

**ESTABLISHING A BASELINE FOR SMOOTH LESSINGIA  
(*LESSINGIA MICRADENIA* VAR. *GLABRATA*)  
POPULATIONS USING HIGH-RESOLUTION  
MULTISPECTRAL AERIAL IMAGERY**

**SANTA CLARA VALLEY HABITAT CONSERVATION PLAN /  
NATURAL COMMUNITY CONSERVATION PLAN**



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## Section 1. INTRODUCTION

Funded by the 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) proposed to provide baseline data for the distribution and abundance of smooth lessingia (*Lessingia micradenia* var. *glabrata*) within the Santa Clara Valley Habitat Plan Habitat Conservation Plan/Natural Community Conservation Plan (Plan) area. This project is intended to inform conservation strategy, monitoring, and adaptive management implementation of smooth lessingia. The impetus for this project is based on a successful remote sensing methodology Nomad implemented for smooth lessingia and rock outcrop habitat on a smaller scale at the Calero Conservation Easement located east of Morgan Hill, in the southern portion of the plan area (Nomad 2018).

The Plan covers a 519,506-acre area in the Santa Clara Valley of Santa Clara County (Figure 1). The Habitat Agency and its partners have acquired approximately 6,493 acres of land for the Reserve System for the Plan as of February 2021 with the goal of protecting approximately 46,496 acres by Year 45 of the permit term. Some of the most important steps in Plan implementation include achieving biological goals and objectives for individual covered species and the implementation of a long-term adaptive management and monitoring program. For plants, these goals and objectives typically target a specific number of populations and minimum number of individuals to be preserved. Collecting baseline data and mapping distribution and abundance of biological resources is a critical first step in planning and implementing conservation and adaptive management goals and actions.

Smooth lessingia is an annual plant of the sunflower family (Asteraceae), a serpentine obligate, and endemic to Santa Clara County. This species occurs in serpentine rock outcrop and serpentine bunchgrass grassland habitat, both of which are also of conservation concern for the Habitat Agency, and has been assigned population-based conservation goals.



Smooth lessingia inflorescence.

After preliminary data collection, remote sensing model creation, ground-truthing, and model adjustment, smooth lessingia was found to occupy approximately 2,660 acres within the entire study area and comprised 72 populations. Of the 72 populations, 50 of them were new occurrences, and all except three met the required minimum Plan conservation goal of 2,000 individuals. Populations were placed into confidence tiers based on the amount of corroborating evidence such as hand-mapping, ground-truthing, or CNDDDB data. A total of 20 populations were allocated to Tier 1, 5 populations were allocated to Tier 2, and the remaining 47 populations were allocated to Tier 3. This report includes a description of these populations, the estimated number of individuals, and whether they were previously reported in CNDDDB.

## **1.1. PROJECT PURPOSE**

This project is designed to provide crucial information related to baseline conditions of smooth lessingia under the Habitat Agency's stewardship, which has yet to be systematically mapped within the Plan area. Utilizing presence and abundance data collected in the field and high-resolution multi-spectral aerial imagery, this project aimed to identify and map the occupied areas within habitat modeled for this species as a part of the development of this Plan. Monitoring of existing populations using remote sensing techniques such as this is easily replicable to help ensure established populations are persisting and continue to meet the Plan expectations for population size, buffers from negative influences, and to assess if population expansion has occurred.

### **1.1.1 MODELED HABITAT AS A PROXY FOR SMOOTH LESSINGIA OCCURRENCES**

The Plan objective for smooth lessingia is to protect at least 12 occurrences and locate or create at least 12 new occurrences, where each occurrence contains a minimum of 2,000 individuals (ICF 2012). During the development of the Plan, 39 occurrences of smooth lessingia were identified within the permit area from various sources, however only eight of those provided adequate information to evaluate whether they meet the requirements for number of individuals (ICF 2012). Additionally, only a fraction of suitable habitat mapped in the Plan area is occupied according to populations identified and recorded in the CNDDDB (CDFW 2019). Areas such as Coyote Ridge, Llagas Creek Watershed, New Almaden, Santa Teresa Hills, and Uvas Creek Watershed are rich with suitable habitat but do not contain CNDDDB records of smooth lessingia. This is likely due to a lack of rare plant surveys or inaccessibility due to private ownership.

However, recent surveys of Plan reserve lands indicate that populations of smooth lessingia are more widespread than previously recorded. In the Coyote Ridge Open Space Preserve, nearly all suitable habitat was found to be occupied as one contiguous occurrence containing millions of plants (Creekside 2018). It is feasible that smooth lessingia spans suitable habitat across the entirety of Coyote Ridge. In Calero County Park conservation easement, the serpentine grassland habitat is patchier; however, it was also found to be occupied by smooth lessingia (Nomad 2018).

### **1.1.2 USING REMOTE SENSING TO DETECT SMOOTH LESSINGIA**

In some cases, rare plant species like smooth lessingia grow in such high abundance and density that populations or colonies of these plants have a different hue or texture on the landscape that is visible from a considerable distance. Smooth lessingia, which has a reddish-brown hue, also blooms late in the summer which accentuates this contrast from the dry annual grasslands it grows in. This characteristic of smooth lessingia compared to the habitat it occupies allows for sophisticated remote sensing techniques to be employed, using aerial imagery, to map new occurrences in areas that are on inaccessible lands or in locations where landscape-scale metapopulations are more difficult to map from ground-level. Monitoring of existing populations using remote sensing techniques such as this, or with drones, is also replicable to help ensure established populations are persisting and continue to meet the Plan expectations for population size, buffers from negative influences, and to assess if population expansion has occurred.

Multi-spectral datasets derived from this high-resolution imagery included natural color, as seen by the naked eye; and normalized difference vegetation index (NDVI), which depicts live green or dead vegetation. Remote sensing techniques utilizing these various bands of high-resolution multi-spectral imagery, coupled with on-the-ground fieldwork, can allow for the identification of target resources and threats on preserves with greater efficiency and accuracy than using an on-the-ground fieldwork approach alone.



December 2020

LAG Report

**Legend**

- Parcels Accessible to the Habitat Agency
- Habitat Plan Permit Area

**Figure 1**  
**Location of the Habitat Plan Permit Area**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy

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**NOMAD**  
ECOLOGY

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Miles

Sources: National Geographic, ESRI, Santa Clara Valley Habitat Plan. Projection: NAD 83 UTM Zone 10 North.

## 1.2. PROJECT GOALS

Due to the difficulty of mapping landscape-scale features such as abundant and contiguous covered plant populations of smooth lessingia, more sophisticated remote sensing methodologies can be employed. The primary goal of this project was to conduct a remote sensing-based analysis along with field data collection and targeted ground-truthing to compile baseline information on smooth lessingia populations in areas of modeled primary habitat totaling approximately 10,491 acres (Figure 1). The results of this effort can then be used to guide the Habitat Agency's land acquisitions that include smooth lessingia populations, which can then be enrolled into the Habitat Plan Reserve System. These results can also be used as a baseline from which to monitor these populations into the future utilizing this same methodology. Efforts associated with this project aim to meet the following goals:

- A. The mapping goals of this project are to improve upon the previous modeling of primary habitat for smooth lessingia (Figure 1) by using on-demand high-resolution multispectral imagery coupled with data collection and targeted ground-truthing of accessible parcels.
- B. The data associated with these polygons would estimate population abundance and include population attributes that would inform the Habitat Agency on the environmental gradients that each population occupies or represents, external influences that may be constraints or opportunities for population acquisition or expansion, and which parcels would be the most beneficial to acquire to meet conservation goals and objectives of the Plan for smooth lessingia.
- C. The monitoring goals of this project are to set a baseline of smooth lessingia spatial distribution and population information from which future monitoring and adaptive management can be based. Following acquisitions that include smooth lessingia populations, monitoring must be conducted per requirements of the Plan. Various monitoring intervals are identified by the Plan depending on attributes of individual covered plant species. As a Group 2 species, the Plan requires smooth lessingia be monitored every 2 to 3 years (Chapter 7, Section 7.3.3 of the VHP).
- D. One of the deliverables of this project will be the high-resolution aerial imagery collected during the month of September 2019. Acquiring a high-resolution aerial imagery dataset is an ideal source of information from which to accurately map the distribution and boundaries of this type of covered plant species for preserve acquisition or management plan development, as well as conducting change detection of these populations at regular intervals, decades into any Natural Community Conservation Plan. This is especially useful if this aerial imagery is taken at appropriate intervals in subsequent years, as it can be used to identify and analyze changes in vegetation, such as population fluctuations or trends of smooth lessingia.

Goals and conservation measures identified in the Plan conservation strategy include those for covered plants, exotic plant control, habitat enhancement and restoration, grassland management, as well as monitoring and adaptive management needs. The following goals and conservation measures of the Plan are addressed as a part of this project:

- Goal 20: Maintain viability, protect, and increase the size and number of populations of covered serpentine plant species, including...smooth lessingia...within the Plan area.
  - This project achieves the objectives of this conservation measure by identifying the distribution of and estimating population size of smooth lessingia so the Habitat Agency can effectively plan and implement efforts aimed at protecting smooth lessingia populations.
- Objective 20.11: Protect at least 12 occurrences of smooth lessingia as part of the Reserve System within the study area, including a buffer zone of 150-meter (500 foot) around each occurrence to reduce external influences and promote expansion of occurrences.

- Mapping the distribution of smooth lessingia allows for the identification of occurrences and buffer zones.
- Objective 20.12: Locate or create at least 12 new occurrences of smooth lessingia and increase the size of all occurrences to ensure each occurrence has at least 2,000 individuals within the Reserve System.
  - Mapping smooth lessingia in previously unmapped locations has located new occurrences and estimated population sizes in all occurrences. Having baseline high-resolution aerial imagery allows for long- and short-term change detection in distribution and population size if this aerial imagery is taken at regular intervals in subsequent years.

### 1.3. STUDY AREA

The approximately 10,491-acre study area (Figure 1) for this project includes all of the modeled primary smooth lessingia habitat that was developed as a part of the Habitat Plan. Within this acreage, 11 protected lands areas (preserves) were accessible for collecting field data necessary to calibrate remote sensing of smooth lessingia populations. It should be noted that the majority of the preserves listed below have not yet been formally enrolled in the Reserve System. Additionally, while some of the properties below may eventually be enrolled in the Reserve System, some are “dedicated” and may not easily be added.

- **Almaden Quicksilver County Park** is a 2,433-acre park on the west side of Santa Clara Valley, west of Santa Teresa County Park. It is owned by Santa Clara County.
- **Anderson Lake County Park** is a 340-acre park on the east side of Santa Clara Valley, adjacent to Coyote Ridge. It is owned by Santa Clara County.
- **Calero CE** is a 3,085-acre<sup>1</sup> easement on the west side of Santa Clara Valley, adjacent to Rancho San Vicente and Calero County Park. It is owned by SCVWD and Santa Clara County.
- **Calero County Park** is a park on the west side of Santa Clara Valley adjacent to Calero CE. This preserve is comprised of approximately 535 acres<sup>1</sup> and is owned by SCVWD, and Santa Clara County.
- **Coyote Lake - Harvey Bear Park** is a 468-acre park on the east side of Santa Clara Valley in the southern end of the study area. It is owned by Santa Clara County.
- **Coyote Ridge** is a 3,325-acre preserve located in the northern end of the study area on the east side of Santa Clara Valley. It is owned by SCVWD, Santa Clara Valley Open Space Authority, and Santa Clara Valley Transit Authority (VTA). This is the only accessible preserve that is also currently enrolled in the Habitat Agency Reserve System.
- **Palassou Ridge** is a 79-acre preserve on the east side of Santa Clara County, south of Coyote Lake-Harvey Bear. It is owned by Santa Clara Valley Open Space Authority.
- **Rancho Cañada del Oro** is a 1,436-acre preserve on the west side of Santa Clara Valley south of Calero County Park. It is owned by Santa Clara Valley Open Space Authority.
- **Rancho San Vicente** is a preserve on the west side of Santa Clara Valley, south of Santa Teresa County Park. This preserve is comprised of approximately 183 acres<sup>1</sup> adjacent to Calero CE and is

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<sup>1</sup> Provided shapefiles contained overlapping parcels between Rancho San Vicente, Calero CE, and Calero County Park, so the exact boundaries of these preserves was unclear. It was assumed that Calero CE comprised the parcels matching the study area from the 2017 Covered Plant Species Inventory (Nomad 2018). Two parcels not overlapping with Calero CE were considered part of Calero County Park, and one parcel was considered part of Rancho San Vicente.

owned by Santa Clara Valley Water District (SCVWD) and Santa Clara County. Provided shapefiles contained overlapping parcels between Rancho San Vicente, Calero CE, and Calero County Park, so the exact boundaries of this preserve were unclear.

- **Santa Teresa County Park** is a 1,124-acre park on the west side of Santa Clara Valley in the northern end of the study area. It is owned by Santa Clara County and American Tower Systems, Inc.
- **Tulare Hill** is a 138-acre preserve in the northern end of the study area, just west of Coyote Ridge. It is owned by the County of Santa Clara.

Additionally, the study area (all modeled primary smooth lessingia habitat) overlaps with several other Habitat Agency Reserves (currently part of the Reserve System) that were not part of the accessible parcels visited for this study. Parcels in the Santa Clara Habitat Agency Reserve System include: Tulare Hill Wedge Reserve, Coyote Ridge Open Space Preserve, East Coyote Ridge Reserve, Tilton Ranch Reserve, Tilton Ranch South Reserve, Davidson Reserve, Uvas South Reserve, and Pacheco Creek Reserve (Santa Clara Valley Habitat Agency 2021). The study area is further described in *Section 3. Environmental Setting*.

## 1.4. TARGET RESOURCES

This study targeted smooth lessingia within modeled primary habitat including serpentine grassland and rock outcrops. To a lesser extent, smooth lessingia found growing outside of modeled habitat was also mapped by hand during preliminary data collection and ground-truthing. Smooth lessingia was targeted based on Plan goals and objectives, the difficulty of mapping and monitoring landscape-scale populations of smooth lessingia, and its suitability for remote sensing techniques due to its unique color and growing season compared to the surrounding habitat.

### Smooth lessingia (*Lessingia micradenia* var. *glabrata*)

#### *Status, Distribution and Habitat Requirements*

Smooth lessingia [*Lessingia micradenia* Greene var. *glabrata* (D.D. Keck) Ferris<sup>2</sup>] 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 2020a). It is an annual herb in the sunflower family (Asteraceae). The type locality<sup>3</sup> 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).

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<sup>2</sup> In botanical literature 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.

<sup>3</sup> 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.



Smooth lessingia in flower.

It 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 0.08 to 0.8 inches (0.2 to 2 centimeters) long as well as 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 2020a).

This species is supported by serpentine substrates, often on roadsides in chaparral, cismontane woodland, and valley foothill grassland between 394 and 1,378 feet (120 and 420 meters) (CNPS 2020a). It is currently recorded as occurring only in Santa Clara county (Ibid.). The CNPS Inventory indicates that this species is potentially threatened by development, vehicles, and possibly non-native plants (CNPS 2020a).



Serpentine grassland at Rancho Cañada del Oro preserve. Smooth lessingia gives the slope a reddish-hue.

## Section 2. STUDY METHODS

The general approach of this project was to utilize a combination of high-resolution multi-spectral aerial imagery supported by initial hand mapping in the field to create a landscape-scale occupancy map of smooth lessingia. Aerial imagery was taken in the fall only in modeled primary habitat, due to cost limitations, to leverage the phenology of smooth lessingia against other grassland species. The red-brown hue of dense stands of smooth lessingia and the signature of serpentine soils and rock outcrops differentiated smooth lessingia from other grassland habitat. Conducting initial field mapping of smooth lessingia, by hand in accessible parcels, allowed for a comparison of remote sensing and hand-mapping techniques from accessible parcels and facilitated model calibration and mapping of smooth lessingia outside of modeled primary habitat.

The process consisted of four general phases: 1) preliminary field data collection, 2) creating the remote sensing model, 3) conducting an accuracy assessment by collecting ground-truthing plots in the field, and 4) model adjustment based on the results of ground-truthing. The first phase, collecting preliminary field data, included reconnaissance quadrats and field mapping polygon methodologies. The second phase included heads-up digitizing of field data and using the segmentation and classification tools in ArcMap for image analysis. In the third phase, accuracy of mapping methodology results was tested by visiting reconnaissance points within final polygons as well as comparing points from preliminary field data collection to the classified polygons. Finally, the fourth phase consisted of modifying smooth lessingia polygons to reflect the results of ground-truthing.

### 2.1. BACKGROUND RESEARCH AND DATA RESOURCES

Background information was compiled and methodology informed by review of the following resources:

- Coyote Ridge Open Space Preserve Annual Report 2018 (Creekside 2019)
- Coyote Ridge Open Space Preserve Baseline Surveys 2016-2017 (Creekside 2018)
- ESRI Spatial Analyst documentation (2020)
- Fine-scale mapping of a grassland from digitized aerial photography: an approach using image segmentation and discriminate analysis (Lobo, Moloney and Chiariello 1998)
- Jepson Flora Project (JFP 2020)
- The Jepson Manual: Higher Plants of California, Second edition (Baldwin et al. 2012)
- A Manual of California Vegetation (MCV), Second Edition (Sawyer et al. 2009) and online updates (CNPS 2020b)
- Novel fine-scale aerial mapping approach quantifies grassland weed cover dynamics and response to management (Malmstrom, et al. 2017)
- Rule-based classification of multi-temporal satellite imagery for habitat and agricultural land cover mapping (Lucas et al. 2007)
- Santa Clara County Habitat Conservation Plan and Natural Community Conservation Plan (ICF International 2012)

Botanical taxonomy and nomenclature conform to *The Jepson Manual* (Baldwin et al. 2012), with the exception of recent circumscriptions posted on the Jepson Flora Project (JFP 2020) website updates. Common names of plant species are derived from the Calflora Database (Calflora 2020).

