Hey, attendees!

- Welcome back from lunch!
- We will be playing a little trivia in a bit, so please go to kahoot.it on your phone, tablet, or computer browser.
- A pin will be provided when we start the game.

Climate Change and Fire

Climate 101 Workshop for Natural Resource Managers

Monica O. Mattox
Oklahoma Assistant State Climatologist
Oklahoma Climatological Survey

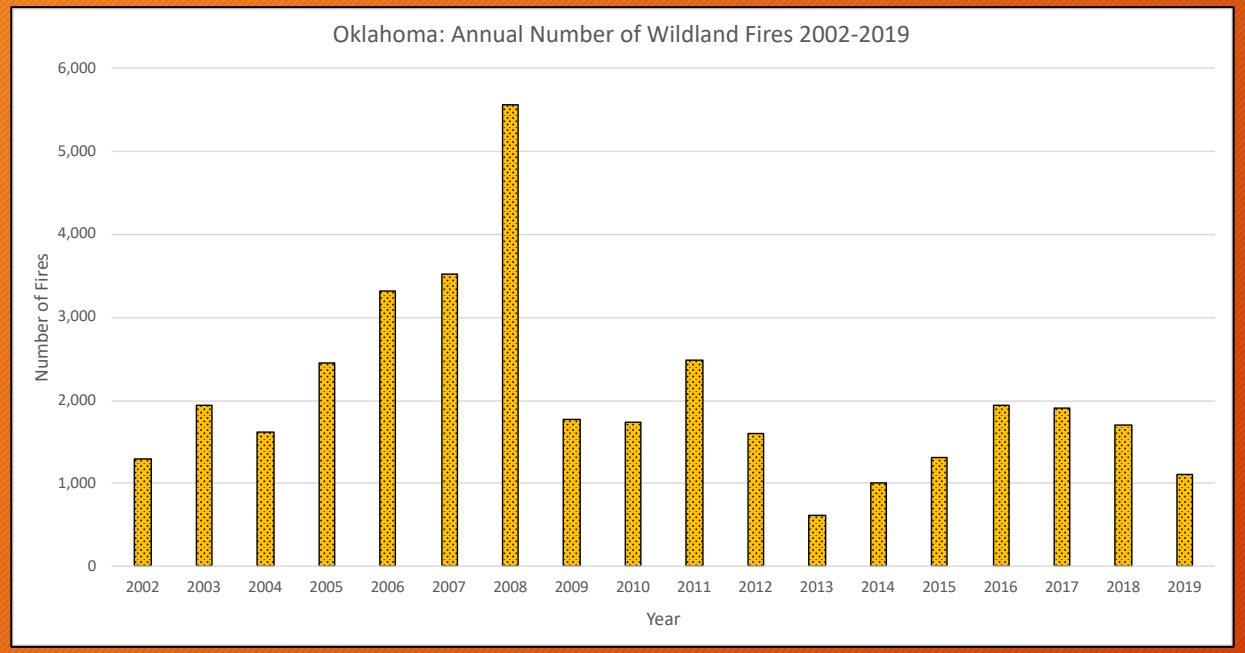
Share in chat!

