Post-Fire Vegetation and Covered Species Monitoring of the 2019 Malech Fire within Coyote Ridge Open Space Preserve

Santa Clara County, California

February 2022

Prepared for

Santa Clara Valley Habitat Agency

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Section 1. INTRODUCTION

On behalf of Santa Clara Valley Habitat Agency (Habitat Agency), and a Local Assistance Grant from the California Department of Fish and Wildlife (CDFW), Nomad Ecology LLC (Nomad) conducted post-fire vegetation and covered species monitoring in 2020 and 2021 following the 2019 Malech Fire, which burned 210 acres within Coyote Ridge Open Space Preserve (CROSP) (Figure 1). The Habitat Agency along with the Santa Clara Valley Open Space Authority (Authority) jointly manage CROSP, which is a NCCP Reserve System Site. The Habitat Agency is the Implementing Entity for the Santa Clara Valley Natural Community Conservation Plan (NCCP). Monitoring included aerial image capture via drone flights, post-fire monitoring for serpentine bunchgrass grassland, monitoring of six covered species that were affected by the burn as well as fire suppression activities, and post-fire invasive plant mapping. Covered plant species occurring within the Malech Fire burn perimeter include: Mt. Hamilton thistle (Cirsium fontinale var. campylon; CRPR 1B.2), Santa Clara Valley dudleya (Dudleya abramsii subsp. setchellii; FE, CRPR 1B.1), fragrant fritillary (Fritillaria liliacea; CRPR 1B.2), smooth lessingia (Lessingia micradenia var. glabrata; CRPR 1B.2), Metcalf Canyon jewelflower (Streptanthus albidus subsp. albidus; FE, CRPR 1B.1), and most beautiful jewelflower (Streptanthus albidus subsp. peramoenus; CRPR 1B.2)

1.1. PROJECT PURPOSE

In Summer 2019, the 210-acre Malech Fire burned the Coyote Ridge Open Space Reserve. The fire was considered a benefit to the reserve; however, standard fire suppression techniques including bulldozer lines and fire retardant were implemented to contain the fire. As a newly enrolled NCCP reserve, the sensitive site resources, the let-burn policy, and the presence of maintained roads that could serve as fuel breaks at CROSP were unknown to the first responders. Fire retardant acts as a source of nitrogen, promoting the growth of annual grasses and invasive species. Bulldozer lines, with heavy bermed roadsides, serve as sediment transport systems into the lower watershed and the equipment itself is a vector for invasive plant seeds onto the property. Monitoring of serpentine grassland, covered species, and invasive plants is intended to document any effects of these fire suppression techniques, and the fire itself, on the landscape.

With predictions of increasing fire frequency, intensity, and size across California due to climate change, a clear understanding of fire effects is key to establishing baseline knowledge of post-fire biodiversity and setting conservation goals for the NCCP. More specifically, information is needed for the guilds of annual or short-lived perennial species that may benefit or rely on ecological process associated with fire. Often, this cryptic flora includes many statewide and locally rare plant species (Nomad, unpublished data). Species diversity and ecological dynamics in these short-lived systems are not well understood regionally in northern California despite high interest from land managers, ecologists, and botanists.

The Santa Clara Valley NCCP requires the development of post-fire monitoring activities and implementation of post-fire remedial measures to enhance or restore representative natural landscapes and maintain or increase native biology diversity (NCCP Goal 3[1] and Objective 3.2a[2]). The objective of this project was to monitor recovery from the Malech Fire within the CROSP. In addition to measuring the effects of the Malech Fire on grassland vegetation and covered species, the potential effects of suppression

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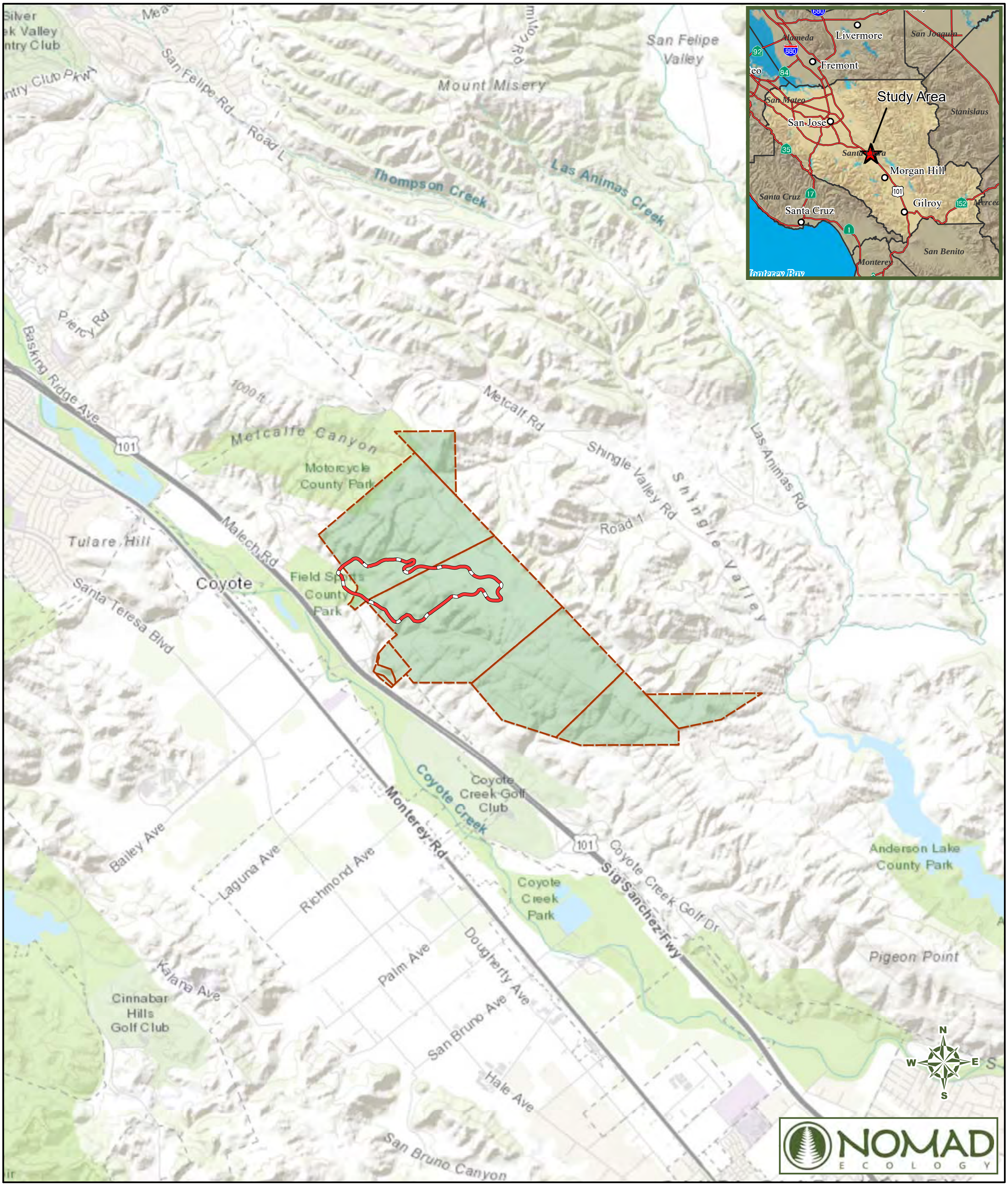
[1] Goal 3. Enhance or restore representative natural and semi-natural landscapes to maintain or increase native biological diversity (ICF 2012).

[2] Objective 3.2a. Ensure natural fire disturbance regimes required for natural community regeneration and structural diversity, and covered species germination and recruitment occur within the Reserve System or implement management actions that mimic those natural disturbances through development of a fire management component of each reserve unit management plant (ICF 2012).



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Post-Fire Monitoring Report

Legend

- Malech Fire Perimeter
- Coyote Ridge Open Space Preserve

Figure 1

Location of Study Area

Post-Fire Vegetation and Covered Species Monitoring

Santa Clara Valley Habitat Agency

1:60,000

0 2,500 5,000 Feet

Sources: SCVHP, ESRI.

Santa Clara County, California

activities are also of interest to the Habitat Agency. These suppression activities include bulldozer containment lines (new lines and on existing roads), hand lines, and areas where fire retardant was dropped.

Covered species and vegetative surveys were conducted within the burn footprint and compared to locations where suppression techniques were implemented (bulldozer containment lines and fire retardant) to document effects on system recovery. Invasive species were mapped to inform additional remedial measures.

1.2. Study Area

The CROSP is an 1,831-acre preserve located in Santa Clara County on the east side of Santa Clara Valley. The preserve occupies the southwest side of a ridge, facing the Santa Clara Valley. Highway 101 runs along the bottom of the ridge. The unincorporated community of Coyote lies to the west, with the cities of Morgan Hill to the south and San Jose to the northwest. Metcalf Motorcycle County Park is located between CROSP and Metcalf Road, and a shooting range, Field Sports County Park, is located at the northeast end of the preserve. Much of CROSP is grazed, and the preserve is in the planning stages of opening for public recreational access.

The study area is centered on the 210-acre burn footprint from the Malech Fire in addition to the areas affected by fire suppression activities and surrounding unburned grassland (Figure 2). This area is located in the northern part of the preserve, east of Highway 101 between Metcalf Road and Bailey Avenue, and just east of Field Sports County Park. It is approximately 1.3 miles to the northeast of the unincorporated community of Coyote, 5 miles north of Morgan Hill, and 12 miles southeast of downtown San Jose. The topography of the study area is characterized by a main ridge with a variety of aspects and elevations. The underlying geology almost exclusively serpentinized ultramafic rock. Further details of the Study Area are discussed in Section 3. Environmental Setting.

View of the study area from Malech Road looking northeast, September 2021.

1.3. Target Resources for Monitoring

1.3.1 Vegetation Composition

Vegetation composition was monitored in the burn footprint, in dozer lines, in the retardant application area, and in unburned grassland. Vegetation composition monitoring targeted herbaceous species including total species richness and cover, native species richness and cover, richness and cover of grasses, herbs, geophytes, vines, and shrubs, and richness and cover of functional groups including fire following annuals, native disturbed taxa, nitrogen fixers, and weeds. Only Serpentine Bunchgrass Grassland was targeted for post-fire vegetation composition monitoring. Dozer lines that were created over existing dirt roads were not considered part of this study due to their routine disturbance from regular blading. Additionally, since hand lines were only created in, or on the edges of oak woodlands, these are also not considered part of this study.

1.3.2 Covered Species

Based on data from the CNDDB, Creekside Science, and the Habitat Agency, covered plant species occurring within the Malech Fire burn perimeter include: Mt. Hamilton thistle, Santa Clara Valley dudleya, fragrant fritillary, smooth lessingia, Metcalf Canyon jewelflower, and most beautiful jewelflower (Table 1; CDFW 2021, Creekside 2019, Creekside 2018). Based on an evaluation of locations of fire suppression activities provided by the Authority, Santa Clara Valley dudleya, smooth lessingia, Metcalf Canyon jewelflower, and most beautiful jewelflower were also potentially affected by suppression activities.

Table 1. Target Covered Plant Species

Species Name / Common Name	Status[1]	CNDDB Populations (EONDX #)	Peak Blooming Period
Federal/State Listed Species			
Dudleya abramsii subsp. *setchellii* Santa Clara Valley dudleya	FE, 1B.1	13933	May/June
Streptanthus albidus subsp. *albidus* Metcalf Canyon jewelflower	FE, 1B.1	none[2]	July
California Native Plant Society Listed Species (Rank 1 & 2)			
Cirsium fontinale var. *campylon* Mt. Hamilton thistle	1B.2	42237	May
Fritillaria liliacea fragrant fritillary	1B.2	9062, 9059	March
Lessingia micradenia var. *glabrata* smooth lessingia	1B.2	53559	September
Streptanthus albidus subsp. *peramoenus* most beautiful jewelflower	1B.2	9989	May

[1]**Explanation of Status Codes**
Federal Codes
FE Federally endangered
California Native Plant Society codes:
1B Rare, threatened, or endangered in California and elsewhere
California Native Plant Society Threat Codes:
.1 Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)
.2 Moderately threatened in California (20-80% occurrences threatened)
[2]In the CNDDB all *Streptanthus* on CROSP are categorized as most beautiful jewelflower. However, the plants on CROSP are likely a mix of Metcalf Canyon jewelflower, most beautiful jewelflower, and hybrids of the two.

1.3.3 Invasive Plants

During the course of this study, Barbed goatgrass (*Aegilops triuncialis**[3]), purple star thistle (*Centaurea calcitrapa**), tocalote (*Centaurea melitensis**), yellow star thistle (*Centaurea solstitialis**), artichoke thistle (*Cynara cardunculus* subsp. *flavescens**), milk thistle (*Silybum marianum**), and mustards such as black mustard (*Brassica nigra**), field mustard (*Brassica rapa**), hoary mustard (*Hirschfeldia incana**), charlock

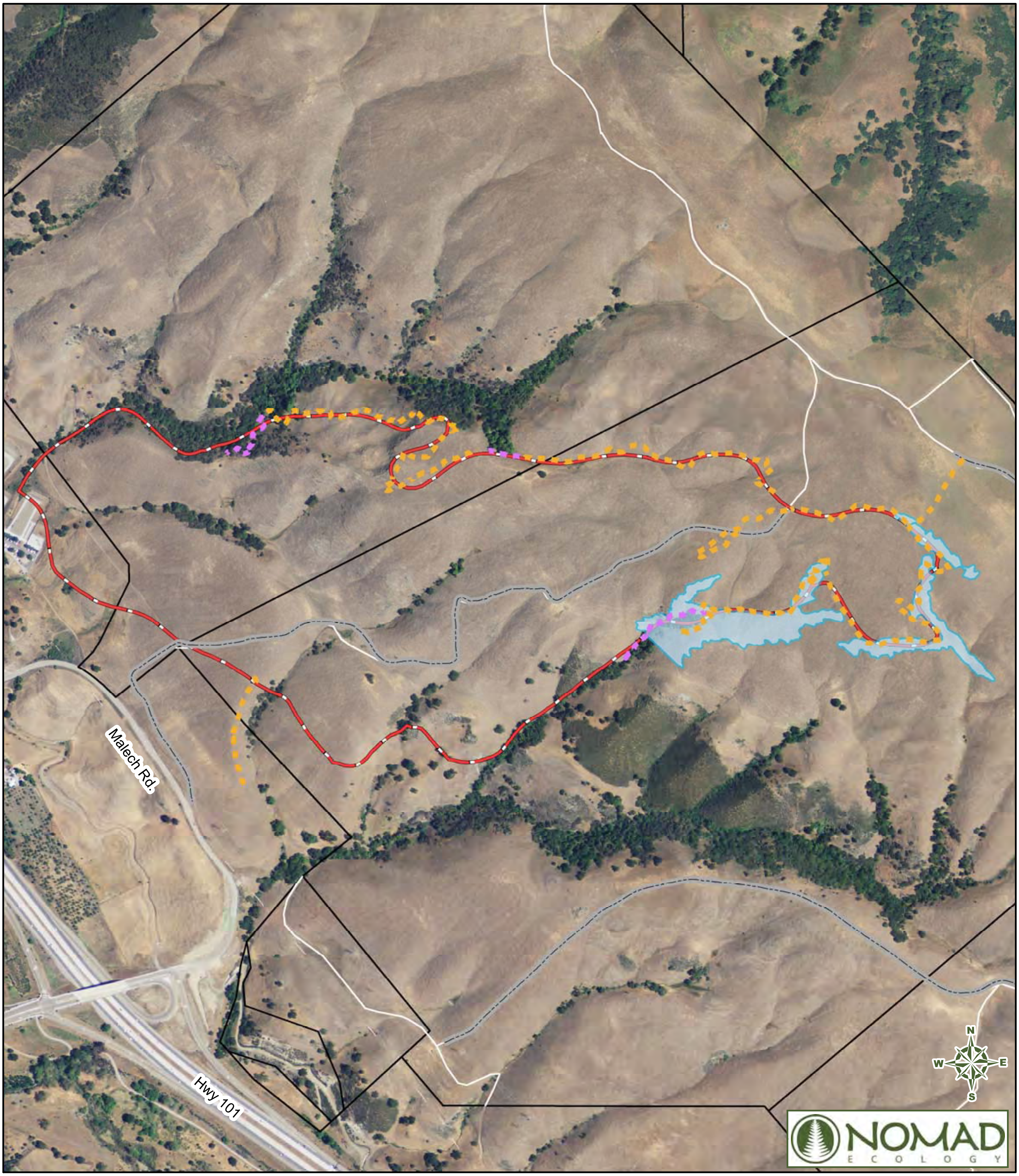
[3] * Denotes a species with an origin other than California

(*Sinapis arvensis**), and London rocket (*Sisymbrium irio**) were targeted for invasive plant mapping within the Malech burn perimeter. These non-native plant species are tracked by the California Department of Food and Agriculture (CDFA 2022) and/or the California Invasive Plant Council (Cal-IPC 2022) due to their noxious, invasive, or weedy behavior. Species tracked by these organizations are given a certain rating based on criteria such as ecological impacts, treatment or eradication priority, and threats they pose to agricultural economics (Table 2).

Table 2. Non-Native Species with Elevated Threat Rankings Targeted within the Study Area

Species Name	Common Name	California Invasive Plant Council Rank[1]	California Department of Food and Agriculture Noxious Weed List[2]
Aegilops triuncialis	barbed goatgrass	Moderate	On List
Brassica nigra	black mustard	Moderate	---
Brassica rapa	field mustard	Limited	---
Centaurea calcitrapa	purple star thistle	Moderate	On List
Centaurea melitensis	tocalote	Moderate	On List
Centaurea solstitialis	yellow star thistle	High	On List
Cynara cardunculus	artichoke thistle	Moderate	On List
Hirschfeldia incana	hoary mustard	Moderate	---
Silybum marianum	milk thistle	Limited	---
Sinapis arvensis	charlock	Limited	---
Sisymbrium irio	London rocket	Moderate	---

[1] Cal-IPC Weed Ranking Definitions (Cal-IPC 2022):
High: These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
Moderate: These species have substantial and apparent - but generally not severe - ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
Limited: These species are invasive, but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic (Cal-IPC 2021).
[2] Species considered a noxious weed by CDFA are listed on the California Noxious Weed List (CDFA 2021).



Legend

- Preserve Boundary
- Roads
- Malech Fire Perimeter

Suppression Activities

- Dozer Line - New Cut
- Dozer Line - Road
- Hand Lines
- Retardant

Figure 2

Malech Fire and Fire Suppression Activities

Post-Fire Vegetation and Covered Species Monitoring
Santa Clara Valley Habitat Agency

1:10,800
0 450 900 Feet

Sources: SCVHP, SCVOA, NAIP 2012.

Santa Clara County, California

Section 2. STUDY METHODS

2.1. STUDY DESIGN

The post-fire research methodology is intended to provide information that may aid the Habitat Agency in understanding how serpentine grassland on Coyote Ridge has responded to wildfire and fire suppression techniques, the status of covered species populations within the burned area as well as their response to fire, and what invasive species may pose threats to serpentine grassland and covered species post-fire. The study methods have been divided into four parts: 1) drone aerial imagery capture, 2) vegetation composition monitoring, 3) covered species monitoring, and 4) invasive plant mapping.

2.1.1 DRONE AERIAL IMAGERY CAPTURE

Post-fire vegetation communities rapidly change within, and between, growing seasons. These rapid changes can be difficult to capture on the ground. Using drones to analyze small-scale temporal changes in vegetative cover via high-resolution aerial imagery capture can assist with ecological evaluations and increase the efficiency of mapping the spatial distribution of certain plant species. Nomad developed high-resolution georectified aerial imagery via drone flights of the 210-acre Malech Fire from multiple time periods over two years.

Drone flights occurred in March, April, June, and September 2020 and in April, June, and September 2021. The March/April drone flights supported vegetation composition sampling, the June flights assisted in identifying and mapping weed infestations, and the September flights supported mapping smooth lessingia. After drone flights were completed, the imagery was post-processed on a desktop computer using Pix4D for georectification and stitching into a single mosaic. Once post-processed these image mosaics were then transferred to the Geographic Information System (GIS) platform ArcGIS 10.7.1 for spatial analysis.

2.1.2 POST-FIRE VEGETATION COMPOSITION MONITORING

Nomad conducted vegetation composition monitoring in Serpentine Bunchgrass Grassland within the Malech Fire burn perimeter as well as outside the burned area to provide a comparison of burned and unburned conditions. This study design uses a plot-based approach that focuses on the herbaceous layer to investigate distribution, abundance, and gradient dynamics of post-fire taxa. Percent cover data of all plant species were collected to provide information on species and functional group richness and abundance at all plot locations. This study was specifically designed to capture species that appear on the landscape infrequently and to compare response of vegetation within burned, unburned, and fire suppression areas.

Plot Selection

A total of 16 plots were established within the Malech Fire burn perimeter and outside the burned area. Four plots were placed within the burn footprint (Burn treatment), four plots were placed in bulldozer containment lines (Doze treatment), four plots were placed in areas where fire retardant was applied (Retardant treatment), and four plots were placed outside of the burn perimeter and outside of any fire suppression activities (Unburn treatment) (Figure 3). Throughout the report, treatment refers to plots from Burn, Doze, Retardant, and Unburn areas and fire suppression activities refers to both Burn and Doze treatments.

The general locations of plots were chosen during a pre-winter assessment in October 2019 when the different treatments were more visible on the landscape, before the following spring after the fire. Final plot locations were chosen when plots were installed the following spring, in 2020. The plots comprised 50-meter long transects and the 0-meter and 50-meter ends of plots were recorded using Backcountry Navigator

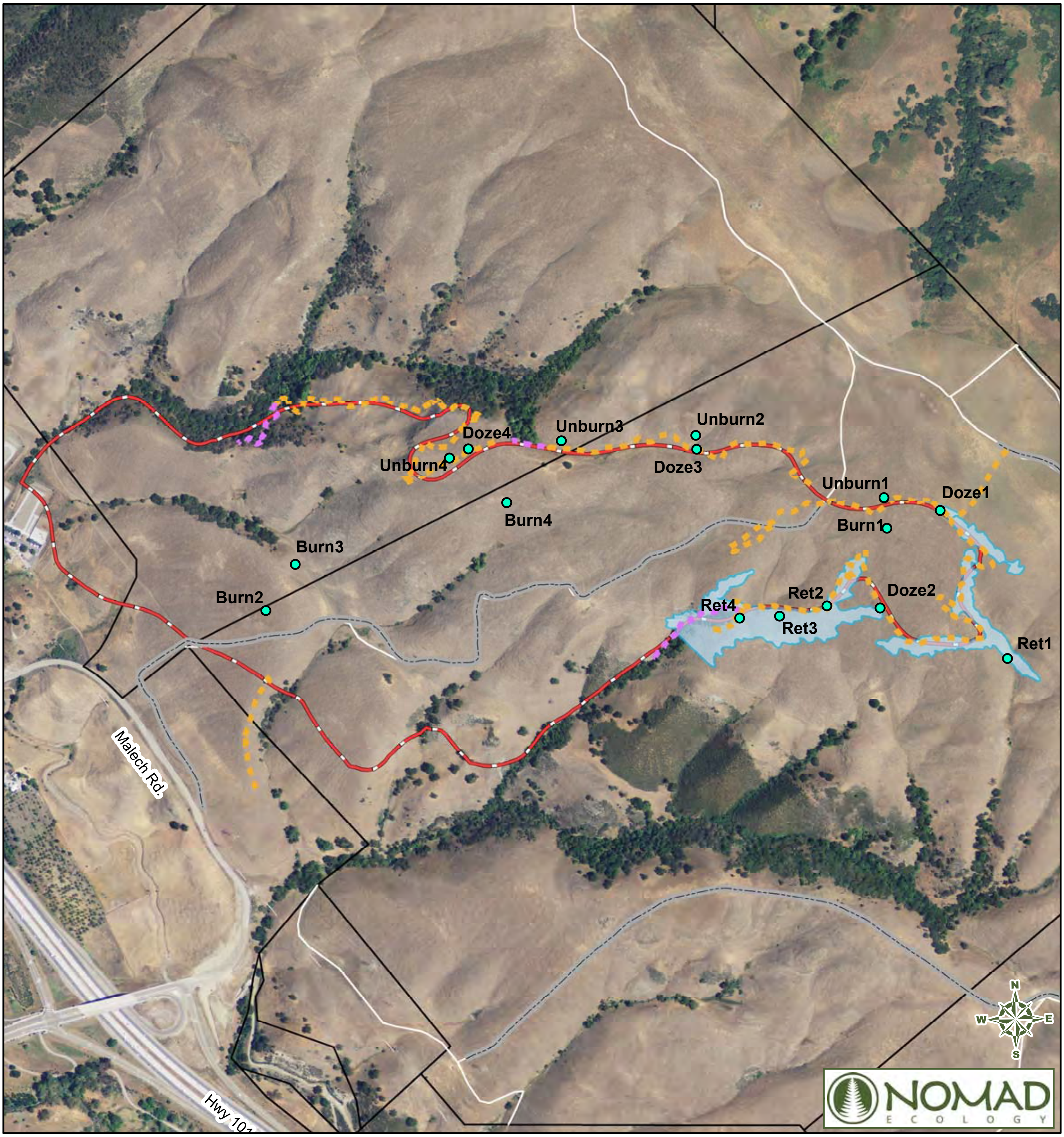
Pro on an Android device, or Gaia GPS on an Apple device and marked using plastic whiskers. Outside of fire suppression activities, plots were installed at least 20 meters away from roads, or other significant human caused ground disturbance to avoid influence from anthropogenic variables but were also limited to areas with reasonable access. Environmental variables such as slope, aspect, and fire severity were recorded at each plot when installed.

Field Measurements

Each of the 16 plots consisted of a 50-meter x 1-meter belt transect. Vegetation data was collected within a 1-meter-square quadrat every three meters along the 50-meter belt transect. This resulted in the sampling of 17 quadrats in each plot and a total of 272 quadrats across the entire study area each spring for a total of 544 quadrats over two years. Vegetation data were collected in the form of absolute percent cover at each quadrat in March/April 2020 and April 2021 to maximize ideal phenology for a majority of herbaceous plant taxa.

Field measurements of vegetation for this project are specifically designed to capture a more comprehensive picture of post-fire herbaceous species. The belt transect method, in combination with percent cover data, is more effective than other methods (including the point-intercept method) at capturing richness and abundance of species that are less common or have a clustered distribution. Absolute percent cover[4] of all species, bare ground, rock, and thatch were recorded in all 17 quadrats within each plot. Absolute cover of plants was visually estimated and recorded for each individual plant species using the CNPS method for

[4] Absolute cover refers to the actual percentage of the ground (surface of the plot) that is covered by a species or group of species.



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Post-Fire Monitoring Report

Legend
- Vegetation Composition Monitoring Plots
- Preserve Boundary
- Roads
- Malech Fire Perimeter

Suppression Activities
- Dozer Line - New Cut
- Dozer Line - Road
- Hand Lines
- Retardant

1:10,800
0 450 900
Feet

Figure 3

Vegetation Composition Monitoring Locations

Post-Fire Vegetation and Covered Species Monitoring
Santa Clara Valley Habitat Agency

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

estimating cover values. Percent cover diagrams (available on the CNPS Vegetation Program website) were used to facilitate species cover estimates. Photos were taken of each plot at 0-meters, 25-meters, and 50-meters.

Data Analysis and Definitions

All data collected in the field was stored in a relational database that links environmental data, vegetation data, and ecological attributes for California plant species. Both absolute cover and relative cover[5] were used as a part of data analysis, as well as species richness. Since absolute cover of vegetation within plots was sometimes very low, relative cover was helpful to better visualize the proportion of vegetation belonging to different categories.

Analysis of these data include comparison of study-wide species richness and percent cover by life form and functional group. Study-wide species richness and relative cover as a function of life form (grass, herb, geophyte, and shrub) did not meet the assumptions for ANOVA thus, the non-parametric Kruskal-Wallis test was used with post-hoc Wilcoxon rank sum tests. Frequency of species in plots, and frequency of species presence at the four treatment levels (Burn, Doze, Retardant, and Unburn) was also computed for different functional groups. Chi-squared tests were used to test for differences in frequency of functional groups among treatments.

ANOVA, Kruskal-Wallis, and Wilcoxon rank sum tests were used to assess the effects of fire and fire suppression activity on species richness and cover. When data met the assumptions of homogeneity of variance and normality of residuals for ANOVA, the statistical model included treatment (Burn, Doze, Retardant, or Unburn), year (2020 or 2021), and the interaction of treatment and year. Tukey multiple comparisons tests were used if the treatment or interaction terms were significant. When the data did not meet the assumptions for ANOVA, Kruskal-Wallis tests with post-hoc Wilcoxon rank sum tests were used to test for differences between treatments and Wilcoxon rank sum tests were used to test for differences between years. Response variables included: total species richness, absolute vegetative cover, native species richness, native relative cover, grass, herb, geophyte, and shrub richness, grass, herb, geophyte, and shrub relative cover, fire follower richness and relative cover, native disturbed richness and relative cover, nitrogen fixer richness and relative cover, and weeds richness and relative cover. All exploratory analysis and statistical tests utilized the statistical computing program, R (R Core Team 2021).

Species data were analyzed using the functional group categories defined below. A list of all species observed in plots and their relation to the below categories is in Appendix A.

Life Form: Plant taxa were segregated into respective life form categories including:

- Ferns - Vascular flowerless plants that have feathery or leafy fronds and reproduce by spores released from the undersides of the fronds.
- Grasses - Herbaceous monocots of the family Poaceae.
- Herbs - Plants that, at least above ground, are generally non-woody and of less than one year or growing season in duration. These may be annual, biennial, perennial, or subshrubs (Baldwin et al. 2012).

[5] Relative cover refers to the amount of the surface of the plot sampled that is covered by a group of species as compared to (relative to) the amount of surface of the plot or stand covered by all species. Relative Cover Native Plants = (Absolute Cover of Native Plants)/(Absolute Cover All Plants)*100.

- Geophytes - plants that have an underground storage organ that allows them to die back into the ground and go dormant during unfavorable seasons. For the purpose of this study geophytes include plants with bulbs, corms, or tubers.
- Shrubs - Woody plant of relatively short maximum height, with generally many branches from the base (Baldwin et al. 2012).

Fire Followers: Fire followers were determined from two sources for this study. The first source was a search of the Jepson Manual (Baldwin et al. 2012) identifying any taxon descriptions that included the words “fire” or “burn”. The other is based on personal observations of Nomad botanists through experience and field work related to other fire studies. The Jepson Manual (Baldwin et al. 2012) search is a data mining method and by no means provides a comprehensive data set. There is no standardization by the authors of taxonomic descriptions for the Jepson manual, therefore it is left to individual authors to include fire information at their discretion or if that information is available. It is possible that taxa that have fire or burn in their description are often found in post-fire environments but are not true fire followers. Likewise, it is possible that a taxon is a true fire follower but the author was not compelled to mention it in the taxonomic description. Because of these imperfections and existing data gaps, which this study is intended to help address, the list of fire followers herein is considered a starting point with species being removed and added as more information is gathered. Future goals also include assigning species to fire following categories as described by Keely and Davis (2017) that have not previously been categorized or documented as fire followers. These categories include: Native post-fire endemics, native post-fire specialists, and native post-fire opportunists.

Native Disturbed: Native Disturbed, like fire followers, is a distinction given in Baldwin et al. (2012) to native taxa whereby their germination and abundance are increased by disturbance. Native taxa with the words “disturbed” or “disturbance” in their description were compiled under this category. This disturbance can either be related to fire or some other ground or soil disturbance such as road grading, however it is not considered similar to the process that obligate fire followers are dependent on. Again, this is by no means complete list but a work in progress.

Nitrogen Fixers: Plant species belonging to the family Fabaceae and genus *Ceanothus* (in the family Rhamnaceae) are known nitrogen fixers. Nitrogen fixation is the biological assimilation of atmospheric nitrogen to form organic nitrogen-containing compounds. In these organisms, this process is achieved by symbiotic bacteria within nodules in their root systems that fix nitrogen into the soil (Hopkins and Huner. 2004).

Rare Taxa: Rare plant species are defined as those species listed as endangered or threatened, proposed or candidates for listing under one or more of the following regulatory statutes: Federal Endangered Species Act, as amended (Code of Federal Regulations, Title 50, Section 17); California Endangered Species Act (California Code of Regulations Title 14, Section 670.5); California Fish and Game Code (Sections 1901, 2062, 2067), and the Native Plant Protection Act (NPPA) of 1977. Their status is based on their rarity and endangerment throughout all or portions of their range.

The California Native Plant Society (CNPS) has developed and maintains an inventory of Rare, Threatened and Endangered plants of California. This information is published in the Inventory of Rare and Endangered Vascular Plants of California (CNPS 2022). The rarity ranking contained in the CNPS inventory is endorsed by the CDFW and effectively serves as a list of potential “candidate” plant species. The following identifies the definitions of the CNPS California Rare Plant Ranks:

- Rank 1A: Plants presumed to be extinct in California;
- Rank 1B: Plants that are rare, Threatened, or Endangered in California and elsewhere;

- Rank 2A: Plants presumed extirpated in California, but more common elsewhere;
- Rank 2B: Plants that are rare, Threatened, or Endangered in California, but are more common elsewhere;
- Rank 3: Plants about which more information is needed (a review list)
- Rank 4: Plants of limited distribution (a watch list).

Weed Species: The California Invasive Plant Council (Cal-IPC) is the entity that maintains the California Invasive Plant Inventory (Cal-IPC 2022). Cal-IPC uses a three-tier system where invasive weeds are ranked as high concern, moderate concern, or of limited concern. These ranks are defined below.

- High – These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
- Moderate – These species have substantial and apparent, but generally not severe, ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
- Limited – These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

2.1.3 Post-Fire Covered Species Monitoring

Mt. Hamilton Thistle

Two drainages and two seeps that support Mt. Hamilton thistle are present within the burn perimeter. All four colonies were monitored in 2020 and 2021. The northern drainage was designated as Drainage 1, the southern drainage was named Drainage 2, the western seep was named Seep 1 and the eastern seep was designated as Seep 2 (Figure 4). Nomad monitoring differed slightly from Creekside Sciences methods, where the linear occupied area for each occurrence was mapped and index plots were used to calculate the average mature individuals per linear meter across all occurrences (Creekside 2018).

Field Measurements

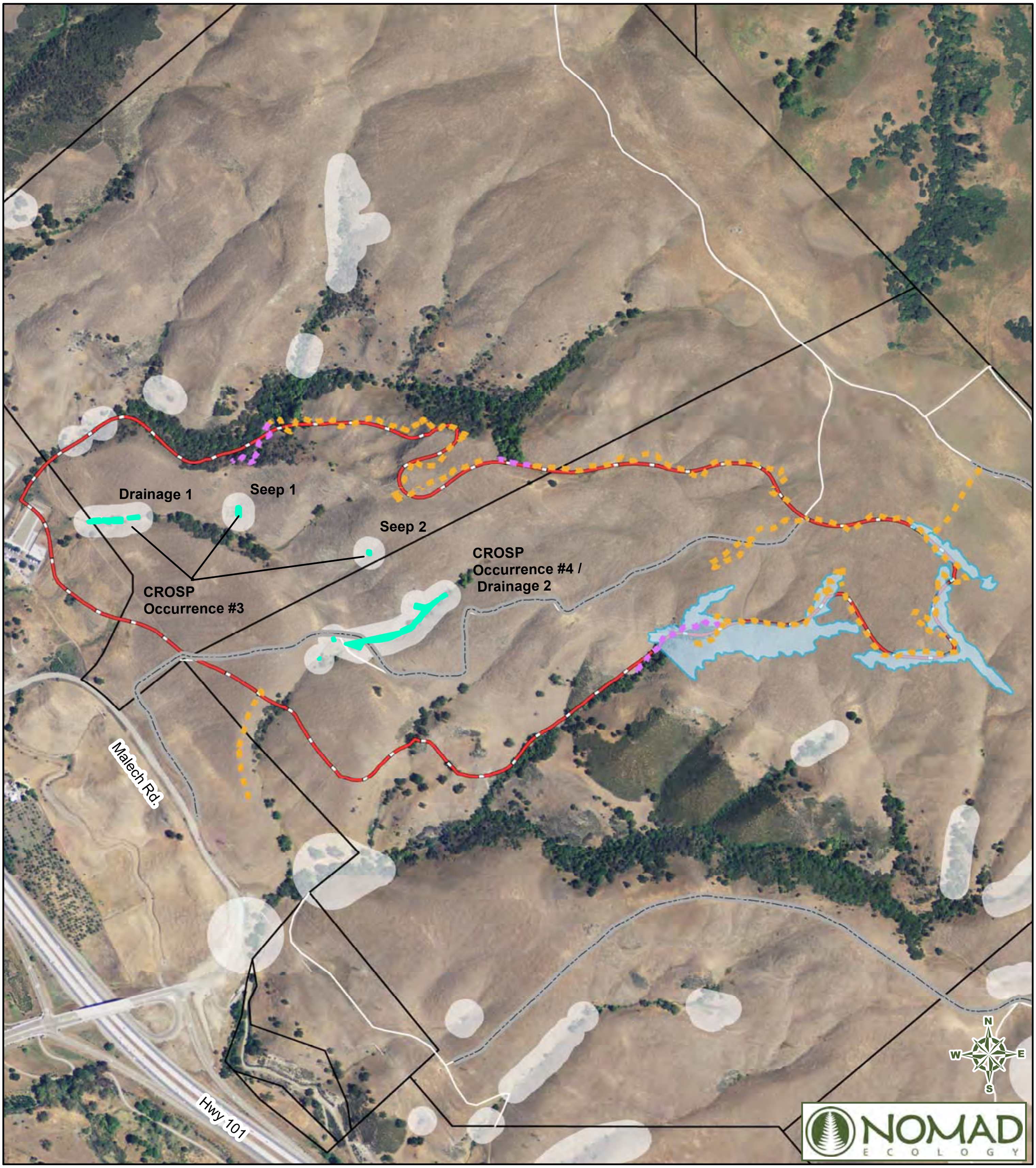
Monitoring consisted of a visual estimate of the number of individuals within each of the colonies. Since this taxon is either a biennial or short-lived perennial, each individual was noted as immature (not yet reproducing) or mature (reproducing). The number of inflorescences was also recorded for each mature individual. Transect tapes and pin flags were used to split up colonies into smaller areas as needed. Because seedlings can be numerous and cryptic, plants were only counted if the longest leaf was more than 3 cm long.

