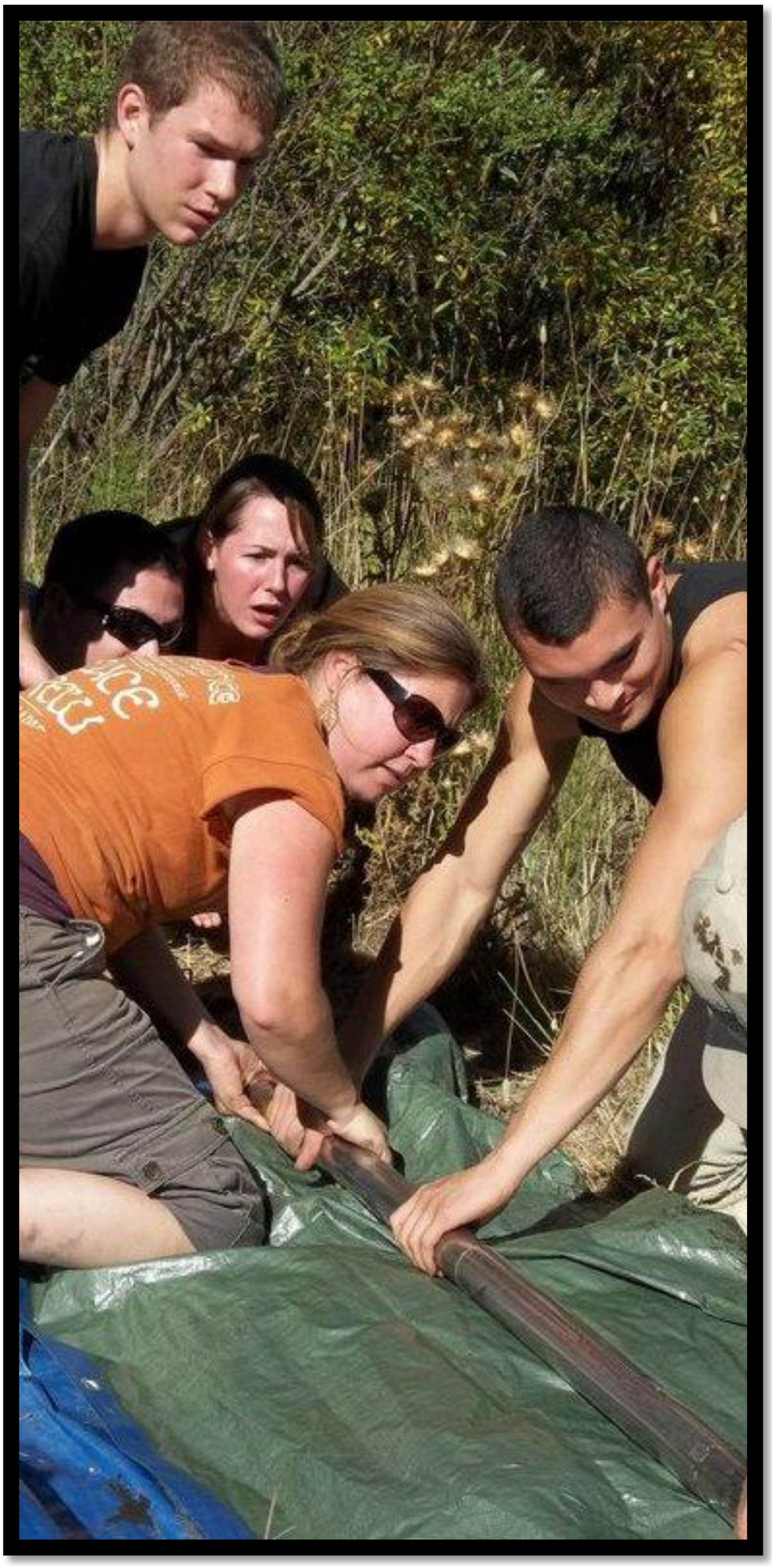
Soil and Sediment Analysis at Fairfield Osborn Preserve



A final report by the class of Geography 317

Fall Semester 2012

WATERS Collaborative

Watershed Academics to Enhance Regional Sustainability

PREFACE

Lab methods in Physical Geography (Geography 317) was taught for the first time in the Fall of 2012 at SSU. This course is designed to provide hands-on experience with laboratory analysis techniques commonly used in physical geography. Course topics include sample collection methods, stratigraphic and laboratory analyses (e.g. grain size, organic composition, macro- and micro- fossil analysis), report writing and data presentation. Data collected from sediment or soil profiles was used to interpret environmental conditions both past and present. Throughout the course students were exposed to laboratory methods, protocols and analytical equipment. Geography 317 was a *service learning* course.

Course Goals and Objectives:

- Introduce laboratory techniques for collecting and analyzing sedimentary/soil material for scientific inquiry.
- Learn how to characterize and describe physical components of sedimentary samples and relate the findings to biologic, climatic and geomorphic processes.
- Acquire data in the lab and use these data for scientific analysis and presentation.
- Provide high quality, meaningful data to our Community Partner (Fairfield Osborn Preserve).
- Civic learning through personal and professional responsibility to others, i.e. the common good.

ACKNOWLEDGEMENTS

We are grateful to Fairfield Osborn for partnering with us. Suzanne DeCoursey (FOP preserve coordinator) and Dr. Claudia Luke (SSU Director of Field Stations and Nature Preserves) not only gave us their time but importantly let us literally poke holes into the preserve. We are also very much appreciate the grant we received from the WATERS collaborative. This money purchased a soil riffle sorter and also provided funds to date our sediment core from the wetland with ^{210} Pb and ^{137}Cs. We also gratefully acknowledge the help of Dr Richard Bopp of Rensselaer Polytechnic Institute (RPI). Richard pulled out all the stops for us so that we would have our dating results back by the first week of December.

DISCLAIMER

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INTRODUCTION AND PROBLEM STATEMENT

In Geography 317 (Lab Methods in Physical Geography), under the guidance of Professor Goman, we undertook a scientific soil and sediment analysis of the nearby nature preserve, Fairfield Osborn Preserve (FOP). This is not an ordinary class because we are applying a different type of learning experience, known as service learning. This type of learning involves direct experience, with hands on interactions and community involvement. Through service learning we are able to work in collaboration with FOP and The WATERS (Watershed Academics to Enhance Regional Sustainability) project. WATERS is a collaborative that helps to create projects aimed at enhancing the academic training for the next generation of professionals and inform them about sustainable management practices in local watersheds. This collaborative is comprised of an interdisciplinary team of Sonoma County Water Agency (SCWA) staff and Sonoma State University (SSU) faculty, staff, and students. By working with the WATERS collaborative and FOP we hope to carry out the direct experience of community involvement aspects through service learning, by analyzing soil and sediment of the FOP and making the data available for future research.

FOP is located at the foothills of the Sonoma Mountains, where diverse habitats make this 411-acre nature preserve a perfect place to learn and apply lab techniques to build scientific knowledge about the environment through our soil analysis. The mission of Geography 317 is to develop a better understanding of the characteristics of the soil at FOP. We have focused on soil because little is known about soil characteristics at FOP. This provides us the chance to rectify that problem, or at least take the initial steps and lay down a foundation to build on for future generations interested in understanding the soil at FOP. We also seek to apply the FOP soil sample data collected, in order to provide data for the WATERS Collaborative projects. One reason these FOP locations were specifically chosen is because the erosive geology of the headwaters of Copeland Creek that pass through this area provides an astonishing amount of sediment despite its tiny size, only 5.1 square miles. This sediment is transported through mass wasting, and deposited downstream. The soil data we collect can be applied by the WATERS collaboration in order to further understand questions like: How much and what kind of sediment is produced? Where does the sediment come from? How has the amount and type of sediment changed with settlement?

The questions pertaining to soil at FOP that we set out to understand, are broad and general questions that have to do with soil and sediment, such as; does soil differ between different dominant plant communities? And how much does the soil range in variation from one ecological habitat to another? The three habitats we sampled were oak mixed woodland, grassland prairie, and marshland. The marsh site was of particular interest because it was once open water, most likely a man-made lake, and has since filled in with biomass. More importantly the marsh site also gave us a chance to get really muddy in the name of science! By using soil-sampling tools known as corers and arguers we were able to penetrate the surface going down in the ground, which gave a view into the environmental history of the preserve. This story about the man-made lake filling in with biomass raised the question of:

how rapidly did the lake fill in and become a marsh? Legends about a fossilized rowboat only stirred our curiosity.

ENVIRONMENTAL SETTING AND HISTORICAL BACKGROUND

Climate

Climate is the amount and distribution of heat and moisture received for a given area. Heat and moisture are important to FOP because of the influence that other elements of FOP receive from these two factors. Climate influences, the manner of soil that forms, the volume and type of vegetation grown, the rate that organic matter decomposes, the rate that minerals weather, and the removal or accumulation of material in the different soil horizons. FOP is considered to be located in a Mediterranean region, with cool wet winters and hot dry summers (Figure 1). Much of FOP's temperature is affected by the Pacific Oceans' cooler sea surface temperature; the sea surface temperature ranges from 12.7°C in summer to 11.6°C in winter. Due to these cooler temperatures, air temperatures at FOP stay fairly cool in summer and reach cooler levels in winter (Miller, 1972).

During the day the earth receives the sun's radiation and sunlight that influence FOP in numerous ways. First, direct sunlight is abundant in the summer. The southern-facing slopes of FOP receive sunlight at a more direct angle, which support higher surface temperatures and greater energy reception. Sunlight is necessary for vegetation to experience photosynthesis; as a result, slope direction is contributed to varied vegetation cover. Nightly temperatures provide the coolest temperatures for FOP because of its rate of loss for radiation. Higher elevations are surrounded by a less sparse atmosphere that does not effectively absorb outgoing radiation from the surface. Those areas of FOP that are covered by tree canopies will retain longwave radiation loss at night and prevent minimum cooling temperatures. We must also be aware that during winter seasons deciduous vegetation will be unable to retain radiation due to loss of canopy cover. In the summer, nightly minimum temperatures tend to be below 10°C and in winter may remain around 5.5°C (Miller, 1972).

The lowest recorded temperature at neighboring mountainous areas has been -10°C. Average annual temperatures decrease as elevation increases in FOP and may reach to about to about 5.5°C at higher ridges where some of the winter precipitation may be snow. No data concerning high temperatures were found in mountainous areas (Miller, 1972).

Summer season's dryness may be attributed to semi-permanent sub-tropical high-pressure systems offshore. The Hawaiian High pressure system in the Pacific "blocks" migrating eastward mid-latitude cyclones and redirects them north. The lack of storms deprives FOP of the uplift mechanisms necessary for precipitation. During the winter months, the Hawaiian high weakens, shrinking in size, and migrates toward the equator. This allows for cyclones access inland to provide precipitation. Average annual rainfall at FOP will usually remain around 180 or more centimeters which the majority happens within the six colder months of the year and may only occur in light amounts during the rest of the months. Summer dry months at times may be long enough to deplete stored moisture in the soil and provide the undernourishment of plants to restrict growth.

Climographs are unable show extreme variability inherent with winter rainfall. Although some winters may be dry, others may bring a rush of sequential storms that create major flooding which produce hillside erosion. During dry years FOP may only experience 100-125 cm of precipitation, while the extreme opposite may experience 250 cm of rainfall. These most extreme precipitation events are predominantly caused by atmospheric rivers; long, narrow zones (400 km wide and thousands of kilometers long) that are found within the lower 2.5 km of the troposphere that contain large quantities of water vapor and strong winds. Winter temperatures will usually remain mild, but may occasionally drop below freezing. When precipitation events do occur, mid-latitude cyclones carry relatively warm, maritime polar air that counteracts freezing effects. Thus precipitation almost exclusively appears as rain, but may fall as snow in extreme cases. At the highest peaks of FOP an annual average level of snowfall may be 10 cm or more (Miller, 1971).

In addition, Sonoma Mountain is regularly covered in summer fog, allowing some organisms to harvest moisture during the hot summer months. Due to narrow boundary layers (space for weather to occur) in the region, fog is frequently squeezed inland along valley bottoms, leaving the upper slopes of the mountain fogless.

Geology

Fairfield Osborn Preserve was formed approximately 200 million to about 60 million years ago. Back then, the whole California coast was dotted in a north-south pattern with massive volcanoes which eventually went dormant. This is why FOP is largely comprised of bedrock. As the land erodes, volcanic rock left many years ago is exposed. The Franciscan Complex under FOP is largely comprised of sandstone and clay or rock called basalt, rhyolite, and volcanic ash or tuff. It is these rocks that give us the identity of the mountain. Rhyolite and Healdsburg Tuff are two prevalent rocks on the preserve. Unfortunately, they are also the weakest rocks. It is because of these rocks that the preserve experiences mass wasting. One of the areas where the mass wasting is currently happening is called the *Moving Trail*. This is right above our oak mixed woodlands field site and is one of the largest mass wasting regions on the preserve. The land FOP is located on is constantly disposing of sediment which creates an alluvial fan. The grassland site which is near the visitor center is below the moving mountain trail. The mixed woodlands site goes up the *Madrone Trail* and is on a slight slope. The last site we did was the Marsh on the bottom end of the preserve. This is where the toe of several mass wasting can be seen. Sediment is slowly making its way down the mountain to the marsh which is filling it up (FOP Naturalist Training Reader, 2010).

Soils

Sonoma Mountain contains a relatively thick accumulation of Neogene sedimentary and volcanic rocks, which is typically characterized by vast exposures of the Jurassic-Cretaceous Franciscan Complex. The entire area is located within a large ancient landslide complex extending west from the near top of the peak of Sonoma Mountain to the base where Copeland Creek crosses Lichau Road. Fairfield Osborne Preserve occupies a relatively small area within the large landslide complex north of Copeland Creek, yet a majority of the Preserve is within a smaller landslide complex that appears to have altered the course of the creek. Since deposition of the non-marine Petaluma formation ceased about 3.5 Ma, the mountain has undergone uplift and incision. This resulted in over-steepened flanks coupled with weak interbedded sedimentary units and has resulted in numerous deep seated landslide complexes in this area of the Preserve. The bedrock consists of siltstone and sandstone of the middle and upper Petaluma Formation, with interbedded volcanics (after Allen, 2009). According to the Sonoma Soil survey, three main types of soils are found on the Preserve: Goulding, Raynor and Diablo.

The Goulding series consists of well-drained clay loams. Goulding soils are young inceptisols, typically found in Mediterranean climates on mountainous uplands. Goulding soils are formed by metamorphosed basic igneous and weathered andesitic basalt of old volcanic formations. Goulding soils have a surface layer of brown and dark-brown clay loam or cobbly clay loam that grades to a subsoil of dark-brown very gravelly clay loam. The loamy Goulding soils have a lighter hue than most local inceptisols. Inceptisol soil profiles tend to have well developed soil horizons and give some indication of clay minerals, metal oxides or humus accumulation. Slopes are 5 to 75 percent. In the field you will find many stones within the soil. In a typical profile the surface layer is about 28 cm thick. The subsoil is dark-brown, slightly acidic and very gravelly. Fractured basalt occurs at a depth of about 56 cm. Depth to shattered bedrock ranges from 51 to 61 cm. These soils have low fertility. Available water capacity is approximately 9 to 11.5 cm and has a low to moderate shrink-swell potential. Runoff is medium and the erosion is moderate. Depth to the seasonal high water table is 60 cm. Permeability of the Goulding series is 0.63-2.0 and moderate in the subsoil. Average pH values range from 5.6-6.5 (after Miller, 1972).

The Raynor series consists of well-drained clays underlain, at a depth of 51 to 150 cm, by volcanic and andesitic rocks. These soils are found on rolling hills in Mediterranean climates. Raynor soils are considered vertisols due to the soil's clay content with little presence of organic matter. A higher tendency of landsliding and frequency occurs in regions with distinct wet and dry seasons. Parent material of the Raynor soils consists of sediment in seeps and ponds in basaltic hills. Slopes are 2 to 30 percent. In a typical profile, the surface layer is black and olive-gray, slightly acidic to moderately alkaline to a depth about 119 cm.

At about 119 cm, soils are pale-olive, moderately alkaline, very cobbly and stony. Basaltic cobblestones and stones are common at a depth of 142 cm. Depth to bedrock is 46 to 152 cm. Fertility is moderate in Raynor soils. Permeability is slow with a moderate to high shrink-swell potential. Runoff is slow to medium, and the hazard of erosion is slight to moderate. The available water capacity is 13 to 23 cm. Depth to the seasonal high water table is 61 cm. Average pH values range between 6.1-8.4 (after Miller, 1972).

Diablo soils are also vertisols that are found on terraces and rolling uplands. The soils in this series are subject to land slippage, especially those that have steep slopes. These soils are formed in mixed alluvium and material derived from coarse-grained soft sandstone and clay shale. Their substratum is light olive-gray calcareous clay underlain by calcareous sandstone or shale. Diablo soils are well drained. Slopes are 2 to 50 percent. In a typical profile, the surface layer is dark-gray and very dark gray, slightly acidic and moderately alkaline to a depth about 76 cm. Flecks and blotches of lime are in the A horizon at depths ranging from 18 to 46 cm. The next layer is dark-gray, moderately alkaline. From about 96 to 152 cm, soils are light olive-gray, moderately alkaline. Weathered sandstone, shale or siltstones occur at depths of 102 cm to more than 152. Depth to bedrock is 61 to 152 cm. Permeability is slow with a high shrink-swell potential. Runoff is medium and the hazard of erosion is moderate. The surface layer is prone to deep irregular cracks upon drying. Land slippage is a concern to management in some areas for this soil. Depth to the seasonal high water table is 61 cm. Fertility is moderately high. Average pH values are from 6.1-8.4 (after Miller, 1972).

Vegetation

The Fairfield Osborn preserve encompasses an area of 411 acres with a varied composition of vascular plant communities determined by many factors including soil type, microclimate conditions, water availability, and other site specific characteristics including solar exposure, aspect and slope. The preserve consists of mature oak woodlands intermingled with freshwater marsh, upland vernal pool, grassland, chaparral, Douglas-fir forest, and riparian habitat (FOP Naturalist Manual, 2010). The three main habitats where core samples were taken include a marsh area characterized by water saturated soils, mixed woodland and open canopy grasslands. The composition of these areas are presented to help better illustrate the connection of these species to our research area and to further explore and understand the history of the preserves diversity in connection with these plant communities.

The largest plant community on the preserve is the oak woodland (FOP Naturalist Manual, 2010). Oaks are the dominant tree in the upper canopy. The four main oaks (*Quercus spp*.), are coast live oak (*Quercus agrifolia*), California black oak (*Quercus kellogii)*, scrub oak (*Quercus berberidifolia)*, and Oregon Oak (*Quercus garryanna*). California Bay (*Umbellularia californica*) is also dominate in the woodlands, as well as many riparian species like big leaf maple (*Acer macrophyllum*), California buckeye (*Aesculus californica*), California hazelnut (*Corylus cornuta*), both the red willow and the arroyo willow (*Salix spp*.), white alder (*Alnus rhombifolia*), and the western cottonwood(*Populus fremonti*i), along creeks and ephemeral water systems. Several vine and shrub species are prominent alongside oaks and in the riparian area. Snowberry (*Symphoricarpos alba*), wood rose (*Rosa spp*.), honeysuckle (*Lonicera spp.)* red stem dogwood *(Cornus sericea*), pacific madrone (*Arbutus menzezsii)* and woodland manzanita *(Arctostaphylos* spp.*)* and others comprise the understory of the canopy, with many herbaceous annual and perennial species as ground cover (Trees and Shrubs of California, 2001).

The grassland community is the second largest plant community on the preserve and occurs in areas that are too dry to accommodate forest tree growth. Grasses dominate this community and at least 40 species have been identified and many others probably await discovery (FOP Naturalist Manual, 2010). The grasslands at the preserve thrive in conditions that allow full solar exposure. These herbaceous perennial and annual grasses are the lower canopy and serve as soil protection and erosion control, as well as habitat and food for many of the preserves terrestrial invertebrates and insects. Grasses are the most varied and numerous of plants in this community. The native species occurring in open grasslands tend to be perennial herbaceous bunching grass species, but with European introduction of nonnative species and heavy grazing regimens the original California grasses have been replaced or out competed (Grasses in California, 1974). Today the main species in these communities are European introductions and include Velvet grass *(Holcus lanatus)*, Harding grass *(Phalaris aquatica)* and several *Bromus*, *Lolium*, *Avena*, and *Poa* species (Vascular Plants of the Fairfield Osborne Preserve, 2010).

