CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

ANALYSIS OF THE TREES AT

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

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By

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ABSTRACT

ANALYSIS OF THE TREES AT CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

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The purpose of this study is to investigate the environmental suitability of the trees at California State University, Northridge by analyzing their water use and native climate, together with other considerations such as whether they are native to the South Coast bioregion. Using a geographic information systems (GIS) analysis of all the trees on campus, a table of their frequency was compiled. Using these data, their native habitats were mapped and used to investigate their mean annual rainfall amounts relative to Northridge as well as how much warmer or cooler their mean annual temperatures are than Northridge. In addition, other important factors, such as biogenic volatile organic compound (BVOC) emissions, whether the trees provide shade, and whether they are native to this region, were investigated. Using all of these factors, trees were rated according to how beneficial they are for campus using three scales. The trees tended to be rated as moderately suitable in all three rating scales.

INTRODUCTION

This study presents an analysis of the trees on campus to determine whether they are suitable for the environment. Trees that are the most suitable environmentally demand little or no water, come from climates similar to or warmer than Northridge, are known to reduce ozone pollution, provide shade, and are native to the South Coast bioregion. In addition, new trees were proposed to add to the university that have the good qualities of low water needs, low ozone production, evergreen, and providing shade (Table 1). The recommended trees were based on the assessment of the existing trees in terms of both quality and the numbers of different tree types.

California's water resources are limited by a relatively dry climate. California frequently has droughts that last several years, reducing the availability of water (Blomquist, Schlager, & Heikkila, 2004, p. 3). The state's natural water sources are greatest during the winter and early spring while water demands are greatest during the summer and autumn due to more demand for irrigation, waste disposal, drinking, recreation, and hydropower for electricity. Not enough water is available to meet the demands during the summer and autumn (Blomquist et al., 2004, p. 9). Global warming will decrease California's water supply. As winter temperatures increase, it is predicted that the state's snowpack will decrease by one-third or more in the middle of this century (Schlenker, Hanemann, & Fisher, 2007, p. 20).

Furthermore, the demands for water are increasing, making water scarcity more problematic because this is resulting in insufficient water to meet every demand in many time periods and places. Several factors are increasing the overall demand for water in the state. Population growth, which has been the greatest among all the states (U.S.

Census Bureau, 2001), raises its total usage despite greater conservation efforts. California's rate of increase in water usage is much higher than the overall United States.

The urban and agriculture sectors combined demand tremendous amounts of California's water. Agriculture is the sector that is the largest consumer of water in California (Blomquist et al., 2004, p. 5), using 84% of the 32 million acre-feet of the state's developed water to irrigate 9.68 million acres of land (Howitt & Sunding, 2003, p. 181). While the average annual usage of water by this sector is expected to decrease by 2.3 million acre-feet, a 6.7% decrease, by 2020 from what it was in 1995 due to expected decreases in irrigated crop acres and the government's requirement of efficient water management practices, water usage by urban areas is expected to rise by 3.3 million acre-feet during this period (California Department of Water Resources, 1998). In addition, the California Department of Water Resources (DWR) predicts that the state's population might exceed 65 million by 2050, leading to major increases in urban water use (Howitt, MacEwan, Medellin-Azuara, and Lund 2010).

Urbanization and agriculture in California remove water from rivers and are damaging riverine habitats because plant and animal species living in or near rivers no longer get enough water to survive (Blomquist et al., 2004, p. 6). For example, the Central Valley Project Improvement Act (CVPIA), Section 3406(d)(2) requires the U.S. Bureau of Reclamation to purchase groundwater from water agencies in order to deliver water to the wetlands in the San Joaquin and Sacramento valleys to support these habitats (Blomquist et al., 2004, p. 8). Also, the bureau was required by the CVPIA to ensure that the Kern National Wildlife Refuge had at least 80 percent of the amount of water it needed for the 2000-2001 water year, 90 percent for the 2001-2002 water year, and 100 percent for all water years after that (Blomquist et al., 2004). Due to the amount of water needed to sustain habitats in California, if the state were to ensure there is sufficient water to support all habitat areas, there would literally be no water available for agriculture or urban areas. The combination of the water demand for agriculture, urban use, and environmental needs per year is at least one million acre-feet more than the annual water supply in California, and this deficit is resulting in a depletion of California's groundwater supply.

Similar to habitat needs, recreational activities require water in the lakes and rivers for people to enjoy activities such as fishing, boating, white water rafting, kayaking, etc. In addition, hydropower also demands water and will be particularly important in the future because all types of electricity generation will be necessary in California. Agriculture, urban use, hydropower, recreation, and river habitat are all competing with each other for water (Blomquist et al., 2004, pp. 8-9).

Because of this stress on our water supply, it is important for everyone to conserve, and this can be accomplished by using native vegetation rather than ornamental vegetation in landscaping. In addition to reducing water use, native tree species fit in well with the natural environment of the area and do not require as much maintenance such as irrigation, fertilization, and artificial pesticides (Hatch, 2007, pp. 48-49). Reducing pesticide use is important because it results in health problems like cancer, asthma, respiratory diseases, birth defects, and neurotoxicity (Levine, 2007, p. 195). Also, native species reduce negative environmental impacts by reducing energy use and conserving water and other resources.

California has a very diverse climate with many eco-regions, including deserts, grassland and chaparral, montane forests, alpine tundra, interior woodland, and coastal scrub. One bioregion is the North Coast bioregion, located in the Northern California coastal area, which receives 76 cm to 305 cm of annual precipitation with mixed evergreen and Redwood forests (Welsh, 1994). In addition, there are several mountain bioregions in California including Klamath, Cascade, North Sierra, South Sierra, Transverse Range, and Peninsular. These mountain bioregions tend to receive a lot of precipitation, especially in the northern parts of the state, with coniferous trees like Douglas-fir, Yellow Pine, Red Fir, Ponderosa Pine, Jeffrey Pine, Pinyon-juniper, etc. Additionally, California's Central Valley is composed of two similar bioregions, the Sacramento Valley and the San Joaquin Valley, which are composed of mainly California prairie, but in the eastern portions, have Blue Oak-digger Pine, chaparral in the uplands, and Yellow Pine in the Sierra foothills. Also, two desert bioregions exist in the state, the Mojave Desert and the Colorado Desert, which have Creosote-bush and desert scrub. Joshua-trees are also present in the Mojave Desert. Lastly, the South Coast bioregion includes the coastal and inland valley areas of Southern California (Welsh, 1994).

California State University, Northridge is located in the South Coast bioregion. Its natural environment is characterized by an abundance of coastal scrub, chaparral, annual grasslands, and coastal oak woodlands. In addition, some of the secondary vegetation in this bioregion includes valley oak woodland and closed-cone pine-cypress (Welsh, 1994).

California State University, Northridge has a Mediterranean climate, meaning that it has wet winters and dry summers, and 92% of its rainfall occurs between November 1st

and April 30th (National Oceanic and Atmospheric Administration, 2008). The average annual rainfall in Los Angeles, where California State University, Northridge is located, ranges from less than 30 cm right at the coast to more than 51 cm over the foothills, and downtown Los Angeles receives 37.52 cm on average (N.O.A.A., 2008).

The inland valleys of Los Angeles, like the one where the university is located, are mild in the winter and hot in the summer. In the winter, the average daily temperature of Los Angeles's inland valleys is about 12.8° C with a 13.6° C diurnal range. During the first half of August, Los Angeles's inland valleys have an average daily temperature of about 25.3° C with a 21.2° C diurnal range (N.O.A.A., 2008). During the summer, the daily high temperatures sometimes exceed 38° C in the San Fernando Valley, where the university is located.

Urbanization in Los Angeles has replaced much of the coastal sage scrub with ornamental trees, resulting in the disappearance of many bird species, such as Wrentits (*Chomaea fasciata*), Cactus Wrens (*Campylorhynchus brunneicapillus*), California Thrashers (*Toxostoma redivivum*), and Roadrunners (*Geococcyx californianus*) from the urban areas (Guthrie, 1974). However, some of the birds that depend on coastal sage scrub are also present in the tree filled foothill canyons, such as Mockingbird (*Mimus polyglottos*), Scrub Jay (*Aphelocoma coerulescens*), Orioles (*Icterus spp.*), Titmouse (*Parus inornatus*), and Anna's Hummingbird (*Calypte anna*), and are therefore usually able to do well in urban areas. However, some of them, including Acorn Woodpeckers (*Melanerpes formicivorus*) and Bushtits (*Psaltriparus minimus*), will not survive in urban areas unless there are a number of native Live Oak trees (*Quercus agrifolia*), trees they need to survive (Guthrie, 1974). In addition, urbanization in Los Angeles also adds some types of birds, including English Sparrow (*Passer domesticus*), House Finch (*Carpodacus mexicanus*), Rock Dove (*Colomba livia*), and Starling (*Sternus vulgarus*), that do not depend on coastal sage scrub (Guthrie, 1974). The House Finch (*C. mexicanus*) and the Starling (*S. vulgarus*) also inhabit the tree filled canyons of the foothills. The changes in bird habitat wrought by urbanization have led to the loss of some bird species. Other species are retained, and a few new species are attracted, including some that are native to the local woodland foothill canyons. One solution to retain the local bird species might be to plant coastal sage scrub, but coastal sage scrub has little value in an urban setting because it is both a fire hazard and tends to be easily overwatered by enthusiastic irrigators (Guthrie, 1974). A better solution might be to plant Live Oak trees (*Q. agrifolia*) to help retain many of the local bird species.

Planting ornamental trees provides many benefits to urban areas. First, ornamental trees help cool the air and reduce CO_2 emissions in several ways. Trees help keep buildings cooler by blocking sunlight from reaching buildings. They cool the air by providing shade and by evapotranspiration, and thereby help reduce energy use indirectly by reducing air conditioning demands which therefore reduces CO_2 emissions (McPherson et al., 2000, p. 14). In addition, Simpson (1998) notes that trees keep buildings cooler by reducing wind speed which in turn reduces the amount of hot air entering buildings. Trees also absorb CO_2 and therefore reduce the greenhouse effect. Also, trees can help reduce air pollution by absorbing particles (e.g. smoke, pollen, ash, and dust), nitrogen oxides, and ozone (McPherson et al., 2000, p. 15). They also reduce air pollution indirectly by producing oxygen and by cooling the air which in turn reduces ozone in the air. Despite reducing ozone in the air, most trees release biogenic volatile organic compounds (BVOCs) which can help produce ozone, with some tree types releasing more than others (McPherson et al., 2000, p. 15). If trees release only a small amount of BVOCs, they can actually reduce ozone in the air, whereas trees releasing high amounts likely increase it (Taha, 1996). Thus, there is a complex relationship between ozone production and release of BVOCs which varies from tree to tree. Ozone pollution causes serious health problems such as problems in pulmonary functioning, lung inflammation (World Health Organization, 2008), and cardiopulmonary disease (Dockery et al., 1993). Additionally, urban trees also reduce storm runoff by capturing the rainfall, causing a reduction of pollution entering rivers and the ocean. In California, evergreen and conifer trees do so more than deciduous trees due to the majority of rainfall occurring in the winter when deciduous trees do not have their leaves (McPherson et al., 2000, pp. 16-17). Trees also make cities more beautiful and help relax people (McPherson et al., 2000, p. 18).

There are numerous options for arborists in the region, so it is important to consider the various qualities and disadvantages of each tree species. Table 1 contains a summary of tree species and their characteristics that are suitable for planting at California State University, Northridge.