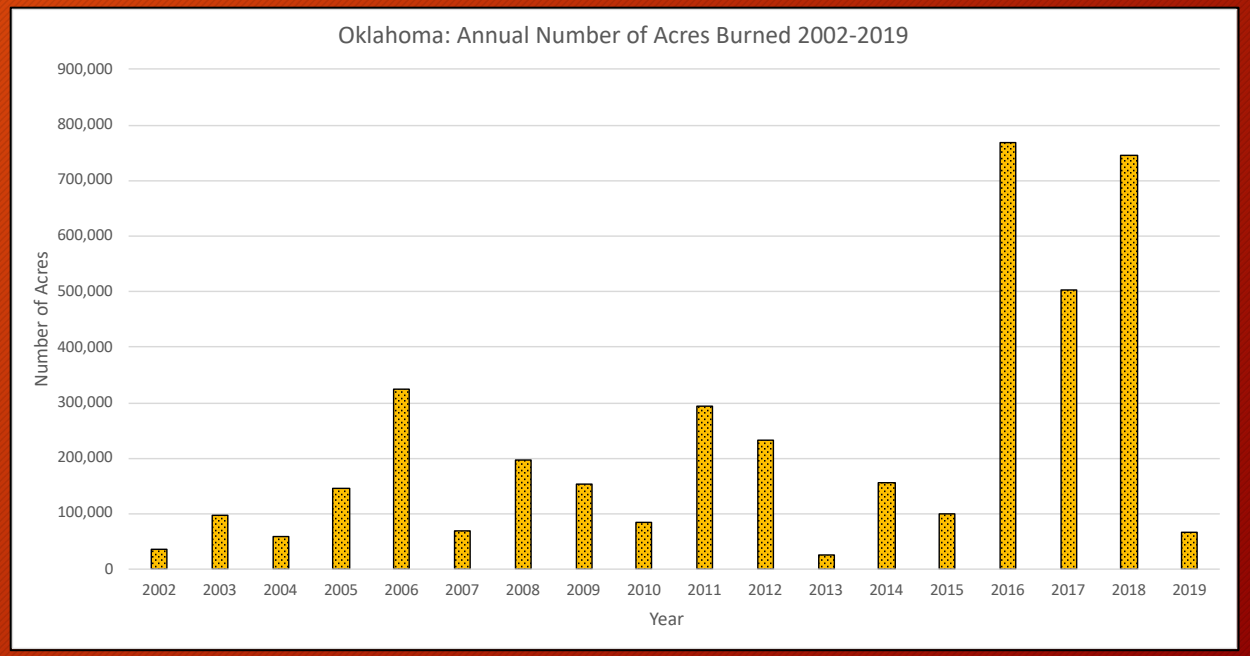
Game on!

Go to **kahoot.it** in a browser

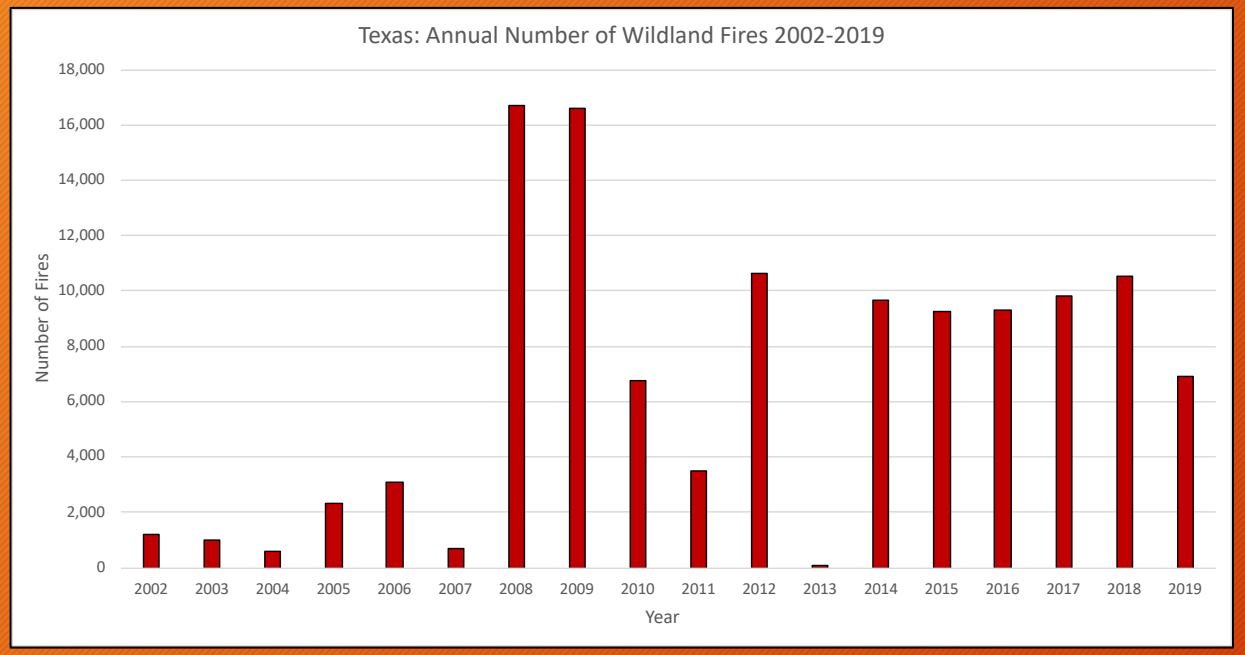
Side by side of graphs—participants chime in

