Analysis of anthropogenic effects on topsoil throughout the California Polytechnic State University campus in San Luis Obispo

Senior Project

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APPROVAL PAGE

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ABSTRACT

Soils reflect the health of a landscape, and in many cases carry the burden of anthropogenic activity, continually changing in characteristics such as pH, soil texture, soil structure, carbon:nitrogen ratios (C:N), and chemical composition. In a study sampling six different soils on the California Polytechnic State University campus in San Luis Obispo, these five soil characteristics were tested for and the results were determined. Soil samples consist of the top 5-10 cm of soil profiles, with sample sites varying according to degree of human contact; the locations the samples were taken from are as follows: (1) Walters Creek Ranch pasture, which is situated on Highway 1 across from Cuesta College; (2) the wooded area next to the Cal Poly "P"; (3) the footpath/bike path going to and from Cal Poly campus and the Poly Canyon Village student housing development; (4) the pre-dug soil pits on the hillside, adjacent to the "P" (periodically used for soil science and soil morphology courses); (5) the bike path behind the parking structure on Grand Avenue next to the Performing Arts Center; (6) the footpath in the parking lot behind the red brick dormitories.

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INTRODUCTION

The discipline of soil science has been practiced throughout history, but in a more limited context than it is today. Soil scientists tended to work independently or with other like organizations, and there have been problems communicating with other fields, such as politics and economics (Hartemink and McBratney, 2008). However, in the past several decades, soil quality has become a more pressing issue. With the surface of the earth changing more rapidly than ever, soil scientists must communicate and work with people from a wide variety of fields. Attention to soils has become absolutely necessary to the health of the planet, as soils are life's foundation--mythically, historically, and physically.

The number of soil science publications has been increasing yearly. In a study conducted in 2008, researchers found that there is an increase of about 545 soil science publications per year (Hartemink and McBrateny, 2008). Journals that focus specifically on soil science have also gained more ground in recent years, increasing in popularity and impact (being read and referenced more often). A few of these publications are *Journal of Soil Science*, *Geoderma*, *Soil Biology & Biochemistry*, and *Soil Science Society of America Journal* (Hartemink and McBratney, 2008).

Because healthy people are directly linked to healthy soils, it will always be necessary to maintain nutrient-filled, balanced soils and to rejuvenate depleted ones. This project explores the effects of human activity on top soil, on a minor scale. A few characteristics are tested and soils are compared to one another. Because of the small scope of the study and its location on a university campus, the influence of trekking is discussed frequently. Location and land use are considered in the explanation for each sample's qualities.

LITERATURE REVIEW

In an article published in *Geoderma* in December of 2008, called "A soil science renaissance", authors reflect on the recent surge in soil science studies and the relevance of the field in today's rapidly-changing world (Hartemink and McBrateny, 2008). Past barriers to communication in soil sciences, as well as the limited nature of past relationships between it and other fields is noted. Today, these barriers are disintegrating, as care of the environment becomes more of a pressing issue worldwide. The authors highlight revealing statistics, such as the growing number of soil science publications and reference works. In today's environment, soils are a foundational issue that must be addressed when considering matters concerning the future: agriculture, poverty, urban development, tourism, and the health of the world in general.

An article entitled "Environmental impact assessment of mountain tourism in developing regions: A study in Ladakh, Indian Himalaya", published in *Environmental Impact Assessment Review* (Geneletti and Dawa, 2009), explores the environmental repercussions of tourism in the Indian Himalayas. Although several stressors were tested for and analyzed, the article particularly focuses on the soil stresses associated with trekking, which was investigated through field work, data collection, and GIS modeling. The study reveals that several activities have negative effects on the region, as mountain tourism has experienced an increase in popularity in recent years. These influential activities include waste dumping, off-roading, and the use of a few concentrated trails rather than many, less trod ones. The latter is particularly relevant to the present study as several of the soil samples were taken from paths that experience heavy usage.

