The Impacts of Urbanization and Restoration on Soils in Goleta

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Introduction:

The area of the West Campus of UCSB, adjacent to the college town of Isla Vista, California is a unique example of a place that contains soils that are developed on, preserved, and restored, all within extremely close proximity of each other. This takes the form of residential development in Goleta, preservation of the Coal Oil Point Reserve, and the restoration of the North Campus Open Space (NCOS). Prior to its remediation, the NCOS was used as the Ocean Meadows Golf Course, but due to issues of flooding, it posed problems not only for the course, but for the wider community as well (Kettmann, 2013). This led to its eventual shutdown, and a large, ongoing project to restore the area to its original state as an effective wetland ecosystem in order to bring back the environmental benefits that came along with it (Rickard, 2022). By comparing the restored soils to the nearby developed and preserved soils, I hope to answer how urbanization and restoration affect soil characteristics and ecologies in Goleta, CA.

Site Overview Description:

Figure 1: Map of West Campus, Area of Interest from Web Soil Survey.

Due to the current and previous human conditions of development in the West Campus of UCSB, much of the area is made up of newer/disturbed soils such as Entisols. A good proportion of these Entisols found are Xerorthents, which do not have further classifications such as naming of the subgroups or family. In terms of Xerorthents, which are defined as “cut and fill areas” (WSS), the main soil forming factor which drives their presence is human development, which in Goleta’s case comes from the building of housing and other infrastructure such as Stroke Road. This causes compression, erosion, and damage of the topsoil which leads to the stagnation of soil development.

An additional soil that is present in the area of interest are mollisols. These come in the form of “Conception Soils”, which are Fine, smectitic, thermic Xeric Argialbolls. These form due to the mediterranean/xeric, semi-arid climate of the California central coast, along with the presence of grass and its roots which leads to the accumulation of organic matter in the upper horizons of the soil. These soils are primarily found in the preserved Coal Oil Point Reserve area of west campus.

Methods:

This report used data from the Web Soil Survey from the United States Department of Agriculture to obtain much of the information cited in the project, including maps and exported data. Moreover, SoilWeb was used in order to gain additional insights, especially for visual depictions of the data. Additionally, peer reviewed sources were found by querying Google Scholar and the Georef database using terms such as “entisols”, “urbanization and soils”, “North Campus Open Space restoration”, and “mollisol restoration”.

Results:

The urbanization of the Ellwood neighborhoods as well as university housing along Storke road (Figure 1) contributes to degradation of soil health and the alteration of soil characteristics such as bulk density, organic matter, erosion, among others. Specific data from the Web Soil Survey is very limited in the North Campus Open Space restoration, due to much of it being composed of Xerorthents and Aquents (shaded white in Figure 2). However, the UCSB Cheadle Center publishes data on the area, which along with other peer reviewed sources, will be used to fill in the gaps left by the Web Soil Survey.

The soils in the preserved areas are composed of fine sandy loam textures (Web Soil Survey), and mostly contain bulk densities between 1.48 and 1.67 g/cm^3 (Figure 2). Although not available through Web Soil Survey, studies have shown that new urbanization and human activity significantly increases the bulk density of soils compared to undeveloped soils (Scharenbroch et al, 2005) From this, we can infer that the Xerorthents in the restored and developed areas have a higher bulk densities, which negatively impacts plant root penetration, soil aeration, and other indicators of soil health.