### 2.1.1 AERIAL PHOTOGRAPHY DATASET

Nomad coordinated with TerrAvion (a fixed-wing aerial imagery provider) to arrange the high-resolution multi-spectral aerial imagery flyover schedule for the study area. Image capture occurred in September 2019. The timing of the flights was intended to target the summer dormancy period of non-native annual grasses and peak bloom period for smooth lessingia. Overall, there were three flyover dates including; September 3<sup>rd</sup>, September 4<sup>th</sup>, and September 6<sup>th</sup> 2019. The imagery datasets were delivered by TerrAvion as georectified normal color (NC) and NDVI TIFF images compatible with existing GIS datasets. Supplementary imagery that was also evaluated included imagery served through Google Earth and ESRI satellite basemaps.

## 2.2. PRELIMINARY FIELD DATA COLLECTION

Preliminary field data collection consisted of two parts: smooth lessingia cover and abundance data from quadrats, and mapping the extent of smooth lessingia by hand only from accessible parcels. These two methods were conducted concurrently on smooth lessingia habitat accessible to Nomad botanists in September and October 2019. The purpose of preliminary field data collection was to assist with calibrating the remote sensing model.

Preliminary field data collection targeted modeled smooth lessingia habitat accessible to Nomad botanists that was also accessible by vehicle and/or foot. The preserves that were visited for preliminary field data collection included: Coyote Ridge OSP, Tulare Hill, Santa Teresa, Almaden Quicksilver, Rancho San Vicente, Rancho Cañada del Oro, and Coyote Lake Harvey Bear. Anderson Lake and Palassou Ridge were not visited due to lack of accessibility. Calero County Park Conservation Easement was not targeted because lessingia on this easement had already been mapped in recent years (Nomad 2018).

At each of these preserves, 1 x 1-meter quadrats were semi-randomly placed in areas of occupied smooth lessingia habitat. For each quadrat, a photo was taken, and the GPS location, a visual estimate of smooth lessingia cover, and the number of individuals within the quadrat were recorded. Abundance data were used to get an average number of individuals per acre, which was then used to estimate population size for each smooth lessingia occurrence. Cover data was not used in population estimates, but could be used to determine if certain populations or acquisitions support higher densities of smooth lessingia.

While placement of quadrats was semi-random, a variety of smooth lessingia density, substrates, and aspects were sampled. Data at a total of 371 quadrats were collected, with 151 at Coyote Ridge, 13 at Tulare Hill, 108 at Santa Teresa, 56 at Almaden Quicksilver, 17 at Rancho San Vicente, and 26 at Rancho Cañada del Oro (Table 1). No quadrats were sampled at Coyote Lake Harvey Bear because no smooth lessingia was found growing there. A much smaller number of GPS waypoints, 14, were also recorded where no smooth lessingia was encountered to help calibrate the model.

**Table 1. Reconnaissance Quadrats in Preserves**

NUMBER OF QUADRATS	PRESERVE							TOTAL
	COYOTE RIDGE OSP	TULARE HILL	SANTA TERESA	ALMADEN QUICKSILVER	RANCHO SAN VICENTE / CALERO	RANCHO CAÑADA DEL ORO	COYOTE LAKE HARVEY BEAR	
Smooth lessingia present	151	13	108	56	17	26	0	<b>371</b>
Smooth lessingia absent	5	2	3	4	0	0	0	<b>14</b>

While surveying target preserves, the extent of smooth lessingia was also mapped by hand to further aid in assessing the accuracy of aerial imagery classification. Maps printed at approximately 1:600 to 1:1000 scale from 2018 Google Earth imagery were used to draw patches of smooth lessingia. Hand-mapping focused on the study area polygons (modeled lessingia habitat), but if smooth lessingia was observed outside of the study area, that too was recorded on maps.



Example of a quadrat placed in smooth lessingia habitat at Coyote Ridge preserve.

## 2.3. REMOTE SENSING METHODOLOGY

Following the collection of field data, the remote sensing model was completed using the Spatial Analyst extension in ArcMap 10.7. Model development consisted of downloading the multi-spectral imagery raster files, segmentation, choosing training polygons, training the classifier, and finally, classifying the imagery.

### 2.3.1 HIGH-RESOLUTION MULTI-SPECTRAL IMAGERY

TerrAvion provided both normal color and NDVI raster files. These files were numerous (around 400 individual TIFF files) and could be quite large (around 700 KB and up to 300,000 KB each), so instead of merging imagery for the entire study area, imagery was merged in six sections of the study area surrounding Santa Clara Valley: northwest, northeast, central west, central east, southwest, and southeast. Individual raster files from TerrAvion were merged using the Mosaic to New Raster tool to create NC and NDVI layers for each section.

Manipulation of multi-band aerial imagery helped to better visualize and accentuate smooth lessingia patches within serpentine grassland. Normal color imagery, especially the red band, was useful in detecting the brown-red hue of smooth lessingia, but NDVI was also useful in differentiating trees and shrubs, especially when the normal color was distorted due to steep slopes or shade. The NDVI is an index that uses the near infrared and red bands to calculate a value ranging from -1 to 1, which indicates plant health or vigor.  $NDVI = (NIR - VIS) / (NIR + VIS)$ , where NIR = near infrared and VIS = visible bands. Values in the negative range are often water, values in the zero range are inanimate objects (rock outcrops etc.), and values in the positive range are associated with vegetation. NDVI is used widely to identify drought stress in plants, a potentially valuable tool when trying to differentiate between dead and living plants on the landscape.

### 2.3.2 SEGMENTATION

Segmentation was used on the high-resolution imagery raster files prior to classification. Segmentation is a process where nearby pixels having similar spectral and spatial characteristics get grouped into larger segments, sometimes called super pixels. The Segment Mean Shift tool in ArcMap uses the Mean Shift approach, which is a moving window that calculates the average pixel value to determine which pixels should be included in each segment. Segmentation depends on what spectral detail (on a scale of 1 to 20), spatial detail (on a scale of 1 to 20), and minimum segment size are designated. Higher spectral detail differentiates better between objects with similar spectral characteristics such as different tree species. More spatial detail picks up features that are smaller and more clustered together such as individual shrubs instead of a shrubland. Because smooth lessingia has a subtle color signature in grasslands, a high level of spectral detail was desired. The goal was to map patches of smooth lessingia without ending up with unnecessary noise, or too many minuscule lessingia areas. It was found that a moderate level of spatial detail, and increasing the minimum segment size provided good results for smooth lessingia mapping. For segmenting normal color imagery, spectral detail = 19, spatial detail = 12, and minimum segment size = 40 was used.

The NDVI layer (spectral detail = 19, spatial detail = 15, minimum segment size = 40) and the red band from the normal color imagery (spectral detail = 18, spatial detail = 10, minimum segment size = 1000) were also segmented and tested in classification. However, when designating the model for classification, better results were achieved using segmented normal color raster as the primary raster input than with segmented NDVI or red band rasters.

### 2.3.3 TRAINING POLYGONS

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. Ideally, training polygons only encompass segments (or pixels if the imagery is not segmented) that belong to the class of interest. The spectral characteristics of different classes are often characterized by a normal distribution, and the classification works best when the distributions are different for each class. For example, the spectral distribution of training samples from broadleaf trees might range from 2-4 with a mean of 2, where training samples from roads might range from 0-4 with a mean of 1. It is also helpful for training polygons to reflect the size and shape of the objects in each class. For example, training samples the size of individual trees will help differentiate trees from potentially similar colored objects such as shrubs. Additionally, some classifiers require a statistically significant number of training samples in order to produce meaningful results.

All training polygons were created within the central east section because that section had the largest number of smooth lessingia quadrat locations. Training polygons for smooth lessingia were created from a 0.5-meter buffer around a subset of quadrat locations. Training samples for grassland without smooth lessingia, were based on hand-drawn maps and GPS waypoints from preliminary data collection. Trees, shrubs, and roads could all be easily distinguished on aerial imagery and were selected in ArcMap using TerrAvion imagery. The size and shape of training samples for grassland, trees, shrubs, and road was based on segments from segmented imagery.

### 2.3.4 CLASSIFIER DEFINITION FILE

After training samples were selected, the next step was to train the classifier and generate a classifier definition file. The spatial analyst extension in ArcMap includes four classifiers: Maximum Likelihood, Iso Cluster, Support Vector Machine, and Random Trees. Random Trees and Support Vector Machine classifiers do not require a normal distribution of samples and can work with fewer samples. These two classifiers are newer and used often by researchers (ESRI 2020). A classifier definition file (file ending .ecd) is unique for each classifier, raster inputs, and training sample attributes. It was found that the best

classifications used a classifier definition file created for the Random Trees classifier with the segmented normal color raster, and the unsegmented NDVI raster as an additional raster input (both rasters were from the central east section). The default settings for the classifier were used (Max number of trees = 50, Max tree depth = 30, and Max number of samples per class = 1000) and all training sample attributes were considered, including: color, mean, STD, count, compactness, and rectangularity.

### 2.3.5 CLASSIFICATION

The classifier definition file was used as input for the Random Trees classifier with segmented normal color rasters and unsegmented NDVI rasters from each of the six sections to create a classified raster for each of those sections. For example, the segmented normal color raster from northeast, NDVI raster from northeast, and classifier definition file were fed into the Random Trees classifier to obtain a classified raster for the northeast section as output. The same classifier definition file would be used with the segmented normal color and NDVI rasters from the northwest to classify the northwest section. Theoretically, the classes in the definition file (e.g., smooth lessingia, non-lessingia grassland, trees, shrubs, and road) would have similar spectral characteristics across all six sections of the study area, so a new classifier definition file for each section was not necessary.

It is necessary to be particular about the inputs for the classifier tool, otherwise it will often fail. Some of the key points that were found to be helpful were making sure that the same types of inputs that were used to create the definition file are used in the classifier (aka. a segmented normal color raster with unsegmented NDVI as additional raster), make sure the two input rasters are clipped to the exact same area, and do not create a name for the output raster file that is more than 13 characters long.

### 2.3.6 ASSESSMENT OF CLASSIFICATION

As previously mentioned, multiple classifications were attempted using different raster layers, training polygons, and classifiers. In order to choose the best classification across all sections, each of the classified rasters were visually assessed in addition to the accuracy assessment tools. Visual assessment consisted of visually comparing the classified raster to hand-mapped smooth lessingia. The Update Accuracy Assessment Points and Compute Confusion Matrix tools were used to update quadrat locations with ground-truth and classified classes to calculate producer's accuracy, or type 2 error.

It should also be mentioned that some of the steps in segmentation and classification use a substantial portion of the computer's memory and can take some time. Merging the files from TerrAvion took 10 or more minutes for each section, segmentation was the longest step, usually taking about an hour to complete, training the classifier took about 3 minutes, clipping layers for input for the classifier took about 20 minutes, and classification of each section took around 20 minutes. These steps were streamlined by 1) turning off background processing – this makes it so one cannot work in the same mxd while a tool is running, but allows more memory to be devoted to that tool – and 2) batch processing – this enables the use of one tool on multiple datasets. Using batch processing, segmentation of each of the six sections could be set up and the tool would run overnight instead of waiting for each segmentation to complete before starting the next one.

## 2.4. GROUND-TRUTHING

Once a reasonable classified raster was produced, it was time for ground-truthing. Ground-truthing took place in February 2020. Dried inflorescence stalks of smooth lessingia from the previous season were still standing and recognizable when ground-truthing took place. Additionally, herbaceous vegetative cover was still low at this point in the growing season, making the standing dead smooth lessingia more visible. Ground-truthing locations focused on modeled smooth lessingia habitat in areas that were not visited in

September 2019 and were viewable from road pull-outs, neighborhood streets, parking lots, or from other public lands. Ground-truthing locations also focused on CNDDDB records and serpentine geology and soils that overlapped with modeled habitat.

In the office, 26 general locations were chosen based on accessibility interpreted from Google Maps. Then, each location was visited in the field to verify presence or absence of smooth lessingia. For each location, how the area was classified and the actual conditions were noted along with GPS waypoints and photographs. It was also noted whenever smooth lessingia was known from an area according to the CNDDDB database, or if it had been mapped during past projects. Accuracy was judged based on whether smooth lessingia was present at the location where it was classified and whether the boundaries of the polygon were similar to the boundaries of the smooth lessingia patch in situ. Often, a classified polygon would be “partly correct” compared to the actual distribution of smooth lessingia. Additionally, because ground-truthing areas were often on private property, it was not possible to travel through them on foot. Most often, ground truthing areas were viewed from the road and sometimes the entire classified polygon was not completely visible. For these reasons, ground-truth points were categorized as “mostly correct”, “partially correct”, or “mostly incorrect”. The mostly correct polygons had smooth lessingia classified correctly with similar boundaries to the actual distribution. Locations categorized as partially correct usually had smooth lessingia confirmed in the vicinity of classified smooth lessingia polygons, but the classified boundaries either over- or under-represented the actual distribution. Mostly incorrect polygons either classified smooth lessingia where it wasn’t observed, or did not classify lessingia where it was found during ground-truthing. If smooth lessingia was observed outside of the study area during ground-truthing, that too was recorded on maps. Often each general location chosen in the office resulted in multiple ground-truthing GPS points. A total of 55 waypoints were recorded in the field.



Smooth lessingia confirmed growing on private property during ground-truthing on February 11, 2020.

## 2.5. MODEL ADJUSTMENT

The classified raster was converted into a shapefile (Raster to Polygon tool) to enable modifications to classified smooth lessingia polygons based on preliminary hand-mapping and ground-truthing. A set of rules were used to decide when to add or subtract from modeled smooth lessingia polygons to improve their accuracy. The following rules were used:

1. Subtract smooth lessingia from paved roads.
  - i. It is possible that smooth lessingia could grow on road shoulders, but wouldn't be found growing on paved areas.
2. If classification shows smooth lessingia only growing in a non-paved road footprint but nowhere else in the vicinity, then subtract smooth lessingia from non-paved roads.
3. If smooth lessingia was hand-mapped in an area during preliminary data collection or ground-truthing, then classified smooth lessingia polygons should cover at least approximately 50% of that area.
  - i. Often, slopes would have a speckled "salt and pepper" appearance due to many small segments being classified as smooth lessingia. This speckling was acceptable as long as areas with confirmed lessingia had  $\geq 50\%$  cover of classified lessingia polygons. However, if the total cover of classified polygons is lower than 50%, smooth lessingia polygons need to be added.
4. If smooth lessingia was said not to grow in an area according to preliminary data collection or ground-truthing, then classified smooth lessingia should cover no more than approximately 50% of that area.
  - i. A few small patches are ok but if the total cover of classified polygons is higher than 50%, then smooth lessingia needs to be subtracted.
  - ii. This leaves some margin of error for low cover of Lessingia that may have been difficult to see during ground-truthing.
5. If classification shows smooth lessingia in an area that obviously is not grassland (e.g., looks like tree, shrub, water, etc. on aerial imagery), then subtract smooth lessingia from that area.

Additionally, the smallest smooth lessingia polygons were removed in order to keep a more streamlined and neat result. These polygons were likely artifacts of segmentation versus patches of grassland that actually shared spectral characteristics with smooth lessingia grassland. Additionally, these polygons did not add a significant acreage to modeled smooth lessingia and made the shapefile very large, difficult to manage, and visually difficult to see patterns on the landscape (the speckled "salt and pepper" effect mentioned above). Polygons less than or equal to 0.0001 acres (4.4 square feet) were deleted from the shapefile.

The resulting shapefile was used to calculate acreage of smooth lessingia within parcels and modeled smooth lessingia habitat. Based on preliminary quadrats, the average number of individuals per quadrat was calculated and used to estimate the number of individuals per acre in the classified smooth lessingia shapefile.

## 2.6. PERSONNEL AND FIELD DATA COLLECTION DATES

### 2.6.1 PERSONNEL

The following personnel conducted the field data collection and report preparation:

**Heath Bartosh**  
Senior Botanist

**Adam Chasey**  
Botanist

**Cody Ender**  
Botanist

### 2.6.2 PRELIMINARY FIELD DATA COLLECTION DATES

Preliminary field data were collected by Nomad botanists Adam Chasey and Cody Ender. This work consisted of hand mapping and collecting quadrat data for smooth lessingia within accessible Habitat Agency parcels. The dates each parcel was visited are outlined in Table 2. A list of plant species recorded during this project is included in Appendix A.

**Table 2. Preliminary Field Data Collection Work Dates**

SURVEY TIMING		PRESERVE						
MONTH	DAY(S)	COYOTE RIDGE OSP	TULARE HILL	SANTA TERESA	ALMADEN QUICKSILVER	RANCHO SAN VICENTE / CALERO	RANCHO CAÑADA DEL ORO	COYOTE LAKE HARVEY BEAR
September	5	X						
September	6	X						
September	11		X				X	
September	12				X			
September	13				X			
September	17			X				
September	18					X		X
September	19	X						
October	1			X				

### 2.6.3 GROUND-TRUTH DATA COLLECTION DATES

Ground-truthing data were collected by Ms. Ender on February 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup>, 2020. Ground-truthing consisted of collecting data for locations based on classified aerial photography, CNDDDB records, and serpentine geology.

## 2.7. LIMITATIONS

Limitations identified for this study include; general difficulties in mapping grassland species, complex topography, inaccurate georectification, and fluctuations in annual plant populations.

Principally, 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.

The georectification of aerial photography can be difficult in complex topography such as is present within the study area because varied topography greatly increases the distortion of aerial photography and thus accuracy. In the past, TerrAvion, a company that works primarily with agriculture clients capturing images on flat farmland, had difficulty with the georectification process on topographically variable lands like the study area. For this project, georectification of imagery was much more accurate than in the past, but there was still some discrepancy between aerial imagery and web-served ESRI basemaps as well as between normal color and NDVI aerial images. Since both NC and NDVI aerial imagery were used in classification,

discrepancies between the two raster layers could provide incorrect spectral characteristics for training samples and during classification if images are not well aligned.

Varied topography was an additional barrier to creating consistently viable remote sensing models. Segmentation and classification work best when spectral and spatial signatures are relatively homogeneous within a class but are different between classes. Due to varied topography, features from different classes sometimes had similar spectral characteristics, or differences between classes were obscured. For example, grasslands on shaded slopes had a very different visible spectral signature than grasslands on exposed slopes, and actually had spectral characteristics that were more similar to dark forested areas. Similarly, on shaded slopes, differences between grassland with and without smooth lessingia were difficult to determine.

