PG&E Vegetation Tree Assessment Tool Development and Application

Documentation of methodologies, stakeholders and data sources

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Vegetation Management Study

This document outlines the approach, methodology and final process refinements to identify and abate vegetation in the High Fire Threat Districts within the PG&E system to reduce wildfire risk posed by trees falling into PG&E overhead electric conductors. The culmination of this review and process will result in the replacement of the Hazard Tree Rating System (HTRS) with the Enhanced Vegetation Management Tree Assessment Tool (EVM-TAT). This paper includes project scope, methodology, analysis, key PG&E team members, and data sources used.

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Context

In 2017, PG&E recognized the increasing risk of wildfire and responded by modifying the objective of the Public Safety and Reliability (PS&R) Vegetation Management Program to be weighted more heavily towards preventing catastrophic wildfire ignitions. This change was in effect for the PS&R 2018 project year (Nov 2017-Dec 2018). This resulted in select line segments in Tier 3 of the High Fire Threat District (HFTD) determined to be of highest likelihood of tree failure targeted for tree pruning and removal of trees that do not fall under the work requirements mandated by State regulations but had been determined by PG&E to be at elevated risk of failing into conductors.

The wildfire events taking place in 2017 resulted in recognition that more was required; during the 2018 project year, the Fuel Reduction (FR) Program was developed and implemented. The FR Program was transformed later in 2018 to the Accelerated Wildfire Risk Reduction (AWRR) emergency response effort. Like PS&R, these efforts were focused in Tier 3 of HFTD but went well beyond the PS&R scope by achieving greater radial clearances around conductors while also removing vegetation above and beneath conductors. AWRR also more aggressively targeted the removal of ten tree species based on their history of causing outages and/or ignitions in HFTD during wildfire season. Not only was the scope of work expanded, but a focus on performing the work on the entire Tier 3 region was adopted over the select line segments targeted by PS&R.

In adopting the top ten species scope portion of the AWRR scope, it was recognized that the result would be the removal of trees that would generally be considered in good health. While it was recognized healthy tree abatements could be called into question, PG&E analysis of past tree failures that resulted in outages and ignitions demonstrated that the majority of such incidents were from trees that did not show any signs of poor health or other defect. It was deemed necessary to implement a program scope that mitigated the risk posed by such healthy trees if the objective of preventing catastrophic wildfires was to be achieved.

The top ten species approach remained part of the project scope at the close of 2018 as the effort was further refined and renamed the Enhanced Vegetation Management (EVM) program and the area of work was again expanded from the Tier 3 area to include the Tier 2 area as well, at total of 25,200 overhead distribution circuit miles

The State of California Public Utility Commission's RULEMAKING 18-10-007, DECISION ON PACIFIC GAS AND ELECTRIC COMPANY'S 2019 WILDFIRE MITIGATION PLAN PURSUANT TO SENATE BILL 901, has required PG&E to modify its approach to mitigating the wildfire risk posed by healthy trees falling into conductors.

The immediate response to 18-10-007 was to proceed with the increased clearance and overhang removal components of the EVM prescription but suspend removal of healthy trees based on species alone. Fall-in risk tree removals were limited to trees that are determined to be hazardous based on our existing Hazard Tree Rating System (HTRS). Previously, the HTRS had been in use by PG&E as the means of identifying and mitigating hazard trees. The HTRS, while effective at identifying clear hazardous trees per State Regulations, is not expected to adequately address the known risk of wildfire posed by healthy trees.

The Tree Assessment Tool has been developed to more accurately and efficiently identify and mitigate wildfire risk. This is accomplished by using criteria that are more objective, directly relevant to tree failure, and better informed by the latest outage and ignition data. In keeping with the direction provided in 18-10-007, The TAT does not direct removal of trees that have no signs of health issues or structural defect. However, it does provide a species wildfire risk rating based on regional outage and ignition data taking into account the frequency of the species in the population. Only species determined to be of highest risk will be removed when exhibiting minor health or structural issues. Species with lower risk require a greater degree of health or structural issues to result in removal. In this way, PG&E will remove trees that are at elevated risk in a targeted way and remain in compliance with 18-10-007. However, it must be recognized that in complying with 18-10-007, the risk posed by trees exhibiting no health or structural issues remains unmitigated. Trees in this category were responsible for 76 percent of the May-Nov vegetation outages in HFTD 2012-2019[1] and 82 percent of the HFTD vegetation ignitions.

Scope

On the basis of the CPUC decision described earlier, PG&E defined the scope of its approach to additional TAT refinement as follows:

Scope Details

a) Develop a tree assessment tool to better assess vegetation wildfire risk characteristics within High Fire Threat Districts across the PG&E territory during fire season that leveraged data and analytics on outages, ignitions and wire down events;
b) Validate / test analytics and approach while incorporating feedback from accredited subject matter experts to help interpret and supplement available datasets and corresponding data analytics;
c) Identify key vegetation and environmental characteristics that drive tree failure and wildfire risk in vegetation management that is not already being mitigated by the increased clearance and scope overhang scope;
d) Socialize key findings with PG&E senior management and document chosen approach.

Deliverables

- Data analysis to develop a fact base to indicate which species, tree health attributes, environmental attributes and other factors are most likely to predict tree failure:
    - Exploratory data analysis of tree species failures by region to determine the top species that account for ignition and non-ignition related failures;
    - Correlation analysis of various features on tree failure such as: tree health, terrain, extent of tree lean, soil conditions and other features related to age, height and diameter breast height (DBH);

[1] PG&E Outage Investigation Reports

- Documented review and revision sessions with external vegetation and forestry management subject matter experts to validate data and analytics interpretations and facilitate the incorporation of best practices into the revised enhanced vegetation inspection process.

- Develop and refine a Tree Assessment Tool (TAT) incorporating additional features and enhanced functionality around overall tree and tree environment scoring, causes of failure by tree species by region and validation by PG&E / non-PG&E subject-matter experts listed in Appendix A.

- Documentation to support final Tree Assessment Tool (TAT).

Methodology and General Findings

Methodology

The Tree Assessment Tool leveraged data, internal PG&E SME expertise, external subject matter guidance, and field testing to focus on attributes most likely to cause a vegetation outage, ignition, or wire down event in High Fire Threat Districts within the PG&E system. First, all relevant PG&E datasets[2] were collected and analyzed through descriptive and predictive analytics to identify key tree and environmental attributes the indicate which trees are most likely to be a threat to utility assets. These results were then reviewed with key decision makers within PG&E and supplemented by external subject matter experts in vegetation / forestry management. The overall tree assessment process was then simplified to enable complexity reduction to decrease inspection time and increase consistency of inspection results. The final tree assessment tool will then be digitalized to enable worker processes and automate data collection.

Summary of Key Insights

The study provided the following insights to refine the enhanced vegetation management risk assessment inspection process:

Data limitations: PG&E vegetation datasets of outage, ignition, and wire down events were segmented by time series, species, and region combined with data visualization to incorporate data-driven insights into the tree inspection process. However, the PG&E analysis was limited to the current data of record, which is not exhaustive and is not captured in such a way to be precisely matched between tree inspection and outage/ignition investigation records nor matches all attributes that PG&E now collects. This limitation was mitigated in part by the input and from internal and external SMEs that could provide additional insights from their academic studies and experiences in the field.

Outages and ignitions: The majority of PG&E outages (~76 percent) occur in the non-fire season[3] months while the majority of ignitions (~82 percent) take place in the fire season[4] months.

Tree health: The majority of trees (~80-90 percent) of trees that failed across the six regions were alive and healthy trees. However, when tree health is poor, there appears to be a high correlation with failure. This confirmed that attributes besides tree health must remain a component of the evaluation process.

Tree species variation: There was a high variation among the tree species failures across the six PG&E regions with no one or combination of species dominant across all regions, which confirmed the data analytics applied in the final analysis must take regional segmentation into account.

[2] See Appendix B for a complete list of data sources for the Tree Assessment Tool development
[3] December to April
[4] May to November, November was added as a fire season month for this analysis in light of the 2018 fire season and climate change expectations

Complexity reduction: Initial benchmarking against common tools indicated that the Hazard Tree Rating System (HTRS) was best suited for an occasional use setting where a limited number of trees require assessment. The HTRS process is time consuming, requires scoring that is too precise to be consistent, and routinely results in borderline abatement decisions that required individual judgement. This benchmarking was validated by external subject matter experts and indicated a revised process must be simplified, streamlined and limit ambiguous abatement recommendations.

Digitalization and data retention: Challenges in managing a large contract inspection workforce, combined with the requirement to better document and retain inspection records, created a strategic imperative to digitalize the inspection process. Digitalization accelerates of the inspection process and automates records retention, which decreases inspection time, ensures a system of record on which to further improve the process.

Data Limitations

Data collection: The PG&E vegetation data review included outages, ignitions and wire down events per CPUC guidance. Two main datasets were combined: the outages investigation database and recorded ignition data. The time-frame applied for analysis ranged from January 2012 to April 2019 as this period was most consistent in methodology and contained fewer null values in the datasets. Both datasets were combined and filtered by time series[5] and by High Fire Threat Districts. This reduced the dataset from the original 72,268 values to 8,461 values (8,033 values for outages and 428 values for ignitions). The combined dataset was cleaned to remove duplicate values, exclude non-relevant[6] and remove missing data[7] from the analyses.

Tree Population Estimates: Actual tree populations by species were not available for this analysis; rather, PG&E extrapolated regional samples as a proxy for the actual tree species population by region. PG&E performs annual vegetation inspections of 100% of the overhead conductors. This inspection includes quantity of trees by species worked previously, or being listed for work, as part of the current inspection. This data served as a proxy sample of the tree population in PG&E territory. From this sample, species percentage representation in the population was derived by region.

The outage and ignition information collected for each tree failure in the PG&E system included the following vegetation-related variables that were assessed as part of the analysis:

Time series and location: Date, month, year and location (district and region) of observed incident

[5] For the purposes of this analysis fire season months were defined as May to November
[6] Non-relevant data included non-vegetation related failure causes (i.e., third party), transmission asset outages, inspector name, customer information, equipment IDs, division codes, and feeder name
[7] Columns with more than 95% NULL values were excluded, specifically weather during an outage event investigation

Tree features: Species, cause of failure, standard tree features (age, diameter-to-breast height and height), tree condition and health (extent of lean and external and internal rot)

Environment features: Terrain (plain, creek, hillside and valley), tree slide, soil condition (saturated, dry, compact, good and shallow)

Other variables: Domino trees, number of customers, surface, circuit, construction, insulation, major event, equipment type, growth rate, feeder name, total risk score, risk after replacement, safety risk component, population density and population density per sq. mile.

A review of the broader tree inspection dataset (VMD routine inspections) was also conducted. A more limited set of characteristics was recorded for trees that had not failed which included: diameter-to-breast (DBH) and height. This limited PG&E's ability to conduct predictive analytics given that features collected during inspection relative to outages/ignition incidents needed to be consistent when evaluating fallen versus standing trees. The objective of the classification models was to determine the probability of tree failure by evaluating variables that were consistently collected during both the routine tree inspection and the outage/ignition investigation processes.

As such, the objective of the predictive modeling effort was revised to determine the probability of an ignition given an outage, which also did not yield any meaningful insights on tree failure. The absence of features in the dataset that were collected during outages investigations limited the value of logistic regression. Ideally, the dataset would have been a combination of standing and failed trees for which the same features were recorded. Limiting the regression to diameter-to-breast height, height and age (recorded in both datasets) excluded variables that may otherwise impact tree failure as these features were not available within both datasets.

Further refinements in data recorded during PG&E outage investigations are being considered and more complete set of tree characteristics would be captured through the Tree Assessment Tool to support on-going analysis.