The California State University, Northridge campus is 356 acres (California State University, Northridge, 2008) with roughly 3,700 trees. Of the more common trees on campus, there are about 166 Crape Myrtle (*Lagerstroemia indica*) trees, which are deciduous and grow to be 25 ft. tall and wide (Hatch, 2007, p. 268). These are able to grow in both moist and dry soil and are drought tolerant (Urban Forest Ecosystems Institute, 2010). Crape Myrtle (*L. indica*) trees grow flowers in the summer that are pink, lavender, purple, rose, red, or white. Another popular campus tree is the pine (*Pinus* spp.), of which there are about 268, with the majority being Canary Island Pine (*Pinus canariensis*). Canary Island Pine (*P. canariensis*) trees range from 50 ft. to 80 ft. tall and 20 ft. to 35 ft. wide when they are mature. Canary Island Pine (*P. canariensis*) trees grow in moist and dry soil and are also drought tolerant (U.F.E.I., 2010). In addition, there are about 191 Eucalypt trees on campus. The majority have heights ranging from 33 ft. to 164 ft., but a Eucalypt species common on campus called Blue Gum (Eucalyptus globulus) reaches heights of 148 ft. to 230 ft. (Doughty, 2000, p. 4). Also, Eucalypts do well in regions receiving 60 cm to 100 cm of annual rainfall (Doughty, 2000, p. 3). California State University, Northridge has an orange grove in which there are about 600 Valencia Orange trees (*Citrus sinensis* 'Valencia'). The most ideal precipitation range for these is 12.5 cm to 50 cm, and the most ideal temperature range for these trees is 13° C to 38° C (Discover Life, 2012).

METHODS

Analysis of the Existing Trees On Campus

The data for the existing trees on campus were taken from a database created between spring 2008 and spring 2010 by a group of geography students working under the direction of faculty member, Dr. Helen Cox. This database contains information on the location of each tree, its species, size and type (CSUN, 2011).

ArcMap 9.3.1, a geographic information systems (GIS) application program used to map and analyze geographic data, was used to create maps of the native distributions of the species found on campus. The GRIN Taxonomy for Plants website (2010), together with Hatch (2007) and a website of Australian species were used to find these distributions. With the GRIN website, the species' names were entered into the query, as shown in Figure 1, to retrieve their native distributions as Figure 2 shows. Using these, rainfall and temperatures relative to Northridge could be determined for the trees' native habitats. These were used to generate ΔP (precipitation amounts relative to Northridge), and ΔT (temperature differences from Northridge) values for the trees using ArcMap.

To estimate the water needs of the existing trees at the university, each tree was assigned a water need score based on the reported precipitation of that tree's native habitat. Each water need score was then analyzed against the precipitation record for Northridge to determine the difference between the native and local precipitation. The difference or ΔP for each tree was put in a database. Trees native to areas receiving less rainfall than Northridge were assumed to not need any irrigation, whereas, trees from places that receive more precipitation than Northridge were presumed to require irrigation, and the more rainfall in the native range above Northridge's rainfall average, the higher the irrigation demands would be. To get the median ΔP value for each species, layers were created within ArcMap to show the ΔP between the species' native ranges and the local conditions in Northridge. To create these layers, first, a raster layer from (European Distributed Institute of Taxonomy, 2007a), showing the global mean annual rainfall for 1950 to 2000 was added (Figure 3). Then, a vector layer showing the global ΔP was created by calculating the rainfall differences from Northridge of the previous layer, with positive ΔP numbers representing more rainfall than Northridge and negative numbers representing less (Figure 4). Then, the species' native distribution layers were overlaid on top of the global ΔP layer (Figure 5) to select the ΔP in the native habitats, finally producing the species' distributions' ΔP layers (Figure 6). Median values were calculated from the individual pixel ΔP values within each species distribution. Rainfall data were available for about 90% of the trees on campus. For some trees, the species' distributions are unknown. For the *Citrus sinensis* trees, the minimum of the ideal rainfall range was taken from Discover Life (2012).

The temperature ranges of the campus tree species' native distributions were analyzed in the same way to calculate the differences between the trees' native climate conditions and the local temperature regime. It is assumed that trees native to areas warmer than Northridge would require less water at the university because they would not lose as much water through Transpiration on campus compared with their native habitats. Likewise, trees from places cooler than Northridge lose more water through transpiration on campus compared to their native area and would therefore require more water when situated at the university. The median ΔT for the species' native habitats were acquired using the exact same methods as the species' ΔP data were. A raster layer showing the mean annual temperatures in tenths of degrees Celsius for the world for 1950 to 2000 was taken from E.D.I.T. (2007b), and the median ΔT values were derived from this layer (Figure 7).

In addition to climate considerations, several other factors were used to determine the overall suitability of the university's trees. Levels of BVOC emissions for the trees, whether they are native to the South Coast bioregion, and whether they provide shade, were used in determining the overall quality of the university's trees. Additionally, the percentage of trees on campus that are known to provide shade and the percentage that are Coast Live Oak (*Q. agrifolia*) were calculated. The percentage of trees that are Coast Live Oak (*Q. agrifolia*) was examined because some bird species will not survive unless Coast Live Oak is present (Guthrie, 1974). Data on which species provide shade were taken from U.F.E.I. (2010).

Determining which species are native to the South Coast bioregion involved several steps. First, a GIS layer showing all of the bioregions of California was downloaded from the Russian River Watershed Council (2011). Figure 8 shows the South Coast bioregion. Then, spatial data layers of the tree species' native distributions were overlaid on top of the bioregions layer using GIS to determine if they are native to this bioregion (Figure 9). After that, of the trees with native distribution data, the percentage of them that are native to this bioregion was calculated.

In addition, the percentages of the trees on campus that are known to have low, moderate, and high BVOC emissions were examined. Data on how much BVOCs the species emit were primarily taken from McPherson et al. (2000, pp. 59-65), but some with low emissions not listed in McPherson et al. (2000) were taken from U.F.E.I.

(2010). The emissions data in McPherson et al. (2000) were from Benjamin and Winer (1998) and were based on the number of grams of daily BVOC emissions on a typical summer day. Low emissions were defined as less than 1 gram per day, moderate emissions were 1 to 10 grams per day, and high emissions were more than 10 grams per day. For the BVOC emissions from U.F.E.I. (2010), low emissions were defined as less than 1 microgram per gram of dry leaf per hour (Benjamin et al., 1996). The data on emissions were taken primarily from Benjamin and Winer (1998) because the emissions in the Benjamin et al. (1996) study are overestimates, while the emissions in the study by Benjamin and Winer (1998) are more accurate.

Furthermore, three separate sets of weightings were used to rate the suitability of the trees, using several variables. For each variable, a score was assigned for each tree species to indicate its rating. For example, a score of 0.5 was given for trees that have moderate BVOC emissions. Then, the scores were multiplied by the weights, with each weight indicating the importance of each variable, to get the final weighted scores. For each rating scale a different set of weights was used, but ΔP was weighted the highest in all scales due to California's water scarcity being the most important factor, and ΔT was rated the next highest in all scales because it significantly factors into water loss amounts through Transpiration, and trees from climates much cooler than Northridge could lose much more water on campus then in their native habitats. An increase or decrease of 3° C results in an increase or decrease of 14% in potential evapotranspiration (Ramirez & Finnerty, 1996). Although weighted less than ΔT, BVOC emissions were still weighted high because trees with low BVOCs reduce ozone pollution, while trees with moderate or high BVOCs significantly increase ozone pollution (Taha, 1996). Whether the trees are native to the South Coast bioregion was also included in the rating factors because of the environmental and health problems that non-native trees can cause. Native trees help to retain natural habitat and reduce the use of pesticides, artificial fertilizers, and energy use (Hatch, 2007, p. 49). It is important to minimize pesticide use because of its environmental and health problems. Airborne pesticides increase the risk of cancer, respiratory diseases, asthma, neurotoxicity, and birth defects (Levine, 2007, p. 195). BVOC emissions and being native to the South Coast bioregion were weighted differently in the three rating scales but were weighted higher than shade in all scales. Coast Live Oak (*Q. agrifolia*) trees were given additional weight. Tables 2, 3, and 4 show the variables, weights, and final weighted scores. For each tree, the weighted scores for all the variables were summed to get a final score, with higher scores indicating trees better suited to the university environment. Finally, for each scale, these weighted scores were categorized with higher ratings assigned to trees more appropriate for the campus. Tables 5, 6, and 7 show the score ranges for each rating.

An additional assessment was conducted in which ArcMap was used to determine the COTypes of the trees by performing a Local Moran's I analysis to investigate the extent the trees cluster with those of similar or contrasting median rainfall values because the clustering of trees with contrasting water requirements could result in under or over irrigation. COTypes indicate whether features cluster with similar or contrasting values at a statistically significant level of 0.05 with the COType HH indicating high values clustering, LL indicating low values clustering, LH indicating low values surrounded by high values, and HL indicating high values surrounded by low values. Features without

COTypes indicate that they do not cluster near features of similar or contrasting values statistically significantly.

RESULTS

Precipitation Differences from Northridge

To analyze the water requirements, the median ΔP amounts of the trees were calculated. Table 8 shows that a slight majority of the trees on campus are from regions receiving only a little more rainfall than Northridge at most. Almost half of the campus' trees are from areas receiving less precipitation than Northridge, suggesting that the majority likely need little or no irrigation with many likely requiring none. In addition, Table 8 indicates that slightly more than half the trees originate from climates receiving more rainfall than Northridge, but only about 20% of the campus trees are from areas receiving much more (more than 82.5 cm) than Northridge, which indicates that the majority require some irrigation, but only a small number need a high amount. Figure 10 shows the distribution of water needs for the trees on campus.

The results of Local Moran's I are shown in Table 9 and Figure 11. Table 9 shows that the majority of the trees have no COType, and a significant percent of the trees are either high rainfall trees clustering together or low rainfall trees clustering together. This indicates that few trees are under or over irrigated due to proximity to neighboring trees with very different water demands. Figure 11 shows the COType of each tree.

Temperature Differences from Northridge

A table was created to show the number of trees and percent of trees in each ΔT category, because trees coming from cooler climates would lose more water through transpiration on campus compared to their native habitats. Trees coming from warmer climates would lose less water through transpiration on campus. Table 10 shows that

39.1% of the trees on campus originate from climates cooler than Northridge, indicating that many of them lose more water on campus than in their native habitats, and therefore require more water than in their native habitats. However, this table shows that of the trees originating from climates cooler than Northridge, the majority of them originate from climates only slightly cooler, indicating that they only lose slightly more water on campus than in their native habitats. Despite many trees coming from cooler climates, Table 10 shows that the majority (60.9%) of the trees originate from warmer climates including a small number originating from climates more than 5° C warmer than Northridge, indicating that most of the trees on campus lose less water through Transpiration on campus compared to their native habitats. However, as Table 10 shows, most of these are from climates only slightly warmer. Figure 12 shows the origins of trees on campus.

Additional Variables

The results of the additional variables are as follows. Only 8.1% of all the trees are native to the South Coast bioregion. All the other trees originate from every continent except Antarctica, with Australia (especially the east coast), eastern China, and the eastern United States as some of the more common origins. With regard to BVOCs emitted, Figure 13 shows that very few trees are known to emit high amounts, whereas about a quarter of the trees are known to give off low amounts. BVOCs are unknown for the majority of the trees (Figure 13). 3.6% of all trees on campus are Coast Live Oak (*Q. agrifolia*).

Overall Ratings of Trees

Table 11 indicates that the percentages of the trees in the rating categories are similar across all three scales. For each scale, the highest percentage of trees tends to be rated as moderately suitable for the university with the trees overall being slightly on the more suitable side of the scale. Not many trees are rated very low (Table 11). The biggest difference between the rating scales is that scale 3 has ratings slightly more skewed toward the more suitable side compared to scale 2 (Table 11). Figures 14, 15, and 16 show the ratings for the campus trees according to these three weighting scales.

DISCUSSION

Using three rating scales which take into consideration ΔP, ΔT, nativity to the South Coast bioregion, BVOC emissions, and provision of shade, most trees on campus show moderate ratings with slightly more rating high than rating low. There are not very many trees that are rated very highly or poorly in any of the scales.

Overall, the majority of the trees originate from climates receiving at most slightly more rainfall than Northridge, indicating that most of them demand little or no irrigation. However, a fairly large number of trees originate from areas with much greater rainfall totals than Northridge, indicating that they may demand a fair amount of irrigation. Fortunately, very few trees on campus come from climates receiving excessively more rainfall (e.g. 110 cm more) than Northridge, meaning that very few demand a lot of irrigation. Overall, the trees demand little water, and therefore the university is helping to preserve California's water resources. However, some improvement can be made by removing the high irrigation demand trees and replacing them with ones more suitable to the local climate.

