Bushwhacking through Claremont Canyon: A Vegetation Composition Analysis

Madison R. Wheeler

ABSTRACT

Climate change, management, and introduction of invasive species have all altered the vegetation composition of open spaces. California, a hotspot of biodiversity, is at risk of losing endemic species due to these driving forces. Claremont Canyon is a particular area of study that I resurveyed to assess how vegetation had changed from a survey in 1992, and which pioneer species would emerge after eucalyptus removal treatment in December of 2021. I used transects to identify understory species in a 50-acre site in Claremont Canyon, and identified pioneer species along Claremont Avenue in the site to track these changes. The dominant species found in the site were *Baccharis pilularis* (coyote bush), *Genista monspessulana* (french broom), *Toxicodendron diversilobum* (poison oak), and *Diplacus aurantiacus* (sticky monkey flower). The pioneer species in the eucalyptus removal treatment site were Galium aparine (bedstraw), *Centaurea melitensis* (Maltese star thistle), and french broom. Non-native species abundance increased from 31% to 48% from 1992 to 2022, and much of the distribution and dominant species changed over time. I found most of the pioneer species should be considered a fire risk to surrounding communities. Management of future treatment sites should consider fire risk of invasive species that emerge after eucalyptus removal. Further studies should continue to track vegetation composition.

KEYWORDS

dominant species, non-native, species distribution, temporal study, abundance

INTRODUCTION

The ecosystem health of local parks and preserves is impacted by climate change. Droughts and wildfires have been increasing in frequency in the northern Sierra Nevada since the mid 1990's, in part due to climate warming (Collins et al. 2019). Likely to be the primary driver of ecosystem change, the combination of fire and climate-caused disturbances like drought will influence vegetation distribution (Halofsky et al. 2020). Studies concerning future plant distribution project that up to 66% of California's endemic plant taxa will have over 80% reductions in range within the next 100 years (Loarie et al. 2008). However, biodiversity can increase resilience in ecosystems from higher severity impacts of a warming planet. For example, communities with lower biodiversity may be less protected against climate change related disturbances than that of more diverse communities (Chapin et al. 1998). Thus, California's ecosystem health is especially important to monitor because the species richness and vegetation can help mitigate the effects of the severe droughts to come.

Intrinsically linked to climate change, invasion of non-native species in local ecological communities has been detrimental to ecosystem health and invasive species pose a threat to ecosystem health and resilience. European grasses like *Bromus tectorum* have increased fire hazard in the Western United States (Knapp 1996). Non-native species are sometimes equipped with advantages over native species, leading to their proliferation. This decreases native diversity and impacts species composition (Hillerislambers et al. 2010). For example, French broom (*Genista monspessulana*) is a common invasive species in California. *Genista monspessulana* has "fruits dehisce explosively, propelling the seeds a short distance," and when unmanaged, "form thick patches that shade native plants and compete for nutrients" (Dennehy et al. 2011). California, more specifically the San Francisco Bay area, has its own unique challenges with invasive species.

The California Floristic Province, in particular, is a hot spot for species diversity and prevalence of endemism (Loarie et al. 2008). Thus, the introduction and management of invasive species requires special consideration. Furthermore, some non-native species are intentionally introduced into the environment, such as Eucalyptus planted in the Oakland hills of the San Francisco Bay Area, including in Claremont Canyon. Research shows mixed results on the biotic impacts of Eucalyptus in California ecosystems; some research shows that blue gum eucalyptus outcompete native trees, especially in grasslands grazed by livestock (Burns and Honkala 1990).

The impact on understory vegetation beneath blue gum eucalyptus stands varys in studies: some report sparse growth, while others show that vegetation is largely native species (Wolf and DiTomaso 2016).

Management of open spaces likewise impacts vegetation composition and can mitigate or promote the growth of invasive species. In California, management of open space largely centers around fuel management to reduce fire risk. Studies show human-caused wildfire has increased exponentially across California, often due human ignition, high fire risk vegetation and a prolonged fire season (Steel et al. 2015). One fuel management technique is the use of fuel breaks in shrublands, which limit woody shrubs to assist in fire suppression activities (Grupenhoff and Malorini 2021), but implementation of firebreaks are can increase non-native species abundance, and repeated disturbances can result in replacement of native species with their invasive competitors (Merriam et al 2006). Other fuel management techniques include removal of invasive tree stands that pose increased fire risk, such as Eucalyptus stands (Wolf and DiTomaso 2016). Their shredded, draping bark and volatile sap is the perfect recipe for increasing fire intensity and spread (Wolf and DiTomaso 2016).

University of California has implemented one such project, the Claremont Canyon Evacuation Support Project, to remove tree stands within 100 feet of Claremont Avenue and Grizzly Peak Boulevard. Research on pioneer species that emerge after removal, and their own fire risk, remains an area in need of further research. Anthropogenic climate warming and non-native species proliferation have impacted the stability and health of ecosystems, both globally and locally. My goal is to understand how the vegetation composition and profile has changed in Claremont Canyon especially in terms of emergence of non-native species. More specifically, what is the present species composition and distribution in the site? How has vegetation changed since surveys in 1992 over the past 30 years? And, given the recent management for fire hazard, what pioneer species emerge after Eucalyptus removal?

METHODS

Study Site

Claremont Canyon is a 208-acre nature preserve in the Berkeley Hills. The preserve is a diverse landscape sitting on an urban-wildland interface (Figure 1). The canyon was originally used by Huichan Ohlone Indians as a “thoroughfare that connected them to valleys to the east,” and their efficient land management led to a thriving healthy ecosystem (EBRPD 2022). In the 1860’s, Pony Express used the canyon to carry mail to the Contra Costa Area. Eventually, the early 20th century brought cattle grazing, dairying, quarrying, spring development, and for eucalyptus and Monterey pine plantations (EBRPD 2022). More than just sociologically significant, the canyon is an important ecological site. Monterey pine and eucalyptus groves serve as non-native islands in the canyon, and researchers can study their impact on the plants that grow beneath their canopy, also known as understory plants. European grasses introduced in the 1850’s for cattle grazing have largely pushed out native shrubs and grasses (Winsor 1992). However, the northern coastal scrubland remains largely undisturbed, and native oak and Bay Laurels are also present. With climate change and invasive species introduction impacting vegetation distribution, Claremont Canyon is a good site to track changes over time. The coordinates of the site are 37°53’06.79” N, 122°12’57.62” W, with a trailhead starting at the inward point of Claremont Avenue.