Exploratory Data Analysis

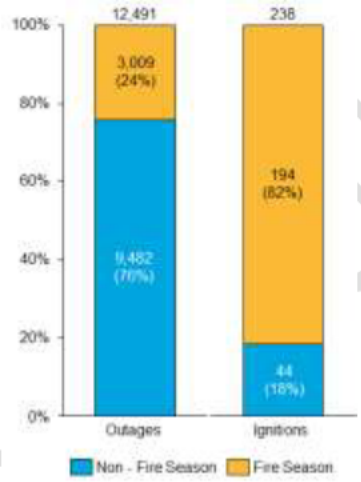
The objective of exploratory data analysis was conducted to ensure a data-driven hypothesis and guide any predictive modeling. This process helped determine tree failure insights and possible causes of tree failure. Ignitions and wire down events were mapped to outages where relevant to ensure events were not double counted. The final dataset for analysis was pared to fire season months within High Fire Threat Districts (HFTD)[8]. Further, this data was segmented into six regions to take into account geographical differences that could lead to a different prevalence of both species and drivers. PG&E analysis also considered analysis and the system and divisional level; the divisional level was found to be too granular as many divisions lacked sufficient outages, ignitions and wire down events in the reviewed timeframe for meaningful analysis.

[8] Includes zone 1, tier 2 and tier 3 areas

PG&E used the parsed and segmented data to identify the species types that caused the majority of vegetation related outages, wire down events and ignitions over the time period by region[9]. The decision to adopt a region-based analysis built on the top ten species assessment but did not limit itself to the targeting of healthy trees, but rather provided more insights on specific tree species. In many cases the most prevalent species are also likely the most common.

This dataset confirmed that ~90 percent of outages, ignitions and wire down events were caused by healthy and alive trees (Exhibit A). Approximately 76 percent of vegetation-related outages are in the non-fire season[10], while around 82 percent of ignitions take place during the fire season[11].

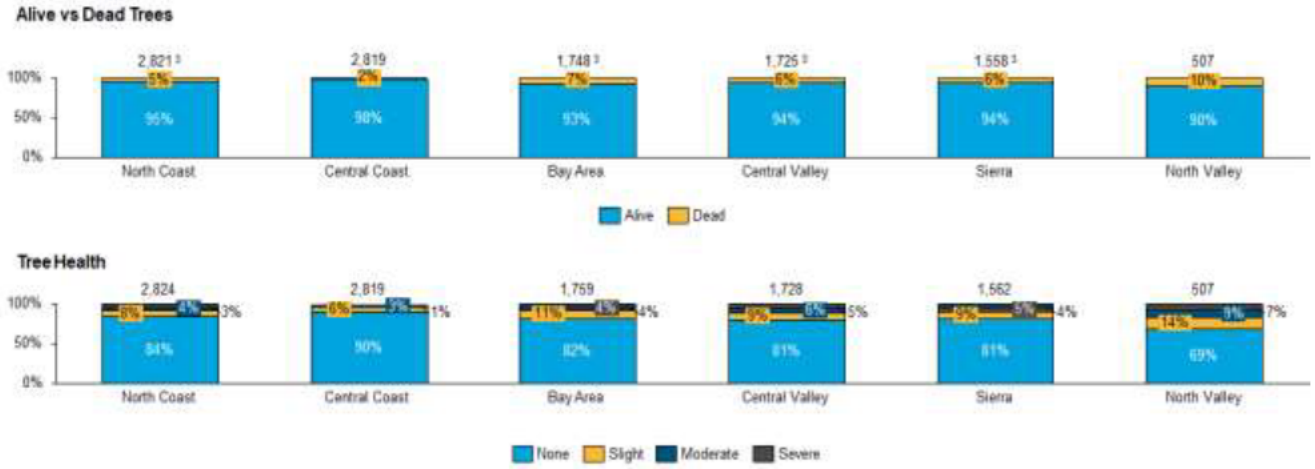
Exhibit A: Total Outages and Ignitions by Season (2012-2018)



Tree species causing outages, ignitions and wire down events in the fire season vary from the species in the non-fire season. Further, there is a high variation among the top ten tree species failures across the six regions. No particular or combination of tree species was dominant. Regional segmentation indicated that a limited number of species and their drivers could be targeted to help reduce ignitions.

[9] The six regions for the purpose of this study are Bay, North Coast, North Valley, Central Coast, Central Valley and Sierra
[10] Defined as December to April
[11] Defined as May to November

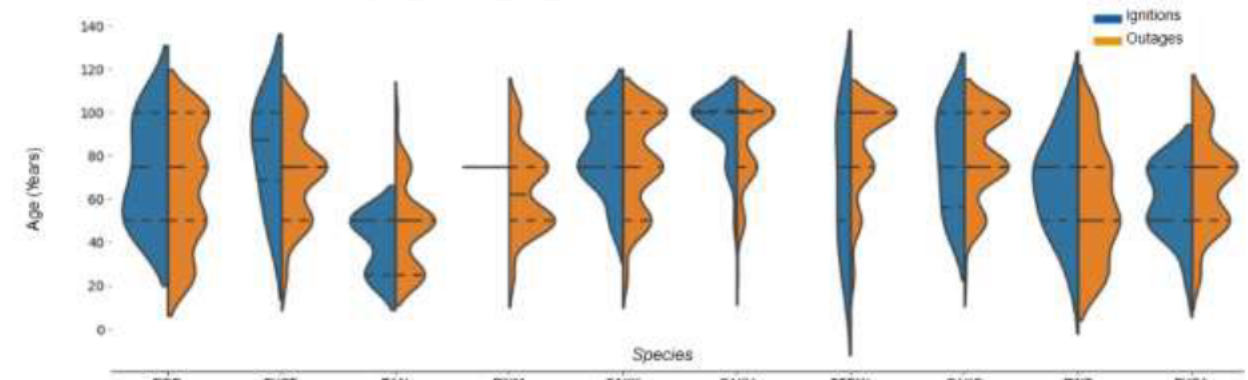
Exhibit B – Alive versus Dead Trees and Tree Health Profiles by Region



Notes: (1) Fire months include the months from May to November; (2) Data time period is January 2016 to April 2019; (3) Differenceis due to NULL values
Source: PG&E Outage and Ignition data

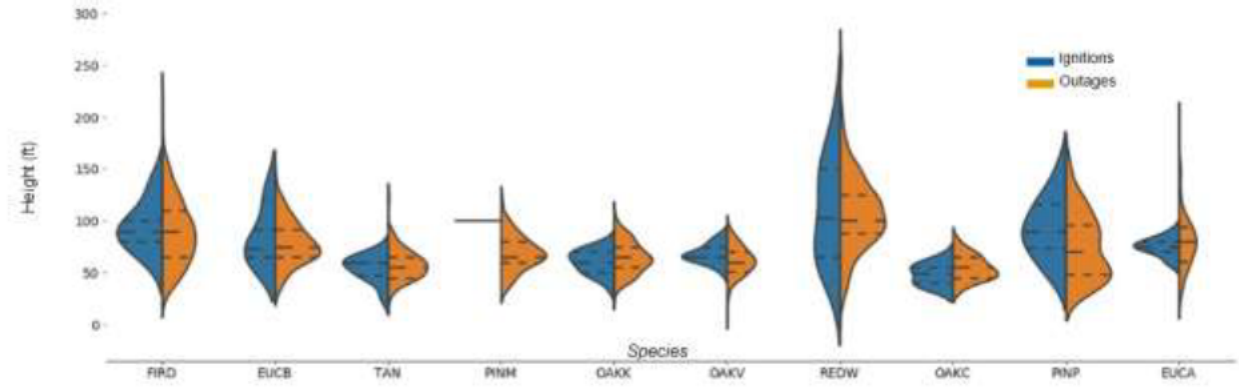
PG&E also conducted analysis of the vegetation related outages, wire down events and ignitions during fire season within High Fire Threat Districts and determined that DBH and height characteristics across the top species that failed were similar with an average DBH of ~20-45 inches across the failed tree species and heights ranging on average 60 to 110 ft. Trees that failed were on average 65+ years in age. See exhibits below for further details.

Exhibit C – Top 10 Tree Species Fire Season – Age Profile



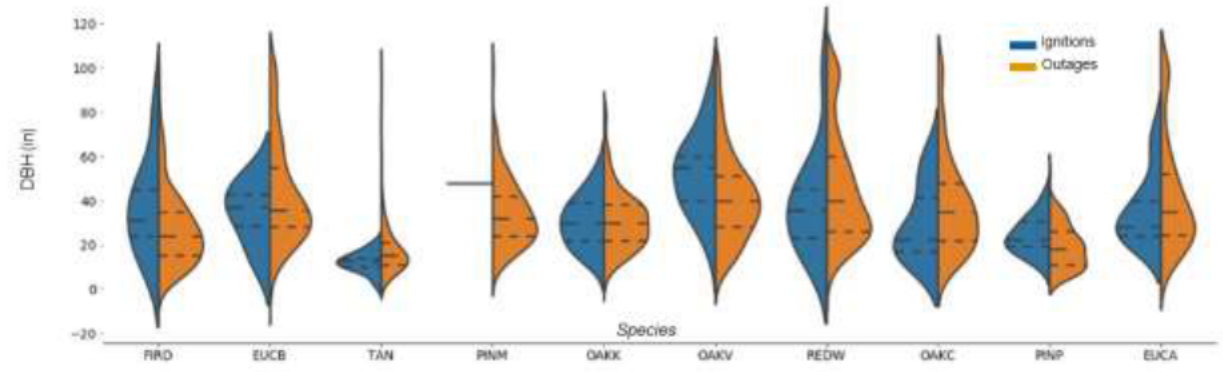
	FIRD	EUCB	TAN	PINM	OAKK	OAKV	REDW	OAKC	PINP	EUCA
Count	204	112	170	105	231	173	266	161	95	135
Min	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Median	75.0	75.0	50.0	75.0	75.0	100.0	100.0	75.0	50.0	75.0
Mean	66.8	71.9	59.5	64.3	77.0	86.7	83.1	79.6	59.5	66.9
St.Dev	27.1	21.1	19.3	19.0	21.8	18.6	21.9	19.9	25.1	21.2
Max	101.0	101.0	100.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0

Exhibit D – Top 10 Tree Species Fire Season – Height Profile



	FIRD	EUCB	TAN	PINM	OAKK	OAKV	REDW	OAKC	PINP	EUCA
Count	207	138	172	108	236	183	278	166	97	176
Min	30.0	34.0	20.0	34.0	25.0	6.0	20.0	30.0	30.0	25.0
Median	90.0	75.0	55.0	32.0	65.0	63.0	100.0	34.0	75.0	79.0
Mean	**90.4**	**78.9**	**58.0**	**69.4**	**64.1**	**62.4**	**109.1**	**55.0**	**77.5**	**80.0**
St. Dev	32.9	21.1	12.7	17.0	15.2	14.0	38.2	12.2	32.0	25.9
Max	220.0	140.0	125.0	120.0	108.0	95.0	260.0	85.0	157.0	195.0

Exhibit E – Top 10 Tree Species Fire Season – Diameter-to-Breast Height (DBH) Profile



	FIRD	EUCB	TAN	PINM	OAKK	OAKV	REDW	OAKC	PINP	EUCA
Count	207	138	172	108	236	183	278	166	97	176
Min	3.0	1.0	3.0	9.0	4.0	8.0	6.0	8.0	6.0	9.0
Median	24.0	35.5	14.0	32.0	30.0	40.0	40.0	34.0	19.0	34.0
Mean	**28.0**	**43.1**	**18.0**	**34.9**	**31.4**	**43.3**	**45.8**	**37.3**	**19.9**	**41.8**
St. Dev	17.7	22.7	12.7	15.4	13.9	20.4	25.0	21.5	9.8	24.7
Max	99.0	99.0	99.0	99.0	80.0	99.0	99.0	99.0	53.0	99.0

Correlation analysis was performed on the combined outage and ignition datasets to determine the relationship between key features of tree failures such as tree health, extent of internal and external tree rot, terrain features, extent of tree lean, tree slide, slope parameters, diameter-to-breast height, height age, soil conditions and assets impacted. The main insights derived from the analysis were:

a) Poor tree health was highly correlated with tree failure;

