Effects of soil quality on the growth and abundance of *Artemisia californica* and other CSS plants

Annabel Long[1], Dr. Lisa Stratton[1]

[1]UC Santa Barbara

UC SANTA BARBARA
Cheadle Center for Biodiversity & Ecological Restoration

Introduction

- Coastal sage scrub (CSS) ecosystems are home to hundreds of bird and butterfly species. Less than 10% remains in California [1].
- CSS plants struggle at the Audubon Overlook of North Campus Open Space, but they thrive on South Parcel.
- Soil bulk density is a measure of soil compaction [2].
- In clay soils, soil bulk densities less than 1.10 g/cm^3 are ideal while soil bulk densities more than 1.47 g/cm^3 inhibit root growth. In sandy soils, soil bulk densities less than 1.60 g/cm^3 are ideal while soil bulk densities more than 1.80 g/cm^3 inhibit root growth [3].
- California sagebrush (*Artemisia californica*) is a foundation species that grows best in sandy, well-draining soils [4, 5, 6] (Figure 1).
- In 2021, UCSB researchers found a weak negative correlation between soil bulk density and California sagebrush longest branch length in Audubon Overlook ($R^2 = 0.161$, r = -0.413) [7]. Increased soil bulk density was associated with smaller shrubs.
- **Hypothesis 1:** California sagebrush responds negatively to high soil bulk density in clay soils but not in sandy soils.
- **Hypothesis 2:** California sagebrush are larger and CSS plants are more abundant on South Parcel because the soil is sandier.

Figure 1: Living California sagebrush (left) and dead California sagebrush (right) at the Audubon Overlook

Methods

- We revisited 70 Audubon Overlook locations where soil bulk density was sampled in 2021 with the soil clod method [7]. We identified 10 locations on South Parcel and measured soil bulk density using the core method [8].
- We assessed the vigor of and measured the dimensions of the California sagebrush closest to each location (Figure 2).
- We counted all California sagebrush and all living *Baccharis pilularis*, *Encelia californica*, *Elymus condensatus*, *Eriophyllum confertiflorum*, and *Salvia leucophylla* in a 3 meter radius.
- We measured soil texture for 6 Audubon Overlook locations and 10 South Parcel locations using the soil texture by feel protocol [9].
- We ran statistical tests in R.

Figure 2: Annabel measures the height of a California sagebrush

Results

The mean soil bulk density is 1.58 g/cm^3 at the Audubon Overlook and 1.33 g/cm^3 on South Parcel (Figure 3). There is no significant difference in California sagebrush volume at the Audubon Overlook for soil bulk densities greater than 1.47 g/cm^3 and less than 1.47 g/cm^3. The median volume of California sagebrush is 0.55 m^3 at the Audubon Overlook and 4.68 m^3 on South Parcel (Figure 4). The differences between sites are ecologically and statistically significant (p-value < 0.05).

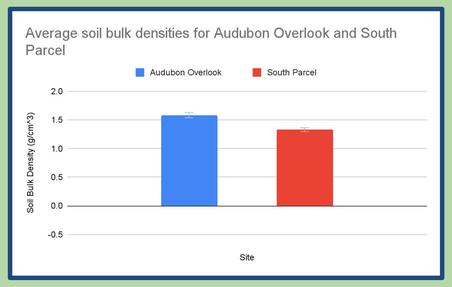

Figure 3: Average soil bulk densities for Audubon Overlook and South Parcel

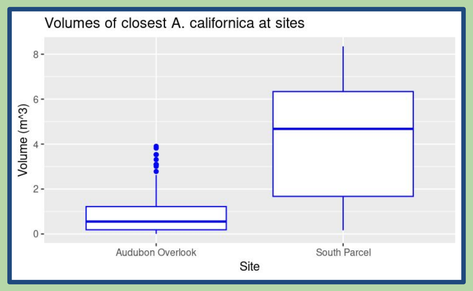

Figure 4: Volumes of closest *A. californica* at sites

The median number of mature California sagebrush within 3 meters of a location is 0.00 plants at the Audubon Overlook and 2.50 plants on South Parcel (Figure 5). Including California sagebrush, the median number of living CSS plants in a 3 meter radius is 4.00 plants for the Audubon Overlook and 9.00 plants for South Parcel (Figure 6). Both differences are statistically significant (p-value < 0.05).