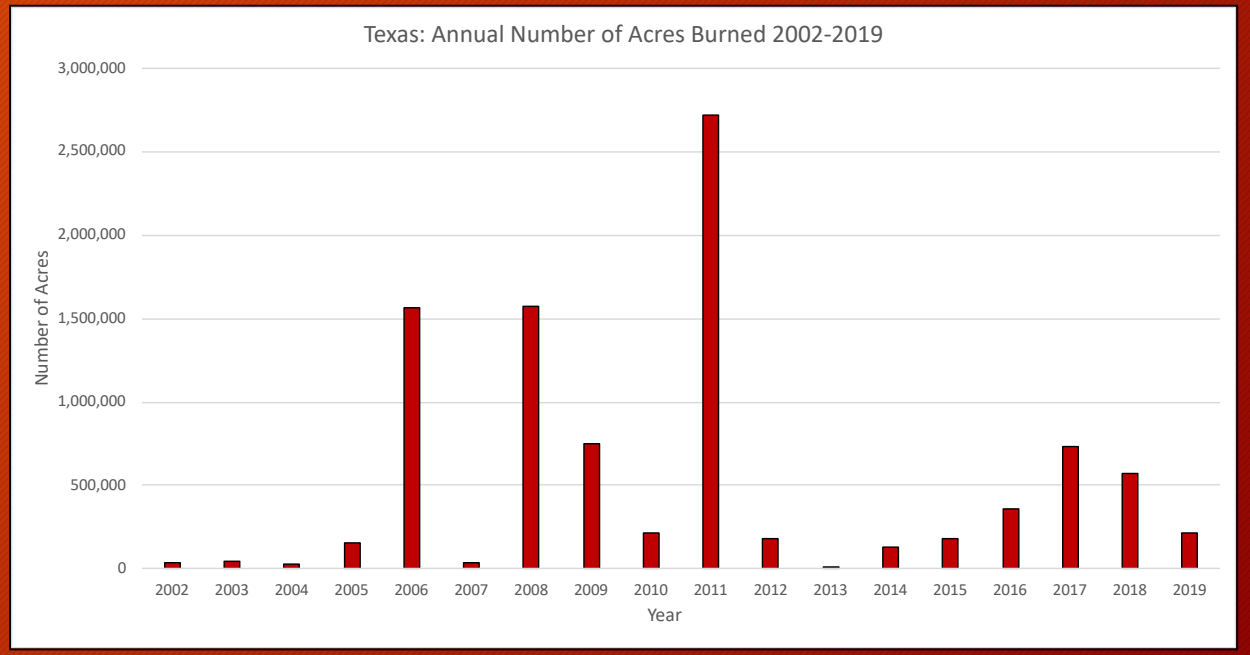
Oklahoma


Oklahoma: Annual Number of Wildland Fires 2002-2019
Number of Fires
6,000
5,000
4,000
3,000
2,000
1,000
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