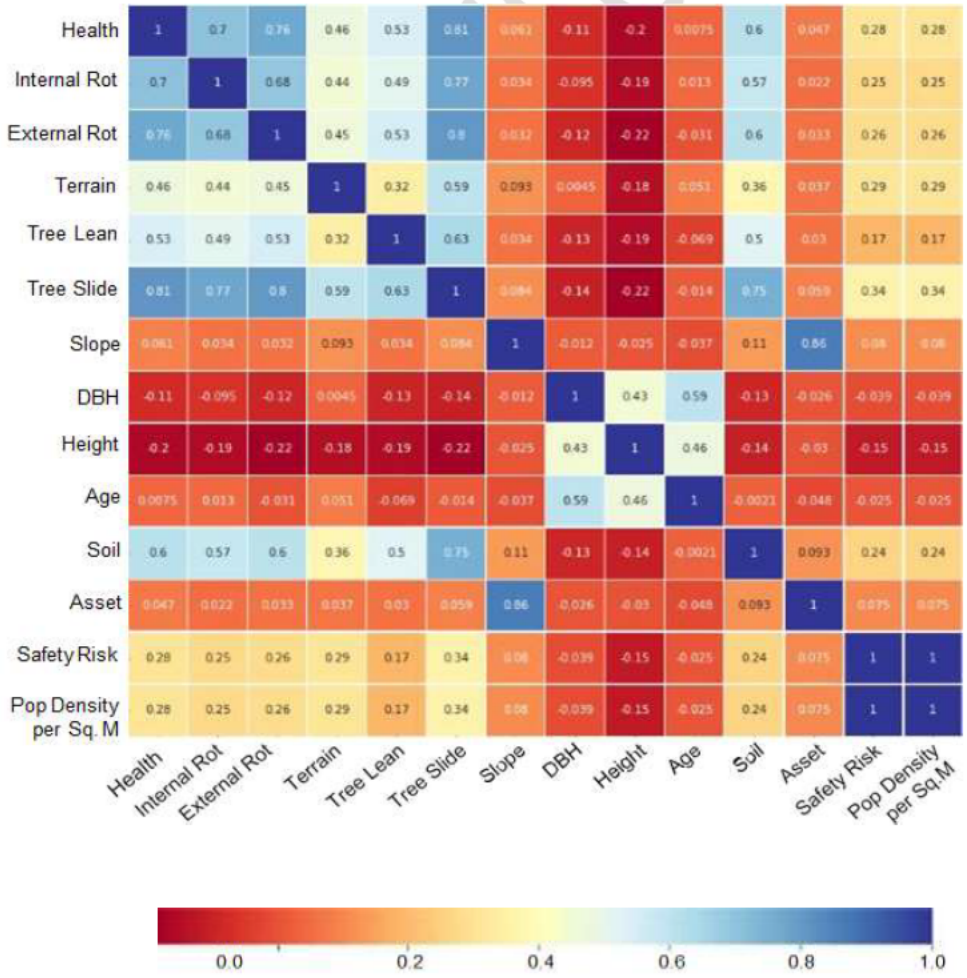
b) A high degree of correlation was present between terrain features, tree lean and slide relative to overall tree health;

c) A high correlation between internal and external rot and extent of tree lean may help identify at-risk trees that appear outwardly healthy;

d) A negligible correlation between terrain and slope indicate these are independent environmental factors impacting tree condition;

e) A high correlation between soil conditions and extent of tree lean and slide may also suggest that unfavorable soil conditions contribute to declining tree health.

Exhibit F: Correlation Matrix of Tree Health and Environment Features



Predictive Analytics

PG&E also performed predictive analytics to determine which variables best explain the probability of ignitions happening during the fire season based on a combined dataset comprised of outages and ignitions during fire season. In order to conduct the logistic regression and random forest analyses, PG&E distinguished between trees that resulted in outages but no ignitions and trees that resulted in outages and led to ignitions. Two variables were compared as part of the logistic regression and random forest models: trees failures that caused outages but not ignitions and tree failures that caused outages and resulted in ignitions. An ignition was defined as a tree failure that caused an ignition. A non-ignition was defined as a tree failure that caused an outage but not an ignition.

Given the disproportionate number of ignition-related outage observations relative to non-outage observations (94 percent non-ignition and six percent ignition) the Synthetic Minority Oversampling Technique (SMOTE) was selected based on a cross-validation of several under-sampling and over-sampling techniques to 'balance' the dataset so as to avoid model overfitting. Subsequently, the dataset was divided between the training and the test sets (~75 percent train set and 25 percent test set) for purposes of fitting the classification algorithms on the training data prior to testing their predictive accuracy on the test set.

Two classification modeling techniques were used to assess ignition probability – logistic regression and random forest classification. The former used a logistic function to model a binary dependent variable (ignition or no ignition). The random forest model built multiple decision trees (ignition or no ignition) during the training phase of the analysis process and determined the mean prediction (regression) of the individual trees.

Through various feature selection[12] methodologies, the following features from the dataset were included in the modeling: extent of tree slide, distance of the tree from the asset, tree age, tree height, tree diameter-to-breast height, terrain features (plain, valley, hillside, creek and ridge) and soil condition (good, dry, shallow, compacted, saturated and other).

While the analysis outcomes were preliminary and could be revised as additional data is included (wind factor, humidity, precipitation), initial results indicated that tree features such as distance from the asset and soil conditions (dry and saturated soil) were the most significant features in predicting observation outcomes. The logistic regression and random forest models displayed overall predictive accuracy rates of 72 percent and 89 percent, respectively. The random forest model had higher specificity (was able to correctly predict a higher number of non-ignition observations) while the logistic regression model displayed higher sensitivity (was able to correctly predict a higher number of ignition observations) but misclassified a higher number of non-ignition observations as being ignition-related.

Approximately 50 percent of ignition observations were correctly predicted by the logistic regression model relative to the 20 percent correctly predicted by the random forest model. Approximately 93

[12] The purpose of feature selection is to include those features from the dataset that are most relevant to the outcome being assessed. Some of the methods used for feature selection included Pearson's Correlation, Recursive Feature Elimination, Chi-Square tests and Analysis of Variance (ANOVA)

percent of the non-ignition (outage) observations were correctly predicted by the random forest model relative to the 74 percent correctly predicted by the logistic regression model.

Given the data limitations reviewed earlier in the document, the insights from the predictive analytics effort were not incorporated into the revised Tree Assessment Tool due the absence of granular regional tree species population data and hence the uncertain share of standing and failed trees of the broader population. Further, only attribute data collected or available could be incorporated into the analysis; reviews with external SMEs indicated there are likely critical attributes not available for the analysis. As a result, the analysis that has been incorporated into the revised tool is limited to tree species failure as a percentage of overall tree failure recorded in the region and a segmentation of failure by vegetation-related causes.[13]

Tool Benchmarking

The PG&E tree assessment process was benchmarked against three common vegetation assessment tools: 1) The International Society of Arboriculture (ISA) Tree Hazard Evaluation Form, 2) The U.S. Department of Agriculture (USDA) Forest Service Community Tree Risk Form and 3) The International Society of Arboriculture (ISA) Tree Risk Assessment Form. The benchmarking demonstrated the PG&E Tree Assessment Tool and assessment process were broadly consistent with common forestry standards. However, several critical differences were identified during the benchmarking process:

- The benchmarked assessment tools neither incorporate historic datasets nor take into account regional differences or variation of tree species;
- The benchmark assessment tools collect considerably more data than the PG&E Tree Assessment Tool with a materially longer estimated average assessment time which makes them difficult to assess large tree populations;
- The benchmark assessment tools are generally more reliant on individual SME subjective input;
- The benchmark assessment tools are designed for urban forestry and do not specifically seek to mitigate wildfire threats.

[13] Includes trunk fail, root fail, branch fail, tree growth into the conductor, palm frond failure, snow load, wind and bark

Exhibit G – Tree Assessment Qualitative Benchmarking

Assessment Tool	Advantages	Disadvantages	Primary Application
PG&E Wildfire Tree Assessment Tool	• Data-led process supplement with SME review to guide on-site inspection process • Creates a consistent, repeatable process to identify and mitigate wildfire risk in HFTDs • Quicker assessment than traditional TATs	• Collects less history and condition detail in the interest of efficiency and focus on wildfire risk • Reliance on numerical risk rating risk abatement matrix	• Wildfire management
ISA Tree Hazard Evaluation Form	• Industry-accepted method for documenting risk and prioritizing hazard abatement efforts • Creates hazard rating that can prioritize pruning, removals, and other mitigation options	• Significant time require to complete form makes it difficult to apply form to large tree populations • Heavy reliance on numerical risk rating	• Commercial arborist or urban forester working with smaller tree populations
USDA Community Tree Risk Evaluation Form	• Relatively simple to use and quick to complete • Process can prescribe remedial measures for evaluated trees at the time of assessment	• Collects a lack of history and condition detail • Limited flexibility in describing unique problems • Does not include a section for tree height; the stem diameter is the sole size measurement	• Commercial arborists or urban foresters
ISA Tree Risk Assessment	• Provides a flexible, yet standardized means of coping with multi-faceted assessment scenarios • Risk rating derived from a sequence of decision matrices, which factor in target, likelihood of failure, and consequence of failure	• High level of detail increases time to complete inspection process • Reducing the final, cumulative rating to four possible outcomes limits ability to prioritize tree mitigation efforts	• Arboriculture and Urban Forestry

Tree health and defect data among the benchmarked tools was compared to identify key attributes common across all forms. While the benchmarked assessment tools indicate a greater proportion of attributes in regards to inspection and site information, the Tree Assessment Tool applies more specificity towards tree health and tree structure.

Exhibit H – Tree Assessment Comparison of Tree Health and Defect Data

	ISA Tree Hazard Evaluation Form	USDA Forest Service Community Tree Risk Form	ISA Tree Risk Assessment Form	EVM Tree Assessment Tool
Inspection Data				
- Client Information	X	X	X	
- Inspector/Assessor	X	X	X	X
- Date/Time	X	X	X	X
- Address/Location	X	X	X	X
- Last Inspection Date	X			
- Time Frame			X	
- Assessment Tools Used			X	
- Equipment Information (EL Condition, Type)				
Site Condition / History				
- Site Type/Zoning	X			X
- Past Construction Activity	X		X	X
- Root Conflicts/Restrictions	X		X	X
- Soil Conditions/Drainage	X		X	
- Wind Conditions/Exposure	X		X	X
- Sign Obstruction	X	X		
- Distance of Trunk to Lines				X
- History of Failures			X	X
- Common Weather			X	
- Site Changes			X	X

	ISA Tree Hazard Evaluation Form	USDA Forest Service Community Tree Risk Form	ISA Tree Risk Assessment Form	EVM Tree Assessment Tool
Tree Health				
- Vigor Rating	X		X	X
- Foliar Condition	X		X	X
- Woundwood Development	X		X	X
- Pest/Disease	X		X	X
- Species Failure Profile		X	X	X
- Tree Condition				X
- Tree Nativity				
Tree Structure				
- Height	X		X	X
- DBH	X	X	X	
- Root/Root Crown Defect List	X	X	X	X
- Trunk Defect List	X	X	X	X
- Scaffold Branches/Limbs Defect List	X	X	X	X
- Crown/Branches Defect List	X	X	X	X
- Palm Frond Defect				X
- Bark Shedding Defect				X
- Tree Lean				X
- Tree Slide				X
- Tree Growth				

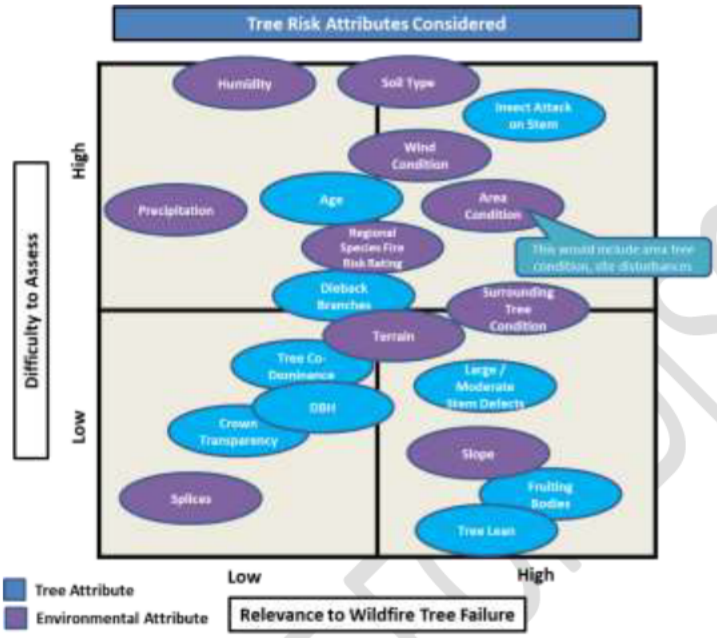
Exhibit I – Tree Assessment Comparison of Ratings

