IRVINE RANCH CONSERVANCY

Enhancing Tecate Cypress to Promote Population Resilience
Grant Agreement Q1950301
Final Report

Project Background

Necessity

The primary goal of the County of Orange Central and Coastal Subregion Natural Communities Conservation Plan/Habitat Conservation Plan (NCCP/HCP) is to protect and manage habitat supporting a broad range of plant and animal populations, and Tecate cypress (*Hesperocyparis forbesii*) is one of the identified covered species. Tecate cypress is a rare endemic restricted to southern California and northern Baja California with the northernmost population occurring in the Santa Ana Mountains. Its current distribution in the Santa Ana Mountains is restricted to an area of 235.5 hectares in Gypsum and Coal Canyons that is largely in the NCCP Reserve (Figure 1, Rodriguez-Buritica, 2010). The species is classified as a List 1B Species by the California Native Plant Society and is adapted to a fire regime with a fire return interval of 30-40 years, a period sufficient for stands to develop cones to ensure replacement. Too-frequent fires can cause the loss of adult stands and threaten population persistence.

Frequent fires in the northern Santa Ana Mountains have strongly reduced densities of adult Tecate cypress and as well as areas of active recruitment (Figure 2). Some portions of the stands in the Reserve have burned as many as six times since 1914, with the most recent fire occurring in March 2006. The extent of the 2017 Canyon Fire II reached less than 300 meters from the population.

Background and Rationale

The Santa Ana Mountains Tecate Cypress Management Plan (SAMTCM) (Rodriguez-Buritica, 2010) was developed to protect and manage Tecate cypress within the Santa Ana Mountains to ensure the continued persistence of this species. The plan identifies frequent, large wildfires as the major threat to Tecate cypress in the Santa Ana Mountains because, for the population to persist, individuals must reach reproductive maturity and supply sufficient seed for replacement between fire events, a time period of at least 30 years. According to the plan, areas where Tecate cypress currently occur have similarly high burn susceptibilities.

The plan suggests that reducing fire frequency will ensure the continued persistence of Tecate cypress, and several strategic and tactical management recommendations have already been formulated to

4727 Portola Parkway, Irvine, Ca 92602 714.508.4757 FAX 714.508.4758

prevent and control fires. However, the plan also recommends restoring and expanding the population to increase the likelihood that some individuals would survive to reproductive maturity and contribute to population recovery if a fire occurs within the desired 30-year return interval.

The plan identified priority areas for restoration based on a model of seedling habitat suitability within the recent distribution of Tecate cypress, and Coal Canyon Ecological Reserve was identified as containing suitable locations (Figure 3). Although the area has a less than 0.5 burn probability under Santa Ana wind conditions (according to burn probability maps developed for the SAMTCM plan), it has burned four to five times since 1914, with the most recent being the 2006 Sierra Peak fire (Figure 2). Additionally, the plan recommends the use of trial plantings to verify the important environmental limitations of the species.

From 2011 to 2020, Irvine Ranch Conservancy (IRC) conducted a three-phased Tecate cypress restoration trial in Fremont Canyon near Windy Ridge Road (Windy Ridge restoration trial, Burger, 2013). Phase I was planted in January 2011, and the intent was to compare establishment success and efficacy of low- and high-frequency supplemental watering. Phase II was planted in January 2012 with the aim of comparing establishment success between seeds and seedlings. Phase III was planted in January 2015 and was intended to determine if establishment success varied with overall water supply. Based on the results of the trial, establishment from seedlings was more successful than that from seed; the condition of the seedlings influenced the likelihood of survival; and supplemental watering was necessary during years with low rainfall. Furthermore, the success of plantings was strongly influenced by planting year, likely due to differences in rainfall.

In our application, we proposed combining the results from the Windy Ridge restoration trial with higher-resolution topography data from drone imagery as well as the most current available climate, soil, and vegetation data to update the environmental variables used in the habitat model, which we then used to identify additional suitable habitat areas that experience less-frequent fire. We subsequently established additional Tecate cypress stands using the recommendations from the previous trials to mitigate the threat of fire to the existing populations.

Pre-Award Activities

Prior to the finalization of the grant agreement, IRC staff obtained high-resolution elevation, aspect, and slope data at Windy Ridge restoration trial sites using an unmanned aerial system (UAS) in December 2019. These data were intended for future analysis and selection of new Tecate cypress restoration sites.

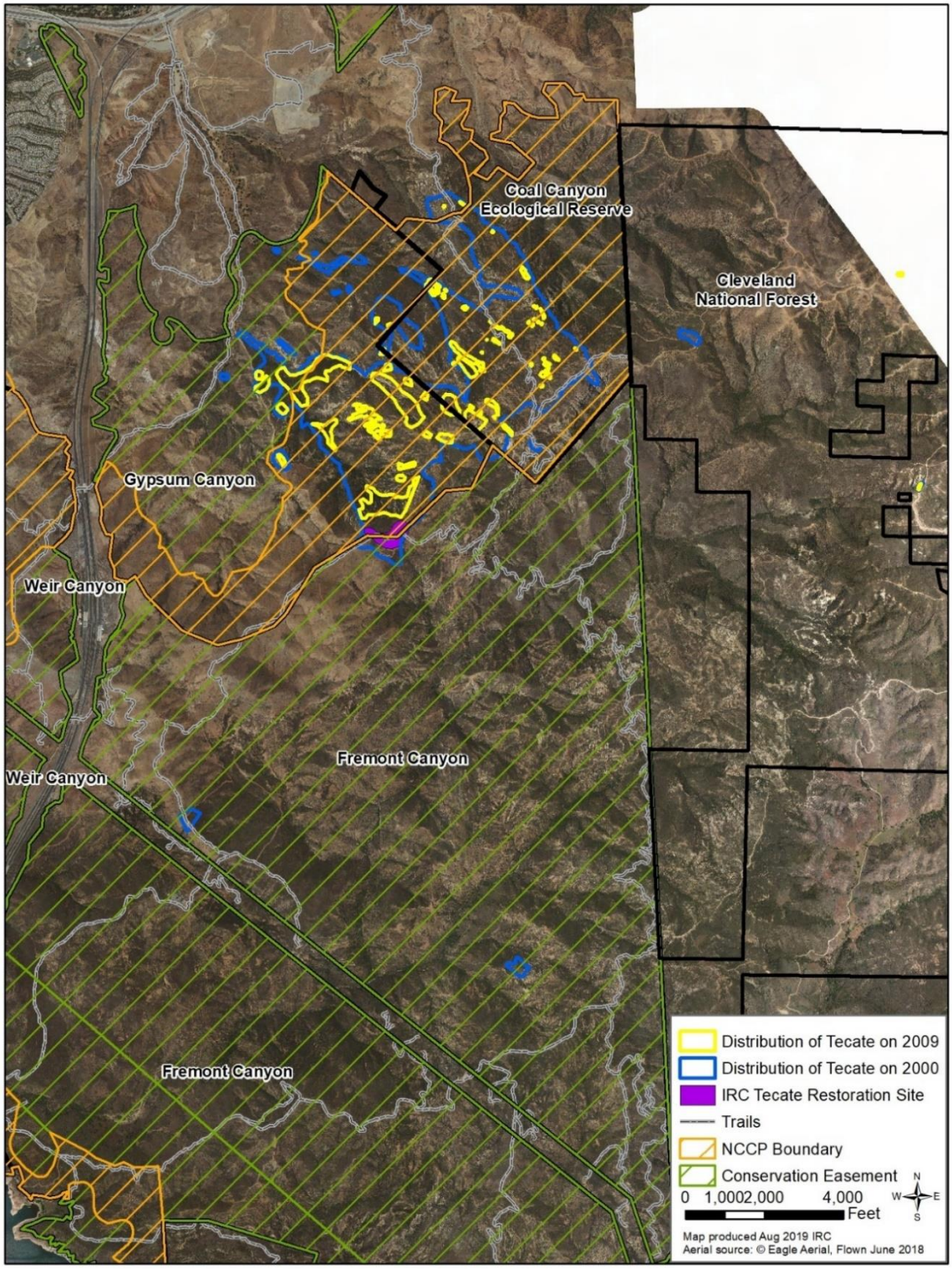


Figure 1. Distribution and reduction of the Tecate cypress population in the Santa Ana Mountains since 2000. The IRC Windy Ridge restoration trial is identified in purple.

