Localized Risk Assessment Model Overview

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T&D Asset Performance

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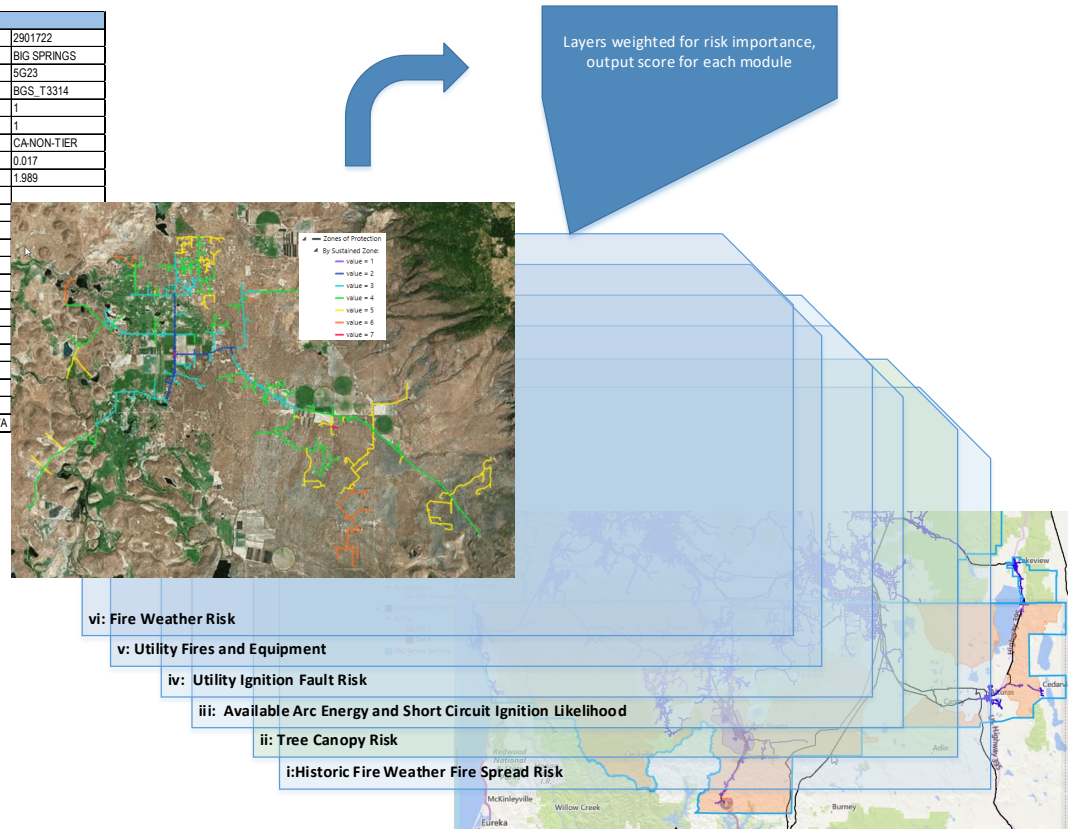
Localized Risk Assessment Model (LRAM) Fundamentals

- Rank each zone of protection (ZOP) based on *relative risk of a utility caused ignition leading to a wildfire*
- We are ranking each ZOP based on the final Combined Score which consists of:
  - Environmental Risk Score -> represents the consequence of an ignition
  - Utility Risk Score -> Represents the relative probability of a utility caused ignition
- The Utility/Environmental Risk scores are themselves composed of other risk layers (described later)
  - All scores are calculated on a 0-1 scale
- Integration of layers can occur based on the risk(s) being considered