	ISA Tree Hazard Evaluation Form	USDA Forest Service Community Tree Risk Form	ISA Tree Risk Assessment Form	PG&E EVM Tree Assessment Tool
Target Assessment				
- Form Section Title	*Target Rating*	*Probability of Target Impact*	*Likelihood of Impacting Target*	*Preliminary Strike Assessment*
- Rating Type	Numeric (1-4 Points)	Numeric (1-3 Points)	Descriptive (4 Categories)	Descriptive (3 Categories)
- Levels	(1) Occasional Use (2) Intermittent Use (3) Frequent Use (4) Constant Use	(1) Occasional Use (2) Intermediate Use (3) Frequent Use	Very Low Low Medium High	Yes – Abatement No – Continue TAT No – STOP Assessment
Likelihood of Failure				
- Form Section Title	*Failure Potential*	*Probability of Failure*	*Likelihood of Failure*	*Tree Health vs. Tree Environment*
- Rating Type	Numeric (1-4 Points)	Numeric (1-4 Points)	Descriptive (4 Categories)	Descriptive and Numeric (8 / 6 Categories)
- Levels	(1) Low (2) Medium (3) High (4) Severe	(1) Low (2) Moderate (3) High (4) Extremely High	Improbable; Possible; Probable; Imminent	Tree Health: Tree Dead (binary); Fruiting Bodies (binary); Major Wounds (binary); Insect Attack (binary); Canopy Health; Minor Wounds; Lean; Codominance Tree Environment: Regional Species Fire Risk Rating; Surrounding Tree Risk Signs; Slope; Terrain; Wind Condition; Area Disturbance
Consequences of Failure				
- Form Section Title	*Size of Part*	*Size of Defective Part(s)*	*Consequences of Failure*	*Outage, Ignition or Wire Down Event resulting in Fire Ignition*
- Rating Type	Numeric (1-4 Points)	Numeric (1-4 Points)	Descriptive (4 Categories)	Descriptive and Numeric (2 Categories)
- Levels (in inches if applicable)	(1) Less than 6 (2) 6-18 (3) 18-30 (4) Greater than 30	(1) Less than 4 (2) 4-20 (3) Greater than 20	Negligible Minor Significant Severe	None Slight Moderate Severe
Final Rating				
- Form Section Title	*Hazard Rating*	*Risk Rating*	*Risk Ratings*	*Scoring Matrix*
- Rating Type	Numeric (3-12 Points)	Numeric (3-12 Points + 2 Optional Points)	Descriptive (4 categories)	Abate / Not Abate
- Derived From	Sum of "Failure Potential Rating," "Size of Part," and "Target Rating"	Sum of "Probability of Failure," "Size of Defective Part," and "Probability of Target"	Series of guided decision matrices	Combination of aggregate Tree Health and Tree Environment Scores
- Levels	Number from 3-12	Number from 3-10 (12)	Low; Moderate; High; Extreme	Very Low; Low; Moderate; High

Enhanced Vegetation Management Tree Assessment Tool Modifications

Attributes considered for the PG&E Tree Assessment Tool were primarily derived from the data analysis. However, this attribute list was supplemented by internal and external SME input to ensure that a complete, robust list was considered for inclusion. The efficacy of each attribute was balanced in the attribute selection process against the difficulty to assess, relevance to wildfire tree failure, degree of analytical and SME support for each feature, amount of time required for each attribute to be reliably measured, and required skills and training in the field.

Exhibit J – Tree Assessment Tool Tree Health Attributes Considered and Condition Definitions

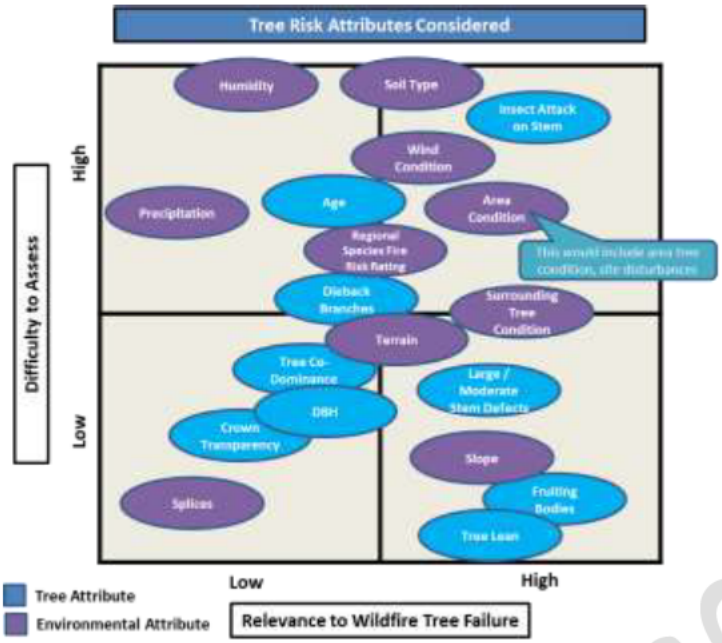


Tree Health Definitions

Tree Condition Attributes for Consideration:

1. **Age:** Relative tree age as an indicator of failure
2. **Crown Transparency:** Measures the amount of light that shines through the live portion of a tree's crown as a percent of total light that would be visible if the light were unblocked
3. **DBH:** Diameter at breast height, or DBH, is the standard for measuring trees; it is an indicator of age
4. **Dieback Branches:** Common symptom or name of disease characterized by progressive death of twigs, branches, shoots, or roots, starting at the tips
5. **Fruiting Bodies:** Decaying fungi destroy the tree's internal supportive or structural component
6. **Insect Attack:** Wood-boring insects cause girdling, branch dieback, structural weakness, and decline while also providing entry points for plant pathogens; borers rarely infest healthy plants growing in their natural environments, e.g. bark beetles identified by sawdust or holes in stem from insects
7. **Stem Defects:** wounds larger than 4" wide and 24" long and .75" deep which are outside indicators of damaged wood and the loss of the strength of a cylinder, in this case the tree trunk or major branch
8. **Tree Co-dominance:** 2 or more main stems (or "leaders") that are about the same diameter and emerge from the same location on the main trunk; as the tree grows older, the stems remain similar in size without any single one becoming dominant
9. **Tree Lean:** Trees that do not grow perfectly upright are often considered predisposed to failure; the International Tree Failure Database found that 10% of root failures and 7% of all reported trunk failures were related to a pre-failure lean

Exhibit K – Tree Assessment Tool Tree Environment Attributes Considered and Environment Definitions



Tree Environment Definitions

Tree Environment Attributes for Consideration:

1. **Humidity:** High humidity has been linked to tree failure issues such as "Branch Drop"
2. **Precipitation:** Saturated or waterlogged conditions (the results of heavy rains, excessive irrigation or both) as would a high water table that restricts down-ward and lateral root growth
3. **Regional Species Fire Risk Rating:** Fire risk rating per species is calculated by taking an outage rating and adding it to an ignition rating times a certain weightage; the outage and ignition ratings are calculated by taking the outage and ignition-related trunk and root failure observations for the particular tree species and dividing it by the share of that species of the tree population for the region
4. **Site Condition**: Unusual area activity since last survey that impacts tree density (e.g. logging, construction) as post-mass tree removal the frequency of landslides can increase
5. **Slope:** Potential destabilizing effect of vegetation on slope stability documented in several studies
6. **Soil Type:** Soil characteristics like hard pans or caliche, soil compaction (as a result of site construction traffic or natural conditions), thin or shallow soils (either naturally thin or made thin by site grading) or a rocky layer further reduce the ability of soils to effectively anchor tree roots
7. **Splices:** KPMG experience indicates a conduct span with greater than three splices tends to be weakened; lines with multiple splices are generally the resulted of repeated vegetation failures
8. **Terrain:** Plain, valley, creek, hillside
9. **Wind Condition:** While non-catastrophic winds do not typically impact an otherwise healthy tree, moderate to severe winds can impact

After consultation with various external Subject Matter Experts, attributes were selected or removed to increase simplicity and specificity while reducing ambiguity. Attributes were removed if they relied too heavily on complex individual judgement or interpretation, and critical attributes were expanded to multiple items to clarify the attribute.

Exhibit L – Tree Assessment Tool Attributes Included and Not Included

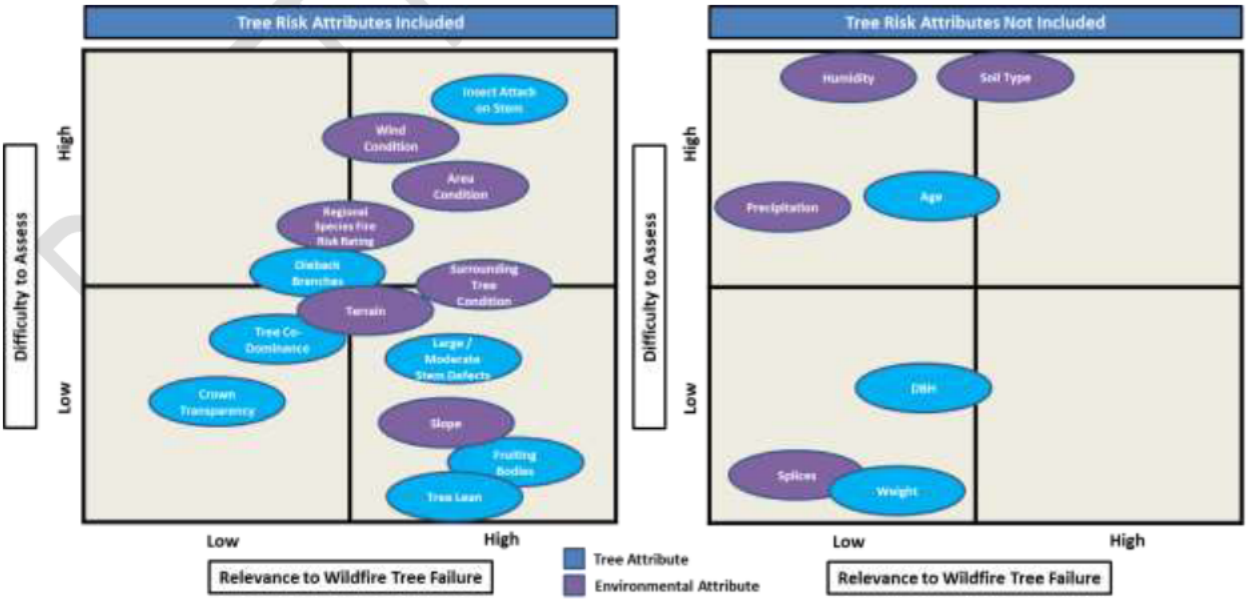


Exhibit M – Tree Assessment Tool Attribute Selection Rationale – Attributes Included[14]

Key Factors					Attribute	Rationale
Difficulty to Assess	Relevance to Wildfire Tree Failure	Degree of Analytical/ SME Support	Time Required	Field Skills Required		
Attributes Included						
					Area Condition	SMEs, field experience and research indicate mass tree removal or site disturbances (logging, construction, etc.) can increase the frequency of landslides and / or adversely impact tree health
					Canopy / Crown Health	Crown health and dieback branches are indicative of overall tree health
					Codominance	Many co-dominant stems feature bark that grows into the union between the stems, causing a weak v-shaped branch union. Trees with co-dominant stems and included bark have an increased risk of failure. Maples, oaks, and conifers are examples of trees that commonly form co-dominant stems.
					Fruiting Bodies	Fruiting bodies are a sign of internal rot and an indicator of accelerated tree mortality
					Insect Attack	Insects can cause girdling, branch dieback, structural weakness, and decline, typically tree cannot be saved
					Large Stem Defects	Wounds larger than 4" wide and 24" long and .75" deep which are outside indicators of damaged wood and the loss of the strength of a cylinder
					Lean	Trees that do not grow perfectly upright are often considered predisposed to failure. Per PRC 4293 California utilities must address tree lean through abatement if it represents a potential threat to electric assets
					Regional Species Fire Risk Ranking	Large historical datasets are effective and relevant in predicting future trends; PG&E datasets indicate some species are more prone to cause ignitions when they fail
					Slope	Potential destabilizing effect of vegetation on slope stability documented in several studies, supported by SMEs
					Surrounding Tree Notable Health Condition	Indicates general health problem with an area or span, also creates a trigger to look back at Tree Health attributes with greater scrutiny if issue appears to be widespread
					Terrain	Datasets indicate certain terrain types are more likely to have tree failures; TAT criteria simplified to try and eliminate subjectivity, supported by SME experience
					Wind Condition	Wind alone does not cause non-branch tree failure but it will accelerate the failure for trees in poor tree health / environment

Very easy to assess / very relevant / information readily available / little time and skill — Difficult to assess / Not relevant / information not readily available / more time and skill

[14] **PRC Section 4293 which justifies the Tree Lean attribute states:**

Except as otherwise provided in Sections 4294 to 4296 , inclusive, any person that owns, controls, operates, or maintains any electrical transmission or distribution line upon any mountainous land, or in forest-covered land, brush-covered land, or grass-covered land shall, during such times and in such areas as are determined to be necessary by the director or the agency which has primary responsibility for the fire protection of such areas, maintain a clearance of the respective distances which are specified in this section in all directions between all vegetation and all conductors which are carrying electric current:

(a) For any line which is operating at 2,400 or more volts, but less than 72,000 volts, four feet.

