Power Lines and Wildland Fire

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Prepared by M-bar Technologies and Consulting

Cost of power line fires – Oct. 2007

- 9 out of 20 fires alleged to have been started by power lines.
- Witch Fire burned 197,990 acres, destroyed 1,650 structures, valued at over $236 million, costing taxpayers $18 million in suppression costs. There were two civilian fatalities, 40 firefighters injured.
- Insurance Commissioner estimated that overall claims will exceed $1.6 B for all Oct. 2007 fires (most losses are from power line fires).
- Almost 100,000 acres that burned in 2003 in San Diego burned again in 2007 and are threatened with permanent habitat loss.

Wind and Power Lines

Santa Ana Winds

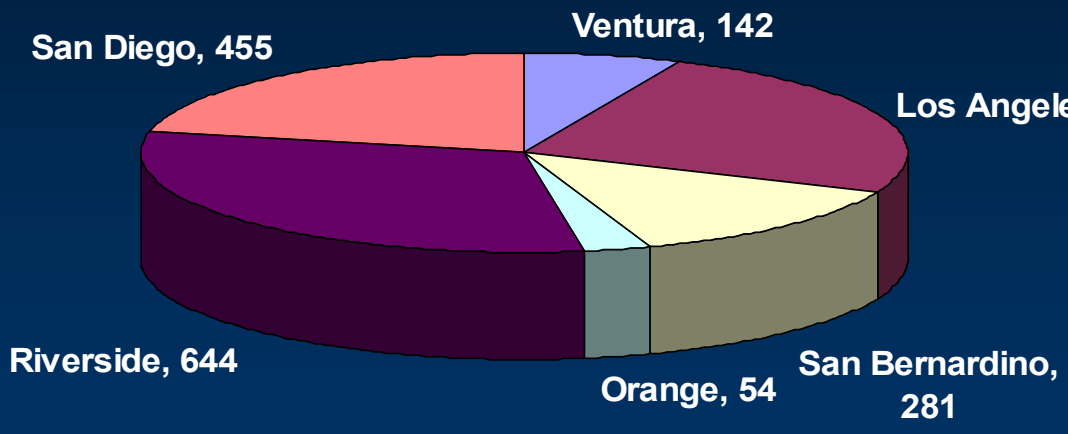
(strong wind, low humidity)

Catastrophic Wildland Fire

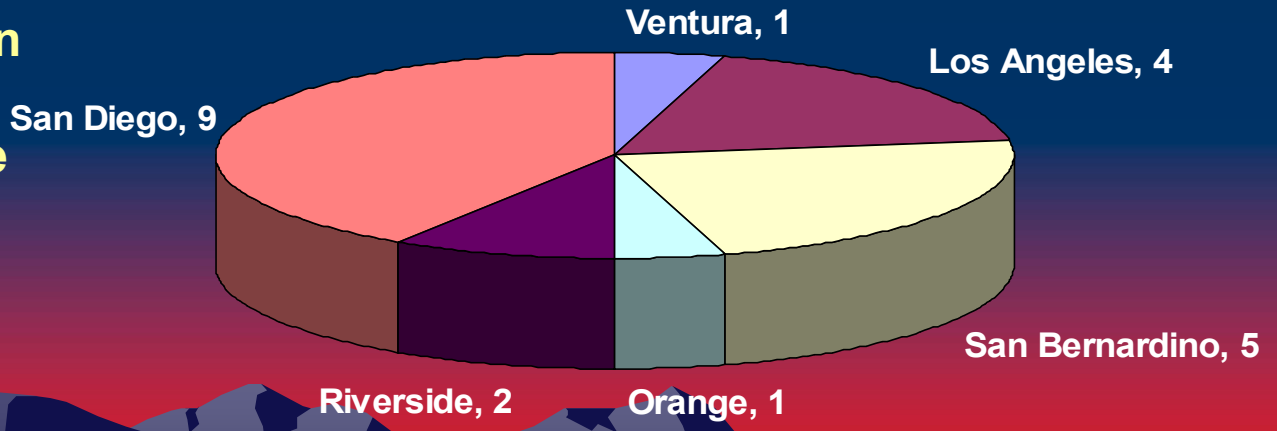
Where do they occur in S. CA?