The marsh areas are seasonally flooded with fresh water and the soil is consistently saturated, creating conditions for certain plants with such tolerances. These include both sedges and rushes. Certain grasses such as slim head manna grass *(Glyceria leptostachya)*, tuffted hairgrass (*Deschampsia cespitosa*), and creeping wild rye *(Leymus triticoides)* only grow in these conditions (FOP Naturalist Manual, 2010). Other plants include stinging nettle, *(Urtica dioica*), giant horsetail and scouring rush, *(Equisetum spp.)* and several types of rush species *(Juncus spp.).* Sedges including *Carex gracilior*, *Carex nudata, Carex dudleyi*, along with nutsedge *(Cyperus eragrostis*), spike-rush (*Eleocharis macrostachya)*, cattail *(Typha spp.)*, and tule *(Schoenoplectus acutus)* make up the marsh plant communities composition (FOP Naturalist Manual, 2010).

Ethnographic Overview

The research area within the Fairfield Osborne Preserve is located in the prehistoric territory of the Coast Miwok and Southern Pomo (Kroeber 1925; Kelly 1978; McLendon and Oswalt 1978). These Native Californian groups based their subsistence around a hunting-and-gathering economy that took advantage of both marine (coastal) and terrestrial (inland) resources. Up to seven species of acorns provided the main vegetable staple, while a number of other nuts, berries, seeds, kelp and seaweed were also relied upon. Deer and elk were the chief big game animals, but a number of other mammals and birds, including bear, sea lion and sea otter, squirrel, rabbit, and a variety of inland and shore birds, were on the menu. Shellfish, including abalone, mussel and clam species, were also important to the diet and exchange economy, their shells providing material for both currency and decorative ornaments. The Miwok and Pomo divided themselves into smaller autonomous village-communities that made use of designated tracts of land. These smaller communities moved around within their areas, and sometimes, with permission, across the territories of other groups, in order to take advantage of the range of seasonally available subsistence and exchange resources.

During the post-contact or historic period, the Coast Miwok and southern Pomo occupied an area including modern day Marin County and southern Sonoma County, the northern limits of which were defined on the coast by Duncan's Point and inland by the town of Glen Ellen (Barrett 1908; Kroeber 1925; Kelly 1978). Native American habitation sites found throughout most of this area are marked by the presence of midden deposits, anthropogenic soils that are essentially the long-term build-up of organic debris. These soils typically include marine shell, faunal bone, and carbonized organic material – the byproducts of food preparation and consumption activities. Charcoal carbon from domestic hearths has given these soils an almost black color. Implements of stone, bone and wood are also part of the assemblages at these sites, and flakes of obsidian or chert (from the manufacture of projectile points and cutting tools) are frequently encountered. Rock outcroppings can be found throughout the region and in many cases these exposures have been culturally modified with either petroglyphs (etchings into the rock surface) or used as bedrock mortars (milling stones for the processing of fruits and seeds; Miller and Haslam 1974; Miller 1977).

In the early years of the twentieth century, the ethnographer S.A. Barrett traveled around the greater Sonoma County region recording the linguistic boundaries of native groups and the locations of both active and old village sites (Barrett 1908). His purpose was to reconstruct the cultural geography and social relationships of the various native groups that had formerly inhabited the region. Among the village sites recorded by Barrett for the Coast Miwok, *Kota'ti* is the closest to the current research area. Barrett described this site, from which the former land grant to the west of the study area and the modern town take their names, as being "just north of the town of Cotati" (1908: 311). No actual description of the site was given aside from it being listed under "Old Village Sites."

Historic Overview

A review of the historic records for the Cotati-Penngrove area indicated that the Fairfield Osborne Preserve is located immediately adjacent to the Mexican era land grant of Rancho Petaluma, east of Rancho Cotati, and near the town of Penngrove. Rancho Petaluma was a 66,600+ acre grant and one of over 700 ranchos created between 1824 and 1846, following the formation of the Mexican Republic in 1823. The Rancho Petaluma was granted by the Mexican government to Mariano Guadalupe Vallejo, a commander of the northern frontier at Sonoma, in 1834 (Durham 1998). The name Petaluma comes from a nearby

Native American village. It was one of seven North Bay landholdings belonging to Vallejo's family in present-day Sonoma County. Rancho Petaluma was the largest of these holdings, with a total of 66,622 acres. Vallejo established the Petaluma Adobe on this property, and it produced such commodities as candles, soap, blankets, shoes and saddles, but earning its main income from both hides and tallow (National Park Service 2012). By 1897, the land had been sectioned, sold, and subdivided into numerous parcels ranging in size from 88 acres to 480 acres (Reynolds and Proctor 1897; Durham 1998). The city of Petaluma was laid out in 1851 by G.W. Keller (Gudde 1998:287).

A map of the research area, as pictured in Thompson's Historical Atlas of Sonoma County from 1877, depicts the study area within the northeast and southeast quadrants of Section 26, Township 6 North, Range 7 West. The southeast quadrant of Section 26 is listed under the ownership of one E.H. Puckett with possession of 193.75 acres. Immediately north of this property, in the northeast quadrant of Section 26 and still within the study area, is listed the ownership of one J. Russel, whose property is depicted at the head of the "Petaluma Water Works" (Thompson 1877:54). A spring is depicted on this property, which is also shown as being near the source of Copeland Creek. During 1880 it is noted that Copeland Creek was owned by the Sonoma County Water Company who, "owned the rights to the water of Adobe and Copeland Creek, and certain claims of Lynch Creek" (Alley, Bowen and Co. 1880:343). One structure is noted within J. Russels property. By 1898 the Illustrated Atlas of Sonoma County depicts the southeastern quadrant of Section 26 still under the ownership E.H. Puckett, now with 160 acres, while the property to the north is now owned by one T.R Elphick, with an ownership of 160 acres.

The 1916 USGS 15' topographic map of the research area depicts that there was a standing building within the Fairfield Osborne Preserve near the present wetland study area (USGS 1916). The building in this location was included on subsequent editions (Raballino 2012). The USGS Glen Ellen 7.5' quadrangle map from 1954 (photorevised 1980) indicates two additional buildings near the research area; one depicting a building at the present location of the extant barn and the other indicating a building at present location of the extant studio.

The 411-acre property that comprises the Fairfield Osborn Preserve was purchased by Joan and William Roth, daughter and son-in-law of Fairfield Osborne, in the 1950s as a summer retreat for their family (Sonoma State University 2008). The Roth family donated some 200 acres of the property to The Nature Conservancy in 1972. Through a conservation easement The Nature Conservancy donated the 200 acres to Sonoma State University in 1997. In 2004, the Roth family donated the remaining property to Sonoma State University, again through a conservation easement with the Sonoma County Agricultural and Open Space District. The entire property is owned and managed by Sonoma State University as a non-profit organization (Sonoma State University 2008).

Cultural Resources

A 2012 cultural resource study conducted by Sonoma State graduate student Kyle Rabellino indicated that at least eight archaeological or other cultural resources are recorded within a one-half radius of the Fairfield Osborne Preserve. Of those seven, three are noted as being located within the preserve. These include the prehistoric site CA-SON-657/108 and historic sites SP-12 and CA-SON-2118H. The site designated CA-SON-657/108 is described as a prehistoric site containing obsidian point fragments, a mortar fragment, obsidian debitage and shell fragments. These artifacts indicate Native American occupation, either seasonal or permanent, who were utilizing the resources within the landscape.

Cultural resources recorded as CA-SON-2118H, as well as SP-12 (a temporary designation), both comprise of historic-era sites containing stone fences made from unmortared and unmodified vesicular and fine-grain basalt cobbles. SP-12's recorded resources include three stacked stone fences, a natural spring capped with a wooden box, as well as an historic-era artifact concentration (Rabellino 2012:6). The construction of these rock fences is most likely attributed to historic ownership of the property as a way to delimit boundaries, while the Sonoma County Water Companies title to Copeland Creek in the nineteenth century (Alley, Bowen and Co. 1880:343) might attribute to the presence of the spring box.

METHODS

Field Methods

Auguring

Auguring is a great way to collect soil samples. An auger is a tool used for collecting sediment samples in the field that are at or near the surface. The auger acts somewhat like a drill and is pushed into the soil and rotated clockwise by hand, which allows the auger to drive down into the soil until a sufficient sample size has been collected. The soil is forced into the auger head where it is kept until it gets taken out of the hole and emptied (Figure 2). This process is repeated until the desired depth is reached. Augers have three main components: handle, rod, and auger head. At FOP, we used four different augers for our four different groups (A-D) at the Visitor Center Grasslands site and the Mixed Woodland site. The type of auger that our four groups used is called a "Bucket Auger." This type of auger can be used in many different soil types (ranging from mud all the way up to fine sand) and is known as the most universal auger. Many samples were collected using these augers by our four different groups. An example of the type of soil we augured in at the grassland site is shown in Figure 3**,** here group B is releasing the soil from their auger and preparing it to be bagged. An auger is assembled by attaching a metal pole (with handles) onto the bottom part which scoops up the dirt. A person then grabs the handles and rotates the Auger in a circular motion. This allows the auger to drive deep into the soil and collect a good-sized sample.

Many of our groups ran into rocks as we augured further and further down, and thus had to move to a different area and start a different hole. The augers are fragile pieces of equipment and could be broken if they were to come in contact with any rocks.

Our four groups augured in the same sites, however some of us (Group D and others) augured on a hill. At the Visitor Center Grassland site, auguring on a hill resulted in redder sediment than other samples taken at the bottom of the hill. Also at the Visitor Center Grassland site, our four groups augured at an average distance of 19.33 m from each other, and at the Mixed Woodland site we augured at an average distance of 34.00 m from each other. Depth of auguring varied between groups and sites; for instance, at the Visitor Center Grassland site, Group D augured down to 50 cm and collected 4 different bags of sediment while at the Mixed Woodland site, Group D augured down to 30.48 cm.

Coring

In order to core for geog 317 a lake like area was needed, which was found at the wetland on the Fairfield Osborne preserve. Once we made it to the man-made lake on the property, which has turned into a marsh, we put together our two coring devices. Because the area in which we were testing was run over with plants we were able to walk out over the preexisting lake and take several cores.

There were two different types of corers which were used to take the sediment cores, the Livingstone Corer and the Russian Peat Corer. The Russian Peat Corer is a 50 cm hollow metal barrel with one wall of the tube sharpened. The corer is pushed into the sediment and then the top handle is turned, pivoting the sharpened side of the barrel into the sediment locking the core against the metal cover plate. Figure 4 shows how the corer locks the mud on the pivoting metal flap. The Livingstone Corer is rather different from the Russian Peat corer as it does not have a sharpened side; rather it is a complete barrel that is pushed straight into the sediment. To make sure that the sediments stay in place there is a piston that moves through the barrel during coring and which helps move the sediment out of the barrel after coring.

Each core taken with the Russian Peat corer started on the surface and went as far as it could down into the 50 cm barrel, we could not get the corer in the same coring spot as the hole would close up each time we pulled it out. The Russian Peat Corer proved to be an effective method to quickly get cores as you push the corer as hard as you can into the sediments and then turn the handle on the coring device which locks the sediments in to place. The Livingstone corer provided for a more accurate block of sediment as it was pushed into the ground acquiring sediments into a 1 meter core retrieval tube unlike that Russian Peat Corer. This is because the core is taken into its own tube within the corer and is transferred to a butyrate tube to preserve it. Three of the 4 cores were taken with the Russian Peat Corer, which gave us an average of 30-50 cm recovery.

To ensure that there was no cross contamination of sediments the corers were wiped clean each time a new core was taken and the cores were put in protective plastic tubes. Each plastic tube was labeled with the top and the bottom of each sediment core, the date as well as where it was taken.

Lab Methods

Munsell Color System

Albert H. Munsell, a former professor at the Massachusetts Normal Art School, created the Munsell Color System early in the 20th Century. The majority of the development of the system was conducted by Munsell between 1900 and 1904. Nearly thirty years after its original development and following the publication of the “1929 Munsell Book of Color” the system was chosen by the United States Department of Agriculture as the official color system for soil research and color classification (Berns, 2007). It remains the official color system today. Munsell created the color system in an effort to “separate hue, value, and chroma into perceptually uniform and independent dimensions” (Kuehni, 2002).

The class used standard Munsell Soil Color Classification books to analyze all sample soil color, including soil and sediment samples. Munsell books are produced for quick color classification, where the researcher can place part of their sample on a white page behind the color palette and match their sample to the according color. Colors were fully described by the students listing the three numbers for hue, value, and chroma (Figure 5). An example of this recording of color would be 5Y 5/10, where 5Y shows the hue or lightness, 5/ meaning the color in the middle of the hue band, and a chroma of 10 (Landa and Fairchild 2005).

Texture By Feel

Texture by feel is a classic soil texture classification system. Texture by feel analysis has been used successfully to classify soils for decades. In 1979, a flow chart was produced and published in the Journal of Agronomic Education by Dr. SL. Thien that has become the standard for texture by feel analysis (Thien, 1979). Texture classification through texture by feel is usually one of the first analyses conducted when a soil is looked at.

All of the collected soil samples were first analyzed using this texture by feel flowchart (Figure 6). Student researchers started by placing approximately 25g of soil sample in their palm and then added a small amount of water and rolled into a small ball (Figure 7). Various texture by feel tests were conducted following the flowchart, including squeezing the rolled ball, forming a soil ribbon, and squeezing the sample between the forefingers to determine grit. If the soil does not remain in a ball when squeezed, it is likely to have high sand content. If it stays in a ball but does not produce a ribbon, it is more loamy sand. Whether the soil feels gritty, smooth, or neither and performing the accompanying steps determines whether the soil is part clay, sand, loam, or a combination of these types. These analyses can be performed quickly in either the lab or the field. For our analyses, we brought our samples into the laboratory to conduct texture by feel.

Loss On Ignition Analysis

Loss on ignition (LOI) is a process used to establish the water, organic, and calcium carbonate content of a soil/sediment sample taken from a core. The process consists of the repeated heating of a sample from a core at specified temperatures and durations to evaporate volatile substances till the sample's mass ceases to decrease. LOI can be used for a variety of analyses that involve the measure of previously mentioned substances. For example, in a study on historical hurricane in northwestern Florida, the loss on ignition process was used to identify hurricane deposits in sediment cores (Liu and Fearn, 2000). Sand layers were identified by changes in water and organic content of core samples from a lake near the ocean.

In our analysis, the loss on ignition process was begun by weighing a crucible before and after adding 10ml of soil or 2 ml of sediment to determine the wet soil/sediment weight. The sample was then placed in an oven for 24 hours at 105° C to remove any moisture. Once the water had been removed from the soil, the sample was placed in a desiccator to cool down. In addition to cooling the samples, the desiccator was also an important tool because of its ability to prevent any moisture from penetrating the dried out samples. The sample was then placed back into the oven for 2 hours at 550° C to burn off any organic matter then the sample was cooled and weighed again. After cooling and weighing, the sample was placed into the oven again for two hours at 950° C, to burn any calcium carbonate, then cooled and weighed (Figure 8; Heiri et al., 2001 and Geog 317 LOI Procedure).

With the data collected from weighing the samples after each heating, we were then able to calculate percentages of water, organic, inorganic, and calcium carbonate content. Percentage of each matter type is determined by finding the difference in weight of the sample alone before and after burning off the substance of interest then dividing that weight by the original wet weight of the sample for percent water or dry weight for the other analyses. A constant value of 1.36 (the difference between the molecular weights of CO_2 and CO_3) was used to derive the carbonate content (Heiri et al., 2001). Also, in our analysis we calculated the density of our samples. To calculate density we simply divided the mass of the sample by its volume.

Grain Size Analysis

Grain size analysis is a process that determines the different particle sizes from another in soils and sediments. Sizes pertaining to this specific experiment can range from sizes large to small (gravel, sand, silt, and clay). This laboratory method requires time and pretreatment.

To begin, the soil sample was cut into quarters as carefully as possible (no riffle cutter was available at the time) and two subsamples were taken. One sample was dried in the oven at 105^{o} C, this was used to obtain moisture content of the sample so that the primary sample weights used for grain size analysis can be adjusted for moisture content during the final calculations. The second sample was sieved with the 2 mm sieve to sift out any grains larger than 2 mm. The gravel that was separated was cleaned with distilled water (DI water) to remove any remaining soil. The clean gravel was placed into the oven at 105^{o} C. The wet and dry fines were combined creating a slurry to this we added 50 ml of DI water and 10 ml of 30-35% Hydrogen Peroxide (H_2O_2). A foaming reaction occurred and the beaker was placed on a hot plate so that the reaction would be sped up. The H_2O_2 was added to the slurry to remove any organic material. We continued adding H_2O_2 if organic material was present and until all organic material was digested (Geog 317 Pretreatment for particle size analysis handout).

The next step to the grain size analysis was adding 20 ml dispersant, which separates the clays and letting it sit overnight. Once dispersion was complete we sieved the slurry through a 63 micron fabric mesh (which will separate out sand size grains) into in a 1000 ml cylinder. The grains larger than 63 micron were placed in a 50 ml beaker and dried in the oven overnight (cooled and weighed). Once this had been done we checked the ambient room temperature to determine settling times (the larger particles fall faster, this has been established by stokes law). We noted the 20 cm depth on the cylinder and agitated the sample for 30 seconds. We recorded the start time and drew off 20 ml of the sample from the 20 cm line using a pipette then placed it into a 50 ml beaker and add 20 ml of DI water and placed it in the oven (Figure 9). This established the dry weight of the silt and clay. Waiting the established time, we drew off 20 ml of the sample 5 cm down from the water line. We repeated the process of placing the aliquot into a 50 ml beaker and adding 20 ml of DI water and placing in the oven to dry. This determines the dry weight of the clay. We poured the remaining slurry into the original 1000 ml beaker used to digest the organics and placed it in the oven to dry. The point of the pipette analysis is to establish the weight of the samples clay and silt content in our pipette draws and then establish the total amount of these constituents in the original sample through mathematical calculation. (Folk, 1984; Geog 317 Grain Size Pretreatment Part II Handout).

pH

The pH of the soil can tell us many things about the environment from which that soil came. These can include weathering, vegetation and organism activity, salt content, CO_2 content, and pollution in the atmosphere. The pH can be used to indicate base saturation as a factor of availability of plant nutrition (Burt 2004). The pH test was conducted in the lab. There are a few prepping steps to take before recording the pH. After recording the weight, and ID number of a 100 ml beaker we weighed out 15 g of soil (air dried for the mixed woodland and grassland and wet sediment for the marshland) and add 15 ml of distilled water. Regular water would add minerals and change the pH and so it is important to use distilled water. We agitated the sample by repeatedly stirring it throughout the class period and then let it sit for at least a day. To record the pH of the sample we stuck a digital probe in the solution just above the settled soil. We waited for the probe to stabilize and recorded the pH. The two probes we used were the Lab Safety Supply Probe and Hanna Digital Probe.

Magnetics

The magnetic susceptibility will vary from place to place, this happens by the same processes of natural soil redistribution. Soils that have been affected by pollution will have other minerals added to them that may change the magnetic susceptibility (Quijanp et al. 2011). To find the magnetic susceptibility of our soil samples we tightly packed soil/sediment so that there were no air pockets into a 10 cc vial. We then took three readings using the SI option of the Bartington MS2 meter and then calculated the average of the three values.

Macrofossil analysis (seeds and charcoal)

An important part of our soil sample analysis has to do with the quantification of macrofossils. The two macrofossils we focused on are seeds and charcoal. This information is important to better understand the ecological interactions that take place at FOP. Clues to the Preserves complex ecological interactions lay hidden in the soil. Therefore we are undertaking a soil analysis to tap into the environmental history of the preserve. The soil is deposited in one way or another, and when it settles it rests as a historical reference. As new layers of soil pile up on top of old, functions of the environment are captured. These functions are dynamic by nature, constantly in motion, changing, evolving, adapting, transforming into what we title as ecological interactions. Understanding the contents and context of the soil itself is essential in understanding the complex ecological functions and interactions that take place at FOP.

One major portion of our soil analysis is charcoal. The importance of charcoal when doing our soil analysis is to understand how fire plays a role in the ecological system of FOP. The presence of charcoal itself is the evidence for past fires taking place on these lands at some time in history (Whitlock and Larsen, 2001; Hart et al., 2008). Realizing that fire may have played an important role in shaping the landscape of the preserve, it is important to understand the charcoal content of the soil. It is well known that fire is part of a natural ecological process that shapes the landscape. However many aspects of the fire cycle are still under investigation, in order to answer such questions as: How often does natural fire occur without human interaction? How much has human manipulation of fire played a role in shaping the landscape? For there to be charcoal in soil sediments, there had to have been a fire at some point. Therefore a charcoal presence is a proxy for fire history (Whitlock and Larsen, 2001; Hart et al., 2008). If we do find charcoal it might hold some significance, and while we might not find all the answers to the fire history of FOP buried in the soil, we hope to begin an understanding through this soil analysis.