(b) For any line which is operating at 72,000 or more volts, but less than 110,000 volts, six feet.

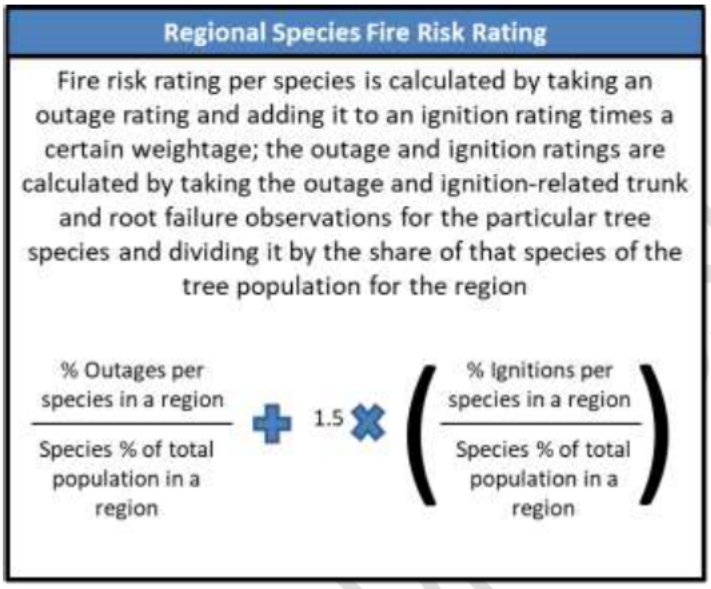
(c) For any line which is operating at 110,000 or more volts, 10 feet.

In every case, such distance shall be sufficiently great to furnish the required clearance at any position of the wire, or conductor when the adjacent air temperature is 120 degrees Fahrenheit, or less. Dead trees, old decadent or rotten trees, trees weakened by decay or disease and trees or portions thereof that are leaning toward the line which may contact the line from the side or may fall on the line shall be felled, cut, or trimmed so as to remove such hazard. The director or the agency which has primary responsibility for the fire protection of such areas may permit exceptions from the requirements of this section which are based upon the specific circumstances involved.

Further explanation of complex methodologies:

Regional Species Fire Risk Rating Methodology:

Exhibit N: Regional Species Fire Risk Rating Calculation



The regional species fire risk rating was calculated on the basis of an overall outage and ignition rating. The outage rating was calculated by dividing the percentage of outage root and trunk fail for the particular species in the given region by the tree species population as a percentage of the overall regional population (calculated based on tree samples collected). Similarly, the ignition rating was calculated by dividing the percentage of ignition root and trunk fail for the species in question in a given region by the estimated tree species population as a percentage of total tree population. This methodology for calculating the species fire risk rating was developed by the PG&E Vegetation Management team under the guidance of senior leadership and considered an acceptable methodology by external subject matter experts.

Wind Methodology:

Wind scoring was calculated by taking the average maximum wind speed of all daily maximum wind speeds from May to November[15] 2006 – 2018[16] within PG&E territories and utilizing a tree's latitude and longitude to determine where that specific tree location's wind speed falls within the standard distribution. Slight wind is determined by having a wind speed less than or within one standard deviation of the average maximum wind speed, moderate wind within two standard deviations above the average maximum wind speed, and severe wind greater than two standard deviations above the average maximum wind speed.

[15] This was intended to estimate the windiest areas of the PG&E High Fire Threat Districts during fire season; this data was provided by the PG&E meteorology team

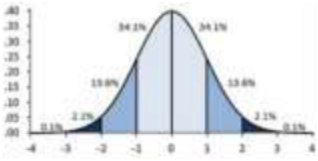
[16] A broader data range for meteorology data was applied as weather dataset was consistent across the time period and to ensure the assumptions were not overly biased to short-term weather patterns.

Exhibit O: Wind Speed Scoring Methodology

Data — Daily maximum wind speeds from May to November 2006 – 2019

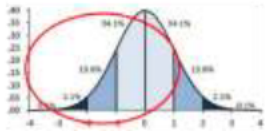
Calculation — Average and standard deviations of daily maximum wind speeds per lat/long

Methodology — Utilize assessed tree lat/long to determine average maximum wind speeds in the area, as wind gusts are likely predictions of outages / ignitions / wire down events



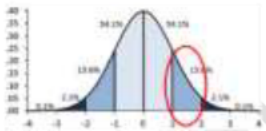
1 Slight Wind

Slight wind at the tree location characterized by average maximum wind within one standard deviation of the average maximum wind speed



2 Moderate Wind

Moderate wind at the tree location characterized by average maximum wind within two standard deviations of the average maximum wind speed



3 Severe Wind

Severe wind at the tree location characterized by average maximum wind greater than two standard deviations of the average maximum wind speed

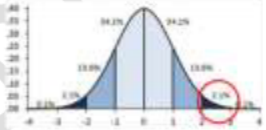


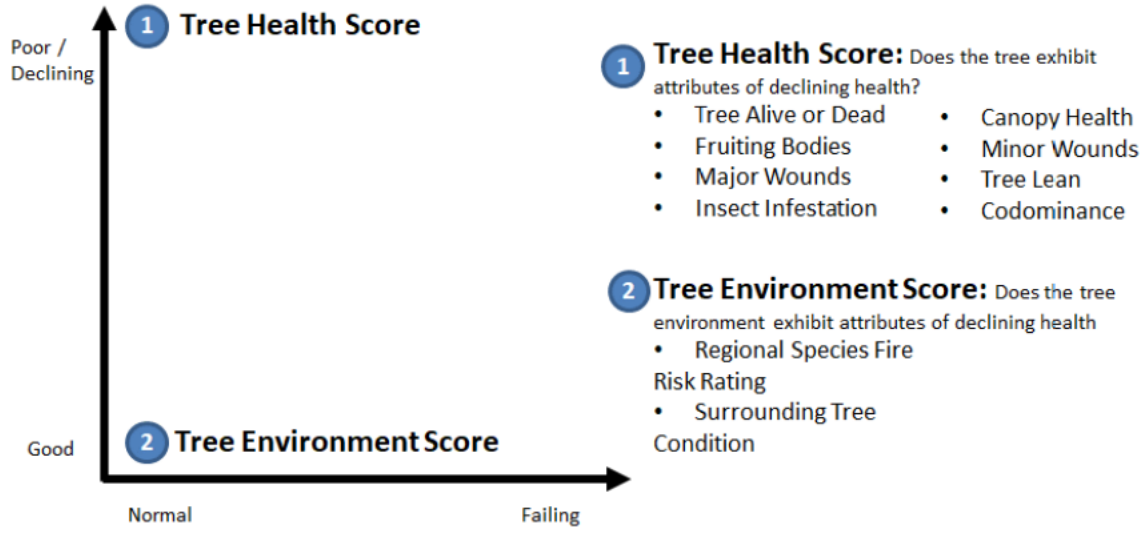
Exhibit P – Tree Assessment Tool Attribute Selection Rationale – Attributes Not Included

Key Factors					Attribute	Rationale
Difficulty to Assess	Relevance to Wildfire Tree Failure	Degree of Analytical/ SME Support	Amount of Time Required	Field Skills Required		
Attributes Not Included						
●	◐	●	◐	●	Age	SMEs indicate as trees age they are clearly more likely to fail but age itself is not an indicator of overall tree health or imminent failure
●	◐	●	◐	●	DBH	DBH is a proxy for tree age
◕	◕	◕	◕	n/a	Humidity	Accurate data not available; outside humidity not an indicator of humidity within internal tree ecosystem
◕	◕	◕	◕	n/a	Precipitation	Not relevant to wildfire prevention in wet fire season months
◕	●	●	◕	◕	Soil Type	SMEs and research indicate soil type can be a good indicator of potential tree failure but requires significant time and training to assess accurately and consistently
●	●	●	◐	●	Splices	PG&E research does indicate a growing number of splices on a span weakens a conductor, but this is primarily relevant to branch failures which are addressed outside of the tree assessment tool
●	◐	◐	◐	●	Weight	Similar outcome to "Lean", more relevant to branch failures

● Very easy to assess / very relevant / information readily available / little time and skill ◕ Difficult to assess / Not relevant / information not readily available / more time and skill

The Tree Assessment Tool evaluates trees that are a strike threat based on Tree Health and Tree Environment scores. These options are balanced on an X and Y axis to form a Scoring Matrix.

Exhibit Q – Tree Assessment Tool Scoring Matrix



Scoring Matrix and Abatement Recommendations

The Tree Assessment Tool is comprised of three sections that outputs a recommend abate/no abate decision. This differs from the prior Hazard Tree Rating System (HTRS), which recommended three possible decisions: abate, use professional judgement, and no abate. The Tree Assessment Tool focuses on complexity reduction to ensure a repeatable process. Key areas of process improvement include:

- **Speed vs. Exhaustiveness:** Most other tree assessment tools were designed for an urban environment, taking ~20 minutes per tree; this was an ineffective approach due to the size of tree populations in PG&E's High Fire Threat Districts
- **Simplicity:** Removal of questions that relied too heavily on high complex individual judgement or complex interpretation
- **Specificity**: Critical attributes such as Tree Health were expanded from one item to clarify the process and produce multiple focal points with varying degrees of importance
- **Reduced ambiguity**: Scoring scales have primarily been converted from scales of 1 to 5 to scales of 1 to 3 to improve accuracy at the expense of precision or binary questions

Exhibit R – Tree Assessment Tool Attributes and Scale

	No/Low Impact	Moderate Impact	High Impact
Preliminary Strike Assessment			
Is the tree tall enough to reach the conductor?	No – continue to next question	n/a	Yes – continue TAT
Is the tree completely blocked from falling towards the conductor?	No – continue TAT	n/a	Yes – STOP TAT
Is the whole tree leaning severely (>25 degrees)?	No , Parallel- continue TAT	Away from Conductors - STOP	Towards Conductors - abate
Tree Health			
Is the tree dead?	No – continue TAT	n/a	Yes - abate
Are there fruiting bodies on butt or trunk?	No – continue TAT	n/a	Yes - abate
Are there major wounds? (larger than 4" wide x 24" long and .75" deep)	No – continue TAT	n/a	Yes - abate
Are there significant insect attacks to the butt or trunk?	No – continue TAT	n/a	Yes - abate
Canopy Health/Transparency & Branch Condition	Crown less than 20% transparent	Crown 20% to 60% transparent and / or 4 or less dieback branches	Crown greater than 60% transparent and / or 4 or more dieback branches
Location of wounds (larger 3" wide x 12" long and .75" deep)	No wounds larger than this size	Found on upper half of tree or scaffold	Found on lower half of tree or scaffold
Whole Tree Lean	Tree leaning away from conductor	No tree lean or parallel lean	Tree leaning towards conductor
Codominance	No codominance	n/a	Codominance
Tree Environment			
Regional Species Fire Risk Rating	Calculated using historical species outage data per region		
Surrounding Tree Risk Signs	None	One to four trees	More than four trees
Slope	Less than 15% slope	15% - 45% slope	Greater than 45% slope
Terrain	Plain, Flat	Valley, Creek (broken out)	Hillside
Wind Condition	No wind	Moderate wind	Severe wind
Area Disturbance (changes to site that can impact tree health)	No change	Low to moderate (20% or less tree change)	High to very high (more than 20% tree change)

The three sections are as follows:

(1) The **Preliminary Strike Assessment** provides three (binary "yes"/"no" and extent of lean) questions that addressed the potential to strike the conductor due to height, location, or lean of the tree in relation to the conductor. The purpose of this section was to determine whether the tree should be inspected because it is a threat to the conductor. If all questions lead to continue TAT, the Tree Health and Tree Environment categories were then completed by the assessor.