The majority of the trees on campus originate from climates warmer than Northridge's, which suggests these trees are apt to lose slightly less water through transpiration at the university compared to their native habitats. Hopefully, this lessens campus irrigation demands. Nevertheless, some originated in slightly cooler climates than Northridge's, which suggests that they are apt to lose slightly more water through transpiration here, and may require more irrigation to create conditions comparable to their native habitats.

Only a very small percent of the trees on campus are truly native to the South Coast bioregion. Therefore, many of the university's trees may require additional maintenance such as artificial pesticides and fertilizers and demand greater energy use and other resources, some of which may be environmentally hazardous (Hatch, 2007, pp. 48-49).

The ozone analysis could not be completed with great certainty because too many campus trees have unknown BVOC emission characteristics. The trees known to have low BVOC emissions are about a quarter of the trees on campus, meaning that it is safe to assume that a significant portion of them reduce ozone pollution. Only a very small proportion of the trees are known to contribute significantly to ozone pollution through emissions, however the actual percentage of trees with high BVOC emissions could be much higher due to lack of BVOC emissions data.

Only 3.6% of the trees are Coast Live Oak (*Q. agrifolia*), which means that some native bird species, such as Acorn Woodpeckers (*Melanerpes formicivorus*) and Bushtits (*Psaltriparus minimus*), cannot survive well on campus despite the other tree species supporting some of the other native bird species.

Recommended Trees to Consider Adding

As the university changes its tree composition, the trees recommended for addition were based on the study of the existing trees and the number of different tree types. Tree genera were recommended to be added if they are virtually nonexistent on campus, and only species of the genera that require little irrigation were recommended. Furthermore, the recommended percentage of trees of each genus and of each species was based on additional qualities such as whether they are drought tolerant, provide shade, are known to have low BVOC emissions, and are native to the South Coast bioregion. The trees with more good qualities were recommended in higher percentages, but only small percentages of each tree type were suggested in order to preserve tree variety. All of the information on tree attributes in making these recommendations were taken from U.F.E.I. (2010). The types and number of each type are as follows.

Numerous species were recommended to add to the campus. First, many Coast Live Oak (*Q. agrifolia*) trees should be added because there are not enough of them (currently 134 trees) on campus. Only about 5% of the campus trees are oak (*Quercus* spp.). They are desirable for a number of reasons. First, they originate from the South Coast bioregion, and according to McPherson et al. (2000, p. 60), they have low irrigation requirements. As mentioned previously, Coast Live Oak (*Q. agrifolia*) supports many of the local bird species that live in the foothills, including Acorn Woodpeckers (*Malanerpes formicivorus*) and Bushtits (*Psaltriparus minimus*), that are not supported by other ornamental trees (Guthrie, 1974). Furthermore, Coast Live Oak (*Q. agrifolia*) is evergreen, so clean up costs associated with leaf removal would be minimized. However, the ozone forming potential for Coast Live Oak (*Q. agrifolia*) is high according to Benjamin and Winer (1998), and therefore caution should be exercised with this species. It is recommended that about 10% of the trees on campus should be Coast Live Oak (*Q. agrifolia*) due to all of these good qualities (Table 12). Currently, only 3.6% of the campus trees are Coast Live Oak (*Q. agrifolia*), and about 240 more Coast Live Oak (*Q. agrifolia*) trees would need to be planted. In addition, adding Torrey Pine (*Pinus torreyana*) trees is recommended because this species is native to the South Coast bioregion and has low irrigation needs (U.F.E.I., 2010). Only approximately 7% of the university's trees are pine with only 2 Torrey Pine (*P. torreyana*) trees on campus. However, this species has moderate BVOC emissions (Benjamin & Winer), so it would not be good to plant a huge number of them. Perhaps 5% of the campus trees could be Torrey Pine (*P. torreyana*) (Table 12). California Sycamores (*Platanus racemosa*) are also recommended as additional trees due to their low water requirements (U.F.E.I., 2010) and their origin in the South Coast bioregion. Also, just 4% of the campus trees are *Platanus* spp., so adding California Sycamores (*P. racemosa*) would not create an excessive number of *Platanus* trees. However, this species emits high BVOC amounts (U.F.E.I., 2010). For these reasons, about 2.5% of the trees should be California Sycamores (*P. racemosa*) (Table 12). Furthermore, because only 0.2% (6 trees) of the campus trees are *Juglans* spp., *Juglans* trees should be planted, including Southern California Walnut (*J. californica*) and California Black Walnut (*J. hindsii*). Due to its low irrigation needs and origin in the South Coast bioregion, Southern California Walnut (*J. californica*) should be added. However, this tree may be less desirable because of the staining properties of its fruit. California Black Walnut (*J. hindsii*) is recommended because it has low water needs and tolerates drought (U.F.E.I., 2010). *Juglans* should make up 5% of the university's trees. Four percent of the campus trees should be California Walnut (*J. californica*) because they are from the South Coast bioregion, while only 1% of the campus trees should be California Black Walnut (*J. hindsii*) because they do not originate from the South Coast bioregion (U.F.E.I., 2010) (Table 12). In addition, Arizona Ash (*Fraxinus valutina*) should be added because it requires little irrigation, is native to the South Coast bioregion, and according to U.F.E.I. (2010), emits low BVOC amounts. In addition, only about 2% of the campus trees are ash (*Fraxinus* spp.).

Because of these good attributes and the small number of ash trees, it is recommended that about 7.5% of the trees be this species (Table 12). Adding many *Acacia* trees is suggested because many, but not necessarily all, *Acacia* species require little water and are evergreen (U.F.E.I., 2010). The *Acacia* species that are recommended include *A. abyssinica*, *A. aneura*, *A. baileyana*, *A. baileyana* 'Purpurea', *A. boormanii*, *A. craspedocarpa*, *A. cultriformis*, *A. cyclops*, *A. dealbata*, *A. decurrens, A. howittii*, *A. longifolia*, *A. melanoxylon*, *A. pendula*, *A. podalyriifolia*, *A. retinodes*, *A. salicina*, *A. saligna*, *A. subporosa*, and *A. verticillata* because they all require low amounts of irrigation (U.F.E.I., 2010), and *Acacia* trees are not present on campus. Of these species, there should be a greater number of *A. baileyana*, *A. craspedocarpa, A. cultriformis*, *A. Cyclops*, *A. howittii*, *A. longifolia*, *A. melanoxylon*, and *A. salicina* because they are drought tolerant (U.F.E.I., 2010) (Table 13). However, all of the *Acacia* species mentioned above, not just the drought tolerant species, should be present for variety. Sydney Red Gum (*Angophora costata*) should also be planted in the future because it has low irrigation demands, is evergreen, and there are currently no *Angophora* trees on campus (Table 13). Also, Marina Madrone (*Arbutus* 'Marina'), Madrone (*Arbutus menziesii*), and Strawberry Madrone (*Arbutus unedo*) should be added because they require little irrigation, are evergreen, and the university has no *Arbutus* trees (U.F.E.I., 2010) (Table 13). All three of these species should be added for variety, but there should be a much greater emphasis in adding Madrone (*A. menziesii*) and Strawberry Madrone (*A. unedo*) because they are known to have low BVOC emissions (U.F.E.I., 2010). Mexican Blue Palm (*Brahea armata*), San Jose Hesper Palm (*Brahea brandegeei*), and Guadalupe Palm (*Brahea edulis*) are also recommended because they require little irrigation, tolerate drought, are evergreen, and there are almost no *Brahea* trees on campus (U.F.E.I., 2010) (Table 14). Because *Brahea* trees are drought tolerant, they should be added if not every suggested tree can be added. River She-oak (*Casuarina cunninghamiana*) and Horsetail (*Casuarina equisetifolia*) should be planted because they are evergreen, have low irrigation requirements, are drought tolerant, and there is only one *Casuarina* tree on campus (U.F.E.I., 2010) (Table 14). Also, White Floss Silk Trees (*Ceiba insignis*) and Floss Silk Trees (*Ceiba speciosa*) should both be added due to them being evergreen, requiring little irrigation, and there being no *Ceiba* trees at the university (U.F.E.I., 2010) (Table 14). Adding Texas Olive trees (*Cordia boissieri*) is also suggested because they have low irrigation requirements, are drought tolerant, are evergreen, and there are no *Cordia* trees on campus (U.F.E.I., 2010) (Table 14). Also, if not every recommended species can be added, this species should be because it is drought tolerant. In addition, Bronze Dracaena (*Cordyline australis* 'Atropurpurea'), Cabbage Palm (*Cordyline australis*), and Blue Dracaena (*Cordyline indivisa*) trees should be planted because they tolerate drought, have low water demands, are evergreen, and *Cordyline* trees are absent from the campus (U.F.E.I., 2010) (Table 14). Also, because they are drought tolerant, these species should be planted even if not all of the suggested species can be. In addition, Western Redbud (*Cercis occidentalis*) was also recommended to add to the university because there are almost no trees of the *Cercis* genus on campus, and Western Redbud trees have low irrigation needs, are drought tolerant, and have low BVOC emissions (U.F.E.I., 2010). Furthermore, the majority of the species of this genus should be Western Redbud (*C. occidentalis*) (Table 14). Another recommended species is Hollyleaf Cherry (*Prunus ilicifolia*) because less than

1% of the university's trees are *Prunus* spp., and Hollyleaf Cherry (*P. ilicifolia*) trees have low water demands, are native to the South Coast bioregion, are evergreen, and emit low amounts of BVOCs (U.F.E.I., 2010). About 2.5% of the trees on campus should be *Prunus* spp., and most of the *Prunus* trees should be Hollyleaf Cherry (*P. ilicifolia*) trees (Table 14). Furthermore, Catalina Ironwood (*Lyonothamnus floribundus* subsp. *asplenifolius*) should be planted because *Lyonothamnus* trees are not present on campus, and Catalina Ironwood trees require little irrigation, tolerate drought, are evergreen, and have low BVOC emissions (U.F.E.I., 2010) (Table 14).

Summary

About 8.9% (300 trees) of the trees on campus with known native distributions are native to the South Coast bioregion, which means that about 91.1% (3,060 trees) of the university's trees with known native distributions are ornamental. These ornamental trees' native distributions receive on average 32.6 cm more rainfall than Northridge, but have a wide variance varying, varying from receiving 32.8 cm less than Northridge to 210.7 cm more. On average, the temperatures of the ornamental trees' native distributions are about 0.2 °C higher than Northridge, but the temperatures range from 12.6 °C less than Northridge to 9.5 °C more. Many of the species recommended to add to the campus are *Acacia* spp. because they have low water demands, and many of them are drought tolerant. Furthermore, the genera that are recommended in the greatest quantities are *Quercus agrifolia*, *Pinus torreyana*, *Juglans Californica*, and *Fraxinus Valutina* because they are native to the South Coast bioregion. Some of the other recommended trees include the *Brahea* genus, the *Arbutus* genus, and the *Casuarina* genus.

