Analysis of Utility Wildfire Risk Assessments and Mitigations in California

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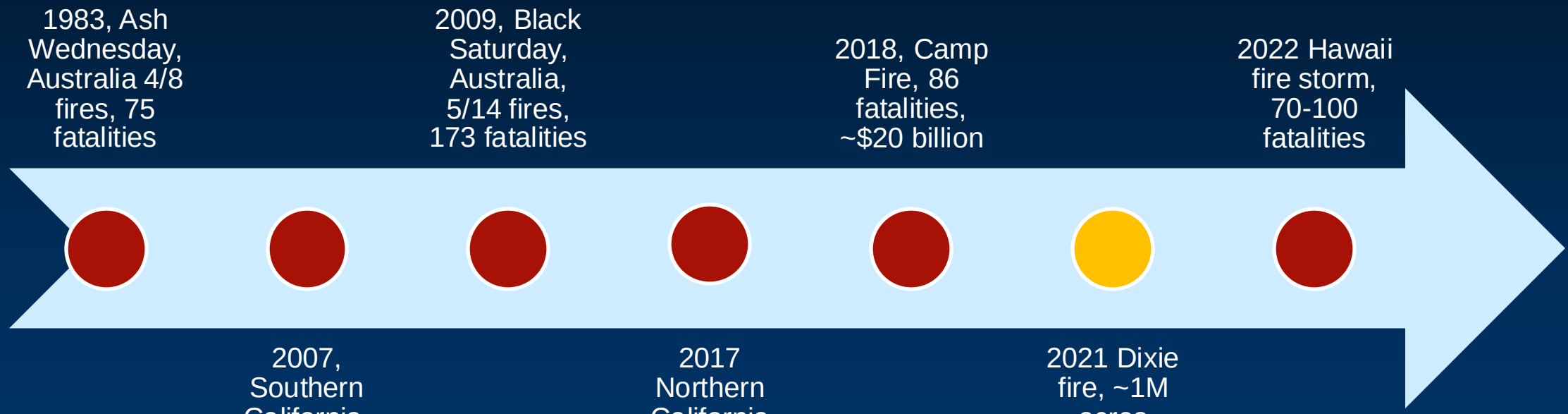
Prepared by M-bar Technologies and Consulting

History of Major Power Line Wildfires

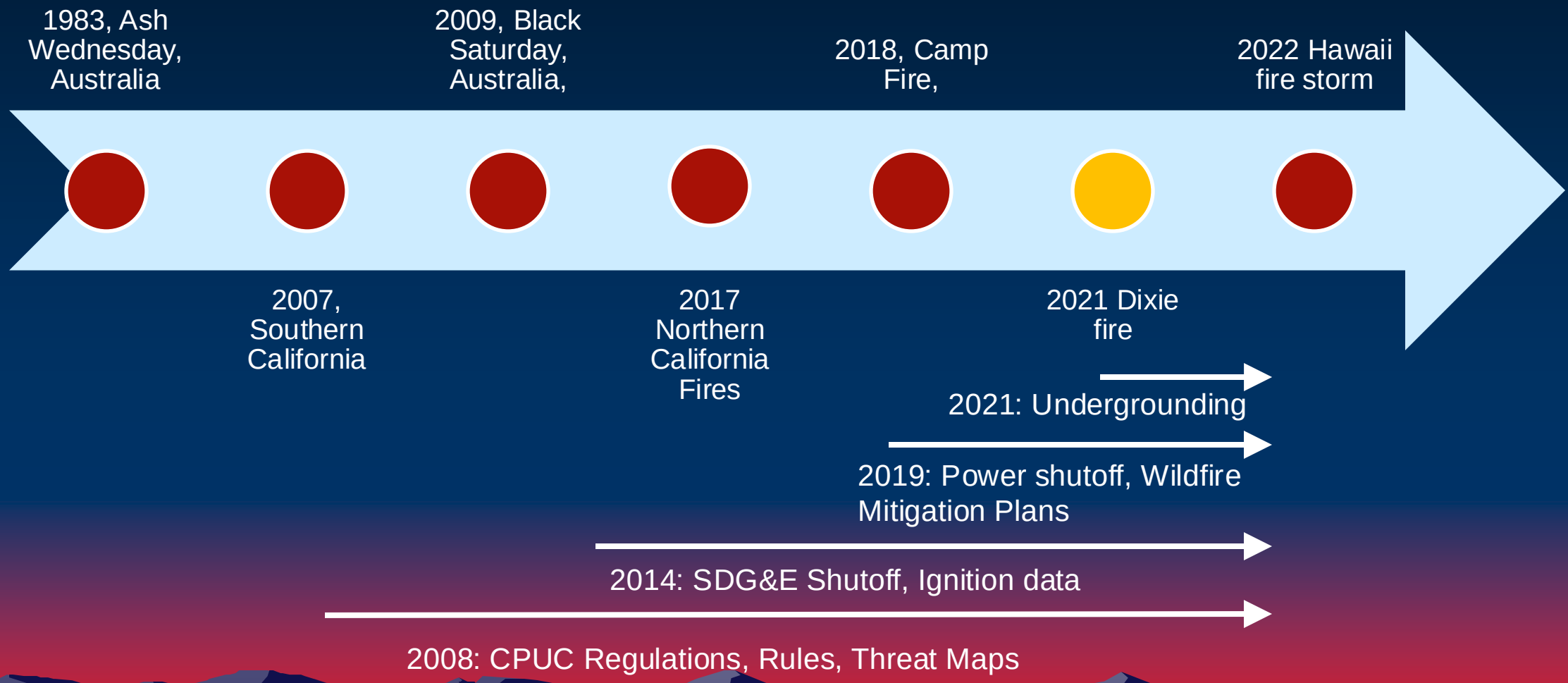


Wind-Driven

Drought/ Plume Driven

Electrical Utility Wildfires are:
Deadlier
More Destructive
(CAL FIRE)