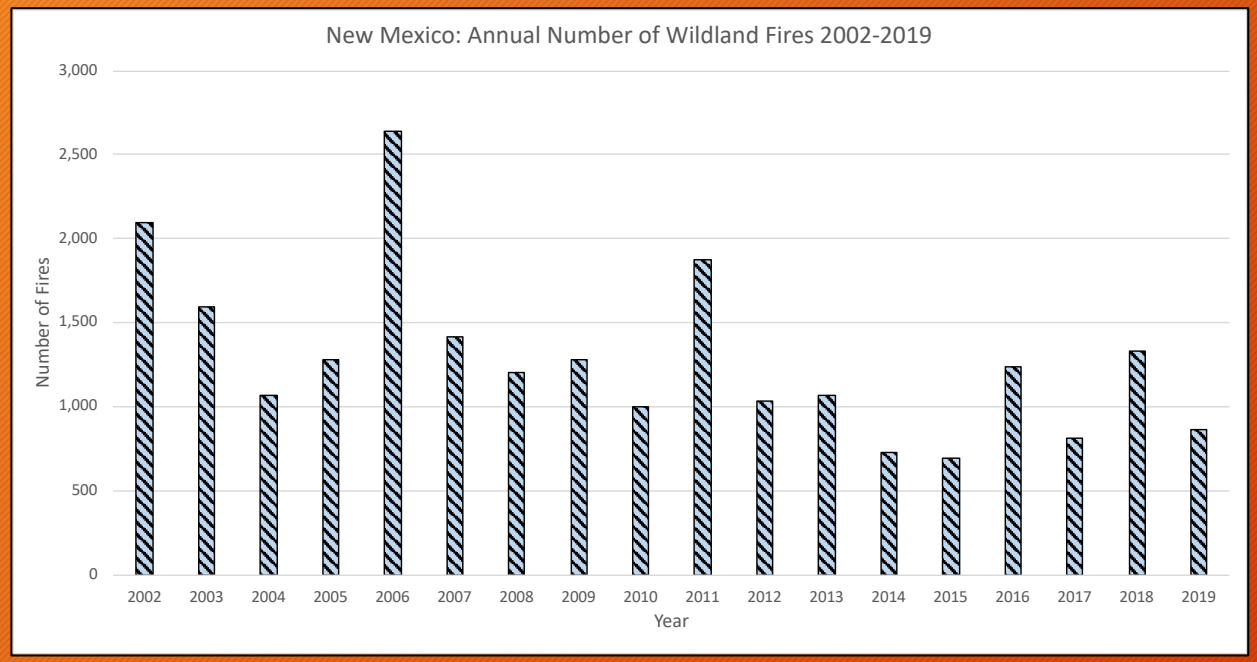

Oklahoma: Annual Number of Acres Burned 2002-2019
Number of Acres
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

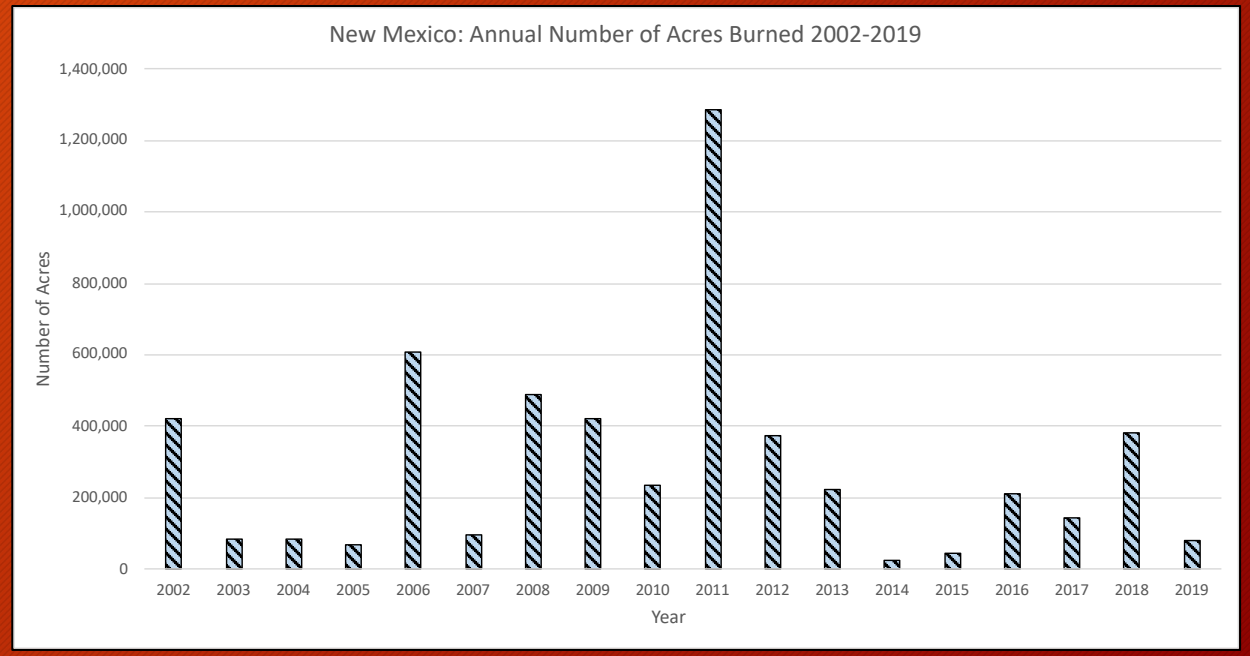
Texas


Texas: Annual Number of Wildland Fires 2002-2019
Number of Fires
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Year