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APPENDIX A: TABLES

COMMON NAME	SCIENTIFIC NAME	LOW WATER	LOW OZONE	EVERGREEN	SHADE (Crown Spread)
Silk trees	*Chorisia speciosa*	X			
red ironbark	*Eucalyptus sideroxylon*	X		X	
Indian laurel fig	*Ficus micropcarpe nitida*	X		X	X (40 to 60 ft.)
Canary island pine	*Pinus canariensis*	X	X	X	
stone pine	*Pinus pinea*	X	X	X	X (35 to 60 ft.)
Torrey pine	*Pinus torreyana*	X		X	X (40 to 50 ft.)
coastal live oak	*Quercus agrifolia*	X		X	X (50 to 60 ft.)
Australian willow	*Geijera parviflora*	X	X	X	
Camphor tree	*Cinnamomum camphora*		X	X	X (50 to 70 ft.)
jacaranda	*Jacaranda mimosifolia*		X		
fern pine	*Podocarpus gracilior*		X	X	
Chinese elm	*Ulmus parvifolia* 'Athena'		X		
sawleaf zelkova	*Zelkova serrata*		X		
cape chestnut	*Calcodendrum capense*		X		
Mexican ash	*Fraxinus uhdei*			X	X (40 to 60 ft.)
Southern magnolia	*Magnolia grandiflora*			X	
Brisbane box	*Tristania conferta*			X	
California laurel	*Umbellularia californica*			X	X (40 to 60 ft.)
Hong Kong orchid tree	*Bauhina blackeana*			X	
toogtree	*Bischofia javanica*			X	
bottle tree	*Brachychiton populneus*			X	
fiddleleaf fig	*Ficus lyrata*			X	
evergreen pear	*Pyrus kawakamii*			X	

TABLE 1 – Trees suitable for planting at the university (information taken from McPherson et al., 2000, pp. 59-65)

VARIABLE	SCORE	WEIGHT	WEIGHTED SCORE
Precipitation Range			
192.5 cm < Δp <= 220.0 cm	0	1	0
165.0 cm < Δp <= 192.5 cm	0.125	1	0.125
137.5 cm < Δp <= 165.0 cm	0.25	1	0.25
110.0 cm < Δp <= 137.5 cm	0.375	1	0.375
82.5 cm < Δp <= 110.0 cm	0.5	1	0.5
55.0 cm < Δp <= 82.5 cm	0.625	1	0.625
27.5 cm < Δp <= 55.0 cm	0.75	1	0.75
0 cm < Δp <= 27.5 cm	0.875	1	0.875
Δp <= 0 cm	1	1	1
Temperature Range			
-15° C <= ΔT < -10° C	0	0.75	0
-10° C <= ΔT < -5° C	0.25	0.75	0.1875
-5° C <= ΔT < 0° C	0.5	0.75	0.375
0° C <= ΔT < 5° C	0.75	0.75	0.5625
5° C <= ΔT < 10° C	1	0.75	0.75
Native to South Coast Bioregion			
Yes	1	0.6	0.6
No	0	0.6	0
BVOC Emissions			
Low	1	0.4	0.4
Moderate	0.5	0.4	0.2
High	0	0.4	0
Unknown	0	0.4	0
Shade			
Yes	1	0.1	0.1
No	0	0.1	0
Unknown	0	0.1	0
Coast Live Oak			
Yes	1	0.1	0.1
No	0	0.1	0

TABLE 2 – Variables, scores, and weights for scale 1

VARIABLE	SCORE	WEIGHT	WEIGHTED SCORE
Precipitation Range			
192.5 cm < Δp <= 220.0 cm	0	1	0
165.0 cm < Δp <= 192.5 cm	0.125	1	0.125
137.5 cm < Δp <= 165.0 cm	0.25	1	0.25
110.0 cm < Δp <= 137.5 cm	0.375	1	0.375
82.5 cm < Δp <= 110.0 cm	0.5	1	0.5
55.0 cm < Δp <= 82.5 cm	0.625	1	0.625
27.5 cm < Δp <= 55.0 cm	0.75	1	0.75
0 cm < Δp <= 27.5 cm	0.875	1	0.875
Δp <= 0 cm	1	1	1
Temperature Range			
-15° C <= ΔT < -10° C	0	0.9	0
-10° C <= ΔT < -5° C	0.25	0.9	0.225
-5° C <= ΔT < 0° C	0.5	0.9	0.45
0° C <= ΔT < 5° C	0.75	0.9	0.675
5° C <= ΔT < 10° C	1	0.9	0.9
Native to South Coast Bioregion			
Yes	1	0.5	0.5
No	0	0.5	0
BVOC Emissions			
Low	1	0.7	0.7
Moderate	0.5	0.7	0.35
High	0	0.7	0
Unknown	0	0.7	0
Shade			
Yes	1	0.15	0.15
No	0	0.15	0
Unknown	0	0.15	0
Coast Live Oak			
Yes	1	0.2	0.2
No	0	0.2	0

TABLE 3 – Variables, scores, and weights for scale 2

VARIABLE	SCORE	WEIGHT	WEIGHTED SCORE
Precipitation Range			
192.5 cm < Δp <= 220.0 cm	0	1	0
165.0 cm < Δp <= 192.5 cm	0.125	1	0.125
137.5 cm < Δp <= 165.0 cm	0.25	1	0.25
110.0 cm < Δp <= 137.5 cm	0.375	1	0.375
82.5 cm < Δp <= 110.0 cm	0.5	1	0.5
55.0 cm < Δp <= 82.5 cm	0.625	1	0.625
27.5 cm < Δp <= 55.0 cm	0.75	1	0.75
0 cm < Δp <= 27.5 cm	0.875	1	0.875
Δp <= 0 cm	1	1	1
Temperature Range			
-15° C <= ΔT < -10° C	0	0.6	0
-10° C <= ΔT < -5° C	0.25	0.6	0.15
-5° C <= ΔT < 0° C	0.5	0.6	0.3
0° C <= ΔT < 5° C	0.75	0.6	0.45
5° C <= ΔT < 10° C	1	0.6	0.6
Native to South Coast Bioregion			
Yes	1	0.4	0.4
No	0	0.4	0
BVOC Emissions			
Low	1	0.4	0.4
Moderate	0.5	0.4	0.2
High	0	0.4	0
Unknown	0	0.4	0
Shade			
Yes	1	0.075	0.075
No	0	0.075	0
Unknown	0	0.075	0
Coast Live Oak			
Yes	1	0.05	0.05
No	0	0.05	0

TABLE 4 – Variables, scores, and weights for scale 3

RATING	SCORE RANGE
1	0 - 0.295
2	0.296 - 0.59
3	0.591 - 0.885
4	0.886 - 1.18
5	1.181 - 1.475
6	1.476 - 1.77
7	1.771 - 2.065
8	2.066 - 2.36
9	2.361 - 2.66

TABLE 5 – Score ranges for each rating for scale 1

RATING	SCORE RANGE
1	0 - 0.336
2	0.3361 - 0.672
3	0.6721 - 1.008
4	1.0081 - 1.344
5	1.3441 - 1.68
6	1.6801 - 2.016
7	2.0161 - 2.352
8	2.3521 - 2.688
9	2.6881 - 3.025

TABLE 6 – Score ranges for each rating for scale 2

RATING	SCORE RANGE
1	0 - 0.258
2	0.2581 - 0.516
3	0.5161 - 0.774
4	0.7741 - 1.032
5	1.0321 - 1.29
6	1.2901 - 1.548
7	1.5481 - 1.806
8	1.8061 - 2.064
9	2.0641 - 2.322

TABLE 7 – Score ranges for each rating for scale 3

MEDIAN	NUMBER OF TREES	PERCENT OF TREES WITH KNOWN VALUES
Δp <= 0 cm	1506	0.448
0 cm < Δp <= 27.5 cm	433	0.129
27.5 cm < Δp <= 55.0 cm	425	0.126
55.0 cm < Δp <= 82.5 cm	302	0.09
82.5 cm < Δp <= 110.0 cm	527	0.157
110.0 cm < Δp <= 137.5 cm	35	0.01
137.5 cm < Δp <= 165.0 cm	27	0.008
165.0 cm < Δp <= 192.5 cm	3	0.001
192.5 cm < Δp <= 220.0 cm	102	0.03

TABLE 8 – Numbers of trees in each class representing rainfall amounts relative to Northridge with values less than zero being less rain than Northridge (NOTE: Northridge receives 46.3 cm per year.)

COTYPE	NUMBER OF TREES	PERCENT OF CAMPUS TREES WITH PRECIP DATA
HH	510	0.152
LL	735	0.219
HH or LL	1245	0.371
HL	19	0.006
LH	51	0.015
HL or LH	70	0.021
No COType	2045	0.609

TABLE 9 – Number and percent of trees in COType categories for precipitation requirements

MEDIAN	NUMBER OF TREES	PERCENT OF TREES WITH KNOWN VALUES
-15° C <= ΔT < -10° C	3	0.10%
-10° C <= ΔT < -5° C	243	7.20%
-5° C <= ΔT < 0° C	1,067	31.80%
0° C <= ΔT < 5° C	1,744	51.90%
5° C <= ΔT < 10° C	303	9.00%

TABLE 10 – Number and percent of trees in median temperature categories relative to Northridge, with negative values being cooler than Northridge (NOTE: The mean annual temperature in Northridge is 16.5° C.)

RATING	**SCALE 1**	**SCALE 2**	**SCALE 3**
1 Worst	0%	0.0%	0.0%
2	0.3%	0.3%	0.0%
3	2.3%	3.6%	0.9%
4	21.6%	21.7%	15.7%
5 Moderate	24.7%	35.3%	19.5%
6	32.9%	20.7%	36.8%
7	13.0%	8.8%	17.4%
8	4.1%	8.6%	8.8%
9 Best	1.1%	1.0%	1.0%

TABLE 11 – Percentage of trees for each rating in each of the three rating scales

GENUS OR SPECIES (%)	**RATIONALE**
***Quercus* 10%**	
Q. agrifolia 10%	native, low water needs, supports many local bird species
Pinus	
P. torreyana 5%	native, low water needs
Platanus	
P. racemosa 2.5%	native, low water needs
***Juglans* 5%**	
J. californica 4%	native, low water needs
J. hindsii 1%	low water needs, drought tolerant
Fraxinus	
F. valutina 7.5%	native, low water needs, low BVOC emissions

TABLE 12 – Tree Recommendations for the Campus (NOTE: The recommended genus is in bold, and the recommended species of each genus are listed immediately below the genus.)

GENUS OR SPECIES (%)	**RATIONALE**
***Acacia* 1%**	**low water needs, evergreen**
A. abyssinica	low water needs, evergreen
A. aneura	low water needs, evergreen
A. baileyana	low water needs, evergreen, drought tolerant
A. baileyana 'Purpurea'	low water needs, evergreen
A. boormanii	low water needs, evergreen
A. craspedocarpa	low water needs, evergreen, drought tolerant
A. cultriformis	low water needs, evergreen, drought tolerant
A. cyclops	low water needs, evergreen, drought tolerant
A. dealbata	low water needs, evergreen
A. decurrens	low water needs, evergreen
A. howittii	low water needs, evergreen, drought tolerant
A. longifolia	low water needs, evergreen, drought tolerant
A. melanoxylon	low water needs, evergreen, drought tolerant
A. pendula	low water needs, evergreen
A. podalyriifolia	low water needs, evergreen
A. retinodes	low water needs, evergreen
A. salicina	low water needs, evergreen, drought tolerant
A. saligna	low water needs, evergreen
A. subporosa	low water needs, evergreen
A. verticillata	low water needs, evergreen
Angophora	
A. costata 1%	low water needs, evergreen
***Arbutus* 1%**	
Arbutus 'Marina'	low water needs, evergreen
A. menziesii	low water needs, evergreen, low BVOC emissions
A. unedo	low water needs, evergreen, low BVOC emissions

TABLE 13 – Other trees recommended (NOTE: The recommended genus is in bold, and the recommended species of each genus are listed immediately below the genus.)

GENUS OR SPECIES (%)	RATIONALE
***Brahea* 1%**	
B. armata	low water needs, evergreen, drought tolerant
B. brandegeei	low water needs, evergreen, drought tolerant
B. edulis	low water needs, evergreen, drought tolerant
***Casuarina* 1%**	
C. cunninghamiana 0.5%	low water needs, evergreen, drought tolerant
C. equisetifolia 0.5%	low water needs, evergreen, drought tolerant
***Ceiba* 1%**	
C. insignis 0.5%	low water needs, evergreen
C. speciosa 0.5%	low water needs, evergreen
Cordia	
C. boissieri 1%	low water needs, evergreen, drought tolerant
***Cordyline* 1%**	
C. australis	low water needs, evergreen, drought tolerant
C. australis 'Atropurpurea'	low water needs, evergreen, drought tolerant
C. indivisa	low water needs, evergreen, drought tolerant
***Cercis* 1%**	
C. occidentalis	low water needs, drought tolerant, low BVOC emissions
***Prunus* 2.5%**	
P. ilicifolia	low water needs, native, evergreen, low BVOC emissions
***Lyonothamnus* 1%**	
L. floribundus subsp. *asplenifolius*	low water needs, drought tolerant, evergreen, low BVOC emissions

TABLE 14 – Other trees recommended (NOTE: The recommended genus is in bold, and the recommended species of each genus are listed immediately below the genus.)

