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NATIONAL LABORATORY

WILDFIRE RISK & RESILIENCE
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Metrics in Wildfire Mitigation Plans

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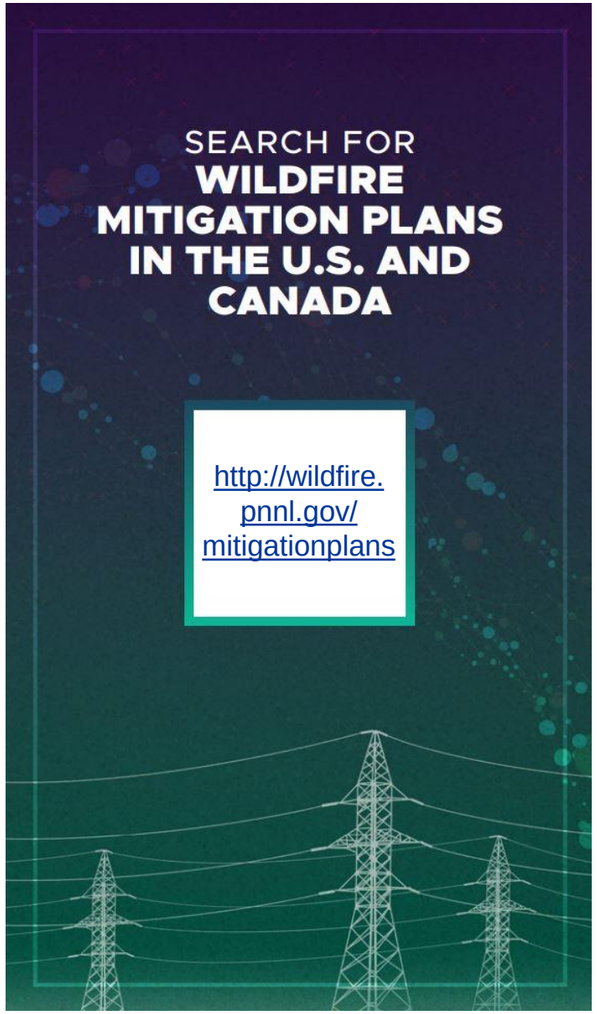
Background

- Sponsored by the U.S. Department of Energy's Grid Deployment Office, PNNL created a database of all known and discrete utility Wildfire Mitigation Plans (WMPs) from across the United States and Canada.
- The goal is to provide a single consolidated location for access to all WMPs. Plans are organized by various metadata:
  - Location of the authoring utility or entity
  - Year or range of years of the plan implementation period
  - Type of utility or entity
- The database is a component of a larger research program to establish credible industry metrics to assess and mitigate wildfire risk.
- To help make sense of hundreds of WMPs and their contexts, PNNL produced a series of citable short decks, organized by technical topics.



What is a metric?

A metric is a quantifiable value that reflects the status or performance of a system. Changes upward or downward can inform or influence decision-making.

Metrics are applied for various reasons in WMPs:

- Evaluating performance and/or effectiveness
- Risk-based assessment of hazards
- Risk mitigation prioritization
- Resource allocation and investment
- Demonstration of regulatory compliance
- Public accountability and transparency

Metrics Analysis Methodology

- Although WMPs vary widely in content and rigor, standardized metrics are key for understanding and comparing overall plans' effectiveness.
- PNNL primarily focused on publicly reported quantifiable metrics found in plans currently housed in the WMP Database.
- Of the 407 WMPs currently in the database, PNNL reviewed 25 through deep-dive analyses to inform overall key metrics.
- Metrics are aligned around several core WMP functions including:
  - **Vegetation Management**
  - **System Hardening**
  - **PSPS & EPSS**
  - **Risk Assessment**
  - **Forecasting & Situational Awareness**
  - **Customer Engagement**