Photos were taken of each colony at established photo points, and any fire effects or identified threats such as overgrazing, extensive trampling or erosion, changes in water quality or quantity, severe insect infestations, etc., were also recorded.

Data Analysis

The total number of individuals within each colony was compared to estimates from Creekside Sciences from 2017.

In addition to comparing the number of individuals, the percentage of mature and immature individuals and the average number of inflorescences per mature individual were calculated. Data did not meet the assumptions for ANOVA, so the non-parametric Wilcoxon test was used to compare inflorescences per mature individual by year (2020 or 2021) and the Kruskal-Wallis test with post-hoc Wilcoxon rank sum tests were used to compare inflorescences per mature individual by colony (Drainage 1, Drainage 2, Seep 1, or Seep 2). Statistical tests utilized the statistical computing program, R (R Core Team 2021).



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Post-Fire Monitoring Report

Legend

- Cirsium fontinale var. campylon
- CNDDB occurrence(s)
- Monitored Colonies
- Preserve Boundary
- Roads
- Malech Fire Perimeter
- Suppression Activities
- Dozer Line - New Cut
- Dozer Line - Road
- Hand Lines
- Retardant

1:10,800
0 450 900 Feet

Figure 4

Mt. Hamilton Thistle Monitoring Locations

Post-Fire Vegetation and Covered Species Monitoring

Santa Clara Valley Habitat Agency

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

Santa Clara Valley Dudleya

Monitoring was based on plots located on discrete rock outcrops supporting Santa Clara Valley Dudleya. Plots were located in Burn, Retardant, and Unburn treatments. The purpose of monitoring for this species was to determine if burning or retardant application had a measurable effect on rosette or inflorescence abundance. Nomad monitoring differed slightly from Creekside Sciences methods, where a log estimate for number of rosettes was recorded at each mapped rock outcrops (Creekside 2018).

Plot Selection

A total of 13 plots were established within the Malech Fire burn perimeter and outside the burned area. Five plots were located within the Burn treatment, four plots were located in the Retardant treatment, and four plots in the Unburn treatment (Figure 5).

Plots were located on discrete rock outcrops. Potential rock outcrops for plots were chosen during a pre-winter assessment in October 2019 while the different treatments were more visible on the landscape. Final plot locations were chosen when plots were installed the following spring, in 2020. The location of plots was recorded near the center of the outcrop using Backcountry Navigator Pro on an Android device or Gaia GPS on an Apple device and marked using plastic whiskers. Photo points were established at each plot and the length and width of the rock outcrop was measured using transect tapes.

Field Measurements

The total number of rosettes were enumerated for each plot, tallying rosettes as dead or alive and vegetative or flowering. The total number of inflorescences (peduncles) was also recorded. Transect tapes and chaining pins were used to split rock outcrops into smaller areas as needed.

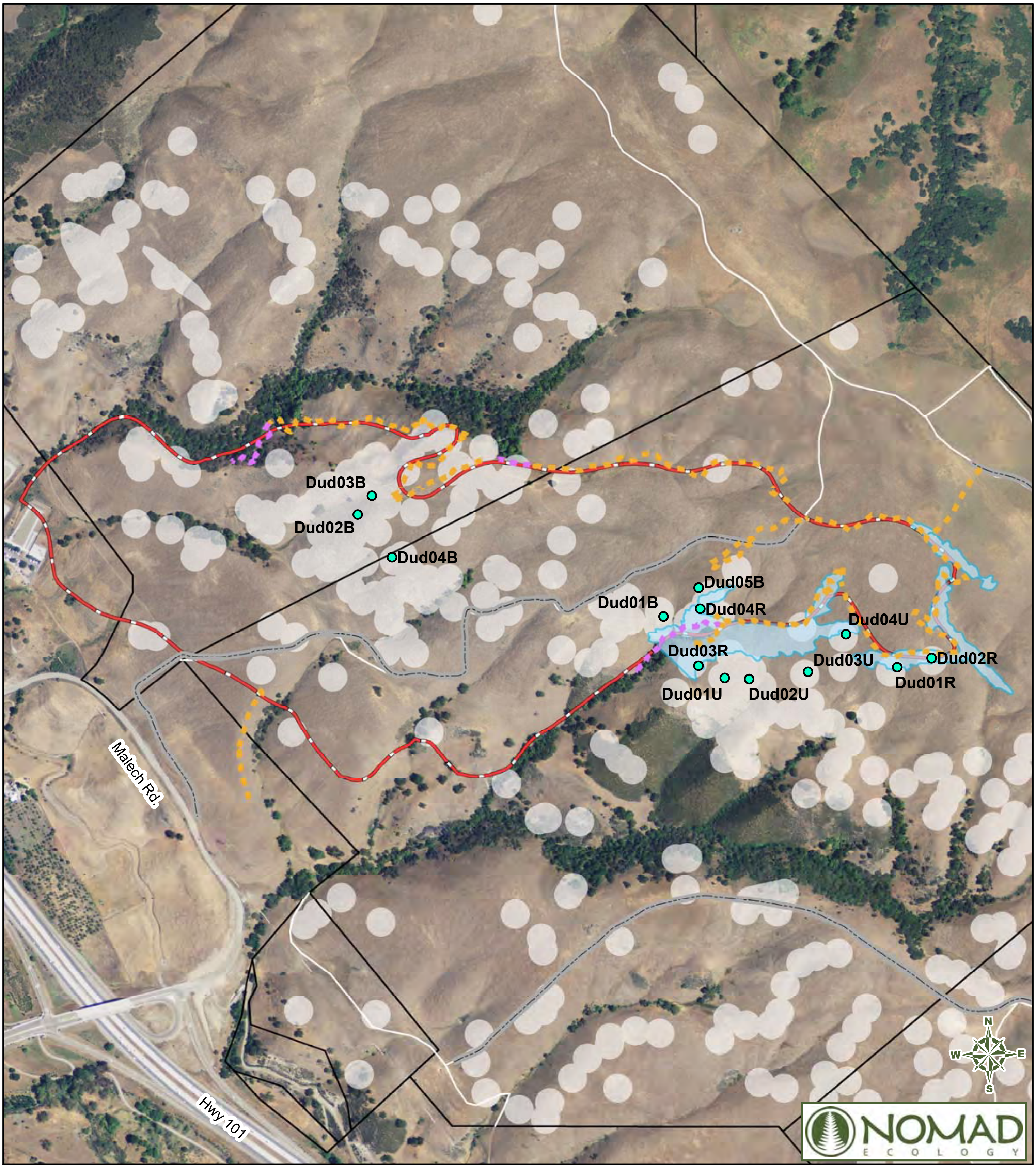
An individual with multiple rosettes can have the same appearance as multiple individuals and it can be impossible to distinguish an individual without guessing or damaging plants. To create a precise and repeatable count, and to be able to compare numbers with Creekside Sciences data, rosettes, not individuals were be counted.

Photos were taken of each colony at established photo points. Burn scar evidence and retardant damage were noted where relevant, and any identified threats such as overgrazing, extensive trampling or erosion, changes in water quality or quantity, severe insect infestations, etc., were also recorded.

Data Analysis

The area of each rock outcrop was estimated using the measured length and width of the plot and the equation for the area of an ellipse (π * length * width). The density of rosettes was then calculated as total number of living rosettes divided by plot area.

Rosette density as a function of treatment (Burn, Retardant, or Unburn) and year (2020 or 2021) did not meet the assumptions for ANOVA thus, the non-parametric Wilcoxon rank sum test and Kruskal-Wallis test with post-hoc Wilcoxon rank sum tests were used to test for differences. Non parametric tests were also used to test for differences in percent dead rosettes as a function of treatment and year. ANOVA was used to test for differences across treatment, year, and their interaction for percent vegetative rosettes, percent flowering rosettes, and number of inflorescences per flowering rosette. All statistical tests utilized the statistical computing program, R (R Core Team 2021).



February 2022

Post-Fire Monitoring Report

Legend

Dudleya abramsii subsp. *setchellii*

CNDDB occurrence(s)

Monitoring Plots

Preserve Boundary

Roads

Malech Fire Perimeter

Suppression Activities

Dozer Line - New Cut

Dozer Line - Road

Hand Lines

Retardant

Figure 5

Santa Clara Valley Dudleya Monitoring Locations

Post-Fire Vegetation and Covered Species Monitoring
Santa Clara Valley Habitat Agency

1:10,800
0 450 900
Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

Fragrant Fritillary

Post-fire monitoring of this species focused on presence and abundance trends that can be compared to on-going monitoring. This on-going sampling effort relies on a macroplot methodology established by Creekside Sciences (Creekside 2018). Fragrant fritillary monitoring also included an estimate of plant height based on size classes and notation of reproductive maturity to evaluate any post-fire effects on this species.

Plot Selection

Two fragrant fritillary macroplots were sampled in 2020 and 2021, one within the burn perimeter, and one outside the burned area (Figure 6). Both macroplots were already established by Creekside Sciences, corresponding to CROSP occurrences Frit-1 and Frit-3. One 75 x 20 m macroplot was located within the burned area at CROSP occurrence Frit-3. Four 50 x 50 m macroplots were located outside of the burned area at CROSP occurrence Frit-1. The northern macroplot west of the access road (labeled 4 in Appendix E from the Creekside Sciences 2018 Baseline Report) was sampled in 2020 and 2021 because it encompassed the largest area of mapped fragrant fritillary.

Macroplot Setup

Within macroplots, measurements were recorded along belt transects with a restricted random distribution. For the 50 x 50 m macroplot outside of the burn perimeter, ten 0.5 x 50 m transects were sampled (10% of the area). For the 75 x 20 m macroplot within the burn perimeter, 30 1 x 20 m transects were sampled (40% of the area).

Belt transects had a restricted random distribution where the macroplot baseline was divided into 5-meter segments, with random starts within each segment. Creekside Sciences recommended that the same transects sampled during baseline monitoring in 2017 and 2018 be used in subsequent years so that fine-scale dynamics of distribution within the macroplots were directly comparable. Transect starting points for macroplot Frit-1, outside of the burned area, were: 2, 6, 11, 16, 21, 26, 32, 36, 42, and 46 meters. Transect starting points for macroplot Frit-3, inside the burn footprint, were not reported so the following starting points were generated: 2, 3, 6, 9, 14, 15, 19, 20, 22, 24, 26, 30, 33, 35, 37, 40, 41, 44, 47, 48, 52, 54, 57, 58, 63, 64, 68, 70, 71, and 72 meters.

To begin plot setup, parallel baselines were laid out from the corners marked a0m to corners a50m or a75m (tape a) and between corners b0m to b50m or b75m (tape b). These baselines designated the starting and ending points of the sampling transects. The sampling transect was set up by running a third tape perpendicular to the baselines from the designated starting point on tape a to the same point on tape b.

Field Measurements

Within sampling transects, the total number of individuals, the number of mature and immature individuals, and height of plants were recorded. Quadrats were read to the right of the transect tape in 1 m segments. The number of flowering and non-flowering individuals were entered for each 1 m segment, then summed to give a total for the quadrat. An estimate of plant height based on size classes (< 5 cm, 5-10 cm, 10-20 cm, 20-30 cm, and >30 cm) was also be recorded at each meter. Plants were considered an individual if they had separate stems emerging from the ground.

Representative photos were taken of each macroplot, and any identified threats such as overgrazing, extensive trampling or erosion, changes in water quality or quantity, severe insect infestations, etc., were also recorded. Photographs and notes on fire damage were not included because as a geophyte, fragrant fritillary would not have been aboveground during the Malech Fire.

Data Analysis

The total number of individuals within each macroplot was estimated with 80% confidence intervals and compared to estimates from 2017 and 2018. We can be 80% confident that estimates with overlapping confidence intervals do not represent a true change in the number of individuals within the macroplot. The macroplot average and confidence intervals were calculated using the following equations (from Creekside 2018):

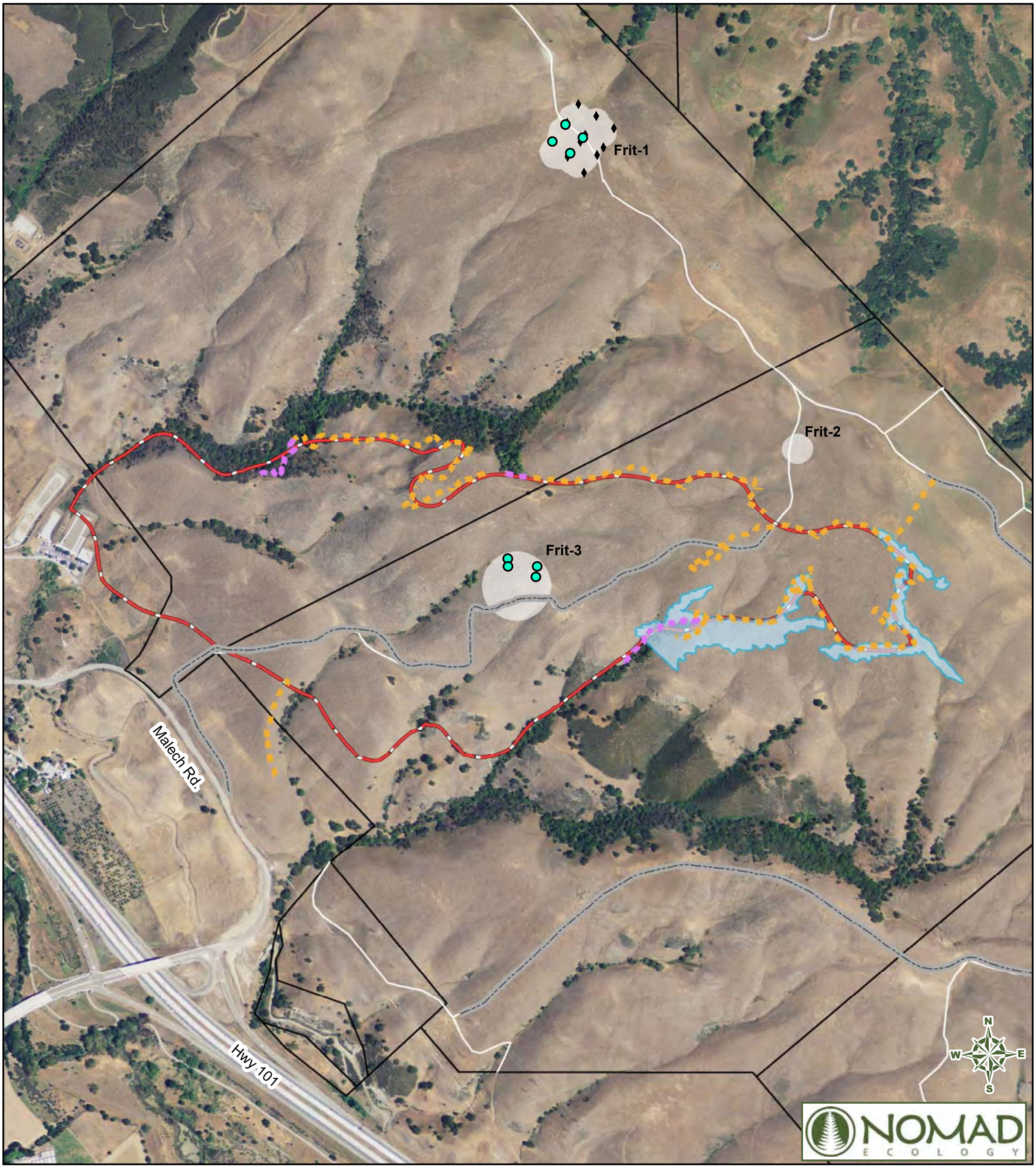
1) Macroplot average = Transect average * N
2) Macroplot confidence interval = Transect confidence interval * N
3) Transect confidence interval = FPC * t * SE
4) FPC (finite population correction) = $\sqrt{\frac{(N-n)}{N}}$
5) SE = Transect standard deviation / $\sqrt{n}$

Where:

- Transect average = the average number of individuals in belt transects for each macroplot.
- Transect standard deviation = the standard deviation of the number of individuals in belt transects for each macroplot.
- N = Total possible transects = 100 for the 50 x 50 m macroplot (Frit-1), and 70 for the 75 x 20 m macroplot (Frit-3)[6].
- n = number of transects = 10 for Frit-1 and 28 for Frit-3.
- t = standard statistical value from student's t table, based on desired confidence interval and degrees of freedom = 1.383 for Frit-1 and 1.315 for Frit-3.

In addition to estimating the number of individuals in each macroplot, the percentage of mature and immature individuals and range of heights of individuals from sampled transects were summarized.

[6] In 2018, 2020, and 2021, zero plants occupied the last 5 meters of macroplot Frit-3 (70-75 meters). So the last five meters, containing two transects, were thrown out of macroplot calculations. This makes the macroplot 70 x 20 m in area, with 28 1m transects sampled, and 70 total possible transects.



Legend

Fritillaria liliacea
CNDDB Occurrence(s)
Monitored macroplots
Unmonitored macroplots
Preserve Boundary
Roads
Malech Fire Perimeter
Suppression Activities
Dozer Line - New Cut
Dozer Line - Road
Hand Lines
Retardant

Figure 6

Fragrant Fritillary Monitoring Locations

Post-Fire Vegetation and Covered Species Monitoring

Santa Clara Valley Habitat Agency

1:12,000
0 500 1,000
Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

Smooth Lessingia

Smooth lessingia is abundant within the burn perimeter as well as where suppression activities were located. Typically, smooth lessingia occurs in dense and contiguous patches which can make monitoring difficult when trying to enumerate and map the population. To alleviate this difficulty, a methodology was developed for population estimation and mapping across the NCCP area using a combination of on-demand high-resolution aerial imagery and remote sensing techniques (Nomad 2018; Nomad 2021). For a finer scale comparison of fire and fire suppression effects, percent cover, density, and plant height were sampled at paired transects inside and out of burned and fire suppression areas. Nomad monitoring differed from Creekside Sciences methods, where a log-scale density values were recorded at each point on a 100m grid (Creekside 2018).

Remote Sensing Methodology (Segmentation and Classification)

For this effort, high-resolution drone imagery was paired with ground-truthed points to create a model that classified smooth lessingia within the burn footprint. As described earlier, high-resolution drone imagery was captured during the month of September in 2020 and 2021, when smooth lessingia was most visible.

To inform the classification of aerial imagery, 1 x 1 m quadrats were placed throughout the burned area, a minimum of 20 quadrats were placed in occupied smooth lessingia habitat and another 20 were placed in unoccupied habitat each year. Quadrat locations were haphazardly (semi-randomly) chosen to include a variety of slopes, aspects, lessingia density, substrates, and co-occurring species. The location of quadrats was recorded using Gaia GPS on an Apple device, and percent cover and number of smooth lessingia individuals were recorded for each quadrat. Quadrat locations were ground-truth points to feed into the classification model, and they were also used to estimate smooth lessingia abundance. While walking the burn footprint to sample quadrats, the broad-scale distribution of smooth lessingia was also mapped by hand on printed maps. Hand-drawn maps were not as detailed as the results from classification, but acted as an additional source of information for creating the classification model and refining the results.

Segmentation and classification generally followed the remote sensing methodology described in *Establishing a Baseline for Smooth Lessingia (*Lessingia micradenia *var.* glabrata*) Populations Using High -Resolution Multispectral Aerial Imagery* section 2.3 (Nomad 2021). Some changes were made to the previous methodology based on a much smaller study area, only using imagery with visible bands, and familiarity with ESRI Spatial Analyst extension in ArcMap 10.7. Model development consisted of preparing post-processed aerial drone imagery, choosing training polygons, training the classifier, classifying the imagery, and post-processing.

Preparing Imagery: Post-processed aerial imagery was segmented using the Segment Mean Shift tool in ArcMap. Based on baseline smooth lessingia mapping, drone imagery from the Malech Fire perimeter taken in September 2020 and 2021 were each segmented using, spectral detail = 19, spatial detail = 10, and minimum segment size = 1,000.

Drone imagery taken in April 2020 and 2021 were also used in classification because areas with dense vegetation were more obvious earlier in the season. Areas with high cover of grasses or flowering plants showed up as green or yellow, where areas with lower cover, where smooth lessingia is more likely to grow, were more gray or brown. Both April imagery and segmented September imagery were clipped to the extent of the burn footprint.

Training Samples: Choosing training polygons is an important step in model development, because the spectral and spatial characteristics of the training polygons are what inform the classifier definition. Spectral characteristics of a class are often characterized by a normal distribution, ideally, the spectral characteristics of different classes have different distributions. Because smooth lessingia has a subtle color signature in grasslands, it was important to choose training polygons that distinguished smooth lessingia from other grassland.

Training polygons were created from a 0.5-meter buffer around a subset of quadrat locations and, for classes where quadrats were not available like trees, by creating polygons about 1,000 pixels in size. Keeping training samples small and around the same size helped to not have any one sample overpower the spectral statistics. Multiple classes were created for grasslands and trees in order to capture color variation while keeping the spectral characteristics for each class somewhat narrow. Classes for both years included: Smooth Lessingia, Grassland-light, Grassland-medium, Grassland-dark, Tree-light, Tree-dark, and Burned Tree.

Training the Classifier: After training samples were selected, the next step was to train the classifier and generate a classifier definition file. The segmented September imagery, the unsegmented April imagery as additional raster input, and training polygons were entered into the Random Trees classifier. The default settings for the classifier were used (Max number of trees = 50, Max tree depth = 30, and Max number of samples per class = 1,000) and all training sample attributes were considered, including: color, mean, STD, count, compactness, and rectangularity.

Classification: The classifier definition file was used as input for classification along with the segmented September imagery, and the unsegmented April imagery. Multiple classifications were attempted using different segmentations and training polygons. In order to choose the best classification, each of the classified rasters were visually assessed by comparing the classified raster to hand-mapped smooth lessingia and ground-truth quadrat locations.

Post-processing: The final classification was post-processed using the Majority Filter, Boundary Clean, and Nibble tools before being converted into a shapefile using the Raster to Polygon tool. Only the classified smooth lessingia was exported to another shapefile for modifications based on hand-mapping and ground-truth quadrats. Smooth lessingia was removed from the road as roads were false positives, and from areas that should obviously have been classified as trees, seeps, or drainages.

Data analysis: The classified smooth lessingia shapefile was used to calculate the total acreage of smooth lessingia within the burn perimeter. The average number of individuals per ground-truth quadrat was calculated and extrapolated to estimate the number of individuals in the burned area in both monitoring years.

Paired Transects Selection

For a finer scale comparison of fire and fire suppression effects a total of 6 50-meter transects were also installed in the study area. Transects were paired, in Burn and Unburn treatments, in Unburn and Retardant treatments, and in Unburn and Doze treatments (Figure 7).

Transect locations were chosen in the field in September 2020, so that transects could be placed within patches of smooth lessingia. Transects were established by marking the downhill end and uphill ends with plastic whiskers and recording the locations using Gaia GPS on an Apple device. Outside of fire suppression locations, transects were installed at least 20 meters away from roads or other significant human caused ground disturbance to avoid influence from anthropogenic variables but were also limited to areas with reasonable access.

Field Measurements for Paired Transects

Smooth lessingia cover was sampled based on the point intercept method. Point intercept data was taken every 25 cm starting at 0 meters for a total of 200 points. Additionally, the number of individuals, and the heights of the shortest and tallest smooth lessingia individuals were recorded at three 0.5 x 0.5 m quadrats along the transect. Quadrats were placed to the right of the transect tape at 0 meters, 25 meters, and 49.5 meters.

Photographs were taken at transects at 0 meters, 25 meters, and 50 meters at the time of monitoring. Any identified threats such as overgrazing, extensive trampling or erosion, changes in water quality or quantity, severe insect infestations, etc., were also recorded.

Data Analysis for Paired Transects

The percent cover of smooth lessingia was calculated for each paired transect and compared between treatments. The density of smooth lessingia was calculated for each of the three quadrats placed along transects. For two pairs of transects, ANOVA was used to test for differences in smooth lessingia density across treatment (Doze or Unburn, and Burn or Unburn), year (2020 or 2021), and their interaction. Density within Unburn and Retardant paired transects did not meet the assumptions for ANOVA, thus, Wilcoxon rank sum tests were used instead. All statistical tests utilized the statistical computing program, R (R Core Team 2021). In addition, the range of heights within transect quadrats were summarized.

February 2022

Post-Fire Monitoring Report

Legend
Lessingia micradenia var. glabrata
CNDDB occurrence(s)
Monitoring Transects
Preserve Boundary
Roads
Malech Fire Perimeter
Suppression Activities
Dozer Line - New Cut
Dozer Line - Road
Hand Lines
Retardant

Figure 7
Smooth Lessingia Monitoring Locations
Post-Fire Vegetation and Covered Species Monitoring
Santa Clara Valley Habitat Agency

1:10,800
0 450 900
Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

Metcalf Canyon and Most Beautiful Jewelflowers

Post-fire monitoring of these two taxa focused on presence and abundance trends that can be compared to on-going monitoring. Like fragrant fritillary, this on-going sampling effort relies on a macroplot methodology established by Creekside Sciences (Creekside 2018). Metcalf Canyon and most beautiful jewelflower monitoring also included an estimate of flower color within macroplots.

Plot Selection

Four jewelflower macroplots were sampled in 2020 and 2021, two in the Burn treatment, one within the Retardant treatment, and one in the Unburn treatment (Figure 8). Three of the macroplot locations were censused by Creekside Sciences in 2017 without establishing macroplots. These plots include Strep-1 in the Unburn treatment (Creekside point 10), Strep-2 in the Burn treatment (Creekside point 14), and Strep-4 in the Retardant treatment (Creekside point 11). One new plot location, Strep-3, was chosen within the Burn treatment.

The final plot locations and orientations were chosen when plots were installed in spring 2020. Plot corners were recorded using Backcountry Navigator Pro on an Android device, or Gaia GPS on an Apple device and marked using plastic whiskers. Outside of fires suppression locations, plots were installed at least 20 meters away from roads, fire lines, or other significant human caused ground disturbance to avoid influence from anthropogenic variables but were also limited to areas with reasonable access.

Macroplot Setup

All four macroplots measure 50 x 50 meters. Data were recorded along ten 0.5 x 50 m belt transects (10% of the macroplot area). Belt transects had a restricted random distribution where the macroplot baseline was divided into 5-meter segments, with random starts in each segment. Creekside Sciences generated the following random starting points for all jewelflower macroplots, which were also used in 2020 and 2021: 5, 9.5, 14, 19.5, 25, 29.5, 31.5, 36, 45, and 49.5 meters. Plot setup followed the same methods as fragrant fritillary macroplots.

Field Measurements

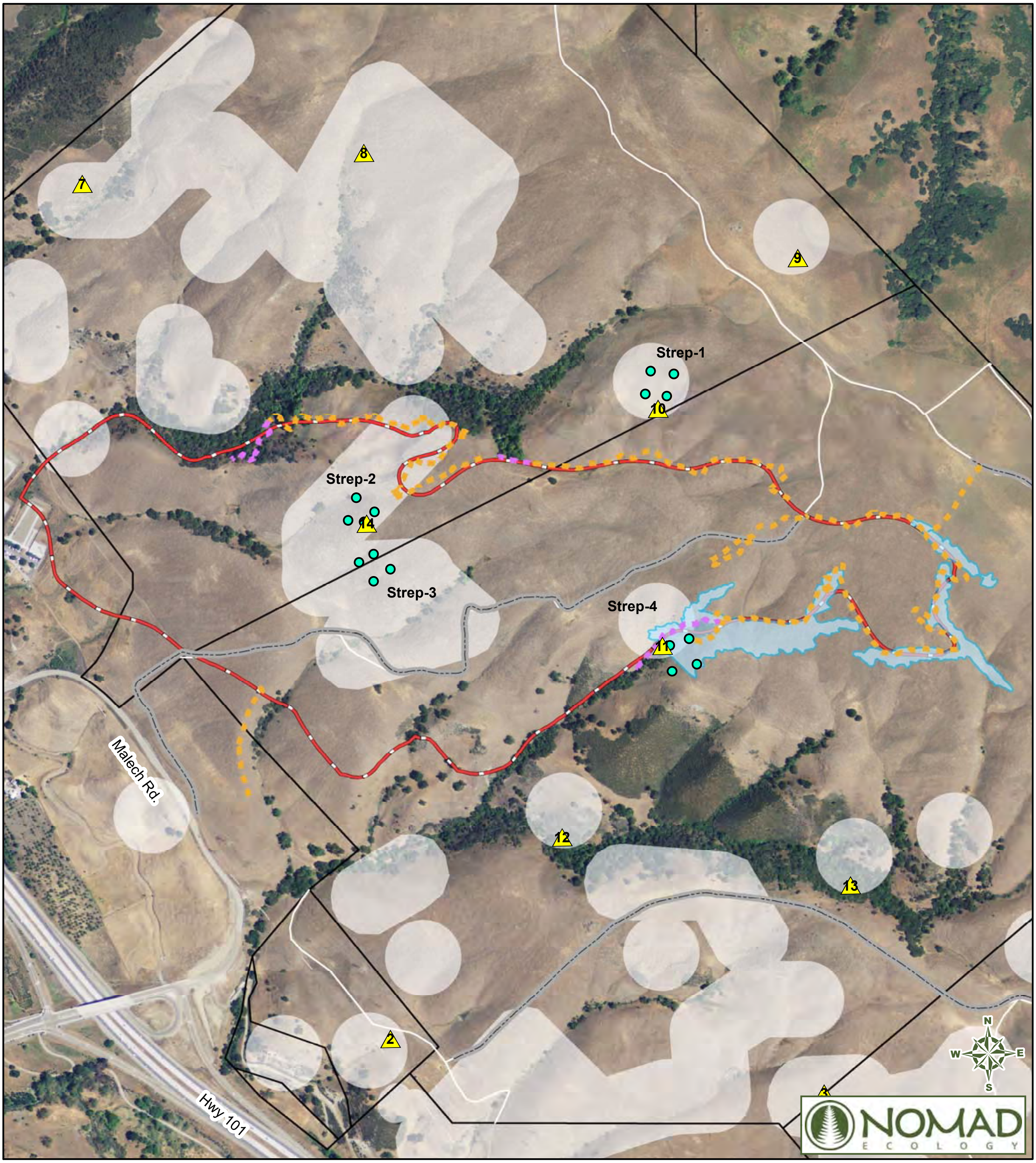
Belt transects were read to the right of the transect tape in 1 m segments. The number of individuals were entered for each 1 m segment, then summed to give a total for the quadrat. An estimate of the dominant flower color (ultra-white, white, tween, or pink) was also be recorded at each meter. All plants from the current growing season, regardless of phenological stage, were counted.

Representative photos were taken of each macroplot, and any identified threats such as overgrazing, extensive trampling or erosion, changes in water quality or quantity, severe insect infestations, etc., were also recorded.

Data Analysis

As with fragrant fritillary, the total number of individuals within each macroplot was estimated with 80% confidence intervals. We can be 80% confident that estimates with overlapping confidence intervals do not represent a true change in the number of individuals within the macroplot. The macroplot average and confidence intervals were calculated using the same equations as the fragrant fritillary macroplots; in this case the total possible transects N = 100, the number of sampled transects n = 10, and t =1.383.

In order to be able to compare 2020 and 2021 estimates with 2017 census data, macroplot averages were used to calculate number of individuals per square meter. Macroplot density was calculated as the macroplot average divided by 2,500 m^2 (area of a 50 x 50 m plot). In addition to estimating the number of individuals and density in each macroplot, the percentage of sampled individuals with each flower color was also calculated.



February 2022

Post-Fire Monitoring Report

Legend

Streptanthus albidus ssp. peramoenus
- CNDDB occurrence(s)
- Macroplot corners
- Creekside plots
- Preserve Boundary
- Roads
- Malech Fire Perimeter

Suppression Activities
- Dozer Line - New Cut
- Dozer Line - Road
- Hand Lines
- Retardant

Figure 8

Metcalf Canyon and Most Beautiful Jewelflowers Monitoring Locations

Post-Fire Vegetation and Covered Species Monitoring

Santa Clara Valley Habitat Agency

1:10,800

0 450 900 Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

2.1.4 INVASIVE PLANT MAPPING

Nomad mapped target invasive weeds within the burn perimeter to evaluate any post-fire trends and management needs. Mapping was based on a combination of field work and high-resolution aerial imagery flown in June 2020 and 2021.

Field Measurements

A data point was recorded for each occurrence of target weed species encountered using Backcountry Navigator Pro on an Android device or Gaia GPS on an Apple device. These datapoints aided the creation of weed infestation polygons. If the infestation was larger than 20 feet in diameter, the approximate extent of the infestation was also mapped by hand on printed maps.

Each data point included the following information: observer, date, target species, an estimation of gross infested area (in acres), cover of target species (<1%, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, or 95-100%), number of individuals (<10, 10-50, 50-100, 100-500, 500-1,000, or >1,000), distribution (isolated, patchy, scattered, linear, or monoculture), phenology (vegetative, flowering, fruiting, or senescent), habitat value (low, medium, or high), vegetation type of surrounding area, and other invasive species in the area were recorded for each point. Data collected during fieldwork is based on the California Weed Mapping Handbook (CDFA 2002) and the North American Invasive Plant Mapping Standards (NAISMA 2018).

Data Analysis

Final shapefiles with infestation points and polygons were completed in ArcGIS using GPS points from the field, hand-drawn maps, and high-resolution aerial imagery. Infested area was calculated from the total area of each polygon (gross area) along with the midpoint of the cover class recorded with the associated point. The attribute data provides information about the degree and spatial extent of infestations, as well as the quality of surrounding habitat, all of which is necessary for prioritizing and planning control efforts.

2.2. PERSONNEL AND FIELD INVESTIGATION

The following personnel conducted the field investigations. Ms. Ender and Mr. Bartosh authored the report.

Heath Bartosh
Senior Botanist
Rare Plant Specialist
Nomad Ecology, LLC

Adam Chasey
Senior Botanist
Nomad Ecology, LLC

Cody Ender
Botanist
Nomad Ecology, LLC

Leanne Feely
Botanist
Nomad Ecology, LLC

Brian Peterson
Botanist and Fire Ecologist
Nomad Ecology, LLC

Talaya Rachels
Botanist
Nomad Ecology, LLC

All drone imagery was captured and post-processed by Nomad Senior Botanist and Drone Pilot Heath Bartosh (HB). Drone flights occurred March 31, April 1-2, June 8-9, and September 23-24, 2020 and April 1-2, June 23-24, and September 20-21, 2021.

On October 23, 2019, Mr. Bartosh and Nomad Botanists Cody Ender (CE) and Brian Peterson (BP) conducted a pre-winter assessment to evaluate the areas that burned and locate general areas for post-fire sampling. Mr. Bartosh, Ms. Ender, Nomad senior botanist Adam Chasey (AC), and Nomad botanist Talaya Rachels (TR) installed and collected data for vegetation composition monitoring plots on March 31 and April 1-3, 2020. Mr. Chasey, Ms. Ender, Mr. Peterson and Nomad botanist Leanne Feely (LF) returned to collect a second year of vegetation composition plot data on April 8-9, 2021.

Covered species monitoring was conducted in March, May, June, and September in 2020 and 2021 by Mr. Chasey, Ms. Ender, Ms. Feely, Mr. Peterson, and Ms. Rachels. Fragrant fritillary was monitored March 9-10, 2020 and again on March 18-19, 2021. Macroplots for Metcalf Canyon and most beautiful jewelflowers were established May 21-22, 2020 and revisited on May 21 and 24-26, 2021. Rock outcrops supporting Santa Clara Valley dudleya were monitored May 26-28, 2020 and again on May 24-27, 2021. Mt Hamilton thistle was monitored June 4, 2020 and June 7-8, 2021. Finally, smooth lessingia was mapped September 17-18, 2020 and on September 24, 2021.

Ms. Ender and Ms. Rachels mapped invasive species within the Malech burn perimeter on June 8, 2020. Invasive plants were mapped again by Mr. Chasey and Ms. Ender on June 8 and 9, 2021. Table 3 below, outlines the dates and personnel for field investigations.

Table 3. Timing of Field Investigation Efforts

Survey Timing			Activity	Personnel
Month	Day(s)	Year		
October	23	2019	Pre-winter assessment	HB, CE, BP
March	9-10	2020	Covered species monitoring: fragrant fritillary	CE, BP
	31	2020	Drone imagery capture	HB
			Vegetation composition	HB, CE, TR
April	1-2	2020	Drone imagery capture	HB
			Vegetation composition	CE, TR
	3	2020	Vegetation composition	AC, CE
May	21-22	2020	Covered species monitoring: jewelflowers	CE, TR
	26-28	2020	Covered species monitoring: Santa Clara Valley dudleya	CE, TR
June	4	2020	Covered species monitoring: Mt. Hamilton thistle	CE, TR
	8	2020	Invasive plants	CE, TR
	8-9	2020	Drone imagery capture	HB
September	17-18	2020	Covered species monitoring: smooth lessingia	CE
	23-24	2020	Drone imagery capture	HB
March	18-19	2021	Covered species monitoring: Fragrant fritillary	CE, LF
April	1-2	2021	Drone imagery capture	HB
	8-9	2021	Vegetation composition	AC, CE, LF, BP
May	21, 24-27	2021	Covered species monitoring: jewelflowers and Santa Clara Valley dudleya	CE, LF
June	7-9	2021	Invasive plants and Covered species monitoring: Mt Hamilton thistle	AC, CE
	23-24	2021	Drone imagery capture	HB
September	20-21	2021	Drone imagery capture	HB
	24	2021	Covered species monitoring: smooth lessingia	CE, LF

2.3. LIMITATIONS

Survey efforts were carefully designed to maximize the likelihood that the timing and effort of the surveys coincided with the optimum timing of flowering phenology and were conducted in suitable habitat for each of the target species. However, this subsection discusses the unavoidable limitations inherent in rare plant surveys, with respect to specifics of this effort.

Data collection for vegetation composition transects was carefully timed to maximize phenology of many different species for positive identifications. Though flowering phenology was near peak for the majority of species encountered during data collection, there were some taxa that could not be identified to species. During the time of the survey, all instances of *Cuscuta* sp. were unable to be identified because of the lack of characters needed for proper identification.

Grassland species such as smooth lessingia can be hard to see from a distance, especially at lower densities. Further, due to the complex nature of grassland species composition, it is difficult to establish hard boundaries between vegetation types as species densities and associated boundaries often manifest as gradients rather than clear boundaries, making mapping difficult both in the field and remotely from aerial photography. Therefore, the boundaries of smooth lessingia polygons generated by this effort should be interpreted as density gradients rather than hard boundaries of species occurrence.