Fire Risk Conceptual Model

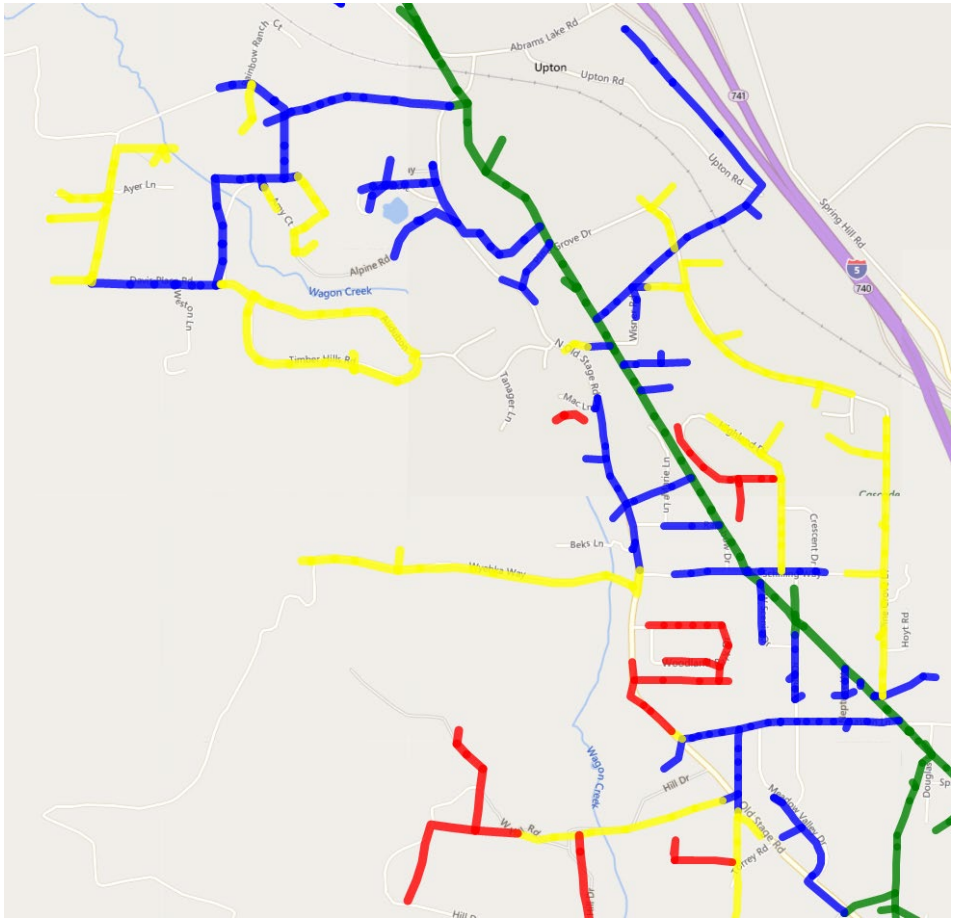
Modules		
ID	840895	2901722
Substation	BIG SPRINGS	BIG SPRINGS
Circuit	5G23	5G23
Source	BGS_T3314	BGS_T3314
Sustained Zone	1	1
Momentary Zone	1	1
FireThreatTier	CA-NON-TIER	CA-NON-TIER
Segment Fault Rate	0.017	0.017
Sus Zone Fault Rate	1.989	1.989
UpstreamFP		
DownstreamFP		
Sustained AIP	BGS_CB5G23	
Sustained Class	breaker	
Sustained Size	0	
Momentary AIP	BGS_CB5G23	
Momentary Class	breaker	
Momentary Size	0	
Construction	BUS	
Connection	wye	
LengthFt	10.11118	
PhaseNo	111	
Phases	3	
LinePKID	85FEB3AE-677A	



Fire Threat Designation for pacifiCorp Service Territory

Zones of Protection

- A ZOP is defined as downstream circuit segments from a protective device to the next protective device
- Represents the smallest subsection of a circuit that can be controlled (without specific ad-hoc efforts, such as lifting jumpers)
- Scores from all individual risk layers are assigned to each ZOP
- The scores are then combined to obtain the final Combined Score which is used to risk rank the ZOPs



Utility Risk Layers

- **Outage Ignition Risk** - aggregated by ZOP and cause
  - Categorized into vegetation, equipment failure, animal, interference, and other
  - We can monitor these outage rates to track how system hardening reduces outages
- **Arc Energy Risk** – combines available inrush current and device clearing time determine arc energy and potential for conductor damage using about ten different fault conditions within each ZOP (work in progress outside of CA)
- **Tree Canopy Density** – NLCD data was used to capture risk of outages due to vegetation proximity to ZOPs
  - Additionally piloting satellite/LIDAR technologies to improve risk estimation
- **Ignition History** – frequency of ignitions (if any) at the ZOP
  - More of a constant factor addition rather than a continuous 0-1 variable
- **Future Plans -** include incorporating asset health index and equipment failure history into LRAM

