Rulemaking (R.) 20-07-013: Phase 3
Workshop #2: July 26, 2023

Tail Risk: Consequence Modeling

California Public
Utilities Commission


NEVER RELEASE
METALLIC BALLOONS.
PREVENT OUTAGES.
SOUTHERN CALIFORNIA
EDISON®

Fire Extinguishers

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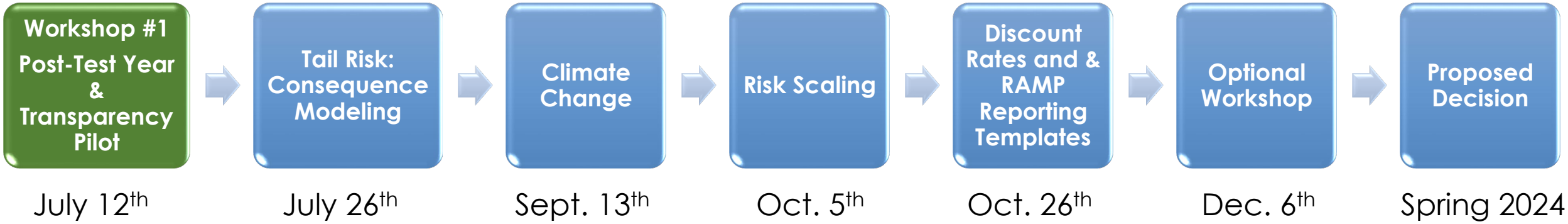
- **National Fire Protection Association**
  - Inspections every 30 days to ensure the unit is pressurized and unobstructed
  - Annual inspection and service by a qualified technician
  - https://www.nfpa.org/News-and-Research/Publications-and-media/Blogs-Landing-Page/NFPA-Today/Blog-Posts/2020/10/30/guide-to-fire-extinguisher-inspection-testing-and-maintenance

Workshop #2 Agenda

Introductions & Purpose and Expected Outcomes of Workshop 2	10:00 – 10:05 am
Tail Risk: Consequence Modeling: MGRA Presentation	10:05 – 10:35 am
Tail Risk: Discussion	10:35 – 11:00 am
Break	11:00 – 11:10 am
General Discussion	11:10 – 11:50 pm
CPUC Close	11:50 am – 12:00 pm

Review of Phase 3 Timeline

Phase 3 Timeline



PURPOSE & EXPECTED OUTCOMES OF THE WORKSHOP

Purpose & Outcomes for Workshop #2

- Discuss the issue of tail risk events, which are known to be low probability, high consequence risk events.
- The power law distribution is one method for addressing tail risk within a risk model.
- Commission Staff must monitor the way tail risks are addressed in Risk Assessment Mitigation Phase (RAMP) filings (D.21-11-009)
- Consider better ways for tail risk to be reflected within the Risk-Based Decision-Making Framework (RDF).
- Attendees will provide feedback on modeling of tail risk events more generally in the RDF and RAMP filings

Party Proposal for Tail Risk: Consequence Modeling

Presenter: Dr. Joseph Mitchell, Mussey Grade Road Alliance

10:05 am – 10:35 am

Tail risk and event statistics for utility planning

Prepared for:
Mussey Grade Road Alliance
R.20-07-013
Risk-Based Decision-Making Framework, Phase III

July 26, 2023

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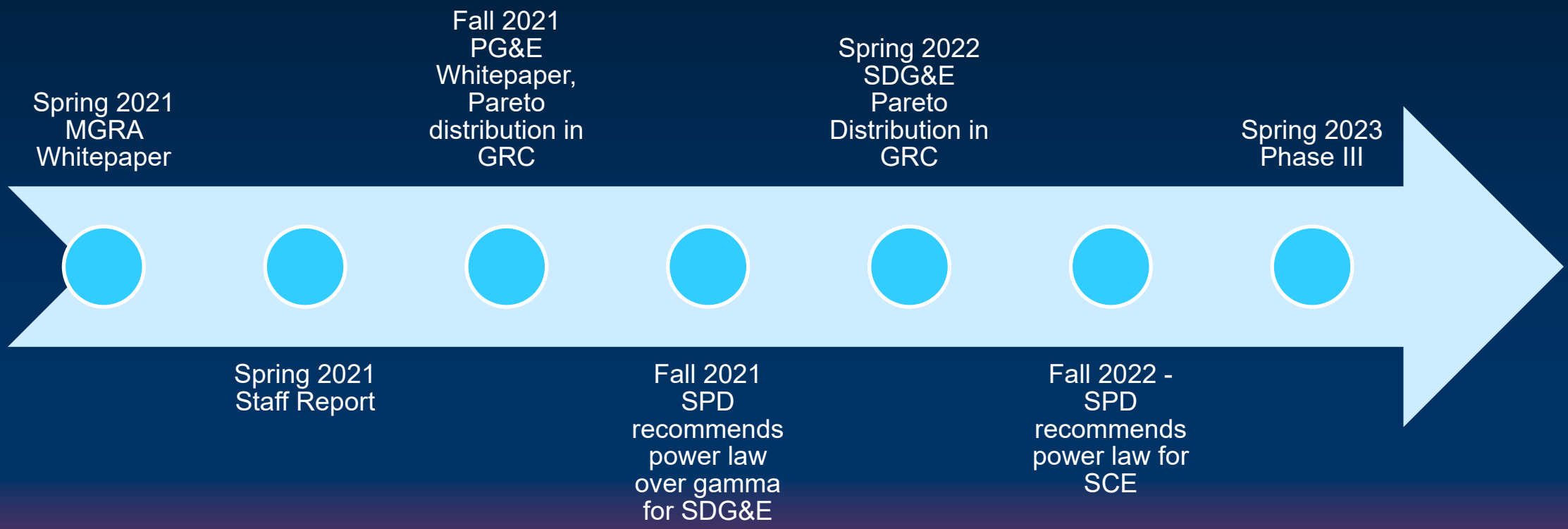
Prepared by M-bar Technologies and Consulting

“Power Law” History R.20-07-013



Questions

- ***How is "tail risk" defined for the purpose of utility wildfire mitigation?***
- ***What might be the consequences of failing to adequately model tail risk in enterprise, planning, and operational models? How significant are these consequences?***
- ***Are there specific drivers of "tail risk" (catastrophic) events or are "tail risk" events simply the limit of a continuous distribution?***
- ***What should be the appropriate cap, or method for determining the appropriate cap, in the case of a truncated power law probability distribution?***
- ***Should the power law probability distribution be required as the baseline distribution function for modeling the consequences of wildfire risk? Should it be recommended as a best practice?***
- ***Does the power law probability distribution appropriately incorporate tail risk events in the wildfire risk, as compared to the use of other distribution functions?***
- ***Currently, power law distributions are applied only to enterprise risk calculations. How can we represent tail risk in 1) planning and 2) operational risk models?***
- ***Should there be any additional reporting requirements or guidelines to accompany the application of the power law distribution to make the results accessible to the layperson?***
- ***Should the use of the power law distribution be required (or other Commission guidance provided) to address other non-wildfire risk events that similarly have low probability, high consequence risk events (e.g., hyrdo dam failure, seismic events, etc.)?***

Critical Phenomena, Power Laws, and Tail Risk

- Landslides
- Earthquakes
- Species Extinction
- Wildfires
- 1/f Noise
- Etc…

Accumulation, Instability, Cascade

Tail Risk:

Most of the damage comes from the most severe events

Per Bak

“self-organized criticality”

“complex behavior in nature reflects the tendency of large systems with many components to evolve into a poised, ‘critical’ state, way out of balance, where minor disturbances may lead to events, called avalanches, of all sizes. **Most of the changes take place through catastrophic events** rather than by following a smooth gradual path”

Power Laws

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

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

- Extreme events dominate the result. “Fat- tailed”, known as “tail risk” in this proceeding

- For $\alpha < 1$, we can’t even predict average from past events. This is important.