An article published in *Applied Soil Ecology* (Kissling and Hegetschweller, 2009), entitled "Short-term and long-term effects of human trampling on above-ground vegetation, soil density, soil organic matter and soil microbial processes in suburban beech forests", relates more about the effects of human trekking on soil stress. Specific soil characteristics were investigated, and include factors such as vegetative effects, organic nitrogen content, organic matter content, soil compaction, and soil moisture. Trampling experiments were performed to demonstrate the effects of short-term and long-term trekking. Researchers also investigated the influence of soil compaction on microbial activity. The study reveals that vegetation was strongly affected by trekking, which has further implications as to reduced microbial activity in these areas.

In an intriguing article called “Soil stress distribution related to neutralizing antipersonnel landmines from human locomotion and impact mechanisms”, published in *Journal of Terramechanics* (Kushwaha and Shankhla, 2003), authors investigated activities associated with soil stress that surround the neutralizing of landmines. Tests were conducted using load cells to observe the weight burden necessary to set off a landmine. Results found that though mechanical devices are heavier, people impart loads for a longer duration of time. Furthermore, increased human weight and load duration increase the soil stress, and the likeliness of setting off a landmine. Though the content of the article goes far beyond the scope of the present study, it does illustrate the large impact a human presence has on soils.

Finally, in another related article, called “The influence of different land uses on mineralogical and chemical composition and horizonation of urban soil profiles in Qingdao, China”, published in *Journal of Soil and Sediments* (Norra and Fjer, 2008), the implications of modern land uses on soil quality are explored. The article focuses largely on pollution of the top soil by heavy metals, as well as the poorly-controlled spreading of building rubble, as the study was performed in an urban setting. Though the scope of the present study does not go so deep as to test for chemical pollutants, this is a serious issue in urban areas because of its unavoidable connection to the health of the community. Pollutants are absolutely necessary to consider when research is being conducted on the health of local, or global, soils.

MATERIALS AND METHODS

Soil pH

A simple pH test was conducted using a pH meter, with one part soil (10.0 g) and two parts water (20.0 mL). Prior to testing, soil was sieved through a #10 sieve.

Soil Texture

To analyze soil texture, a soil particle analysis was done using the Bouyoucos Hydrometer method. The first reading for each sample was taken 40 seconds after plunging and the second reading was taken 2 hours after plunging. Time was kept using a stop watch, and care was taken to assure that hydrometers remained undisturbed for the duration of the testing period.

Soil Structure

Soil structure was recorded in the field, based on analysis of structural form, hardness, and aggregate size.

Carbon:Nitrogen Ratios

To determine C:N ratios, a CNS Combustion Analyzer was used. One gram of each sample, ground with a mortar and pestle, was placed in a clean, dry VarioMax graphite crucible and run through the CNS Combustion Analyzer.

RESULTS AND DISCUSSIONS

Sample Locations and Photographs

Figure 1. Walters Creek Ranch

Figure 2. Walters Creek Ranch pasture

Figure 3. Wooded area next to “P”

