US Wildfire

What do we know?

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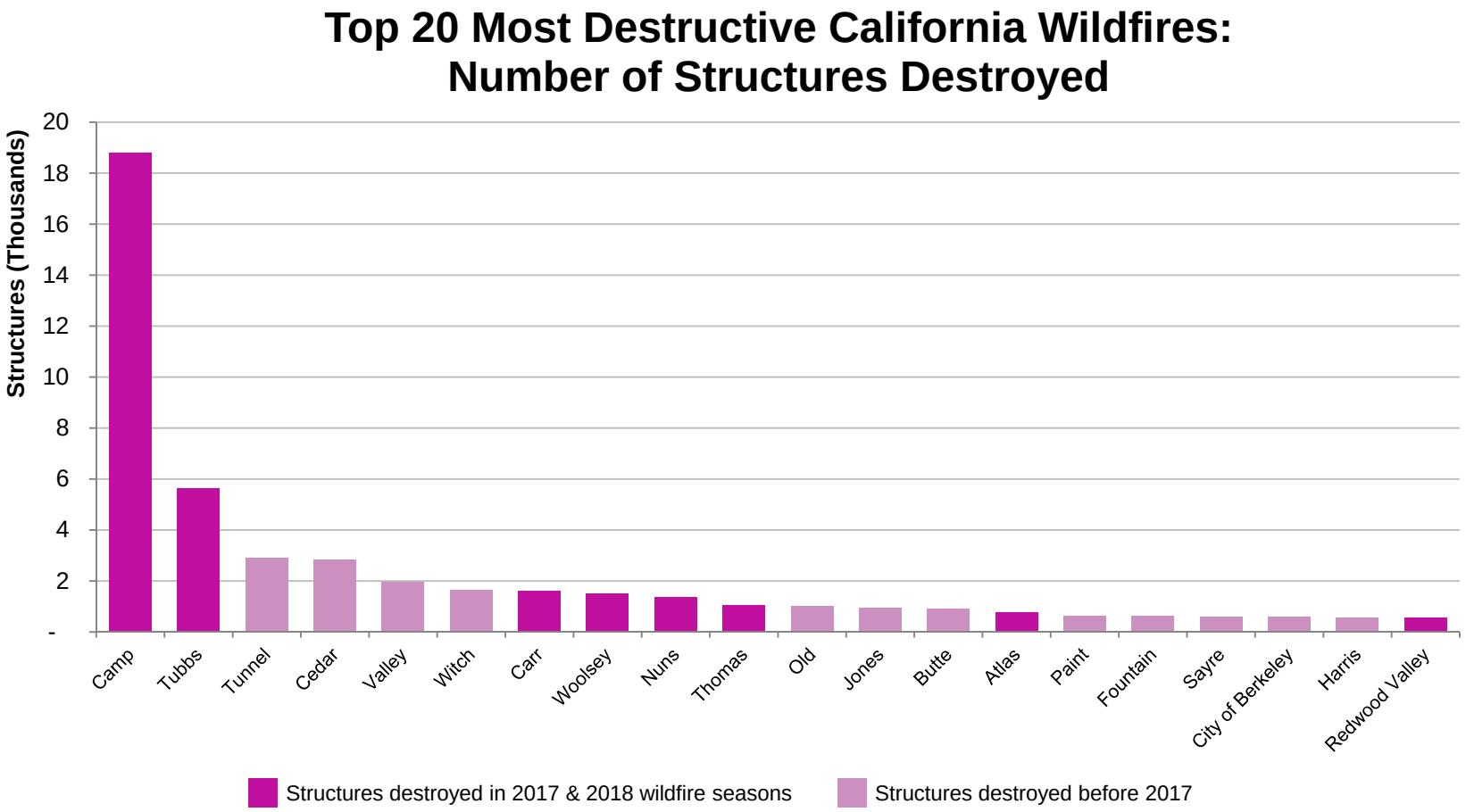
North American Wildfire

- Recent Events
- Changing Risk Environment
- Available Tools
- Evaluation
- Conclusions

Recent Events

CA Wildfire State of the Market

Top 20 Most Destructive Wildfires



67.3% of structures in top 20 were destroyed in last 14 months

Cal Fire data as of 11/25/2018

Questions

- Is wildfire risk changing?
- If so, why?
- How well can we quantify wildfire risk?