Regulator and Utility Response



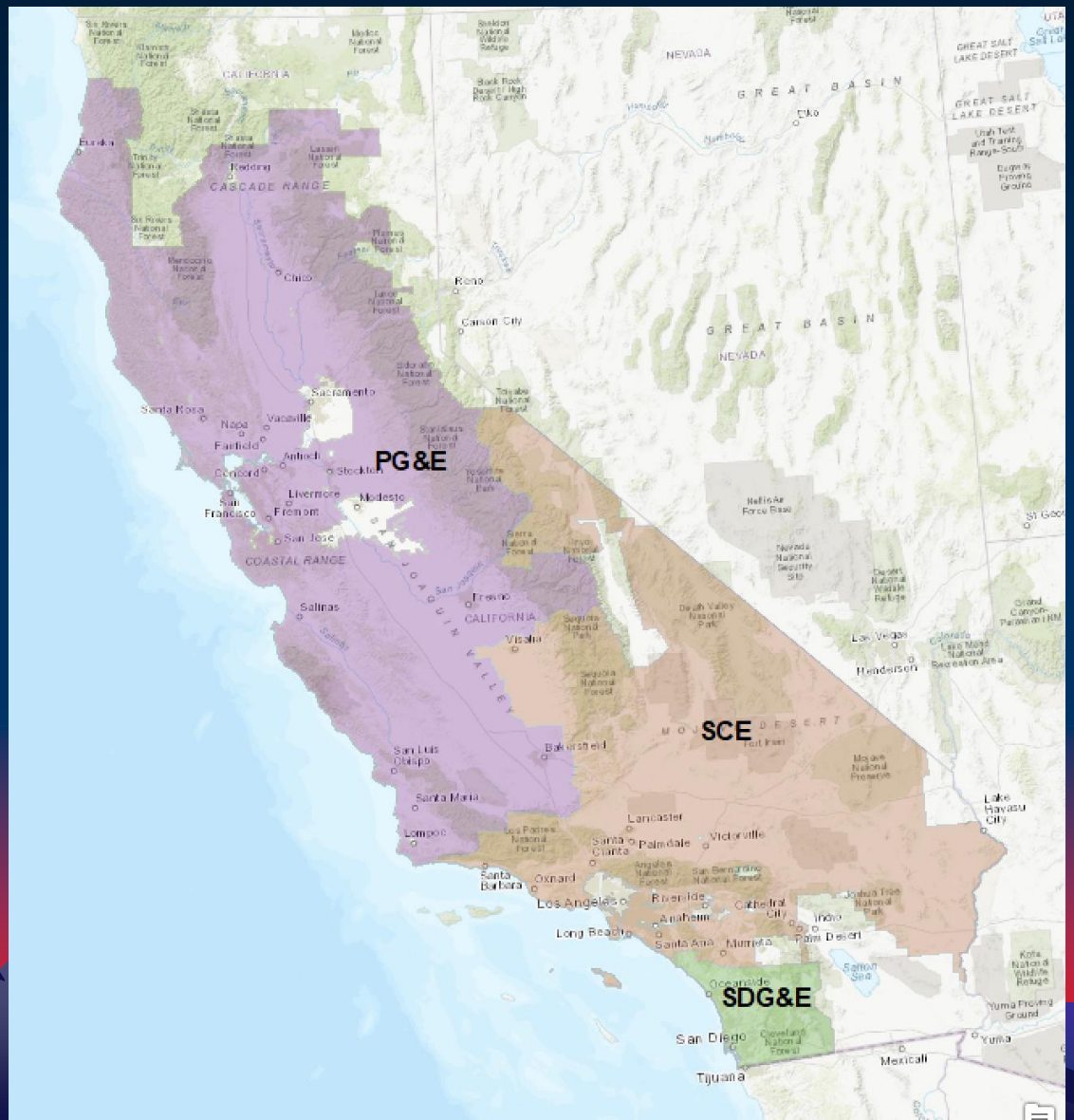
California Acronyms

- CPUC - California Public Utilities Commission (Safety and Rates)
- WMP – Wildfire Mitigation Plans (annual form every utility). Requires risk analysis. 1000s of pages, lots of data.
- OEIS – Office of Energy Infrastructure Safety (former CPUC)
- CAL FIRE – California state fire agency
- GRC – General Rate Case. Utility funding and safety proceeding at the CPUC.

- MGRA – Community Organization at CPUC that I support

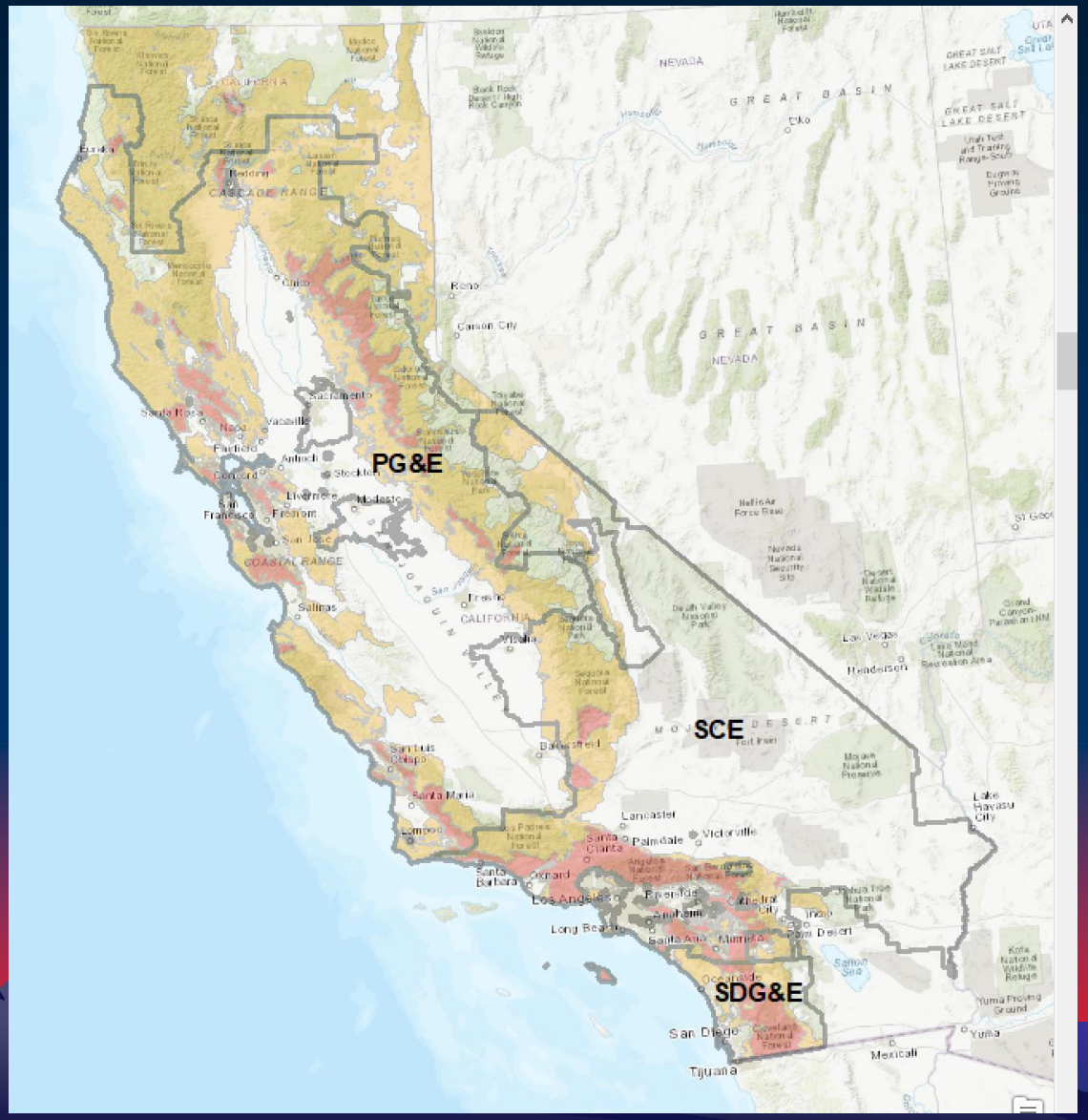
Largest California Utilities

- Pacific Gas and Electric Company (PG&E)
- Southern California Edison Company (SCE)
- San Diego Gas and Electric Company (SDG&E)