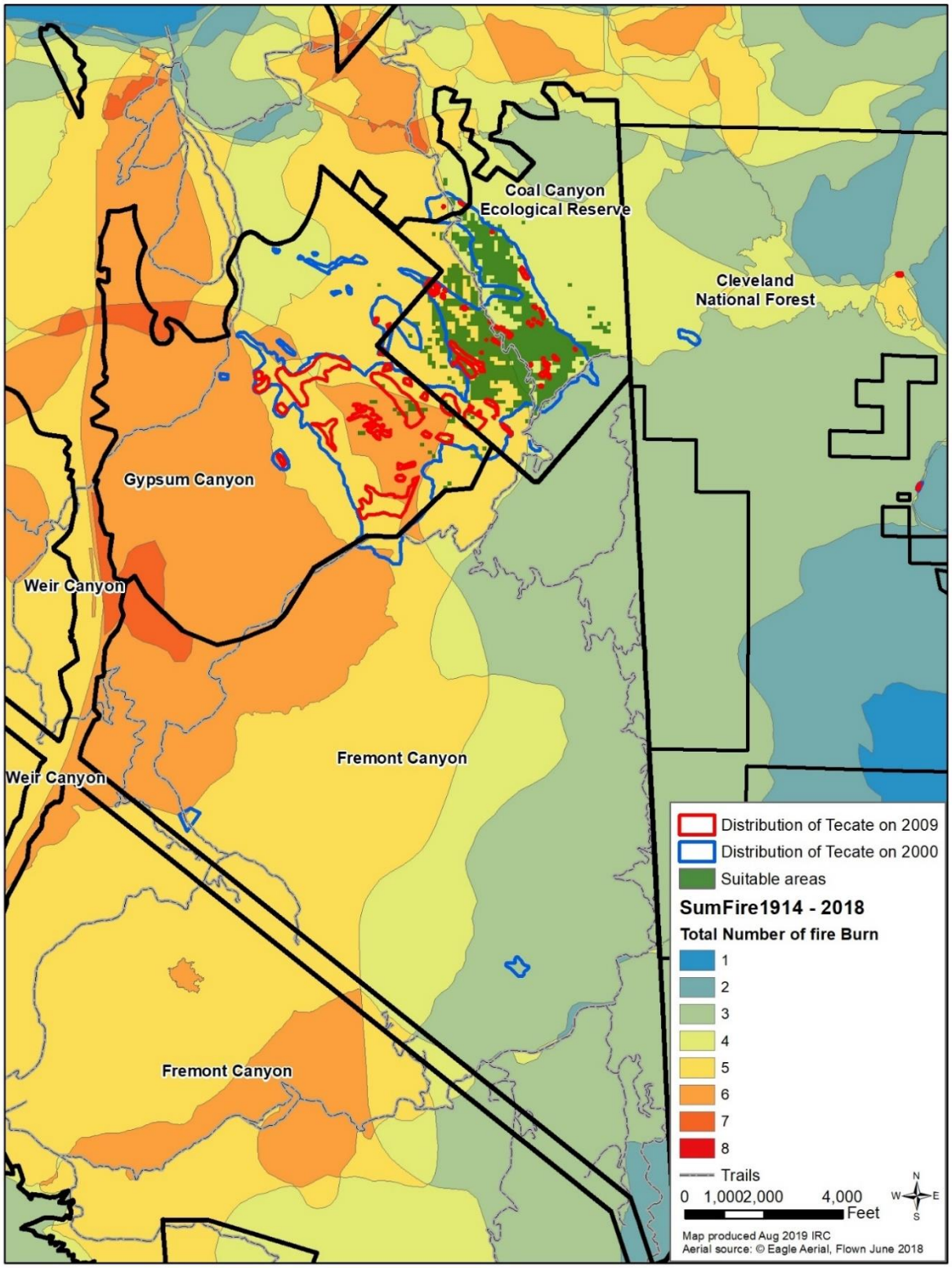


Figure 2. Total number of fires near existing Tecate cypress stands between 1914 and 2018.

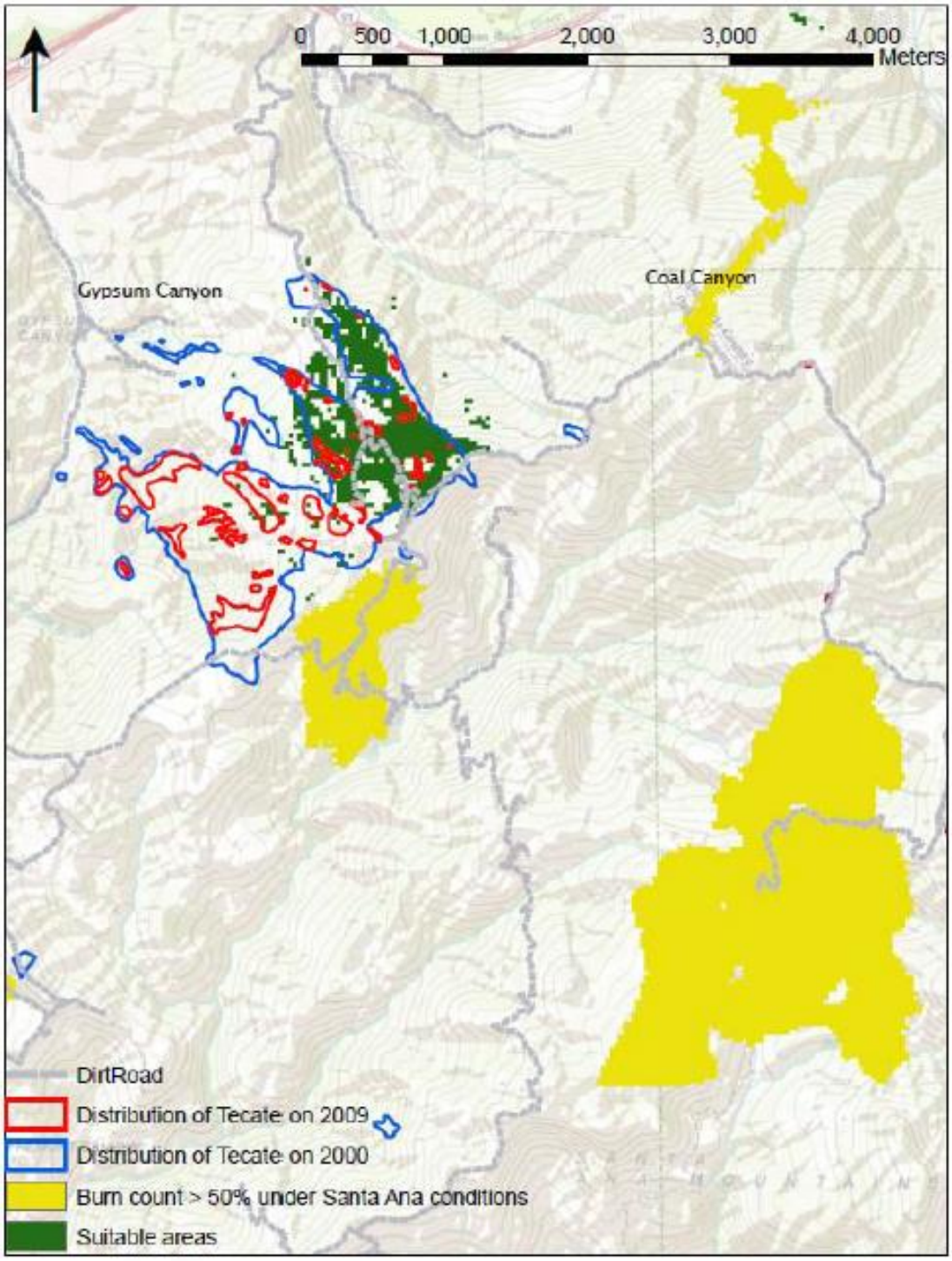


Figure 3. Map from Figure 4-8 in the SAMTCM plan showing suitable areas for Tecate cypress restoration identified after combining burn probabilities and habitat suitability predictions. Suitable areas in green were estimated by selecting those areas with a predicted habitat suitability greater than 0.5 for seedlings and a burn probability of less than 0.5 under Santa Ana Wind conditions. The study area is in the USGS Black Star Canyon 7.5-minute quadrangle.

Goals and Objectives

Project Goal

Enhance Tecate cypress distribution to mitigate the threat of fire and promote population resilience

Project Objectives:

The objectives of this project are to: (1) identify important environmental limitations to Tecate cypress establishment at the Windy Ridge restoration trial site; (2) identify suitable Tecate cypress habitat in an area subject to less-frequent fire using in the habitat model from the SAMTCM Plan; and (3) plant Tecate cypress at identified sites and monitor success.

Important Environmental Limitations to Tecate Cypress Establishment

Analysis

The Extract Values to Points ArcTool was used to obtain various environmental variables (Appendix A) for the locations of individual Tecate cypress. Then, the topography, soil, climate, and vegetation data related to living Tecate cypress at the Windy Ridge restoration trial site were compared to the environmental attributes of locations where adults or seedlings are currently present (Table 4-2 from the SAMTCM shown below).