Environment Risk Layers

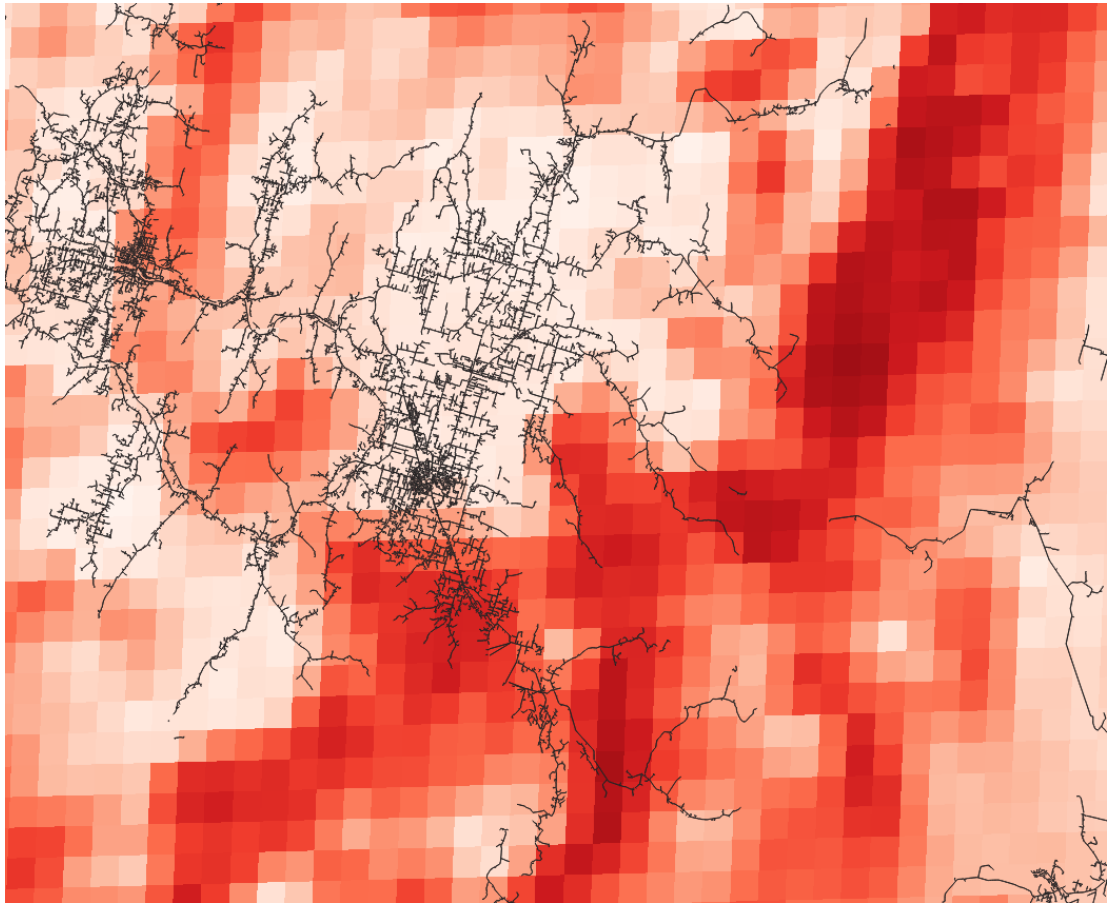
- **iUTI** – Probabilistic modeled fire spread on historic fire weather days with legacy fuel data from LANDFIRE within local terrain (leveraged HFTD mapping efforts)
- **Wildfire Risk Score** – Combo of Fire Weather Risk Score & Fuel Density Score
  - Fire Weather Risk Score - quantifies the intensity/frequency of extreme fire weather calculated using KBDI, Fosberg, and wind gust using high resolution rapid refresh (HRRR) data from 2016 forward
  - Fuel Density Score – Obtained from 2020 LANDFIRE total available biomass layer
- **Fire Area Score** – Using wildfire perimeter data obtain the total number of acres burned within a certain distance of all ZOPs
  - Used to highlight locations which have experienced large wildfire growth and spread, and assume future performance similar to past experience
- All three of these scores essentially highlight a different aspect of wildfire consequence (long term modeled, short term modeled, realized)