Exhibit S – Tree Assessment Tool Preliminary Strike Assessment Section

Preliminary Strike Assessment			
Is tree tall enough to strike the conductor?	**Not Assessed**	**Continue to Next Question**	
Is the tree completely blocked from falling towards conductor?	**Not Assessed**	**Continue TAT**	
Is the tree leaning severely (>25 degrees)?	**Not Assessed**	**Continue TAT**	

(2) The **Tree Health**[17] score provides a rating (1 = slight, 3 = severe) on tree health based on multiple conditions that include binary ("yes"/"no") questions addressing the mortality status of the tree and ternary (1-3 scale) attributes that provide an overall tree health score on selected attributes that could indicate potential tree failure. Binary attributes include tree alive/dead, fruiting bodies, major wounds, and insect attacks. Ternary attributes include canopy health/transparency, minor wounds, lean, and

[17] Tree Health score was designed to incorporate attributes specified in regulatory guidance, hence the inclusion of codominance and lean which would not be considered traditional tree health attributes.

codominance. When the section is completed by the assessor, each attribute is scored based off of severity (1-3 scale) that is weighted to the overall rating used in the Scoring Matrix.

Exhibit T – Tree Assessment Tool Tree Health Section

Tree Health Score				
Is the tree dead?	Not Assessed	Continue TAT		
Are there fruiting bodies on butt or trunk?	Not Assessed	Continue TAT		
Are there major wounds on the roots, butt or trunk? (larger than 4" wide and 24" long and .75" deep)	Not Assessed	Continue TAT		
Are there significant insect attacks to the butt or trunk?	Not Assessed	Continue TAT		
Canopy Health/Transparency & Branch Condition Transparent canopy = further inspection of dieback branches etc.	Not Assessed	n/a	n/a	
Location of Wounds (larger than 3" wide and 12" long and .75" deep)	Not Assessed	n/a	n/a	
Lean	Not Assessed	n/a	n/a	
Codominance	Not Assessed	n/a	n/a	

(3) The **Tree Environment** score comprises of attributes that provide a rating (0 = very low, 3 = high) on tree environment. The regional species fire risk rating is automated based on the species and region input at the start of the Tree Assessment Tool. The Wind Condition score is also auto-calculated based on the latitude and longitude information entered by the inspector. Location data (latitude and longitude) are linked to a database comprising corresponding average and maximum daily wind speeds at each point coordinate within a 3 kilometer by 3 kilometer grid space. The wind scoring component may be further modified depending on the outcome of the digital TAT. All other attributes are ternary (1-3 scale) that provide an overall tree environment score based on the impact the environment has on potential tree failure. Attributes included are surrounding tree risk signs, slope, terrain, wind condition, and area disturbance. When the section is completed by the assessor, each attribute was provided a score based off of severity (1-3 scale) that is weighted to the overall rating used in the Scoring Matrix.

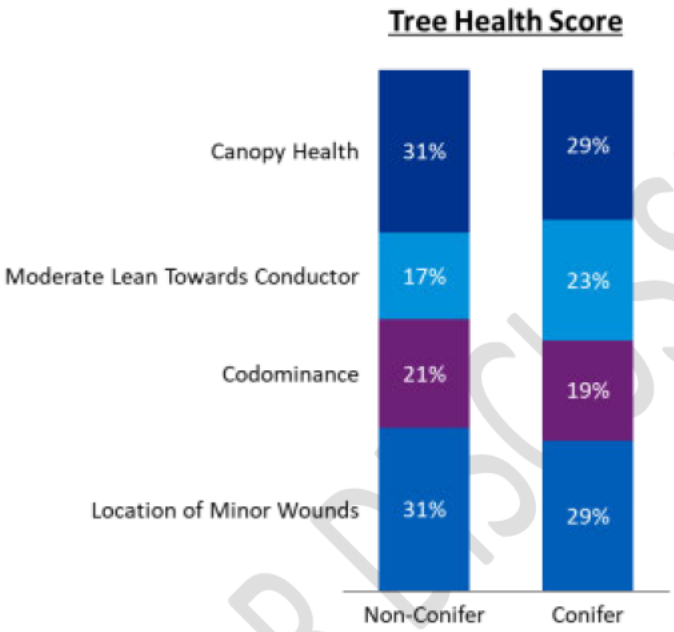
Exhibit U – Tree Assessment Tool Tree Environment Section

Tree Environment Score				
Regional Species Fire Risk Rating			5	
Surrounding Trees Risk Signs Number of trees in the immediate area with risk signs (disease/pathogen spreading past failures trees at high risk of failing and causing domino strike of conductors)	Not Assessed	n/a	n/a	
Slope	Not Assessed	n/a	n/a	
Terrain	Not Assessed	n/a	n/a	
Wind Condition Average relative wind speed in the high fire thread district	Not Assessed	n/a	n/a	
Area Disturbance Changes to site that can impact tree health, stability or exposure to wind force (logging/tree removal, compaction, trenching, lands ide, flooding, etc.)	Not Assessed	n/a	n/a	

Abatement recommendations took into account the Tree Health and Tree Environment scores after the Preliminary Strike Assessment and Tree Health binary questions determine if the tree should be inspected. An abate/no abate recommendation was provided by the Scoring Matrix with each attribute within a category weighted based on the significance of the attribute on the status of the tree. Scoring

Matrix weightages were determined after consultation with external experts and comparison with HTRS decision-making by analyzing the impact each attribute's score had on the overall abatement recommendation. Not all attributes were applied equal weighting in the scoring matrix.

Exhibit V – Tree Assessment Tool Tree Health Attribute Weightage Comparison[18]

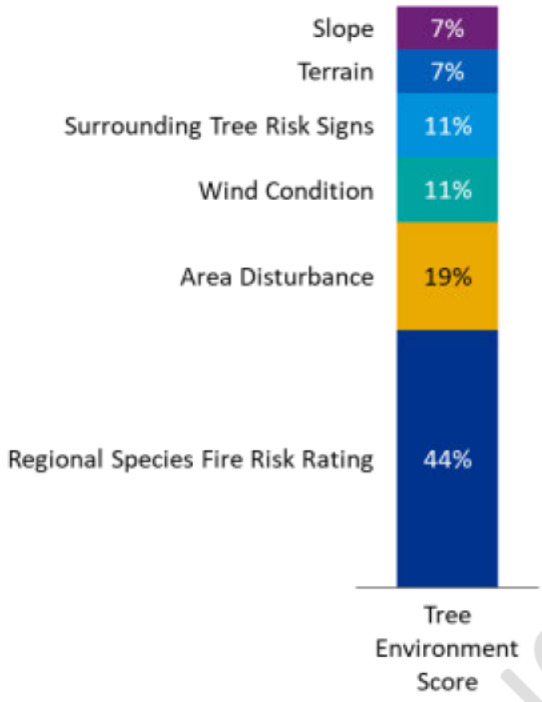


The scoring weightings were determined as follows (lowest to highest)

- Moderate Tree Lean (towards conductor): The attribute only represented moderate lean and was the lowest weighed attribute for Non-Conifers as these tree species tend to have more tree lean as a natural trait and hence was less indicative of increased risk of failure. Conversely, tree lean was a higher weighting for conifers where lean towards the conductor was more likely to indicate higher risk of failure for these species types.
- Codominance: Trees with codominant stems are more likely to fail than trees without codominant stems. While this attribute was considered relevant to tree health, it has a lower indicator of overall tree health than canopy health or location of minor wounds.
- Canopy Health: Crown transparency and die-back branches were considered by the SMEs to be a strong indicator of tree health. However, this attribute was weighted lower than the location of minor wounds as poor tree canopy health could be a result of a temporary condition caused by factors that do not greatly increase risk of failure
- Location of Minor Wounds: Minor wounds were given the highest tree health weighting as they were considered by the internal and external subject matter experts to be the clearest indicator of future tree failure. The location of the wounds and associated decay also informs the risk of failure.

[18] Excludes binary tree health questions namely "Is the tree dead?", "Are there fruiting bodies on the butt or trunk?", "Are there major wounds on the roots, butt or trunk (larger than 4" wide and 24" long and .75" deep)?" and "Are there significant insect attacks to the butt or trunk?" which were assessed prior to the Tree Health questions. As these are binary attribute questions, they do not contribute to the matrix scoring.

Exhibit W – Tree Assessment Tool Tree Environment Attribute Weighting



The scoring weightings were determined as follows (lowest to highest)

- Slope / Terrain: Slope and terrain were found to have an extremely low correlation within internal PG&E data set with validation by outside subject matter experts. While both were likely tree environment predictors of tree failure, these attributes were considered to be the least relevant to predict tree failure. Further, large areas of the PG&E footprint with High Fire Threat Districts have terrain that would rate high for these attributes.
- Surrounding Tree Risk Signs: This attribute provided an additional check for tree health to determine if there is a general tree health issue in the area. As tree health is already heavily weighted in the tool, it was determined a lower weighting within the tree environment score was warranted.
- Wind Condition: While non-catastrophic wind by itself will not cause tree failure, it could accelerate the failure on a tree with existing health issues.
- Area Disturbance: This attribute to the only subject component of the PG&E Tree Assessment Form. Internal and external SMEs, combined with academic reach, indicated that areas of significant disturbance (e.g. logging) indicate a highly likelihood of future tree failure.
- Regional Species Fire Risk Rating: This attribute was applied the highest rating as it leveraged the historic data to incorporate tree species considerations by region into an indicator of which species types tend to cause ignitions during failure, hence being the environmental attribute most relevant to wildfire.

The Tree Health Score attributes sum to the y-axis of the Scoring Matrix and the Tree Environment Score attributes sum to the x-axis. The difference between an abate and a no abate decision were based on the scale and weightage of each attribute, determined after testing various scenarios and combinations with PG&E internal SMEs and external experts.

Exhibit X – Tree Assessment Tool Scoring Matrix

Tree Health Score	5	Abate	Abate	Abate	Abate
	4	Abate	Abate	Abate	Abate
	3	Do not abate	Do not abate	Abate	Abate
	2	Do not abate	Do not abate	Do not abate	Abate
	1 (Very Low)	Do not abate	Do not abate	Do not abate	Do not abate
		0 (Very Low)	1 (Low)	2 (Mod)	3 (High)
		Tree Environment Score			

Exhibit Y – Hazard Tree Rating System Scoring Matrix

Tree Score	7 (Very High)	prof. judgement	prof. judgement	abate	abate	abate
	6 (High)	prof. judgement	prof. judgement	abate	abate	abate
	5 (High)	no abate	prof. judgement	prof. judgement	abate	abate
	4 (Mod)	no abate	prof. judgement	prof. judgement	prof. judgement	abate
	3 (Mod)	no abate	no abate	prof. judgement	prof. judgement	prof. judgement
	1, 2 (Low)	no abate	no abate	prof. judgement	prof. judgement	prof. judgement
	0 (Very Low)	no abate	no abate	no abate	no abate	prof. judgement
		0 (Very Low)	1 (Low)	2 (Mod)	3 (High)	4 (Very High)
		Impact Score				

Abatement recommendations are designed with the objective to prevent outages, fire ignitions, and wire down events caused by vegetation failures as part of the WSIP.

Digitalization

Per [redacted] – this section should note this process satisfied the digitalization concerns raised by the SMEs in their sign-off letters.

Digitization of the TAT is underway under in the Survey123 platform and integrated in to the ARC Collector Application

The benefits of a digitalized tool include, but are not limited to:

a) **Effective data recording and management** – The app will record all TAT responses in a database that will organize critical data in a structured manner. A structured database will serve as a key source of information for analyzing tree risk failure, supporting outage and ignition investigations and help identify potential improvements to the data collection methodology.

b) **Process effectiveness** – The app is expected to increase the speed of the TAT field applications while improving data accuracy by minimizing the number of manual touchpoints. Retaining data accuracy will help address documentation issues for enhanced vegetation management.

c) **Flexibility** – A mobile app platform presents flexibility for technology enhancement and feature addition/modification as needs and requirements evolve during the tree assessment process

Field Testing

Per [redacted] – this section should note this process satisfied the field testing concerns raised by the SMEs in their sign-off letters.