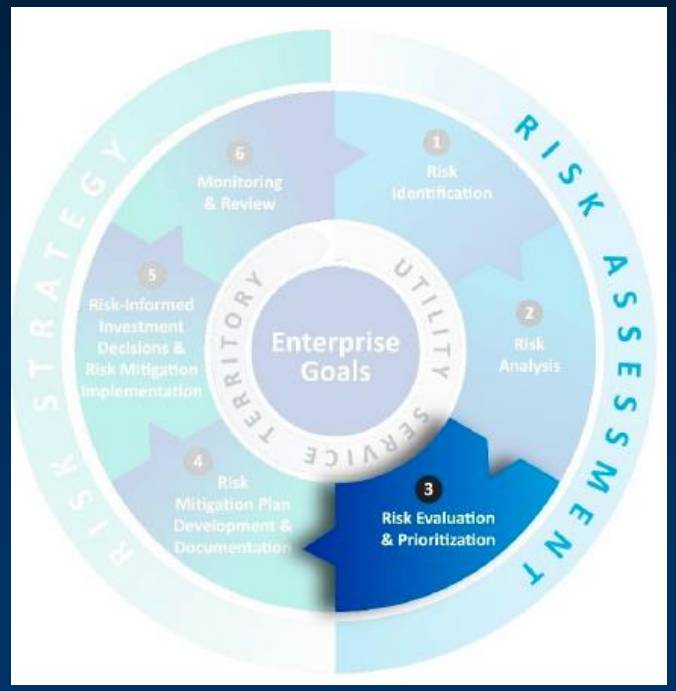


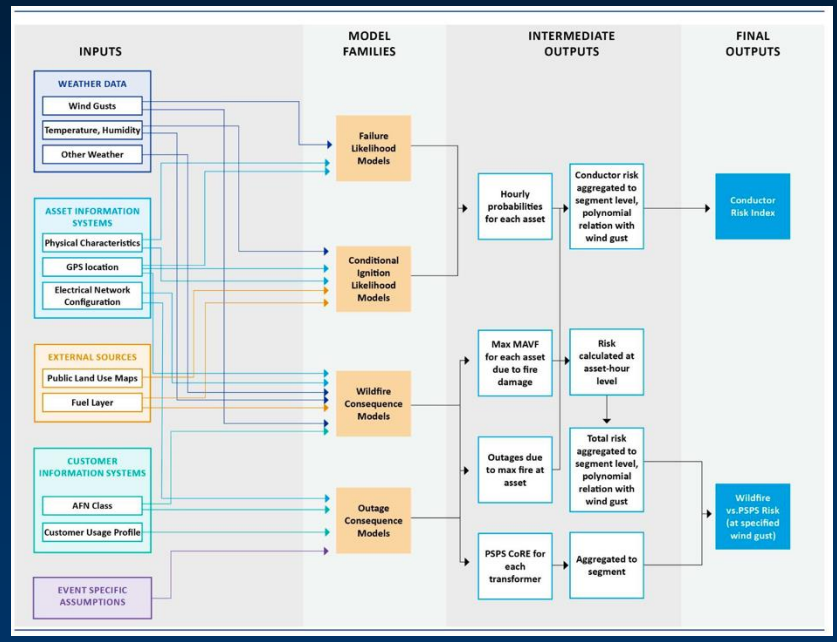
CAL FIRE High Fire Threat Districts

- Red – Tier 3 – Extreme
- Yellow - Tier 2 - Elevated



Utility Wildfire and Mitigation Risk Planning





Enterprise:

How do wildfire risks compare against other risks? (A: Bigly)

Planning:

Where to fund mitigations such as undergrounding and covered conductor

Operational:

Shut-off Thresholds

Utility Risk Models and Limitations

- Risk = P(ignition) X $\Sigma w_i C_i$ over attributes (i)
  - *Assumes risk and consequence independent – not so for wind events*
- Machine Learning using outages/ignitions (SDG&E: regression / PG&E: MaxEnt / SCE: Random Forest)
  - *Uses annually aggregated weather data, and predict wind as small contribution*
  - *Includes power-off times in training set (PG&E corrects this)*
- Worst-case weather days for simulations
  - *But not correlated with "worst-case" drivers*
- Wildfire spread simulations limited in time to 8 hours
  - *Puts risk near ignition point, not true for wind-driven large fires*
- Wildfire Smoke not included
  - *Largest threat to health is ignored*
  - *SDG&E includes a fatalities/acre estimate from outdates sources*

Ignition Drivers

- Possibly Wind-Related

Often event-driven

- Independent agent

~Poisson time distribution

Utility Machine Learning Models

- Numerous wildfire-related landscape attributes included
- Utilize historical outage and ignition data
- Weather data is represented by annual aggregations (maximum, average, etc)
- Predict that wind speed is a poor predictor of ignition

Severe wildfires have wind-related drivers

Reported Ignitions 2022 WMPs

Ignition Driver	Percentage		
	SDG&E	SCE	PG&E (RFW)
Vehicle	17	7	Red flag warning
Balloon	17	13	
Veg Contact W	15	11	59
Other Contact W	8	6	4 (all external)
Animal	5	13	
Wire Contact W	3	5	1
Vandalism	2	5	0
Equipment W	33	42	33

