Mesa Associates, Inc.
Engineers and Consultants

3670 W. Temple Ave., Ste. 152
Pomona, CA 91768
P 909.348.1100
F 909.348.1103
www.mesainc.com

Southern California Edison

Effectiveness Study of Southern California Edison's Hazard Tree Management Plan and Tree Risk Calculator for Hazard Tree Identification and Mitigation

Summary Report of Analysis and Recommendations after Field Study

December 23, 2020

Contact Information

Brett Varner, P.E.
Vice President
Power Delivery
Transmission & Distribution
423.424.7490
bvarner@mesainc.com

Dwayne Robinson, P.E.
Program Manager
Power Delivery
Transmission & Distribution
678.907.7344
dwrobinson@mesainc.com

www.mesainc.com

Table of Contents

1 INTRODUCTION

Southern California Edison's (SCE) Vegetation Management Program emphasizes inspections and maintenance of vegetation clearances near power facilities to help reduce ignitions and outages stemming from vegetation contact with energized electrical infrastructure. SCE's Vegetation Management Program is designed and implemented to meet the requirements of California Public Utilities Commission's (CPUC) General Order (GO) 95, as well as other compliance documents such as CAL FIRE and the North American Electrical Reliability Corporation (NERC) Reliability Standards. The Hazard Tree Management Plan (HTMP), part of SCE's Vegetation Management Program, is part of the wildfire mitigation program for CPUC-designated High Fire Risk Areas (HFRA) within SCE's service territory.

SCE has prepared a comprehensive Wildfire Mitigation Plan (WMP) covering the years 2020 through 2022. The WMP integrates mitigation measures targeting improvements in several areas, including infrastructure hardening, inspections and remediation, situational awareness, Public Safety Power Shutoffs (PSPS), and vegetation management. SCE's Vegetation Management Program has been in place for many years. The program includes pre-inspection and pruning to maintain clearance distance compliance for trees located adjacent to SCE's electric facilities, as well as tree removal, pole clearing/brushing, and weed abatement, especially within high fire risk areas where there is increased risk of ignition due to vegetation contact with conductor and other utility infrastructure. The objectives of the Vegetation Management Program include removal of fast-growing species, vegetation maintenance at prescribed regulatory clearance distances, and prevention of grow-ins, blow-ins, and side grow-ins.

SCE's HTMP is an integral component of the WMP and Vegetation Management Program; it focuses on assessment of the structural condition of trees that could impact energized electrical facilities and potentially lead to ignitions and outages by using an assessment tool called the Tree Risk Calculator. The Tree Risk Calculator is used in the field by an International Society of Arboriculture (ISA) Certified Arborist to document the risk each subject tree poses to SCE's electrical facilities due to potential tree failure, and the Tree Risk Calculator generates rankings for each tree to prioritize mitigation based on the risk rank score of each tree.

By ranking hazard trees in HFRA and prioritizing mitigation for structurally unsound trees, use of SCE's HTMP Tree Risk Calculator in a standardized and consistent manner can greatly reduce the potential risk to SCE's electrical facilities as well as reduce the likelihood of potential ignition events. Mitigation for structurally unsound trees and tree parts (such as palm fronds that might be dislodged in high winds) is prioritized using the Tree Risk Calculator based on risk rankings; this approach provides a timeframe for completion of recommended mitigation tasks to ensure high risk hazard trees receive immediate attention to reduce risk to SCE's utility infrastructure.

This report studies the need and effectiveness of SCE's HTMP and the Tree Risk Calculator for hazard tree identification and mitigation. The value of the HTMP and the Tree Risk Calculator was assessed by conducting a field study in High Fire Risk Areas within SCE's service territory. The HTMP Effectiveness Study Project Plan was executed by the HTMP Effectiveness Study Project Team (the Project Team), which consisted of an ISA Certified Arborist (the Team Arborist), a Distribution Field Engineer, and a Quality Control Scientist, who together evaluated trees and distribution circuitry throughout the study areas. The Project Team's diverse backgrounds and knowledge contributed to the overall success of the thorough evaluation of the HTMP, Tree Risk Calculator, and the distribution circuitry. The Team Arborist has a Bachelor Science in Forestry Management with an emphasis in Wildlife Management and a minor in Biology. The Team Arborist has thirty-seven years of experience with vegetation management. The Distribution Engineer has a Bachelor of Science in Electrical Engineering and is a licensed Professional Engineer with over twenty-six years of experience in distribution engineering. The Distribution Engineer has also been a firefighter for over 18 years and is uniquely aware of the acute risks and risk drivers associated with topographic and climatological risk factors throughout the different parts the service territory and has experience with incorporating design standard changes to reduce those risks. The Quality Control Scientist has a degree in Electrical Engineering and is a Professional Engineer with over fifteen years of regulatory experience in the State of California.

2 HAZARD TREE MANAGEMENT PLAN EFFECTIVENESS STUDY

2.1 HTMP Effectiveness Study Project Approach

The HTMP Effectiveness Study evaluated the following:

- Need and effectiveness of SCE's Hazard Tree Management Plan.
- Need and effectiveness of the Tree Risk Calculator in implementing Hazard Tree Removal, including recommendations for the logic and methodology that is embedded and used in the Tree Risk Calculator.
- The electrical impacts of an evaluated tree on a particular distribution line section and evaluation of the distribution system hardening and resiliency to reduce wildfire risk.

2.1.1 High Fire Risk Areas within Southern California Edison's Service Territory

The Project Team conducted field visits for three consecutive weeks in three different SCE HFRAs with a goal of assessing an equal number of trees per week using the Tree Risk Calculator. The Project Team were trained as HTMP assessors to fully understand the process and procedure of evaluating a tree with the Tree Risk Calculator.

A map of SCE's 50,000 square mile service territory is shown in Figure 1. During the Project Team's study period, there were limitations to access of the entire service territory due to ongoing fires and air quality issues throughout the service territory. The Project Team chose three distinct areas, referred to as SCE districts, which had various types of trees, climate, and distribution circuitry representative of typical conditions across SCE's service territory.

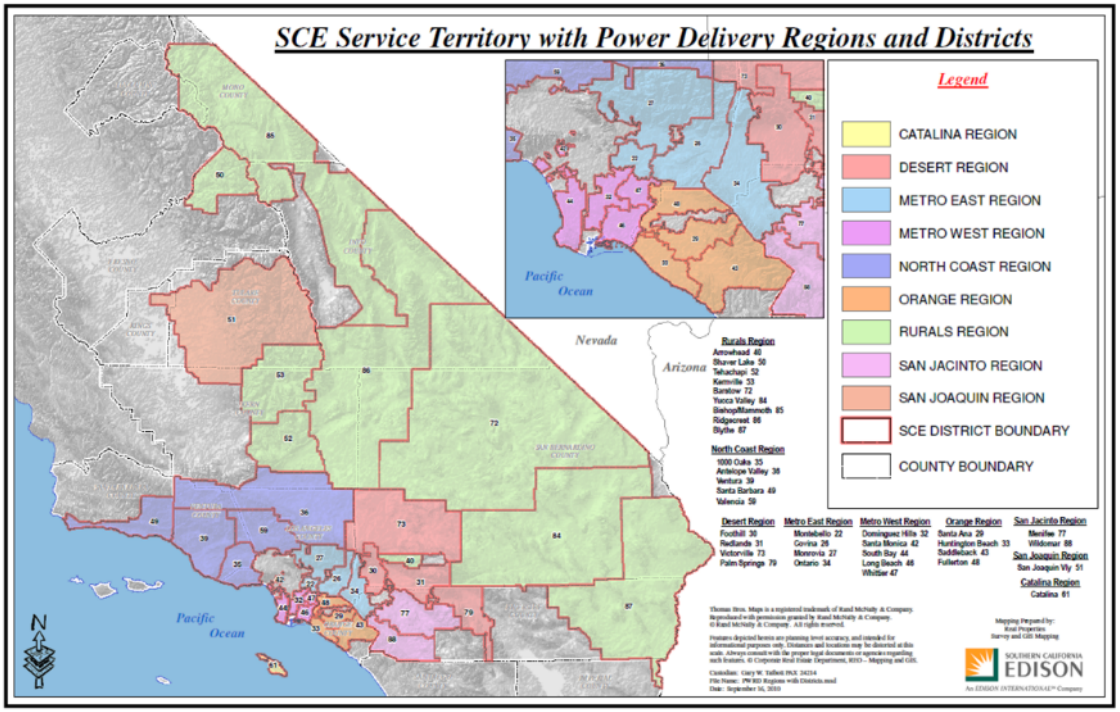

Figure 1 SCE Service Territory with Power Delivery Regions and Districts

2.1.2 Field Tree Assessments

The first week of the study was spent in the Idyllwild area, which is an HFRA within the SCE service territory - Menifee District #77. Idyllwild is located in Riverside County within the San Bernardino National Forest and borders Mount San Jacinto State Park. Trees within this HFRA are predominately conifers and other vegetation including flammable brush. The terrain is mountainous with intact conifer forest interspersed by roads and buildings and other limited developed areas. The area contained 12 kilovolt (kV) distribution circuitry, where the Project Team observed the majority of new construction using composite crossarms and fully insulated covered conductor. A hazard tree observed in the Idyllwild study area is shown in **Figure 2.**