Other Data Incorporated

- Slope/Elevation – Average and maximum slope/elevation underneath the ZOP details how rough the terrain is for access and fire growth
  - Also looking into incorporating road access
- Census Tract Classification – Urban, Rural, Highly Rural
- USGS GAP Landcover Classification – identify percentage of ZOP in each category
  - Forest/Shrubland
  - Barren
  - Developed
  - Agriculture
- Length of ZOP and number of customers on and downstream from it

HRRR Weather Data for Fire Weather Risk Layer

- Goal is to leverage HRRR in LRAM for short term/real time application
- Hourly 3 km HRRR: wind speed/dir, gust, temperature, relative humidity, rainfall
- Created a detailed weather history for each ZOP
- Much more resolved analysis compared to what is possible with weather stations
- Other gridded fire weather indices can also be used if deemed valuable including Fosberg, KBDI, VPD, DFM and others



Fire Weather & Wildfire Risk Layer

- To rank the intensity of the fire weather we can perform a simple sum of the weather variables of interest
  - Can be thought of as a measure of intensity at each ZOP
- To generate the Fire Weather Risk Score we combine the following*:
  - Sum of the hourly Fosberg values
  - Sum of the hourly wind gust values
  - Sum of the daily KBDI values
- Wildfire Risk Score is combination of total fuel density (LANDFIRE 2020 remap) and Fire Weather Score
- We plan on updating this layer each year as new data is available
  - Working on getting a 30yr WRF reanalysis dataset

*Only calculated during fire season and then mapped to a 0-1 scale

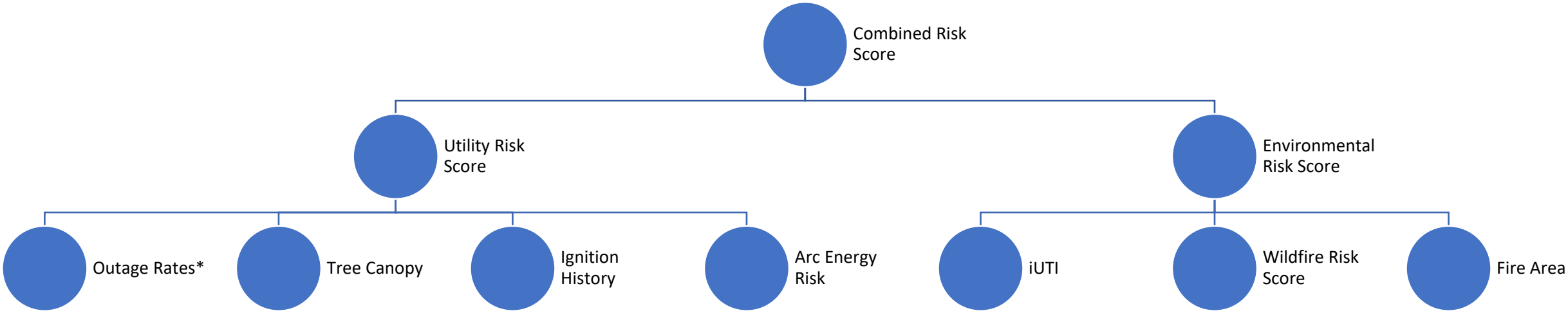
Combining Layers Together

- The output of each risk layer is a relative ranking between 0-1
- We can then perform a linear combination
  - Using the normalized ranking for that layer and chosen coefficient
  - This is a simple approach, but easily explainable and flexible
  - The final value is a length independent risk score