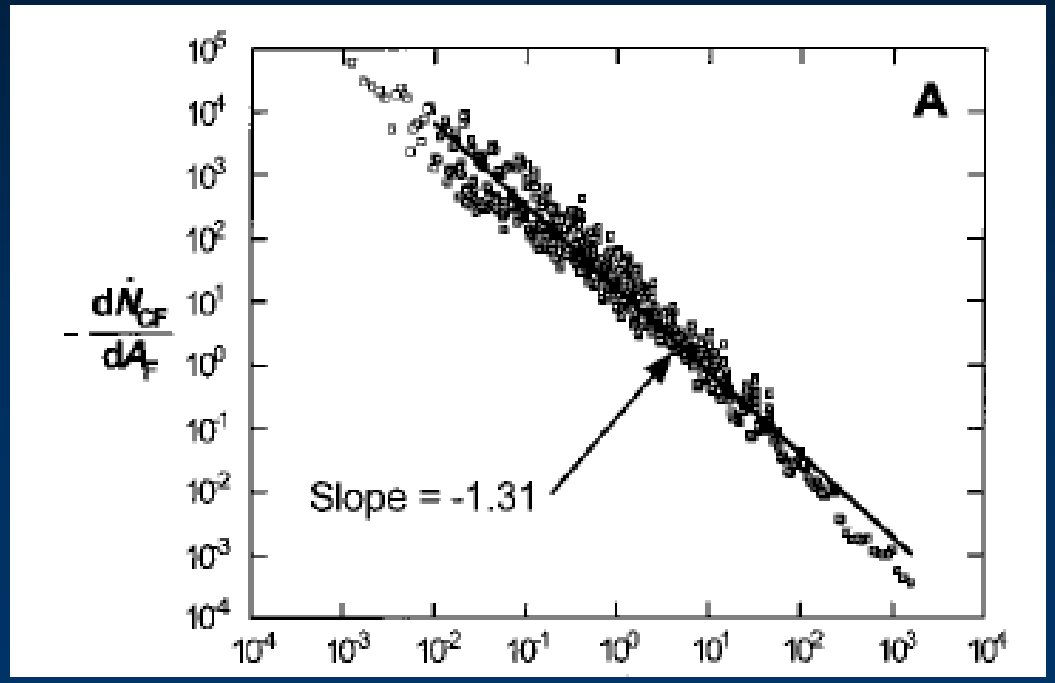
Wildfire and Power Laws

US Fish & Wildlife wildfires 1986-1995

Simple models reproduce behavior

Shows as linear on log-log plot

2% of wildfires do 98% of damage



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

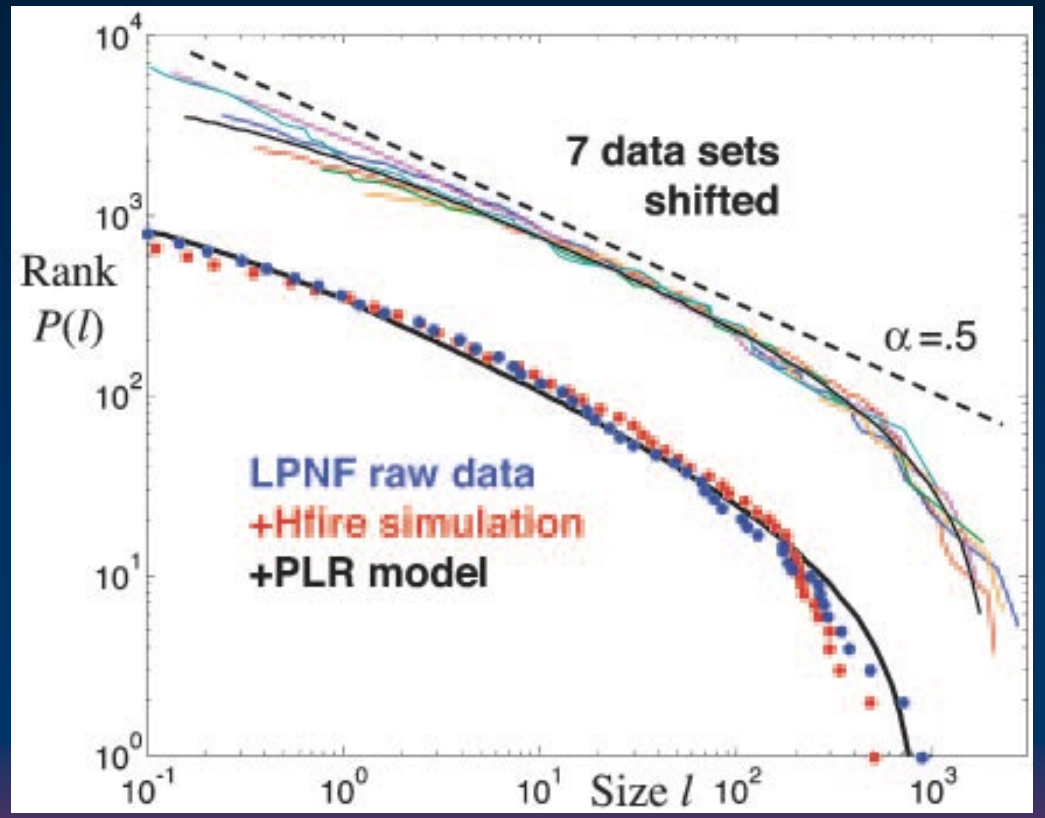
Truncated Power Law with Cutoff

Moritz et. al. 2005

- Larger data set
- PLR/HOT model

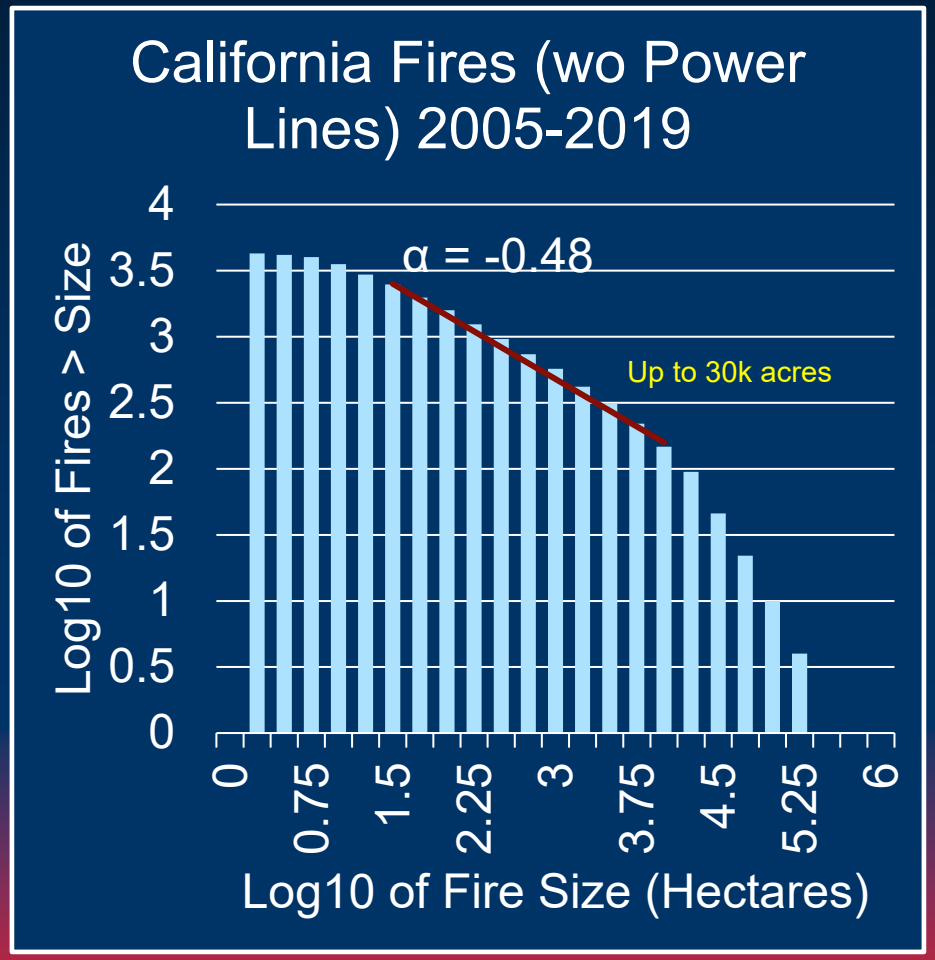
$$y = C[(a + x)^{-\alpha} - (a + L)^{-\alpha}]$$