The soil also holds another macrofossil clue as it stores seeds, almost as if the soil is a seed bank. Seeds are dispersed and most often end up being deposited in the soil, resting as a historical reference to the ecological interactions that take place. By classifying and quantifying our seed collection data we can hopefully make some connections to the past, possibly even seeing changes throughout time on the landscape recognizable in the seed content of the soil. Through cross-referencing seed distribution with charcoal data it may be possible to make some ecological connections (Whitlock and Larsen, 2001; Hart et al., 2008). The analysis of macrofossils in the soil is just one piece of the puzzle when understanding the natural processes that take place at FOP and elsewhere, but an important piece nonetheless.

In order to prepare the soil for a macrofossil analysis a procedure had to be initiated in accordance with a protocol adapted from Whitlock and Larsen (2001). Using a 1000 ml cylinder we put in 200 ml of water and approximately 50 ml of sediment in order to find the volume of the soil using the water displacement method. Then we proceeded to pour the fluid and sediment into a 500 ml beaker after we noted the volume. From this point we then added 50 ml of a sodium hexametaphosphate solution comprised from an initial solution made up of 5 g of sodium hexametaphosphate and 495 ml of tap water. Sodium hexametaphosphate works as a dispersant helping to facilitate separation between materials in our sample. Then we proceeded to put the 500 ml beaker and its contents on a hot plate until the dispersant had sufficient time to break up the material, stirring gently with a plastic stick. After at least a day of the soil sample basking in the dispersant it was time to sieve the samples through a 2 mm sieve for the soil samples and a 250 micron sieve for the sediment samples. After material larger than the sieve was caught, it was thoroughly cleaned, and was ready to be placed on a petri dish with some water. Then using tweezers and 10x binocular microscopes we sifted through to locate the macrofossils and charcoal. Putting them in a vial to then be dried and weighed. The next step in the process was to sketch out the seeds themselves as well as record the amount of seeds in each sample. We also tried to identify the seeds when possible. Charcoal was also quantified in this process. Identifying the charcoal from ordinary organic material proved to be a challenge. However charcoal often has a distinct shimmer as well as breaks apart, or fragments in a distinct way. The absence of charcoal was also noted and considered when analyzing the macrofossils in the soil. We were not able to identify many of the seed types and they remain as unknowns. However, we hope future groups will be able to further our studies.

^{210}Pb and ^{137}Cs

^{210}Pb and ^{137}Cs dating are both used to date relatively young sediments, while radiocarbon is used for much older materials. Our understanding was that the wetland was possibly of historic construction, so we chose to use lead and cesium dating as opposed to radiocarbon dating (Bowman 1990).

^{210}Pb dating is based on the uranium decay series, which entails naturally occurring uranium moving up into the atmosphere and decaying into ^{210}Pb, which is then re-deposited on the earth's surface. There are multiple models of pathways by which ^{210}Pb may be deposited, but ultimately, the dating is based on the idea that ^{210}Pb decays at a fixed rate, and thus we may date the soil by matching the stage of decay (radioactivity) of the ^{210}Pb found in the soil to the known decay curve (Allen et. al. 1993). ^{210}Pb is ultimately good for discerning dates of about 125-150 years ago, but no older, as it becomes inert (and thus undateable) by that age (U.S. Geological Survey 2003).

^{137}Cs dating is equally useful for modern soils, but is based on a non-naturally occurring isotope. ^{137}Cs is a fission product from nuclear explosions – which begins to appear in the soil in the early 1950's, shortly after nuclear detonations first occurred (Nahm et. al. 2010). ^{137}Cs soil profiles mirror historically known nuclear events (Hiroshima, nuclear testing programs, the nuclear test ban, Chernobyl, etc). This means that analysis of ^{137}Cs levels at various depths can be matched to this historically known pattern of nuclear events. This allows us to approximate when certain sediments were deposited and from that pattern of information, we may infer rates of sediment deposition.

We submitted twenty-one sediment samples from the wetland site to the soils lab at Rensselaer Polytechnic Institute for ^{210}Pb and ^{137}Cs testing. The core that produced these samples was collected from the wetland site at FOP using a Russian peat corer. We hoped that the results from these dating analyses would give us a better understanding of how old the sedimentary deposits are at each depth.

We prepared our samples for ^{210}Pb and ^{137}Cs analysis in the following way. We divided C1P1 and C1P2 (pushes 1 and 2 from core 1) into twenty-one 2 cm segments. We sampled more heavily from the upper part of the core (17 samples) than from the lower part (4 samples). We dried each segment sample overnight in the oven at 60° C and then ground the sample into a fine consistency before shipping them to Rensselaer Polytechnic Institute in New York. The lab, under the direction of Dr. Richard Bopp, processed the samples using a well-type intrinsic germanium crystal Ortec GWL-120 gamma counter.

RESULTS

Grassland

Group A

Group A sample site was located at 38° 20' 38.834" N, 122° 35' 38.630" W (Figure 10). There was no slope. The sample was taken from the bottom of a westward facing slope next to a seasonal creek and under a treeline. The vegetation in the area includes a mixture of native and non-native grasses, oaks, bay and laurel trees. There was no recent rainfall.

Sample 1 (0-10 cm) was munselled dry as 10YR, 3/3 Dark Brown. Sample 2 (10-18 cm) was munselled dry as 7.5YR 2.5/2 very dark brown, and wet munselled as 10YR, 2/1, black. Sample 3 (18-25 cm) was dry munselled as 10yr, 3/1 dark brown, and wet munselled as 10yr, 3/1, very dark gray. Texture by feel analysis of all levels was described as gravelly clay loam. The upper two levels yielded pH values of approximately 7. All three levels gave magnetic susceptibility readings in the mid to high 200s, with the numbers going down as depth increased. No charcoal was found in the top two levels, and only the first level (Sample 1, 0-10) had macrofossils (n = 14, all of one kind). The third and lowest level was not tested for charcoal and macrofossils. Water content increased in each level as depth increased. Please refer to Figures 11 and 12.

Group B

The grasslands site group B is located within Fairfield Osborne preserve, at approximately sixty-seven meters northeast of the present visitor center and a current hiking trail bisects the project area (Figure 10). Group B within the grasslands site is situated on a relatively level surface on an approximate one to five-percent slope with an aspect of two-hundred and eight degrees south by southwest. The soil appears deposited from mainly alluvial events, although as the area has active landslides colluvium deposits are also likely. The exposure of the site is approximately 70-80% with vegetation consisting of local native and non-native, annual and perennial, grasses and forbs including milk thistle and wild oats. The remnants of a fallen tree are located less than 5 m north of Site B and appears to be a species of oak. The latitude and longitude coordinates taken with a handheld GPS of site B are 122°35’39.277”West by 38°20’38.225”North. Group B is situated four meters east of an unnamed ephemeral creek. The creek measures approximately 1.2 meters wide by 0.60 meters in depth. Exposure from the cut-bank revealed a vertical profile that contained gravels ranging from granules, pebbles, and cobbles with few boulders at the base of the creek-bed. Most of the gravels appear surrounded and bedrock was not exposed. Three other auger groups are located within the project area and include group A located nineteen meters and 40 degrees from group B, group D at 115 degrees and 16.5 meters from group B, and group C at 185 degrees and 36 meters from group B **(**Figure 10).

Using a bucket auger group B retrieved three soil samples with a total basal depth of thirty-five centimeters below surface and an auger-hole twelve centimeters in diameter. Soil sample #1, collected at 0-20 cm, is noted as having a Munsell color that is a very dark greyish brown (10YR3/2). A texture by feel analysis indicated it is a gravelly clay loam that contains few to common, fine to very fine roots. Gravels range from granules to pebbles, subrounded to subangular and contain sedimentary (chert from the Franciscan Formation) as well as igneous rocks (basalt from the Sonoma Volcanics), and are poorly sorted. The soil is relatively dry (Figure 13).

Soil sample #2, (20-25 cm), was Munselled as a dark brown (10YR3/3) and had a texture by feel analyses indicate it was a gravelly silt loam and contained few very fine roots.

An increase in basaltic gravel material is noted. The gravels appear mostly subrounded and poorly sorted. Soil appears more moist than previous level (Figure 13). Sample #3, (25-35 cm), was Munselled as a dark brown (10YR3/3). A texture by feel analysis indicated the soil is a gravelly silt/clay loam containing few very fine roots. Gravels appear mostly subrounded and poorly sorted. The soil moisture appeared the same as the previous level (Figure 13).

Within the three samples taken from group B's auger testing, the average Munsell value ranged from 10yr 3/2 and 10yr 3/3, a dark brown to very dark greyish brown clay loam. LOI testing performed in the lab indicated that within the three samples the percentage of water was increasing with depth from approximately five percent water in the first sample (0-20cm), to six percent in the second sample (20-25 cm) and finally seven percent water in at the final sample (25-35cm). The percentage of water also correlates with the percentage of organics within the samples that appeared to decrease in depth below surface. This ranged from approximately seven and one-half percent at sample B1, 0-20 cm, to five and one-half percent at sample B3, 25-35cm. Calcium carbonate percentages stayed relatively constant in all samples at 1 and one-half percent while density fluctuated with one to two percent as depth from surface increased. Testing on pH levels indicated a range between 6.5 on average and magnetic susceptibility averaged on a range from 181 to 222.667 SI, with higher measurements obtained from sample B3 (20-35cm). Macrofossil analysis included a weight of seeds that increased with depth from .0237 grams in sample B1, .0568 grams in sample B2, and finally .109 grams in sample B3. No charcoal was collected or observed within the soil samples.

Group C

The site is adjacent to the parking lot and visitor center, the latitude 38^{o} 20‘ 37.02“ north, longitude 122 35’ 39.43” west (Figure 10). The site was in the shade of Oak (*Quercus spp.*), but we were not under the canopy. The grassland contains many non-native species including dog tail (*Cynosurus echinatus)* and harding grass (*Phalaris aquatica*), wild oat (*Avena fatua*), with forbes and other herbaceous grasses. We took a total of 3 samples. The topsoil is about 30 to 40 % pebbles. The distance from other group sites are as follows, from our site to site A= 51 m, from our site to site B=36.70 m, from our site to site D=21.60 m. We took a total of four pushes in the core hole. Sample 1, topsoil with 35-40% pebbles, granular soil structure with clay and some roots and grasses. The total depth is 12 cm. Sample 2 had fewer pebbles and grass, about 10%, total depth is 21 cm. Sample 3 has sparse pebbles, < 10%, loose soil structure, crumbly some roots and little vegetation, the total depth is 28 cm (Figure 14).

The Munsell color for sample 1, 0-12 cm, (10YR4/4) brown. The Munsell color for sample 2, 12-21 cm (7.5YR3/4) dark brown. Texture by feel indicates gravelly clay loam for sample 1, 0-12 cm, and gravelly sandy loam for sample 2, 12-21 cm. The percent gravel in the soil samples at depth 0-12 cm was 0.0%, at the 12-21 cm depth it is about 3.0%. The VCG sample averages show the % water at 5.5% in the upper depths 0-10 cm, the lower depths 10-21 cm 4.6%. The average organics are 8.0% at the upper depths 0-10 cm, and the lower depths average 2.0% 10-21 cm. The carbonate material at 0-10 cm averages 2.0% and at the upper depths 4.5%. The density is 1.2% at the 0-10 cm depths and 1.5% at the lower depths. The pH is 6.3 at the 0-10 cm depth and 6.6 at the lower depths. The magnetics are at 792 SI at the 0-10 cm depth and 680 SI at the 10-21 cm depth. In the 0-12 cm sample 27 seeds were located, in the 12-21 cm sample 13 seeds were located. No charcoal was recovered from the cores (Figures 14, 15 and 16).

Group D

We visited our first site, the Visitor Center Grassland site, at FOP on a nice sunny day (8/30/12). The site where we were to collect our soil samples was located halfway up a hill. The vegetation around us was moss, different types of grass, a few bushes and various tree species. Our slope was 22°33" SE and our coordinates for our site were: Lat: 38°20'38.05" N and Long: 122°35'85" W (Figure 10).

Our first sample was taken from 0 cm to 15 cm deep, and we found some small rocks in our sample. Further down in this sample we found a coarse root and some bigger rocks. The color of this sediment was brown on the top and as we got deeper it became redder and redder. The munsell for this sample is 5R 3/2. Our next sample was taken from 15 cm to 25 cm deep, and the sediment began to become even redder than the previous sample. The sediment was mostly clay and some clay peds, and we started hitting some rhyolitic tuff. The Munsell for this sample is: 10R 3/4. Our next sample was taken from 25 cm to 40 cm, and the sediment remained a similar color red to the previous sample. The munsell for this sample is: 10R 3/4. Finally, our fourth and final sample was taken from 40 cm to 50 cm, and the sediment color actually started to take on an orange-like hue. The Munsell for this sample is: 10R 3/4 on page. There was some moisture in the soil, but not a ton. Also, the texture of the soil was dry, grainy peds, clay, and clay formed into peds.

In the following weeks, we took these samples back to the lab and studied them in many different ways. We started off with grain size pretreatment and quickly moved onto LOI and magnetic susceptibility (Figure 17). Our magnetic susceptibility was in the low 700's, which indicates that there high iron concentrations in our soil. We then did soil preparation for charcoal analysis in order to see if there was any proof of a fire that may have occurred in the area. The charcoal would have showed up in our sample after doing this, however we did not find any traces of it. Next, we took the pH of our samples. The pH of our samples were in the upper 6's and lower 7's. This shows us that our first sample is slightly acidic and our second sample is slightly basic. Then we did our macrofossil analysis on these samples. Unfortunately, we were not able to find any macrofossils in our samples. Finally, we put our sample into a 1000 ml beaker and added peroxide to it to digest off any organic material. This same sample was later used to do a pipette analysis where we separated the fines from the rest of the soil.

Our percents for sand, silt, and clay stayed very similar to each other throughout. The percent sand ranged from 35.06% to 40.73%, the percent silt ranged from 16.55% and 24.55%, and our percent clay ranged from 44.11% to 44.84%. The textures of the soils in these samples were sandy clay loam and clay loam. Finally, our percents for LOI: water, organics, inorganics, and carbonate were fairly different from one another. The percent water ranged from 1.38% to 10.77%, the percent organics ranged from 2.07% to 3.51%, the percent inorganics ranged from 96.49% to 97.93%, and the percent carbonate ranged from 0.33% to 0.62%.

Mixed Woodland

Group A

Group A site was located at 38°20’ 42.144” N, 122°35’ 31.690” W (Figure 18). The surface where we cored had a 15%, southwest facing slope. Vegetation includes bay trees, oak, and maple trees, and a mixture of native and non-native grasses and poison oak. There is a dry creek bed nearby. The sample was taken at the base of a large hill near a fallen tree. There are grasses present at the surface of the sample location. There was no recent rainfall.

Sample 1 (0-10 cm) was dry munselled as 7.5YR, 4/3 Brown and wet munselled as 10YR 3/2, very dark greyish brown, with a texture of loam. Sample 2 (10-13 cm) was dry munselled as 7.5YR, 4/3, brown and wet munselled as 7.5YR 2.5/2, very dark brown, with a texture of loam. Sample 3 (13-20 cm) was dry munselled as 7.5YR, 4/3, brown and wet munselled as 10YR 10/2, very dark greyish brown, with a texture of loamy sand. The upper two levels yielded pH values of approximately 7. Sample 1 and 3’s average magnetic values were in the low 300s while Sample 2 had an average value of approximately 400. No charcoal was found in any of the levels and just a few macrofossils were found in the upper two levels (the third and lowest level was not tested for charcoal and macrofossils). Organic content decreased slightly with depth (Figures 19 and 20).

Group B

The GPS coordinates for the mixed woodlands site are 122˚35’31.781”W 38˚20’42.229”N and the slope and aspect is 5% and 236˚ south south west. The site consisted mostly of bay trees but also contained oak trees and grasses. There was a creek with large boulders in it nearby and although it was a sunny day, there was still a lot of shade. The Munsell for the first sample (0-25cm) was 2.5Y 4/2 dark greyish brown and the soil texture was gravely sandy clay loam with 4-6 inch cobbles and roots. The pH was 6.98 and the magnetic susceptibility reading was 7.04. The Munsell for the second sample (25-38 cm) was 2.5Y 4/2 dark greyish brown and the soil texture was sandy loamy and contained slightly smaller cobbles than the first sample. The pH of the second sample was 6.97 and the magnetic susceptibility reading was 422.3 SI (Figure 21).

Group C

This site was in the creek area of FOP with shaded tree cover in the riparian area at the bottom of a hill. The tree composition consisted of Oaks, (*Quercus spp*.), big leaf maple, (*Acer macrophyllum)*, California Bay, (*Umbellularia californica)*. The understory consists of shrubs mainly poison oak with other unknown shrubs and exotic non-native grasses. Group C sample site was at approximately 11.20 m from group B, 38.85 m from group D, and 18.80 m from group A. The GPS coordinates are 122^{o} 35’32.18” West, 38^{o} 20’42.4” North. Slope 16% and aspect 195^{o} south. There was an abundance of organic matter consisting of mainly leaf litter and small branches from tree cover. The site had a dry creek bed with many unconsolidated cobbles of various sizes over laying and interspersed with gravel over the soil. We had to try several locations around our actual auger hole to avoid large rocks that prevented the auger from penetrating the soil layer. We found a location adjacent to a big leaf maple, approximately 3.40 m to the north, and an oak approximately 4.60 m to the south west. We began with the auger, but had to stop at about the 5 cm mark, as the auger hit a cobble and would go no further without damage. We continued by digging with a trowel and shovel until we reached more stones, we finally reached the 30 cm depth and had to stop. There were many stones in the auger hole and the process was slow and difficult (Figure 14).

The Munsell color for sample 1, 0-15 cm (2.5Y3/2) very dark greyish brown. The second sample 15-30 cm, (2.5Y3/2) very dark greyish brown. Texture by feel indicates a sandy clay loam for sample 1, 0-15 cm depth, and silty clay loam for sample 2, 15-30 cm depth. The percent gravel in sample 1, 0-15 cm is at about 40%, sample 2, 15-30 cm depth is at about 28%. The mixed woodland samples of 0-15 cm and 15-30 cm group C average for % water was at about 6.2% in the upper depths of 0-15 cm and about 6.8% in the lower depths 15-30 cm. The percent organic material in the upper depths was low 15.9% and much higher in the lower depths at 16.2%. The carbonate material in the upper depths are 4.4% and the lower depths 2.0% at 25-30 cm. The bulk density is about 2.9% in the upper depths and 2.8% in the lower depths. In the upper depths the magnetic susceptibility is 185 SI and in the lower depths the magnetics 190 SI. The sample 0-15 cm depth macrofossil analysis included 15 seeds, 15-30 cm depth included 6 seeds, no charcoal was present in the samples (Figure 22 and 23).

Group D

The mix woodland site was positioned at the FOP on a slope in the wooded area of the preserve. The types of vegetation that were close to the area or part of it were oaks, bays and a couple different types of grasses.

The first sample which we augured up went from 0-10 cm and it consisted of loose clay like soils with a tannish brownish color. The next sample in which we took went from 10-20 cm inches and consisted of a lot of small rocks and more damp soils. We also encountered a lot of roots on the second attempt to auger. The last drive was the hardest of all of them and it went from 20-30 cm. The soil colors all stayed the same as we went deeper and deeper, however the further we went down the more rocks we encountered. All of the soils texture had the same consistency which was clay.

In lab we were able to test the magnetic susceptibility for two of the drives. We tested the 0-10 cm drive and got an average reading of 543 SI. We then tested the 10-20 cm drive down and got an average reading of 808 SI suggesting that the further down we went the more metal content there was in the soils. The pH of the soils were different as well the first drive (0-10 cm) gave us a reading of 7.36 pH and the second drive (10-20 cm) 7.9 pH, which shows that the youngest level of soils has a more acidic reading than deeper. We did not obtain grain size results for the first auger drive. However, we did acquire data for the second drive. The sand percentage for the 10-20 cm drive was 22.7 % while the silt was 55.4 % and the clay percentage was 21.8 % (Figure 24 and 25).