$$RiskScore = \sum_{layer=i}^{\#layers} r_i * c_i$$

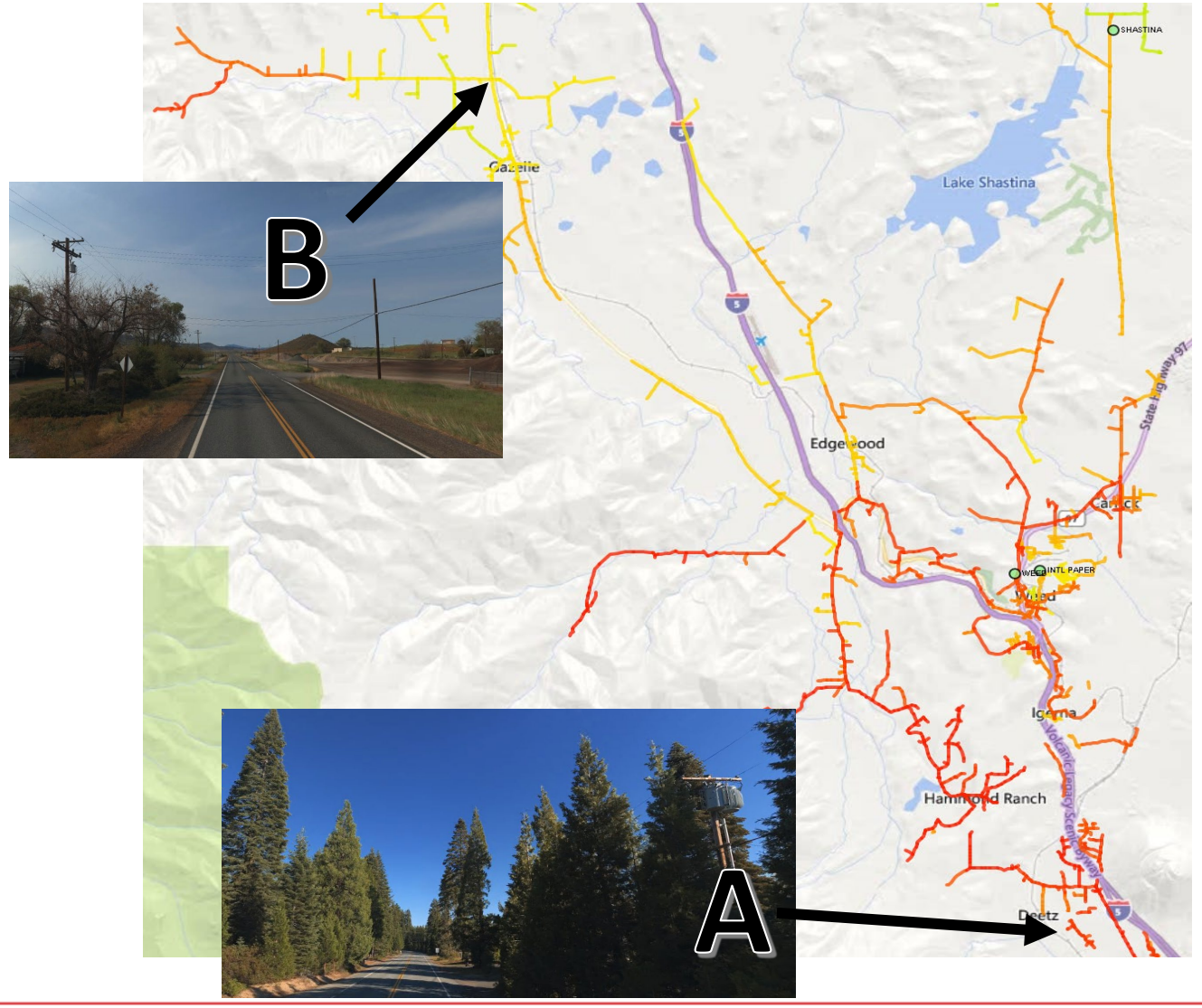
- Can use the line lengths to obtain a final length dependent risk score
- The weight is shared equally between Environmental and Utility risks when calculating the Combined Score
- Weighting on sublayers done by analyzing edge cases with subject matter experts
- Depending on the analysis, various layers can be selected/removed, i.e. long term prioritization doesn't consider forecast and short-term risks, but focuses on long term patterns