Field Testing of the Tree Assessment Tool will indicate the tool's accuracy and effectiveness. Two champions of each of PG&E's regions (Sierra, North Valley, Central Valley, Central Coast, North Coast, Bay) will utilize the tool to inspect a population of trees. The population of 153 trees is predetermined based off of region and location. The results of Tree Assessment Tool field testing can be compared to the same tree's results using the Hazard Tree Rating System to determine variances in decision making or data gathered.

Appendix

Appendix A: Stakeholders

Role	Name(s)	Title	Role
CHAMPION	Sumeet Singh	Vice President, Asset & Risk Management, Community Wildfire Safety Program	Leadership and advocacy
Initiative Lead	[redacted]	Senior Director, Electric Asset Strategy	Liaison between Champion and project team
PG&E Project Team Members	[redacted]	Manager, Vegetation Management Quality	EVM Program Manager overseeing data analysis and Tree Assessment Tool development
	[redacted]	Vegetation Management Senior Manager	EVM Program Manager overseeing Tree Assessment Tool development
	[redacted]	Senior Vegetation Program Manager	EVM Program Manager overseeing Tree Assessment Tool development
	[redacted]	Vegetation Management Manager	EVM Program Manager overseeing Tree Assessment Tool development
	[redacted]	Vegetation Management Manager	EVM Program Manager overseeing Tree Assessment Tool development
	[redacted]	Vegetation Management Specialist	Facilitating identification of external SMEs for inputs to the Tree Assessment Tool
	[redacted]	Data Scientist, Meteorology Operations & Analytics	PG&E meteorology data expert for use in Tree Assessment Tool
External Stakeholders	[redacted]	Bay Area Environmental Horticulture and Urban Forestry Advisor, University of California	External Subject Matter Expert for the Tree Assessment Tool
	[redacted]	California Polytechnical State University (Cal Poly), Urban Forest Ecosystems Institute	External Subject Matter Expert for the Tree Assessment Tool
	[redacted]	University of California Berkeley, Department of Environmental Science, Policy, and Management	External Subject Matter Expert for the Tree Assessment Tool

Appendix B: Data Sources

File Name	Source	Description	Date Received
Master Outage data 2012 to 20190424_Region.xlsx	[redacted], Senior Vegetation Program Manager	Tree failure outage data from December 2015 to April 2019	5/30/2019
species composition_system_3.xlsx	[redacted], Senior Vegetation Program Manager	Tree species population samples collected by region	5/30/2019
MASTER_qryFire_Report_20140424_REGION.xlsx	[redacted], Senior Vegetation Program Manager	Ignition-related outage data from January 2007 to April 2019	5/30/2019
Outage investigation procedure document.pdf	[redacted], Senior Vegetation Program Manager	Outage investigation guide that describes each of the outage investigation entries recorded by inspectors	5/31/2019
DIVISION NAME_CODE.xlsx	[redacted], Senior Vegetation Program Manager	Description of each of the 18 divisions used in the ignition and non-ignition outage datasets	5/31/2019
Tree Assessment Tool[redacted] 5_14_19.xlsx	[redacted], Manager, Vegetation Management Quality	Tree Assessment Tool designed by PG&E to enable inspectors to assess tree risk	6/5/2019
TAT Line Descriptions Job Aid [redacted]_14_19.docx	[redacted], Manager, Vegetation Management Quality	Job Aid describing each of the line items in the Tree Assessment Tool	6/5/2019
Tree Assessment Tool[redacted] revision to EVM focused.xlsx	[redacted], Senior Vegetation Program Manager	Revised Tree Assessment Tool from PG&E	6/5/2019
TAT Line Descriptions Job Aid EVM focused[redacted] 20190522.docx	[redacted], Senior Vegetation Program Manager	Revised Job Aid description for each of the line items in the Tree Assessment Tool	6/5/2019
2019 EVM species RX guide BAY REGION_population factored_DRAFT_v4.xlsx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the Bay Region that includes fire risk ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	6/5/2019
PS&R Prescription Guide DA.xlsx	[redacted], Senior Vegetation Program Manager	Reliability prescription guide for the De Anza division calculating tree species failure due to trunk, branch and root fails	6/5/2019
USDA Field Guide for hazard tree ID WA and OR 2014.pdf	[redacted], Manager, Vegetation Management Quality	US Department of Agriculture guide for hazard tree identification and mitigation on developed sites in Oregon and Washington forests	6/7/2019
Forest Service hazard tree assessment.pdf	[redacted], Manager, Vegetation Management Quality	Hazard tree guidelines for Forest Service facilities and roads in the Pacific southwest region, published in April 2012	6/7/2019

Univ of Florida tree assessment method comparison.pdf	[redacted], Manager, Vegetation Management Quality	A comparison of three tree hazard assessment forms: ISA (International Society of Arboriculture) Tree Hazard Evaluation Form, 2) USDA (US Department of Agriculture) Forest Service Community Tree Risk Form and the ISA Tree Risk Assessment Form	6/7/2019
Splice Inventory Master_29apr2019.xlsx	[redacted], Senior Vegetation Program Manager	Splice information for ignition and non-ignition related outages by region and division; includes vegetation and non-vegetation related causes	6/13/2019
Tree Assessment Tool for EVM_V 2.xlsx	[redacted], Senior Vegetation Program Manager	Updated Tree Assessment Tool received from PG&E with the following changes made: expanded tree matrix scores to allow for better gradation between hazard tree and risk reduction trees; additional option to designate highest rate tree matrix scores as accelerated priority; Addition of new notes section	6/20/2019
"2019 EVM Species RX Guide *REGION*_population factored_DRAFT_vk.xlsx"	[redacted], Senior Vegetation Program Manager	Fire Risk Ratings for each tree species by region based off of historical regional outages and ignitions as created by Ken Loomis	6/20/2019
EVM 3.22.219 (002).docx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management Scope document (Utility Bulletin: TD-7102B-020); Publication date: 03/22/2019	6/14/2019
Master qryFire_Report_incl outage report data_2004 to 2019.xlsx	[redacted], Senior Vegetation Program Manager	Revised fire ignition-related outage dataset including incidents starting from 2004 till April 2019	6/18/2019
Master Outage Investigation data_minus cReason_2004 to 2019.xlsx	[redacted], Senior Vegetation Program Manager	Revised outage data including tree features information and including all tree-failure related outages from January 2004 to April 2019	6/18/2019
2019 EVM species RX guide CENTRAL VALLEY REGION_population factored_DRAFT_v6.xlsx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the Central Valley Region that includes fire risk ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	6/20/2019
2019 EVM species RX guide NORTH COAST REGION_population factored_DRAFT_v6.xlsx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the North Coast Region that includes fire risk ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	6/20/2019
2019 EVM species RX guide CENTRAL COAST	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the Central Coast Region that includes fire risk	6/20/2019

REGION_population factored_DRAFT_v6.xlsx		ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	
2019 EVM species RX guide NORTH VALLEY REGION_population factored_DRAFT_v6.xlsx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the North Valley Region that includes fire risk ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	6/20/2019
2019 EVM species RX guide BAY REGION_population factored_DRAFT_v6.xlsx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the Bay Region that includes fire risk ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	6/20/2019
2019 EVM species RX guide SIERRA REGION_population factored_DRAFT_v6.xlsx	[redacted], Senior Vegetation Program Manager	Enhanced Vegetation Management (EVM) tree species prescription guide for the Sierra Region that includes fire risk ratings for each tree species identified, outage and ignition rating, species failures as a percentage of tree population, outage and ignition tree trunk and root-related failures	6/20/2019
GR-20190820_DRAFT report - PGE Veg Mgmt Tree Assessment Tool vF_DRAFT.pdf	[redacted], Vegetation Program	Enhanced Vegetation Management (EVM) Tree Assessment Tool (TAT) user guide that provides methodology and detailed description for how the TAT was formulated.	8/20/2019
"winds_for_kpmg_tree_tool.csv"	[redacted]	Wind data providing latitudes and longitudes for average maximum wind speeds in MPH for 3km by 3km gridpoints within PG&E territories	8/20/2019

Appendix C: [redacted] Review Letter

UNIVERSITY OF CALIFORNIA, BERKELEY

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[redacted]
Forest Pathology and Mycology
Extension Specialist & Adjunct Professor
Department of Environmental Science, Policy and Management
Ecosystem Sciences Division
[redacted]

October 18, 2019

To:

Sumeet Singh
Vice-President
Pacific Gas and Electric Company
Mailbox
San Francisco, CA 94105

Re: PG&E Enhanced Vegetation Management Tree Assessment Tool (EVM TAT) support

To whom it may concern:

From June 2019 to August 2019 I worked with PG&E to provide guidance for a Tree Assessment Tool (TAT) which PG&E intends to use to mitigate wildfire threats in High Fire Threat Districts (HFTD) within the PG&E service territory caused by non-branch tree and root vegetation failures resulting in outages, ignitions and / or wire down events. My role with regard to the TAT was to review and provide recommendations for improvements in light of my review of the data, my observations of the tool, and my experience, expertise, and knowledge of the general state of knowledge accepted in the field of vegetation management. I have no responsibility or obligation for the actual results of implementing this new tool. As part of this TAT review, I assumed branch failures would be primarily addressed by the PG&E enhanced trimming program and hence was not an area of focus during my reviews. Rather, I focused my feedback on trunk and root failures.

Based upon five separate reviews performed at various stages of the PG&E TAT development process, I have concluded:

- The overall tree assessment process is both reasonable and appropriate provided steps are correctly followed by field inspectors;
- The attributes chosen to determine abatement decisions are supported by underlying PG&E data, my past experiences, and general academic research or knowledge in the vegetation space;
- The transition from a highly complex, precise scoring system to a less complex system with more specific questions is more likely to result in consistent, accurate outcomes;
- The scoring matrix recommendations are reasonable to mitigate outages, ignitions and wire down events which have the potential to initiate wild fires in high fire threat districts without unduly impacting otherwise healthy trees or adjacent private property;

- However, I have advised PG&E that it is critical to digitalize the inspection process and create a system of record for inspections, including but not limited to inspection details, tree attributes and final abatement recommendations.

I was first contacted by phone by [redacted] on June 28th 2019.

My first review of the PG&E TAT development process occurred on July 18, 2019, when I reviewed the development version of the PG&E TAT set forth in excel file "TAT-Modified-28JUN2019v4.XLSX", which included:

- PG&E historic data from 2006 to early 2019 that included vegetation failures from outages, ignitions and wire down events by region and species, inclusive of the splits between High Fire Threat District and Fire Season;
- The proposed tree assessment tool attributes and scoring matrix.

I conducted an in-depth review of the tool and provided initial feedback:

- The overall tool concept was an improvement over the PG&E Hazard Tree Rating System (HTRS), which was overly complex for tree inspections of this scale;
- The HTRS tool required multiple complex individual judgements in the field, which were likely to lead to inspection process and abatement decision inconsistency;
- The Tree Health question was overly generic. More specificity will help guide the inspection process, ensure inspectors focus on the most relevant tree health attributes and improve consistency;
- I further suggested the Tree Health question should be broken down into ~three to four specific Tree Health Attributes which should weigh more heavily on the scoring matrix than non-Tree Health attributes; attributes discussed included: canopy transparency, die-back branches, insect infestation, tree wounds;
- I asked to review further internal data on site-specific influences such as terrain and soil;
- I noted that soil can be an excellent predictor of tree failure but may be too complex to interpret consistently and accurately for most field inspectors;
- I noted that wind does not directly cause non-branch tree failure, as only catastrophic winds will bring down an otherwise healthy tree. However, wind gusts can cause a tree with other issues to fail sooner than otherwise would be expected;
- Finally, I noted that digitalization could be addressed at the end of my review but noted a digital process is critical to managing a large contractor inspector workforce, and it would increase process consistency while ensuring better records retention.