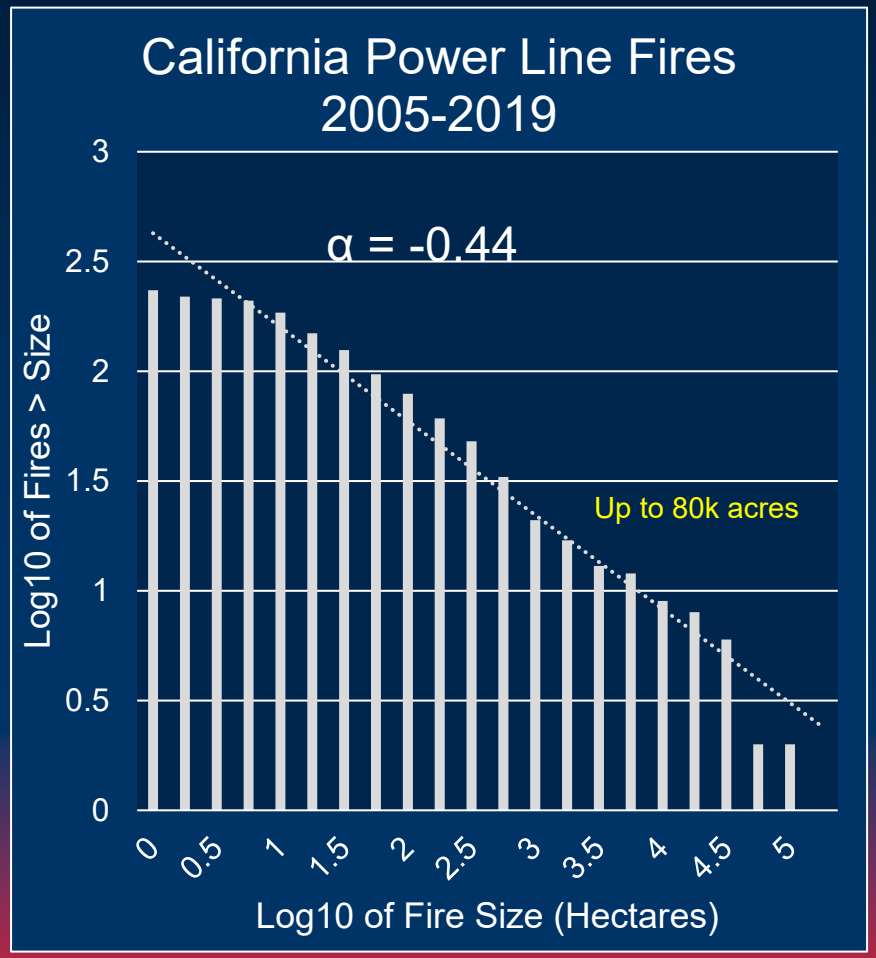
- Cutoff at large sizes (everything burns)
- **α < 1 (!!!!!)**



Moritz, M.A., Morais, M.E., Summerell, L.A., Carlson, J.M., Doyle, J., 2005. Wildfires, complexity, and highly optimized tolerance. Proceedings of the National Academy of Sciences 102, 17912–17917. https://doi.org/10.1073/pnas.0508985102

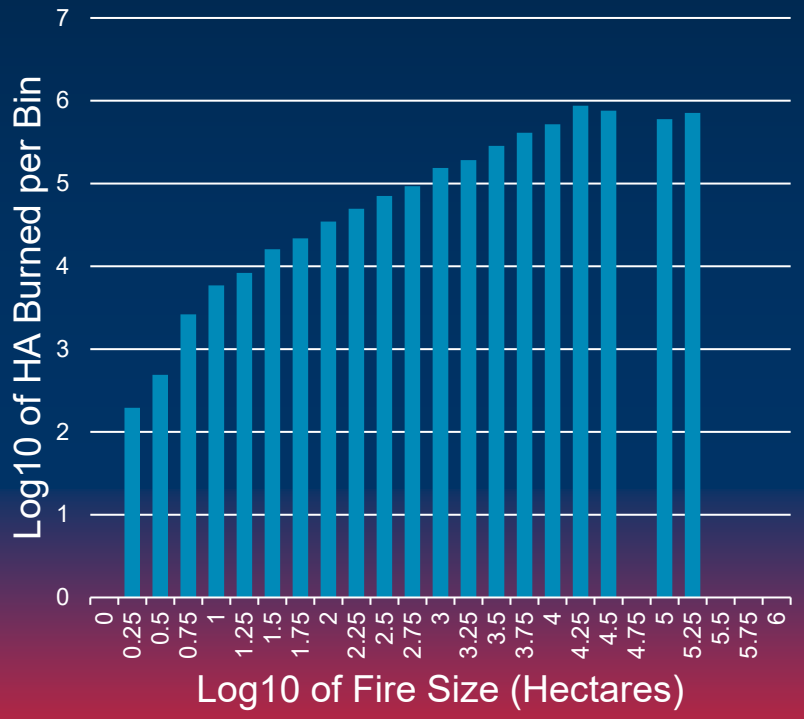
Power Line Fires



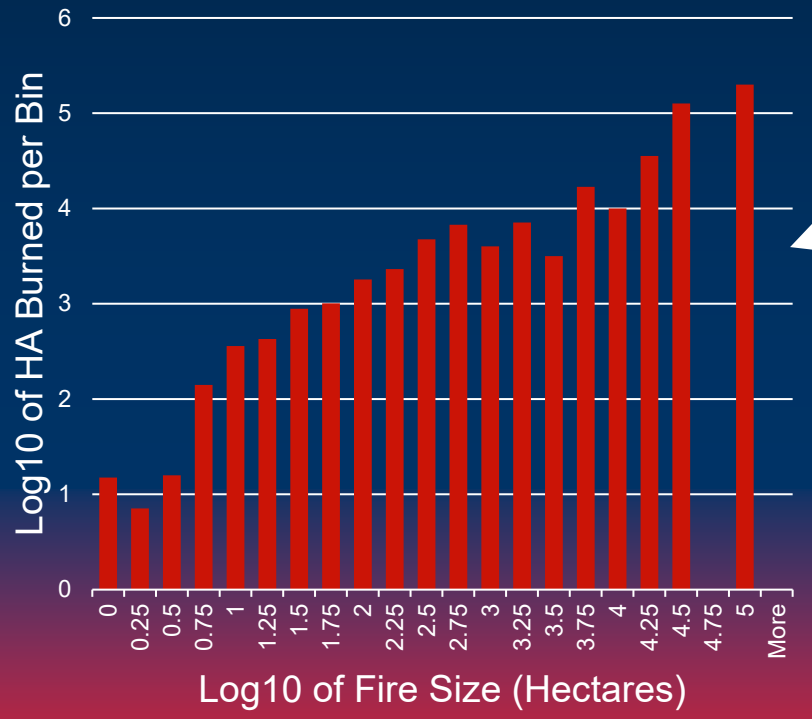


Area Burned as Risk Proxy

California Fires (No Power Line) 2005-2019
Total Area Burned per Bin



California Power Line Fires
2005-2019
Total Area Burned per Bin

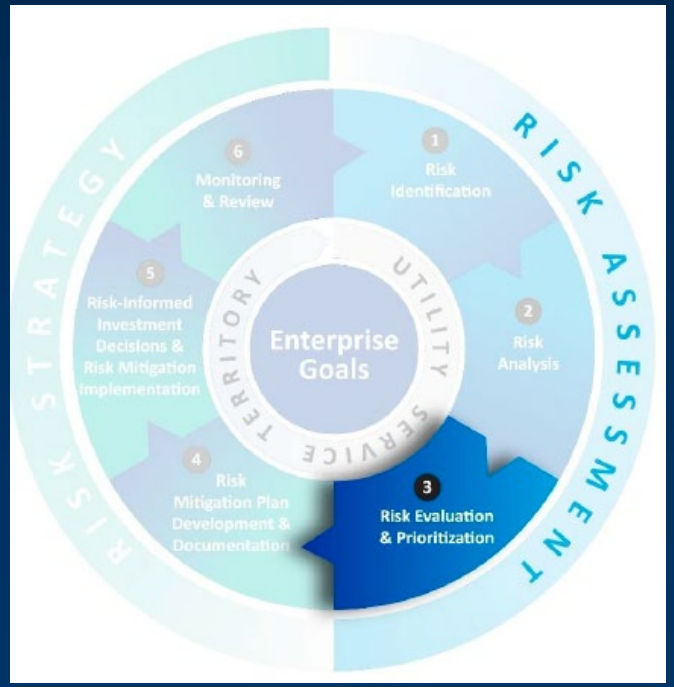


Tail Risk!!!