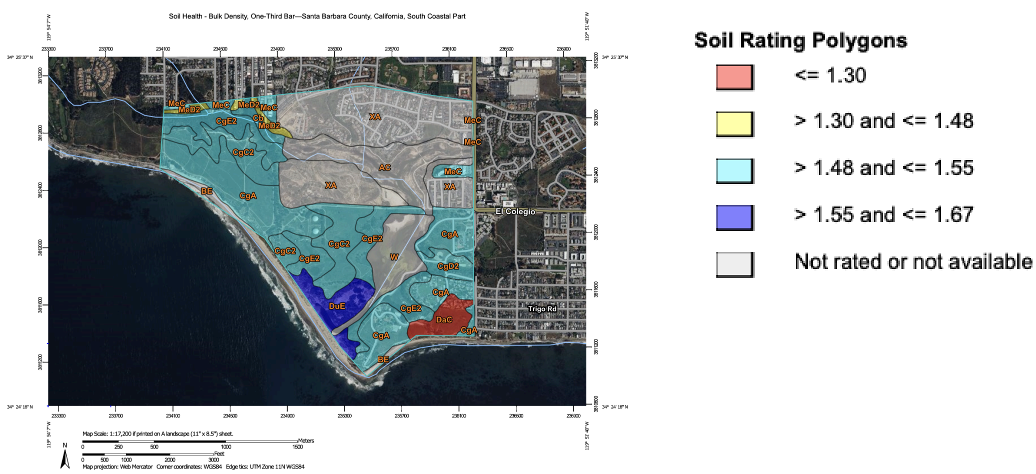

Figure 2: Soil Bulk Density map of West Campus from Web Soil Survey.

Additionally, urbanization catalyzes soil erosion, compaction, and the stunting of soil development. Generally, human development increases erosion, with “anthropogenic soil erosion proceed[ing] rapidly, significantly faster than soil formation rates” (Dror, Ishai, et al, 2021). These impacts homogenize profile composition in urban soils, impacting carbon sequestration and particle texture, decreasing their ecological functions (Dustin L Herrmann et al, 2020). Essentially, humans destroy soil faster than it can form, leading to soil losses which is shown in Goleta, with the gray shaded areas in figure 2 experiencing soil loss marked by cut and fill Xerorthents.

Moreover, the beginning processes of restoration in Goleta caused short term harm to the soils as well. When restoration first began, over 350,000 cubic yards of soil were removed from the project's area (Rickard, 2022). Naturally, this disturbance led to compaction and removal of soil layers, impacting porosity, aeration, and water holding capacity (Web Soil Survey). This restarted the clock on soil forming processes, creating Xerorthents, being younger and less developed soils in the area.

Although initially damaging, we see that the restoration process has caused the improvement of soil conditions over time, especially in terms of organic factors. Studies in other areas of North America found that through restoration practices, soil organic carbon in Mollisols can be restored to levels effective for vegetation growth. (Xu et al, 2020). In Goleta specifically, figure 4 shows that several years after the restoration, vegetation and species diversity has increased in all habitats throughout the restored area, which has led to increased soil organic matter comparable to the preserved areas shown in figure 3. Moreover, invertebrate species found in both the soil and lagoon areas of the restoration project " have equivalent, if not slightly greater species richness and evenness" (Rickard, 2022), demonstrating the effectiveness of restoration in improving soil health.

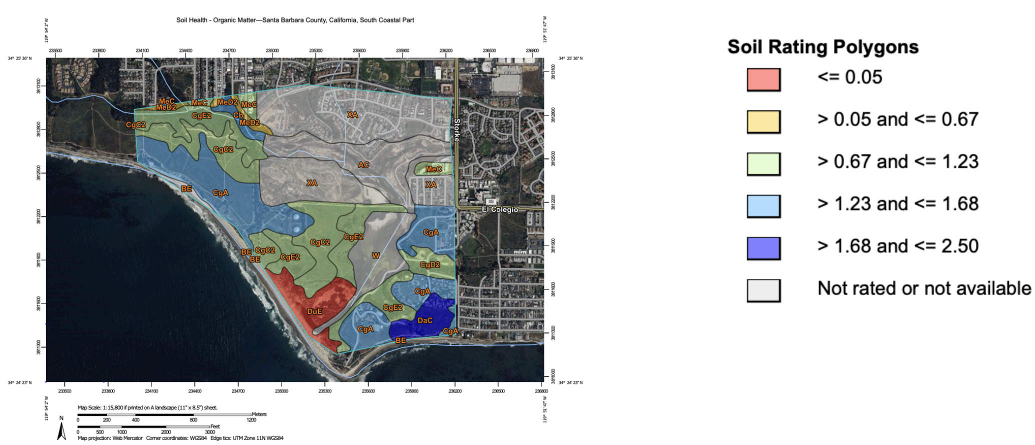

Figure 3: Soil organic matter map of West Campus from Web Soil Survey

Table 3. Comparison of vegetation monitoring data with proposed minimum success criteria for target habitats/plant communities from the Restoration Plan for the North Campus Open Space project. The proposed minimum criteria are in italicized font in the five columns in the middle of the table and the monitoring data is in the columns on the right-hand side of the table. Table cells that are bold and green indicate monitoring data that meets or exceeds the corresponding criteria for each year.