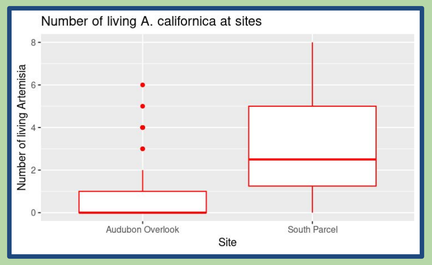

Figure 5: Number of living *A. californica* at sites

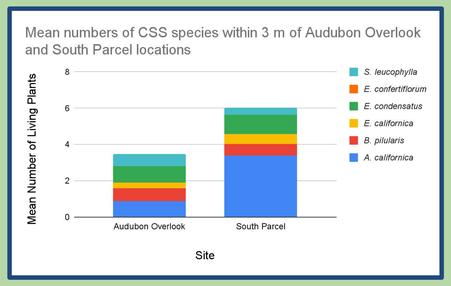

Figure 6: Mean number of CSS plants at sites

Figure 6 shows means to display the distribution of different plant species. California sagebrush volunteer seedlings were not included in the graphs above for ease of visualization. All Audubon Overlook locations have 0.00 volunteer seedlings in a 3 meter radius while the South Parcel locations have an average of 59.30 seedlings in a 3 meter radius (see Figure 8).

The most common soil texture at the Audubon Overlook is sandy clay while the most common soil texture at South Parcel is loamy sand. Based on the soil texture triangle [9], the soils in South Parcel tend to be sandier, and the clay content is about 4 times higher at the Audubon Overlook (Figure 7).

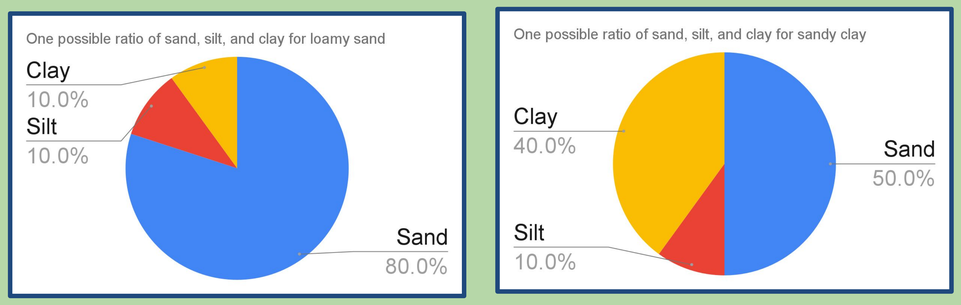

Figure 7: Possible ratios of sand, silt, and clay for loamy sand and sandy clay

Discussion

- The mean soil bulk density at the Audubon Overlook is 1.44 times higher than the maximum ideal soil bulk density for clay soil.
- The mean soil bulk density on South Parcel falls in the ideal range for sandy soil.
- California sagebrush tend to be larger and CSS plants tend to be more abundant on South Parcel.
- The data indicate that soil texture interacts strongly with soil bulk density and the combination has an impact on CSS growth and survivorship.
- The differences in CSS plant size and abundance may occur because soil bulk densities are over the ideal range for clay soils at the Audubon Overlook but within the ideal range for sandy soils on South Parcel.
- More research is needed to determine if soil bulk density combined with sand content or something else is the main factor determining CSS plant size and abundance. Other possible factors include soil saturation, soil pathogens, soil nutrient levels, and reinvasion by invasive species [10].
- More research is needed on why volunteer seedlings grow on South Parcel but not at the Audubon Overlook (Figure 8).

Figure 8: California sagebrush volunteer seedlings in South Parcel

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Acknowledgements

Funding was provided by the EEMB URS Planning Committee. Special thanks to Dr. Lisa Stratton, Dr. Thomas Even, and Dr. Gail Drus for data analysis, Dr. Jack Miller for help with R, Wayne Chapman and Darwin Richardson for materials, Zephyr Moss, Jacob Pike, and Kellen Pierce for soil bulk density data, Jeremiah Bender for photos, and the EEMB URS Planning Committee for feedback on the abstract.