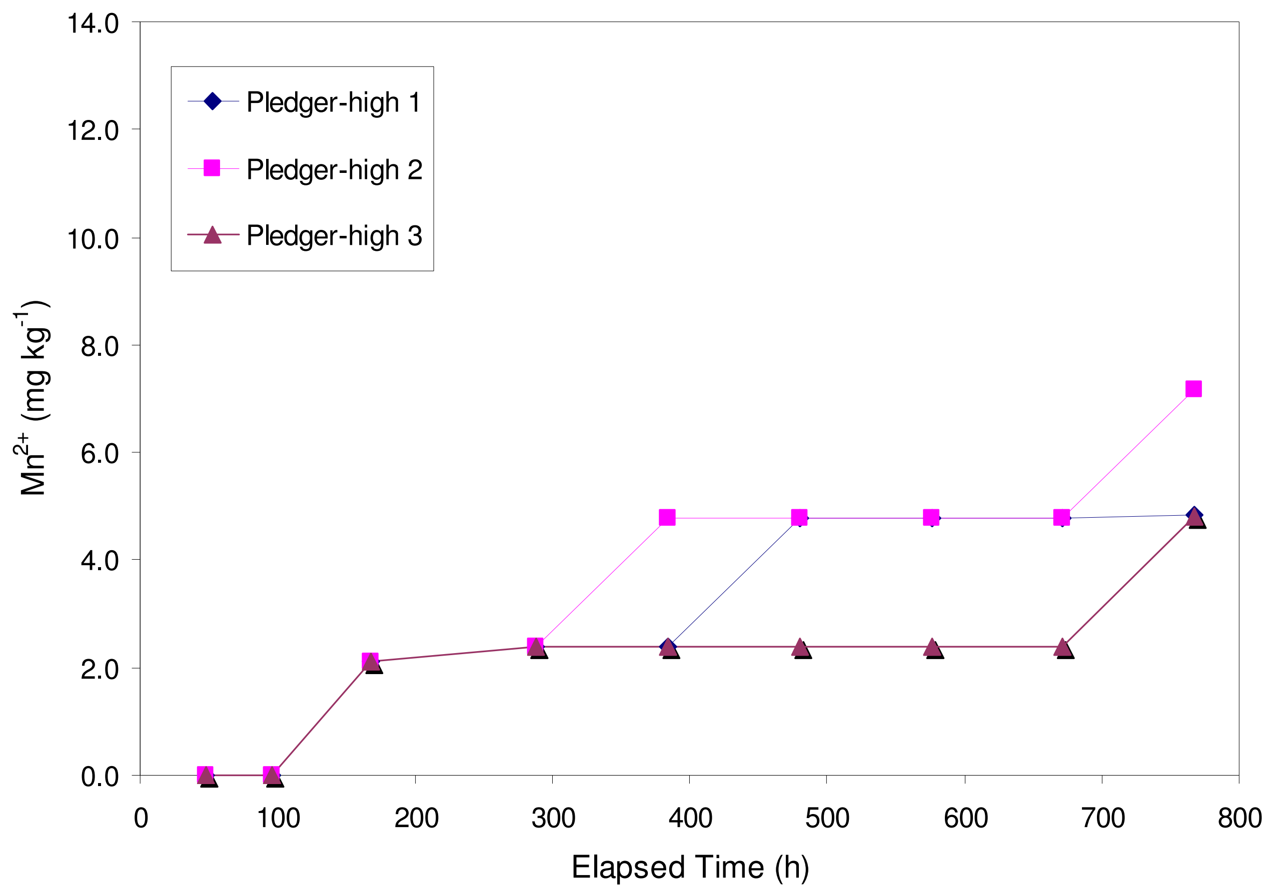

Figure C-7. Reduced Mn concentration in soil solution over time in the Pledger-high soil.

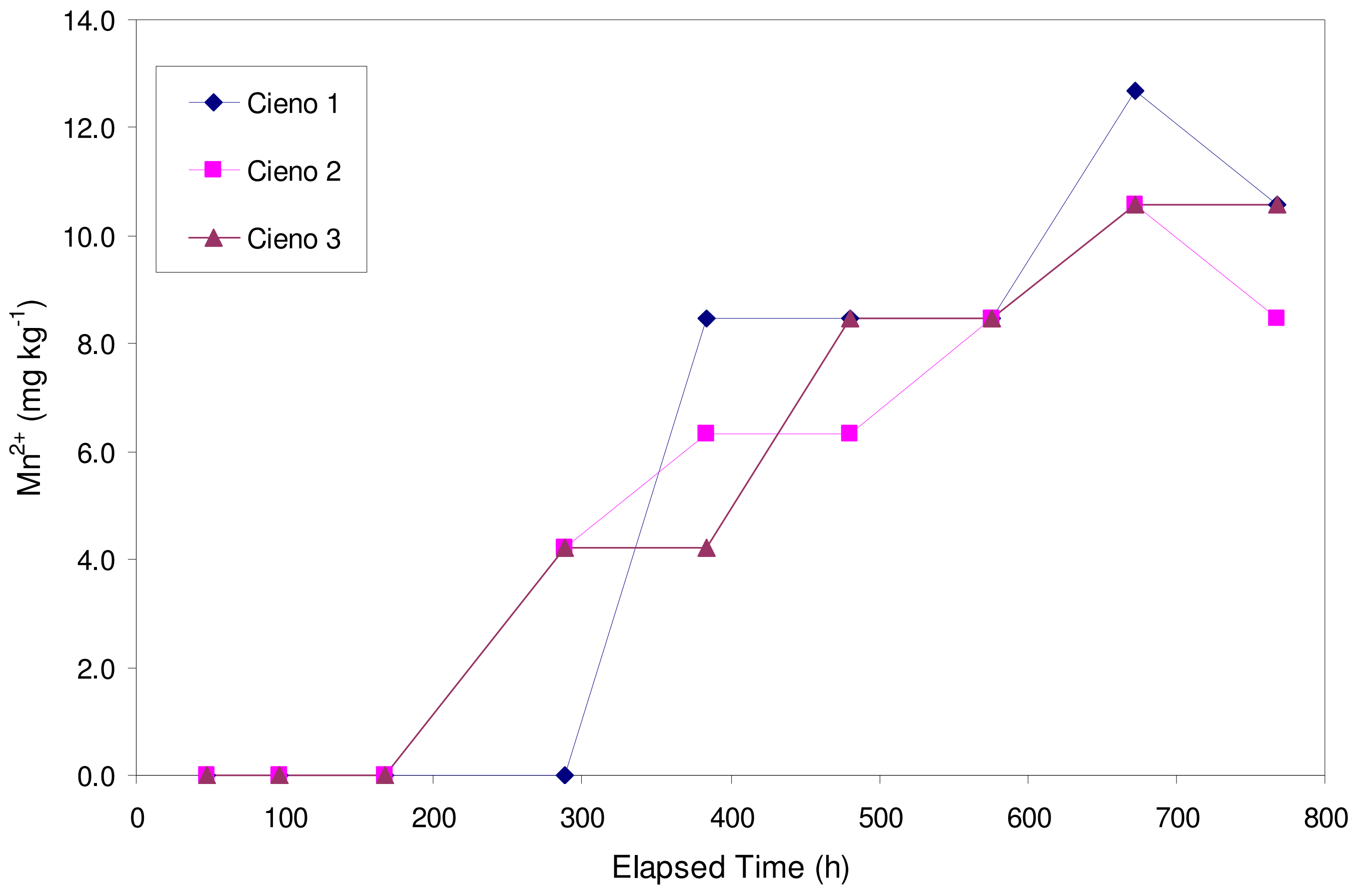

Figure C-8. Reduced Mn concentration in soil solution over time in the Cieno soil.

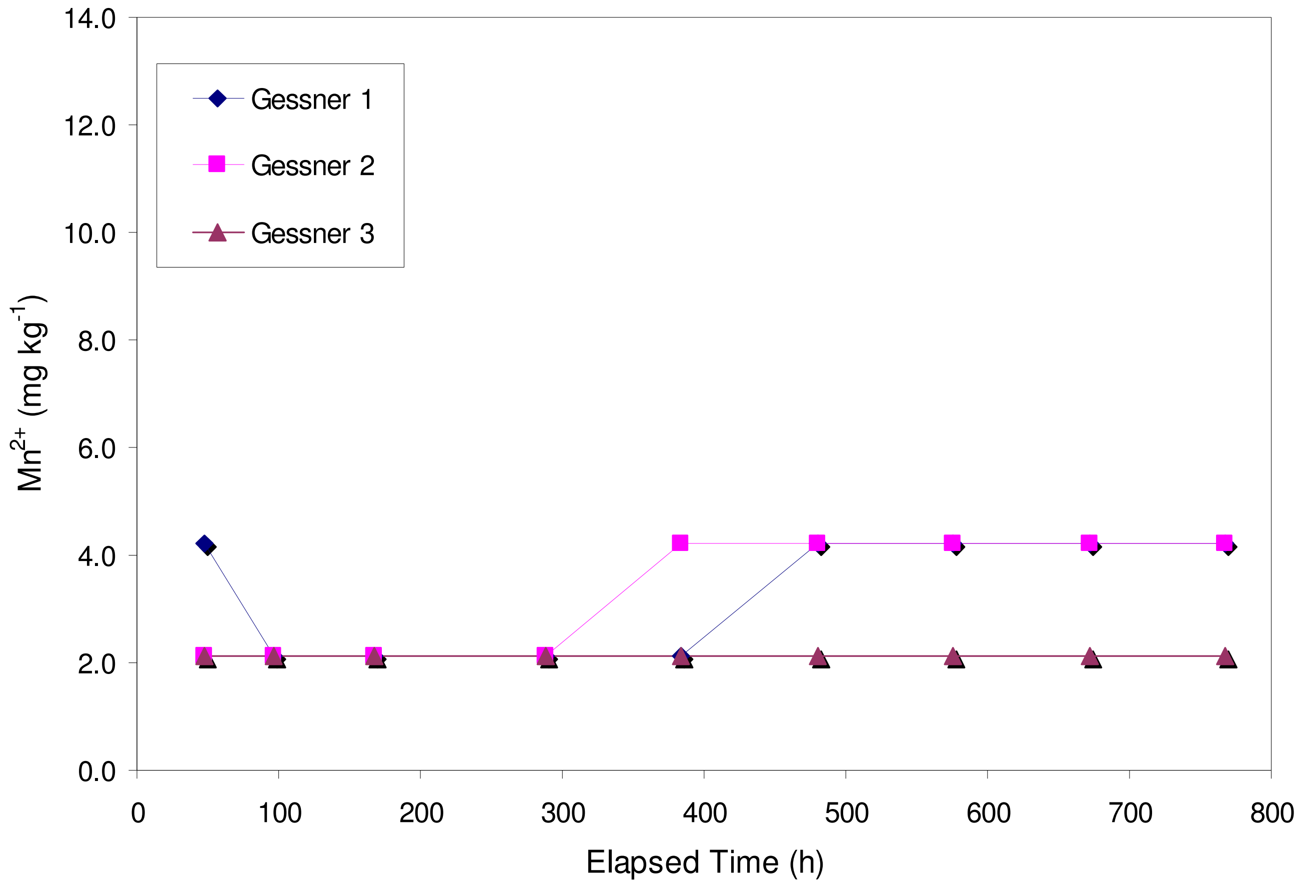

Figure C-9. Reduced Mn concentration in soil solution over time in the Gessner soil.

Table C-1. Redox potential (Eh) readings with statistical calculations from Study #1.

Elapsed Time (h)	Electrode	Pledger-high 1	Pledger-high 2	Pledger-high 3	Pledger-high 1,2,3	Cieno 1	Cieno 2	Cieno 3	Cieno 1,2,3	Gessner 1	Gessner 2	Gessner 3	Gessner 1,2,3
		mV											
24	1	276	387	474	-	137	467	216	-	337	337	340	-
	2	415	193	315	-	323	142	443	-	343	259	130	-
	3	249	358	438	-	210	438	254	-	343	216	213	-
	Mean	313	313	409	345	223	349	304	292	341	271	228	280
	SD	89	105	83	55	94	180	122	64	3	61	106	57
36	1	258	309	389	-	131	422	189	-	307	302	253	-
	2	325	110	283	-	304	88	417	-	313	194	122	-
	3	186	275	396	-	174	390	227	-	303	196	173	-
	Mean	256	231	356	281	203	300	278	260	308	231	183	240
	SD	70	106	63	66	90	184	122	51	5	62	66	63
48	1	246	279	337	-	128	376	174	-	283	275	217	-
	2	302	111	250	-	280	88	403	-	282	176	112	-
	3	162	254	389	-	166	348	217	-	274	194	144	-
	Mean	237	215	325	259	191	271	265	242	280	215	158	217
	SD	70	91	70	59	79	159	122	44	5	53	54	61
60	1	236	250	315	-	127	330	167	-	255	243	191	-
	2	296	109	232	-	266	92	379	-	255	166	106	-
	3	150	237	375	-	158	321	211	-	244	198	130	-
	Mean	227	199	307	244	184	248	252	228	251	202	142	199
	SD	73	78	72	56	73	135	112	38	6	39	44	55
72	1	228	236	283	-	123	303	160	-	228	221	177	-
	2	275	104	221	-	217	89	243	-	236	156	103	-
	3	143	228	217	-	153	281	210	-	232	195	120	-
	Mean	215	189	240	215	164	224	204	198	232	191	133	185
	SD	67	74	37	26	48	118	42	31	4	33	39	50
96	1	212	178	256	-	107	269	155	-	167	180	155	-
	2	260	101	201	-	176	98	180	-	176	154	190	-
	3	139	197	227	-	150	273	207	-	176	196	106	-
	Mean	204	159	228	197	144	213	181	179	173	177	150	167
	SD	61	51	28	35	35	100	26	35	5	21	42	14
120	1	205	147	244	-	96	241	150	-	74	66	144	-
	2	232	89	198	-	152	102	121	-	55	142	199	-
	3	135	176	213	-	145	260	189	-	83	171	94	-
	Mean	191	137	218	182	131	201	153	162	71	126	146	114
	SD	50	44	23	41	31	86	34	36	14	54	53	39

Table C-1 Continued.

Elapsed Time (h)	Electrode	Pledger-high 1	Pledger-high 2	Pledger-high 3	Pledger-high 1,2,3	Cieno 1	Cieno 2	Cieno 3	Cieno 1,2,3	Gessner 1	Gessner 2	Gessner 3	Gessner 1,2,3
		mV											
144	1	200	135	235	-	90	127	136	-	43	53	128	-
	2	229	77	200	-	143	98	89	-	11	104	200	-
	3	136	153	199	-	141	236	178	-	56	133	91	-
	Mean	188	122	211	174	125	154	134	138	37	97	140	91
	SD	48	40	21	47	30	73	45	15	23	41	55	52
168	1	180	99	225	-	72	99	127	-	-57	-46	138	-
	2	138	44	197	-	115	96	61	-	-56	101	205	-
	3	129	86	124	-	134	187	163	-	-28	116	76	-
	Mean	149	76	182	136	107	127	117	117	-47	57	140	50
	SD	27	29	52	54	32	52	52	10	16	90	65	94
192	1	158	20	211	-	65	-40	110	-	-102	-91	139	-
	2	-9	18	197	-	104	85	42	-	-89	72	209	-
	3	118	74	61	-	126	155	142	-	-61	90	56	-
	Mean	89	37	156	94	98	67	98	88	-84	24	135	25
	SD	87	32	83	60	31	99	51	18	21	100	77	109
240	1	130	-22	183	-	52	-38	69	-	-139	-125	141	-
	2	-38	-7	183	-	69	86	12	-	-121	40	218	-
	3	92	4	47	-	118	134	114	-	-99	-1	41	-
	Mean	61	-8	138	64	80	61	65	68	-120	-29	133	-5
	SD	88	13	79	73	34	89	51	10	20	86	89	128
288	1	106	-50	135	-	30	-30	1	-	-172	-148	126	-
	2	-70	-44	64	-	27	91	-15	-	-144	10	230	-
	3	60	-42	-3	-	114	102	94	-	-131	-55	32	-
	Mean	32	-45	65	17	57	54	27	46	-149	-64	129	-28
	SD	91	4	69	57	49	73	59	17	21	79	99	143
384	1	45	-70	54	-	11	-119	-44	-	-191	-139	-115	-
	2	-79	-42	-26	-	-72	81	-66	-	-170	-15	244	-
	3	215	-36	-13	-	60	-14	63	-	-146	-122	18	-
	Mean	60	-49	5	5	0	-17	-16	-11	-169	-92	49	-71
	SD	148	18	43	55	67	100	69	9	23	67	181	111
480	1	-7	-61	60	-	20	-178	-59	-	-213	-173	-193	-
	2	-149	-44	102	-	-115	71	-143	-	-178	-12	246	-
	3	235	-6	-62	-	-66	-120	22	-	-172	-93	5	-
	Mean	26	-37	33	8	-54	-76	-60	-63	-188	-93	19	-87
	SD	194	28	85	39	68	130	83	11	22	81	220	104

Table C-1 Continued.

Elapsed Time (h)	Electrode	Pledger-high 1	Pledger-high 2	Pledger-high 3	Pledger-high 1,2,3	Cieno 1	Cieno 2	Cieno 3	Cieno 1,2,3	Gessner 1	Gessner 2	Gessner 3	Gessner 1,2,3
		mV											
576	1	-24	-51	46	-	12	-190	-69	-	-228	-200	-210	-
	2	-163	-61	87	-	-125	82	-164	-	-47	-21	244	-
	3	238	-1	-67	-	-102	-153	-26	-	-175	-204	-2	-
	Mean	17	-38	22	0	-72	-87	-86	-82	-150	-142	11	-94
	SD	204	32	80	33	73	148	71	9	93	105	227	90
672	1	-41	-53	24	-	29	-200	-78	-	-233	-196	-216	-
	2	-176	-71	51	-	-136	102	-183	-	-53	-25	238	-
	3	237	-13	-17	-	-103	-168	-32	-	-177	-212	-8	-
	Mean	7	-46	19	-7	-70	-89	-98	-85	-154	-144	5	-98
	SD	211	30	34	34	87	166	77	14	92	104	227	89
768	1	-55	-50	0	-	17	-205	-96	-	-238	-208	-219	-
	2	-176	-57	24	-	-158	95	-194	-	-61	-51	231	-
	3	234	-11	-25	-	-119	-189	-33	-	-184	-214	-13	-
	Mean	1	-39	0	-13	-87	-100	-108	-98	-161	-158	0	-106
	SD	211	25	25	23	92	169	81	11	91	92	225	92

Table C-1 Continued.

Elapsed Time (h)	Electrode	Pledger-high 1	Pledger-high 2	Pledger-high 3	Pledger-high 1,2,3	Cieno 1	Cieno 2	Cieno 3	Cieno 1,2,3	Gessner 1	Gessner 2	Gessner 3	Gessner 1,2,3
		mV											
2208	1	-170	-187	-107	-	-63	-227	-205	-	-234	-228	-227	-
	2	-207	-206	-82	-	-207	5	-224	-	-224	-140	86	-
	3	171	-97	-58	-	-178	-212	-171	-	-228	-223	-169	-
	Mean	-69	-163	-82	-105	-149	-145	-200	-165	-229	-197	-103	-176
	SD	208	58	25	51	76	130	27	31	5	49	167	65
2232	1	-196	-196	-119	-	-98	-233	-216	-	-233	-232	-225	-
	2	-217	-206	-153	-	-216	-48	-232	-	-223	-183	65	-
	3	149	-84	-102	-	-209	-209	-182	-	-226	-223	-174	-
	Mean	-88	-162	-125	-125	-174	-163	-210	-183	-227	-213	-111	-184
	SD	206	68	26	37	66	101	26	24	5	26	155	63
2256	1	-201	-204	-132	-	-96	-230	-209	-	-224	-229	-224	-
	2	-223	-158	-120	-	-210	-39	-229	-	-207	-177	63	-
	3	142	-6	-164	-	-207	-166	-180	-	-219	-216	-173	-
	Mean	-94	-123	-139	-118	-171	-145	-206	-174	-217	-207	-111	-178
	SD	205	104	23	23	65	97	25	31	9	27	153	58
2280	1	140	-210	-124	-	-99	-233	-208	-	-211	-227	-224	-
	2	-223	-171	-117	-	-213	-42	-229	-	-213	-188	60	-
	3	-198	-5	-164	-	-211	-206	-174	-	-221	-208	-153	-
	Mean	-94	-129	-135	-119	-174	-160	-204	-179	-215	-208	-106	-176
	SD	203	109	25	22	65	103	28	22	5	20	148	61
2304	1	138	-210	-136	-	-101	-234	-210	-	-212	-185	-125	-
	2	-221	-179	-123	-	-213	-45	-232	-	-215	-186	53	-
	3	-190	-10	-179	-	-212	-188	-178	-	-221	-214	-149	-
	Mean	-91	-133	-146	-123	-175	-156	-207	-179	-216	-195	-74	-162
	SD	199	108	29	29	64	99	27	26	5	16	110	77

Table C-2. One-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) for Eh vaules from Stuc

Elapsed Time: 48 h						
Sample No.	Pledger-high	Cieno	Gessner			
	-------------------------mV-----------------------					
1	246	128	283			
2	302	280	282			
3	162	166	274			
4	279	376	275			
5	111	88	176			
6	254	348	194			
7	337	174	217			
8	250	403	112			
9	389	217	144			
Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	9	2330	258.8888889	7102.611111		
Cieno	9	2180	242.2222222	13036.69444		
Gessner	9	1957	217.4444444	4219.527778		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7828.074074	2	3914.037037	0.482047352	0.623368773	3.402826105
Within Groups	194870.6667	24	8119.611111			
Total	202698.7407	26				

Elapsed Time: 168 h						
Sample No.	Pledger-high	Cieno	Gessner			
	-------------------------mV-----------------------					
1	180	72	-57			
2	138	115	-56			
3	129	134	-28			
4	99	99	-46			
5	44	96	101			
6	86	187	116			
7	225	127	138			
8	197	61	205			
9	124	163	76			
Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	9	1222	135.7777778	3263.444444		
Cieno	9	1054	117.1111111	1666.861111		
Gessner	9	449	49.88888889	9673.361111		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	36732.51852	2	18366.25926	3.772941347	0.037603017	3.402826105
Within Groups	116829.3333	24	4867.888889			
Total	153561.8519	26				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
67.88	Ph vs C	18.67	Accept			
	Ph vs G	85.89	Reject			
	C vs G	67.22	Accept			

Table C-2 Continued.

