2024 RESTORATION & ECOLOGICAL MONITORING PLAN FOR SAGE HILL AT UCLA

AUTHORS

Advisor:
Andrew Kleinhesselink

Prepared for
the Institute of the Environment & Sustainability
at the University of California, Los Angeles
&
Andrew Kleinhesselink
Restoration Ecologist and Managing Director of Sage Hill at UCLA

Bec Chenoweth
Data Manager
Kolby Emison
Communication Manager
Jacqueline Gonzalez Hurtado
Web Content Manager
Isaac Law
GIS/Field Data Manager
Angela Saruncharti nonth
Co-Manager
Sarah Schmitt
Lead Editor
Emma Strassner
Co-Manager

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Indigenous Land Acknowledgement

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INTRODUCTION

Overview

This document contains the entire restoration and monitoring plan for Sage Hill, located at UCLA's campus. This project focused on developing this plan through the use of field and research methods throughout the 2023-2024 academic year. We began with an initial literature review before moving on to multiple methods of field work. We then created our restoration guidelines, as well as a GIS Story Map (found in Appendix F) and a species identification guide (found in Appendix G).

Background

Sage Hill is a 3.5-acre natural area in the northwest corner of UCLA campus, wedged between Bellagio Dr. and Sunset Blvd. Despite its small acreage, the landscape supports over 100 native plant, mammal, insect, and avian species. Though it has endured constant anthropogenic disturbance and encroachment from invasive species, it remains one of the last pieces of native habitat in the West Los Angeles area. It serves as a place for students to relax, for classes to take place, and for research to be conducted. The site was significantly disturbed by the clearing of native plants in 1962 (McKell et al., 1966). This event, along with the introduction of non native vegetation, has resulted in habitat and biodiversity loss. Certain invasive species require more equipment and planning for their removal, such as ornamental trees, resulting in restoration efforts with varied degrees of success over the years. Although there is documentation of the species in the site, a greater understanding of the layout of the present vegetation and fauna, as well as the topography of the site, would aid in the creation of a holistic restoration effort and monitoring plan.

Ecological History of Sage Hill

Prior to 1960, UCLA's campus looked tremendously different to what it looks like today. Construction of the UCLA campus began in 1927 with the building of Powell Library, Royce Hall and Janss Steps. Over time the UCLA campus has expanded outward and to the west. In the late fifties there were still large plots of open land located on UCLA's campus, with the northwest corner of campus, known as "faculty hill", being largely undeveloped until the late 1950's. From the 1950's to 1970's, faculty hill was developed with the construction of many student dormitories and Sunset Canyon Recreation Center. By the 1970's the only undeveloped area left was the steep west facing slope below parking lot 11 and above Veteran Ave. This place was not officially recognized on campus maps but was given the name "Sage Hill" by Geography Professor Dr. Hartmut Walter (Gillespie and Longcore, personal communication).

In relation to the types of vegetation that were present on campus before 1960, coastal sage scrub was prominent then and continues to be a big part of Sage Hill today. It has been noted that "prior to the construction of the UCLA West Terrace and east arroyo, the area was occupied by coastal sage scrub" (Mattoni et al., 1997). When a survey of the area was done during UCLA's early

years, the site “was characterized by a fairly continuous ground cover of small bushy shrubs with a “few taller shrubs, primarily laurel sumac, scattered among the smaller ones” (Mattoni et al., 1997). Prior to large-scale modification of the area, “twenty-three species of shrubs which dominated the coastal sage scrub association are as follows: California sagebrush, mule fat, Jimson weed, bush sunflower, white buckwheat, California buckwheat, chaparral bedstraw, Nuttall bedstraw, matchweed, Palmer goldenbrush, southern honeysuckle, deerweed, bush mallow, bush monkeyflower, tree tobacco, prickly pear cactus, fuchsia-flowered gooseberry, laurel sumac, white sage, purple sage, black sage, chaparral yucca, and California fuchsia” (Vogel, 1968). In addition to these plants, other grasses were believed to be on the site prior to construction including “four species of brome, Bermuda grass, hairy crabgrass, watergrass, golden top, Italian ryegrass, annual bluegrass, and beard grass” (Vogel, 1968). In 1996, Sage Hill as we know it today was surveyed by Dr. Travis Longcore and students in the UCLA Geography department (Mattoni et al. 1997). They described three different areas:“area one was dominated by giant ryegrass, California sagebrush, and California sunflower. Area two was dominated by coastal sagebrush and area three was dominated by black sage, California sunflower and giant rye grass” (Mattoni et al., 1997). The report concluded that, “despite the number and variety of exotic species present on the site, it [Sage Hill] still remains the only location on the UCLA campus with vegetation representative of coastal sage scrub” (Mattoni et al., 1997). When they compared data from 1997 to the biodiversity documented by Mary Vogel in 1968, Longcore and Rich (1998) concluded that only half of the native plant species present before 1960 still remained at Sage Hill in the late 1990’s. Since then, even more species have likely been lost from this habitat fragment, underscoring the need for restoration today to conserve what remains and reintroduce some of the lost biodiversity at the site.

ECOLOGICAL MONITORING

ECOLOGIOCAL MONITORING PLAN

Prior to developing the restoration plan, our team collected data on Sage Hill's topography, vegetation, and soil. We collected vegetation data through point-intercept monitoring of vegetation cover, and by digitizing tree and shrub cover observed in high resolution drone imagery. All data collection methods informed the development of the restoration plan, as it helped to describe the exact environment of Sage Hill and to theorize which native plants would flourish there.

This section discusses how we completed the first iteration of data collection for our ecological monitoring plan, which should be replicated based on the instructions appendix and timeline outlined in this document (See Appendix E; and Monitoring Plan, pgs. 41-42). Regular vegetation monitoring is a critical component of successful restoration plans. As restoration progresses, monitoring data can reveal whether exotic species cover is decreasing and native species cover and diversity is increasing. Monitoring vegetation change spatially, using drone imagery, can pinpoint areas where restoration has been unsuccessful and where additional management actions are needed. Restoration tracking changes in vegetation cover, soil chemistry and landscape will help us make adjustments to treatments in any specific area, if needed.

Point-Line Intercept Monitoring

Whereas drone imagery easily spans the entire extent of Sage Hill, it only captures the topmost plant layer and fails to capture smaller understory plants. On the other hand, point-intercept monitoring provides more detailed plant cover data but is difficult to perform at every square meter of the site. Our team used these complementary approaches to develop a detailed and spatially complete understanding of the baseline vegetation conditions at Sage Hill. Our specific methods were developed so they could be repeated each year to provide a continuously updated picture of changing vegetation at Sage Hill as restoration continues.

Methodology

We established 12 permanent transects spaced 25 meters apart on a parallel grid across Sage Hill. Each transect ran east to west and span the width of Sage Hill, 40 meters to 100 meters. The transect end points were marked with aluminum tags stamped with the transect number (1-12) attached to a landscape u-stake. Transect positions were established in ArcGIS. Since GPS accuracy is unreliable on Sage Hill (±15 ft-50 ft), we navigated with a mobile compass app to correct for cardinal direction. We also measured 25 meters between the West endpoints to ensure sufficient spacing. A map can be found in Appendix D.

We monitored vegetation on each transect between April 8, 2024 and April 19, 2024 in order to make sure that data was collected within a close timeframe. We chose to conduct data collection only throughout the month of April and advise future field surveyors to do the same. The point-line intercept monitoring is a sampling method that observes the presence of plant species along a straight line, or a transect, at regular intervals. At each transect we pulled the meter tape straight from

east endpoint to west endpoint, weaving it through branches and around tree trunks as needed. Regardless of the total transect length, at every 1 meter mark on the tape, we “dropped” a slender metal pin or rod and recorded each plant species that the pin intersected from top to bottom. The pin/rod that contained an orange flag was also lifted directly upwards to see if other plants hit the point of interest. Sampling poles were also used for plants that were out of reach to accurately record which plants were present. In the rightmost column of the data sheet, we also recorded the ground cover intersected by the pin as soil (S), leaf litter (LL), wood (W), or rocks (R; rocks >0.5mm in diameter). The data was recorded on a paper sheet (See Appendix A), and then entered on Google Sheets (See Appendix A). The transect data sheet organized plants into four columns, from the tallest plant to the shortest plant. The first column (“TOP LAYER”) was reserved exclusively for trees. For data points with several trees, the tallest tree would take precedence, and smaller trees would fill out the second to the fourth column (CODE 1, 2, 3, 4). Data points without trees would leave the “TOP LAYER” column blank but fill in CODE 1-4 as normal.

Species identification knowledge was developed through several Sage Hill tours led by our Project Advisor and plant inventory readings. Gaps in knowledge were supplemented by the SEEK@iNaturalist identification app, which uses artificial intelligence and a large community scientific database to name plants through photos. When neither surveyors nor SEEK could name a plant, the surveyor took a photo of the unknown, used a temporary unique code to label the observation, and planned to identify retroactively with further research. For future reference, we created a Species Identification Guide to help the uninitiated identify common Sage Hill plants. Furthermore, any dangerous or inaccessible areas that ran through the transect, like cacti patches and dense brushes, were estimated from the closest meter possible. (See Appendix E to see step-by-step instructions to replicate this method of data collection. See Appendix G for Species Identification Guide.)

751 data points were collected across the 12 lines. We calculated the total percentage plant cover based on the vegetation type, nativity, transect line, and species frequency. The analysis of this data helped us to determine the exact nativity versus invasiveness of the plants on Sage Hill. Moreover, it provided key restoration plan information by outlining plant alliances throughout the soil, subcanopy and canopy level, which we could extrapolate the resource needs and topographic preferences of based on current SMM guidelines. If future funding and resource allocation permits, additional transects would be ideal in allowing restorationists to track vegetation changes at a closer scale. A physical compass and technological improvements in GPS can also improve the spatial tracking of this method.

Results

Each data point collected at 1 meter apart was entered into Google Sheets, where the data was processed to analyze the main vegetation trends. This included: the amounts of native versus nonnative species present, the divisions of vegetation types (woody, grass, and forb), and the difference in trends between the top layer of vegetation and the lower layers.

The trends for the different vegetation types showed the amounts of native and nonnative species for each of the three types we designated. Woody plants were defined as any species with woody stems and branches. This includes both trees and shrubs. Grasses and shrubs both have no woody elements. While grasses have hollow stems, forbs generally have solid stems (IROAM). The vegetation data showed that out of the three vegetation types, the woody plants at the site had the

highest ratio of native to nonnative species (Figure 1). Many of these nonnative species were seen in the trees, which was highly influenced by the presence of *Eucalyptus spe*. (Eucalyptus) that was introduced to the site. The most prominent native tree was *Quercus agrifolia* (coast live oak). The presence of native shrubs made up for a large portion of the native woody species. This includes species such as *Heteromeles arbutifolia* (toyon), *Artemisia californica* (California sagebrush), and *Malosma laurina* (laurel sumac). The vegetation group with the highest amount of nonnative species was the grasses, while forbs had almost equal amounts of both (Figure 1). Grasses are easy to spread, and were likely introduced either intentionally for landscaping purposes or unintentionally by blowing in from the nearby Santa Monica Mountains. Some of the prominent nonnative grass species include *Ehrharta erecta* (panic veldtgrass) and multiple species of *Bromus*. As we saw the highest native species with woody plants, we used these results to help guide our restoration guidelines. We sought to protect the native specimens already there, building communities around the species already present and well established.

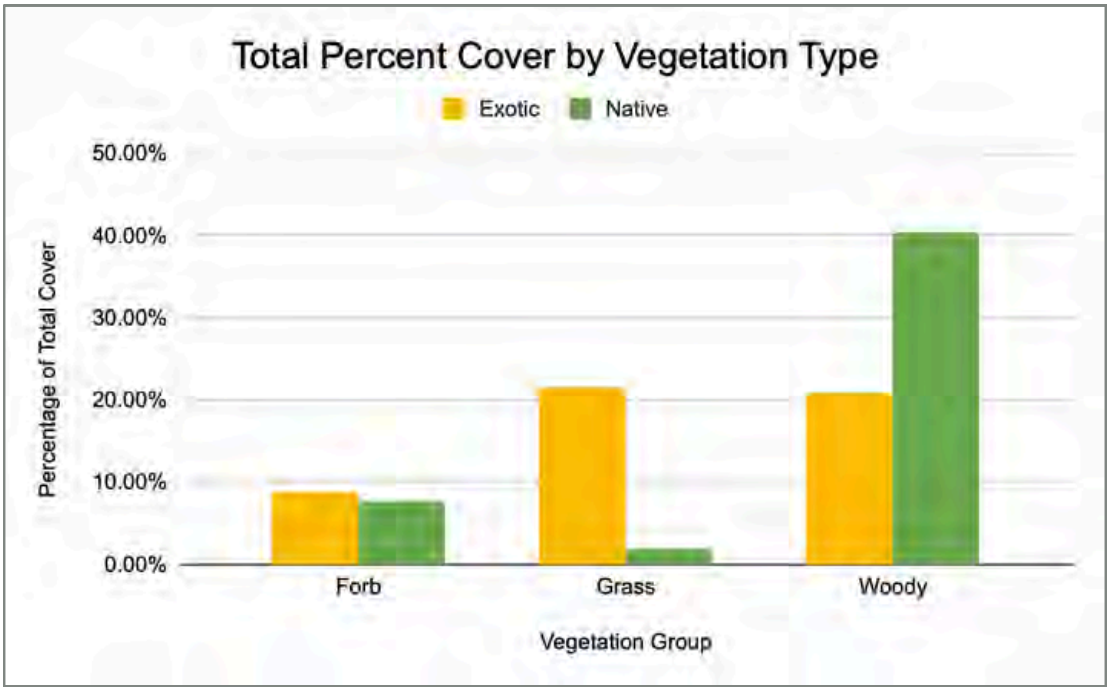


Figure 1: Bar Graph of Total Percentage Cover by Vegetation Type

When examining the results by individual transect, we also notice a few prominent trends. First, there are two transects that have extremely high amounts of nonnative vegetation across all types: Transect 2 (at the southern end of the site) and Transect 12 (at the northern end) (Figure 2). About 75% of the vegetation at Transect 12 was nonnative, while approximately 60% was nonnative at Transect 2. This indicates that these transects are likely in zones that require more restoration efforts. The longest transects (3, 4, and 5) were all more than 90 meters long. They all had similar ratios, with Transects 4 and 5 having almost identical amounts of native plants (Figure 2). There were large areas across the site that had no vegetation cover at all, meaning all that was present was likely either bare soil or leaf litter. Multiple transects did have native species ratios that outnumbered nonnative species (4, 5, 6, 8, and 9), but these still did not account for more than half of the data at these lines. While Transects 4 and 5 had the highest percentages of native species, it could be due to the length of these transects.