LRAM Model Structure



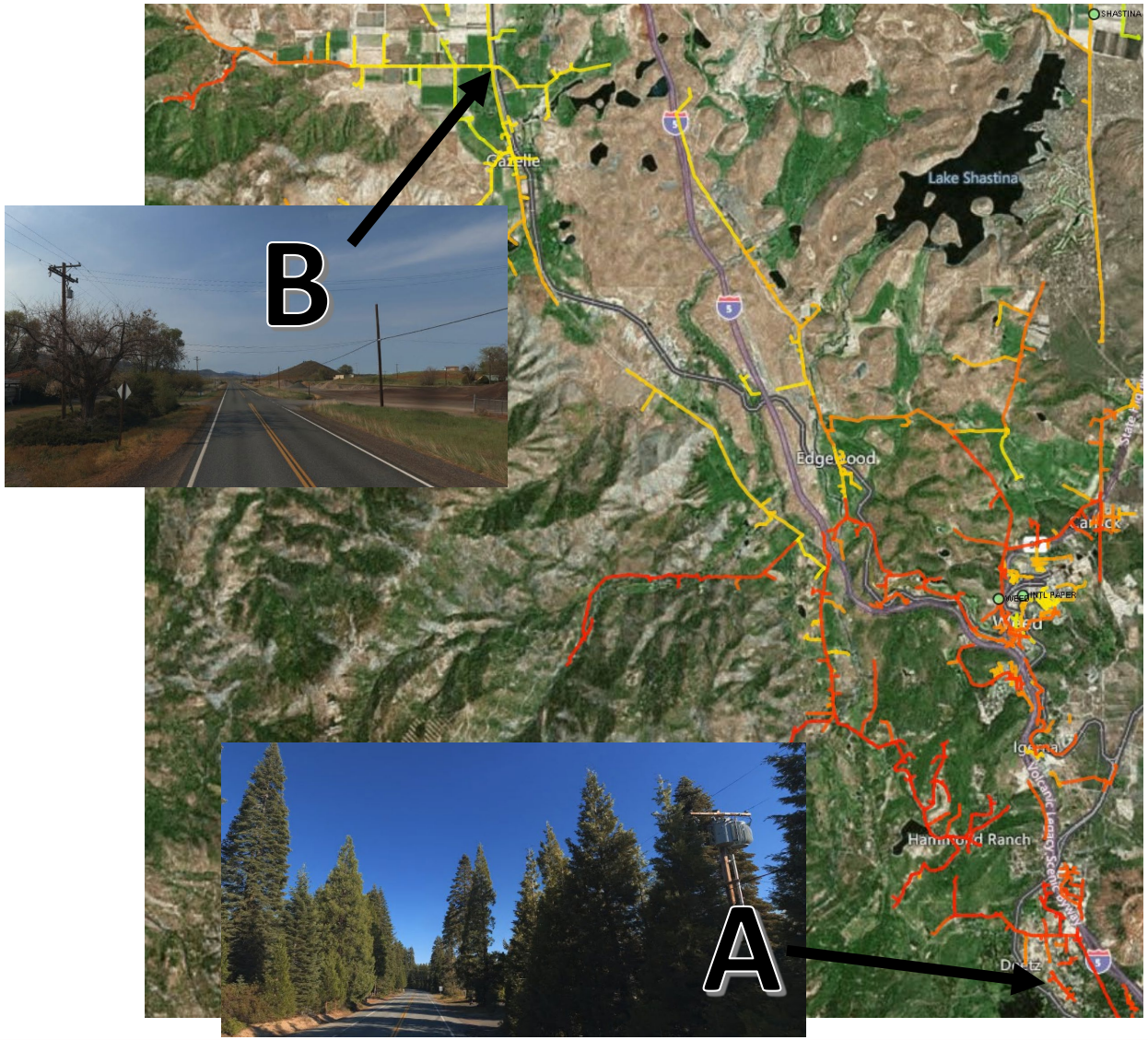
*Comprised of vegetation, equipment failure, animal, interference, and other outage rates weighted by their ignition frequency

Weed Example: Combined Score



	Location A	Location B	
Circuit	5G83	5G21	
ZOP	OH_151300_1911	RC_036401_1910	
Customers	1904	701	
Combined Score	**0.873**	**0.479**	
Enviormental Risk Score	**0.951**	**0.637**	Environmental Risks
iUTI	**0.980**	0.594	
Fire Area Score	**0.675**	0.631	
Wildfire Risk Score	**0.875**	0.539	
Wind Gust Score	**0.371**	0.263	
Forsberg Score	0.366	**0.421**	
KBDI Score	0.599	**0.883**	
Fuel Density	**0.949**	0.486	
Utility Risk Score	**0.631**	**0.255**	Utility Risks
Tree Canopy Risk Score	**0.928**	0.023	
Tree Outage Score	**0.350**	0.232	
Animal Outage Score	**0.388**	0.308	
Equipment Failure Score	0.537	**0.568**	
Interference Outage Score	0.191	**0.241**	
Other Outage Score	0.419	**0.536**	
Average Slope	**7.475**	0.999	Other Data
Census Tract	Rural	Rural	
Forest/Shrubland	**0.771**	0.396	
Barren	0.009	**0.010**	
Agriculture	0.000	**0.368**	
Developed	0.220	**0.224**	
Lower Fire Danger Mask	0.220	**0.593**	