Conditional inference trees (ctree function in R), which are a non-parametric class of decision trees and provide a recursive partitioning approach for continuous and multivariate response variables in a conditional inference framework, were created for the environmental variables of each phase of the Windy Ridge restoration trial to determine if any variables strongly influence Tecate cypress survivorship.

Table 4-2. Average (± standard deviation) environmental attributes at locations where Tecate cypress adults or seedlings are currently present.

Variable Name	Adult Locations	Seedling Locations
Elevation (m.a.s.l)	530.5 (±150.4)	566.9 (±108.3)
Aspect	SW (255 degrees)	SW (262 degrees)
Slope	15.7 (± 6.4)	14.9 (±4.8)
Temperature during the growing season (°C)	13.6 (±0.6)	13.6 (±1.0)
Temperature during non growing season months (°C)	20.1 (± 0.3)	20.1 (±2.2)
Precipitation during the growing season (mm)	371 (± 20.7)	415 (±12.0)
Precipitation during non-growing season months (mm)	70.8 (±4.8)	70.7 (± 3.4)
pH	6.4 (±0.7)	6.4 (±1.0)
% Sand	59.7 (±13.4)	60.4 (±12.3)
% Clay	15.9 (± 6.1)	15.7 (± 5.8)
% Organic matter	0.8 (±0.2)	0. 8 (±0.1)
Available water capacity(cm^3 water/ cm^3 soil)	0.14 (± 0.01)	0.14 (±0.01)
Depth to any restrictive layer (cm)	35.3 (±33.2)	29.3 (±24.9)
Vegetation type	Primarily California Marine Chaparral	
% Vegetation coverage	30.3 (±18.4)	21.8 (±14.4)

Results

The environmental variables (topography, climate, soils, and vegetation) identified in the SAMTCM habitat model were examined at the Windy Ridge restoration trial sites with live Tecate cypress, and the elevation, soil characteristics, and vegetation coverage were found to be within the range of wild Tecate cypress populations surveyed in 2009 (Table 1 and Table 4-2). In the SAMTCM, the majority of Tecate cypress are in California Marine Chaparral, which is the same vegetation type as that of the Windy Ridge restoration trial site (Southern California Dry-Mesic Chaparral) according to the 2016 vegetation layer (Appendix B). In contrast, the temperature and precipitation at the Windy Ridge restoration trial site during the period from 2010 to 2019 were outside the range of the values observed for the wild Tecate cypress from 1971 to 2000 (Table 4-2). However, the conditions were similar for all locations during the 2010 to 2019 period (Table 2).

Table 1. Average (± standard deviation) environmental attributes at locations of live Tecate cypress planted at the Windy Ridge restoration trial sites.

Variable Name	Live Tecate Cypress Locations
Elevation (m)	524.4 (± 5.1)
Slope	35.0 (± 12.3)
Temperature during the growing season (°C)	16.1 (± 0.02)
Temperature during non-growing season months (°C)	21.2 (± 0.01)
Precipitation during the growing season (mm)	305.7 (± 2.8)
Precipitation during non-growing season months (mm)	36.1 (± 0.4)
pH	6.5 (± 0.3)
% Sand	53.2 (± 16.7)
% Clay	20.0 (± 8.5)
% Organic matter	1.1 (± 0.4)
Available water capacity (cm^3 water/cm^3 soil) (AWC)	0.14 (± 0.016)
Depth to any restrictive layer (cm) (TRI)	48.3 (± 21.8)
Vegetation type	Primarily Southern California Dry-Mesic Chaparral
% Vegetation coverage	37.51 (± 5.47)

Table 2. Average (± standard deviation) monthly temperature and average total (± standard deviation) precipitation per year at locations of Tecate cypress identified in the SAMTCM.

Variable Name	Live Tecate Locations
Temperature during the growing season (°C)	15.9 (± 0.1)
Temperature during non-growing season months (°C)	21.3 (± 0.1)
Precipitation during the growing season (mm)	315.7 (± 13.8)
Precipitation during non-growing season months (mm)	36.9 (± 2.1)

The aspect and slope at the Windy Ridge trial site were outside the range for wild Tecate cypress (Table 4-2). Compared to the wild populations, most of the Tecate cypress at the Windy Ridge trial site were planted on more north-facing (Figure 4) and steeper slopes (Table 1). Based on the success of these trials, steeper and more north-facing slopes appear to be viable options when identifying suitable planting areas for Tecate cypress restoration.

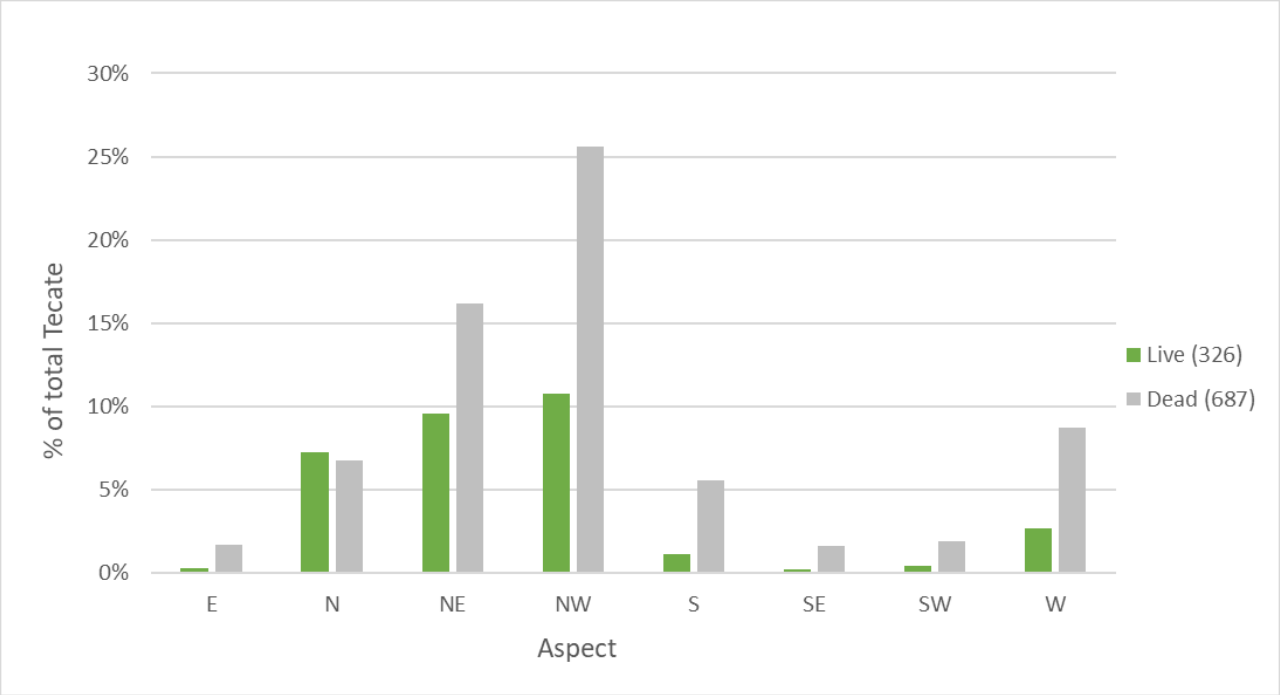
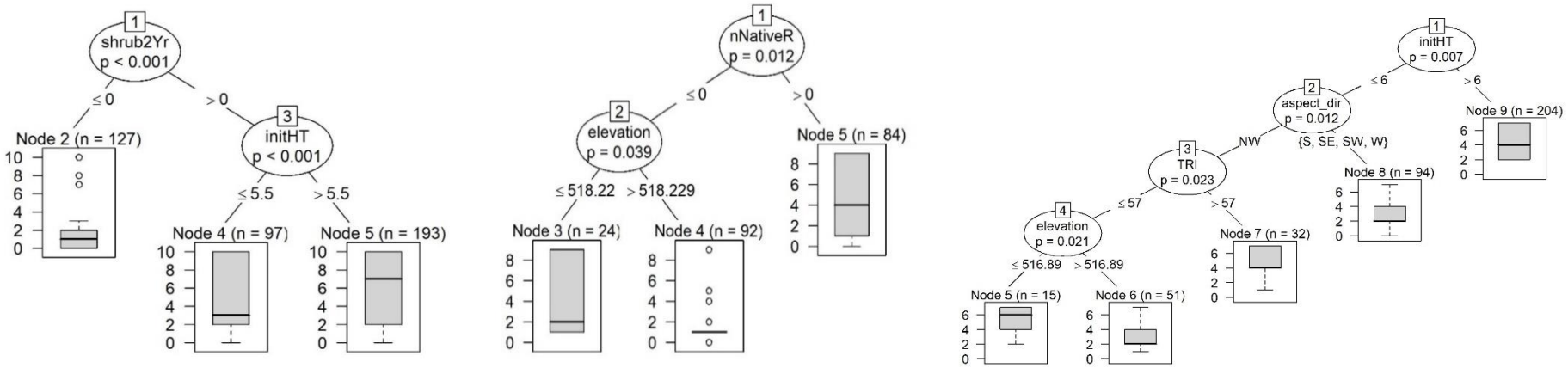


Figure 4. Percentage of living (326) and dead (687) individuals out of a total of 1,013 planted Tecate cypress seedlings by aspect at the Windy Ridge trial sites.