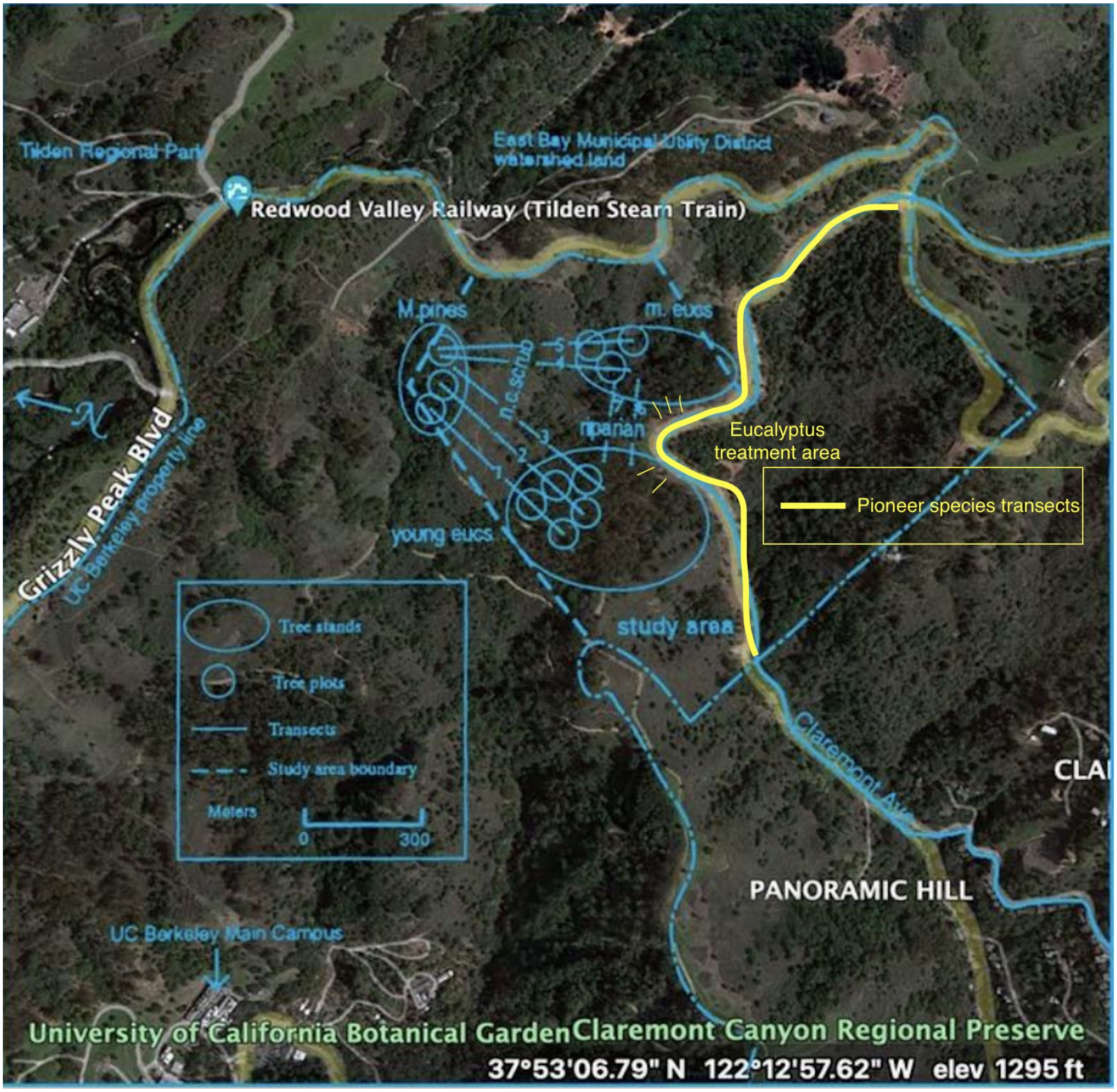

Figure 1. Study site in Claremont Canyon. Map from Winsor 1992 research is overlaid with a Google Maps image of the site.