Elapsed Time: 384 h						
Sample No.	Pledger-high	Cieno	Gessner			
	------------------------mV----------------------					
1	45	11	-191			
2	-79	-72	-170			
3	215	60	-146			
4	-70	-119	-139			
5	-42	81	-15			
6	-36	-14	-122			
7	54	-44	-115			
8	-26	-66	244			
9	-13	63	18			
Analysis of Vairance (ANOVA): Single Factor - Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	9	48	5.333333333	8244.5		
Cieno	9	-100	-11.11111111	4871.611111		
Gessner	9	-636	-70.66666667	18658.5		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	28779.85185	2	14389.92593	1.358624898	0.276079328	3.402826105
Within Groups	254196.8889	24	10591.53704			
Total	282976.7407	26				

Elapsed Time: 576 h						
Sample No.	Pledger-high	Cieno	Gessner			
	------------------------mV----------------------					
1	-24	12	-228			
2	-163	-125	-47			
3	238	-102	-175			
4	-51	-190	-200			
5	-61	82	-21			
6	-1	-153	-204			
7	46	-69	-210			
8	87	-164	244			
9	-67	-26	-2			
Analysis of Vairance (ANOVA): Single Factor - Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	9	4	0.444444444	13035.52778		
Cieno	9	-735	-81.66666667	8089.25		
Gessner	9	-843	-93.66666667	23944.25		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	47229.40741	2	23614.7037	1.57190236	0.228289656	3.402826105
Within Groups	360552.2222	24	15023.00926			
Total	407781.6296	26				

Table C-2 Continued.

Elapsed Time: 768 h						
Sample No.	Pledger-high	Cieno	Gessner			
	-------------------------mV-----------------------					
1	-55	17	-238			
2	-176	-158	-61			
3	234	-119	-184			
4	-50	-205	-208			
5	-57	95	-51			
6	-11	-189	-214			
7	0	-96	-219			
8	24	-194	231			
9	-25	-33	-13			
Analysis of Vairance (ANOVA): Single Factor - Summary						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	9	-116	-12.88888889	11791.61111		
Cieno	9	-882	-98	10961.25		
Gessner	9	-957	-106.3333333	23201.5		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	48135.62963	2	24067.81481	1.571198961	0.228431684	3.402826105
Within Groups	367634.8889	24	15318.12037			
Total	415770.5185	26				

Table C-3. One-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) for ferrous Fe concentrations from Study #1.

Elapsed Time: 48 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	6.4	0.0	2.1			
2	2.1	0.0	0.0			
3	10.6	0.0	0.0			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	19.1214	6.3738	18.05570064		
Cieno	3	0	0	0		
Gessner	3	2.1124	0.704133333	1.487411253		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	73.2662503	2	36.63312515	5.62343275	0.042103987	5.14325285
Within Groups	39.08622379	6	6.514370631			
Total	112.3524741	8				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
5.10	Ph vs C	6.37	Reject			
	Ph vs G	5.67	Reject			
	G vs C	0.70	Accept			

Elapsed Time: 168 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	6.4	2.1	0.0			
2	2.1	4.2	0.0			
3	2.1	4.2	8.4			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	10.5984	3.5328	6.05361204		
Cieno	3	10.565	3.521666667	1.488256333		
Gessner	3	8.4496	2.816533333	23.79858005		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.010374907	2	0.505187453	0.04835803	0.953160076	5.14325285
Within Groups	62.68089685	6	10.44681614			
Total	63.69127176	8				

Elapsed Time: 384 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	28.7	14.8	6.3			
2	47.8	8.5	8.4			
3	14.3	6.3	0.0			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	90.82665	30.27555	281.8382022		
Cieno	3	29.582	9.860666667	19.34733233		
Gessner	3	14.7868	4.928933333	19.33634629		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1083.540432	2	541.7702158	5.070825877	0.051358204	5.14325285
Within Groups	641.0437616	6	106.8406269			
Total	1724.584193	8				

Table C-3 Continued.

Elapsed Time: 576 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	50.2	33.8	29.6			
2	71.7	29.6	23.2			
3	33.5	21.1	4.2			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	155.361375	51.787125	367.5322501		
Cieno	3	84.52	28.17333333	41.67117733		
Gessner	3	57.0348	19.0116	174.0271166		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1715.783554	2	857.8917768	4.412792431	0.066285456	5.14325285
Within Groups	1166.461088	6	194.4101814			
Total	2882.244642	8				

Elapsed Time: 768 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	59.8	52.8	29.6			
2	78.9	40.1	25.3			
3	69.3	40.1	12.7			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	207.945225	69.315075	91.40698449		
Cieno	3	133.119	44.373	53.577228		
Gessner	3	67.5968	22.53226667	77.34538517		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3287.755893	2	1643.877947	22.18163435	0.001690877	5.14325285
Within Groups	444.6591953	6	74.10986589			
Total	3732.415089	8				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
17.20	Ph vs C	24.94	Reject			
	Ph vs G	46.78	Reject			
	C vs G	21.84	Reject			

Table C-4. One-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) for reduced Mn concentrations from Study #1.

Elapsed Time: 48 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	0.0	0.0	4.2			
2	0.0	0.0	2.1			
3	0.0	0.0	2.1			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	0	0	0		
Cieno	3	0	0	0		
Gessner	3	8.4496	2.816533333	1.487411253		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	15.86572004	2	7.932860018	16	0.003936434	5.14325285
Within Groups	2.974822507	6	0.495803751			
Total	18.84054254	8				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
1.41	Ph vs C	0.00	Accept			
	G vs Ph	2.82	Reject			
	G vs C	2.82	Reject			

Elapsed Time: 168 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	2.1	0.0	2.1			
2	2.1	0.0	2.1			
3	2.1	0.0	2.1			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	6.3492	2.1164	0.00020172		
Cieno	3	0	0	0		
Gessner	3	6.3372	2.1124	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.94139872	2	4.47069936	66488.68769	9.18463E-14	5.14325285
Within Groups	0.00040344	6	6.724E-05			
Total	8.94180216	8				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
0.02	Ph vs C	2.12	Reject			
	G vs Ph	0.00	Accept			
	G vs C	2.11	Reject			

Table C-4 Continued.

Elapsed Time: 384 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	2.4	8.5	2.1			
2	4.8	6.3	4.2			
3	2.4	4.2	2.1			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	9.5607	3.1869	1.904312177		
Cieno	3	19.017	6.339	4.464769		
Gessner	3	8.4496	2.816533333	1.487411253		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	22.4806773	2	11.24033865	4.292120974	0.069630926	5.14325285
Within Groups	15.71298486	6	2.61883081			
Total	38.19366216	8				

Elapsed Time: 576 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	4.8	8.5	4.2			
2	4.8	8.5	4.2			
3	2.4	8.5	2.1			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	11.950875	3.983625	1.904312177		
Cieno	3	25.356	8.452	0		
Gessner	3	10.562	3.520666667	1.487411253		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	44.498754	2	22.249377	19.67970926	0.002314469	5.14325285
Within Groups	6.78344686	6	1.130574477			
Total	51.28220086	8				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
2.12	C vs Ph	4.47	Reject			
	Ph vs G	0.46	Accept			
	C vs G	4.93	Reject			

Table C-4 Continued.

Elapsed Time: 768 h						
Sample No.	Pledger-high	Cieno	Gessner			
	--------------------mg kg^{-1}------------------					
1	4.8	10.6	4.2			
2	7.2	8.5	4.2			
3	4.8	10.6	2.1			
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-high	3	16.750875	5.583625	1.888785238		
Cieno	3	29.582	9.860666667	1.488256333		
Gessner	3	10.562	3.520666667	1.487411253		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	62.7444825	2	31.37224125	19.34785415	0.002419114	5.14325285
Within Groups	9.72890565	6	1.621484275			
Total	72.47338815	8				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
2.54	C vs Ph	4.28	Reject			
	Ph vs G	2.06	Accept			
	C vs G	6.34	Reject			

APPENDIX D

ADDITIONAL STUDY #2 DATA

Table D-1. Weight of clods and sucrose addition from Study #2.

Sample	Pledger-low	China	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	--------------------------------------Wet Weight of Clods (g)-----------------------------------						
N-1	347.34	327.05	338.45	286.59	249.44	275.21	250.87
N-2	343.89	329.23	337.64	290.37	236.04	273.86	250.57
N-3	351.01	317.23	338.86	283.37	250.70	268.76	250.95
0-1	348.56	326.67	340.05	289.88	231.21	274.54	250.53
0-2	346.20	321.82	337.62	288.79	249.78	274.65	250.25
0-3	350.91	326.81	336.21	289.77	245.54	274.05	250.31
10-1	351.97	328.12	338.60	286.53	249.28	273.50	249.59
10-2	347.75	327.49	337.20	289.78	249.43	274.37	250.57
10-3	351.03	321.28	336.56	283.78	249.19	273.44	246.05
30-1	345.63	329.64	334.12	289.04	248.00	272.68	240.91
30-2	344.98	329.16	337.80	289.23	238.65	271.62	249.31
30-3	349.60	327.60	337.48	290.72	250.05	274.72	249.91
60-1	344.60	327.82	336.16	287.01	250.01	271.67	252.37
60-2	346.90	321.91	338.66	287.57	249.95	271.14	229.70
60-3	349.34	327.97	338.60	284.40	250.68	273.83	232.23
100-1	346.90	328.69	337.62	284.62	249.72	273.06	229.60
100-2	345.50	329.45	334.01	289.02	230.85	273.70	249.78
100-3	347.45	329.45	337.07	287.93	235.68	272.43	237.99
pH	343.89	265.56	302.27	288.30	254.34	274.77	238.68
DC Fe	346.28	261.32	256.84	286.45	245.69	272.62	250.10

Sample	Pledger-low	China	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	--------------------------------------Dry Weight of Clods (g)-----------------------------------						
N-1	229.57	251.38	224.88	243.49	234.22	234.42	237.12
N-2	227.29	253.06	224.34	246.70	221.63	233.27	236.83
N-3	232.00	243.84	225.16	240.76	235.40	228.93	237.19
0-1	230.38	251.09	225.94	246.29	217.10	233.85	236.80
0-2	228.82	247.36	224.33	245.36	234.54	233.94	236.53
0-3	231.93	251.20	223.40	246.19	230.55	233.43	236.59
10-1	232.63	252.21	224.98	243.44	234.07	232.96	235.91
10-2	229.84	251.72	224.05	246.20	234.21	233.71	236.83
10-3	232.01	246.95	223.63	241.10	233.98	232.91	232.56
30-1	228.44	253.37	222.01	245.57	232.86	232.27	227.70
30-2	228.01	253.01	224.45	245.73	224.08	231.36	235.64
30-3	231.06	251.81	224.24	247.00	234.79	234.00	236.21
60-1	227.76	251.98	223.36	243.85	234.75	231.41	238.53
60-2	229.28	247.43	225.02	244.32	234.69	230.95	217.11
60-3	230.89	252.09	224.98	241.63	235.38	233.25	219.50
100-1	229.28	252.64	224.33	241.82	234.48	232.59	217.01
100-2	228.35	253.23	221.93	245.56	216.76	233.13	236.09
100-3	229.64	253.23	223.97	244.63	221.30	232.05	224.94
pH	227.29	204.12	200.84	244.94	238.82	234.05	225.60
DC Fe	228.87	200.86	170.66	243.37	230.69	232.21	236.39

Table D-1 Continued.

Sample	Pledger-low	China	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	------------------------------------- Weight of Sugar (g) -----------------------------------						
N-1	-	-	-	-	-	-	-
N-2	-	-	-	-	-	-	-
N-3	-	-	-	-	-	-	-
0-1	11.52	12.55	11.30	12.31	10.85	11.69	11.84
0-2	11.44	12.37	11.22	12.27	11.73	11.70	11.83
0-3	11.60	12.56	11.17	12.31	11.53	11.67	11.83
10-1	11.63	12.61	11.25	12.17	11.70	11.65	11.80
10-2	11.49	12.59	11.20	12.31	11.71	11.69	11.84
10-3	11.60	12.35	11.18	12.06	11.70	11.65	11.63
30-1	11.42	12.67	11.10	12.28	11.64	11.61	11.39
30-2	11.40	12.65	11.22	12.29	11.20	11.57	11.78
30-3	11.55	12.59	11.21	12.35	11.74	11.70	11.81
60-1	11.39	12.60	11.17	12.19	11.74	11.57	11.93
60-2	11.46	12.37	11.25	12.22	11.73	11.55	10.86
60-3	11.54	12.60	11.25	12.08	11.77	11.66	10.97
100-1	11.46	12.63	11.22	12.09	11.72	11.63	10.85
100-2	11.42	12.66	11.10	12.28	10.84	11.66	11.80
100-3	11.48	12.66	11.20	12.23	11.06	11.60	11.25
pH	11.36	10.21	10.04	12.25	11.94	11.70	11.28
DC Fe	11.44	10.04	8.53	12.17	11.53	11.61	11.82

Table D-2. Mean and standard deviation of Eh values over time during sucrose amendment from Study #2.

			Elapsed Time											
Soil	Sample	24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
			Eh Value (mV)											
Pledger-low	1	-283	-266	-285	-263	-248	-117	-250	14	217	142	18	139	187
	2	-282	-279	-286	-265	-265	-206	-251	-218	4	-43	82	48	109
	3	-282	-294	-292	-274	-284	-286	-281	-198	-174	50	140	116	131
	4	-289	-297	-289	-290	-270	-260	-255	-227	-248	-258	-261	-249	-254
	5	-294	-296	-291	-285	-278	-264	-287	-286	-205	-94	119	159	177
	6	-299	-306	-294	-284	-335	-265	-292	-283	-242	-141	-182	120	212
	7	-292	-296	-282	-279	-281	-266	-293	-287	-319	-205	46	189	201
	8	-298	-294	-285	-285	-284	-284	-289	-288	-295	-285	-251	-148	147
	9	-280	-303	-299	-300	-300	-301	-299	-267	15	158	177	184	205
	10	-218	-295	-292	-289	-282	-273	-291	-125	-137	-257	-226	-93	108
	11	-298	-306	-291	-290	-137	-144	-104	-238	-95	-271	26	73	162
	12	-281	-308	-296	-298	-21	-158	-36	100	208	219	190	145	150
	13	-294	-295	-305	-296	-299	-199	-130	-122	-175	-175	-134	-165	-173
	14	-311	-303	-277	-263	-262	-260	-153	-115	-115	-7	108	115	173
	15	87	-289	-292	-302	-309	-293	-276	-279	-111	-210	-223	-184	180
	16	-92	-294	-287	-285	-283	-275	-235	-230	-232	-230	-208	-192	-90
	17	-25	-305	-312	-312	-312	-279	-185	-122	-40	-6	32	49	81
	18	30	-276	-298	-304	-299	-288	-271	-248	-120	-46	41	134	224
	19	318	-212	-302	-301	-281	-243	-196	-175	-147	-141	-105	-35	173
	20	317	-245	-300	-304	-304	-313	-311	-308	-66	-194	-198	-209	-149
	21	385	-264	-287	-277	-273	-282	-280	-292	-297	-290	-261	-132	60
	22	45	-285	-300	-256	-216	-141	-167	-146	-131	-22	-19	33	195
	23	-199	-307	-305	-300	-294	-270	-239	-100	21	84	136	160	200
	24	220	-275	-294	-295	-300	-301	-294	-295	-291	-286	-150	-169	-249
	25	-101	-288	-292	-296	-300	-289	-123	-130	-91	-76	-42	-3	47
	26	-182	-285	-289	-291	-298	-302	-286	-293	-165	-237	-180	45	150
	27	-32	-298	-310	-301	-292	-171	138	203	233	215	177	193	199
	28	202	-142	-278	-270	-220	-68	123	103	-13	-10	-17	3	232
	29	275	-287	-300	-279	-227	-110	-83	-69	243	203	78	-17	173
	30	123	-259	-294	-300	-306	-280	-230	-212	-195	-232	-253	-246	25
	Mean	-88	-282	-293	-288	-269	-240	-204	-171	-99	-88	-45	2	100
	SD	231	34	9	14	60	68	117	133	159	165	154	145	141

Table D-2 Continued.

Soil	Sample	24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
		--------Elapsed Time--------												
		--------Eh Value (mV)--------												
Pledger-high	1	-238	-209	-196	-230	-222	-70	-218	-31	126	21	-48	73	70
	2	-217	-240	-214	-154	-216	-184	-225	-177	-43	-101	-18	21	22
	3	-218	-169	-280	-209	-248	-117	-198	-203	-178	19	47	11	92
	4	-159	-229	-261	-120	-252	-222	-199	-234	-220	-182	-199	-209	-130
	5	-224	-160	-240	-237	-262	-141	-267	-241	-190	-160	-20	75	38
	6	-190	-274	-267	-172	-299	-258	-271	-248	-226	-154	-196	65	86
	7	-145	-121	-247	-246	-227	-131	-164	-239	-231	-77	13	72	165
	8	-70	-232	-224	-142	-239	-195	-190	-235	-200	-229	-145	-125	59
	9	-145	-153	-276	-286	-276	-141	-210	-254	-88	65	14	32	103
	10	-53	-156	-251	-132	-266	-215	-202	-170	-146	-190	-195	-139	51
	11	-241	-147	-209	-163	-159	-161	-168	-174	-69	-226	-12	1	74
	12	-119	-190	-237	-256	-87	-171	-92	44	91	182	84	98	176
	13	-232	-162	-231	-226	-225	-209	-149	-177	-97	-147	-90	-116	-123
	14	-146	-138	-222	-247	-219	-240	-162	-48	-138	50	17	-16	166
	15	80	-236	-286	-141	-297	-222	-241	-157	31	-141	-190	-51	102
	16	-23	-175	-263	-217	-264	-214	-213	-106	-208	-82	-173	-110	21
	17	13	-208	-152	-153	-174	-265	-181	-84	44	-38	96	166	64
	18	6	-77	-212	-281	-182	-243	-245	-107	-119	-19	10	65	182
	19	244	-152	-228	-111	-198	-162	-194	-135	-79	-125	-66	1	88
	20	237	-165	-231	-205	-239	-242	-245	-159	-109	-49	-107	-139	7
	21	287	-231	-288	-270	-269	-111	-196	-262	-105	-252	-240	-24	-20
	22	112	-161	-288	-246	-203	-190	-169	-71	-88	-76	-72	64	108
	23	-23	-177	-182	-240	-253	-237	-254	-57	0	43	50	209	142
	24	191	-156	-182	-206	-230	-190	-212	-230	-176	-155	-135	-50	-113
	25	-120	-194	-208	-148	-261	-269	-73	-108	-152	-135	-21	-21	-12
	26	-155	-118	-231	-195	-266	-261	-171	-260	-152	-208	-117	-14	46
	27	-1	-222	-256	-274	-206	-93	57	32	108	91	145	113	108
	28	113	-4	-230	-224	-174	-143	14	33	-31	-93	-7	-48	74
	29	193	-229	-256	-241	-238	-139	-151	-103	69	42	-24	-50	65
	30	103	-139	-250	-262	-281	-250	-231	-234	-180	-191	-243	-211	-35
	Mean	-38	-174	-237	-208	-231	-190	-181	-147	-92	-84	-61	-9	56
	SD	163	54	34	52	45	56	74	93	105	109	104	102	82

Table D-2 Continued.