Since each phase of the Windy Ridge restoration trial consisted of different treatments, we ran conditional inference trees separately for each phase (Figure 5). Generally, Tecate cypress seedlings can survive seven years if they are surrounded by shrub cover in the first two years and have an initial height of over 5.5 centimeters. It should be noted that surrounding shrub cover data were only collected for live individuals, so only data from years 1 and 2 could be used and availability varied by Phase. In the future, this information should be collected for all individuals, even those that have died, to create a more robust data set to examine the relationship between shrub cover and survival. In comparison, individuals without shrub cover only live for one to three years ($p < 0.001$). During Phase II, non-native cover and elevation were also shown to influence survivorship ($p = 0.012$ and 0.039), but those sites had more bare ground and less shrub cover relative to Phase I sites. For Phase III, the initial height of planted Tecate cypress (initHT, $P = 0.007$) and aspect ($P = 0.012$) appeared to influence survivorship, but the individual contributions of these variables are unclear. To better explore the relationship between survivorship and the surrounding shrub cover/initial height of seedlings at the trial sites, survival curves were plotted, and the Phase I data indicated a strong, significant influence (Figure 6). Tecate cypress with surrounding shrub cover of more than 10% and taller seedlings exhibit increased survival.



Phase I Phase II Phase III

Figure 5. Conditional inference trees for Phase I, Phase II, and Phase III data. The Y-axis of each box plot shows the number of years of survivorship.

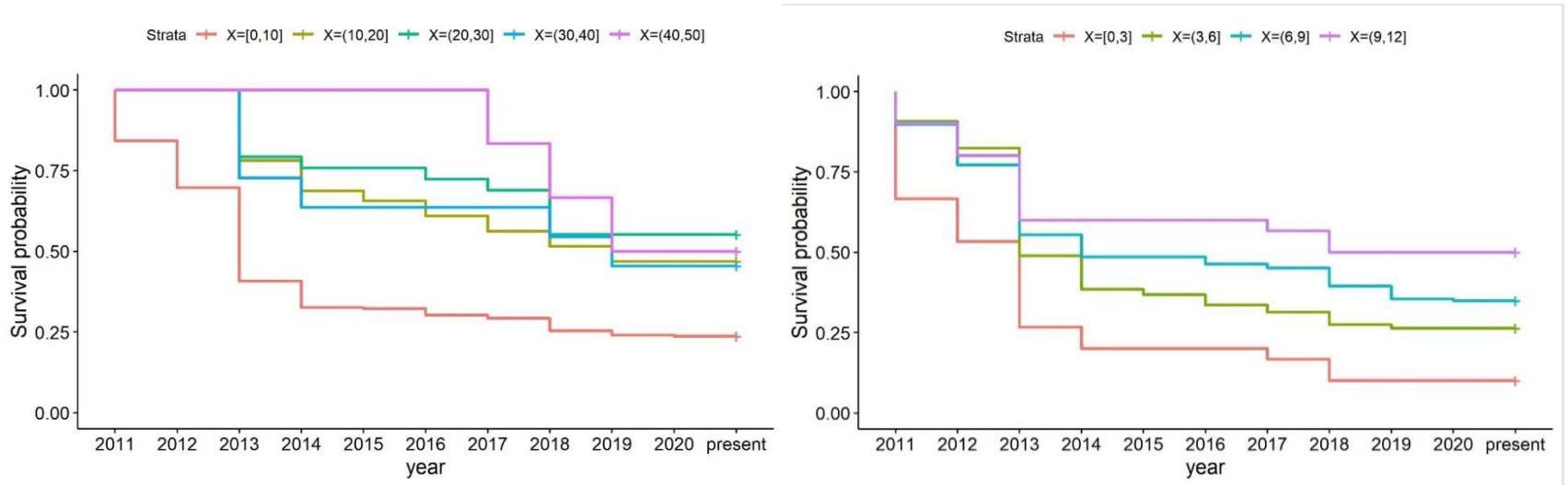


Figure 6. Ten-year survival plots as a function of shrub cover (left) and initial seedling height (right) based on Phase I data.

Identify Suitable Planting Areas

The Natural Communities Coalition had planned to re-survey the Tecate cypress population in 2019, but this did not occur. As a result, instead of re-running the habitat suitability model based on the 2009 population survey with updated environmental variables to identify planting areas, habitat suitability predictions for adult and seedling Tecate cypress generated in the SAMTCM plan were used along with fire information from the last 40 years. Areas with high habitat suitability for both seedlings and adults were selected that are both outside frequently burned areas and close to trails and roads to facilitate access and maintenance. Based on these criteria, an area in Fremont Canyon near State Spur Road and Black Star SCE was identified as a suitable location for the restoration component of the project (the locations of potential Tecate cypress planting areas are shown as purple polygons in Figure 7).

Site visits were conducted at the potential suitable locations, and two planting sites were chosen based on natural openings in the chaparral vegetation that would allow for container planting as well as facilitate access and maintenance (Figure 8). Site 1 was located on a northwest-facing, moderately steep slope, similar to the Windy Ridge restoration trial site. Site 2 was located on a south-facing, relatively flat slope, similar to the locations of wild populations of Tecate cypress. Two sites were chosen due to the limited space for planting within the existing dense chaparral. Additionally, diversifying site locations may lower the risk of fire impacts to both sites.

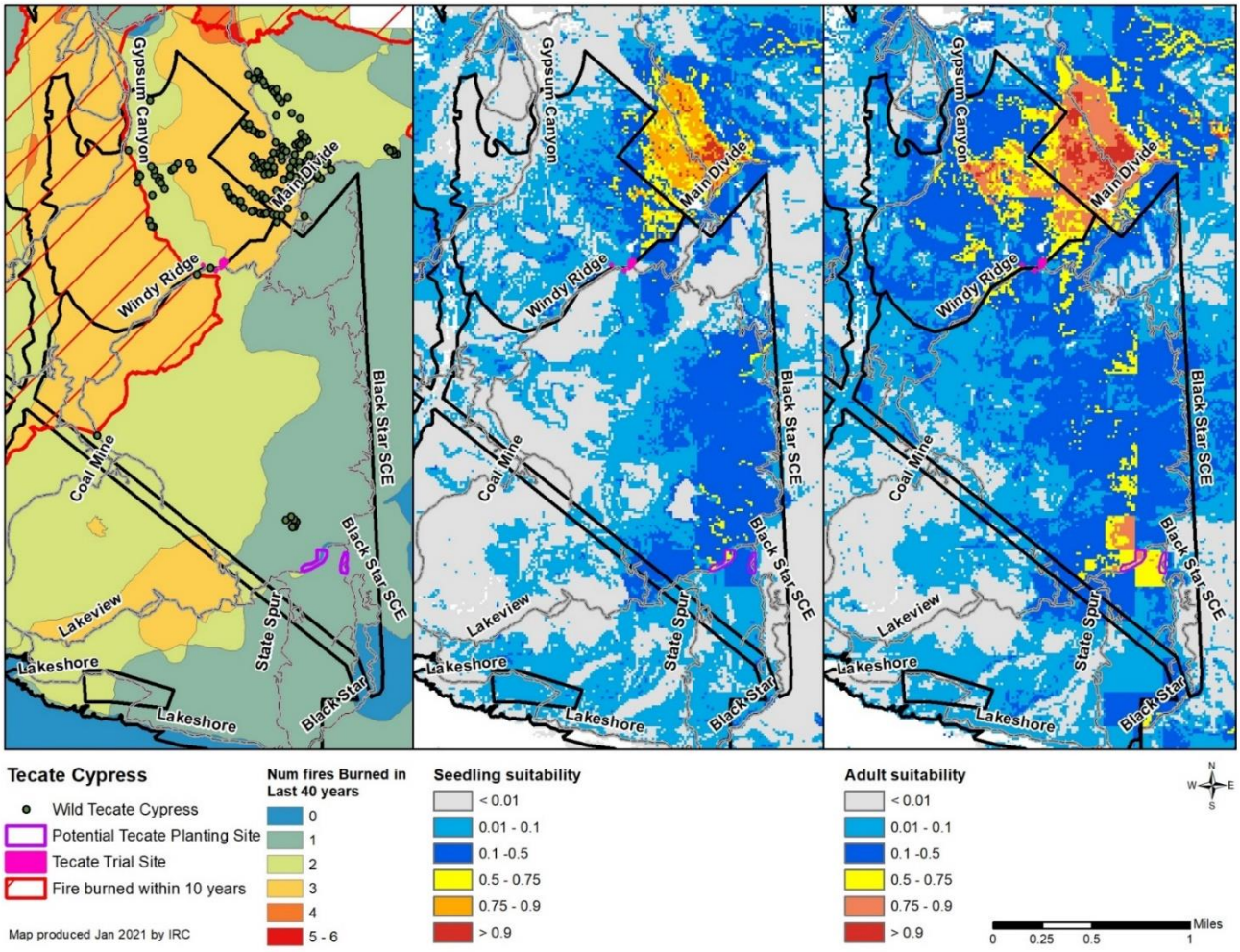


Figure 7. Map of potential Tecate cypress planting sites. Base layers shown from left to right: number of fires burned in last 40 years, habitat suitability predictions for seedling Tecate cypress in the Santa Ana Mountains (SAMTCM), and habitat suitability predictions for adult Tecate cypress in the Santa Ana Mountains (SAMTCM).