Model Performance

Notable Wildfires

Carr (2018)

1,857
structures burned

60% Extreme

40% High

0 Moderate to Negligible risks

Camp (2018)

14,500
structures burned

16,000+
Within perimeter

16% Extreme

64% High

20% Moderate

0 Negligible risks

Woolsey (2018)

1,500
structures burned

18,000+
Within perimeter

9% Extreme

63% High

28% Moderate

16 Negligible risks

Wildfire Modeling

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Choosing a Wildfire Model

Overview of available tools

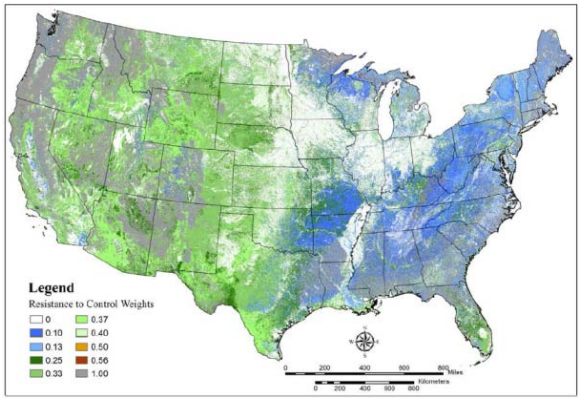
	Tool	Geographic Coverage	Willis Re Overview	Market Utilization
Stochastic Model	AIR Wildfire Model (new)		For many portfolios results are increasing	New to market
	AIR Wildfire Model (pre-2018)		Stochastic model that has not been updated since original release 10+ years ago	Most utilized probabilistic model
	CoreLogic® RQE Brushfire Model		Overall vendor has become a distant third to AIR and RMS in the past decade	Some usage
	RMS Probabilistic Model		New RMS Model with a planned release in late 2018 / early 2019	Unreleased
Risk Hazard Score	Willis Re Wildfire Hazard Score		Up to date scientific modeling that outperformed other vendors in 2017 fires	New to market
	CoreLogic® Risk Score		Tool that combines wildfire with 8 other hazards to develop a single score	2nd most utilized risk scoring tool
	FRAP Score		Location based hazard score based upon geography sourcing data from California Department of Forestry and Fire Protection	Limited usage
	Historical Wildfire Frequency		Used to identify the frequency of wildfires affecting individual locations sourcing data from California Department of Forestry and Fire Protection	Limited usage
	ISO FireLine Score		Provides a score for the risk factors of fuel, slope, access and does not consider weather or proximity to vegetation	Most utilized risk scoring tool
	RedZone		Wildfire tracking, exposure assessment and underwriting	Some usage
	RMS Wildfire Hazard Score		Utilizes several data sources to estimate hazard in and around high-risk wildland-urban interface	Some usage
	Wildfire Hazard Potential Score		Hazard score based tool that has not been updated in several years	Limited usage
	Wildfire Defense Systems®		Combines professional wildfire consulting with wildfire suppression services	Limited usage