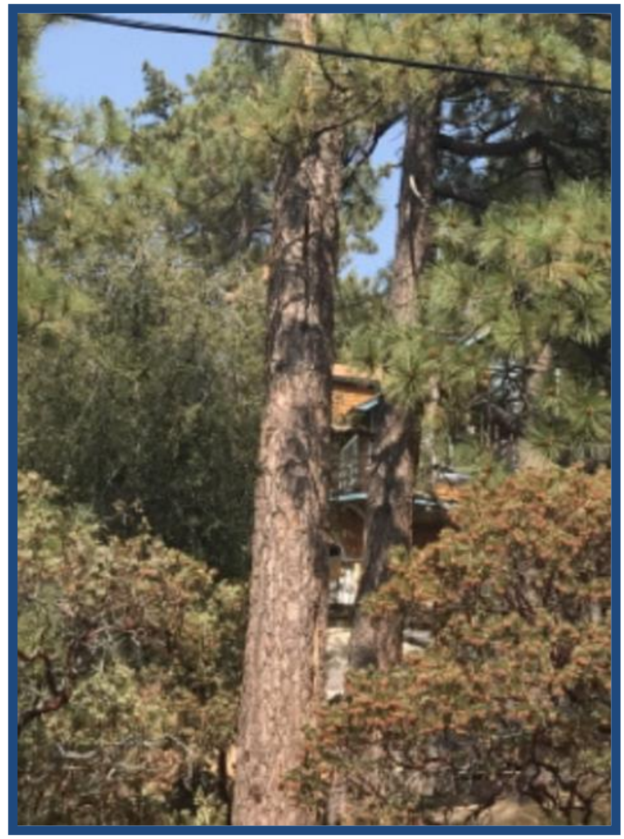

Figure 2 High Risk Coulter Pine (Pinus coulteri) Tree at Idyllwild in Menifee District #77

Note: Tree is growing between power lines (note major vertical cracks in bark, sparse foliage and branch dieback, bleeding sap; severe insect issues also present)

The second week of the study was spent in Ventura County and northern Los Angeles County to the northwest of the City of Los Angeles. The Project Team conducted assessments in the Cities of Filmore, Santa Paula, and Santa Clarita, which are all part of the HFRA in SCE service territory - Ventura District #39. The Ventura study area included trees such as oaks (Quercus), conifers such as pines (Pinus), Eucalyptus, and palms, and land use in the area consisted of rural residential development and agriculture on flat terrain in small valleys and canyons with a distinct wildland-urban interface between the surrounding grass-dominated hillsides and developed areas. The distribution circuity is 16 kV, and the distribution system consisted of poles with wood crossarms and bare conductor throughout the study area. Eucalyptus near powerlines in the Ventura County are shown in **Figure 3.**

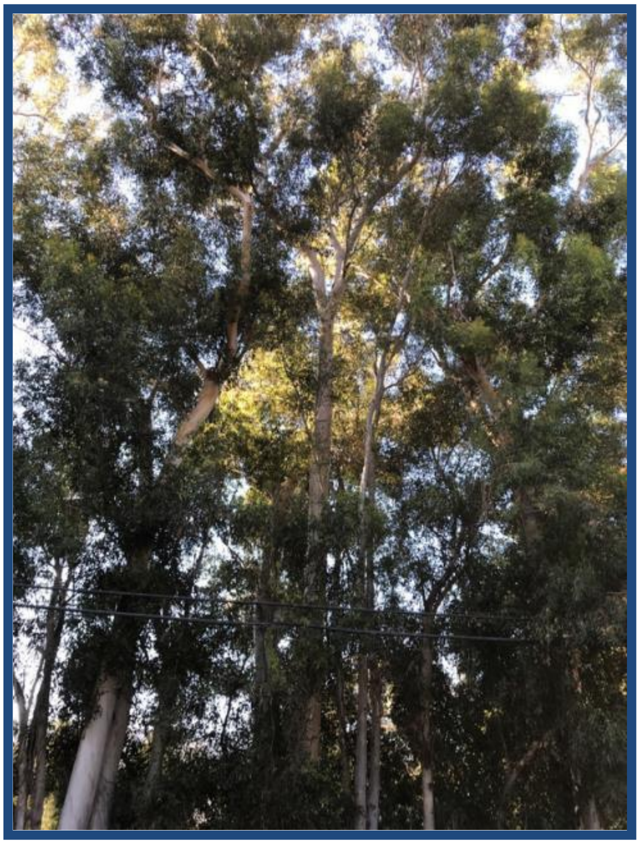

Figure 3 High Risk Tasmanian Blue Gum Eucalyptus (Eucalyptus globulus) in Ventura District #39

Note: Tree adjacent to power lines near Ojai in Ventura County (cracks in trunk, codominant stems, twig dieback)

The third week of the study was spent in the Cities of Santa Barbara and Ojai located in Santa Barbara County to the northwest of the City of Los Angeles along the Pacific coast in SCE service territory – Santa Barbara District #49. This area has trees such as eucalyptus, palms, and oaks and included more heavily developed residential, agricultural, and commercial areas. The distribution circuitry is 16 kV, with a mix of wood crossarm with bare conductor and fully insulated conductor. Street trees in the Santa Barbara study area are shown in **Figure 4.**

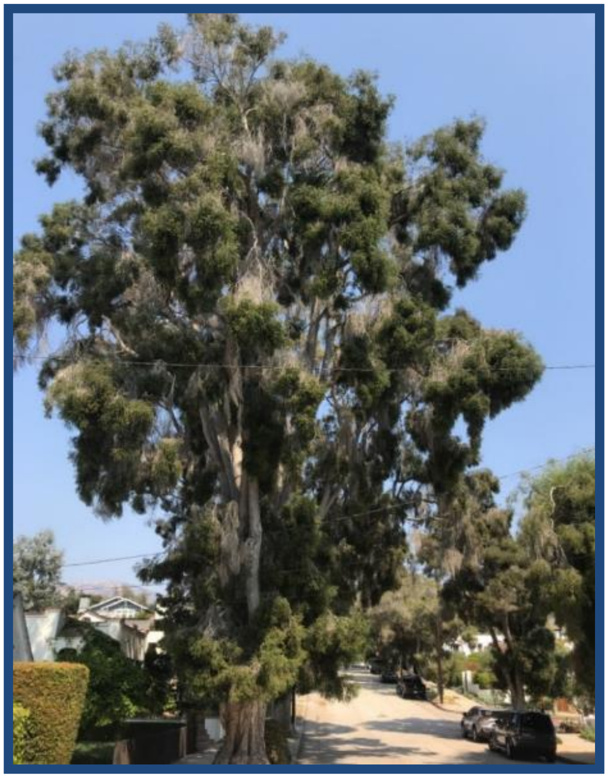
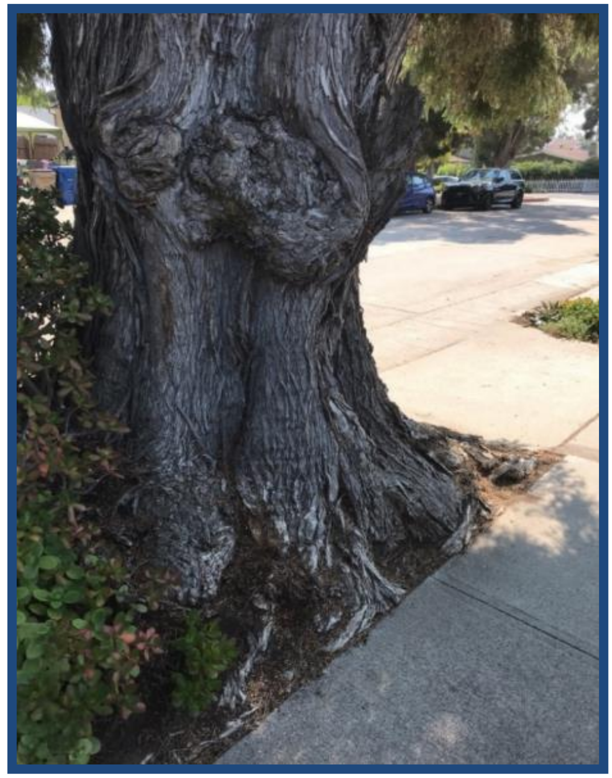

Figure 4 High Risk Snowy Fleece Tree (Melaleuca decora) in Santa Barbara District #49

Note: Codominant stems, twig dieback, poor pruning practices, epicormic sprouts.

2.1.3 HTMP Tree Risk Calculator and Data Collections

Tree evaluation data for the Tree Risk Calculator was collected in the field at each assessed tree location using the Fulcrum software application (APP) loaded on smartphones and electronic tablets. Overview of the Tree Risk Calculator APP: The Tree Risk Calculator APP consists of a comprehensive digital form with detailed fields to document tree species, height, lean, tree condition and defects, and other tree information; site-specific conditions that could impact tree health or exacerbate hazards; and circuitry information such as likelihood of impact, district, and voltage. Also included with each tree record are tree and site condition photographs, general observations, and global positioning system (GPS) coordinates. Data from the Tree Risk Calculator APP can be viewed and analyzed on a web browser with map and table views, and records can be updated from either the field or upon review in the office. The ability to review and update data is an important feature, as some trees may require consultation with other experts to fine-tune assessments of tree health and site conditions.