As an annual species, the abundance of smooth lessingia is subject to fluctuations from year to year. The population sizes presented in this report are expected to fluctuate based on annual and seasonal weather patterns. Additionally, population size was estimated on the acreage of a population and the average number of plants per square meter as measured during preliminary field data collection. As the density of plants per square meter can vary greatly within and between populations, the number of plants presented in this report should be considered rough estimates.

Finally, no smooth lessingia was mapped within the footprint of the Malech fire, which burned in the summer of 2019, weeks prior to the TerrAvion flyover. Mapping of smooth lessingia within the fire footprint following the Malech fire is currently underway. The distribution of smooth lessingia within the burn footprint and an estimate of population size will be provided for 2020 and 2021, one- and two- years post-burn.

## **Section 3. ENVIRONMENTAL SETTING**

The study area is located in Santa Clara County, spanning the area between San Jose and Gilroy, on both sides of US 101. The study area consists of 10,491 acres of modeled primary smooth lessingia habitat. The study area is geographically situated along Santa Clara Valley and the foothills on either side. These foothills are part of the two mountain ranges that flank the Santa Clara Valley which are the Santa Cruz Mountains to the west and the Hamilton Range to the east. As mentioned above, the study area for this project was delineated into six sections: northwest, northeast, central west, central east, southwest, and southeast. The modeled habitat and Plan areas included in these six sections are described as follows.

- **Northeast:** The northeast section occurs east of Hwy 101 and north of Metcalf Rd. It includes modeled habitat southeast of Milpitas as well as the hills north of Coyote Ridge in southern San Jose. No parcels accessible to the Habitat Agency are included in this section.
- **Northwest:** The northwest section includes the Almaden Quicksilver, Calero CE, Calero County Park, Rancho San Vicente, and Santa Teresa parcels. Additionally, this section includes modeled habitat north and south of Almaden Quicksilver and in the hills surrounding Santa Teresa. This section of the study area lies west of Hwy 101, primarily between Blossom Hill Rd. and south of Bailey Ave. in South San Jose and New Almaden.
- **Central East:** The central east section includes Tulare Hill, Coyote Ridge, and Anderson Lake parcels plus additional modeled habitat surrounding those parcels. Except for Tulare Hill, which lies west of Hwy 101, this section lies east of Hwy 101 between Metcalf Rd. and Cochrane Rd. in southern San Jose.
- **Central West:** The central west section includes Rancho Cañada del Oro and modeled habitat along Manzanita Ridge, in the hills surrounding Chesbro Reservoir, along Uvas Creek, and the hills above Hayes Valley. The modeled habitat is found west of Madrone, Morgan Hill, and San Martin all west of Hwy 101 and south of Bailey Ave.
- **Southeast:** The southeast section includes Coyote Lake Harvey Bear, and Palassou Ridge plus some modeled habitat west of Anderson Lake, and south of Coyote Lake. This section of the study area lies east of Hwy 101, between Cochrane Rd. and Hwy 152 in Morgan Hill and east of San Martin and Gilroy.
- **Southwest:** The southwest section includes modeled habitat in the hills on either side of Little Arthur Creek, to the east of Mt. Madonna, on the eastern edge of the foothills west of Gilroy, north of Pescadero Creek, and around the Carlyle Hills. No parcels accessible to the Habitat Agency are included in this section. This section lies west of Hwy 101 between Redwood Retreat Rd. and the southern Santa Clara County border in unincorporated portions of Santa Clara County west of Gilroy.

The study area lies within the San Francisco Bay Area and the Central Coast Subregions of the California Floristic Province (Baldwin et al. 2012) and the watersheds this area drain into include Lower Penitencia Creek, Coyote Creek, Alamos Creek, Guadalupe River, Pajaro River, Uvas Creek, and Llagas Creek (CIWMC 2004).

### 3.1. REGIONAL SETTING

As described in the *Ecological Subregions of California* (USDA 1997), the study area is located within the Santa Clara Valley and Leeward Hills subsections of the Central California Coast section and the Fremont-Livermore Hills and Valleys, and Western Diablo Range subsections of the Central California Coast Ranges section. The *Ecological Subregions of California* form the basis for describing regional variation in California alliance descriptions in *A Manual of California Vegetation* (Sawyer et al. 2009) and are provided here for regional context.

#### 3.1.1 SANTA CLARA VALLEY

The Santa Clara Valley subsection is located on an alluvial plain that extends from Hollister to San Francisco Bay, plus an alluvial plain along the southwest side of San Francisco Bay. The climate is hot and subhumid; it is modified greatly by marine influence (USDA 1997). The alluvial plain is mostly gently sloping to nearly level floodplain and alluvial fans. Elevation in this subsection ranges from sea-level up to about 250 feet on the alluvial plains. Fluvial erosion and deposition are the main geomorphic processes. Late Quaternary alluvium is predominant in this subsection. There are small areas of Pliocene and Pleistocene nonmarine sediments (USDA 1997).

For this subsection, the mean annual precipitation is about 12 to 20 inches, practically all of which is rain. The mean annual temperature is about 56° to 60° F. The mean freeze-free period is about 250-275 days. Runoff is rapid from hills, but slow across alluvial plains. All but the larger streams are dry through most of the summer and natural lakes are absent.

This area includes portions of the central east, central west, and southwest study area sections.

#### 3.1.2 LEEWARD HILLS

The Leeward Hills subsection is located on the interior, or northeast side of the Santa Cruz Mountains that is between the San Andreas fault and the alluvial plain in the Santa Clara Valley and at the south end of San Francisco Bay. The climate is hot and subhumid, with moderate marine influence. This is a subsection of northwest trending mountains and hills with steep sides and narrow canyons. Elevation ranges from about 200 feet up to 3,790 feet on Loma Prieta. Mass wasting and fluvial erosion are the main geomorphic processes. This subsection consists mostly of folded, faulted, and generally metamorphosed sediments and volcanics of the Franciscan Complex and less extensive Cretaceous sediments of the Great Valley Sequence (USDA 1997).

For this subsection, the mean annual precipitation is about 15 to 30 inches, most of which is rainfall, except for some snow at higher elevations. Mean annual temperature is about 50° to 60° F and the mean freeze-free period is about 225 to 275 days. Runoff is rapid and the streams are generally dry during the summer. Natural lakes are absent, but there are numerous reservoirs present (USDA 1997).

This area includes the northwest study area section, and portions of the central west, and southwest study area sections.

#### 3.1.3 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. The climate is hot and subhumid. 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. Elevation ranges from about 100 feet in the Santa Clara Valley to 2,594 feet on Monument Peak northeast of the valley. Mass wasting and fluvial erosion are the main geomorphic processes. 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 (USDA 1997).

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. 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 (USDA 1997).

This area includes the northeast study area section and portions of the central east and southeast study area sections.

### **3.1.4 WESTERN DIABLO RANGE**

The Western Diablo Range subsection is located on mountains in the western part of the Diablo Range, south-southeast of the Livermore-San Ramon Valley. It is the more moist part of the Diablo Range, the climate is hot and subhumid. This is a subsection of mountains with rounded ridges, steep and moderately steep sides, and narrow canyons. Most of the mountains are aligned in the north-northwest to northwest directions. Elevation ranges from about 1,000 feet adjacent to the Santa Clara Valley to about 4,000 feet on the higher mountains like Mt. Hamilton. Mass wasting and fluvial erosion are the main geomorphic processes. This subsection is dominated by Franciscan sedimentary, minor volcanic, and metamorphic rocks. They are intensely folded and faulted. Also, there are some Cretaceous sedimentary rocks of the Great Valley Sequence. Ultramafic rocks are widely scattered through this subsection (USDA 1997).

For this subsection, the mean annual precipitation is about 20 to 30 inches, most of which is rainfall, with a little snow at higher elevations. Mean annual temperature is about 52° to 58° F and the mean freeze-free period is about 200 to 250 days. Runoff is rapid and all but the larger streams are dry throughout the summer. Natural lakes are absent, but there are a few reservoirs in the area (USDA 1997).

This area includes a portion of the southeast study area section.

## **3.2. LOCAL SETTING**

The study area, consisting of all modeled lessingia habitat, falls within multiple Habitat Agency parks as well as areas that have not been acquired by the Habitat Agency. The study area also excludes urban zones.

Beginning at the northernmost portion of the study area and moving clockwise around Santa Clara Valley, modeled habitat occurs in the foothills southeast of Milpitas and north of Alum Rock Canyon at Berryessa Creek and Dutard Creek. Farther south, large expanses of smooth lessingia habitat are modeled along the entire length of Coyote Ridge. On the northern end of the ridge, Metcalf Canyon divides the ridge in an east-west direction. On the southern end, Pigeon Point (1,361 feet) forms the highest point on the ridge, overlooking Anderson Lake. East of Morgan Hill and San Martin, potential lessingia habitat occurs around Anderson Lake and Coyote Lake, which are connected via Coyote Creek. A small amount of modeled habitat occurs east of Coyote Lake on Palassou Ridge as well as south of Coyote Lake near Live Oak Creek and San Ysidro Creek. At the southern end of Santa Clara Valley, south of Castro Valley and southwest of Gilroy, more modeled lessingia habitat occurs in the Carlyle Hills. Immediately west of Gilroy, small patches of modeled habitat occur in the hills around Farman Canyon, South Fork, Babbs Canyon, Reservoir Canyon, McCutchin Canyon, and Ousley Canyon. The hills between Mount Madonna (1,888 feet) and Uvas Creek support some modeled habitat as well as the slopes above Murphy Canyon. Continuing clockwise, modeled lessingia habitat occurs just east of Hayes Valley near San Martin. More habitat is located along Little Uvas and Uvas Creeks, which, feed into Uvas Reservoir. To the east, modeled habitat can be found around Morgan Hill near Llagas Creek, Paradise Valley, Willow Springs Canyon, surrounding Chesbro Reservoir, and on Manzanita Ridge. The area surrounding Calero Reservoir also contains substantial

modeled lessingia habitat and includes features such as Chilianian Gulch, Cherry Canyon, Bald Peaks, Baldy Ryan Canyon and Fern Peak (1,702 feet). East of Calero Reservoir is the portion of the study area between Almaden Reservoir and Guadalupe Reservoir including Almaden Canyon, Jaques Gulch, Jaques Ridge, Mine Hill (1,720 feet), Deep Gulch, Church Hill (1,464 feet), and Bull Run (1,603 feet). This portion of the study area occurs near the towns of Twin Creeks, New Almaden, and Almaden. East of Guadalupe and Almaden Reservoirs, more modeled habitat is located in the Santa Teresa Hills and on Tulare Hill (570 feet), which are located in South San Jose.

The study area overlaps with multiple Habitat Agency parks including Almaden Quicksilver County Park, Anderson Lake County Park, Calero CE, Calero County Park, Coyote Lake-Harvey Bear Park, Coyote Ridge, Pacheco Creek, Palassou Ridge, Rancho Cañada del Oro, Rancho San Vicente, Santa Teresa County Park, and Tulare Hill. The bulk of modeled Lessingia Habitat occurs in the northern part of the Habitat Plan Permit Area along Coyote Ridge, and in the Santa Teresa Hills. Generally, the study area is characterized by rolling foothills and broad valleys with scattered rock outcrops.

These are primarily grasslands with an abundance of serpentine habitats. The diversity of vegetation types is high due to the diversity in bedrock and soil types, topography, aspects, and hydrologic features. Some modeled lessingia habitat lies adjacent to developed areas such as residential developments or highways, while other habitat is part of a larger matrix of open space. Grazing and associated infrastructure is present at some locations. In summer 2019, the Malech fire burned 210 acres on Coyote Ridge Open Space Preserve.

### **3.2.1 TOPOGRAPHY AND CLIMATE**

The topography of the study area is characterized by broad valleys, rolling hills, and gentle to steep slopes. All aspects are represented. The larger prominences in the vicinity of modeled habitat – Mine Hill (1,720 feet), Mt. Madonna (1,888 feet), and Loma Prieta (3,780 feet) – are generally located on the western side of the study area. Elevations range from approximately 240 feet (73 meters) above mean sea level at the lower points in the valley to 1,800 feet (549 meters) near the western edge in Mt. Madonna County Park.

Locally the climate of the study area is characterized as Mediterranean with cool, wet winters and warm, dry summers. The study area is outside of the coastal fog incursion zone and a majority of the moisture it receives is direct precipitation. Annual precipitation ranges from 25 to 33 inches annually (PRISM 2012).

### **3.2.2 GEOLOGY AND SOILS**

The underlying geology mainly comprises of Franciscan mélangé (Lower Tertiary and Upper Cretaceous), Temblor sandstone (Middle Miocene or Middle Miocene to Oligocene), and serpentized ultramafic rock (Wagner 2002, Wentworth et al. 1999). Mudstone, Alluvium, Graywacke, Radiolarian Chert, Basaltic Volcanic Rocks, Landslide Deposits, Silica-Carbonate rock, and Silver Creek gravels, are also found within the study area (Wagner 2002, Wentworth et al. 1999).

Numerous soil types are mapped as occurring within the study area. These types include rock land, gravelly loam, rocky fine sandy loam, fine sandy loam, loam, rocky clay loam, clay loam, stony clay, and clay (USDA 2014, USDA/NRCS 2001). The more common soil types within the study area include Montara Rocky clay loam, and Gilroy clay loam. Soils such as Montara sandy loam, Montara-Rock outcrop complex, and Montara-Santerhill complex are described as being derived from serpentine parent material. Serpentine soils within the greater region are considered important ecologically due to the large number of special status plant species that are associated with, or limited to the edaphic soils type. These soil types are what supports smooth lessingia.

### **3.2.3 LAND-USE**

Parts of the study area are open for general public access while others are closed to the public. Public parks within the reserve system include Calero County Park, Almaden Quicksilver County Park, Santa Teresa County Park, and Coyote Lake-Harvey Bear Park. Other parks like Coyote Creek Park and Mount Madonna County Park are not part of the reserve system but also overlap with the study area. Parts of the study area are grazed by cattle. Private lands including residential areas are also scattered throughout the study area.

## Section 4. RESULTS

### 4.1. REMOTE SENSING AND MAPPING TECHNIQUES RESULTS

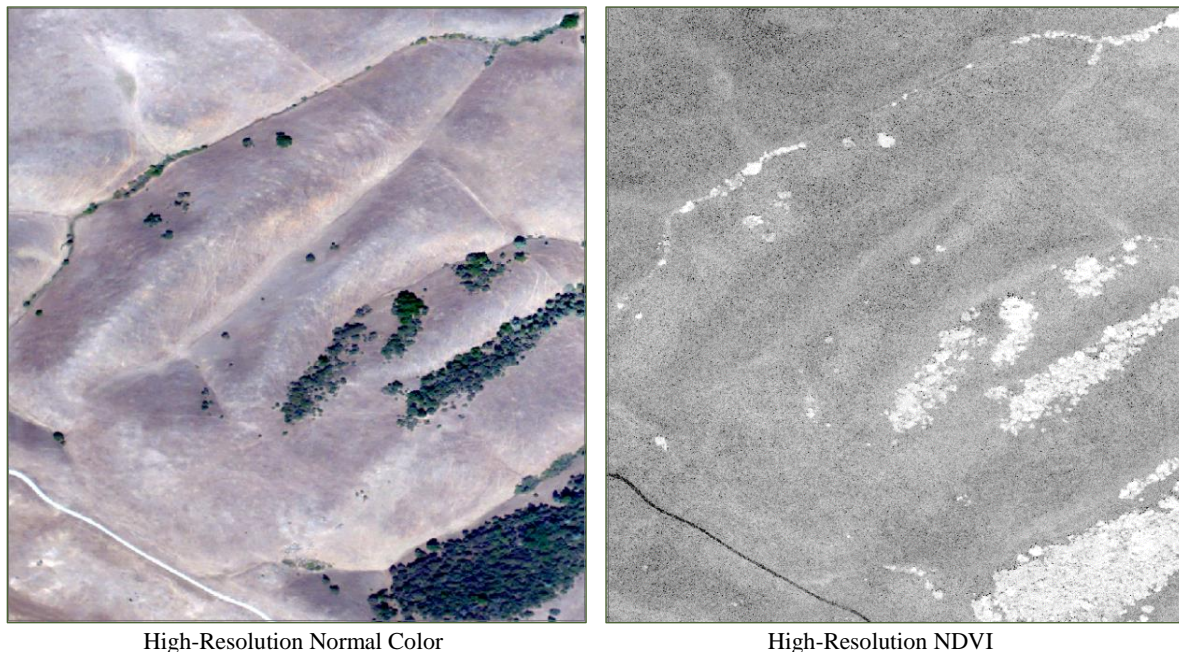
Remotely mapping smooth lessingia using segmentation and classification software and high-resolution aerial imagery was combined with field-based methods of mapping. Classification using the model alone had lower accuracy than anticipated, but by combining field work and location information from CNDDDB and CalFlora, model results were found to produce reliable results for smooth lessingia at the population scale.

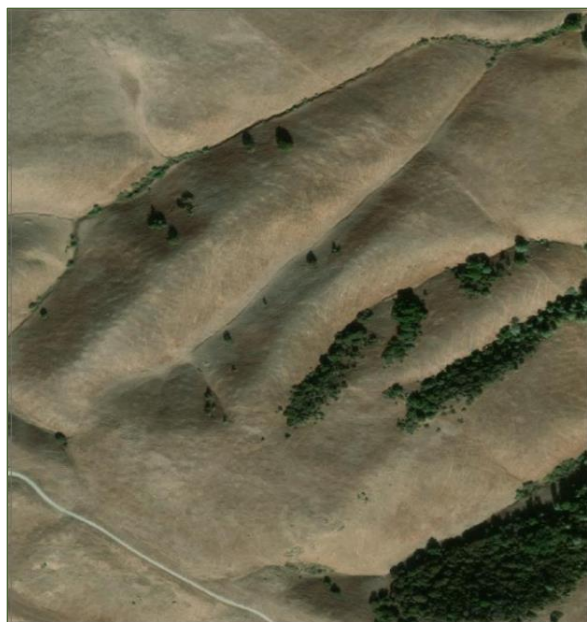
Overall, the smooth lessingia signature was distinct enough to detect through segmentation and classification under ideal conditions, but because the signature was subtle, it was more difficult to classify smooth lessingia over varied terrain. Both normal color and NDVI imagery were useful in creating the remote sensing model, including both normal color and infrared bands proved helpful in finding the slight spectral differences within grasslands. Classification results varied across the study area, with better results on exposed aspects and less accurate results on shaded slopes.