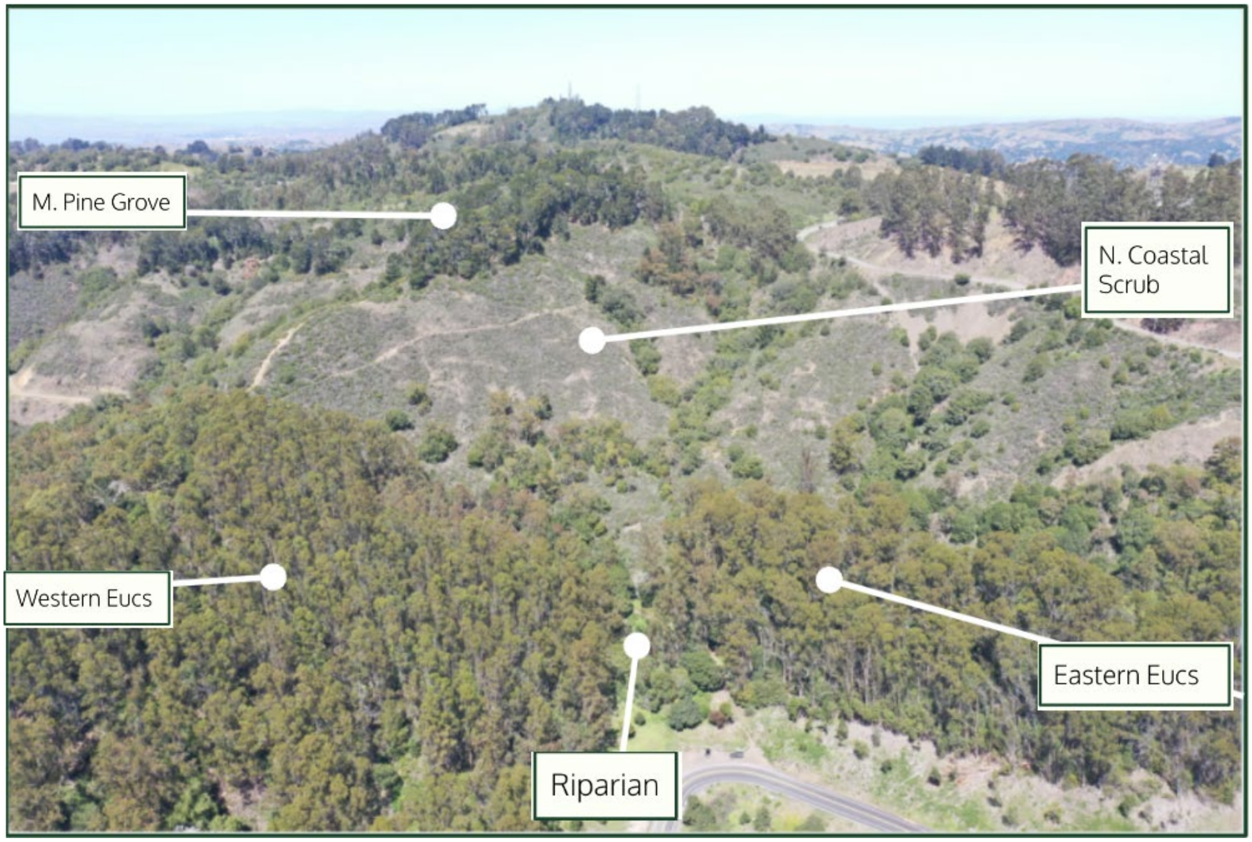

Figure 2. Study site in Claremont Canyon with five distinct habitats identified. Photo by Antonio Tambornino.

Current Vegetation Composition

To find the species distribution and changes through transitioning zones at the site, I used a combination of line transects and large plots (Figure 1). The methods were developed by Shannon Winsor and Forestry Professor Lee Wensel for the original data taken in 1992 (Winsor 1992). Transects are linear sample sites during which plants are identified at a regular interval (Phillips 1959). I used 350m and 130m transects to identify transitions of plant species in the understory, including shrubs, grasses and herbs. The $100m^2$ plots contained the standing trees to capture the tree composition. I took data along seven transects and in eleven large plots (Winsor 1992). There are five ecologically distinct areas I looked at to identify species composition at the site (Figure 2): the Monterey pine grove (MPG), the mature and young eucalyptus groves, the northern coastal scrubland, and the riparian area between the eucalyptus groves. The mature and young eucalyptus groves I will refer to as Western (WEG) and Eastern eucalyptus groves (EEG).

To identify the tree distribution in Claremont Canyon, I used large plots in three locations at the site. With a measured out 5.6m piece of rope, my colleague held one end of the rope at the center point of the plot while I held the other end taut and walked a circle around them, thus determining which trees fell within the plot. In the MPG, I identified the species of trees within three circle plots, the WEG contained five plots, and the EEG contained three. I recorded all trees within the 100m^2 (5.6m radius) circle. I randomized the order in which I took the data for the plots and the transects using a number generator to keep the results as unbiased as possible. To identify the understory species composition, I used transects that connected the major areas within the site. Along the 350m transects from the MPG to the eucalyptus groves, I identified the species of understory vegetation at 2m intervals, with 2m wide sections to collect the data. This interval allowed me to track the transitions of plants between different areas. Using the app PictureThis, https://www.picturethisai.com, and Claremont Canyon Plant List resources, https://www.ebparks.org/sites/default/files/ebrpd_claremont_canyon_plants.pdf, I confirmed my identifications.

Comparing 1992 to 2022 Vegetation Data

To compare the vegetation composition of the site today to the 1992 data, I compared dominant species identified in each section of the transect. The transects were divided into the main habitats (Figure 2), as well as three transition zones between habitats. Transition zone A was a section of 40 meters between northern coastal scrub (NCS) and the eucalyptus groves. Transition zone B was a section of 20 meters between the MPG and NCS. Dominant species were those that were present in over 35% of the transect sections. I calculated the total percentage of non-native species identified and compared this to the 1992 total percentage of non-native species.

Abundance of Pioneer Species after Eucalyptus Removal

To assess vegetation composition of the pioneer species, I used transects within the clearing treatment zone (CTZ) along Claremont Ave. The treatment overlapped with my study site, so I selected the bounds of the site to border the transects. Using a random number generator from 20 even distributed transects, I selected five transects. Each was 10 meters long, and species were identified at one meter intervals with a width of two meters. I analyzed the data using rank abundance curves, and I noted dominant species that were present in over 30% of the transect sections.

RESULTS

Current Vegetation Composition

I identified 93 unique species in the Claremont Canyon site. There were 45 non-native species and 48 native species. Of the total species, I identified 59 herbs, 10 grasses, 17 shrubs, and 1 tree (Table 1).

Latin Name	Common Name	California Native?	Type
Acmispon americanus	Spanish clover	no	herb
Aesculus californica	Buckeye	yes	tree
Allium ursinum	Wild garlic	no	herb
Anagallis arvensis	Scarlet Pimpernel	no	herb
Artemisia californica	California sagebrush	yes	herb
Artemisia douglasiana	California mugwort	yes	herb
Avena fatua	Wild oat	no	grass
Baccharis pilularis	Coyote bush	yes	shrub
Berberis pinnata ssp. insularis	Island barberry	yes	shrub
Brandegea bigelovii	Desert starvine	yes	vine
Brassica negra	Black mustard	no	herb
Brassica tournefortii	Asian mustard	no	herb
Bromus catharticus	Rescue grass	no	grass
Bromus diandrus	Great brome	no	grass
Bromus madritensis	Foxtail chess	no	grass
Bromus rubens	Red brome	no	grass
Calystegia macrostegia ssp. tenuifolia	Island false bindweed	yes	herb
Cardamine hirsuta	Hairy bittercress	no	herb
Cardamine oligosperma	Littler Bittercress	no	herb
Carduus pycnocephalus	Italian thistle	no	herb
Castilleja foliolosa	Wooly indian paintbrush	yes	shrub
Centaurea melitensis	Maltese star thistle	yes	herb
Chlorogalum pomeridianum	Wavy leaf soap plant	yes	herb
Cirsium arvense	Creeping thistle	no	herb
Cirsium vulgare	Bull thistle	no	herb
Claytonia perfoliata	Miner's lettuce	yes	herb
Clinopodium douglasii	Yerba buena	yes	herb
Conium maculatum	Poison hemlock	no	herb
Diplacus aurantiacus	Sticky monkey flower	yes	shrub
Distichlis spicata	Desert SaltGrass	no	grass
Doves-foot cranes-bill	Dove’s foot cranesbill	no	herb
Drymocallis glandulosa	Sticky Cinquefoil	yes	herb
Dryopteris arguta	Coastal wood fern	yes	fern
Ehrharta erecta	Panic Veldt Grass	no	grass
Elymus condensatus	Wild Rye	yes	grass
Epilobium canum	California fuschia	yes	herb
Eriogonum fasciculatum	California buckwheat	yes	herb
Eriogonum nudum	Naked buckwheat	yes	herb
Eriophyllum confertiflorum	Golden yarrow	yes	shrub
Erodium cicutarium	Redstem stork's bill	no	herb
Euphorbia oblongata	Egg leaf spurge	no	herb
Galium aparine	Bedstraw	no	herb
Galium nuttallii	Climbing bed straw	yes	herb
Genista monspessulana	French broom	no	shrub
Geranium dissectum	Cut Leaf geranium	no	herb
Geranium robertianum	Robert geranium	no	herb
Gutierrezia sarothrae	Broom Snakeweed	yes	shrub
Hedera canariensis	Algerian ivy	no	vine
Hedera helix	English ivy	no	shrub
Heracleum lanatum	Cow parsnip	yes	herb