The Tree Risk Calculator was developed using standards established and set forth by the ISA Tree Risk Assessment Qualification (TRAQ) Program. The TRAQ Program has a standardized systematic process for assessing tree risk and incorporates attributes in subject areas such as tree biology, tree mechanics, and tree inspections. ISA's TRAQ integrates a variety of methods and data to assess tree risk. SCE's Tree Risk Calculator tool was built using the ISA TRAQ's principles of advanced diagnostic techniques of assessing trees.

For tree assessments and evaluations in HFRA, SCE uses the Tree Risk Calculator. The purpose of an HTMP assessment using the Tree Risk Calculator is to identify trees in the HFRA utility strike zone (USZ) that pose a risk to utility infrastructure based on the tree's observed structural integrity and site conditions. In an HFRA, SCE defines each tree within the USZ that has the potential to strike the conductors or fall within the Minimum Vegetation Clearance Distance (MVCD) as a "subject tree". After an assessment, a "subject tree" can remain a "subject tree" or be newly classified as a "hazard tree" or a "reliability tree". A hazard tree has conditions within or at the tree that pose an expected risk to power facilities. A reliability tree is considered a healthy tree but is located in an area where the site conditions pose an expected risk to power facilities.

The data from trees assessed by the Tree Risk Calculator are used to generate an inventory of trees located within the potential USZ that pose a risk to electrical facilities and that require management. These trees can be evaluated on a consistent inspection schedule to determine if the tree health or site conditions have improved or deteriorated since the last inspection. The Tree Risk Calculator assigns each tree a score from 1-100 based on results of the tree assessment. 100 is the highest risk score, and any risk score equal to or greater than 50 is considered a hazard tree. The risk score is derived from tree defects and site conditions. Applying a score to each set of criteria allows a standardized process for subject tree evaluation.

The combined total score is made up of Impact Strike Score (ISS) with a possible score of 25, and the Likelihood of Failure (LoF) Score with a possible score of 75. Fields that impact scoring are: High Fire Risk Area, Voltage/Line Type, Overall Tree Condition, Tree Defects, Site Conditions, Tree Lean, Tree Height, and Likelihood of Impact. When needed and the preferred mitigation option is tree removal, then each tree risk score is associated with a priority for removal and removal timeframe.

HTMP Effectiveness Study Project: During this study, each subject tree was evaluated for the presence of codominant stems, rot, fungal growths, rot, cracks in trunk and/or stems, broken or dead branches and twigs, and other symptoms. The crown, trunk, branches, trunk flare, and root and root collar areas were carefully examined. Major defects could be a crack in the trunk or branches, prevalent rot, history of branch or trunk failure, codominant stems, prevalent signs of serious disease, and several minor and/or moderate defects. The site conditions that were evaluated were history of tree failure in the area, topography, site changes, soil conditions, and common weather patterns.
The Team Arborist evaluated the tree for defects and site conditions and then selected the relevant conditions in dropdown menus in the Tree Risk Calculator. After the Tree Risk Calculator generated a final score, the Team Arborist provided the mitigation recommendation based on observed conditions and the professional judgment of the Team Arborist.

The Project Team evaluated a total of 376 trees in the three study areas (Idyllwild, Ventura County and northern Los Angeles County, and Ojai and Santa Barbara in Santa Barbara County) over the three-week study period. Each tree assessment was entered into the Tree Risk Calculator, and saved within the APP. The Project Team also created a record of the distribution circuitry information in the vicinity of assessed trees. The distribution circuitry information was gathered separately from the Tree

Risk Calculator using the ArcGIS Collector application, which enabled the distribution engineer to collect additional circuitry information to assist in the evaluation of the Tree Risk Calculator. The SCE electrical distribution system was reviewed while accompanying the Team Arborist testing the Tree Risk Calculator and evaluating trees outside of the SCE-maintained vegetation right-of-way. The electrical review was conducted within the same span of conductor as the tree that was evaluated by the Team Arborist. The data accuracy of each record, including, but not limited to GPS, grid/circuit data, photographs, SCE general information, customer information, and tree assessment documentation, was captured and reviewed.

3 HTMP EFFECTIVENESS STUDY ANALYSIS

SCE manages easements and ROWs that support hundreds of thousands of trees, some of which have the potential to fail and contact power lines and/or other utility infrastructure within the USZ, potentially resulting in vegetation ignition and wildfires outside of the SCE-maintained vegetation ROW. The HTMP was developed to mitigate risk of ignition from trees that could impact utility infrastructure. The purpose of the HTMP is to identify, document, and mitigate trees located within the USZ that pose a risk to electric facilities based on the tree’s observed structural condition and site considerations. To execute this task, a tree inspection process has been developed so that tree and site conditions are assessed in SCE’s service area on a scheduled, prioritized basis to evaluate tree risk and determine if work is required to mitigate the identified risk.

Although predicting tree failure is challenging in even the best circumstances, a systematic approach to hazard tree assessment conducted by an experienced ISA Certified Arborist allows for proactive and expedited mitigation of hazard trees prior to failure.

The HTMP details hazard tree characteristics and site attributes associated with potentially hazardous conditions. These characteristics and attributes have been incorporated into the Tree Risk Calculator as described below. The Tree Risk Calculator ranks attributes to generate a hazard tree risk rank that assesses the potential likelihood of a tree failure or of detached tree parts that could adversely affect SCE’s infrastructure and produce severe consequences. Identified hazard trees that pose a potential risk to electrical facilities and require management are included in SCE’s tree inventory for tracking purposes. Tree management may include tree removal, pruning, and heavy topping. Evaluation and management of any potential risks that may arise from the work, such as erosion and wind shear, are included with post tree removal, inspection, and quality reviews.

SCE’s HTMP Tree Risk Calculator includes criteria for site attributes, leaning trees, tree height relative to utility infrastructure, likelihood of impact, palms with fronds that can fly into power lines, and a comprehensive list of tree risk factors such as codominant stems, girdling roots, insect infestations, and other attributes that provide more detailed tree risk assessments than the list of tree defects contained in the CAL FIRE Field Guide. This effective tool is evaluated below.

3.1 Tree Risk Calculator Evaluation

The Tree Risk Calculator methodically and systematically evaluates trees for their ability and likelihood to fail, contact with power lines, and potentially cause wildfires outside of the SCE-maintained vegetation right-of-way. The Team Arborist used his 37 years of wide-ranging vegetation management experience to evaluate the methodology of the Tree Risk Calculator. The Team Arborist's evaluation considered GO 95 Rule 35, CAL FIRE Public Resources Code (PRC) 4293, American National Standards Institute (ANSI) A300 (Part 9), ISA's Best Management Practices (BMP) – Tree Risk, ISA's Tree Risk Assessment Manual, and incorporated years of experience with a variety of standards and specifications related to tree risk assessment in a variety of settings.

As previously discussed, the methodology of the Tree Risk Calculator was developed using ISA TRAQ standards supporting industry practice. After using the Tree Risk Calculator for three weeks the Project Team arborist evaluated the key performance indicators for the tool and its effectiveness. The Tree Risk Calculator assessed the site condition attributes (SCA), overall tree conditions (OTC), and likelihood of impact (LoI) of the tree falling into powerlines based on tree height and tree lean to assign an accurate risk value.

Site Conditions Attributes (SCA). SCA within the calculator includes the following:

Site Conditions Attributes
Bad branch unions
Basal wound
Bleeding and/or resinous
Codominant or multiple stems from base or higher on trunk (small, moderate, large, multiple trunks with low codominant stems categories)
Crack in trunk, major cracks, seams/ribs categories
Dead branches and/or top
Dieback of twigs and/or branches
Epicormic sprouts
Failing or uprooted tree, requires immediate removal
Fungal fruiting bodies
History of limb failure(s) on tree (branch failure, trunk failure categories)
Included bark (minor and major categories
Insect or mistletoe infestations (nuisance, moderate, and severe insect or mistletoe infestation categories)
Lightning damage
Live crown ratio below 50%
Minor disease
Poor pruning practices
Roots (minor exposed or girdling roots - minor, moderate, serious categories)

Site Conditions Attributes
Rot (minor, moderate, prevalent, major categories)
Serious disease (early stages, prevalent signs)
Severely diseased
Some dead wood
Species prone to failure
Structurally unsound trunk, poor taper
Tree dead
Unfavorable species
Weak, unsound branch attachments

Overall Tree Conditions (OTC). Variables in the Overall Tree Conditions category include major tree defects such as cracks in trunk, prevalent rot, history of branch and trunk failure, codominant stems, prevalent signs of serious disease or infestations, and several minor and/or moderate defects, see below.

Overall Tree Conditions
Areas known to be affected by invasive tree pathogens (such as bark beetles)
Areas of recent clearing, thinning logging, new edge
Change in grade
Changes in drainage
Construction – including trenching, paving or road construction
Cultural disturbance to landscape - natural or unnatural
Fire Damage
High winds
History of repeated outages on a circuit
Soils prone to slides
Stand density with single species composition
No impact

Likelihood of Impact (LoI). The Likelihood of Impact into a powerline incorporates the Tree Height Factor, Tree Lean, and proximity to utility infrastructure.