Vegetation Management Examples

Metric Name	Meaning
Miles of vegetation managed	▪ Total miles of line (both distribution and transmission are usually tracked) where vegetation management activities are performed (HCE 2023, pg. 40). ▪ Accomplished in cycles for both distribution and transmission lines through means such as ground and aerial patrols, LIDAR, and infrared sensing (SCE 2023-2025, pg. 14) ▪ Several derivative/similar metrics including "*Percentage of circuit miles inspected for vegetation compliance*", "*Number of routine vegetation inspections completed*", *"Vegetation inspections by type (routine, off-cycle, detailed, or emergency"* or *"HTFD-specific miles managed for vegetation"* (SDG&E 2020-2022, pg. 445)
Number of trees trimmed or removed	▪ Total number of trees pruned or eliminated for compliance or risk reduction during a reporting period (often further broken out by type – routine, enhanced, or hazardous – or on a per mile basis) (LADWP 2023-2025, pg. 34)
Count of direct vegetation-caused ignitions and/or outages	▪ Number of ignition events or power outages explicitly caused by vegetation contact (often normalized by overhead conductor miles or within/outside HTFD areas) (Kootenai Electric Co-op 2025, pg. 19)
Counts of trees fallen into lines	▪ Reducing the number of tree falls between years is one component of a wildfire mitigation strategy (Avista 2023, pg. 4).
Maximum allowable clearance distance	▪ Case-by-case distance between vegetation and the transmission line; determined by subject matter experts in cases where a standard vegetation height of 25 feet below the maximum sag of the transmission lines cannot be met due to legal or physical constraints (BPA 2024, pg. 16)

System Hardening Examples

Metric Name	Meaning
Number of Wildlife Guards Installed	▪ Wildlife guards are intended to reduce animal (especially bird) related ignitions (SDG&E 2020-2022 pg. 262).
Number of Lightning Arrestors Installed	▪ Lightning arrestors are primarily installed to protect equipment from electrical surges, but can also help dissipate the electrical energy of a lightning strike (PG&E 2023-2025, pg. 507).
Miles of Conductor Undergrounded	▪ Replacing overhead distribution cables with underground cables reduces ignition risk (PG&E 2023-2025, pg. 453).
Number of poles replaced	▪ Wood poles can be replaced with steel or ductile iron (SMUD, 2023-2025, pg. 32).
Number of SCADA Reclosers Installed	▪ SCADA (Supervisory Control and Data Acquisition) reclosers allow operators to control the recloser remotely, including disabling the reclosing function (SMUD 2023-2025, pg. 40).

PSPS and EPSS Examples

Metric Name	Meaning
Number of Critical Care Customers	▪ Total number of customers who cannot be without life support equipment for at least two hours (SCE 2021, pg. 89)
Count of PSPS Events	▪ Count of Public Safety Power Shutoff events: proactive/preventative line shutoffs in High Fire Threat Districts under certain risk environments (PG&E 2023-2025, pg. 443)
Number of EPSS Events	▪ Number of Enhanced Powerline Safety Settings events: automatic line shutoffs due to fault or object strike (PG&E 2023-2025, pg. 394)
Scope of PSPS Events	▪ Estimated customers impacted by PSPS (SCE 2021, pg. 539)
Customer Hours of PSPS per RFW OH Circuit Mile Day	▪ Duration of PSPS events (customer hours per year) divided by Red Flag Warning Overhead circuit mile days in time period (SCE 2021, pg. 529)
Critical Infrastructure Impacted by PSPS	▪ Incorporated into a score used to weight PSPS impacts (SCE 2021, pg. 538)
System Average Interruption Duration Index (SAIDI)	▪ Sum of all interruptions in time-period where each interruption is defined as sum(duration of interruption * number of customer interruptions) / (total number of customers served) (SCE 2021, pg. 538)
System Average Interruption Frequency Index (SAIFI)	▪ Sum of all interruptions in time-period where each interruption is defined as (total number of customer interruptions) / (total number of customers served) (SCE 2021, pg. 538)

Risk Assessment Examples

Metric Name	Meaning
Fire Risk Index	▪ Long-term risk assessment to help develop a risk-informed decision framework to 1) quantify identified wildfire risks and 2) drive mitigation planning (APS 2025, pg. 20).
Fuel Classifications	▪ Classifies and describes fuels in the planning area that would contribute to fire behavior using the Standard Fire Behavior Fuel Model classification system + 2019 LANDFIRE data. This analysis of the fuel data is done in order to allow comparison between plans and illustrate changes to the landscape over time (GEC 2024, pg. 23).
Event Damage Estimate	▪ Risk assessment methodology that includes an overview of assets at risk and historic average annual dollar losses from event data, when available. Used to estimate potential dollar losses for structures in vulnerable areas (MPPD 2021, pg. 20).
Percent of Infrastructure Assets that are categorized as high risk	▪ Overlay service territory asset maps on the Wildfire Hazard Potential (WHP) maps to develop a Fire Threat Assessment Map (HEC 2022, pg. 14)
Industrial Fire Precaution Levels (IFPL)	▪ This system, which helps prevent wildfires by regulating work in the woods, is known as the Industrial Fire Precaution Level (IFPL) system (HEC 2022, pg. 20).