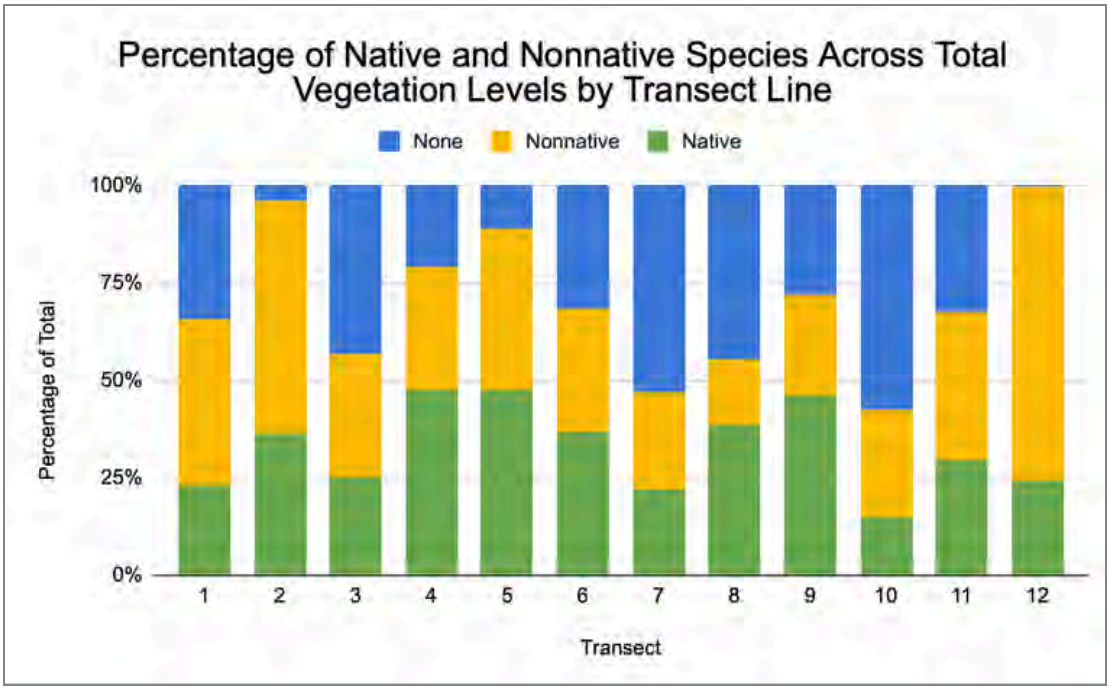


Figure 2: Bar Graph of Species Origin by Transect Line

These results indicate that the site has many issues that need to be addressed by restoration. They provided a good starting point for our team to develop our restoration plan, with the hopes of working with the native populations already present. Despite the issues we see, there is still a significant amount of native specimens to work with. The site has some healthier areas within it that we aim to work with. Future transects that are completed will supplement this initial data that we collected, and they should provide a clearer picture of the progress of restoration. More extensive charts can be found in Appendix A, as well as the data for each individual transect.

Photo Point Monitoring

Photo point monitoring serves to create a visual document of a landscape at a specific angle and location by creating points of interest where repeated photos will be taken. It will be used to track obvious changes in environmental and biotic conditions, such as the encroachment or diminishment of a certain plant group within an area. While photo point monitoring may not be able to glean major transformations within a short timeframe, it will capture gradual changes on Sage Hill, which will compound to show entirely distinct ecological structures if we were to compare one decade to another.

Methodology

Although the establishment of novel photo points was possible, we opted to imitate and re-label areas of interest from past reports and snapshots of Sage Hill. Although some historical photos have inadequate lighting and resolution, our photo point team attempted to match enduring landscape and topographic features from the past to current day. Key visual cues included long-lived plant species, man-made structures, hilly slopes, and varying elevations. Some replications are nearly exact, but other photo points are loosely inspired. References were extracted from a report by McKell in 1961-1963, Westman in 1962, Scow in 1995, Hartman in 2013, and Longcore (2010-2023).

All of the reference photos and documents lacked exact coordinates, so replication had to be visually sorted and somewhat biased. Thus, our team made sure to record the location of photos to streamline the duplication process. Simultaneously, we used an app called GeoTag Photos Pro to label GPS coordinates on photos and enabled the cellphone camera setting to attach locations to photos. Both GPS coordinates from the internal phone and the GeoTag app were compared for similarity and accuracy. A compass was used to determine the orientation with which photos were taken.

During photo point monitoring, it is critical to align the GPS coordinate, angle, and lighting of all matching images. This eliminates irrelevant visual differences and simplifies photo comparisons. During the UCLA academic Winter Quarter, photos were taken during sunny weather, between the hours of 12:00PM to 4:00PM PST. We stored all images in a Google Photos album. The unique identifier, GPS-coordinate locations, annotations, time and dates of all relevant photos are recorded in a Google Sheets table. Unique identifiers for each image combine the photo number in our catalog, the first two letters of the reference author's last name, the photo number in the author's catalog, and the year the photo was taken. For example, a photo from Westman (1962) was the twentieth photo point in our entire selection, the third photo of the author's collection, and was taken in 2024. This ID is "20WE032024."

Results

Over the course of a month, we completed 30 photo points based on historical reference photos. A map of these locations can be found in Appendix B. We matched together our historical photos with the new ones, and the images can be found in Appendix B.

We can clearly see through our photos that Sage Hill has undergone many major changes since initial documentation in 1962. As seen in the reference photos below, Sage Hill was cleared of vegetation entirely for fire reasons, and has had multiple resurgences in vegetation growth. The site today has much more vegetation, but the effects of the clearance linger in the fact that much of the vegetation seen are nonnative species that were introduced over the years. The site continues to get healthier, especially as there have been different efforts in the past decades to reintroduce native species that were seen before the land was cleared.

Figure 3: Photo Point comparison of Zone 7 (Ground Squirrel Slopes), 61 years apart

Westman, 1963

Sage Hill Team, 2024

This photo monitoring, when analyzed through the lens of our point-intercept vegetation results, also shows us how native and nonnative species were spread throughout the site. Many of the nonnative species seen in the photos, including eucalyptus, became more prominent in the past couple of decades as they were introduced by the university for landscaping reasons. The spread of nonnative grasses is seen quite clearly in the Scow photos, taken in 1995, which show how vegetated the site became following the clearances in the 1960s.

Soil Collection & Analysis

Soil characteristics impact plant health and growth, as it controls for water supply, nutrient supply, physical support, and pH. Understanding the soil conditions at Sage Hill, and why certain native or invasive species grew in certain areas, motivated our soil monitoring.

Methodology

Due to time and budget constraints, our soil collection has been limited to six key plant sites on Sage Hill. Given that our main goal for Sage Hill restoration is to increase the cover of native plant life, we considered how we could tailor soil monitoring to inform restoration decisions. We established three "undisturbed" sites and three "disturbed" sites to collect 12 pounds of soil in total, or 2 pounds of soil per area. The categorization of "undisturbed" sites depended on the following criteria: 80-100% of vegetation cover occupied by native plants and lack of intense land-clearing throughout the immediate past. Conversely, the categorization of "disturbed" sites depended on 80-100% vegetation cover by nonnative plants and a history of human activity.

When sampling the soil, the depth of the sample was taken at about 4 inches, or half the length of a shovel. A total of 2 pounds of soil was retrieved from approximately 5-10 places in each respective section to form one sample, and these were then homogenized to ensure consistent results. The homogenized zones are displayed in Figure 4. UCLA Ecology Professor Dr. Nathan Kraft's lab was utilized to conduct soil moisture tests. About 100g from each of the 6 samples were

Figure 4: Soil Moisture Map

separated into tins, and measurements of the soil before and after being placed in the Thermo Fisher Scientific Drying Oven were recorded. These measurements were then used to calculate the percent moisture in each soil sample. The remainder of each sample of 2 pounds was then shipped to Western A&L Laboratory to receive a Standard Soil Test S-101 package with an additional texture-analysis. The S-101 package measures for pH, PO4-P ratio, CEC, Exchangeable Ca, Mg, Na, K, organic matter, and NO3-N.

Results

After completing a basic moisture test on the 6 soil samples in Dr. Nathan Kraft's lab, the results for the % moisture are shown in Figure 5. The bars shown in orange represent the disturbed sites, and the blue are undisturbed. The site that had the highest percent moisture level was the area

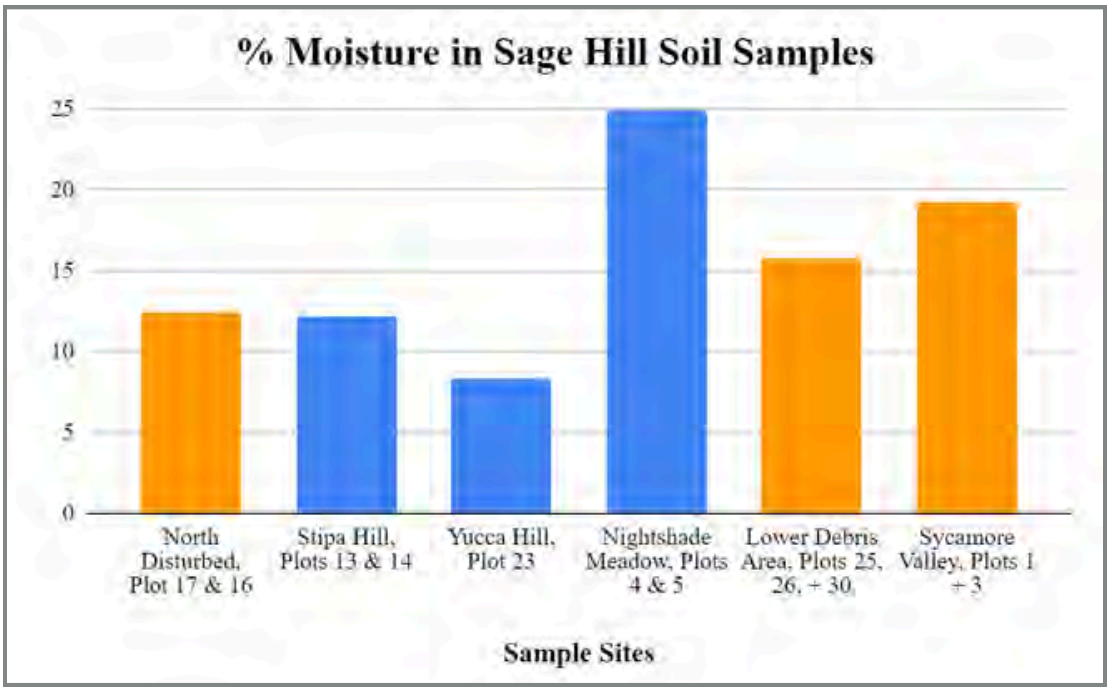


Figure 5: Soil Moisture Bar Graph

Tin Weight (g)	2.12					
Sample Number	Title	Wet Weight (g)	Dry Weight(g)	Water Weight(g)	% Water	Classification
1	North Disturbed (Plots 17 & 16)	71.14	63.28	7.86	12.42	Disturbed
2	Stipa Hill (Plots 13 & 14)	59.48	53.02	6.46	12.18	Undisturbed
3	Yucca Hill (Plot 23)	62.05	57.28	4.77	8.33	Undisturbed
4	Nightshade Meadow (Plots 4 & 5)	111.05	88.9	22.15	24.92	Undisturbed
5	Lower Debris Area (Plots 25, 26, & 30)	85.39	73.73	11.66	15.81	Disturbed
6	Sycamore Valley (Plots 1 & 3)	122.67	102.84	19.83	19.28	Disturbed

Figure 6: Soil Moisture Table

labeled as Nightshade Meadow. The site that had the lowest percent moisture was Yucca Hill. When looking at Figure 4, 5, and 6, it is estimated the results with the highest percent moisture were in the southern portion of Sage Hill due to the downhill position from the steep areas on the right side. They likely receive the majority of rainwater drainage during high precipitation. Compared to other data on coastal sage scrub and oak woodland (Haq et. al., 2021), these moisture levels are similar to averages in those areas.

Chemical Composition

Five out of six of the sampling sites were classified as having a Sandy Loam texture, and Stipa Hill was classified as Loam. The calcium found in each site was relatively similar, close to 1600 ppm, apart from Nightshade meadow with 2360 ppm. Most sandy loam soils have an average of 2100 ppm (Loide, 2004) Coastal sage scrub tends to have higher amounts of calcium in the soil (UC Agriculture and Natural Resources, 2024)

For Magnesium, Stipa Hill contained the highest concentration at 1090 ppm. The Lower Debris Area had the lowest at 220 ppm. Most sandy loam has a range of 70-850 ppm of Magnesium. 5 out of 6 of the samples fall within that range.

When looking at the calcium-to-magnesium, Stipa Hill has both the highest magnesium levels and the smallest ratio. These both indicate that this site has less habitable soil for target vegetation. The Lower Debris Area has the largest calcium-to-magnesium ratio, with the lowest levels of magnesium. This also indicates that the soil health at this site is not ideal for the sandy loam texture classification.

The Potassium levels at all sites had low variability, with an average of 155.5 ppm. When looking at other sites with sandy loam, the average Potassium is 111. The potassium concentration across the sites are proportionately close to the average. The sites North Disturbed and Stipa Hill have the highest sodium, and they are both outliers when compared to the average of the other four sites at 27.3. Figure 7 displays the Calcium, Magnesium, Potassium, and Sodium levels at each sample site.

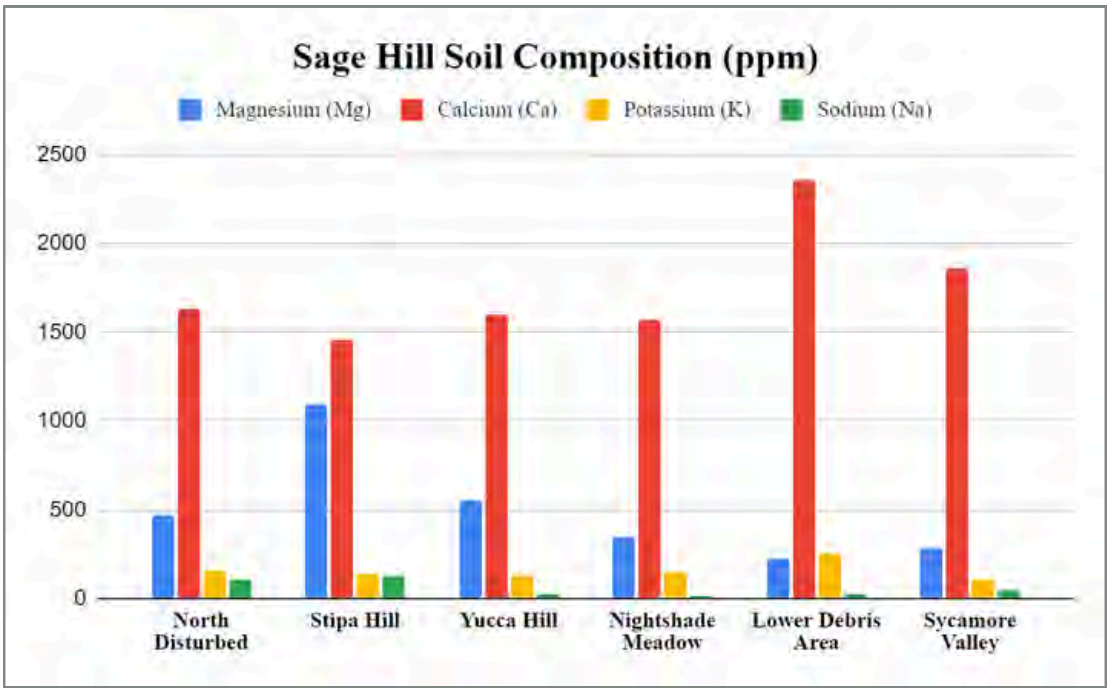


Figure 7: Bar Graph for Soil Chemical Composition

When comparing the pH at the sampling sites, the three undisturbed areas were the most acidic, with a pH of approximately 5. This can be seen in Figure 8. These three sites also had the highest % Organic Matter. The Lower Debris Area had the lowest % organic matter. Overall, the two sites that appear to be of the most concern in regards to soil health are Stipa Hill and the Lower Debris Area. All chemical composition results from Western A&L Laboratory can be seen in Figures 9 and 10.