General comments: The Team Arborist determined that the Tree Risk Calculator was an efficient field data collection tool, and the data collected was sufficient to determine if a tree poses a potential risk to electrical facilities. The types and details of data for tree health and conditions are comprehensive and incorporate established and effective standards. The hazard determination of an assessed tree is not shown during data entry, a feature that assists an arborist in completing the form fields without bias; however, if the hazard determination is contrary to the instinct and experience of the arborist,

data can be viewed or edited to update the score. Edits are tracked for each tree record, so these changes are visible in the system, and the data allows for comparison, analysis, and review across a region. Because the data is standardized as pre-set drop-down values for each observation category within the Tree Risk Calculator APP, the determinations are replicable between multiple arborists.
While the HTMP and Tree Risk Calculator are effective at identifying hazard trees for mitigation, the following items are of note. First, there are many variables that can affect the risk ranking of an individual tree. Second, each evaluator comes to his or her own conclusions based on individual professional experiences and the depth of their knowledge of individual tree species and their growth patterns.

Study Results using the Tree Risk Calculator: The Project Team assessed 376 trees using the Tree Risk Calculator within three different and distinct grid areas in SCE's service territory. The 376 trees were all within the HFRA and outside of the right-of-way (ROW). The tool relies predominantly on the values from Overall Tree Conditions, Site Conditions Attributes, and Likelihood of Impact, with Tree Height Factor and Tree Lean as contributing factors, in generating the tree risk score.

The data below in Figures 5-10 present the range of values for all 376 trees in the study areas within each category: Overall Tree Condition, Tree Height Factor, Tree Lean, Site Conditions Attributes, and Likelihood of Impact. Each hazard tree is color-coded based on tree risk score, with green representing trees with no defects or minor defects and red representing hazard trees with severe defects or that had failed.

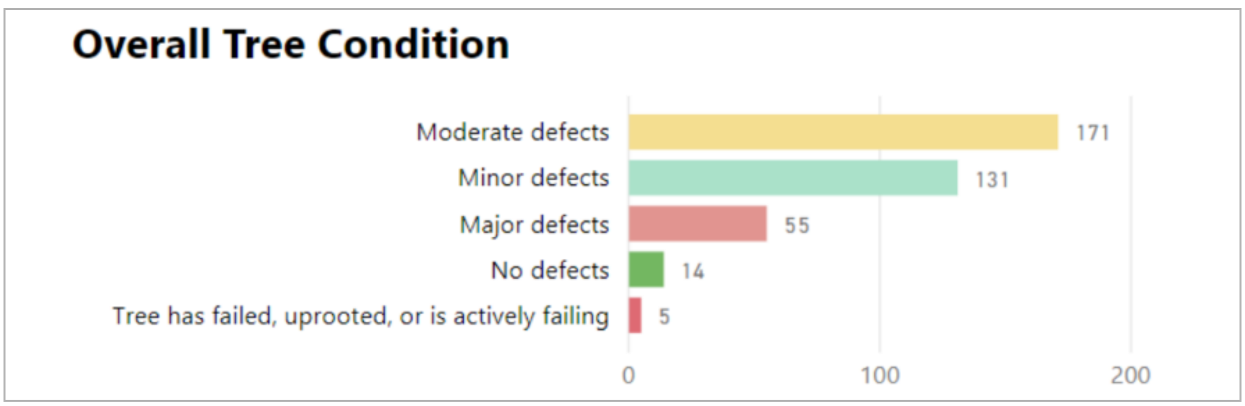

Figure 5: Tree Risk Calculator Data for 376 Trees in Study Area based on Overall Tree Condition

Out of the 376 trees assessed in the three study areas, 55 trees exhibited major defects, based on Overall Tree Condition (Figure 5); although the Overall Tree Condition calculator suggests and 5 individuals had failed or died, none of these 5 trees had died, but they were actively failing due to major disease signs and symptoms. The majority of trees (171) exhibited moderate defects that did not pose an immediate hazard, and many trees (131) exhibited minor defects, with only 14 trees with no defects observed.

Site Conditions Attributes

Site Conditons	Total Count
Cultural disturbance to landscape - natural or unnatural	178
No Impact	133
Construction including trenching, paving or road construction	25
High winds	20
High stand density with single species composition	15
Fire damage	3
Areas of recent clearing/thinning/logging/new edge	1
Change in grade	1
Total	**376**

Figure 6 Tree Risk Calculator Data for 376 Trees in Study Area based on Site Conditions Attributes

A total of 178 of the 376 trees sampled using the Tree Risk Calculator occurred at sites with visible disturbance, including urban areas, roadsides, and other hardscape or infrastructure elements; 25 additional trees were affected by construction activities (Figure 6). Of these, 9 hazard trees occurred in Idyllwild, 9 in Ventura County, and 24 in Santa Barbara County, where the surveys were conducted primarily in residential and roadside settings. Hardscape and construction affect tree health by severing roots, compacting the soil, reducing oxygen and water availability, and confining the root system to a smaller footprint than normal for the species.

Twenty trees grew on sites with high winds (all in Idyllwild), and 15 occurred in stands composed primarily of one species (pines and Eucalyptus), which can result in decimation a vulnerable species to disease or insect infestation outbreaks.

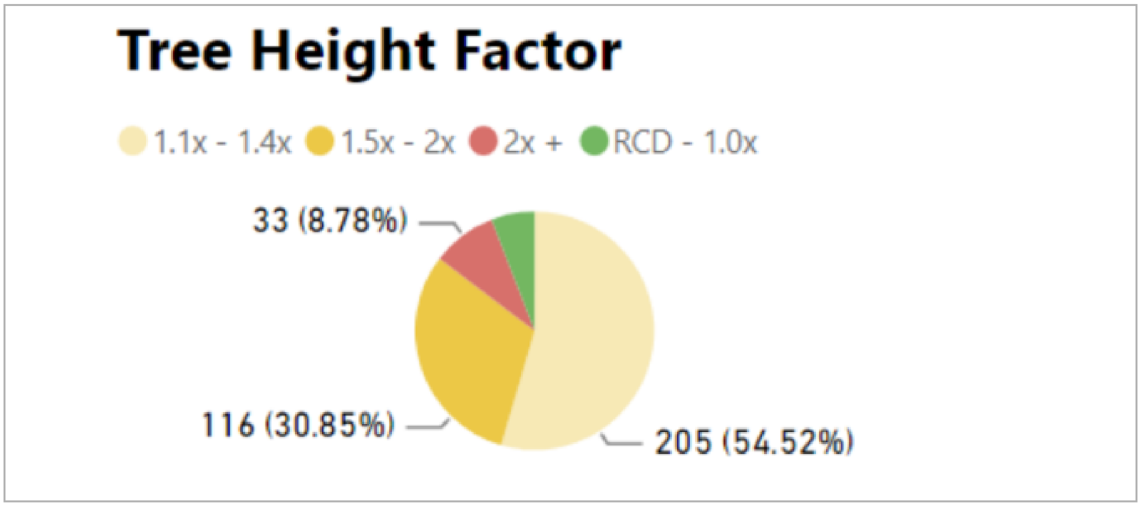

Figure 7 Tree Risk Calculator Data for 376 Trees in Study Area based on Tree Height Factor

The Tree Height Factor evaluates the ratio of tree height to the distance between the closest powerline and the tree base (RCD). A RCD of less than 1 indicates that a tree will not strike utility infrastructure; a RCD of 1.0x may barely strike; with a RCD of 1.1x to 1.4X the top third may strike; with a RCD of 1.5x to 2.0x the top half to third may strike; and with a RCD of greater than 2.0x the top half or more will fall over the powerline or other utility infrastructure. For the trees evaluated in this study, the majority had an RCD of 1.1x -1.4x (205 trees); 116 trees had an RCD of 1.5x to 2.0x; and 33 trees had an RCD of greater than 2.0x. A total of 22 trees had an RCD of 1.0x or less **(Figure 7).**

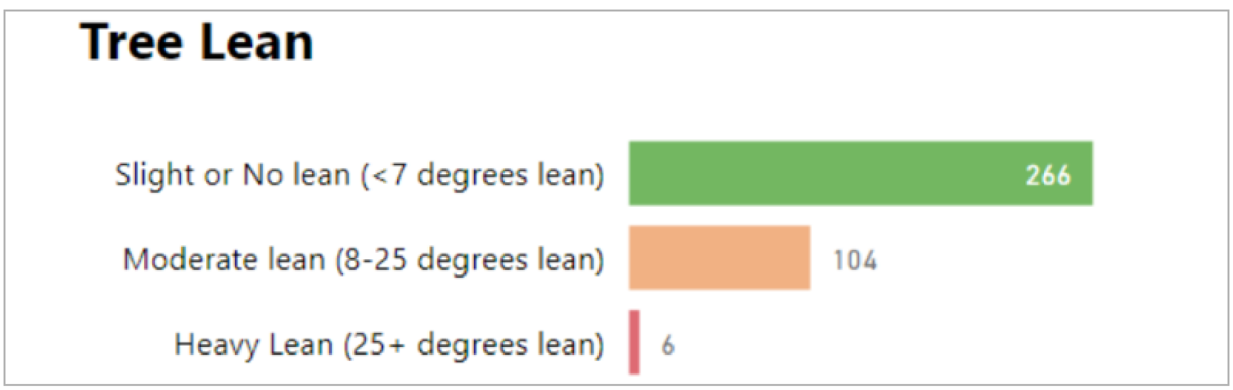

Figure 8 Tree Risk Calculator Data for 376 Trees in Study Area based on Tree Lean

A total of 266 trees exhibited no or little lean (71%), whereas 6 trees exhibited heavy lean and 104 trees exhibited moderate lean; trees exhibiting heavy lean included 3 pines, 2 western sycamores (Platanus racemosa), and 1 bunya (Araucaria bidwillii). Tree lean is an enhanced risk factor on steep slopes within striking distance of utility infrastructure **(Figure 8).** The Likelihood of Impact metric considers these variables in combination.