APPENDIX B: FIGURES

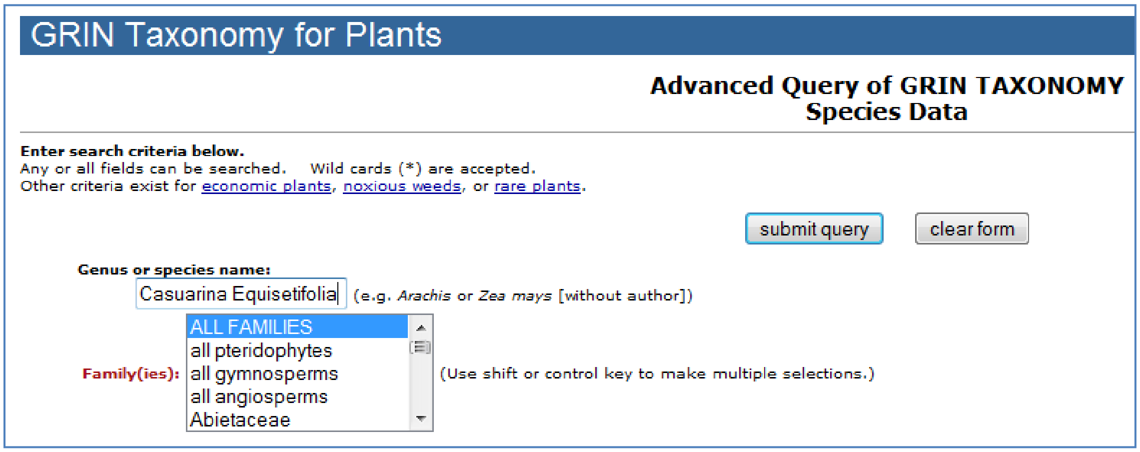

FIGURE 1 – GRIN Taxonomy for Plants species query

Distributional range:

Native:

- **ASIA-TROPICAL**
  North Indian Ocean: **India** - Andaman and Nicobar
  Indo-China: **Myanmar**; **Thailand**; **Vietnam**
  Malesia: **Indonesia**; **Malaysia**; **Philippines**
- **AUSTRALASIA**
  Australia: **Australia** - New South Wales [n.e.], Queensland [n. & e.]
- **PACIFIC**
  South-Central Pacific: **French Polynesia**
  Southwestern Pacific: **Fiji**; **Vanuatu**

Naturalized: (links to other web resources are provided for some distributions)

- **NORTHERN AMERICA**
  United States [s.e.]
- **PACIFIC**
  North-Central Pacific: **United States** - Hawaii
- **SOUTHERN AMERICA**
  Caribbean: **West Indies**
  Western South America: **Ecuador** - Galapagos Islands
- naturalized in tropical & s. Africa, Mascarenes, Melanesia, Polynesia

FIGURE 2 – Search results of GRIN Taxonomy for Plants species query showing the species' native distribution

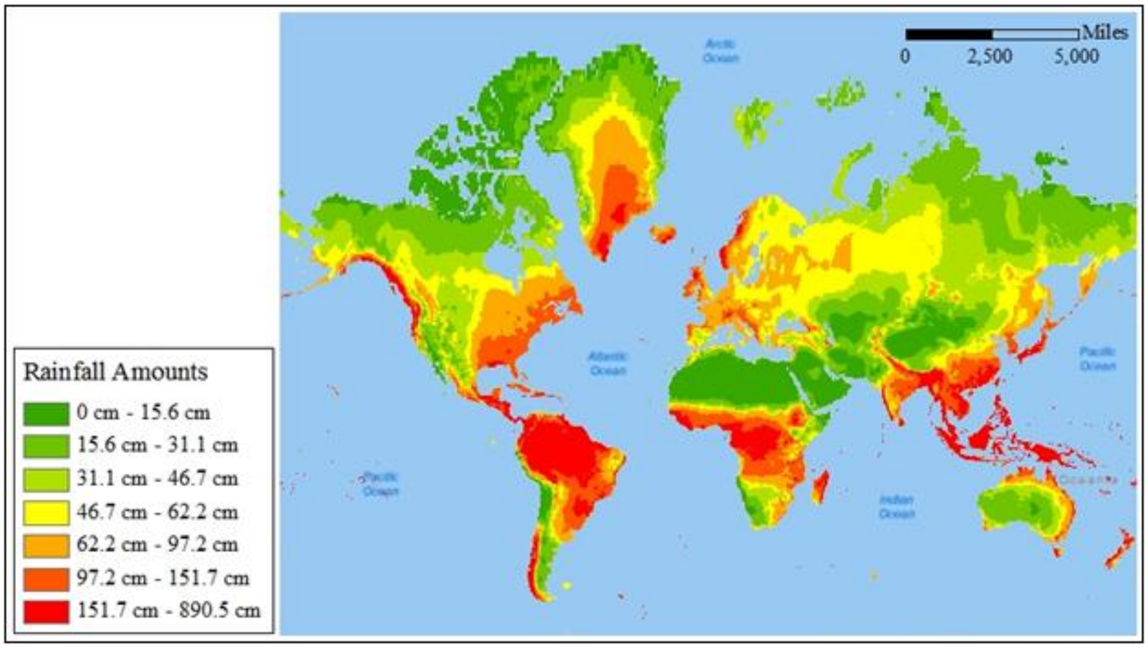

FIGURE 3 – Global mean annual rainfall layer

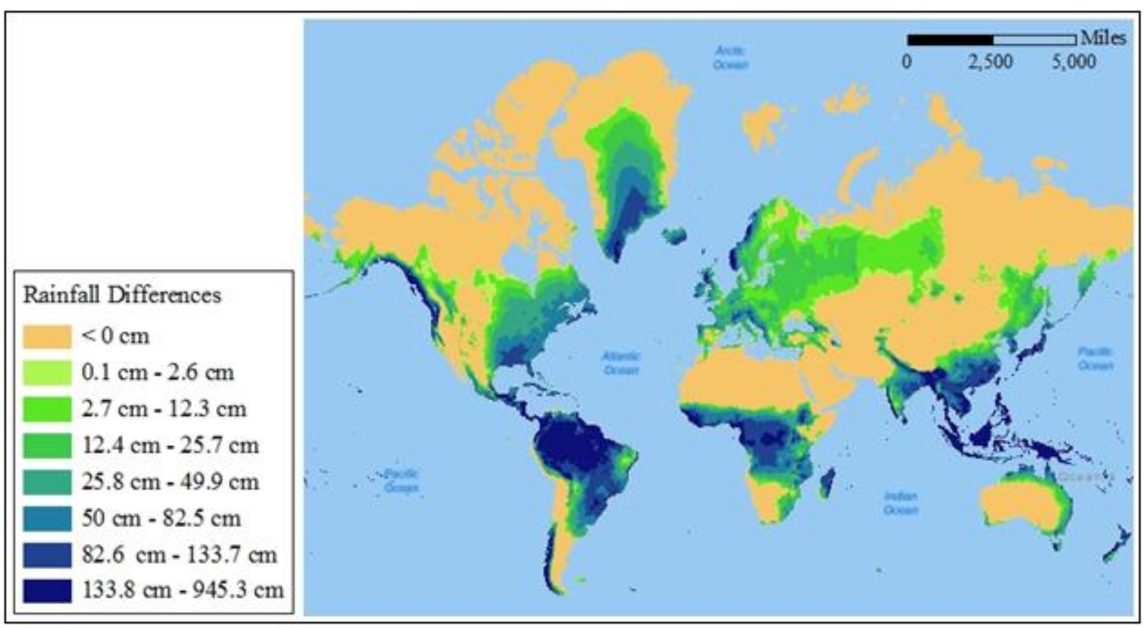

FIGURE 4 – Global rainfall amounts relative to Northridge (ΔP) derived from global mean annual rainfall layer (NOTE: Northridge receives 46.3 cm per year.)

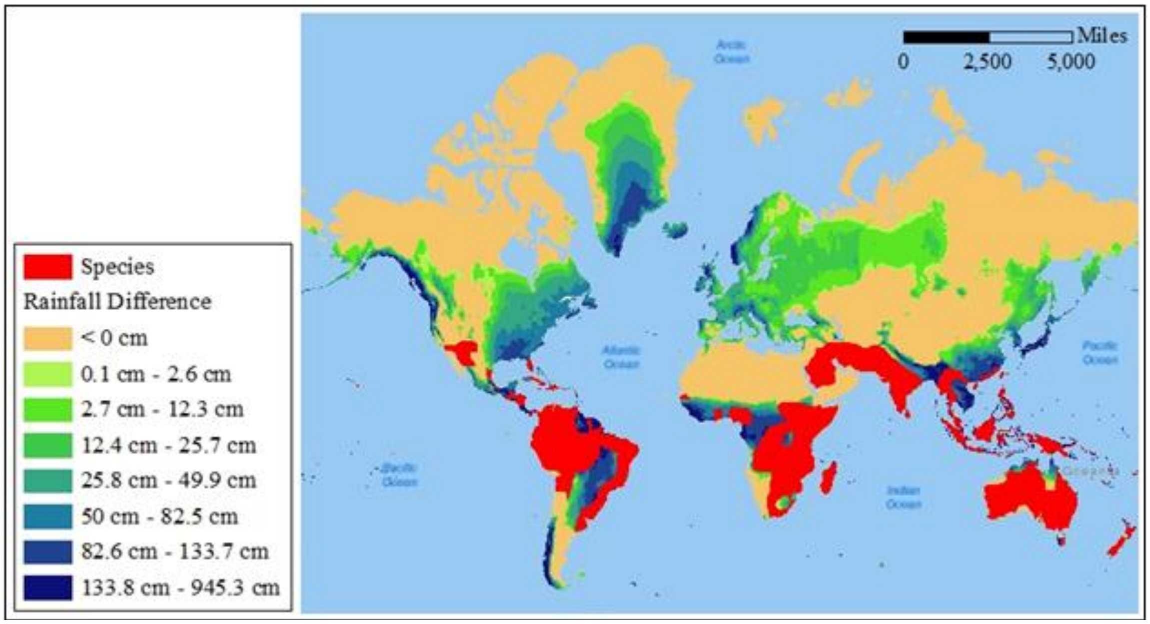

FIGURE 5 – Sample species (*Dodonaea viscose*) distribution layer overlaid on top of the global rainfall amounts relative to Northridge

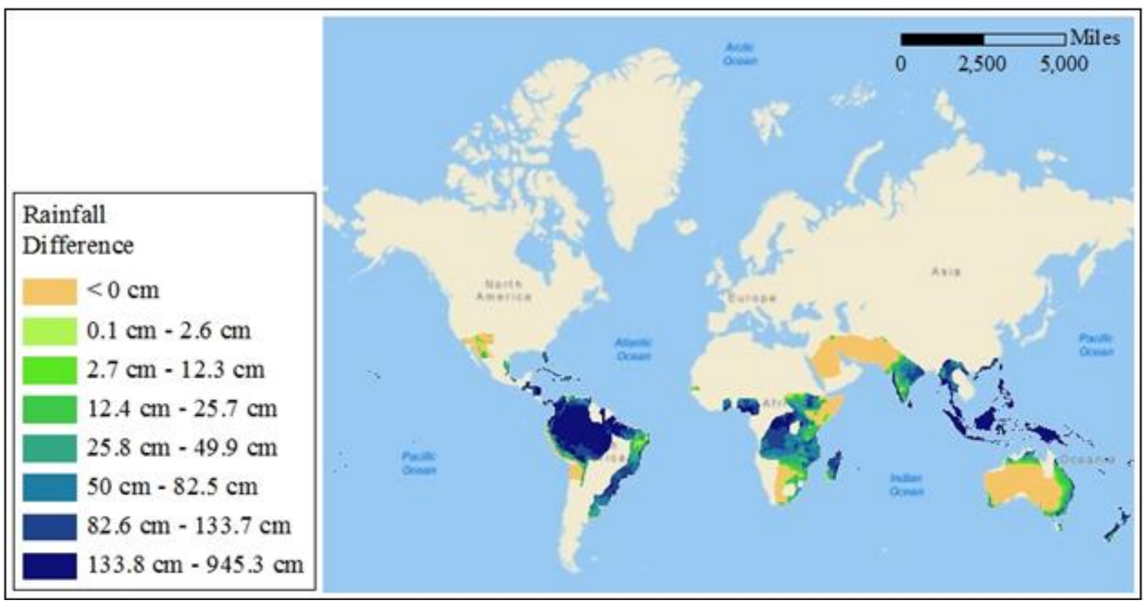

FIGURE 6 – Rainfall amounts relative to Northridge throughout *Dodonaea viscosa* species distribution