#### 4.1.1 HIGH-RESOLUTION, MULTI-SPECTRAL AERIAL IMAGERY

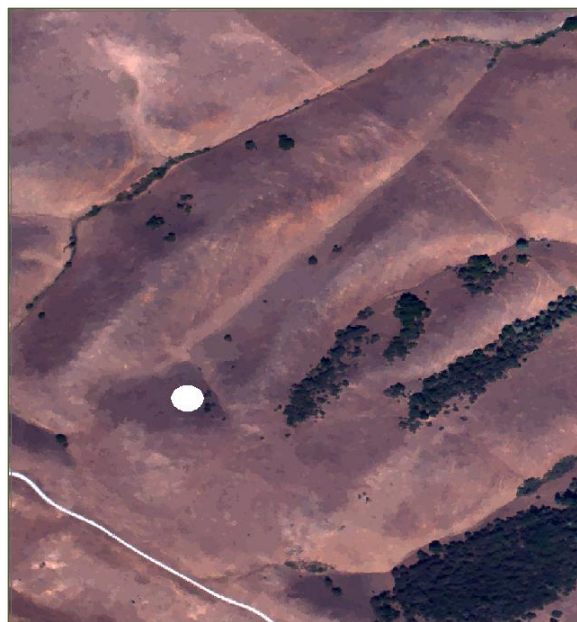
High-resolution, multi-spectral aerial imagery collected in early September, during smooth lessingia growing season was the fundamental data underpinning the mapping methodology for this project. Multispectral data allowed for creation of band arrangements that recognize growth and vigor (greenness) of vegetation (NDVI), and separating out single bands like the red band to better visualize differences in vegetation. High-resolution imagery allows for the fine scale mapping required to capture subtle and small-scale details of grassland species distribution. Figure 2 shows high-resolution normal color and NDVI imagery in comparison to ESRI web-served basemap imagery and segmented NC imagery.

**Figure 2. Comparison of High-Resolution Imagery**





ESRI Web-Served Basemap



Segmented Normal Color

NDVI was particularly effective in identifying trees and shrubs, but did not show a lot of variation within grasslands – possibly due to the lower resolution of the infrared band. Normal color, especially the red band most clearly showed differences between smooth lessingia patches and other grassland. In the end, all color bands were used in creating the remote sensing model. Including all bands allowed for maximum information that could be used in finding slight spectral differences within grasslands.

#### 4.1.2 SEGMENTATION AND CLASSIFICATION

The segmentation and classification method used training polygons, informed by reconnaissance points and hand-mapping, on segmented NC imagery to develop a classifier definition file to detect and map smooth lessingia. The Random Trees classifier was used with segmented normal color imagery as the primary input, and unsegmented NDVI imagery as a secondary raster.

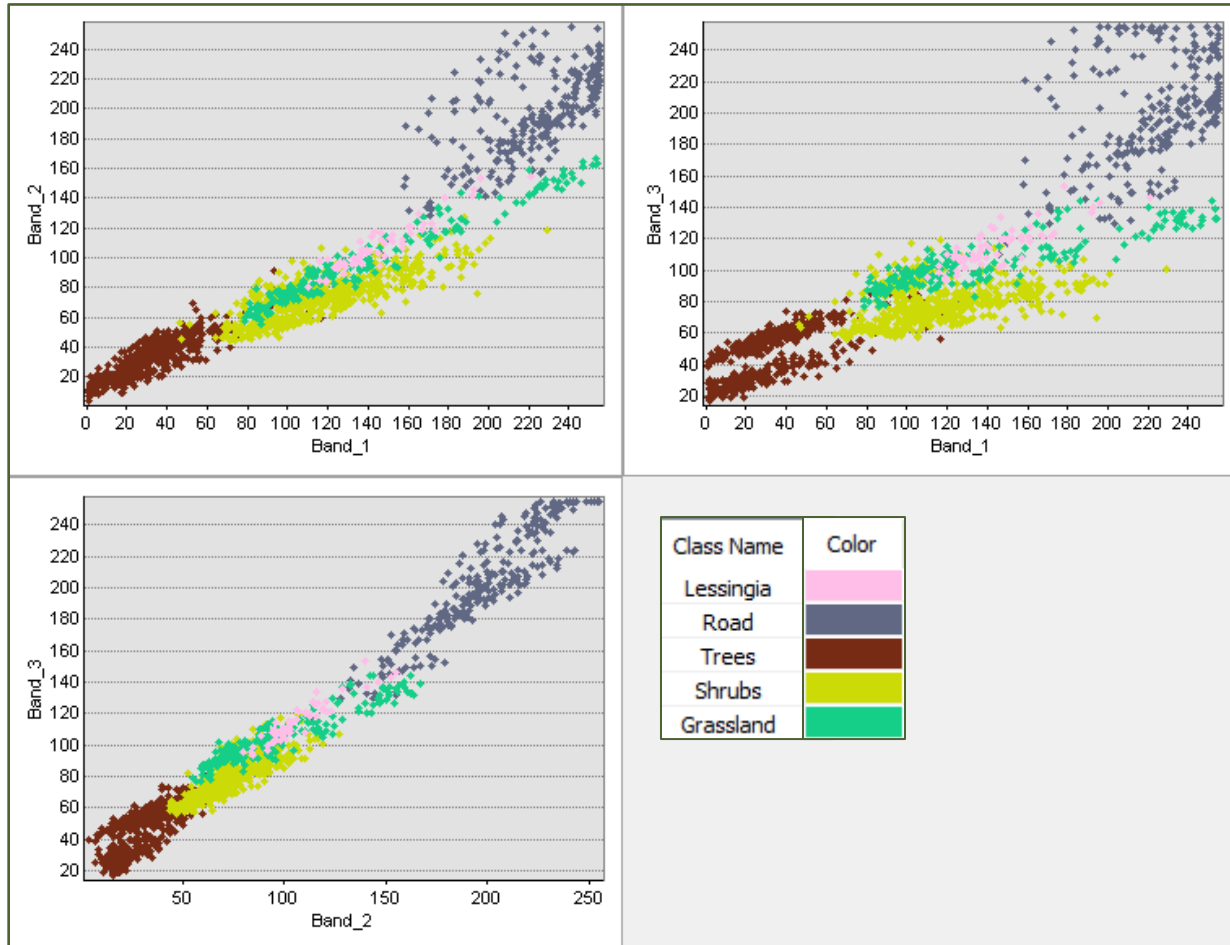
A total of 41 training polygons (1,083 pixels total) were created for smooth lessingia, 22 polygons (55,292 pixels) for grassland, 13 polygons (36,679 pixels) for trees, 15 polygons (45,208 pixels) for shrubs, and 4 polygons (28,199 pixels) for roads which were used to create the classifier definition file. Statistics for spectral characteristics, namely minimum, maximum, mean, and standard deviation, of each of the classes are shown in Table 3. In order for the classifier to reliably classify segments, each of the classes should ideally have differing spectral statistics. For example, Band 1 in the trees class is much lower than for any of the other classes with a mean of  $29.08 \pm 15.15$  (mean  $\pm$  Std. dev) compared to other classes with means in the 100's and above. Band 1 is much more similar for the Lessingia and grassland classes, with means of  $143.43 \pm 19.81$  for Lessingia and  $124.31 \pm 40.67$  for Grassland. If classification was only based on Band 1, then the classifier should reliably differentiate between Trees and the other classes, but might have more mistakes in differentiating between Lessingia and grassland. The actual classification for smooth lessingia was based on three visible color bands plus the NDVI layer, and also took shape into account (rectangularity and compactness), so while the spectral statistics in the table and scatterplots below give some indication of characteristics used to train the classifier, additional information was also included in the model.

**Table 3. Spectral Statistics of Training Polygons**

STATISTIC	BAND 1	BAND 2	BAND 3
<b>Lessingia</b>			
Minimum	110	80	94
Maximum	221	155	154
Mean	143.43	106.41	114.85
Std.dev	19.81	14.59	11.42
<b>Grassland</b>			
Minimum	79	55	77
Maximum	254	167	144
Mean	124.31	90.02	101.68
Std.dev	40.67	24.54	14.83
<b>Trees</b>			
Minimum	1	4	17
Maximum	128	91	93
Mean	29.08	32.39	49.21
Std.dev	15.15	11.75	13.64
<b>Shrubs</b>			
Minimum	46	44	56
Maximum	229	127	119
Mean	110.67	71.84	79.55
Std.dev	27.56	13.55	12.16
<b>Road</b>			
Minimum	146	103	110
Maximum	255	255	255
Mean	246.74	229.53	228.17
Std.dev	15.00	29.51	32.88

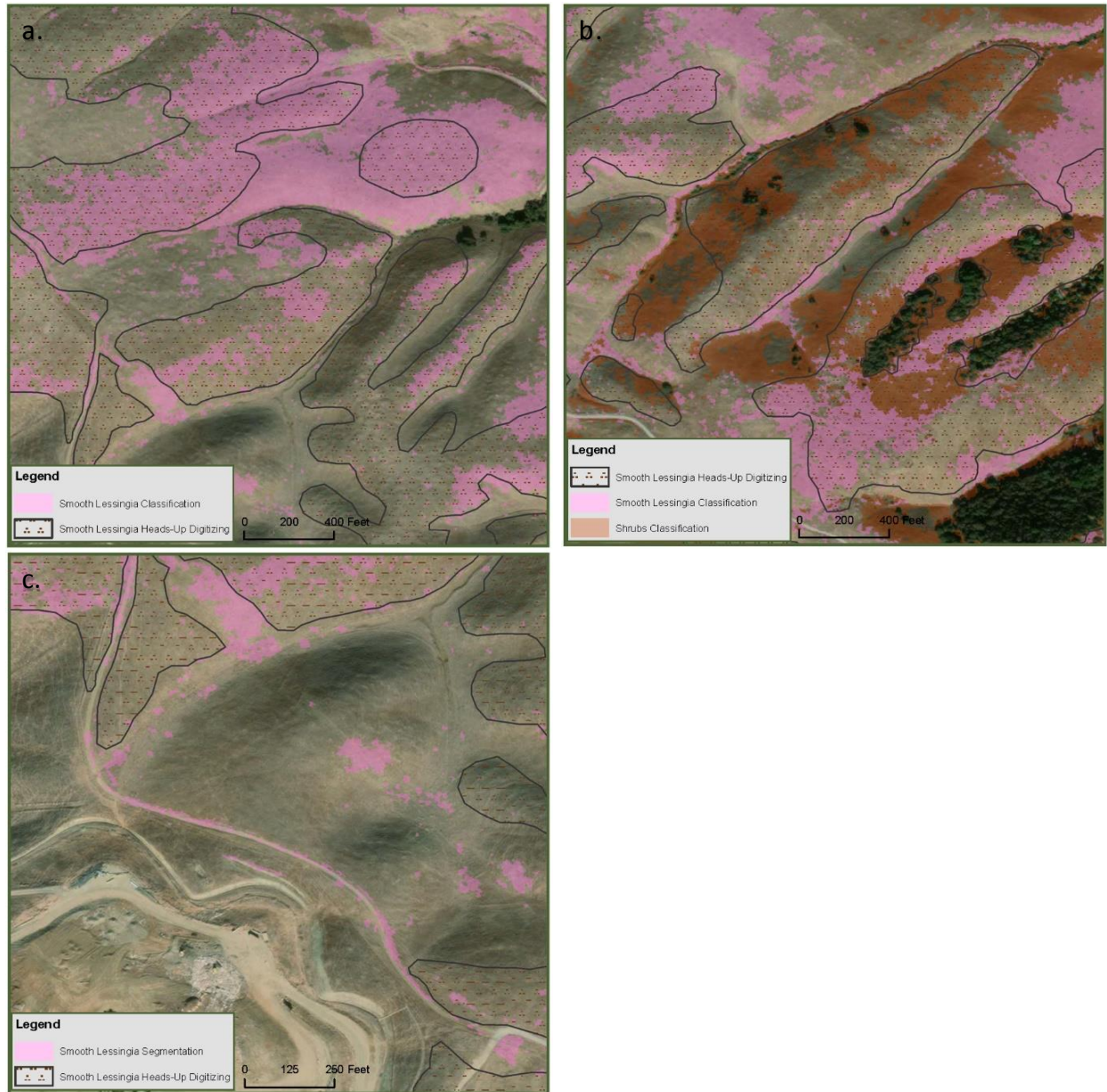
The spectral statistics are better visualized as scatterplots as shown in Figure 3. Figure 3 provides scatterplots of the three normal color bands for each of the five classes. The scatterplots show clear separation between trees and road, with less separation between smooth lessingia, grassland, and shrubs. Where smooth lessingia overlaps with grassland and/or shrubs, the classifier may end up mis-classifying segments with those spectral characteristics, either classifying a segment as smooth lessingia when it is not or classifying a segment as shrub or grassland when it should be smooth lessingia. The overlap between these three classes is why it was more difficult to accurately classify smooth lessingia at a fine-scale. Although smooth lessingia, grassland, and shrubs overlap on the scatterplot, they do clump together in slightly different areas, and therefore are on average distinguishable during classification. It is possible that in future projects, choosing training samples based on individual segments instead of polygons would lead to less variation within each class. Part of the reason the spectral characteristics for these three classes is similar could be due to landscape position. For example, on a shaded slope, smooth lessingia and non-lessingia grassland would look very similar. On an exposed slope, the reddish coloration of smooth lessingia or the signature of low vegetation cover is more apparent and helps distinguish it from non-lessingia grassland.

Figure 3. Spectral Characteristics of Training Polygons



Classification results were promising for much of the study area however, results were not consistent across the entire study area. Figures 4a-c show areas with digitized polygons from hand-mapping smooth lessingia in contrast with the classified smooth lessingia polygons generated from the segmentation and classification algorithm. Sometimes the classification closely aligned with hand-mapped areas (Figure 4a), but in some instances the classification was off (Figure 4b, c). These inconsistencies were likely due to the overlap in spectral characteristics between smooth lessingia, grassland, and shrubs and are explored further in the following paragraphs.

**Figure 4. Comparison of Field Confirmed Heads-up Digitizing and Object-based Classification Results**



Figures 4a-c show polygons from heads-up digitizing hand-mapped smooth lessingia in contrast with the classified smooth lessingia polygons generated from the segmentation and classification algorithm. Clockwise from upper left: 4a. demonstrates an area where the hand-mapping and classified polygons more or less agree. 4b. includes classified shrubs as well as smooth lessingia polygons and shows an example of shaded slopes mistakenly classified as shrubs. 4c. shows an example of an area where lack of vegetation in the road was mistakenly classified as smooth lessingia.

It should be noted that it can be difficult to accurately map species at the landscape scale, so the heads-up digitized layer is likely not completely accurate either. Hand-mapping took place over a limited number of field days and was conducted at a coarse scale and often from vantage points, while classification produced results at a much finer scale. Rough contiguous polygons that were hand-drawn on maps likely include areas without smooth lessingia and may not capture the entire extent, especially if plants were sparse. Overall, the failure of classification results to perfectly match the hand-mapped layer does not indicate a

failure of the classification technique. Rather, each result adds evidence that smooth lessingia occurs or does not occur in a given area.

Figure 4a shows classified Lessingia more or less following the hand-mapped outlines. In some areas of Figure 4a, smooth lessingia is underrepresented in the classification compared to hand-mapping, such as the ridges in the lower righthand corner. In other areas, it is over-represented compared to hand-mapping, such as the hilltop in the upper-righthand corner. However, the general distribution of smooth lessingia matches between the two mapping methods. At the landscape scale, the area in the figure would all be a part of one lessingia occurrence.

Figure 4b and 4c illustrate some issues that were encountered in using the object-based classification technique. The algorithm often confused shaded slopes with trees and shrubs, both which had darker color signatures in NC (Figure 4b). The northern side of the ridge in the center of Figure 4b was largely classified as shrubs instead of smooth lessingia, and other shaded slopes in the figure that are obviously grassland were also mistakenly classified as shrubs. The red-brown hue from smooth lessingia that was detected on exposed, south-facing slopes, was less detectable on shaded north-facing slopes. Timing aerial imagery flyovers for times of day with fewer shadows, or combining multiple flyover times for different aspects could help with this issue for future classifications. It is possible that the time and effort spent obtaining higher quality aerial imagery could save time down the road in post-model corrections. Also, using training polygons from a variety of aspects helps train the classifier to recognize targets on different types of terrain. For this project, training polygons for smooth lessingia were restricted to reconnaissance quadrats sampled during preliminary field data collection. While reconnaissance quadrats did cover a variety of aspects, shaded slopes were underrepresented. Finally, it is possible that restricting the classification to grasslands could help reduce confusion between trees or shrubs and shaded slopes. Future classifications might consider using a mask over woodland and shrubland areas to restrict training samples and classification to grasslands.

It also appears that the algorithm may have picked up the signature for exposed soil as well as the color of smooth lessingia. Since smooth lessingia grows on serpentine grassland and rock outcrops, both of which have lower vegetation cover, the classifier tended to classify dirt roads and the areas alongside dirt roads as smooth lessingia (Figure 4c). While exposed soils and low plant cover can be a good predictor of smooth lessingia, especially on serpentine, the presence of this type of habitat does not necessarily mean that smooth lessingia is growing there.

Overall, the signature for smooth lessingia was subtle, yet detectable on most terrains. There is room for improvement in the timing of aerial imagery, collection of reconnaissance points, and classification in “problem areas” such as steep, shaded slopes. It may be more reliable to classify dense stands of smooth lessingia, using training polygons from high cover reconnaissance quadrats than to include quadrats with low cover of lessingia, as those areas appear more similar to non-lessingia grassland in aerial photographs.

### **4.1.3 MAPPING ACCURACY**

Accuracy of the model prior to any adjustments was assessed by comparing classified cover versus the class of reconnaissance quadrats and by visiting ground-truth locations post-classification. Once accuracy was assessed, the classification model was adjusted to better fit hand-mapping in accessible parcels and to reflect the results of ground-truthing.