Willis Re Wildfire Score

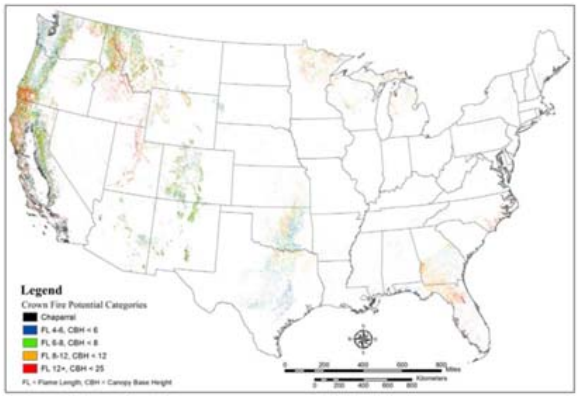
Model Foundation – USFS

- 50,000 years of stochastic wildfires developed by the US Forest Service
- Developed by leading wildfire science research group in the country
- Latest and highest resolution data sources available
  - Dataset updated on regular basis
- Highest resolution data source available
- Employs cutting edge fire physics
- Evaluates the risk of large wildfire occurrence and its interaction with populated regions

Resistance to Control Weights



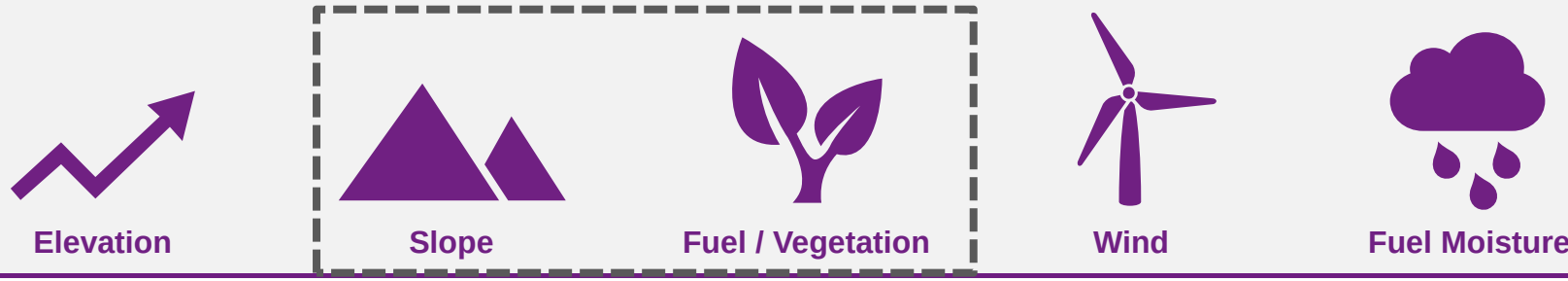
Crown Fire Events



Willis Re Wildfire Score

Model Foundation – USFS

Deterministic, physically-based fire propagation considers the following:



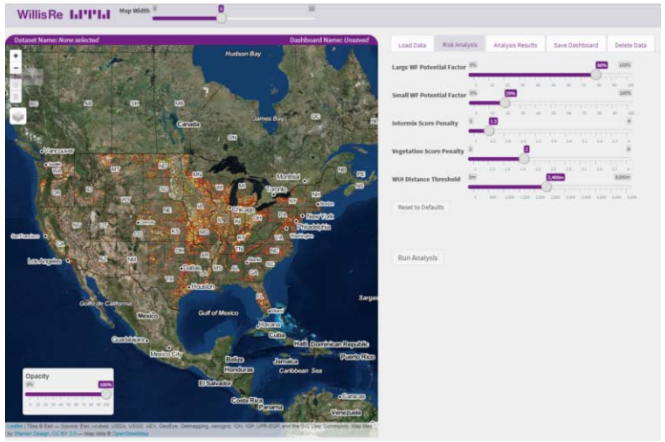
FireLine considerations

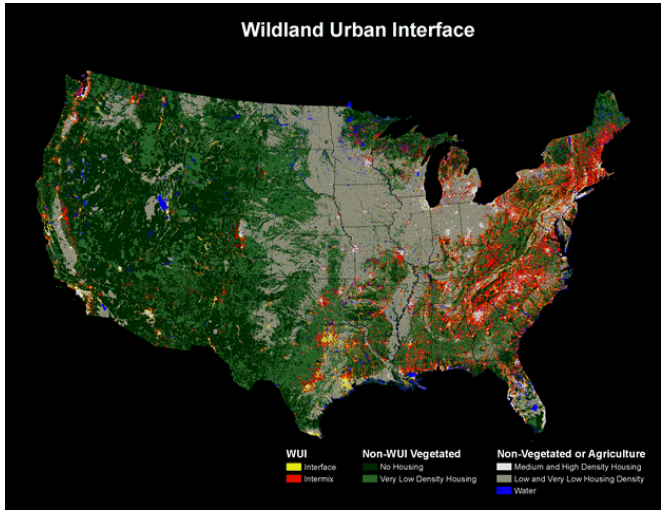
Synthetic weather generated nationally, with hourly characteristics including:

Willis Re Wildfire Score

Willis Re Proprietary Model Components

- Historical wildfire occurrence based on 100 years of data
  - Considers frequency of small fires that are not modeled in stochastic dataset
- Analyzes the most extreme types of wildfire risk, such as crown fires
- Considers regional efficiency of suppressing wildfires
- Contemplates distance from the wildland urban interface (WUI)
  - The WUI is the intersection of populated and wildland regions





AIR 2018 Wildfire Model

First updated stochastic wildfire model in nearly ten years.

First stochastic wildfire model with coverage outside of California

Release comes at a time of changing risk perceptions for wildfire

AIR®
A Verisk Business

New Touchstone v6 AIR Wildfire Model

Expanded model domain:

Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington, Wyoming

- Previously California only

Entirely new hazard module,

which uses weather and wildfire relationships in relation to ecological regions (Ecoprovinces)

- **Landscape ecology** considered with historical fire data
- **Fuels data** updated to now include LANDFIRE 2014 along with 40 Scott Burgan fire behavior fuel models
- **Weather patterns** now considered year over year to determine fire size and number of fires per year

Prior model used LANDFIRE 2007, 13 Anderson fuel models for fire season, and was based on statistical distributions of historical wildfire activity.

New event catalog

10,000 year stochastic catalog of **729,836 events**

Includes fire clusters defined by the hours clause

Minimum fire size is **100 acres**

17 historical events are now available

New feature!

1. 1991 Oakland Hills, CA
2. 1993 Laguna Canyon, CA
3. 1993 Old Topanga, CA
4. 2000 Cerro Grande, NM
5. 2002 Rodeo-Chediski, AZ
6. 2003 Cedar, CA
7. 2003 Old, CA
8. 2007 Witch, CA
9. 2010 Four Mile Canyon, CO
10. 2011 Bastrop, TX
11. 2012 Waldo Canyon, CO
12. 2013 Black Forest, CO
13. 2015 Butte, CA
14. 2015 Valley fire, CA
15. 2017 Mendocino Lake Complex, CA
16. 2017 Thomas, CA
17. 2017 Tubbs/Atlas fire, CA

Previous Model

- Included only 211,040 events
- Did not include fire clusters
- Had 640 acre minimum fire size

New Touchstone v6 AIR Wildfire Model

Fire spread model incorporates four types of fire spread:

- Surface
- Canopy
- Surface to canopy
- Fire branding /spotting

Wildland Urban Interface (WUI) penetration algorithm to advance fires into urban areas

- Previously based on distance into the urban area instead of burnable fuels

New secondary risk characteristics introduced

- Defensible space
- Firewise community

Damage estimation uses flame length as intensity parameter

- Prior used windspeed.