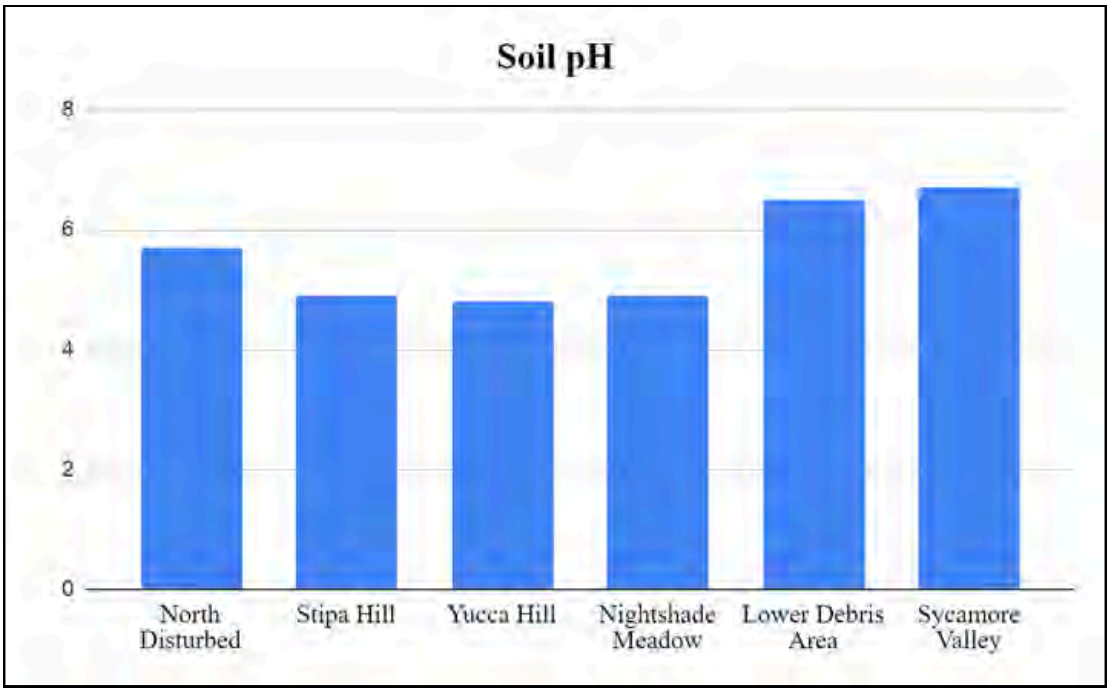


Figure 8: Bar Graph for Soil pH at all six sites

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH			Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)			
		% Rating	ENR lbs/A	P1 (Weak Bray) ppm	$NaHCO_3$-P (OlsenMethod) ppm	K ppm	Mg ppm	Ca ppm	Na ppm	Soil pH	Buffer Index		C.E.C. meq/100g	K %	Mg %	Ca %	Na %
PLOT 17-16	S85889-01	2.4	91	30.8	12.3	155	470	1630	109	5.7			12.9	3.1	30.4	63.0	3.7
PLOTS 13-14	S85889-02	3.0	101	25.8	9.52	136	1090	1460	125	4.9			17.3	2.0	52.7	42.1	3.1
PLOT 23	S85889-03	3.0	101	40.7	15.5	130	557	1600	28.5	4.8			13.1	2.5	35.4	61.1	0.9
PLOT 4-5	S85889-04	3.7	131	19.3	9.88	154	343	1570	14.1	4.9			11.2	3.5	25.5	70.0	0.5
LOTS 25 26 3	S85889-05	1.9	81	43.6	31.9	254	224	2360	24.4	6.5			14.4	4.5	13.0	81.9	0.7

SAMPLE NUMBER	Nitrogen NO_3-N ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		PARTICLE SIZE ANALYSIS			
												SAND %	SILT %	CLAY %	SOIL TEXTURE
S85889-01	12.7											62.5	21.3	16.3	Sandy Loam
S85889-02	9.57											43.8	33.8	22.5	Loam
S85889-03	12.1											61.3	21.3	17.5	Sandy Loam
S85889-04	23.9											56.3	31.3	12.5	Sandy Loam
S85889-05	19.9											66.3	18.8	15	Sandy Loam

Figure 9: A&L Western Laboratory chemical composition table for sites 1, 2, 3, 4, and 5

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH			Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)			
		% Rating	ENR lbs/A	P1 (Weak Bray) ppm	$NaHCO_3$-P (OlsenMethod) ppm	K ppm	Mg ppm	Ca ppm	Na ppm	Soil pH	Buffer Index		C.E.C. meq/100g	K %	Mg %	Ca %	Na %
PLOTS 1 3	S85889-06	2.0	81	32.9	18.6	104	280	1860	42.3	6.7			12.1	2.2	19.3	76.8	1.5

SAMPLE NUMBER	Nitrogen NO_3-N ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		PARTICLE SIZE ANALYSIS			
												SAND %	SILT %	CLAY %	SOIL TEXTURE
S85889-06	17.4											67.5	20	12.5	Sandy Loam

Figure 10: A&L Western Laboratory chemical composition table for site 6

Drone Imagery & Digitization

Methodology

A high-resolution image of the site was taken from above using a multispectral sensor attached to a Mavic 3 Enterprise drone. The sensor collects radiance data from the three visible light spectrums: red, green, and blue, which can be later displayed as a true-color image. The drone was initially flown on March 13th, 2024 at 1PM in conjunction with Dr. Kyle Cavanaugh's lab, and was flown at 100 meters. The image was georeferenced with the use of 15 calibration squares representing ground control points, which were spread around the site and assigned GPS coordinates with a GPS device. As the image was distorted through the natural flight patterns of the drone, the coordinates on the image were stretched to their true locations, which corrected the image. Afterwards, the image was used to draw polygons around plants and vegetation features around the site. The data was stored and edited in a polygon shapefile through ArcGIS Pro and QGIS. Each polygon was drawn around individual plants and identified by species from the image or knowledge of the site. This species data was later used to assign each polygon to a vegetation category (tree, shrub, forb, other) and an origin (native or exotic). Because the image was taken from above, the polygons could only record the top-layer of the site. In many cases, this was the highest tree canopy, and plants underneath could not be detected. Furthermore, identification of grass and herbaceous species was difficult for much of the site because they were either covered by other vegetation types or difficult to determine from the image. Any polygon that could not be identified by species was given a NA species tag, and many grassy areas were left without polygons.

Results

The resulting image contains 3 visible bands and a resolution of 10 centimeters. Shadows are minimal and many vegetation features are easily identified. Digitization of canopy polygons was conducted over the March 13th image, and included 423 individual polygons representing over 12,000 square meters of vegetation. The species with the most cover include Coast Live Oak (3038 m^2), Eucalyptus (2747 m2), Laurel Sumac (1180 m2), Canary Island pine (968 m2), and California Sagebrush (805 m2). About 6262 m2 of the vegetation is native, with 4493 m2 being exotic. Tree canopy represented about 8189 m2 of the vegetation, while shrubs represented about 2846 m2. However, all of these statistics are underscored by the lack of substantial grass and forb vegetation data.

Full drone imagery is shown below.

Sage Hill Drone Image (3/13/24)

Figure 11: Ortho/Drone Imagery of the entire extent of Sage Hill

Sage Hill Common Plant Species

Figure 12: Ortho/Drone Imagery of the entire extent of Sage Hill with the canopy polygon layer visible & Table of the area with which common species occupy

Species	Area (m^2)
California Brittlebush (Bush Sunflower)	70
California Sagebrush	805
Coast Live Oak	3039
Coastal Prickly Pear	68
Eucalyptus	2747
Laurel Sumac	1180
Canary Island Pine	968
Purple Nightshade	31
Stipa Grass	91
Toyon	323

RESTORATION PLAN

Site-Partitioning Methods & Analysis

When partitioning the site into restoration zones, we provided an algorithm with a set of raster layers of the site that would separate the site into similar zones through unsupervised classification. The inputs to this algorithm included layers for slope, northness, eastness, mean curvature, topographic wetness index, canopy height, and a moving window of tree cover. The layers underwent unsupervised classification to separate the site into zones of similar pixels.

A LIDAR-based digital elevation model was previously created by the Institute of Environment and Sustainability and used to generate layers for slope, mean curvature, and aspect through ArcGIS's Surface Parameters tool. The aspect layer was then used to generate northness (cosine of aspect in radians) and eastness (sine of aspect in radians), which range from -1 to 1 and determine how north-facing or east-facing a slope is.

In addition, a canopy height model was added, which represents the relative height of vegetation from the ground. This was generated with a height model taken by drone, which had the height of vegetation including elevation, and subtracting the digital elevation model, which gave the relative height of vegetation off the ground. Finally, a moving window of tree cover was generated by taking a tree cover layer from LARIAC and turning it into a binary raster, with 0 representing open space and 1 representing tree cover. Then, a moving window was used to average each pixel with its surrounding 15x15 square of pixels to generate an edge canopy gradient. This was used to classify pixels along a gradient of cover instead of a binary yes/no system.

Finally, each of these input rasters was masked along the Sage Hill site boundary and rescaled to a linearly normalized scale from 0 to 100. Then, each raster was sent into an ArcGIS script for unsupervised classification, which uses ISO Cluster and Maximum Likelihood to separate each pixel, which has associated values under each raster, to a set of seven zones, where each zone contains pixels that are similar to pixels in the same zone but different from pixels in different zones. Zonal statistics was calculated to determine the mean slope, northness, eastness, and concavity of each zone to determine where the natural boundaries in topography and canopy cover, which were used to inform the final classification of restoration zones, in addition to the existing species at each site.

Based on our monitoring results collected in the field, we decided to split Sage Hill into 19 distinct reference zones. This is due to the different vegetation characteristics, as well as topographic aspects such as slope. Once these zones were determined, we decided to compare them to vegetation characteristics in the nearby Santa Monica Mountains. To do this, we primarily used the Vegetation Classification of the Santa Monica Mountains National Recreation Area and Environs in Ventura and Los Angeles Counties, California by Keeler-Wolf and Evens (2006). This expansive vegetation manual classified vegetation types into groups. The broadest is an alliance, which is the most general unit determined by the most "dominant and/or characteristic plant species" that is seen largely in the uppermost vegetation layer (Keeler-Wolf and Evens, 2006). The next division is the

association, which is more specific and describes areas with “similar dominant and characteristic species” in the uppermost vegetation layer, which makes these species combinations distinctive (Keeler-Wolf and Evens, 2006). The furthest classification is the phase, which depends largely on local conditions that create species associations not seen on a wider scale (Keeler-Wolf and Evens, 2006).

We decided on these reference sites based on what was already present in each of these zones. Most of the zones were assigned a vegetation association within the Santa Monica Mountains. Alliances were assigned if the vegetation varied enough that a secondary dominant species could not be identified. There were two instances of phases being assigned. These references then dictated what restoration actions we recommended. Rather than overhauling the entire site, we chose to work with the native species that are already present, and make recommendations to supplement the native species in each zone. Asterisks indicate which zones are higher priority, explained further in the Restoration Timeline section.

We recognize that this restoration plan may include idealized conditions, both for the site and for restoration work to occur. It is possible that changes may need to be made to the zones. This includes both the physical areas of the zones, as well as targets for them to aspire to. We hope that these zones are a good starting point for restoration work, and the inclusion of extensive vegetation data means alterations can be made to exact plans while out in the field.

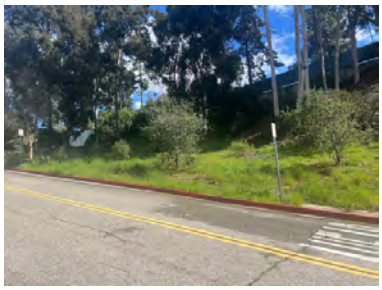
Our map of zones is found below. For physical values, including slope and other values calculated from the drone imagery, please refer to the restoration attributes table in Appendix D.

Sage Hill Restoration Zones

Figure 13: Ortho/Drone Imagery of the entire extent of Sage Hill with semi-transparent restoration zones overlayed. A total of 19 restoration zones, each assigned a number and a name.

1. Northern Meadow
2. Northern Eucalyptus
3. Stipa Steppes
4. Oak Avenue
5. Sagebrush Strip
6. Yucca Hill
7. Ground Squirrel Slopes
8. Elsie's Forest
9. Needlegrass Valley
10. Sunshine Scrub
11. Elderberry Thicket
12. West Entrance
13. Monkeyflower Hill
14. Coast Live Oak Forest
15. Toyon Treetop
16. Prickly Pear Trail
17. Miller's Gulch
18. Ryegrass Ridge
19. Hitch Lookout

RESTORATION ZONE TABLE SUMMARY

ZONE	AREA (M^2)	CURRENT PLANT ASSOCIATION	TARGET PLANT ASSOCIATION	MONITORING PHOTO
***1. Northern Meadow**	1570	California Annual Grassland Alliance (5000/4340)	*Nassella lepida* Alliance (4090)	Scow 1, 2024 
***2. Northern Eucalyptus**	336	Eucalyptus Alliance (9510), *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	*Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	Scow 1 (back), 2024 
3. Stipa Steppes	684	*Nassella lepida* Alliance (4090)	*Nassella lepida* Alliance (4090)	Sage Hill Site 3 
4. Oak Avenue	648	*Quercus agrifolia* South Coastal Association (6122)	*Quercus agrifolia* South Coastal Association (6122), *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	Scow 3, 2024; McKell 2, 2024 
5. Sagebrush Strip	1665	*Opuntia littoralis* Alliance (2410)	*Opuntia littoralis* Alliance (2410), *Opuntia spp.* - Mixed Coastal Sage Scrub Shrubland Association (2412)	Scow 2, 2024 

***6. Yucca Hill**	158	*Pennisetum setaceum-Coreopsis gigantea-Yucca whipplei-Malosma laurina* Association (4061)	*Malosma laurina* Shrubland Association (7142), *Heteromeles arbutifolia* Association (2130)	Scow 9, 2024 
7. Ground Squirrel Slopes	3195	*Malosma laurina* Shrubland Association (7142)	*Malosma laurina-Artemisia californica* Shrubland Association (7148)	Westman 5, 2024 
***8. Elsie's Forest**	500	Eucalyptus Woodland/Forest Alliance (9510)	*Quercus agrifolia/Heteromeles arbutifolia* Association (6117)	Scow 10 (back), 2024 
***9. Needlegrass Valley**	925	California Annual Grassland Alliance (5000/4340)	*Nassella lepida* Alliance (4090)	McKell 3, 2024 
10. Sunshine Scrub	395	*Salvia mellifera-Artemisia californica* Association (8321/3421)	*Opuntia spp.* - Mixed Coastal Sage Scrub Shrubland Association (2412), *Salvia mellifera-Artemisia californica* Association (8321/3421)	Scow 12, 2024 