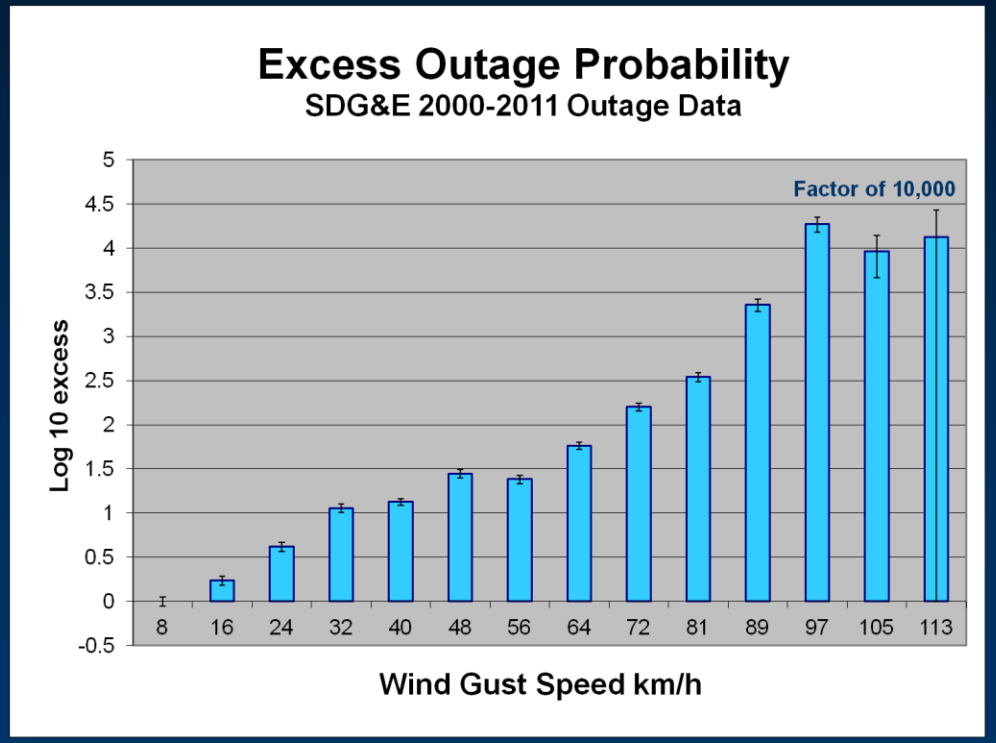
W Wind-related/Non-Agent

Severe Utility Wildfires

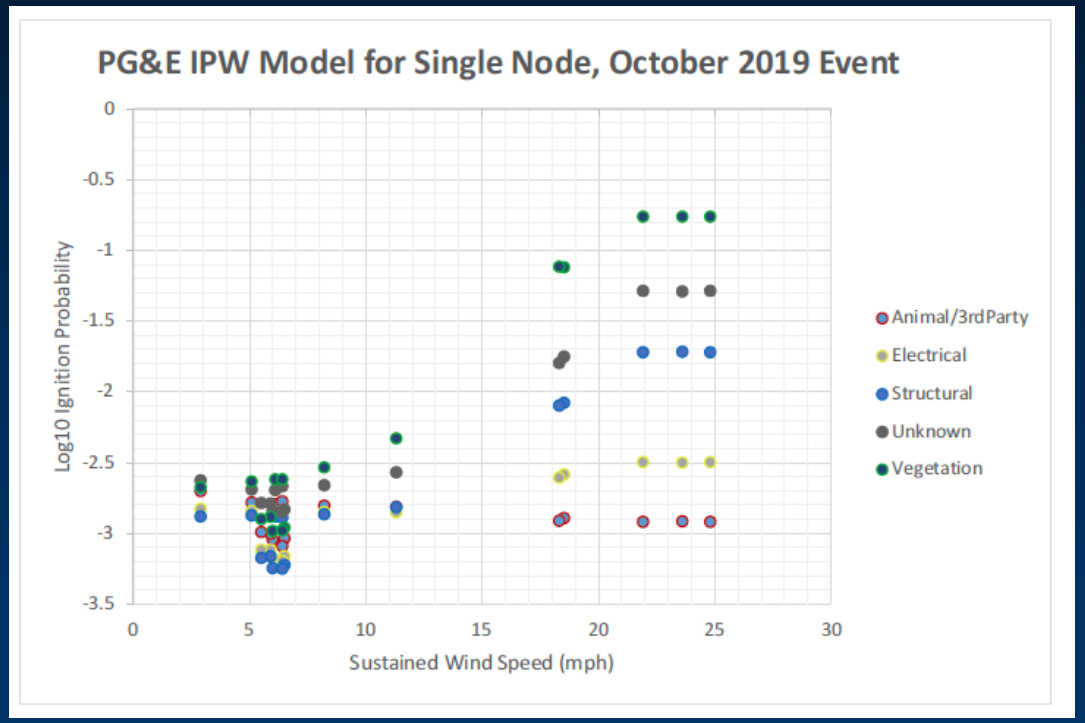
Driver	Observed	Expected	Chi2	Yates
Non-Agent	31	24.09	1.98	1.71
Agent	4	10.91	4.38	5.03
Total	35	35	6	7
P - Chi2	0.01168126			
P - Yates	0.00943576			

Wind-related fires make up most of the damaging wildfires

Outages During Wind Events



From Mitchell 2013



PG&E Ignition Probability Weather Model 2022

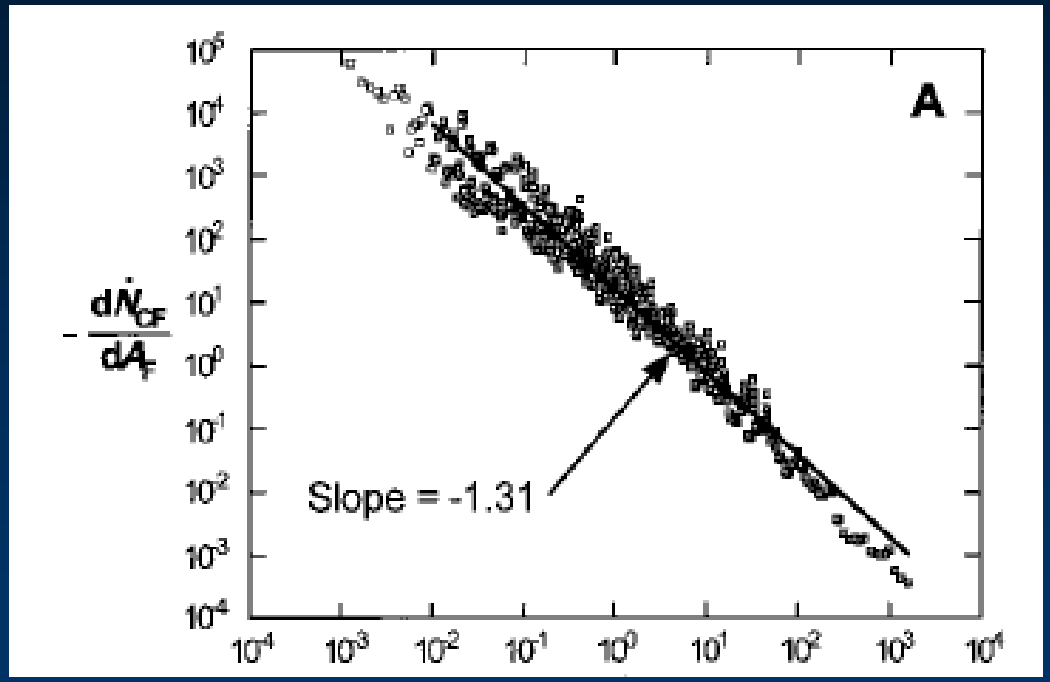
All utilities accept that winds make outages and ignitions more likely
They all use this in operational risk models (shutoff)
Not used for long-term planning models
<u>Expect to lead to underweighting of areas subject to high fire winds</u>