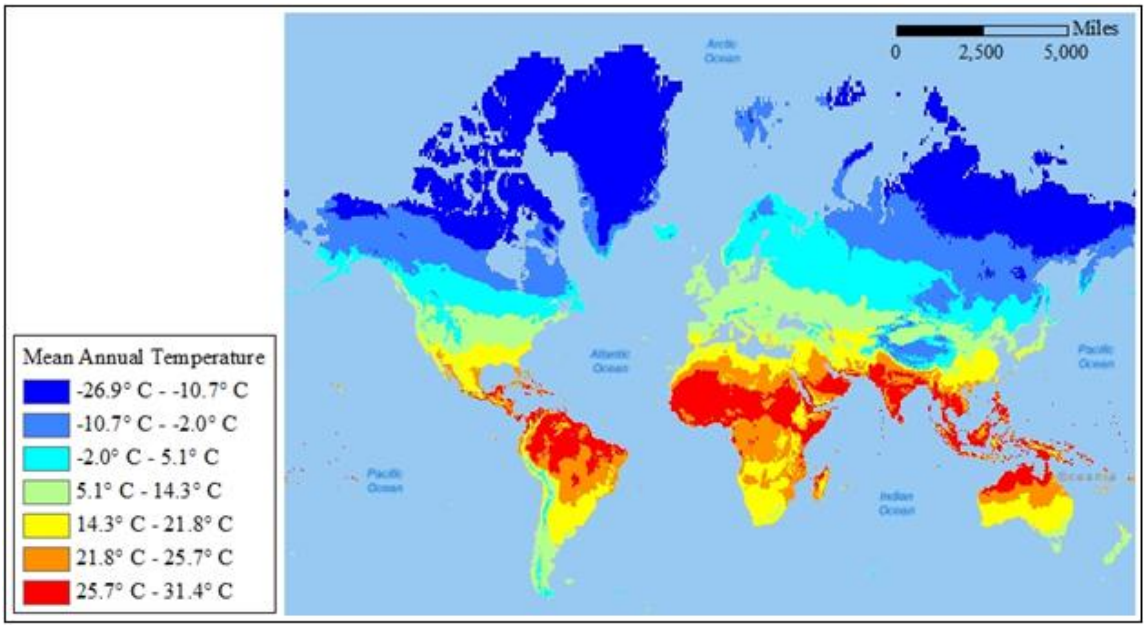

FIGURE 7 – Raster layer of global temperature

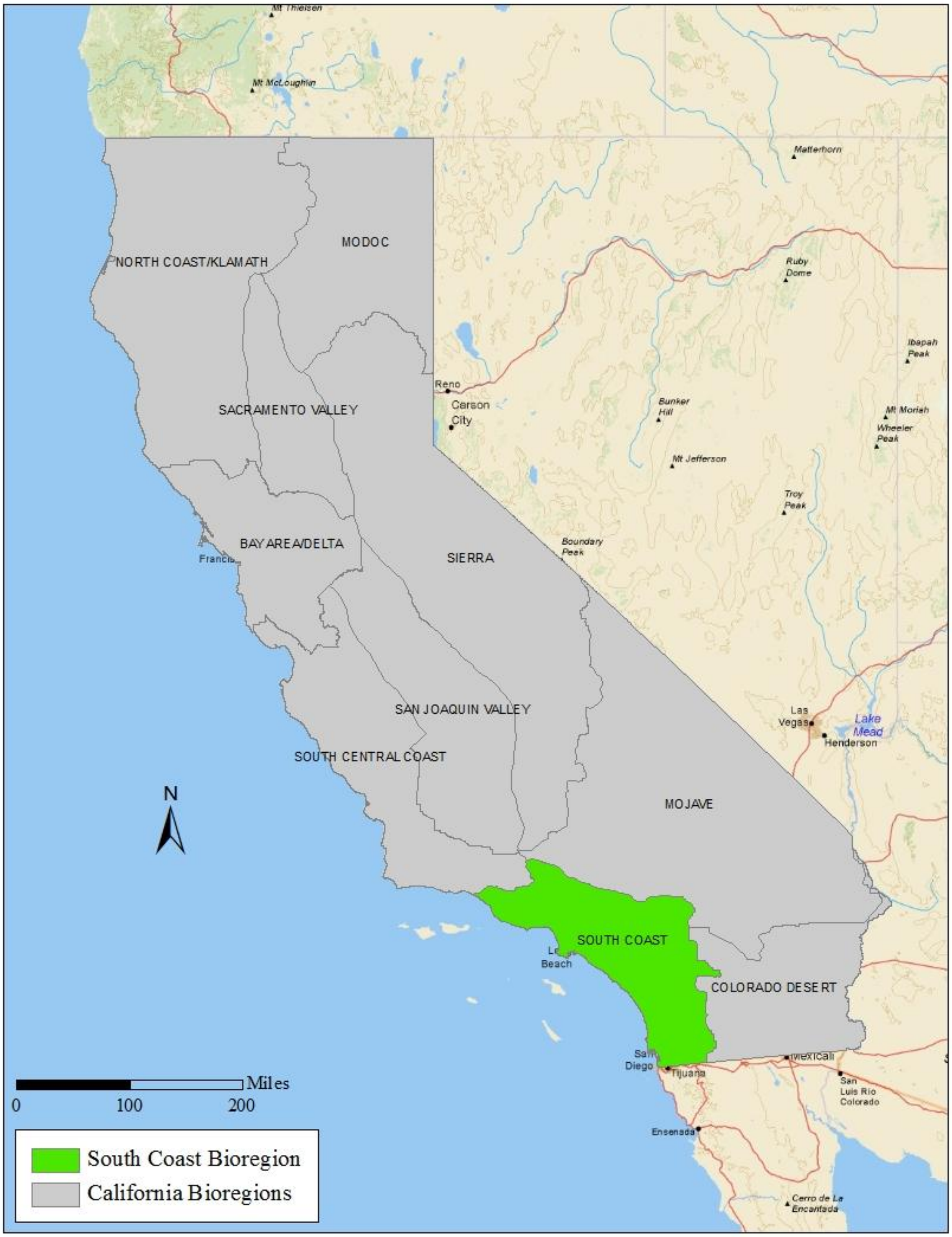

FIGURE 8 – South Coast bioregion

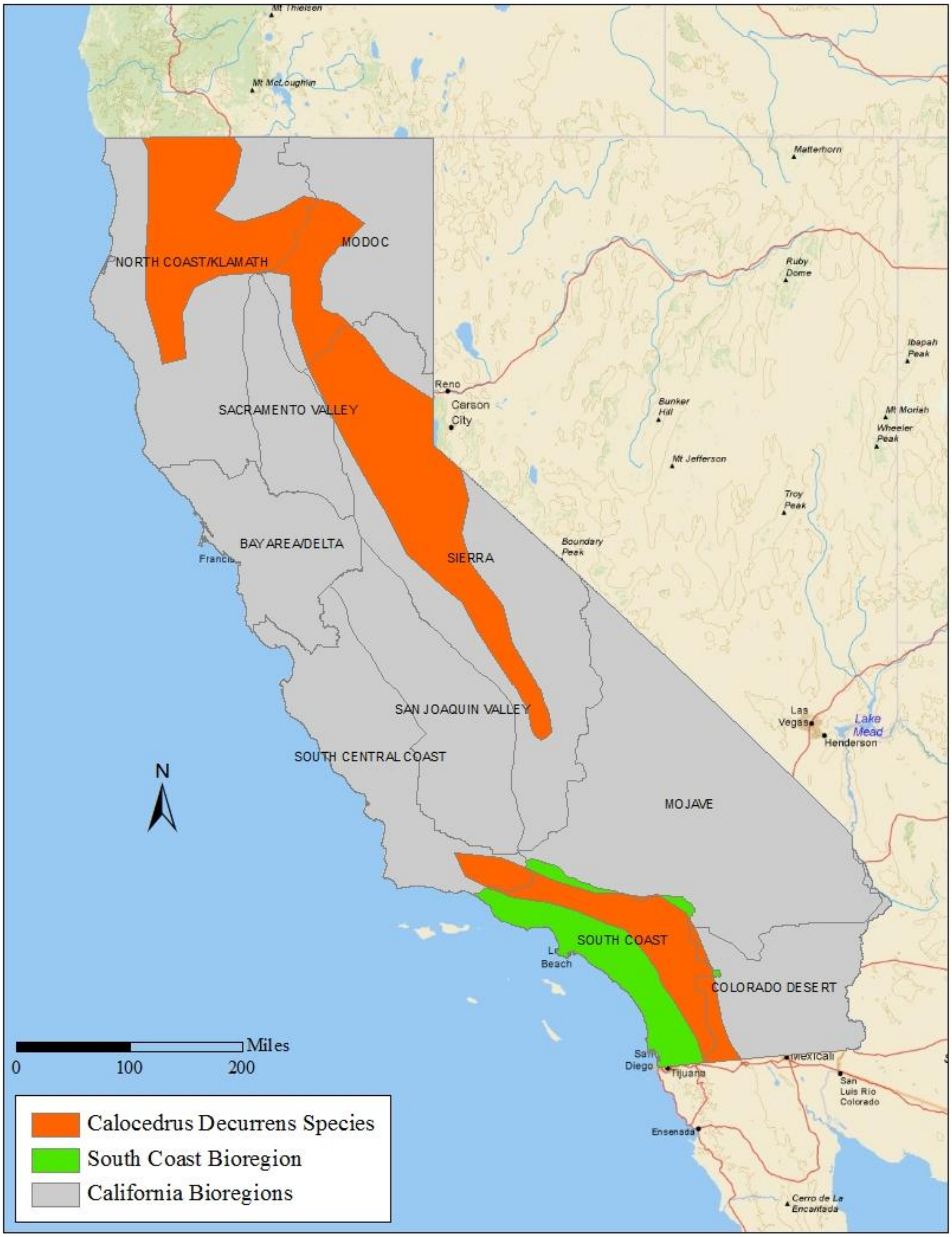

FIGURE 9 – Example tree species overlaid on top of the South Coast bioregion

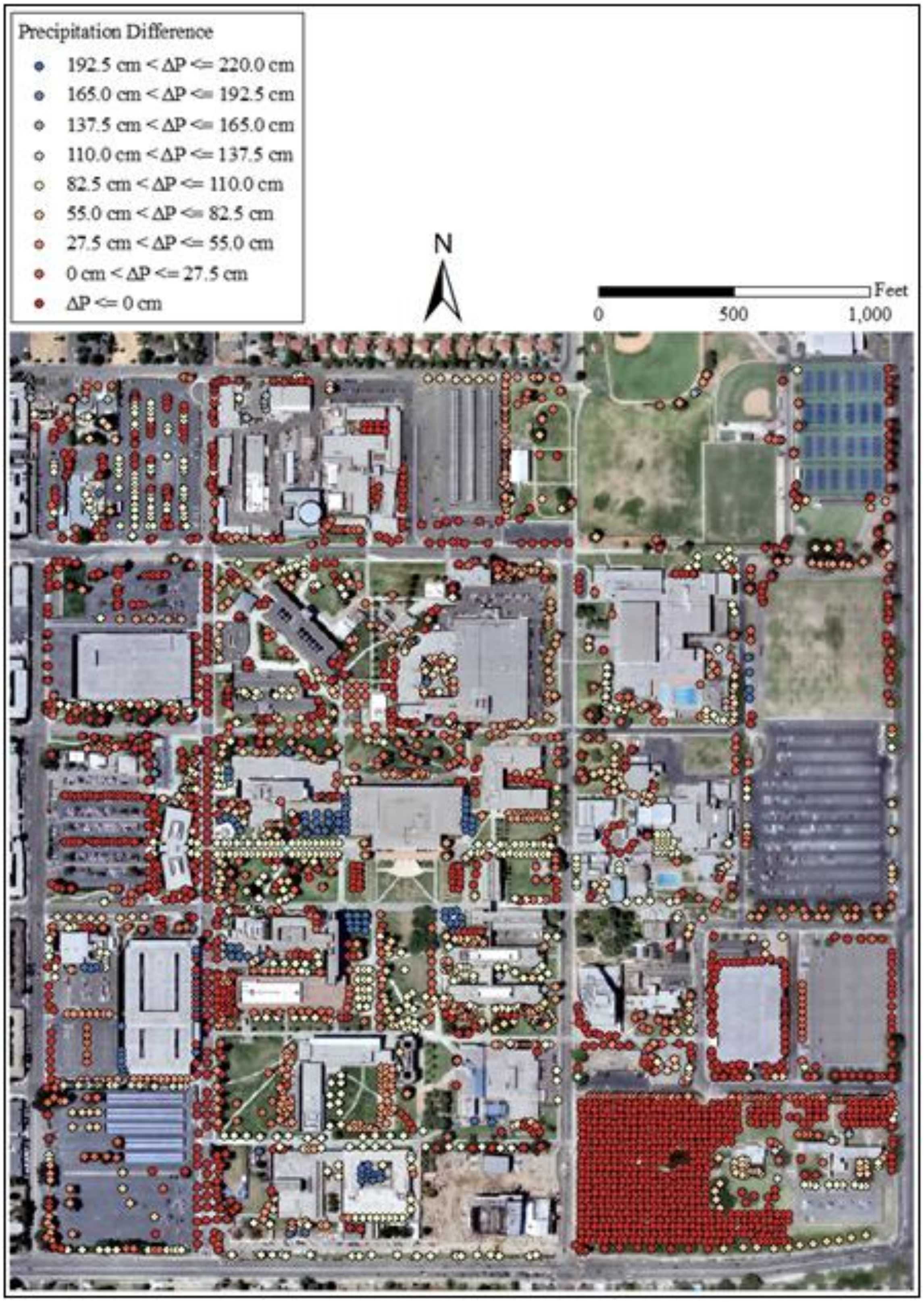

FIGURE 10 – Precipitation needs relative to Northridge for the campus trees (NOTE: Values less than zero are from climates with less rain than Northridge.)