11. Elderberry Thicket	579	*Malosma laurina* Association (7142)	*Malosma laurina* Shrubland Association (7142), *Salvia mellifera-Artemisia californica* Association (8321/3421)	Scow 12, 2024 
***12. West Entrance**	502	Eucalyptus Woodland/Forest Alliance (9510), *Bromus diandrus* Association (50005)	*Platanus racemosa-Quercus agrifolia-Salix lasiolepis* Woodland/Forest Association	McKell 3 (back), 2024 
13. Monkey-flower Hill	1252	*Quercus agrifolia*/*Malosma laurina* Phase (6116), *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	*Quercus agrifolia*/*Malosma laurina* Phase (6116), *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	McKell 1, 2024 
14. Coast Live Oak Forest	947	*Quercus agrifolia* South Coastal/Woodland Association (6122)	*Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	Sage Hill Site 14 
***15. Toyon Treetop**	1567	Eucalyptus Woodland/Forest Alliance (9510)	*Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	Scow 19 (back), 2024 

16. Prickly Pear Trail	1632	*Opuntia spp*. -Mixed Coastal Sage Scrub Shrubland Association (2412)	*Opuntia spp*. -Mixed Coastal Sage Scrub Shrubland Association (2412), *Quercus agrifolia*/*Toxicodendron diversilobum* Association (1117)	Sage Hill Site 16 
17. Miller's Gulch	1819	*Heteromeles arbutifolia* Association (2130)	*Quercus agrifolia* South Coastal Association (6122)	Westman 6, 2024 
18. Ryegrass Ridge	851	*Quercus agrifolia*/*Malosma laurina* Phase (6116), *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	*Quercus agrifolia*/*Malosma laurina* Phase (6116), *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117)	Sage Hill Site 18 
*** 19. Hitch Lookout**	638	Eucalyptus Woodland/Forest Alliance (9510)	*Quercus agrifolia* South Coastal/Woodland Association (6122), *Quercus agrifolia*-*Juglans californica* Association (1115)	Sage Hill Site 19 

-- End of Restoration Zone Table Summary --

Zone 1 – Northern Meadow

Zone 1 is located on the northern end of Sage Hill, located along the road and across from the Krieger Center. It is right below zone 2 and touches zone 3. This area is mostly grassy, consisting of *Carpobrotus edulis* (ice plant) and young coast live oaks. With ice plant considered to be an invasive species in coastal California (CDFW), a direct match was not found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006), however, based on the geography of the area and the presence of young oaks, we believe that the California Annual Grassland Alliance (5000/4340) is the closest match to this zone. This alliance consists of grasslands or forb lands strongly dominated by nonnative annual grasses and forbs including *Bromus rubens* (red brome), *Bromus diandrus* (ripgut brome), *Lolium multiflorum* (italian ryegrass), *Avena fatua* (wild oat), *Centaurea solstitialis* (star thistle), and *Brassica nigra* (black mustard) (Keeler-Wolf and Evens, 2006). Additionally, it consists of some native species but in relatively low cover (Keeler-Wolf and Evens, 2006). Using this as a guide, recommendations will be made that support the already established coast live oak and implementation of native grasses, along with the removal of invasives.

Based on the conditions of this zone, we would recommend removal of all of the ice plant and introduction of native grass species such as *Nassella pulchra* (purple needlegrass) and *Nassella lepida* (foothill needlegrass). Our target alliance from the vegetation manual is the *Nassella lepida* Alliance (4090). As recommended for zone 9, the native grasses would do well in the chaparral ecosystem that is Sage Hill. Both types of needlegrass are drought tolerant and do well under the canopy of larger trees (Calscape). These types of grasses also do well with native shrubs, so implementation of those shrubs could also be taken into consideration if the native grasses thrive in this location. Removal of the ice plant is going to be ever more important for the health of this zone. The priority for this area should be the removal of the invasive species first and foremost and then concentrate on introducing the native grasses. The young oaks should remain in this location and be supported throughout the removal of other species and introduction of native ones.

Zone 2 – Northern Eucalyptus

Zone 2 is located at the northernmost part of Sage Hill and it is located at the very top of the northernmost hill. It contains mostly eucalyptus trees and toyon with some other tree species scattered throughout. This area borders the parking lot located at the top of Sage Hill, making litter a concern for this area. Based on the conditions of this area, we were able to match this zone to the Eucalyptus Woodland/Forest Alliance (9510) and *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). Since this zone is dominated by two types of trees, it applies to two different alliances/associations. The alliance is characterized by eucalyptus being the dominant species in the canopy with a minor presence of other native trees/shrubs (Keeler-Wolf and Evens, 2006). The association is characterized by the understory being dominated by toyon with laurel sumac present and coast live oak being in the overstory (Keeler-Wolf and Evens, 2006).

This zone should continue to be based in the *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117). Based on the conditions of this zone, we would recommend the removal of the eucalyptus if feasible and the planting of coast live oak along with toyon. With eucalyptus being an invasive species, its removal would benefit the health of Sage Hill. However, cost and regulations must be taken into consideration. Removal of the eucalyptus could be expensive and not practical for

the potentially hard to navigate area in which they are currently located. Additionally, agreements with neighboring homes may make removal of the eucalyptus harder as the university may have agreements with them about visibility of the university. Further investigation about agreements between the university and local residents would be needed before the eucalyptus trees could be removed. Planting of coast live oak and toyon could be achievable and still benefit this area even with the eucalyptus trees still present. Coast live oak attracts a variety of birds and butterflies and is a resilient tree (Calscape). They are easy to care for and can tolerate colder temperatures but still thrive in full sun (Calscape). With coast live oak scattered across Sage Hill, adding it to this area could prove to be beneficial. We would recommend the upkeep and addition of toyon in this zone as it attracts butterflies and other pollinators and various types of birds (Calscape). Toyon is drought adapted and can handle a wide variety of soils (Calscape), making it a good candidate for this area.

Zone 3 – Stipa Steppes

Zone 3 is a steep, west facing hill located towards the northernmost part of Sage Hill. This area is dominated by *Nassella lepida* (foothill needlegrass) and instances of *Stipa spe*. (smilo grass). This zone is nested between Zone 2 and parts of zones 4 and 1. It comprises a smaller portion of the northern part of Sage Hill. Based on the conditions of this area, we were able to match this zone to the *Nassella lepida* Alliance (4090) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This alliance is characterized by native grasses with the dominant species being foothill needlegrass alone or in shared dominance with other native and nonnative grasses and forbs (Keeler-Wolf and Evens, 2006). This zone was relatively healthy when we last did observations of Sage Hill.

Based on the conditions of this zone, we recommend leaving it as is or bringing in companion species such as native annual wildflowers or perennials to fill in large gaps. Some of these companion species include *Eschscholzia californica* (California poppy) and *Eriogonum fasciculatum (*California buckwheat) (Calscape). Foothill needlegrass is healthiest when in the presence of other native species, so we would also recommend the removal of any invasive species present. We do not recommend bringing in any non native plants to this area as that could be detrimental to the foothill needlegrass. If foothill needlegrass were to be propagated in this area we would recommend propagating by seeds already present or by divisions. Depending on the time of year, you would do a different method. For summer you would propagate the foothill needlegrass by seed and in the winter you would propagate by division (Calscape). California poppies are self-seeding flowers and not particularly invasive, preferring sunnier areas but also tolerant of shade (Calscape). With zone 3 being a sunny area, California poppies would be a good addition to the already present foothill needlegrass. California poppies also attract birds, butterflies, bees, and other pollinators, making them a species that will enhance the health and wildlife of Sage Hill (Calscape).

Zone 4 – Oak Avenue

Zone 4 is located along the road, right across the street from The Krieger Center. It contains coast live oak and very few other types of plants. There may be some grasses present such as *Ehrharta erecta* (panic veldtgrass) and *Bromus diandrus* (annual grass/great brome). Based on the conditions of this area, we were able to match this zone to the *Quercus agrifolia* South Coastal Association (6122) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf

and Evens, 2006). This alliance is characterized by coast live oak being the dominant species present and an understory that is sparse to low in cover with occasional shrubs and herbs (Keeler-Wolf and Evens, 2006). With this zone being so close to the street, it is important to take into consideration possible disturbances from cars, such as pollution. When deciding which species to bring into this area, durability should be a high priority.

We believe this zone should follow the guidance of the current association, as well as *Quercus agrifolia*/*Heteromeles Arbutifolia* Association (6117). Based on the conditions of this zone, we would recommend the maintenance of the coast live oak that is already present and the introduction of coast live oak companion species such as *Baccharis pilularis* (coyote brush), California buckwheat, coast sagebrush, toyon, *Rhamnus californica* (California coffeeberry), *Trichostema lanatum* (wooly bluecurls), or annual wildflowers (Calscape). California natives such as the ones mentioned in the previous sentence thrive as understory plants, which would compliment this zone well (Calscape). Shrubs such as buckwheat propagate by seed and do not need extensive treatment (Calscape) making them pretty self-sufficient in an ecosystem like Sage Hill. Additionally, many of the companion species mentioned above are supporters of wildlife such as bees, caterpillars, and pollinators, giving them even more value. Having a good mix of the understory species with the coast live oak will help to restore zone 4 to an even healthier area.

Zone 5 – Sagebrush Strip

Zone 5 is a steep, west facing slope that consists mostly of California sagebrush and *Opuntia littoralis* (coastal prickly pear cactus). It is a long strip on the northern part of Sage Hill, located right below zone 8 and right above zone 4. It is located below the eucalyptus trees located in zone 8, which could be taken into consideration when new plants are introduced to the area. Based on the conditions of this area, we were able to match this zone to the *Opuntia littoralis* Alliance (2410) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This alliance is characterized by coastal prickly pear as the dominant or codominant species with coastal sage scrub species and possible other types of cactus. This alliance is characterized by a mixture of species such as the prickly pear cactus and sagebrush. When looking at the accessibility of this zone, it may prove to be beneficial to leave the cactus current in this location alone and not reintroducing more for safety reasons and looking into a companion plant instead. Looking for complementary plants for this zone could be beneficial for Sage Hill.

We believe this zone should stay within the current alliance, but more specifically aim towards the target of the *Opuntia spp.* Mixed Coastal Sage Scrub Shrubland Association (2412). Based on the conditions of this zone, we would recommend the addition of more sagebrush and other companion plants to sagebrush and prickly pear cactus. As seen with zone 11, California sagebrush has the companion plant of California buckwheat. Bringing the sagebrush, cactus, and buckwheat together to prove to be a cohesive unit of plants to have in Zone 5. A mixture of *Eriogonum spp*. (wild buckwheat), *Encelia californica* (California brittlebush), and California sagebrush would all be good additions to this zone. The addition of more prickly pear cactus could be further investigated, however the feasibility of that would have to be taken into account. Considering the steepness of this area and the difficulty accessing it, bringing in prickly pear cactus may prove to be harmful and not worth the risk of the volunteers undertaking that action. On the flip side, prickly pear cactus could thrive in this area as this type of cactus thrives in chaparral habitats and proves to be an important wildlife plant

with little care needed (Calscape). Another plant that could be useful to introduce would be *Salvia apiana* (white sage). This native plant does well in a variety of chaparral environments, and is key to include in at least one zone at Sage Hill. Seeds can be collected at a nursery, and it does well with the sagebrush and cacti species that are also included in this area (Calscape). White sage also has important indigenous cultural uses, so discussions with local indigenous groups could be useful for this plant in particular in order to know the best way to introduce and cultivate this species.

Zone 6 – Yucca Hill

Zone 6 is located towards the middle portion of Sage Hill, sandwiched in between Zone 4 and Zone 7. It slightly touches Zone 9 and Zone 5. This area is dominated by *Yucca whipplei* (yucca) and has a small amount of laurel sumac. It is west facing and mostly shrubby. Based on the current conditions, we were able to mostly match this area to the *Pennisetum setaceum-Coreopsis gigantea-Yucca whipplei-Malosma laurina* Association (4061) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This association is characterized by fountain grass being dominant with native coastal shrubs being subdominants such as *Coreopsis gigantea*, *Malosma laurina* and *Yucca whipplei* (Keeler-Wolf and Evens, 2006).

We believe this zone should stay within the reference vegetation. Based on the conditions of this zone, we would recommend the upkeep of the yucca and laurel sumac currently there and the potential addition of laurel sumac companion plants to increase diversity of the zone. Some of these companion plants include toyon, wooly bluecurls, coyote brush, buckwheat, and California brittlebush. On our last observation of Sage Hill, this area appeared to be in healthy conditions, making upkeep of the area a top priority. Increasing diversity of this area could also be a priority in order to support other types of wildlife that live at or currently frequent Sage hill. Laurel sumac is drought adapted and needs very little water to thrive (Calscape) so this could be a good species to have in abundance in zone 6. It flowers in the winter and spring so we would recommend planting it during the late fall/winter season (Calscape). Since this area is mostly adapted to the chaparral ecosystem, new introductions of species will most likely not be needed. The focus of this area should be the support of the native species present and the increase of those native species. Yucca is native to Southern California where it occurs in chaparral and coastal sage scrub habitats (Calscape). It is extremely drought adapted and local indigenous people use this plant extensively (Calscape), giving UCLA an opportunity to work with local indigenous groups. Yucca has companion plants of California buckwheat and California Sagebrush (Calscape), making this a good fit for Sage Hill.

Zone 7 – Ground Squirrel Slopes

Zone 7 is located on the hill just below where the aviaries are found, in the northern portion of the site. It is steep and west-facing. It is primarily composed of laurel sumac and *Solanum xanti* (purple nightshade). Given the changing conditions of the aviary above, this zone may be able to be extended further up the slope should restoration permit. Further research will be needed upon complete removal of all structures and concrete present to determine whether it can support vegetation. Based on the current conditions, we matched this zone to the *Malosma laurina* Shrubland Association (7142) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This association is characterized by the dominance of laurel sumac in the shrub layer, with a smaller presence of herbaceous plant materials (Keeler-Wolf and Evens, 2006).

To restore this area, we narrowed the reference plants down to the *Malosma laurina-Artemisia californica* Shrubland Association (7148) (Keeler-Wolf and Evens, 2006). This association sees laurel sumac present with California sagebrush, as well as the presence of grasses including *Leymus condensatus* (giant wild rye). We would recommend removal of any nonnative annual grasses present in this area to begin with. Propagation of California sagebrush is best done with clippings from existing plants at the site that can be replanted here. Purple nightshade growth should be promoted as well to complement the existing laurel sumac, and giant wild rye planting should be done with rhizomes collected at the site (Calscape). If space permits, additional introductions of *Marah macrocarpus* (wild cucumber) seeds from a nursery would be beneficial to promote the eventual establishment of more pollinators at the site (Calscape). As previously mentioned, any of these actions can be taken further up into Zone 20 (eastward) should the aviary remnant area become ready for plantings in the future.

Zone 8 – Elsie's Forest

After our point intercept data collection of Zone 8, we found the most common species in this area to be eucalyptus and *Pinus canariensis* (Canary Island pine). This zone is steep and has west facing slopes. Zone 8 contained little to no herbaceous plant matter at the time of observation. Based on the current conditions, we were able to match this area to the Eucalyptus Woodland/Forest Alliance found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). Other plants in this alliance include coast live oak, laurel sumac, toyon, and a variety of non-native grasses including *Hirschfeldia incana* (shortpod mustard).

This zone should aim towards the target *Quercus Agrifolia*/*Heteromeles Arbutifolia* Association (6117). Based on the zone itself we would recommend removing half of the eucalyptus trees present and replacing them with native trees such as laurel sumac and toyon. Given the geography of this zone, we believe that laurel sumac and toyon will be suited for this area and for the success of this area. However, we do recognize that the removal of the eucalyptus trees may affect local residents and may not be feasible to remove. Further information regarding agreements with local residents would have to be taken into consideration before the removal of the eucalyptus. If faced with push from neighboring residents we recommend that the restoration action prioritizes the planting of coast live oak instead as this species will provide more cover. Oak seeds do not store well, so the best way to propagate them at Sage Hill would be to directly collect and plant them in the beginning of winter (USDA, n.d.). For laurel sumac the best method is to collect seeds from a nursery and possible planting with a companion species such as *Adenostoma fasciculatum* (chamise) and California brittlebush. Lastly, for toyon we would recommend collecting seeds from the plants already present at Sage Hill and replanting at zone 8.