Marshland Site

Coring Site Overview

The site we chose to core for the marsh sample was at the lower man-made pond of the FOP property. There was a small creek that drained outward from the pond and maintained a small amount of water. The pond seasonally dries out in the summer months and fills in with rain from the surrounding hilltops in the winter and fall months. The dominant vegetation includes many wetland plants like cattails (*Typha* spp.), Willows (*Salix* spp.), reeds, rushes (*Juncus* spp.), and sedges (*Carex* spp., *Scirpus* spp.) and others. We took four core samples (Figure 26). The GPS coordinates for the four coring site locations are; Core 1: Latitude 38° 20' 25.84" north, Longitude 122° 35' 49.33" west, Core 2: Latitude 38° 20' 25.89" north, Longitude 122° 35' 49.17" west, Core 3: same as Core 2, Core 4: Latitude 38° 20' 26.05" north Longitude 122° 35' 49.31" west. Core 1 was to a depth of 50 cm. It was difficult to get the corer down past the thick roots and layer of vegetation. The radius for all samples taken were within 10 m distance from one another.

^{210}Pb and ^{137}Cs Dating

Testing for ^{210}Pb dating results were complicated as the lead was too diffuse within the sediment to produce a well-developed curve. This is likely because of very high rates of sedimentation (Figure 27). Testing for ^{137}Cs, however, proved more successful, and the lab at Rensselaer was able to identify a spike for the 1963 mark of peak nuclear activity, and thus calibrate depths for age. This resulted in their estimating a sedimentation rate of 0.3 cm per year for this site from 1950 to present. Rates prior to this are estimated at 0.5 cm per year assuming the reservoir that infilled to form the wetland was created ~1850 (Figure 28).

There are two points of caution when considering these analyses. First, the Cesium interpretation assumed our cores reached the bottom of the sediments, and that this "bottom" dated to 1850 when the wetland was thought to have been built. This may or may not be entirely correct, so recalibration may be necessary in the future.

Second, the extremely diffuse ^{210}Pb suggests that the wetland maybe experiencing mass sedimentary influxes, perhaps from the mass wasting events the area is known for. Both of these factors complicate dating with ^{210}Pb and ^{137}Cs at this site.

Group A

Group A core came from Core site 3, Push 1, which is just offset from Core site 2, at 38° 20' 25.89" North, 122° 35' 49.17" W. The first 6 cm (measured from the original 40) were "missing," as the core had compacted down by the time we got it back to the lab. At 6-12 cm, we noted lots of fine to medium roots and a very wet texture, with a wet Munsell of 10YR 2/2 very dark brown. At 12-16 cm we noted a large chunk of root 2 cm wide which comprised the majority of material in this sample. We noted a wet Munsell of 2.5Y 2.5/1 for this level. At 16-26 cm we noted that the sample was smoother and denser with less moisture than in the previous levels, but it contained an equal abundance of fine roots. We noted a wet Munsell of 2.5Y 3/2 very dark grayish brown for this level. Levels 26-36 and 36-40 cm had identical features in terms of texture and Munsell. Textures for all of these tended to be silty clay (Figure 29).

PH for all of these levels ranged around 6-7, seeming to drop very slightly with depth. Magnetic values rose with depth, from the mid-teens and 20s up to the high 50s. Calcium carbonate content in each sample seemed to rise a bit with depth (Figure 29). Each level contained macrofossils and two of the levels contained charcoal. The most charcoal was found between 38 and 40 cm, which corresponds roughly to 1910 AD. The greatest number and diversity of macrofossils were found between 24-26 cm, which corresponds to about 1940 AD (Figure 30).

Group B

The core is characterized by relatively low organic levels (~5%) with a slight increase in the top 10 cm (~15%). A similar pattern is seen the water content with higher amounts in the top 10 cm (~60%) decreasing to ~40% in the rest of core. Density increased downcore. Relatively high magnetic susceptibility was recorded in the middle section of the core (~50 SI) and then the lower portion of the core magnetics dropped markedly (30 SI). Figure 31 shows the results for group B.

Group C

The Munsell color for C4P1 is gley (2.5/10Y) greenish black. The averages for all samples of C4P1 marsh sample for water content at 0-7 cm were 60%, 7-14 cm 60%, 14-28 cm 50%, the water content drops at a depth of about 25 cm to 35%.The samples have an average organic content from 0-7 cm depth of 7%, at depths 7-14 cm 6.0%, 14- 28 cm 8.0%, 28-45 cm 4.0%. The carbonate material is 4.0% at depths to about 25 cm and decreased at 45 cm depth to 2.0%. The average density for samples is 0.2%-0.4% until about 25 cm depth and then increase to 1.4%. The average pH at 0-5 cm is 6.4 the highest reading, with the second depth of 5 to 10 cm having the lowest t 5.6. The magnetic susceptibility was similar in all depths, but the 10-15 cm was the highest at 40 SI. There were extensive seeds in the 0-18 cm layers of the core sample. Charcoal was also found throughout several layers but not quantified by weight (Figure 32).

Group D

For our particular core sample we split the Livingstone core in half with group B (C2P1). It was split down the middle. We did testing for Macrofossils, Magnetics, pH, and LOI. For the Macrofossils we found that there was not too much charcoal and some unidentified seeds. The magnetics varied by depth of the sample ranging from low in the topmost layers getting higher towards the middle than lowering at the bottom. The pH was for the most part basic with an average of 7.6. The LOI showed interesting results; there was a spike in the Organics for 0-2 cm then leveled out to a much lower percentage for the rest of the core (Figure 33).

CROSS GROUP ANALYSIS AND SYNTHESIS

Grassland

The grasslands project area had good conditions and is situated approximately 38 meters north-east from the Fairfield Osborne Preserve visitor center and 26 meters east from the main parking lot. There were eleven soil samples taken with a bucket auger at the Grassland site within the Fairfield Osborne Preserve from four different groups (groups A, B, C, and D) located in various regions throughout the area. Group A: 38° 20’ 38.834 N by 122° 35’ 38.630 West, Group B: 122° 35’ 39.277” West by 38° 20’38.225 north, Group C: 122° 35’ 39.43 West by 38° 20’ 37.02 north, Group D: 122° 35’ 38.865 west by 38° 20’ 30.053 north (Figure 10). Groups A and B were situated in a lowland section within the site on a gentle slope, and relatively close to an unnamed ephemeral creek that appears to be a tributary for Copeland Creek. While both within the lowland region, Group A were located under the canopy of oak trees while Group B was situated within an area of no trees and a high percentage of exposure. Both Groups D and C are situated within an upland area of the site on what appears to be a slide area or natural geologic formation that contains an increased elevation from the lowland region

For Group A (Figure 11 and 12), the three sample depths included 0-10 cm, 10-18 cm, and 18-25 cm. The Munsell values of these samples include a 10YR, 3/2, Very dark greyish brown loam in the first sample, 7.5YR 2.5/2, very dark brown loam in the second sample and 10YR 10/2, very dark greyish brown loamy sand in the last sample. Group B (Figure 13) had a total of three sample depths and include 0-20cm, 20-25cm, and 25-35cm. Munsell values for these samples included a very dark greyish brown gravelly clay loam (10YR3/2) in the first sample, a dark brown gravelly silt loam (10YR 3/3) in the second sample and a dark brown (10YR 3/3) gravelly clay loam in the third sample. Group C (Figures 14 -16) had two soil samples at depths of 0-12cm and 12-21cm. Munsell values for these include 5 YR 3/2 (dark reddish brown) in the first layer, but the second depth was 7.5 YR 3/2 (dark brown).

The four groups within FOPVCG performed testing for Macrofossils, Magnetics, pH, and LOI. For the Macrofossils it was noted that no charcoal was present, yet a variety of unidentified seeds were observed within the samples. The magnetics varied by depth of the sample as well as group location as the lowland groups contained similar readings as the upland groups also contained similar magnetic averages. Magnetic susceptibility seems to be related to the differences in slope and possibly elevation by location of the respective sites and be correlated with geologic properties within the upland areas. The pH for the most part had an average between 6 and 7 around the grassland area. The LOI test resulted in a correlation of both water as well as organics decreasing with depth.

Mixed Woodland

There are some interesting patterns found while comparing the four mixed woodland sites (Figure 18). All groups have a similar water percentage except for group A (Figure 19). This is possibly due to an error. Group C (Figure 22) had a high organic percentage and group D (Figure 24) had a high carbonate percentage. All groups had a similar density. There was a correlation between the pH and magnetic susceptibility. Groups B (Figure 21) and D had a higher SI reading and a higher pH reading while groups A and C had lower readings. Out of all the groups D had the highest readings. Grain size analysis holds some different patterns. Groups A and B had a much higher sand content than groups C and D. Groups A and D had a high silt content and all groups had a similar clay content.

Marshland Site

For the following discussion please refer to figures 26-33. For core site 1 the sample was identified as follows: 0-4 cm was composed of plant roots and a Munsell of 10YR 3/2, 4-6 cm a lot of roots Munsell of 2.5 YR 2.5/1, 6-10 cm few roots mostly clay with Munsell of 5Y 2.5/1, the samples that followed were similar but with fewer roots and a similar Munsell color.

For Core Site 2, the sample was split in half down the middle and tested by two groups, so the stratigraphy for the two groups was very much the same. From the top: 0-10 cm it was mostly root mass and organic material,10-20 cm it was mostly a clay composition with some root material, 20-30 cm was mostly clay with fewer roots, 30-40 cm was mostly clay, 40-50 cm was mostly clay with more roots which may be due to error, they were peeled off. The Munsell color that the entire core sample was identified as for both sampling groups was 5Y 2.5/1.

For Core Site 3, only 40 cm was recovered. No information for 0-6 cm, 6-12 cm had lots of fine roots with a clay texture and a Munsell of 10YR 2/2, 12-16 cm had roots with a texture of silty clay and a Munsell of 2.5 Y 2.5/1, 16-26 cm had roots mostly silty clay Munsell 2.5 Y 3/2. The rest of the sample was the same as the 16-26 cm level.

LOI Overview

For the % water in sediment site cores, Group D has the lowest readings while Group C & B have fairly similar readings. For the % organics, Group C has the lowest percentage. Group B has a dramatic spike of increased organic percentage after 45 cm, or at about 1905. Both Group D & B have high organic percentage from surface level till 10 cm in depth. All cores have similar readings for % CaC03. In sum, most groups have a higher organic percentage in upper levels and there is relatively low water content in all cores.

pH Overview

Group A conducted five pH readings on their core, FOPC3P1. The pH values ranged from a low of 5.88 at 30-32 cm to a high of 7.24 pH at 6-8 cm. There was no trend in regards to depth and pH fluctuation. The average pH of all five samples was 6.3.

Groups B and D both conducted analyses on the FOPC2P1 core. Though the sample was split in half, individual analyses were conducted by both groups on each half. Unfortunately, the data for each group was not consistent. Group B had an average pH of 6.78 with a range of 6.59 and 6.92. Group D, however, had a range of pH data from 6.72 and 7.68, with a fairly consistent decrease with depth. Group B did not see this steady decrease in pH with depth, instead pH values remained fairly consistent throughout.

Group C conducted analyses on the FOPC4P1 core. They conducted 5 pH analyses at depths ranging from 2 cm to 27 cm. The group had a range of 5.7 - 6.6 pH. The group saw a fairly consistent increase in pH starting with a depth of 7 cm and going to 27 cm. Group C saw the most consistent increase in pH with depth.

Magnetic Susceptibility Overview

Group A conducted 10 magnetic susceptibility readings for the FOPC3P1 sample. They ranged from a low of 13 at 8-10 cm depth to a high of 57 at 36-38 cm depth. For the most part, this groups reading increased with depth, with some exceptions. The group had an average magnetic susceptibility reading of 35.63 SI.

Group C conducted five magnetic susceptibility readings. The readings ranged from a low of 30 to a high of 45. The highest readings were found at a depth of 17cm, where the lowest readings were found at a depth of 7 cm. There was no consistent increase or decrease in magnetics with depth.

Group B and D, which both conducted SI readings on the FOPC2P1 core, also saw some interesting differences on their data despite each group taking readings on one half of the same sample. The SI data was more consistent than the pH data overall for the two groups. Group B took 10 SI readings ranging from a low of 28 at 40-42 cm to a high of 64 at 18-20 cm. Group B had an average SI reading of 46.56 SI. Group D also conducted 10 magnetic susceptibility readings for their half of the core. They saw a range of readings between a low of 31 at 2 cm to a high of 66 at 27 cm. The two groups had similar ranges of readings but the depths at which the readings were similar were not consistent.

Overall, our magnetic susceptibility readings for all the cores showed little in regards to trends associated with the readings and increased depth. The only trend seen is a weak correlation between an increase in readings between 2- and 20 cm in depth. There also seems to be a wide range of magnetic susceptibility at the FOP marshland site, with a range of all cores between a low of 13 top a high of 66.

Charcoal and Macrofossil Overview

Very little charcoal was found in Groups A and D, although group A noted a spike in charcoal at 38 cm of depth (around 1910). Group C found no charcoal at all.

Group A noted a dramatic spike in kind and quantity of macrofossils at about 24 cm of depth, which correlates to 1940. Group C noted a large amount of seeds in the top 18 cm.

ANALYSES AND CONSISTENCY

In analyzing our data on soil composition, the class discovered many inaccuracies in the final calculations. These inaccuracies in calculations may have occurred in the field, due to equipment, or human errors. Most samples had duplicates tests run on the same depth levels. If an error was found in these cases, averages could be used and standard error was calculated. However, with the grain size component this was not possible because of time constraints. The grain size data should therefore be considered in a qualitative rather quantitative manner (because of this we do not include the grain size raw data in the Appendix).

Equipment Error

- Inaccuracies of weighing scales. There were three scales available in the class – one digital and two manual. We believe the digital scale was accurate and not a source of the errors. However, the manual scales were dated and may not have been very accurate. As well, the scales may not have been read properly. These mistakes caused errors primarily in grain size analysis and Loss on Ignition.

- Addition of water to dry weights of measured samples. It is possible that some LOI samples absorbed water from the atmosphere as the desiccant needed recharging.

- Group C had errors with the Hannah pH meter. It was not reading the pH correctly for the Core 4-Push 1 first three depth samples. The team used a second meter on the samples and compared the readings. The team cleaned the reader and took three more readings. The new readings were 0.5 more acidic, which was concurrent with the second reader.

Field Error

- Contamination: While taking samples from the visitors center site (VCG) and the mixed woodlands site (MW) with the soil augers, the topsoil was loose and some teams experienced top layer soil falling back into the sample holes. The small amounts of soils from the shallower depths were then collected along with the deeper soil depths. Not only did this affect the composition of the lower spoil depths, but it also contaminated the lower soil samples with organic material such as seeds.

- The core sample depths were not uniform. Some soil sample depths had more roots and organic material than available soil

Human Error

- There were some errors in note-taking and writing down results. These occurred primarily in the loss on ignition process where numbers were mixed and led to negative numbers for loss of some substances.

- There was a class wide error on Sept 18. We were using air dried samples for LOI analysis when we should have been using soil directly from the bag. The air drying allowed the soils to lose some moisture.

- Spilling of soil or sediment slurry during pretreatment for grain size analysis. This error primarily affected the grain size analysis. Each loss of material would have a cumulative effect of the total weight of each grain size.

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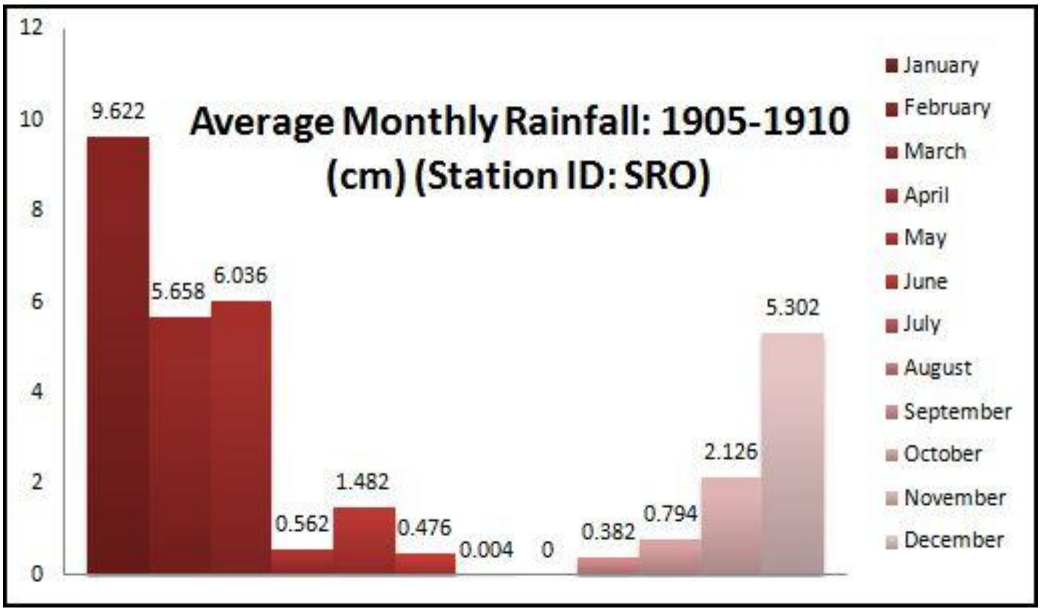


Figure 1: Average monthly rainfall (cm) for Santa Rosa.

Figure 2: Team A auguring at the grassland site.

Figure 3: Team B is shown emptying their bucket Auger at the Visitor Center Grassland site).

Figure 4: Sediment core collected by Russian Peat Corer.

Figure 5: Students using the Munsell Color System to classify their soils.

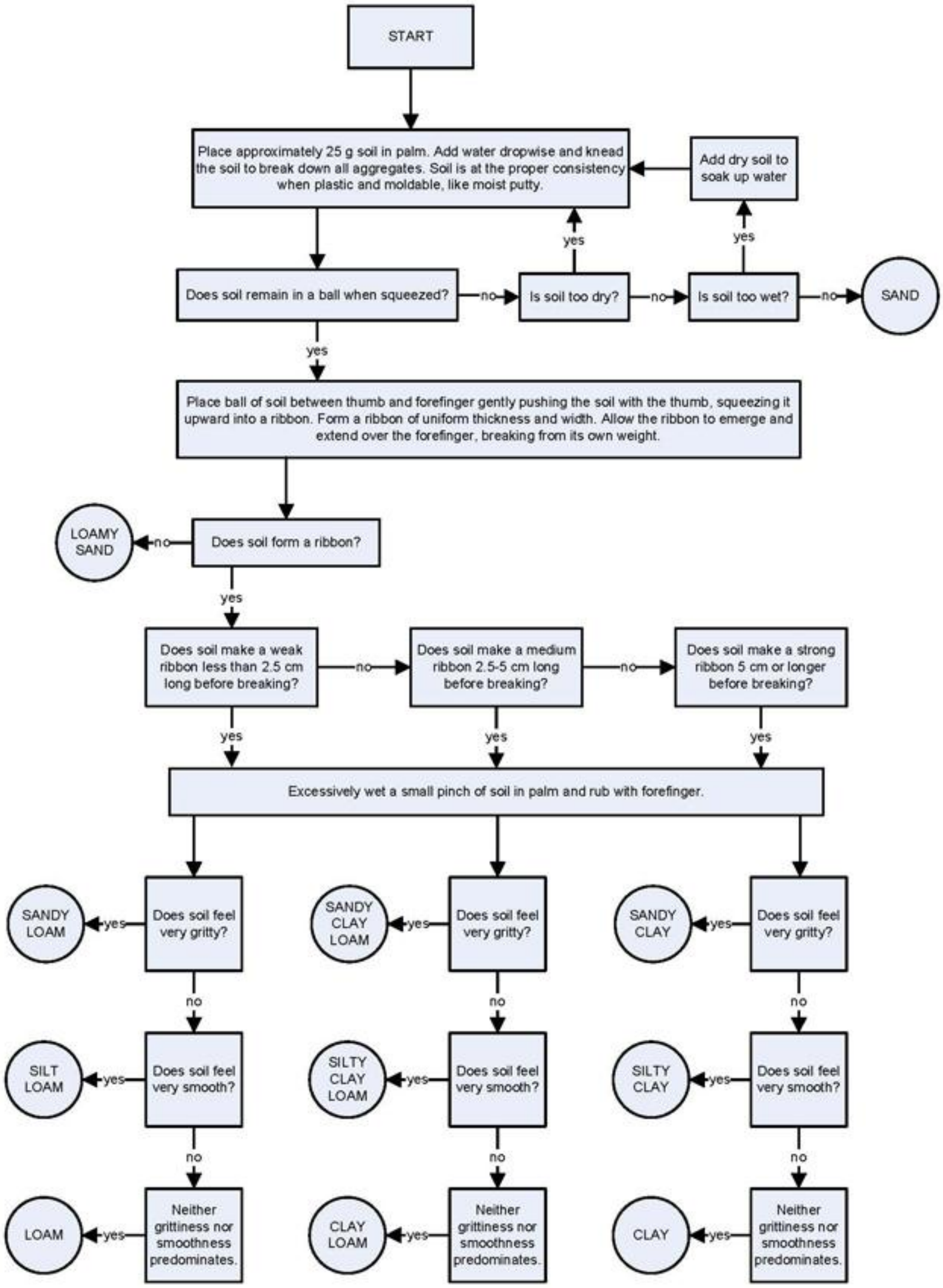


Figure 6: Texture by Feel flow chart

Figure 7: Group C undertaking texture by feel.