		Elapsed Time												
Soil	Sample	24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
		Eh Value (mV)												
China	1	-268	-279	-225	-275	-277	-285	-214	-291	-293	-291	-295	-301	-307
	2	-256	-272	-278	-272	-274	-277	-289	-268	-262	-257	-263	-247	-254
	3	-284	-278	-268	-267	-263	-268	-218	-221	-264	-241	-252	-258	-256
	4	-290	-285	-274	-271	-286	-284	-291	-288	-267	-264	-236	-232	54
	5	-275	-279	-279	-283	-281	-277	-253	-265	-252	-269	-163	-32	58
	6	-274	-288	-296	-301	-299	-282	-250	-239	-212	-144	-77	-52	-38
	7	-256	-275	-274	-276	-276	-274	-257	-249	-199	-192	-249	-240	-266
	8	-252	-271	-277	-271	-273	-271	-259	-259	-236	-223	-97	-99	-51
	9	-258	-283	-281	-280	-281	-280	-280	-275	-266	-254	-253	-186	-215
	10	-272	-273	-265	-264	-267	-264	-274	-284	-285	-244	-236	-177	-197
	11	-258	-275	-291	-286	-291	-300	-297	-297	-187	-256	-190	-117	-77
	12	-265	-270	-276	-271	-272	-275	-264	-256	-205	-224	-208	-148	13
	13	-275	-279	-286	-283	-288	-287	-277	-271	-251	-242	-238	-206	-86
	14	-271	-278	-279	-276	-280	-282	-269	-252	-181	-236	-268	-186	-41
	15	-230	-277	-283	-296	-304	-306	-302	-300	-294	-282	-269	-262	-169
	16	-211	-279	-287	-288	-293	-301	-299	-297	-288	-283	-283	-277	-271
	17	-235	-257	-275	-273	-280	-293	-284	-275	-237	-179	-27	56	196
	18	-226	-258	-282	-279	-298	-301	-294	-298	-303	-303	-296	-277	-289
	19	-237	-270	-289	-290	-291	-298	-285	-207	-249	-240	-101	-215	-140
	20	-259	-277	-290	-287	-292	-297	-285	-306	-288	-284	-179	-113	-75
	21	-272	-277	-278	-278	-283	-277	-268	-209	-301	-304	-299	-298	-184
	22	-257	-272	-285	-287	-295	-280	-291	-300	-295	-296	-296	275	-295
	23	-304	-354	-313	-312	-307	-303	-301	-293	-268	-273	-262	-255	-214
	24	-280	-291	-293	-291	-292	-291	-292	-292	-270	-268	-247	-237	-201
	25	-268	-279	-278	-279	-276	-273	-278	-272	-264	-153	31	77	166
	26	-263	-278	-278	-276	-276	-274	-270	-266	-268	-269	-232	-260	-49
	27	-271	-277	-304	-275	-283	-287	-276	-272	-153	-131	-78	1	152
	28	-276	-280	-277	-286	-286	-286	-286	-284	20	-275	-289	-288	-315
	29	-242	-279	-298	-288	-287	-292	-281	-281	-273	-267	-248	-246	-227
	30	-236	-266	-297	-273	-273	-273	-290	-283	-287	-259	-222	-243	-190
	Mean	-261	-279	-282	-281	-284	-285	-276	-272	-246	-247	-211	-168	-126
	SD	20	16	15	10	11	11	21	26	63	46	87	134	147

Table D-2 Continued.

Soil	Sample	24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
			Elapsed Time											
			Eh Value (mV)											
Cieno	1	-230	-242	-268	-266	-274	-273	-298	-283	-271	-223	-171	-161	-125
	2	-242	-237	-263	-262	-268	-273	-277	-292	-301	-293	-284	-275	-265
	3	-177	-82	-271	-265	-266	-273	-262	-263	-278	-272	-275	-272	-260
	4	20	-129	-265	-265	-268	-275	-266	-251	-240	-208	-220	-183	122
	5	318	-119	-261	-275	-282	-281	-279	-274	-271	-270	-278	-287	-246
	6	-205	-259	-266	-270	-280	-281	-276	-268	-290	-279	-258	-37	-44
	7	75	-33	-255	-271	-285	-311	-306	-298	-264	-232	-117	-174	-169
	8	262	30	-281	-293	-306	-310	-297	-296	-300	-293	-289	-280	-275
	9	400	58	-223	-280	-289	-297	-296	-291	-282	-285	-279	-277	-270
	10	362	-52	-257	-265	-268	-269	33	-263	-260	-267	-264	-260	-150
	11	211	70	-266	-274	-273	-271	-266	-261	-251	-245	-228	-222	-198
	12	74	17	-275	-278	-280	-217	21	44	93	114	109	109	129
	13	77	-263	-263	-254	-258	-238	-218	-221	-233	-191	-202	-255	-187
	14	6	-203	-260	-254	-256	-262	-252	-252	-250	-257	-258	-261	-244
	15	7	-250	-280	-282	-286	-294	-286	-251	-108	89	134	148	187
	16	-47	-213	-271	-268	-275	-279	-309	-282	-232	-91	117	144	162
	17	175	26	-239	-273	-277	-277	-282	-271	-244	-212	-89	55	113
	18	-181	-239	-274	-271	-266	-259	-254	-251	-244	-240	-231	-113	-56
	19	64	-119	-271	-262	-260	-261	-257	-254	-265	-257	-254	-249	-38
	20	41	19	-280	-281	-271	-290	-300	-289	-272	-248	-129	-51	-17
	21	103	-123	-304	-291	-251	-125	-93	-116	-114	-101	-78	-55	-53
	22	163	-217	-285	-288	-299	-302	-306	-299	-288	-221	-211	-150	-109
	23	89	-116	-284	-298	-308	-316	-316	-316	-293	-217	-137	-99	-15
	24	95	-99	-255	-270	-286	-298	-307	-296	-216	-166	-62	-75	-74
	25	179	-132	-268	-280	-285	-312	-316	-313	-288	-267	-169	-163	-53
	26	-214	-94	-265	-278	-284	-297	-305	-296	-287	-285	-41	-64	-69
	27	262	-132	-254	-256	-261	-263	-261	-257	-252	-244	-229	-220	-214
	28	-185	-253	-260	-260	-272	-284	-296	-295	-191	-192	-238	-209	-164
	29	34	-33	-231	-252	-254	-259	-239	-226	-226	-197	25	16	25
	30	60	65	-154	-245	-277	-286	-272	-271	-266	-270	-264	-248	-219
	Mean	53	-112	-262	-271	-276	-274	-255	-258	-239	-211	-162	-139	-93
	SD	179	109	26	13	14	36	87	68	78	98	126	133	138

Table D-2 Continued.

Soil	Sample	Elapsed Time												
		24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
		Eh Value (mV)												
Orelia-loamy	1	-201	-253	-301	-283	-293	-301	-302	-313	-281	-271	-268	-276	-262
	2	-245	-270	-290	-297	-297	-304	-300	-298	-298	-290	-267	-265	-270
	3	-374	-376	-311	-327	-319	-307	-302	-287	-234	-241	-204	-142	12
	4	-346	-335	-338	-315	-319	-311	-331	-312	-314	-310	-275	-279	-195
	5	-150	-284	-309	-321	-311	-254	-300	-294	-291	-285	-266	-272	-210
	6	-333	-338	-322	-326	-309	-299	-309	-301	-283	-297	-289	-294	-277
	7	-333	-326	-306	-308	-306	-306	-226	-202	-40	-39	-13	-41	-74
	8	-343	-339	-306	-322	-311	-304	-231	-180	15	12	-10	-11	85
	9	-266	-301	-331	-303	-304	-296	-301	-280	-271	-267	-259	-262	-247
	10	-300	-314	-341	-303	-300	-315	-297	-292	-280	-268	-254	-252	-255
	11	-229	-232	-332	-316	-314	-297	-294	-286	-106	-38	-19	-114	203
	12	74	-84	-341	-338	-319	-314	-296	-280	-212	-155	-86	-87	-44
	13	-354	-356	-345	-332	-329	-334	-327	-321	-316	-300	-302	-304	-266
	14	-352	-348	-315	-303	-304	-301	-282	-276	-264	-254	-257	-253	-247
	15	-334	-341	-317	-302	-329	-289	-264	-253	98	-47	-210	-211	-160
	16	-308	-308	-296	-291	-286	-291	-276	-249	-285	-150	-199	-208	-168
	17	306	263	28	-116	-202	-156	-83	-56	6	133	-90	-193	-187
	18	43	-250	-303	-316	-318	-324	-317	-308	-250	-265	-262	-261	-256
	19	-358	-352	-319	-314	-310	-320	-313	-310	-278	-263	-272	-277	-269
	20	-345	-329	-313	-312	-309	-311	-306	-298	-257	-231	-182	-163	-125
	21	66	19	-332	-327	-315	-320	-303	-296	-279	-257	-226	-202	-138
	22	62	7	-321	-333	-323	-328	-314	-275	-278	-277	-270	-282	-293
	23	-346	-336	-321	-314	-314	-309	-290	-274	-158	-79	-52	-73	-83
	24	-347	-346	-315	-302	-299	-302	-154	-280	-111	-119	-262	-178	-148
	25	-247	-288	-324	-317	-297	-304	-297	-290	-297	-269	-181	-212	-231
	26	-152	-303	-310	-309	-288	-298	-279	-272	-256	-245	-245	-255	-244
	27	-82	-264	-308	-311	-317	-323	-278	-190	41	225	209	152	202
	28	-235	-271	-306	-311	-313	-325	-306	-287	-263	-244	-3	-8	-88
	29	-317	-335	-331	-322	-266	-130	-272	-177	-253	-292	-283	-284	-258
	30	-323	-346	-337	-325	-321	-309	-291	-294	-130	-68	-259	-259	-245
	Mean	-222	-265	-307	-307	-305	-296	-281	-268	-204	-182	-185	-192	-158
	SD	172	139	65	38	24	44	51	56	119	137	122	109	135

Table D-2 Continued.

Soil	Sample	24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
		Elapsed Time												
		Eh Value (mV)												
Gessner	1	-268	-262	-238	-240	-253	-249	-245	-269	-129	-155	-178	-100	11
	2	-260	-260	-238	-245	-258	-255	-253	-264	-203	-229	-159	-3	-93
	3	-269	-252	-244	-247	-252	-255	-186	-115	33	23	31	52	37
	4	-274	-257	-244	-242	-252	-253	-261	-253	-158	-153	-158	13	-124
	5	-262	-257	-251	-251	-255	-249	-248	-243	-245	-235	-237	159	-217
	6	-270	-267	-271	-274	-286	-280	-282	-281	-263	-263	-263	143	-238
	7	-276	-265	-253	-252	-255	-270	-270	-256	-149	-162	-186	-164	-203
	8	-293	-281	-272	-273	-277	-286	-287	-281	-282	-278	-277	-268	-253
	9	-280	-268	-271	-270	-275	-274	193	-262	-248	-242	-236	-207	-200
	10	-274	-264	-255	-258	-261	-260	-261	-248	-237	-248	-252	-233	-102
	11	-271	-251	-250	-248	-239	-241	-253	-250	-230	-112	-81	-148	-1
	12	-277	-254	-236	-239	-234	-233	-232	-223	-215	-206	-225	-214	-226
	13	-271	-258	-257	-262	-263	-259	-241	-224	-130	-71	-7	21	18
	14	-269	-252	-262	-252	-256	-253	-253	-241	-234	-218	-221	-202	-227
	15	-236	-254	-255	-250	-250	-245	-243	-229	-155	-152	-183	-127	-57
	16	-229	-252	-253	-250	-241	-238	-242	-257	-242	-209	-174	-155	-133
	17	-252	-264	-261	-255	-258	-256	-263	-256	-246	-102	-83	-38	-28
	18	-204	-253	-269	-261	-259	-260	-246	-241	-155	-198	-163	-114	-64
	19	-248	-249	-252	-245	-250	-236	-263	-202	-222	-256	-262	-232	-194
	20	-241	-253	-248	-247	-256	-255	-241	-184	-96	-43	38	70	75
	21	-224	-245	-257	-256	-253	-256	-253	-243	-261	-268	-274	-277	-252
	22	-224	-245	-258	-255	-245	-247	-240	-229	-213	-207	-186	-179	-171
	23	-166	-256	-249	-253	-259	-244	-261	-269	73	-235	-125	135	-132
	24	-235	-259	-250	-255	-251	-246	-77	-234	47	-212	-221	185	51
	25	-212	157	-249	-246	-257	-247	-255	-231	-174	-196	-165	-161	-174
	26	-229	-248	-264	-270	-266	-260	-261	-252	-228	-192	-157	-115	-28
	27	-257	-280	-292	-295	-302	-292	-268	-254	-247	-224	-228	-212	-213
	28	-231	-252	-257	-295	-256	-240	-236	-230	-248	-234	-224	-207	-223
	29	-256	-251	-255	-267	-255	-247	-247	-257	-245	-221	-165	-99	-39
	30	-214	-249	-252	-254	-256	-252	-250	-251	-133	-191	-234	-215	-84
	Mean	-249	-243	-255	-257	-258	-255	-231	-241	-181	-190	-175	-96	-116
	SD	28	76	12	14	13	14	88	32	92	70	83	137	102

Table D-2 Continued.

Soil	Sample	24 h	48 h	96 h	168 h	192 h	216 h	288 h	360 h	432 h	504 h	528 h	600 h	672 h
			Elapsed Time											
			Eh Value (mV)											
Orelia-sandy	1	-343	-330	-295	-285	-283	-281	-243	-288	-1	-238	-241	-231	-217
	2	-343	-323	-291	-281	-266	-263	-251	-270	-268	-272	-258	-263	-232
	3	-347	-336	-294	-291	-266	-268	-250	-232	-247	-205	-95	-136	-151
	4	-344	-334	-303	-296	-285	-289	-267	-283	-241	-247	-194	-158	-197
	5	-294	-277	-193	-168	-160	-169	-154	-260	-240	-233	-220	-228	-208
	6	-341	-321	-300	-291	-275	-267	-261	-235	-277	-275	-268	-269	-261
	7	-307	-306	-276	-275	-262	-262	-266	-231	-262	-263	-233	-218	-114
	8	-299	-297	-272	-264	-258	-248	-249	-248	-253	-231	-200	-187	-81
	9	-342	-322	-306	-266	-260	-258	-257	-269	-258	-251	-240	-249	-244
	10	-325	-319	-306	-289	-282	-273	-255	-276	-116	-129	-209	-226	-116
	11	-333	-336	-303	-293	-267	-263	-251	-294	-247	-237	-236	-243	-241
	12	-341	-334	-318	-303	-291	-283	-281	-246	-271	-255	-225	-245	-247
	13	-354	-347	-295	-294	-280	-276	-270	-268	-294	-185	-199	-208	-188
	14	-344	-347	-299	-318	-306	-274	-238	-246	-209	-219	-244	-242	-231
	15	-324	-321	-292	-283	-266	-255	-245	-299	-242	-210	-229	-234	-218
	16	-305	-336	-184	-287	-265	-257	-245	-297	-241	-235	-235	-234	-231
	17	-349	-332	-295	-136	-290	-299	-161	-268	-121	-149	-189	-210	13
	18	-302	-309	-290	-203	-151	-136	-129	-294	-244	-208	-220	-262	-241
	19	-346	-327	-295	-288	-273	-268	-274	-226	-170	-131	-136	-158	-146
	20	-338	-326	-293	-281	-268	-246	-246	-246	-102	-242	-242	-246	-241
	21	-327	-331	-311	-302	-292	-298	-280	-275	-195	-258	-245	-249	-229
	22	-318	-313	-294	-288	-277	-275	-260	-248	-274	-186	-88	-78	-90
	23	-327	-313	-288	-272	-241	-249	-247	-239	-244	-235	-229	-233	-223
	24	-339	-320	-271	-236	-154	-152	-153	-159	-181	-206	-89	-223	-210
	25	-340	-336	-308	-305	-299	-290	-272	-252	-235	-243	-216	-216	-215
	26	-335	-326	-294	-280	-267	-234	-197	-243	-150	-193	-194	-160	-151
	27	309	299	179	-112	-234	-204	-171	-141	-170	-170	-151	-162	-156
	28	346	295	200	-20	-223	-215	-242	-203	-224	-205	-185	-213	-186
	29	-339	-332	-303	-296	-277	-273	-262	-257	-249	-249	-236	-246	-237
	30	-344	-336	-304	-294	-274	-269	-273	-276	-255	-249	-240	-248	-185
	Mean	-288	-283	-256	-260	-260	-253	-238	-252	-216	-220	-206	-216	-189
	SD	168	158	125	67	40	40	42	36	65	39	49	44	62

Table D-3. One-way analysis of variance (ANOVA) and Fisher's lease significant difference (LSD) for redox potential (Eh) during sucrose amendment from Study #2.

Elapsed Time: 168 h							
Sample No.	Pledger-low	Pledger-high	China	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	---			-mV-	---		
1	-263	-230	-275	-266	-283	-240	-285
2	-265	-154	-272	-262	-297	-245	-281
3	-274	-209	-267	-265	-327	-247	-291
4	-290	-120	-271	-265	-315	-242	-296
5	-285	-237	-283	-275	-321	-251	-168
6	-284	-172	-301	-270	-326	-274	-291
7	-279	-246	-276	-271	-308	-252	-275
8	-285	-142	-271	-293	-322	-273	-264
9	-300	-286	-280	-280	-303	-270	-266
10	-289	-132	-264	-265	-303	-258	-289
11	-290	-163	-286	-274	-316	-248	-293
12	-298	-256	-271	-278	-338	-239	-303
13	-296	-226	-283	-254	-332	-262	-294
14	-263	-247	-276	-254	-303	-252	-318
15	-302	-141	-296	-282	-302	-250	-283
16	-285	-217	-288	-268	-291	-250	-287
17	-312	-153	-273	-273	-116	-255	-136
18	-304	-281	-279	-271	-316	-261	-203
19	-301	-111	-290	-262	-314	-245	-288
20	-304	-205	-287	-281	-312	-247	-281
21	-277	-270	-278	-291	-327	-256	-302
22	-256	-246	-287	-288	-333	-255	-288
23	-300	-240	-312	-298	-314	-253	-272
24	-295	-206	-291	-270	-302	-255	-236
25	-296	-148	-279	-280	-317	-246	-305
26	-291	-195	-276	-278	-309	-270	-280
27	-301	-274	-275	-256	-311	-295	-112
28	-270	-224	-286	-260	-311	-295	-20
29	-279	-241	-288	-252	-322	-267	-296
30	-300	-262	-273	-245	-325	-254	-294
SUMMARY							
Groups	*Count*	*Sum*	*Average*	*Variance*			
Pledger-low	30	-8634	-287.8	206.786207			
Pledger-high	30	-6234	-207.8	2695.13103			
China	30	-8434	-281.133333	108.74023			
Cieno	30	-8127	-270.9	161.334483			
Orelia-loamy	30	-9216	-307.2	1461.68276			
Gessner	30	-7707	-256.9	195.265517			
Orelia-sandy	30	-7797	-259.9	4485.54138			
ANOVA							
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	
Between Groups	177591.314	6	29598.5524	22.243843	4.5822E-20	2.14345288	
Within Groups	270119.967	203	1330.64023				
Total	447711.281	209					

Table D-3 Continued.

Elapsed Time: 168 h							
Fisher's LSD							
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*				
18.46	Pl vs Ph	80.00	Reject				
	Pl vs Ch	6.67	Accept				
	Pl vs C	16.90	Accept				
	Pl vs Os	19.40	Reject				
	Pl vs G	30.90	Reject				
	Pl vs Or	27.90	Reject				
	Ph vs Ch	73.33	Reject				
	Ph vs C	63.10	Reject				
	Ph vs Os	99.40	Reject				
	Ph vs G	49.10	Reject				
	Ph vs Or	52.10	Reject				
	Ch vs C	10.23	Accept				
	Ch vs Os	26.07	Reject				
	Ch vs G	24.23	Reject				
	Ch vs Or	21.23	Reject				
	C vs Os	36.30	Reject				
	C vs G	14.00	Accept				
	C vs Or	11.00	Accept				
	Os vs G	50.30	Reject				
	Os vs Or	47.30	Reject				
	G vs Or	3.00	Accept				
Elapsed Time: 504 h							
Sample No.	Pledger-low	Pledger-high	China	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	----------	----------	----------	mV	----------	----------	----------
1	142	21	-291	-223	-271	-155	-238
2	-43	-101	-257	-293	-290	-229	-272
3	50	19	-241	-272	-241	23	-205
4	-258	-182	-264	-208	-310	-153	-247
5	-94	-160	-269	-270	-285	-235	-233
6	-141	-154	-144	-279	-297	-263	-275
7	-205	-77	-192	-232	-39	-162	-263
8	-285	-229	-223	-293	12	-278	-231
9	158	65	-254	-285	-267	-242	-251
10	-257	-190	-244	-267	-268	-248	-129
11	-271	-226	-256	-245	-38	-112	-237
12	219	182	-224	114	-155	-206	-255
13	-175	-147	-242	-191	-300	-71	-185
14	-7	50	-236	-257	-254	-218	-219
15	-210	-141	-282	89	-47	-152	-210
16	-230	-82	-283	-91	-150	-209	-235
17	-6	-38	-179	-212	133	-102	-149
18	-46	-19	-303	-240	-265	-198	-208
19	-141	-125	-240	-257	-263	-256	-131
20	-194	-49	-284	-248	-231	-43	-242
21	-290	-252	-304	-101	-257	-268	-258
22	-22	-76	-296	-221	-277	-207	-186
23	84	43	-273	-217	-79	-235	-235
24	-286	-155	-268	-166	-119	-212	-206
25	-76	-135	-153	-267	-269	-196	-243
26	-237	-208	-269	-285	-245	-192	-193
27	215	91	-131	-244	225	-224	-170
28	-10	-93	-275	-192	-244	-234	-205
29	203	42	-267	-197	-292	-221	-249
30	-232	-191	-259	-270	-68	-191	-249

Table D-3 Continued.