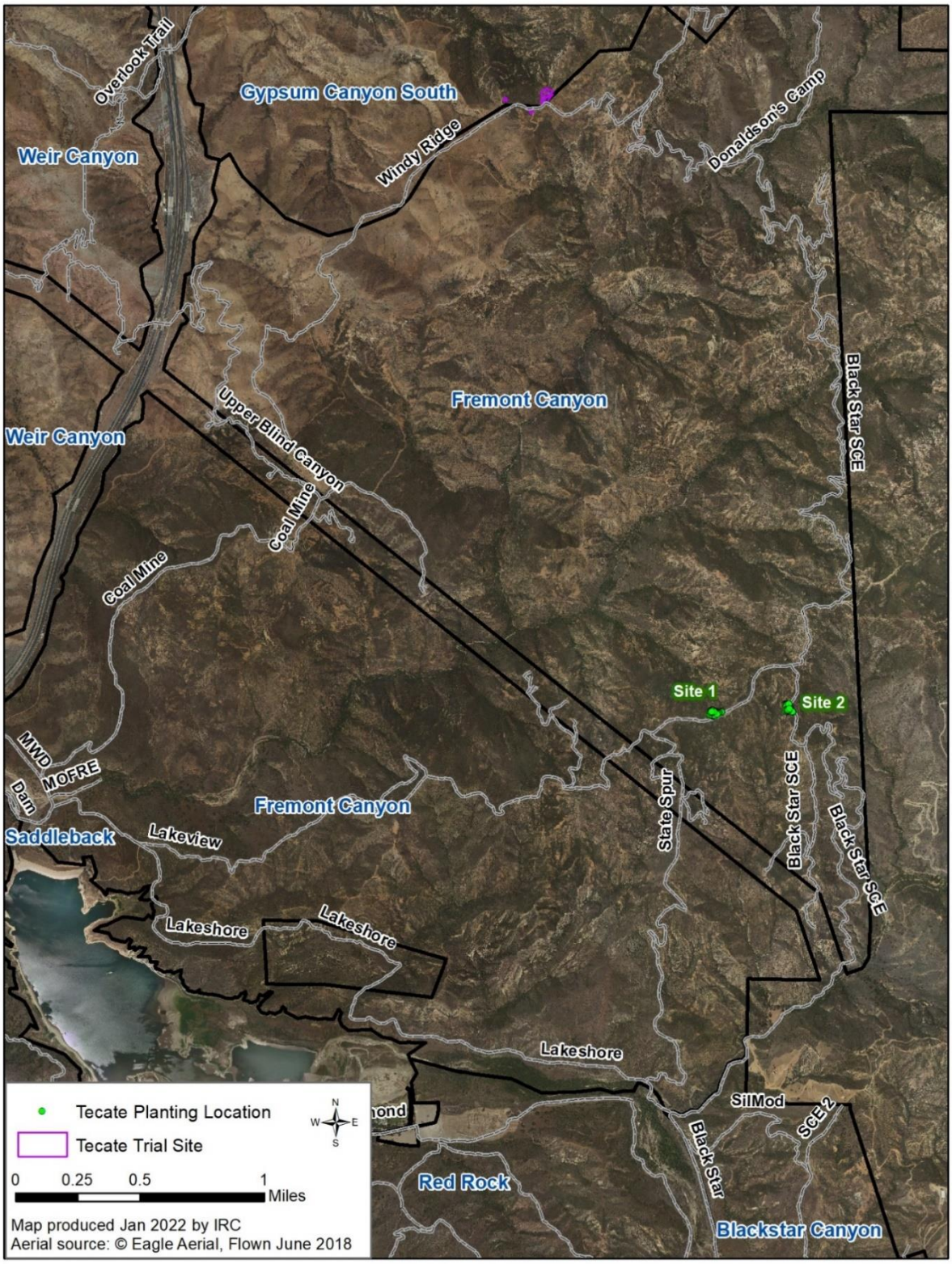


Figure 8. 2021 Tecate cypress planting locations site 1 and site 2.

Planting

IRC stores Santa Ana Mountain-sourced Tecate cypress seed with the California Botanic Garden (CBG) to properly maintain a seedbank. IRC contracted with CBG to grow 400 Tecate cypress seedlings for this restoration project, and CBG sowed two rounds of seed to reach 400 total plants because germination of the first round was low. The staggered germination effectively created two groups of seedlings. A total of 200 seedlings from the first round were slated to be planted at site 1, and 200 seedlings from the second round were slated to be planted at site 2. Also, due to higher germination rates than expected, CBG was able to grow out an additional 160 seedlings that were also purchased by IRC. Seedlings were at varying stages of development at the time of delivery, most of which were smaller than the ideal size.

Planting took place across two days in February and March 2021. A total of 200 seedlings from the first round of germination were planted at site 1 on February 24, 2021, and a total of 200 seedlings from the second round of germination were planted at site 2 on March 17, 2021. March is later than ideal timing for planting, but seedlings for site 2 were held in the IRC nursery for a month to mature since the Windy Ridge restoration trials demonstrated that seedling size at planting impacts survivorship. Upon installation, all plantings were irrigated and provided with above-ground plant protection (Figure 9).

In natural settings, Tecate cypress seedlings would receive a nutrient pulse associated with post-fire conditions and develop with natural mycorrhizae associations to aid their growth. In the future, techniques should be used to mimic the conditions in natural settings, which could aid the growth of seedlings prior to planting.

The additional 160 seedlings were held in the IRC nursery over the course of 2021 and planted at site 1 and site 2 in February 2022. These seedlings were supplemented with natural mycorrhizae collected at wild Tecate cypress stands and grown out in a nursery setting for an additional year and were much more mature at the time of planting than seedlings planted in 2021.

Figure 9. Tecate cypress plantings at site 1

Maintenance and Monitoring

The Tecate cypress plantings were watered every two or three weeks from the time they were installed in February and March 2021. The decision to water more frequently than the proposed plan was based on the low precipitation in 2020-2021 as well as sufficient staff capacity. Each individual planting received approximately two to three liters per watering event.

Weed control took place at the same time as the watering and monitoring events. Very little weeding was required because both sites contained minimal non-native cover and seedbank. The soil disturbance associated with planting and accessing the site did not produce a flush of weeds as would be expected in more disturbed sites.

Monitoring events occurred in February/March (baseline), July, and October 2021 using the same monitoring protocol as for the Windy Ridge trial. Each planting was given a unique ID, and seedling height, health (% green on a 1-5 scale), number of branches > 1 centimeter, and percent shade within 0.25 meters of the planting were recorded.

Results

In October 2021, there was 76% survival at site 1 and 52% survival at site 2. The survival percentage averaged across both 2021 sites was 64%, which is similar to that (72%) at the Windy Ridge restoration trial after one year (Figure 10).