Prior to a follow-up meeting with PG&E on July 29, 2019, I shared detailed notes from my further review of the July 18, 2019 version of the TAT. PG&E reviewed the following proposed modifications to address my feedback which included:

- Expansion of the Tree Health attributes, including fruiting bodies, insect infestation, stem location of serious defects on the stem (wounds that are larger than 2" wide by 12" long by 0.75" deep. For the TAT, the recommended threshold of 4" wide by 24" long by 0.75" deep will be considered serious), canopy health (combination of canopy transparency and die-back branched), codominance, surrounding tree/other conditions;
- Additional features, specifically region and species selection that auto-populate outage, ignition, and wire down historical data;
- Auto-populated fire risk rating based on historical failure data for specific tree species and region;
- Updated Scoring Matrix with "No Abate" and "Abate" decision results based on assessment scores;
- Inclusion of terrain (plain, flat, creek, valley, hillside), and splice conductor count as additional attributes.

I determined that this version of the Tree Assessment Tool was an improvement from prior PG&E versions due to its new automated features and inclusion of additional tree-health specific elements along with increased ease of use.

In a follow-up meeting with PG&E on August 2, 2019, I reviewed the following proposed modifications to address my feedback on the TAT and provided a new version of the Tool, excel file "08012019_Tree Assessment Tool Concept Review – [redacted]vShared.xlsx", which included:

- Updated objectives for TAT to focus on mitigation efforts for the Wildfire Safety Inspection Program;
- Providing a binary ("Yes" or "No") response to the first seven questions (Preliminary Strike Assessment and first four questions of the Tree Health Score section) of the questionnaire that minimize evaluation ambiguity;
- Scoring processed updated to an 1-3 scale, with each attribute on a scale of slight, moderate, or severe in order to streamline and simplify assessment process (1-3 scale scoring exceptions were Lean and Terrain, which each had four options)
- Simplified attribute selection process enabled by use of drop-down menus for each attribute;
- Auto-populated scores based on selection of severity per attribute;
- Boundaries of Scoring Matrix updated to reflect abatement decisions for various combinations of attribute scoring after individual attribute discussion;
- Auto-populated abatement decision based on scoring that provides an "Abate" or "Do not abate" recommendation on the basis of the tree health and tree environment scoring.

After the August 2nd meeting, in preparation for the August 6th, 2019 review, I reviewed the Tree Assessment Tool modifications including process simplicity and inclusion of attributes, with proposed modifications to add "yes/no" selection options for preliminary tree assessment.

On August 8, 2019 in a follow-up meeting, PG&E reviewed the following modifications to address my feedback and provided a new version of the Tool, excel file "080619_TAT vMGFinal.xlsm". Further modifications included:

- Refining the binary preliminary assessment questions, including "Can the tree reach the conductor?", "Does the tree have an indirect path to the conductor?", Is the tree leaning severely?", "Is the tree dead?", "Are there fruiting bodies?", "Are there major wounds?" and "Are there significant insect attacks?" to allow the assessor to make an auto-abatement decision if specific characteristics are identified;
- Updated attribute descriptions for "Surrounding Tree Notable Health Problems" and "Area Condition" to correctly identify what assessors should seek during inspection;
- Inclusion of the Terrain attribute criteria, based on a higher correlation between outage or ignition and specific terrains (e.g., hillside, valley) compared to others (e.g., plain) depending on region;
- Alignment on the following attributes and the order in which they should be assessed within the tool: Canopy Health, Codominance, Lean, Surrounding Tree Condition, Slope, Terrain, Splice, Hazard Rating; these factors showed high correlation to overall tree condition based on the analysis conducted by PG&E;
- Updated weighting of each attribute to take into account its importance on the potential failure of the tree;
- Updated moderate "lean" attribute to indicate different scores for a tree leaning towards the conductor based on whether the tree species is a conifer or non-conifer, due to the higher probability for conifer trees (Score of 12) to fail compared to a more natural growth tendency for non-conifer trees (Score of 8)
- Updated Scoring Matrix to address Tree Health and Tree Environment scores and their impact on the abatement decision; and
- Removal of additional assessment column.

Based on this review I provided feedback that this version of the Tree Assessment Tool was nearly final due to its appropriate prioritization of attributes and scoring results, subject to proposed modifications to additional attributes based on wound size and lean.

On August 15, 2019, I reviewed additional modifications made to the updated version of the tool, excel file "081419_TAT vMG.xlsm" to address my feedback. Upon this review I found:

- My recommendations were incorporated into the tool or directly addressed, specifically my concern that Tree Lean might be too heavily weighted on the tool;

PG&E noted it was reasonable the Tree Lean maximum score be treated with similar weight as any other maximum health score component both from failure experiences in the field and regulatory guidance per Public Resources Code Section 4293,[1] which I found to be an acceptable approach after review and discussion:

- The revised tool addressed all attributes that are considered crucial to tree assessment; and
- The revised scoring methodology reduced ambiguity and provides a reasonable decision regarding tree abatement.

My final recommendation is that PG&E conduct additional field testing and tool digitalization prior to full deployment of the TAT to ensure a more standard process, decrease inspection time, and better enable inspection record-keeping. To the best of my knowledge, PG&E is pursuing further field testing and digitalization in-line with my recommendations.

[redacted]

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[1] **PRC Section 4293 states:**

Except as otherwise provided in Sections 4294 to 4296, inclusive, any person that owns, controls, operates, or maintains any electrical transmission or distribution line upon any mountainous land, or in forest-covered land, brush-covered land, or grass-covered land shall, during such times and in such areas as are determined to be necessary by the director or the agency which has primary responsibility for the fire protection of such areas, maintain a clearance of the respective distances which are specified in this section in all directions between all vegetation and all conductors which are carrying electric current:

(a) For any line which is operating at 2,400 or more volts, but less than 72,000 volts, four feet.

(b) For any line which is operating at 72,000 or more volts, but less than 110,000 volts, six feet.

(c) For any line which is operating at 110,000 or more volts, 10 feet.

In every case, such distance shall be sufficiently great to furnish the required clearance at any position of the wire, or conductor when the adjacent air temperature is 120 degrees Fahrenheit, or less. Dead trees, old decadent or rotten trees, trees weakened by decay or disease and trees or portions thereof that are leaning toward the line which may contact the line from the side or may fall on the line shall be felled, cut, or trimmed so as to remove such hazard. The director or the agency which has primary responsibility for the fire protection of such areas may permit exceptions from the requirements of this section which are based upon the specific circumstances involved.

Appendix D: [redacted] Review Letter

CAL POLY
College of Agriculture, Food & Environmental Sciences

Natural Resources Management and Environmental Sciences Department
College of Agriculture, Food and Environmental Sciences
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October 9, 2019

Sumeet Singh
Vice-President
Pacific Gas and Electric Company
Mailbox
San Francisco, CA 94105

Re: PG&E Enhanced Vegetation Management Tree Assessment Tool (EVM TAT) Support

To whom it may concern:

From July 2019 to September 2019, I worked with PG&E to provide guidance for a Tree Assessment Tool (TAT), which PG&E intends to use to mitigate wild fire threats in High Fire Threat Districts (HFTD) within the PG&E service territory caused by non-branch trunk and root vegetation failures resulting in outages, ignitions, and/or wire down events. As part of this TAT review, I assumed branch failures would be primarily addressed by the PG&E enhanced trimming program and hence focused on trunk and root failures.

Based upon three separate reviews performed at various stages of the PG&E TAT development process, I have concluded:

- The overall tree assessment process is both reasonable and appropriate provided steps are correctly followed by field inspectors;
- The attributes chosen to determine abatement decisions are supported by underlying PG&E data, my past experiences, and general academic research or knowledge in the vegetation space;
- The transition from a highly complex, precise scoring system to a less complex system with more specific questions is more likely to result in consistent, accurate outcomes;
- The scoring matrix recommendations are reasonable to mitigate outages, ignitions and wire down events which have the potential to initiate wildfires in high fire threat.

My first review of the PG&E TAT development process occurred on July 12, 2019, when I reviewed the development version of the PG&E TAT set forth in excel file "TAT-Modified-28JUN2019v4.xls", which included:

- PG&E historic data from 2006 to early 2019 that included vegetation failures from outages, ignitions and wire down events by region and species, inclusive of the splits between High Fire Threat District and Fire Season;
- The proposed tree assessment tool attributes and scoring matrix.

Based on this review, I provided feedback that this version of the Tree Assessment Tool was an improvement from the prior PG&E Hazard Tree Rating System Tool due to its simplified structure, inclusion of historic data, and inclusion of additional attributes.

After this meeting, I field tested this tool from July 14-20, 2019, in order to understand how the TAT would perform in real-life situations under different scenarios. After the field testing, I provided PG&E with a written summary of my experiences, which included the following findings about the TAT:

- Direction for strike likelihood was too generalized due to its use of the word "facility"; if inspectors were to literally follow the instructions, a small tree next to a guy wire or pole would rate as "Abate" even

Letter

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though it was not a realistic threat to the assets in terms of causing an outage, ignition, or wire down event;

- Lean criteria were overly precise, resulting in a high level of ambiguity on how to rate trees;
- The species list included values of "Null" and "Other"; I recommended when 'Other' is selected on the form there should be an option for the user to enter a species name;
- The Site-Specific Influences on the Tree had ratings that were too subjective (Low, Moderate, High and Very High); I recommended examples or definitions for each of the subjective ratings to increase consistency across inspectors and inspections;
- The Terrain attribute definition was open to interpretation; I recommended examples and improved definitions of these terms to improve consistency;
- The tracking for the revised TAT process should be improved through the ability to save a completed TAT Form and attach it to a field collector record for an individual tree, which would aid in verification of ratings when necessary and could be useful for training and improved consistency.

In a follow-up meeting with PG&E on August 2, 2019, I reviewed the following proposed modifications to the TAT (in tool version "TAT-Scoring-1AUG2019.xlsx") made to address my feedback:

- Simplification of the strike assessment process to minimize subjectivity and shifting from a "facility" definition to a "conductor" definition, which provided clearer guidance to field inspectors while minimizing inspections of trees that are not a realistic threat to PG&E facilities;
- Simplifying the Lean criteria to avoid inspector confusion;
- Removing "Null" and "Other" as species options. The "Unknown" option was added, and PG&E noted their intent to make this an area where the inspector would enter their best assumption on tree species in the final version of the tool;
- Modifying the "Site-Specific Influences to "Area Condition," which the tool defined as "Events since last survey that affected tree density (logging/tree removal, construction, flooding, extreme weather, etc.)" and conducted scoring as a rough percentage of trees in the immediate area impacted;
- Redefining and clarifying the Terrain attribute criteria to include options Plain / Flat, Valley, Creek and Hillside;
- For tracking purposes PG&E added a reset button so an inspector could reset the Excel-based form after each inspection. PG&E also noted their intent upon completion of the TAT concept to develop the app to store additional information such as: Inspector, Time, Region, Species, Longitude, Latitude, Individual Attributes Recorded, and Final Abatement Recommendation.

On September 4, 2019, I reviewed additional modifications made to the tool separate from those stemming from my direct recommendations or consultations. Upon this review of the TAT as set forth in version "20190820_TAT_vFINAL.XLSM" and "20190816_DRAFT report - PGE Veg Mgmt Tree Assessment Tool vJeffReimer_NoAppendix.pdf", I found:

- The revised tool provided greater specificity in data collection by assessing tree health-related features, among others, such as fruiting bodies, tree canopy health and insect attacks;
- The revised scoring methodology reduced ambiguity;
- The tool included additional attributes, including whether the tree is dead, location of wounds (larger than 3" wide and 12" long and .75" deep), stem co-dominance, greater specificity around fruiting bodies around the butt or trunk of the tree, and extent of lean;
- The tool had removed the attribute number of splices in the conductor (the rationale being that irrespective of the number of splices, a conductor would break if impacted by a tree vs. a branch).

My final recommendation is that PG&E conduct additional field testing and app development prior to full deployment of the TAT to ensure a more standard process, decrease inspection time, and better enable inspection record-keeping. To the best of my knowledge, PG&E is pursuing further field testing and development in-line with my recommendations.

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[redacted]
Interim Executive Director
Urban Forest Ecosystems Institute
California Polytechnic State University (Cal Poly)
San Luis Obispo, CA 93407

Appendix E: Glossary of Terms

Acronym	Description
CPUC	California Public Utilities Commission
EVM	Enhanced Vegetation Management
HTRS	Hazard Tree Rating System
HFTD	High Fire Threat District
TAT	Tree Assessment Tool
WSIP	Wildfire Safety Inspection Program