Wildfire Size and Power Laws

- Self-organized critical events show “power law” behavior

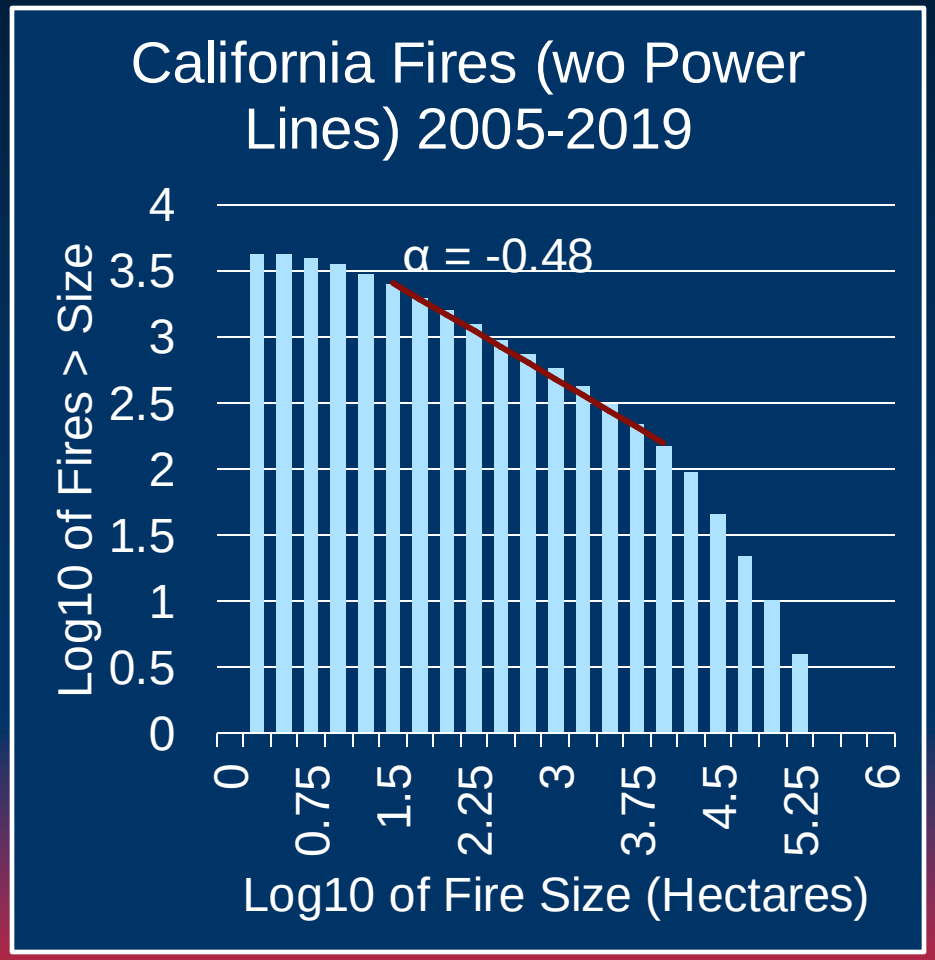
$$y = Cx^{-\alpha}$$

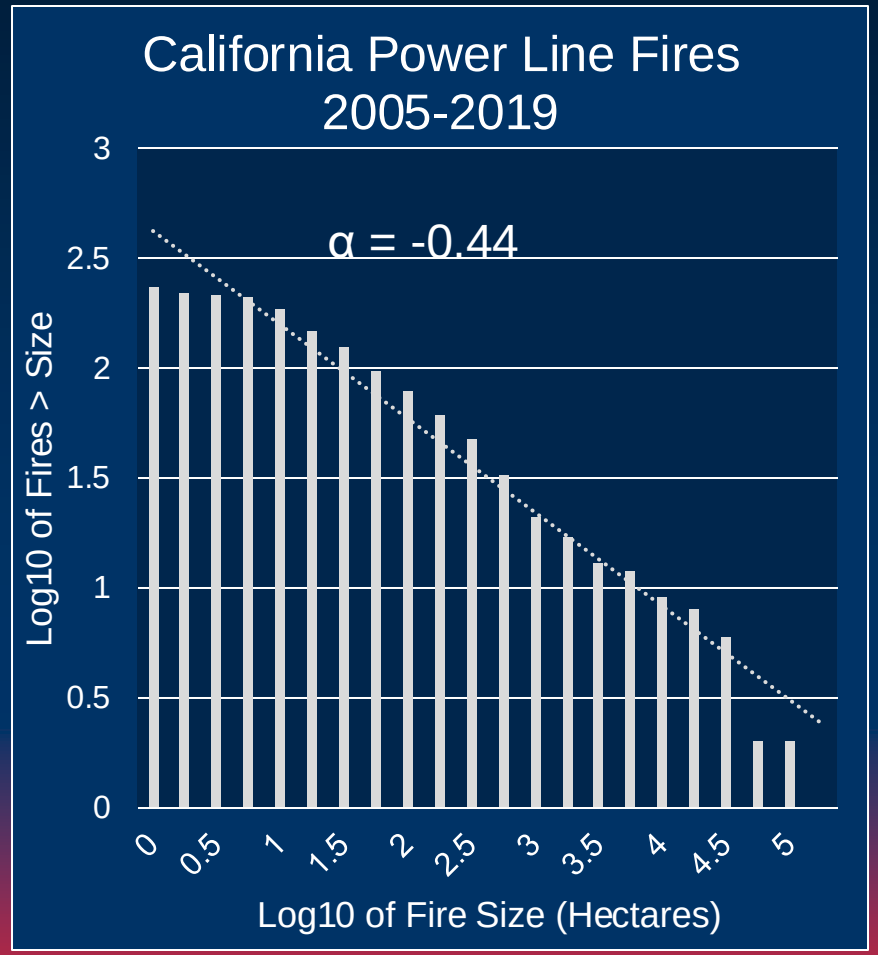
- 2% of wildfires do 98% of damage
- Extreme events dominate the result. “Fat- tailed”.
- For α < 1 (cumulative) we can’t even predict average from past events. This is important.
- Truncation expected when everything burns (Moritz et. al. 2005)



Malamud, B.D., Morein, G., Turcotte, D.L., 1998. Forest Fires: An Example of Self-Organized Critical Behavior. Science 281, 1840–1842.