Zone 9 – Needlegrass Valley

Zone 9 consists of a flat clearing mostly clear of shrubs and other plants. With this zone being so close to the parking lot and to zone 11 which used to harbor a large metal tank, not many species have taken to this area. Based on the conditions of this area, we were able to match this area to the California Annual Grassland Alliance (5000/4340) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This alliance makes reference to relatively low cover of plant material, similar to what is seen at zone 9. Native grasses that could thrive at Sage Hill

include purple needlegrass and foothill needlegrass.

We recommend this zone follow the *Nassella lepida* Alliance (4090). Based on the conditions of this zone, we would recommend introducing grasses such as the one mentioned in the above paragraph or *Helianthus annuus* (sunflowers). Sunflowers are native to the Americas and widespread in California, making this a good candidate for Sage Hill (Calscape). Sunflowers have a fast growth rate and flowers in the summer so we would recommend planting in the later spring/early summer. Foothill needlegrass is a native bunchgrass that does well in chaparral or coastal sage scrub habitats (Calscape). It is drought tolerant and does well under the canopy of oaks and other native trees (Calscape). We would recommend propagating this plant by seed in the summer or fall and by divisions if planting in the winter (Calscape). Purple needlegrass is California's most widespread native grass and is very drought tolerant (Calscape). It does well in poor and disturbed soils and tends to self-sow under favorable conditions (Calscape). Since this zone is relatively clear of most plant species, a combination of grasses and sunflowers could prove to be beneficial to this area. Depending on the feasibility of acquiring seeds and the amount of personnel able to replant such a large area, you may want to plant different ratios of grasses and sunflowers.

Zone 10 – Sunshine Scrub

Zone 10 is located south of where the aviaries were located, occupying the slope along the existing concrete drainage path. It is west-facing and is one of the steepest parts of Sage Hill, dropping down directly into the flat clearing detailed in Zone 11. This zone is primarily composed of small shrubs and herbaceous matter that can handle the slope and direct sunlight. Vegetation characteristic of this site includes *Salvia mellifera* (black sage), purple nightshade, and small instances of larger shrubs, including California sagebrush and laurel sumac. There are small patches of invasive annual grasses as well. Based on the current conditions, we matched this zone to the *Salvia mellifera* Alliance (3320) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). More specifically, we narrowed it down to the *Salvia mellifera-Artemisia californica* Association (8321/3421), which has the bigger presence of both black sage and California sagebrush and is what restoration could aim for (Keeler-Wolf and Evens, 2006).

We recommend increased plantings of both black sage and California sagebrush in this area to stabilize the hillside. These species should make up between 50-60% of the shrub layer after introductions. Since black sage is more prominent on this site, that should be prioritized through plantings of seeds carried by nurseries, as propagation is easier this way (Calscape). Purple nightshade can continue to be planted here as well using existing seedlings from other zones on the site. Notable species introductions that could help the area would primarily include California sagebrush using rhizomes from existing specimens. A further combination of yucca and California buckwheat would continue to promote a more diverse zone. The yucca exists in a few locations at Sage Hill as well, and seed can be collected from these sites. It also supports a variety of caterpillars and pollinators. California buckwheat is a vital species in sagebrush zones to support wildlife, and seeds can be collected from a nursery. This combination of shrubs being introduced will provide structural support for the steep hillside leading down into the clearing, and should only be done following removal of the annual grasses that are currently on the hill.

Zone 11 – Elderberry Thicket

Zone 11 is a semi-sloped area consisting of laurel sumac and *Baccharis salicifolia* (mule fat). This zone used to have a large tank present, but the tank has been removed. Due to this disturbance, there is a large ditch which could serve as a good space to reintroduce new plants. Based on the conditions of this area, we were able to match this zone to the *Malosma laurina* Association (7142) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This alliance is characterized by laurel sumac occurring as the codominant to dominant species in an open to intermittent shrub overstory. The main characteristic of this alliance is that laurel sumac is dominant, which is what we see in zone 11. Other plants in this alliance include California buckwheat, black sage, and California sagebrush.

We believe this zone can combine both the current association and a target association of the *Salvia mellifera*/*Artemisia californica* Association (8321/3421). Based on the conditions of this zone, we would recommend planting more laurel sumac or mule fat or reintroducing shrubs such as California buckwheat, black sage, or california sagebrush. Laurel sumac is drought adapted and needs very little water to thrive (Calscape) so this could be a good addition to the bare area in zone 11. It flowers in the winter and spring so we would recommend planting it during the late fall/winter season (Calscape). California buckwheat has been shown to be a good companion plant to laurel sumac (Calscape), so planting these together could immensely benefit Sage Hill. Mule fat is a type of shrub that flowers throughout the entire year, making it a good candidate if something is urgently needed. Once mule fat has been established, it becomes quite tolerant and does not need much care (Calscape). California buckwheat is a perennial shrub that flowers most of the year and they thrive in sunny conditions (Calscape). California buckwheat thrives in sagebrush scrub ecosystems, making this a good plant to have on Sage Hill. California buckwheat also has the companion plant of California sagebrush, which is a resilient and easy to grow shrub that is extremely drought tolerant (Calscape). Using a combination of the above plants could help reintroduce wildlife to a currently bare zone 11.

Zone 12 – West Entrance

Zone 12 is located towards the center western edge of the site, at the bottom of the parking lot. It is mostly flat, and has a path running through it. The dominant species in this area are nonnative, including eucalyptus, smilo grass, great brome, and *Hordeum murinum* (wall barley). There is also sparse cover of laurel sumac and *Oxalis pes-caprae* (Bermuda buttercup), but the majority of the cover under the trees is nonnative grass, aside from a small patch of *Verbena lasiostachys* (western vervain). Alongside the path, we find the only instance of *Toxicodendron diversilobum* (western poison oak) spilling over from Zone 16. Based on the tree cover and herbaceous cover, we believe this site can be matched to two references in the Santa Monica Mountains. One is the Eucalyptus Woodland/Forest Alliance (9510) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This is characterized by the dominant presence of eucalyptus in the tree layer. The other reference is the *Bromus diandrus* Association (50005), characterized by the dominant presence of great brome and other nonnative grasses (Keeler-Wolf and Evens, 2006).

Given the high presence of nonnative species of trees and grasses in this zone, we recommend identifying a different reference site to aim to create. We chose the *Platanus racemosa-Quercus agrifolia-Salix lasiolepis* Woodland/Forest Association (6452) based on the physical

characteristics, as well as the inclusion of western poison oak (Keeler-Wolf and Evens). To begin with, we recommend removal of the nonnative grasses that are present through weeding. This includes the great brome and smilo grass, as well as the few instances of wall barley that are seen along the path. The eucalyptus is big, and may not be able to be removed unless sufficient funding is acquired. The other large invasive tree, *Erythrina falcata* (Brazilian coral tree), should be removed as well. Following removal, we recommend planting of coast live oak to supplement the tree layer and provide cover, done through seed collection on site. We also recommend planting of both *Platanus racemosa* (western sycamore) for the upper tree layer. These trees will counter the presence of the eucalyptus, and provide diverse cover near the entrance to the site. *Salix lasiolepis* (arroyo willow) should be dominant in the shrub layer, with seeds collected on site (Calscape). If the western poison oak continues to spread into this zone from neighboring Zone 16, it should be left to grow, as it is included in this association. Other shrubs worthy of introduction include mule fat and toyon, also collected on site. To supplement the herbaceous layer, giant wild rye should be introduced in smaller quantities. This zone requires extensive restoration work, and it should be kept in mind that it runs right up to the parking lot at the site, and the path means frequent human travel through the area. If funding does not permit large-scale removal of invasive species, priority should include first removing the nonnative grasses before planting largely the native shrubs that are easily introduced. Coast live oak is posed to be the easier of the two suggested tree species to introduce, as it is found in abundance on the site, so restoration teams should prioritize this and arroyo willow if funding limits choice.

Zone 13 – Monkeyflower Hill

Zone 13 is located primarily in the middle of the site. It covers the area directly south of the hill and clearing detailed in zones 10 and 11. It is moderately steep, and the primary species present are coast live oak, laurel sumac, and *Mimulus aurantiacus* (bush monkeyflower). There are also specimens of California sagebrush, giant wild rye, *Prunus ilicifolia* (hollyleaf cherry), and some nonnative annual grasses. Based on these characteristics, we matched this zone to the *Quercus agrifolia*/*Malosma laurina* Phase (6116) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This phase fits within the *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117). This phase within the association is characterized by the dominant presence of coast live oak and laurel sumac in the tree and shrub layers (Keeler-Wolf and Evens, 2006). This is due to local conditions that can be harder to see at a widespread scale in the Santa Monica Mountains.

The target vegetation remains within the same association and phase. For restoration in this zone, we recommend removal of the nonnative annual grasses to start with, including panic veldtgrass. However, this site is largely populated by native plants. Efforts should be made to continue to promote the health of these specimens, primarily the coast live oak and laurel sumac. To better match with the overall association, we recommend plantings of toyon as well through seeds collected onsite (Calscape). The few instances of California sagebrush and hollyleaf cherry can be kept at this site as well. The major introduction aside from toyon should be giant wild rye in the herbaceous layer. The easiest propagation of this plant is through seeds collected on site (Calscape). Overall, this site possesses many native plants and does not require much extensive restoration work or funding.

Zone 14 – Coast Live Oak Forest

Zone 14 is located in the middle of the site, between Zones 13 and 15. It is moderately steep and is covered primarily by coast live oak. There are instances of *Lantana montevidensis* (creeping lantana) and purple nightshade as well. Some of the pathways that cover the site run through this zone, increasing human traffic in the area. Based on these conditions, we matched this zone to the *Quercus agrifolia* South Coastal Woodland/Forest Association (6122) (Keeler-Wolf and Evens, 2006). This zone is characterized by the dominance of coast live oak and toyon, with many different herbaceous plants (Keeler-Wolf and Evens, 2006).

We believe this zone should aim for the target *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117). For restoration, we recommend leaving all of the present coast live oak, as well as introducing more plantings along the trails. Toyon should be introduced in this area. Specimens of California sagebrush are found in the neighboring zones, so they should be introduced in this zone as well. The creeping lantana presence should be removed, as they are nonnative, as well as any remnant patches of nonnative annual grasses such as panic veldtgrass. A species that is worthy of introduction is bush monkeyflower, as this shrub supports many different forms of wildlife and does well with a wide variety of plants (Calscape). These seeds can be collected from a nursery. The coast live oak should make up more than 50% of the plants present.

Zone 15 – Toyon Treetop

Zone 15 is located at the eastern edge of the site, alongside the fence behind the neighboring dorm buildings. It is a moderately steep slope, and a majority is dominated by nonnative plants. This includes eucalyptus, Canary Island pine, *Ulmus parvifolia* (Chinese elm), and a variety of nonnative annual plants like great brome and panic veldtgrass. There are a few specimens of toyon, sagebrush, California brittlebush, and *Galium aparine* (catchweed bedstraw). Due to the very high presence of nonnative trees, we matched this zone to the general Eucalyptus Woodland/Forest Alliance (9510) in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This is characterized by the dominance of eucalyptus and Canary Island pine.

This zone requires extensive restoration work. Funding is required to remove the species of eucalyptus, Canary Island pine, and Chinese elm that are present. It is worth noting that because the trees run right up to student residents, there may be more restrictions with removal as the university may be keen to keep them for landscaping purposes. However, the primary effort should be made here to remove as many trees as feasible, which may be around 50-60% of the existing trees. In their place, we recommend planting coast live oak through seeds collected on site during the winter (Calscape). These planted trees should cover 50-60% of the site following the removal of other species. The nonnative grasses that are present may be easier to remove with less funding. This includes removal of the *Bromus* species present, as well as the panic veldtgrass. California brittlebush is a key native species that should be protected here. More specimens may be planted through seeds from the site (Calscape). To complement, we recommend planting more toyon and sagebrush as well to fill out the shrub layer. This is best done through seeds and clippings collected at the site (Calscape). All of these species serve to also promote healthy wildlife communities as well. If time and funding permit, we recommend the introduction of two other shrubs to this area: chamise and *Rhus integrifolia* (lemonade berry). Because the initial conditions of the zone were unhealthy, these shrubs will create an even more diverse area. Chamise in particular does extremely well with

almost any chaparral plant, and can be introduced via seeds collected at a nursery (Calscape). This will allow this zone to more rapidly become a healthier area. Lemonade berry is a notable chaparral species that does well near the coast, provides a stable slope, and serves as fire protection (Calscape). Seeds can be collected at a nursery. To fill out the herbaceous layer following removal, introduction of giant wild rye is recommended at this site as well. A good reference to aspire to in this area is the *Quercus agrifolia*/*Heteromeles arbutifolia* Association, which has many of the previously listed plants. While not a perfect match, it does provide more guidance on the tree and shrub ratios to aim towards.

Zone 16 – Prickly Pear Trail

Zone 16 is situated at the southern end of the site, along the path closest to the western fence line that runs along Veteran Avenue. It is a moderately steep, west-facing slope dominated primarily by coastal prickly pear cactus and species of sage scrubs, including California sagebrush. There is also a small presence of *Calystegia macrostegia* (coast morning glory), catchweed bedstraw, and nonnative grasses including Panic veldtgrass. Alongside the path, we find the only instance of western poison oak at the site. The poison oak borders Zone 12 as well. Based on the current conditions, we matched this zone to the Opuntia spp.-Mixed Coastal Sage Scrub Shrubland Association (2412) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This association is classified by dominant cover of coastal prickly pear cactus, with other instances of California sagebrush, yucca species, and a diverse herbaceous layer (Keeler-Wolf and Evens, 2006).

We believe this area should stay within the reference vegetation. For restoration, we first recommend removal of the small patches of invasive grasses in this area. The already present coastal prickly pear cacti should be kept wholly intact, and new specimens introduced if space permits through collections from nurseries (Calscape). The poison oak should remain untouched as well, in accordance with the *Quercus agrifolia*/*Toxicodendron diversilobum* Association (1117). While this is not the main association in this area, it does give guidance for the poison oak that can remain. If space permits, plantings of young coast live oak should be included to support the poison oak present. However, the prickly pear cactus takes precedence, as it already exists with the poison oak at this site. There should also be introduction of other sagebrush species, including black sage, through seeds collected from nurseries. Together, these species should make up 50-60% of the zone's open shrub layer. Other notable species to introduce would be California buckwheat through seeds from a nursery and California brittlebush/bush sunflower through seeds collected on-site. The bush sunflower will attract pollinators and complement the other flowering shrubs already there, including the coast morning glory. Finally, lemonade berry could be introduced as well through nursery seeds, as it is noted to complement the cacti and sagebrush species that are already present in this zone. These species are all quite tolerant of the area, and will provide a more diverse shrub cover alongside a healthy patch of cactus that is not seen often at the site. If time and money permits, additional herbaceous introductions, including *Melica imperfecta* (small flowered melica) and optionally the California Poppy through seeds from nurseries would promote a more even understory. However, the priority remains with the species at the shrub layer should herbaceous plantings not be feasible.