Section 3. ENVIRONMENTAL SETTING

Coyote Ridge Open Space Preserve and the Malech Fire burn perimeter are located in Santa Clara County on the east side of Santa Clara Valley. The preserve is depicted on the Morgan Hill 7.5-minute USGS topographic quadrangle and lies within the San Francisco Bay Area subregion of the California Floristic Province (Baldwin et al. 2012). CROSP is part of the Coyote Creek watershed.

3.1. REGIONAL SETTING

As described in the *Ecological Subregions of California* (USDA 1997), the study area is located within the Fremont-Livermore Hills and Valleys subsection of the Central California Coast Ranges section.

3.1.1 FREMONT-LIVERMORE HILLS AND VALLEYS

The Fremont-Livermore Hills and Valleys subsection consists of the Livermore-San Ramon Valley and hills around it, between the Greenville and the Calaveras Faults, and hills southeast of Fremont that are between the Calaveras fault and the Santa Clara Valley (USDA 1997). The climate is hot and subhumid (Ibid.). This subsection includes a late Quaternary alluvial plain running east to west across the middle of the Livermore-San Ramon Valley; and moderately steep to steep hills along the Calaveras fault and between the fault and the Santa Clara Valley (Ibid.). Elevation ranges from about 100 feet in the Santa Clara Valley to 2,594 feet on Monument Peak northeast of the valley (Ibid.). Mass wasting and fluvial erosion are the main geomorphic processes (Ibid.). Mainly Miocene marine sediments are found along the Calaveras fault south of the Livermore-San Ramon Valley, and much of the subsection is bounded by Mesozoic rocks of the Franciscan Complex and the Great Valley Sequence, and some of those rocks are included in this subsection (Ibid.).

For this subsection, the mean annual precipitation is about 15 to 20 inches, most of which is rainfall. Mean annual temperature is about 55° to 60° F and the mean freeze-free period is about 250 to 275 days (Ibid.). Runoff to the alluvial plain is rapid and all but the larger streams are dry through most of the summer. Natural lakes are absent, but there are a few reservoirs in the area (Ibid.).

3.2. LOCAL SETTING

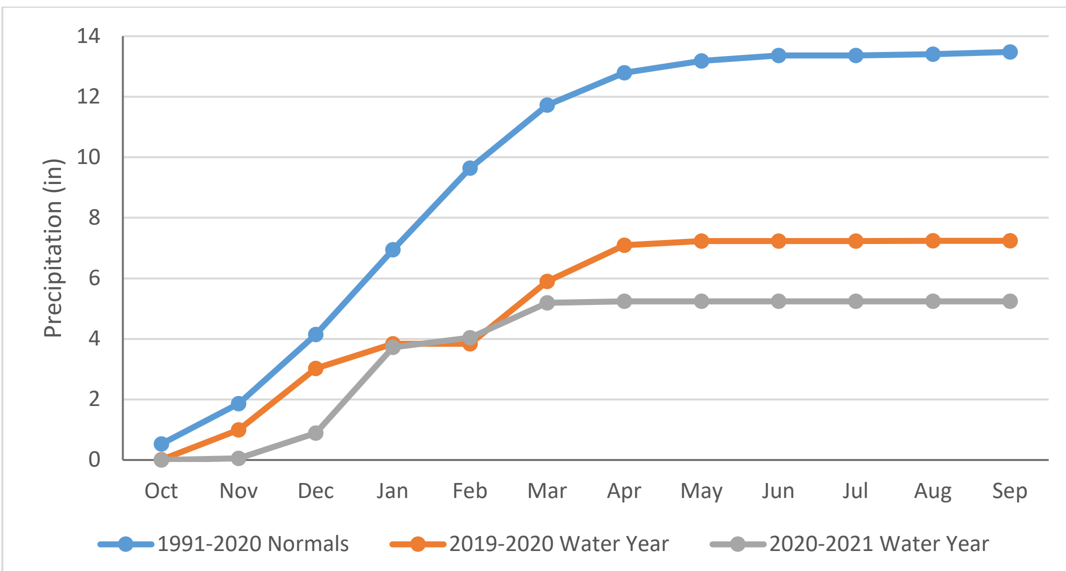
The study area at CROSP is located east of Highway 101 between Metcalf Road and Bailey Avenue (Figure 1). It is approximately 1.3 miles to the northeast of the unincorporated community of Coyote, 5 miles north of Morgan Hill, and 12 miles southeast of downtown San Jose. Metcalf Motorcycle County Park is located between CROSP and Metcalf Road, and Field Sports County Park is located at the northeast end of the preserve. The 210-acre burn footprint from the Malech Fire is located in the northern part of the preserve, just east of Field Sports County Park (Figure 2). The study area was accessed from a staging area off of Malech Road at the bottom of the ridge, or from an access road off of Metcalf Road that runs along the top of the ridge.

3.2.1 TOPOGRAPHY AND CLIMATE

The topography of the study area is characterized by a main ridge running northwest to southeast. Steep slopes are generally west facing, draining into Coyote Creek at the base of the ridge. The burn perimeter is located between two large drainages with a few smaller drainages inside the burn perimeter. Elevations range from approximately 280 feet (85meters) above mean sea level at the staging area off of Malech Road up to 1,406 feet (429 meters) at the top of the ridge southeast of the burned area.

Locally the climate of the study area is characterized as Mediterranean with cool, wet winters and warm, dry summers. The study area is near the edge of the coastal fog incursion zone and a majority of the moisture it receives is direct precipitation. The 2020 water year (October 1, 2019 – September 30, 2020) showed lower than average precipitation levels for the area with 7.24 inches of rain at the San Jose weather station compared to the 30-year normal of 13.48 inches (Figure 9, NOAA 2022). Precipitation records were retrieved from the National Centers for Environmental Information for the San Jose weather station (USW00023292) at the San Jose airport, approximately 14 miles northwest of the study area. Precipitation in the 2021 water year (October 1, 2020 to September 30, 2021), was even lower than the 2020 water year, measured at just 5.24 inches (NOAA 2022). In the 2020 water year, the majority of rain fell in December 2019 and March 2020 with no precipitation in February and very little precipitation May through September. In the 2021 water year, the most precipitation was measured in January 2020, with a smaller amount in March 2021 and very little precipitation April through September. Overall, 2020 and 2021 were two very dry years, with 2021 being exceptionally dry.

Figure 9. Cumulative Precipitation for the 2020 and 2021 Water Years



Low amounts of precipitation likely affected germination and abundance of populations monitored in 2020 and 2021. Low rainfall can have a positive effect on rare plants by relieving competition from fast-growing annual grasses and other weedy species. However, the exceptionally low amount of precipitation seen in 2021 could have affected the vigor and abundance of target populations even with lower levels of competing weedy species.

3.2.2 Geology and Soils

The underlying geology is comprised mostly of serpentinized ultramafic rock, but also includes some areas along the top and bottom of the ridge that are alluvial fan and landslide deposits (Wentworth et al. 1999; Table 4) Within the burn perimeter, the underlying geology is almost exclusively serpentinized ultramafic rock. A total of 15 soil mapping units are located within the CROSP study area, and six are located within the Malech burn perimeter (USDA/NRCS 2015; Table 5). The majority of the Malech burn footprint is composed of the Montara rocky clay loam soil series, which has serpentine influence (SoilWeb 2022).

Table 4. Geology Units in the CROSP Study Area

Symbol	Geology Mapping Unit	Acreage in CROSP	Acreage in Burn Footprint
Jbk	Coast Range Ophiolite	74.11	0.10
Jsp	Serpentinized ultramafic rock	1,453.35	199.11
Qhf2	Older alluvial fan deposits	5.50	0
Qls	Landslide deposits	25.89	0.006
Tsg	Silver Creek Gravels	242.45	0
	Total	**1,801.30**	**199.22**

Table 5. Soil Mapping Units in the CROSP Study Area

Symbol	Soil Mapping Unit	Acreage in CROSP	Acreage in Burn Footprint
AcE	Altamont clay, 15 to 30 percent slopes	96.67	3.07
AcF	Altamont clay, 30 to 50 percent slopes	2.82	0
AuE	Azule clay loam, 15 to 30 percent slopes	140.05	0
AuG	Azule clay loam, 30 to 75 percent slopes	14.18	0
AuG2	Azule clay loam, 30 to 75 percent slopes, eroded	50.40	0
CID	Climara clay, 9 to 30 percent slopes	18.73	0.011
CmE	Climara stony clay, 15 to 50 percent slopes	39.30	0
GaA	Garretson loam, gravel substratum, 0 to 2 percent slopes	3.67	0
GoD	Gilroy clay loam, 5 to 30 percent slopes	18.81	0
GoF	Gilroy clay loam, 30 to 50 percent slopes	76.93	14.22
McB	Maxwell clay, 0 to 5 percent slopes	0.55	0
MwF2	Montara rocky clay loam, 15 to 50 percent slopes, eroded	1,198.91	170.71
RnG	Rock land	110.85	11.17
SbE2	San Benito clay loam, 15 to 30 percent slopes, eroded	1.70	0.052
SbF3	San Benito clay loam, 30 to 50 percent slopes, severely eroded	27.71	0
	Total	**1,801.30**	**199.23**

3.2.3 Land-Use

Land-use east of CROSP is mostly open space. Metcalf Motorcycle County Park at the north end and Field Sport County Park at the northwestern end are open for recreational use. To the west, land use is a mix of urban, agriculture, and open space.

3.2.4 Fire History

The lands comprising the San Francisco Bay Area, including the study area, have a long history of fire including infrequent lightning-ignited fires prior to human occupation up to the mid-Holocene (roughly 7,000 to 5,000 years ago) with limited Native American populations (Keeley 2005). Cultural burning by Native Americans increased from the mid-Holocene to the late 18th century and was intense enough to expand the distribution of grasslands in the East Bay (Ibid.). Euro-American settlers continued to use fire in the late 18th century to maintain and expand grazing lands for livestock (Ibid.). Due to population growth and urban sprawl in the 19th and 20th centuries, frequency of ignitions increased and subsequent fire suppression policies drastically reduced fire rotation intervals (Ibid.).

Based on California Department of Forestry and Fire Protection (Cal Fire) 2021 data, a fire perimeter spatial database, four fires have been recorded on CROSP since the start of recordkeeping in 1878. The Sheriff Fire was recorded in 1979, it burned 429 acres. In 1981, the Pistol Range Fire burned 306 acres. In 1999, the Malech Fire burned 1,200 acres. Most recently, another fire named Malech ignited in 2019, covering 207 acres.

3.3. Vegetation Communities

Land cover data provided by the Habitat Agency includes several land cover types within the burn perimeter including: California Annual Grassland, Serpentine Bunchgrass Grassland, Mixed Serpentine Chaparral, Coast Live Oak Forest and Woodland, Pond, and Serpentine Seep (Table 6). Only Serpentine Bunchgrass Grassland was the target of post-fire vegetation composition monitoring. A portion of the burn area is mapped as California Annual Grassland, and this area was only surveyed for invasive weeds. Mixed Serpentine Chaparral and Coast Live Oak Forest and Woodland were not targets of vegetation composition monitoring based on direction from the Habitat Agency.

Table 6. Vegetation Communities Mapped within the Malech Burn Perimeter

Vegetation Community	Acreage
Herb Dominated Vegetation Types	
California Annual Grassland	3.23
Serpentine Bunchgrass Grassland	182.99
Shrub Dominated Vegetation Types	
Mixed Serpentine Chaparral	2.16
Tree Dominated Vegetation Types	
Coast Live Oak Forest and Woodland	10.89
Wetland Vegetation Types	
Pond	0.030
Serpentine Seep	0.0092
Total	**199.31**

Section 4. RESULTS AND DISCUSSION

4.1. RESULTS OVERVIEW

During this study, 16 vegetation composition plots within the Malech burn perimeter were monitored in 2020 and 2021 (32 plots combined over both years). Sampling these plots yielded 93 plant taxa, 70 (75%) are considered native and 22 (24%) are non-native. Grasses and herbs were the dominant life forms within plots, with 69.31% and 27.84% average relative cover, respectively. Geophyte, shrub, and vine taxa occurred below 2% relative cover on average. No fire following species were recorded within plots, but 17 native disturbed taxa, ten nitrogen fixing taxa, two geophyte taxa, one rare species, and 11 taxa considered invasive by Cal-IPC were recorded in the plots. One taxon, smooth lessingia (CRPR 1B.2) is considered rare based on the California Native Plant Society's Inventory of Rare and Endangered Plants of California (CNPS 2022).

Six covered plant species were monitored to assess population abundance trends and fire effects. Four colonies belonging to one CNDDB occurrence of Mt. Hamilton thistle were censused, totaling 4,481 individuals in 2020 and 5,539 individuals in 2021. A total of 13 rock outcrops belonging to one CNDDB occurrence of Santa Clara Valley Dudleya were monitored, totaling 1,570 rosettes in 2020 and 1,949 rosettes in 2021. Two macroplots belonging to two different CNDDB occurrences of fragrant fritillary were sampled, encompassing an estimated 4,812 individuals in 2020 and 6,373 individuals in 2021. Smooth lessingia distribution was mapped within the Malech burn footprint, all belonging to a single CNDDB occurrence. An estimated 15,014,882 individuals were mapped in 2020 and 5,266,687 individuals in 2021. Four macroplots belonging to one CNDDB occurrence of most beautiful jewelflower were sampled, encompassing an estimated 5,700 individuals in 2020 and 1,690 individuals in 2021.

Seven targeted plant species with elevated threat rankings (e.g. Cal-IPC rating of Limited, Moderate, or High or on the California Noxious Weed List) were mapped within the study area. These species covered an estimated 6.37 acres across 34 polygons in 2020 and 12.76 acres across 37 polygons and 26 points in 2021.

View of Serpentine Grassland approximately 6 months after the Malech Fire.

4.2. POST-FIRE VEGETATION COMPOSITION MONITORING

The sampling of 16 plots within the Malech burn perimeter in 2020 and 2021 (32 plots combined over both years) yielded 93 plant taxa. Of these, 70 (75%) are considered native and 22 (24%) are non-native. One taxon, smooth lessingia (CRPR 1B.2) is considered rare based on the California Native Plant Society's Inventory of Rare and Endangered Plants of California (CNPS 2022). 11 species are considered noxious weeds by Cal-IPC (2022).

The following sections describe results of vegetation composition monitoring grouped by all recorded species, native species, life form (i.e. herb, geophyte, and shrubs), and the following herbaceous species categories:

- Fire following annuals. Species which have a germination response directly related to fire whether it be chemicals or heat germination cues.
- Native disturbance following annual species. These native species are not obligate fire followers, but take advantage of the disturbance created by the fire;
- Nitrogen fixers. Species that have the ability to fix nitrogen.
- Rare plants. Species not common on the landscape and are determined by various resource agencies and non-governmental organizations to have special status.
- Invasive weed species. Species categorized as invasive by Cal-IPC.

Appendix A includes a comprehensive species list recorded within all vegetation composition monitoring plots. Appendix B includes a table of species richness of functional groups by plot. Appendix C includes a table of absolute and relative cover of functional groups by plot. Appendix D includes a photo appendix of vegetation composition plots.

Throughout the results, treatment refers to plots from Burn, Doze, Retardant, and Unburn areas and fire suppression activities refers to both Burn and Doze treatments. In reporting the effects of treatment (Burn, Doze, Retardant, and Unburn plots) and year (2020 and 2021), F and p values (and when non-parametric tests were used, chi-squared and W values) for significant ($p < 0.05$) and marginally significant ($p < 0.1$) results are included parenthetically. A table with ANOVA, Kruskall-Wallis, and Wilcoxon test results, including non-significant results, can be found in Appendix D.

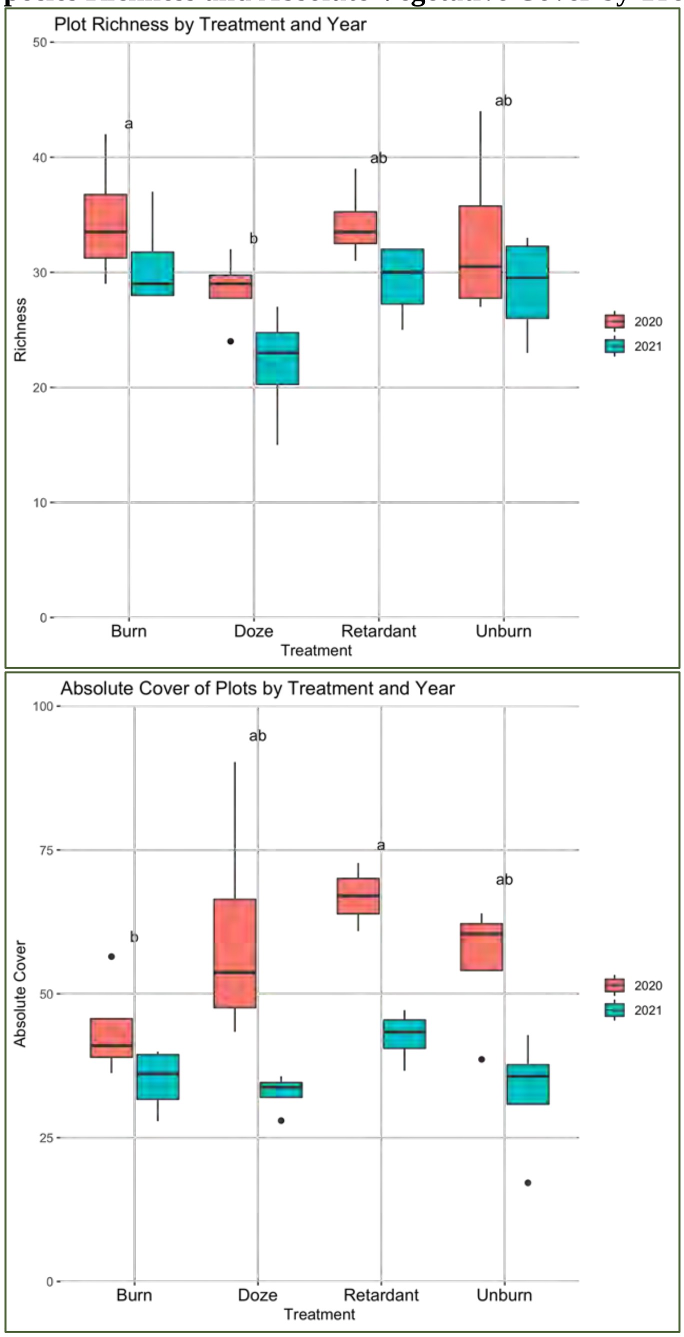
4.2.1 TOTAL SPECIES RICHNESS AND VEGETATIVE COVER

Overall species richness averaged 30.1 species per plot and ranged from 15 to 44 species per plot. The highest species richness was found at plots Unburn4 in 2020 (44 species), Burn3 in 2020 (42 species), and Ret4 in 2020 (39 species). Plot richness was significantly different between treatments, with richness in the Burn treatment significantly greater than richness in the Doze treatment, and neither being significantly different than richness in the Retardant or Unburn treatments (ANOVA, $F_{3,24} = 3.70$, $p < 0.05$; Figure 10). Additionally, species richness in plots was significantly higher in 2020 than 2021 (ANOVA, $F_{1,24} = 7.94$, $p < 0.01$). The interaction of treatment and year did not have a significant effect on species richness (Appendix D).

Absolute vegetative cover of all plots sampled averaged 46.25% and ranged from 17.15% to 90.28%. The highest absolute cover was recorded in plots Doz1 (90.28%), Ret3 (72.74%), and Ret 2 (69.15%) all in 2020. Similar to species richness, both treatment and year had significant effects on absolute cover. Retardant plots had significantly higher cover than Burn plots, but neither Retardant nor Burn plots were significantly different from Doze and Unburn plots (ANOVA, treatment: $F_{3,24} = 3.064$, $p < 0.05$; Figure

10). Absolute vegetative cover was also significantly higher in 2020 than 2021 (ANOVA, $F_{1,24} = 32.62$, $p < 0.001$). Again, the interaction of treatment and year did not have a significant effect on absolute vegetative cover (Appendix D).

Figure 10. Total Species Richness and Absolute Vegetative Cover by Treatment and Year[7]



Total species richness (top) and absolute vegetative cover (bottom) in plots by treatment and year. Letters above bars correspond to the results of pairwise comparisons using Tukey multiple comparisons tests. Different letters

[7] In all box plots, bold lines represent the median value and the lower and upper hinges correspond to the first and third quartiles. The whiskers extend from each hinge to the largest (or smallest) value but no further than 1.5 times the inter-quartile range. Outliers beyond the end of the whiskers are plotted individually.

are significantly different from one another using a significance level of $p < 0.05$. Year had a significant effect on both richness and absolute cover.

Discussion

Both species richness and absolute vegetative cover were greater in 2020 than 2021. This could be partly due to the post-fire nitrogen pulse, providing nutrients to plant species in the spring immediately following the fire. Typically, there is a nutrient pulse in the spring immediately after a fire. Organic matter is rapidly consumed by fire, changing organic nitrogen into inorganic forms immediately available to plants. This nitrogen pulse however, is short-lived as inorganic forms of nitrogen are more easily leached from soils causing a net loss of nitrogen after a fire (Christensen 1973, Dunn et al. 1979). The significant effect of year could also be attributed to the extreme lack of rain in the 2021 water year. Although there was little rain in 2020 as well, there was even less precipitation in 2021, which likely reduced annual species germination and survival.

Although there was a significant effect of treatment on total species richness and absolute cover, the effect was not very large. However, Burn plots do appear to have had lower absolute cover the first year after fire compared to unburned grassland and other fire suppression activities.

Transect in Burn treatment in April 2020.

Transect in Dozer treatment in April 2020.

Transect in Retardant treatment in April 2020.

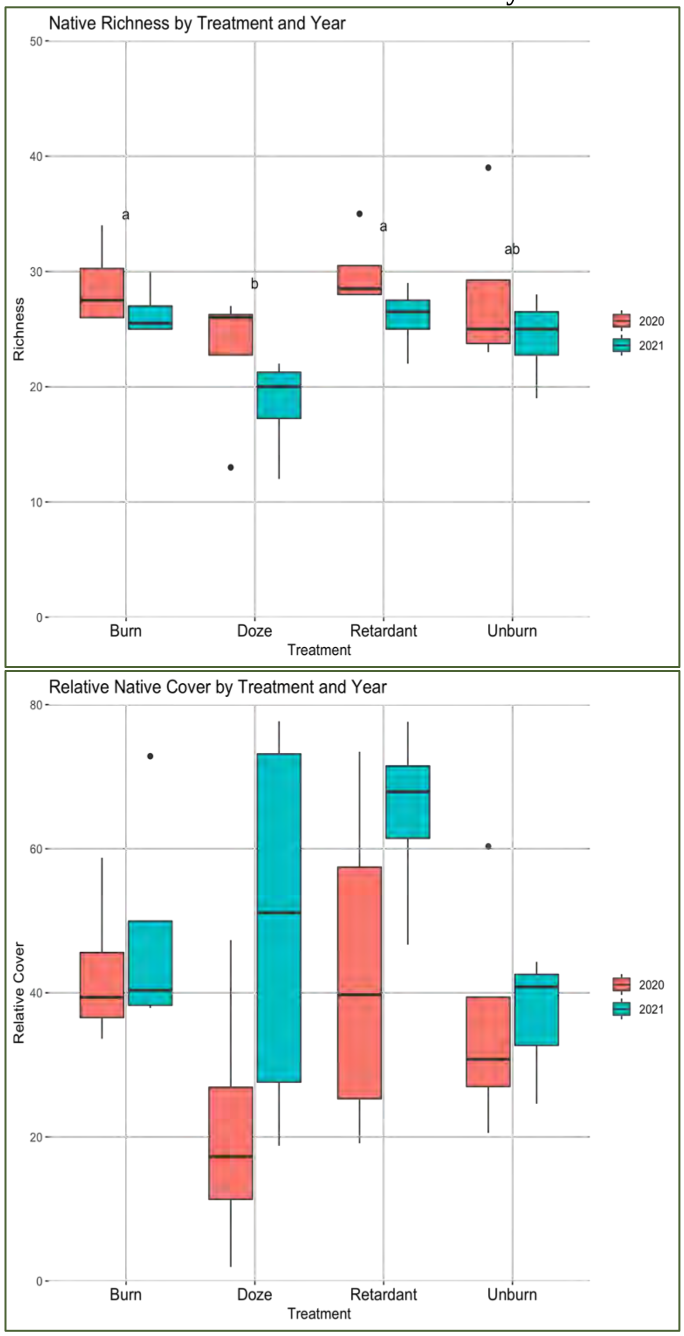
Transect in Unburn treatment in April 2020.

4.2.2 NATIVE SPECIES RICHNESS AND COVER

Native richness across all plots averaged 30.12 taxa ranging from 15 to 44. Similar to overall richness, the highest native richness was also in plots Unburn4 (39 species), Ret4 (35 species), and Burn3 (34 species), all in 2020. Native richness was significantly different between treatments, with richness significantly higher in Retardant and Burn plots compared to Doze plots, and no difference in native richness between Unburn and other treatments (ANOVA, $F_{3,24} = 4.099$, $p < 0.05$; Figure 11). Native richenss was also significantly higher in 2020 than in 2021 (ANOVA, $F_{1,24} = 4.801$, $p < 0.05$; Figure 11). The interaction between year and treatment had no significant effects on native richness (Appendix D).

Of the total vegetative cover, relative native plant cover averaged 44.37% (average absolute native plant cover was 19.80%) and ranged from 90.52% in plot Unburn1 in 2021 to 1.95% in plot Doz1 in 2020. Native relative cover was significantly higher in 2021 than 2020 (ANOVA, $F_{1,24} = 5.625$, $p < 0.05$; Figure 11). Native relative cover was not significantly affected by treatment or the interaction of treatment and year (Appendix D).

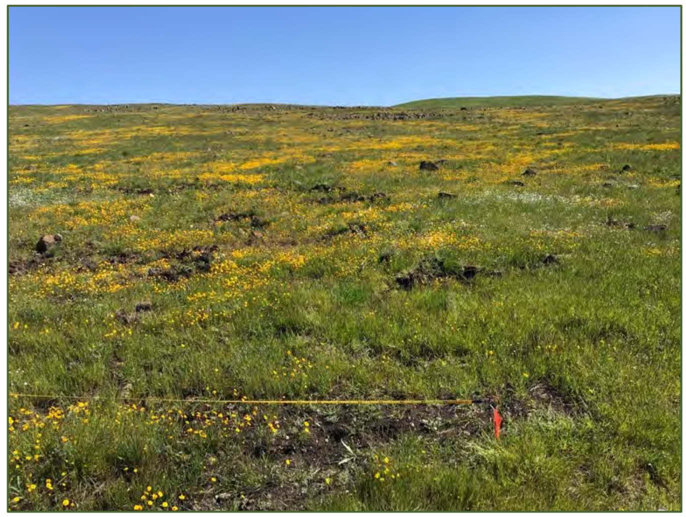
Figure 11. Native Richness and Relative Cover by Treatment and Year



Native species richness (top) and relative cover (bottom) in plots by treatment and year. Letters above bars correspond to the results of pairwise comparisons using Tukey multiple comparisons tests. Different letters are significantly different from one another using a significance level of $p < 0.05$. Year did not have a significant effect on either richness or relative cover.

Discussion

Similar to total species richness and absolute vegetative cover, fire and fire suppression activities did not have large effects on native richness or native cover – even when the effect was significant. Perhaps this is due the fact that a large proportion of native species in the study area are also annual species that are less impacted by a late-season fire. There was a lot more variability in native cover of plots, especially in Doze and Retardant treatments, compared to native richness. This suggests that similar species were present in plots, but that some native species were more successful (more individuals or larger individuals) in some plots than others, even within the same treatment. This could be explained by differences in microclimates, microhabitat, or a number of other untested differences between plots.



View of Serpentine Grassland approximately 6 months after the Malech Fire.

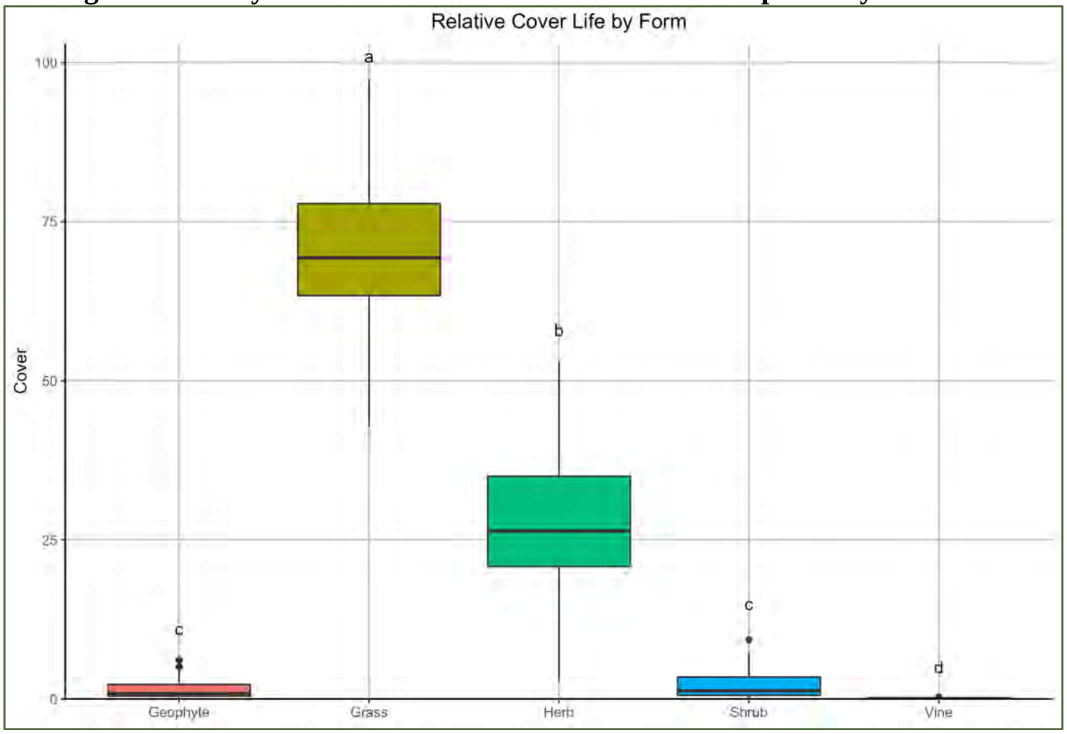
4.2.3 LIFE FORM CATEGORIES

Plant species field data were categorized into life forms by herb (69 taxa), grass (19 taxa), geophyte (2 taxa), shrub (2 taxa), and vine (1 taxon). The only life forms that were found in all plots included herbs and grasses. In contrast, geophytes were found in 31 plots, shrubs in 15 plots, and vines in 4 plots.

Species richness varied significantly by life form with each life form significantly different from the other (Kruskal-Wallis, chi-squared = 105.29, df = 4, $p < 0.0001$). Average herb richness was significantly greater than other life forms with 22.1 species per plot, ranging from 10 to 34. Average grass richness was the next largest with 5.7 species per plot, ranging from 3 to 9 taxa. Geophytes had significantly lower richness, an average of 1.8 ranging from 0 to 2 taxa. Average shrub species richness was 0.5 and ranged from 0 to 1 across all plots. The only vine species recorded was a dodder species (*Cuscuta* sp.), which only appeared in four plots.

Relative cover also varied significantly by life form (Kruskal-Wallis, chi-squared = 98.65, df = 4, $p < 0.0001$; Figure 12). Grasses had the highest relative cover with an average of 69.31% ranging from 42.77% to 97.26%. This was significantly greater than the relative cover of other life forms. Herbs had the second highest average relative cover at 27.84%, ranging from 2.74% to 52.92%. Herbs had significantly higher relative cover than Geophytes, Shrubs, and Vines. Geophytes and Shrubs were not significantly different from each other but were significantly greater than the relative cover of Vines. Geophytes had an average relative cover of 1.67%, ranging from 0% to 6.11%. Shrubs ranged from 0 to 9.26% with an average of 1.17% relative cover. The average relative cover of Vines across the whole project was 0.013%.

Figure 12. Study-wide Relative Percent Cover of Plant Species by Life Form



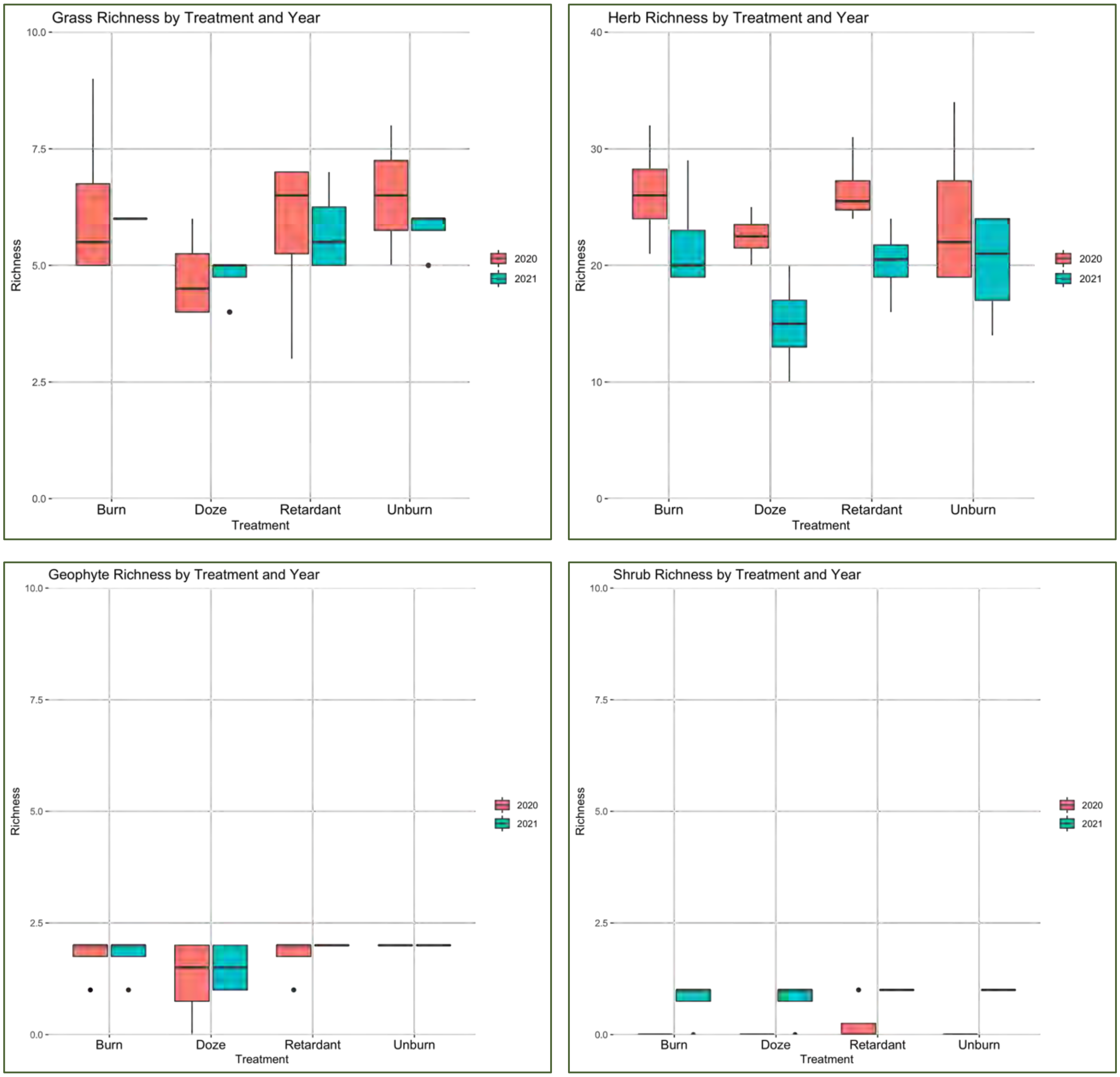
Relative percent cover of vegetation in plots from 2020 and 2021 by life form. Letters above bars correspond to the results of pairwise comparisons using Wilcoxon rank sum test. Different letters are significantly different from one another using a significance level of $p < 0.05$.

Effects of Fire and Fire Suppression Activities

Treatment was marginally significant in its effects on grass species richness (ANOVA, $F_{3,24} = 3.38$, p = 0.091; Figure 13). Treatment was also marginally significant in its effects on geophyte richness (ANOVA, $F_{3,24} = 2.33$, p = 0.099; Figure 13). Fire suppression treatment did not have a significant effect on species richness of herbs or shrubs (Appendix D; Figure 13).

Year had a significant effect on richness of herbs (ANOVA, $F_{1,24} = 12.37$, $p < 0.01$) and shrubs (Wilcoxon, W = 24, $p < 0.001$), with higher richness in 2020 than 2021 in both cases (Figure 13). Species richness of grasses and geophytes was not significantly different between 2020 and 2021 (Appendix D; Figure 13). Finally, the interaction of treatment and year was not significant for grasses, herbs, or geophytes and was not computed for shrubs (Appendix D).