Use of Power Law vs Technosylva Simulation

Enterprise

- PG&E – PL
- SDG&E – PL
- SCE - 8 hr TS

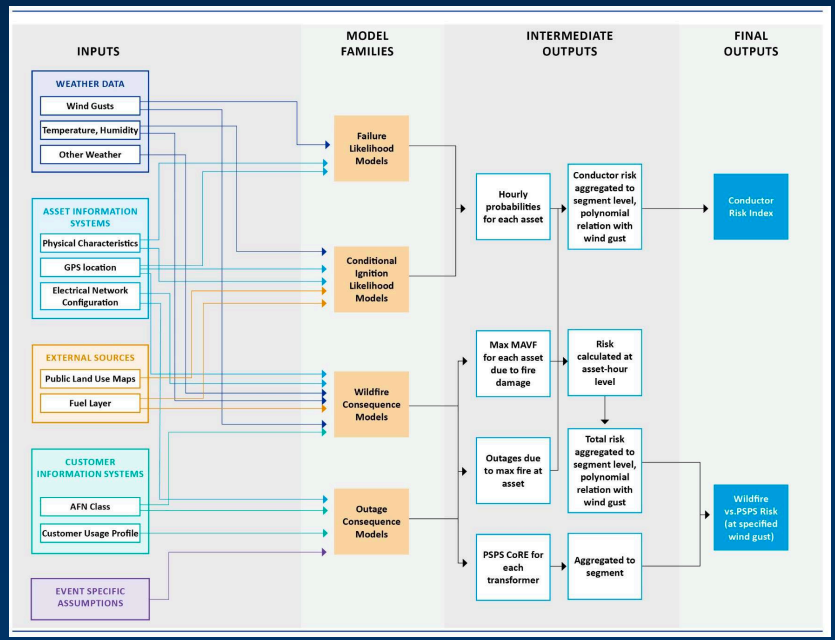


Planning

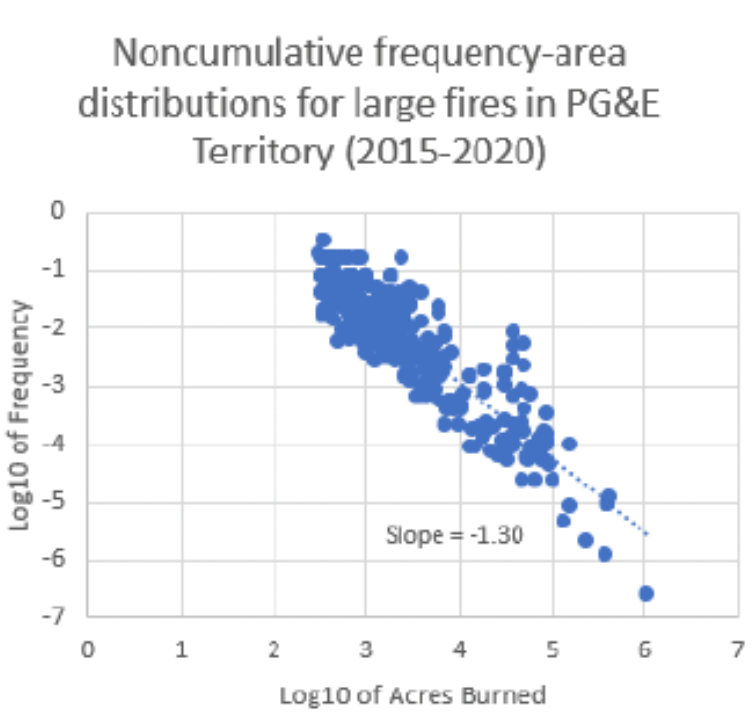
- PG&E – Hybrid
- SDG&E – 8 hr TS
- SCE – 8 hr TS

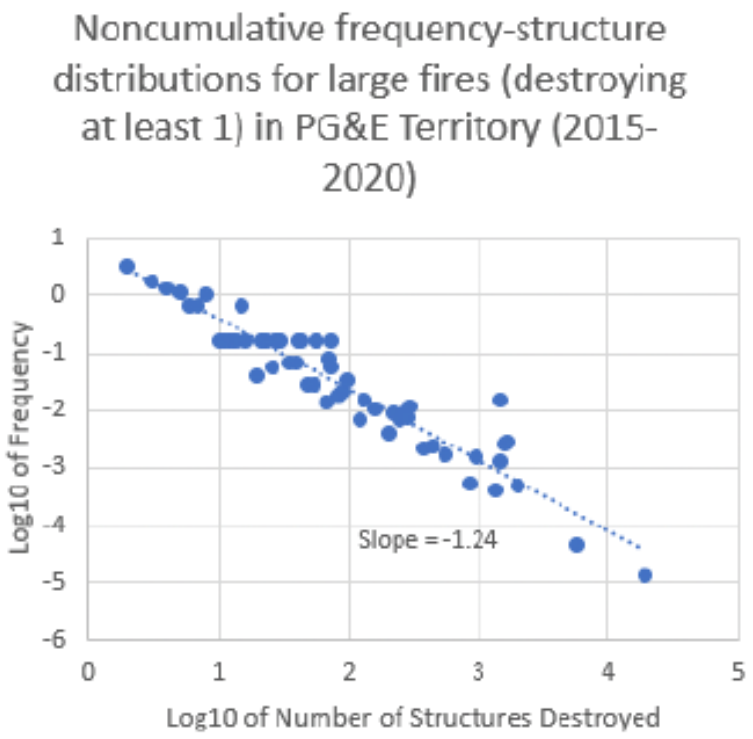
Operational

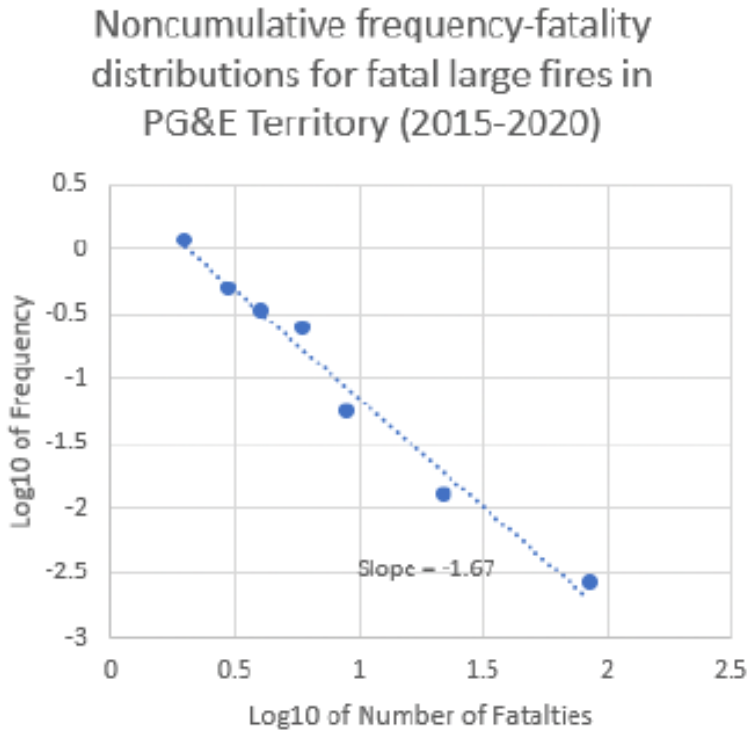
- PG&E – TS ++
- SDG&E – TS ++
- SCE – TS ++



PG&E Whitepaper 2021

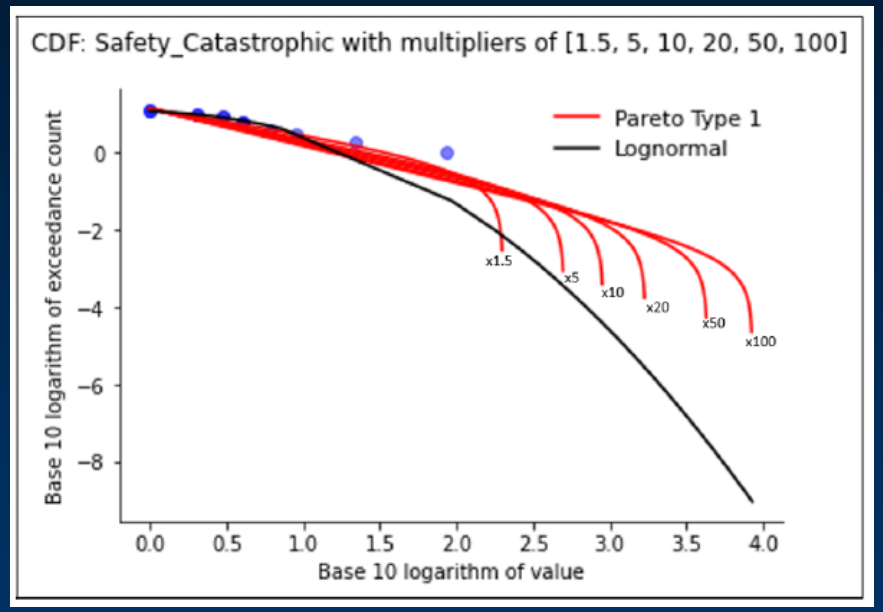






Area, structure, and fatality distributions all follow power law

“Truncated Pareto”



PG&E Whitepaper

Truncated Pareto with cap at 500k acres.