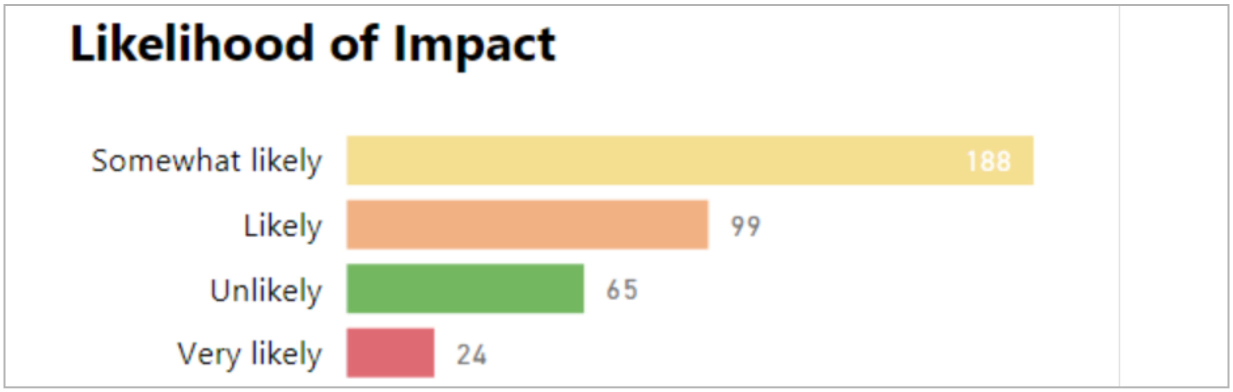

Figure 9 Tree Risk Calculator Data for 376 Trees in Study Area based on Likelihood of Impact

The Likelihood of Impact metric combines the Tree Height Factor, Tree Lean, and site features (Figure 9). The Tree Risk Calculator LOI score determined that 24 trees in the study were very likely to impact utility infrastructure, 99 were likely, 188 trees were somewhat likely, and 65 trees in the study were unlikely to impact utility infrastructure.Of the 24 trees likely to impact utility infrastructure, 7 occurred in Idyllwild, 3 in Ventura County, and 14 in Santa Barbara County.

Idyllwild (7 trees): 5 trees with Tree Height Factor >2.0x; tree height ranged from 35 to 120 feet; 1 tree had a heavy lean greater than 25 degrees and 2 had moderate lean (8 to 25 degrees), with the remainder with no or small lean; 3 trees were subject to construction or cultural disturbance; and all exhibited some type of branch dieback or dead wood, along with other defects.

Ventura County (3 trees): 1 California fan palm, 140 feet tall, with no defects but high risk from detached palm fronds; 1 pine, 70 feet tall, with moderately exposed and girdling roots, branch dieback, and nuisance insect or mistletoe infestation; and 1 Norfolk Island pine (Araucaria heterophylla), 87 feet tall, with bleeding bark, major included bark in large codominant stems, and epicormic sprouts.

Santa Barbara County (14 trees): 11 palms, height ranging from 54 to 155 feet, 9 with cultural disturbance conditions; and 3 Eucalyptus, 66 to 88 feet tall, Tree Height Factor ranging from 1.5x to 2.0x+, all with insect infestations (2 severe), 2 with branch dieback, 2 with codominant stems, and 1 with history of branch failure.

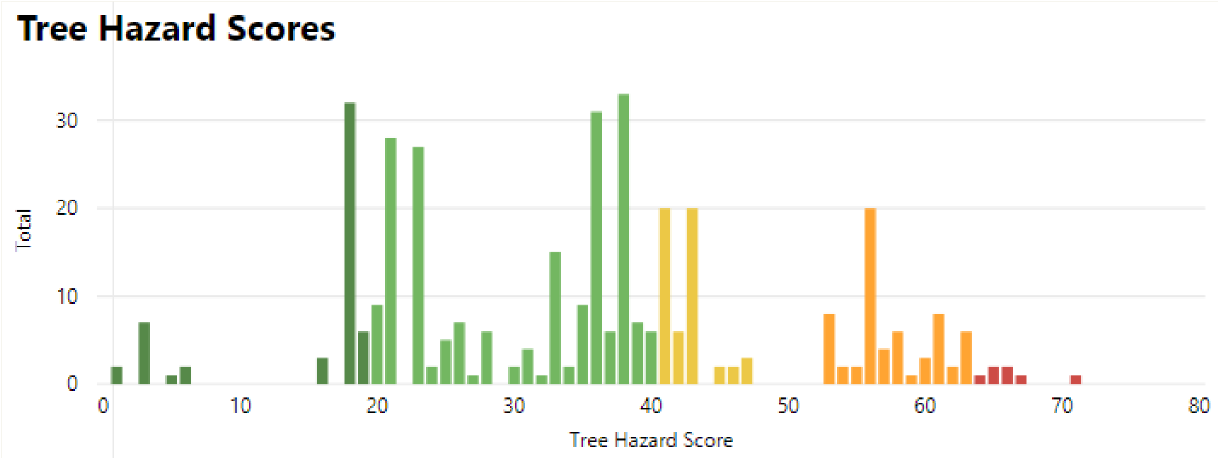

Figure 10 Tree Risk Calculator Data for 376 trees in Study Area Showing Total Tree Hazard Scores

Out of the 376 trees assessed in the three study areas, 69 had a tree risk score greater than 50 indicating a hazard tree, or approximately 18% of sampled trees (Figure 10). Of these, 7 trees had tree hazard score greater than 64 (shown in red in Figure 10), with signs and symptoms including major included bark between codominant stems, bleeding/resinous, structurally unsound trunks with poor taper, prevalent signs of serious disease, dead top and branches, moderate to severe insect or mistletoe infestations, fungal fruiting bodies, dieback of twigs or branches, and epicormic sprouts; 2 of these trees were located in Idyllwild, 3 in Ventura County, and 2 in Santa Barbara County. An additional 62 trees had tree hazard scores ranging from 50 to 63 (shown in orange); these trees exhibited such as cracks in trunk, broken major stems, girdling roots, fire damage, and major included bark. Trees with hazard tree rankings between 50 and 63 included 13 trees in Idyllwild, 21 in Ventura County, and 28 in Santa Barbara County. A total of 307 trees with tree hazard scores below 50 including 14 trees with no defects, 131 with minor defects, and 162 with moderate defects.

Figures 11-13 below show assessed trees mapped within each of the three study areas. Each tree is represented by a color-coded dot based on the tree risk score, and a hazard tree with a score greater than 50 is also shown with a potential strike zone radius in these figures. An objective of SCE's HTMP is to identify trees that would be a hazard that could strike the electrical facilities and to actively mitigate the tree to lower the risk of fire and infrastructure damage in HFRA.

