A spark of life:
California coastal sage scrub regeneration post-Woolsey Fire

Native annual vegetation colonizes the burnt slopes in Cheseboro Canyon 3.23.19

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Introduction

Despite California coastal sage scrub (CSS)'s resilience to millennia of human interactions, the loss of 90% of its historic range has left the remaining islands of biodiversity sensitive to disturbance (Engelberg et al. 2013). As a plant community in which reproduction is both sensitive and reliant upon factors such as fire and precipitation, alterations in intensity and frequency may retard recovery of CSS species in favor of introduced pioneer species (Syphard et al. 2019; Keeley, Fotheringham, and Baer-Keeley 2005). Long-term stewardship of this ecosystem requires an understanding of the driving forces behind its regenerative processes.

Through his 2006 thesis, Scott Eckardt examines native CSS and exotic species composition in the Santa Monica Mountains. He builds upon past studies that used historic aerial photos to observe changing CSS boundaries, by adding a focus on the impacts of wildfire intervals to vegetation population dynamics (Eckardt 2006). The transect sites were selected as transition zones between historic burns and CSS boundaries observed in aerial photos. Where past studies focused on the physical range change, Eckardt's purpose was to address the significance of fire frequency and return intervals as drivers to the expansion or decline of CSS. But because fire in addition to other driving forces of ecological succession occurs over decades, identifying patterns and correlations requires multi-generational studies.

Eckardt's thesis was followed by undergraduate documentation of species in 2017 and pre-fire 2018, which recorded species richness and percent cover at the same research site (Figure 1). The 2018 Woolsey fire and subsequent high precipitation provided an opportunity to observe individual CSS and exotic species behaviors at early stages of succession and changing resource availability (Guo 2017). The purpose of our research in March 2019 is to re-visit and document species composition in Cheseboro Canyon and answer the following *research questions:*

- How will 2019 species data compare to those from 2005, 2017, and 2018 studies?
- What is the overall species richness of each transect site?
- What proportions of native and exotic species occur post-Woolsey Fire, 2019?

Site Description:

Cheseboro Canyon is a public open space at the northern expanse of the Santa Monica Mountains National Recreation Area and is currently managed by the National Park Service. Local management of the landscape changed over the past 200 years from indigenous burning practices to Euro-American livestock grazing, which ceased after 1985 (Eckardt 2006). Local plant communities are characterized by CSS, riparian woodland, grassland, and valley oak (*Quercus lobata*) savanna (Figure 2a). The area's topography contains hills and valleys, with maximum elevation of 150m and slope angles of over 70% (Eckardt 2006). With the exception of its connection to the Simi Hills, Cheseboro Canyon is fragmented from other open space by suburban settlement, the 101 Freeway to the south, and Calabasas Landfill to the east.