New Loss calculation for risks with unknown characteristics

AIR 2018 Wildfire Model

Model Domain & Data Sources

Model Domain

Data Sources

- Historical wildfires
- Ecoprovinces
- Weather
- Fuels
- Wildland Urban Interface
- Wind
- USFS Fire Occurrence Database
- USFS Ecoregions
- US CPC
- Landfire 2014
- 2010 USFS WUI (Martinuzzi)
- NOAA NARR Model

Model Performance

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Is Wildfire Risk Changing

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Changes in Wildfire Risk in the Western US

Three Possible Mechanisms

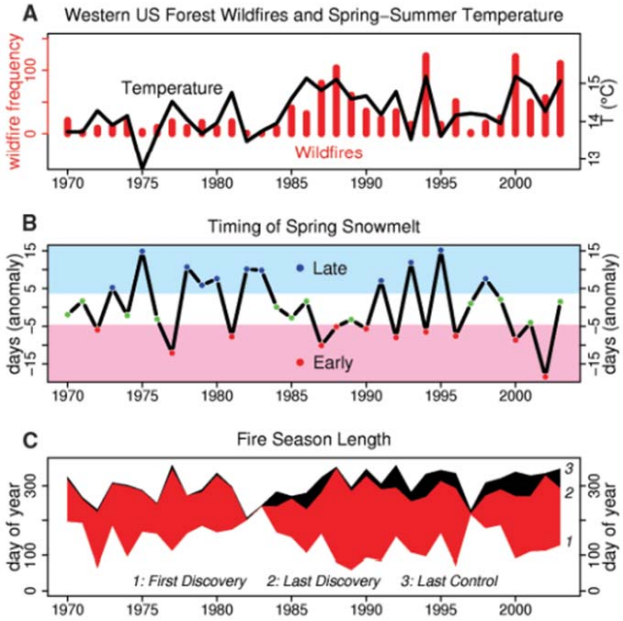
Climate Change

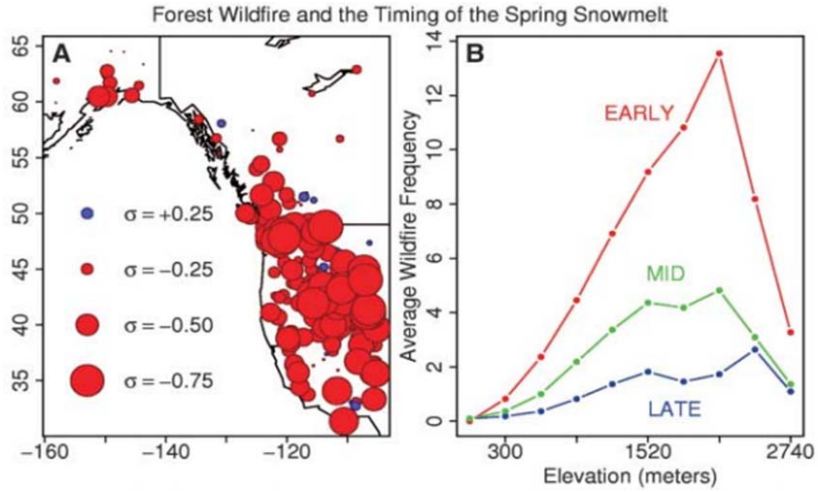
Exposure Change

Land Use History

Climate Change

- Increase in Moisture Variability
  - PDO
  - ENSO
- Snowmelt Timing
- Spatial Distribution of the Forest Area
- Sensitivity to Water Balance
  - N Rockies
  - N California