Fires since 1960, >100 acres

All Wildland Fires

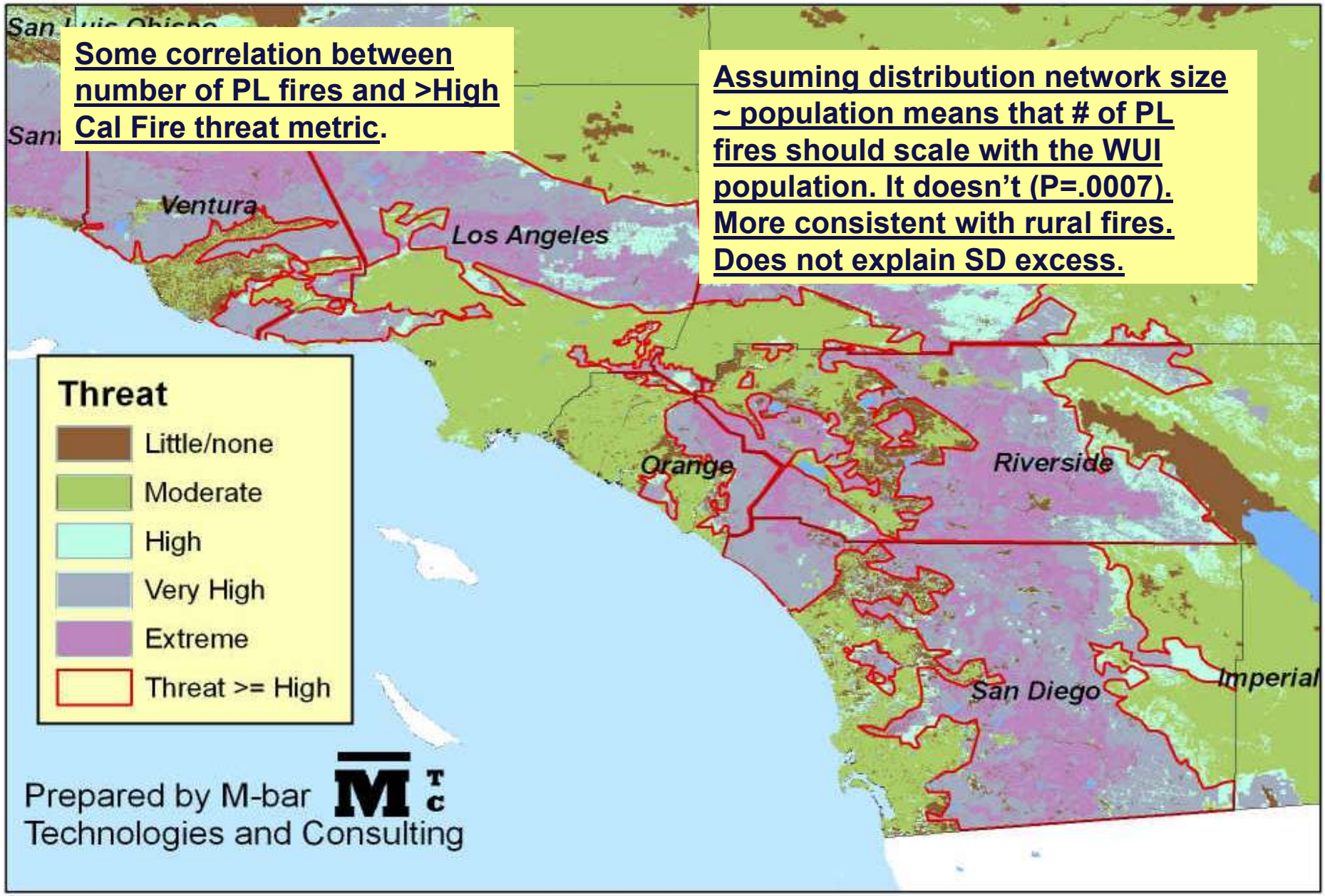


Power Line Fires

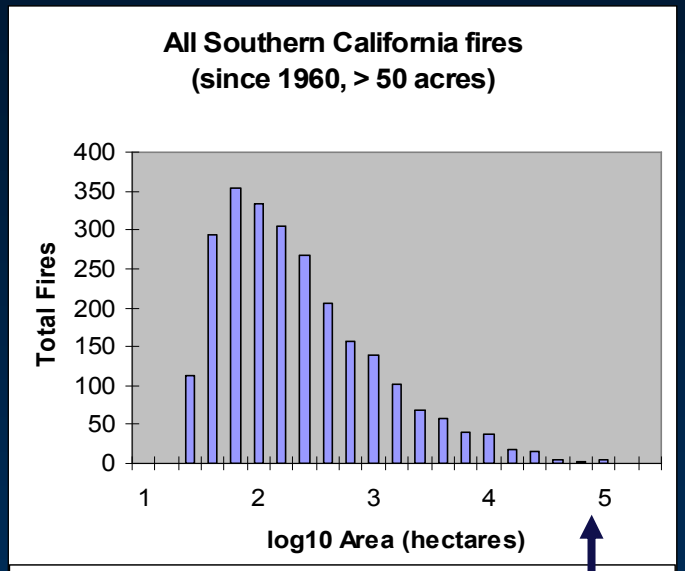


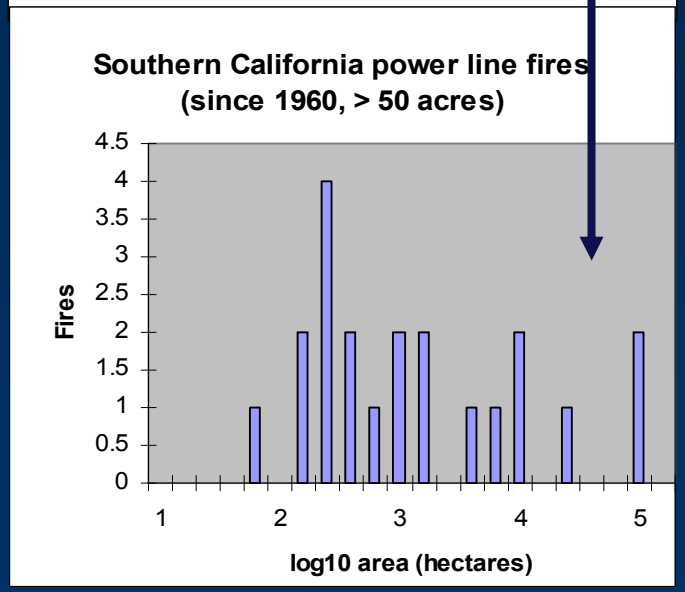
Excess of power line fires in San Diego County:
-partially explained by large area of high fire risk
-but NOT by WUI exposure

Cal Fire Threat Zones in Southern California



Power line fire sizes