Texas: Annual Number of Acres Burned 2002-2019
Number of Acres
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Year

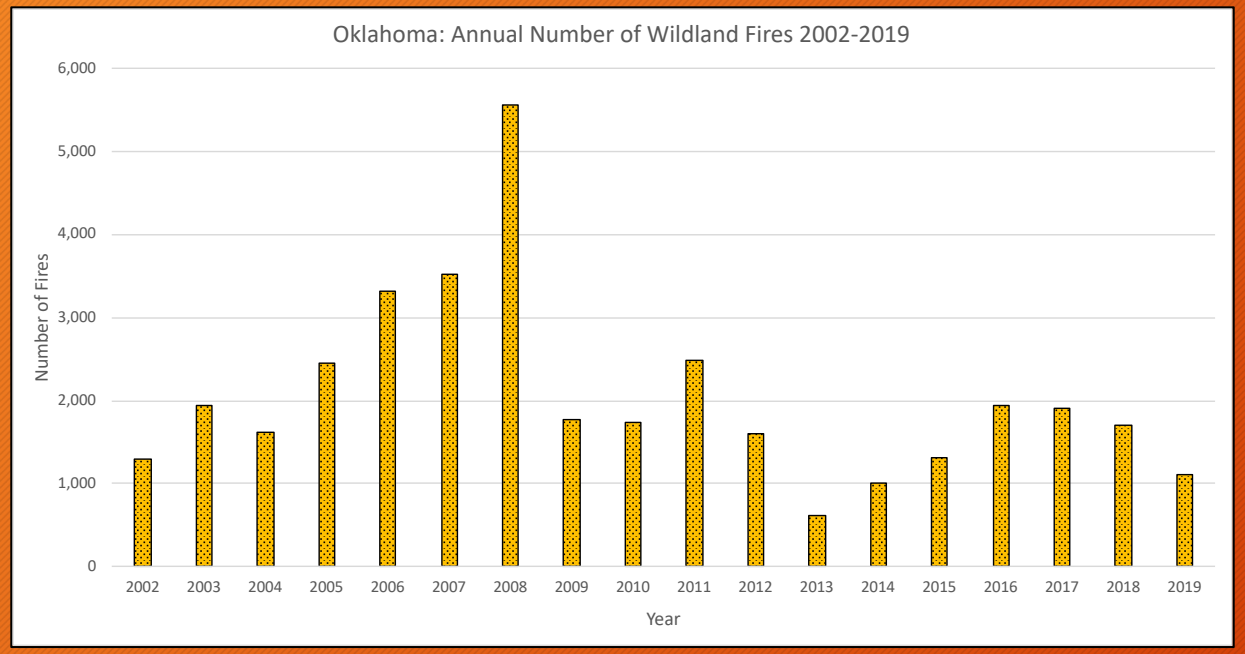
New Mexico

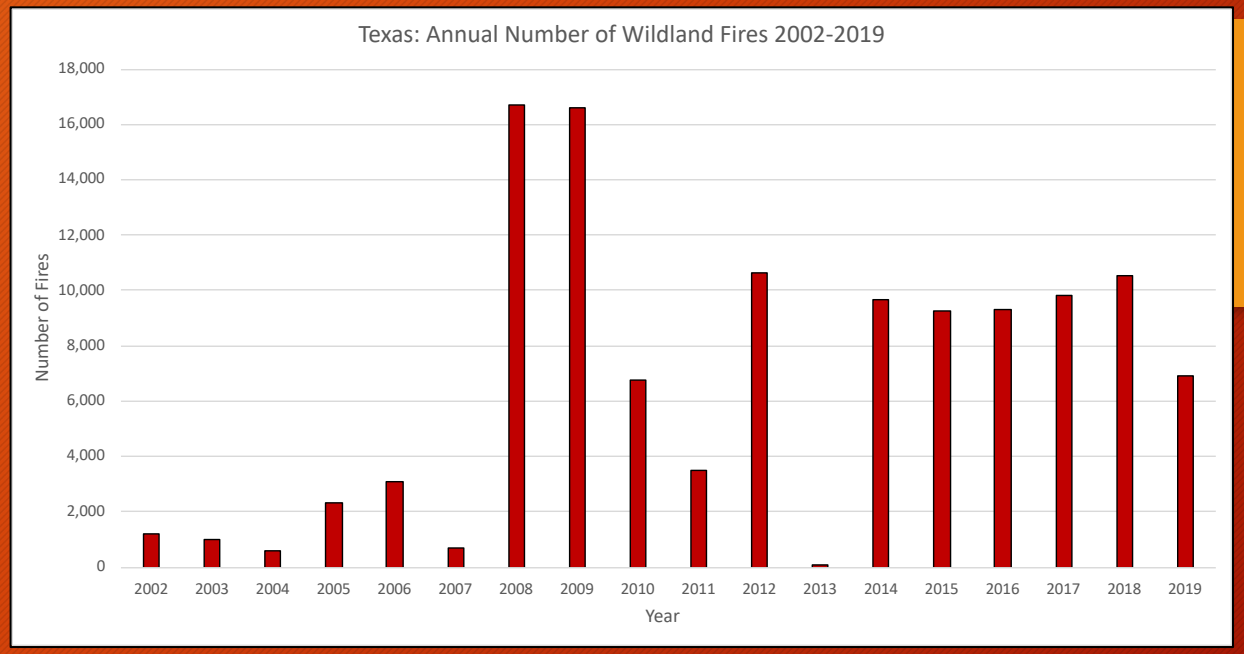

New Mexico: Annual Number of Wildland Fires 2002-2019
3,000
2,500
2,000
1,500
1,000
500
0
Number of Fires