Best fit to tails

Used in enterprise risk model

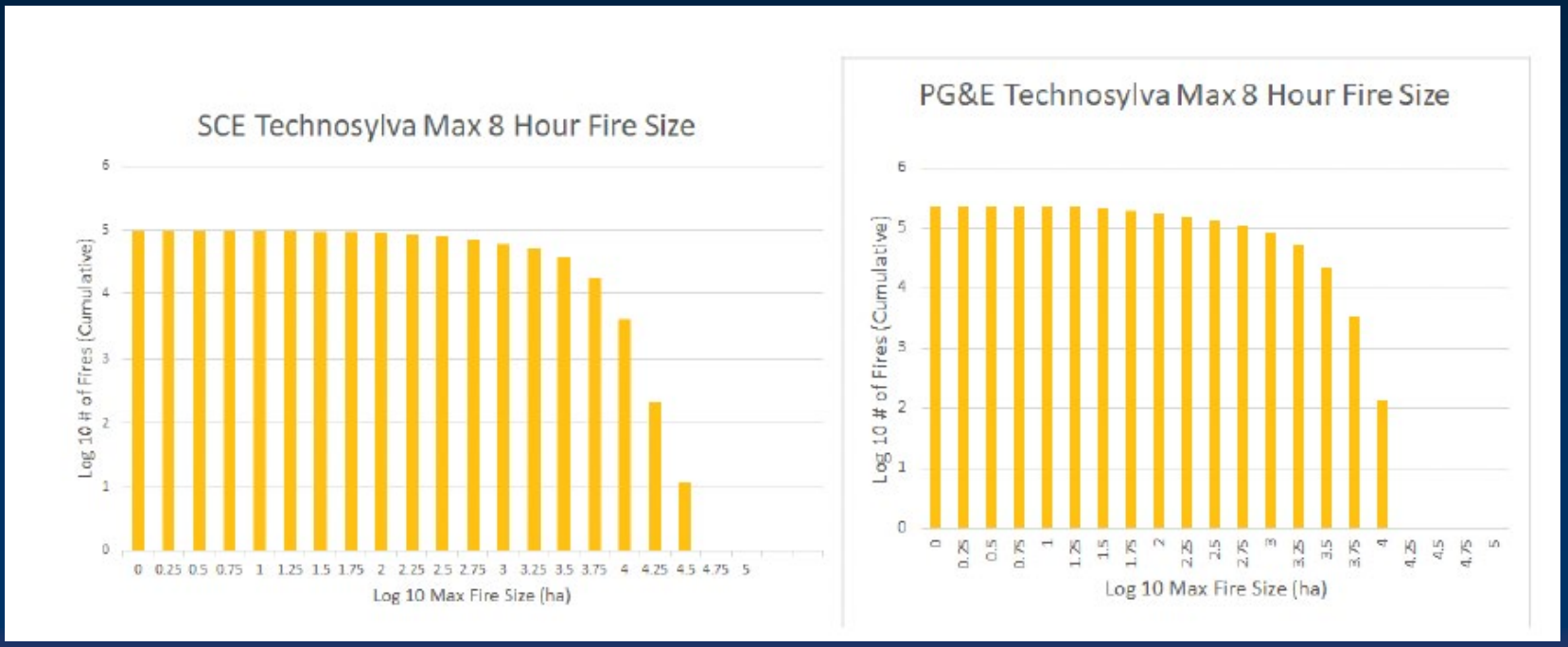
Li and Banerji 2021

Spatial and temporal pattern of wildfires in California from 2000 to 2019

Confirms truncated Pareto provides best fit

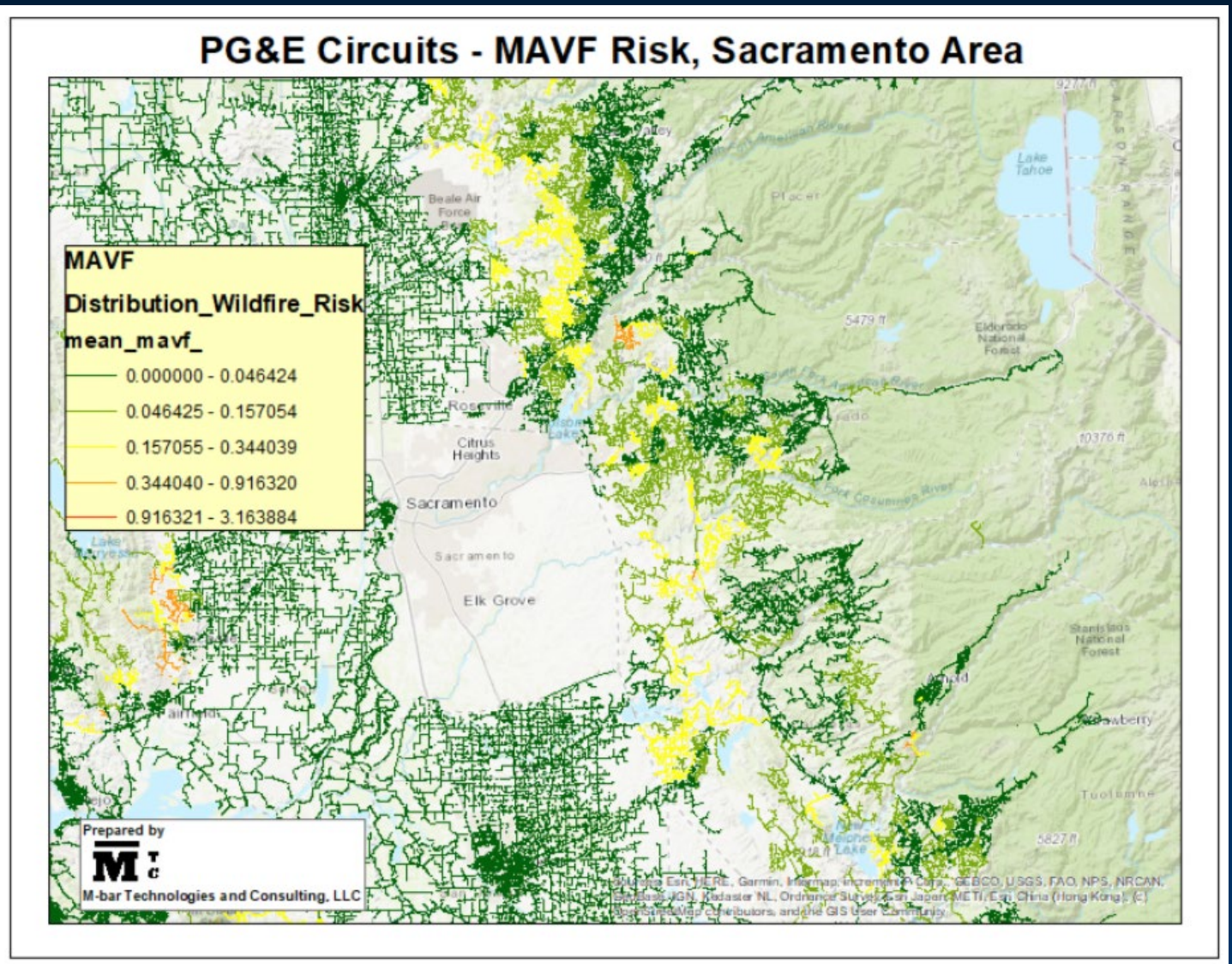
Distribution	Wildfires in 1920–1999			Wildfires in 2000–2019		
	AIC	K-S	CvM	AIC	K-S	CvM
Gamma	186,942.2	0.2967	277.72	75,814.81	0.4713	240.94
Lognormal	178,499.6	0.0234	1.37	69,481.42	0.0869	13.24
Pareto	178,987.2	0.0333	2.38	69,470.16	0.1033	5.69
Truncated pareto	177,643.5	0.0317	3.40	67,562.65	0.0129	0.15
Weibull	180,347.5	0.0764	19.02	71,096.81	0.1637	31.55