Latin Name	Common Name	California Native?	Type
Heteromeles arbutifolia	Toyon	yes	shrub
Hirschfeldia incana	Shortpod mustard	no	herb
Juncas xiphiodes	Iris leaf rush	yes	herb
Lactuca serriola	Prickly Lettuce	no	herb
Lonicera hispidula	Pink honeysuckle	yes	vine
Lupinus albifrons	Silver lupine	yes	shrub
Marahfabaceus	Creeping cucumber	yes	vine
Marrubium vulgare	White horehound	no	herb
Medicago hispida	Bur clover	no	herb
Melilotus indicus	Annual yellow sweet clover	no	herb
Melissa officinalis	Lemon balm	no	herb
Momordica charantia	Bitter melon	no	herb
Monardella villosa	Coyote mint	yes	herb
oliaago californica	California goldenrod	yes	herb
Phalacia imbricata	Imbricate phacelia	yes	herb
Prunus americana	American plum	yes	shrub
Prunus mexicana	Mexican plum	yes	shrub
Pseudognaphalium californicum	Ladies tobacco	yes	herb
Pteridium aquilinum pubescens	Bracken Fern	yes	fern
Pterostegia drymarioides	Woodland pterostygia	yes	herb
Rhamnus californica	Rhamnus californica	yes	shrub
Ribes Californicum	Hillside gooseberry	yes	shrub
Ribes sanguineum	Red flowering currant	yes	shrub
Rubus ursinus	California blackberry	yes	herb
Rumex pulcher	Fiddle dock	no	herb
Sanicula crassicaulis	Pacific black snake root	no	herb
Scrophularia californica	California figwort	yes	herb
Sidalcea malviflora	Checker bloom	yes	herb
Silybum marianum	Blessed milk thistle	no	herb
Solanum umbelliferum	Blue witch nightshade	yes	shrub
Sonchus asper	Spiny sowthistle	no	herb
Stachys bullata	California hedgenettle	yes	herb
Stachys rigida	Rough hedgenettle	yes	herb
Stellaria media	Chickweed	no	herb
Symphoricarpus albus	Tall Snowberry	yes	herb
Symphyotrichum chilense	Common california wild aster	yes	herb
Torilis arvensis	Hedge parsley	no	herb
Toxicodendron diversilobum	Poison oak	yes	shrub
Trifolium hirtum	Rose clover	no	herb
Trifolium subterraneum	Subterranean clover	no	herb
unknown	Barley	no	grass
unknown	European spiky grass	no	grass
Vicia sativa	Narrow leaved vetch	no	herb

Table 1. Plant species found in Claremont Canyon.

The vegetation composition of the transects are displayed by abundance curves. Abundance refers to the number of transect sections a species was present. The dominant species in the transects were coyote bush, french broom, scarlet pimpernel, poison oak, and sticky monkey flower. Generally, both non-native and native species dominated the transects. Transect 6 and 7, which were through the riparian habitat, differed from transects 1, 2, and 3. Galium and blackberry were dominant through the riparian zone, and there were fewer species overall compared to the longer 350-meter transects 1, 2, and 3.

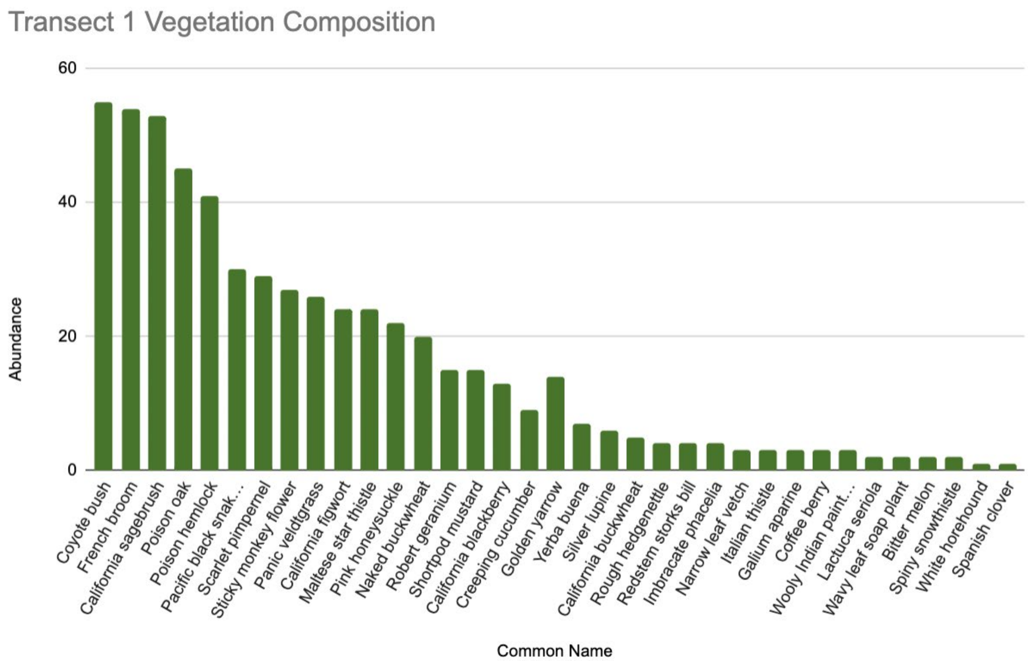

Figure 3. Vegetation abundance in Transect 1.