Figure 8: Image on left shows crucible placement in the furnace and image on the right shows furnace at about 550^{o}C.

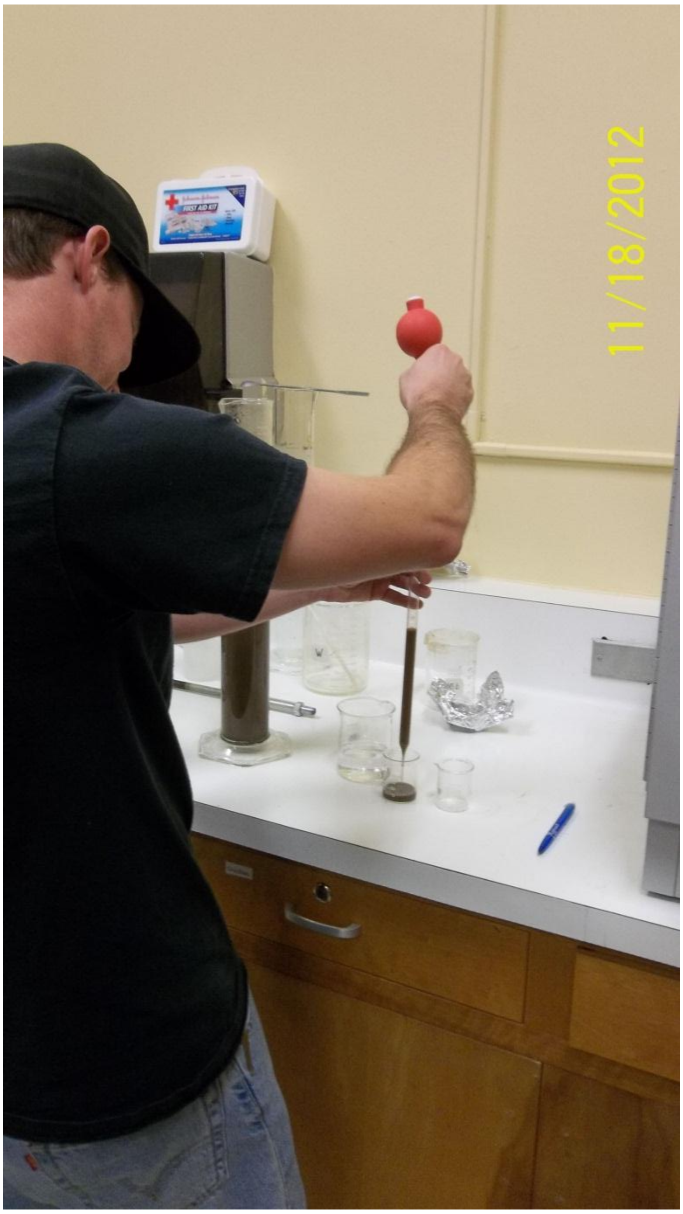


Figure 9: Expelling a grain size aliquot into a preweighed beaker.

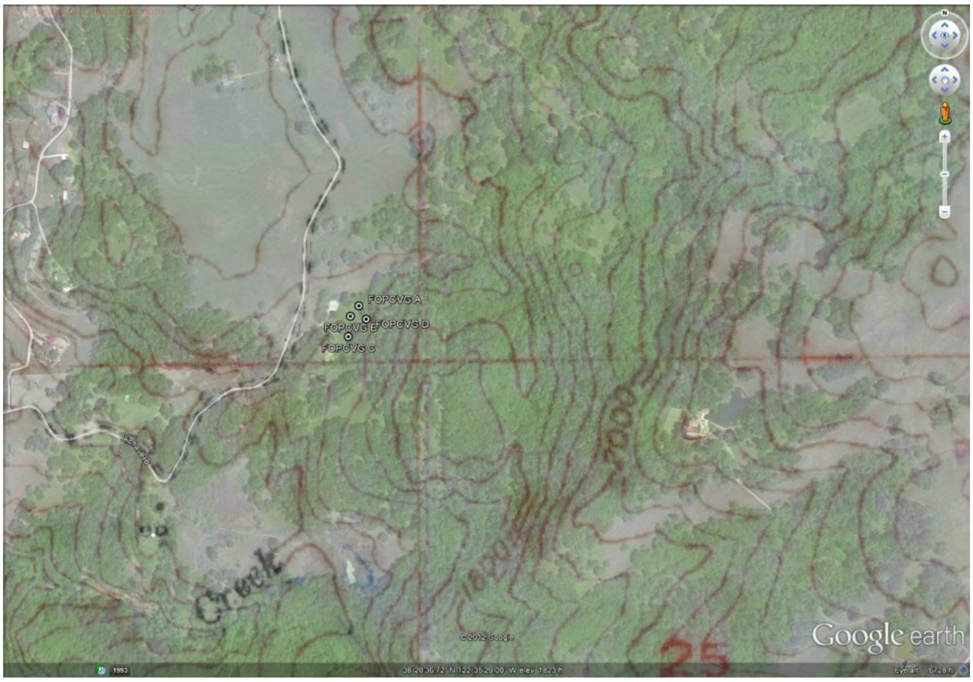


Figure 10: Upper image: Google Earth image of grassland sampling locations. The FOP visitor center is located in the lower left corner of the image. Lower image: Topographic map (20' contour interval) overlaying Google Earth image.

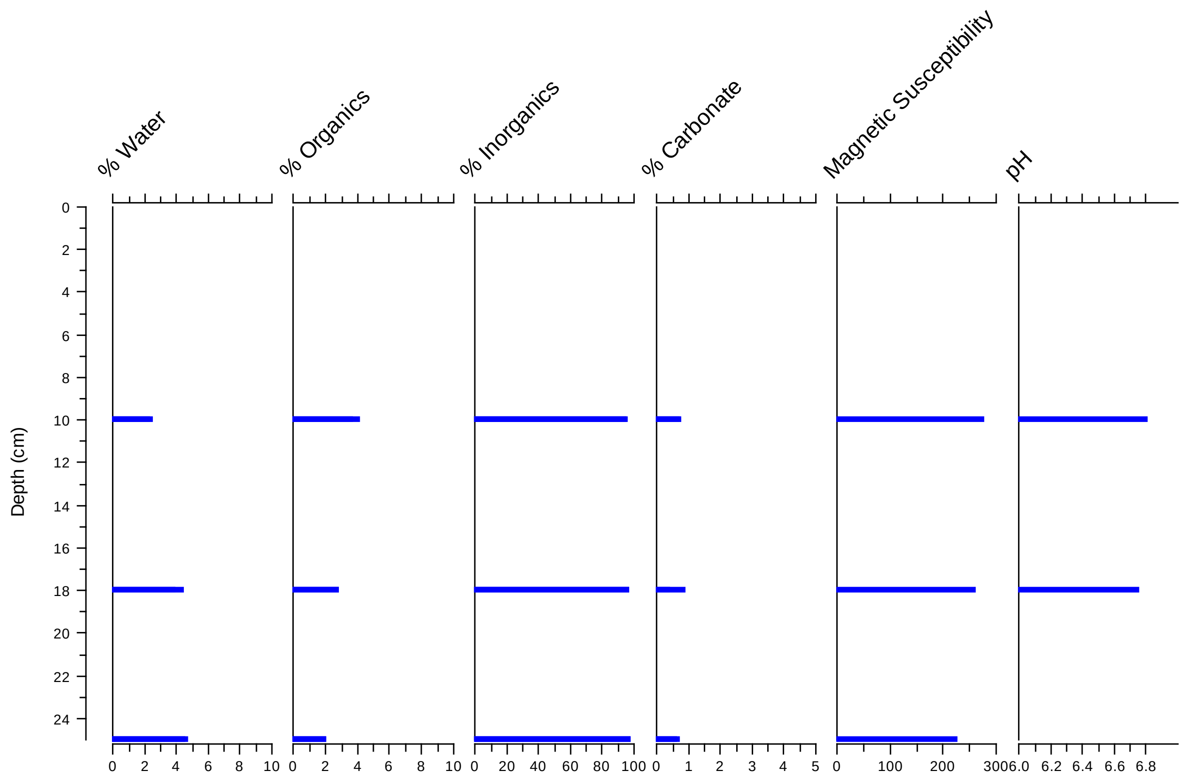


Figure 11: Grassland Group A LOI, Magnetic Susceptibility and pH results.

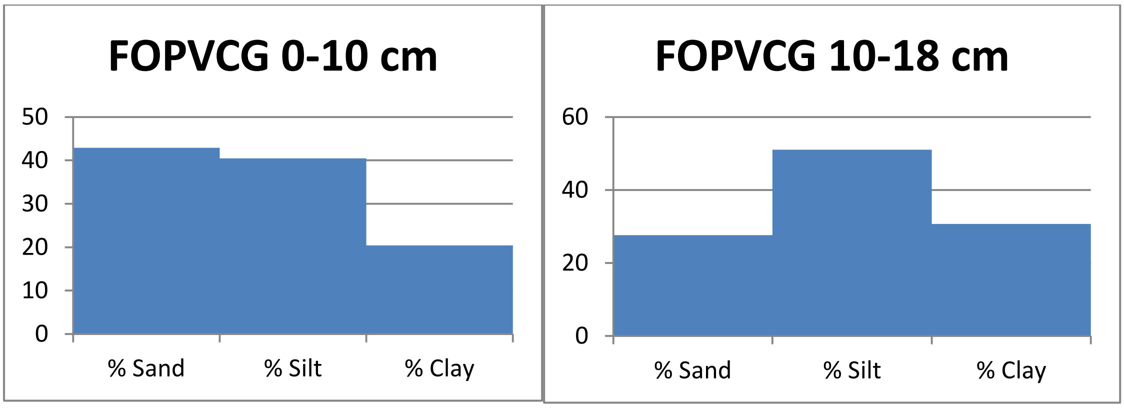


Figure 12: Grassland Group A grain size results.

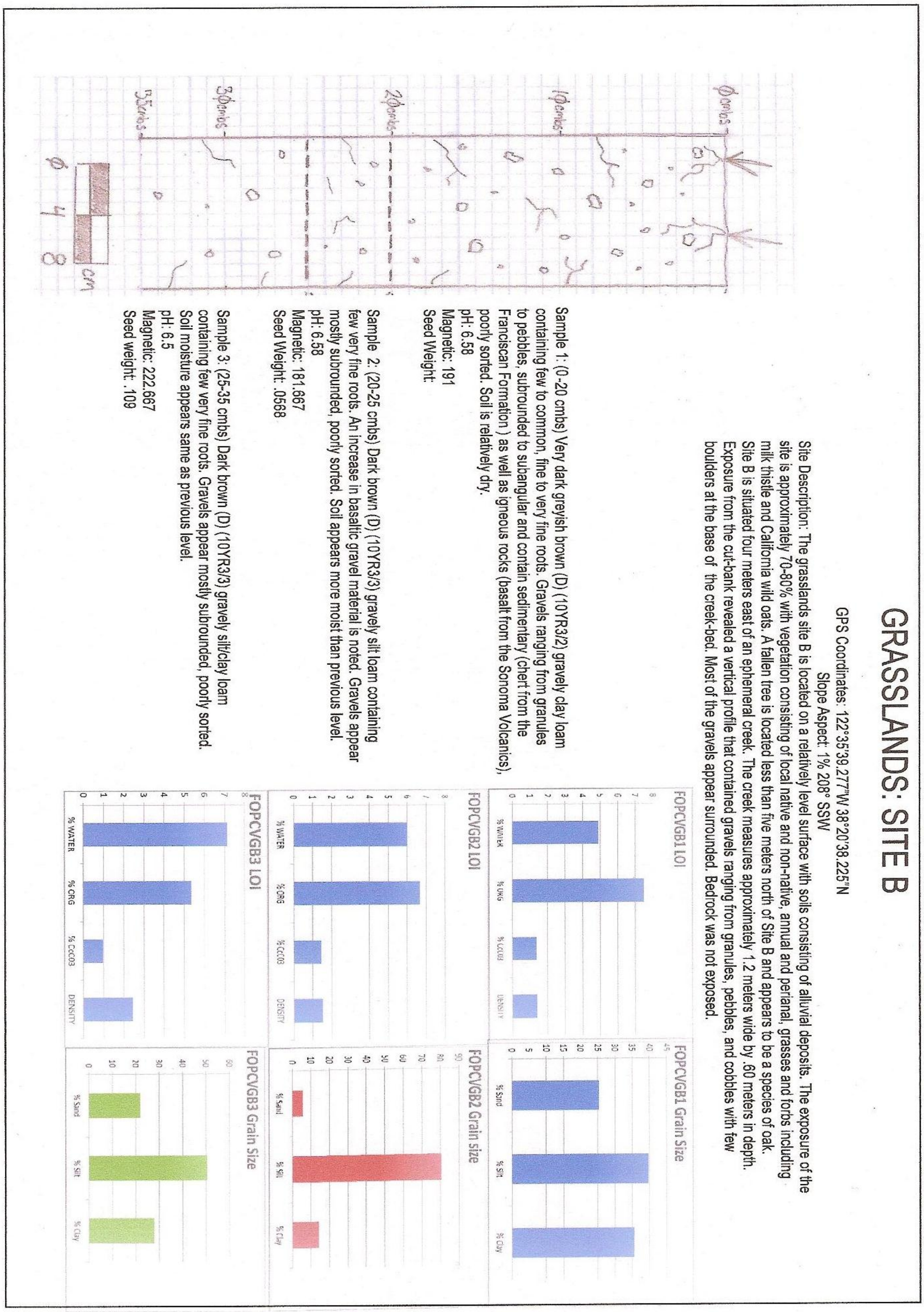


Figure 13: Grassland Group B LOI, Magnetic Susceptibility and pH results grain size results.

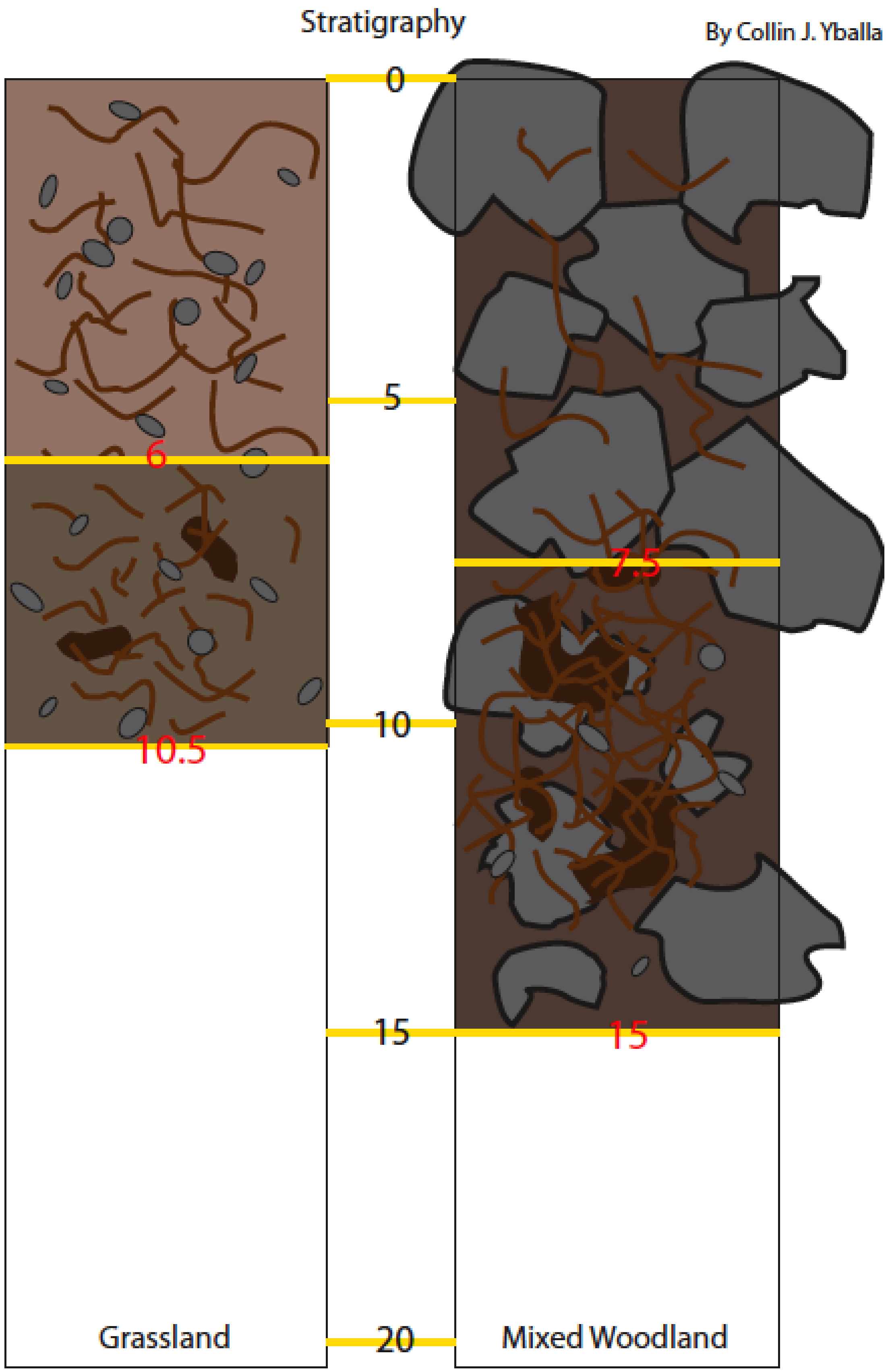


Figure 14: Group C soil stratigraphy for the Grassland (left image) and Mixed Woodland (right image). Depths shown in centimeters.

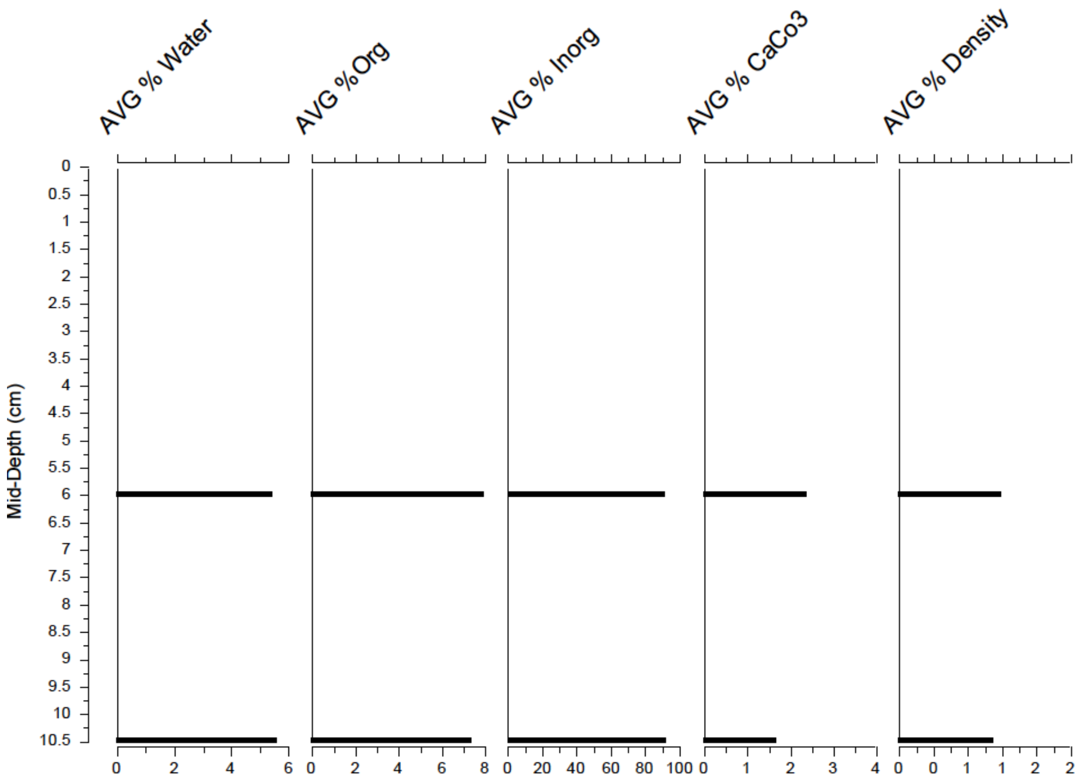


Figure 15: Grassland Group C LOI results.