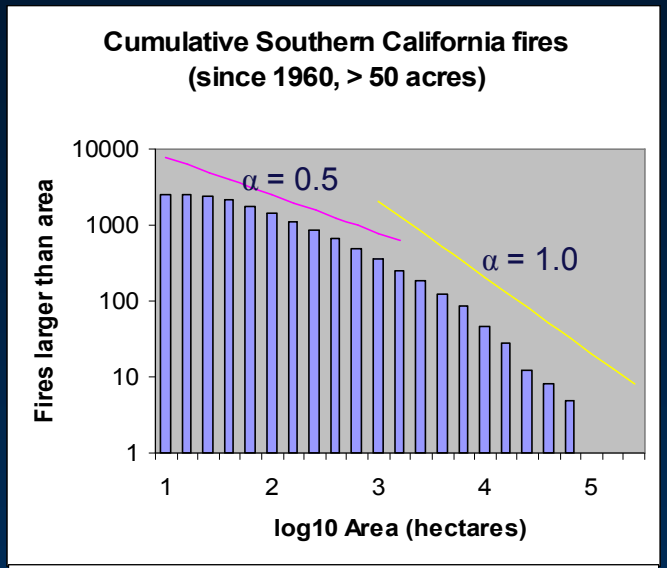


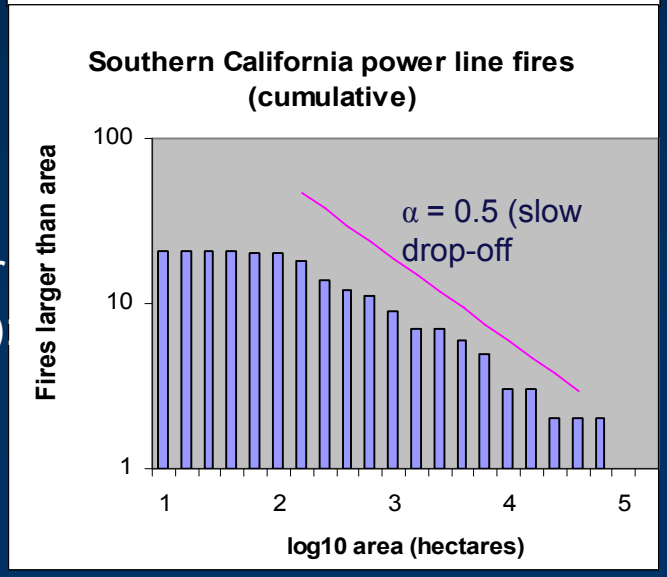


Power line fires fires more likely to be large; fewer medium-sized.

Scaling exponents:

Carson & Doyle:
(HOT models)
-0.5 (variety)
-1.0 (California)
Moritz et al. (HOT)
-1.0 (California)
Boer et al. (weather severity correlation)
-0.32 to -0.64 (Australia)



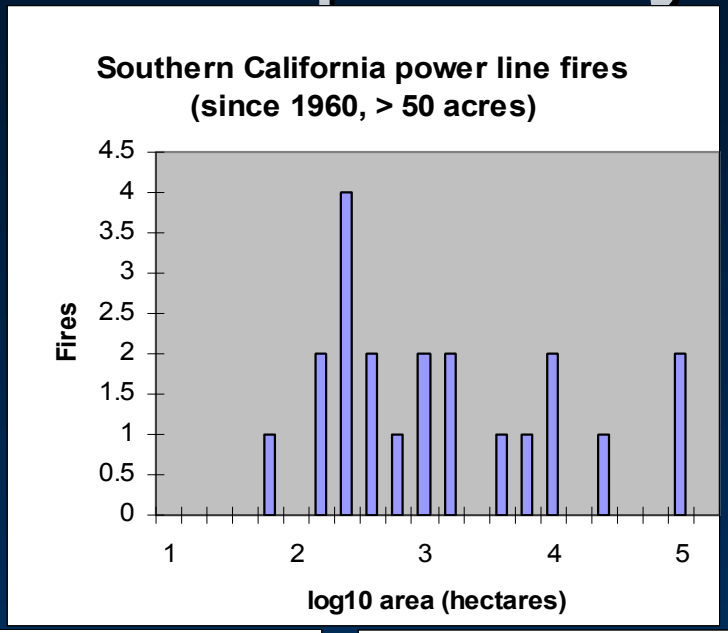


Summary: Power Line Fires are Larger (10X)