Impact of 8 Hour Fire Spread Limit



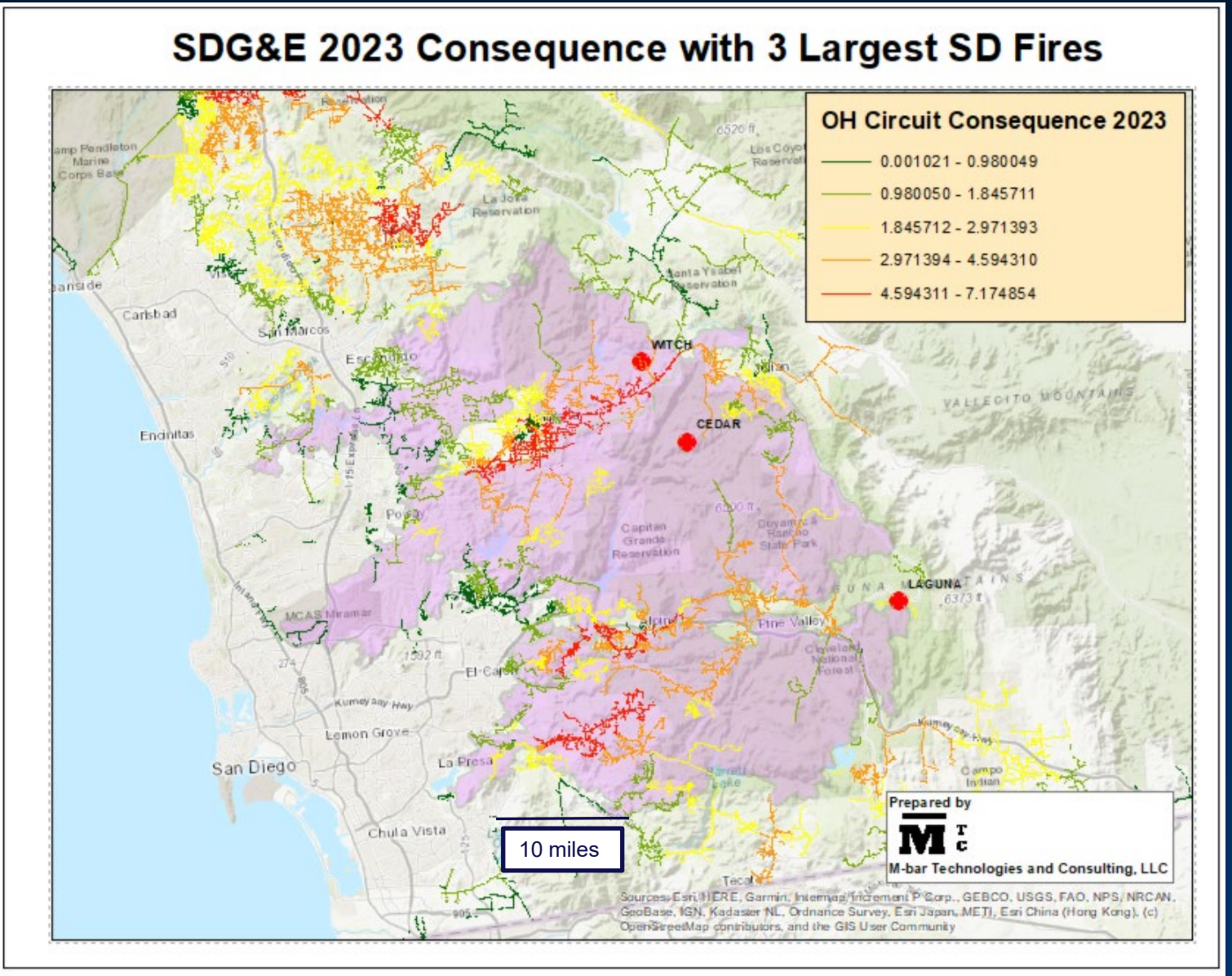
- “Mesa” shape because not weighted for probability
- Should be checked against power law
- Upper limits 50k acres PG&E and 25k acres SCE

Implications of Wildfire Size Limit



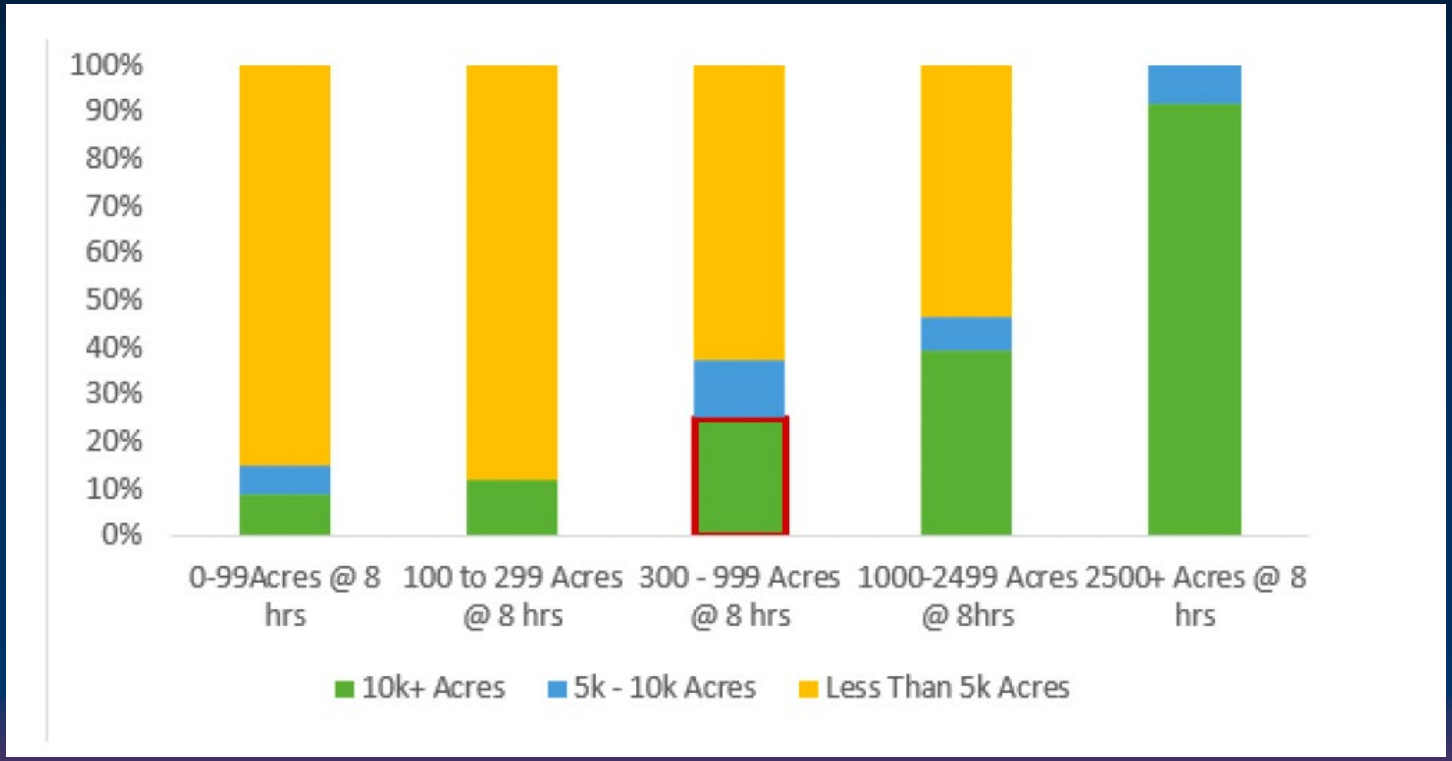
- PG&E WDRM v2 (old model)
- Consequence model with 8 hour Technosylva limit
- Low risk = dark green
  Moderate risk = light green
  Higher risk = yellow, orange
- “Urbanization” of risk: remote areas where fires start are underweighted