Weed Example: Combined Score



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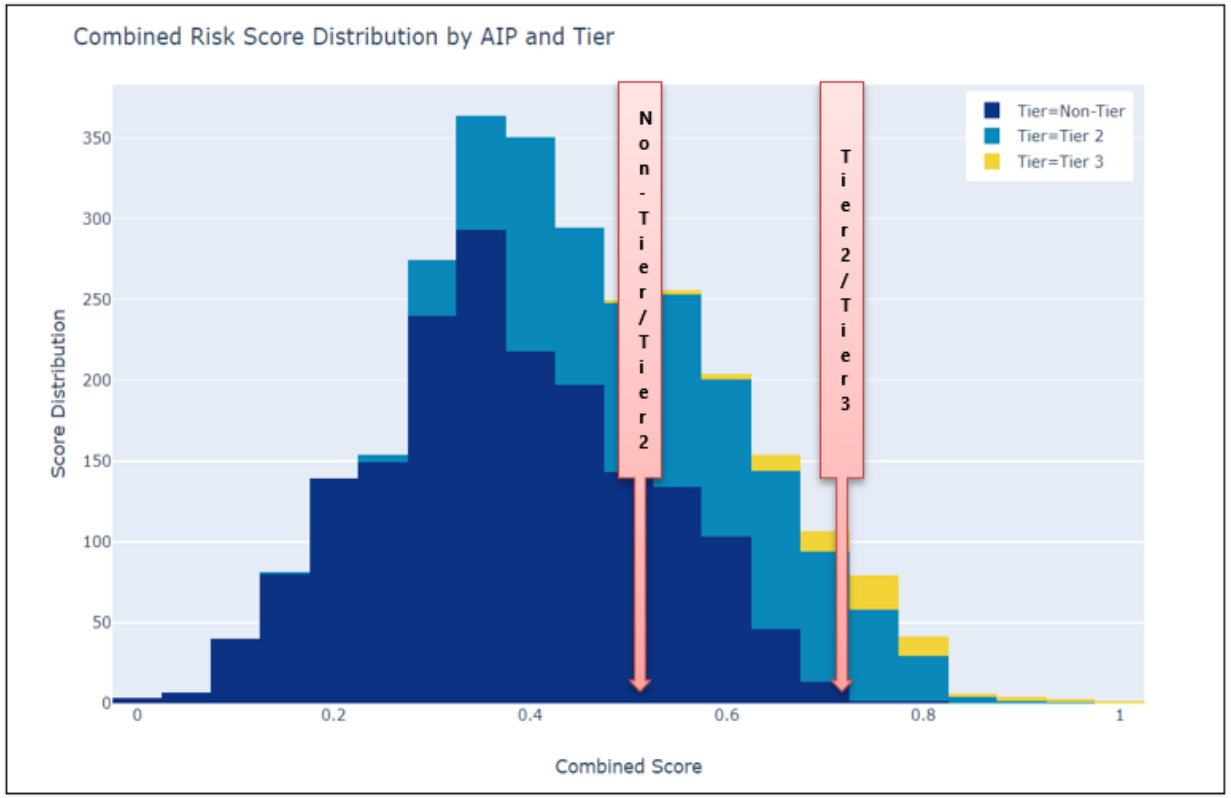
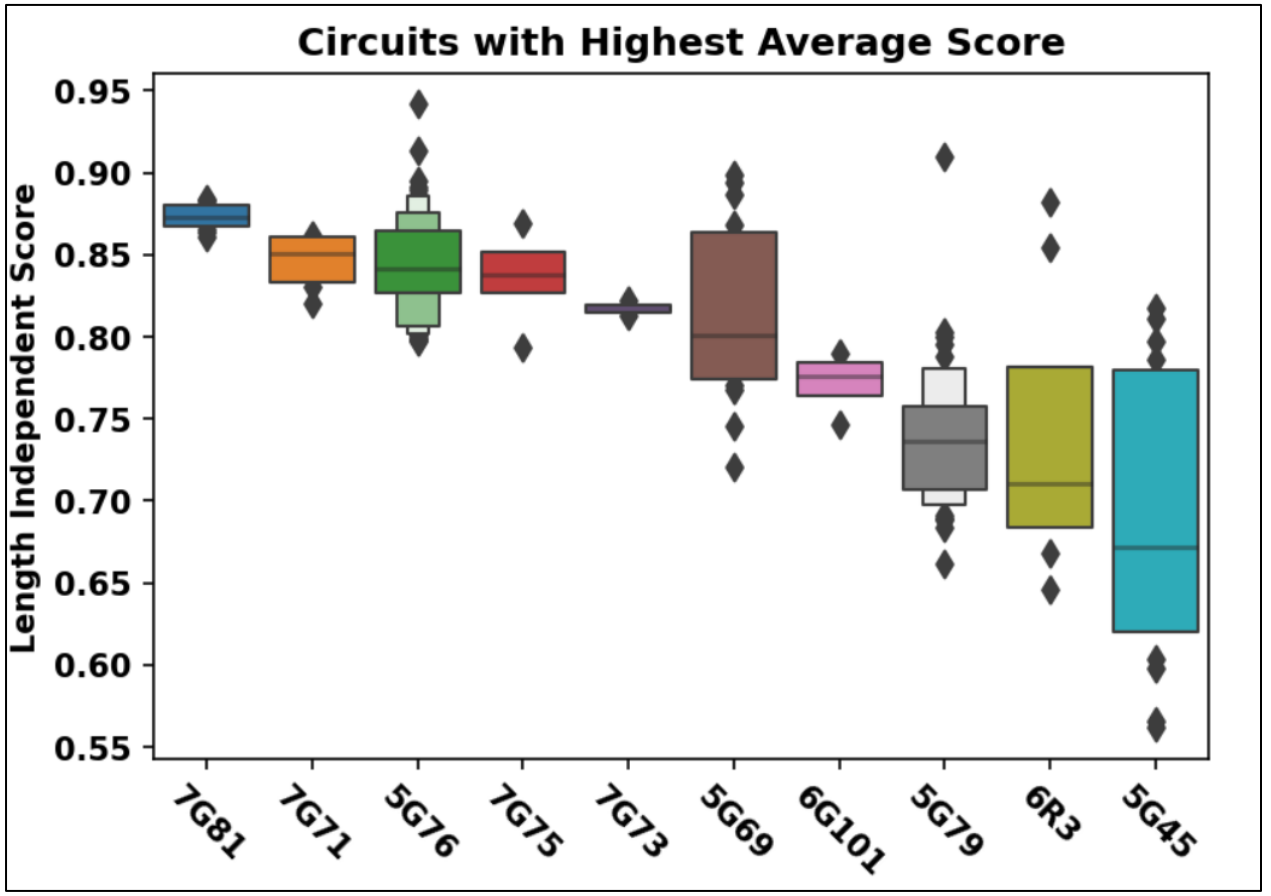
Environmental Risks

Utility Risks

Other Data

LRAM Tier Comparison & Circuit Score Analysis





Closing Thoughts

- We plan on updating this model on an annual basis and additionally analyze each year independently to see how the scores are trending
- We have combined the current LRAM with the Cal-Adapt climate models to identify how the various climate scenarios will impact the scores across our territory
- The Wildfire Risk Score consists of variables we consider for PSPS with the addition of fuel density
  - Looking at the Wildfire Risk Score in conjunction with Downstream CC we can get a sense of good areas for hardening to reduce PSPS necessity

Closing Thoughts

- This work enables us to rank the relative risk of a utility caused fault (or ignition risk event) at each zone of protection
  - Helps us prioritize system hardening and modernization efforts
  - Combining LRAM & RSE will aid our mitigation prioritization, i.e. covered conductor versus vegetation management versus equipment replacement
- Allows us to understand the unique risk profile at each ZOP
- Currently preparing a 30yr WRF 2km reanalysis dataset for future inclusion
- Ongoing collaboration with meteorology department, Pyregence, and wildfire experts, so expect refinements to the model going forward

Thank you! Questions?

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