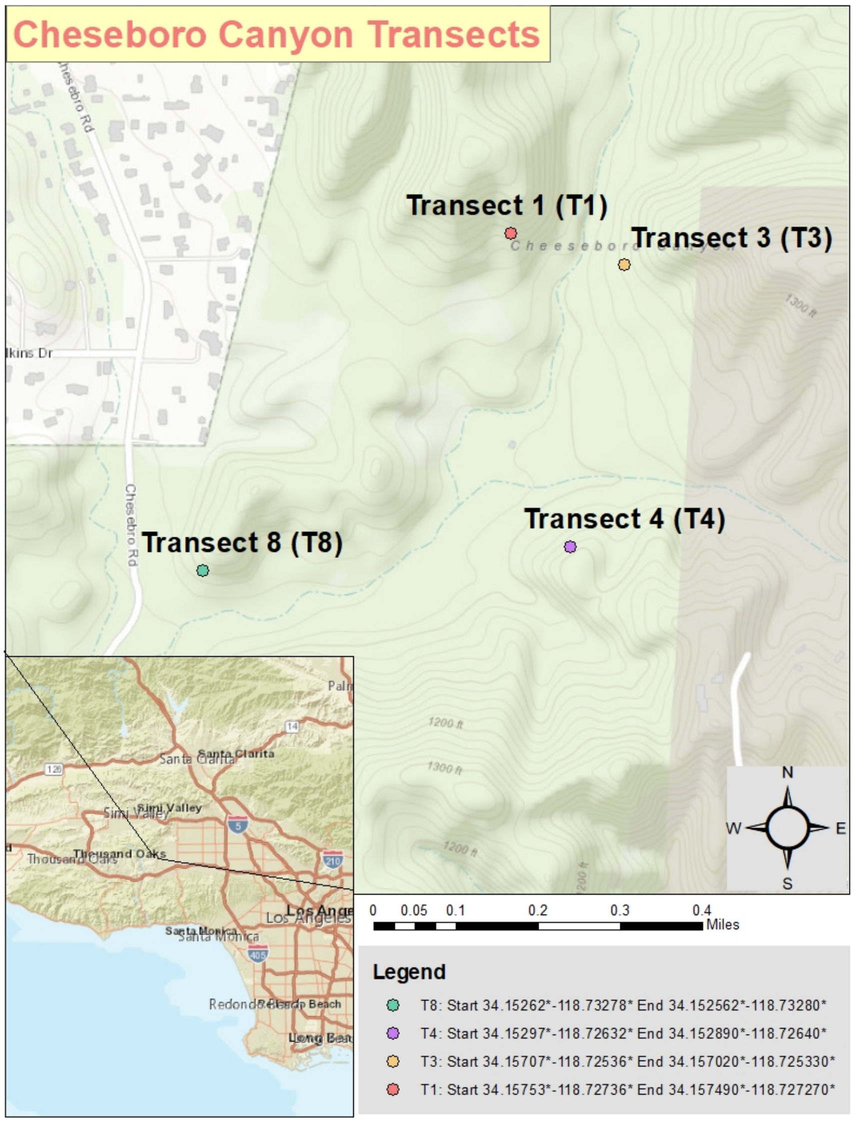


Figure 1. Research site Cheseboro and Palo Comando Canyon, Agoura Hills, Los Angeles County, California

Figure 2a: (Above) Diverse topography and plant communities of study sites.

Figure 2b: (Above) Quadrat and belt transect methods.

Methodology:

Our research team consisted of mixed undergraduate and graduate students from the CSULB Geography 442 and 640 spring 2019 classes. Fieldwork involved revisiting 4 of Eckardt's 8 original transects (T1,T3,T4,T8) and used a series of 8 continuous 1x1 meter quadrats for each 8 meter long transects (Figure 2b). To locate each transect, we used a Garmin GPS device to locate starting coordinates and recorded our start and end points. Within the quadrat, we estimated the percent coverage of each individual species divided into four categories of native CSS, native annual and herbaceous perennials, exotic species focusing on forbs, and exotic grass species. Species abundance and percent coverage were quantified using belt transect and quadrats, in addition to recording the specific number of observable CSS woody seedlings found within each transect. Native and exotic vegetation were identified using Calfora.org database, with bag samples of unfamiliar plants collected for further proofing. Soil qualities and burn intensity were observed and documented qualitatively.

To compare multiple biodiversity measures of the site, we translated our percent coverage data to relative abundances per transect as well as total species richness. Species diversity was calculated in multiple forms. Using Microsoft Excel, we calculated the Shannon's Index (Appendix 1a), Shannon's Equitability, Simpson's Index, Simpson's Inverse Diversity, Simpson's Reciprocal Index, Simpson's Equitability, and Simpson's Diversity index (Appendix 1b). The Shannon's Diversity Index calculates a general evenness of biomass in a species, which relates more to our percent coverage as oppose to the specific count of biodiversity in species richness. Within the Simpson's Index, the closer the index is to 0, the higher the biodiversity and closer to 1, the less. Simpson's Inverse is the opposite where the closer to 1 is the highest diversity and 0 the least. The table and charts are based on the total species richness and percent coverage of each species groupings.