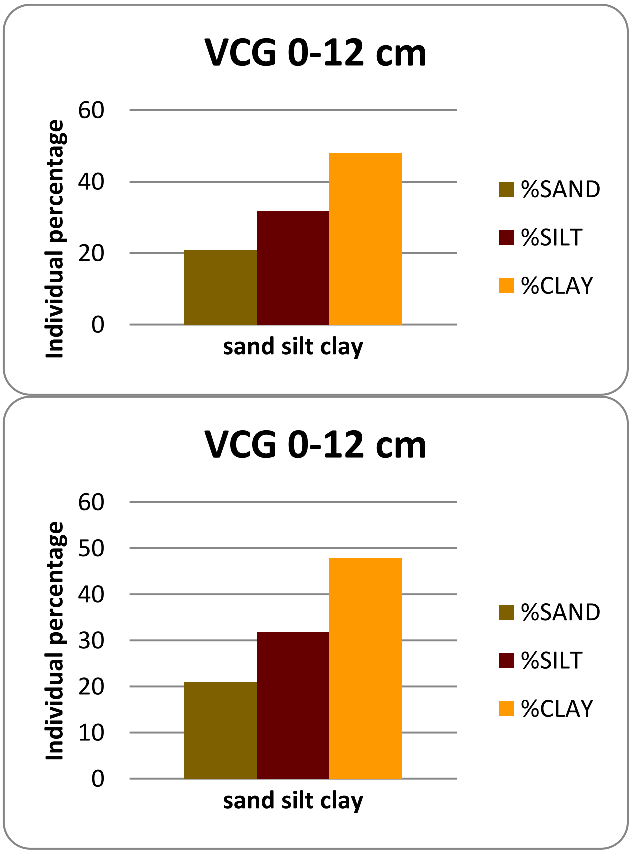


Figure 16: Grassland Group C Grain Size results.

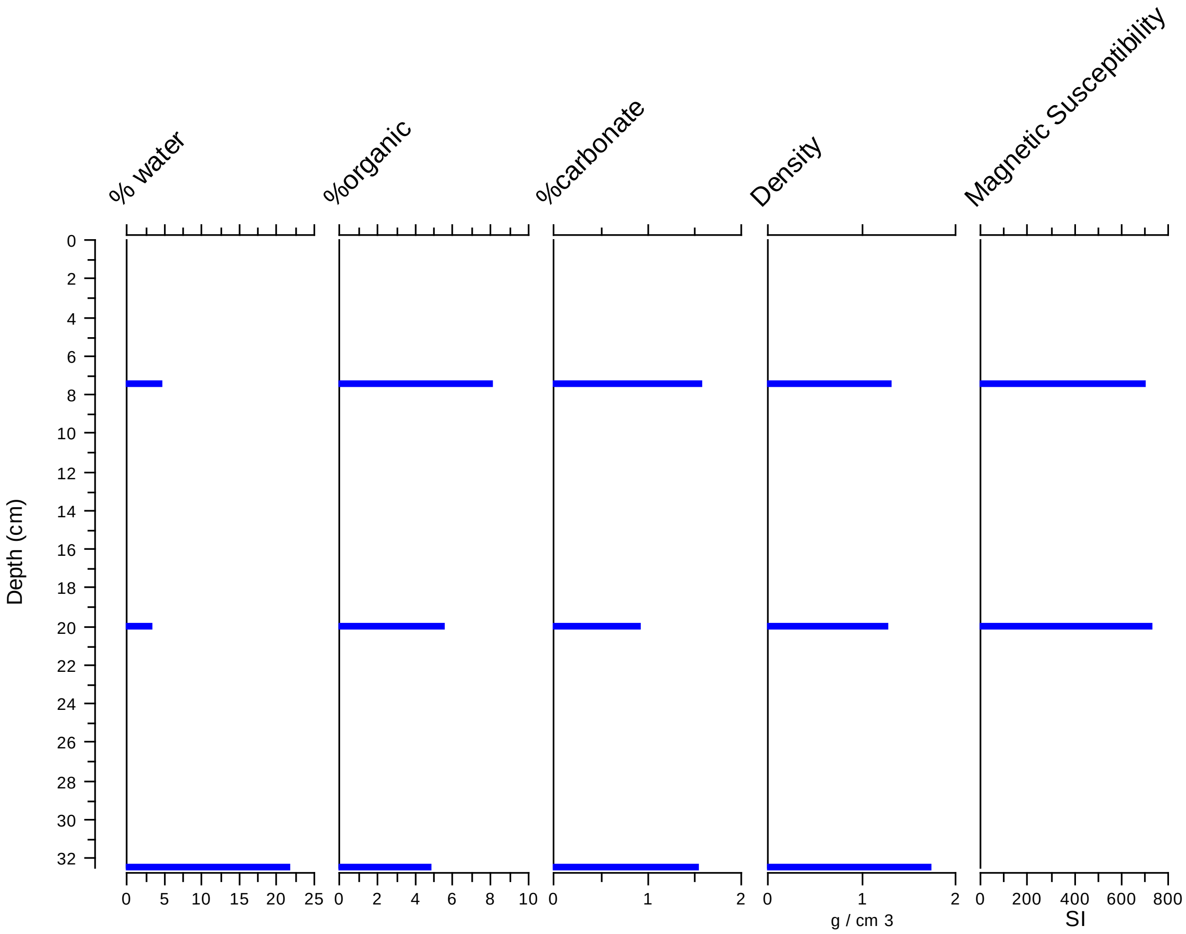


Figure 17: Grassland Group D LOI and magnetic susceptibility results.

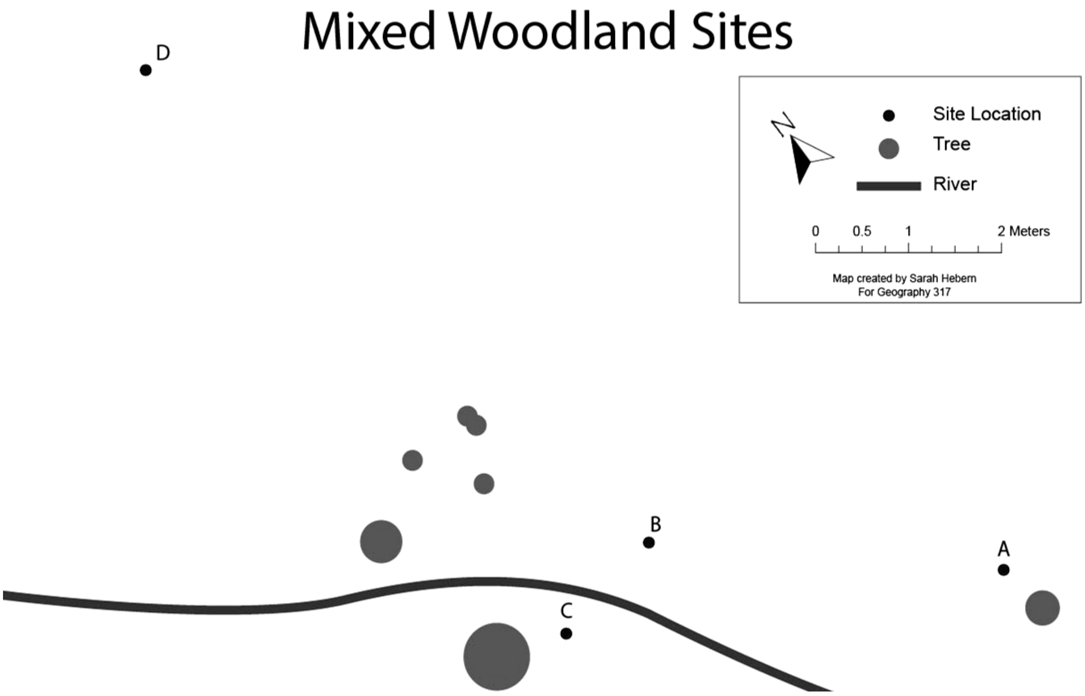


Figure 18: Location of mix woodland auger sites (drafted by Sarah Hebern).

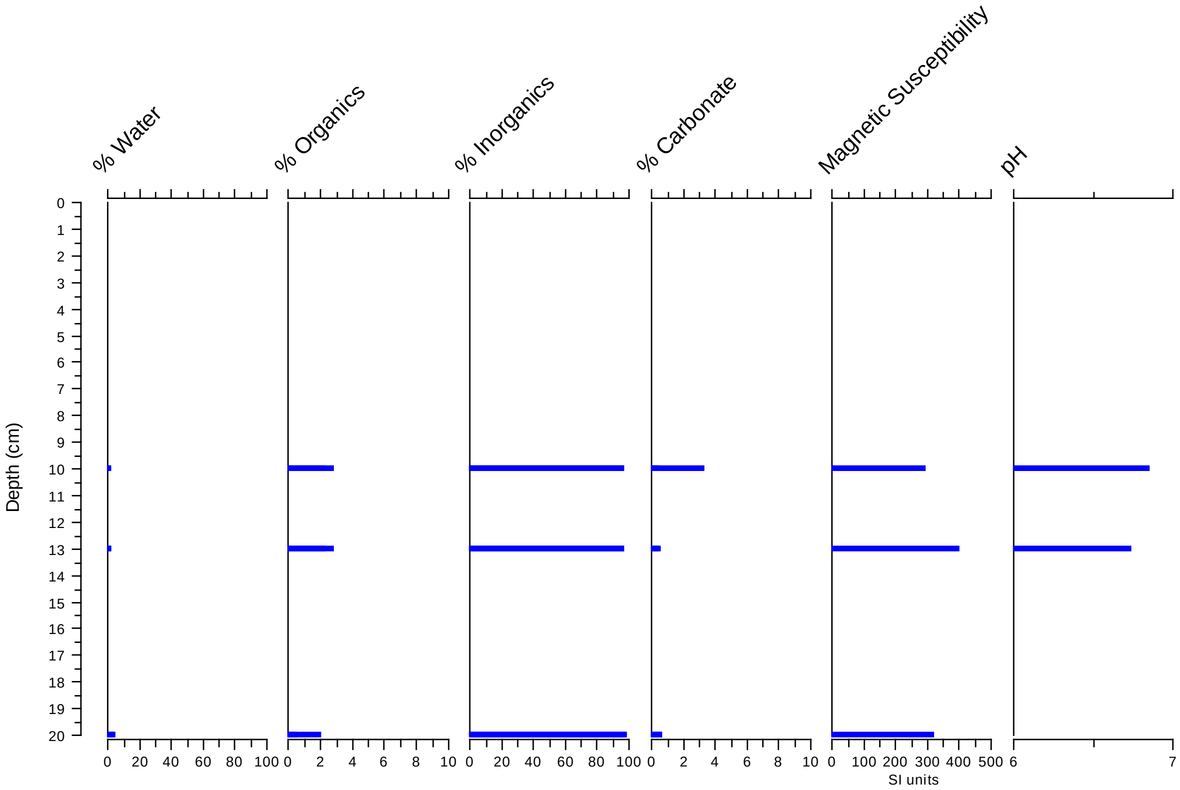


Figure 19: Mixed woodland Group A LOI, magnetic susceptibility and pH results.

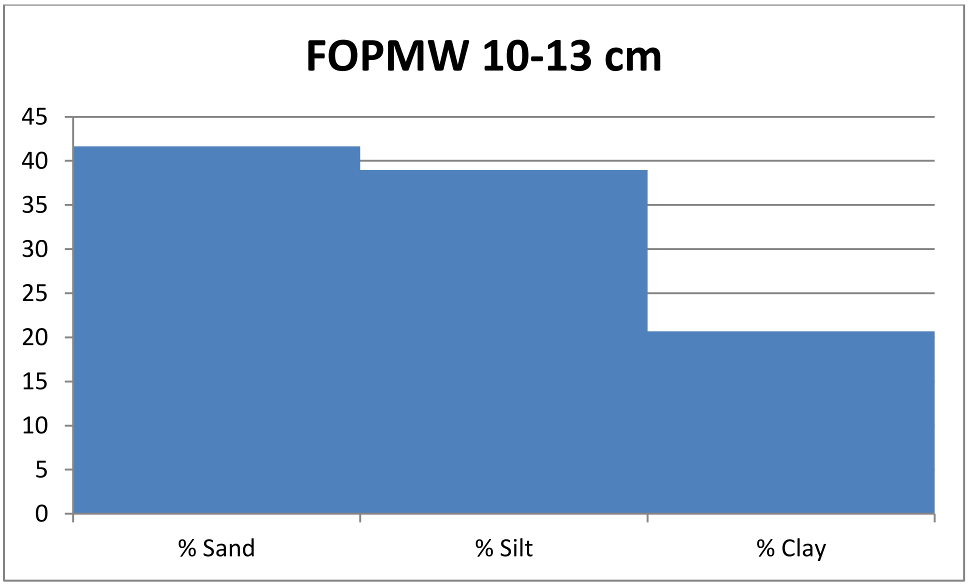


Figure 20: Mixed woodland Group A grainsize results.

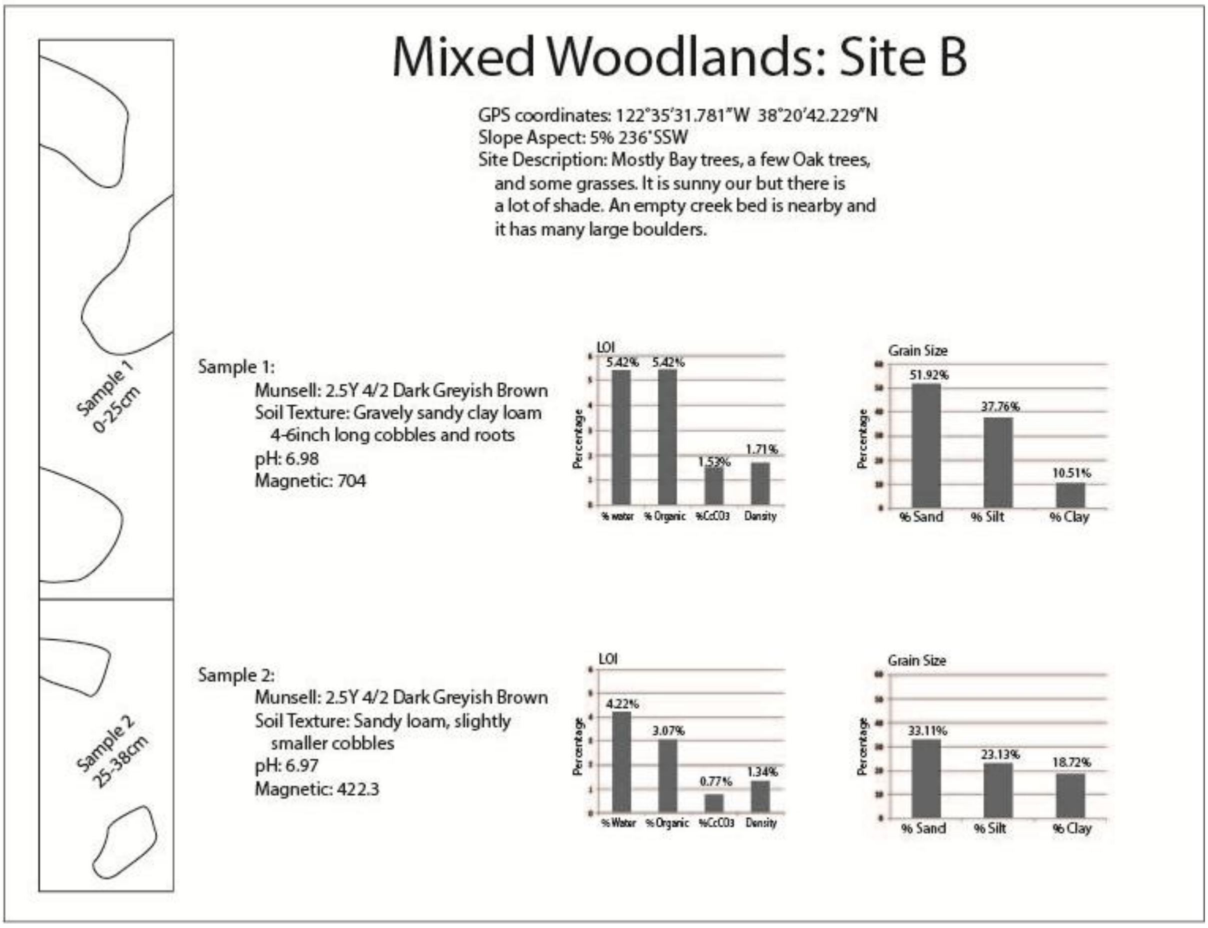


Figure 21: Mixed woodland B LOI, Magnetic Susceptibility and pH results grain size results.

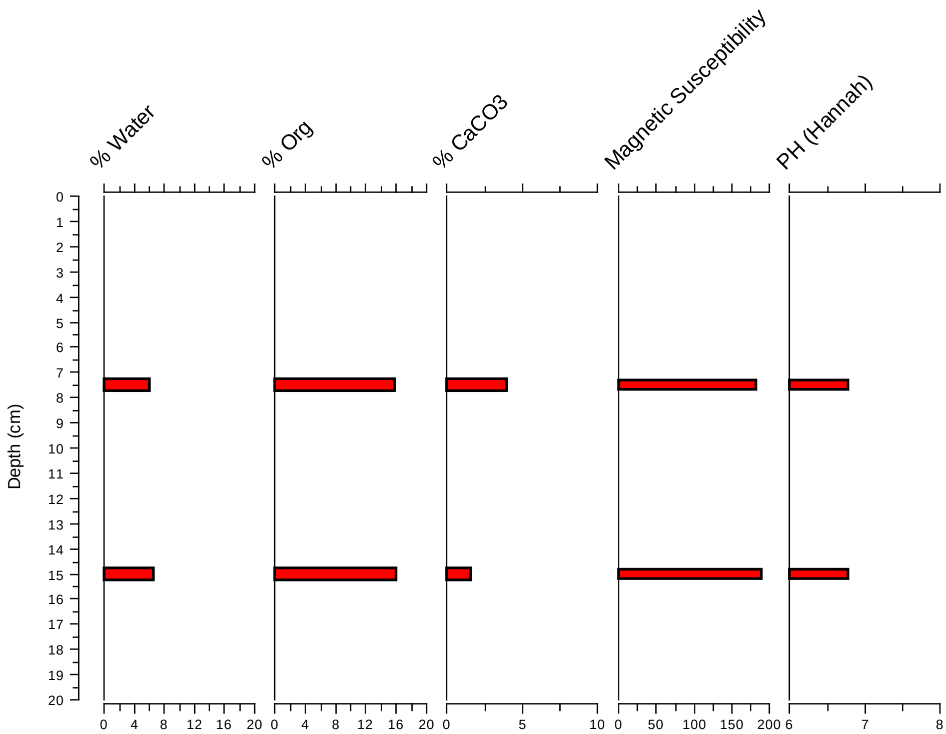
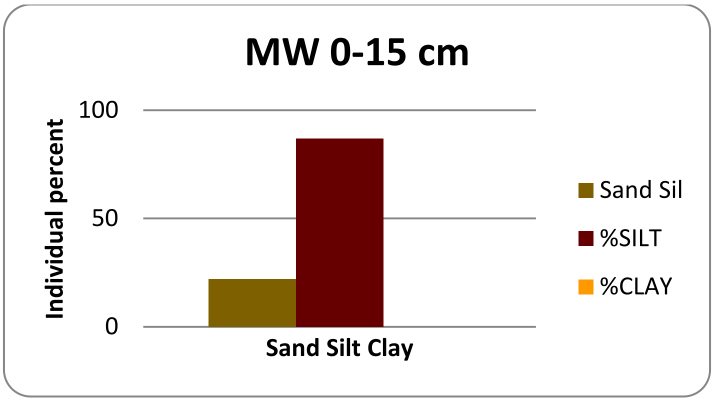


Figure 22: Mixed woodland group C LOI, Magnetic Susceptibility and pH results.