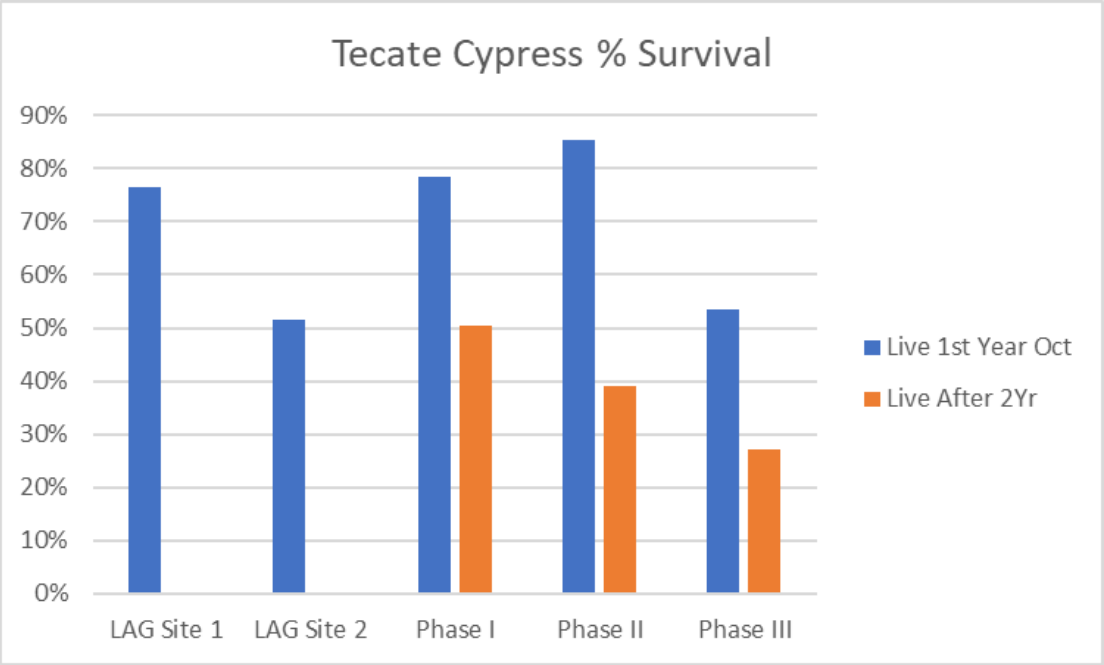


Figure 10. October 2021 monitoring results compared to the Windy Ridge restoration trial sites.

All topography and vegetation coverage values for live Tecate cypress locations at site 1 and site 2 are shown in Table 3. Due to variability in soil features over short distances, soil mapping is best used for general planning purposes and not for highly granular site assessments. The cieneba-rock outcrop map unit at site 1 and site 2 is particularly variable (Appendix C). Therefore, soil data from the Soil Survey Geographic Database (SSURGO 2020) was not considered in the analysis.

Table 3. Average (± standard deviation) environmental attributes at locations of live Tecate cypress planted.

Variable Name	Live Tecate Cypress Locations	Site 1	Site 2
Elevation (m)		639.3(± 3.2)	643.3(± 2.1)
Aspect		NW (307 degree)	S (180.6 degree)
Slope		26.54(± 11)	13.44(± 5.1)
Vegetation type		Southern California Dry-Mesic Chaparral	
% Vegetation coverage		8.58(± 11.3)	10.24(± 12.7)

Climate variables were compared across all years of the various Tecate cypress plantings conducted by IRC (2011, 2012, 2015, and 2021). The total rainfall was relatively low in 2021 compared to previous restoration trial years in 2011, 2012, and 2015 (Figure 11 and Figure 12).

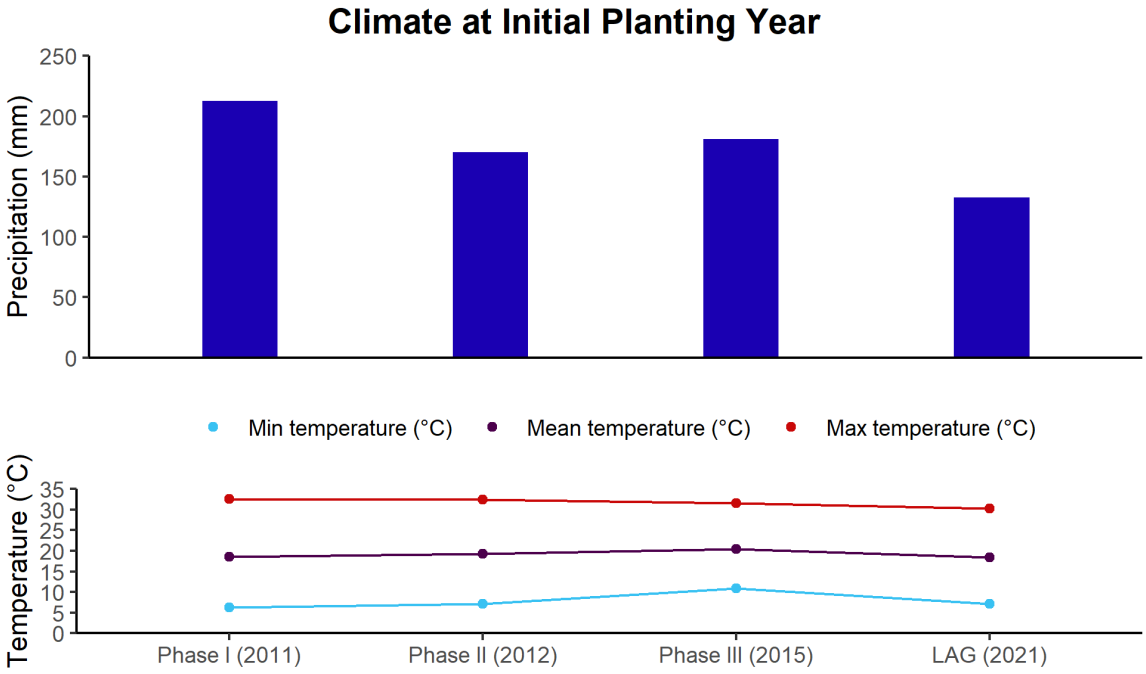


Figure 11. Climate at locations of Tecate cypress planted by IRC.

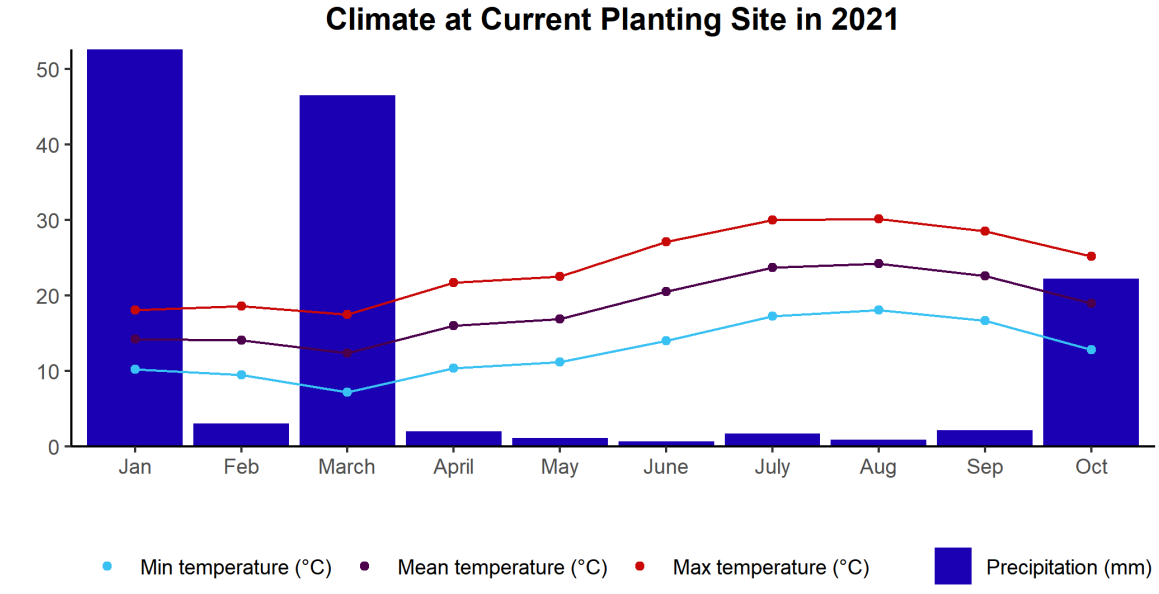


Figure 12. Climate at locations of Tecate cypress planted by IRC.

Among the environmental variables and plant characteristics (topography, surrounding vegetation type, vegetation cover, and initial plant condition) at the 2021 planting locations, aspect, elevation, slope, and initial seedling height differed significantly between site 1 and site 2 (Figure 13). Based on a binominal regression model (Figure 14), factors that may have contributed to a lower survival percentage include site and aspect ($p < 0.001$). Key differences between site 1 and site 2 that may have contributed to the difference in survival percentage were the aspect, timing of planting, the condition of plants at time of planting, and a shallow rocky substrate in portions of the planting site.