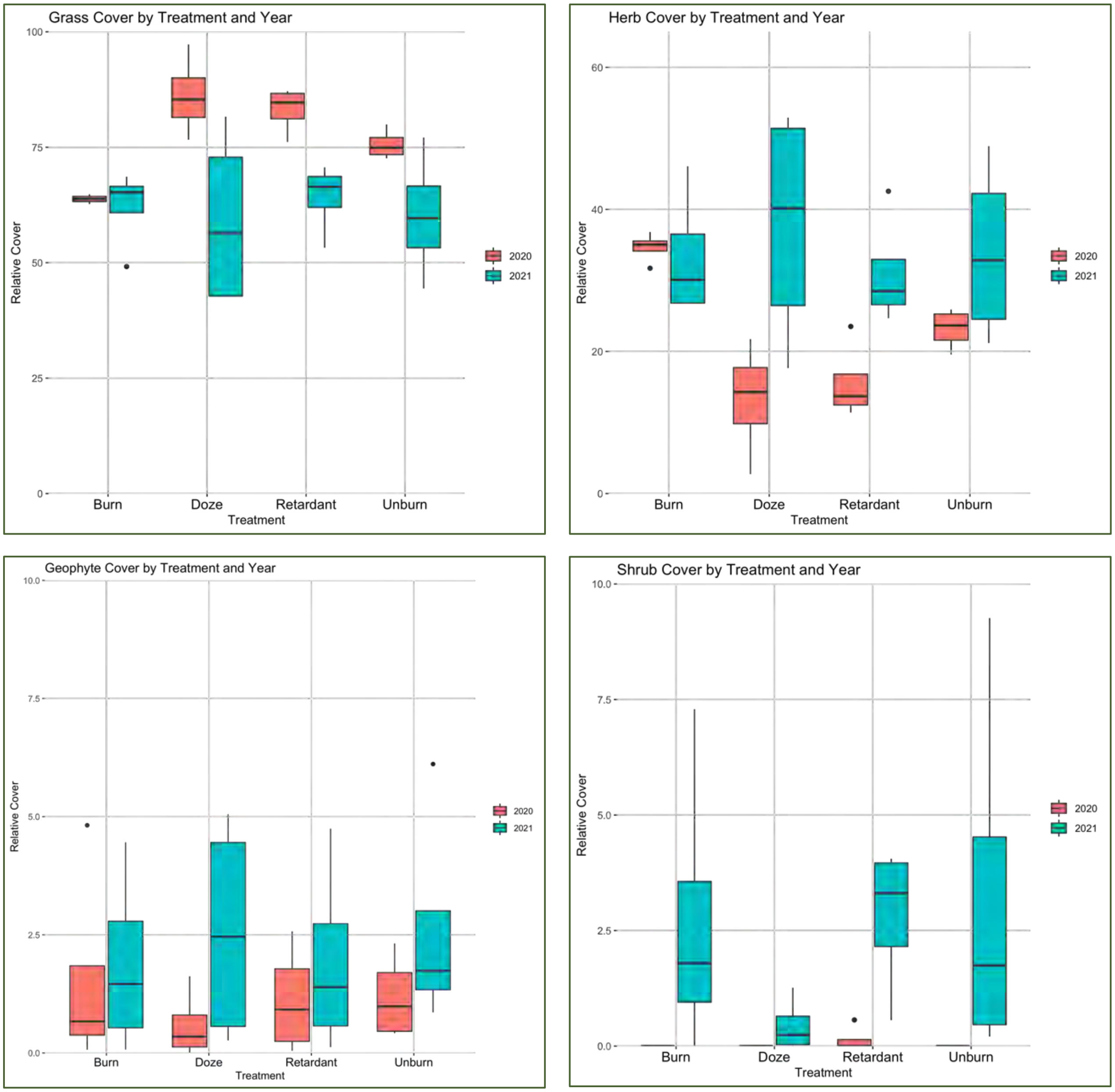
Figure 13. Species Richness of Life Forms by Treatment and Year



Species richness of grasses (upper left), herbs (upper right), geophytes (lower left), and shrubs (lower right) in plots by treatment and year. Note the scale of y-axes may be different between panels. Year had a significant effect on herb and shrub richness but not on grass or geophyte richness.

Fire and fire suppression activities did not significantly affect the relative cover of grasses, herbs, geophytes or shrubs (Appendix D, Figure 14). However, Year did have a significant effect on grasses (Wilcoxon, W = 209, $p < 0.01$), herbs (Wilcoxon, W = 53, $p < 0.01$), and shrubs (Wilcoxon, W = 3.22, $p < 0.001$), and was marginally significant for geophytes (Wilcoxon, W = 82, $p = 0.086$; Figure 14). Relative cover of herbs and shrubs was significantly greater in 2021 than in 2020. Grasses on the other hand, had significantly greater relative cover in 2020.

Figure 14. Relative Cover of Life Forms by Treatment and Year



Relative cover of grasses (upper left), herbs (upper right), geophytes (lower left), and shrubs (lower right) in plots by treatment and year. Note the scale of y-axes may be different between panels. Year had a significant effect on grass, herb, and shrub relative cover and a marginally significant effect on geophyte relative cover.

Discussion

Since plots were placed in Serpentine Grassland, it makes sense that grasses and herbs were the dominant life forms. This also means that plots were dominated by annual species, and may not experience the same lasting effects of burning or bulldozer treatments as perennial shrubs would. Fire and fire suppression activities did not have any significant effects on richness or cover of grasses or herbs, again suggesting that treatments don't prevent these annual species from growing and don't have negative effects on the seedbank (at least not at this fire interval).

Perennial geophytes and shrubs were also not affected by treatments, possibly because only the aboveground portions were removed in the fire or by a bulldozer, allowing the plant to resprout the following spring.

There was a significant effect of year on grass cover. It is possible that grasses were able to capitalize on the nitrogen surge the year after the Malech Fire more than other life forms. Once the cover of grass decreased in 2021, other life forms like herbs were able to have higher cover.

4.2.4 Post-Fire Herbaceous Categories

Herbaceous species include groups of taxa with different functional and life history traits including fire following annuals, native disturbed species, nitrogen fixing species, geophytes, rare taxa, and weeds. The results for these categories are detailed below.

Fire Following Annuals

No fire following herbaceous species were recorded in plots in 2020 or in 2021. This is not unexpected since plots were placed in grassland and fire following annuals are most frequently seen in chaparral and scrub vegetation types.

Native Disturbed

Occurrence Study-Wide

Average species richness of native disturbed species (as defined in Section 2.4.2) per plot was 7.2 with a range of 4 to 12. Average relative cover was 17.41%, and ranged from 0.64% to 57.57%. The highest relative cover of native disturbed taxa was in plots Ret2 in 2020 and 2021 and Ret3 in 2020 and 2021.

A total of 17 native disturbed taxa were observed within all plots, 13 of these were observed in burned plots. Of the 17 taxa, 8 are nitrogen fixers, none are weeds, and none have rarity status. The native disturbed species found most frequently in plots included: calf lotus (*Acmispon wrangelianus*) in 31 plots, dwarf loco weed (*Astragalus gambelianus*) in 28 plots, and Eastwood fescue (*Festuca microstachys*) in 27 plots (Figure 15; Table 7).

Figure 15. Frequency of Native Disturbed Taxa Across All Plots

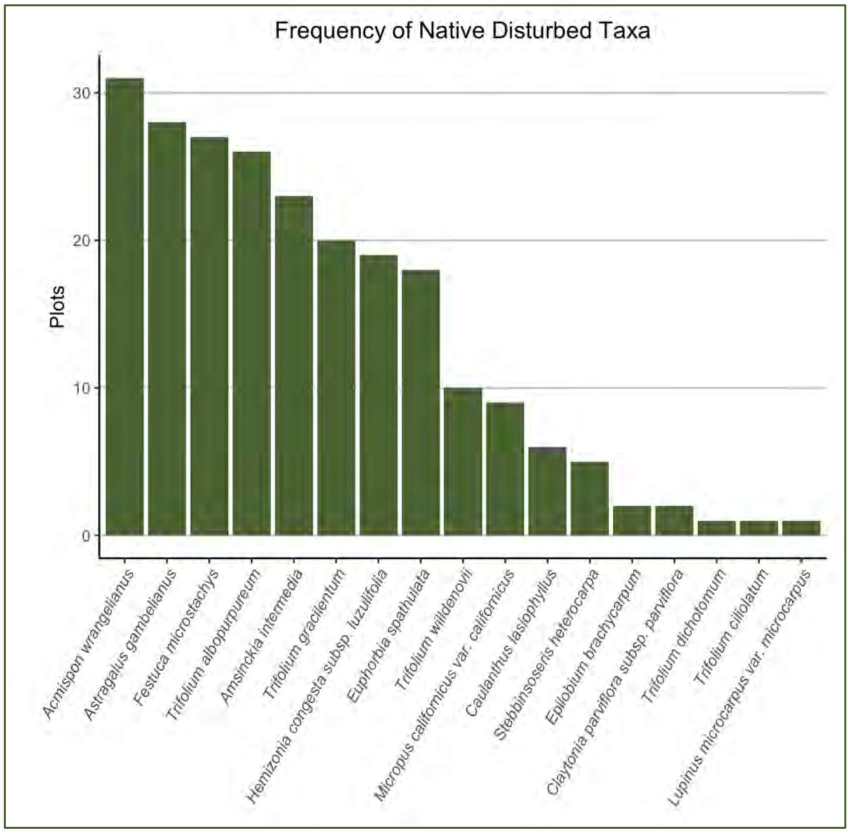


Table 7 shows the species categorized as native disturbed, their frequency in plots overall, and frequency within each treatment. Native disturbed taxa tended to be just as frequent between Burn, Doze, Retardant, and Unburn treatments, except hayfield tarweed (*Hemizonia congesta* subsp. *luzulifolia*) was more frequent in Retardant plots, and warty spurge (*Euphorbia spathulata**) was more frequent in Doze plots. However, differences in frequency could not be statistically tested for individual species due to low frequency. Native disturbed taxa as a whole were not significantly more likely to be recorded in any given treatment (Chi-squared, $\chi^2 = 0.33$, df = 3, p = 0.955).

Table 7. Native Disturbed Species Frequency in Plots

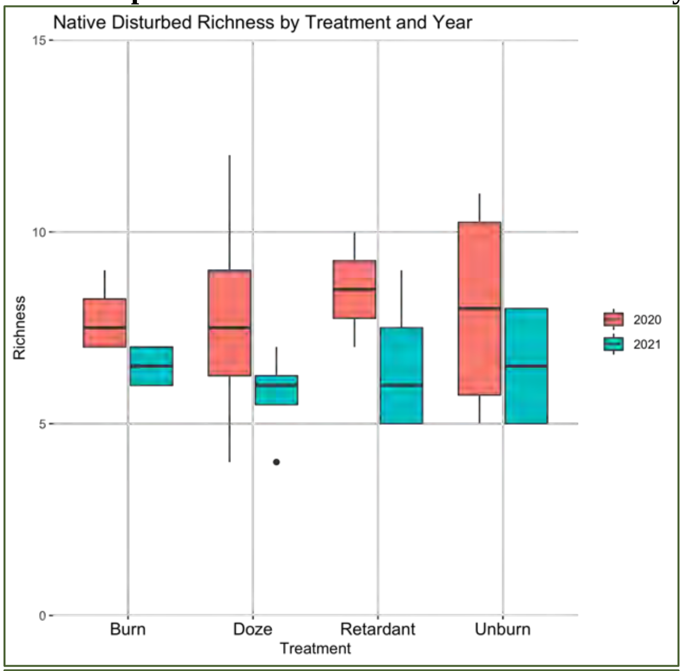
Species Name (Common Name)	Frequency in Plots				
	Overall	Burn	Doze	Retardant	Unburn
Acmispon wrangelianus (calf lotus)	31	8	7	8	8
Amsinckia intermedia (common fiddleneck)	23	6	5	6	6
Astragalus gambelianus (dwarf loco weed)	28	8	5	7	8
Caulanthus lasiophyllus (California mustard)	6	0	2	1	3
Claytonia parviflora subsp. *parviflora* (narrow leaved miner's lettuce)	2	0	0	2	0
Epilobium brachycarpum (tall annual willow-herb)	2	0	1	1	0
Euphorbia spathulata (warty spurge)	18	4	7	3	4
Festuca microstachys (Eastwood fescue)	27	6	6	8	7
Hemizonia congesta subsp. *luzulifolia* (hayfield tarweed)	19	4	4	7	4
Lupinus microcarpus var. *microcarpus* (chick lupine)	1	0	1	0	0
Micropus californicus var. *californicus* (slender cottonweed)	9	2	2	1	4
Stebbinsoseris heterocarpa (grassland stebbinsoseris)	5	1	1	2	1
Trifolium albopurpureum (Indian clover)	26	7	6	8	5
Trifolium ciliolatum (tree clover)	1	1	0	0	0
Trifolium dichotomum (branched Indian clover)	1	1	0	0	0
Trifolium gracilentum (pinpoint clover)	20	6	5	4	5
Trifolium willdenovii (tomcat clover)	10	3	2	2	3
Total	**229**	**57**	**54**	**60**	**58**

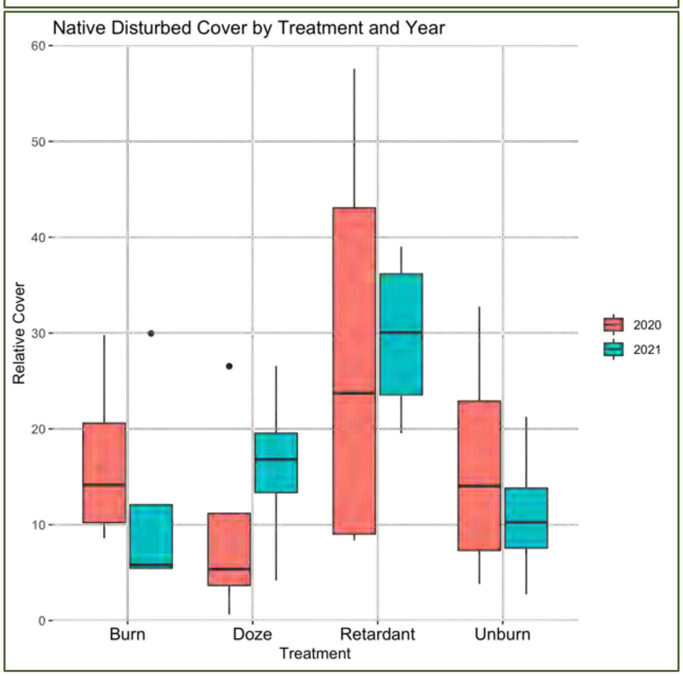
Effects of Fire and Fire Suppression Activities

Native disturbed richness was not significantly different between the treatment groups (Appendix D); but it was significantly higher in 2020 than 2021 (ANOVA, $F_{1,24} = 5.93$, $p < 0.05$; Figure 16). The interaction of treatment and year did not have a significant effect on native disturbed richness (Appendix D).

Native disturbed relative cover was marginally significantly different between the treatment groups with Retardant plots having higher cover than Doze plots (ANOVA, $F_{3,24} = 2.88$, $p = 0.0568$; Figure 16). Native disturbed cover was not significantly affected by year or the interaction of treatment and year (Appendix D).

Figure 16. Relative Cover and Species Richness of Native Disturbed Taxa by Treatment and Year





Species richness (left) and relative cover (right) of native disturbed taxa in plots by treatment and year. Year had a significant effect on native disturbed richness but not on relative cover.

Discussion

These species, though native, can behave like weeds, capitalizing on the open ground the fire or fire suppression creates allowing for colonization. However, the results from this study show much lower cover of native disturbed taxa (17.41% on average) than weedy taxa (54.94% on average). Further, native disturbed taxa were not more likely to be found in the more disturbed treatments, Burn or Doze.

Similarly, native disturbed richness did not vary by treatment, and native disturbed cover was only marginally significant. It does appear that relative cover in the Retardant treatment was higher than other treatments, perhaps due to the extra nitrogen in the fire retardant application.

Native disturbed richness was higher in 2020 than in 2021, perhaps due to the nitrogen pulse from the fire, or lack of rain in 2021. The difference in native disturbed richness was significant but small, fewer than five species different.

Nitrogen fixers

Occurrence Study-Wide

Average nitrogen fixer species richness was 3.9 and ranged from 1 to 5 across all plots. Average relative cover of nitrogen fixers was 5.07%, ranging from 0.46% to 14.90%. The highest relative cover of nitrogen fixers was at plots Unburn2 in 2020, Burn1 in 2020, and Burn2 in 2020.

Ten nitrogen fixing taxa were observed in the study area, eight of these were observed in burned plots. The three most common nitrogen fixers found in the study area were calf lotus (31 plots), dwarf loco weed (28 plots), and Indian clover (*Trifolium albopurpureum*; 26 plots) (Figure 17; Table 8). Of the ten taxa, two are weeds: rose clover (*Trifolium hirtum**) and burclover (*Medicago polymorpha**). All of the nitrogen fixing taxa are herbs, and all of them are annual.

Figure 17. Frequency of Nitrogen Fixers Across All Plots

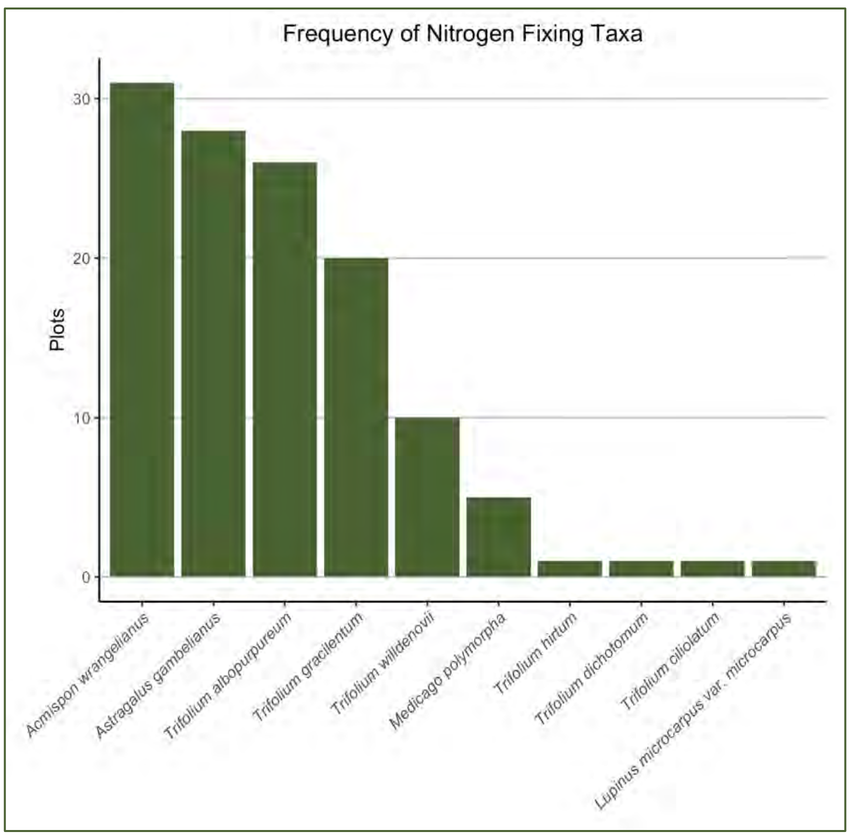


Table 8 shows the nitrogen fixing species, their frequency in plots overall, and frequency in each treatment. Nitrogen fixing species tended to be just as frequent between Burn, Doze, Retardant, and Unburn treatments. However, differences in frequency could not be statistically tested for individual species due to low frequency. Nitrogen fixing taxa as a whole were not significantly more likely to be recorded in any given treatment (Chi-squared, $\chi^2 = 0.77$, df = 3, p = 0.856).

Table 8. Nitrogen Fixer Frequency in Plots

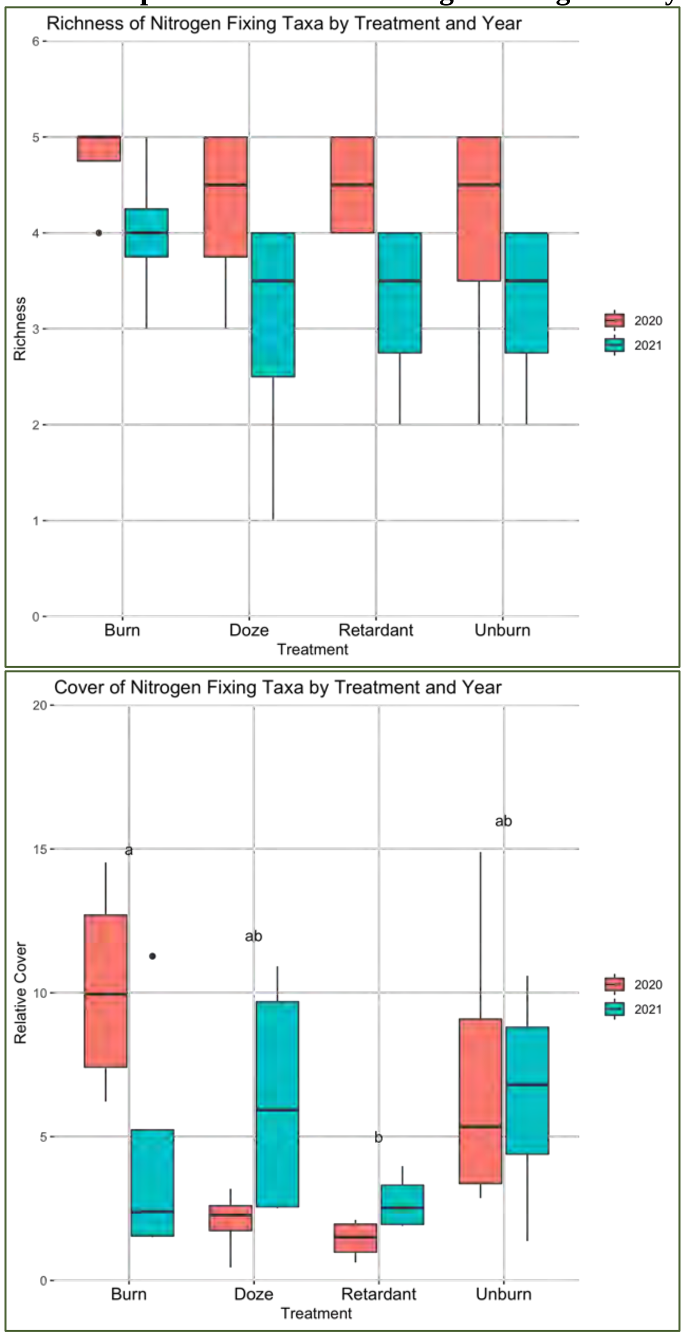
Species Name (Common Name)	Frequency in Plots				
	Overall	Burn	Doze	Retardant	Unburn
Acmispon wrangelianus (calf lotus)	31	8	7	8	8
Astragalus gambelianus (dwarf loco weed)	28	8	5	7	8
Lupinus microcarpus var. *microcarpus* (chick lupine)	1	0	1	0	0
Medicago polymorpha (burclover)	5	1	2	2	0
Trifolium albopurpureum (Indian clover)	26	7	6	8	5
Trifolium ciliolatum (tree clover)	1	1	0	0	0
Trifolium dichotomum (branched Indian clover)	1	1	0	0	0
Trifolium gracilentum *(pinpoint clover)*	20	6	5	4	5
Trifolium hirtum (rose clover)	1	0	1	0	0
Trifolium willdenovii (tomcat clover)	10	3	2	2	3
Total	**124**	**35**	**29**	**31**	**29**

Effects of Fire and Fire Suppression Activities

Nitrogen fixer richness was not significantly different between treatment groups (Appendix D), but was significantly higher in 2020 than 2021 (Wilcoxon, W = 201.5, p < 0.01; Figure 18).

Relative cover of nitrogen fixing species was significantly different between the treatment groups, where Burn plots had higher cover than Retardant plots, and Doze and Unburn plots were not significantly different (ANOVA, $F_{3,24} = 3.54$, $p < 0.05$; Figure 18). Year had no significant effect on nitrogen fixing cover (Appendix D). The interaction of treatment and year had a marginally significant effect on relative cover of nitrogen fixing taxa, where it appears the difference between treatments was more pronounced in 2020 than 2021 (ANOVA, $F_{3,24} = 2.73$, p = 0.066).

Figure 18. Relative Cover and Species Richness of Nitrogen Fixing Taxa by Treatment and Year



Species richness (left) and relative cover (right) of nitrogen fixing taxa in plots by treatment and year. Year had a significant effect on nitrogen fixer richness but not on relative cover.

Discussion

Nitrogen fixers have long been seen as an important functional group in the post-fire environment (Jorgensen and Wells 1971; Youngberg and Wollum 1976; Christensen and Muller 1975). Nitrogen fixing species can help ameliorate the loss of nitrogen after the short-lived nutrient pulse by returning nitrogen to the soil through the process of a symbiotic relationship with bacteria that can covert atmospheric nitrogen to a form usable by plants (Christensen 1973).

Nitrogen fixer species richness and cover was relatively low in plots. The same suite of species was seen in plots regardless of treatment, although slightly more species were recorded in 2020 than in 2021. Although species richness did not change drastically, relative cover did vary by treatment, with higher cover in Burn plots than Retardant plots. This result suggests that the more of the nitrogen increase due to fire is being returned to the soil than the added nitrogen from fire retardant application. This could partly be due to less competition for space in the Burn treatment.

Geophytes

Occurrence Study-Wide

Two geophyte taxa were observed across all plots. Geophytes are perennial herbaceous species that produce underground storage tissues. These underground parts are typically deep enough in the soil to avoid excessive heat, and thus mortality from fire and readily resprout following fire events. Taxa in this category include both monocots and dicots. Geophytes mostly had low cover and richness in plots. Average geophyte richness in plots was 1.8 ranging from 0 to 2 taxa and average relative cover was 1.67%, ranging from 0% to 6.11%.

The two geophyte species observed in the study area were soap plant (*Chlorogalum pomeridianum* var. *pomeridianum*), in 28 plots, and blue dicks (*Dipterostemmon capitatus* subsp. *capitatus*), in 28 plots (Figure 19; Table 9). Both of these taxa are native, and neither are nitrogen fixers, weeds, or have rarity status.

Figure 19. Frequency of Geophytes across All Plots

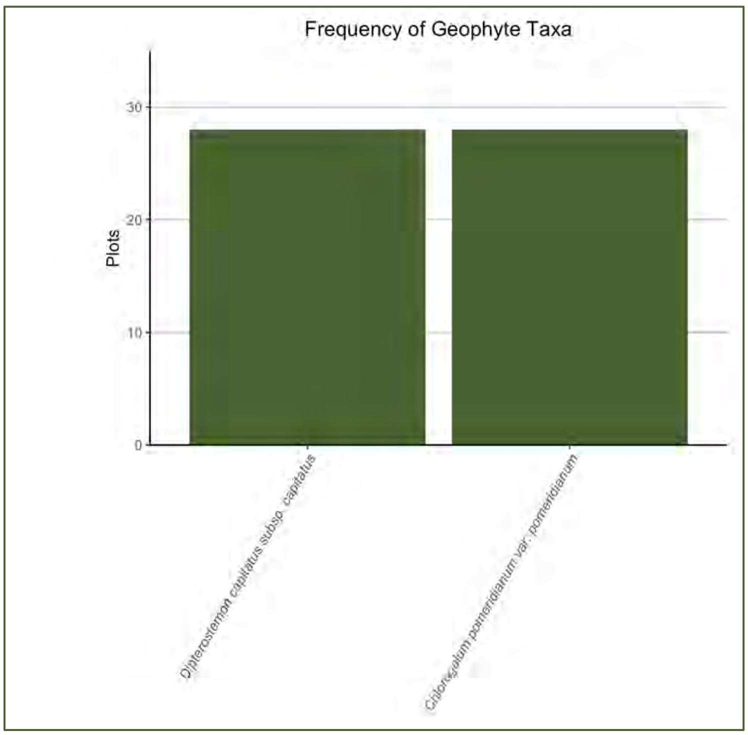


Table 9 below shows geophyte species present in plots, their frequency in plots overall, and frequency in each treatment. Neither soap plant nor blue dicks were statistically more likely to be recorded in any given treatment (Chi-squared, $\chi^2 = 0.44$, df = 3, p = 0.931).

Table 9. Geophyte Frequency in Plots

Species Name (Common Name)	Frequency in Plots				
	Overall	Burn	Doze	Retardant	Unburn
Chlorogalum pomeridianum var. *pomeridianum* (soap plant)	28	6	6	8	8
Dipterostemmon capitatus subsp. *capitatus* (blue dicks)	28	8	5	7	8
Total	**56**	**14**	**11**	**15**	**16**

Effects of Fire and Fire Suppression Activities
These results are summarized above, under Section 4.2.3.

Discussion
Geophyte frequency and cover within the study area was low compared to other herbaceous groups and other life forms; average richness was 1.8, and average relative cover was under 2%. Although richness and cover were low, these two species were recorded in almost all plots.

Geophytes had consistently low richness and cover across treatments and years, so it is likely that these species occur at low levels in the grasslands on Coyote Ridge and were not impacted much by the wildfire or fire suppression activities. It is possible that the low rainfall in 2020 and 2021 could have reduced the size and thus the percent cover of geophytes visible within plots as they may have remained dormant underground.

Rare Taxa

Occurrence Study-Wide
Average rare plant richness was 0.5 and average relative cover was 0.63%. One taxon with rarity status, smooth lessingia, was recorded in vegetation composition plots (Table 10). Smooth lessingia is known from Coyote Ridge and from within the Malech Fire footprint (CDFW 2021). A description of this species and results from monitoring smooth lessingia within the Malech Fire footprint can be found in Section 4.3.4.

Smooth lessingia was found in 17 plots, with the highest cover in Burn4 and Unburn4 in 2020. Plot Burn4 had 2.29% absolute cover and 5.75% relative cover of smooth lessingia in 2020 while Plot Unburn4 had 2.85% absolute cover and 4.63% relative cover in 2020.

Table 10 below shows rare species present in the plots, their frequency in plots overall, and frequency in each treatment. Treatment does not appear to have had an effect on the frequency of smooth lessingia, although this could not be tested statistically due to low frequency.

Table 10. Rare Plant Frequency in Plots

Species Name (Common Name)	CRPR[1]	Frequency in Plots				
		Overall	Burn	Doze	Retardant	Unburn
Lessingia micradenia var. *glabrata* (smooth lessingia)	1B.2	17	4	4	4	5

[1]**Explanation of State and Federal Listing Codes**
California Native Plant Society codes:

1B Rare or Endangered in California and elsewhere
California Native Plant Society Threat Codes:
.2 Moderately threatened in California (20-80% occurrences Threatened)

Closeup of smooth lessingia inflorescence.

Effects of Fire and Fire Suppression Activities

Rare species richness was not significantly different between treatment groups or year (Appendix D). Rare species relative cover was also not significantly different between treatments or year (Appendix D).

Discussion

Smooth lessingia, while considered rare statewide, is locally common on CROSP and surrounding serpentine soils. Unlike the other covered species monitored within the Malech Fire footprint, smooth lessingia was captured within vegetation composition monitoring plots.

The Malech Fire occurred in the month of June, after smooth lessingia has germinated but before it flowers and sets seed. Although plants in the fire perimeter likely burned, it appears the seedbank was robust enough to support smooth lessingia at the same frequency the following year. However, frequent fires before smooth lessingia has set seed may decrease the seed bank over time, and any regular prescribed burns should take place either in the spring before smooth lessingia has germinated or in the fall after it has set seed.

Weeds

Occurrence Study-Wide

Average weed species richness was 3.4 and ranged from 2 to 8 taxa per plot. Average relative cover of weeds was 54.94% ranging from 0.48% to 97.98%. The highest relative cover of weeds was at plots Doz1 and Doz4 in 2020, plot Doz4 in 2021, and plot Ret4 in 2020.

A total of 11 weed taxa were observed across all plots, 6 of these were observed in burned plots. The three most frequent taxa were Italian ryegrass (*Festuca perennis**) in 32 plots, slender oats (*Avena barbata**) in 26 plots, and soft chess (*Bromus hordeaceus**) in 24 plots (Figure 20; Table 11). Of the 11 observed weed taxa, one is of high concern, six are of moderate concern, and four are of limited concern (Table 11; Cal-IPC 2022). Two taxa are also nitrogen fixers: burclover* and rose clover*.

Figure 20. Frequency of Weeds Across All Plots

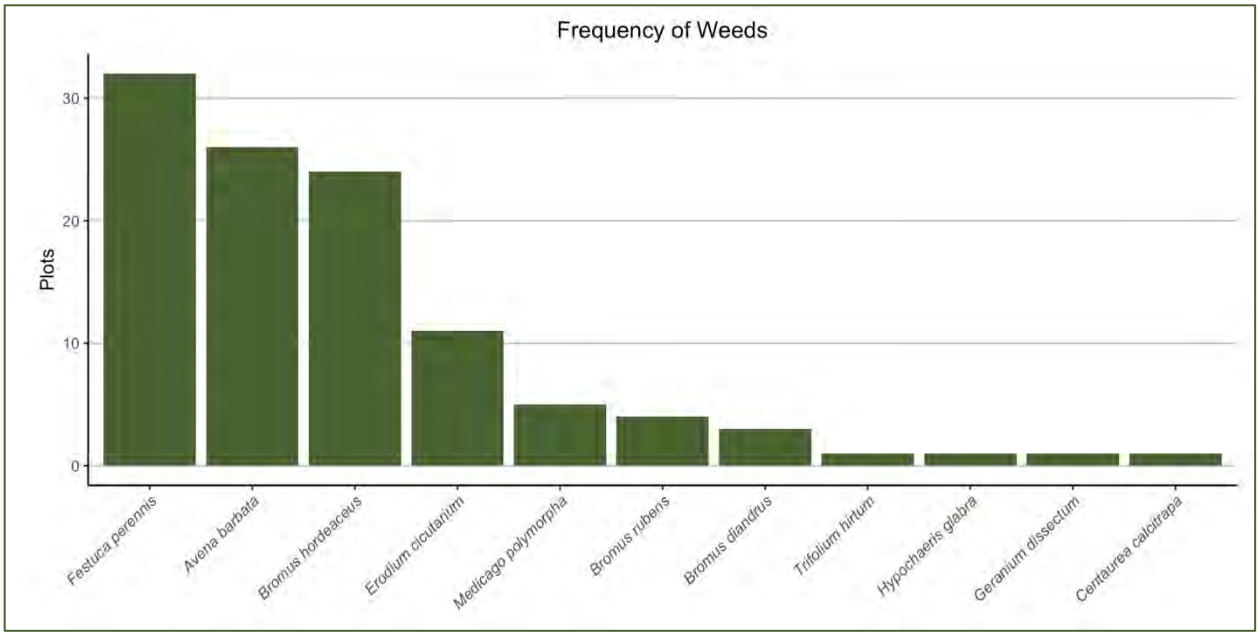


Table 11 shows weed species, their frequency in plots overall, and frequency in each treatment. Weedy species tended to be just as frequent between Burn, Doze, Retardant, and Unburn treatments, except red stem filaree (*Erodium cicutarium**) was more frequent in Burn and Unburn plots and soft chess* was less frequent in Doze plots. However, differences in frequency could not be statistically tested for individual species due to low frequency. Weedy taxa as a whole were not significantly more likely to be recorded in any given treatment (Chi-squared, $\chi^2 = 1.57$, df = 3, p = 0.667).

Table 11. Weed Frequency in Plots

Species Name (Common Name)	Cal-IPC Rank[1]	Frequency in Plots				
		Overall	Burn	Doze	Retardant	Unburn
Avena barbata (slender oats)	Moderate	26	7	6	6	7
Bromus diandrus (ripgut brome)	Moderate	3	2	1	0	0
Bromus hordeaceus (soft chess)	Limited	24	7	4	5	8
Bromus rubens (red brome)	High	4	0	1	1	2
Centaurea calcitrapa (purple star thistle)	Moderate	1	0	1	0	0
Erodium cicutarium (red-stemmed filaree)	Limited	11	5	2	0	4
Festuca perennis (Italian ryegrass)	Moderate	32	8	8	8	8
Geranium dissectum (cut-leaf geranium)	Moderate	1	0	1	0	0

Species Name (Common Name)	Cal-IPC Rank[1]	Frequency in Plots				
		Overall	Burn	Doze	Retardant	Unburn
Hypochaeris glabra (smooth cat's ear)	Limited	1	0	0	0	1
Medicago polymorpha (burclover)	Limited	5	1	2	2	0
Trifolium hirtum (rose clover)	Moderate	1	0	1	0	0
Total		**109**	**30**	**27**	**22**	**30**

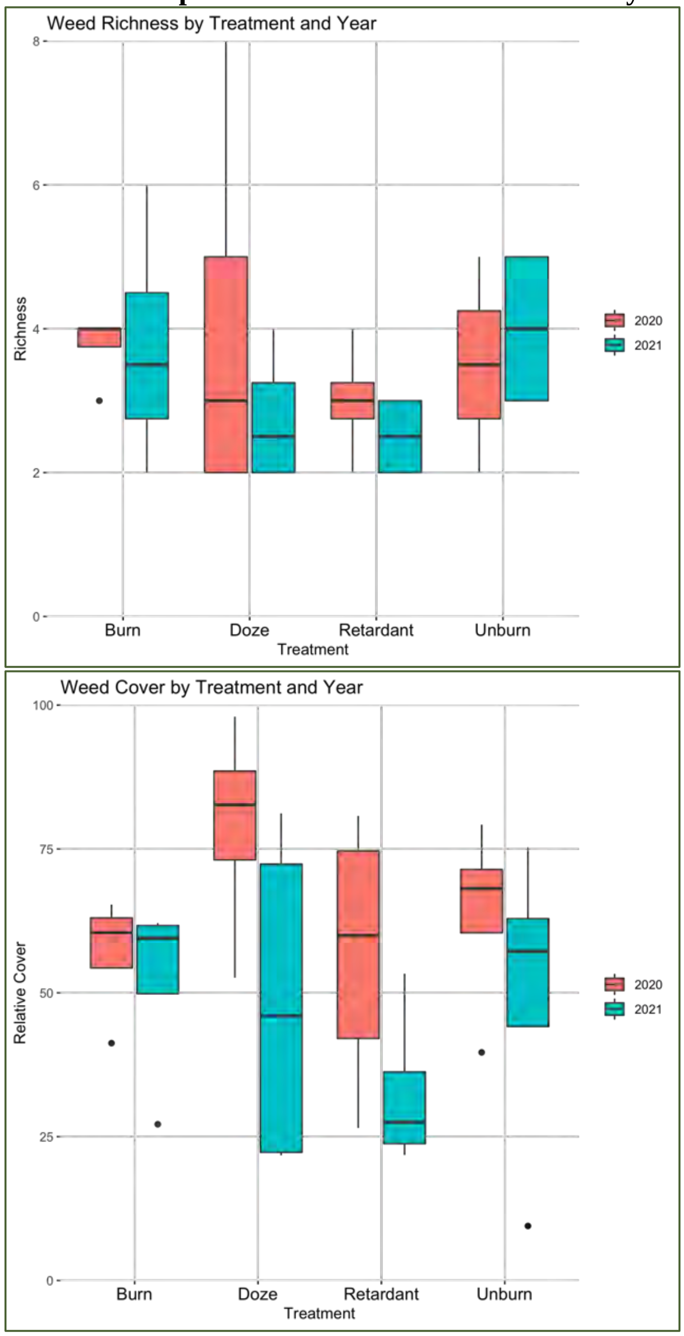
[1] Cal-IPC Weed Ranking Definitions:
High: These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
Moderate: These species have substantial and apparent - but generally not severe - ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
Limited: These species are invasive, but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic (Cal-IPC 2021).