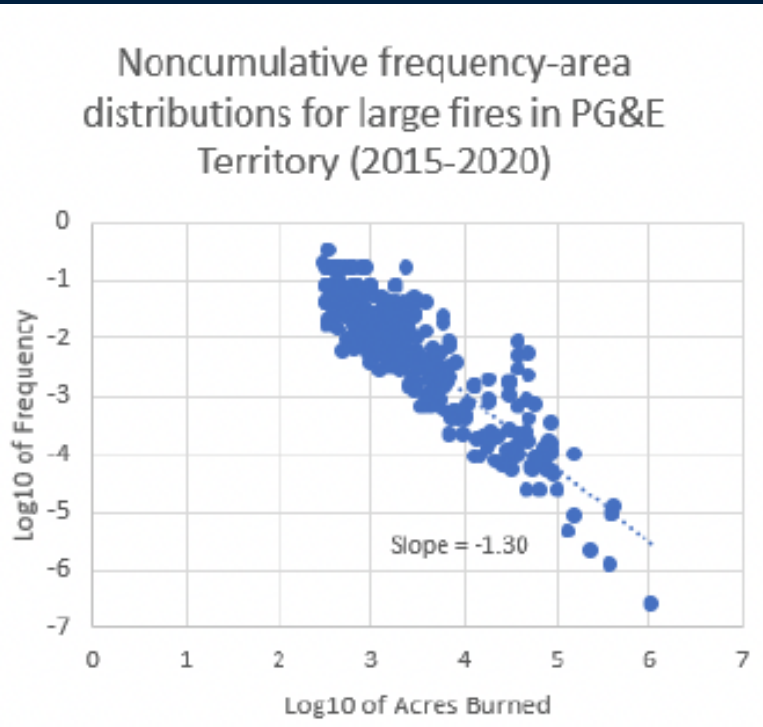
California Wildfire Sizes

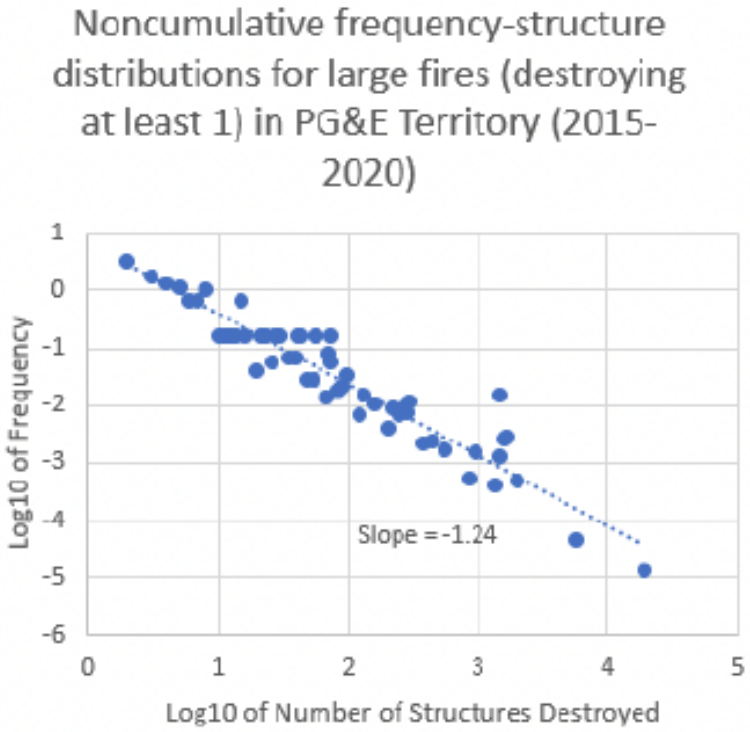


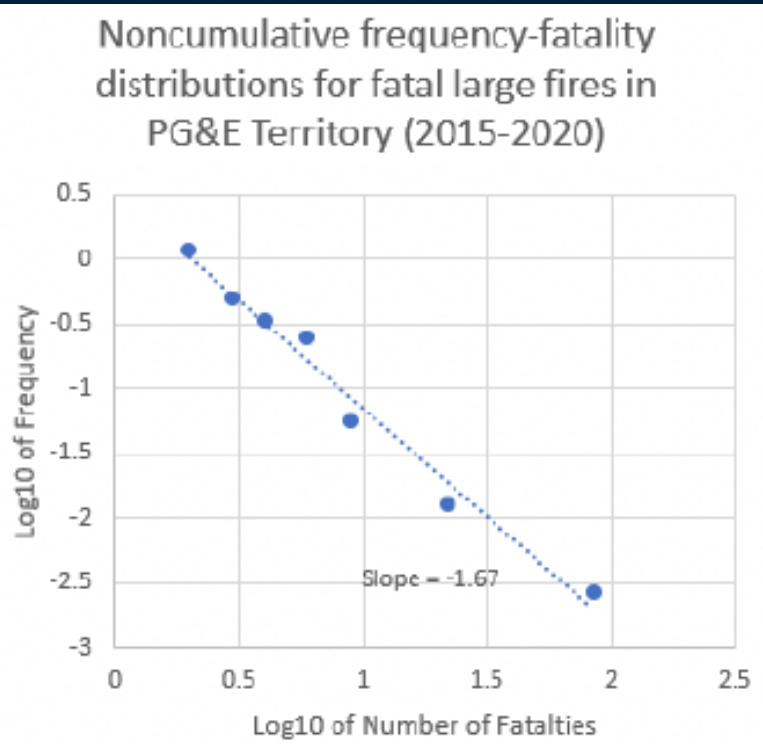


True for Wildfire Impacts as well

PG&E Whitepaper 2021

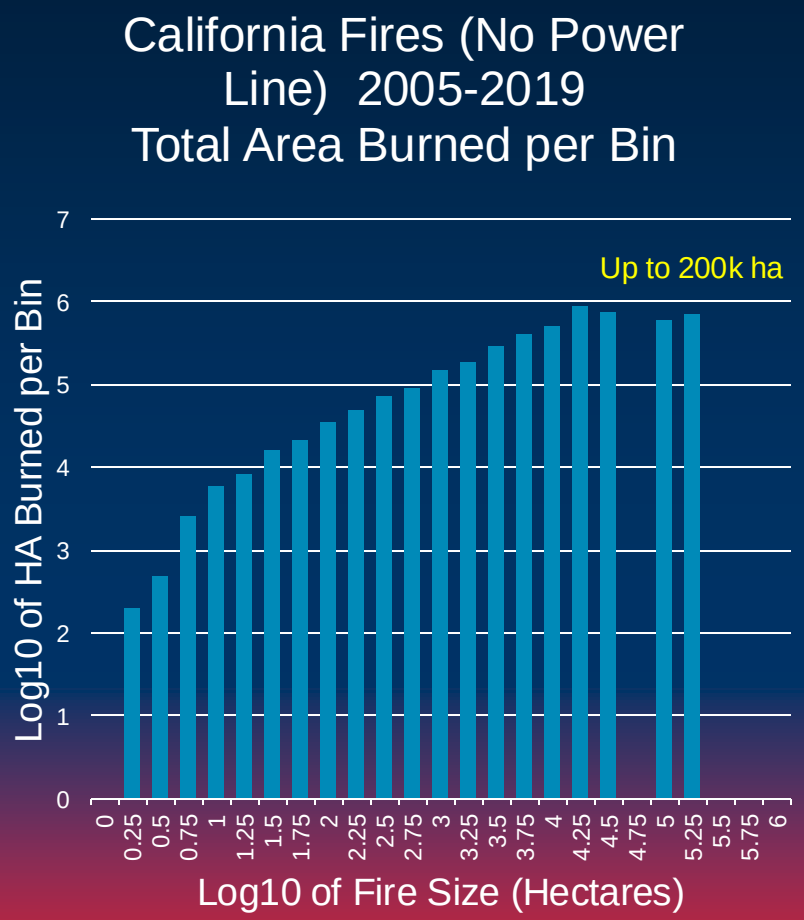


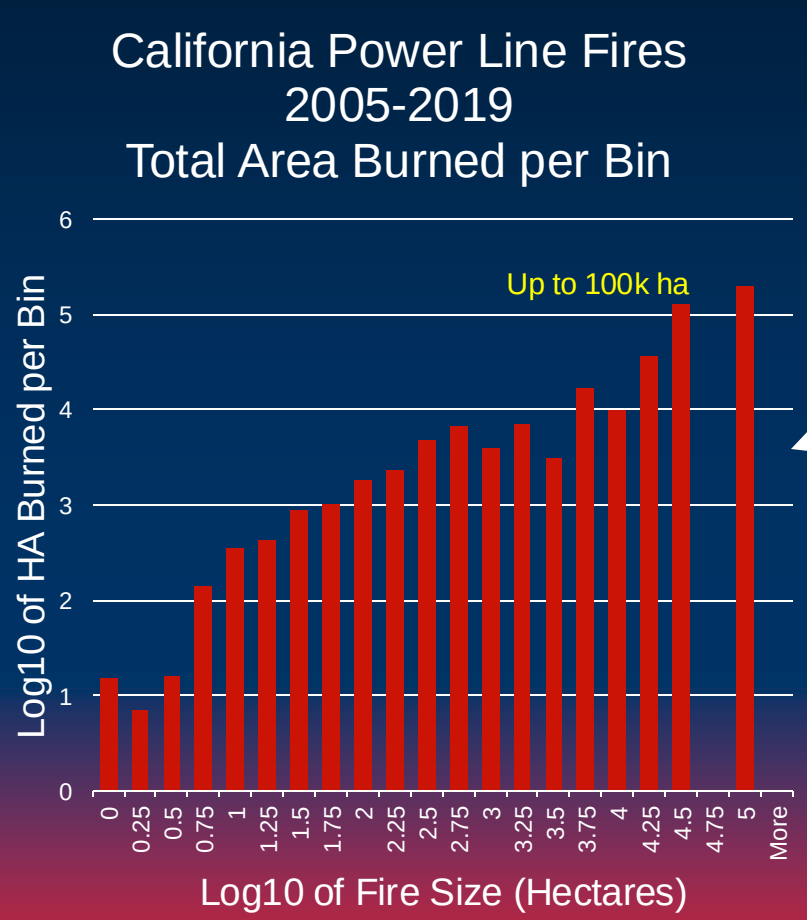




Area, structure, and fatality distributions all follow power law

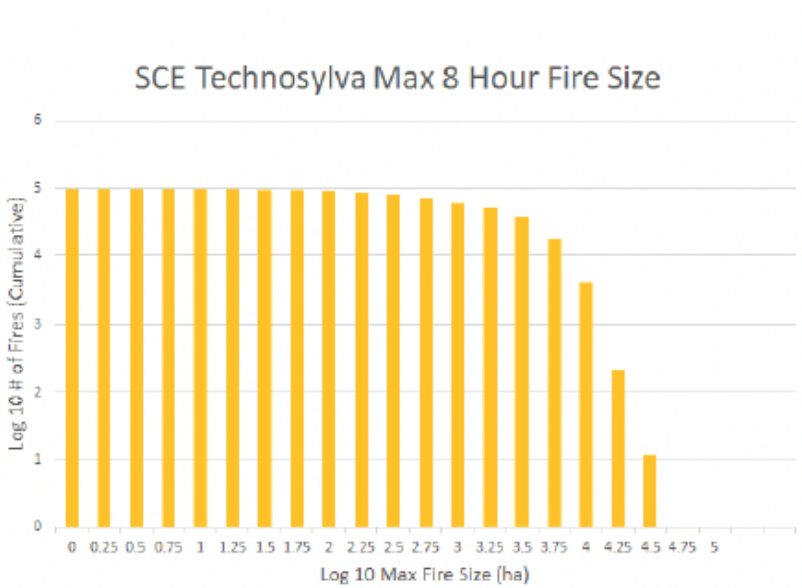
Area Burned as Risk Proxy

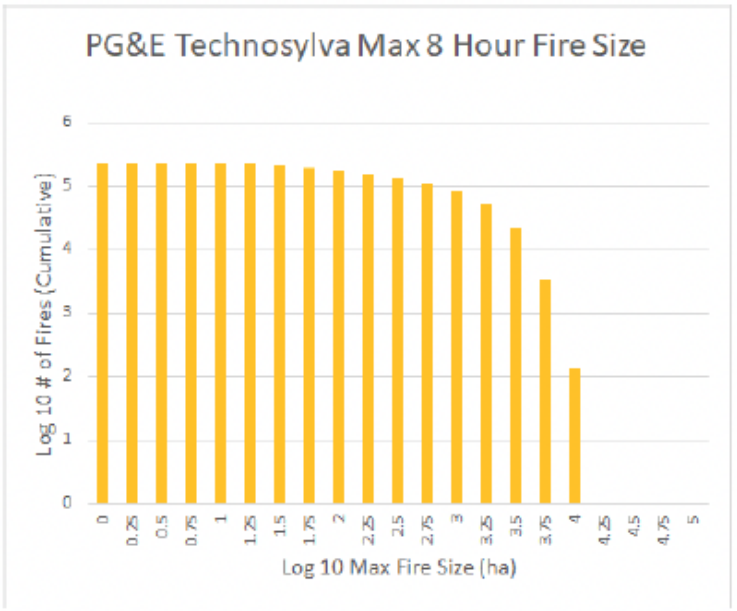




Tail Risk!!!