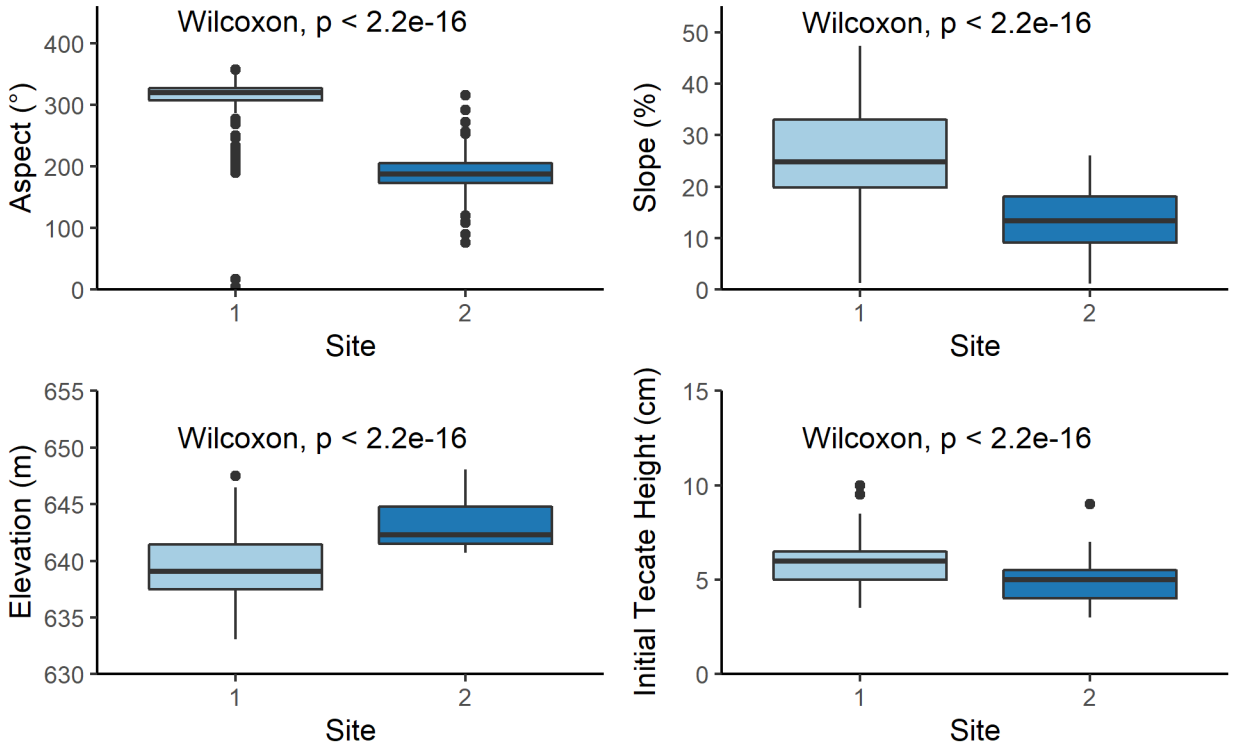


Figure 13. Differences in aspect, elevation, slope and initial seedling height at Sites 1 and 2.

```
Call:
glm(formula = LiveOCt21 ~ Site + I_Height + I_branches + Vegcov +
    Aspect_1m + SlopePr_1m + DEM_1m, family = "binomial", data = TecateLAG)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.4127  -1.0926   0.5892   0.9508   1.9665

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) 76.831016  31.457673   2.442 0.014592 *
Site        -1.794026   0.527312  -3.402 0.000668 ***
I_Height     0.141055   0.122527   1.151 0.249644
I_branches   0.216544   0.086920   2.491 0.012728 *
Vegcov      -0.011106   0.008428  -1.318 0.187573
Aspect_1m   -0.013330   0.004035  -3.304 0.000955 ***
SlopePr_1m   0.029859   0.016041   1.861 0.062683 .
DEM_1m      -0.111585   0.048361  -2.307 0.021035 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 523.87  on 399  degrees of freedom
Residual deviance: 466.10  on 392  degrees of freedom
AIC: 482.1

Number of Fisher Scoring iterations: 4


Call:
glm(formula = LiveOCt21 ~ Site + I_branches + Aspect_1m + SlopePr_1m +
    DEM_1m, family = "binomial", data = TecateLAG)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.2483  -1.1051   0.6027   0.9343   2.0244

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) 78.789929  31.394251   2.510 0.012084 *
Site        -2.134976   0.494927  -4.314 1.61e-05 ***
I_branches   0.239505   0.081577   2.936 0.003326 **
Aspect_1m   -0.014957   0.003985  -3.753 0.000175 ***
SlopePr_1m   0.031773   0.015826   2.008 0.044686 *
DEM_1m      -0.112330   0.048312  -2.325 0.020066 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 523.87  on 399  degrees of freedom
Residual deviance: 469.07  on 394  degrees of freedom
AIC: 481.07

Number of Fisher Scoring iterations: 4
```

Figure 14 Binomial Regression results.

Summary

Several factors may have contributed to the lower survival percentage at site 2 compared to site 1. Site 1 was planted earlier in the rainy season and received the most mature seedlings at the time of planting. Seedlings installed at site 2 were less mature despite the extra month in the nursery which, combined with the later timing of planting, may have contributed to the lower survival percentage. Additionally, the south-facing aspect likely made site 2 hotter and dryer than site 1. These differences in micro-climates between slope aspects may be especially important during drought years such as 2021. Site 2 also contained a sandstone layer of rock roughly 30 centimeters below the soil surface in a portion of the site. Due to the lack of open space for planting across the site, some seedlings were installed in this area, which seemed to have hindered establishment.

Despite the challenges at site 2, the average survival percentage across both sites and the high survival percentage at site 1 compare favorably to the results of the Windy Ridge restoration trial. Overall, the restoration efforts appear to be successful, and the installation of more mature seedlings in 2022 should help in the establishment of successful and resilient Tecate cypress stands. IRC will continue to maintain and monitor these restoration sites and may pursue additional Tecate cypress restoration efforts as resources permit.

There are several factors to consider in future Tecate cypress restoration efforts. Aspect and climatic conditions appear to have an impact on successful establishment. The south-facing aspect of site 2 may have contributed to the lower survival percentage compared to site 1, but it is too early to determine if aspect is the most important factor since the restoration trial was conducted during a year with low rainfall. Additionally, aspect may impact initial Tecate cypress establishment but may have a different effect on the ongoing success of restored stands. Other site conditions including vegetation cover, weed pressure, and micro-environmental factors such as rocky substrates and soils may also influence establishment. Timing of planting and the condition of seedlings at time of planting seem to play a large role in Tecate cypress survival after one year. Minimal competition from non-native vegetation cover, which is often low in intact chaparral habitats, may also have contributed to the overall success of the plantings at both sites.

For future Tecate Cypress restoration, north-facing slopes may be considered for restoration to mitigate the risk of negative impacts from drought. Identifying sites with open areas to plant within existing chapparal is also a challenge to consider. Rather than utilizing natural bare areas in the vegetation, clearing planting areas by pruning existing shrubs is recommended because natural openings often signal poor conditions for plant establishment. The shade provided by surrounding native shrubs appears to benefit seedlings in the establishment phase, but there is also a risk of overcrowding as they mature. Therefore, monitoring growth and maintaining surrounding vegetation are important. Taking advantage of as much natural precipitation as possible is also important; planting early in the winter

between December and February, just before or after the first large rain events, can reduce the amount of supplemental watering needed and may facilitate seedling establishment. Also, installing more mature seedlings may increase the chance of successful establishment. Growing out seedlings earlier in the summer and inoculating them with native mycorrhizae would likely improve development in the nursery and growth after planting. This longer timeline from the point of nursery germination to planting should be considered in future project plans.

Appendix

Appendix A. Environmental data collected.

Topography

The UAS flight covered an area of approximately 21 acres and encompassed all existing Tecate restoration trial sites and the surrounding areas. Before the flight, staff established centimeter-accurate ground control points dispersed throughout the flight area to ensure the accuracy of the derived elevation data. The UAS flew at 200 feet above ground level and collected images with at least 80% overlap. The UAS images were stitched and orthorectified. Elevation, slope, and aspect data were derived from the orthorectified UAS image, and an NDVI image was generated from near-infrared data. The final UAS image could effectively be used to identify the locations of individual plants.

However, U.S. Geological Survey, 20200330, USGS one meter x43y374 CA SoCal Wildfires B1 2018: U.S. Geological Survey was ultimately used in the analysis because it provides more accurate results than the UAS image due to problems separating the vegetation from bare ground to create clean digital terrain models.

Climate

Climate data were gathered for the period of the previous Tecate cypress restoration trial. Seven different environmental variables were derived from monthly temperature and precipitation layers provided by PRISM Climate Group (https://prism.oregonstate.edu/) and averaged over the years that planting occurred. These monthly layers were grouped into growing-season layers (October to March) and non-growing season layers (April to September). Subsequently, the minimum and maximum temperature and precipitation values during the growing and non-growing season months were estimated, and the average temperature and total precipitation during these two periods were also calculated.