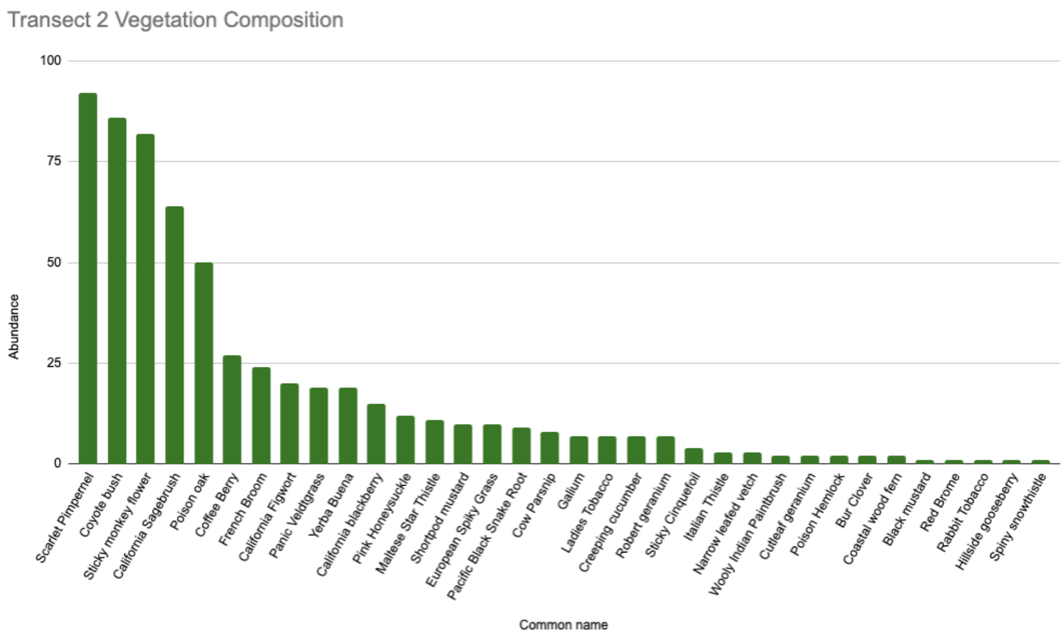

Figure 4. Vegetation abundance in Transect 2.

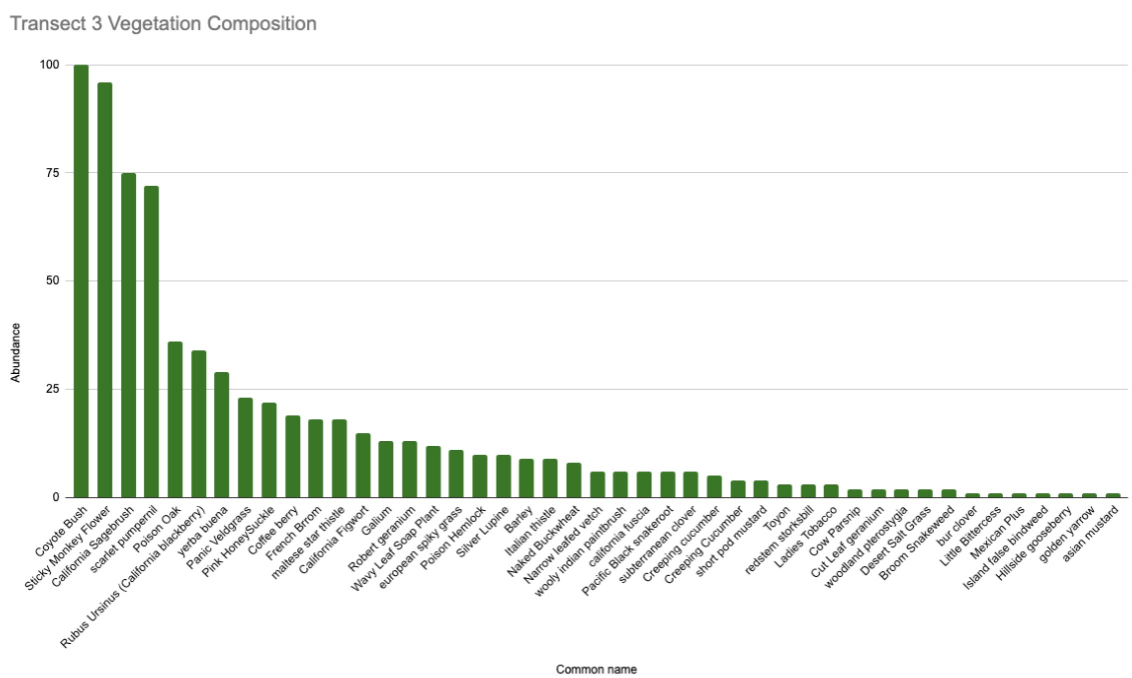

Figure 5. Vegetation abundance in transect 3.