Importance of Large Fires



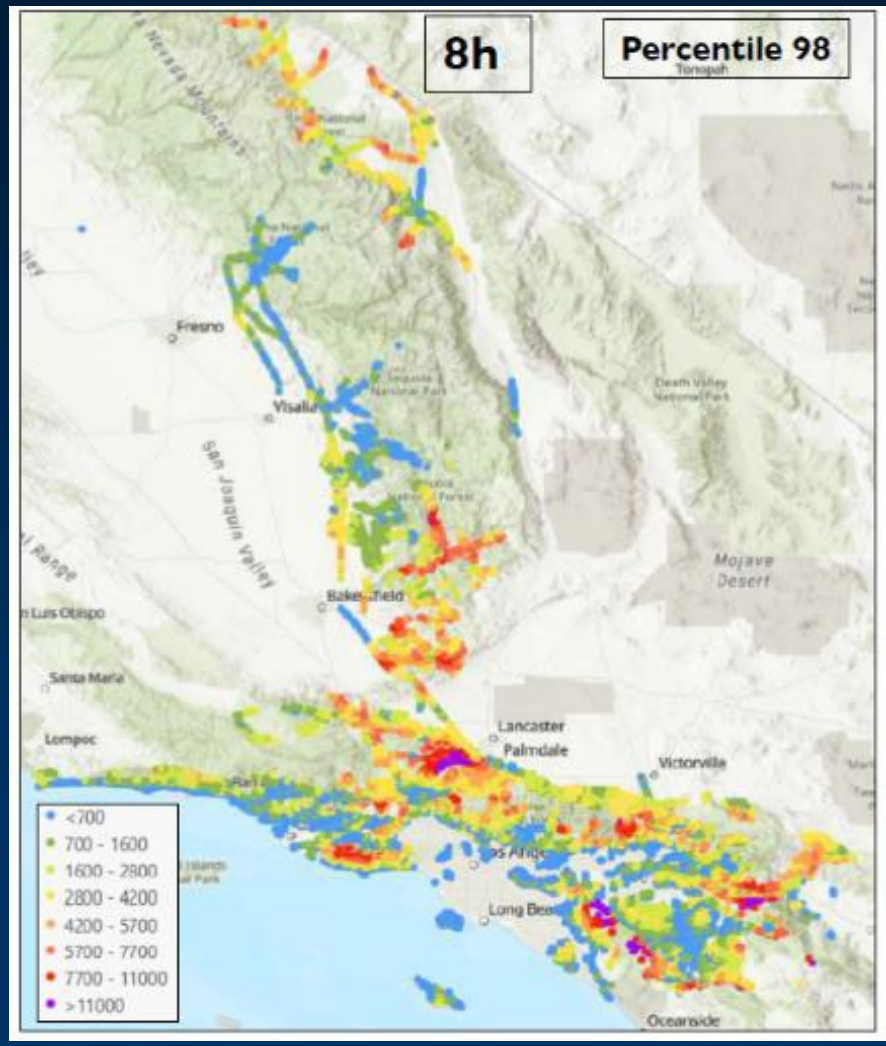
- Extreme weather events
- Most historical damage from a few large events

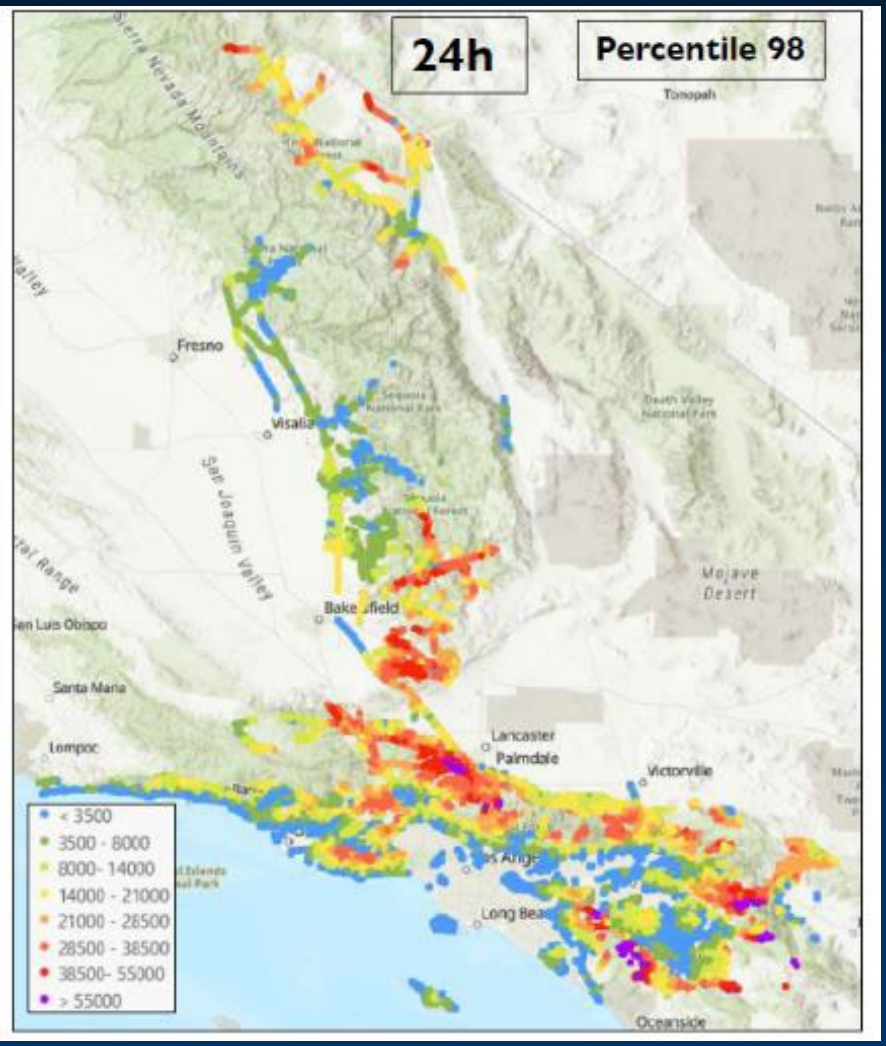
SCE WMP: 8 Hour Study



- Simulation of historical fires
- Claim: can extrapolate final size from 8 hour size
- **Magnitude** of losses increase, but qualitatively the same