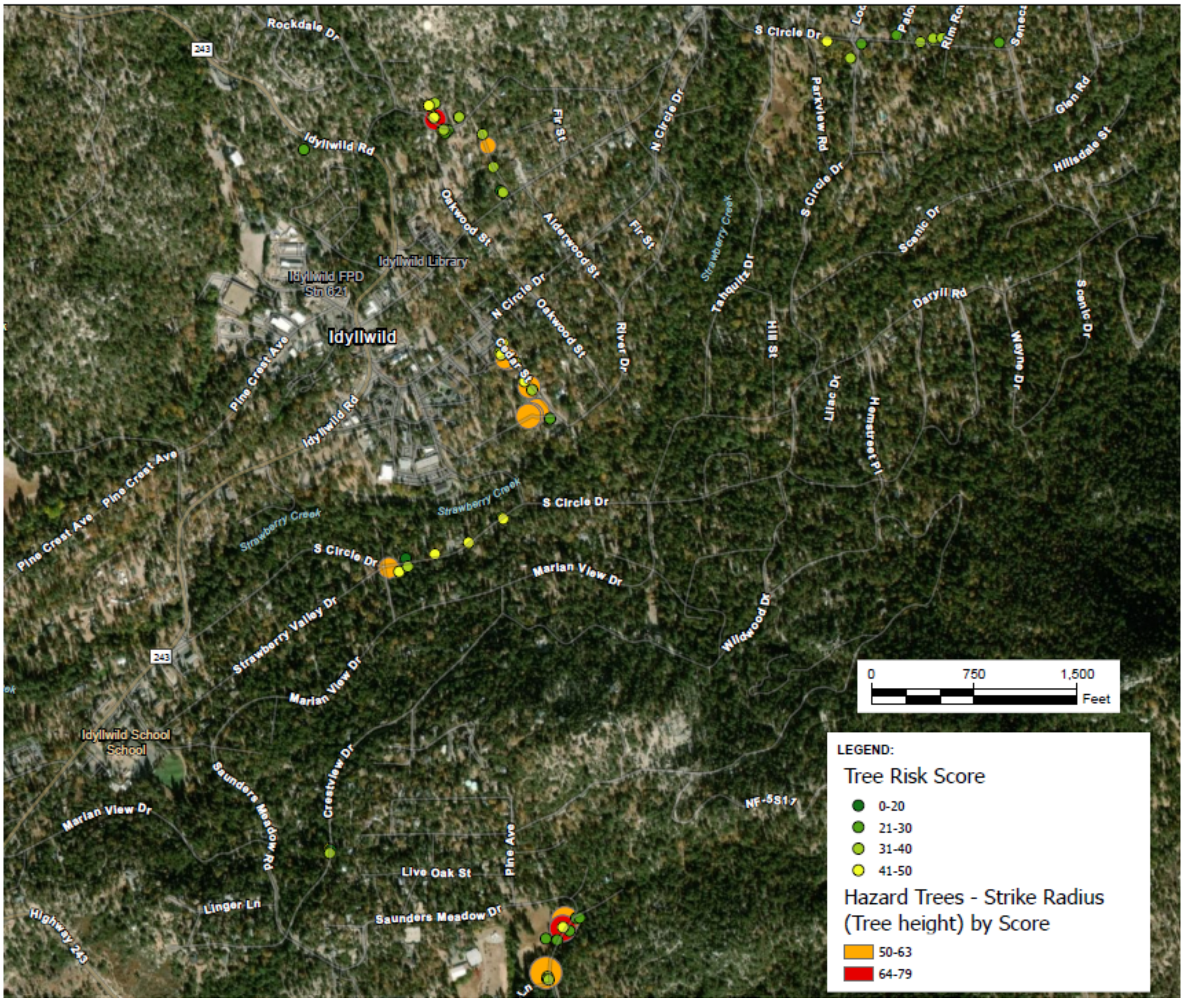

Figure 11 Trees in Study Area in Idyllwild

Note: Tree risk scores shown with color codes; the strike radius for each hazard tree is also shown.

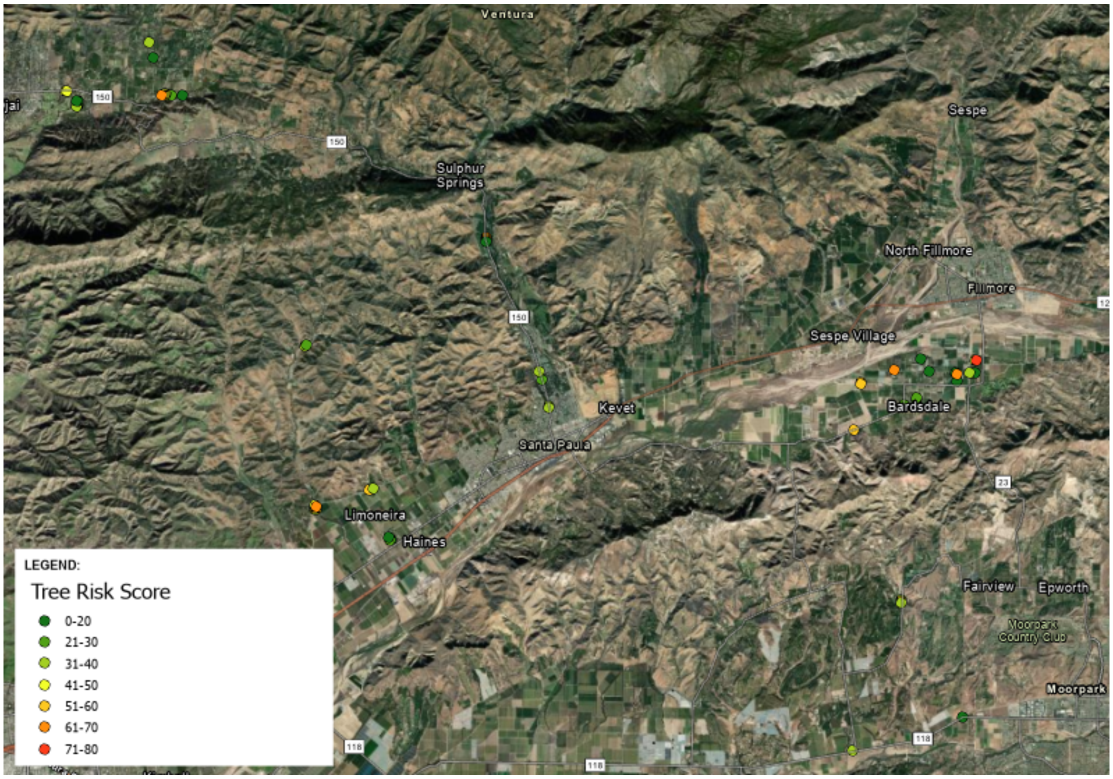

Figure 12 Trees in Study Area in Ventura County with Tree Risk Scores shown with Color Codes

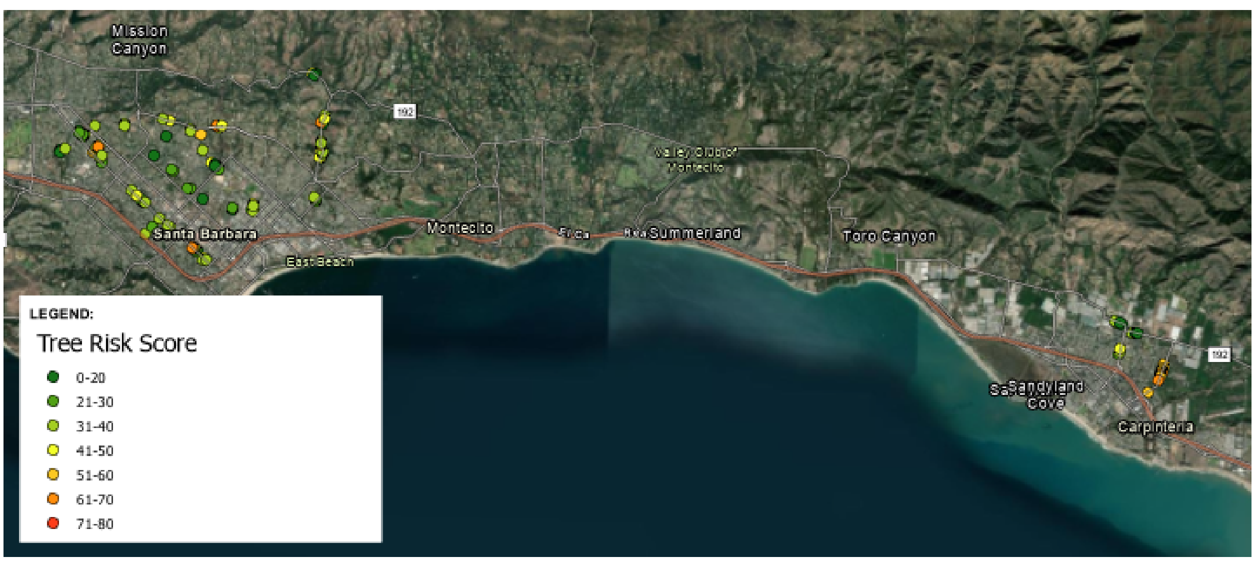

Figure 13 Trees in Study Area in Santa Barbara County with Tree Risk Scores shown with Color Codes

Data for the 69 hazard trees is shown below based on Overall Tree Condition, Tree Height Factor, Tree Lean, Site Conditions Attributes, and Likelihood of Impact.

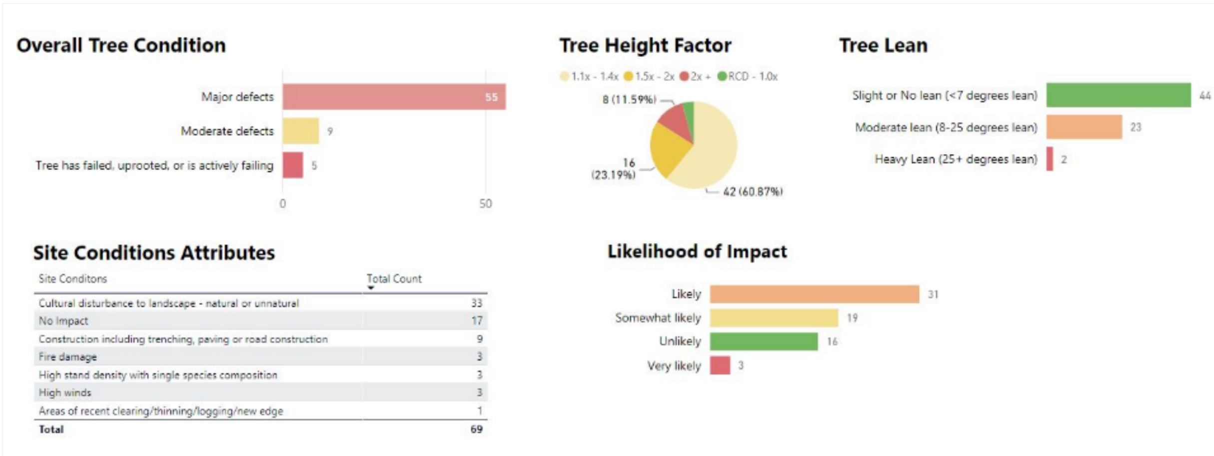

Figure 14 Tree Risk Calculator Data for 69 Trees with Hazard Rankings

Of the identified 69 hazard trees, data from 31 hazard trees produced scores indicating a likelihood of impact of utility infrastructure (LoI), which greatly increases risk of wildfire ignition.
The Overall Tree Condition and Site Conditions Attributes scoring classifications were the primary driving factors in determining whether a tree was classified as a hazard tree. In the OTC category, 55 of the 69 hazard trees had major tree defects, 5 of the hazard trees were failing, uprooted, or are currently failing/uprooting and required immediate attention, and 9 of the hazard trees had moderate defects.