Totals for all Southern California

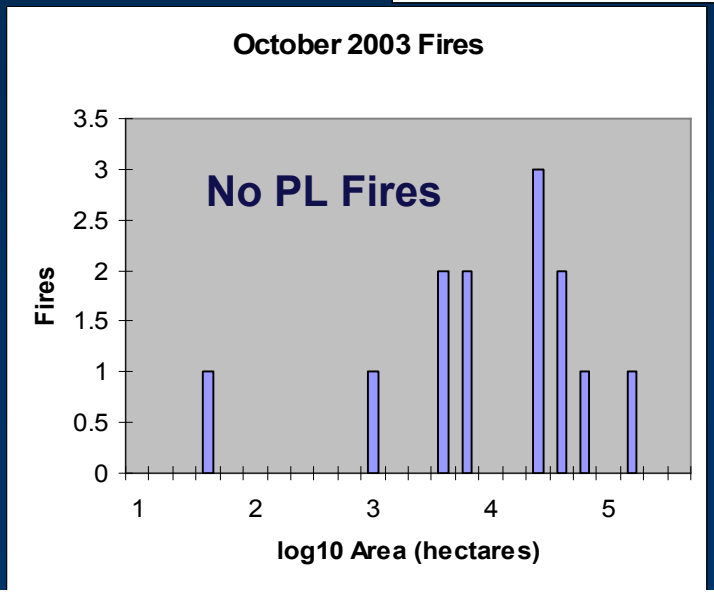
Fires (since 1960, >40 ha)	2,090
Area burned (ha)	2,376,369
Average size (ha)	1,137
Power line fires	22
PL area burned (ha)	239,407
PL average size (ha)	10,882
Fraction PL fires	1.05%
Fraction PL area / total	10.05%

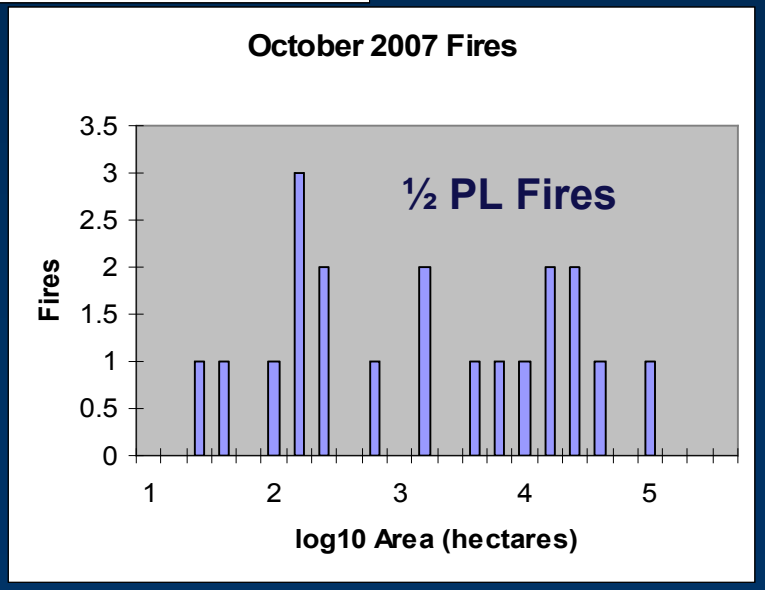
Wind: The primary cause



Comparison of power line fires with 2003 and 2007 fire storms shows a similar size distribution.

Implicates wind as the primary cause.