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

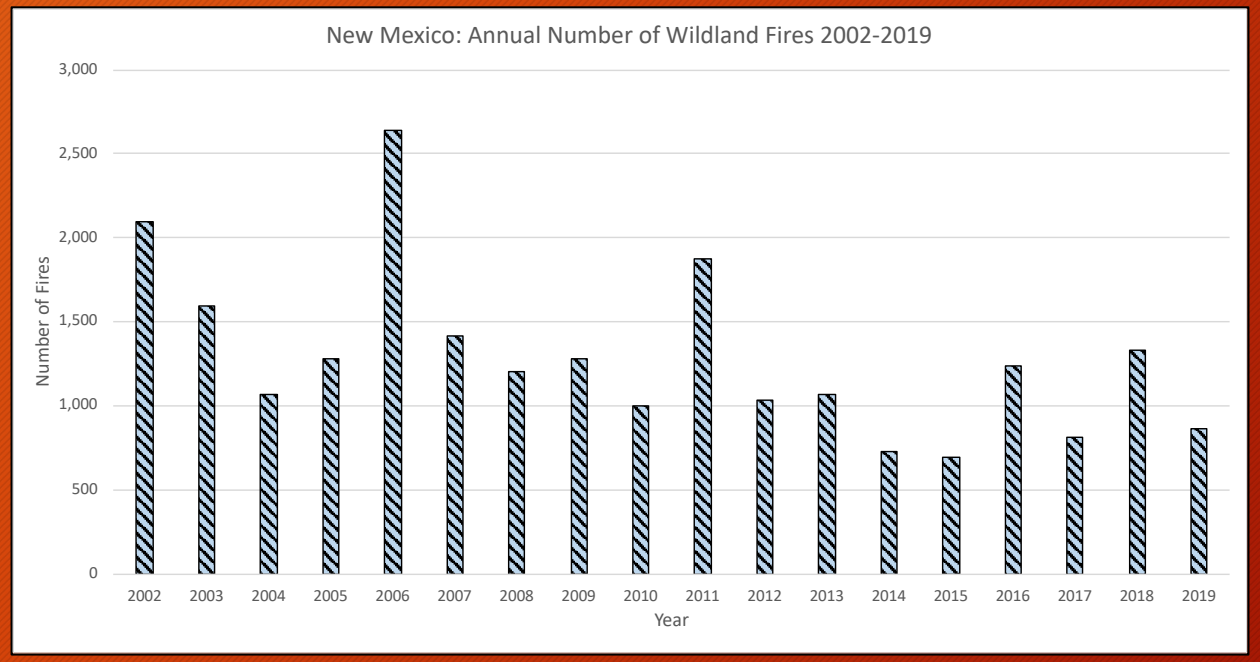

New Mexico: Annual Number of Acres Burned 2002-2019
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Number of Acres
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Year

How have things been stacking up?