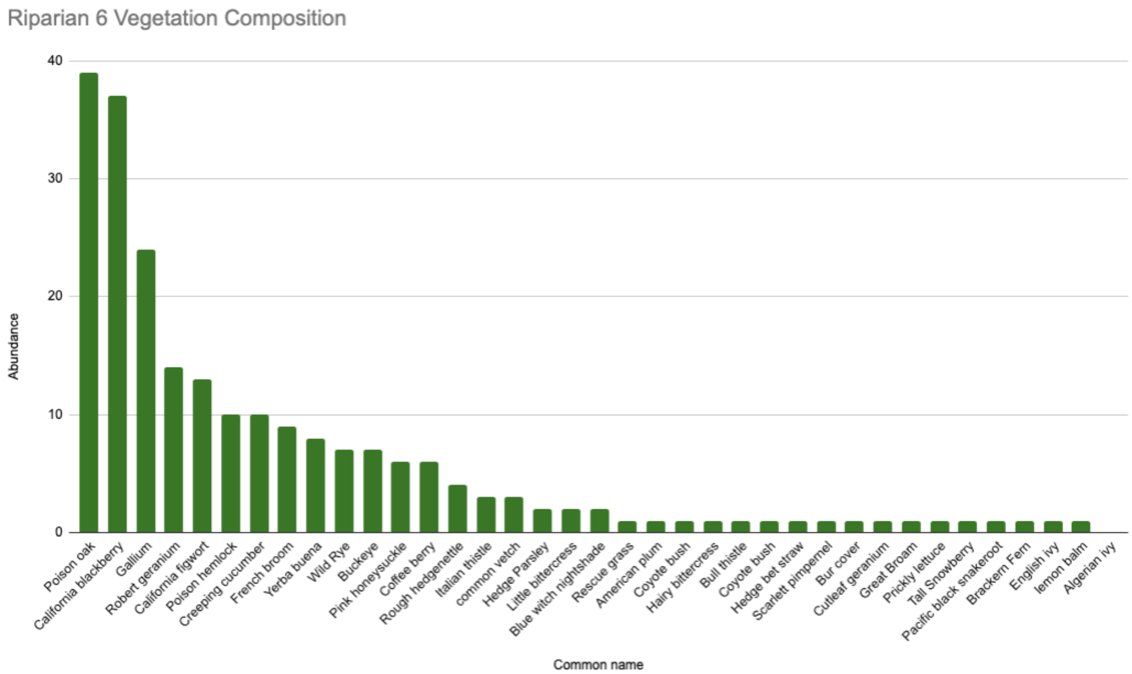

Figure 6. Vegetation abundance in riparian transect 6.

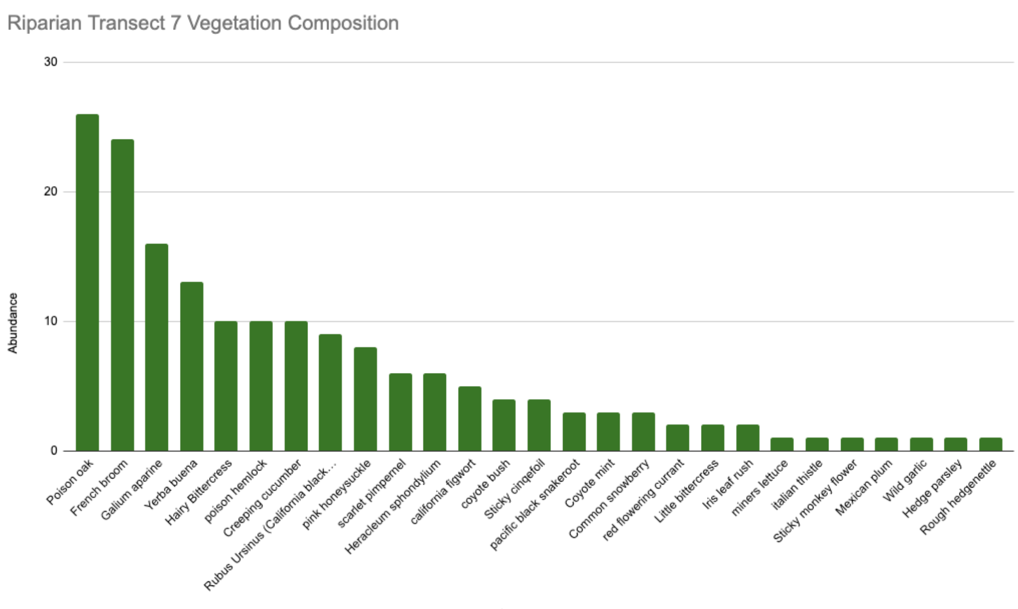

Figure 7. Vegetation abundance in riparian transect 7.

Temporal Comparison of Vegetation Composition from 1992

Many of the dominant species in each transect changed from the data surveyed in 1992 to 1993, especially within the MPG, Transition Zone A (TZA), and EEG. Within the MPG, *Rubus ursinus* (California blackberry) was dominant in both years, but *Toxicodendron diversilobum* (poison oak), became extremely prevalent in 2022 (Table 2). Additionally, *Genista monspessulana* (french broom) and *Ehrharta erecta* (panic veldt grass), both non-native, were dominant species in 2022. Notably missing in the dominant species of the NCS in 1992 is *Diplacus aurantiacus* (sticky monkey flower). In surveying this zone of the transect in 2022, sticky monkey flower was extremely prevalent along the mountain side, occuring in 79% of the transect sections in transect 3 (Table 4). The major difference between the EEG survey in 1992 and 2022 was that I found more dominant species, including *Lonicera hispidula* (pink honeysuckle), *Geranium robertianum* (robert geranium), and *Conium maculatum* (poison hemlock). Both robert geranium and poison hemlock are non-native species (Table 6).

Monterey Pine

Transect #	Dominant Species (1992)	Dominant Species (2022)
1	*Rubus ursinus* *Umbellularia Californica* *Unknown grass*	*Rubus ursinus* *Toxicodendron diversilobum* *Genista monspessulana* *Ehrharta erecta*
2	*Rubus ursinus* *Umbellularia california*	*Toxicodendron diversilobum* *Ehrharta erecta* *Genista monspessulana*
3	*Galium aparine* *Cytisus monspessulanus*	*Baccharis pilularis* *Ehrharta erecta*

Table 2. Dominant species over 35% frequency from 1992 and 2022. Non-native species are marked in red.

Transition zone B

Transect #	**Dominant Species (1992)**	**Dominant Species (2022)**
1	*Baccharis pilularis* *Erigonium sp.* *Unknown grass*	*Baccharis pilularis* *Conium maculatum* *Centaurea melitensis* *Anagallis arvensis* *Artemisia californica*
2	*Galium aparine* *Cystisus monspessulanus* *Ehrharta erecta*	*Anagallis arvensis*
3	*Cystisus monspessulanus*	*Baccharis pilularis* *Genista monspessulana* *Diplacus aurantiacus*

Table 3. Dominant species over 35% frequency from 1992 and 2022. Non-native species are marked in red.