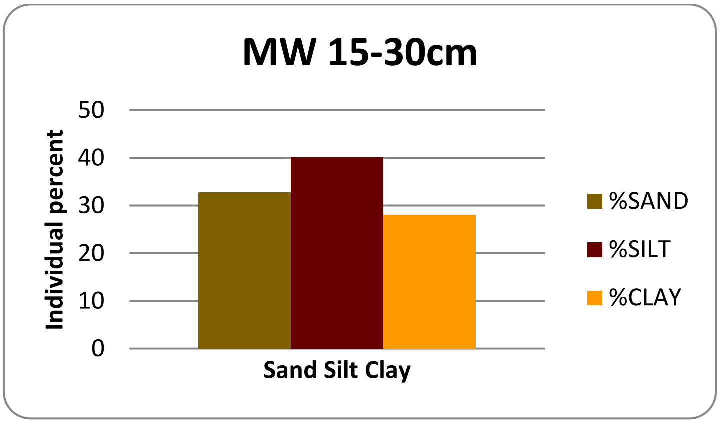


Figure 23: Mixed woodland group C Grain size results.

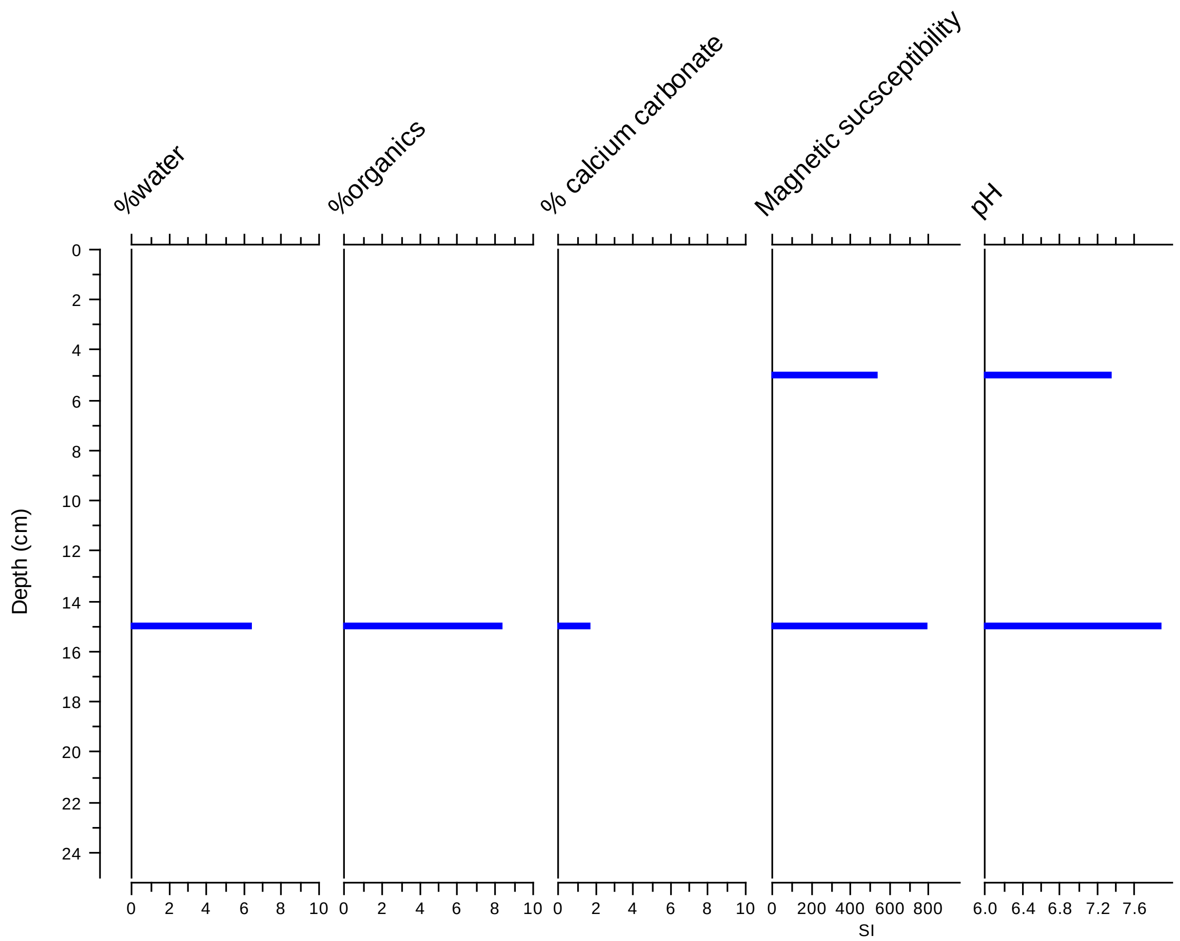


Figure 24: Mixed woodland group D LOI, Magnetic Susceptibility and pH results.

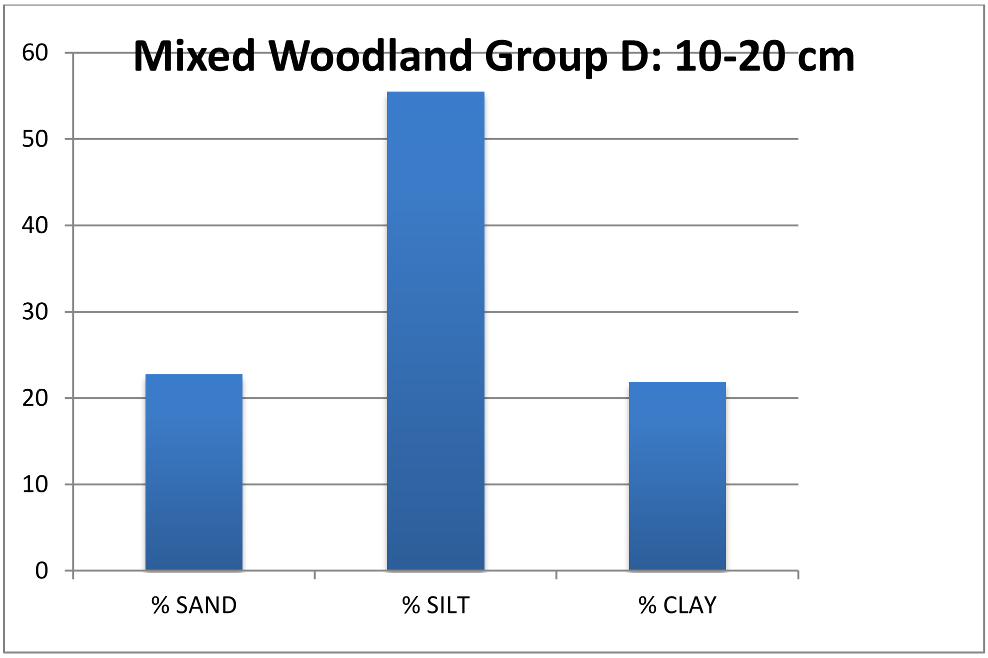


Figure 25: Mixed woodland group D Grain size results for 10-20 cm depth.

Figure 26: Left: Google Earth image showing location of the wetland and the visitor center. Right: Close up of the wetland in Google Earth showing the location of the sediment core sites.

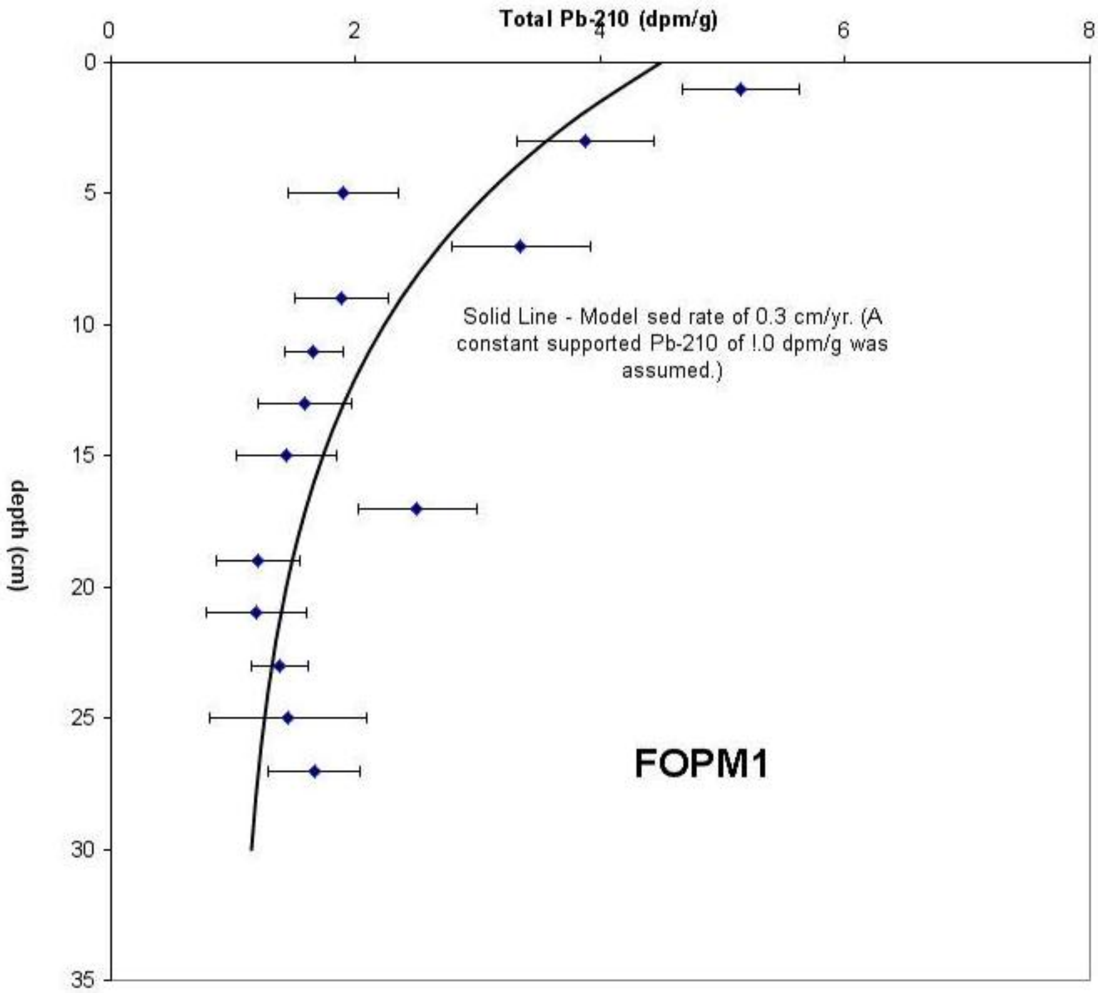


Figure 27: ^{210}Pb results from FOP wetland site.

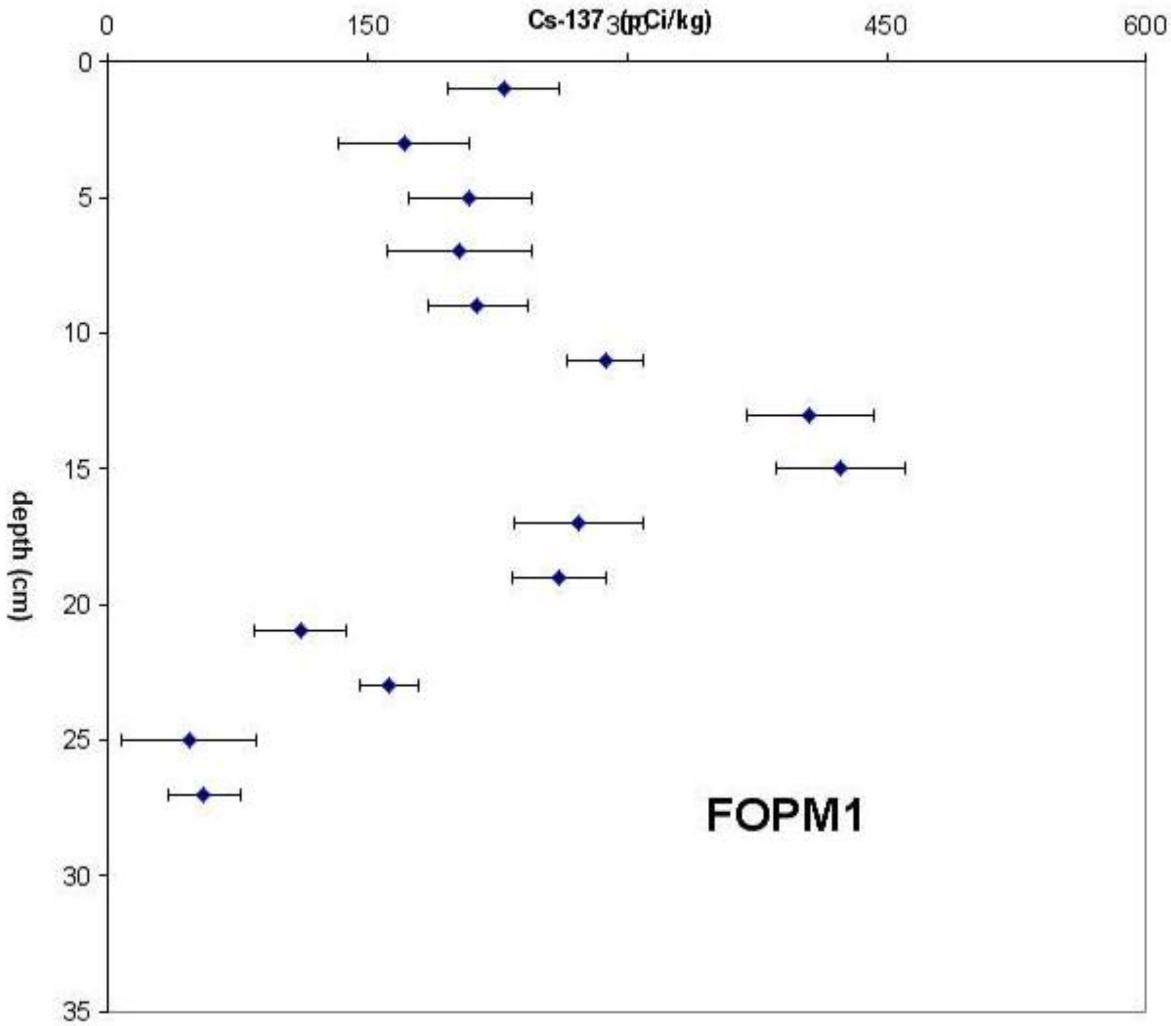


Figure 28: ^{137}Cs results from FOP wetland site.

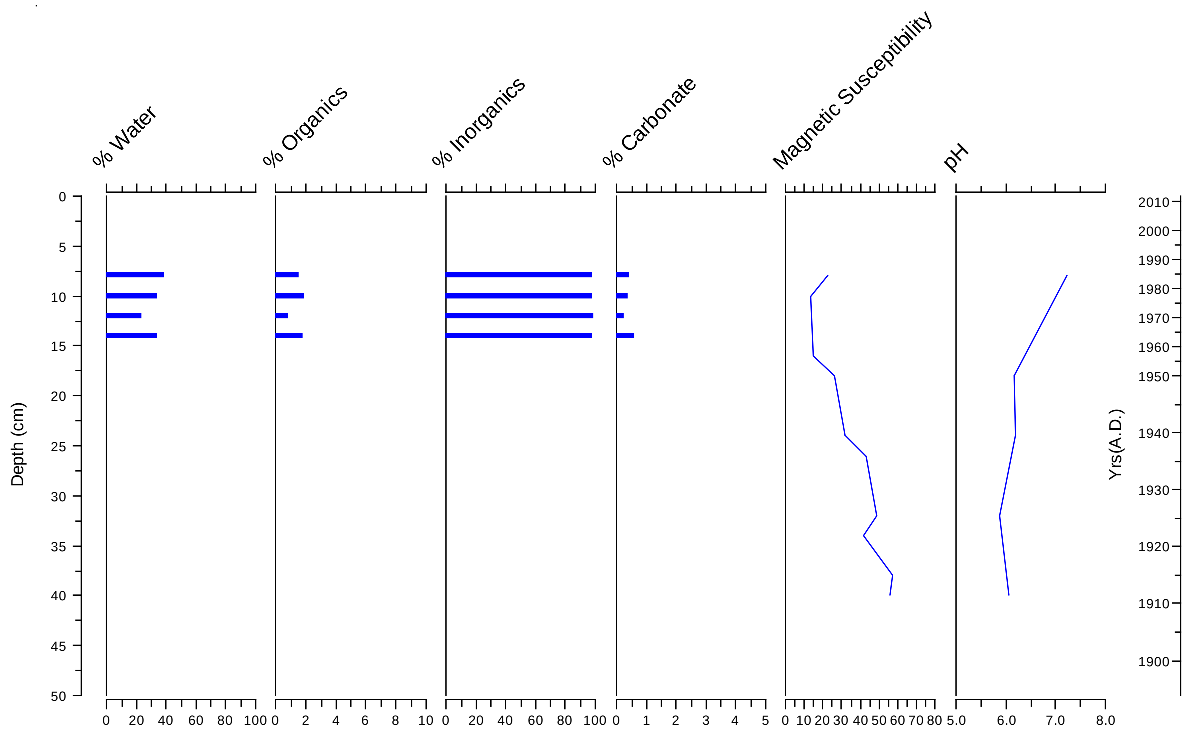


Figure 29: Wetland Group A LOI, Magnetic Susceptibility and pH results.

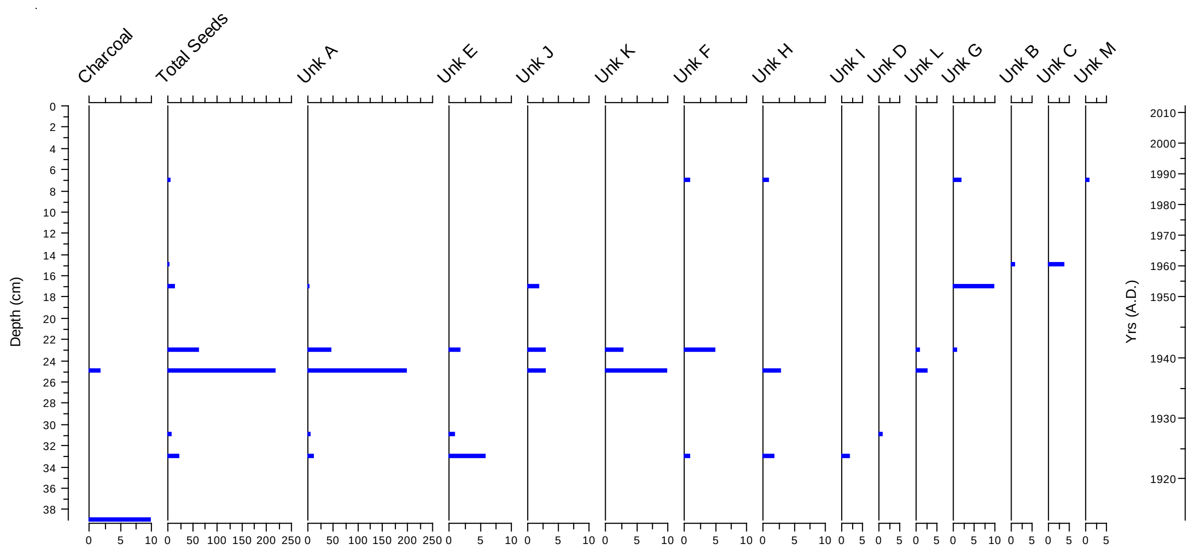


Figure 30: Wetland Group A macrofossil data. Seed types remain as unknowns.