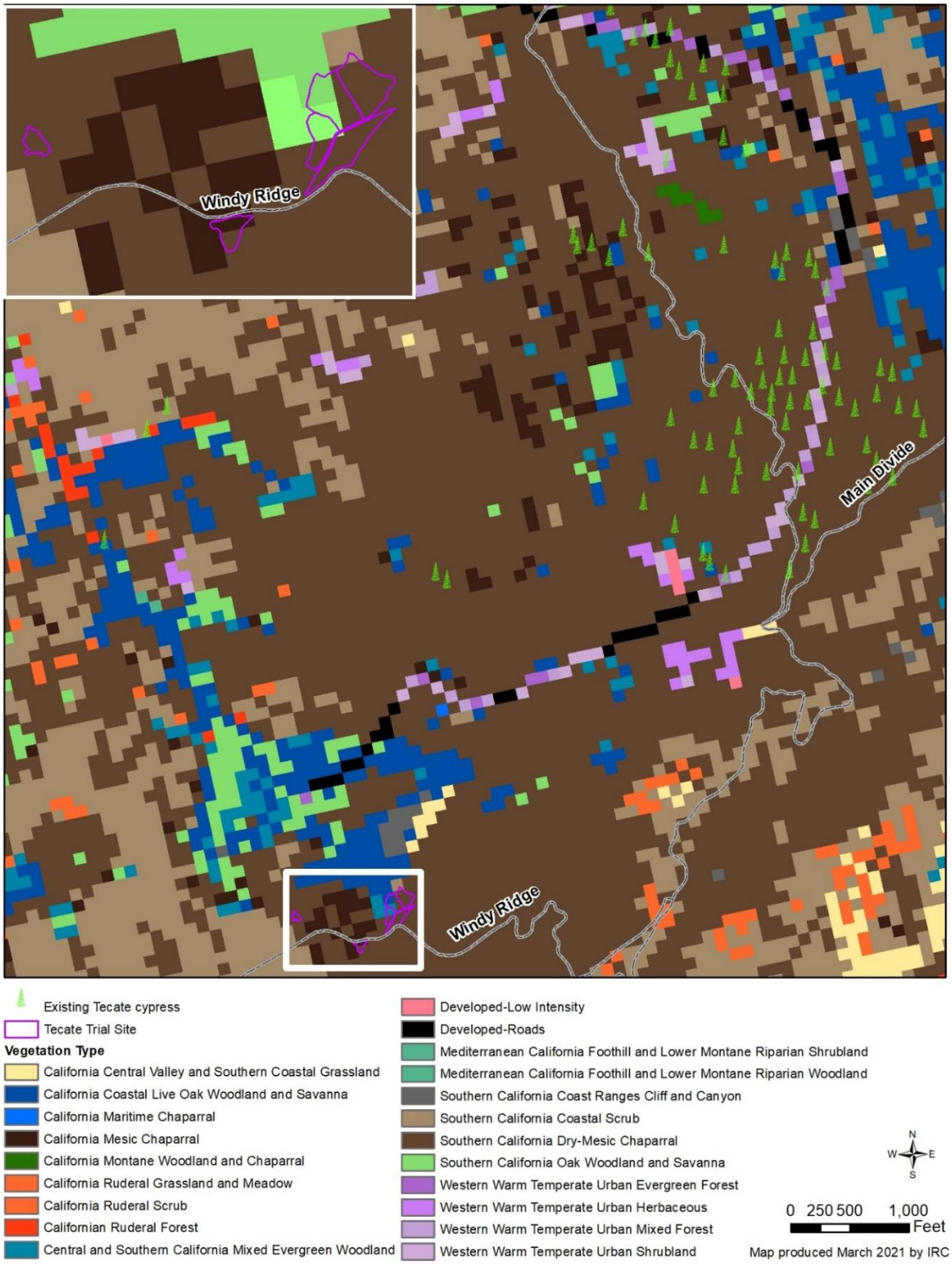
Soils

The soil data used in the analysis (pH, % sand, % clay, % organic matter, absolute water content, and depth to any restrictive layer for root penetration) were downloaded from the Soil Survey Geographic Database (SSURGO 2020).

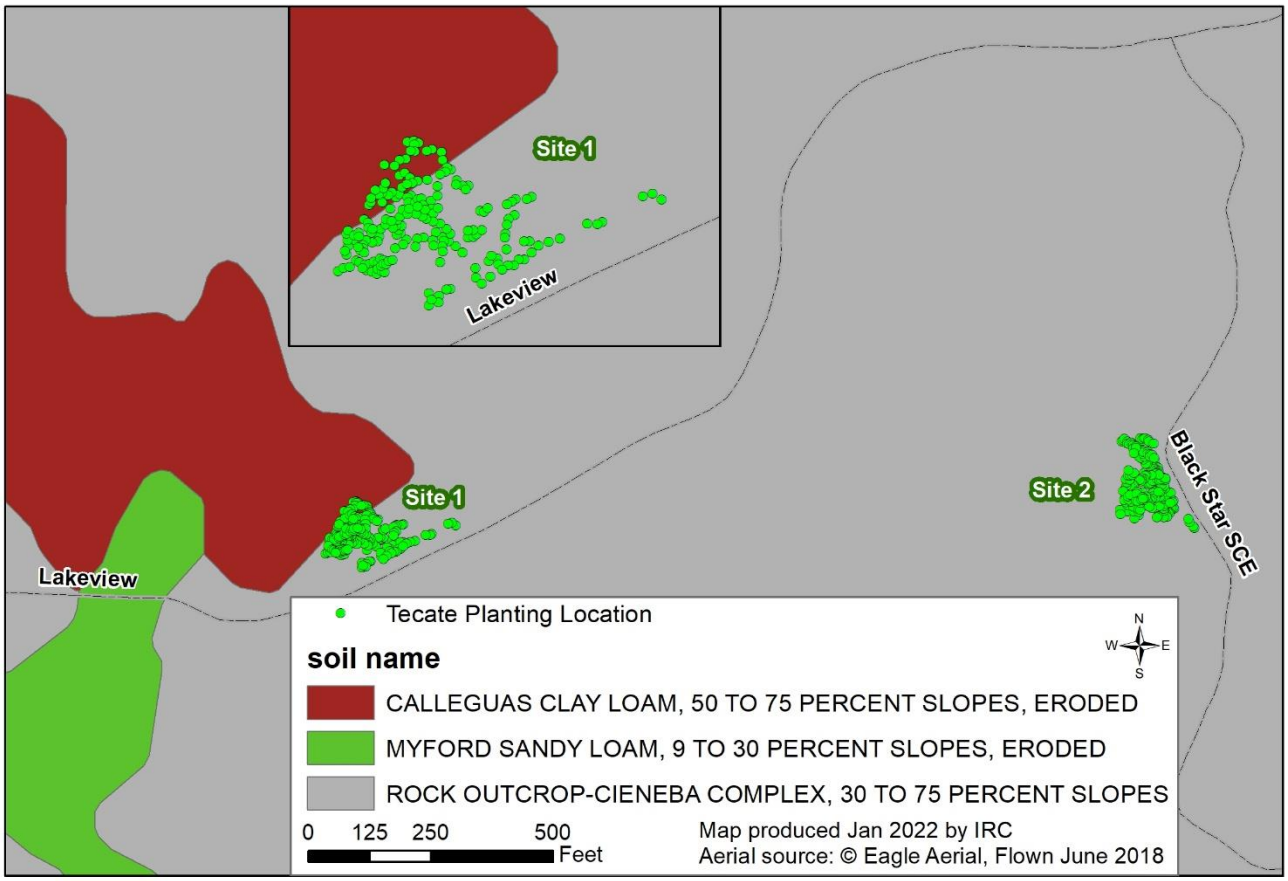
Vegetation

Information on the surrounding vegetation at the time of planting was sourced from monitoring data and included surrounding shrub cover, native cover, and non-native cover. Vegetation cover and type data were also downloaded from the LANDFIRE vegetation layer (2016) (https://www.landfire.gov/evt.php).
Vegetation cover data used in the analysis were collected from monitoring survey.

Appendix B. Vegetation types surrounding existing wild Tecate cypress and at the existing trial sites



Appendix C. Soil at the 2021 Tecate cypress planting locations.



Appendix D. References.

Burger, J. C., Q. Sorenson, YC. Fang. 2013. *Restoring Tecate Cypress in the Santa Ana Mountains* FWS Partners' program project 2013 report

Rodriguez-Buritica, S., K. Suding, and K. Preston. 2010. *Final Santa Ana Mountains Tecate Cypress (Cupressus forbesii) Management Plan.* Prepared for the California Department of Fish and Game and the Nature Reserve of Orange County. Contract #P0750005 01. May 17, 2010 160pp.