Elapsed Time: 504 h						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	30	-2645	-88.1666667	27115.1782		
Pledger-high	30	-2517	-83.9	11983.6103		
China	30	-7403	-246.766667	2084.04713		
Cieno	30	-6320	-210.666667	9672.43678		
Orelia-loamy	30	-5451	-181.7	18835.8724		
Gessner	30	-5689	-189.633333	4871.34368		
Orelia-sandy	30	-6609	-220.3	1507.80345		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	737123.457	6	122853.91	11.3050357	6.9106E-11	2.14345288
Within Groups	2206038.47	203	10867.1846			
Total	2943161.92	209				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
52.76	Pl vs Ph	4.27	Accept			
	Pl vs Ch	158.60	Reject			
	Pl vs C	122.50	Reject			
	Pl vs Os	93.53	Reject			
	Pl vs G	101.47	Reject			
	Pl vs Or	132.13	Reject			
	Ph vs Ch	162.87	Reject			
	Ph vs C	126.77	Reject			
	Ph vs Os	97.80	Reject			
	Ph vs G	105.73	Reject			
	Ph vs Or	136.40	Reject			
	Ch vs C	36.10	Accept			
	Ch vs Os	65.07	Reject			
	Ch vs G	57.13	Reject			
	Ch vs Or	26.47	Accept			
	C vs Os	28.97	Accept			
	C vs G	21.03	Accept			
	C vs Or	9.63	Accept			
	Os vs G	7.93	Accept			
	Os vs Or	38.60	Accept			
	G vs Or	30.67	Accept			

Elapsed Time: 672 h							
Sample No.	Pledger-low	Pledger-high	China	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	--mV--						
1	187	70	-307	-125	-262	11	-217
2	109	22	-254	-265	-270	-93	-232
3	131	92	-256	-260	12	37	-151
4	-254	-130	54	122	-195	-124	-197
5	177	38	58	-246	-210	-217	-208
6	212	86	-38	-44	-277	-238	-261
7	201	165	-266	-169	-74	-203	-114
8	147	59	-51	-275	85	-253	-81
9	205	103	-215	-270	-247	-200	-244
10	108	51	-197	-150	-255	-102	-116
11	162	74	-77	-198	203	-1	-241
12	150	176	13	129	-44	-226	-247
13	-173	-123	-86	-187	-266	18	-188
14	173	166	-41	-244	-247	-227	-231
15	180	102	-169	187	-160	-57	-218

Table D-3 Continued.

Elapsed Time: 672 h							
Sample No.	Pledger-low	Pledger-high	China	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	---mV---						
16	-90	21	-271	162	-168	-133	-231
17	81	64	196	113	-187	-28	13
18	224	182	-289	-56	-256	-64	-241
19	173	88	-140	-38	-269	-194	-146
20	-149	7	-75	-17	-125	75	-241
21	60	-20	-184	-53	-138	-252	-229
22	195	108	-295	-109	-293	-171	-90
23	200	142	-214	-15	-83	-132	-223
24	-249	-113	-201	-74	-148	51	-210
25	47	-12	166	-53	-231	-174	-215
26	150	46	-49	-69	-244	-28	-151
27	199	108	152	-214	202	-213	-156
28	232	74	-315	-164	-88	-223	-186
29	173	65	-227	25	-258	-39	-237
30	25	-35	-190	-219	-245	-84	-185
SUMMARY							
Groups	*Count*	*Sum*	*Average*	*Variance*			
Pledger-low	30	2986	99.5333333	19778.4644			
Pledger-high	30	1676	55.8666667	6714.25747			
China	30	-3768	-125.6	21671.9724			
Cieno	30	-2776	-92.5333333	19032.3954			
Orelia-loamy	30	-4738	-157.933333	18273.5816			
Gessner	30	-3484	-116.133333	10337.0851			
Orelia-sandy	30	-5674	-189.133333	3874.6023			
ANOVA							
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*	
Between Groups	2161557.87	6	360259.644	25.2985337	2.4385E-22	2.14345288	
Within Groups	2890788.4	203	14240.3369				
Total	5052346.27	209					
Fisher's LSD							
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*				
60.39	Pl vs Ph	43.67	Accept				
	Pl vs Ch	225.13	Reject				
	Pl vs C	192.07	Reject				
	Pl vs Os	257.47	Reject				
	Pl vs G	215.67	Reject				
	Pl vs Or	288.67	Reject				
	Ph vs Ch	181.47	Reject				
	Ph vs C	148.40	Reject				
	Ph vs Os	213.80	Reject				
	Ph vs G	172.00	Reject				
	Ph vs Or	245.00	Reject				
	Ch vs C	33.07	Accept				
	Ch vs Os	32.33	Accept				
	Ch vs G	9.47	Accept				
	Ch vs Or	63.53	Reject				
	C vs Os	65.40	Reject				
	C vs G	23.60	Accept				
	C vs Or	96.60	Reject				
	Os vs G	41.80	Accept				
	Os vs Or	31.20	Accept				
	G vs Or	73.00	Reject				

Table D-4. Mean and standard deviation of Eh Values during Fe equilibration from Study #2.

Soil	Sample	24 h [N]	24 h [0]	24 h [10]	24 h [30]	24 h [60]	24 h [100]	48 h [N]	48 h [0]	48 h [10]	48 h [30]	48 h [60]	48 h [100]	96 h [N]	96 h [0]	96 h [10]	96 h [30]	96 h [60]	96 h [100]	144 h [N]	144 h [0]	144 h [10]	144 h [30]	144 h [60]	144 h [100]
		Eh (mV)																							
Pledger-low	1	-158	177	198	-65	196	96	-1	169	194	-52	187	64	-	165	191	-40	183	69	22	173	190	186	216	97
	2	-80	129	148	147	-42	143	12	121	151	146	-36	137	-	122	149	140	-24	134	87	172	158	158	-5	171
	3	41	113	189	213	172	195	53	111	184	214	181	192	-	109	183	196	174	188	8	147	191	206	184	194
	4	-92	-179	125	53	175	235	27	-96	130	66	179	234	-	7	133	66	179	234	54	128	159	87	226	208
	5	-194	163	167	86	201	161	-70	171	167	88	197	165	-	169	174	88	196	165	5	178	169	133	209	173
	6	-61	156	133	211	-210	105	-45	154	134	205	-196	125	-	143	141	188	-184	129	9	169	128	214	74	147
	Mean	-91	93	160	108	82	156	-4	105	160	111	85	153	-	119	162	106	87	153	31	161	166	164	151	165
	SD	82	135	30	106	170	53	46	102	26	100	164	59	-	60	24	89	157	56	33	20	24	48	94	39
Pledger-high	1	43	96	74	45	46	27	131	158	174	-28	76	95	-	31	96	-34	83	-2	93	98	139	250	210	84
	2	120	136	161	147	-44	63	124	6	166	69	90	66	-	10	70	78	18	99	213	142	80	153	65	137
	3	155	91	125	197	61	143	184	161	46	94	58	212	-	58	16	91	62	110	84	90	186	133	123	235
	4	103	5	116	84	62	123	114	45	128	73	135	114	-	2	22	-8	20	62	202	220	127	8	78	62
	5	-37	43	131	210	209	131	107	154	93	133	118	72	-	107	164	136	110	58	35	197	208	103	128	174
	6	136	124	107	267	-44	-6	46	72	206	188	-49	98	-	70	136	158	-123	70	143	96	48	198	43	76
	Mean	87	83	119	158	48	80	118	99	136	88	71	110	-	46	84	70	28	66	128	141	131	141	108	128
	SD	72	50	29	83	93	62	44	67	59	72	65	53	-	40	60	77	82	39	70	56	61	83	60	67
China	1	449	-286	-295	-168	-173	171	397	-226	-303	-184	-209	170	-	-202	-295	-197	-144	170	316	114	-205	30	-103	152
	2	433	-131	-82	-3	-68	148	346	-169	-106	-61	-76	159	-	-157	-108	-69	-42	169	243	22	130	0	105	185
	3	325	-272	-223	-231	-108	45	246	-275	-212	-240	-88	29	-	-278	-195	-236	-34	24	155	-190	146	-13	49	93
	4	186	58	-135	-271	151	-14	102	-22	-21	-273	-235	-282	-	-6	14	-267	-199	-290	20	149	152	-152	-104	-271
	5	362	74	72	194	-2	-197	302	92	140	163	6	-176	-	106	151	150	-62	-148	171	124	187	125	-48	-222
	6	391	-42	129	-156	-203	-227	346	-47	132	-73	-212	-222	-	-25	148	-34	-228	-224	284	116	159	185	-195	-171
	Mean	358	-100	-89	-106	-67	-12	290	-108	-62	-111	-136	-54	-	-94	-48	-109	-118	-50	198	56	95	29	-49	-39
	SD	96	157	165	173	129	169	105	139	180	160	97	199	-	143	183	157	84	200	107	128	148	117	110	204
Cieno	1	244	-153	-139	26	-234	-87	175	-110	-107	62	-228	-111	-	-180	-80	42	-211	-127	115	18	97	182	-26	-207
	2	255	-264	-271	-229	10	-61	198	-268	-267	-40	17	-51	-	-265	-264	154	25	-47	139	-261	-216	244	156	5
	3	276	-42	-270	187	-36	-208	145	98	-274	192	-45	-210	-	152	-263	193	-53	-225	50	241	-265	186	-53	-198
	4	162	139	-179	150	-225	-155	103	139	-173	156	-213	-159	-	145	-158	160	-219	-151	50	172	-120	168	-211	-117
	5	200	-239	-197	95	-74	12	131	-232	-199	78	-72	2	-	-234	-201	72	-68	-51	63	36	-196	58	-63	-20
	6	176	-35	69	297	-76	-200	107	-38	59	-72	-77	-185	-	-37	29	-86	-77	-201	-42	-66	-27	-86	-88	-109
	Mean	219	-99	-165	88	-106	-117	143	-69	-160	63	-103	-119	-	-70	-156	89	-101	-134	63	23	-121	125	-48	-108
	SD	46	151	126	180	101	86	38	167	124	104	97	82	-	186	114	103	96	74	63	178	135	120	119	88

Table D-4 Continued.

Soil	Sample	24 h [N]	[0]	[10]	[30]	[60]	[100]	48 h [N]	[0]	[10]	[30]	[60]	[100]	96 h [N]	[0]	[10]	[30]	[60]	[100]	144 h [N]	[0]	[10]	[30]	[60]	[100]
		Eh (mV)																							
Orelia-loamy	1	-167	-267	-89	-274	-198	-221	-167	-269	-60	-284	-224	-228	-	-218	-123	-282	-173	-233	-174	-167	60	-265	40	32
	2	-31	-276	84	-253	-132	-255	-101	-277	89	-247	-126	-254	-	-237	-219	-247	-84	-248	-191	-259	118	-241	60	-253
	3	-142	23	-244	-124	-134	184	-117	24	-239	-49	-124	211	-	-110	-253	58	-103	223	-127	70	-215	114	47	232
	4	-98	-10	-265	-156	-293	-102	-62	13	-264	-122	-292	-73	-	-229	-242	-74	-286	-56	-50	89	-262	-140	-128	11
	5	-131	-87	173	-205	-91	-258	-135	-19	159	-208	-76	-227	-	-235	-252	-197	-62	-203	-159	54	142	-211	62	32
	6	-176	-308	-37	-259	-140	-255	-200	-296	-36	-259	-124	-250	-	-264	-254	-256	-96	-247	-218	-2	-10	-256	60	66
	Mean	-124	-154	-63	-212	-165	-151	-130	-137	-59	-195	-161	-137	-	-216	-224	-166	-134	-127	-153	-36	-28	-167	24	20
	SD	53	147	174	61	72	175	49	158	170	91	80	183	-	54	51	132	83	186	59	144	172	145	75	156
Gessner	1	655	-104	-193	0	-210	-128	467	-164	-194	-1	-202	-168	-	-174	-188	-8	-163	-156	351	-25	-187	53	-130	-104
	2	490	-78	-248	-164	60	-23	405	-71	-249	-199	69	-23	-	-63	-239	-196	84	-23	297	-16	-240	-152	96	-13
	3	412	69	-183	-69	-224	-200	358	46	-175	-75	-200	-198	-	1	-165	-84	-120	-146	273	27	-128	-40	-74	-187
	4	431	-34	-50	-176	-168	-208	392	-37	-32	-191	-102	-220	-	-83	-35	-167	-160	-209	347	77	42	-164	-187	-217
	5	301	-198	-53	-30	83	-76	223	-206	-38	-11	81	-72	-	-197	-44	20	70	-68	158	-206	-34	59	44	-35
	6	279	-196	-220	-60	177	-87	198	-229	-209	-68	165	-71	-	-203	-190	-64	139	-96	148	-236	-213	-65	131	6
	Mean	428	-90	-158	-83	-47	-120	341	-110	-150	-91	-32	-125	-	-120	-144	-83	-25	-116	262	-63	-127	-52	-20	-92
	SD	137	102	85	72	174	73	107	107	92	86	157	80	-	84	84	85	137	67	90	128	110	96	129	94
Orelia-sandy	1	153	-216	-83	-207	-153	-215	132	-217	-103	-211	-178	-217	-	-261	-40	-222	-247	-213	67	-232	-93	-147	-173	-193
	2	277	-232	-91	-236	-248	-111	265	-238	-158	-229	-251	-135	-	-270	89	-222	-251	-137	238	-232	-75	-56	-253	-128
	3	160	-126	-253	-223	-170	-120	125	-117	-255	-226	-168	-138	-	34	-240	-231	-210	-170	60	-140	-263	-232	169	-181
	4	121	-217	-198	-237	-147	-109	99	-223	-219	-238	-170	-181	-	19	-267	-239	-202	-215	-26	-245	-48	-249	-66	-166
	5	153	-225	-251	20	-222	-259	28	-231	-253	23	-222	-244	-	18	156	39	-232	-244	-148	-237	-122	74	-241	-253
	6	159	-269	-254	54	-223	-171	120	-265	-256	63	-221	-201	-	-281	-25	85	-221	-232	96	-269	-249	162	-232	-207
	Mean	171	-214	-188	-138	-194	-164	128	-215	-207	-136	-202	-186	-	-124	-55	-132	-227	-202	48	-226	-142	-75	-133	-188
	SD	54	47	81	137	42	62	77	51	64	140	34	44	-	161	171	151	20	41	129	44	92	167	163	42

Table D-4 Continued.

Soil	Sample	192 h [N]	192 h [0]	192 h [10]	192 h [30]	192 h [60]	192 h [100]	240 h [N]	240 h [0]	240 h [10]	240 h [30]	240 h [60]	240 h [100]	288 h [N]	288 h [0]	288 h [10]	288 h [30]	288 h [60]	288 h [100]	336 h [N]	336 h [0]	336 h [10]	336 h [30]	336 h [60]	336 h [100]
		Eh (mV)																							
Pledger-low	1	-	166	186	-17	211	179	-	157	184	-14	207	191	-	161	182	16	212	192	-96	148	184	41	142	202
	2	-	173	149	146	4	179	-	165	145	141	21	191	-	205	146	154	39	187	-149	207	153	153	57	200
	3	-	131	181	199	190	192	-	121	180	188	185	206	-	127	184	198	184	188	-60	94	179	204	202	188
	4	-	133	151	91	222	199	-	134	142	95	203	205	-	162	160	104	200	181	-4	143	158	118	195	171
	5	-	176	167	147	215	163	-	175	163	150	204	183	-	170	163	162	203	166	-119	165	166	190	211	164
	6	-	164	130	207	85	146	-	159	127	196	83	171	-	152	124	207	115	151	-112	146	124	236	130	156
	Mean	-	157	161	129	155	176	-	152	157	126	151	191	-	163	160	140	159	178	-90	151	161	157	156	180
	SD	-	20	21	83	90	19	-	20	23	78	79	13	-	25	23	71	68	16	51	37	22	70	59	19
Pledger-high	1	-	103	132	38	122	95	-	148	107	63	125	86	-	160	125	37	220	120	-29	121	105	76	184	96
	2	-	72	123	129	76	149	-	112	118	108	32	125	-	151	129	114	127	125	-72	124	215	202	81	159
	3	-	95	30	122	180	143	-	209	83	259	241	150	-	151	59	171	167	134	-39	91	167	153	132	199
	4	-	112	64	12	161	63	-	152	74	20	89	214	-	168	95	63	132	124	-29	110	245	156	150	174
	5	-	89	172	116	115	56	-	117	93	105	128	88	-	107	118	109	123	122	-84	166	169	218	183	180
	6	-	86	121	139	31	88	-	68	45	166	53	208	-	79	68	174	73	109	-75	133	182	213	117	276
	Mean	-	93	107	93	114	99	-	134	87	120	111	145	-	136	99	111	140	122	-55	124	181	170	141	181
	SD	-	14	51	54	55	39	-	47	26	84	74	56	-	35	30	55	49	8	25	25	48	54	40	58
China	1	-	119	-172	53	-119	151	-	121	-149	80	-114	154	-	97	-116	124	53	144	-2	115	-62	142	136	144
	2	-	32	136	6	115	188	-	38	131	39	127	199	-	42	160	80	127	190	34	37	155	108	143	216
	3	-	-87	-48	6	55	99	-	-2	-35	41	62	104	-	56	-2	78	-70	106	-109	91	0	85	-120	105
	4	-	158	163	-150	-28	-187	-	145	144	-85	-4	-133	-	142	121	-40	-156	-100	22	129	107	-15	-145	-125
	5	-	124	191	117	-8	-193	-	124	189	113	36	-190	-	125	182	113	71	-195	34	121	163	104	142	106
	6	-	113	158	211	-150	-50	-	110	161	229	-45	18	-	117	156	213	0	60	82	103	151	250	259	81
	Mean	-	77	71	41	-23	1	-	89	74	70	10	25	-	97	84	95	4	34	10	99	86	112	69	88
	SD	-	90	147	121	101	169	-	58	135	103	84	158	-	40	118	82	103	150	64	33	95	86	163	114
Cieno	1	-	-14	103	193	60	-184	-	-106	105	201	147	-117	-	-24	113	208	215	-55	-84	61	112	218	220	0
	2	-	-265	-81	247	163	99	-	-253	-8	252	170	125	-	-230	64	245	170	142	-112	38	101	260	152	155
	3	-	204	-267	186	-42	-131	-	196	-258	189	-37	90	-	230	-252	192	-19	206	64	218	-71	190	90	188
	4	-	178	-105	170	-194	-105	-	173	-96	171	-176	-108	-	171	-26	175	-95	77	-87	153	103	174	135	134
	5	-	-176	-195	57	-41	-35	-	22	-190	56	-20	-28	-	199	-171	125	47	88	-77	224	4	162	97	127
	6	-	-20	-80	-85	-86	-106	-	17	-138	-53	-72	-21	-	56	-15	169	46	167	-125	73	59	239	74	212
	Mean	-	-16	-104	128	-23	-77	-	8	-98	136	2	-10	-	67	-48	186	61	104	-70	128	51	207	128	136
	SD	-	186	126	122	123	99	-	170	130	113	133	100	-	174	139	40	116	92	68	82	72	38	54	74

Table D-4 (continued). Mean and standard deviation of Eh Values during Fe equilibration from Study #2.