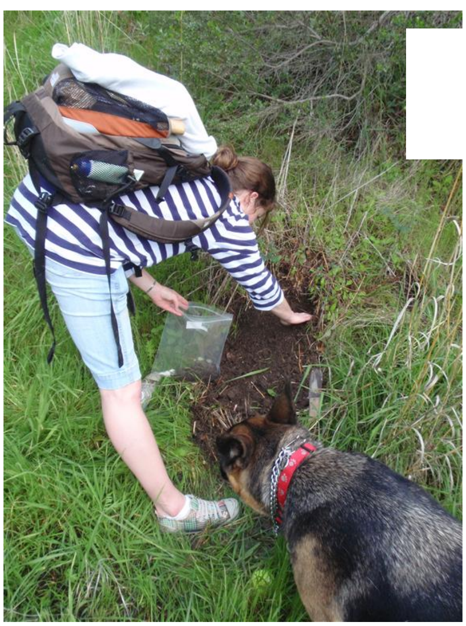

Figure 4. View from site #2

Figure 5. Poly Canyon Village path

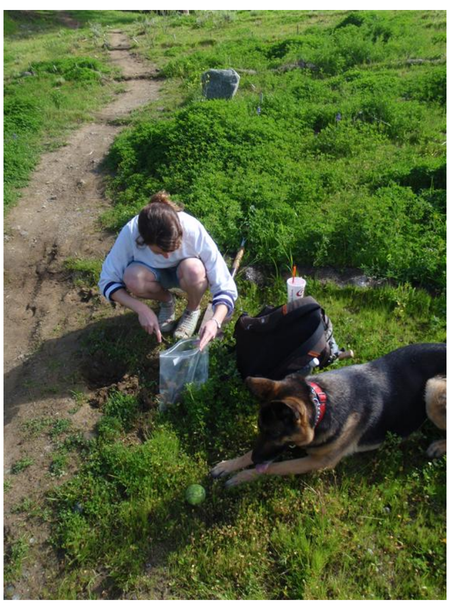

Figure 6. Soil pits

Figure 7. Bike path behind parking structure

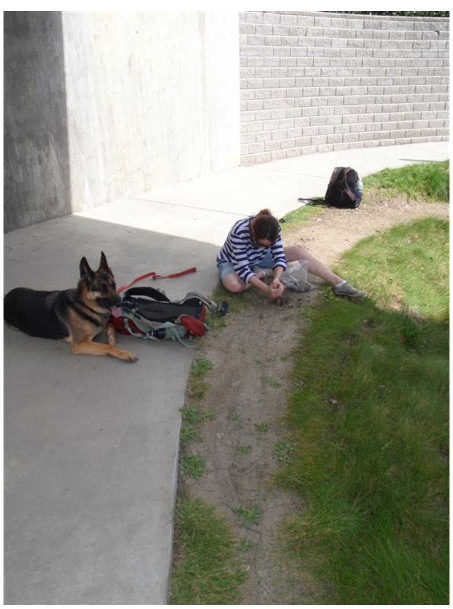

Figure 8. Footpath behind red brick dormitories

Figure 9. Footpath and staircase behind red brick dormitories

Sample 1 lies in a relatively undisturbed cow pasture. Cattle trudge and graze throughout the site, with a network of gates used to guide them into desired pastures, periodically. Sample 2 lies in a wooded area that experiences very little anthropogenic contact. Samples 3, 5, and 6 experience a significant amount of interaction with students every day, year-around, as each constitutes a campus pathway. Finally, sample 4 is more intermediate as students hike to the site to learn the basics of soil testing periodically throughout the school year. It can also be assumed that students other than earth and soil science majors occasionally pass through or visit the site.

Over all, few conclusions could be drawn from the analyses, as only basic parameters were measured. Testing did, however, provide a certain amount of insight into the degree of human influence upon the environment--specifically, the top soil. In general: pH testing showed little correlation to anthropogenic relationships; samples with a greater degree of human contact had soil textures containing higher percentages of sand; soils that experienced more trekking (anthropogenic or otherwise) had stronger, more massive structures; soils derived from paths experienced higher C: N ratios (more carbon).

pH

The pH tests revealed little about human impact. However, as each sample is from a different area, affected by many compounding factors, it is not altogether surprising that pH had little correlation to degree of human activity.

Table 1. pH

Sample #	1	2	3	4	5	6
pH	6.57	7.19	8.12	6.30	7.85	6.42

Soil Texture

The soils particle analysis revealed that the samples were of similar composition, which makes for more comparable test results concerning soil structure and carbon:nitrogen ratios. One of the immediately clear correlations within the results is that the three soils with the greatest amount of human activity are classified as sandy clay loams whereas the three soils without a significant human imprint are classified as clays. This might have to do with construction of paths and the deliberate deposition of sand, or with the unintentional deposition of sand by walking and riding on pathways. Texture differences may be due to natural soil variability, not due to human influences.