SCE : 8 vs 24 Hour Study





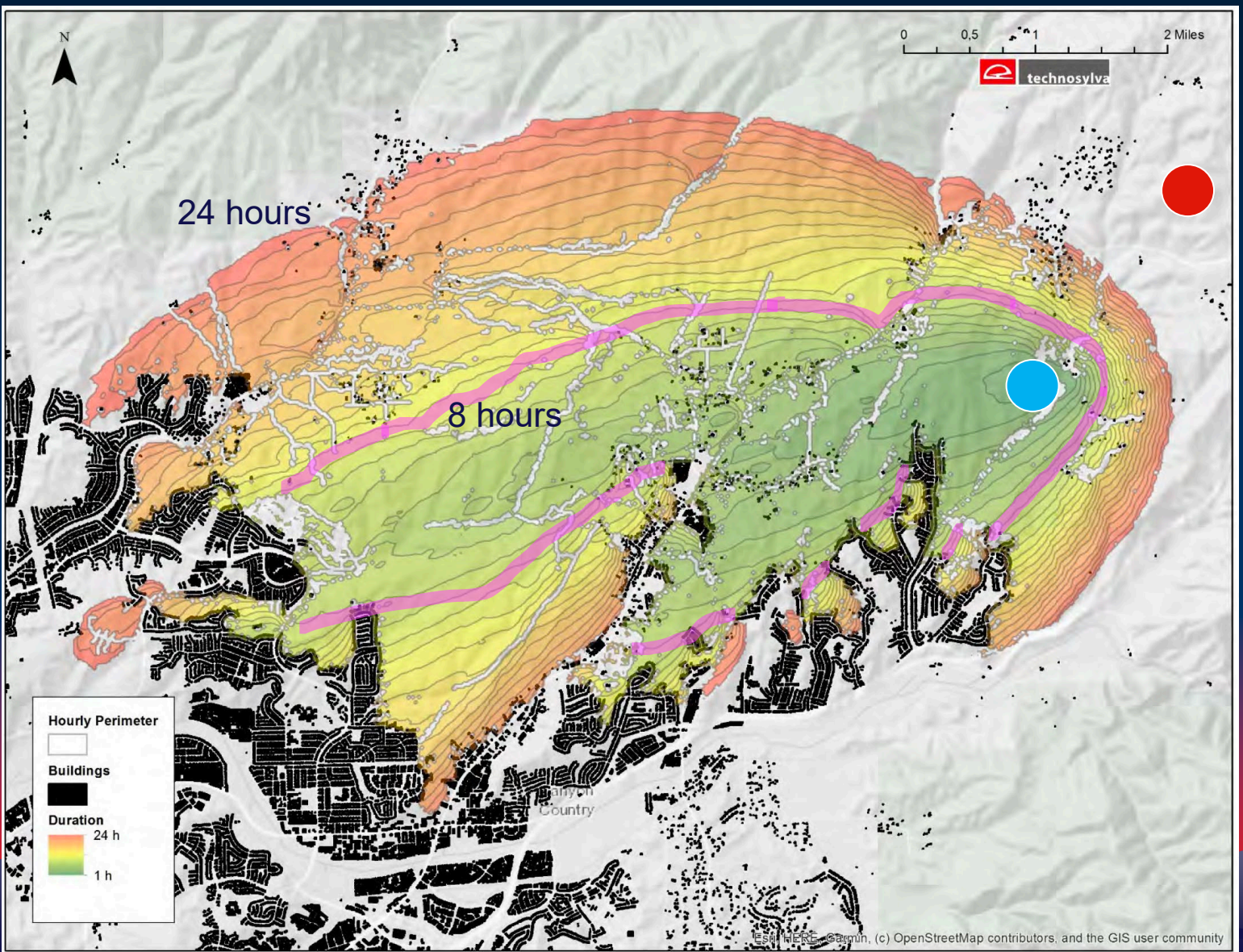
SCE:

- Losses larger after 24 hours
- Shapes essentially the same

MGRA:

- Places where 8 hour and 24 hour differ will be underweighted

8 Hour Versus 24 Hour Simulation



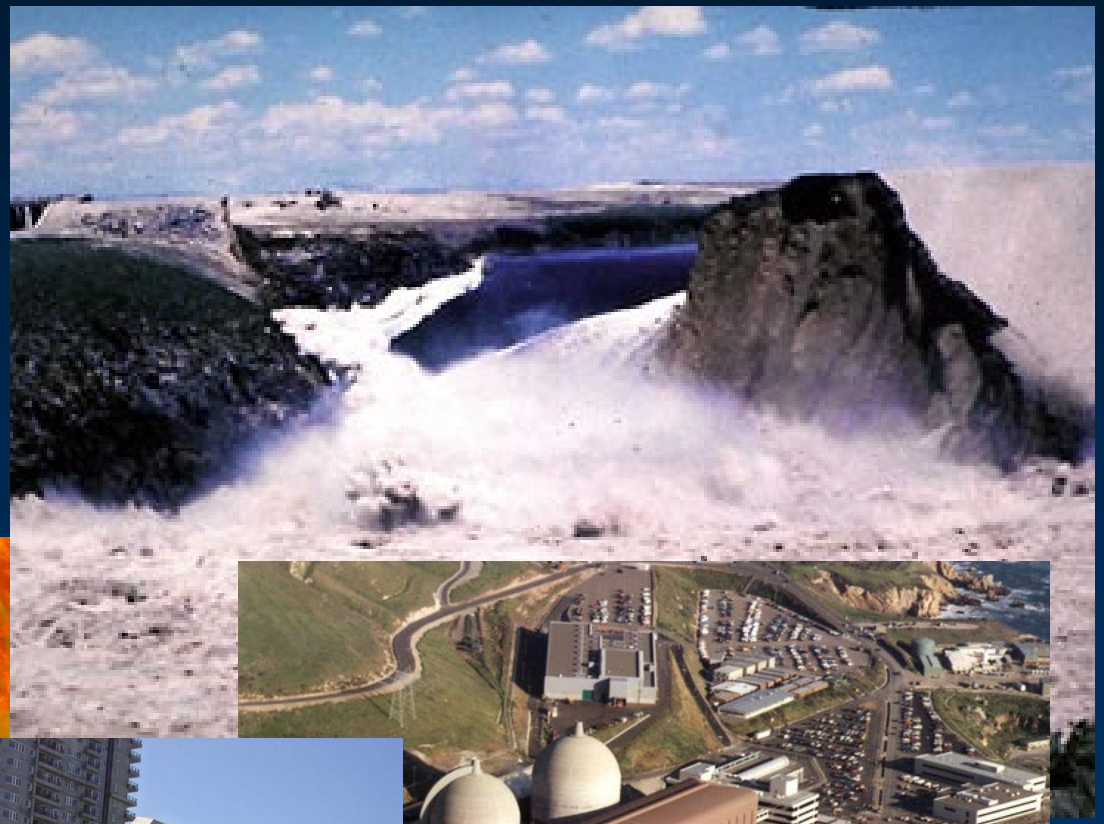
What if ignition point were here?

- Burn areas are limited by geographic barriers
- Barriers reduce 8hr/24 hour shape difference
- If barriers are not reached in 8 hours, will result in significant underestimation of consequence.

- Technosylva report: See 2019 CPUC PSPS post event report data. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/documents/technosylva-report-on-sce-psps-events-2019.pdf

Other Tail Risks

- Power laws specific to certain risk classes
- Other standards specific to engineering disciplines
- Contingency plans – Scenario analysis, tabletop exercises with essential partners



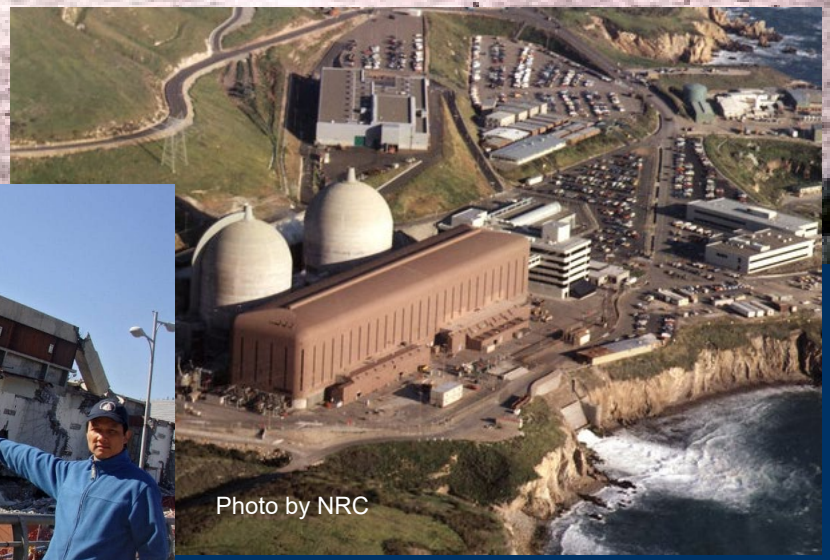


Photo by NRC

Photo by Dr. HungJui Tsai, Taiwan National Ocean University

Summary of Recommendations

Current phase:

- Power law (Pareto) suitable for enterprise risk models
- Current cap of 500k acres good, validate further
- Contingency plans and scenario analysis for all foreseeable tail risks

Future phase/proceeding:

- Validate fire spread modeling against power law
- Incorporation of tail risk (worst case) into planning and operational risk models

Thank you

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Prepared by M-bar Technologies and Consulting

Tail Risk: Discussion

10:35 am – 11:00 pm

Break

11:00 – 11:10 am

Discussion

11:10 am – 11:50 pm

Planning Questions

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Planning Questions (Cont.)

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CPUC Close and Next Steps

11:50 pm – 12:00 pm

Next Steps

1. Workshop Recording on Youtube (3-4 days)

   https://www.youtube.com/user/CaliforniaPUC

2. MGRA Files Tail Risk Proposal (August 1)

3. Workshop #2 Opening Comments (September 8)

4. Workshop #2 Reply Comments (September 15)

Thank you!

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