Northern Coastal Scrub

Transect #	**Dominant Species (1992)**	**Dominant Species (2022)**
1	*Erodium spp.* *Eriogonum sp.* *Unknown grass*	*Baccharis Pilularis* *Geranium robertianum* *Erodium cicutarium* *Lupinus albifrons* *Artemisia californica*
2	*Erodium spp.* *Eriogonum sp.* *Artemisia californica* *Unknown grass*	*Artemisia californica* *Anagallis arvensis* *Diplacus aurantiacus* *Baccharis pilularis*
3	*Baccharis Pilularis* *Erodium spp.* *Artemisia californica* *Unknown grass*	*Artemisia californica* *Baccharis pilularis* *Diplacus aurantiacus*

Table 4. Dominant species over 35% frequency from 1992 and 2022. Non-native species are marked in red.

Transition Zone A

Transect #	**Dominant Species (1992)**	**Dominant Species (2022)**
1	None >35%, mostly bare soil	*Toxicodendron diversilobum* *Genista monspessulana* *Sanicula crassicaulis*
2	Unknown, of Family Cruciferae	*Baccharis pilularis* *Toxicodendron diversilobum* *Scrophularia californica* *Rhamnus californica* *Clinopodium douglasii*
3	*Rubus ursinus* *Carduus pycnocephalus* *Artemisia douglasiana* Unknown grass	*Baccharis pilularis* *Toxicodendron diversilobum* *Scrophularia californica* *Rhamnus californica* *Lonicera hispidula* *Rubus ursinus* *Diplacus aurantiacus* *Clinopodium douglasii*

Table 5. Dominant species over 35% frequency from 1992 and 2022. Non-native species are marked in red.

Eastern Eucalyptus

Transect #	Dominant Species (1992)	Dominant Species (2022)
1	*Rubus ursinus* *Galium aparine* Unknown grass	*Toxicodendron diversilobum* *Lonicera hispidula*
2	*Rubus ursinus* *Toxicodendron diversilobum* *Sanicula crassicaulis*	*Toxicodendron diversilobum* *Lonicera hispidula*
3	*Rubus ursinus* *Toxicodendron diversilobum* *Sanicula crassicaulis* *Vicia spp.* Unknown grass	*Toxicodendron diversilobum* *Galium aparine* *Geranium robertianum* *Lonicera hispidula* *Conium maculatum* Unknown european barley *Rubus ursinus*

Table 6. Dominant species over 35% frequency from 1992 and 2022. Non-native species are marked in red.

Year	Percent Non-native	Total number of species
1992	31%	71
2022	48%	93

Table 7. Non-native percentage from 1992 and 2022 total species data.

Species Abundance Pioneer Species after Eucalyptus Removal

The dominant species in the CTZ were *Galium aparine* (bedstraw), *Centaurea melitensis* (Maltese star thistle), *Genista monspessulana* (french broom), and *Toxicodendon diversilobum* (poison oak). Bedstraw, Maltese star thistle and french broom are all non-native.

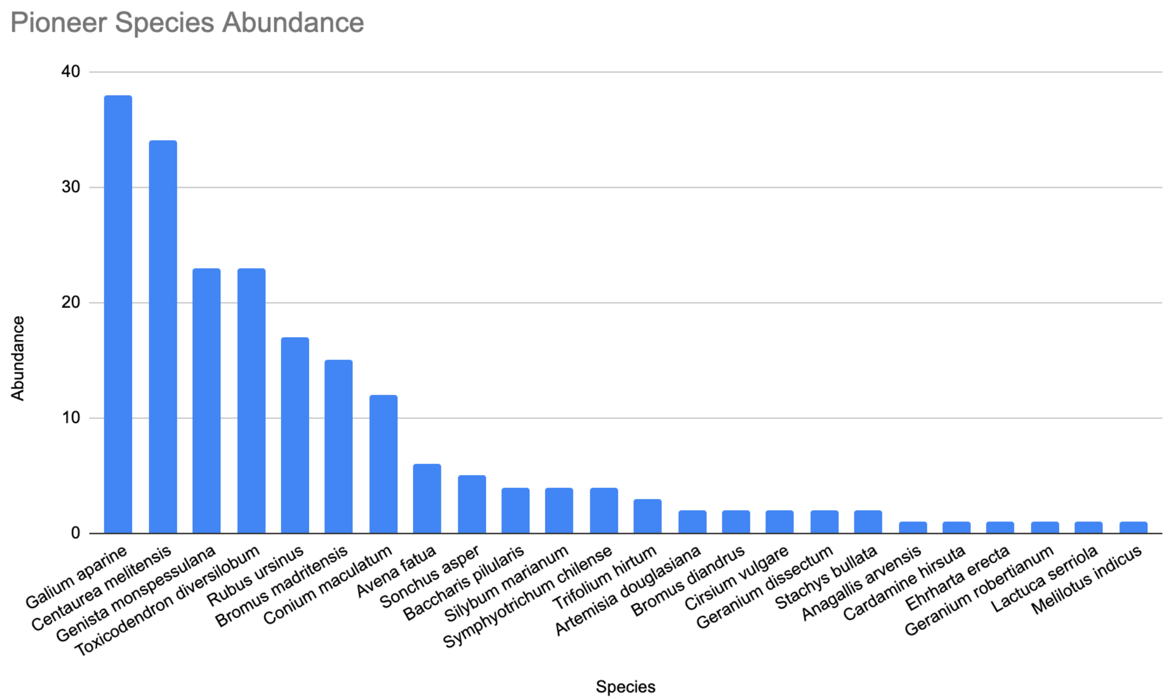

Figure 6. Plant species abundance for pioneer species in eucalyptus removal treatment area.

I was unable to complete transects 4 and 5 due to a large amount of fresh mountain lion scat found in the areas. While this limits the data, the presence of the mountain lion is beneficial for the ecosystem as a whole because the apex predator has returned to the Berkeley hills after several decades of absence (Vickers et. al. 2015). Additionally, I did not analyze the tree plot surveys because it was difficult to identify the location of the plots based on the original map, and comparison to the 1992 surveys would be inaccurate.

DISCUSSION

Vegetation composition in Claremont Canyon has changed over time. At the site, I found a total of 95 unique species, 48% of which were non-native. I discovered a change in dominant species in each section of the transects, suggesting a shift in species distribution from 1992. A majority of the pioneer species I surveyed in the treatment area for eucalyptus removal were non-native, and some pose a fire risk to the area. This research addresses the gap in knowledge for local vegetation changes over time, although limitations in data collection present an opportunity for further research.