Effects of Fire and Fire Suppression Activities

Weed species richness was not significantly different between the treatment groups, years, or their interaction (Appendix D; Figure 21).

Relative weed cover was not significantly different between the treatment groups (Appendix D), but was significantly higher in 2020 than 2021 (ANOVA, $F_{1,24} = 5.93$, $p < 0.05$; Figure 21). The interaction of treatment and year did not have a significant effect on relative weed cover (Appendix D).

Figure 21. Relative Cover and Species Richness of Noxious Weeds by Treatment and Year



Species richness (left) and relative cover (right) of species considered invasive by Cal-IPC by treatment and year. Year had a significant effect weed relative cover but not on richness.

Discussion

Weed species were somewhat ubiquitous within plots with at least two Cal-IPC ranked species present in every plot and with average relative cover of 54.94%. The three most ubiquitous species were non-native annual grasses Italian ryegrass*, slender oats*, and soft chess*, that likely account for much of the relative cover as well. These three species much too widespread to be concerned about. However, a couple of species could be of concern in terms of impacts to Serpentine Grassland

and feasibility for treatment. One Cal-IPC High ranked species, red brome*, was found in four plots; and purple star thistle*, a Moderate ranked species, was found in only one plot.

Weed species cover was higher in 2020 than 2021, likely due to the difference in precipitation and the increase of nitrogen post-fire in 2020. Additional results from mapping target weed species across the burned area are presented in section 4.4.

4.3. Post-Fire Covered Species Monitoring

4.3.1 Mt. Hamilton Thistle (*Cirsium fontinale* var. *campylon*)

Status, Distribution and Habitat Requirements

Mt. Hamilton thistle [*Cirsium fontinale* (Greene) Jeps. var. *campylon* (H. Sharsm.) D.J. Keil & C.E. Turner[8]] has a California Rare Plant Rank of 1B.2, indicating that it is rare in California and elsewhere, and is moderately threatened throughout its range (CNPS 2022). It is an herbaceous biennial or short-lived perennial species of the sunflower family (Asteraceae). The type locality[9] of this species is from El Puerto Creek in the Mount Hamilton Range in Stanislaus County, California (CCH2 2022). The genus *Cirsium* is derived from the Greek word for thistle (Keil in Baldwin et al. 2012).

Mt. Hamilton thistle can grow to heights of up to 6.6 feet (2 meters) with one to several stems and densely cobwebby leaves (Keil in Baldwin et al. 2012). Inflorescence heads are strongly nodding with strongly recurved phyllaries (Ibid.). Heads are composed only of disk flowers, colored white to pink or lavender (Ibid.). It differs from other species in the genus by its distribution in serpentine wetlands in the eastern San Francisco Bay Area, and by having nodding heads, longer spines on cauline leaves (0.39 to 0.71 inches [10 to 18 mm]), and phyllaries without marginal spines (Ibid.). Mt. Hamilton thistle blooms from April to October (CNPS 2022). Plants are monocarpic, flowering once before dying.

This species is supported by serpentine seeps and springs in chaparral, cismontane woodland, and valley and foothill grassland between 330 and 2,920 feet (100-890 meters) in elevation (CNPS 2022; JFP 2022). It is known from Alameda, Santa Clara, and Stanislaus Counties.

[8] In botanical literature binomial scientific names are followed immediately by the name of or the abbreviation for the publishing author(s) who validated the name. A scientific name is not strictly complete without the name(s) of the validating author(s) attached. Plant species that appear in this report that have regulatory significance are referred to by their binomial scientific name and author for nomenclatural relevance.

[9] A type locality is the geographical location where the type specimen, which is used to describe a species for the first time, was originally found.

Mt. Hamilton thistle rosette (left) and in bloom (right), June 2020.

Occurrence Data

One CNDDB occurrence (EONDX #42237) overlaps with the Malech burn perimeter (Table 12; Figure 4). This population is a specific area composed of 21 parts, four of which occur within the burn perimeter, two drainages and two seeps. The most recent population data for this occurrence in the CNDDB is 300 individuals for a portion of the population in 2017 (CDFW 2021).

On the east side of Coyote Valley, the Santa Clara Valley Habitat Plan defines a Mt. Hamilton thistle occurrence as all colonies in a discrete drainage (Creekside 2018). Therefore, the four colonies within the Malech burn perimeter were considered two occurrences when Creekside Sciences conducted surveys. CROSP occurrence #3 is composed of both seeps and the northern drainage (Table 12; Figure 4). CROSP occurrence #4 is composed of the southern drainage. Index plots were used to create a population estimate for each occurrence by multiplying the average mature individuals per linear meter (for all index plots) by total linear occupied area for each occurrence (Creekside 2018). CROSP occurrence #3 was estimated to have 3,756 individuals and CROSP occurrence #4 was estimated to have 7,579 individuals in 2017 (Ibid.).

Table 12. Crosswalk of Mt. Hamilton Thistle Occurrences within the Study Area

EONDX # / Precision	CROSP Occ. #	General Description	Total Number of Individuals
42237 / Specific	3	Southern drainage and two seeps	CNDDB 2017: 300* Creekside 2017: 3,756^ Nomad 2020: 639+ Nomad 2021: 864+

	4	Northern drainage	CNDDB 2017: 300* Creekside 2017: 7,579^ Nomad 2020: 3,842+ Nomad 2021: 4,675+

* CNDDB estimate is from most recent available data only and pertains to an unknown portion of the population.
^ Number of individuals estimated based on linear area of each occurrence and average mature individuals per linear meter in index plots.
+ Number of individuals determined by direct population count.

In 2020 and 2021, Nomad censused the two seeps and two drainages (CROSP occurrences #3 and 4) within the Malech Fire perimeter. A total of 639 individuals were recorded at CROSP occurrence #3 in 2020 and 864 individuals were recorded in 2021 (Table 12; Figure 22). At CROSP occurrence #4, 3,842 individuals were recorded in 2020 and 4,675 individuals were recorded in 2021. Although the total number of individuals increased from 2020 to 2021, both population counts were big reductions from previous estimates in 2017. Taking into account that the 2017 estimates were for mature individuals only, and 2020 and 2021 counts included both mature and immature individuals, the Mt. Hamilton thistle population has drastically decreased since 2017. This downward trend could be due to low precipitation amounts in 2020 and 2021. It should be noted that estimates from 2017 were extrapolated from subsamples of the population and are not directly comparable to the census counts conducted in 2020 and 2021.

In both 2020 and 2021 plants appeared to be in good condition. Bumblebees and other pollinators were abundant around colonies. Some evidence of browsing and insect tunneling were noted; approximately 10% of mature plants were browsed or grazed in Drainage 2 (the southern drainage) in 2021. Also in 2021, a handful of desiccated rosettes were observed in Seep 2 (the eastern seep).

Drainage 1 supporting Mt. Hamilton thistle, June 2020.

Insect tunnel in Mt. Hamilton thistle stem, June 2020.

Figure 22. Mt. Hamilton Thistle Abundance Over Time

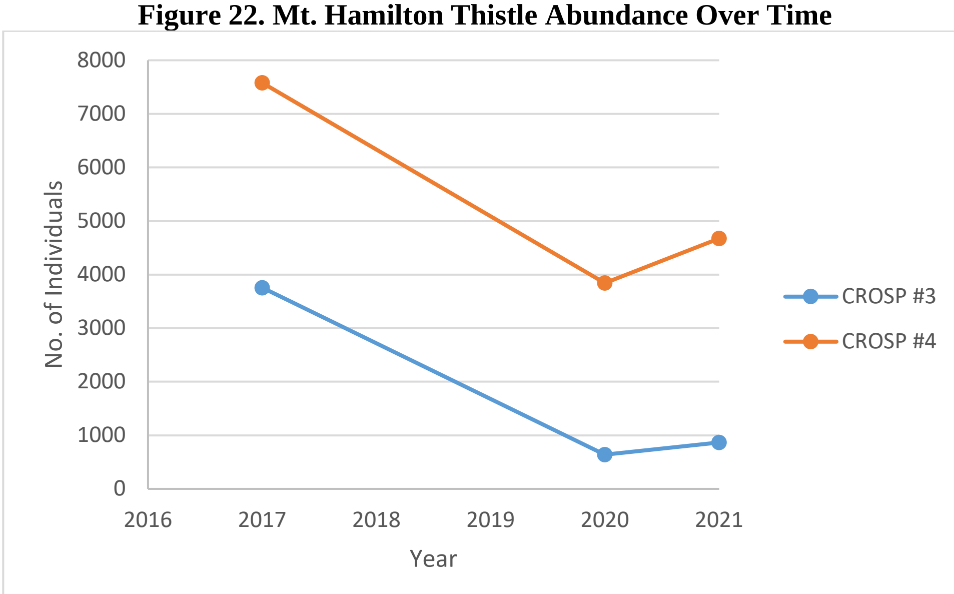


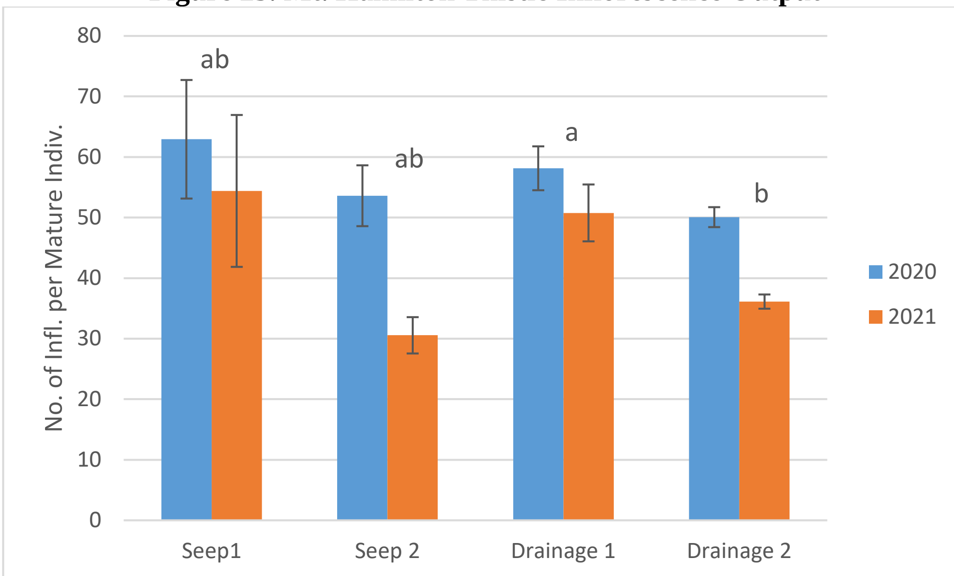
Table 13. Mt. Hamilton Thistle Colonies Monitored in 2020 and 2021

CROSP Occurrence	Colony	No. of Individuals			Avg. Infl. per Mature Individual (±1 SE)	
		2017	2020	2021	2020	2021
Occurrence #3	Seep 1	NA	133 total 43 mature (32%) / 90 immature (68%)	223 total 10 mature (4%) 213 immature (96%)	62.93 (±9.79)	54.40 (±12.54)
	Seep 2	NA	125 total 38 mature (30%) 87 immature (70%)	90 total 36 mature (40%) 54 immature (60%)	53.61 (±5.03)	30.56 (±3.00)
	Drainage 1	NA	381 total 180 mature (47%) 201 immature (53%)	551 total 82 mature (15%) 469 immature (85%)	58.14 (±3.62)	50.77 (±4.70)
Total for CROSP Occurrence #3		3,756	639 total 261 mature (41%) 378 immature (59%)	864 total 128 mature (15%) 736 immature (85%)	NA	NA
Occurrence #4	Drainage 2	7,579	3,842 total 718 mature (19%) 3,124 immature (81%)	4,675 total 612 mature (13%) 4,063 immature (87%)	50.07 (±1.65)	36.12 (±1.18)

Nomad also recorded the number of mature and immature individuals and number of inflorescences at each of the colonies (Table 13). The majority of individuals in each colony each year were immature, suggesting a stable or positive rate of population growth.

The average number of inflorescences per mature individual varied from 50.1 to 62.9 in 2020 and from 30.6 to 54.4 in 2021 (Table 13; Figure 23). Reproductive output was significantly lower in 2021 than in 2020 (Wilcoxon, W = 432,889, $p < 0.0001$). Additionally, average inflorescences per mature individual varied significantly by colony with Drainage 1 (the northern drainage) having significantly higher reproductive output than Drainage 2 (Kruskal-Wallis, chi squared = 26.53, df = 3, $p > 0.0001$). Flower output was likely reduced in 2021 due to an extreme lack of rainfall. However, the monitored colonies are still producing a large number of inflorescences, suggesting reproduction is sufficient to maintain this population over the long term.

Figure 23. Mt. Hamilton Thistle Inflorescence Output



Average number of inflorescences per mature individual ± 1SE for each of the two seeps and two drainages supporting Mt. Hamilton thistle within the Malech burn footprint. Letters above bars correspond to the results of pairwise comparisons using Wilcoxon rank sum tests. Different letters are significantly different from one another using a significance level of $p < 0.05$. Year also had a significant effect on reproductive output.

Effects of Fire and Fire Suppression Activities

While the colonies supporting Mt. Hamilton thistle within the burn perimeter were left largely unburned, it was posited that nutrient loading from post-fire runoff could have an effect on these colonies. Without comparing population size, age structure, and flower output at other colonies outside of the burn footprint, it is difficult to draw conclusions on what effects the fire may have had. Additionally, while we can compare population size of these colonies before and after the Malech Fire, it is unclear whether changes in the population are due to different monitoring methods, changes in precipitation, annual variation, or fire effects. No evidence of burned plants was observed within the two seeps and two drainages, and colonies appeared healthy. Reduced precipitation and soil moisture may have contributed to a reduction in area and number of individuals within the seeps and drainages.

Seep 1 supporting Mt. Hamilton thistle in June 2020 (left) and June 2021 (right).

Threats and Management Considerations

The rare plant inventory lists urbanization, trampling, non-native plants, grazing and possibly recreational activities and erosion as threats to Mt. Hamilton thistle. Cattle hoof punch and grazing were observed in the four colonies, but these impacts were minimal. The largest impacts from cattle were at Drainage 2 where the access road crosses the drainage. Here, there is a large flat muddy area that appeared to be heavily used by cattle, which, could be negatively impacting Mt. Hamilton thistle. Potential threats from yellow star thistle (*Centaurea solstitialis**) was noted along both drainages and the eastern seep and barbed goatgrass (*Aegilops triuncialis**) was noted along the southern drainage. Additionally, changes in hydrology due to reduced precipitation, a predicted effect of climate change, could increase stress and reduce suitable habitat for these plants.

Flat portion of Drainage 2 with cattle impacts, June 2020.

4.3.2 SANTA CLARA VALLEY DUDLEYA (*DUDLEYA ABRAMSII* VAR. *SETCHELLII*)

Status, Distribution and Habitat Requirements

Santa Clara Valley dudleya [*Dudleya abramsii* Rose subsp. *setchellii* (Jeps.) Morin] is listed as Federally endangered and has a California Rare Plant Rank of 1B.1 indicating that it is rare in California and elsewhere and is seriously threatened throughout its range (CNPS 2022). It is an herbaceous perennial in the stonecrop family (Crassulaceae). The type locality is from a Jepson collection on Tulare Hill, Santa Clara County, California (CCH2 2022). The genus *Dudleya* is named for W.R. Dudley, of the Botany Department at Stanford University (McCabe in Baldwin et al. 2012).

This taxon grows in rosettes 0.79 to 3.54 inches (2 to 9 cm) wide (McCabe in Baldwin et al. 2012). The leaves are oblong-triangular to lance-elliptic to lanceolate and glaucus (Ibid.). The inflorescence peduncle can be 1.97 to 7.87 inches (5 to 20 cm) tall, with 2-3 simple branches and ascending pedicels (Ibid.). Flowers have elliptic pale-yellow petals that are 0.31 to 0.51 inches (8 to 13 mm) long (Ibid.). Santa Clara Valley dudleya differs from other species in the genus by petal color, shorter stature of the stem and peduncle, having a simple branched inflorescence, and its restricted distribution on serpentine in the south Santa Clara Valley (Ibid.). This taxon can be in bloom from April to October, but usually is flowering May to June (CNPS 2022; JFP 2022).

This species is supported by rocky serpentine substrate in cismontane woodland and valley and foothill grassland between 195 and 1,755 feet (60 to 535 meters) (CNPS 2022). It is recorded as occurring only in Santa Clara County (CNPS 2022).

Santa Clara Valley dudleya in flower, May 2020.

Occurrence Data

One CNDDB occurrence (EONDX #13933) overlaps with the Malech burn perimeter (Table 14; Figure 5). This population is a specific area composed of 312 colonies spanning Coyote Ridge. The most recent population data for this occurrence in the CNDDB is at least 15,000 individuals for a portion of the population in 2018 (CDFW 2021).

Creekside Sciences conducted mapping of Santa Clara Valley dudleya within CROSP in 2016; they recorded two occurrences, one of which overlaps with the burn footprint (Creekside 2018). CROSP Occurrence #1 spans much of Coyote Ridge and was estimated to contain 66,885 individuals in 2016 (Table 14).

Table 14. Crosswalk of Santa Clara Valley Dudleya Occurrences within the Study Area

EONDX # / Precision	CROSP Occ. #	General Description	Total Number of Individuals
13933 / Specific	1	many locations across Coyote Ridge	CNDDB 2018: >15,000* Creekside 2016: 66,885^ Nomad 2020/2021: NA**

* CNDDB estimate is from most recent available data only and pertains to an unknown portion of the population.
^ Number of individuals based on visual estimate.
** NA indicates a population estimate is not available as it was not a part of monitoring for this taxon in 2020 or 2021.

In 2020 and 2021, Nomad monitored 13 rock outcrops (plots), five within the burn footprint, four in the area that received retardant application, and four unburned outcrops. The total number of individuals in the population in 2020 and 2021 was not estimated.

Plants were in good condition both years although they appeared to be water stressed in 2021. Also in 2021, some sort of white fungus appeared to be growing on a handful of rosettes from Burn plots and light to moderate herbivory of flowering stalks was noted on plants from Burn and Retardant plots. Barbed goatgrass* was noted as growing near two of the Retardant plots, but likely isn't a threat.

Rock outcrop supporting Santa Clara Valley dudleya, May 2020.

Effects of Fire and Fire Suppression Activities

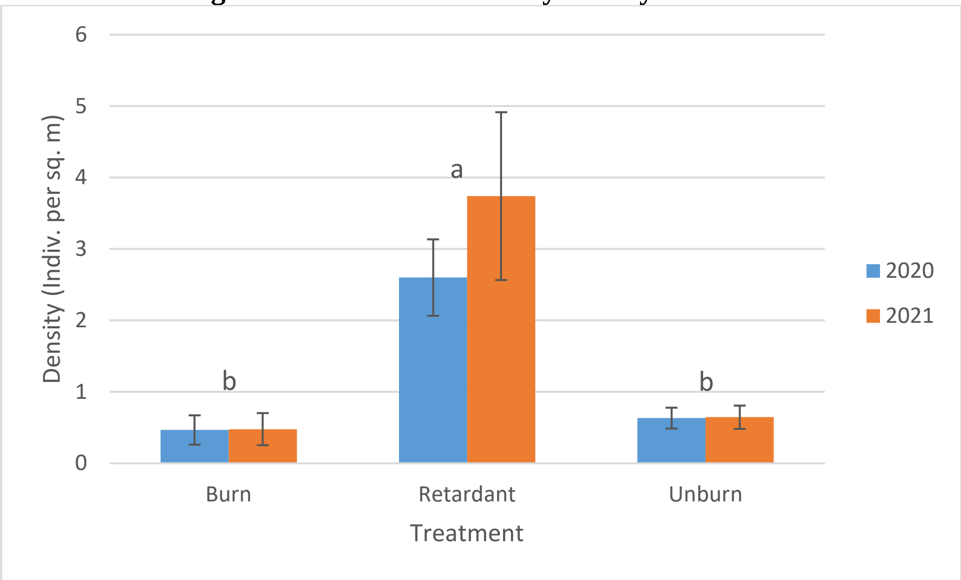
The number of living rosettes on monitored rock outcrops ranged from 2 to 453 in 2020 and from 0 to 605 in 2021 (Table 15). Rock outcrops were not of uniform size, so density of rosettes per square meter is used to compare different treatments (Table 15; Figure 24). The density of living rosettes was significantly higher in the Retardant treatment, and the density of rosettes was not significantly different between the Burn and Unburn treatments (Kruskal-Wallis, chi-squared: 15.42, df = 2, $p < 0.001$). The density of living rosettes was not significantly different between 2020 and 2021 (Wilcoxon, W = 79.5, $p = 0.818$).

Table 15. Santa Clara Valley Dudleya Plots Monitored in 2020 and 2021

Treatment	Plot ID	Outcrop Size (square meters)	No. of Living Rosettes		Density (Indiv. / m^2)	
			2020	2021	2020	2021
Burn	Dud01B	91.73	2	0	0.02	0.00
Burn	Dud02B	59.69	66	76	1.11	1.27
Burn	Dud03B	74.14	17	18	0.23	0.24
Burn	Dud04B	183.78	35	41	0.19	0.22
Burn	Dud05B	95.44	74	63	0.78	0.66
Retardant	Dud01R	79.17	206	217	2.60	2.74
Retardant	Dud02R	50.89	179	343	3.52	6.74
Retardant	Dud03R	142.50	453	605	3.18	4.25
Retardant	Dud04R	160.22	177	197	1.10	1.23

Treatment	Plot ID	Outcrop Size (square meters)	No. of Living Rosettes		Density (Indiv. / m²)	
			2020	2021	2020	2021
Unburn	Dud01U	145.61	110	145	0.76	1.00
Unburn	Dud02U	411.23	184	186	0.45	0.45
Unburn	Dud03U	96.57	33	29	0.34	0.30
Unburn	Dud04U	34.87	34	29	0.98	0.83

Figure 24. Santa Clara Valley Dudleya Rosettes



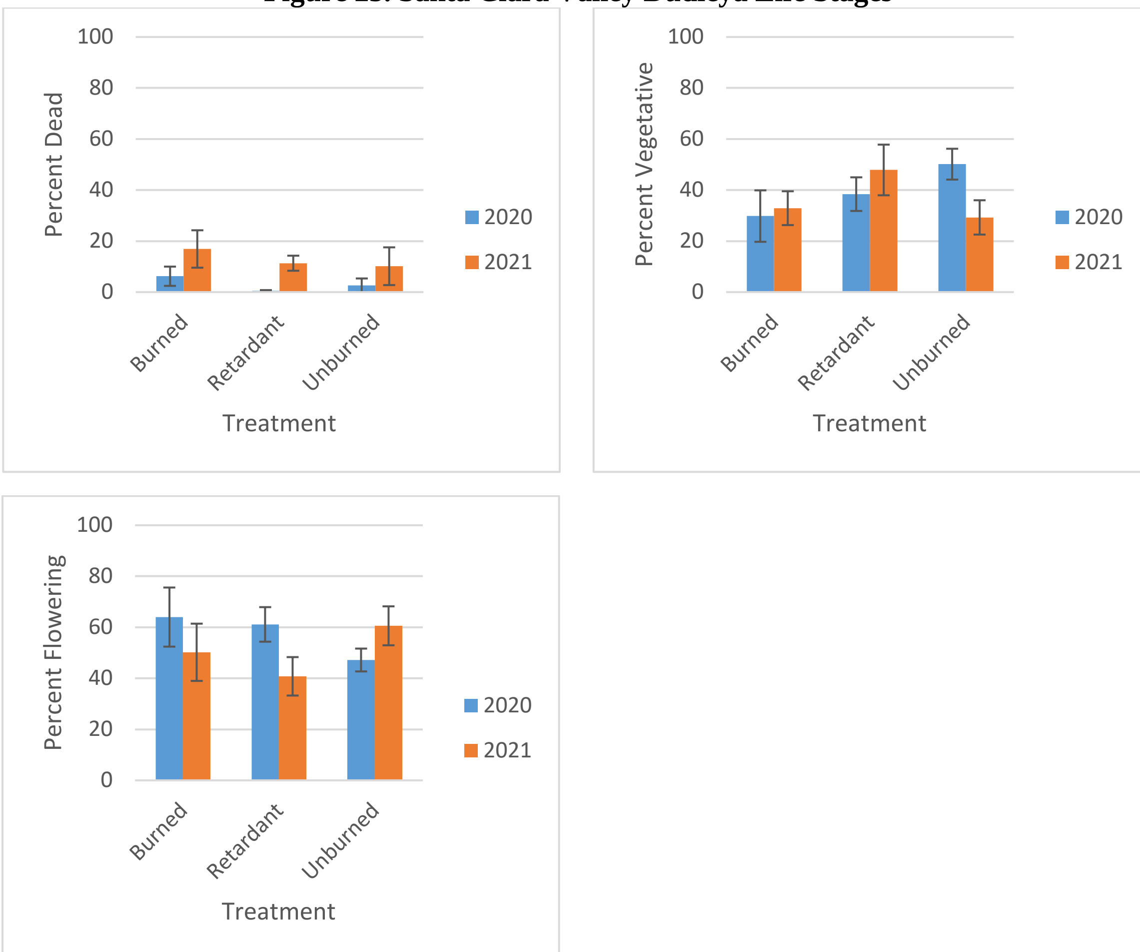
Average number of living rosettes of Santa Clara Valley dudleya per square meter ± 1SE by treatment and year. Letters above bars correspond to the results of pairwise comparisons using Wilcoxon rank sum tests. Different letters are significantly different from one another using a significance level of $p < 0.05$. Year was not significant.

Since rosettes were tallied as dead, vegetative or flowering, comparing these life stages was also possible. The percentage of dead rosettes averaged 3.4%, ranging from 0 to 20.5% in 2020 and averaged 12.8%, ranging from 0 to 38.8% in 2021. Treatment did not affect the percentage of dead rosettes on rock outcrops (Kruskal-Wallis, chi-squared = 0.90, df = 2, p = 0.639; Figure 25). Year however, did have a significant effect, there was a higher percentage of dead rosettes in 2021 than in 2020 (Wilcoxon, W = 36, $p < 0.05$).

The percentage of living, vegetative rosettes ranged from 0 to 64.7% with an average of 38.7% in 2020 and ranged from 16.7% to 65.9% with an average of 36.7% in 2021. No significant effect of treatment, year, or the interaction on percent vegetative rosettes was found (ANOVA, treatment: $F_{2,19} = 1.18$, p = 0.329; year: $F_{1,19} = 0.09$, p = 0.767; interaction: $F_{2,19} = 1.82$, p = 0.189; Figure 25).

The percentage of flowering rosettes ranged from 35.5% to 100% with an average of 57.9% in 2020 and ranged from 25.4% to 83.3% with an average of 50.5% in 2021. Again, no significant effect of treatment, year, or the interaction on percent flowering rosettes was found (ANOVA, treatment: $F_{2,19} = 0.26$, p = 0.777; year: $F_{1,19} = 0.97$, p = 0.337; interaction: $F_{2,19} = 1.82$, p = 0.189; Figure 25).

Figure 25. Santa Clara Valley Dudleya Life Stages



Percentage of total Santa Clara Valley dudleya rosettes ± 1SE that are dead (upper left), vegetative (upper right), or flowering (lower left) by treatment and year. Year was significant only for percent dead rosettes.

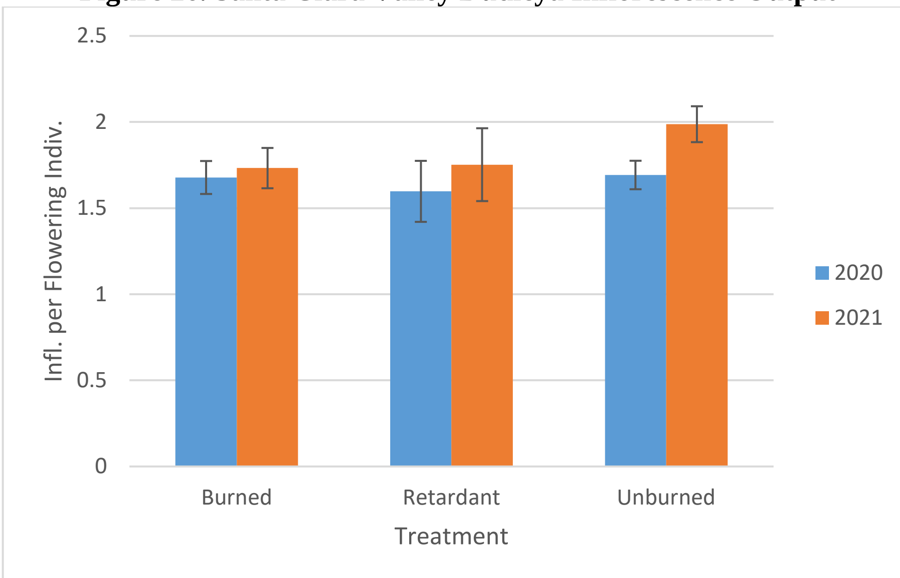
Nomad also recorded the number of inflorescences at each of the plots. The average number of inflorescences per flowering individual varied from 1.53 to 2.0 in 2020 with an average of 1.7 and from 1.35 to 2.32 in 2021 with an average of 1.8 (Figure 26). Number of inflorescences was not significantly different between treatments, year, or their interaction (ANOVA, treatment: $F_{2,19} = 0.76$, $p = 0.481$; year: $F_{1,19} = 2.17$, $p = 0.157$; interaction: $F_{2,19} = 0.38$, $p = 0.687$). Although rosettes appeared stressed due to lack of water in 2021, percentage of flowering rosettes and flower output per rosette did not change.

Some burned rosettes were noted during the pre-winter survey and monitoring, and no obvious damage from retardant application was observed. No change was detected between the different treatments for the majority of measurements with the one exception being density of living rosettes. While both years had low precipitation, the 2021 water year was especially dry. Lack of rain in 2021 could explain the increase in dead rosettes.

Dessicated Santa Clara Valley dudleya from Unburn treatment, May 2020.

Water-stressed Santa Clara Valley dudleya, May 2021.

Figure 26. Santa Clara Valley Dudleya Inflorescence Output



Number of inflorescences per flowering Santa Clara Valley dudleya rosette ± 1SE grouped by treatment and year.

Threats and Management Considerations

The rare plant inventory lists urbanization, development, vehicles, non-native plants, and grazing as threats to Santa Clara Valley dudleya (CNPS 2022). Although barbed goatgrass* was noted at two of the Retardant plots, it isn't likely a threat to a species that grows on a rock outcrop. Although the number of rosettes at some rock outcrops was very low, they are part of a much larger population with many rock outcrops, so this occurrence is very likely to be self-sustaining in the long term.

Santa Clara Valley dudleya with herbivory of flowering stalks, May 2020.

4.3.3 FRAGRANT FRITILLARY (*FRITILLARIA LILIACEA*)

Status, Distribution and Habitat Requirements

Fragrant fritillary [*Fritillaria liliacea* Lindl.] has a California Rare Plant Rank of 1B.2 indicating that it is rare in California and elsewhere and is moderately threatened throughout its range (CNPS 2022). It is a perennial bulbiferous herb in the lily family (Liliaceae). The type locality is from a Douglas collection probably in the vicinity of San Francisco, California (Abrams 1955). The genus *Fritillaria* is derived from the Latin word for dicebox, referring to fruit shape (McNeal and Ness in Baldwin et al. 2012).

This taxon can grow to heights of 3.9 to 3.8 inches (1 to 3.5 decimeters) and has 2 to 20 alternate leaves that are linear to ovate and 1.4 to 4.7 inches (3.5 to 12 centimeters) long (McNeal and Ness in Baldwin et al. 2012). It has 2 to 7 large bulb scales and 1 to 2 small scales. It has nodding flowers with perianth parts that are 0.39 to 0.63 inches (1 to 1.6 centimeters) long, that are white and striped with green (Ibid.). The flowers have nectaries that are 1/2 to 2/3 the perianth, narrowly linear and more or less purple to green (Ibid.). It differs from other species in the genus by flower color, number of leaves, and nectary size (Ibid.). Fragrant fritillary blooms from February to April (CNPS 2022).

This species is supported by heavy soils, often serpentine, in cismontane woodland, coastal prairie, coastal scrub, and valley and foothill grassland between 10 and 1,345 feet (3 to 410 meters) (CNPS 2022, JFP 2022). It is currently recorded as occurring in Alameda, Contra Costa, Marin, Monterey, San Benito, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties (CNPS 2022).

Fragrant fritillary in flower from February 2020 (left) and March 2021 (right).

Fragrant fritillary in fruit from March 2020.

Occurrence Data

Four CNDDB occurrences are recorded within 0.5 miles of the Malech burn perimeter (Table 16; Figure 6). CNDDB occurrence EONDX #9062 is a specific location at the top of the ridge, approximately 0.4 miles north of the burn footprint; 18,680 ± 5,000 plants were observed here in 2017 (CDFW 2021). CNDDB occurrence EONDX #9060 is a specific location approximately 0.1 miles north of the burn footprint; 41 plants were observed here in 2017 (Ibid.). CNDDB occurrence EONDX #9059 is a specific location within the burn footprint, near the center of the burned area; 150 plants were observed here in 1989 (Ibid.). Finally, CNDDB occurrence EONDX #51585 is a specific location approximately 0.14 miles west of the burn footprint around the firing range; and unknown number of individuals were observed here in 1993 (Ibid.).

Creekside Sciences surveyed for fragrant fritillary within CROSP in 2017 and 2018; they recorded three occurrences, one of which, falls within the burn footprint (Creekside 2018). CROSP occurrence Frit-1 corresponds to CNDDB occurrence #9062 (Table 16; Figure 6). In 2017, it was estimated that CROSP occurrence Frit-1 contained between 13,693 and 23,667 individuals (Creekside 2018). CROSP occurrence Frit-2, which corresponds to CNDDB occurrence #9060 was small enough to perform a direct count, with 41 individuals in 2017 and 104 individuals in 2018 (Ibid.). CROSP occurrence Frit-3 corresponds to CNDDB occurrence #9059 and was estimated to contain between 689 and 1,297 individuals in 2018 (Ibid.). Macroplot methodology was used to estimate the number of individuals in CROSP occurrences Frit-1 and Frit-3.

Table 16. Crosswalk of Fragrant Fritillary Occurrences the Study Area

EONDX # / Precision	CROSP Occ. #	General Description	Total Number of Individuals
9062 / Specific	Frit-1	top of ridge, 0.4 miles north of burn footprint	CNDDB 2017: 18,680 ± 5,000* Creekside 2017: 18,680 ± 4,987^ Nomad 2020: 4,190 ± 2,880+ Nomad 2021: 5,520 ± 3,085+
9060 / Specific	Frit-2	top of ridge, 0.1 miles north of burn footprint	CNDDB 2017: 41 Creekside 2017: 41** Creekside 2018: 104** Nomad 2020/2021: NA^^
9059 / Specific	Frit-3	center of burn footprint	CNDDB 2017: 0 Creekside 2018: 993± 304^ Nomad 2020: 622 ± 201^ Nomad 2021: 853 ± 294^
51585 / Specific	NA	bottom of ridge, 0.14 miles west of burn footprint	CNDDB 1993: Unk++ Creekside 2017: NA Nomad 2020/2021: NA

* CNDDB estimates are from most recent available data only
^ Number of individuals estimated based macroplot methodology.
+ Population estimated for only a portion of the population. Number of individuals estimated based on macroplot methodology.
** Number of individuals determined by direct population count.
^^ NA indicates a population estimate is not available because it was not monitored.
++ Unk = unknown number of individuals.

In 2020 and 2021, Nomad monitored two of the macroplots installed by Creekside Sciences, one outside of the burn perimeter at CROSP occurrence Frit-1 (the macroplot labeled 4 in Appendix E from Creekside Sciences 2018 Baseline Report), and one within the burn perimeter at CROSP occurrence Frit-3. An estimated 4,190 ± 2,880 individuals (between 1,310 and 7,070) were at one of four macroplots at CROSP occurrence Frit-1 in 2020 and 5,520 ± 3,085 individuals (between 2,435 and 8,605) individuals were recorded in 2021 (Table 16; Figure 27). At CROSP occurrence Frit-3, 622 ± 201 individuals (between 422 and 823) were estimated in 2020 and 853 ± 294 individuals (between 559 and 1,147) individuals were estimated in 2021. For the purposes of comparing population estimates, the number of individuals from CROSP occurrence #1 in 2017 was divided by 4 as a proxy for individuals in one macroplot. The total number of individuals in macroplots has stayed consistent since previous estimates in 2017 and 2018, suggesting fairly stable populations.

In both 2020 and 2021 plants appeared to be in good condition, although herbivory was common on flowering stems. The unburned macroplot (in CROSP occurrence Frit-1) was heavily grazed with low vegetative cover. Some soil mounds and dug up common muilla (*Muilla maritima*) bulbs were also observed indicating possible wild pig damage. The area across the road from the burned macroplot appeared to be less heavily grazed. The burned macroplot (CROSP occurrence Frit-3) was grassier and weedier than the unburned macroplot, especially at the lower end of the plot.