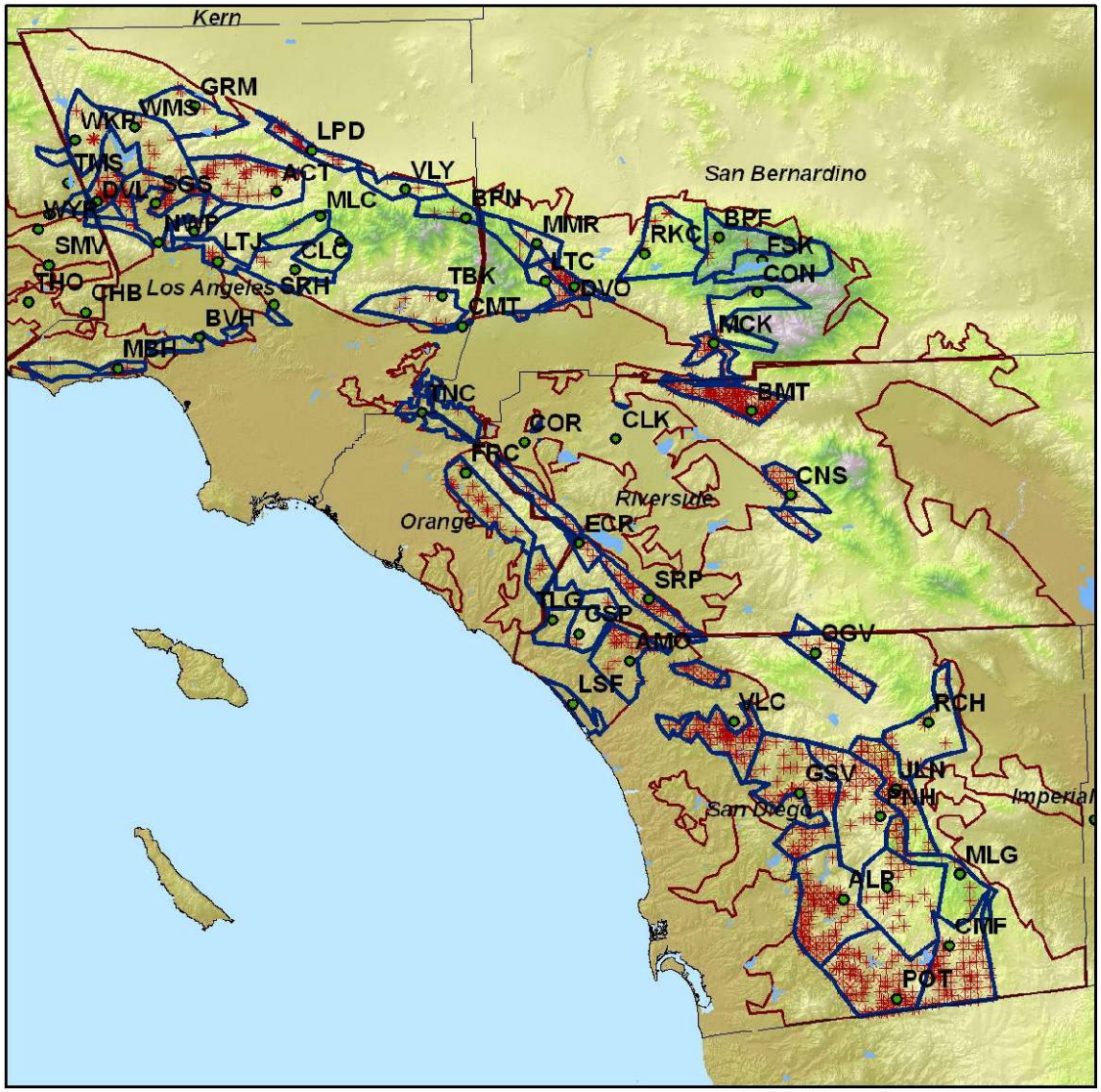


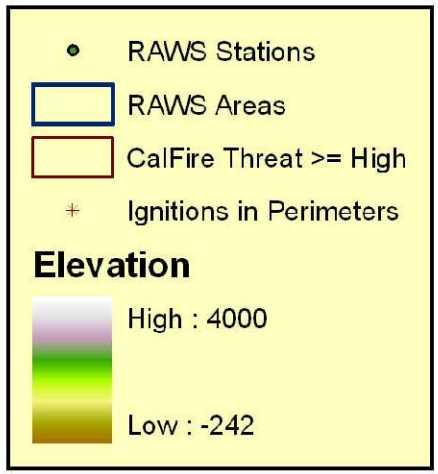
Wind and Fire Suppression

How does the wind affect the ability of firefighters to contain fires (of any type)?

- Use weather station data
- Use Cal Fire ignition history
- Use Cal Fire vegetation (Fire Threat) maps

Ignitions Near Weather Stations, 1998-2008





Ignition data courtesy of Cal Fire.