Zone 17 – Miller's Gulch

Zone 17 is the largest zone that we have made for Sage Hill. It would be described as a large riparian zone consisting of annual grasses, Chinese elm, and toyon. It is north facing and located on the southernmost part of Sage Hill. Based on the conditions of this area, we were able to mostly match this zone to the *Heteromeles arbutifolia* Association (2130) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This alliance is characterized by toyon occurring as a codominant to dominant shrub in an open to continuous shrub overstory (Keeler-Wolf and Evens, 2006). With this zone being so large, there is a lot of potential for invasive species removal and for introduction of new and existing species.

We believe this zone should aim for the target *Quercus agrifolia* South Coastal Association (6122). Based on the conditions of this zone, we would recommend planting coast live oak or Salix lasiolepis (arroyo willow). Coast live oak attracts a variety of birds and butterflies and is a resilient tree (Calscape). They are easy to care for and can tolerate colder temperatures but still thrive in full sun (Calscape). With coast live oak scattered across Sage Hill, adding it to this area could prove to be beneficial. Additionally, we would recommend the upkeep of the toyon in this zone as it attracts butterflies and other pollinators and various types of birds (Calscape). Toyon is drought adapted and can handle a wide variety of soils (Calscape). Toyon has companion species of sagebrush and buckwheat which are scattered throughout Sage Hill. Willow is a type of tree that is native to California that is important for birds, insects, amphibians and mammals (Calscape). It does well in full sun and can tolerate the cold along with being a species that is easy to take care of (Calscape). With the combination of coast live oak and willow, the overall wildlife of Sage Hill will benefit and the diversity of the area will be increased. With this zone being the largest on Sage Hill, there is lots of room for improvement and for an increase in biodiversity along with supporting the native biodiversity that is already there.

Zone 18 – Ryegrass Ridge

Zone 18 is situated at the southern end of the site, directly along the path closest to the western fence line. It runs right up to the service road and is at the end of a path. It is moderately steep, and is dominated primarily by coast live oak in large numbers. There is a small presence of laurel sumac there, as well as herbaceous plants including giant wild rye. *Hedera canariensis* (Canary Island ivy) is also found along the fenceline, as well as small patches of nonnative grasses including panic veldtgrass. Based on the current conditions, we matched this zone to the *Quercus agrifolia*/*Malosma laurina* Phase (6116) found in the vegetation classification of the Santa Monica Mountains (Keeler-Wolf and Evens, 2006). This phase fits within the *Quercus agrifolia*/*Heteromeles arbutifolia* Association (6117). It is characterized by the prominence of coast live oak, as well as the presence of laurel sumac.

We believe this zone should stay with the reference vegetation. For this zone, we recommend primarily planting toyon through seeds from the site. This would allow the zone to better fit within the main association. Removal of the Canary Island ivy would also help the zone. In place, introduction of more giant wild rye along the side would be a healthier herbaceous species to have where the path is. This can be done through clippings on site as well (Calscape). Overall, this site is relatively healthy due to the native plants that are already there. Restoration here would be similar to restoration in Zone 13, with the exception of less species being introduced as the space available is hampered by

the path running through it. If space and funding permits, we recommend planting of California sagebrush to supplement the shrub layer.

Zone 19 – Hitch Lookout

Zone 19 is at the southern end of the site, alongside the eastern fence line and pushing up against the riparian area in zone 17. It is a steeper part of Sage Hill, and is dominated by primarily nonnative plants. This includes eucalyptus, great brome, and Chinese elm. Chinese elm is primarily an introduced species in Southern California, and was likely introduced by the university for landscaping purposes following one of the instances where vegetation at the site was removed. As such, it was not included in the Keeler-Wolf and Evens vegetation manual. However, the presence of eucalyptus alongside the prominent Chinese elm allowed us to match this site generally to the Eucalyptus Woodland/Forest Alliance (9510) (Keeler-Wolf and Evens, 2006).

This site requires extensive restoration work. Funding is required to remove both the eucalyptus and Chinese elm, and this is a top priority. For restoration purposes, we recommend that this site uses the *Quercus agrifolia* South Coastal Woodland/Forest Association (6122) and the *Quercus agrifolia-Juglans californica* Association (1115) from the vegetation manual (Keeler-Wolf and Evens, 2006). Trees that could be planted in their place include specimens of coast live oak and the *Juglans californica* (California walnut). This reference also includes the presence of western sycamore. These trees do well in moist areas, meaning they could do well at this zone considering that it is directly adjacent to the designated riparian area. Coast live oak should be the dominant tree species, with western sycamore supplementing through seeds collected at a nursery (Calscape). Additionally, the California walnut should be subdominant to the coast live oak. There should also be removal of the nonnative herbaceous species, which include great brome and bermuda buttercup, as well as small patches of nonnative annual grasses. There is a small presence of catchweed bedstraw, which can be expanded in this area. It is not easily found in nearby nurseries, so it would be best to collect and propagate the seeds on site (Calscape). If time and money permits, we would also recommend plantings of laurel sumac or toyon. These shrubs do well in any site at Sage Hill, and would allow for an even more diverse plant community. This is key, as the site runs up to a service road at the southern end and will require a healthier community to continue being successful.

TIMELINES

Each zone includes basic information regarding the general order for restoration. We are operating under idealized conditions, which means assuming that funding and resources are less of a limit. Based on information we gathered from other restoration projects (Malibu Lagoon, Ballona Wetlands) in an earlier literature review, we expect total restoration time for this project to be 5-10 years. This includes time spent acquiring funding and labor for invasive species removal, followed by preparations for seeding of the site. Additional time is needed following plantings for species to become established, as well as to assess how successful the restoration efforts will be. It is expected that roadblocks will arise, as not all plant recommendations in this document may work perfectly out in the field, and adjustments may be needed.

Some zones are higher priority than others. Zones in the section above that are denoted with an asterisk are considered high priority areas, as they have high levels of nonnative plants and may require more funding and resources to address. These zones should begin removal first.

Management/Restoration Actions

1. Removal of invasive/harmful species – This is the first priority. Due to the volume of nonnative plants at this site, this should be an ongoing process that is done frequently within the first few years of restoration efforts. We anticipate that after the first few years of restoration, removal will decrease, as there should be less present at the site.
2. Subsequent planting of new species – As nonnative species are removed, this will clear the way for new species to be introduced. Introductions will be done through seeds collected both onsite and at nurseries. This stage is expected to take the longest, as success can only be determined through trial and error regarding the self-sufficiency of the site.

Timelines are expected to vary as restoration begins to take place. Any adjustments that need to be made can be based on the general guidelines in this document.

Monitoring Timeline

Vegetation Transects: Every 1-2 years, April

Data collection of the vegetation transects should be completed every year in the month of April within the first several years of the restoration plan. Many changes are expected to occur within the vegetation at Sage Hill, and in order to accurately adapt restoration efforts, it is essential to have concise, yearly vegetation data.

Ideally, vegetation cover will transform to become both more native and relatively stable. The frequency of this data collection can then be steadily decreased, contingent on active restoration projects that may affect this data.

Photo-Point Monitoring: Every 3-5 years, March

Repeat Photography at all 30 areas on the photo-map is recommended to begin at a frequency of every 3 years in order to portray changes in vegetation and provide a visual representation of Sage Hill's site composition.

As the restoration plan continues, the frequency of the photo-point monitoring can be decreased to display long-term variability of each area.

Soil Sampling: Every 1-3 years, April

It is recommended that new samples be taken in each of the new dedicated restoration zones, rather than solely in the previous 6 sections. Budget constraints limited the number of samples that could be taken. Ideally, a greater amount of samples taken from each restoration zone could provide a more clear understanding of the soil conditions.

New soil samples should be taken every 1-3 years to monitor the changes in the composition of each sampled area. If species were recently removed or planted, frequency of sampling should be increased. All samples should be taken within the same seasonal range as the original samples, during the month of April.

Aerial Imagery: Every 1-3 years, March

Repeated drone flights supplying aerial imagery of the site should occur every year in March, subject to reassessment depending on compiled monitoring data. Several environmental indicators are displayed within this imagery, and digitization will permit data analysis of the site on a yearly basis.

As this imagery provides vegetation data, the frequency of these drone flights may also be decreased as the vegetation composition stabilizes.

FINAL REMARKS

We acknowledge that no restoration document will ever be truly perfect. There will be necessary changes for this document as restoration and monitoring takes place. However, we believe that this document contains enough information to inform future restoration at this site, even if conditions change. Adaptive management is crucial for understanding this site. Changing conditions warrant changing methods. Throughout this process, we learned just how important restoration ecology in urban areas is. There are different considerations, due to working within such a dense and small area. These challenges deserve attention, and we hope that Sage Hill can be the first of many sites to take advantage of urban restoration opportunities. Ultimately, we hope that our work here will create a healthy ecosystem that can be used by humans and wildlife alike for generations to come.

APPENDIX

APPENDIX A: TRANSECTS

Transect Data Collection Sheet:
https://ucla.app.box.com/file/1557938493575
Transect Data:
https://ucla.app.box.com/file/1559370846108

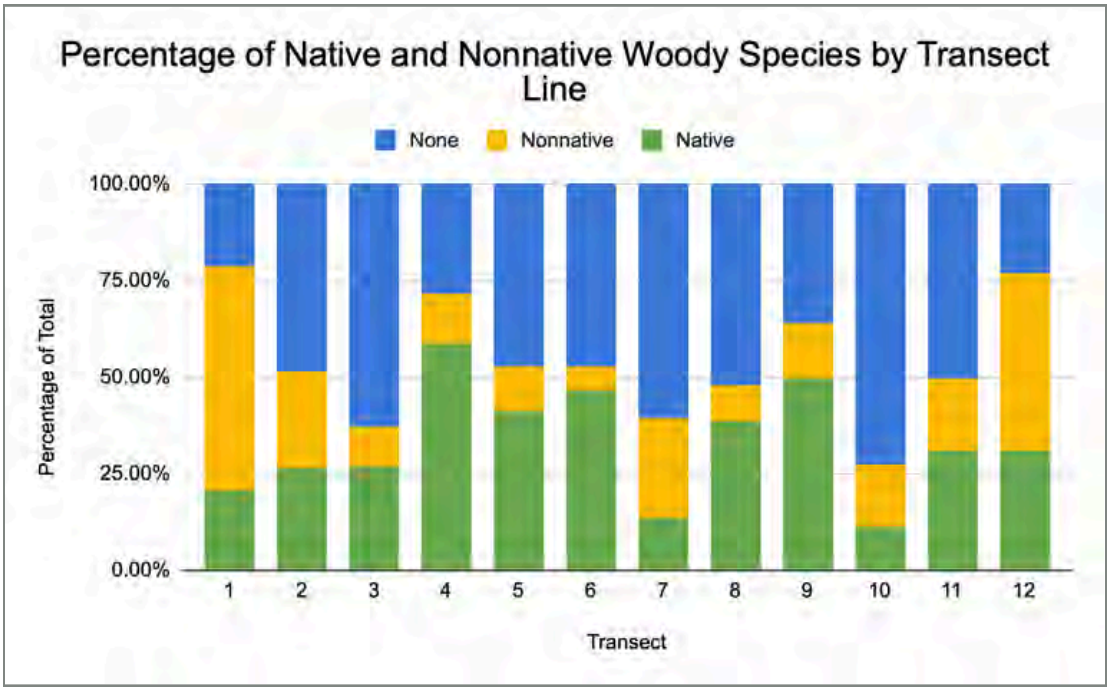


Figure 14: Bar graph of transect data by the percentage of native and nonnative woody species at each transect line.

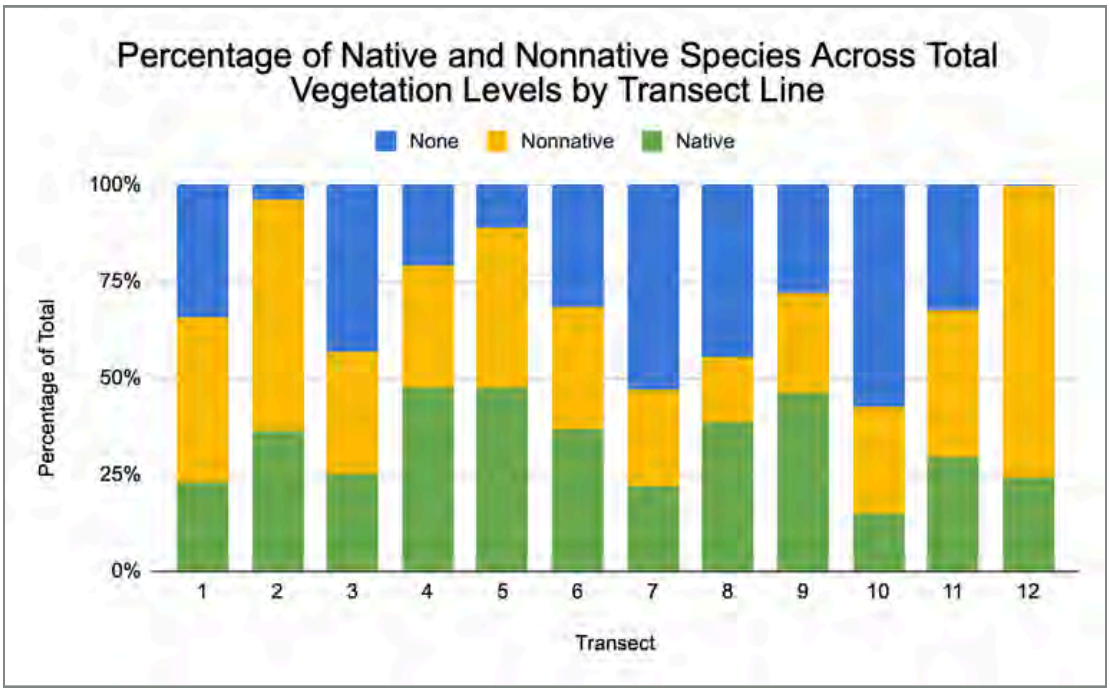


Figure 15: Bar graph of transect data by the percentage of all native and nonnative across vegetation levels at each transect line.