	Proposed Minimum Criteria					Monitoring Data				
	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	2018	2019	2020	2021	2022
Native Perennial Grassland										
% Total cover	*35*	*45*	*60*	*70*	*80*	12	24	58	58	77
% Native Relative	*50*	***60***	***70***	*70*	*70*	19	**65**	**79**	51	51
% Invasive Relative	***<5***	***<5***	***<5***	***<5***	***<5***	**0**	**0**	**0**	**0**	**0**
Diversity (Native Species)	***3***	***4***	***6***	***7***	***7***	**8**	**18**	**21**	**25**	**23**
Peripheral Upland (Mixed Grassland/Shrubland)										
% Total cover	*35*	*45*	***60***	***70***	*80*	24	42	**66**	**71**	50
% Native Relative	*50*	***60***	*70*	*70*	***70***	43	**61**	50	39	**70**
% Invasive Relative	***<5***	***<5***	***<5***	***<5***	*<5*	**0**	**0**	**0**	**0**	**0**
Diversity (Native Species)	***3***	***4***	***6***	***7***	***7***	**15**	**40**	**36**	**35**	**31**
Salt Marsh										
% Total cover	*30*	***40***	***60***	*70*	***70***	15	**50**	**62**	68	**73**
% Native Relative	***70***	***80***	***80***	***80***	*90*	**94**	**88**	**87**	**91**	88
% Invasive Relative	***<5***	***<5***	***<5***	***<5***	***<5***	**0**	**0**	**0**	**0**	**0**
Diversity (Native Species)	***4***	***6***	***7***	***7***	***8***	**11**	**15**	**30**	**14**	**17**
Transitional/High Salt Marsh										
% Total cover	*30*	***40***	***50***	***60***	***65***	24	**46**	**74**	**72**	**92**
% Native Relative	***50***	***60***	***65***	***70***	***80***	**55**	**86**	**79**	**80**	**77**
% Invasive Relative	***<5***	***<5***	***<5***	***<5***	***<5***	**0**	**0**	**0**	**0**	**0**
Diversity (Native Species)	***8***	***8***	***10***	***12***	***15***	**20**	**22**	**28**	**20**	**25**
Fresh/Brackish Marsh (Seasonal Pond)										
% Total cover	*50*	*50*	*60*	*70*	***80***	8	20	43	39	**96**
% Native Relative	***70***	***70***	***70***	***80***	***80***	**99**	**78**	**99**	**98**	**91**
% Invasive Relative	***<5***	***<5***	***<5***	***<5***	***<5***	**0**	**0**	**0**	**0**	**0**
Diversity (Native Species)	*7*	***7***	***10***	***12***	***14***	6	**7**	**17**	**16**	**16**

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Figure 4: Vegetation monitoring data of the North Campus Open Space 2018-2022 (Rickard, 2022)

Conclusion

Urbanization and human development in Goleta (and generally) relies on soil as an engineering medium for the foundations of our homes, roads, and infrastructure. This reliance leads to overall soil loss and degradation of soil health by reducing soil organic matter, increasing erosion, and compaction of the soil which increases bulk density, affecting aeration and plant growth. However, environmental restoration works have proven successful in Goleta at remedying these effects by returning the previously damaged area to its original state and allowing for vegetation and other processes to improve soil characteristics such as organic matter richness and other chemical properties to levels comparable to preserved areas. These findings answered my research question on the effects of urbanization and restoration on soil characteristics.

To revise my initial motivating question, I would have chosen a more specific aspect of soil health that I would research, as soil health as a whole is very broad and difficult to quantify based on only a few characteristics. Additionally to answer my question more thoroughly, I would need to collect more specific data on Xerorthents, which currently has less information available on Web Soil Survey compared to other soil types.

References

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