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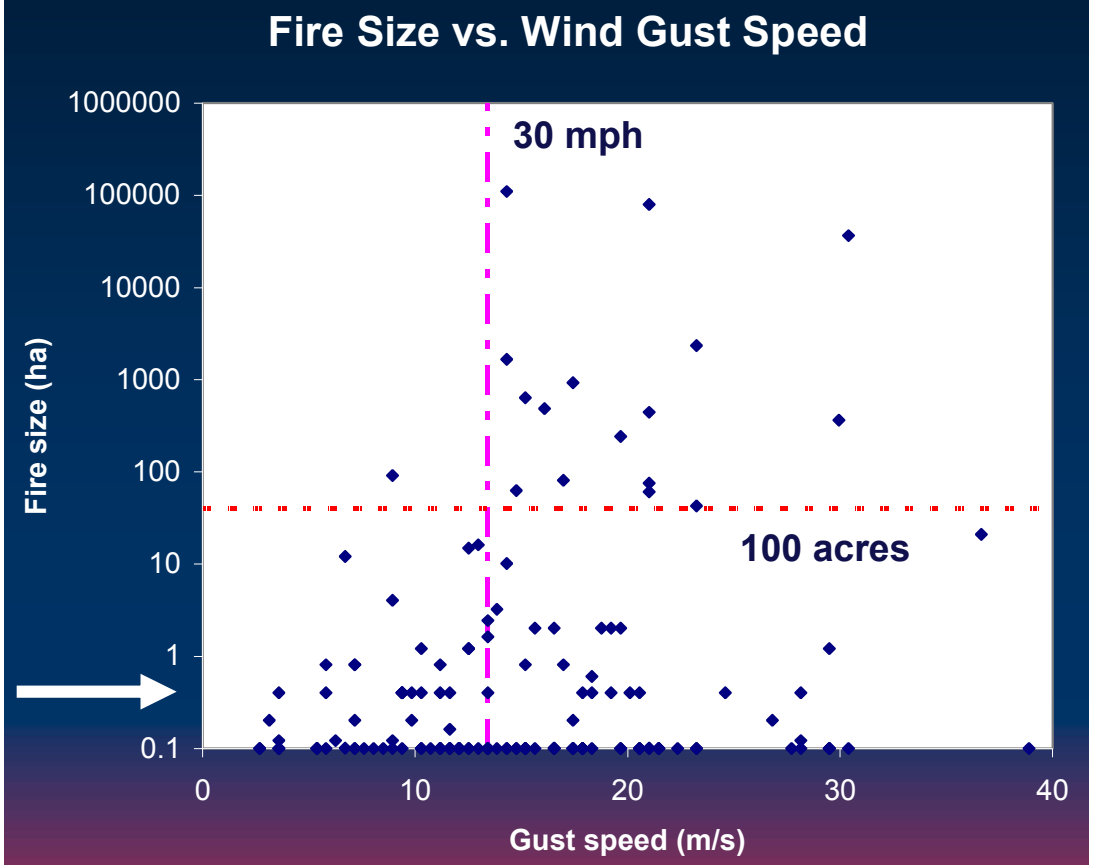
Suppression & Wind Results

	Fires	>40ha	%
Total Fires	19,715	231	98.8
Near Station + high fire threat	2333	66	97.2
Sept. – March	802	34	95.8
Santa Ana (low humidity)	158	17	89.2
Wind gust > 30 mph	83	16	80.3

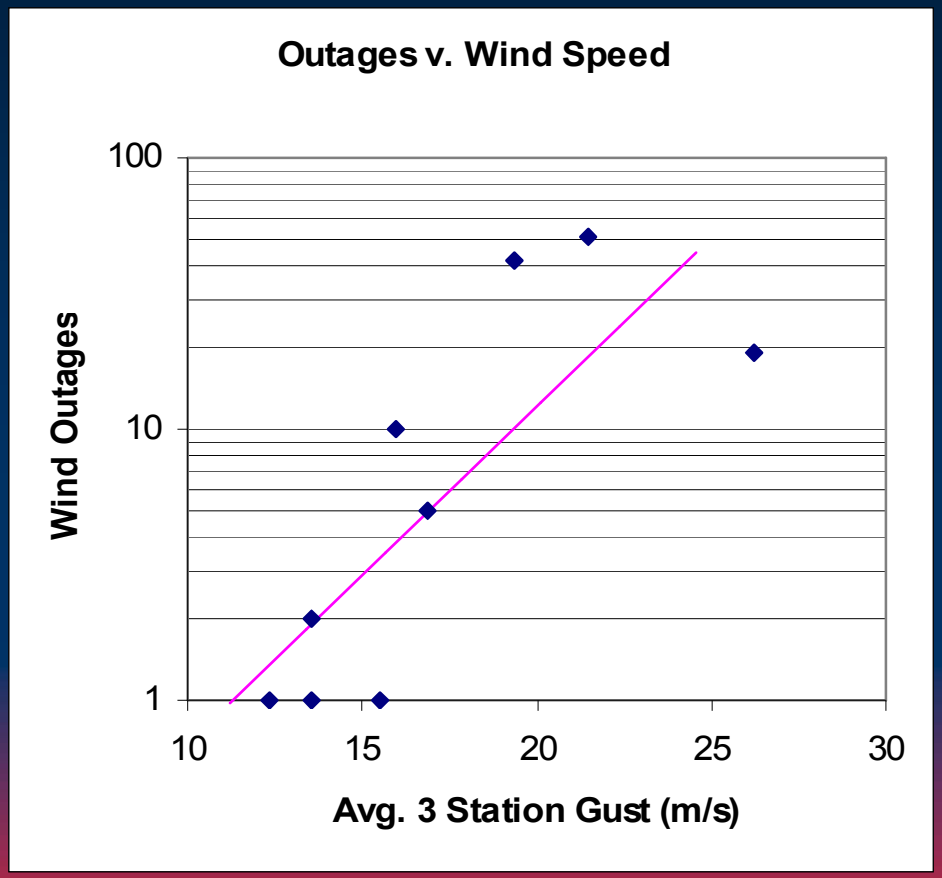


Line faults and wind speed

SDG&E transmission line outage data, 2000-2007

Multiple outages in 12 h versus average of wind gust speed at three weather stations in SD County