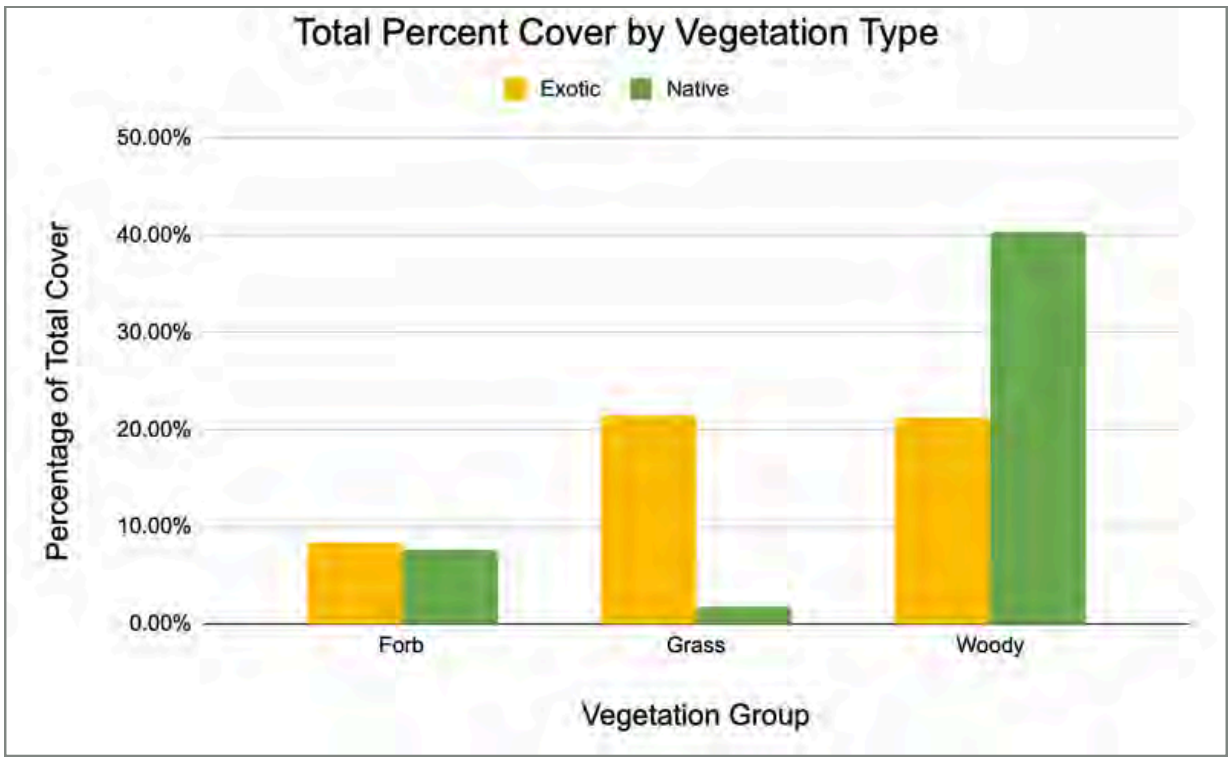


Figure 16: Bar graph of all transect data measured by the total percent cover of exotic versus native species based on vegetation type (forb, grass, or woody).

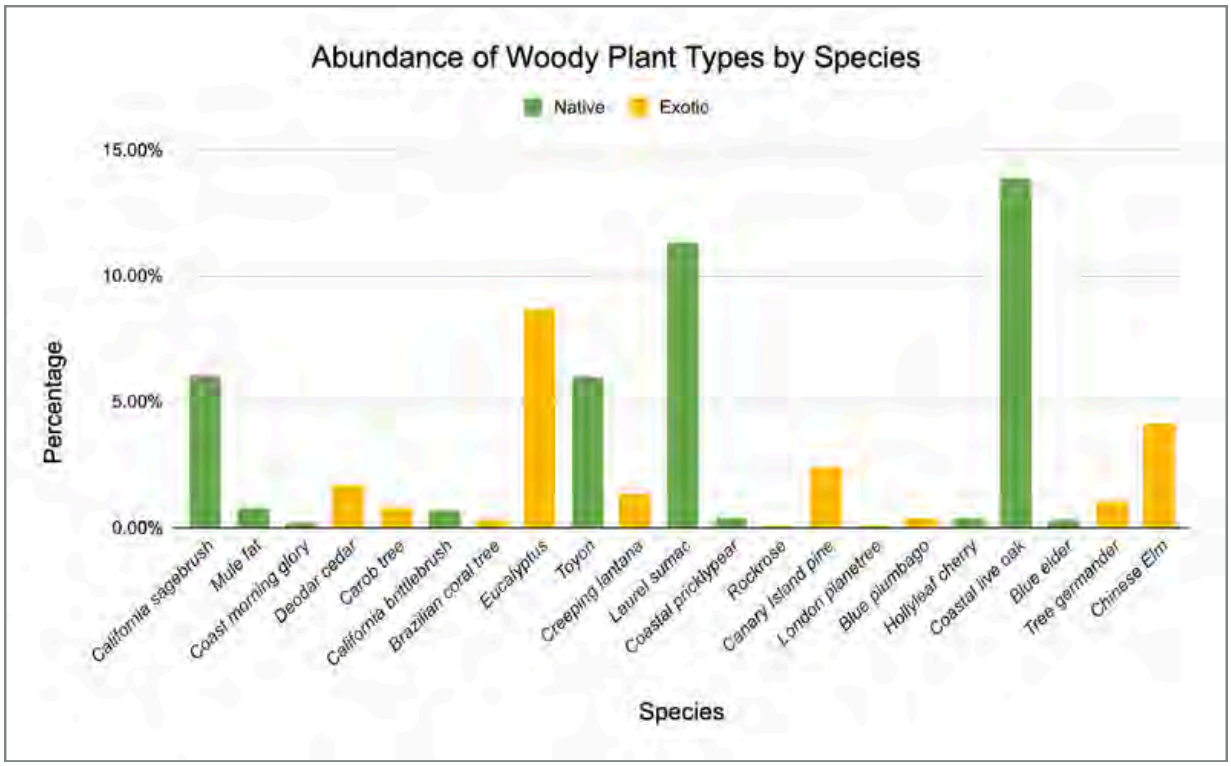


Figure 17: Bar graph of transect data measuring the total percent cover of woody plant types only. Native woody plants outrank exotic woody plants. From order of most abundant to less abundant, the most common woody plant species on Sage Hill are coast live oak (native), California sagebrush (native), laurel sumac (native), and eucalyptus (exotic).

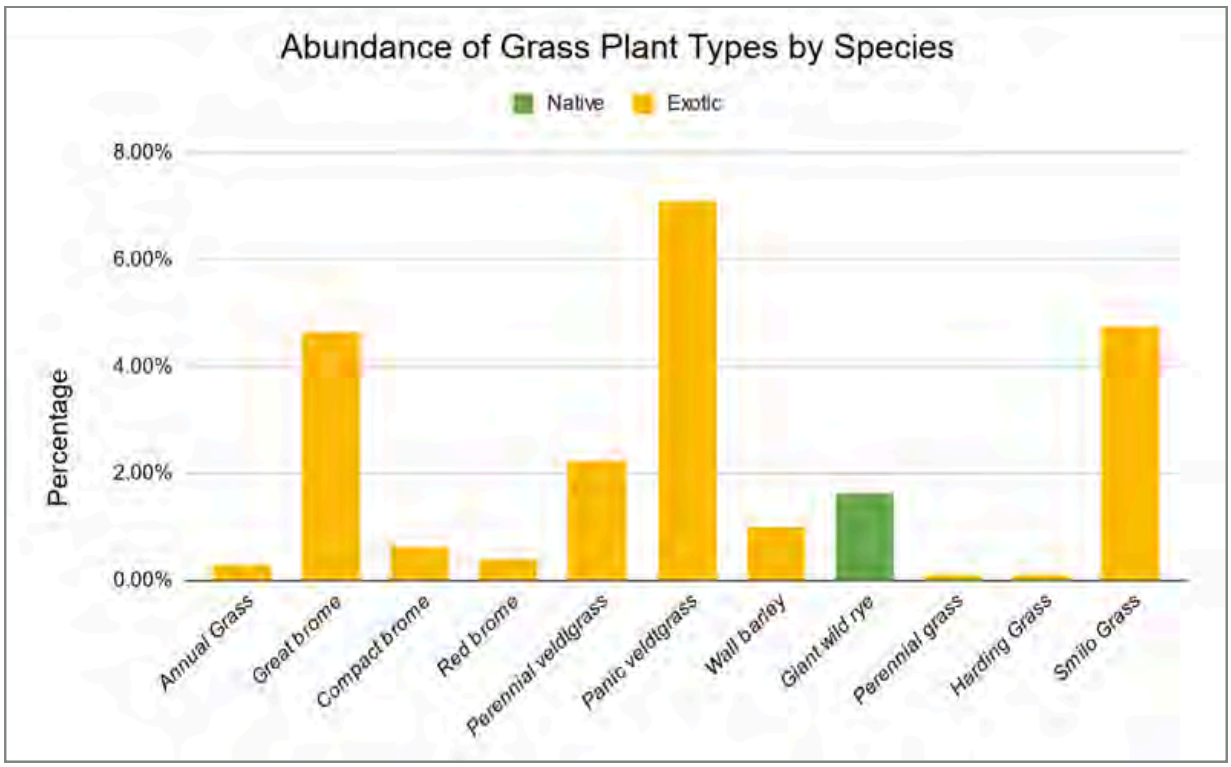


Figure 18: Bar graph of transect data measuring the total percent cover of grass plant types only. Exotic grass species outrank native grass species. From order of most abundant to less abundant, the most common grass species on Sage Hill are Panic veldgrass (exotic), Great brome (exotic), and Smilo Grass (exotic).

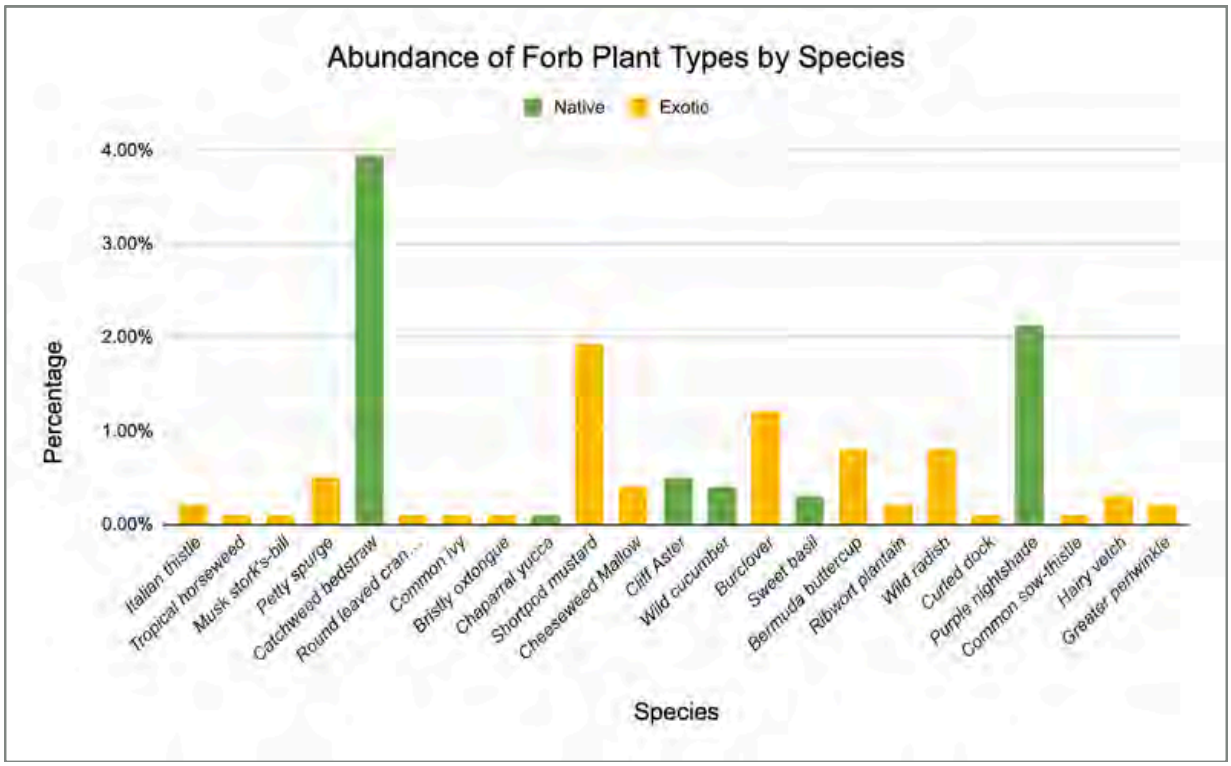


Figure 19: Bar graph of transect data measuring the total percent cover of forb plant types only. The native catchweed bedstraw is the most abundant forb species at ~4.00% abundance out of 751 transect measurements.

APPENDIX B: PHOTO POINT

Photos Folder:
https://ucla.app.box.com/file/1559366228711
Photo Table:
PDF: https://ucla.app.box.com/file/1559953348367
XLSX: https://ucla.app.box.com/file/1559953348367

Figure 20: Snapshot of ArcGIS StoryMap created by Jacqueline Gonzalez Hurtado. The StoryMap is a public-facing, interactive website. It summarize much of this document into a digestible format. It also contains many of our photo points and has slider comparisons.

APPENDIX C: SOIL

Figure 21: Soil Moisture Map with six sites colorized by varying levels of moisture.

The soil with the highest moisture content among the sites was in Sycamore Valley, which we also refer to as a riparian zone. During wet seasons, this area often has a running stream.

The soil with the lowest moisture content was in Yucca Hill, located at the center of the map. Plants to be cultivated in Yucca Hill should be tolerant of dryness and low water reception.

Tin Weight (g)	2.12					
Sample Number	Title	Wet Weight (g)	Dry Weight(g)	Water Weight(g)	% Water	Classification
1	North Disturbed (Plots 17 & 16)	71.14	63.28	7.86	12.42	Disturbed
2	Stipa Hill (Plots 13 & 14)	59.48	53.02	6.46	12.18	Undisturbed
3	Yucca Hill (Plot 23)	62.05	57.28	4.77	8.33	Undisturbed
4	Nightshade Meadow (Plots 4 & 5)	111.05	88.9	22.15	24.92	Undisturbed
5	Lower Debris Area (Plots 25, 26, & 30)	85.39	73.73	11.66	15.81	Disturbed
6	Sycamore Valley (Plots 1 & 3)	122.67	102.84	19.83	19.28	Disturbed

Figure 22: Soil Moisture table with the exact values of the wet weight of soil in g (grams) and the dry weight in g. The exact water weight in g and the percentage of water that was apart of the soil weight is listed in the fifth and sixth columns, respectively. The classification of the site as “disturbed” or “undisturbed” is also recorded in the rightmost column.

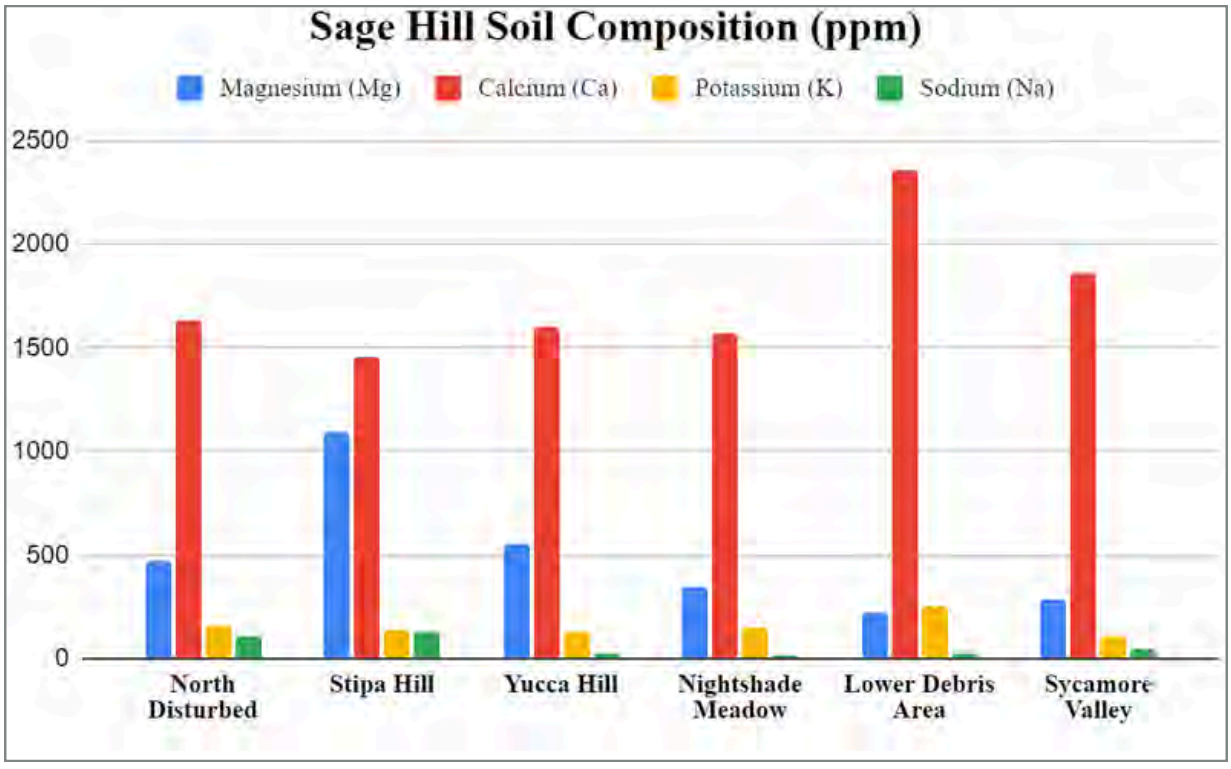


Figure 23: Bar graph of the chemical concentration of the soil in terms of Magnesium (Mg), Calcium (Ca), Potassium (K), and Sodium (Na)-- in terms of ppm. Notably, the site is generally lacking in K at all six sites. Mg is higher at all “undisturbed” sites. It is hard to make other claims without additional soil collection.