Current Vegetation Composition

In understanding the current vegetation composition of Claremont Canyon, it is helpful to view composition in the context of each habitat. In the MPG, the understory was dominated by *Rubus ursinus*, *Ehrata erecta,* and *Toxicodendron diversilobum.* In transect 2, *E. erecta,* a non-native grass, was present in 95% of the intervals. The presence of *E. erecta* can change community composition, so future remediation efforts should consider this invasive grass as high risk (Ray et al. 2018). Comparatively, the MPG had fewer species present, likely because the thick canopy and dense pine needle ground cover prohibited vegetation growth. In the EEG, a similar pattern to the understory of the MPG emerged. I found relatively fewer plants in the Eucalyptus grove, and the most prevalent species were *Toxicodendron diversilobum* and *Lonicera hispidula.* The density of the canopy and leaf debris could explain the lack of vegetation. Some studies suggest that while Eucalyptus prohibits many species from growing, native species are most prevalent in the grove (Wolf and DiTomaso 2016).

The Northern coastal scrub showed distinct vegetation composition dominated by *Diplacus aurantiacus, Artemisia californica, and Lupinus albifrons*. However, the non-native *Anagallis arvensis* was remarkably successful in dominating the ground cover beneath the dominant species. Northern coastal scrub ecosystem is a significant hotspot for biodiversity, and studies recommend non-native species removal to protect the species richness (Wrubel and Parker 2017). Studies show coastal scrub restoration is best achieved using seeds to improve diversity and species richness, so future management could potentially utilize native understory seeds to combat the proliferation of *A. arvensis* (McGuire et al. 2022). *Baccharis pilularis* dominated the northern and southern areas of the northern coastal scrub.

Comparing 1992 to 2022 Vegetation Data

Major changes to the diversity and distribution of vegetation in Claremont Canyon have occurred. I identified 24 more species than were identified in 1992. In 2022, 48% of the species were non-native compared to 31% non-native in the 1992 survey, indicating a trend that non-native species are increasing in the area. With almost 50% of the total species identified as non-native, the trends are contingent with similar studies of vegetation analysis in California and the western United States (Dennehy et. al. 2011). Additionally, some native species were not identified in 2022. Some of the notable absent native species were *Arbutus menziesii* (pacific madrone), *Salix spp.* (willow), and *Eschscholzia californica* (California poppy). Although the California poppy was not identified along the transect, I identified it on the site outside of the transect lines.

While it is possible that climate change could be a factor in reducing the ability for these native plants to grow in Claremont Canyon, a more likely explanation would be that the trends in increased non-native species abundance are outcompeting native species in the area (Hillerislambers et al. 2010). Many of the dominant species in each zone of the transects changed from the survey in 1992; non-native species became more prevalent, including scarlet pimpernel, robert geranium, and french broom (Tables 2-6). Scarlet pimpernel in particular was widespread in the NCS, creating a blanket layer beneath the native plants that dominated the mountainside. Removal of scarlet pimpernel would be both costly and time consuming, and little research exists in combating its proliferation. Further community distance analysis would illuminate differences in species distribution and how it has changed from 1992.

Abundance of Pioneer Species after Eucalyptus Removal

The dominant species in the treatment area for eucalyptus removal were galium, Maltese star thistle, french broom, and poison oak. In the literature, disturbed areas are often dominated by non-native species, and my findings support this hypothesis. In their own right, french broom and Maltese star thistle pose their own fire hazard risks and future management should consider rehabilitation of the treated area to promote native plant regrowth. Galium was present in 76% of the sections of the 5 transects, maltese star thistle was present in 68%, and french broom was present in 46%. French broom is deer tolerant, so other removal methods including biological control with the beetle *Lepidapion argentatum* have been studied. While effective at targeting the seed production of french broom, research shows this beetle can also negatively impact California native lupines (Kerdellant et al. 2021).

Thistle has been shown to be a severe fire risk in the United States, and "spreads clonally by rhizomes as well as wind dispersed seeds" (Faccenda and Daehler 2022). Also resistant to deer grazing, mechanical methods may be necessary for removal of thistle. Coyote bush has been shown to be an effective native plant rehabilitator, so future managers of the site should consider planting this species to reduce the fire risk of non-native vegetation (Brennan et al. 2018). After the eucalyptus removal, a portion of the site was string trimmed, while avoiding native plants like coyote bush. This process may need to be repeated until the coyote bush establishes dominance in the area.

Overall, the change in vegetation composition in Claremont Canyon is apparent in the increased species richness, and the proliferation of non-native species. While I identified more species in 2022, 48% of these species were non-native. Some native vegetation was not present in 2022 while it was in surveys from 1992. Over 30 years, important native species have established dominance, including sticky monkey flower in the NCS. However, general trends show an increased human disturbance and invasive species spread have altered the species distribution and abundance in the area. Without intervention, it is likely the stability and health of this ecosystem will continue to deteriorate, as non-native like french broom and thistle dominate the area.

Limitations

To continue to track the health of our ecosystems, future research should be done to track the changes in Claremont Canyon. Repeating this study every 5 years would allow a greater depth of understanding of how this open space is changing. As previously mentioned, further analysis of community distance data would further illuminate how vegetation has changed over time. Major limitations of the study were an inability to complete the survey for transects 4 and 5, and in locating the tree plots on the site. New plots and tree stand analysis can be researched using exact coordinates to ensure continuity in comparison of the data.

Future directions

Management implications

The Claremont Canyon vegetation composition, and California's plant species distribution at large, are in flux. This research suggests detrimental changes in regards to proliferation of non-native species and the disappearance of native species, which tracts trends researched beyond the Claremont Canyon hills (Gaertner et al. 2009). If we wish to preserve the local flora and the habit it provides for native fauna, careful management should be undertaken. Removal of non-native species is a tedious process as often plants need to be removed one at a time to both effectively eradicate them, and to not disturb native plants. For example, cut-leaf geranium and other invasive geraniums can be effectively removed by hand-pulling because it is an "annual with a slender taproot" (Dennehy et al. 2011). However, the pervasiveness of geranium might provide a unique challenge for complete removal, especially using hand mechanical removal techniques.

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