Threshold at ~ 30 mph



How does # of ignitions increase with wind? (Answer: Rapidly)

- Three effects:
  - Force & flexing will increase as v^2 (tree limb)
  - Rapid increase of faults near threshold (line slap); possibly a Weibull distribution:

$$N(s,v) = N_0 \exp\left(-\left(s / Bv^2\right)^{\gamma}\right)$$

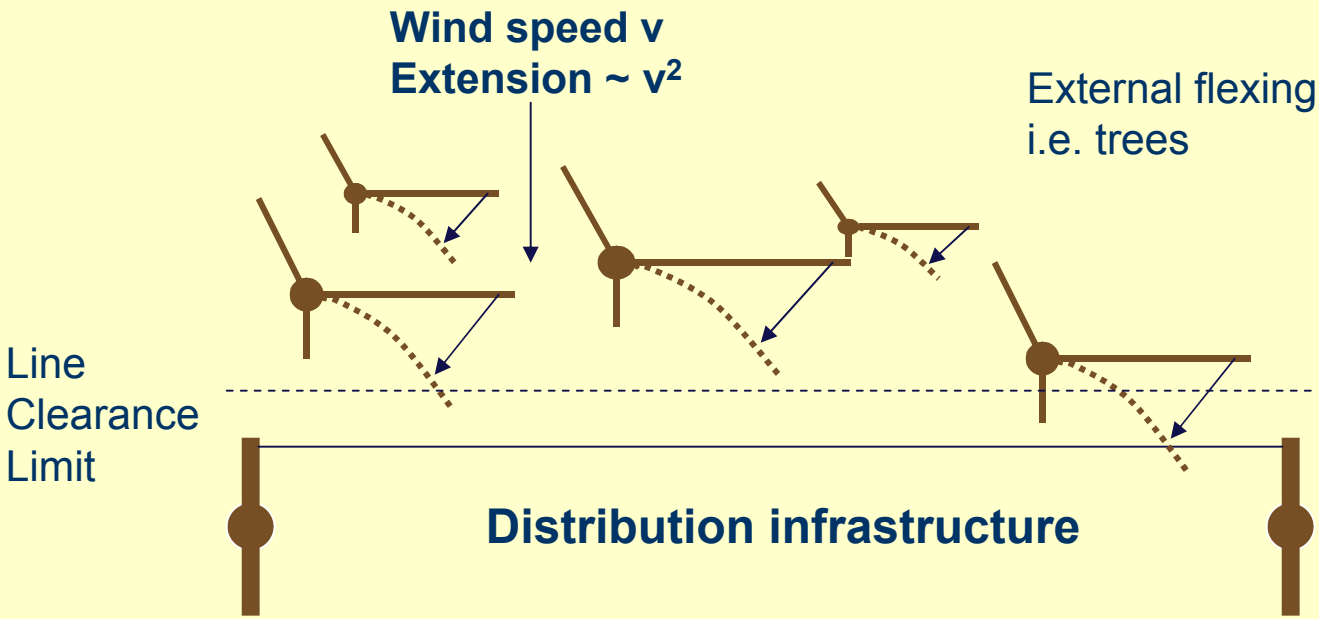
  - Fatigue failures increase as power law (Basquin & Miner's Rules), with threshold effects.

$$P(v) \sim v^{-2/b}$$

$$N(v) \approx N_0 \exp\left(-\left(v^{-2/b}\right)^{\gamma}\right)$$

High-Impedance Faults

Objects flex and contact conductors



potential object-line contacts depends on
- linear density of objects
- flexibility (k) of objects
- force (varies as v^2)

Mid-Line Slap


P-64 MG Close-up view of damage to lines

Witch Fire origin (Photo by Cal Fire)

Depends on:
- **length between spans**
- **tension**
- **wind speed ($F \sim v^2$)**
- **thickness**
- **landscape roughness (oscillation out of phase)**

How do we expect the number of slap loci to increase with wind speed?