		192 h						240 h						288 h						336 h					
Soil	Sample	[N]	[0]	[10]	[30]	[60]	[100]	[N]	[0]	[10]	[30]	[60]	[100]	[N]	[0]	[10]	[30]	[60]	[100]	[N]	[0]	[10]	[30]	[60]	[100]
		Eh (mV)																							
Orelia-loamy	1	-	-164	53	-264	94	-32	-	-181	54	-260	122	-44	-	-79	51	-268	231	-56	-139	14	26	-271	188	-33
	2	-	-256	112	-244	59	-253	-	-243	106	-241	58	-254	-	-213	100	-245	65	-257	-184	-87	86	-254	83	-271
	3	-	76	-222	115	73	230	-	72	-217	115	82	233	-	70	-178	116	72	217	-76	63	65	122	83	200
	4	-	97	-254	-169	216	49	-	99	-200	-238	0	74	-	101	-143	-255	12	69	-102	94	5	-269	39	98
	5	-	58	130	-213	72	35	-	60	125	-205	81	36	-	163	120	-190	74	46	-146	185	109	-2	91	149
	6	-	7	-7	-258	66	104	-	15	-4	-258	69	123	-	33	-1	194	58	123	-190	63	10	-76	73	144
	Mean	-	-30	-31	-172	97	22	-	-30	-23	-181	69	28	-	13	-9	-108	85	24	-140	55	50	-125	93	48
	SD	-	145	167	145	60	161	-	145	151	146	40	166	-	137	125	207	75	164	45	90	43	166	50	175
Gessner	1	-	-56	-175	20	-86	-129	-	-176	-191	-55	-97	-137	-	-3	-202	0	-103	-152	92	-21	-188	22	-15	-185
	2	-	-33	-234	-90	99	-10	-	-50	-215	-126	108	-9	-	-37	-253	-75	110	-15	15	-115	-225	-23	97	-66
	3	-	46	-129	-50	-75	-185	-	31	-134	-165	-64	-184	-	39	-136	-40	-66	-180	243	6	-135	-83	-61	-181
	4	-	89	30	-145	-187	-219	-	66	-16	-164	-182	-209	-	38	-34	-146	-177	-209	4	-84	-96	-180	-189	-221
	5	-	-214	-34	52	45	-43	-	-206	-56	50	47	-52	-	-231	-44	41	47	-64	-95	-239	-73	35	-50	-79
	6	-	-233	-212	-67	130	-2	-	-228	-196	-57	128	1	-	-254	-209	-75	129	-8	36	-244	-201	-13	129	-22
	Mean	-	-67	-126	-47	-12	-98	-	-94	-135	-86	-10	-98	-	-75	-146	-49	-10	-105	49	-116	-153	-40	-15	-126
	SD	-	132	104	72	123	93	-	127	82	83	124	91	-	133	91	65	124	87	113	106	61	80	116	80
Orelia-sandy	1	-	-235	-64	-77	-218	-202	-	-232	50	-50	-208	-204	-	-137	77	-26	-179	-202	-195	-11	65	-25	31	-209
	2	-	-247	-46	-47	193	-138	-	-245	82	-31	-253	-150	-	-126	157	-9	-156	-156	-218	-85	171	11	-37	-176
	3	-	-144	-263	-231	165	-179	-	-137	-263	-231	151	-187	-	-125	-259	-224	156	-189	-219	-74	-47	69	125	-180
	4	-	-245	-146	-247	-83	-227	-	-244	-196	-247	-77	-190	-	-224	-152	-247	-53	-160	-206	-111	14	-170	-51	-217
	5	-	-244	-128	55	-243	-252	-	-242	-118	57	-239	-245	-	-212	54	66	-232	-218	-186	-104	18	52	37	59
	6	-	-268	-249	112	-230	-210	-	-265	-236	107	-225	-200	-	-113	-112	114	-205	-114	-214	-73	-87	87	-68	100
	Mean	-	-231	-149	-73	-69	-201	-	-228	-114	-66	-142	-196	-	-156	-39	-54	-112	-173	-206	-76	22	4	6	-104
	SD	-	44	91	146	201	40	-	46	148	146	157	31	-	49	159	149	145	38	13	36	90	94	73	143

Table D-5. One-way analysis of variance (ANOVA) and Fisher's lease significant difference (LSD) for redox potential (Eh) during equilibration at 336 h from Study #2.

Pledger-low						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	---------------	---------------	--------------- mV	---------------	---------------	---------------
1	-96	148	184	41	142	202
2	-149	207	153	153	57	200
3	-60	94	179	204	202	188
4	-4	143	158	118	195	171
5	-119	165	166	190	211	164
6	-112	146	124	236	130	156
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	-540	-90	2627.6		
[0]	6	903	150.5	1335.5		
[10]	6	964	160.666667	463.866667		
[30]	6	942	157	4906.4		
[60]	6	937	156.166667	3466.96667		
[100]	6	1081	180.166667	372.166667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	317856.25	5	63571.25	28.9563485	1.2521E-10	2.53355455
Within Groups	65862.5	30	2195.41667			
Total	383718.75	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
55.24	N vs 0	-240.50	Reject			
	N vs 10	-250.67	Reject			
	N vs 30	-247.00	Reject			
	N vs 60	-246.17	Reject			
	N vs 100	-270.17	Reject			
	0 vs 10	-10.17	Accept			
	0 vs 30	-6.50	Accept			
	0 vs 60	-5.67	Accept			
	0 vs 100	-29.67	Accept			
	10 vs 30	3.67	Accept			
	10 vs 60	4.50	Accept			
	10 vs 100	-19.50	Accept			
	30 vs 60	0.83	Accept			
	30 vs 100	-23.17	Accept			
	60 vs 100	-24.00	Accept			

Pledger-high						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	---------------	---------------	--------------- mV	---------------	---------------	---------------
1	-29	121	105	76	184	96
2	-72	124	215	202	81	159
3	-39	91	167	153	132	199
4	-29	110	245	156	150	174
5	-84	166	169	218	183	180
6	-75	133	182	213	117	276
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	-328	-54.6666667	627.466667		
[0]	6	745	124.166667	627.766667		
[10]	6	1083	180.5	2273.5		
[30]	6	1018	169.666667	2899.46667		
[60]	6	847	141.166667	1590.16667		
[100]	6	1084	180.666667	3421.46667		

Table D-5 Continued.

Pledger-high						
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	244225.583	5	48845.1167	25.6184414	5.47132E-10	2.53355455
Within Groups	57199.1667	30	1906.63889			
Total	301424.75	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
51.48	N vs 0	-178.83	Reject			
	N vs 10	-235.17	Reject			
	N vs 30	-224.33	Reject			
	N vs 60	-195.83	Reject			
	N vs 100	-235.33	Reject			
	0 vs 10	-56.33	Reject			
	0 vs 30	-45.50	Accept			
	0 vs 60	-17.00	Accept			
	0 vs 100	-56.50	Reject			
	10 vs 30	10.83	Accept			
	10 vs 60	39.33	Accept			
	10 vs 100	-0.17	Accept			
	30 vs 60	28.50	Accept			
	30 vs 100	-11.00	Accept			
	60 vs 100	-39.50	Accept			
China						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	---mV---					
1	-2	115	-62	142	136	144
2	34	37	155	108	143	216
3	-109	91	0	85	-120	105
4	22	129	107	-15	-145	-125
5	34	121	163	104	142	106
6	82	103	151	250	259	81
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	61	10.1666667	4156.96667		
[0]	6	596	99.3333333	1112.66667		
[10]	6	514	85.6666667	8931.06667		
[30]	6	674	112.333333	7376.26667		
[60]	6	415	69.1666667	26582.1667		
[100]	6	527	87.8333333	13110.1667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	38800.25	5	7760.05	0.75992871	0.585737664	2.53355455
Within Groups	306346.5	30	10211.55			
Total	345146.75	35				
Cieno						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	---mV---					
1	-84	61	112	218	220	0
2	-112	38	101	260	152	155
3	64	218	-71	190	90	188
4	-87	153	103	174	135	134
5	-77	224	4	162	97	127
6	-125	73	59	239	74	212

Table D-5 Continued.

Cieno						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	-421	-70.1666667	4655.76667		
[0]	6	767	127.833333	6710.96667		
[10]	6	308	51.3333333	5216.26667		
[30]	6	1243	207.166667	1471.36667		
[60]	6	768	128	2882		
[100]	6	816	136	5484.4		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	273593.806	5	54718.7611	12.4263073	1.39977E-06	2.53355455
Within Groups	132103.833	30	4403.46111			
Total	405697.639	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
78.23	N vs 0	-198.00	Reject			
	N vs 10	-121.50	Reject			
	N vs 30	-277.33	Reject			
	N vs 60	-198.17	Reject			
	N vs 100	-206.17	Reject			
	0 vs 10	76.50	Accept			
	0 vs 30	-79.33	Reject			
	0 vs 60	-0.17	Accept			
	0 vs 100	-8.17	Accept			
	10 vs 30	-155.83	Reject			
	10 vs 60	-76.67	Accept			
	10 vs 100	-84.67	Reject			
	30 vs 60	79.17	Reject			
	30 vs 100	71.17	Accept			
	60 vs 100	-8.00	Accept			

Orelia-loamy						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	---mV---					
1	-139	14	26	-271	188	-33
2	-184	-87	86	-254	83	-271
3	-76	63	65	122	83	200
4	-102	94	5	-269	39	98
5	-146	185	109	-2	91	149
6	-190	63	10	-76	73	144
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	-837	-139.5	2002.3		
[0]	6	332	55.3333333	8078.66667		
[10]	6	301	50.1666667	1840.56667		
[30]	6	-750	-125	27446.4		
[60]	6	557	92.8333333	2508.96667		
[100]	6	287	47.8333333	30668.5667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	309082.556	5	61816.5111	5.11264292	0.001654002	2.53355455
Within Groups	362727.333	30	12090.9111			
Total	671809.889	35				

Table D-5 Continued.

Orelia-loamy						
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
129.64	N vs 0	-194.83	Reject			
	N vs 10	-189.67	Reject			
	N vs 30	-14.50	Accept			
	N vs 60	-232.33	Reject			
	N vs 100	-187.33	Reject			
	0 vs 10	5.17	Accept			
	0 vs 30	180.33	Reject			
	0 vs 60	-37.50	Accept			
	0 vs 100	7.50	Accept			
	10 vs 30	175.17	Reject			
	10 vs 60	-42.67	Accept			
	10 vs 100	2.33	Accept			
	30 vs 60	-217.83	Reject			
	30 vs 100	-172.83	Reject			
	60 vs 100	45.00	Accept			
Gessner						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	----------mV----------					
1	92	-21	-188	22	-15	-185
2	15	-115	-225	-23	97	-66
3	243	6	-135	-83	-61	-181
4	4	-84	-96	-180	-189	-221
5	-95	-239	-73	35	-50	-79
6	36	-244	-201	-13	129	-22
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	295	49.1666667	12714.1667		
[0]	6	-697	-116.166667	11289.3667		
[10]	6	-918	-153	3737.2		
[30]	6	-242	-40.3333333	6387.06667		
[60]	6	-89	-14.8333333	13379.3667		
[100]	6	-754	-125.666667	6431.06667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	181092.472	5	36218.4944	4.02888551	0.00646978	2.53355455
Within Groups	269691.167	30	8989.70556			
Total	450783.639	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
111.78	N vs 0	165.33	Reject			
	N vs 10	202.17	Reject			
	N vs 30	89.50	Accept			
	N vs 60	64.00	Accept			
	N vs 100	174.83	Reject			
	0 vs 10	36.83	Accept			
	0 vs 30	-75.83	Accept			
	0 vs 60	-101.33	Accept			
	0 vs 100	9.50	Accept			
	10 vs 30	-112.67	Reject			
	10 vs 60	-138.17	Reject			
	10 vs 100	-27.33	Accept			
	30 vs 60	-25.50	Accept			
	30 vs 100	85.33	Accept			
	60 vs 100	110.83	Accept			

Table D-5 Continued.

Orelia-sandy						
Sample No.	[N]	[0]	[10]	[30]	[60]	[100]
	---mV--					
1	-195	-11	65	-25	31	-209
2	-218	-85	171	11	-37	-176
3	-219	-74	-47	69	125	-180
4	-206	-111	14	-170	-51	-217
5	-186	-104	18	52	37	59
6	-214	-73	-87	87	-68	100
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
[N]	6	-1238	-206.333333	179.466667		
[0]	6	-458	-76.3333333	1265.46667		
[10]	6	134	22.3333333	8154.26667		
[30]	6	24	4	8916.8		
[60]	6	37	6.16666667	5264.16667		
[100]	6	-623	-103.833333	20587.7667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	233090.333	5	46618.0667	6.30429184	0.00041342	2.53355455
Within Groups	221839.667	30	7394.65556			
Total	454930	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
101.38	N vs 0	-130.00	Reject			
	N vs 10	-228.67	Reject			
	N vs 30	-210.33	Reject			
	N vs 60	-212.50	Reject			
	N vs 100	-102.50	Reject			
	0 vs 10	-98.67	Accept			
	0 vs 30	-80.33	Accept			
	0 vs 60	-82.50	Accept			
	0 vs 100	27.50	Accept			
	10 vs 30	18.33	Accept			
	10 vs 60	16.17	Accept			
	10 vs 100	126.17	Reject			
	30 vs 60	-2.17	Accept			
	30 vs 100	107.83	Reject			
	60 vs 100	110.00	Reject			

Table D-6. Mean soil reaction (pH) values from Study #2.

Soil	Native	Amended	[N]	[0]	[10]	[30]	[60]	[100]	Mean
	pH VALUE (s.u.) †								
Pledger-low	5.5	4.7	5.4	5.0	4.6	4.8	4.9	4.6	4.8
Pledger-high	6.8	6.3	6.6	5.9	6.0	5.9	6.0	6.1	6.0
China	5.1	4.2	5.0	4.7	5.0	4.5	4.7	4.6	4.7
Cieno	5.3	4.3	5.2	4.5	4.8	4.8	4.8	4.6	4.7
Orelia-loamy	7.0	6.3	6.5	5.3	5.2	5.5	5.4	5.1	5.3
Gessner	4.9	3.8	4.9	4.6	4.8	4.8	4.6	4.7	4.7
Orelia-sandy	6.6	5.6	6.4	4.9	4.8	5.0	4.7	4.8	4.8

Notes:
Native - Native soil.
Amended - Amended with sucrose for 672 h then analyzed.
[N] - Control #1 (no sucrose amendment, no Fe equilibration); included with equilibrated samples for 336 h.
[0], [10], [30], [60], [100] - Amended with sucrose for 672 h then equilibrated at given concentration for 336 h.
Mean includes [0], [10], [30], [60], and [100].
† Values are means of three replicants.

Table D-7. Ferrous Fe removed and CD extractable Fe reduction from Study #2.

Soil	Elasped Time (h)	Fe^{2+} in Solution	Fe^{2+} by Soil Weight
		mg L^{-1}	mg kg^{-1}
Pledger-low	168	3.56	251.70
	504	3.35	237.09
	672	3.13	221.53
		Total Removed	710.31
		% CD Fe Reduction	8
Pledger-high	168	2.54	164.43
	504	3.18	205.59
	672	2.51	162.30
		Total Removed	532.32
		% CD Fe Reduction	5
China	168	10.34	749.54
	504	9.82	711.85
	672	10.28	745.19
		Total Removed	2206.58
		% CD Fe Reduction	18
Cieno	168	0.94	57.69
	504	1.14	69.96
	672	0.84	51.55
		Total Removed	179.19
		% CD Fe Reduction	22
Orelia-loamy	168	0.38	24.75
	504	0.30	19.54
	672	0.30	19.54
		Total Removed	63.84
		% CD Fe Reduction	8
Gessner	168	0.90	58.02
	504	0.86	55.25
	672	0.78	50.28
		Total Removed	163.55
		% CD Fe Reduction	41
Orelia-sandy	168	0.54	34.89
	504	0.50	32.30
	672	0.40	25.84
		Total Removed	93.04
		% CD Fe Reduction	17

Table D-8. Comparison of milliequivalents of Fe in solution and milliequivalents of soil exchange capacity during equilibration from Study #2.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c$ kg^{-1}		%
Pledger-low	N-1	229.57	1.14	0.57	201.38	114.75	0.8	2.3	0.08	47.4	108.82	0.08
	N-2	227.29	1.14	0.57	199.38	113.61	0.4	1.1	0.04	47.4	107.74	0.04
	N-3	232.00	1.14	0.57	203.51	115.96	0.9	2.6	0.09	47.4	109.97	0.09
	Mean	-	-	-	-	-	0.7	2.0	0.1	47.4	108.8	0.1
	0-1	230.38	1.14	0.57	202.08	115.15	3.6	10.4	0.37	47.4	109.20	0.34
	0-2	228.82	1.14	0.57	200.72	114.37	5.3	15.2	0.54	47.4	108.46	0.50
	0-3	231.93	1.14	0.57	203.45	115.93	3.0	8.7	0.31	47.4	109.93	0.28
	Mean	-	-	-	-	-	4.0	11.4	0.4	47.4	109.2	0.4
	10-1	232.63	1.14	0.57	204.06	116.28	5.5	16.0	0.57	47.4	110.27	0.52
	10-2	229.84	1.14	0.57	201.62	114.88	3.8	10.9	0.39	47.4	108.94	0.36
	10-3	232.01	1.14	0.57	203.52	115.97	4.0	11.6	0.42	47.4	109.97	0.38
	Mean	-	-	-	-	-	4.4	12.8	0.5	47.4	109.7	0.4
	30-1	228.44	1.14	0.57	200.39	114.18	3.6	10.3	0.37	47.4	108.28	0.34
	30-2	228.01	1.14	0.57	200.01	113.97	2.2	6.3	0.22	47.4	108.08	0.21
	30-3	231.06	1.14	0.57	202.69	115.49	1.7	4.9	0.18	47.4	109.52	0.16
	Mean	-	-	-	-	-	2.5	7.2	0.3	47.4	108.6	0.2
	60-1	227.76	1.14	0.57	199.79	113.84	2.5	7.1	0.26	47.4	107.96	0.24
	60-2	229.28	1.14	0.57	201.12	114.60	3.1	8.9	0.32	47.4	108.68	0.29
	60-3	230.89	1.14	0.57	202.54	115.41	3.2	9.2	0.33	47.4	109.44	0.30
	Mean	-	-	-	-	-	2.9	8.4	0.3	47.4	108.7	0.3
	100-1	229.28	1.14	0.57	201.12	114.60	3.9	11.2	0.40	47.4	108.68	0.37
	100-2	228.35	1.14	0.57	200.31	114.14	7.1	20.3	0.73	47.4	108.24	0.67
	100-3	229.64	1.14	0.57	201.44	114.78	6.6	18.9	0.68	47.4	108.85	0.62
	Mean	-	-	-	-	-	5.9	16.8	0.6	47.4	108.6	0.6

Table D-8 Continued.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c$ kg^{-1}		%
Pledger-high	N-1	224.88	1.11	0.58	202.60	117.74	0.2	0.6	0.02	57.2	128.63	0.02
	N-2	224.34	1.11	0.58	202.11	117.45	0.3	0.9	0.03	57.2	128.32	0.02
	N-3	225.16	1.11	0.58	202.84	117.88	0.1	0.3	0.01	57.2	128.79	0.01
	Mean	-	-	-	-	-	0.2	0.6	0.0	57.2	128.6	0.0
	0-1	225.94	1.11	0.58	203.55	118.29	1.8	5.3	0.19	57.2	129.24	0.15
	0-2	224.33	1.11	0.58	202.10	117.45	1.5	4.4	0.16	57.2	128.32	0.12
	0-3	223.40	1.11	0.58	201.26	116.96	2.1	6.1	0.22	57.2	127.78	0.17
	Mean	-	-	-	-	-	1.8	5.3	0.2	57.2	128.4	0.1
	10-1	224.98	1.11	0.58	202.69	117.79	3.2	9.3	0.33	57.2	128.69	0.26
	10-2	224.05	1.11	0.58	201.85	117.30	3.3	9.7	0.35	57.2	128.16	0.27
	10-3	223.63	1.11	0.58	201.47	117.08	4.6	13.4	0.48	57.2	127.92	0.37
	Mean	-	-	-	-	-	3.7	10.8	0.4	57.2	128.3	0.3
	30-1	222.01	1.11	0.58	200.01	116.23	3.2	9.3	0.33	57.2	126.99	0.26
	30-2	224.45	1.11	0.58	202.21	117.51	3.9	11.5	0.41	57.2	128.38	0.32
	30-3	224.24	1.11	0.58	202.01	117.40	4.2	12.3	0.44	57.2	128.26	0.34
	Mean	-	-	-	-	-	3.8	11.0	0.4	57.2	127.9	0.3
	60-1	223.36	1.11	0.58	201.22	116.94	2.9	8.5	0.30	57.2	127.76	0.24
	60-2	225.02	1.11	0.58	202.72	117.81	3.1	9.1	0.33	57.2	128.71	0.25
	60-3	224.98	1.11	0.58	202.69	117.79	3.3	9.7	0.35	57.2	128.69	0.27
	Mean	-	-	-	-	-	3.1	9.1	0.3	57.2	128.4	0.3
	100-1	224.33	1.11	0.58	202.10	117.45	5.7	16.7	0.60	57.2	128.32	0.47
	100-2	221.93	1.11	0.58	199.94	116.19	6.3	18.2	0.65	57.2	126.95	0.51
	100-3	223.97	1.11	0.58	201.77	117.26	3.7	10.9	0.39	57.2	128.11	0.30
	Mean	-	-	-	-	-	5.2	15.3	0.5	57.2	127.8	0.4