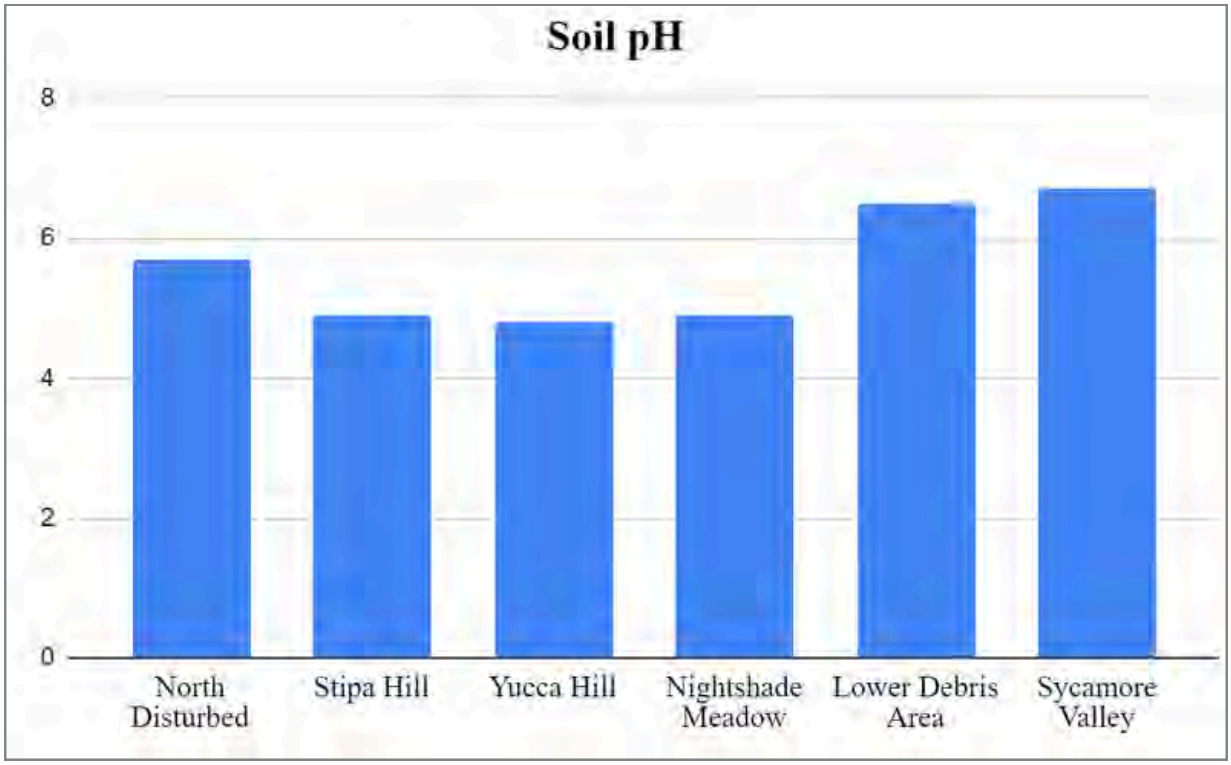


Figure 24: Bar graph of the soil pH at all six sites. The undisturbed sites has lower pH levels on average compared to the disturbed sites (North Disturbed, Lower Debris Area, and Sycamore Valley).

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH			Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED			
		% Rating	ENR lbs/A	P1 (Weak Bray) ppm	$NaHCO_3$-P (OlsenMethod) ppm	K ppm	Mg ppm	Ca ppm	Na ppm	Soil pH	Buffer Index		C.E.C. meq/100g	K %	Mg %	Ca %	Na %
PLOT 17-16	S85889-01	2.4	91	30.8	12.3	155	470	1630	109	5.7			12.9	3.1	30.4	63.0	3.7
PLOTS 13-14	S85889-02	3.0	101	25.8	9.52	136	1090	1460	125	4.9			17.3	2.0	52.7	42.1	3.1
PLOT 23	S85889-03	3.0	101	40.7	15.5	130	557	1600	28.5	4.8			13.1	2.5	35.4	61.1	0.9
PLOT 4-5	S85889-04	3.7	131	19.3	9.88	154	343	1570	14.1	4.9			11.2	3.5	25.5	70.0	0.5
PLOTS 25 26 3	S85889-05	1.9	81	43.6	31.9	254	224	2360	24.4	6.5			14.4	4.5	13.0	81.9	0.7

SAMPLE NUMBER	Nitrogen NO_3-N ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		PARTICLE SIZE ANALYSIS			
												SAND %	SILT %	CLAY %	SOIL TEXTURE
S85889-01	12.7											62.5	21.3	16.3	Sandy Loam
S85889-02	9.57											43.8	33.8	22.5	Loam
S85889-03	12.1											61.3	21.3	17.5	Sandy Loam
S85889-04	23.9											56.3	31.3	12.5	Sandy Loam
S85889-05	19.9											66.3	18.8	15	Sandy Loam

Figure 25: A&L Western Laboratory chemical composition table for sites 1, 2, 3, 4, and 5. It records Organic Matter, two forms of Phosphorous (P), Potassium (K), Magnesium (Mg), Calcium (Ca), Sodium (Na), pH, and Cation Exchange Capacity (CEC) of the soil. Texture is in the bottom portion.

SAMPLE ID	LAB NUMBER	Organic Matter		Phosphorus		Potassium	Magnesium	Calcium	Sodium	pH			Cation Exchange Capacity	PERCENT CATION SATURATION (COMPUTED)			
		% Rating	ENR lbs/A	P1 (Weak Bray) ppm	$NaHCO_3$-P (Olsen Method) ppm	K ppm	Mg ppm	Ca ppm	Na ppm	Soil pH	Buffer Index		C.E.C. meq/100g	K %	Mg %	Ca %	Na %
PLOTS 1 3	S85889-06	2.0	81	32.9	18.6	104	280	1860	42.3	6.7			12.1	2.2	19.3	76.8	1.5

SAMPLE NUMBER	Nitrogen NO_3-N ppm	Sulfur SO_4-S ppm	Zinc Zn ppm	Manganese Mn ppm	Iron Fe ppm	Copper Cu ppm	Boron B ppm	Excess Lime Rating	Soluble Salts mmhos/cm	Chloride Cl ppm		PARTICLE SIZE ANALYSIS			
												SAND %	SILT %	CLAY %	SOIL TEXTURE
S85889-06	17.4											67.5	20	12.5	Sandy Loam

Figure 26: A&L Western Laboratory chemical composition table for site 6.

Figure 27: Soil Magnesium (Mg) Map with six sites colorized by varying levels of Mg in units of ppm.

The soil with the highest Mg content among the sites was in Stipa Hill, in the northern corner of the map.

The soil with the lowest Mg content was in the Lower Debris Area.

Figure 28: Soil Calcium (Ca) Map with six sites colorized by varying levels of Ca in units of ppm.

The soil with the highest Ca content among the sites was in the Lower Debris area. This area has experienced strong disturbance and has generally been cleared of vegetation.

The soil with the lowest Ca content was in Stipa Hill, which holds a great amount of needlegrass individuals.

Figure 29: Soil pH Map with six sites colorized by varying levels of pH.

The soil with the highest pH was in Sycamore Valley, at the bottom of the map. This soil is more basic compared to the other sites.

The soil with lowest pH in the was the Lower Debris Area.

Figure 30: Soil Potassium (K) Map with six sites colorized by varying levels of K in units of ppm.

At 254 ppm of K, the Lower Debris Area had the highest concentration of K.

Conversely, the site with the lowest K concentration is was Sycamore Valley.

APPENDIX D: DRONE IMAGERY & MAPS

GIS Files:
https://ucla.app.box.com/file/1559370066423
High-Quality Maps:
https://ucla.app.box.com/file/1559372951764

Table of average topographic factors at each restoration zone:

Site	Slope (degrees)	Northness	Eastness	Area (square m^2)
1. Northern Meadow	17.13531	0.523028	-0.63854	500.246
2. Northern Eucalyptus	18.87085	0.472018	-0.77801	924.821
3. Stipa Steppes	29.27047	0.248328	-0.93138	158.1807
4. Oak Avenue	21.93709	0.206498	-0.83747	1664.873
5. Sagebrush Strip	26.08379	0.120591	-0.92239	648.2432
6. Yucca Hill	23.62798	0.179455	-0.90642	395.2859
7. Ground Squirrel Slopes	19.99378	-0.41122	-0.57175	578.7757
8. Elsie's Forest	21.79003	-0.15926	-0.86399	1570.417
9. Needlegrass Valley	6.689342	-0.34657	-0.79348	336.2702
10. Sunshine Scrub	23.54214	-0.58026	-0.7237	501.7583
11. Elderberry Thicket	8.914848	0.015446	-0.69395	683.5435
12. West Entrance	9.483649	-0.11884	-0.67886	1251.75
13. Monkeyflower Hill	19.6474	0.227711	-0.84993	1566.684
14. Coast Live Oak Forest	13.53336	-0.73207	-0.4556	946.9823
15. Toyon Treetop	16.70087	-0.443	-0.44862	1631.853
16. Prickly Pear Trail	19.65882	-0.18882	-0.67314	638.2023
17. Miller's Gulch	10.92669	-0.6973	-0.16603	3194.755
18. Ryegrass Ridge	17.44548	-0.56157	-0.2389	850.6617
19. Hitch Lookout	22.40734	0.164676	-0.87419	1817.842

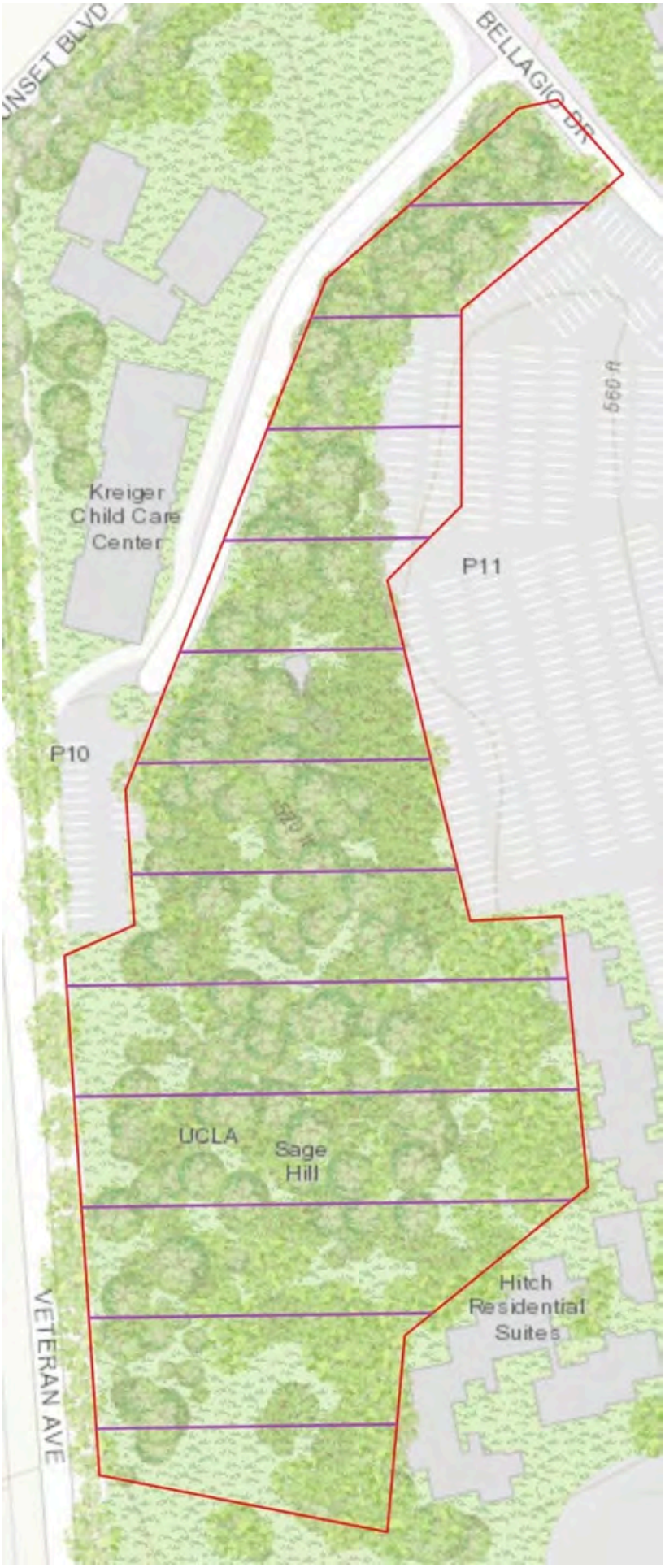


Figure 31: Map of Sage Hill boundary (in red) over a 2D-basemap.

The purple lines represents where we conducted the 12 transects, which we reported the results of in this document.

They are spaced 25 meters apart.

APPENDIX E, F, G: VISUALS & GUIDES

Appendix E

ArcGIS StoryMap:
https://storymaps.arcgis.com/stories/ea92d13ed39d40b5a333820620e5a14a
ArcGIS StoryMap QR Code & Links Flyer:
https://ucla.app.box.com/file/1559742659160

The ArcGIS StoryMap succinctly summarizes key points of this document and is meant to be easy to understand. It covers our Introduction, Project Goals, Vegetation Transects, Photo Points, Drone Imagery, Restoration Plan, and Conclusion.

Appendix F

Instruction manuals to replicate our ecological monitoring methods:
https://ucla.app.box.com/file/1559478932942

The instruction manuals are meant to help others replicate the methods we used to collect data on the abiotic and biotic conditions on site. Any student volunteers or future Sage Hill habitat restorationists should be able to gain a strong grasp on our four monitoring methods.

Appendix G

Species Identification Guide:
https://ucla.app.box.com/file/1559672474110

We encourage the uninitiated Sage Hill ecologist to use the Species Identification Guide to learn about common species on site. Many species are hard to detect through apps such as iNaturalist and SEEK. Using this guide in conjunction with the transect instruction (see above) will aid vegetation monitoring efforts.

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