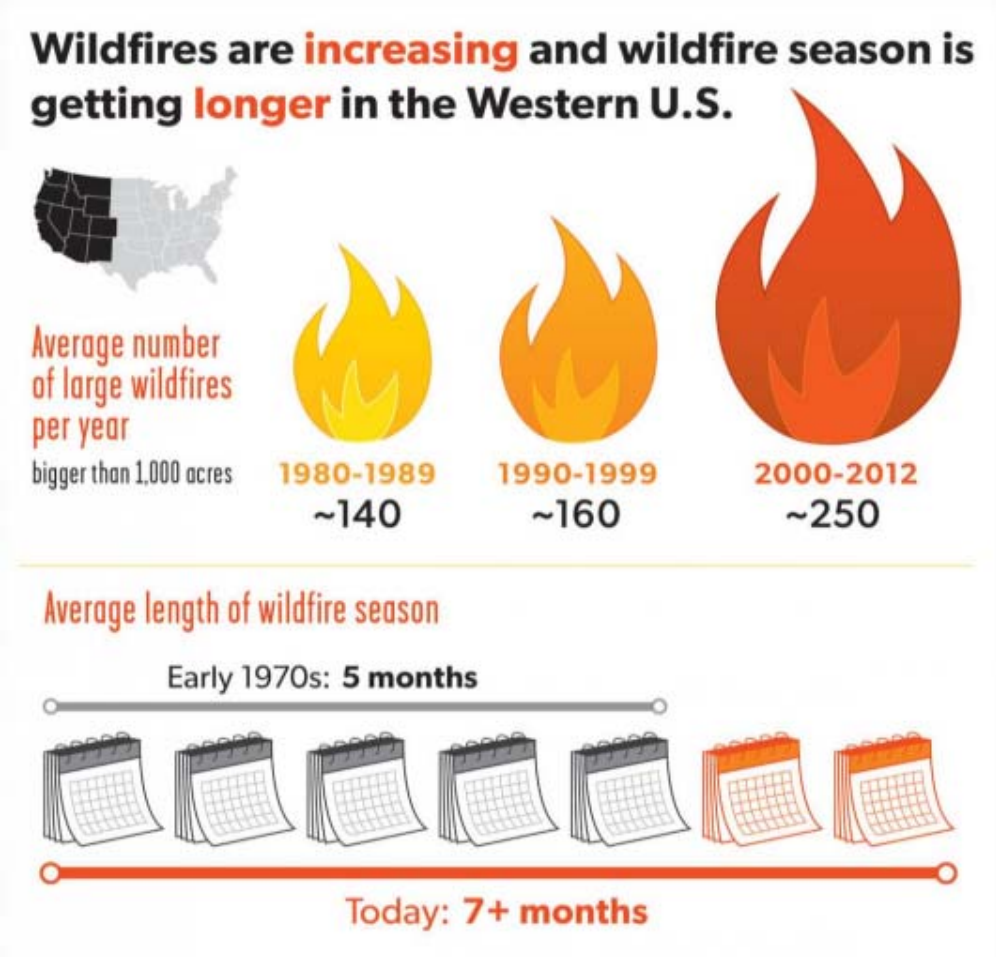
Climate Change

Regions of Notable Increase

- Colorado
- Northern California

Regions of Lower Increase

- Southern California
- Arizona



If increased risks are largely due to changes in climate during recent decades, then restoration and fuels treatments may be relatively ineffective in reversing current wildfire trends.

Exposure Growth

State	Rank	Total area	Area of WUI (km2)			Expansion of WUI Area (km2) 1990-2010	Percent Change in WUI Area 1990-2010
		km2	1990	2000	2010		
Idaho	1	216,442	2,451	3,318	4,220	1,769	**72.20%**
Montana	2	380,831	3,168	4,079	5,304	2,135	**67.40%**
Colorado	3	269,602	5,713	7,600	9,438	3,725	**65.20%**
Utah	4	219,884	2,197	2,735	3,549	1,352	**61.50%**
Nevada	5	286,380	1,513	2,069	2,440	927	**61.20%**
Wyoming	6	253,334	1,541	1,868	2,412	871	**56.50%**
…							
California	41	423,967	22,618	24,375	27,026	4,407	**19.50%**

Conclusions

Summary

- It isn't immediately clear which is driving the most significant changes in wildfire risk, changing weather patterns or changes in exposure.
  - But both are contributing.
- Today's models rely on historical information to predict extreme future event frequencies.
  - Spatial Changes
  - Frequency Changes
  - Intensity Changes
  - All invalidate this assumption
- Modern models are undoubtedly an improvement over prior tools and can assist in pricing, underwriting and portfolio management.

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