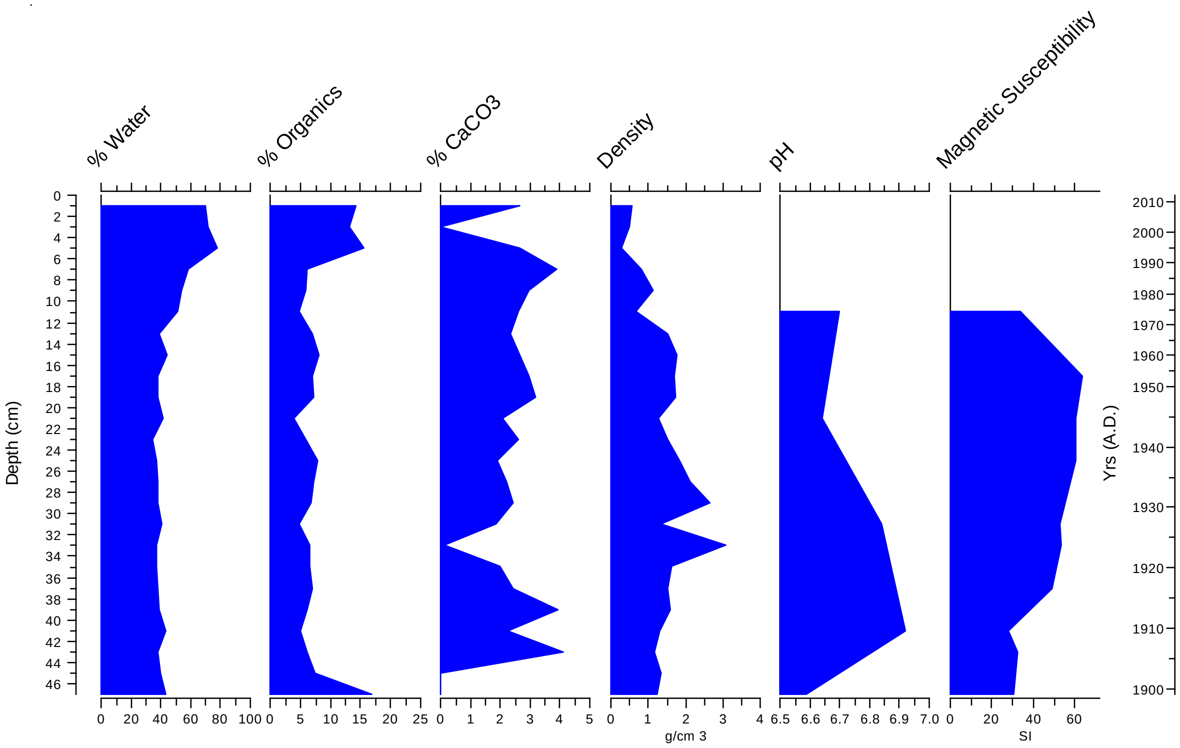


Figure 31: Wetland Group B LOI, Magnetic Susceptibility and pH results.

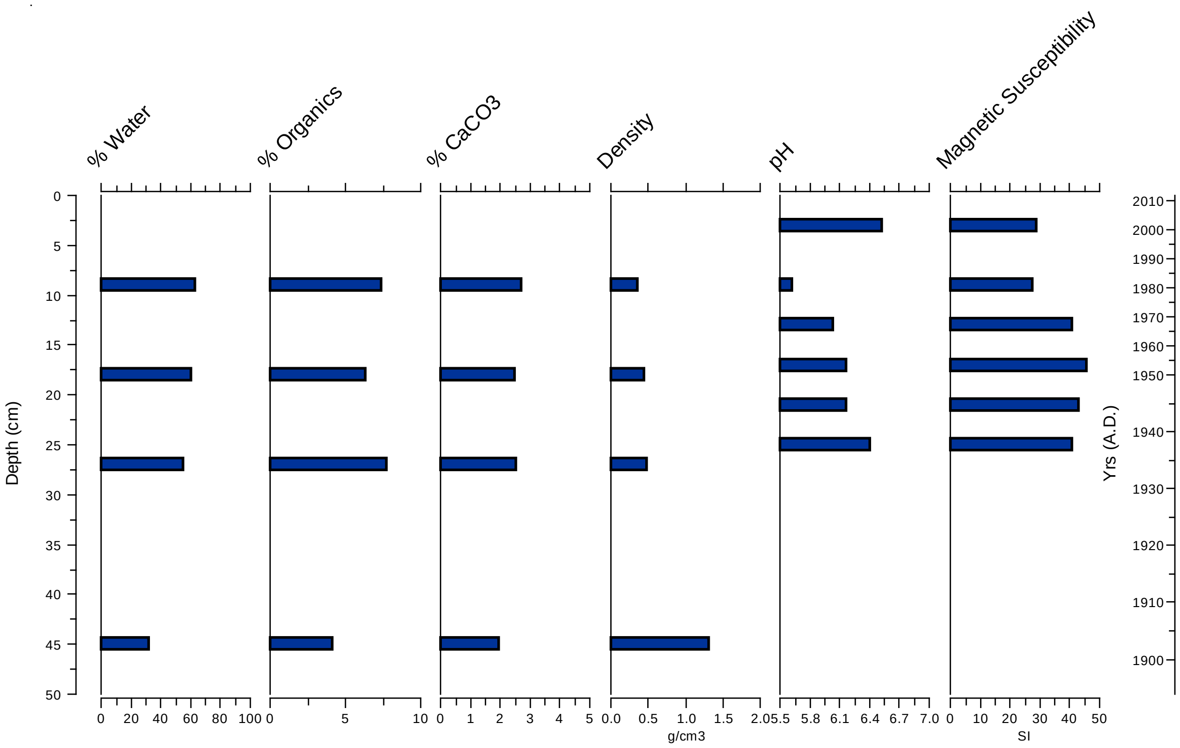


Figure 32: Wetland Group C LOI, Magnetic Susceptibility and pH results.

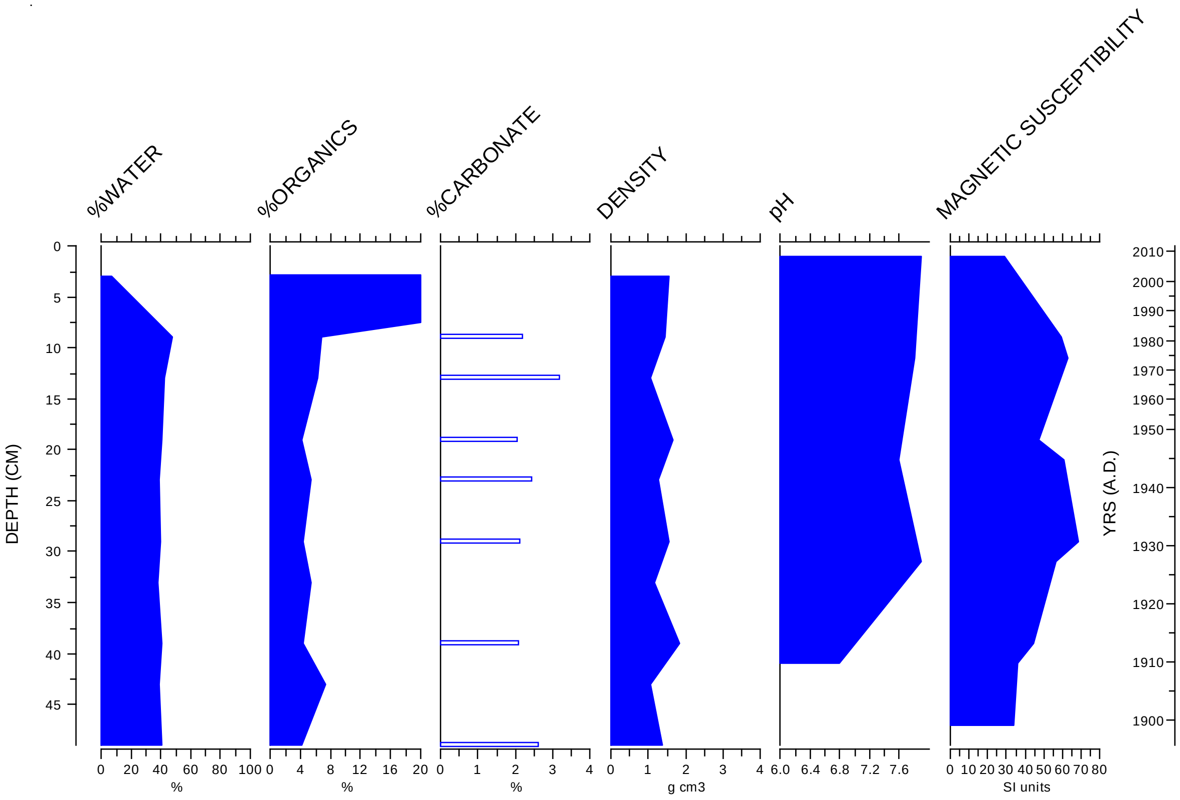


Figure 33: Wetland Group D LOI, Magnetic Susceptibility and pH results.

APPENDIX

Table 1: FOP Visitor Center Grassland Site LOI raw data.

Depth (cm)	**Wet weight (g)**	**Dry Weight (g)**	**Weight after 550C (g)**	**Weight after 950C (g)**
A				
0-10	19.2381	18.3074	16.9015	16.6925
0-10	17.7443	16.8175	15.3140	15.1089
10-18	16.1262	14.5612	13.6094	13.3856
10-18	13.7684	12.4223	11.4899	11.3847
18-25	13.3823	11.8557	11.1839	11.0339
18-25	14.4310	12.7639	12.0613	11.8736
B				
0-20	14.6644	13.9471	12.9051	12.7647
0-20	13.3232	12.7123	11.9168	11.7804
20-25	17.936	18.8865	16.2454	15.9299
20-25	16.3739	15.3927	14.3654	14.2036
25-35	27.2042	22.8017	21.6603	21.3508
25-35	26.1847	24.3174	23.0195	22.8464
C				
0-12	12.8041	12.0859	11.0845	10.8136
0-12	12.7471	12.0684	11.0641	10.9059
12-21	19.5991	18.8527	18.8527	17.8323
12-21	11.2018	10.2818	9.5141	9.3672
D				
0-15	14.345	13.695	12.6067	12.4328
0-15	13.5721	12.8844	11.8091	11.6701
15-25	10.7149	10.2568	9.5752	9.5182
15-25	16.2166	15.7281	15.0068	14.8769
25-40	23.2371	18.1062	17.2507	17.0624
25-40	21.726	17.0465	16.1813	15.9683

Table 2: FOP Visitor Center Grassland Site Magnetic Susceptibility Data. Data in SI units.

Depth (cm)	**# 1**	**# 2**	**# 3**	**Average**
A				
0-10	281	278	280	279.667
10-18	263	264	262	263
B				
0-20	192	190	191	191
20-25	180	182	183	181.667
25-35	224	222	222	222.667
C				
0-12	786	786	789	787
12-21	741	556	738	678.333
D				
0-15	708	710	708	708.667
15-25	601	799	808	736

Table 3: FOP Visitor Center Grassland Site pH data.

Depth (cm)	**pH**
A	
0-10	6.81
10-18	6.76
B	
0-20	6.58
20-25	6.58
25-35	6.5
C	
0-12	6.3
12-21	6.6
D	
0-15	6.71
15-25	7.3

Table 4: FOP Mixed Woodland Site LOI raw data.

Depth (cm)	**Wet weight (g)**	**Dry Weight (g)**	**Weight after 550C (g)**	**Weight after 950C (g)**
A				
0-10	11.8083	11.1431	10.4482	10.3399
0-10	16.4639	15.5343	14.5276	13.6666
10-13	12.0054	11.1471	10.3552	10.2183
10-13	16.6251	15.6281	14.6148	14.4504
13-20	19.0406	17.3722	16.5895	16.4059
13-20	17.0783	15.3148	15.1089	14.9407
B				
0-25	18.1358	17.1516	16.2165	16.0225
0-25	16.5611	15.7435	14.9828	14.8509
25-38	14.003	13.4116	12.9986	12.9217
25-38	14.5829	13.8728	13.3541	13.4326
C				
0-15	9.5	8.9054	7.4879	7.2228
15-30	8.22	7.6664	6.4272	6.3302
D				
0-10	12.585	12.0713	12.0964	11.2113
0-10	11.2545	10.7213	10.7485	9.2952
10-20	9.5417	8.9394	8.3663	8.2524
10-20	15.1726	14.1766	12.6953	13.0368
20-30	18.2405	16.071	14.935	14.8123
20-30	15.5913	15.5913	13.8974	13.7764

Table 5: FOP Mixed Woodland Site Magnetic Susceptibility Data. Data in SI units.

Depth (cm)	**# 1**	**# 2**	**# 3**	**Average**
A				
0-10	294	294	296	294.667
10-13	405	402	403	403.333
13-20	320	320	327	322.333
B				
0-25	701	704	707	704
25-38	419	408	440	422.333
C				
0-15	184	185	185	184.667
15-30	223	126	223	190.667
D				
0-10	545	541	543	543
10-20	799	800	808	802.333

Table 6: FOP Mixed Woodland Site pH data.

Depth (cm)	**pH**
A	
0-10	6.86
10-13	6.74
B	
0-25	6.98
25-38	6.97
C	
0-15	6.8
15-30	6.8
D	
0-10	7.36
10-20	7.9

Table 7: FOP Mixed Woodland Seed Data Group C

Depth	UNK 1	UNK 2	UNK 3	UNK 4	UNK 5	TOTAL Seeds	Charcoal
0-15	3	6	1	4	1	15	0
15-30	1	1	3	1	0	6	0

Table 8: FOP Marshland Site LOI raw data.

Core	Depth (cm)	Wet weight (g)	Dry Weight (g)	Weight after 550C (g)	Weight after 950C (g)
A					
C3P1	8	4.2	0.9	0.844	0.8261
C3P1	10	3.8	0.8	0.6888	0.6726
C3P1	12	2.1	0.5	0.4269	0.4165
C3P1	14	4.5	1.3	1.1817	1.1547
B					
C2P1	0-2	3.8	1.1	0.98	0.9577
C2P1	2-4	3.5	1	0.8531	0.829
C2P1	4-6	2.4	0.5	0.4505	0.4351
C2P1	6-8	3.9	1.6	1.5221	1.4755
C2P1	8-10	5	2.3	2.1562	3.0045
C2P1	10-12	2.8	1.4	1.3036	1.2774
C2P1	12-14	4.3	2.5	2.4165	2.3798
C2P1	14-16	4.5	2.7	2.5564	2.5097
C2P1	16-18	4.6	2.6	2.4636	2.4212
C2P1	18-20	4.4	2.5	2.0666	2.3257
C2P1	20-22	4.3	2.5	2.4185	2.3798
C2P1	22-24	4.6	3	2.8432	2.7848
C2P1	24-26	5.9	3.7	3.4002	3.348
C2P1	26-28	6.9	4.3	3.9682	3.8986
C2P1	28-30	8.6	5.3	4.954	4.859
C2P1	30-32	4.5	2.7	2.5564	2.5197
C2P1	32-34	9.7	6.1	5.7364	5.7312
C2P1	34-36	5.2	3.3	3.0407	2.9936
C2P1	36-38	4.9	3	2.8283	2.7743
C2P1	38-40	5.2	3.2	2.9777	2.8862
C2P1	40-42	4.6	2.6	2.4636	2.4209
C2P1	42-44	3.8	2.3	2.1901	2.1194
C2P1	44-46	4.4	2.7	2.4717	2.7133
C2P1	46-48	4.4	2.5	2.0666	2.3257
C					
C4P1	7.5	9.5	8.9	7.4879	7.2228
C4P1	15	8.2	7.7	6.4272	6.3302
C4P1	9	2	0.7	0.6717	0.657

C4P1	18	2.4	0.9	0.8572	0.8402
C4P1	27	2.2	1	0.9014	0.8829
C4P1	45	4	2.6	2.5326	2.4935
D					
C2P1	2-4	3.3	3.1	0.9151	N/A
C2P1	8-10	5.5	2.9	2.682	2.6387
C2P1	12-14	3.7	2.1	1.9839	1.9378
C2P1	18-20	5.5	3.3	3.1664	3.1182
C2P1	22-24	4.1	2.5	2.3988	2.3556
C2P1	28-30	5.2	3.1	3.0046	2.9577
C2P1	32-34	3.8	2.4	2.2242	N/A
C2P1	38-40	6.2	3.7	3.5122	3.4585
C2P1	42-44	3.5	2.1	1.9415	N/A
C2P1	48-50	4.7	2.8	2.6618	2.6111

Table 9: FOP Marshland Site Magnetic Susceptibility Data. Data in SI units.

Core	Depth (cm)	# 1	# 2	# 3	Average
A					
C3P1	8	23	23	21	22.3333
C3P1	10	16	13	11	13.3333
C3P1	16	19	16	10	15
C3P1	18	34	24	21	26.3333
C3P1	24	38	30	28	32
C3P1	26	49	38	43	43.3333
C3P1	32	48	50	48	48.6667
C3P1	34	42	39	44	41.6667
C3P1	38	57	59	57	57.6667
C3P1	40	55	55	58	56
B					
C2P1	10-12	35	33	34	34
C2P1	16-18	65	63	64	64
C2P1	20-22	60	61	61	60.6667
C2P1	24-26	60	61	60	60.3333
C2P1	30-32	54	53	51	52.6667
C2P1	32-34	54	54	53	53.6667
C2P1	36-38	48	50	49	49
C2P1	40-42	29	28	27	28
C2P1	44-46	33	33	32	32.6667
C2P1	46-48	31	31	30	30.6667
C					

C4P1	3	28	29	30	29
C4P1	9	27	28	29	28
C4P1	13	41	41	42	41.3333
C4P1	17	46	46	46	46
C4P1	21	44	44	42	43.3333
C4P1	25	42	42	40	41.3333
D					
C2P1	0-2	28	30	30	29.3333
C2P1	8-10	59	60	60	59.6667
C2P1	10-12	62	63	64	63
C2P1	18-20	48	48	47	47.6667
C2P1	20-22	60	61	61	60.6667
C2P1	28-30	72	66	67	68.3333
C2P1	30-32	57	57	55	56.3333
C2P1	38-40	46	44	43	44.3333
C2P1	42-44	35	36	37	36
C2P1	46-48	35	35	32	34

Table 10: FOP Marshland Site pH data.

Core	Depth (cm)	pH
	A	
C3P1	8	7.24
C3P1	18	6.17
C3P1	24	6.2
C3P1	32	5.88
C3P1	40	6.05
	B	
C2P1	10-12	6.7
C2P1	20-22	6.64
C2P1	30-32	6.84
C2P1	40-42	6.92
C2P1	46-48	6.59
	C	
C4P1	3	6.54
C4P1	9	5.63
C4P1	13	6.05
C4P1	17	6.18
C4P1	21	6.18
C4P1	25	6.41
	D	
C2P1	1	7.9
C2P1	11	7.8
C2P1	21	7.6
C2P1	31	7.9
C2P1	41	6.8

Table 11: Marshland site macrofossil data group A

Core	Depth (cm)	Charcoal	Unk A	Unk B	Unk C	Unk D	Unk E	Unk F	Unk G	Unk H	Unk I	Unk J	Unk K	Unk L	Unk M	Total Seeds
C3P1	7	0	1	0	0	0	0	1	2	1	0	0	0	0	1	6
C3P1	15	0	0	1	4	0	0	0	0	0	0	0	0	0	0	5
C3P1	17	0	3	0	0	0	0	0	10	0	0	2	0	0	0	15
C3P1	23	0	49	0	0	0	2	5	1	0	0	3	3	1	0	64
C3P1	25	2	200	0	0	0	0	0	0	3	0	3	10	3	0	219
C3P1	31	0	6	0	0	1	1	0	0	0	0	0	0	0	0	8
C3P1	33	0	13	0	0	0	6	1	0	2	2	0	0	0	0	24
C3P1	39	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 12: Marshland site ^{210}Pb and ^{137}Cs data.

Control #	Upper cm	Lower cm	Plot cm	Cs-137 (pCi/kg)	1σ	ΣPb-210 (dpm/g)	1σ	K-40 (pCi/g)	1σ
R1887A	0	2	1	***228***	***32***	***5.15***	***0.48***	***5.63***	***0.58***
R1887B	2	4	3	***171***	***38***	***3.88***	***0.56***	***5.87***	***0.74***
R1887C	4	6	5	209	36	1.90	0.45	5.67	0.67
R1887D	6	8	7	***203***	***42***	***3.36***	***0.57***	***5.74***	***0.77***
R1887E	8	10	9	214	28	1.89	0.39	4.47	0.50
R1887F	10	12	11	287	22	1.66	0.24	6.04	0.41
R1887G	12	14	13	406	36	1.59	0.39	5.48	0.56
R1887H	14	16	15	423	37	1.44	0.41	6.58	0.60
R1887I	16	18	17	272	37	2.51	0.48	6.89	0.70
R1887J	18	20	19	261	27	1.21	0.34	6.23	0.52
R1887K	20	22	21	111	26	1.20	0.41	6.44	0.60
R1887L	22	24	23	162	17	1.38	0.24	6.56	0.44
R1887M	24	26	25	47	39	1.45	0.64	6.81	0.90
R1887N	26	28	27	56	21	1.67	0.37	6.14	0.54

Values in red are from partially filled tubes and include an additional "sample geometry" correction.