Figure 27. Fragrant Fritillary Abundance Over Time

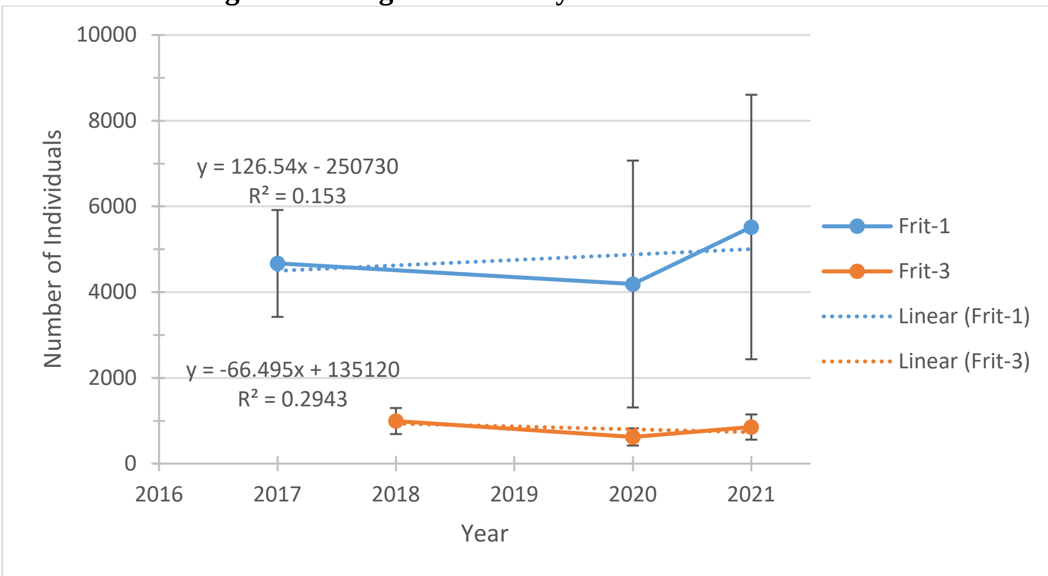
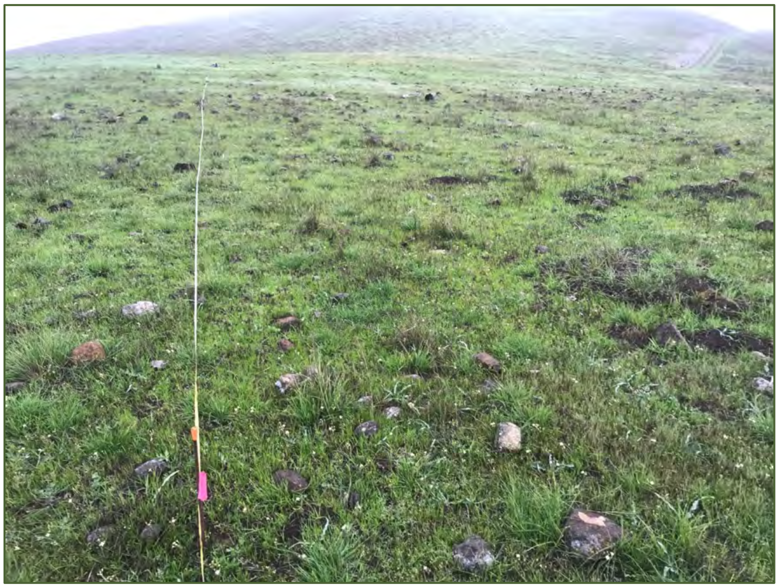


Table 17. Fragrant Fritillary Macroplots monitored in 2020 and 2021

CROSP Occurrence	Macroplot Treatment	Percent Flowering / Non-flowering		Size Range (cm)	
		2020	2021	2020	2021
Frti-1	Burn	36% flower (150) / 64% non-flower (269)	47% flower (164) / 53% non-flower (183)	<5 to 20	<5 to 20
Frit-3	Unburn	50% flower (30) / 50% non-flower (30)	50% flower (30) / 50% non-flower (30)	<5 to 20	<5 to 30

Nomad tallied individuals as flowering or non-flowering and noted the size class of plants at each meter in macroplot transects. The unburned macroplot was composed of 36% flowering and 64% non-flowering plants in 2020 and 47% flowering, 53% non-flowering plants in 2021 (Table 17). Within the burned macroplot, 50% of plants were flowering and 50% were non-flowering both in 2020 and in 2021 At least half of individuals in each macroplot each year were not flowering, suggesting a stable or positive rate of population growth. The size of individuals generally ranged from under 5 cm to 20 cm (under 1.97 to 7.87 inches) (Table 17). Some plants in the unburned macroplot in 2021 reached up to 20 to 30 cm (7.87 to 11.81 inches) tall.

It appears that lack of rain in 2020 and 2021 did not negatively affect the population size or height of plants within macroplots. Perhaps this is because fragrant fritillary flowers relatively early in the year when soil moisture is higher.



Unburned fragrant fritillary macroplot, March 2021.

Effects of Fire and Fire Suppression Activities

It is not likely that differences in population size between 2020 and 2021 reflect real changes since their 80% confidence intervals overlap. There was a lower proportion of immature individuals in the burned macroplot. It is possible that the fire negatively affected the survival of younger, less established individuals. However, there were other differences between the two macroplots in terms of slope, level of grazing, and total vegetative cover that could also explain differences in population growth and number of immature individuals.

Threats and Management Consideration

The rare plant inventory lists grazing, agriculture, urbanization, non-native plants, and possibly recreational activities and foot traffic as threats to fragrant fritillary. Barbed goatgrass* was recorded later in the season near the burned macroplot and could potentially threaten fragrant fritillary by increasing thatch. Grazing is also present at both macroplots but appears to be heavier at the unburned macroplot. Herbivory of flowering stems was observed, but appeared to be herbivory from rabbits and rodents, not grazing from cattle. However, the nearby cattle trough to population Frit-3 may draw more cattle to the area, which could also increase incidence of browsing when passing through this population to the trough.

Herbivory on fragrant fritillary flower flowering stem, February 2020.

Small, water-stressed, fragrant fritillary, March 2021.

4.3.4 SMOOTH LESSINGIA (*LESSINGIA MICRADENIA* VAR. *GLABRATA*)

Status, Distribution and Habitat Requirements

Smooth lessingia [*Lessingia micradenia* Greene var. *glabrata* (D.D. Keck) Ferris] has a California Rare Plant Rank of 1B.2 indicating that it is rare in California and elsewhere and is moderately threatened throughout its range (CNPS 2022). It is an annual herb in the sunflower family (Asteraceae). The type locality is from east of Los Gatos on the road to Almaden (Abrams 1955). The genus is named after German botanist C.F. Lessing (Markos in Baldwin et al. 2012).

This taxon can grow to heights of 2.0 to 23.6 inches (5 to 60 centimeters) with ascending branches and is tan to brown and glabrous (Markos in Baldwin et al. 2012). Stems support linear, awl-shaped leaves and flower heads that bear 3 to 5 white to pale lavender flowers (Ibid.). Leaves and phyllaries lack stalked glands (Ibid.). It differs from other species in the genus by flower color, having glabrous phyllaries, and glandless cauline leaves (Ibid.). Smooth lessingia blooms from July to November (CNPS 2022).

Smooth lessingia is supported by serpentine substrates, often on roadsides, in chaparral, cismontane woodland, and valley and foothill grassland between 395 and 1,380 feet (120 to 420 meters) (CNPS 2022). It is recorded as occurring only in Santa Clara County (Ibid.).

Smooth lessingia growing around rock outcrop, September 2020.

Occurrence Data

One CNDDB occurrence (EONDX #53559) overlaps with the Malech burn perimeter (Table 18; Figure 7). This population is a specific area spanning Coyote Ridge and beyond. The most recent population data for this occurrence in the CNDDB is an estimated 21.7 million individuals on Coyote Ridge Open Space preserve in 2017 (CDFW 2021).

Creekside Sciences conducted surveys for smooth lessingia within CROSP in 2016; they recorded one large occurrence covering much of the serpentine habitat on the preserve (Creekside 2018). CROSP Occurrence #1 was estimated to contain 21,730,000 individuals in 2016 (Table 18).

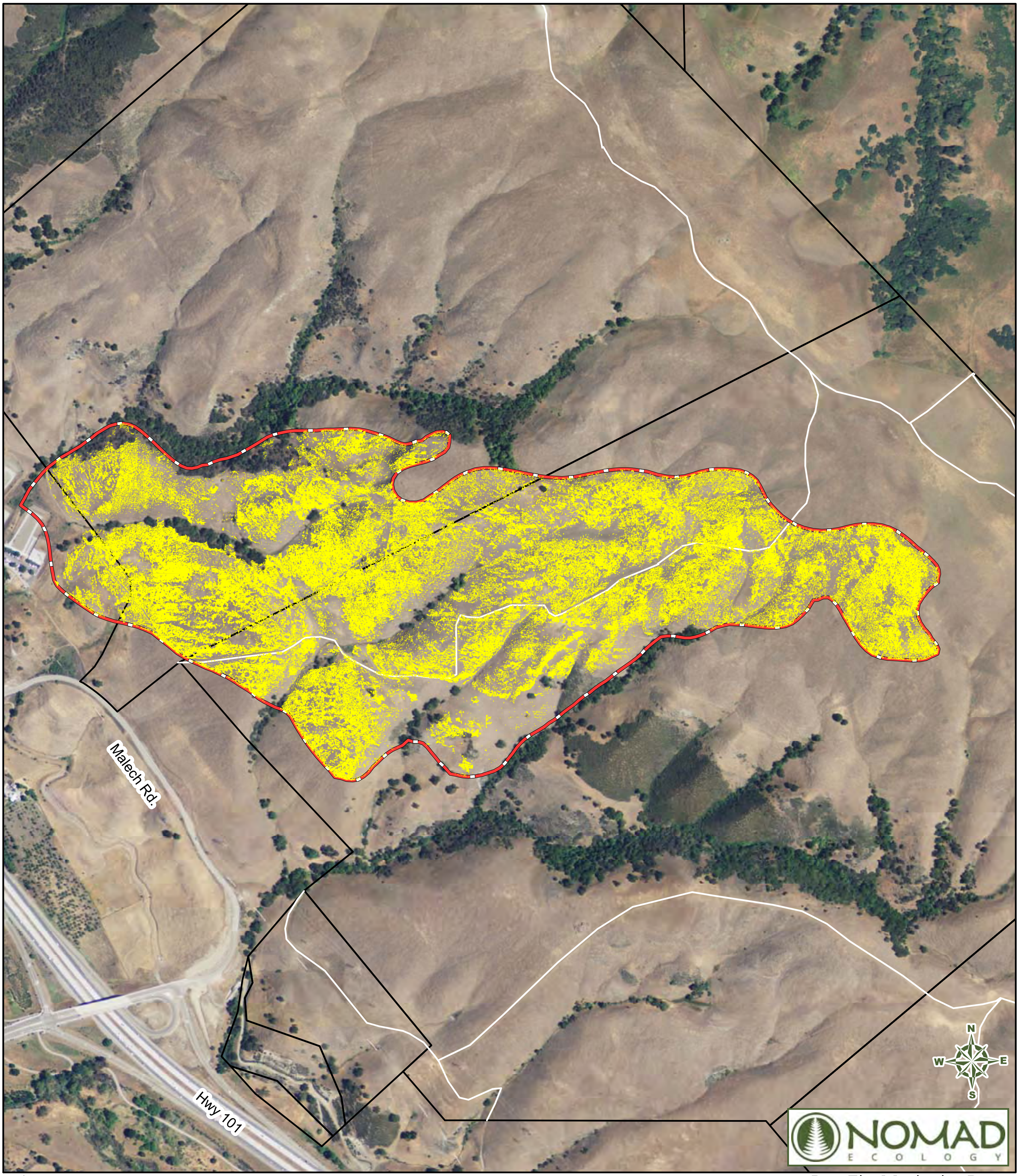
Table 18. Crosswalk of Smooth Lessingia Occurrences within the Study Area

EONDX # / Precision	CROSP Occ. #	General Description	Total Number of Individuals
53559 / Specific	1	many locations across Coyote Ridge	CNDDB 2017: 21,700,000* Creekside 2016: 21,730,000^ Nomad 2020: 15,014,882** Nomad 2021: 5,266,687**

* CNDDB estimate is from most recent available data only and pertains the portion of the population on Coyote Ridge Open Space Preserve.
^ Number of individuals is an estimate extrapolated from average density at points on a 100m grid.
** Number of individuals is an estimate for Malech Fire footpring only. Abundance was extrapolated from average density within ground truth quadrats.

In 2020 and 2021, Nomad used random sampling, aerial imagery, and remote sensing to map smooth lessingia and estimate abundance within the burn footprint. In 2020, an estimated 15,014,882 individuals covering 85.34 acres were classified by the remote sensing methodology (Figure 28). The average number of individuals per square meter in 2020 was 43. In 2021, 54.82 acres supporting an estimated 5,266,687 individuals were classified as smooth lessingia (Figure 29). The average number of individuals per square meter in 2021 was 24. There appears to have been a large decrease in the smooth lessingia population from 2020 to 2021, likely due to lack of precipitation.

Ground-truth quadrat with smooth lessingia (red colored stems), September 2020



February 2022

Post-Fire Monitoring Report

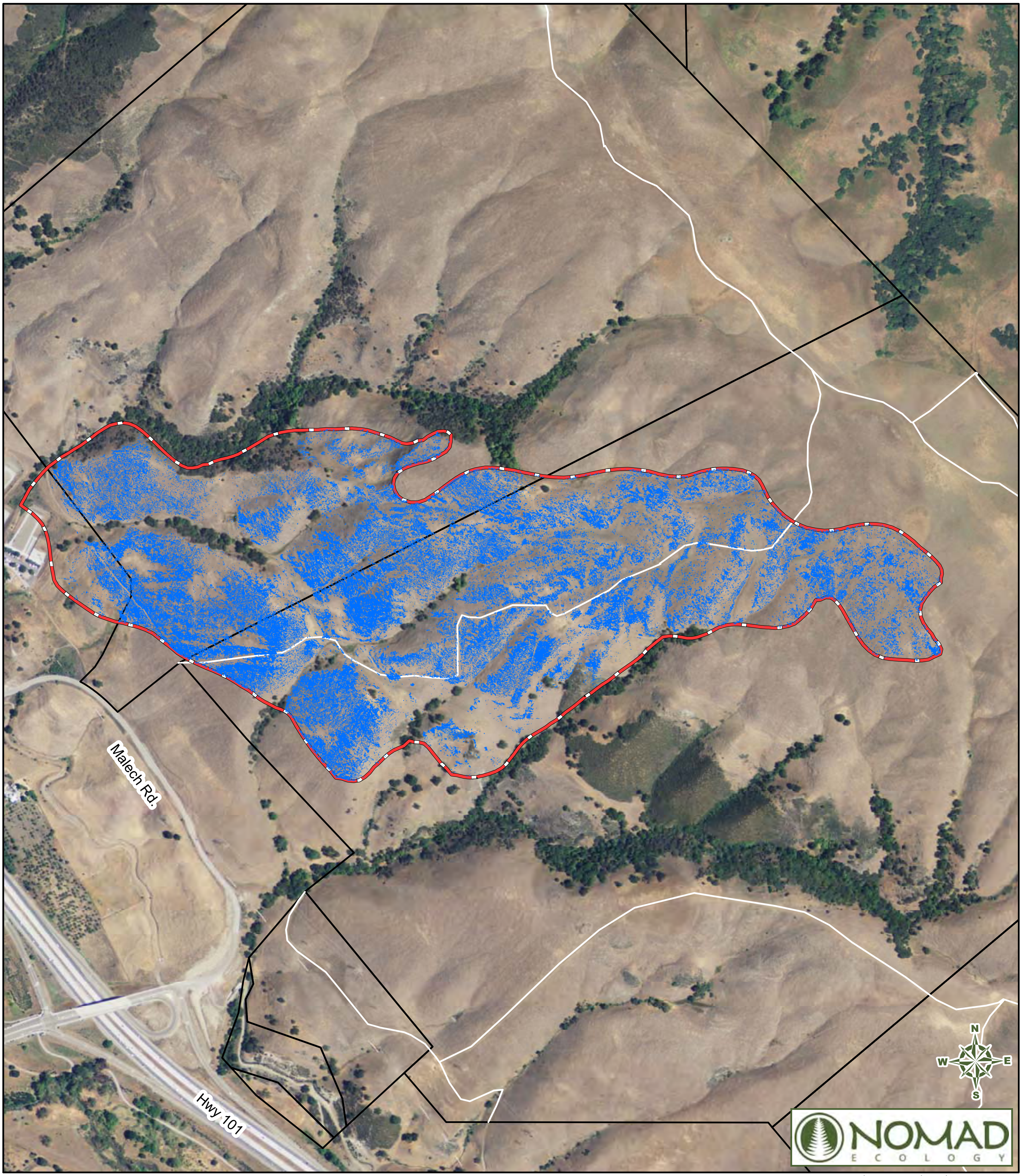
Legend
Lessingia micradenia var. glabrata
Preserve Boundary
Roads
Malech Fire Perimeter

Figure 28
Classified Smooth Lessingia in 2020
Post-Fire Vegetation and Covered Species Monitoring
Santa Clara Valley Habitat Agency

1:10,800
0 450 900
Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California



February 2022

Post-Fire Monitoring Report

Legend
- Lessingia micradenia var. glabrata
- Preserve Boundary
- Roads
- Malech Fire Perimeter

Figure 29

Classified Smooth Lessingia in 2021

Post-Fire Vegetation and Covered Species Monitoring

Santa Clara Valley Habitat Agency

1:10,800

0 450 900 Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

The distribution of spectral characteristics for training sample classes for each year of imagery is shown in Figures 30 and 31 below. Although there is some overlap with other classes, such as burned trees and dark grassland, for the most part, points from smooth lessingia training polygons group together separately from other grassland and tree classes. This allows for a more accurate classification. is mostly differentiated from the other classes. Tables summarizing the spectral characteristics for training polygons can be found in Appendices F and G.

Plants were in good condition both years although they appeared to smaller in 2021, likely due to water stress.

Figure 30. Spectral Characteristics of 2020 Training Polygons

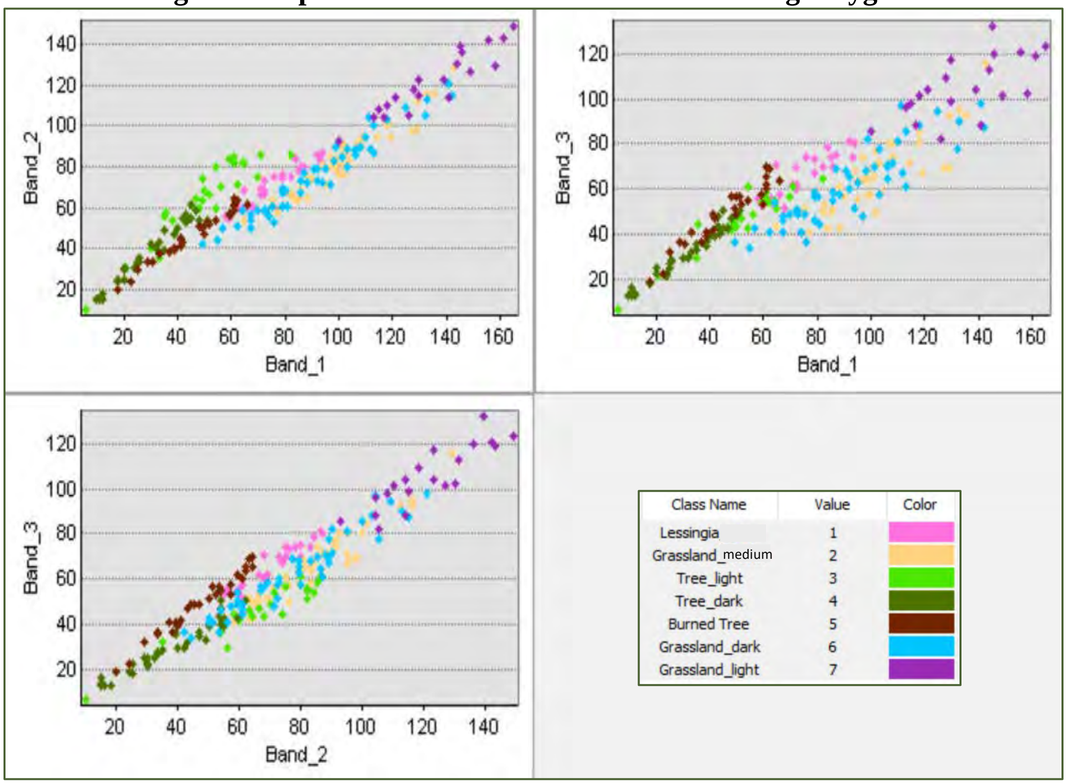
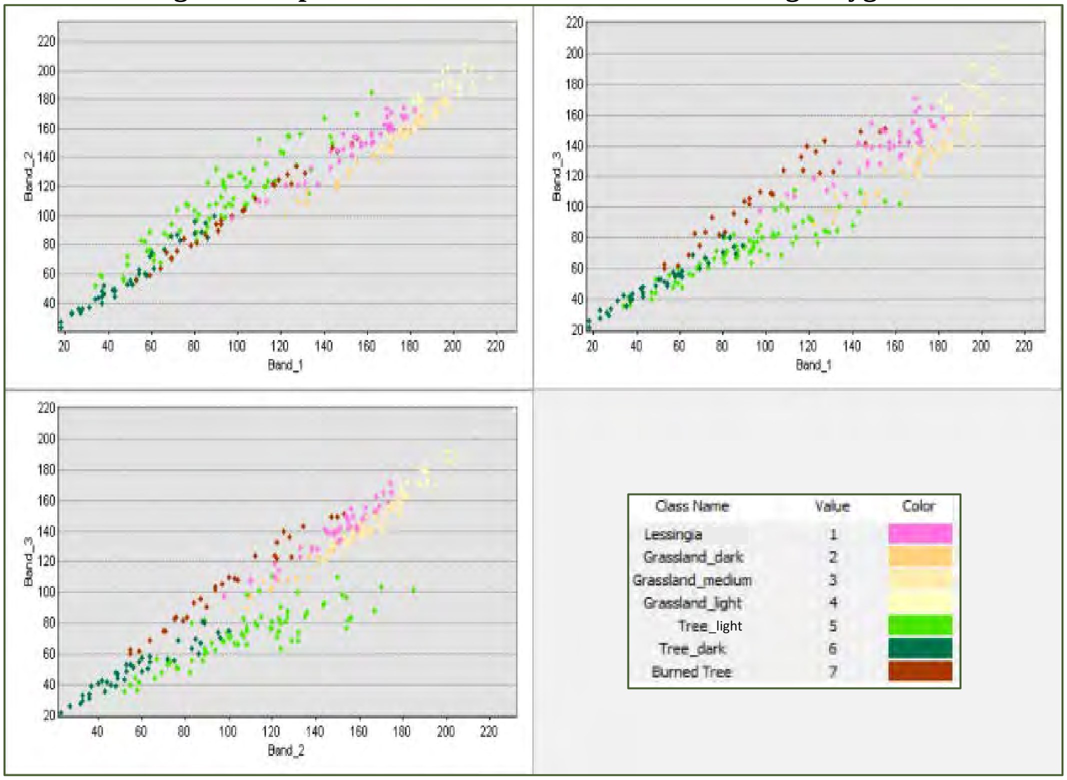


Figure 31. Spectral Characteristics of 2021 Training Polygons



Effects of Fire and Fire Suppression Activities

In addition to estimating the total number of individuals within the burn footprint, Nomad also monitored six transects to compare Burn, Doze, Retardant, and Unburn treatments (Figure 7).

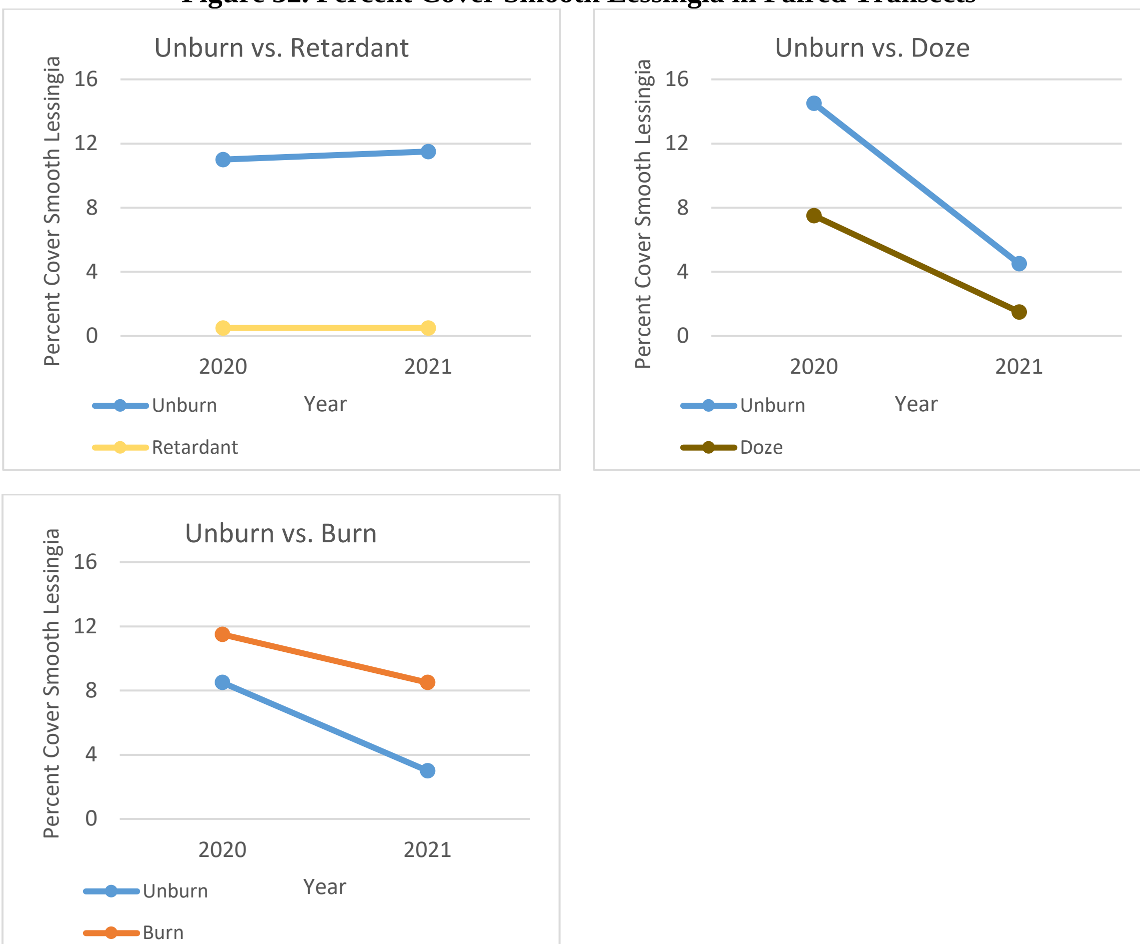
Percent cover of smooth lessingia along transects generally decreased from 2020 to 2021, although the paired transects in Unburn and Retardant treatments remained more or less constant (Table 19; Figure 32). Once again, very low rainfall in 2021 likely reduced growth and survival of smooth lessingia resulting in lower cover. Due to the patchy coverage of smooth lessingia, and because only one transect was monitored for each treatment except for Unburn, results are not necessarily representative of the response of smooth lessingia to fire and fire suppression activities as a whole.

Table 19. Smooth Lessingia Transects Monitored in 2020 and 2021

Transect	Treatment	Percent Cover		Average Density (Indiv. / m^2)		Height (cm)	
		2020	2021	2020	2021	2020	2021
Pair 1:							
Less1	Unburn	11	11.5	61.60	17.33	14-33	5-24.5
Less2	Retardant	0.5	0.5	0	0	NA	NA
Pair 2:							
Less3	Doze	7.5	1.5	10.67	5.33	9-30	5-12
Less4	Unburn	14.5	4.5	45.33	34.67	7-25	5-28

Pair 3:							
Less5	Unburn	8.5	3	20.00	8.00	10-48	4.5-30
Less6	Burn	11.5	8.5	40.00	24.00	6-23	4.5-18.8

Figure 32. Percent Cover Smooth Lessingia in Paired Transects



Percent cover of smooth lessingia within paired transects in 2020 and 2021. Paired transects were placed in Unburn and Retardant (upper left), Unburn and Doze (upper right), and Unburn and Burn (lower left) treatments.


Transect in Unburn treatment, September 2020

The average number of smooth lessingia individuals per square meter was calculated for the three quadrats along each transect along with a range of plant heights. No significant effects of treatment or year on density of plants was found between quadrats from paired transects. Density within quadrats in Unburn and Retardant paired transects was not significantly different between treatments or years (Wilcoxon, year: W = 23.5, p = 1; treatment: W = 30, p = 0.244). Density within quadrats in Unburn and Doze paired transects was also not significantly different between treatments, years, or their interaction (ANOVA, year: $F_{1,8}$ = 0.21, p = 0.661; treatment: $F_{1,8}$ = 3.32, p = 0.106; interaction: $F_{1,8}$ = 0.02, p = 0.883). Finally, density within quadrats in Unburn and Burn paired transects was not significantly different between treatments, years, or their interaction (ANOVA, year: $F_{1,8}$ = 1.63, p = 0.237; treatment: $F_{1,8}$ = 2.70, p = 0.139; interaction: $F_{1,8}$ = 0.03, p = 0.860).

Smooth lessingia height ranged from 7 to 48 cm in Unburn transect in 2020 and from 4.5 to 30 cm in 2021. Plants in the Doze treatment quadrats ranged from 9 to 30 cm in 2020 and from 5 to 12 cm in 2021. The Burn transect supported plants that ranged from 6 to 23 cm in 2020 and from 4.5 to 18.8 cm in 2021. No plants were found in designated quadrats for the Retardant treatment. In all cases, the heights of plants decreased in 2021.

Overall, no definitive conclusions can be drawn about the impacts of fire or fire suppression activities on smooth lessingia.

Threats and Management Considerations

The rare plant inventory indicates that this species is potentially threatened by development, vehicles, and possibly non-native plants (CNPS 2022). This population is expansive and protected from most threats. Invasive, non-native species could potentially threaten smooth lessingia if their cover increased dramatically, but invasive species do not appear to pose a threat at this time.

4.3.5 MOST BEAUTIFUL AND METCALF CANYON JEWELFLOWER (*STREPTANTHUS ALBIDUS* SUBSP. *PERAMOENUS* AND *S. A.* SUBSP. *ALBIDUS*)

Status, Distribution and Habitat Requirements

Most beautiful jewelflower [*Streptanthus albidus* Greene subsp. *peramoenus* (Greene) Kruckeberg], a synonym of *S. glandulosus* subsp. *glandulosus* in *TJM2*, has a California Rare Plant Rank of 1B.2 indicating that it is rare in California and elsewhere and is moderately threatened throughout its range (CNPS 2022; Baldwin et al. 2012). Metcalf Canyon jewelflower [*S. albidus* Greene subsp. *albidus*], a synonym of *S. glandulosus* subsp. *albidus* in *TJM2*, is listed as Federally endangered and has a California Rare Plant Rank of 1B.1 indicating that it is rare in California and elsewhere and is seriously threatened throughout its range (Ibid.). Both taxa are closely related herbaceous annuals in the mustard family (Brassicaceae).

These taxa can grow to heights of up to 3.9 feet (12 decimeters) with basal and clasping cauline leaves that are lance-linear to oblanceolate (Al-Shehbaz in Baldwin et al. 2012). The inflorescence is open, without a terminal sterile flower cluster (Ibid.). Flowers of most beautiful jewelflower generally have lilac-lavender sepals with lavender to purple petals (Ibid.). Flowers of Metcalf Canyon jewelflower generally have green-white sepals with white petals (Ibid.). Fruits of both taxa are spreading to ascending (Ibid.). These taxa are generally differentiated by flower color, however both taxa can co-occur, are interfertile, and can exhibit a range of colors between white and dark pink, making it very difficult to distinguish them in the field (Tropicos 2022; Creekside 2018). Most beautiful and Metcalf Canyon jewelflowers bloom from April to July and occasionally into September (CNPS 2022).

Most beautiful jewelflower is supported by serpentine substrates in chaparral, cismontane woodland, and valley and foothill grassland between 310 and 3,280 feet (95-1,000 meters) (CNPS 2022). It is recorded as occurring in Alameda, Contra Costa, Monterey, San Luis Obispo, and Santa Clara Counties (Ibid.). Metcalf Canyon jewelflower is supported by serpentine substrates on grassy, barren slopes in valley foothill grassland between 150 and 2,625 feet (45 to 800 meters) (CNPS 2022; Al-Shehbaz in Baldwin et al. 2012). It is recorded from 13 occurrences only in Santa Clara County (CNPS 2022).

Metcalf Canyon jewelflower in flower (left) and in fruit (right), May 2020.

Occurrence Data

The nearest CNDDB record of Metcalf Canyon jewelflower (EONDX #9123) is a specific location approximately 0.9 miles north of the Malech burn footprint (CDFW 2021). Over 5,000 individuals were recorded for this population in 2016 (Ibid.). One CNDDB occurrence of most beautiful jewelflower (EONDX #9989) overlaps with the Malech burn perimeter (Table 20; Figure 8). This occurrence is a specific location spanning much of Coyote Ridge south of Metcalf Road. This occurrence also includes polygons from two older Metcalf Canyon jewelflower occurrences since the two taxa appear to be hybridizing in this zone (CDFW 2021). Most recently, 5,450 individuals were observed in a part of this population in 2018.

Creekside Sciences surveyed for Metcalf Canyon and most beautiful jewelflowers within CROSP in 2016 and 2017; they recorded eight occurrences of Metcalf Canyon jewelflower and two occurrences of most beautiful jewelflower, with the caveat that distinguishing subspecies by flower color is not definitive (Table 20; Creekside 2018). Population size of larger occurrences was estimated by extrapolating from plant density within macroplots; smaller occurrences were censused by direct count (Ibid.). Table 20 summarizes the occurrences from CNDDB and Creekside Sciences.

Table 20. Crosswalk of Metcalf Canyon and Most Beautiful Jewelflower Occurrences the Study Area

EONDX # / Precision	CROSP Occ. #	Nomad Macroplot[1]	General Description	Total Number of Individuals
9989 / Specific (*S. a.* subsp. *peramonenus*[2])	STALAL-1	Strep-2, Strep-3	northern end of CROSP, overlaps with burn footprint	CNDDB 2018: 5,450[*] Creekside 2017: 21,913[^] Nomad 2020/2021: NA[+]

EONDX # / PRECISION	CROSP OCC. #	NOMAD MACROPLOT[1]	GENERAL DESCRIPTION	TOTAL NUMBER OF INDIVIDUALS
	STALAL-2	NA	northeastern end of CROSP, 0.3 miles northeast of burn footprint	CNDDB 2018: 5,450* Creekside 2017: 0** Nomad 2020/2021: NA
	STALAL-3	Strep-1	northern end of CROSP, 0.1 miles north of burn footprint	CNDDB 2018: 5,450* Creekside 2018: 9** Nomad 2020/2021: NA
	STALAL-4	Strep-4	central CROSP, overlaps burn footprint	CNDDB 2018: 5,450* Creekside 2017: 0** Nomad 2020/2021: NA
	STALAL-5	NA	central CROSP, 0.1 miles south of burn footprint	CNDDB 2018: 5,450* Creekside 2017: 0** Nomad 2020/2021: NA
	STALAL-6	NA	central CROSP, 0.27 miles south of burn footprint	CNDDB 2018: 5,450* Creekside 2017: 20** Nomad 2020/2021: NA
	STALAL-7	NA	western CROSP, 1.4 miles south of burn footprint	CNDDB 2018: 5,450* Creekside 2017: 350^ Nomad 2020/2021: NA
	STALAL-8	NA	southwestern CROSP, 1.9 miles south of burn footprint	CNDDB 2018: 5,450* Creekside 2017: 912^ Nomad 2020/2021: NA
	STALPE-1	Strep-2, Strep-3	northern end of CROSP, overlaps with burn footprint	CNDDB 2018: 5,450* Creekside 2017: 16,147^ Nomad 2020/2021: NA
	STALPE-2	NA	southwestern end of CROSP, 0.3 miles south of burn footprint	CNDDB 2018: 5,450* Creekside 2017: 770,800^ Nomad 2020/2021: NA

* CNDDB estimates are most recent available data only from an unknown portion of the occurrence.
^ Number of individuals estimated based macroplot methodology.
+ NA indicates a population estimate is not available as it was not a part of monitoring for this taxon in 2020 or 2021.
** Number of individuals determined by direct population count.
[1]Nomad macroplots do not represent the entire CNDDB or CROSP occurrence. One or more macroplots could be placed within a given occurrence.
[2]All CNDDB occurrences on CROSP are classified as *Streptanthus albidus* subsp. *peramoenus* including past occurrences of *Streptanthus albidus* subsp. *albidus*.

In 2020 and 2021, Nomad monitored 4 macroplots, two within the burn footprint, one in the area that received retardant application, and one in the Unburn treatment (Figure 8). Three of the macroplots corresponded to plot locations censused during Creekside Sciences monitoring (plots 10, 11, and 14) (Table 21). A fourth macroplot was established at a new location within the burn perimeter. Macroplots Strep-1, Strep-4, and Strep-3 were all placed in areas classified as Metcalf Canyon jewelflower by Creekside Sciences in 2016 (Creekside 2018). Macroplot Strep-2 was placed in an area with both Metcalf Canyon and most beautiful jewelflowers according to Creekside Sciences (Ibid.). The total number of individuals in the population in 2020 and 2021 was not estimated. In both 2020 and 2021, plants appeared to be in good condition, though plants were smaller with fewer branches in 2021, possibly due to drought.

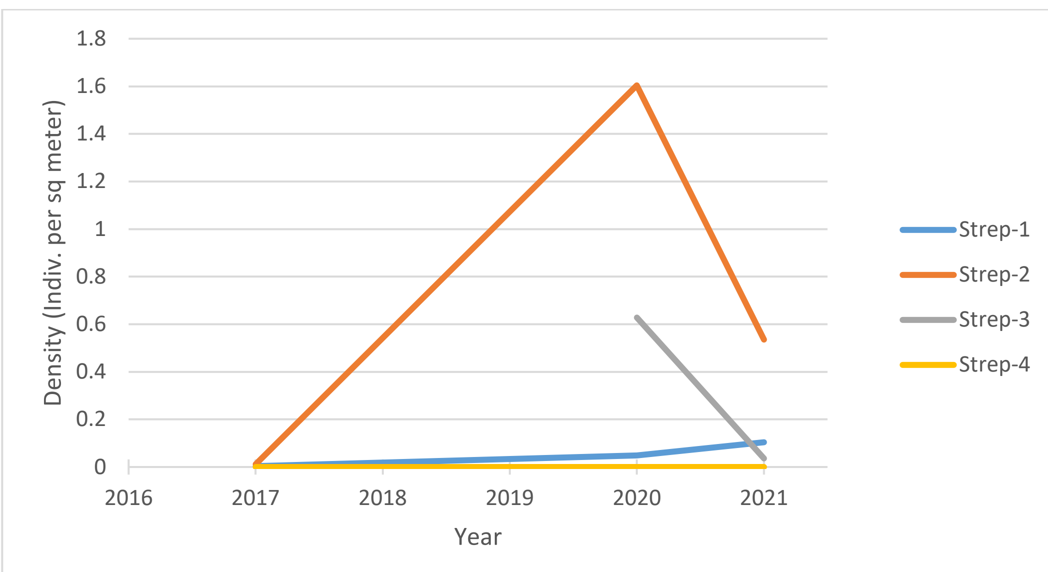
Metcalf Canyon jewelflower abundance for macroplot Strep-1 was estimated at 120 ± 103 (17 to 223) individuals in 2020 and 260 ± 133 (127 to 392) individuals in 2021 (Table 21). Because the 80% confidence intervals overlap, it is not likely that estimates represent a real increase in population size. Strep-2 decreased from 4,010 ± 1,443 (2,567 to 5,452) individuals in 2020 to 1,340 ±779 (560 to 2,119) individuals in 2021. Strep-3 also decreased from 1,570 ± 666 (904 to 2,235) individuals in 2020 to 90 ± 72 (18 to 162) individuals in 2021. Strep-4 had no observed individuals in 2020, or 2021.