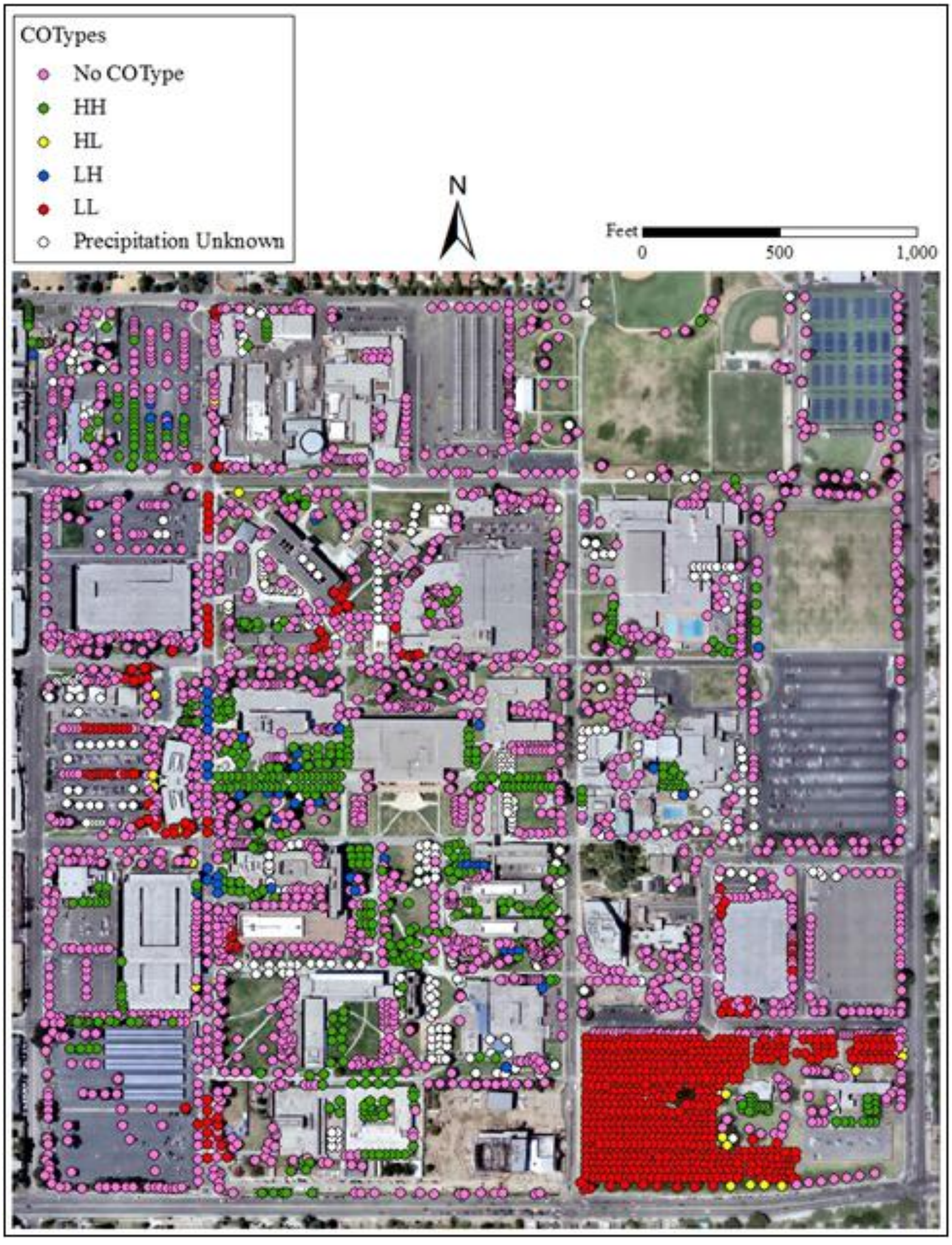

FIGURE 11 – Local Moran's I COTypes for precipitation

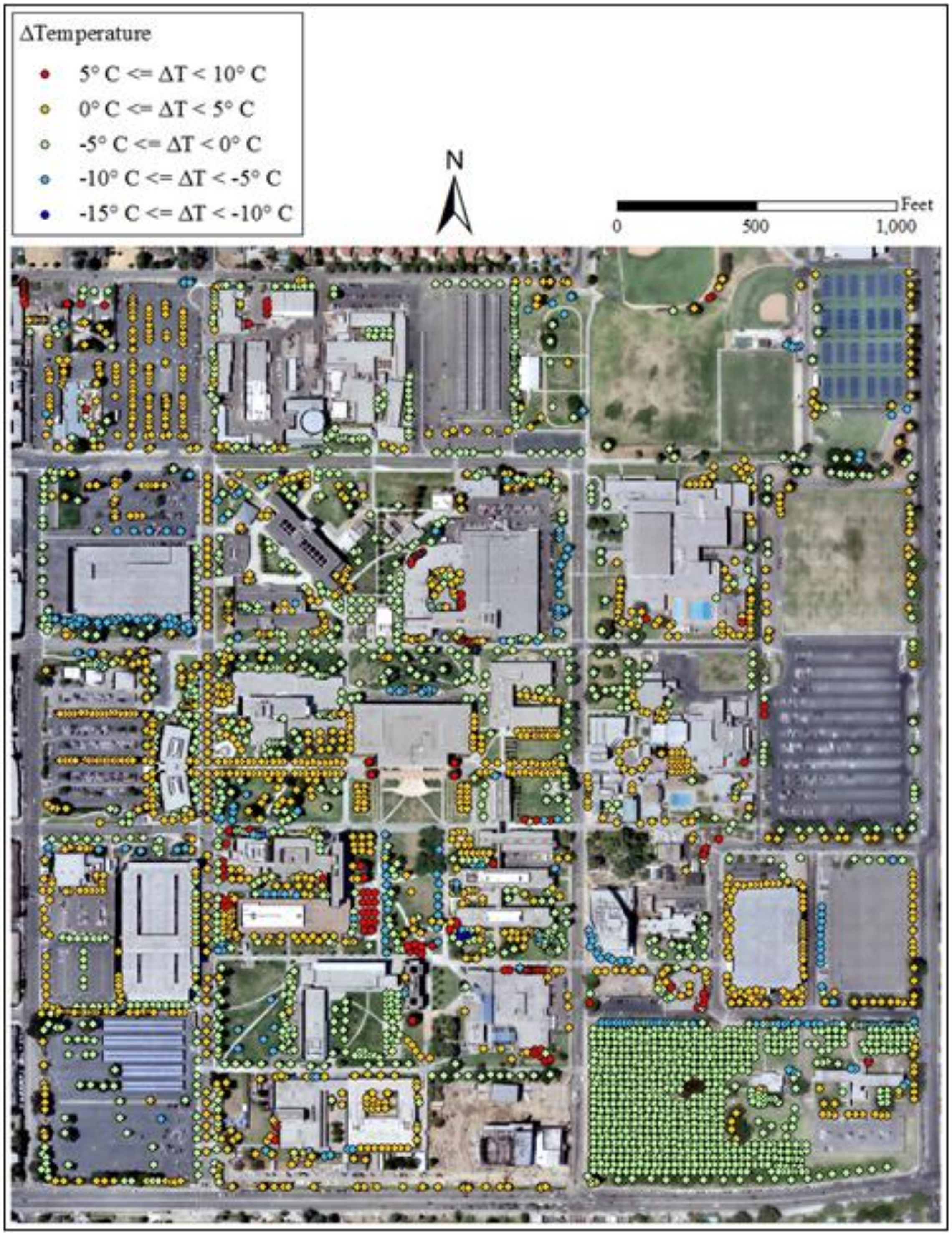

FIGURE 12 – Temperature differences relative to Northridge (NOTE: Positive numbers represent trees from climates warmer than Northridge.)

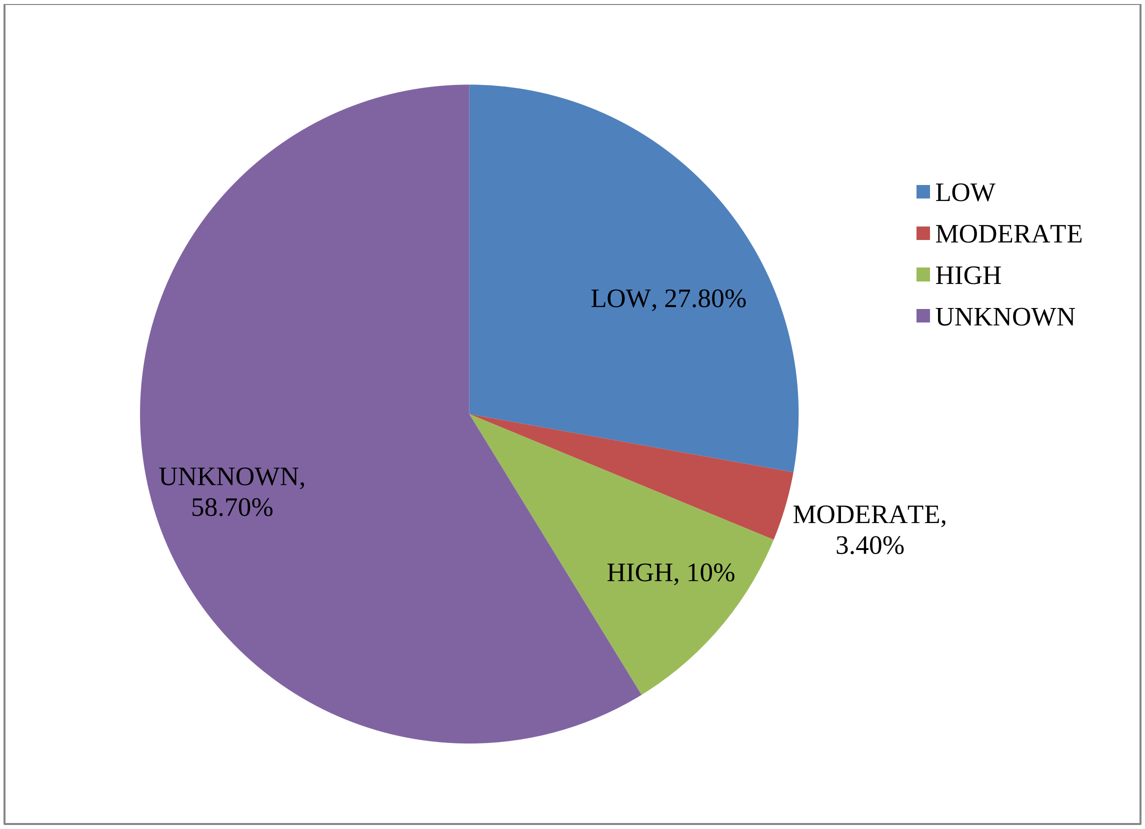

FIGURE 13 – Percentage of all trees on campus in different BVOC emissions categories