Table D-8 Continued.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c\ kg^{-1}$		%
China	N-1	251.38	1.04	0.61	241.71	146.85	2.9	10.6	0.38	50.1	125.94	0.30
	N-2	253.06	1.04	0.61	243.33	147.83	2.5	9.2	0.33	50.1	126.78	0.26
	N-3	243.84	1.04	0.61	234.46	142.44	3.4	12.1	0.43	50.1	122.16	0.36
	Mean	-	-	-	-	-	2.9	10.7	0.4	50.1	125.0	0.3
	0-1	251.09	1.04	0.61	241.43	146.68	9.6	35.2	1.26	50.1	125.80	1.00
	0-2	247.36	1.04	0.61	237.85	144.50	9.8	35.4	1.27	50.1	123.93	1.02
	0-3	251.20	1.04	0.61	241.54	146.75	7.2	26.4	0.95	50.1	125.85	0.75
	Mean	-	-	-	-	-	8.9	32.3	1.2	50.1	125.2	0.9
	10-1	252.21	1.04	0.61	242.51	147.33	8.0	29.5	1.06	50.1	126.36	0.84
	10-2	251.72	1.04	0.61	242.04	147.05	7.5	27.6	0.99	50.1	126.11	0.78
	10-3	246.95	1.04	0.61	237.45	144.26	6.5	23.4	0.84	50.1	123.72	0.68
	Mean	-	-	-	-	-	7.3	26.8	1.0	50.1	125.4	0.8
	30-1	253.37	1.04	0.61	243.63	148.02	9.7	35.9	1.29	50.1	126.94	1.01
	30-2	253.01	1.04	0.61	243.27	147.80	10.1	37.3	1.34	50.1	126.76	1.06
	30-3	251.81	1.04	0.61	242.12	147.10	4.4	16.2	0.58	50.1	126.15	0.46
	Mean	-	-	-	-	-	8.1	29.8	1.1	50.1	126.6	0.8
	60-1	251.98	1.04	0.61	242.28	147.20	5.7	21.0	0.75	50.1	126.24	0.60
	60-2	247.43	1.04	0.61	237.92	144.55	8.4	30.4	1.09	50.1	123.96	0.88
	60-3	252.09	1.04	0.61	242.39	147.27	10.7	39.4	1.41	50.1	126.30	1.12
	Mean	-	-	-	-	-	8.3	30.2	1.1	50.1	125.5	0.9
	100-1	252.64	1.04	0.61	242.93	147.59	8.5	31.4	1.12	50.1	126.57	0.89
	100-2	253.23	1.04	0.61	243.49	147.93	8.9	32.9	1.18	50.1	126.87	0.93
	100-3	253.23	1.04	0.61	243.49	147.93	8.7	32.2	1.15	50.1	126.87	0.91
	Mean	-	-	-	-	-	8.7	32.2	1.2	50.1	126.8	0.9

Table D-8 Continued.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c$ kg^{-1}		%
Cieno	N-1	243.49	1.68	0.37	144.94	53.05	0.2	0.3	0.01	9.3	22.64	0.04
	N-2	246.70	1.68	0.37	146.85	53.75	0.1	0.1	0.00	9.3	22.94	0.02
	N-3	240.76	1.68	0.37	143.31	52.46	0.1	0.1	0.00	9.3	22.39	0.02
	Mean	-	-	-	-	-	0.1	0.2	0.0	9.3	22.7	0.0
	0-1	246.29	1.68	0.37	146.60	53.66	2.2	3.0	0.11	9.3	22.90	0.46
	0-2	245.36	1.68	0.37	146.05	53.46	1.0	1.3	0.05	9.3	22.82	0.21
	0-3	246.19	1.68	0.37	146.54	53.64	1.8	2.4	0.09	9.3	22.90	0.38
	Mean	-	-	-	-	-	1.7	2.2	0.1	9.3	22.9	0.3
	10-1	243.44	1.68	0.37	144.91	53.04	1.7	2.3	0.08	9.3	22.64	0.36
	10-2	246.20	1.68	0.37	146.55	53.64	1.9	2.5	0.09	9.3	22.90	0.40
	10-3	241.10	1.68	0.37	143.51	52.53	2.0	2.6	0.09	9.3	22.42	0.42
	Mean	-	-	-	-	-	1.9	2.5	0.1	9.3	22.7	0.4
	30-1	245.57	1.68	0.37	146.17	53.51	1.4	1.9	0.07	9.3	22.84	0.29
	30-2	245.73	1.68	0.37	146.27	53.54	1.6	2.1	0.08	9.3	22.85	0.34
	30-3	247.00	1.68	0.37	147.02	53.82	2.0	2.7	0.10	9.3	22.97	0.42
	Mean	-	-	-	-	-	1.7	2.2	0.1	9.3	22.9	0.3
	60-1	243.85	1.68	0.37	145.15	53.13	2.3	3.1	0.11	9.3	22.68	0.48
	60-2	244.32	1.68	0.37	145.43	53.23	2.3	3.1	0.11	9.3	22.72	0.48
	60-3	241.63	1.68	0.37	143.83	52.65	2.3	3.0	0.11	9.3	22.47	0.48
	Mean	-	-	-	-	-	2.3	3.0	0.1	9.3	22.6	0.5
	100-1	241.82	1.68	0.37	143.94	52.69	3.1	4.1	0.15	9.3	22.49	0.65
	100-2	245.56	1.68	0.37	146.16	53.50	3.5	4.7	0.17	9.3	22.84	0.73
	100-3	244.63	1.68	0.37	145.61	53.30	4.0	5.3	0.19	9.3	22.75	0.84
	Mean	-	-	-	-	-	3.5	4.7	0.2	9.3	22.7	0.7

Table D-8 Continued.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c$ kg^{-1}		%
Orelia-loamy	N-1	234.22	1.50	0.43	156.14	67.76	0.1	0.2	0.01	17.2	40.29	0.02
	N-2	221.63	1.50	0.43	147.76	64.12	0.0	0.0	0.00	17.2	38.12	0.00
	N-3	235.40	1.50	0.43	156.93	68.10	0.1	0.2	0.01	17.2	40.49	0.02
	Mean	-	-	-	-	-	0.1	0.1	0.0	17.2	39.6	0.0
	0-1	217.10	1.50	0.43	144.73	62.81	0.4	0.6	0.02	17.2	37.34	0.06
	0-2	234.54	1.50	0.43	156.36	67.85	0.6	1.0	0.04	17.2	40.34	0.09
	0-3	230.55	1.50	0.43	153.70	66.70	0.6	1.0	0.04	17.2	39.66	0.09
	Mean	-	-	-	-	-	0.5	0.9	0.0	17.2	39.1	0.1
	10-1	234.07	1.50	0.43	156.04	67.72	0.5	0.8	0.03	17.2	40.26	0.08
	10-2	234.21	1.50	0.43	156.14	67.76	0.6	1.0	0.04	17.2	40.28	0.09
	10-3	233.98	1.50	0.43	155.99	67.69	0.4	0.7	0.02	17.2	40.24	0.06
	Mean	-	-	-	-	-	0.5	0.8	0.0	17.2	40.3	0.1
	30-1	232.86	1.50	0.43	155.24	67.37	1.3	2.2	0.08	17.2	40.05	0.20
	30-2	224.08	1.50	0.43	149.39	64.83	0.5	0.8	0.03	17.2	38.54	0.08
	30-3	234.79	1.50	0.43	156.53	67.93	0.9	1.5	0.05	17.2	40.38	0.14
	Mean	-	-	-	-	-	0.9	1.5	0.1	17.2	39.7	0.1
	60-1	234.75	1.50	0.43	156.50	67.92	1.4	2.4	0.09	17.2	40.38	0.21
	60-2	234.69	1.50	0.43	156.46	67.90	0.4	0.7	0.02	17.2	40.37	0.06
	60-3	235.38	1.50	0.43	156.92	68.10	1.3	2.2	0.08	17.2	40.49	0.20
	Mean	-	-	-	-	-	1.0	1.8	0.1	17.2	40.4	0.2
	100-1	234.48	1.50	0.43	156.32	67.84	2.3	3.9	0.14	17.2	40.33	0.35
	100-2	216.76	1.50	0.43	144.51	62.71	1.5	2.4	0.08	17.2	37.28	0.23
	100-3	221.30	1.50	0.43	147.53	64.02	1.5	2.4	0.09	17.2	38.06	0.23
	Mean	-	-	-	-	-	1.8	2.9	0.1	17.2	38.6	0.3

Table D-8 Continued.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c\ kg^{-1}$		%
Gessner	N-1	234.42	1.68	0.37	139.54	51.08	0.1	0.1	0.00	5.5	12.89	0.04
	N-2	233.27	1.68	0.37	138.85	50.82	0.4	0.5	0.02	5.5	12.83	0.14
	N-3	228.93	1.68	0.37	136.27	49.88	0.2	0.2	0.01	5.5	12.59	0.07
	Mean	-	-	-	-	-	0.2	0.3	0.0	5.5	12.8	0.1
	0-1	233.85	1.68	0.37	139.20	50.95	1.6	2.0	0.07	5.5	12.86	0.57
	0-2	233.94	1.68	0.37	139.25	50.97	0.9	1.1	0.04	5.5	12.87	0.32
	0-3	233.43	1.68	0.37	138.95	50.86	0.9	1.1	0.04	5.5	12.84	0.32
	Mean	-	-	-	-	-	1.1	1.4	0.1	5.5	12.9	0.4
	10-1	232.96	1.68	0.37	138.67	50.76	0.9	1.1	0.04	5.5	12.81	0.32
	10-2	233.71	1.68	0.37	139.11	50.92	0.8	1.0	0.04	5.5	12.85	0.28
	10-3	232.91	1.68	0.37	138.64	50.75	0.9	1.1	0.04	5.5	12.81	0.32
	Mean	-	-	-	-	-	0.9	1.1	0.0	5.5	12.8	0.3
	30-1	232.27	1.68	0.37	138.25	50.61	1.5	1.9	0.07	5.5	12.77	0.53
	30-2	231.36	1.68	0.37	137.72	50.41	1.5	1.9	0.07	5.5	12.72	0.53
	30-3	234.00	1.68	0.37	139.29	50.98	1.7	2.2	0.08	5.5	12.87	0.60
	Mean	-	-	-	-	-	1.6	2.0	0.1	5.5	12.8	0.6
	60-1	231.41	1.68	0.37	137.74	50.42	2.0	2.5	0.09	5.5	12.73	0.71
	60-2	230.95	1.68	0.37	137.47	50.32	2.7	3.4	0.12	5.5	12.70	0.96
	60-3	233.25	1.68	0.37	138.84	50.82	1.7	2.2	0.08	5.5	12.83	0.60
	Mean	-	-	-	-	-	2.1	2.7	0.1	5.5	12.8	0.8
	100-1	232.59	1.68	0.37	138.45	50.68	3.1	3.9	0.14	5.5	12.79	1.10
	100-2	233.13	1.68	0.37	138.77	50.80	2.5	3.2	0.11	5.5	12.82	0.89
	100-3	232.05	1.68	0.37	138.13	50.56	2.6	3.3	0.12	5.5	12.76	0.92
	Mean	-	-	-	-	-	2.7	3.5	0.1	5.5	12.8	1.0

Table D-8 Continued.

Soil	Sample ID	Soil Weight	Bulk Density	Porosity	Volume of Soil	Pore Volume	Fe^{2+} in Solution	Fe^{2+} per PV	meq Fe^{2+}	CEC	meq Soil	meq Fe per meq Soil
		g	g cm^{-3}		cm^{-3}	mL	mg L^{-1}	mg		$cmol_c$ kg^{-1}		%
Orelia-sandy	N-1	237.12	1.44	0.46	164.66	75.19	0.0	0.0	0.00	11.5	27.27	0.00
	N-2	236.83	1.44	0.46	164.47	75.10	0.2	0.4	0.01	11.5	27.24	0.05
	N-3	237.19	1.44	0.46	164.72	75.21	0.1	0.2	0.01	11.5	27.28	0.02
	Mean	-	-	-	-	-	0.1	0.2	0.0	11.5	27.3	0.0
	0-1	236.80	1.44	0.46	164.44	75.08	0.4	0.8	0.03	11.5	27.23	0.10
	0-2	236.53	1.44	0.46	164.26	75.00	0.3	0.6	0.02	11.5	27.20	0.07
	0-3	236.59	1.44	0.46	164.30	75.02	0.4	0.8	0.03	11.5	27.21	0.10
	Mean	-	-	-	-	-	0.4	0.7	0.0	11.5	27.2	0.1
	10-1	235.91	1.44	0.46	163.82	74.80	0.8	1.5	0.05	11.5	27.13	0.20
	10-2	236.83	1.44	0.46	164.47	75.10	0.4	0.8	0.03	11.5	27.24	0.10
	10-3	232.56	1.44	0.46	161.50	73.74	0.3	0.6	0.02	11.5	26.74	0.07
	Mean	-	-	-	-	-	0.5	0.9	0.0	11.5	27.0	0.1
	30-1	227.70	1.44	0.46	158.13	72.20	0.6	1.1	0.04	11.5	26.19	0.15
	30-2	235.64	1.44	0.46	163.64	74.72	0.5	0.9	0.03	11.5	27.10	0.12
	30-3	236.21	1.44	0.46	164.03	74.90	0.7	1.3	0.05	11.5	27.16	0.17
	Mean	-	-	-	-	-	0.6	1.1	0.0	11.5	26.8	0.1
	60-1	238.53	1.44	0.46	165.65	75.64	1.0	1.9	0.07	11.5	27.43	0.25
	60-2	217.11	1.44	0.46	150.77	68.84	0.9	1.5	0.06	11.5	24.97	0.22
	60-3	219.50	1.44	0.46	152.43	69.60	0.5	0.9	0.03	11.5	25.24	0.12
	Mean	-	-	-	-	-	0.8	1.4	0.1	11.5	25.9	0.2
	100-1	217.01	1.44	0.46	150.70	68.81	2.1	3.6	0.13	11.5	24.96	0.52
	100-2	236.09	1.44	0.46	163.95	74.86	1.0	1.9	0.07	11.5	27.15	0.25
	100-3	224.94	1.44	0.46	156.21	71.33	0.9	1.6	0.06	11.5	25.87	0.22
	Mean	-	-	-	-	-	1.3	2.4	0.1	11.5	26.0	0.3

APPENDIX E

ADDITIONAL STUDY #3 DATA

Table E-1. Mean and standard deviation (SD) for redox potential (Eh) after 336 h of equilibration from Study #3.

Soil	Sample	Treatment (mg Fe^{2+} L^{-1}) 0	30	60	100
		Eh (mV)			
Pledger-low	1	-59	52	-55	-149
	2	-136	134	-171	-116
	3	-243	-209	-42	-94
	4	-196	-89	-62	18
	5	-151	120	-138	-96
	6	-38	-22	-55	-56
	Mean	-137	-2	-87	-82
	SD	78	132	54	58
Pledger-high	1	-176	-116	-227	-269
	2	-144	-238	-216	-261
	3	-204	-251	-203	-222
	4	-242	-223	-246	-219
	5	-216	-224	-158	-272
	6	-253	-186	-233	-286
	Mean	-206	-206	-214	-255
	SD	41	49	31	28
Cieno	1	-19	12	7	-93
	2	-61	-9	-177	-123
	3	-32	-53	-19	70
	4	-79	-119	-137	-130
	5	-126	-26	-159	-82
	6	-160	-3	-162	-102
	Mean	-80	-33	-108	-77
	SD	55	48	80	74
Orelia-loamy	1	-133	-159	77	-86
	2	-54	-159	-94	-204
	3	-228	-120	23	-93
	4	-221	62	-83	-90
	5	-187	-156	-105	-76
	6	-185	-92	-127	-100
	Mean	-168	-104	-52	-108
	SD	65	86	82	48
Gessner	1	155	-56	-77	-62
	2	-95	-45	-23	-111
	3	-138	-64	-90	-149
	4	-153	-140	-81	-112
	5	-63	-93	48	-146
	6	-31	-110	-119	-96
	Mean	-54	-85	-57	-113
	SD	112	36	60	32
Orelia-sandy	1	-191	-220	-84	-198
	2	-120	-188	-213	-229
	3	-203	-193	-172	-238
	4	-184	-223	-178	-191
	5	-165	-89	-206	-202
	6	-191	-160	-155	-188
	Mean	-176	-179	-168	-208
	SD	30	50	46	21

Table E-2. One-way analysis of variance and Fisher's least significant difference (LSD) for redox potential (Eh) after 336 h of equilibration from Study #3.

COMPARISON OF TREATMENTS WITHIN INDICATED SOIL						
Pledger-low						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	-------------------------Eh (mV)-------------------------					
1	-59	52	-55	-149		
2	-136	134	-171	-116		
3	-243	-209	-42	-94		
4	-196	-89	-62	18		
5	-151	120	-138	-96		
6	-38	-22	-55	-56		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	6	-823	-137.166667	6159.766667		
30	6	-14	-2.33333333	17422.66667		
60	6	-523	-87.1666667	2870.966667		
100	6	-493	-82.1666667	3332.166667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	55950.125	3	18650.04167	2.504574363	0.088445528	3.098391224
Within Groups	148927.8333	20	7446.391667			
Total	204877.9583	23				
Pledger-high						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	-------------------------Eh (mV)-------------------------					
1	-176	-116	-227	-269		
2	-144	-238	-216	-261		
3	-204	-251	-203	-222		
4	-242	-223	-246	-219		
5	-216	-224	-158	-272		
6	-253	-186	-233	-286		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	6	-1235	-205.833333	1670.566667		
30	6	-1238	-206.333333	2432.266667		
60	6	-1283	-213.833333	962.9666667		
100	6	-1529	-254.833333	773.3666667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9832.125	3	3277.375	2.245097759	0.114380641	3.098391224
Within Groups	29195.83333	20	1459.791667			
Total	39027.95833	23				
Cieno						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	-------------------------Eh (mV)-------------------------					
1	-19	12	7	-93		
2	-61	-9	-177	-123		
3	-32	-53	-19	70		
4	-79	-119	-137	-130		
5	-126	-26	-159	-82		
6	-160	-3	-162	-102		

Table E-2 Continued.

Cieno						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	6	-477	-79.5	2980.3		
30	6	-198	-33	2269.2		
60	6	-647	-107.833333	6452.966667		
100	6	-460	-76.6666667	5487.866667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	17176.83333	3	5725.611111	1.332286233	0.291933896	3.098391224
Within Groups	85951.66667	20	4297.583333			
Total	103128.5	23				
Orelia-loamy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	-------------------------Eh (mV)-------------------------					
1	-133	-159	77	-86		
2	-54	-159	-94	-204		
3	-228	-120	23	-93		
4	-221	62	-83	-90		
5	-187	-156	-105	-76		
6	-185	-92	-127	-100		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	6	-1008	-168	4256		
30	6	-624	-104	7342		
60	6	-309	-51.5	6684.7		
100	6	-649	-108.166667	2267.366667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	40849.5	3	13616.5	2.650405027	0.076703964	3.098391224
Within Groups	102750.3333	20	5137.516667			
Total	143599.8333	23				
Gessner						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	-------------------------Eh (mV)-------------------------					
1	155	-56	-77	-62		
2	-95	-45	-23	-111		
3	-138	-64	-90	-149		
4	-153	-140	-81	-112		
5	-63	-93	48	-146		
6	-31	-110	-119	-96		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	6	-325	-54.1666667	12565.76667		
30	6	-508	-84.6666667	1319.066667		
60	6	-342	-57	3618		
100	6	-676	-112.666667	1055.866667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	13513.125	3	4504.375	0.970838475	0.426000685	3.098391224
Within Groups	92793.5	20	4639.675			
Total	106306.625	23				

Table E-2 Continued.

Orelia-sandy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	-------------------------Eh (mV)-------------------------					
1	-191	-220	-84	-198		
2	-120	-188	-213	-229		
3	-203	-193	-172	-238		
4	-184	-223	-178	-191		
5	-165	-89	-206	-202		
6	-191	-160	-155	-188		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	6	-1054	-175.666667	899.8666667		
30	6	-1073	-178.833333	2470.966667		
60	6	-1008	-168	2162		
100	6	-1246	-207.666667	433.0666667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5422.458333	3	1807.486111	1.211878249	0.331137714	3.098391224
Within Groups	29829.5	20	1491.475			
Total	35251.95833	23				

COMPARISON OF SOILS WITHIN INDICATED TREATMENT						
0 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	---------------------------------------Eh (mV)---------------------------------------					
1	-59	-176	-19	-133	155	-191
2	-136	-144	-61	-54	-95	-120
3	-243	-204	-32	-228	-138	-203
4	-196	-242	-79	-221	-153	-184
5	-151	-216	-126	-187	-63	-165
6	-38	-253	-160	-185	-31	-191
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	6	-823	-137.166667	6159.766667		
Pledger-high	6	-1235	-205.833333	1670.566667		
Cieno	6	-477	-79.5	2980.3		
Orelia-loamy	6	-1008	-168	4256		
Gessner	6	-325	-54.1666667	12565.76667		
Orelia-sandy	6	-1054	-175.666667	899.8666667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	104167.8889	5	20833.57778	4.381056301	0.004107193	2.533554545
Within Groups	142661.3333	30	4755.377778			
Total	246829.2222	35				

Table E-2 Continued.