Results:

There were notable differences between March 2019 data and that of past research with marked heterogeneity of specific CSS and exotic species. The 2019 transects showed an increase in overall species diversity (Figure 4a table) including native annuals and herbaceous perennials, but a decrease in observable CSS (Figure 4b pie charts). Common CSS species and annuals species found at the site in 2019 include are listed in Appendix 2a and categorizes species into 1) native CSS species, 2) native herbaceous and annuals vegetation, 3) exotic annuals and 4) grasses. No native grasses were identified within the quadrat sampling.

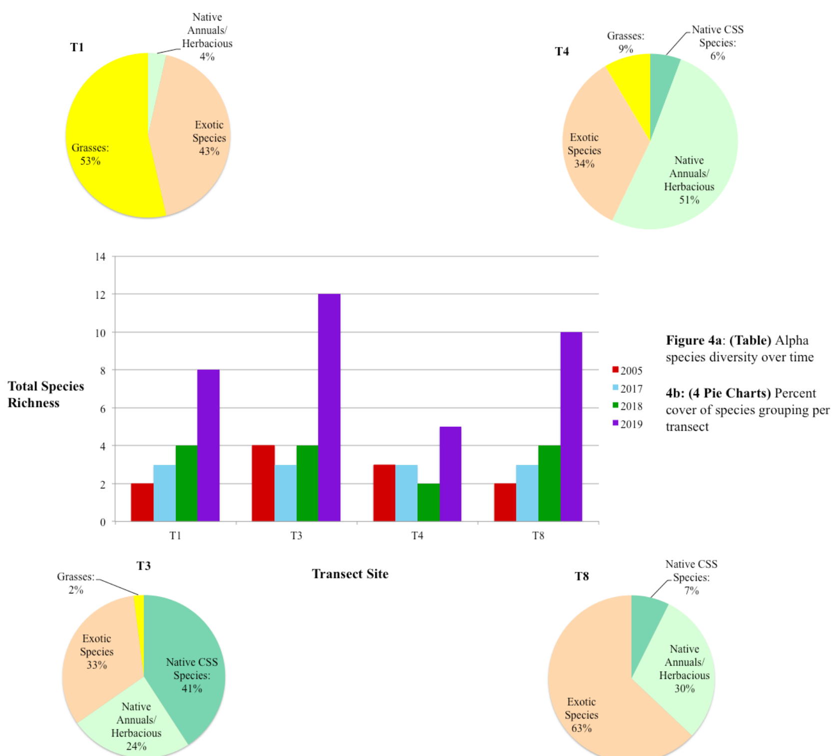
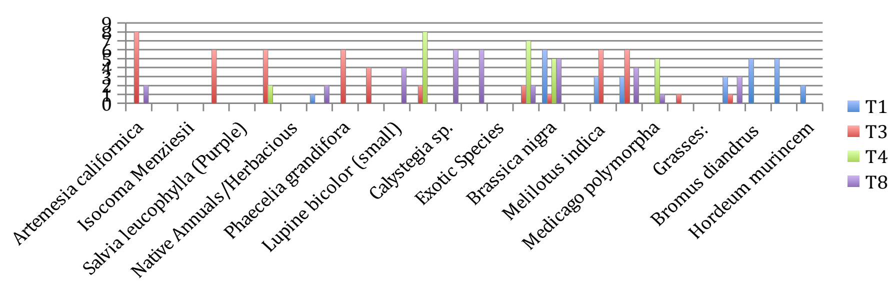


Figure 4a: **(Table)** Alpha species diversity over time

4b: (4 Pie Charts) Percent cover of species grouping per transect

Figure 5: (Table) Species abundance per transect, spring samples



The highest total species diversity of CSS occurred in T3, with comparable numbers of native annuals, herbaceous perennials, and exotic species. The second most species rich was T8, containing high frequency of native annuals and herbaceous perennials in addition to diverse exotic herbaceous plants. T4 contained the least species diversity, yet contained a mix of all categories. Transect 1 was dominated by exotic vegetation, and contained no noticeable *Eriogonum* sp., which in the previous season dominated the site. CSS woody species such as *Artemesia californica., Malacothamnus sp.,* and *Salvia sp*. were absent from T1 transects in 2019 compared to previous years data (Appendix 2b).