The Site Conditions Attributes category was also a driver to high tree risk rankings. A total of 33 of the 69 trees occurred in areas subject to cultural site disturbance and were included in the category Cultural Disturbance to Landscape (Natural or Unnatural). Nine hazard trees occurred in construction areas, 3 showed signs of fire damage, 3 occurred in dense stands of a single tree species, 3 occurred in areas subject to high winds, and 1 was found in a recent clearing.

In summary, our data suggests that trees with major defects that occurred within the USZ were classified as hazard trees.

For trees with moderate defects, other risk assessment categories contributed to the determination of whether a tree was a hazard or not, especially Site Conditions Attributes, Tree Height Factor, and Tree Lean data. Only 9 of the 69 hazard trees had moderate defects, representing 2.4% of total assessed trees. For trees with moderate defects, the tool accurately utilizes site conditions and additional tree data to determine if mitigation is necessary.

The tree risk ranking results using the Tree Risk Calculator in this area was consistent with the experienced Project Arborist's observations and judgment for trees posing an immediate or short-term hazard requiring mitigation within 30 days. Removing trees that are failing or with major defects that may strike an electrical facility within the HFRA is an effective mitigation to prevent fires and damage to utility infrastructure.

The number of trees with a ranking of 50 or more (hazard trees) using the Tree Risk Calculator was similar between the three study areas, ranging from 16% to 21% of all trees assessed in the study. Within the Idyllwild district, 21% of trees were determined to be hazardous and only 1 of 15 hazard trees fell in the moderate category, reflective of drought and bark beetle infestations in the region. Within the Ventura area, 20% of assessed trees were determined to be hazardous, and the Santa Barbara district had 16% hazard trees. These patterns within and between districts illustrate that the Tree Risk Calculator is an effective and nuanced tool to identify potentially hazardous trees for mitigation.

Our assessment indicates that determination of tree risk scores is not biased towards tree removal without sufficient rationale and that the Tree Risk Calculator is an effective tool to assess trees based on potential hazards to electrical facilities.

Observed High Risk Tree Defects

	High Hazard	Moderate Hazard	Not Hazard Tree	**Total**
Dieback of twigs or branches	5	52	195	**252**
Nuisance/moderate insect or mistletoe infestation	5	33	169	**207**
Epicormic sprouts	1	13	27	**41**
Dead branches/dead top	2	15	14	**31**
Included Bark	1	14	14	**29**
Girdling	2	6	18	**26**
Bleeding/resinous	2	2	16	**20**
Structurally unsound trunk/poor taper	2	2	15	**19**
Serious disease		6	2	**8**
Severe insect or mistletoe infestation	2	5		**7**
History of branch/trunk failure		3	3	**6**
Live crown ratio <50%		5		**5**
Rot - moderate/major		2	2	**4**
Fungal fruiting bodies	1	2		**3**

Figure 15 Major Defects in Trees with High Hazard Tree Rankings (64 and above) Compared with Prevalence of the Same Defects in Trees with Hazard Tree Rankings between 50-63 (moderate) and 1-49 (non-hazard trees)

The 7 trees with hazard tree rankings of 64 and above each exhibited a combination of at least four of the following signs and symptoms, as recorded in the Tree Risk Calculator tree defects field: major included bark between codominant stems, bleeding/resinous, exposed and girdling roots, structurally unsound trunks with poor taper, severe insect or mistletoe infestations, dead top and branches, severe and/or nuisance insect or mistletoe infestations, fungal fruiting bodies, dieback of twigs or branches, and epicormic sprouts.

Figure 15 presents the prevalence of these defects in the entire tree sample (376 trees). These data suggest that defects found in high hazard trees also occur in varying degrees in non-hazardous trees and some of these defects could become more serious over time.

Some defects are widespread, such as dieback of twigs or branches (which was noted in 67% of sampled trees) and signs of nuisance or severe insect/mistletoe infestations (65% of sampled trees). Twig dieback can be a symptom of disease and/or insect infestations such as bark beetles and is also a symptom of root girdling. Twig and branch dieback in response to prolonged drought conditions also occurs routinely in nature and so a combination of features that include a symptom (such as twig dieback) coupled with signs of disease or infestations (such as rot, bleeding, fungal bodies, bark borer tunnels or frass) provides a more accurate means of predicting which non-hazard or moderate hazard trees might decline over time and become major hazard trees. For instance, tree defects such as twig dieback, dead branches and/or dead top or trees combined with bleeding and other signs from rot diseases, such fungal fruiting bodies, and/or serious insect infestations indicate trees that may decline over a short time period such as five years or less and require planned mitigation. These combinations could be flagged for follow-up monitoring and potential mitigation.

Root girdling frequently leads to constriction of nutrient distribution within a portion of the tree as the phloem gets cut off and trees exhibiting signs of root girdling should be flagged for follow-up monitoring and/or removed.

Major included bark and structurally unsound trunks and branches can lead to trunk or branch collapse over time, potentially striking utility infrastructure, so these features should be coupled with the Likelihood of Impact data to provide guidance on prioritization of pruning or tree removal.

Incorporating species-specific information can enhance the ability to accurately utilize Tree Risk Calculator data to predict future tree failure. For instance, twig and branch dieback alone may be a response to temporary stressors (drought) or an inherent feature of the tree species' biology, such as self-pruning branches, as in the western sycamore.

In summary, the Tree Risk Calculator provides valuable data and generally accurate tree hazard scores. Trees identified as hazard trees using the Tree Risk Calculator produced scores indicating a likelihood of impact of utility infrastructure or branch/frond blow-ins that could greatly increase risk of wildfire ignition. Prioritized removal or pruning of high-risk trees would reduce wildfire ignition sources. More detailed study of the wealth of data collected in the field using the Calculator can facilitate diagnoses of tree risk and issues, prediction of trees likely to fail within a given time frame based on risk factors, and mitigation of those risks on a prioritized basis.

3.2 Tree Risk Calculator Recommended Refinements

The Project Team has several recommendations to improve and refine the evaluation criteria used in the current SCE Tree Risk Calculator. These recommendations are intended to focus hazard tree designation on trees where mitigation is necessary to reduce fire risk, while also identifying trees where non-removal mitigation or monitoring is sufficient. Adding the refinements below will enhance the risk score on the Tree Risk Calculator and will allow SCE to prioritize trees in the HTMP more effectively.

- Fuel Source Data. Add additional dropdown categories and fields to collect and rank fuel source data at each tree assessment site. Fuel sources increase fire risk and, when incorporated into the risk score, could affect mitigation priorities. Suggested fuel source categories include:
    - Buildings or accessory structures
    - Agricultural/orchard fields
    - Irrigated landscape
    - Forested/timber vegetation with cleared understory
    - Forested/timber vegetation with dense underbrush or heavy leaf litter/deadfall/ladder fuels
    - Shrub-dominated vegetation with occasional to scattered trees
    - Grassland-dominated vegetation with occasional to scattered trees
- Multiple Utility Facilities Impacts. Currently the Tree Risk Calculator evaluates whether the tree will impact a single power line or structure. Adding the option of multiple electrical facilities that could be potentially impacted if a tree falls will provide enhanced understanding of risks to multiple power lines and/or other utility infrastructure. Adding the risk associated with trees that could potentially impact more than one power line, as well as the possibility of under-build, will enhance the risk score.
- Red Flag Immediate Hazard Alert. Add a "Red Flag" Immediate Hazard drop-down feature to the Tree Risk Calculator to be used when there is an immediate hazard found in the field such as: any tree needing immediate vegetation clearance in close proximity to the line, bark or fronds hanging on the conductor, and high-priority distribution circuitry issues. All of these examples could represent immediate fire risk to the electrical facilities and providing a "Red Flag" Immediate Hazard feature will get teams out in the field to mitigate fire risk. This would also allow for HTMP assessors to notify SCE of immediate hazards within the ROW clearance zone as well as other observations outside the HTMP scope.