#### **Classification Accuracy from Reconnaissance Quadrats**

Reconnaissance quadrats that were not used for training polygons were used with accuracy assessment tools to create a confusion matrix, which calculates type 1 and type 2 error. Rather than the accuracy of the entire classification, only the accuracy of classified smooth lessingia was of interest; for this reason, the user’s and producer’s accuracy for smooth lessingia was used to measure accuracy. Other accuracy measurements

that could be used include overall accuracy and kappa statistics (Malmstrom et al. 2017). User's accuracy is the complement of type 1 error also known as false positives. User's accuracy is based on the number of points mistakenly classified as smooth lessingia when reconnaissance quadrats revealed no smooth lessingia was present. Producer's accuracy is the complement of type 2 error also known as false negatives. Producer's accuracy is based on the number of points that should have been classified as smooth lessingia but were not. Only reconnaissance quadrats from Coyote Ridge were used for training polygons, all the other quadrats were used in confusion matrices for accuracy assessment. No reconnaissance quadrats were collected in the northeast, southwest, and southeast sections, so confusion matrices were not generated for those sections.

In the future, it would be advised to distribute the reconnaissance points used for training polygons and those used for accuracy assessment throughout the study area in order to share similar geographic distributions (Malmstrom et al. 2017). In this case, reconnaissance points were not distributed evenly due the need to focus on accessible parts of the study area, and due to the large file size of high-resolution imagery.

Out of 274 total smooth lessingia reconnaissance points used in the classification accuracy assessment, 99 were correctly classified as lessingia, that is 36% producer's accuracy, or type 2 error (Table 4). This indicates there was a fairly high rate of false negatives in the classification prior to any adjustments. For user's accuracy, 99 points were verified as containing smooth lessingia out of 103 points that were classified as such. This comes out to 96% user's accuracy (Table 4) indicating a very low rate of false positives in the classification prior to any adjustments. These accuracy calculations should be taken with a grain of salt as the main focus of preliminary data collection was on areas where smooth lessingia was growing, thus points without smooth lessingia were underrepresented. In the future, collecting both positive and negative reconnaissance points will help with both model creation and accuracy assessment. Additionally, due to segmentation, it is possible that small or sparse areas of smooth lessingia could get grouped together with non-lessingia areas in segments. If the overall spectral characteristics were closer to grassland, then those small or sparse areas of smooth lessingia could get lost, thus leading to a higher rate of false negatives. While producer's accuracy is somewhat lower than ideal, a high rate of false negatives would lead to a conservative estimate of smooth lessingia extent. Additionally, low accuracy is quite common for remote sensing techniques, especially in grasslands (Malmstrom et al. 2017; Lobo, Moloney, and Chiariello 1998).

**Table 4. Classification Accuracy from Reconnaissance Quadrats**

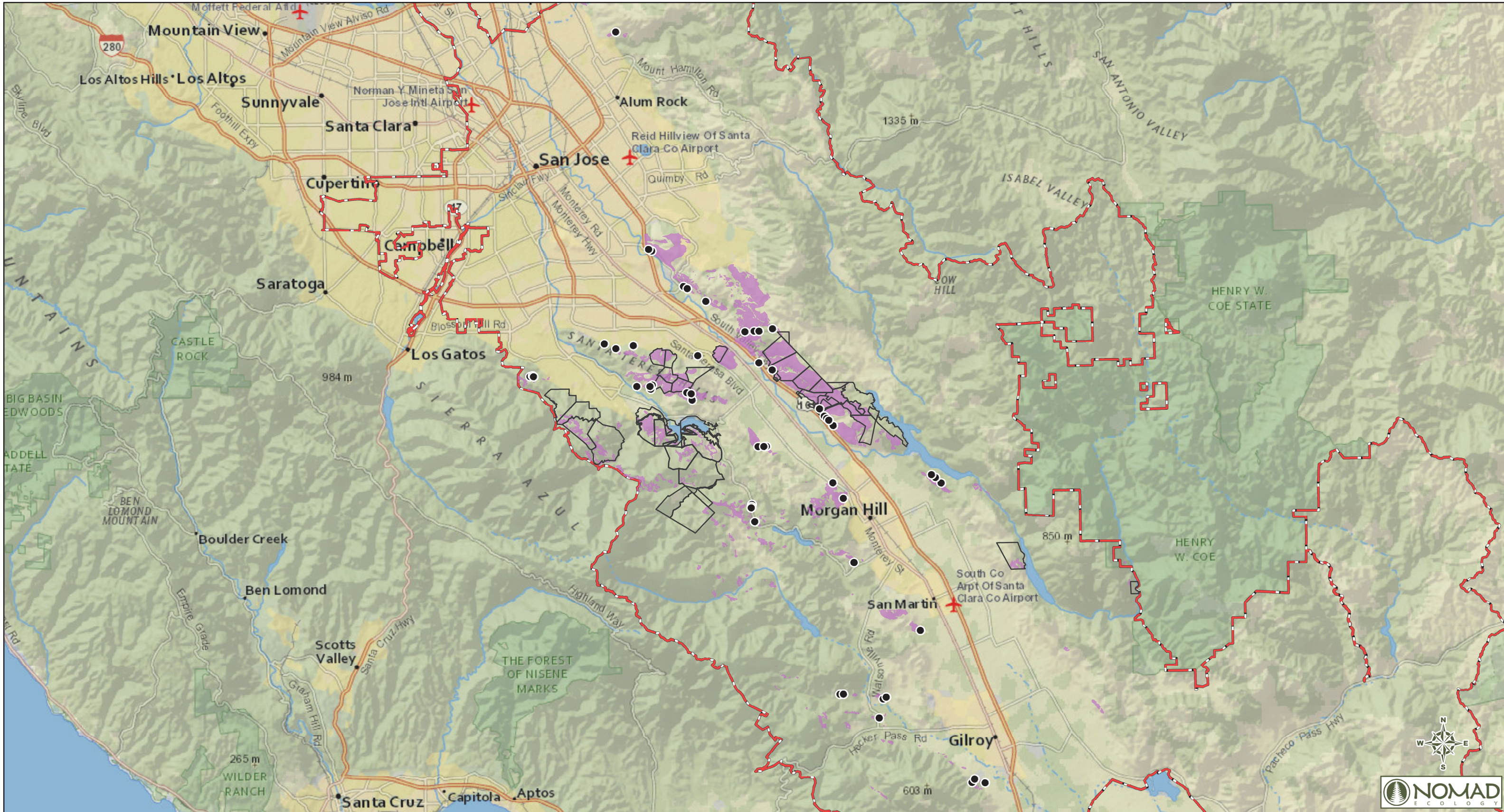
TOTAL # OF QUADRATS COLLECTED WITH LESSINGIA	TOTAL # OF QUADRATS COLLECTED WITHOUT LESSINGIA	PRODUCER'S ACCURACY	USER'S ACCURACY
274	13	36%	96%

### Ground-Truthing Polygon Accuracy

The second method by which classification accuracy was assessed was through ground-truthing locations with classified smooth lessingia polygons and confirming whether smooth lessingia indeed was found there. This method of accuracy assessment is much less precise, but gives a sense of how close the classification was compared to what could be seen on-the-ground. A total of 55 ground-truth points were visited and assessed for model accuracy (Figure 5). Out of 55 ground-truth points, 23 (42%) were mostly correct, 12 points (22%) were partially correct, and 20 points (36%) were mostly incorrect. The majority of partially correct and mostly incorrect ground-truth points were incorrect due to overrepresentations of smooth lessingia. However, the way ground-truth points were chosen – based on where smooth lessingia had been mapped during segmentation and classification versus choosing equal number of points where smooth lessingia was classified and where it was not – makes overrepresentation more likely and does not indicate whether the model is inherently conservative or an overestimate of actual smooth lessingia distribution.

**Table 5. Ground-Truthing Polygon Accuracy**

SECTION	TOTAL GROUND-TRUTH POINTS	TOTAL # (%) “MOSTLY CORRECT”	TOTAL # (%) “PARTIALLY CORRECT”	TOTAL # (%) “MOSTLY INCORRECT”
Total	55	23 (42%)	12 (22%)	20 (36%)



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**Legend**

- Ground Truth Points
- Smooth Lessingia Modeled Habitat
- ▭ Parcels Accessible to the Habitat Agency
- ▭ Habitat Plan Permit Area

**Figure 5**  
**Location of Ground Truth Points**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy

1:221,760

0 1.75 3.5

Miles

Sources: ESRI; Santa Clara Valley Habitat Plan. Projection: NAD 83 UTM Zone 10 North.

## 4.2. SMOOTH LESSINGIA MAPPING RESULTS

Several challenges were encountered in utilizing high-resolution multi-spectral aerial datasets imagery to semi-automate the mapping process at such a large scale, however remote sensing techniques did prove extremely useful for mapping the target species in conjunction with on-the-ground mapping. Although the results of the accuracy assessments are lower than expected, the accuracy assessments were performed on the classified lessingia layer prior to modifications based on hand-mapping and ground-truthing. Adjustments to the classification greatly improve accuracy in those specific areas, although smooth lessingia classified in unvisited areas (not visited during preliminary data collection or ground-truthing) remain unchanged.

Combining information from hand-mapping in accessible parcels with remote sensing classification results provides a more accurate result than either method alone. If existing data from CNDDDB and CalFlora are also taken into account, the multiple sources of information each lend more confidence to the existence of a population, although, the exact boundaries, acreage, and potential abundance of populations may be less precise. For this reason, populations were placed into confidence tiers based on the amount of corroborating evidence.

The top tier (Tier 1) contains populations based on the remote sensing classification that also were verified during preliminary data collection or ground-truthing. The second tier (Tier 2) contains populations based on the remote sensing classification that were not accessible for preliminary data collection or ground-truthing but that are known from the CNDDDB or CalFlora. The third tier (Tier 3) contains populations based on the remote sensing classification that do not have additional evidence corroborating those populations. The populations in the third tier should be considered as potential populations and at the time of acquisition, the distribution and extent of those potential populations need to be verified.

Smooth lessingia was found to occupy approximately 2,660 acres within the entire study area and comprised 72 populations (Table 6; Figure 5). Of the 72 populations, 50 of them were new occurrences, and all except three met the required minimum Plan conservation goal of 2,000 individuals. A total of 20 populations were allocated to Tier 1, 5 populations were allocated to Tier 2, and the remaining 47 populations were allocated to Tier 3. Table 6 summarizes the populations by tier, including each population's acreage, the estimated number of individuals, and whether it overlaps with any known CNDDDB occurrences (EONDX #).

Field data were collected for 371 reconnaissance quadrats characterizing the density and number of individuals throughout accessible parcels. Cover of smooth lessingia based on the quadrat data ranged from 0.5% to 28% cover with an average of 6% cover. Number of individuals per square meter quadrat ranged from 3 to 520 with an average of 89 individuals. The 95% confidence interval was calculated<sup>4</sup> per square meter and extrapolated to individuals per acre. Based on the density in reconnaissance quadrats, we can estimate that there are 360,171 individuals per acre on average (95% confidence interval is 327,796 to 392,545 individuals) and between 871,904,580 and 1,044,130,446 individuals in the study area during the 2019 growing season.

Smooth lessingia was mapped throughout the study area, with large areas mapped on Coyote Ridge, Santa Teresa Hills, and around Calero CE. The majority of smooth lessingia noted during hand-mapping and ground-truthing was within study area polygons (modeled smooth lessingia habitat). However, some small areas of smooth lessingia were also mapped outside of modeled smooth lessingia habitat at Almaden

<sup>4</sup> The 95% confidence interval was calculated as  $mean \pm z \left( \frac{Std. dev.}{\sqrt{n}} \right)$  where  $z$  represents the appropriate  $z$ -value from the standard normal distribution for the desired confidence level, or in this case  $z = 1.96$ , *Std. dev.* is the standard deviation, and  $n$  is the number of samples. Based on this equation, the 95% confidence interval for number of individuals per square meter is  $89 \pm 8$ .

Quicksilver, Coyote Ridge, Rancho Cañada del Oro, and Santa Teresa preserves. These areas were usually adjacent to modeled habitat or extended past the boundaries of modeled habitat.

Smooth lessingia was often found growing on rocky serpentine slopes with very low total vegetative cover or growing amongst non-native annual grasses such as wild oats (*Avena barbata\**, *A. fatua\**), false brome (*Brachypodium distachyon\**), brome fescue (*Festuca bromoides\**), and hare barley (*Hordeum murinum* subsp. *leporinum\**), as well as the native forb, hayfield tarweed (*Hemizonia congesta* subsp. *luzulifolia*). In some parcels, yellow star thistle (*Centaurea solstitialis\**) was also found growing in smooth lessingia patches.



Typical smooth lessingia habitat at Santa Teresa Preserve. Photo taken September 17, 2019.

**Table 6. Smooth Lessingia Populations**

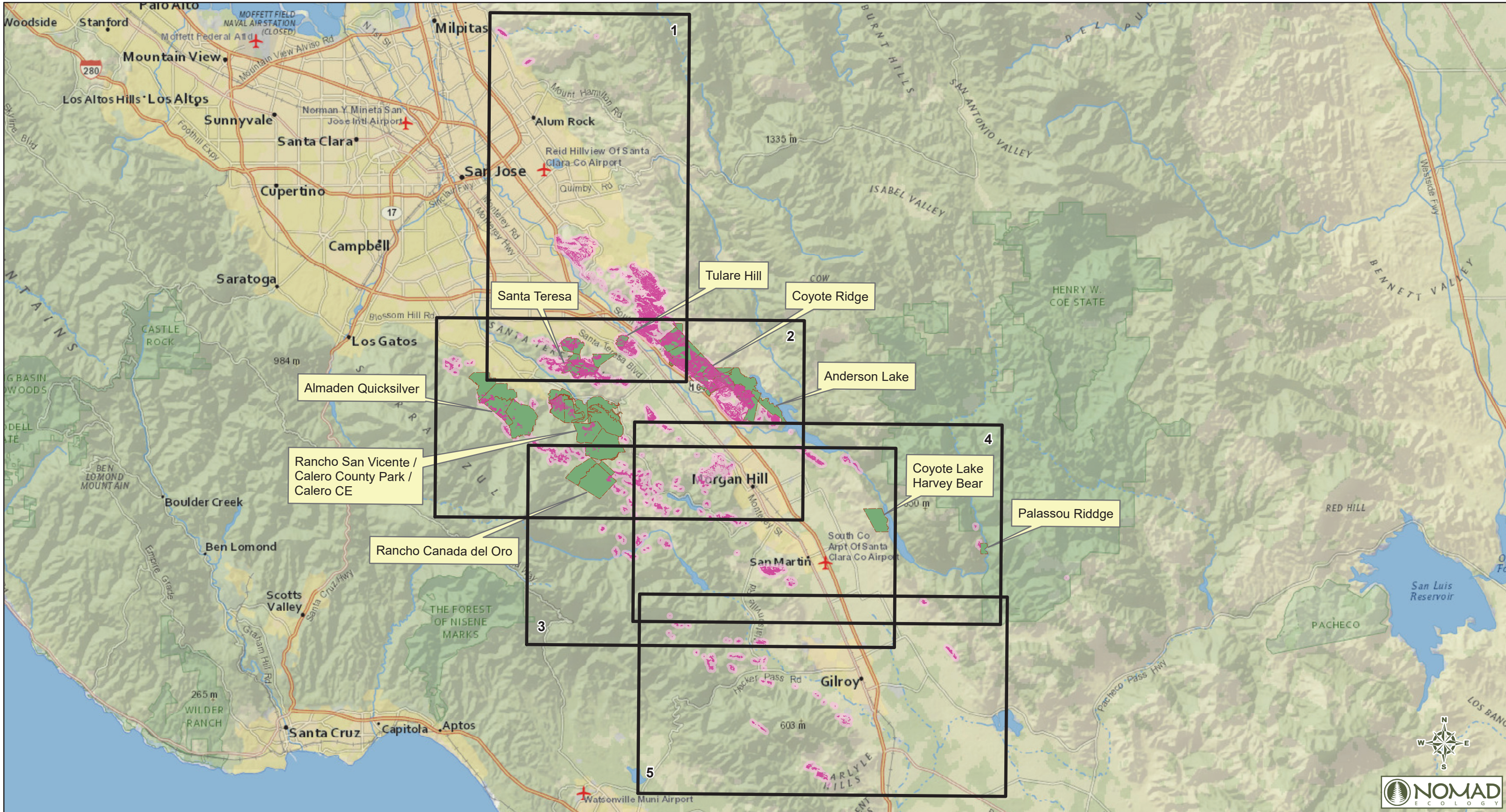
NEW POPULATION	POLYGONS	ACREAGE	EXISTING CNDDDB (EONDX)	POPULATION ESTIMATE	95% CONFIDENCE INTERVAL
<b>Tier 1</b>					
Lesmicgla01*	897	117.44	68192	16,103,353	NA
Lesmicgla02*	137	34.134	94099	3,948,844	NA
Lesmicgla03**	4,335 (77 from Calero)	151.76 (6.29 from Calero)	53560,63334, 68033, 1233	53,121,972 (727,964 from Calero)	48,412,448 - 57,831,485
Lesmicgla05	1,568	32.218	60465	11,603,974	10,560,932 - 12,647,015
Lesmicgla12	369	24.826	1683	8,941,594	8,137,863 - 9,745,322
Lesmicgla13	4	0.013	New Occurrence	4,682	4,261 - 5,103
Lesmicgla14	2195	37.499	94091	13,506,035	12,292,022 - 14,720,045
Lesmicgla15	10581	221.849	1235	79,903,474	72,721,215 - 87,085,716
Lesmicgla17	3,524	42.198	94108	15,198,476	13,832,336 - 16,564,614
Lesmicgla19	62	11.029	New Occurrence	3,972,321	3,615,262 - 4,329,379
Lesmicgla22	46,306	1250.306	30703, 94107, 68179, 53559, 1686, 68189, 68190	450,323,387	409,845,306 - 490,801,369
Lesmicgla23	2892	36.194	68191	13,036,013	11,864,248 - 14,207,774
Lesmicgla42	209	12.389	44287	4,462,153	4,061,065 - 4,863,240
Lesmicgla45	38	3.601	60459	1,296,974	1,180,393 - 1,413,555
Lesmicgla46	9	1.026	New Occurrence	369,535	336,319 - 402,751
Lesmicgla53	1968	43.773	1699	15,765,745	14,348,614 - 17,182,872
Lesmicgla55	1267	18.49	67676	6,659,553	6,060,948 - 7,258,157
Lesmicgla56	23	2.228	68177	802,460	730,329 - 874,590
Lesmicgla67	2245	188.402	60469, 114080, 114079, 114078	67,856,850	61,757,422 - 73,956,263
Lesmicgla70	1407	22.974	1690, 1693	8,274,558	7,530,785 - 9,018,329
<b>Tier 2</b>					
Lesmicgla24	356	81.635	1687	29,402,522	26,759,626 - 32,045,411
Lesmicgla26	1,246	31.661	108682	11,403,359	10,378,349 - 12,428,367
Lesmicgla47	348	39.048	63332, 64169	14,063,939	12,799,778 - 15,328,097
Lesmicgla52	174	7.516	1699	2,707,042	2,463,715 - 2,950,368
Lesmicgla58	198	8.172	108678	2,943,314	2,678,749 - 3,207,878
<b>Tier 3</b>					
Lesmicgla04	97	3.396	New Occurrence	1,223,139	1,113,195 - 1,333,083
Lesmicgla06	8	0.096	New Occurrence	34,576	31,468 - 37,684
Lesmicgla07	19	0.04	New Occurrence	14,767	13,440 - 16,094
Lesmicgla08	22	0.152	New Occurrence	54,746	49,825 - 59,667
Lesmicgla09	29	0.29	New Occurrence	104,449	95,061 - 113,838
Lesmicgla10	41	9.148	New Occurrence	3,294,840	2,998,678 - 3,591,002