Table 2. Soil Particle Analysis

Sample #	1	2	3	4	5	6
% Clay	61.110	43.477	33.584	44.961	33.099	29.465
% Silt	25.395	20.384	21.717	25.005	17.393	19.968
% Sand	13.495	36.139	44.699	30.034	49.508	50.567
Classification	Clay	Clay	Sandy Clay Loam	Clay	Sandy Clay Loam	Sandy Clay Loam

<u>Soil Structure</u>

The soils that experience traffic, whether from humans, bikes, or cattle, tend to have more massive structureless conditions than the natural soils. It is also worth noting the similarities and differences between bike paths and footpaths. Soil sample #5 is used almost solely as a bike path whereas the other two path samples (numbers 3 and 6) are used mainly as footpaths. Though the bike path is denser at the surface, there is less influence to soil structure in the bike path subsoil. Some of the environmental impacts of trekking include soil compaction and erosion (Geneletti and Dawa, 2009). These affects can be observed along the trails from which soil samples were taken (samples 3, 5, and 6). Furthermore, there are biological impacts (not measured in this study) of trekking which include habitat fragmentation and vegetation degradation.

Table 3. Soil Structure

Sample #	1	2	3	4	5	6
Structural Form	Subangular blocky	Subangular blocky	Subangular blocky	Subangular blocky	Subangular blocky	Subangular blocky
Grade/Hard ness	Moderate-dense	Moderate	Moderate-dense	Moderate	Weak-moderate	Massive
Aggregate Size (mm)	2-4 Medium	1-2 Fine	2-3 Medium	1-2 Fine	2-3 Medium	1-2 Fine

<u>Carbon:Nitrogen Ratios</u>

The soil sample areas that had higher C:N ratios (i.e., less nitrogen) were: sample (3), which was collected from the Poly Canyon Village pathway; sample (6), which was collected from the path behind the red brick dormitories; sample (5) which was collected from the bike path next to the Performing Arts Center parking lot. The samples with the lowest C:N ratios (i.e., highest nitrogen contents) were samples samples (4) and (1), which are from the natural environments. These ratios are consistent with expected results. The soils which have experienced the highest degree of human contact—namely in the form of trekking—contain the least amount of nitrogen. Likewise, the soils that have experienced the lowest degree of human contact have lower C:N ratios. In general, higher soil nitrogen content results in healthier vegetative growth.

Table 4. Carbon:Nitrogen (C:N) Ratios

Sample #	1	2	3	4	5	6
C: N Ratio	10.83	14.46	16.79	9.986	22.08	19.78

CONCLUSION

Soil pH and soil texture revealed little in this study concerning anthropogenic influence on soils. There was no controlled relationship between soil texture and site selection in this study. Therefore, even though soil particle analyses showed a difference between those samples with significant human contact and those without, one cannot conclude why more anthropogenically-exposed soils have a greater percentage of sand. Furthermore, if the difference is due to the processes involved in constructing paths, or the accidental deposition of sand from people using the path, this has little to do with the soil quality.

Soil structure appears to be largely influenced by an increased human presence, which may lead to other soil concerns. Biological factors, such as enzyme activity, decrease with trampling and compaction (Kissling and Hegetschweller, 2009). This decrease in biotic activity can also be linked to destruction of vegetative cover, as microbial activity in soils is linked with the presence and health of vegetation above (Kissling and Hegetschweller, 2009). Though humans are not the heaviest of objects passing over the earth's surface, they tend to be one of the largest contributors to compaction because of tendencies for lingering (Kushwaha and Shankhla, 2003). This can be seen in the case of soil sample #5, which was taken from a bike path. Though the soil structure is more compacted on the immediate surface, the grade of soil structure is significantly better than that of the foot paths' subsoil. An individual on a bike may be heavier than a walking individual, but he or she spends significantly less time on one specific piece of ground.

Correlations may also be drawn between carbon:nitrogen (C:N) ratios and the presence of healthy vegetation. Those samples with the lowest C:N ratios (i.e., the most nitrogen) were those derived from locations with abundant vegetative covers.

This study, limited as it is and without controls relative to soil texture, illustrates that humans have a notable influence on the top soils with which they come in contact. It is important that this relationship is monitored closely in any future studies. This is especially necessary in areas where land preservation and soil conservation is vital to the identity of the land and the people on it. However, it is also important that urban land managers monitor soil characteristics, as the anthropogenic influence in cities is far more concentrated than it is in rural areas. Pollutants, improperly disposed waste, and heavy metals are just a few of the concerns that threaten an urban soil and human community. (Norra and Fjer, 2008).

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