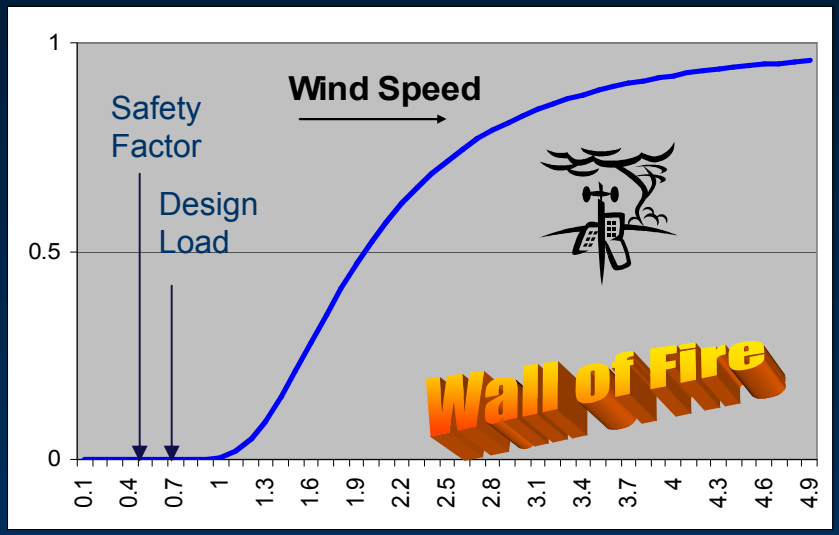
→ Reductio ad absurdum At high enough wind speed they all make contact.

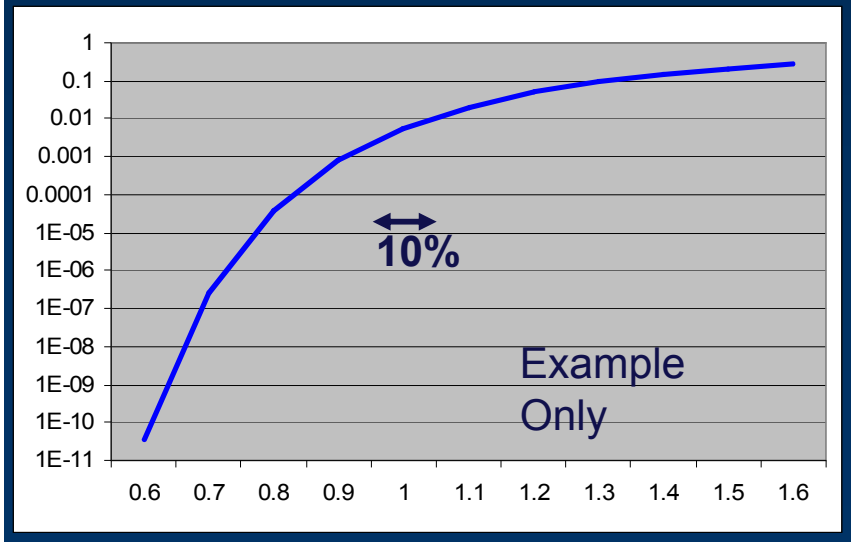
Behavior near the threshold

Example: Weibull distribution ("weakest link")

Fraction of failures

Safety factor of 2X in stress/pressure is only 1.4X in wind speed.





Rapid increase in failure probability in the tail region.

➔ ***Once failures start to appear, we expect the number to increase rapidly with wind speed.***

Stress failures:

Can arise from

- **fatigue**
- **defects in materials**
- **defects in construction**
- **aging and corrosion**
- **stress beyond design limits**

PG&E
Redwood City wetlands
December 26, 2006
High winds & defect

Two conflagrations: 2003 & 2007

Event	**Wind speed** (Max gust speed averaged over 3 weather stations in SD County)	**Number of power line fires in S CA**
October 2003	33 mph	0
October 2007	59 mph	9

Questions: 1) Was the number of ignitions seen in Oct 2007 indicative of a rapidly rising threshold

2) What number of ignitions would we expect if winds were 10 mph or 20 mph greater?

3) How often do we expect events of this severity?

How can we quantify the risk?

- Use historical meteorological data & statistical methods to predict return times for extreme events.
- Obtain historical fire, outage and maintenance records from utilities to estimate vulnerabilities to high winds.
- Improve fine scale wind modeling to identify hazard areas
- Look for wind intensity trends in climate change models

What can be done

- Bury lines in high risk areas
- Separators to prevent mid-line slap
- Engineer for higher wind pressures
- Power down grid in high-risk areas under extreme conditions
- Research to understand extent of the problem

What is actually being done

- California Public Utilities Commission (CPUC) sponsoring two proceedings:
  - R.08-11-005: Revisiting state regulations relating to safety of power lines with respect to fire
  - A.08-12-021: San Diego Gas & Electric application to change rules regarding turning off power.

For more information or to participate, contact the CPUC at: http://www.cpuc.ca.gov

MGRA Proposals

- Public database of utility fire, outage and maintenance data
- Recurrence time > 300 years for engineering against extreme wind events capable of causing “wall of fire” ignitions
- Public safety agency oversight and control over proactive power shut-downs under high-risk conditions.

For further information:

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MGRA testimony before the CPUC can be found at:
www.mbartek.com/cpucspl/cpuc_index.html