The bar graph comparing the total species richness between 2005, 2017, 2018, and 2019 data was developed by comparing total species richness of each transect per year (Figure 4a). The pie charts explore more in depth the species classifications of each of the 2019 bars of total species richness, which can be divided into CSS, numbers native annuals, herbaceous perennials, and exotic species (Figure 4b).

Figure 3a: *Salvia sp.* germination from seed common in open areas and adjacent to annual vegetation.

Figure 3b: *Artemisia californica* regeneration from stumps was common close to the valley bottom and decreased with elevation.

Discussion:

Our team observed an increase in total species richness dominated by early succession native and exotic annuals and herbaceous perennials. Although there was a decrease in CSS richness along transects, high seedling density and stump regeneration outside our samplings reflects greater CSS regeneration and successional potential. Closer to the valley bottom, Artemisia californica was sprouting from charred stumps (figure 3b), although higher elevation sample sites contained less re-sprouting. As our spring 2019 sampling occurred within a high precipitation wet season compared to previous 2005 winter season, spring 2017, which occurred during a drought, and 2018 dry season. 2019 dry season research is recommended to see if the observed CSS seedlings along transect continue to increase cover with annual vegetation dieback.

The assumption of CSS ecological succession implies that native woody species may outcompete short-rooted annual vegetation over time, especially with the presence of key facilitator species (Brennan, Laris, and Rodgriue 2018). Although overall coverage of CSS may increase over time, the number of seedlings and total species richness will likely reduce due to increased competition over resources (Guo 2017). Barely covering .01% of quadrat samples, the high presence of CSS seedlings may support Syphard, Brennan, and Keeley (2019)'s suggestion that available moisture plays a significant role in the regeneration of CSS. The high number of native species germination suggests that adequate precipitation after fire disturbance is a significant driver of CSS regeneration (Figure 3a). Although aerial photography served as a component of past research (Eckardt 2006), our fieldwork provided the opportunity to identify individual species and observe an essential point of seedling germination, which may be undetectable with current remote sensing instruments. The combination of UAV imagery in addition to field proofing during different periods in relation to both fire disturbance and precipitation may be better able to observe and predict changes in CSS boundaries.

Conclusion:

Eckardt's research focus on fire disturbance began a process of correlating biogeographic spatial changes to underlying ecological drivers at Cheseboro Canyon. Monitoring species dynamics following these successional thresholds illuminate limiting resources that drive spatial changes of individual CSS species, annual natives, and exotic species over time (Guo 2017). In addition to the focus on fire disturbance, additional research that examines the significance of moisture availability, soil processes, seed source proximity, and mycorrhizal relationships to CSS regeneration (Engelberg et al. 2013). The long-term case study of both drivers and their biogeographic impacts at Cheseboro Canyon provides an opportunity to understand the interacting factors that affect the successional trajectory of CSS plant communities and can better inform the human stewardship of these increasingly fragmented, yet resilient plant communities.

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References:

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Appendix 1: Methods Formulas

1a: Shannon's Diversity Index

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

1b: Simpson's Diversity Index

$$D = \sum_{i=1}^{S} p_i^2.$$

(http://web.csulb.edu/~rodrigue/geog442/labs/antdiversity.html)

Appendix 2:
Species Diversity Index
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5/4/19