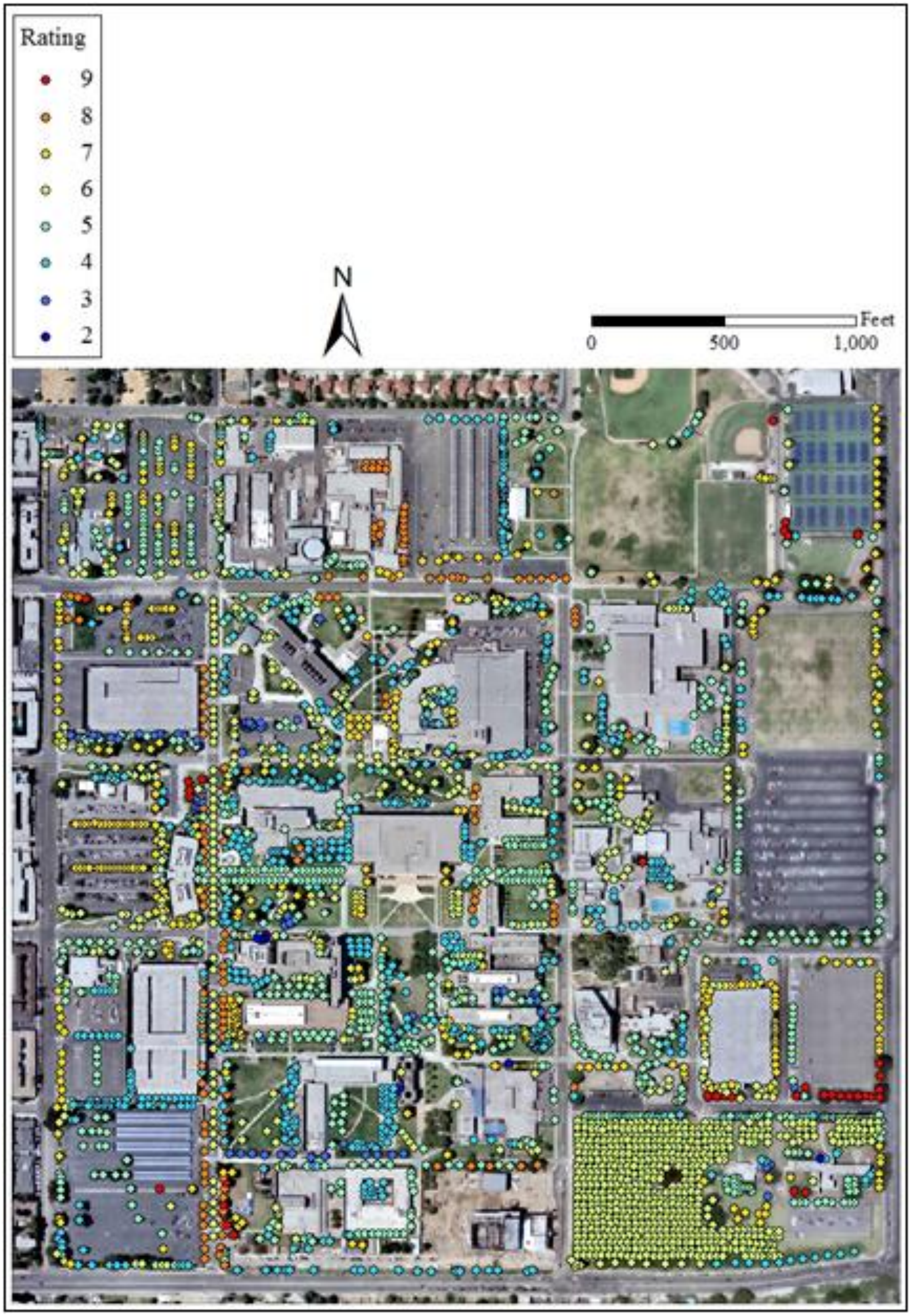

FIGURE 14 – Overall ratings of the trees on campus for scale 1

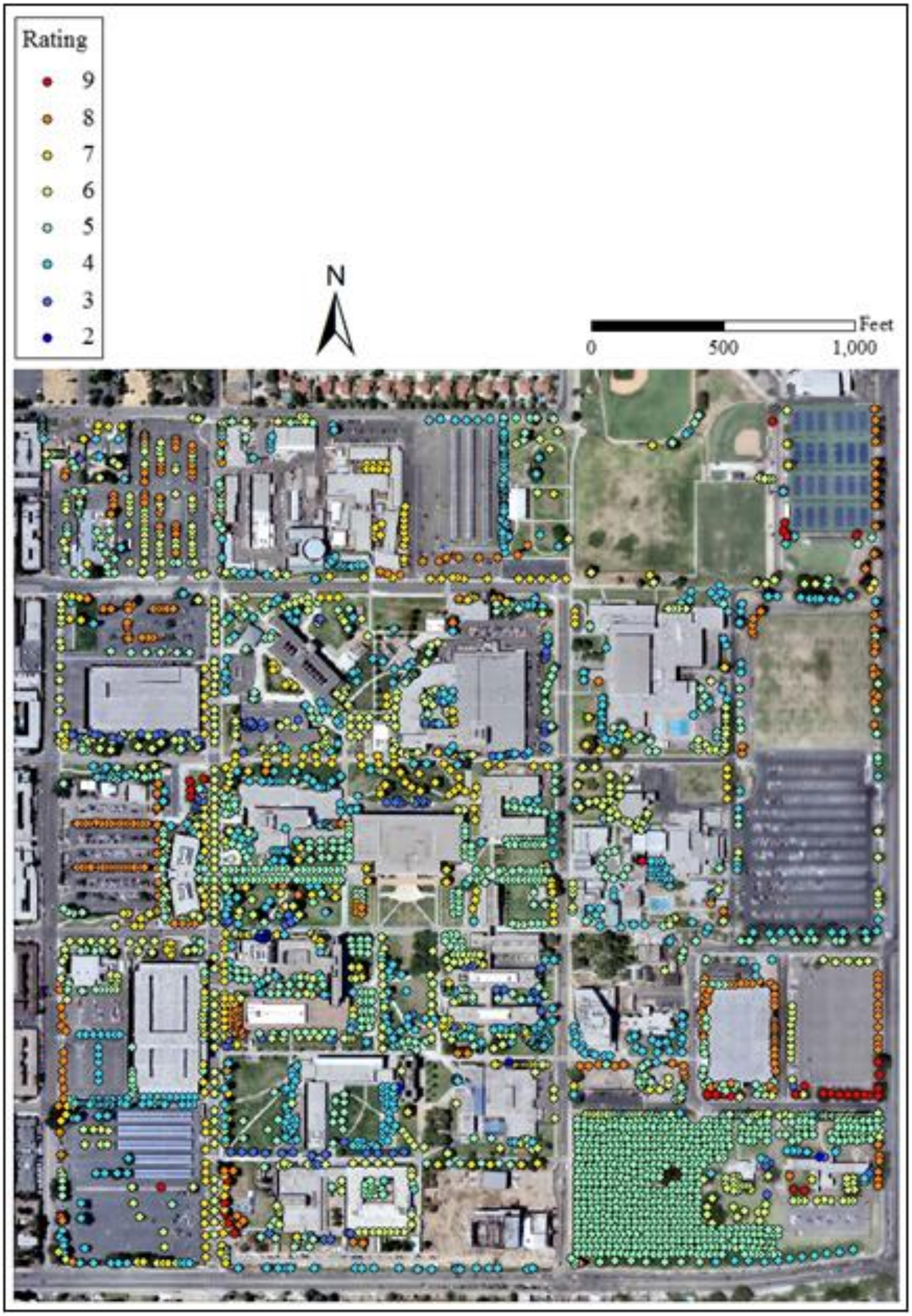

FIGURE 15 – Overall ratings of the trees on campus for scale 2

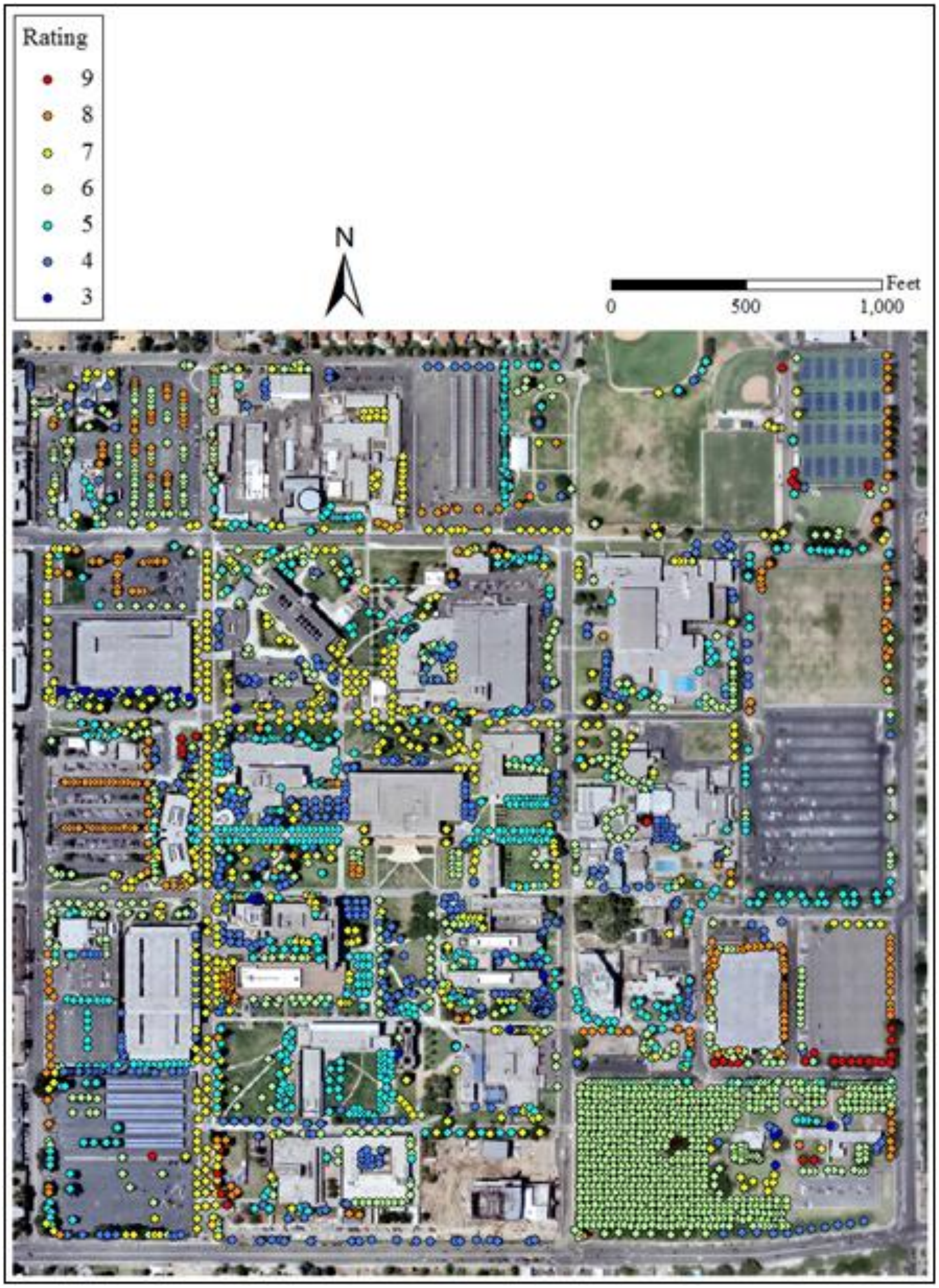

FIGURE 16 – Overall ratings of the trees on campus for scale 3