Risk Assessment Examples (cont.)

Metric Name	Meaning
Risk Associated with Value Exposure	▪ Derived from modeling; considers population, buildings and critical facilities; enhances the ability to visualize and understand risks effectively (Xcel Energy SPS 2024, pg. 24)
Risk Associated with Ignition Location	▪ Derived from modeling; considers the probability of ignition, the fire spread potential, and the consequence of the fire spread (Xcel Energy SPS 2024, pg. 24)
Consequence Score	▪ Derived from modeling; used to estimate wildfire hazard after ignition (SCE 2023-2025, pg. 395)
Fire Risk	▪ Risk rating assigned to counties based on several variables relating to fuels, population, historic fire data, and other variables to determine the most vulnerable areas in a service territory (APS 2025, pg. 19).
Wildfire Risk Tiers	▪ Geospatial characterizations of wildfire hazards in the service territory. Includes calculating Hazard Fire Areas (HFAs), a locally scored and weighted metric where population and utility infrastructure are considered (Xcel Energy SPS 2024, pg. 14) ▪ Using an established wildfire risk modeling methodology, this metric divides the service territory into three Tiers of calculated risk (3 = highest; 1 = lowest) to identify where to implement de-energizing programs in locations where powerlines are more likely to ignite wildfires (Chelan PUD 2024, pg. 19).

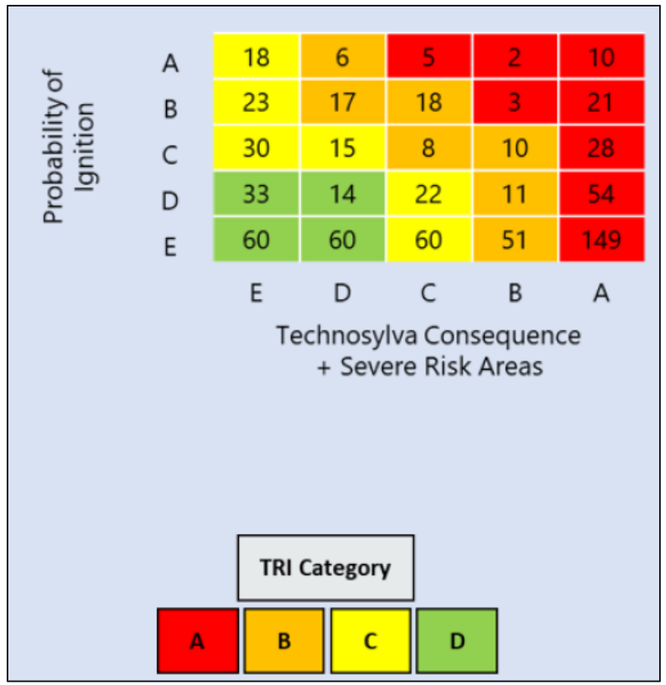
Forecasting and Situational Awareness Examples

Metric Name	Meaning
Number of Red Flag Warning Days	▪ Forecast issued by the National Weather Service; considers temperature, humidity, and wind; days during which there is an increased fire danger risk (SCL 2024, pg. 40)
Conditional Flame Length	▪ Most likely flame length expected at a given location if a fire occurs, based on all simulated fires; an average measure of wildfire intensity (Xcel Energy SPS 2024, pg. 15)
Fire Potential Index	▪ Derived from modeling; quantifies fire activity potential based on different parameters, including fuel type, ratio of dead-to-live fuels, terrain, and weather (APS 2025, pg. 18)
Fire Weather Threat Index	▪ Sliding scale derived from weather observation and forecast inputs; communicates the daily potential for hazardous weather (APS 2025, pg. 18)
Wind Peak & Duration Index	▪ Combines wind gust peak with wind gust duration; forecasted during a wind event (APS 2025, pg. 18)
Fire Growth Index	▪ Combines Burning Index with Wind Gusts; used to forecast short-term fire threat (APS 2025, pg. 18)

Customer Engagement Examples

Metric Name	Meaning
Percent of Customers Notified Prior to Initiation of PSPS Event	▪ Number of Affected Customers Notified divided by Number of Affected Customers (SCE 2021, pg. 538)
Percent of Medical Baseline Customers Notified Prior to Initiation of PSPS Event	▪ Number of Affected Medical Baseline Customers Notified divided by Number of Affected Medical Baseline Customers (SCE 2021, pg. 538)
Number of Mailers sent to customers related to Wildfire Mitigation Activities	▪ Used to quantify community outreach (SMUD 2023-2025, pg. 52)
Visitation of Community Resource Centers (CRCs) and Community Crew Vehicles (CCVs) during PSPS events	▪ Resources intended to provide information and services (SCE 2021, pg. 291)
Number of PSPS events triggered where no de-energization occurred	▪ Number of instances where utility notified the public of a potential PSPS event but no de-energization followed (SCE 2021, pg. 539)

What is the difference between data and metrics?