NEW POPULATION	POLYGONS	ACREAGE	EXISTING CNDDDB (EONDX)	POPULATION ESTIMATE	95% CONFIDENCE INTERVAL
Lesmicgla11	68	2.678	New Occurrence	964,537	877,838 - 1,051,236
Lesmicgla16	521	16.115	New Occurrence	5,804,148	5,282,433 - 6,325,863
Lesmicgla18	4	0.005	New Occurrence	1,801	1,639 - 1,963
Lesmicgla20	450	7.419	New Occurrence	2,672,105	2,431,919 - 2,912,291
Lesmicgla21	2	0.003	New Occurrence	1,081	983 - 1,178
Lesmicgla25	3	0.001	New Occurrence	360	328 - 393
Lesmicgla27	452	15.142	New Occurrence	5,453,702	4,963,487 - 5,943,916
Lesmicgla28	29	1.1	New Occurrence	396,188	360,576 - 431,800
Lesmicgla29	134	2.294	New Occurrence	826,231	751,964 - 900,498
Lesmicgla30	6	0.025	New Occurrence	9,004	8,195 - 9,814
Lesmicgla31	272	1.211	New Occurrence	436,167	396,961 - 475,372
Lesmicgla32	379	9.935	New Occurrence	3,578,294	3,256,653 - 3,899,935
Lesmicgla33	533	47.034	New Occurrence	16,940,261	15,417,557 - 18,462,962
Lesmicgla34	184	7.299	New Occurrence	2,628,885	2,392,583 - 2,865,186
Lesmicgla35	205	7.751	New Occurrence	2,791,682	2,540,747 - 3,042,616
Lesmicgla36	9	0.063	New Occurrence	22,691	20,651 - 24,730
Lesmicgla37	16	0.069	New Occurrence	24,852	22,618 - 27,086
Lesmicgla38	48	0.998	New Occurrence	359,450	327,140 - 391,760
Lesmicgla39	10	0.075	New Occurrence	27,013	24,585 - 29,441
Lesmicgla40	154	6.15	New Occurrence	2,215,049	2,015,945 - 2,414,152
Lesmicgla41	148	6.307	New Occurrence	2,271,596	2,067,409 - 2,475,781
Lesmicgla43	174	6.008	New Occurrence	2,163,905	1,969,398 - 2,358,410
Lesmicgla44	97	13.118	New Occurrence	4,724,717	4,300,028 - 5,149,405
Lesmicgla48	55	0.324	New Occurrence	116,695	106,206 - 127,185
Lesmicgla49	12	0.545	New Occurrence	196,293	178,649 - 213,937
Lesmicgla50	82	5.01	New Occurrence	1,804,454	1,642,258 - 1,966,650
Lesmicgla51	11	0.044	New Occurrence	15,848	14,423 - 17,272
Lesmicgla54	4	0.818	New Occurrence	294,620	268,137 - 321,102
Lesmicgla57	54	2.265	New Occurrence	815,786	742,458 - 889,114
Lesmicgla59	54	2.265	New Occurrence	815,786	742,458 - 889,114
Lesmicgla60	273	15.09	New Occurrence	5,434,973	4,946,442 - 5,923,504
Lesmicgla61	458	7.418	New Occurrence	2,671,745	2,431,591 - 2,911,899
Lesmicgla62	227	2.215	New Occurrence	797,778	726,068 - 869,487
Lesmicgla63	114	6.23	New Occurrence	2,243,862	2,042,169 - 2,445,555
Lesmicgla64	327	4.264	New Occurrence	1,535,767	1,397,722 - 1,673,812
Lesmicgla65	112	4.851	New Occurrence	1,747,187	1,590,138 - 1,904,236
Lesmicgla66	167	11.981	New Occurrence	4,315,203	3,927,324 - 4,703,082
Lesmicgla68	71	3.421	New Occurrence	1,232,143	1,121,390 - 1,342,896

NEW POPULATION	POLYGONS	ACREAGE	EXISTING CNDDDB (EONDX)	POPULATION ESTIMATE	95% CONFIDENCE INTERVAL
Lesmicgla69	98	8.479	New Occurrence	3,053,886	2,779,382 - 3,328,389
Lesmicgla71	5	0.349	New Occurrence	125,700	114,401 - 136,998
Lesmicgla72	7	0.027	New Occurrence	9,725	8,850 - 10,599
<b>Study Area Total</b>	<b>88,603</b>	<b>2,659.90</b>	<b>NA</b>	<b>901,887,621</b>	<b>871,904,580 - 1,044,130,446</b>

\* Data for Lesmicgla01 and Lesmicgla02 includes results from 2017 Covered Plant Inventory for Calero Conservation Easement (Nomad 2018). The 95% confidence interval does not apply to data collected in 2017.

\*\* Data for Lesmicgla03 includes results from 2017 Covered Plant Inventory for Calero Conservation Easement (Nomad 2018) plus any mapped smooth lessingia from 2019 within 0.25 miles. The 95% confidence interval was only applied to the portion of the population mapped in 2019.



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**Legend**

- Smooth Lessingia
- Population Buffer
- Parcels Accessible to the Habitat Agency

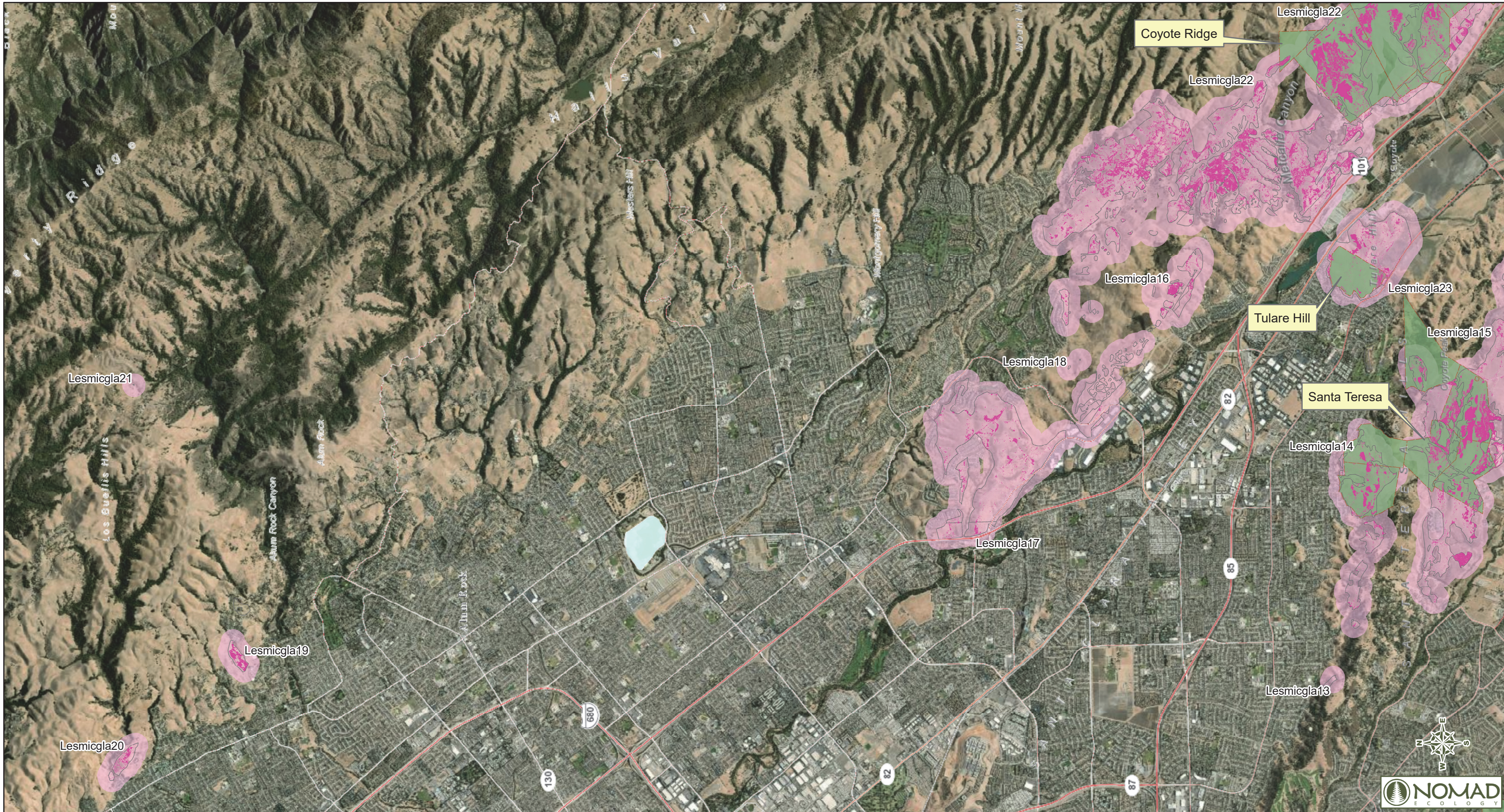
**Figure 6**  
**Smooth Lessingia Distribution**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy

1:253,440

0 2 4

Miles

**Overview**

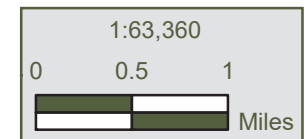


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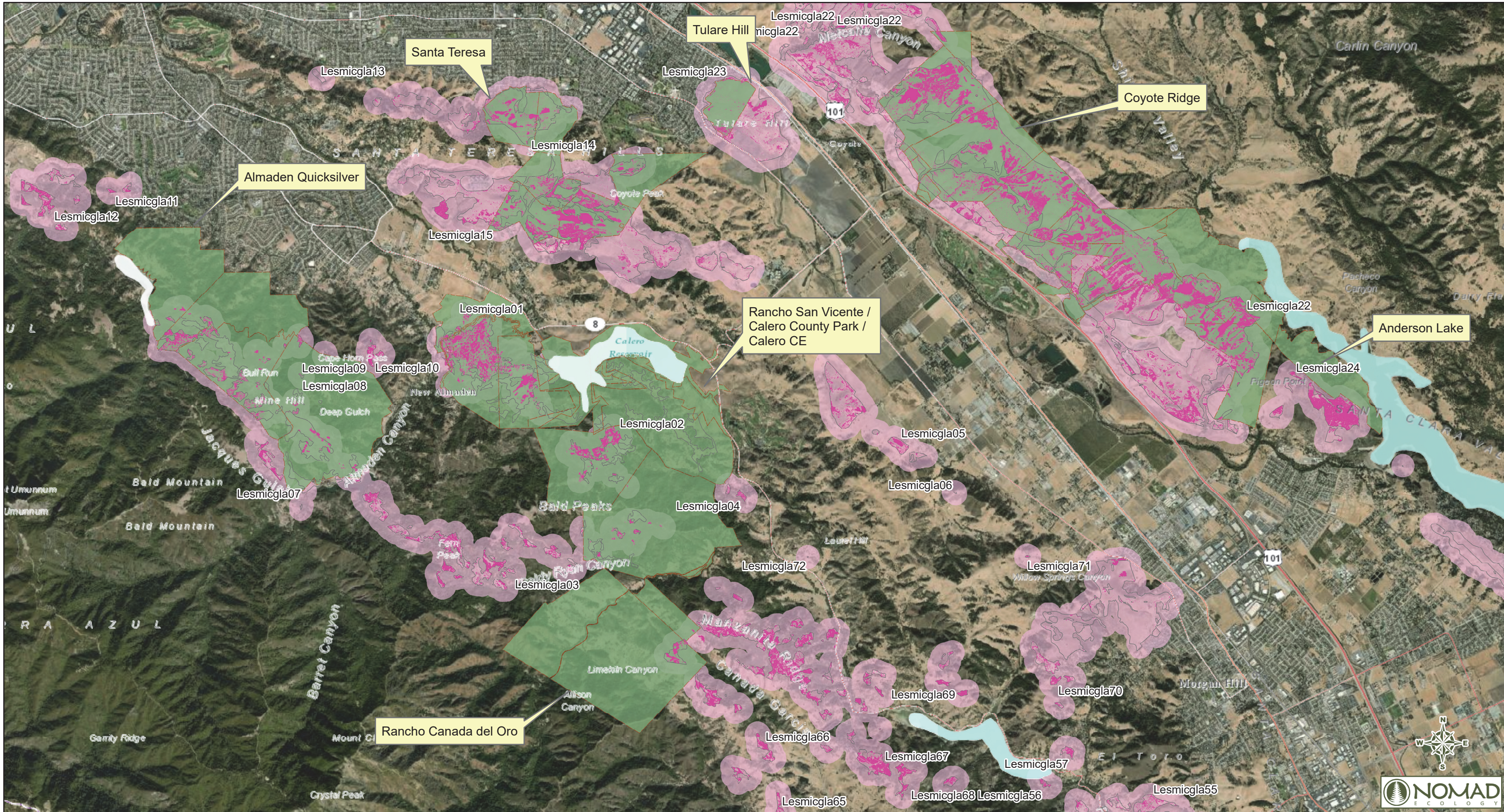
LAG Report

Legend	
<span style="display:inline-block; width:15px; height:10px; background-color: #e91e63; border: 1px solid black;"></span>	Smooth Lessingia
<span style="display:inline-block; width:15px; height:10px; background-color: #fce4ec; border: 1px solid black;"></span>	Population Buffer
<span style="display:inline-block; width:15px; height:10px; background-color: #e0e0e0; border: 1px solid black;"></span>	Smooth Lessingia Modeled Habitat
<span style="display:inline-block; width:15px; height:10px; background-color: #4caf50; border: 1px solid black;"></span>	Parcels Accessible to the Habitat Agency

**Figure 6**  
**Smooth Lessingia Distribution**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy



**Sheet 1 of 5**




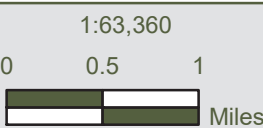
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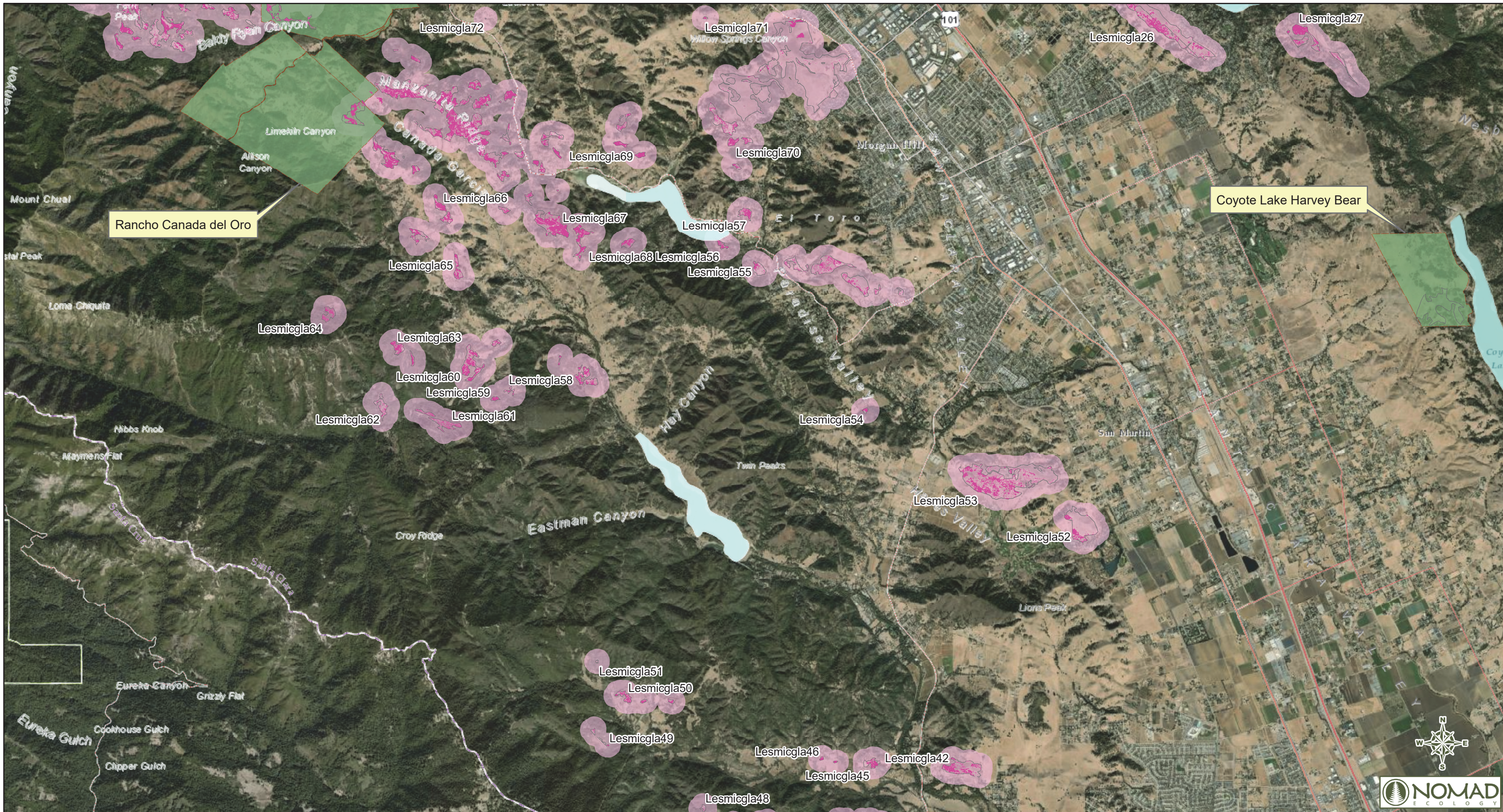
**Legend**

- Smooth Lessingia
- Smooth Lessingia Modeled Habitat
- Population Buffer
- Parcels Accessible to the Habitat Agency

**Figure 6**  
**Smooth Lessingia Distribution**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy

  
  
 1:63,360  
 Miles

Sources: ESRI; Santa Clara Valley Habitat Plan. Projection: NAD 83 UTM Zone 10 North.