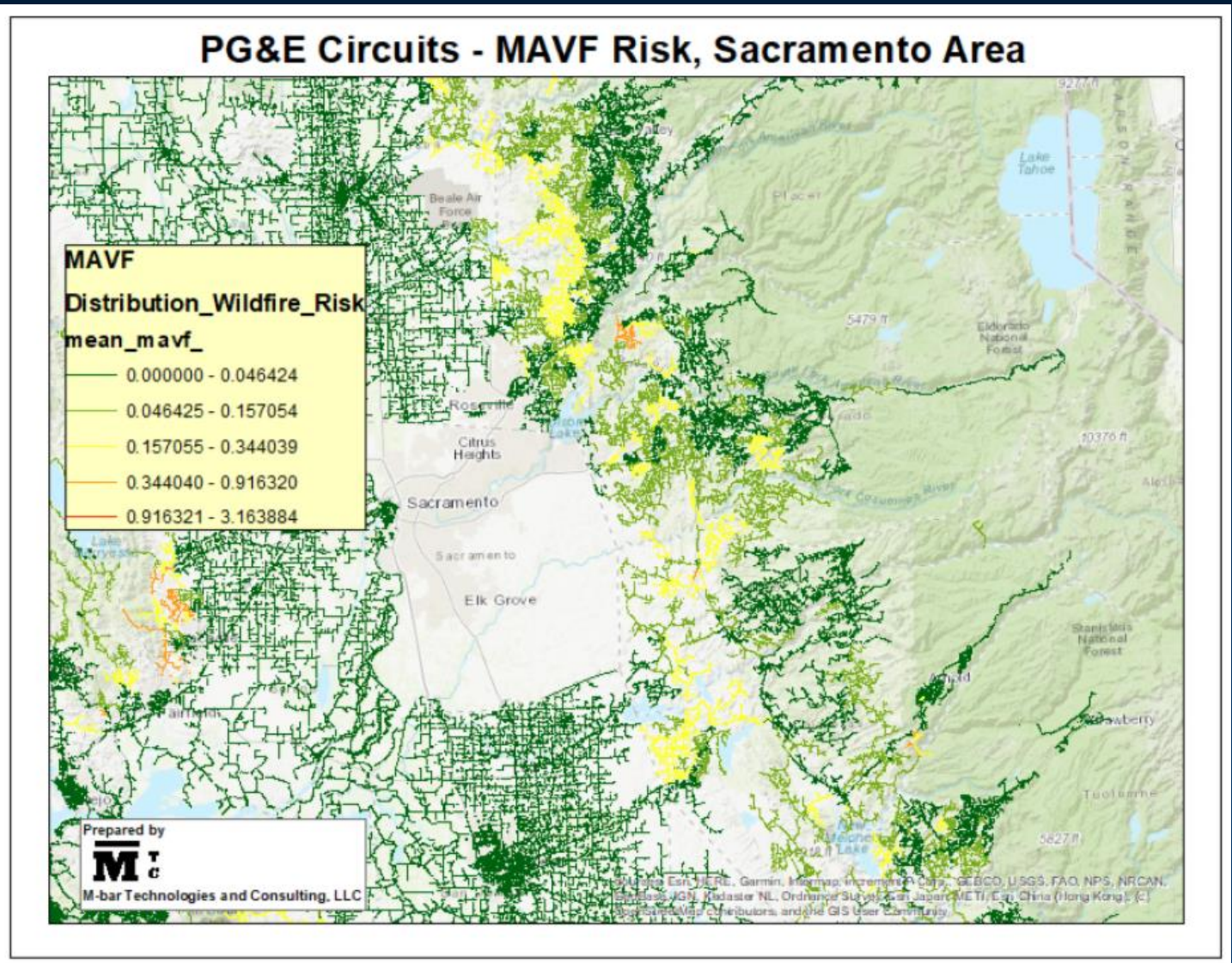
Impact of 8 Hour Fire Spread Limit





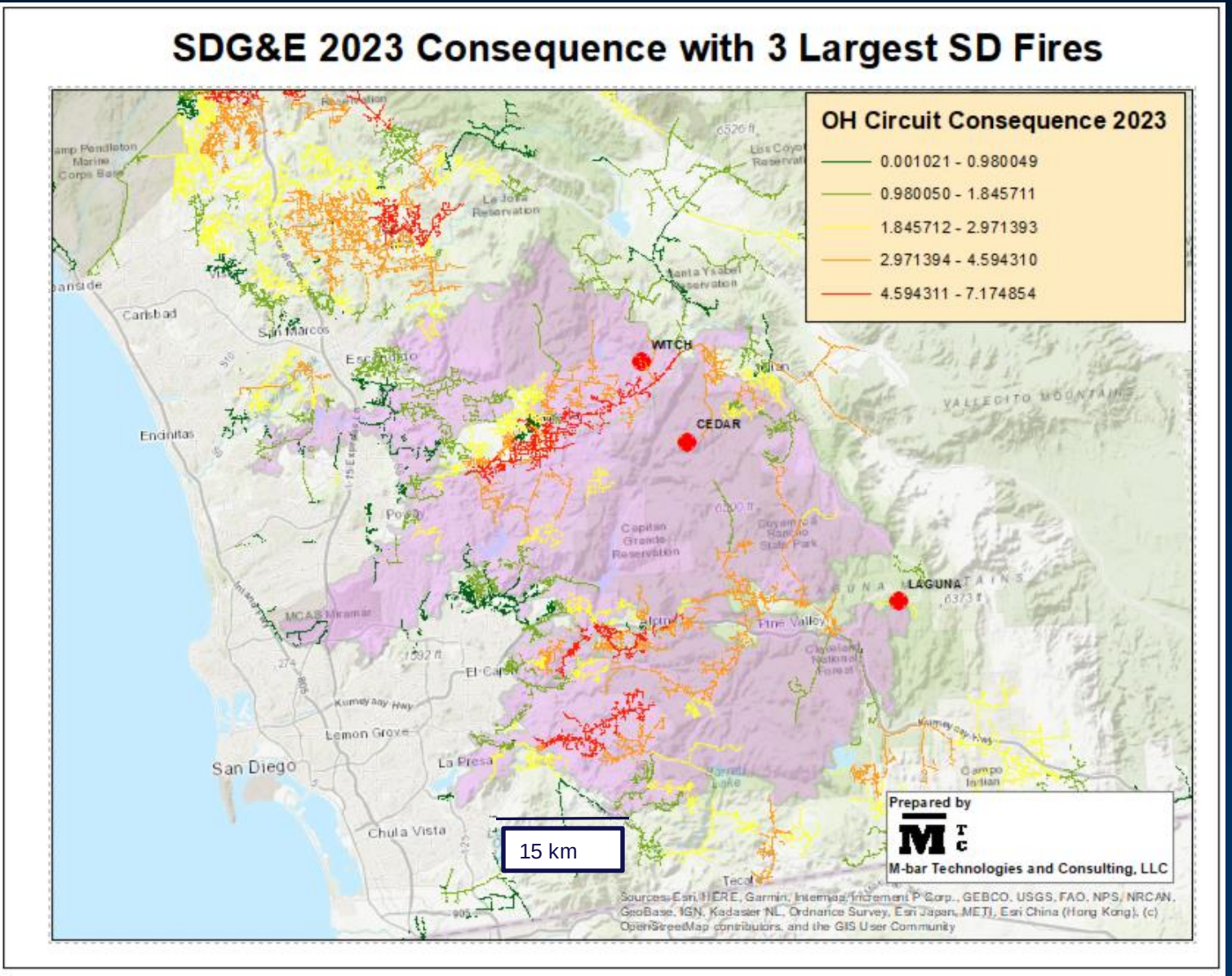
- “Mesa” shape because not weighted for probability
- Upper limits 20k ha PG&E and 10k ha SCE