In order to make the census counts from 2017 directly comparable to macroplot estimates in 2020 and 2021, the density of individuals per square meter was calculated (Table 21; Figure 33). Density of jewelflowers in Strep-1 has an upward trend, with increasing density from 2017, to 2020, to 2021. The number of individuals per square meter in Strep-2 has also increased since 2017, though with a decrease from 2020 to 2021. Strep-3 is a new plot that doesn't have any density data from 2017. Finally, while some plants were apparently observed near Strep-4 (CROSP occurrence STALAL-4) in 2016, no plants were observed there in 2017, and no plants were observed within macroplot Strep-4 in 2020 or 2021.

Table 21. Jewelflower Macroplots monitored in 2020 and 2021

Creekside Point	Nomad Plot	Treatment	Number of Individuals		Density of Individuals (Indiv. / m^2)		
			2020	2021	2017	2020	2021
10	Strep-1	Unburn	120 ± 103	260 ± 133	0.0036	0.048	0.104
14	Strep-2	Burn	4,010 ± 1,443	1,340 ± 779	0.0116	1.604	0.536
new plot	Strep-3	Burn	1,570 ± 666	90 ± 72	NA	0.628	0.036
11	Strep-4	Retardant	0	0	0	0	0

Figure 33. Jewelflower Density Over Time



Flower color was also recorded for flowering individuals within macroplots (Table 22). Generally, the proportion of ultra-white and white flowers has decreased since 2017 and the proportion of tween flowers has increased. While flower color is not the only way to distinguish Metcalf Canyon jewelflower from most beautiful jewelflower, these results show that the same population can change flower color over time and may support the CNDDB's categorization of *Streptanthus* populations on Coyote Ridge as most beautiful jewelflower.

Table 22. Jewelflower Color in Monitoring Plots

Creekside Point	Nomad Plot	2017				2020				2021			
		UW*	W	T	P	UW	W	T	P	UW	W	T	P
10	Strep-1	0%	78%	22%	0%	0%	50%	50%	0%	0%	41%	59%	0%
14	Strep-2	28%	48%	21%	3%	1%	46%	51%	2%	0%	55%	45%	0%
new plot	Strep-3	NA				0%	42%	55%	3%	0%	20%	80%	0%
11	Strep-4	NA				NA				NA			

* Flower color was categorized as either ultra-white (UW), white (W), tween (T), or pink (P).

Ultra-white flowers

White flowers.

Tween flowers

Pink flowers

Effects of Fire and Fire Suppression Activities

The macroplots in the Burn treatment had population spikes the first year after fire, then decreased again in 2021. This is in contrast to Strep-1, in the Unburn treatment, that has increased in density more gradually since 2018. The increase in density within the burn treatment could be attributed to the post-fire nutrient pulse. No effects of retardant application can be inferred since no plants were found within the macroplot or within the entire retardant area. The habitat within the retardant treatment did seem marginal, with high cover of annual grasses and not much exposed rocky soil like the other jewelflower locations. When Creekside Sciences observed jewelflower in this area in 2016, it was a particularly good year for jewelflowers (Creekside 2018). It is possible that this habitat only supports plants in the most favorable conditions.

Rock outcrops in macroplot Strep-3, May 2020.

Marginal habitat at macroplot Strep-4, May 2020.

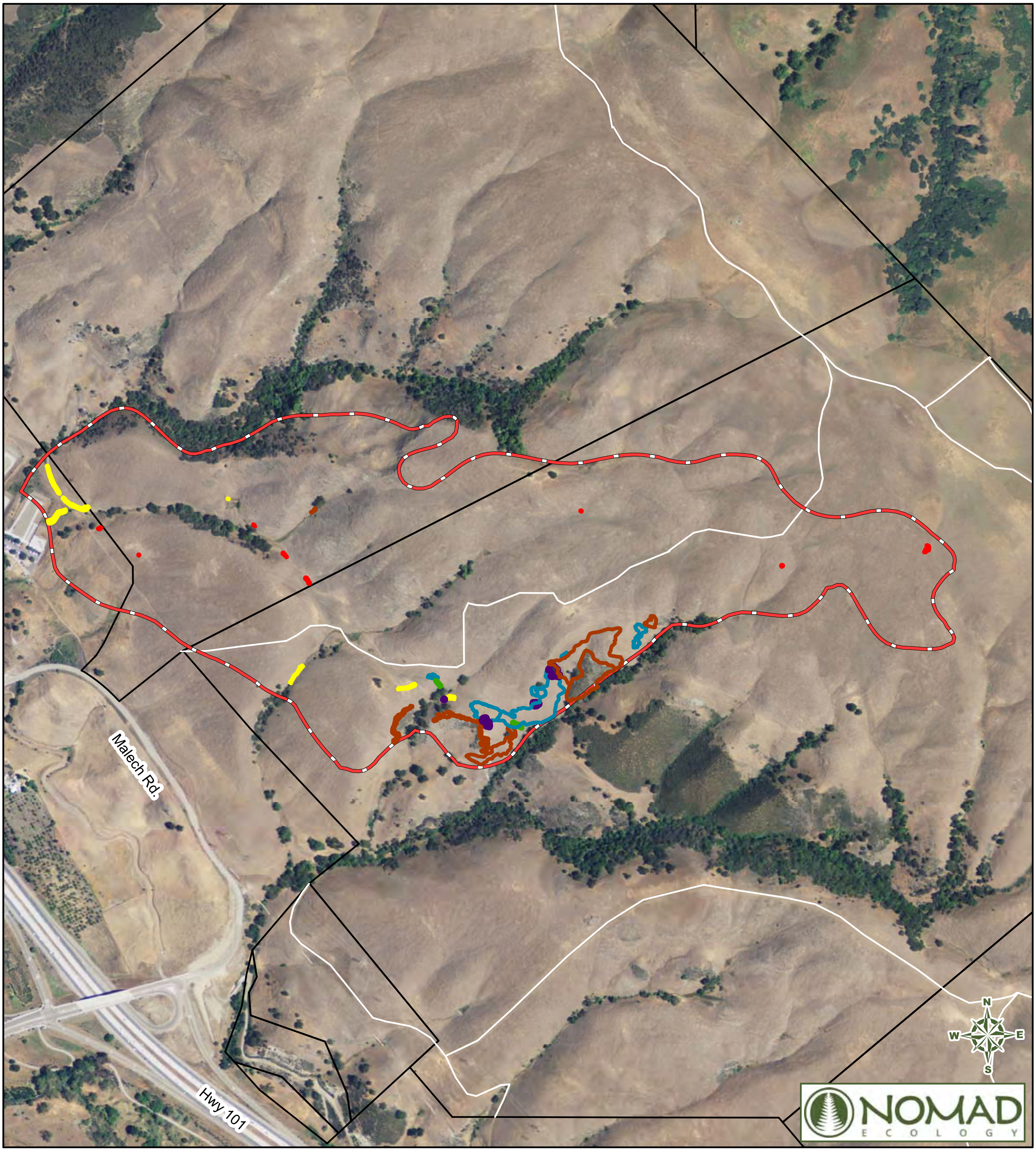
Threats and Management Considerations

The rare plant inventory lists development, road construction, vehicles, non-native, and grazing as threats to Metcalf Canyon and most beautiful jewelflowers. Barbed goatgrass* was noted in the unburned macroplot (Strep-1), and could potentially threaten *Streptanthus* spp. by increasing thatch.

Particularly small, water-stressed jewelflower, May 2021.

4.4. INVASIVE PLANT MAPPING RESULTS

Seven targeted plant species with elevated threat rankings were mapped within the study area: barbed goatgrass*, black mustard*, tocalote*, yellow star thistle*, artichoke thistle*, milk thistle*, and hoary mustard* (Figures 34 and 35). These non-native plant species are tracked by the California Department of Food and Agriculture (CDFA 2022) and/or the California Invasive Plant Council (Cal-IPC 2022) due to their noxious, invasive, or weedy behavior. Species tracked by these organizations are given a certain rating based on criteria such as ecological impacts, treatment or eradication priority, and threats they pose to agricultural economics (Table 23).



Legend

Mapped Weeds
- Aegilops triuncialis
- Centaurea melitensis
- Centaurea solstitialis
- Cynara cardunculus
- Hirschfeldia incana
- Silybum marianum

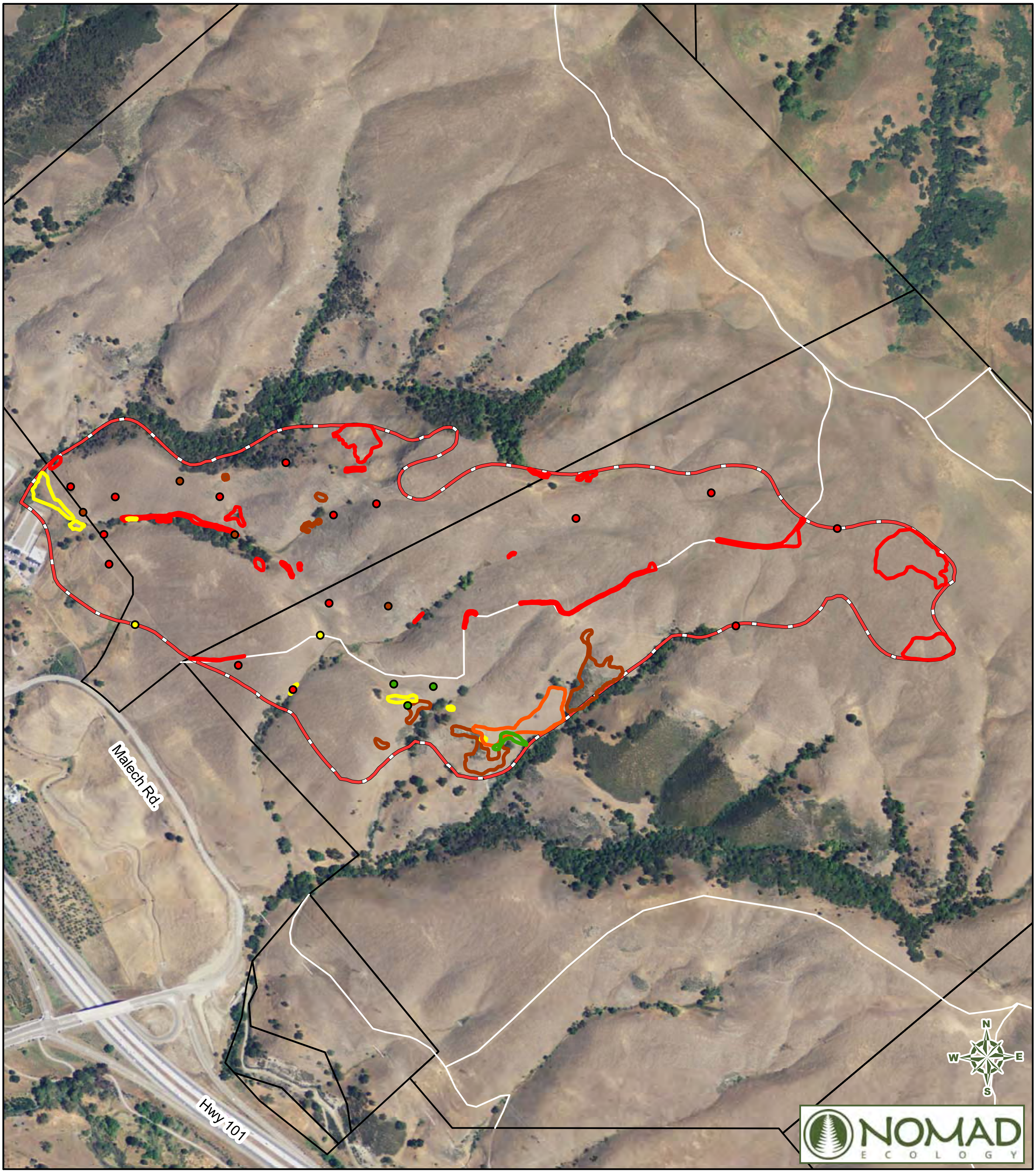
- Preserve Boundary
- Roads
- Malech Fire Perimeter

1:10,800
0 450 900
Feet

Figure 34
Mapped Weeds 2020
Post-Fire Vegetation and Covered Species Monitoring
Santa Clara Valley Habitat Agency

Sources: SCVOA, NAIP 2012.

Santa Clara County, California



February 2022

Post-Fire Monitoring Report

Legend

Mapped Weeds

- Aegilops triuncialis
- Brassica nigra
- Centaurea melitensis
- Centaurea solstitialis
- Cynara cardunculus
- Preserve Boundary
- Roads
- Malech Fire Perimeter

Figure 35

Mapped Weeds 2021

Post-Fire Vegetation and Covered Species Monitoring

Santa Clara Valley Habitat Agency

1:10,800

0 450 900 Feet

Sources: SCVOA, NAIP 2012.

Santa Clara County, California

Table 23. Non-Native Species with Elevated Threat Rankings Targeted within the Study Area

Species Name	Common Name	California Invasive Plant Council Rank[1]	California Department of Food and Agriculture Noxious Weed List[2]
Aegilops triuncialis	barbed goatgrass	Moderate	On List
Brassica nigra	black mustard	Moderate	---
Centaurea melitensis	tocalote	Moderate	On List
Centaurea solstitialis	yellow star thistle	High	On List
Cynara cardunculus	artichoke thistle	Moderate	On List
Hirschfeldia incana	hoary mustard	Moderate	---
Silybum marianum	milk thistle	Limited	---

[1] Cal-IPC Weed Ranking Definitions (Cal-IPC 2022):
High: These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.
Moderate: These species have substantial and apparent - but generally not severe - ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.
Limited: These species are invasive, but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic (Cal-IPC 2021).
[2] Species considered a noxious weed by CDFA are listed on the California Noxious Weed List (CDFA 2021).

4.4.1 Weeds of Concern On Site

Barbed goatgrass*, star thistles (tocalote* and yellow star thistle*), artichoke thistle*, mustards (black mustard* and hoary mustard*), and milk thistle* are weeds found on site that have the potential to cause significant impacts to native plant populations, are of particular concern to rare plant populations, and/or have a very limited distribution and so would be feasible to manage. Below is a brief description of these species and their general locations within the study area.

Barbed goatgrass (*Aegilops triuncialis*)

General Information

Barbed goatgrass* is a winter annual in the grass family (Poaceae) with spikes that resemble those of winter wheat. This species is native to Mediterranean Europe and western Asia (DiTomaso et al. 2013). Barbed goatgrass* flowers from May to August and stays green in the summer after other annual grasses have turned yellow. The spikelet and its associated node and rachis are called a joint. Intact joints can persist on dried grass and disarticulated joints may remain on the ground (Ibid.). Barbed goatgrass* inhabits dry, disturbed sites, fields, pastures, and roadsides but can also invade undisturbed grasslands and oak woodlands (Ibid.). It tolerates serpentine and hard, shallow, dry, gravelly soils (Ibid.).

Barbed goatgrass* reproduces by seeds (DiTomaso et al. 2013). Spikes and joints fall near parent plants or disperse to greater distances with water, human activities, vehicle tires, wind, and by ingestion or clinging to livestock (Ibid.).

Occurrence within the Study Area

Barbed goatgrass* was recorded in 8 polygons in 2020 covering 0.060 gross acres. Plants were observed in small patches along cow paths and drainages. In 2021, barbed goatgrass* was recorded in 19 polygons and 15 points. The gross acreage of mapped polygons in 2021 was 6.68 acres, a huge increase from 2020. Percent cover within polygons was low and was mapped along drainages and roads with some larger patches at the northern and eastern edges.

Management Considerations

It appears that barbed goatgrass* was present prior to the Malech Fire and has been spreading within the grassland, especially along roads and cow paths. The fire in 2019 may have decreased cover of barbed goatgrass substantially in 2020, making mapping more difficult. The large increase in cover in 2021 could be partly due to natural recovery post-fire, and partly due to spreading infestations. Due to the potential threat posed by this species, it is recommended as a target for control on site. Occasional burning in prescribed fires could reduce cover of this species. Additionally, restricting cattle once barbed goatgrass* has set seed would help slow spread.

Barbed goatgrass* along roadside in Malech burn footprint, June 2020.

Tocalote (*Centaurea melitensis*)

General Information

Tocalote* is an annual and occasionally a biennial in the sunflower family (Asteraceae). It is native to southern Europe (DiTomaso et al. 2013). Tocalote* is not as competitive or widespread as yellow starthistle* statewide, but still can form dense stands that displace native plants and animals, increase erosion, and reduce water percolation (Ibid.). Tocalote* inhabits open disturbed sites, open hillsides, grassland, rangeland, open woodlands, fields, pastures, roadsides, wasteplaces, and cultivated fields (Ibid.).

Tocalote* reproduces by seed. Seed production is highly variable. Seed head production is highly variable and depends on a variety of factors including soil moisture and competition (Ibid.). Seeds fall near the parent plant and are dispersed short distances with wind, and to greater distances with human activities, animals, water, mud, and soil movement (Ibid.). Large flushes of seeds typically germinate after the first fall rains, but smaller germination flushes can occur in winters and early spring (Ibid.). Plants exist as basal rosettes through winter and early spring until flower stems develop in late spring or early summer (Ibid.).

Occurrence within the Study Area

Tocalote* was recorded in 7 polygons covering 3.76 gross acres in 2020. It was generally mapped in larger patches on the edge of scrub on the southern end of the burn footprint. In 2021, tocalote* was recorded in 4 points and 9 polygons, covering 3.14 gross acres. This species was mapped in the same locations as 2020 with some additional polygons in the northern end of the burn footprint.

Management Considerations

Tocalote* has not spread substantially since the Malech Fire and appears to be somewhat restricted to scrub vegetation. This species is recommended to be a lower priority for control on site since it appears to have more limited distribution and spread. However, since it was largely mapped within burned scrub and chaparral, treatment would be most feasible in the few years post-fire before shrubs grow back to their full cover.

Tocalote* was mapped around burned scrub in the Malech Fire burn footprint, June 2020.

Yellow Star Thistle (*Centaurea solstitialis*)

General Information

Yellow star thistle* is a winter annual and occasionally a biennial in the sunflower family (Asteraceae). Plants are highly competitive and typically develop dense, impenetrable stands that displace desirable vegetation in natural areas, rangelands, roadside, and other places (DiTomaso et al. 2013). Yellow star thistle* is considered one of the most serious rangeland weeds in the western United States (Ibid.). Yellow star thistle* inhabits open disturbed sites, open hillsides, grassland, rangeland, open woodlands, fields, pastures, roadsides, waste places, and cultivated fields (Ibid.).

Yellow star thistle* reproduces by seed (DiTomaso et al. 2013). Seed head production is highly variable and depends on a variety of factors including soil moisture and competition (Ibid.). Seeds fall near the parent plant and are dispersed short distances with wind, and to greater distances with human activities, animals, water, mud, and soil movement (Ibid.). Large flushes of seeds typically germinate after the first fall rains, but smaller germination flushes can occur in winters and early spring (Ibid.). Shaded conditions reduce flower production and root growth (Ibid.). Plants exist as basal rosettes through winter and early spring until flower stems develop in late spring or early summer (Ibid.).

Occurrence within the Study Area

In 2020, yellow star thistle* was recorded in 7 polygons covering 0.30 gross acres. In 2021, this species was again recorded in 7 polygons as well as at 2 points, covering 0.94 gross acres. Both years this species was mapped on the southern end of the burn footprint, and at the far western end of the burn footprint, near the rifle range.

Management Considerations

Yellow star thistle* increased from 2020, to 2021 but was only mapped in a limited area. Due to the potential threat posed by this species and its limited distribution, it is recommended as a target for control on site.

Bolting yellow star thistle* in Malech burn footprint, June 2020.

Artichoke thistle (*Cynara carduncululus* subsp. *flavescens*)

General Information

Artichoke thistle* is a large perennial in the sunflower family (Asteraceae). This species is native to the Mediterranean region and invades disturbed open sites in grassland, pasture, chaparral, coastal scrub, and riparian areas (DiTomaso et al. 2013). It is often associated with areas impacted by historic or recent overgrazing (Ibid.). Artichoke thistle* can form dense colonies that displace desirable vegetation (Ibid.).

Artichoke thistle* reproduces primarily by seed and usually does not flower until its second year (Di Tomaso et al. 2013). Individual plants can live for many years (Ibid.). Seeds generally fall near the parent plant or disperse up to 60 feet with wind (Ibid.). Seeds can survive about five years in the soil (Ibid.). Plants can sometimes also grow from root fragments following mechanical disturbance (Ibid.).

Flowering artichoke thistle* in Malech Fire burn footprint, June 2020.

Occurrence within the Study Area

Fewer than 10 individuals of Artichoke thistle * were recorded in 2020 in 2 polygons (0.018 gross acres). In 2021, over ten plants were observed in one polygon (0.19 gross acres) and 3 points. In both years, plants were observed at the far southern edge of the burn footprint.

Management Considerations

It appears that the same artichoke thistle individuals were mapped in 2020 and 2021, although more plants were observed in 2021. Due to the very limited distribution of this species, and its potential impacts, it is recommended as a target for control in the study area.

Hoary Mustard (*Hirschfeldia incana*)

General Information

Hoary mustard* is a species in the mustard family (Brassicaceae) that invades disturbed places, roadsides, fields, grasslands, and ditch banks (DiTomaso et al. 2013). Hoary mustard* is a biennial or sort-lived perennial native to the Mediterranean region (Ibid.). Hoary mustard* reproduces solely by seed (DiTomaso et al. 2013). Plants generally flower from mid-spring to late-summer (DiTomaso et al. 2013; Baldwin et al. 2012). Seed production is high, with seeds falling near parent plant (DiTomaso et al. 2013). Many mustard species develop a large, persistent seedbank that can survive for 50 years or more but seeds nearer to the soil surface are not as long-lived under field conditions (Ibid.).

Occurrence within the Study Area

Hoary mustard* was mapped as 5 polygons (2.03 gross acres) in 2020 on the far southern edge of the burn footprint. In 2021, only one mustard polygon (1.81 gross acres) was recorded in the same location.

Management Considerations

Hoary mustard* appears in only one part of the study area and did not spread substantially from 2020 to 2021. This species is recommended to be a lower priority for control on site since patches are somewhat large and they occur in a less sensitive area.

Milk thistle (*Silybum marianum*)

General Information

Milk thistle* is a winter annual or biennial in the sunflower family (Asteraceae). This species is native to the Mediterranean region and invades disturbed sites, roadsides, pasture, waste places and trail margins in chaparral and woodlands (DiTomaso et al. 2013). Milk thistle* often occurs in dense, competitive stands colonies that suppress germination and growth of nearby vegetation and can cause physical injury to livestock (Ibid.).

Milk thistle* reproduces only by seed, which disperse only a short distance by wind or disperse longer distances by human movement in crop seed and feed contaminates (DiTomaso et al. 2013). Seeds can survive at least nine years in the soil under field conditions (Ibid.).

Occurrence within the Study Area

Milk thistle* was only recorded in 2020 where it was mapped as 4 polygons (0.19 gross acres) on the far southern edge of the burn footprint near the mustards and artichoke thistle*. Unlike most other weeds targeted in the study area, this species was recorded with high percent cover, ranging from below 5% cover up to 25-50% cover.

Management Considerations

The milk thistle * infestations recorded in 2020 were likely still present in 2021 but may have been much reduced due to lack of rain, and thus less visible. Although milk thistle* has a Limited ranking according to Cal-IPC, the distribution is limited within the burn footprint and infestations had high percent cover. This species is recommended for control on site.

Dense milk thistle* in Malech Fire burn footprint, June 2020.

Section 5. SUMMARY AND RECOMMENDATIONS

5.1. SUMMARY

5.1.1 POST-FIRE VEGETATION COMPOSITION

The sampling of 16 plots within the Malech burn perimeter in 2020 and 2021 (32 plots combined over both years) yielded 93 plant taxa. Of these, 70 (75%) are considered native and 22 (24%) are non-native.

Grasses and herbs were the found in the most plots (all 32 plots), had the highest species richness (5.7 and 22.1 species on average, respectively), and had the highest relative cover (69.31% and 27.84% on average, respectively) compared to other life forms. This result is intuitive since plots were placed in grassland habitat. Only two geophyte taxa, two shrub taxa, and one vine taxon were recorded within plots. These life forms occurred at low relative cover, below 2% cover on average. High herb and grass cover provide cover, soil protection, and nutrient cycling immediately following fire.

Fire following species, which are frequently documented in recently burned scrub and chaparral, were not documented within plots. Native disturbed taxa are taxa that have been noted to flourish following disturbances such as fire or the creation of fire lines. A total of 17 native disturbed taxa, were recorded in plots, but were not recorded more frequently in the Burn or Doze treatments as may have been expected. Ten nitrogen fixing taxa and 11 taxa considered invasive by Cal-IPC were recorded within all plots. One taxon recorded within plots, smooth lessingia is considered rare based on the California Native Plant Society’s Inventory of Rare and Endangered Plants of California (CNPS 2022).

Effects of Fire and Fire Suppression Activities

The following table summarizes the results of statistical analyses of whether treatment, year, or the interaction of treatment and year had significant effects on the richness and relative cover of all vegetative species, native species, species from different life form categories, and species from different herbaceous categories (Table 24).

When year had a significant effect, percent cover and richness tended to be greater in 2020 than in 2020, likely due to a post-fire nutrient pulse as well as an extreme lack of rain in 2021. The exceptions to this generalization include native, herb, and shrub relative cover. These groups of species may have had lower relative cover in 2020 because the cover of grasses, which were mostly non-native, was very high in 2020. When grass cover was lower in 2021, these other groups made up a higher proportion of the cover.

Treatment often did not have a significant effect on percent cover or richness of groups of species, and when it did, the difference was very small. This lack of effect could be attributed to the fact that plots were dominated by annual grass and herb species, which may not experience the same lasting effects of burning or bulldozer treatments as perennial shrubs would. Low intensity grassland fire, bulldozer lines, and retardant application, did not appear to have a large effect on the germination and survival of these annual species.

Table 24. Summary of Significance of Treatment and Year Effects on Vegetation Composition

Response	Treatment				Year	Interaction[A]
	Burn	Doze	Ret	Unburn		
Richness						
Overall Species Richness	a[b]	b	ab	ab	2020[c]	NS[d]
Native Richness	a	b	a	ab	2020	NS
Life Form Categories						
Grass Richness	Marginal[e]	Marginal	Marginal	Marginal	NS	NS
Herb Richness	NS	NS	NS	NS	2020	NS
Geophyte Richness	Marginal	Marginal	Marginal	Marginal	NS	NS
Shrub Richness	NS	NS	NS	NS	2020	---[f]
Herbaceous Categories						
Native Disturbed Richness	NS	NS	NS	NS	2020	NS
Nitrogen Fixer Richness	NS	NS	NS	NS	2020	---
Rare Richness	NS	NS	NS	NS	NS	---
Weed Richness	NS	NS	NS	NS	NS	NS
Relative Cover						
Absolute Vegetative Cover	b	ab	a	ab	2020	NS
Native Relative Cover	NS	NS	NS	NS	2021	NS
Life Form Categories						
Grass Relative Cover	NS	NS	NS	NS	2020	---
Herb Relative Cover	NS	NS	NS	NS	2021	---
Geophyte Relative Cover	NS	NS	NS	NS	marginal, 2021	---
Shrub Relative Cover	NS	NS	NS	NS	2021	---
Herbaceous Categories						
Fire Follower Relative Cover	---	---	---	---	---	---
Native Disturbed Relative Cover	marginal, ab	marginal, b	marginal, a	marginal, ab	NS	NS
Nitrogen Fixer Relative Cover	a	ab	b	ab	NS	marginal
Rare Relative Cover	NS	NS	NS	NS	NS	---

[a] Interaction between treatment and year. The interaction term was only tested when data met the assumptions for ANOVA.
[b]Letters correspond to the results of pairwise comparisons using Tukey or Wilcoxon rank sum tests. Different letters are significantly different from one another, with a being significantly greater than b and neither a or b being significantly different from ab.
[c] Year indicates which year was significantly greater

[d] Not Significant. Indicates non-significant results, p > 0.1.
[e] Indicates marginally significant results, 0.05 > p < 0.1.
[f] Indicates statistical test was not performed. When data did not meet assumptions for ANOVA, non-parametric tests were used to assess the effects of Treatment (Kruskal-Wallis) and Year (Wilcoxon). In these cases, the interaction of Treatment and Year could not be tested.

5.1.2 Post-Fire Covered Species

Six species covered by the NCCP that were known from the Malech Fire burn perimeter were monitored in 2020 and 2021: Mt. Hamilton thistle, Santa Clara Valley Dudleya, fragrant fritillary, smooth lessingia, and Metcalf Canyon and most beautiful jewelflowers. Table 25 below, summarizes the number of individuals within monitored portions of covered species occurrences on CROSP.

Table 25. Abundance within CROSP Occurrences in the Study Area

Common Name (Species Name)	EONDX #	CROSP Occ. #	Monitoring Coverage	No. Indiv. 2020	No. Indiv. 2021	Change
Mt. Hamilton thistle (*Cirsium fontinale* var. *campylon*)	42237	3	entire CROSP occurrence	639[+]	864[+]	Increase
		4	entire CROSP Occurrence	3,842[+]	4,675[+]	Increase
Santa Clara Valley dudleya (*Dudleya abramsii* subsp. *setchellii*)	13933	1	13 plots, not entire CROSP occurrence	1,570[+,*]	1,949[+,*]	Increase
Fragrant fritillary (*Fritillaria liliacea*)	9062	Frit-1	1 macroplot, not entire CROSP occurrence	4,190 ± 2,880[^]	5,520 ± 3,085[^]	No significant change
	9059	Frit-3	1 macroplot, entire CROSP occurrence	622 ± 201[^]	853 ± 294[^]	No significant change
Smooth lessingia (*Lessingia micradenia* var. *glabrata*)	53559	1	Malech Fire footprint, not entire CROSP occurrence	15,014,882[++]	5,266,687[++]	Decrease
Metcalf Canyon jewelflower (*Streptanthus albi*dus subsp. *albidus*) and most beautiful jewelflower (*S. a.* subsp. *peramoenus*)	9989	STALAL-1 / STALPE-1	2 macroplots in Burn, not entire CROSP occurrence	4,130 ± 1,546[^]	1,600 ± 912[^]	Decrease
		STALAL-3	1 macroplot in Unburn, not entire CROSP occurrence	1,570 ± 666[^]	90 ± 72[^]	Decrease
		STALAL-4	1 macroplot in Retardant, not entire CROSP occurrence	0[^]	0[^]	No significant change

+ Number of individuals determined by direct population count.
* Number of rosettes, not number of individuals
^ Number of individuals estimated based macroplot methodology following Creekside protocol.
++ Number of individuals is an estimate extrapolated from average density within ground truth quadrats.

Effects of Fire and Fire Suppression Activities

Some covered species were monitored within the burn footprint as well as in the Doze, Retardant, and/or Unburn treatments. Not all monitoring was conducive to drawing conclusions about the effects of fire and fire suppression activities, however. Table 26 below, summarizes any effects of Treatment, Year, or their interaction on species monitored in 2020 and 2021.

Table 26. Summary of Significance of Treatment and Year Effects on Covered Species

Response	Treatment				Year	Interaction[a]
	Burn	Doze	Ret	Unburn		
Mt Hamilton Thistle						
---[b]	---	---	---	---	---	---
Santa Clara Valley Dudleya						
Rosette density	b[c]	a	---	b	NS[d]	---
Percent Dead rosettes	NS	NS	NS	NS	2021[e]	---
Percent Vegetative rosettes	NS	NS	NS	NS	NS	NS
Percent Flowering rosettes	NS	NS	NS	NS	NS	NS
Infl. per flowering Indiv.	NS	NS	NS	NS	NS	NS
Fragrant Fritillary						
Indiv. in Frit-1 macroplot	---	---	---	---	NS	---
Indiv. in Frit-3 macroplot	---	---	---	---	NS	---
Smooth Lessingia						
Density in Unburn and Retardant transects	NS	NS	NS	NS	NS	---
Density in Unburn and Doze transects	NS	NS	NS	NS	NS	NS
Density in Unburn and Burn transects	NS	NS	NS	NS	NS	NS
Metcalf Canyon and most beautiful jewelflowers						
Indiv. in Strep-1 macroplot	---	---	---	---	NS	---
Indiv. in Strep-2 macroplot	---	---	---	---	2020	---
Indiv. in Strep-3 macroplot	---	---	---	---	2020	---
Indiv. in Strep-4 macroplot	---	---	---	---	---	---

[a] Interaction between treatment and year. The interaction term was only tested when data met the assumptions for ANOVA.
[b] Indicates statistical test was not performed.
[c] Letters correspond to the results of pairwise comparisons using Wilcoxon rank sum tests. Different letters are significantly different from one another, with a being significantly greater than b and neither a or b being significantly different from ab.
[d] Not Significant. Indicates non-significant results, $p > 0.1$.
[e] Year indicates which year was significantly greater.

5.2. Invasive Plants

Table 27 below, summarizes the number of locations and gross area where target invasive species were mapped in 2020 and 2021.

Table 27. Summary of Results of Invasive Species Mapping

Common Name / (Species Name)	Number of Locations Mapped (Polygons + Points)		Area Mapped (Gross Acres)		Change
	2020	2021	2020	2021	
Barbed goatgrass (*Aegilops triuncialis*)	8	34	0.060	6.68	Increase
Tocalote (*Centaurea melitensis*)	7	13	3.76	3.14	Increase in locations, decrease in area
Yellow star thistle (*Centaurea solstitialis*)	7	9	0.30	0.94	Increase
Artichoke thistle (*Cynara cardunculus* subsp. *flavescens*)	2	4	0.018	0.19	Increase
Hoary mustard (*Hirschfeldia incana*)	5	1	2.03	1.81	Decrease
Milk thistle (*Silybum marianum*)	4	0	0.19	NA	Decrease

5.3. Recommendations

5.3.1 Covered Plant Populations

Covered plant populations generally were in good condition. Threats from cattle were noted for Mt. Hamilton thistle and fragrant fritillary. Threats from invasive species, especially barbed goatgrass*, were noted for Mt. Hamilton thistle, fragrant fritillary, and Metcalf Canyon and most beautiful jewelflowers. Lastly, changes in hydrology could threaten Mt. Hamilton thistle population if the seeps and drainages supporting that taxon dry up. Covered plant populations are relatively large and healthy on CROSP, so rare plant monitoring should continue on a regular basis but can be revisited over longer intervals.

5.3.2 Invasive Plants

Although barbed goatgrass* is somewhat widespread within the Malech Fire footprint, it can have negative effects on serpentine grassland communities and is growing nearby several covered species occurrences. For this reason, we recommend control of this species on site and managing grazing to reduce spread. We also recommend controlling yellow star thistle*, artichoke thistle*, and milk thistle* within the burn footprint due to more limited distribution of these species. Tocalote* and mustard species were of less concern and had larger infestations that may not be feasible for control.

5.3.3 Wildland or Prescribed Fire

In general, fire and fire suppression activities had few significant effects and any significant effects were very small. However, fairly frequent wildland or prescribed fire is likely good for limiting weedy species on CROSP. Weed mapping of barbed goatgrass* showed reduced acreage the year after the Malech Fire but large increases in the second year after fire. Additionally, burning reduces thatch from annual grasses which could increase germination and survival of native serpentine grassland forb species. Indeed, on aerial imagery from March 2020 and 2021, it appeared that forbs within the Malech burn footprint were more prevalent and showier compared to unburned grassland, although this result was not quantified. It is recommended that management of CROSP include reasonable fire return intervals, either through prescribed burns or passively allowing accidentally ignited fires to burn.

Of the few significant effects detected by vegetation composition monitoring, bulldozer lines were associated with lower overall species richness, lower native richness, and marginally lower native disturbed cover. Bulldozer lines create a high degree of disturbance that may require more time for recovery than burned or fire retardant areas. Clearing the area from all vegetation leaves a lot of bare ground that is prone to erosion and can be colonized by the most competitive species, usually weedy or native disturbed species. It is recommended to minimize disturbance from bulldozer lines within serpentine grassland as much as possible. Established access roads can be used as fire breaks and where additional fire breaks are needed, these should be placed outside of serpentine areas and/or near the perimeter of the preserve to allow as much serpentine grassland to burn as possible while reducing habitat fragmentation.