Native CSS Species	T1	T3	T4	T8	T1		T3		T4		T8	
Artemesia californica	0.00	0.16	0.00	0.06		0.00	-0.2958986	0.026655560183257		0.00	-0.1635543	0.00326530612244898
Eriogonum cinereum	0.00	0.00	0.00	0.00		0.00		0.000000000000000		0.00		0.00000000000000000
Isocoma Menziesii	0.00	0.00	0.00	0.00		0.00		0.000000000000000		0.00		0.00000000000000000
Malacothamnus fasciculatus	0.00	0.12	0.00	0.00		0.00	-0.2571503	0.014993752603082		0.00		0.00000000000000000
Salvia leucophylla (Purple)	0.00	0.00	0.00	0.00		0.00		0.000000000000000		0.00		0.00000000000000000
Salvia mellifera (Black)	0.00	0.12	0.07	0.00		0.00	-0.2571503	0.014993752603082	-0.1927918	0.01		0.00000000000000000
Native Annuals/Herbacious						0.00		0.000000000000000		0.00		0.00000000000000000
Phaecelia cicutaria	0.04	0.00	0.00	0.06	-0.1190073	0.00		0.000000000000000		0.00	-0.1635543	0.00326530612244898
Phaecelia grandifora	0.00	0.12	0.00	0.00		0.00	-0.2571503	0.014993752603082		0.00		0.00000000000000000
Acmispon maritimus	0.00	0.08	0.00	0.00		0.00	-0.2045327	0.006663890045814		0.00		0.00000000000000000
Lupine bicolor (small)	0.00	0.00	0.00	0.11		0.00		0.000000000000000		0.00	-0.2478919	0.01306122448979590
Lupine succulentus (Big)	0.00	0.04	0.30	0.00		0.00	-0.1305581	0.001665972511454	-0.3604134	0.09		0.00000000000000000
Calystegia sp.	0.00	0.00	0.00	0.17		0.00		0.000000000000000		0.00	-0.3023295	0.02938775510204080
Camissoniopsis micrantha	0.00	0.00	0.00	0.17		0.00		0.000000000000000		0.00	-0.3023295	0.02938775510204080
Exotic Species						0.00		0.000000000000000		0.00		0.00000000000000000
Erodium circutarium	0.00	0.04	0.26	0.06		0.00	-0.1305581	0.001665972511454	-0.349981	0.07	-0.1635543	0.00326530612244898
Brassica nigra	0.21	0.02	0.19	0.14	-0.3300954	0.05	-0.0794249	0.000416493127863	-0.3122961	0.03	-0.2779872	0.02040816326530610
Marrubium vulgare	0.00	0.00	0.00	0.00		0.00		0.000000000000000		0.00		0.00000000000000000
Melilotus indica	0.11	0.12	0.00	0.00	-0.2393135	0.01	-0.2571503	0.014993752603082		0.00		0.00000000000000000
Centaurea melitensis	0.11	0.12	0.00	0.11	-0.2393135	0.01	-0.2571503	0.014993752603082		0.00	-0.2478919	0.01306122448979590
Medicago polymorpha	0.00	0.00	0.19	0.03		0.00		0.000000000000000	-0.3122961	0.03	-0.1015814	0.00081632653061225
Centaurea solstitialis	0.00	0.02	0.00	0.00		0.00	-0.0794249	0.000416493127863		0.00		0.00000000000000000
Grasses:						0.00		0.000000000000000		0.00		0.00000000000000000
Poa annua	0.11	0.02	0.00	0.09	-0.2393135	0.01	-0.0794249	0.000416493127863		0.00	-0.2105774	0.00734693877551020
Bromus diandrus	0.18	0.00	0.00	0.00	-0.3076369	0.03		0.000000000000000		0.00		0.00000000000000000
Bromus maditensis	0.18	0.00	0.00	0.00	-0.3076369	0.03		0.000000000000000		0.00		0.00000000000000000
Hordeum murincem	0.07	0.00	0.00	0.00	-0.1885041	0.01		0.000000000000000		0.00		0.00000000000000000
Sum	0.75	1	1	1								
Species Richness	22	22	22	22								
Shannon's Index (H)					1.97082091		2.28557371		1.52777846		2.18125155	
Shannon's Maximum H (Hmax)					3.09104245		3.09104245		3.09104245		3.09104245	
Shannon's Equitability (EH)					0.63759102		0.73941842		0.49425994		0.70566858	
Simpson's Index (D)						0.15		0.112869637650979		0.23		0.12326530612244900
Simpson's Inverse Diversity						0.85		0.887130362349021		0.77		0.87673469387755100
Simpson's Reciprocal Index						6.6440678		8.859778598		4.36526946		8.112582781
Simpson's Equitability (ED)						0.30200308		0.402717209		0.19842134		0.368753763

Appendix 3: Species Diversity Indexes for 2005, 2017, 2018 samples

#NAME?						
Artemisia californica	n					
Artemisia dracunculus	n					

(http://web.csulb.edu/~rodrigue/geog330/)