0 mg Fe^{2+} L^{-1}						
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
81.30	Pl vs Ph	68.67	Accept			
	Pl vs C	-57.67	Accept			
	Pl vs Os	30.83	Accept			
	Pl vs G	-83.00	Reject			
	Pl vs Or	38.50	Accept			
	Ph vs C	-126.33	Reject			
	Ph vs Os	-37.83	Accept			
	Ph vs G	-151.67	Reject			
	Ph vs Or	-30.17	Accept			
	C vs Os	88.50	Reject			
	C vs G	-25.33	Accept			
	C vs Or	96.17	Reject			
	Os vs G	-113.83	Reject			
	Os vs Or	7.67	Accept			
	G vs Or	121.50	Reject			
30 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
		--Eh (mV)--				
1	52	-116	12	-159	-56	-220
2	134	-238	-9	-159	-45	-188
3	-209	-251	-53	-120	-64	-193
4	-89	-223	-119	62	-140	-223
5	120	-224	-26	-156	-93	-89
6	-22	-186	-3	-92	-110	-160
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	6	-14	-2.33333333	17422.66667		
Pledger-high	6	-1238	-206.333333	2432.266667		
Cieno	6	-198	-33	2269.2		
Orelia-loamy	6	-624	-104	7342		
Gessner	6	-508	-84.6666667	1319.066667		
Orelia-sandy	6	-1073	-178.833333	2470.966667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	190718.1389	5	38143.62778	6.881784331	0.000219621	2.533554545
Within Groups	166280.8333	30	5542.694444			
Total	356998.9722	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
87.77	Pl vs Ph	204.00	Reject			
	Pl vs C	30.67	Accept			
	Pl vs Os	101.67	Reject			
	Pl vs G	82.33	Accept			
	Pl vs Or	176.50	Reject			
	Ph vs C	-173.33	Reject			
	Ph vs Os	-102.33	Reject			
	Ph vs G	-121.67	Reject			
	Ph vs Or	-27.50	Accept			
	C vs Os	71.00	Accept			
	C vs G	51.67	Accept			
	C vs Or	145.83	Reject			
	Os vs G	-19.33	Accept			
	Os vs Or	74.83	Accept			
	G vs Or	94.17	Reject			

Table E-2 Continued.

60 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	--Eh (mV)--					
1	-55	-227	7	77	-77	-84
2	-171	-216	-177	-94	-23	-213
3	-42	-203	-19	23	-90	-172
4	-62	-246	-137	-83	-81	-178
5	-138	-158	-159	-105	48	-206
6	-55	-233	-162	-127	-119	-155
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	6	-523	-87.1666667	2870.966667		
Pledger-high	6	-1283	-213.833333	962.9666667		
Cieno	6	-647	-107.833333	6452.966667		
Orelia-loamy	6	-309	-51.5	6684.7		
Gessner	6	-342	-57	3618		
Orelia-sandy	6	-1008	-168	2162		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	124774.2222	5	24954.84444	6.581034594	0.000304382	2.533554545
Within Groups	113758	30	3791.933333			
Total	238532.2222	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
72.60	Pl vs Ph	126.67	Reject			
	Pl vs C	20.67	Accept			
	Pl vs Os	-35.67	Accept			
	Pl vs G	-30.17	Accept			
	Pl vs Or	80.83	Reject			
	Ph vs C	-106.00	Reject			
	Ph vs Os	-162.33	Reject			
	Ph vs G	-156.83	Reject			
	Ph vs Or	-45.83	Accept			
	C vs Os	-56.33	Accept			
	C vs G	-50.83	Accept			
	C vs Or	60.17	Accept			
	Os vs G	5.50	Accept			
	Os vs Or	116.50	Reject			
	G vs Or	111.00	Reject			

100 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	--Eh (mV)--					
1	-149	-269	-93	-86	-62	-198
2	-116	-261	-123	-204	-111	-229
3	-94	-222	70	-93	-149	-238
4	18	-219	-130	-90	-112	-191
5	-96	-272	-82	-76	-146	-202
6	-56	-286	-102	-100	-96	-188
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	6	-493	-82.1666667	3332.166667		
Pledger-high	6	-1529	-254.833333	773.3666667		
Cieno	6	-460	-76.6666667	5487.866667		
Orelia-loamy	6	-649	-108.166667	2267.366667		
Gessner	6	-676	-112.666667	1055.866667		
Orelia-sandy	6	-1246	-207.666667	433.0666667		

Table E-2 Continued.

100 mg Fe^{2+} L^{-1}						
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	161285.8056	5	32257.16111	14.4979263	3.02173E-07	2.533554545
Within Groups	66748.5	30	2224.95			
Total	228034.3056	35				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
55.61	Pl vs Ph	172.67	Reject			
	Pl vs C	-5.50	Accept			
	Pl vs Os	26.00	Accept			
	Pl vs G	30.50	Accept			
	Pl vs Or	125.50	Reject			
	Ph vs C	-178.17	Reject			
	Ph vs Os	-146.67	Reject			
	Ph vs G	-142.17	Reject			
	Ph vs Or	-47.17	Accept			
	C vs Os	31.50	Accept			
	C vs G	36.00	Accept			
	C vs Or	131.00	Reject			
	Os vs G	4.50	Accept			
	Os vs Or	99.50	Reject			
	G vs Or	95.00	Reject			

Table E-3. Mean and standard deviation (SD) for ferrous Fe in solution per pore volume after 336 h of equilibration from Study #3.

		Treatment (mg Fe^{2+} L^{-1})			
Soil	Sample	0	30	60	100
		mg Fe^{2+} per Pore Volume			
Pledger-low	1	3.41	0.59	0.32	0.31
	2	2.26	0.98	0.30	0.62
	3	0.32	0.33	0.30	0.31
	Mean	2.00	0.63	0.31	0.41
	SD	1.56	0.33	0.01	0.18
Pledger-high	1	0.56	0.31	0.33	0.61
	2	0.28	0.33	0.57	0.98
	3	0.00	0.32	0.81	4.55
	Mean	0.28	0.32	0.57	2.05
	SD	0.28	0.01	0.24	2.17
Cieno	1	0.00	0.00	0.38	0.66
	2	0.00	0.00	0.26	0.76
	3	0.00	0.14	0.62	0.76
	Mean	0.00	0.05	0.42	0.73
	SD	0.00	0.08	0.18	0.06
Orelia-loamy	1	0.16	0.21	0.34	0.16
	2	0.00	0.00	0.32	0.34
	3	0.00	0.14	0.28	0.13
	Mean	0.05	0.12	0.32	0.21
	SD	0.09	0.11	0.03	0.11
Gessner	1	0.12	0.25	0.35	1.10
	2	0.12	0.13	0.36	0.89
	3	0.12	0.12	0.51	0.90
	Mean	0.12	0.17	0.41	0.96
	SD	0.00	0.07	0.09	0.12
Orelia-sandy	1	0.17	0.00	0.00	0.17
	2	0.00	0.00	0.17	0.14
	3	0.36	0.00	0.14	0.14
	Mean	0.18	0.00	0.10	0.15
	SD	0.18	0.00	0.09	0.02

Table E-4. One-way analysis of variance and Fisher's least significant difference (LSD) for ferrous Fe in solution per pore volume after 336 h of equilibration from Study #3.

COMPARISON OF TREATMENTS WITHIN INDICATED SOIL						
Pledger-low						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	---------------mg Fe^{2+} per Pore Volume---------------					
1	3.41	0.59	0.32	0.31		
2	2.26	0.98	0.30	0.62		
3	0.32	0.33	0.30	0.31		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	5.991091195	1.997030398	2.429541227		
30	3	1.901282936	0.633760979	0.107496969		
60	3	0.923919067	0.307973022	0.000115604		
100	3	1.230704982	0.410234994	0.031622899		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.546922866	3	1.848974289	2.879151449	0.102997356	4.066180557
Within Groups	5.137553397	8	0.642194175			
Total	10.68447626	11				
Pledger-high						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	---------------mg Fe^{2+} per Pore Volume---------------					
1	0.56	0.31	0.33	0.61		
2	0.28	0.33	0.57	0.98		
3	0.00	0.32	0.81	4.55		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0.847645138	0.282548379	0.079466657		
30	3	0.962757801	0.320919267	9.34122E-05		
60	3	1.701774673	0.567258224	0.05900391		
100	3	6.139673077	2.046557692	4.718795003		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.315823987	3	2.105274662	1.733678462	0.237214125	4.066180557
Within Groups	9.714717964	8	1.214339745			
Total	16.03054195	11				
Cieno						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	---------------mg Fe^{2+} per Pore Volume---------------					
1	0.00	0.00	0.38	0.66		
2	0.00	0.00	0.26	0.76		
3	0.00	0.14	0.62	0.76		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0	0	0		
30	3	0.138113881	0.04603796	0.006358481		
60	3	1.259752639	0.419917546	0.032146865		
100	3	2.183475011	0.727825004	0.003081228		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.055704496	3	0.351901499	33.84760644	6.79272E-05	4.066180557
Within Groups	0.083173148	8	0.010396644			
Total	1.138877645	11				

Table E-4 Continued.

Cieno						
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
0.19	0 vs 30	-0.05	Accept			
	0 vs 60	-0.42	Reject			
	0 vs 100	-0.73	Reject			
	30 vs 60	-0.37	Reject			
	30 vs 100	-0.68	Reject			
	60 vs 100	-0.31	Reject			
Orelia-loamy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	---------------mg Fe^{2+} per Pore Volume---------------					
1	0.16	0.21	0.34	0.16		
2	0.00	0.00	0.32	0.34		
3	0.00	0.14	0.28	0.13		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0.155300629	0.051766876	0.008039428		
30	3	0.345940252	0.115313417	0.011298535		
60	3	0.949220126	0.316406709	0.000816323		
100	3	0.631950314	0.210650105	0.012306377		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.120021254	3	0.040007085	4.929915847	0.031665475	4.066180557
Within Groups	0.064921327	8	0.008115166			
Total	0.184942581	11				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
0.17	0 vs 30	-0.06	Accept			
	0 vs 60	-0.26	Reject			
	0 vs 100	-0.16	Accept			
	30 vs 60	-0.20	Reject			
	30 vs 100	-0.10	Accept			
	60 vs 100	0.11	Accept			
Gessner						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	---------------mg Fe^{2+} per Pore Volume---------------					
1	0.12	0.25	0.35	1.10		
2	0.12	0.13	0.36	0.89		
3	0.12	0.12	0.51	0.90		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0.362399146	0.120799715	1.45838E-05		
30	3	0.499456312	0.166485437	0.004970071		
60	3	1.231853156	0.410617719	0.008152837		
100	3	2.885063679	0.961687893	0.014324634		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.341600331	3	0.44720011	65.13699861	5.79453E-06	4.066180557
Within Groups	0.054924251	8	0.006865531			
Total	1.396524582	11				

Table E-4 Continued.

Gessner						
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
0.16	0 vs 30	-0.05	Accept			
	0 vs 60	-0.29	Reject			
	0 vs 100	-0.84	Reject			
	30 vs 60	-0.24	Reject			
	30 vs 100	-0.80	Reject			
	60 vs 100	-0.55	Reject			
Orelia-sandy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
	---------------mg Fe^{2+} per Pore Volume---------------					
1	0.17	0.00	0.00	0.17		
2	0.00	0.00	0.17	0.14		
3	0.36	0.00	0.14	0.14		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0.532918436	0.177639479	0.032953318		
30	3	0	0	0		
60	3	0.306733097	0.102244366	0.007988497		
100	3	0.44635397	0.148784657	0.000264376		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.054622193	3	0.018207398	1.767442902	0.230922231	4.066180557
Within Groups	0.082412384	8	0.010301548			
Total	0.137034577	11				

COMPARISON OF SOILS WITHIN INDICATED TREATMENT						
0 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	------------------------------mg Fe^{2+} per Pore Volume------------------------------					
1	3.41	0.56	0.00	0.16	0.12	0.17
2	2.26	0.28	0.00	0.00	0.12	0.00
3	0.32	0.00	0.00	0.00	0.12	0.36
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	5.991091195	1.997030398	2.429541227		
Pledger-high	3	0.847645138	0.282548379	0.079466657		
Cieno	3	0	0	0		
Orelia-loamy	3	0.155300629	0.051766876	0.008039428		
Gessner	3	0.362399146	0.120799715	1.45838E-05		
Orelia-sandy	3	0.532918436	0.177639479	0.032953318		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8.892492317	5	1.778498463	4.184677299	0.01963214	3.105875239
Within Groups	5.100030429	12	0.425002536			
Total	13.99252275	17				

Table E-4 Continued.

0 mg Fe^{2+} L^{-1}						
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
1.16	Pl vs Ph	1.71	Reject			
	Pl vs C	2.00	Reject			
	Pl vs Os	1.95	Reject			
	Pl vs G	1.88	Reject			
	Pl vs Or	1.82	Reject			
	Ph vs C	0.28	Accept			
	Ph vs Os	0.23	Accept			
	Ph vs G	0.16	Accept			
	Ph vs Or	0.10	Accept			
	C vs Os	-0.05	Accept			
	C vs G	-0.12	Accept			
	C vs Or	-0.18	Accept			
	Os vs G	-0.07	Accept			
	Os vs Or	-0.13	Accept			
	G vs Or	-0.06	Accept			
30 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	------------------------------mg Fe^{2+} per Pore Volume------------------------------					
1	0.59	0.31	0.00	0.21	0.25	0.00
2	0.98	0.33	0.00	0.00	0.13	0.00
3	0.33	0.32	0.14	0.14	0.12	0.00
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	1.901282936	0.633760979	0.107496969		
Pledger-high	3	0.962757801	0.320919267	9.34122E-05		
Cieno	3	0.138113881	0.04603796	0.006358481		
Orelia-loamy	3	0.345940252	0.115313417	0.011298535		
Gessner	3	0.499456312	0.166485437	0.004970071		
Orelia-sandy	3	0	0	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.820903693	5	0.164180739	7.564917701	0.00202418	3.105875239
Within Groups	0.260434937	12	0.021702911			
Total	1.08133863	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
0.26	Pl vs Ph	0.31	Reject			
	Pl vs C	0.59	Reject			
	Pl vs Os	0.52	Reject			
	Pl vs G	0.47	Reject			
	Pl vs Or	0.63	Reject			
	Ph vs C	0.27	Reject			
	Ph vs Os	0.21	Accept			
	Ph vs G	0.15	Accept			
	Ph vs Or	0.32	Reject			
	C vs Os	-0.07	Accept			
	C vs G	-0.12	Accept			
	C vs Or	0.05	Accept			
	Os vs G	-0.05	Accept			
	Os vs Or	0.12	Accept			
	G vs Or	0.17	Accept			

Table E-4 Continued.

60 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	------------------------------mg Fe^{2+} per Pore Volume------------------------------					
1	0.32	0.33	0.38	0.34	0.35	0.00
2	0.30	0.57	0.26	0.32	0.36	0.17
3	0.30	0.81	0.62	0.28	0.51	0.14
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	0.923919067	0.307973022	0.000115604		
Pledger-high	3	1.701774673	0.567258224	0.05900391		
Cieno	3	1.259752639	0.419917546	0.032146865		
Orelia-loamy	3	0.949220126	0.316406709	0.000816323		
Gessner	3	1.231853156	0.410617719	0.008152837		
Orelia-sandy	3	0.306733097	0.102244366	0.007988497		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.359827103	5	0.071965421	3.989802473	0.023026233	3.105875239
Within Groups	0.216448071	12	0.018037339			
Total	0.576275174	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
0.24	Pl vs Ph	-0.26	Reject			
	Pl vs C	-0.11	Accept			
	Pl vs Os	-0.01	Accept			
	Pl vs G	-0.10	Accept			
	Pl vs Or	0.21	Accept			
	Ph vs C	0.15	Accept			
	Ph vs Os	0.25	Reject			
	Ph vs G	0.16	Accept			
	Ph vs Or	0.47	Reject			
	C vs Os	0.10	Accept			
	C vs G	0.01	Accept			
	C vs Or	0.32	Reject			
	Os vs G	-0.09	Accept			
	Os vs Or	0.21	Accept			
	G vs Or	0.31	Reject			
100 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
	------------------------------mg Fe^{2+} per Pore Volume------------------------------					
1	0.31	0.61	0.66	0.16	1.10	0.17
2	0.62	0.98	0.76	0.34	0.89	0.14
3	0.31	4.55	0.76	0.13	0.90	0.14
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	1.230704982	0.410234994	0.031622899		
Pledger-high	3	6.139673077	2.046557692	4.718795003		
Cieno	3	2.183475011	0.727825004	0.003081228		
Orelia-loamy	3	0.631950314	0.210650105	0.012306377		
Gessner	3	2.885063679	0.961687893	0.014324634		
Orelia-sandy	3	0.44635397	0.148784657	0.000264376		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.48247493	5	1.496494986	1.878290564	0.172053127	3.105875239
Within Groups	9.560789034	12	0.79673242			
Total	17.04326396	17				

Table E-5. Statistical analysis of redox concentrations by macromorphic description after 336 h of equilibration from Study #3.

Mean and Standard Deviation					
		------------------Treatment (mg Fe^{2+} L^{-1})-----------------			
Soil	Sample	0	30	60	100
		-----------------% redox concentrations---------------			
Pledger-low	1	20	20	20	20
	2	25	10	25	15
	3	20	20	20	10
	Mean	21.67	16.67	21.67	15.00
	SD	2.89	5.77	2.89	5.00
Pledger-high	1	3	5	1	1
	2	1	1	1	1
	3	2	2	3	2
	Mean	2.00	2.67	1.67	1.33
	SD	1.00	2.08	1.15	0.58
Cieno	1	2	7	15	15
	2	3	10	15	15
	3	7	5	10	3
	Mean	4.00	7.33	13.33	11.00
	SD	2.65	2.52	2.89	6.93
Orelia-loamy	1	0	0	2	4
	2	0	0	3	0
	3	0	1	2	1
	Mean	0.00	0.33	2.33	1.67
	SD	0.00	0.58	0.58	2.08
Gessner	1	3	5	7	15
	2	2	7	1	15
	3	3	3	3	7
	Mean	2.67	5.00	3.67	12.33
	SD	0.58	2.00	3.06	4.62
Orelia-sandy	1	0	0	0	0
	2	0	0	0	0
	3	0	1	0	0
	Mean	0.00	0.33	0.00	0.00
	SD	0.00	0.58	0.00	0.00

COMPARISON OF TREATMENTS WITHIN INDICATED SOIL †						
Pledger-low						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	20	20	20	20		
2	25	10	25	15		
3	20	20	20	10		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	65	21.66666667	8.333333333		
30	3	50	16.66666667	33.33333333		
60	3	65	21.66666667	8.333333333		
100	3	45	15	25		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	106.25	3	35.41666667	1.888888889	0.209895306	4.066180557
Within Groups	150	8	18.75			
Total	256.25	11				

Table E-5 Continued.

Pledger-high						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	3	5	1	1		
2	1	1	1	1		
3	2	2	3	2		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	6	2	1		
30	3	8	2.666666667	4.333333333		
60	3	5	1.666666667	1.333333333		
100	3	4	1.333333333	0.333333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.916666667	3	0.972222222	0.555555556	0.658835707	4.066180557
Within Groups	14	8	1.75			
Total	16.91666667	11				
Cieno						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	2	7	15	15		
2	3	10	15	15		
3	7	5	10	3		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	12	4	7		
30	3	22	7.333333333	6.333333333		
60	3	40	13.33333333	8.333333333		
100	3	33	11	48		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	151.5833333	3	50.52777778	2.901116427	0.101509038	4.066180557
Within Groups	139.3333333	8	17.41666667			
Total	290.9166667	11				
Orelia-loamy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	0	0	2	4		
2	0	0	3	0		
3	0	1	2	1		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0	0	0		
30	3	1	0.333333333	0.333333333		
60	3	7	2.333333333	0.333333333		
100	3	5	1.666666667	4.333333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10.91666667	3	3.638888889	2.911111111	0.100840592	4.066180557
Within Groups	10	8	1.25			
Total	20.91666667	11				

Table E-5 Continued.

Gessner						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	3	5	7	15		
2	2	7	1	15		
3	3	3	3	7		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	8	2.666666667	0.333333333		
30	3	15	5	4		
60	3	11	3.666666667	9.333333333		
100	3	37	12.33333333	21.33333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	172.9166667	3	57.63888889	6.587301587	0.01487858	4.066180557
Within Groups	70	8	8.75			
Total	242.9166667	11				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
5.57	0 vs 30	-2.33	Accept			
	0 vs 60	-1.00	Accept			
	0 vs 100	-9.67	Reject			
	30 vs 60	1.33	Accept			
	30 vs 100	-7.33	Reject			
	60 vs 100	-8.67	Reject			

Orelia-sandy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	0	0	0	0		
2	0	0	0	0		
3	0	1	0	0		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	0	0	0		
30	3	1	0.333333333	0.333333333		
60	3	0	0	0		
100	3	0	0	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.25	3	0.083333333	1	0.44109908	4.066180557
Within Groups	0.666666667	8	0.083333333			
Total	0.916666667	11				

Table E-5 Continued.