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APPENDIX A LIST OF TAXA OBSERVED IN ALL PLOTS

SPECIES NAME	COMMON NAME	ORIGIN	CRPR	LIFE FORM	NITROGEN FIXING	CAL-IPC	FIRE BURN	NATIVE DISTURB
EUDICOTS								
Apiaceae – Carrot Family								
Lomatium caruifolium var. *caruifolium*	caraway leaved lomatium	Native	---	Herb	---	---	---	---
Lomatium macrocarpum	bigseed biscuitroot	Native	---	Herb	---	---	---	---
Lomatium utriculatum	common lomatium	Native	---	Herb	---	---	---	---
Sanicula bipinnata	poison sanicle	Native	---	Herb	---	---	---	---
Sanicula bipinnatifida	purple sanicle	Native	---	Herb	---	---	---	---
Sanicula crassicaulis	Pacific sanicle	Native	---	Herb	---	---	---	---
Asteraceae – Sunflower Family								
Achillea millefolium	yarrow	Native	---	Herb	---	---	---	---
Achyrachaena mollis	blow-wives	Native	---	Herb	---	---	---	---
Agoseris heterophylla var. *cryptopleura*	mountain dandelion	Native	---	Herb	---	---	---	---
Agoseris heterophylla var. *heterophylla*	annual agoseris	Native	---	Herb	---	---	---	---
Artemisia californica	California sagebrush	Native	---	Shrub	---	---	---	---
Calycadenia multiglandulosa	sticky calycadenia	Native	---	Herb	---	---	---	---
Centaurea calcitrapa	purple star thistle	Non-Native	---	Herb	---	Moderate	---	---
Crepis vesicaria subsp. *taraxacifolia*	beaked hawksbeard	Native	---	Herb	---	---	---	---
Hemizonia congesta subsp. *luzulifolia*	hayfield tarweed	Native	---	Herb	---	---	---	X

Species Name	Common Name	Origin	CRPR	Life Form	Nitrogen Fixing	Cal-IPC	Fire Burn	Native Disturb
Hesperevax sparsiflora var. *sparsiflora*	few-flowered evax	Native	---	Herb	---	---	---	---
Hypochaeris glabra	smooth cat's ear	Non-Native	---	Herb	---	Limited	---	---
Lactuca saligna	willowleaf lettuce	Non-Native	---	Herb	---	---	---	---
Lasthenia californica subsp. *californica*	goldfields	Native	---	Herb	---	---	---	---
Lasthenia gracilis	needle goldfields	Native	---	Herb	---	---	---	---
Layia platyglossa	tidy-tips	Native	---	Herb	---	---	---	---
Lessingia micradenia var. *glabrata*	smooth lessingia	Native	1B.2	Herb	---	---	---	---
Micropus californicus var. *californicus*	slender cottonweed	Native	---	Herb	---	---	---	X
Micropus californicus var. *subvestitus*	slender cottonweed	Native	---	Herb	---	---	---	---
Microseris douglasii subsp. *douglasii*	silver puffs	Native	---	Herb	---	---	---	---
Microseris douglasii subsp. *tenella*	Douglas' silverpuffs	Native	---	Herb	---	---	---	---
Rigiopappus leptocladus	wire weed	Native	---	Herb	---	---	---	---
Senecio vulgaris	groundsel	Non-Native	---	Herb	---	---	---	---
Stebbinsoseris heterocarpa	grassland stebbinsoseris	Native	---	Herb	---	---	---	X
Uropappus lindleyi	silverpuffs	Native	---	Herb	---	---	---	---
Boraginaceae – Borage or Waterleaf Family								
Amsinckia intermedia	common fiddleneck	Native	---	Herb	---	---	---	X
Cryptantha flaccida	flaccid cryptantha	Native	---	Herb	---	---	---	---
Brassicaceae – Mustard Family								
Caulanthus lasiophyllus	California mustard	Native	---	Herb	---	---	---	X
Lepidium nitidum	shining peppergrass	Native	---	Herb	---	---	---	---
Caryophyllaceae – Pink Family								

Species Name	Common Name	Origin	CRPR	Life Form	Nitrogen Fixing	Cal-IPC	Fire Burn	Native Disturb
Silene gallica	windmill pink	Non-Native	---	Herb	---	---	---	---
Convolvulaceae – Morning-Glory Family								
Calystegia subacaulis subsp. *subacaulis*	hill morning glory	Native	---	Herb	---	---	---	---
Cuscuta sp.	dodder	Native	---	Vine	---	---	---	---
Crassulaceae – Stonecrop Family								
Crassula connata	pygmyweed	Native	---	Herb	---	---	---	---
Euphorbiaceae – Spurge Family								
Euphorbia peplus	petty spurge	Non-Native	---	Herb	---	---	---	---
Euphorbia spathulata	warty spurge	Native	---	Herb	---	---	---	X
Fabaceae – Pea Family								
Acmispon wrangelianus	calf lotus	Native	---	Herb	X	---	---	X
Astragalus gambelianus	dwarf loco weed	Native	---	Herb	X	---	---	X
Lupinus microcarpus var. *microcarpus*	chick lupine	Native	---	Herb	X	---	---	X
Medicago polymorpha	burclover	Non-Native	---	Herb	X	Limited	---	---
Trifolium albopurpureum	indian clover	Native	---	Herb	X	---	---	X
Trifolium ciliolatum	tree clover	Native	---	Herb	X	---	---	X
Trifolium dichotomum	branched indian clover	Native	---	Herb	X	---	---	X
Trifolium gracilentum	pinpoint clover	Native	---	Herb	X	---	---	X
Trifolium hirtum	rose clover	Non-Native	---	Herb	X	Moderate	---	---
Trifolium willdenovii	tomcat clover	Native	---	Herb	X	---	---	X
Geraniaceae – Geranium Family								
Erodium botrys	long-beaked filaree	Non-Native	---	Herb	---	---	---	---
Erodium cicutarium	red-stemmed filaree	Non-Native	---	Herb	---	Limited	---	---

Species Name	Common Name	Origin	CRPR	Life Form	Nitrogen Fixing	Cal-IPC	Fire Burn	Native Disturb
Geranium dissectum	cut-leaf geranium	Non-Native	---	Herb	---	Moderate	---	---
Geranium molle	dovefoot geranium	Non-Native	---	Herb	---	---	---	---
Montiaceae – Miner's Lettuce Family								
Calandrinia menziesii	red maids	Native	---	Herb	---	---	---	---
Claytonia parviflora subsp. *parviflora*	narrow leavedminer's lettuce	Native	---	Herb	---	---	---	X
Onagraceae – Evening Primrose Family								
Epilobium brachycarpum	tall annual willow-herb	Native	---	Herb	---	---	---	X
Tetrapteron graciliflorum	hill sun cup	Native	---	Herb	---	---	---	---
Orobanchaceae – Broomrape Family								
Castilleja attenuata	valley tassels	Native	---	Herb	---	---	---	---
Castilleja densiflora subsp. *densiflora*	dense flower owl's clover	Native	---	Herb	---	---	---	---
Castilleja exserta subsp. *exserta*	purple owl's clover	Native	---	Herb	---	---	---	---
Triphysaria eriantha subsp. *eriantha*	johhny tuck	Native	---	Herb	---	---	---	---
Papaveraceae – Poppy Family								
Eschscholzia californica	California poppy	Native	---	Herb	---	---	---	---
Plantaginaceae – Plantain Family								
Plantago erecta	dwarf plantain	Native	---	Herb	---	---	---	---
Polemoniaceae – Phlox Family								
Gilia achilleifolia subsp. *multicaulis*	many-stemmed gilia	Native	---	Herb	---	---	---	---
Microsteris gracilis	slender phlox	Native	---	Herb	---	---	---	---
Polygonaceae – Buckwheat Family								
Eriogonum nudum var. *auriculatum*	naked-stem buckwheat	Native	---	Shrub	---	---	---	---

Species Name	Common Name	Origin	CRPR	Life Form	Nitrogen Fixing	Cal-IPC	Fire Burn	Native Disturb
Ranunculaceae – Buttercup Family								
Ranunculus californicus var. *californicus*	California buttercup	Native	---	Herb	---	---	---	---
Rosaceae – Rose Family								
Aphanes occidentalis	Lady's mantle	Native	---	Herb	---	---	---	---
MONOCOTS								
Agavaceae – Agave Family								
Chlorogalum pomeridianum var. *pomeridianum*	soap plant	Native	---	Geophyte	---	---	---	---
Alliaceae – Onion or Garlic Family								
Allium serra	jeweled onion	Native	---	Herb	---	---	---	---
Iridaceae – Iris Family								
Sisyrinchium bellum	blue-eyed grass	Native	---	Herb	---	---	---	---
Poaceae – Grass Family								
Avena barbata	slender oats	Non-Native	---	Grass	---	Moderate	---	---
Bromus berteroanus	Chilean brome	Non-Native	---	Grass	---	---	---	---
Bromus diandrus	ripgut brome	Non-Native	---	Grass	---	Moderate	---	---
Bromus hordeaceus	soft chess	Non-Native	---	Grass	---	Limited	---	---
Bromus madritensis	foxtail chess	Non-Native	---	Grass	---	---	---	---
Bromus racemosus	smooth brome	Non-Native	---	Grass	---	---	---	---
Bromus rubens	foxtail chess	Non-Native	---	Grass	---	High	---	---
Danthonia californica	California oat Grass	Native	---	Grass	---	---	---	---
Elymus multisetus	big squirreltail	Native	---	Grass	---	---	---	---
Festuca bromoides	brome fescue	Non-Native	---	Grass	---	---	---	---
Festuca microstachys	Eastwood fescue	Native	---	Grass	---	---	---	X

Species Name	Common Name	Origin	CRPR	Life Form	Nitrogen Fixing	Cal-IPC	Fire Burn	Native Disturb
Festuca perennis	Italian ryegrass	Non-Native	---	Grass	---	Moderate	---	---
Hordeum marinum subsp. *gussoneanum*	Mediterranean barley	Native	---	Grass	---	---	---	---
Hordeum murinum subsp. *leporinum*	hare barley	Native	---	Grass	---	---	---	---
Melica imperfecta	small flowered melica	Native	---	Grass	---	---	---	---
Poa secunda subsp. *secunda*	one-sided bluegrass	Native	---	Grass	---	---	---	---
Stipa lepida	foothill needlegrass	Native	---	Grass	---	---	---	---
Stipa pulchra	purple needlegrass	Native	---	Grass	---	---	---	---
Trisetum canescens	tall trisetum	Native	---	Grass	---	---	---	---
Themidaceae – Brodiaea Family								
Dipterostemon capitatus subsp. *capitatus*	blue dicks	Native	---	Geophyte	---	---	---	---
Muilla maritima	common muilla	Native	---	Herb	---	---	---	---

APPENDIX B Species Richness By Plot

Plot ID	Year	Richness	Rare Species	Fire Follower	Native Disturbed	Nitrogen Fixing	Weed	Cal-Ipc High	Cal-Ipc Moderate	Cal-Ipc Limited	Shrub	Herb	Geophyte	Grass
BURN1	2020	29	0	24	0	7	5	3	0	2	1	0	21	2
	2021	28	0	24	0	6	4	3	0	2	1	0	19	2
BURN2	2020	32	1	24	0	7	4	4	0	2	2	0	25	2
	2021	30	1	25	0	7	4	4	0	2	2	1	21	2
BURN3	2020	42	0	33	0	8	5	4	0	2	2	0	32	1
	2021	37	0	30	0	7	5	6	0	3	3	1	29	1
BURN4	2020	35	1	27	0	9	5	4	0	2	2	0	27	2
	2021	28	1	24	0	6	3	2	0	2	0	1	19	2
DOZE1	2020	24	0	13	0	4	3	8	0	5	3	0	20	0
	2021	15	0	12	0	4	1	3	0	3	0	0	10	1
DOZE2	2020	29	0	26	0	7	5	2	0	1	1	0	23	2
	2021	24	0	21	0	7	4	2	0	1	1	1	16	2
DOZE3	2020	29	1	25	0	8	4	2	0	2	0	0	22	2
	2021	22	1	18	0	6	3	2	0	2	0	1	14	2
DOZ4	2020	32	1	25	0	12	5	4	0	2	2	0	25	1
	2021	27	1	21	0	6	4	4	1	2	1	1	20	1
RET1	2020	31	1	26	0	8	5	3	0	1	2	0	26	2
	2021	28	0	26	0	5	2	2	0	1	1	1	20	2
RET2	2020	33	1	26	0	9	5	4	1	2	1	0	25	2
	2021	32	0	26	0	7	4	3	0	2	1	1	21	2
RET3	2020	34	1	26	0	7	4	3	0	2	1	1	24	2
	2021	25	1	21	0	5	3	2	0	2	0	1	16	2

Plot ID	Year	Richness	Rare Species	Fire Follower	Native Disturbed	Nitrogen Fixing	Weed	Cal-Ipc High	Cal-Ipc Moderate	Cal-Ipc Limited	Shrub	Herb	Geophyte	Grass
RET4	2020	39	0	34	0	10	4	2	0	2	0	0	31	1
	2021	32	0	29	0	9	4	3	0	2	1	1	24	2
UNBURN 1	2020	27	0	22	0	6	4	2	0	1	1	0	19	2
	2021	27	0	24	0	5	3	3	0	2	1	1	18	2
UNBURN 2	2020	28	1	21	0	5	2	3	0	2	1	0	19	2
	2021	23	1	18	0	5	2	3	0	2	1	1	14	2
UNBURN 3	2020	33	0	26	0	10	5	5	0	2	3	0	25	2
	2021	32	1	25	0	8	4	5	1	2	2	1	24	2
UNBURN 4	2020	44	1	36	0	11	5	4	0	2	2	0	34	2
	2021	33	1	27	0	8	4	5	1	2	2	1	24	2

APPENDIX C PERCENT COVER BY PLOT

Plot ID	Year	Absolute cover	Absolute Cover Native	Relative Cover Native	Absolute Cover Rare Species	Relative Cover Rare Species	Absolute Cover Fire Follower	Absolute Cover Native Disturbed	Relative Cover Native Disturbed	Absolute Cover Nitrogen Fixing	Relative Cover Nitrogen Fixing	Absolute Cover Weeds	Relative Cover Weeds	Absolute Cover Shrubs	Relative Cover Shrubs	Absolute Cover Herbs	Relative Cover Herbs	Absolute Cover Geophyte	Relative Cover Geophyte	Absolute Cover Grass	Relative Cover Grass
BURN1	2020	56.47	33.18	58.75	0	0	0	16.82	29.79	8.21	14.53	23.29	41.25	0	0	17.91	31.72	2.72	4.82	35.82	63.44
	2021	39.26	28.60	72.85	0	0	0	11.76	29.96	4.43	11.27	10.66	27.15	0	0	18.09	46.07	1.75	4.46	19.31	49.18
BURN2	2020	36.24	14.93	41.19	0.06	0.16	0	6.35	17.53	4.38	12.09	21.26	58.69	0	0	12.66	34.94	0.31	0.85	23.26	64.20
	2021	32.94	12.49	37.90	0.03	0.09	0	1.81	5.49	0.51	1.56	20.46	62.10	0.76	2.32	8.84	26.83	0.74	2.23	22.60	68.62
BURN3	2020	42.07	14.15	33.62	0	0	0	4.53	10.77	2.62	6.22	27.49	65.33	0	0	14.78	35.13	0.03	0.07	27.26	64.80
	2021	39.94	15.34	38.40	0	0	0	2.15	5.38	0.60	1.51	24.59	61.56	2.91	7.29	10.71	26.80	0.03	0.07	26.29	65.83
BURN4	2020	39.90	14.99	37.56	2.29	5.75	0	3.43	8.59	3.12	7.81	24.84	62.26	0	0	14.69	36.82	0.19	0.48	25.01	62.70
	2021	27.87	11.79	42.32	0.04	0.16	0	1.71	6.12	0.90	3.22	16.00	57.41	0.35	1.27	9.29	33.35	0.19	0.69	18.03	64.70
DOZE1	2020	90.28	1.76	1.95	0	0	0	0.57	0.64	0.41	0.46	88.46	97.98	0	0	2.47	2.74	0	0	87.81	97.26
	2021	35.66	10.90	30.56	0	0	0	6.13	17.20	3.31	9.28	24.76	69.44	0	0	10.49	29.40	0.24	0.66	24.94	69.94
DOZE2	2020	58.47	11.74	20.07	0	0	0	3.54	6.06	1.26	2.16	46.74	79.93	0	0	9.59	16.40	0.31	0.53	48.57	83.07
	2021	34.21	26.57	77.69	0	0	0	9.09	26.57	3.74	10.92	7.44	21.75	0.01	0.04	18.10	52.92	1.46	4.26	14.63	42.78
DOZE3	2020	48.99	23.18	47.31	0.65	1.32	0	13.00	26.54	1.18	2.40	25.78	52.63	0	0	10.65	21.74	0.79	1.62	37.54	76.64
	2021	27.96	20.03	71.65	0.66	2.37	0	4.59	16.41	0.72	2.58	6.28	22.46	0.35	1.26	14.24	50.92	1.41	5.05	11.96	42.77
DOZ4	2020	43.40	6.28	14.47	0.19	0.44	0	2.03	4.68	1.38	3.19	37.06	85.39	0	0	5.29	12.20	0.07	0.17	38.03	87.63
	2021	33.37	6.26	18.77	0.03	0.09	0	1.40	4.19	0.84	2.51	27.09	81.18	0.15	0.44	5.90	17.67	0.09	0.26	27.24	81.62
RET1	2020	60.90	16.66	27.36	0.07	0.12	0	5.63	9.25	1.16	1.91	44.24	72.64	0	0	14.32	23.52	0.19	0.31	46.38	76.17
	2021	36.63	17.10	46.69	0	0	0	9.12	24.89	1.46	3.97	19.53	53.31	1.44	3.93	9.04	24.69	0.26	0.72	25.88	70.65
RET2	2020	69.15	50.79	73.46	0.01	0.02	0	39.81	57.57	1.46	2.11	18.34	26.52	0	0	10.09	14.59	1.78	2.57	57.28	82.84

Plot ID	Year	Absolute cover	Absolute Cover Native	Relative Cover Native	Absolute Cover Rare Species	Relative Cover Rare Species	Absolute Cover Fire Follower	Absolute Cover Native Disturbed	Relative Cover Native Disturbed	Absolute Cover Nitrogen Fixing	Relative Cover Nitrogen Fixing	Absolute Cover Weeds	Relative Cover Weeds	Absolute Cover Shrubs	Relative Cover Shrubs	Absolute Cover Herbs	Relative Cover Herbs	Absolute Cover Geophyte	Relative Cover Geophyte	Absolute Cover Grass	Relative Cover Grass
	2021	41.84	32.47	77.61	0	0	0	16.32	39.02	0.82	1.97	9.13	21.83	0.24	0.56	12.46	29.77	1.99	4.75	27.15	64.89
RET3	2020	72.74	37.90	52.10	0.04	0.06	0	27.79	38.21	0.46	0.63	34.37	47.25	0.41	0.57	8.29	11.40	1.10	1.52	62.93	86.51
	2021	44.88	29.79	66.38	0.01	0.03	0	15.81	35.22	0.85	1.90	10.97	24.44	1.21	2.69	12.22	27.23	0.93	2.06	30.53	68.02
RET4	2020	64.91	12.41	19.12	0	0	0	5.43	8.36	0.72	1.11	52.41	80.74	0	0	8.32	12.82	0.03	0.05	56.56	87.13
	2021	47.16	32.75	69.44	0	0	0	9.22	19.55	1.46	3.09	14.41	30.56	1.91	4.05	20.07	42.56	0.06	0.12	25.12	53.26
UNBURN 1	2020	63.99	38.60	60.33	0	0	0	20.96	32.75	2.26	3.54	25.37	39.65	0	0	14.25	22.27	0.96	1.49	48.74	76.17
	2021	42.82	38.76	90.52	0	0	0	9.10	21.26	3.51	8.21	4.06	9.48	0.24	0.55	20.94	48.90	2.62	6.11	19.03	44.44
UNBURN 2	2020	38.60	12.51	32.42	0.35	0.91	0	7.57	19.62	5.75	14.90	26.00	67.35	0	0	10	25.90	0.16	0.42	28.44	73.68
	2021	17.15	7.00	40.82	0.28	1.63	0	1.57	9.18	0.93	5.40	10.07	58.75	1.59	9.26	4.40	25.64	0.34	1.97	10.82	63.12
UNBURN 3	2020	59.24	12.18	20.56	0	0	0	5.03	8.49	4.24	7.15	46.93	79.22	0	0	11.60	19.59	0.28	0.47	47.35	79.94
	2021	35.38	8.71	24.61	0.01	0.04	0	0.97	2.74	0.49	1.37	26.63	75.27	0.07	0.21	7.50	21.20	0.53	1.50	27.28	77.10
UNBURN 4	2020	61.57	17.94	29.14	2.85	4.63	0	2.35	3.82	1.76	2.87	42.40	68.86	0	0	15.43	25.05	1.43	2.32	44.72	72.63
	2021	35.96	15.93	44.29	0.85	2.37	0	4.07	11.33	3.81	10.59	20.03	55.71	1.06	2.94	14.40	40.04	0.31	0.86	20.19	56.16

APPENDIX D ANOVA, KRUSKAL-WALLIS, AND WILCOXON TEST STATISTICS

Response	Fixed Effect	df[1]	F[2]	Chi-squared[3]	W[4]	P
Species richness	Treatment	3, 24	3.697	---	---	0.0256
	Year	1, 24	7.936	---	---	0.0095
	Trt x Yr	3, 24	0.120	---	---	0.947
Absolute cover	Treatment	3, 24	3.064	---	---	0.0473
	Year	1, 24	32.220	---	---	7.59e-06
	Trt x Yr	3, 24	1.289	---	---	0.301
Native richness	Treatment	3, 24	4.099	---	---	0.0175
	Year	1, 24	4.801	---	---	0.0384
	Trt x Yr	3, 24	0.086	---	---	0.9672
Native relative cover	Treatment	3, 24	1.085	---	---	0.3745
	Year	1, 24	5.625	---	---	0.0261
	Trt x Yr	3, 24	0.470	---	---	0.7058
Life Form Categories						
Grass richness	Treatment	3, 24	2.418	---	---	0.0911
	Year	1, 24	0.358	---	---	0.5551
	Trt x Yr	3, 24	0.179	---	---	0.9095
Grass relative cover	Treatment	3	---	5.5199	---	0.1375
	Year	---	---	---	209	0.0017
Herb richness	Treatment	3, 24	2.259	---	---	0.1074
	Year	1, 24	12.370	---	---	0.0018
	Trt x Yr	3, 24	0.256	---	---	0.8566
Herb relative cover	Treatment	3	---	5.6477	---	0.1301
	Year	---	---		53	0.0039
Geophyte richness	Treatment	3, 24	2.333	---	---	0.099
	Year	1, 24	0.500	---	---	0.4863
	Trt x Yr	3, 24	0.167	---	---	0.9178
Geophyte relative cover	Treatment	3	---	0.875	---	0.8315
	Year	---	---	---	82	0.0865
Shrub richness	Treatment	3	---	1.3373		0.7203
	Year	---	---	---	24	6.45e-6

Response	Fixed Effect	DF[1]	F[2]	Chi-squared[3]	W[4]	P
Shrub relative cover	Treatment	3	---	2.2415		0.5238
	Year	---	---	---	22	1.62e-5
Herbaceous Categories						
Native disturbed richness	Treatment	3, 24	0.203	---	---	0.8931
	Year	1, 24	5.927	---	---	0.0227
	Trt x Yr	3, 24	0.073	---	---	0.9738
Native disturbed relative cover	Treatment	3, 24	2.881	---	---	0.0568
	Year	1, 24	0.012	---	---	0.9120
	Trt x Yr	3, 24	0.376	---	---	0.7710
Nitrogen fixer richness	Treatment	3	---	2.45	---	0.4844
	Year	---	---	---	201.5	0.0037
Nitrogen fixer relative cover	Treatment	3, 24	3.545	---	---	0.0296
	Year	1, 24	0.033	---	---	0.8577
	Trt x Yr	3, 24	2.728	---	---	0.0663
Rare species richness	Treatment	3	---	0.365	---	0.9474
	Year	---	---	---	136	0.744
Rare species relative cover	Treatment	3	---	2.061	---	0.5598
	Year	---	---	---	142	0.5912
Weed richness	Treatment	3, 24	0.886	---	---	0.462
	Year	1, 24	0.389	---	---	0.539
	Trt x Yr	3, 24	0.554	---	---	0.650
Weed relative cover	Treatment	3, 24	1.109	---	---	0.3648
	Year	1, 24	5.928	---	---	0.0227
	Trt x Yr	3, 24	0.558	---	---	0.6482

[1] Degrees of freedom for ANOVA and Kruskal-Wallis tests.
[2] F statistic for ANOVA.
[3] Chi-squared statistic for Kruskal-Wallis tests when data did not meet assumptions for ANOVA.
[4] W statistic for Wilcoxon tests when data did not meet assumptions for ANOVA.

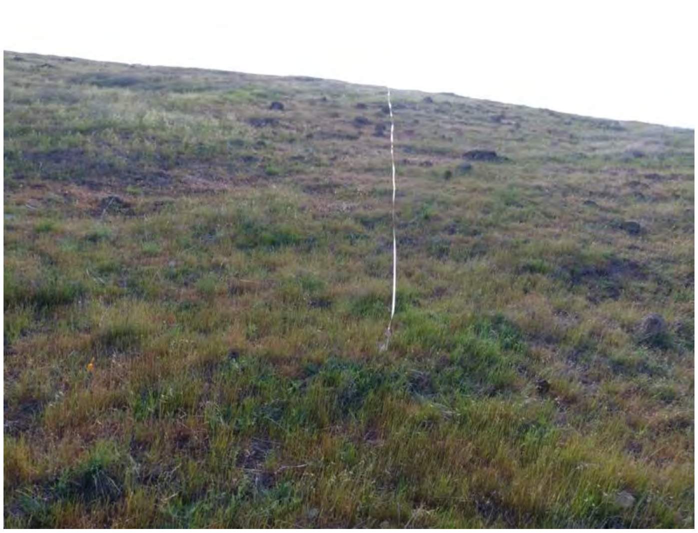
APPENDIX E VEGETATION COMPOSITION PLOTS PHOTO APPENDIX

Plot Burn1
2020 4/02/20 8:34 am


Plot Burn1
2021 4/08/21 9:52 am


Plot Burn2
2020 4/03/20 8:26 am

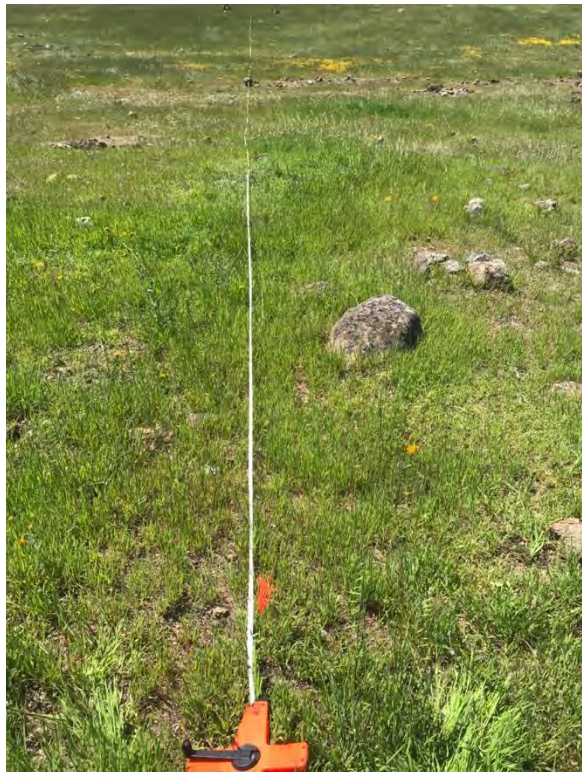

Plot Burn2
2021 4/09/21 8:35 am




Plot Burn3
2020 4/03/20 10:18 am


Plot Burn3
2021 4/09/21 9:55 am

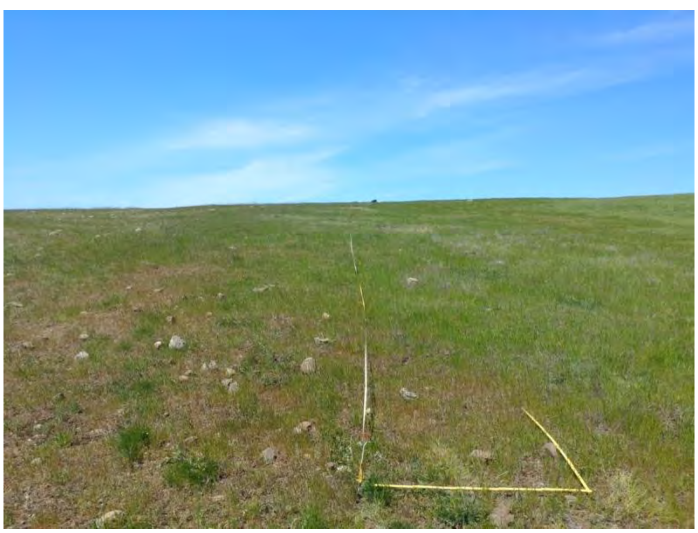

Plot Burn4
2020 4/03/20 12:234 pm



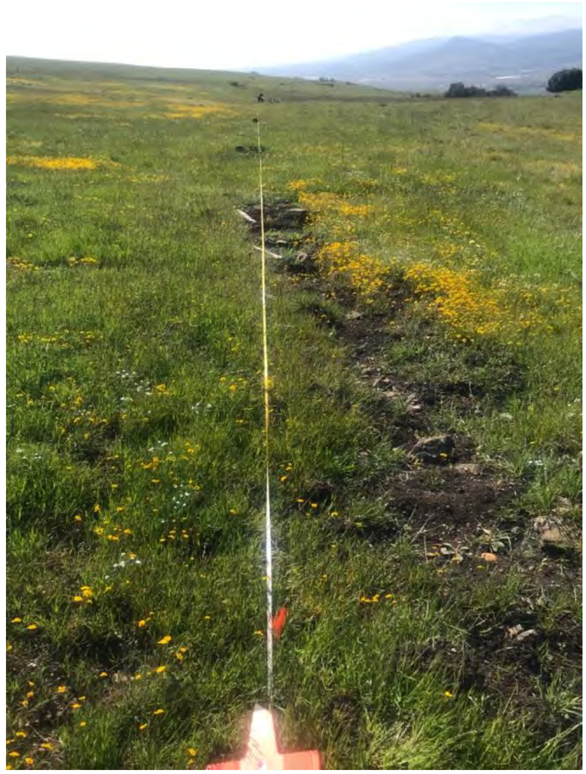
Plot Burn4
2021 4/09/21 12:05 pm

Plot Doze1
2020 4/01/20 8:36 am

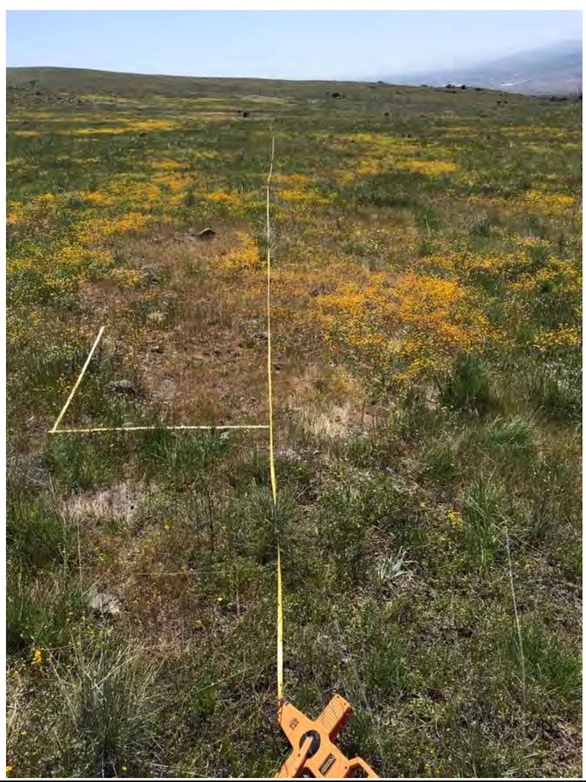

Plot Doze1
2021 4/08/21 1:36 pm




Plot Doze2
2020 4/01/20 10:45 am

Plot Doze2
2021 4/08/21 11:42 am

Plot Doze3
2020 4/02/20 10:00 am


Plot Doze3
2021 4/09/21 12:25 pm


Plot Doze4
2020 4/02/20 12:14 pm

Plot Doze4
2021 4/09/21 10:00 am

Plot Ret1
2020 4/01/20 9:20 am

Plot Ret1
2021 4/08/21 12:00 pm

Plot Ret2
2020 4/01/20 12:10 pm

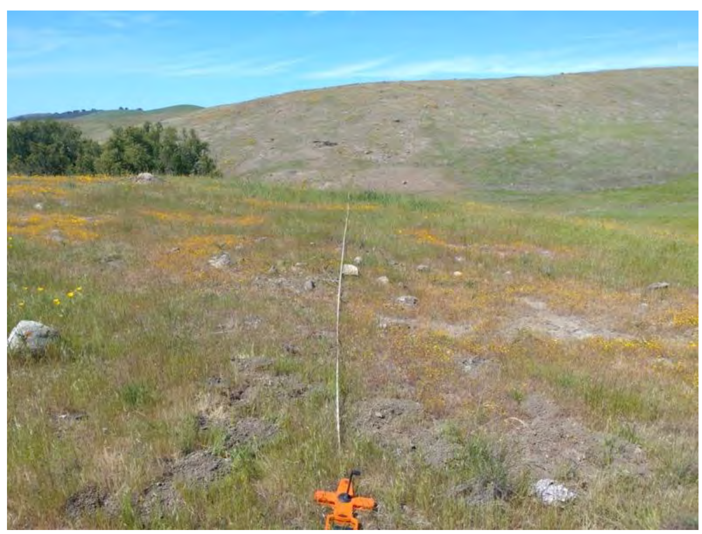

Plot Ret2
2021 4/08/21 1:37 pm


Plot Ret3
2020 4/01/20 1:27 pm

Plot Ret3
2021 4/08/21 2:54 pm

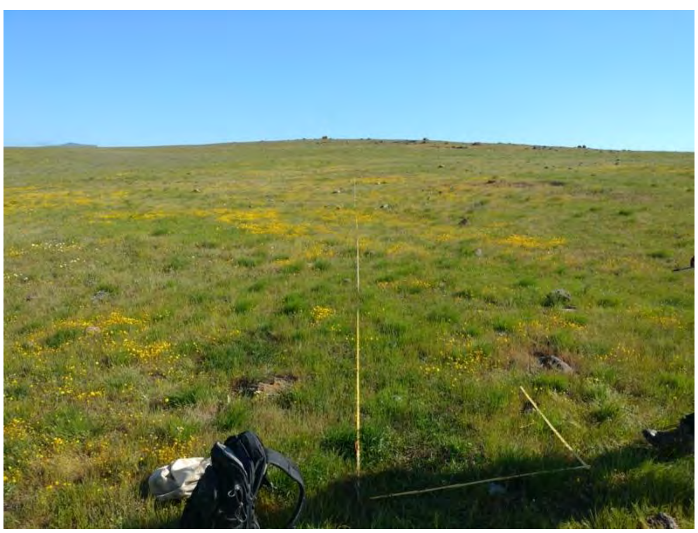
Plot Ret4
2020 4/01/20 2:42 pm

Plot Ret4
2021 4/08/21 2:34 pm

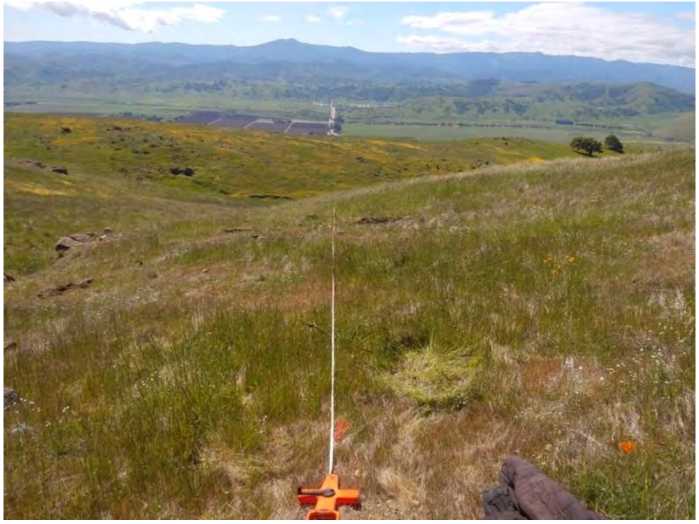


Plot Unburn1
2020 3/31/20 8:42 am


Plot Unburn1
2021 4/08/21 9:30 am




Plot Unburn2
2020 3/31/20 11:49 am

Plot Unburn2
2021 4/09/21 1:48 pm


Plot Unburn3
2020 3/31/20 2:14 pm


Plot Unburn3
2021 4/09/21 1:30 pm


Plot Unburn4
2020 4/2/20 1:45 pm


Plot Unburn4
2021 4/09/21 8:27 am


APPENDIX F 2020 TRAINING POLYGON STATISTICS

STATISTIC	BAND 1	BAND 2	BAND 3
Lessingia			
Minimum	58	55	52
Maximum	94	87	81
Mean	75.43	71.15	66.47
Std.dev	9.94	8.69	8.45
Grassland-light			
Minimum	100	93	82
Maximum	165	149	132
Mean	129.56	116.52	101.83
Std.dev	14.28	11.26	10.21
Grassland-medium			
Minimum	65	54	41
Maximum	143	129	115
Mean	99.77	81.33	63.80
Std.dev	15.46	14.51	13.19
Grassland-dark			
Minimum	49	42	34
Maximum	142	121	98
Mean	89.46	74.48	61.01
Std.dev	19.69	18.16	16.69
Tree-light			
Minimum	6	10	7
Maximum	82	86	65
Mean	52.10	68.00	47.58
Std.dev	12.24	12.79	9.11
Tree-dark			
Minimum	10	15	13
Maximum	51	62	51
Mean	35.86	45.10	36.02
Std.dev	11.70	13.20	11.20
Burned Tree			
Minimum	18	20	19
Maximum	66	64	70
Mean	44.75	46.09	48.68
Std.dev	11.65	10.83	11.59

APPENDIX G 2021 TRAINING POLYGON STATISTICS

STATISTIC	BAND 1	BAND 2	BAND 3
Lessingia			
Minimum	97	98	98
Maximum	182	175	171
Mean	155.11	149.74	140.65
Std.dev	16.93	17.13	16.46
Grassland-light			
Minimum	181	179	161
Maximum	228	231	218
Mean	196.01	191.11	177.91
Std.dev	12.32	12.64	13.43
Grassland-medium			
Minimum	165	142	120
Maximum	199	187	171
Mean	183.51	164.48	143.01
Std.dev	9.89	10.07	10.06
Grassland-dark			
Minimum	122	101	89
Maximum	197	176	156
Mean	163.25	141.31	122.09
Std.dev	19.46	20.49	19.18
Tree-light			
Minimum	34	52	36
Maximum	162	185	111
Mean	99.37	117.26	78.89
Std.dev	26.78	27.65	17.37
Tree-dark			
Minimum	18	23	22
Maximum	89	100	81
Mean	50.80	58.76	50.87
Std.dev	19.36	20.59	14.89
Burned Tree			
Minimum	53	55	60
Maximum	155	153	151
Mean	98.41	100.75	106.77
Std.dev	27.14	26.33	25.11