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**Legend**

- Smooth Lessingia
- Smooth Lessingia Modeled Habitat
- Population Buffer
- Parcels Accessible to the Habitat Agency

**Figure 6**  
**Smooth Lessingia Distribution**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy

1:63,360

0 0.5 1

Miles

Sources: ESRI; Santa Clara Valley Habitat Plan. Projection: NAD 83 UTM Zone 10 North.

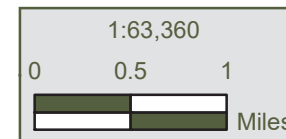


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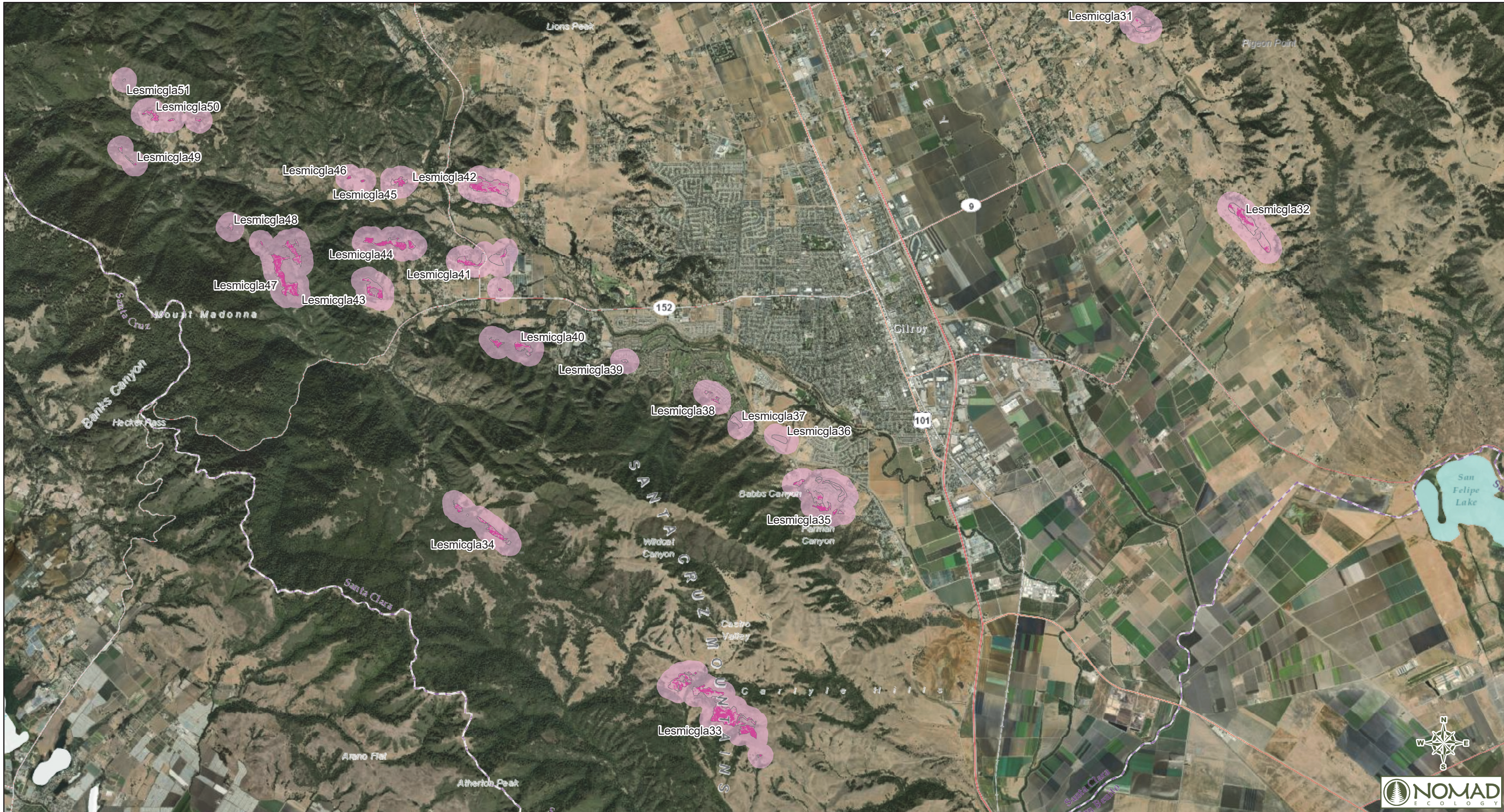
Legend	
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<span style="display:inline-block; width:15px; height:10px; background-color: #fce4ec; border: 1px solid black;"></span>	Smooth Lessingia Modeled Habitat
<span style="display:inline-block; width:15px; height:10px; background-color: #fce4ec; border: 1px solid black;"></span>	Population Buffer
<span style="display:inline-block; width:15px; height:10px; background-color: #4caf50; border: 1px solid black;"></span>	Parcels Accessible to the Habitat Agency

**Figure 6**  
**Smooth Lessingia Distribution**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy



**Sheet 4 of 5**

Sources: ESRI; Santa Clara Valley Habitat Plan. Projection: NAD 83 UTM Zone 10 North.

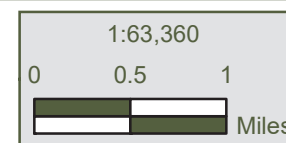


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Legend	
<span style="display:inline-block; width:15px; height:10px; background-color: #e91e63; border: 1px solid black;"></span>	Smooth Lessingia
<span style="display:inline-block; width:15px; height:10px; background-color: #fce4ec; border: 1px solid black;"></span>	Smooth Lessingia Modeled Habitat
<span style="display:inline-block; width:15px; height:10px; background-color: #f8bbd0; border: 1px solid black;"></span>	Population Buffer
<span style="display:inline-block; width:15px; height:10px; background-color: #c8e6c9; border: 1px solid black;"></span>	Parcels Accessible to the Habitat Agency

**Figure 6**  
**Smooth Lessingia Distribution**  
 Establishing a Baseline for Smooth Lessingia  
 Santa Clara Valley Habitat Conservancy



**Sheet 5 of 5**

#### 4.2.1 SMOOTH LESSINGIA WITHIN ACCESSIBLE PARCELS OF THE PRESERVE SYSTEM

Mapped populations of smooth lessingia were found on nine of the ten properties that were accessible during 2019 field work (Table 7 and Figure 6). A total of 11 populations are protected within these properties, only some of which currently make up part of the Habitat Agency’s Reserve System. Three populations – Lesmicgla8, Lesmicgla9, and Lesmicgla29– are new occurrences in the third tier. The majority of mapped acreage, within accessible parcels is found on Coyote Ridge, a total of approximately 631 acres. Santa Teresa and Calero CE had the next most acreage of mapped lessingia with 182 and 158 acres respectively. Coyote Ridge had large dense patches of smooth lessingia that were easy to see from a distance while hand-mapping. The western end of Santa Teresa had relatively little smooth lessingia, but large swaths of smooth lessingia were mapped on the east side. The acreage from Calero CE is based on the mapping done in 2017 and includes the Calero County Park and Rancho San Vicente Parcels as well (Nomad 2018). Notably, no smooth lessingia was mapped within Coyote Lake Harvey Bear preserve. There was relatively little modeled habitat on this parcel and perhaps there was not enough serpentine influence to support smooth lessingia.

**Table 7. Distribution of Smooth Lessingia in Accessible Preserves**

PRESERVE	POPULATION(S)	ACREAGE	POPULATION ESTIMATE	95% CONFIDENCE INTERVAL
Almaden Quicksilver	Lesmicgla03 (Tier 1)	63.29	22,795,346	20,746,209 – 24,844,173
	Lesmicgla08 (Tier 3)	0.152	54,746	49,825 – 59,667
	Lesmicgla09 (Tier 3)	0.29	104,449	95,061 – 113,838
Anderson Lake County Park	Lesmicgla22 (Tier 1)	0.03	9,243	8,413 – 10,074
Calero CE*	Lesmicgla01 (Tier 1)	117.44	16,103,353	NA
	Lesmicgla02 (Tier 1)	34.13	3,948,844	NA
	Lesmicgla03 (Tier 1)	6.29	727,964	NA
Coyote Lake – Harvey Bear	None	0	0	NA
Coyote Ridge	Lesmicgla22 (Tier 1)	631.13	227,313,838	206,881,348 – 247,746,277
Palassou Ridge	Lesmicgla29 (Tier 3)	0.01	2,504	2,279 – 2,730
Rancho Cañada del Oro	Lesmicgla67 (Tier 1)	9.07	3,266,231	2,972,640 – 3,559,821
Santa Teresa	Lesmicgla14, Lesmicgla15	182.20	65,622,267	59,723,699 – 71,520,822
	Lesmicgla14 (Tier 1)	30.75	11,075,309	10,079,786 – 12,070,829
	Lesmicgla15 (Tier 1)	144.33	51,984,096	47,311,418 – 56,656,763
Tulare Hill	Lesmicgla23 (Tier 1)	11.49	4,138,224	3,766,253 – 4,510,194
<b>Total in Preserves</b>	<b>27,054</b>	<b>1,056</b>	<b>341,569,669</b>	<b>312,508,684 – 370,630,582</b>

\* Polygons and acreage from Calero Baseline surveys, includes Calero CE, Calero County Park, and Rancho San Vicente preserves.

#### 4.2.2 SMOOTH LESSINGIA OUTSIDE OF ACCESSIBLE PARCELS OF THE PRESERVE SYSTEM

Outside of accessible parcels, smooth lessingia was mapped in an additional approximately 1,600 acres. Most of the lessingia mapped outside of preserves is located in the northern part of the Plan area in the lands east of Hwy 101 north of Coyote Ridge, the area surrounding Coyote Ridge, and west of Hwy 101 in the hills surrounding Chesbro Reservoir, Uvas Reservoir, and north of CordeValle Golf Club. Some of this mapped area may overlap with current Habitat Agency Reserves that were not accessible at the time of this study.



Smooth lessingia patch in September 2019 on Coyote Ridge.

## **Section 5. DISCUSSION AND CONCLUSION**

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### **5.1. DISCUSSION**

Mapping baseline conditions of target resources such as smooth lessingia is foundational to the Plan's adaptive management and stewardship goals. These baseline maps provide insight into the distribution of smooth lessingia, facilitating strategic management planning at the landscape level. Placing populations into tiers helps distinguish which populations have the highest reliability in order to compensate for the accuracy of the remote sensing model without additional corroborating evidence. The majority of new populations mapped within the study area fall under Tier 3 due to the lack of additional evidence available corroborating their existence. In Tier 1 populations, areas validated by hand-mapping, these data also establish the baseline conditions required for monitoring smooth lessingia into the future. Monitoring, a fundamental phase of the adaptive management cycle, provides tools for assessing success of management actions as well as identifying new potential threats and other issues to natural resources.

#### **5.1.1 BENEFITS OF HIGH-RESOLUTION MULTI-SPECTRAL AERIAL IMAGERY**

High-resolution multi-spectral aerial imagery in combination with field data proved key to creating these baseline data and maps. The high-resolution multi-spectral aerial imagery timed to the unique phenology of smooth lessingia, allowed for remote mapping of smooth lessingia and improved upon past modeled habitat shapefiles. While field data was essential in collecting training polygons and for ground-truthing the remote sensing model, high-resolution aerial images provided a birds-eye view that allowed for more efficient mapping of smooth lessingia extent and also allowed for mapping of smooth lessingia in inaccessible areas.

#### **5.1.2 BENEFITS AND CHALLENGES OF SEGMENTATION AND CLASSIFICATION**

The Spatial Analyst extension in ArcMap was used to analyze aerial photography by developing algorithms to semi-automate the mapping process. These techniques proved to be useful in order to map a large area including inaccessible parcels, but the accuracy of classification without model adjustment was lower than anticipated. On-the-ground data in the form of reconnaissance quadrats, hand-mapping, and ground-truthing was an essential part of the process to help fine-tune the model and provide confidence in the results. Prior to model adjustment, accuracy of classified smooth lessingia polygons varied from 36% producer's accuracy to 96% user's accuracy for reconnaissance quadrats and 62% accuracy for ground-truthing polygons (includes mostly correct and partially correct). While mapping grasslands is notoriously difficult, this level of accuracy suggests that training polygons for different classes were not sufficiently distinct to be able to distinguish between species consistently. It is very possible that advances in the methods of segmentation and classification could produce a more accurate result. Despite challenges in accuracy at a fine scale, with such a large study area and with much of it inaccessible, remote sensing technology is a more efficient way to make an educated guess where smooth lessingia is growing and to track changes in distribution over time. The challenges in consistently classifying smooth lessingia over such a large scale were caused for a variety of reasons including difficulty of mapping grassland species, large size of the study area, and complex topography. At the landscape scale, these challenges were compensated by hand-mapping and ground-truthing accessible portions of the study area and comparing mapped populations to known CNDDDB occurrences and CalFlora observations. Using a tier system helps present mapped populations in order of the most corroborating evidence to the least. Additional evidence gained from on-the-ground techniques (which has accuracy issues of its own) allow for more confidence in the final smooth lessingia distribution.

Mapping grassland species is notoriously difficult, especially when using remote sensing techniques. Although remote sensing techniques have been relatively successful at differentiating species from different functional groups (i.e. grasses, shrubs, and trees), it has had less success separating species in the same functional groups (Bradley 2014). Where remote sensing and segmentation has been successful in mapping grasslands as a whole, it can often only classify land use types or vegetation cover which is then correlated to specific vegetation types in the area, which is not a direct mapping of a specific species (Lobo 1998, Lucas 2007). Grasslands are particularly challenging to map in this way as species often do not have strong unique signatures and the plants are typically small and intermixed leading to distributions which lack hard boundaries. Variation of phenology between species is one of the most promising identifiers for species, although complex environmental gradients can introduce excessive variation into the phenological response, thus obscuring the short window when species differences may be teased out. Because smooth lessingia does have a unique phenology within nonnative annual grasslands, flowering in the fall when most other species have senesced, it should be possible to detect a smooth lessingia signature on the landscape.

Complex topography which is characteristic of the study area for this project, made classification of smooth lessingia more difficult because spectral signatures of non-lessingia grassland and smooth lessingia varied depending on the slope and aspect, and shaded slopes obscured the red-brown hue characteristic of smooth lessingia stands. Strong environmental gradients (slope, aspect, water availability, and elevation) within the study area drive plant growth and vigor in different ways, thus adding a great deal of variability to reconnaissance points and training polygons, making the classifier definition less specific. Segmentation and a site-specific classification algorithm may have better accuracy in a small area (Nomad 2018), but that accuracy is somewhat reduced in scaling up to include such a large heterogeneous area. Most studies that successfully utilize these techniques target areas that are smaller or are often agricultural lands that have little topographic complexity (Lucas 2007, Malstrom 2017).

The segmentation and classification process is also likely more reliable on dense stands that have a stronger signature compared to non-lessingia grasslands. Patches of smooth lessingia with low percent cover were encountered regularly during preliminary data collection. Using training polygons from areas with less visibly distinct lessingia, may have created more overlap in the spectral signatures between smooth lessingia and non-lessingia grasslands, thus creating a less accurate classifier definition and resulting classification.

Based on these challenges in segmentation and classification, certain tweaks to the methods may be helpful in the future including: recording both target and non-target reconnaissance points to use as training polygons, timing aerial photography at midday when shadows are smaller, using segments as the basis for training polygons instead of buffered areas or hand-drawn polygons, creating a classifier definition file for smaller study areas, separate definition files for different aspects, classifying smooth lessingia within cover classes (e.g., >50% cover, 25-50%, 10-25%, and <10%). It should be noted that some of these alternate techniques were tested with the current project (creating separate classifier definition file for study area sections, creating separate classifier definition file for shaded slopes, classifying lessingia in cover classes). In the end, just one classifier definition file was chosen because it classified lessingia closest to the hand-drawn maps from preliminary data collection. Since this is an iterative process however, it is possible that a better solution exists, or that a slightly different solution could work better in the future.

Despite the challenges of utilizing these high-resolution multi-spectral aerial datasets imagery to semi-automate the mapping process, they did prove useful for mapping the target species over a large study area including parcels that were not accessible for hand-mapping. A combination of collecting field data along with remote sensing techniques provided reliable results for populations at the landscape scale although fine-scale results were less accurate, including distribution, acreage, and abundance estimates within populations.

## 5.2. CONCLUSIONS

This project resulted in a highly detailed set of data representing the spatial distribution of smooth lessingia from which to monitor in the future. A total of 72 populations were identified in the study area, 69 of which meet the 2,000-individual minimum, and 50 of which were new occurrences (not recorded in the CNDDDB). Eight Tier 1 populations and three Tier 3 populations are at least partially protected within accessible protected parks and preserves, some of which already make up part of the Habitat Agency's Reserve System.