- It is common to use quantitative data as metrics. These are univariate metrics – where a single variable is measured directly.
- Often, univariate metrics are combined into normalized metrics for comparison across time and space
- There are also compound metrics – where multiple variables are used to develop a calculated value.
- Many univariate metrics are consistently used across WMPs, while compound metrics are less standardized and are often informed by models that tailor outputs to the conditions unique to the service territory of each utility.

Image Credit: SCE 2021 pg. 395-396

Uses of common univariate metrics

These metrics seek to directly measure a single value and are utilized in WMPs as performance indicators, operational triggers, or for quantifying situational awareness.

- Used to **track mitigation efforts**:
  - Miles of overhead conductor installations
  - Transmission structures inspected
  - Number of automated circuit reclosers installed
  - Number of trees trimmed or removed
- Used as **indicators of wildfire prevention or mitigation** performance:
  - Annual ignitions, yearly outages
  - Number of customers impacted by PSPS
  - Average duration of PSPS event before power restoration
- Used for **categorizing situational awareness** of wildfire potential and overall system or territory risk:
  - Red Flag Warnings (RFW)
  - Weather data

Uses of common normalized metrics

These metrics combine multiple variables into a single, normalized calculation to help utilities better understand their specific wildfire prevention and mitigation trends.

- Used to facilitate diverse spatial and temporal comparisons
  - *Per Mile Basis*, which is often used to compare univariate metrics amongst different system sizing scales
  - *Per Customer-Hour*, which quantifies impacts or effectiveness of measures based on average impact duration
  - *Per RFW or HFTD,* which uses weather (like high wildfire potential conditions associated with Red Flag Warning days) or risk-prone areas (like High Fire-Threat Districts) to assess specific risk levels

Uses of common compound metrics

These metrics are used to quantify a value that cannot be directly measured with univariate metrics by aggregating variables into a single number.

- Some compound metrics are **custom developed** by a utility, sometimes using a model, with their own unique wildfire prevention and mitigation posture in mind. Utilities often calibrate compound metrics to the topography and climate of their service territory.
  - *Fire Potential Index (FPI)* is a commonly used metric that is typically informed by fuel moisture content, predicted weather conditions, and other metrics to estimate ignition risk.
  - *Consequence Score* is a metric used by PG&E and SCE to estimate wildfire hazard after ignition.
  - Xcel Energy SPS's *Hazardous Fire Areas (HFA)* is a locally scored and weighted metric where population and utility infrastructure are considered.
  - *Fire Ignition Tracking* is where a risk rating is assigned to counties based on several variables to support mitigation prioritization by APS.

How are the metrics being used?

Metrics reflect how a utility seeks to balance reduction of wildfire risk with provision of reliable service through targeted investments and operational strategies.

- Metrics for **evaluating performance**:
  - Count of ignitions per overhead conductor mile
  - Estimated number of prevented ignitions
  - Number of medical baseline customers impacted by PSPS
  - Number of customers notified prior to initiation of PSPS
- Metrics for **assessing reliability**:
  - Number and duration of customer outages
  - Average post-event restoration time

How are the metrics being used? (cont.)

Metrics have a variety of intermediate uses to support the principal goals of a WMP.

- **Triggering mitigation actions**: Utilities use metrics to inform PSPS implementation and other operational actions:
  - Fire Potential Index (FPI)
  - Real-time wind gust data
  - Topography and modeled weather data
  - Burn Probability or Wildfire Likelihood
- **Geospatial decision-support**: Utilities use spatial data to demonstrate the granularity of fire hazard areas:
  - Proximity to Wildland-Urban Interface (WUI)
  - Wildfire Risk Tiers

Citation, Contacts, and Project Links

Please cite this slide deck as:

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For more information, contact wildfire@pnnl.gov

All WMPs used in this analysis can be found at:

https://wildfire.pnnl.gov/mitigationPlans

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Thank you