  ISA's TRAQ protocol defines the time frame for tree failure as imminent, probable, possible, or improbable. Consider integrating the timeframe for tree failure into this hazard alert category.
- Canopy Weight Distribution Refinements. Weight distribution within the canopy takes into consideration based on the ratio of crown length to total tree height. A ratio less than 50% may suggest a tree in decline or may represent certain site conditions such as dense shade. Within the major defect's category, there is no category representing uneven weight distribution within the crown that may suggest tree health issues or defects; consider adding this category.
- Tree Lean Direction. Within the Tree Lean category, there currently is no field for indicating the direction of tree lean. Add a field for directionality of tree lean parallel with or towards or away from the electrical facilities. Although Tree Lean and Likelihood of Impact are existing assessment categories, adding the additional criteria for directional lean to the risk score would allow the tool to more accurately predict likelihood of a line strike. Adding codes on whether the tree lean is corrected or imbalanced would also be useful.

- Palm Assessments. Build a drop-down for the APP to assist the arborist in documenting tree risk data concerning unmaintained palms or palms with poor skirt stability for palms with the crown greater than or equal to a 45-degree angle from nearby utility lines. Currently the arborist is visually estimating the calculation in the field and if the angle is 45 degrees, then the priority risk of the tree is elevated. Due to the importance of the accuracy of this calculation, it would be helpful to have the calculation automated for field data collection.
- Correct Tree Species Identification. Assessment of tree health and risks is dependent on correct identification of the tree in the sample, preferably to species. Some pine species such as gray pine (Pinus sabiniana) commonly lean and produce reaction wood to enhance trunk support; they also have sparse foliage when in good health. Western sycamore trees also often lean and produce reaction wood as well as branches that self-prune (and thus would exhibit dead branches before branch drop). California bay (Umbellularia californica) frequently produces multiple trunks from a burl. Provide a list on known tree species for each district with links to identification tools and/or features, and details on growth habit that may affect tree assessments. This list should include street trees.
- Data QA/QC. Flag a few key categories for data QA/QC after field events. For instance, one tree with a hazard risk ranking of 56 was recorded as failing with serious disease and major included bark, and a higher risk ranking might have been anticipated.
- Closeup Photos of Defects. In the tree mentioned above with a hazard risk ranking of 56, the tree looks healthy from a distance and there are no closeup photographs of tree issues for desktop assessment. High quality closeup photographs of defects is an important component of QA/QC; closeup photographs could facilitate consultation with disease and insect experts to establish a projected timeline for tree failure or consultation with a City Arborist who may want input on tree mitigation or removal.
- Add a Notes Option for Hazard Tree Attributes. Since tree defects are a major driver in determination of the hazard tree risk ranking, add a notes box so the person selecting features can expand if helpful (examples include notes on tree lean – corrected lean vs. unbalanced crown; bark beetle holes observed on X% of bark; mistletoe infestation affects less than 5% of the branches, etc).
- Add a Field for Recommended Mitigation to Prevent Tree Failure. For instance, for codominant stems, cabling and bracing of codominant stems lacking significant included bark can be an effective mitigation measure. Street trees in many communities are overseen by a City Arborist, who could consider implementing mitigation measures recommended by SCE.

3.3 Distribution Circuitry Analysis and Recommendations

The distribution engineer accompanied the Team Arborist to complete a comprehensive distribution circuitry assessment in the vicinity of each tree evaluated. The electric distribution system, within a span of a conductor, was reviewed for the following:

- Type of conductor
- Primary framing

- Equipment on the pole, including a detailed assessment of the fusing type, tap conductors, and electrical connections
- Pole height and class
- Vegetation type around, under, and near the electrical conductors.

Each specific span of conductor was reviewed in detail to determine the effects of the following:

- If a branch would fall into the conductor
- A momentary contact with the conductor
- If a tree would completely fall and assess the amount of damage which could possibly occur to the conductor and structures

If the evaluated tree was to partially fail and contact the conductors, and if the tree was to fail at ground level and fall into the conductor, these two different contacts would have different impacts on the conductor and the supporting structures.

The project engineer also evaluated the distribution line for vegetation under the power line, which could increase fire risk. The project engineer relied upon over 25 years of experience in electrical design, operations, and storm recovery experience to make the distribution engineering assessments. Additional considerations were evaluated from a fire behavior perspective as the engineer has over 19 years' experience in wildland firefighting.

The project engineer offers the following observations and recommendations after 3 weeks of field activity. SCE has installed covered conductors with the objective of reducing the risk of fire in HFRA. Although new covered conductor has been recently installed in some areas (including in Idyllwild in Menifee District #77) and it is a fully insulated conductor for the system voltage, vegetation management standards still need to be maintained within the ROW. Covered conductor significantly reduces wildfire risk when branches fall into the conductor without breaking the insulated cover. However, if large trees and/or branches are heavy enough to break through the insulation covering the conductor, the exposed conductor may arc and potentially ignite wildfire. Therefore, the HTMP is required in all areas to reduce the risk of hazard trees falling into conductor or other electrical infrastructure.

There are many different solutions for resolving the minimization of an electric fault impact and improving the restoration time. The common indices and metrics reportable are System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) calculations. These different solutions vary in cost and complexity, but the minimal cost solution would incorporate the use of fault indicators beyond the switch. The most expensive option would be a Supervisory Control and Data Acquisition (SCADA) controlled recloser protecting the section beyond the installation. There are several solutions available, complete with communication capabilities with remote operation and control, immediate electrical disturbance, and capturing system data directly into the utilities SCADA system.

There are existing three phase manual operated air-break (MOAB) switches used throughout the electric system that we reviewed. In many of the cases, there were multiple MOAB in series with a line section between them or a tap off the main line had a MOAB on the tap. In either case, using a fault indicator just beyond the MOAB would indicate the line section where the fault occurred. This would decrease restoration time for ease in identification of a faulted line section.
The project engineer recommendation is for a S&C trip saver. One option would be to incorporate S&C trip saver type of device that can be set for single operation or multiple reclose attempts. In the event of a downstream fault, the fuse saver would operate similar to recloser with a time current curve and a minimum trip setting. These devices are ideal for rural feeders as they will isolate a single-phase fault and not open all three phases, assuming there are no three phase motor loads beyond the protection device without single phase fault relaying. The added benefit of the trip saver is during high fire danger season, there is a non-reclosing lever that can be placed into operation without de-energizing the circuit. This non-reclose feature is critical during high fire season, because a downstream fault will open the trip saver and no reclosing will occur.

The project engineer recommends the installation of surge arresters where the Hendrix cable is at a dead-end or at a tap, and a pathway to ground is recommended by the manufacturer to have surge arresters installed. Hendrix documentation recommends lightning arresters installed at every "open" in the covered conductor. Section 3.11, page 20 of the Hendrix Covered Conductor Manual REV 2, AUG 2013 (DM#: 5523521) states "surge arresters must be used at every termination point, open point, or tee-off point".

The installation of the surge arresters at every opening, where the insulation is removed (dead-ends, taps, etc.) creates a pathway to ground to quickly shunt the overvoltage. The purpose of the surge arrestors is to minimize the overvoltage travelling through the length of the conductor. This will extend the life of the covered conductor by minimizing the opportunity for small openings developing in the reducing the insulating value of the covered conductor.

The project engineer recommends the replacement and elimination of all expulsion type fuses in all HFRA. The project engineer recommends the use of fusing devices already in use by SCE, such as, current limiting fuse, SMD type power fuse, or transformer fault tamer fuse limiter. Expulsion type fuses can potentially cause wildland fires, particularly where there is brush, grasses, and vegetation near or around the pole. It is our recommendation that all expulsion type fuses are removed and replaced within high fire danger areas.

4 CONCLUSION

This study finds SCE's HTMP and Tree Risk Calculator are an effective and needed components of SCE's Wildfire Mitigation Plan to identify and assess trees that pose a potential fire risk to utility infrastructure within HRFA in SCE's service territory. The Project Team completed three weeks of field studies throughout various HFRA in SCE's service territory. During field studies, it was determined the Tree Risk Calculator assessment methodology provides a structured process to yield consistent evaluations. The Tree Risk Calculator is effective at streamlining the process of gathering tree risk data and ranking these risks; it identifies a hazardous tree and provides a suggested timeframe for mitigation to reduce the potential wildfire risk resulting from a tree impacting the power lines or other utility infrastructure.

Project Team members also conducted data analysis to understand how the tree risk score was calculated based on field data collection and studied the drivers that contributed to the development of accurate tree risk scores, a critical tool to address increased wildfire concerns. The study shows the Tree Risk Calculator determination of tree risk scores is based on tree and site conditions and is not biased towards tree removal without sufficient analysis of the field data. Data from the 69 trees in this study with a hazard tree risk score exceeding 50 will be given to SCE for further review and hazard tree confirmation. The Project Team members conclude that the HTMP and the Tree Risk Calculator provide an effective and necessary approach to identifying and assessing trees that may be a potential hazard to electrical facilities and pose a risk of wildfire ignition. The Project Team members offered several refinements for consideration to gather more detailed data to enhance the likelihood that resulting data can be utilized to predict tree failure over time. The project engineer simultaneously evaluated the distribution system hardening and resiliency and has recommended specific design changes and equipment removal to reduce wildfire risk.