Implications of Wildfire Size Limit



- PG&E WDRM v2 (old model)
- Consequence model with 8 hour Technosylva limit
- Low risk = dark green
  Moderate risk = light green
  Higher risk = yellow, orange
- “Urbanization” of risk: remote areas where fires start are underweighted

Importance of Large Fires



- Extreme weather events
- Most historical damage from a few large events
- Fire spread models that truncate wildfire growth may significantly underestimate consequences.

Utility Wildfire Mitigations

Covered Conductor

Exponent

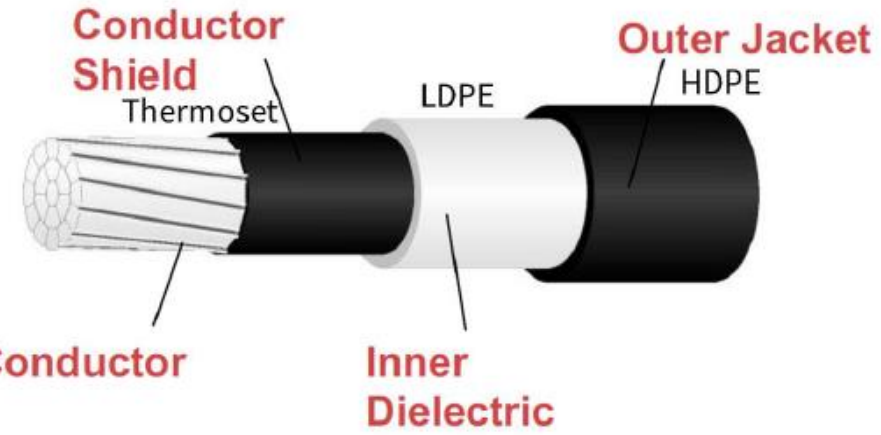


Figure 1. A schematic illustration of a three-layer CC. Diagram modified from Hendrix Aerial Cable Systems [Trager].

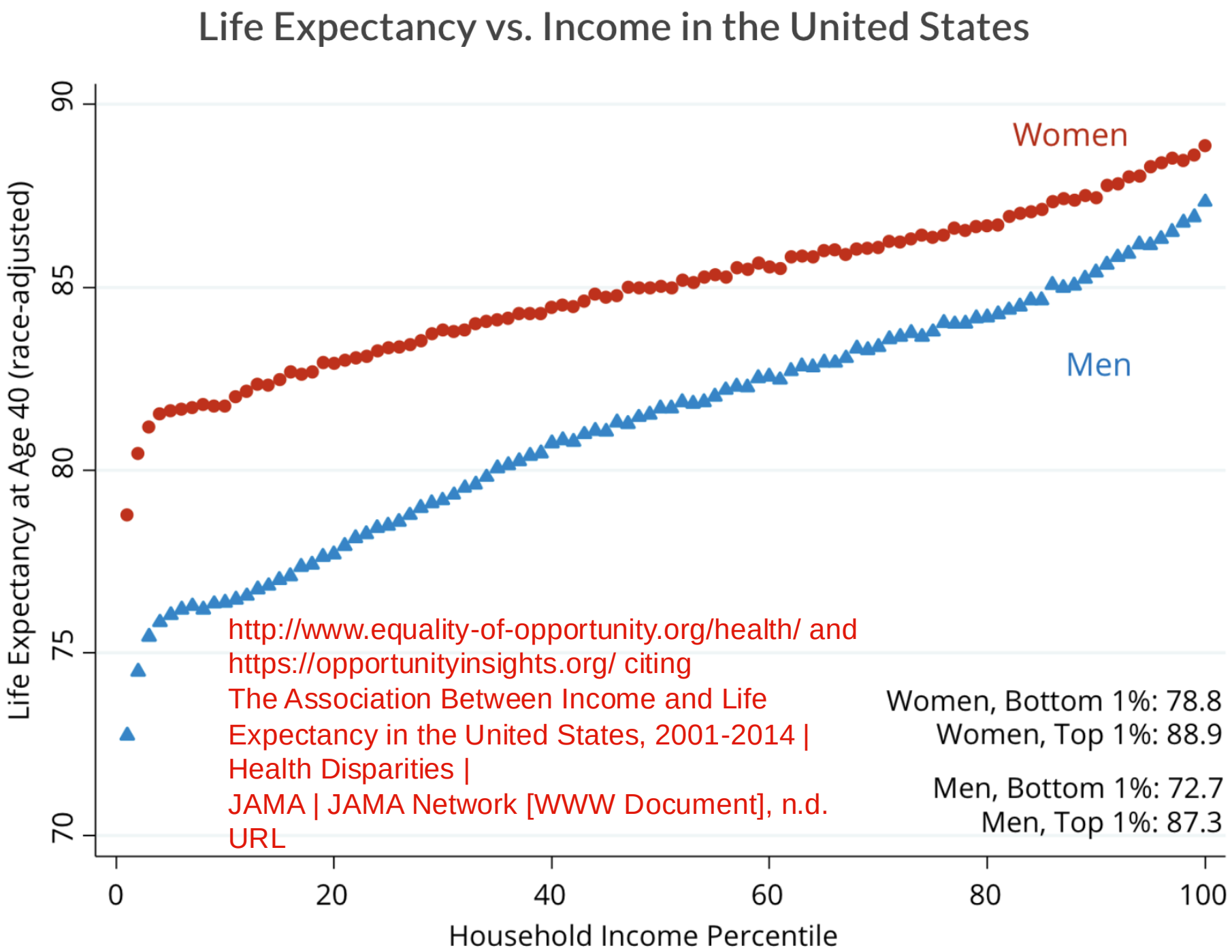
>62% Effective (field data says much higher)
>70% for Drivers linked to catastrophic fire
$350k/km

Undergrounding

99% effective
$1.9 M/km - $50-100B for state
Utilities make 10% on capital spending

+ **ADVANCED TECHNOLOGIES**:

REFCL (Rapid Earth Fault Current Limiter)
Downed Conductor Detection
Falling Conductor Protection
> 90% effectiveness TBD



Rate increases of a few hundred dollars per year may have health effects on the poorest and most vulnerable comparable to wildfire fatalities

MGRA Recommendations

- Minimize undergrounding for most extreme/appropriate conditions
- Massive deployment of covered conductor (SCE did this)
- Retrofit with Advanced Technologies to get to near-undergrounding effectiveness
- Power shutoff with higher thresholds to handle extreme events/black swans
- Active discussions/improvements continuing on risk models.

Thank you

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Extra Slides

A little about me, power line fires, and the CPUC…

- Particle physics research (1981-1996)
- Wildland fire research (home ignition prevention 2002-present)
- CPUC expert witness for neighborhood organization (MGRA – 2007-present)
- Published in Fire Safety Journal, Fire and Materials