COMPARISON OF SOILS WITHIN INDICATED TREATMENT †						
0 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	20	3	2	0	3	0
2	25	1	3	0	2	0
3	20	2	7	0	3	0
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	65	21.66666667	8.333333333		
Pledger-high	3	6	2	1		
Cieno	3	12	4	7		
Orelia-loamy	3	0	0	0		
Gessner	3	8	2.666666667	0.333333333		
Orelia-sandy	3	0	0	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1029.611111	5	205.9222222	74.132	1.33871E-08	3.105875239
Within Groups	33.33333333	12	2.777777778			
Total	1062.944444	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
2.97	Pl vs Ph	19.67	Reject			
	Pl vs C	17.67	Reject			
	Pl vs Os	21.67	Reject			
	Pl vs G	19.00	Reject			
	Pl vs Or	21.67	Reject			
	Ph vs C	-2.00	Accept			
	Ph vs Os	2.00	Accept			
	Ph vs G	-0.67	Accept			
	Ph vs Or	2.00	Accept			
	C vs Os	4.00	Reject			
	C vs G	1.33	Accept			
	C vs Or	4.00	Reject			
	Os vs G	-2.67	Accept			
	Os vs Or	0.00	Accept			
	G vs Or	2.67	Accept			
30 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	20	5	7	0	5	0
2	10	1	10	0	7	0
3	20	2	5	1	3	1
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	50	16.66666667	33.33333333		
Pledger-high	3	8	2.666666667	4.333333333		
Cieno	3	22	7.333333333	6.333333333		
Orelia-loamy	3	1	0.333333333	0.333333333		
Gessner	3	15	5	4		
Orelia-sandy	3	1	0.333333333	0.333333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	568.9444444	5	113.7888889	14.02876712	0.000116623	3.105875239
Within Groups	97.33333333	12	8.111111111			
Total	666.2777778	17				

Table E-5 Continued.

30 mg Fe^{2+} L^{-1}						
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
5.07	Pl vs Ph	14.00	Reject			
	Pl vs C	9.33	Reject			
	Pl vs Os	16.33	Reject			
	Pl vs G	11.67	Reject			
	Pl vs Or	16.33	Reject			
	Ph vs C	-4.67	Accept			
	Ph vs Os	2.33	Accept			
	Ph vs G	-2.33	Accept			
	Ph vs Or	2.33	Accept			
	C vs Os	7.00	Reject			
	C vs G	2.33	Accept			
	C vs Or	7.00	Reject			
	Os vs G	-4.67	Accept			
	Os vs Or	0.00	Accept			
	G vs Or	4.67	Accept			
60 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	20	1	15	2	7	0
2	25	1	15	3	1	0
3	20	3	10	2	3	0
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	65	21.66666667	8.333333333		
Pledger-high	3	5	1.666666667	1.333333333		
Cieno	3	40	13.33333333	8.333333333		
Orelia-loamy	3	7	2.333333333	0.333333333		
Gessner	3	11	3.666666667	9.333333333		
Orelia-sandy	3	0	0	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1096.444444	5	219.2888889	47.55662651	1.69257E-07	3.105875239
Within Groups	55.33333333	12	4.611111111			
Total	1151.777778	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
3.82	Pl vs Ph	20.00	Reject			
	Pl vs C	8.33	Reject			
	Pl vs Os	19.33	Reject			
	Pl vs G	18.00	Reject			
	Pl vs Or	21.67	Reject			
	Ph vs C	-11.67	Reject			
	Ph vs Os	-0.67	Accept			
	Ph vs G	-2.00	Accept			
	Ph vs Or	1.67	Accept			
	C vs Os	11.00	Reject			
	C vs G	9.67	Reject			
	C vs Or	13.33	Reject			
	Os vs G	-1.33	Accept			
	Os vs Or	2.33	Accept			
	G vs Or	3.67	Accept			

Table E-5 Continued.

100 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	20	1	15	4	15	0
2	15	1	15	0	15	0
3	10	2	3	1	7	0
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	45	15	25		
Pledger-high	3	4	1.333333333	0.333333333		
Cieno	3	33	11	48		
Orelia-loamy	3	5	1.666666667	4.333333333		
Gessner	3	37	12.33333333	21.33333333		
Orelia-sandy	3	0	0	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	653.7777778	5	130.7555556	7.924579125	0.001658498	3.105875239
Within Groups	198	12	16.5			
Total	851.7777778	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
7.23	Pl vs Ph	13.67	Reject			
	Pl vs C	4.00	Accept			
	Pl vs Os	13.33	Reject			
	Pl vs G	2.67	Accept			
	Pl vs Or	15.00	Reject			
	Ph vs C	-9.67	Reject			
	Ph vs Os	-0.33	Accept			
	Ph vs G	-11.00	Reject			
	Ph vs Or	1.33	Accept			
	C vs Os	9.33	Reject			
	C vs G	-1.33	Accept			
	C vs Or	11.00	Reject			
	Os vs G	-10.67	Reject			
	Os vs Or	1.67	Accept			
	G vs Or	12.33	Reject			

† Comparison by one-way analysis of variance and Fisher's least significant difference (if applicable).

Table E-6. Statistical analysis of redox concentrations by micromorphic point count after 336 h of equilibration from Study #3.

Mean and Standard Deviation					
		Treatment (mg Fe^{2+} L^{-1})			
Soil	Sample	0	30	60	100
		% redox concentration			
Pledger-low	1	16	47	67	62
	2	36	50	60	39
	3	39	51	41	47
	Mean	30.33	49.33	56.00	49.33
	SD	12.50	2.08	13.45	11.68
Pledger-high	1	31	34	11	7
	2	15	18	31	22
	3	26	19	19	27
	Mean	24.00	23.67	20.33	18.67
	SD	8.19	8.96	10.07	10.41
Cieno	1	2	4	6	19
	2	8	7	15	16
	3	5	12	5	4
	Mean	5.00	7.67	8.67	13.00
	SD	3.00	4.04	5.51	7.94
Orelia-loamy	1	2	1	2	13
	2	2	1	6	6
	3	1	1	3	0
	Mean	1.67	1.00	3.67	6.33
	SD	0.58	0.00	2.08	6.51
Gessner	1	1	5	9	9
	2	2	6	5	9
	3	4	5	5	26
	Mean	2.33	5.33	6.33	14.67
	SD	1.53	0.58	2.31	9.81
Orelia-sandy	1	1	4	3	4
	2	1	4	5	3
	3	1	4	4	2
	Mean	1.00	4.00	4.00	3.00
	SD	0.00	0.00	1.00	1.00

COMPARISON OF TREATMENTS WITHIN INDICATED SOIL †						
Pledger-low						
	Treatment (mg Fe^{2+} L^{-1})					
Sample	0	30	60	100		
1	16	47	67	62		
2	36	50	60	39		
3	39	51	41	47		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	91	30.33333333	156.3333333		
30	3	148	49.33333333	4.333333333		
60	3	168	56	181		
100	3	148	49.33333333	136.3333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1102.25	3	367.4166667	3.074616457	0.090638526	4.066180557
Within Groups	956	8	119.5			
Total	2058.25	11				

Table E-6 Continued.

Pledger-high						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	31	34	11	7		
2	15	18	31	22		
3	26	19	19	27		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	72	24	67		
30	3	71	23.66666667	80.33333333		
60	3	61	20.33333333	101.3333333		
100	3	56	18.66666667	108.3333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	60.66666667	3	20.22222222	0.226579521	0.875341551	4.066180557
Within Groups	714	8	89.25			
Total	774.6666667	11				
Cieno						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	2	4	6	19		
2	8	7	15	16		
3	5	12	5	4		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	15	5	9		
30	3	23	7.666666667	16.33333333		
60	3	26	8.666666667	30.33333333		
100	3	39	13	63		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	99.58333333	3	33.19444444	1.118913858	0.397130763	4.066180557
Within Groups	237.3333333	8	29.66666667			
Total	336.9166667	11				
Orelia-loamy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	2	1	2	13		
2	2	1	6	6		
3	1	1	3	0		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	5	1.666666667	0.333333333		
30	3	3	1	0		
60	3	11	3.666666667	4.333333333		
100	3	19	6.333333333	42.33333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	51.66666667	3	17.22222222	1.46572104	0.295180663	4.066180557
Within Groups	94	8	11.75			
Total	145.6666667	11				

Table E-6 Continued.

Gessner						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	1	5	9	9		
2	2	6	5	9		
3	4	5	5	26		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	7	2.333333333	2.333333333		
30	3	16	5.333333333	0.333333333		
60	3	19	6.333333333	5.333333333		
100	3	44	14.66666667	96.33333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	251	3	83.66666667	3.207667732	0.083263468	4.066180557
Within Groups	208.6666667	8	26.08333333			
Total	459.6666667	11				

Orelia-sandy						
	----------------Treatment (mg Fe^{2+} L^{-1})---------------					
Sample	0	30	60	100		
1	1	4	3	4		
2	1	4	5	3		
3	1	4	4	2		
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
0	3	3	1	0		
30	3	12	4	0		
60	3	12	4	1		
100	3	9	3	1		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	18	3	6	12	0.002485724	4.066180557
Within Groups	4	8	0.5			
Total	22	11				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
1.33	0 vs 30	-3.00	Reject			
	0 vs 60	-3.00	Reject			
	0 vs 100	-2.00	Reject			
	30 vs 60	0.00	Accept			
	30 vs 100	1.00	Accept			
	60 vs 100	1.00	Accept			

COMPARISON OF SOILS WITHIN INDICATED TREATMENT †						
0 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	16	31	2	2	1	1
2	36	15	8	2	2	1
3	39	26	5	1	4	1
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	91	30.33333333	156.3333333		
Pledger-high	3	72	24	67		
Cieno	3	15	5	9		
Orelia-loamy	3	5	1.666666667	0.333333333		
Gessner	3	7	2.333333333	2.333333333		
Orelia-sandy	3	3	1	0		

Table E-6 Continued.

0 mg Fe^{2+} L^{-1}						
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2521.611111	5	504.3222222	12.87631206	0.000177518	3.105875239
Within Groups	470	12	39.16666667			
Total	2991.611111	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
11.13	Pl vs Ph	6.33	Accept			
	Pl vs C	25.33	Reject			
	Pl vs Os	28.67	Reject			
	Pl vs G	28.00	Reject			
	Pl vs Or	29.33	Reject			
	Ph vs C	19.00	Reject			
	Ph vs Os	22.33	Reject			
	Ph vs G	21.67	Reject			
	Ph vs Or	23.00	Reject			
	C vs Os	3.33	Accept			
	C vs G	2.67	Accept			
	C vs Or	4.00	Accept			
	Os vs G	-0.67	Accept			
	Os vs Or	0.67	Accept			
	G vs Or	1.33	Accept			
30 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	47	34	4	1	5	4
2	50	18	7	1	6	4
3	51	19	12	1	5	4
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	148	49.33333333	4.333333333		
Pledger-high	3	71	23.66666667	80.33333333		
Cieno	3	23	7.666666667	16.33333333		
Orelia-loamy	3	3	1	0		
Gessner	3	16	5.333333333	0.333333333		
Orelia-sandy	3	12	4	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5153.833333	5	1030.766667	61.03223684	4.09411E-08	3.105875239
Within Groups	202.6666667	12	16.88888889			
Total	5356.5	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
7.31	Pl vs Ph	25.67	Reject			
	Pl vs C	41.67	Reject			
	Pl vs Os	48.33	Reject			
	Pl vs G	44.00	Reject			
	Pl vs Or	45.33	Reject			
	Ph vs C	16.00	Reject			
	Ph vs Os	22.67	Reject			
	Ph vs G	18.33	Reject			
	Ph vs Or	19.67	Reject			
	C vs Os	6.67	Accept			
	C vs G	2.33	Accept			
	C vs Or	3.67	Accept			
	Os vs G	-4.33	Accept			
	Os vs Or	-3.00	Accept			
	G vs Or	1.33	Accept			

Table E-6 Continued.

60 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	67	11	6	2	9	3
2	60	31	15	6	5	5
3	41	19	5	3	5	4
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	168	56	181		
Pledger-high	3	61	20.33333333	101.3333333		
Cieno	3	26	8.666666667	30.33333333		
Orelia-loamy	3	11	3.666666667	4.333333333		
Gessner	3	19	6.333333333	5.333333333		
Orelia-sandy	3	12	4	1		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6181.833333	5	1236.366667	22.9428866	9.31609E-06	3.105875239
Within Groups	646.6666667	12	53.88888889			
Total	6828.5	17				
Fisher's LSD						
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*			
13.06	Pl vs Ph	35.67	Reject			
	Pl vs C	47.33	Reject			
	Pl vs Os	52.33	Reject			
	Pl vs G	49.67	Reject			
	Pl vs Or	52.00	Reject			
	Ph vs C	11.67	Accept			
	Ph vs Os	16.67	Reject			
	Ph vs G	14.00	Reject			
	Ph vs Or	16.33	Reject			
	C vs Os	5.00	Accept			
	C vs G	2.33	Accept			
	C vs Or	4.67	Accept			
	Os vs G	-2.67	Accept			
	Os vs Or	-0.33	Accept			
	G vs Or	2.33	Accept			

100 mg Fe^{2+} L^{-1}						
Sample	Pledger-low	Pledger-high	Cieno	Orelia-loamy	Gessner	Orelia-sandy
1	62	7	19	13	9	4
2	39	22	16	6	9	3
3	47	27	4	0	26	2
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Pledger-low	3	148	49.33333333	136.3333333		
Pledger-high	3	56	18.66666667	108.3333333		
Cieno	3	39	13	63		
Orelia-loamy	3	19	6.333333333	42.33333333		
Gessner	3	44	14.66666667	96.33333333		
Orelia-sandy	3	9	3	1		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4133.833333	5	826.7666667	11.08926975	0.000362977	3.105875239
Within Groups	894.6666667	12	74.55555556			
Total	5028.5	17				

Table E-6 Continued.

100 mg Fe^{2+} L^{-1}			
Fisher's LSD			
LSD	*Groups*	*Mean Diff.*	*Null Hypoth.*
15.36	Pl vs Ph	30.67	Reject
	Pl vs C	36.33	Reject
	Pl vs Os	43.00	Reject
	Pl vs G	34.67	Reject
	Pl vs Or	46.33	Reject
	Ph vs C	5.67	Accept
	Ph vs Os	12.33	Accept
	Ph vs G	4.00	Accept
	Ph vs Or	15.67	Reject
	C vs Os	6.67	Accept
	C vs G	-1.67	Accept
	C vs Or	10.00	Accept
	Os vs G	-8.33	Accept
	Os vs Or	3.33	Accept
	G vs Or	11.67	Accept

† Comparison by one-way analysis of variance and Fisher's least significant difference (if applicable).

Table E-7: Macromorphic descriptions of soil matrix and redoximorphic features from Study #3. All Munsell colors are determined as moist unless otherwise indicated.

			---Matrix Color---		---Redox Features---	
Soil	Treatment	Replication	Moist	Dry	Concentrations †	Depletions
	mg Fe^{2+} L^{-1}					
Pledger-low	0	A	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
		B	2.5Y 2.5/1	2.5Y 3/1	25% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
		C	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
	30	A	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
		B	2.5Y 2.5/1	2.5Y 3/1	10% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
		C	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings; 2% medium prominent 7.5YR 4/4 Fe-Mn nodules/concretions	1% 2.5Y 5/1
	60	A	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	2% 2.5Y 5/1
		B	2.5Y 2.5/1	2.5Y 3/1	25% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
		C	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
	100	A	2.5Y 2.5/1	2.5Y 3/1	20% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	1% 2.5Y 5/1
		B	2.5Y 2.5/1	2.5Y 3/1	15% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	2% 2.5Y 5/1
		C	2.5Y 2.5/1	2.5Y 3/1	10% fine and medium prominent 7.5YR 4/6 Fe masses; 1% fine prominent 7.5YR 5/6 pore linings	2% 2.5Y 5/1

Table E-7 Continued.

			---Matrix Color---		---Redox Features---	
Soil	Treatment	Replication	Moist	Dry	Concentrations †	Depletions
	mg Fe^{2+} L^{-1}					
Pledger-high	0	A	10YR 2/1	10YR 2/1	3% fine and medium prominent 7.5YR 5/8 Fe masses	
		B	10YR 2/1	10YR 2/1	1% fine and medium prominent 7.5YR 5/8 Fe masses	
		C	10YR 2/1	10YR 2/1	2% fine and medium prominent 7.5YR 5/8 Fe masses; 3% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
	30	A	10YR 2/1	10YR 2/1	5% fine and medium prominent 7.5YR 5/8 Fe masses	
		B	10YR 2/1	10YR 2/1	1% fine and medium prominent 7.5YR 5/8 Fe masses; 1% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
		C	10YR 2/1	10YR 2/1	2% fine and medium prominent 7.5YR 5/8 Fe masses; 1% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
	60	A	10YR 2/1	10YR 2/1	1% fine prominent 7.5YR 5/6 pore linings	
		B	10YR 2/1	10YR 2/1	1% fine and medium prominent 7.5YR 5/8 Fe masses; 2% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
		C	10YR 2/1	10YR 2/1	3% fine and medium prominent 7.5YR 5/8 Fe masses; 2% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
	100	A	10YR 2/1	10YR 2/1	1% fine and medium prominent 7.5YR 5/8 Fe masses; 1% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
		B	10YR 2/1	10YR 2/1	1% fine and medium prominent 7.5YR 5/8 Fe masses; 2% fine prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
		C	10YR 2/1	10YR 2/1	2% fine and medium prominent 7.5YR 5/8 Fe masses; 2% medium prominent 7.5YR 4/4 Fe-Mn nodules/concretions	
Cieno	0	A	10YR 5/2	10YR 6/2	2% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	3% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	7% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
	30	A	10YR 5/2	10YR 6/2	7% fine faint 10YR 6/6 Fe masses; 1% fine distinct 7.5YR 5/6 pore linings	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	10% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	5% fine faint 10YR 6/6 Fe masses; 2% fine distinct 7.5YR 5/6 pore linings	50% 10YR 7/1
	60	A	10YR 5/2	10YR 6/2	15% fine faint 10YR 6/6 Fe masses; 1% fine distinct 7.5YR 5/6 pore linings	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	15% fine faint 10YR 6/6 Fe masses; 2% fine distinct 7.5YR 5/6 pore linings	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	10% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
	100	A	10YR 5/2	10YR 6/2	15% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	15% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	3% fine faint 10YR 6/6 Fe masses	50% 10YR 7/1

Table E-7 Continued.

			---Matrix Color---		---Redox Features---	
Soil	Treatment	Replication	Moist	Dry	Concentrations †	Depletions
	mg Fe^{2+} L^{-1}					
Orelia-loamy	0	A	10YR 3/1	10YR 4/1		2% 10YR 6/1
		B	10YR 3/1	10YR 4/1		1% 10YR 6/1
		C	10YR 3/1	10YR 4/1		2% 10YR 6/1
	30	A	10YR 3/1	10YR 4/1		1% 10YR 6/1
		B	10YR 3/1	10YR 4/1		2% 10YR 6/1
		C	10YR 3/1	10YR 4/1	<1% fine faint 10YR 6/6 pore linings	1% 10YR 6/1
	60	A	10YR 3/1	10YR 4/1	2% fine faint 10YR 6/6 pore linings	1% 10YR 6/1
		B	10YR 3/1	10YR 4/1	3% fine faint 10YR 6/6 pore linings	3% 10YR 6/1
		C	10YR 3/1	10YR 4/1	2% fine faint 10YR 6/6 pore linings	2% 10YR 6/1
	100	A	10YR 3/1	10YR 4/1	2% fine faint 10YR 6/6 pore linings; 2% fine distinct 7.5YR 5/6 pore linings	2% 10YR 6/1
		B	10YR 3/1	10YR 4/1		2% 10YR 6/1
		C	10YR 3/1	10YR 4/1	1% fine faint 10YR 6/6 pore linings	2% 10YR 6/1
Gessner	0	A	10YR 5/2	10YR 6/2	3% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	2% fine faint 10YR 6/6 Fe masses and pore linings	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	3% fine faint 10YR 6/6 Fe masses and pore linings	50% 10YR 7/1
	30	A	10YR 5/2	10YR 6/2	5% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	7% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	3% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
	60	A	10YR 5/2	10YR 6/2	7% fine faint 10YR 6/6 pore linings; 2% fine distinct 7.5YR 5/6 pore linings	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	1% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	3% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
	100	A	10YR 5/2	10YR 6/2	15% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
		B	10YR 5/2	10YR 6/2	15% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
		C	10YR 5/2	10YR 6/2	7% fine faint 10YR 6/6 pore linings	50% 10YR 7/1
Orelia-sandy	0	A	10YR 2/1	10YR 4/1		1% 10YR 6/1
		B	10YR 2/1	10YR 4/1		1% 10YR 6/1
		C	10YR 2/1	10YR 4/1		2% 10YR 6/1
	30	A	10YR 2/1	10YR 4/1		1% 10YR 6/1
		B	10YR 2/1	10YR 4/1		1% 10YR 6/1
		C	10YR 2/1	10YR 4/1	1% fine distinct 7.5YR 5/6 pore linings	1% 10YR 6/1
	60	A	10YR 2/1	10YR 4/1		5% 10YR 6/1
		B	10YR 2/1	10YR 4/1		2% 10YR 6/1
		C	10YR 2/1	10YR 4/1		1% 10YR 6/1
	100	A	10YR 2/1	10YR 4/1		1% 10YR 6/1
		B	10YR 2/1	10YR 4/1		1% 10YR 6/1
		C	10YR 2/1	10YR 4/1		1% 10YR 6/1

† Fe-Mn nodules/concretions were not considered in total redox concentration percentage.

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