All 8 of the Tier 1 populations protected within accessible parks and preserves are estimated to exceed the 2,000-individual minimum (Objective 20.12). However, these populations do not include a 150-meter (500 foot) buffer as noted in Objective 20.11; most of the populations continue outside of preserve boundaries. Although, since these populations are large, the minimum required population size would still be contained within the preserves even subtracting the buffer area. The Tier 3 populations should be confirmed via ground-truthing before being counted towards the Habitat Plan objectives. Two of the Tier 3 populations (Lesmicgla8 and Lesmicgla9) are estimated to exceed the 2,000-individual minimum. The third Tier 3 population, Lesmicgla29, should not be considered as meeting the parameters of Objectives 20.11 and 20.12 because the abundance is estimated at just above the 2,000-individual minimum, and the population is mapped along the border of the preserve and does not include a 150-meter (500 foot) buffer.

Of the accessible preserves, only the population within Coyote Ridge Open Space Preserve is currently protected within the Habitat Agency Reserve System. Additional mapped populations may occur on Habitat Agency Reserves that were not included in the accessible parcels such as Tilton Ranch, Baird, Davidson, and Tulare Hill Wedge reserves. The other seven Tier 1 populations and two Tier 3 populations within accessible parcels may also eventually be added to the Reserve System. Furthermore, there are 12 Tier 1 populations, 5 Tier 2 populations, and 41 Tier 3 populations outside of accessible preserves that could be candidates to meet the Habitat Plan objectives. The following recommendations outline what methods should be used for future monitoring of smooth lessingia. It should be noted that these recommendations apply to this particular study area, and that other study areas might be more or less accessible by roads so more or less of the field component might be preferable or possible. Additionally, this is an iterative process, and small modifications and changes to the methods can continue to improve remote sensing accuracy and efficiency in addition to outside improvements on imagery quality and classification software.

### 5.2.1 METHODS SUMMARY

High-resolution, multi-spectral aerial imagery collected during peak smooth lessingia growing season were the fundamental data underpinning the mapping methodology for this project. A high-resolution aerial imagery dataset is an ideal source of information from which to map the distribution and boundaries of this type of habitat early in preserve acquisition and management plan implementation as well as conducting change detection of these features at regular intervals decades into any HCP/NCCP. Future efforts may consider timing aerial imagery flyovers or using multiple flyovers for different aspects to minimize shadows. The time and effort spent obtaining higher quality aerial imagery may or may not save time down the road in post-model corrections.

High-resolution multi-spectral aerial imagery (natural color and NDVI), in addition to preliminary data consisting of quadrats with density and cover information and hand-mapping in accessible parcels, were analyzed to more accurately map landscape-scale populations of smooth lessingia on accessible and inaccessible parcels. In future projects, reconnaissance quadrats for both presence and absence of the target resource should be collected to more accurately and more quickly create training polygons during the classification portion of the methodology. Georectified normal color imagery was then segmented using the mean shift approach, and training polygons were chosen for several different vegetation classes including smooth lessingia. The training polygons, along with segmented normal color imagery, and unsegmented NDVI imagery from a portion of the study area were used as inputs to train the Random Trees

classifier. In turn, the Random Trees classifier, was used to classify imagery from the entire study area. The resulting raster was converted into a shapefile and modified following pre-set rules based on hand-drawn maps and ground-truth data.

The combination of field mapping and classification using properly timed high-resolution multi-spectral aerial imagery was the most viable method and allowed for the identification of smooth lessingia with greater efficiency and accuracy than using an on-the-ground fieldwork approach alone. Although segmentation and classification may be more efficient, especially for inaccessible parcels, there is still room for improvement since this approach had low accuracy. Classification accuracy suffered especially in areas with shaded slopes and where topography was very different from the training polygons. Due to a high rate of false negatives, it is possible the segmentation model would lead to a conservative estimate of smooth lessingia extent prior to adjustments based on hand-mapping and ground-truthing, which were completed to improve accuracy.

### **5.2.2 FUTURE MAPPING AND MANAGEMENT EFFORTS**

Overall, this project demonstrated that a combination of field work, remote sensing using high-resolution multi-spectral aerial imagery, and ground-truthing was effective for mapping smooth lessingia at the landscape scale. Future mapping efforts should consider the size and accessibility of the study area when deciding how much to rely on hand-mapping versus segmentation and classification. Hand-mapping may be more accurate than classification at smaller scales, at least with the currently available software and imagery resolution, but takes much more time and effort and is difficult for landscape-scale populations like smooth lessingia. The remote sensing model along with validation from hand-mapping, ground-truthing, CNDDDB, and CalFlora, was able to define populations of smooth lessingia and was able to cover a large study area as well as map inaccessible parcels. The challenges of remote sensing are that it is less accurate across complex topography and requires ample ground-truthing for detailed results, however the methodology has room for improvement with the trouble-shooting methods discussed above.

Additionally, Tier 3 populations should be confirmed via ground-truthing before properties are considered for enrollment into the Reserve System. Specifically, Lesmicgla8 and Lesmicgla9 are already protected in parks and preserves and should be verified before counting them towards the Habitat Plan objectives.

## Section 6. REFERENCES

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## APPENDIX A SPECIES LIST

SPECIES NAME	COMMON NAME	ORIGIN	COLLECTION	CAL-IPC RATING	CDFA RATING
<b>FERNS</b>					
<b>Pteridaceae – Brake Family</b>					
<i>Pellaea andromedifolia</i>	coffee fern	Native	---	---	---
<i>Pentagramma triangularis</i> subsp. <i>triangularis</i>	gold back fern	Native	---	---	---
<i>Pteridium aquilinum</i> var. <i>pubescens</i>	bracken fern	Native	---	---	---
<b>GYMNOSPERMS</b>					
<b>Pinaceae – Pine Family</b>					
<i>Pinus coulteri</i>	Coulter pine	Native	---	---	---
<b>MAGNOLIIDS</b>					
<b>Lauraceae – Laurel Family</b>					
<i>Umbellularia californica</i>	California bay	Native	---	---	---
<b>EUDICOTS</b>					
<b>Adoxaceae – Muskroot Family</b>					
<i>Sambucus nigra</i> subsp. <i>caerulea</i>	blue elderberry	Native	---	---	---
<b>Anacardiaceae – Sumac or Cashew Family</b>					
<i>Toxicodendron diversilobum</i>	poison oak	Native	---	---	---
<b>Apiaceae – Carrot Family</b>					
<i>Conium maculatum</i>	poison hemlock	Non-Native	---	Moderate	---
<i>Foeniculum vulgare</i>	fennel	Non-Native	---	High	---
<i>Perideridia kelloggii</i>	Kellogg's yampah	Native	---	---	---
<i>Torilis arvensis</i>	hedge parsley	Non-Native	---	Moderate	---
<b>Apocynaceae – Dogbane Family</b>					
<i>Asclepias fascicularis</i>	narrow-leaved milkweed	Native	---	---	---
<b>Asteraceae – Sunflower Family</b>					
<i>Achillea millefolium</i>	yarrow	Native	---	---	---
<i>Artemisia californica</i>	California sagebrush	Native	---	---	---
<i>Baccharis pilularis</i> subsp. <i>consanguinea</i>	coyote brush	Native	---	---	---
<i>Calycadenia multiglandulosa</i>	sticky western rosinweed	Native	---	---	---

SPECIES NAME	COMMON NAME	ORIGIN	COLLECTION	CAL-IPC RATING	CDFA RATING
<i>Carduus pycnocephalus</i> subsp. <i>pycnocephalus</i>	Italian thistle	Non-Native	---	Moderate	On List
<i>Centaurea calcitrapa</i>	purple star thistle	Non-Native	---	Moderate	On List
<i>Centaurea melitensis</i>	toalote	Non-Native	---	Moderate	---
<i>Centaurea solstitialis</i>	yellow star thistle	Non-Native	---	High	On List
<i>Centromadia fitchii</i>	Fitch's spikeweed	Native	---	---	---
<i>Cirsium vulgare</i>	bull thistle	Non-Native	---	Moderate	On List
<i>Corethrogyne filaginifolia</i>	common sand aster	Native	---	---	---
<i>Cynara cardunculus</i>	cardoan	Non-Native	---	Moderate	On List
<i>Dittrichia graveolens</i>	stinkwort	Non-Native	---	Moderate	---
<i>Helminthotheca echioides</i>	bristly ox-tongue	Non-Native	---	Limited	---
<i>Hemizonia congesta</i> subsp. <i>luzulifolia</i>	hayfield tarweed	Native	---	---	---
<i>Lactuca serriola</i>	prickly lettuce	Non-Native	---	---	---
<i>Lagophylla ramosissima</i>	hare's ear	Native	---	---	---
<i>Layia platyglossa</i>	tidy tips	Native	---	---	---
<i>Lessingia micradenia</i> var. <i>glabrata</i> (CRPR 1B.2)	smooth lessingia	Native	---	---	---
<i>Madia elegans</i>	common madia	Native	---	---	---
<i>Silybum marianum</i>	milk-thistle	Non-Native	---	Limited	---
<i>Symphotrichum chilense</i>	Pacific aster	Native	---	---	---
<i>Xanthium strumarium</i>	cocklebur	Non-Native	---	---	---
<b>Brassicaceae – Mustard Family</b>					
<i>Brassica rapa</i>	field mustard	Non-Native	---	Limited	---
<i>Streptanthus albidus</i> subsp. <i>peramoenus</i> (CRPR 1B.2)	Most beautiful jewelflower	Native	---	---	---
<b>Campanulaceae – Bellflower Family</b>					
<i>Lonicera</i> sp.	honeysuckle	Native	---	---	---
<b>Convolvulaceae – Morning-Glory Family</b>					
<i>Convolvulus arvensis</i>	bindweed	Non-Native	---	---	On List
<i>Cuscuta californica</i> var. <i>californica</i>	California dodder	Native	---	---	---
<b>Crassulaceae – Stonecrop Family</b>					
<i>Dudleya abramsii</i> subsp. <i>setchellii</i> (CRPR 1B.1, Federally Endangered)	Santa Clara Valley Dudleya	Native	---	---	---

SPECIES NAME	COMMON NAME	ORIGIN	COLLECTION	CAL-IPC RATING	CDFA RATING
<b>Dipsacaceae – Teasel Family</b>					
<i>Dipsacus sativus</i>	Indian teasel	Non-Native	---	Moderate	---
<b>Ericaceae – Heath Family</b>					
<i>Arctostaphylos glauca</i>	big berry manzanita	Native	---	---	---
<b>Euphorbiaceae – Spurge Family</b>					
<i>Croton setiger</i>	turkey mullein	Native	---	---	---
<b>Fabaceae – Pea Family</b>					
<i>Acmispon americanus</i> var. <i>americanus</i>	Spanish clover	Native	---	---	---
<i>Genista monspessulana</i>	French broom	Non-Native	---	High	On List
<i>Hoita strobilina</i>	Loma prieta psoralea	Native	---	---	---
<i>Spartium junceum</i>	Spanish broom	Non-Native	---	High	---
<i>Thermopsis</i> sp.	California goldenbanner	Native	---	---	---
<i>Trifolium angustifolium</i>	narrow-leaved clover	Non-Native	---	---	---
<b>Fagaceae – Oak Family</b>					
<i>Quercus agrifolia</i> var. <i>agrifolia</i>	coast live oak	Native	---	---	---
<i>Quercus berberidifolia</i>	inland scrub oak	Native	---	---	---
<i>Quercus douglasii</i>	blue oak	Native	---	---	---
<i>Quercus durata</i> var. <i>durata</i>	leather oak	Native	---	---	---
<i>Quercus kelloggii</i>	black oak	Native	---	---	---
<i>Quercus lobata</i>	valley oak	Native	---	---	---
<i>Quercus wislizeni</i> var. <i>wislizeni</i>	interior live oak	Native	---	---	---
<b>Geraniaceae – Geranium Family</b>					
<i>Erodium cicutarium</i>	red-stemmed filaree	Non-Native	---	Limited	---
<b>Lamiaceae – Mint Family</b>					
<i>Monardella villosa</i> subsp. <i>villosa</i>	coyote mint	Native	---	---	---
<i>Salvia columbariae</i>	chia	Native	---	---	---
<i>Salvia mellifera</i>	black sage	Native	---	---	---
<i>Trichostema lanceolatum</i>	vinegar weed	Native	---	---	---
<b>Malvaceae – Mallow Family</b>					
<i>Malacothamnus</i> sp.		Native	---	---	---
<b>Myrtaceae – Myrtle Family</b>					

SPECIES NAME	COMMON NAME	ORIGIN	COLLECTION	CAL-IPC RATING	C DFA RATING
<i>Eucalyptus globulus</i>	bluegum	Non-Native	---	Moderate	---
<b>Onagraceae – Evening Primrose Family</b>					
<i>Epilobium brachycarpum</i>	tall annual willow-herb	Native	---	---	---
<i>Epilobium canum</i> subsp. <i>canum</i>	California fuschia	Native	---	---	---
<b>Orobanchaceae – Broomrape Family</b>					
<i>Castilleja affinis</i> subsp. <i>neglecta</i>	Tiburon paintbrush	Native	---	---	---
<i>Cordylanthus rigidus</i> subsp. <i>rigidus</i>	rigid bird's beak	Native	---	---	---
<b>Papaveraceae – Poppy Family</b>					
<i>Eschscholzia californica</i>	California poppy	Native	---	---	---
<b>Phrymaceae – Lopseed Family</b>					
<i>Mimulus guttatus</i>	common yellow monkeyflower	Native	---	---	---
<b>Plantaginaceae – Plantain Family</b>					
<i>Kickxia elatine</i>	sharp leaved fluellin	Non-Native	---	---	---
<i>Plantago erecta</i>	dwarf plantain	Native	---	---	---
<i>Plantago lanceolata</i>	English plantain	Non-Native	---	Limited	---
<b>Polemoniaceae – Phlox Family</b>					
<i>Leptosiphon liniflorus</i>	narrowflower flaxflower	Native	---	---	---
<b>Polygonaceae – Buckwheat Family</b>					
<i>Eriogonum covilleianum</i>	Coville's buckwheat	Native	---	---	---
<i>Eriogonum gracile</i> var. <i>gracile</i>	slender buckwheat	Native	---	---	---
<i>Eriogonum luteolum</i> var. <i>luteolum</i>	golden buckwheat	Native	---	---	---
<i>Eriogonum nudum</i> var. <i>auriculatum</i>	naked-stem buckwheat	Native	---	---	---
<i>Polygonum aviculare</i> subsp. <i>depressum</i>	common knotweed	Non-Native	---	---	---
<i>Rumex obtusifolius</i>	bitter dock	Non-Native	---	---	---
<b>Rhamnaceae – Buckthorn Family</b>					
<i>Ceanothus papillosus</i>	wartleaf ceanothus	Native	---	---	---
<i>Frangula californica</i> subsp. <i>californica</i>	coffeeberry	Native	---	---	---
<b>Rosaceae – Rose Family</b>					
<i>Adenostoma fasciculatum</i> var. <i>fasciculatum</i>	chamise	Native	---	---	---
<i>Heteromeles arbutifolia</i>	toyon	Native	---	---	---
<i>Prunus ilicifolia</i> subsp. <i>ilicifolia</i>	holly-leaved cherry	Native	---	---	---

SPECIES NAME	COMMON NAME	ORIGIN	COLLECTION	CAL-IPC RATING	CDFA RATING
<b>Sapindaceae – Soapberry Family</b>					
<i>Aesculus californica</i>	California buckeye	Native	---	---	---
<b>Verbenaceae – Vervain Family</b>					
<i>Verbena lasiostachys</i> var.	vervain	Native	---	---	---
<b>Viscaceae – Mistletoe Family</b>					
<i>Phoradendron leucarpum</i> subsp. <i>tomentosum</i>	oak mistletoe	Native	---	---	---
<b>MONOCOTS</b>					
<b>Agavaceae – Agave Family</b>					
<i>Chlorogalum pomeridianum</i> var. <i>divaricatum</i>	soap plant	Native	---	---	---
<b>Liliaceae – Lily Family</b>					
<i>Calochortus</i> cf <i>albus</i>	white fairy lantern	Native	---	---	---
<b>Poaceae – Grass Family</b>					
<i>Aegilops triuncialis</i>	barbed goatgrass	Native	---	High	On List
<i>Avena barbata</i>	slender oats	Non-Native	---	Moderate	---
<i>Avena fatua</i>	wild oats	Non-Native	---	Moderate	---
<i>Brachypodium distachyon</i>	false brome	Non-Native	---	Moderate	---
<i>Briza minor</i>	little quaking grass	Non-Native	---	---	---
<i>Bromus madritensis</i> subsp. <i>rubens</i>	foxtail chess	Non-Native	---	High	---
<i>Cortaderia jubata</i>	jubata grass	Non-Native	---	High	---
<i>Cynosurus echinatus</i>	dogtail grass	Non-Native	---	Moderate	---
<i>Elymus glaucus</i> subsp. <i>glaucus</i>	blue wildrye	Native	---	---	---
<i>Elymus multisetus</i>	big squirreltail	Native	---	---	---
<i>Elymus triticoides</i>	creeping wildrye	Native	---	---	---
<i>Festuca bromoides</i>	brome fescue	Non-Native	---	---	---
<i>Festuca microstachys</i>	Eastwood fescue	Native	---	---	---
<i>Festuca perennis</i>	Italian ryegrass	Non-Native	---	Moderate	---
<i>Gastridium phleoides</i>	nit grass	Non-Native	---	---	---
<i>Hordeum murinum</i> subsp. <i>leporinum</i>	hare barley	Non-Native	---	Moderate	---
<i>Lamarckia aurea</i>	goldentop	Non-Native	---	---	---
<i>Phalaris aquatica</i>	Harding grass	Non-Native	---	Moderate	---
<i>Polypogon monspeliensis</i>	rabbitsfoot grass	Non-Native	---	Limited	---

SPECIES NAME	COMMON NAME	ORIGIN	COLLECTION	CAL-IPC RATING	C DFA RATING
<i>Stipa pulchra</i>	purple needlegrass	Native	---	---	---
<b>Typhaceae – Cattail Family</b>					
<i>Typha latifolia</i>	broad-leaf cattail	Native	---	---	---