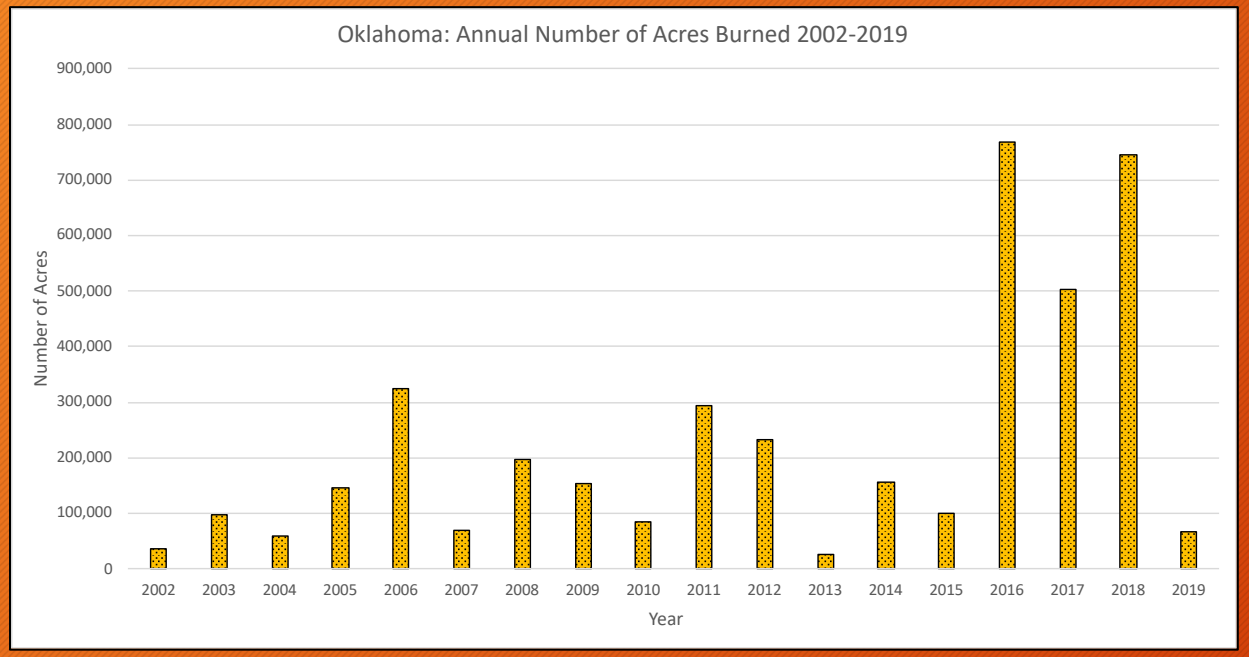
Annual Number of Fires

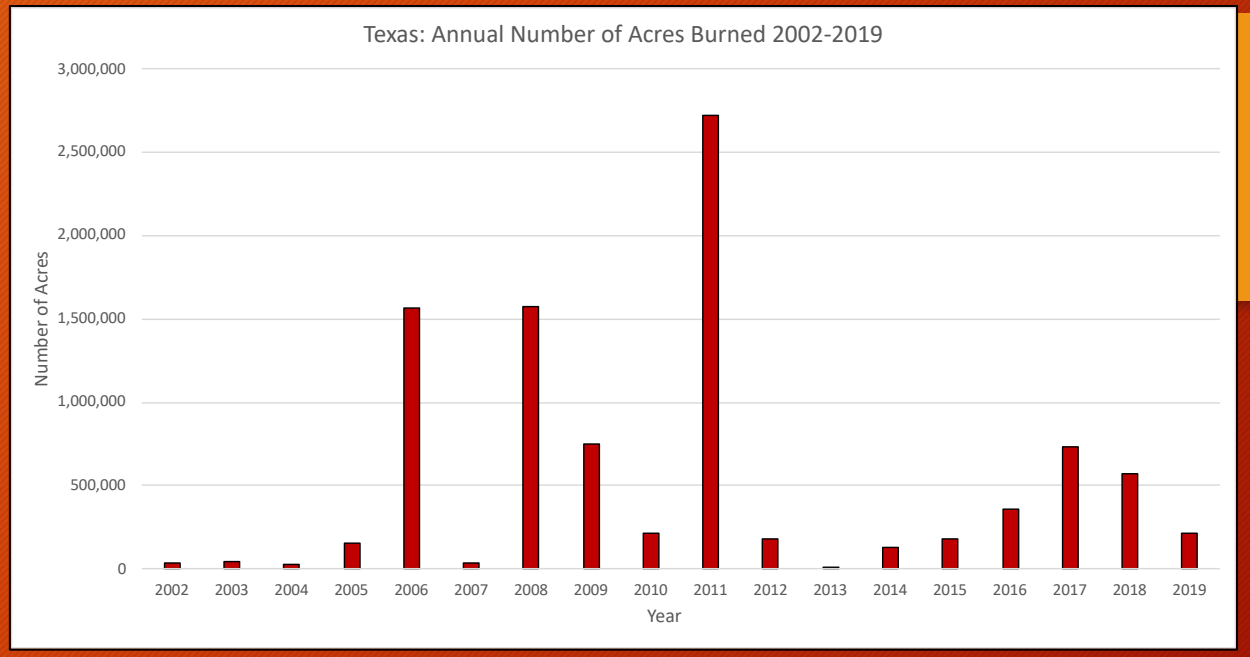


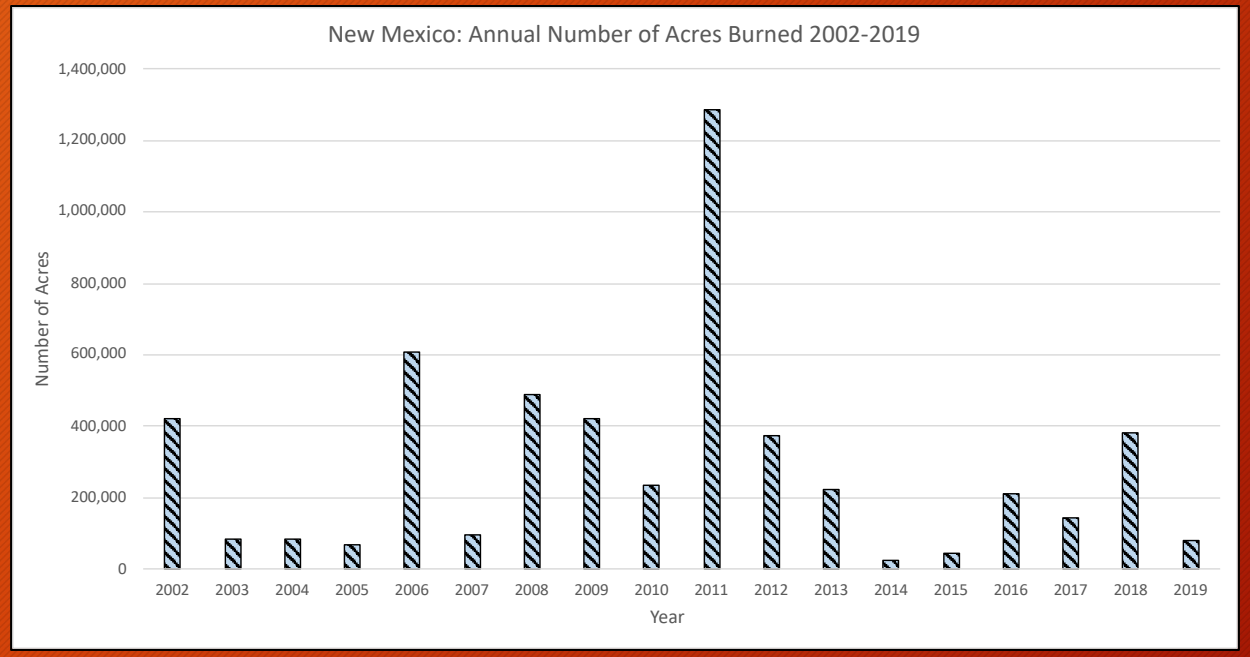




Area Burned Annually







Historic Megafires in OK, TX, & NM 1997-2019

TOP 3

TEXAS		
East Amarillo Complex (2 fires)	2006	907,245 acres
Perryton	2017	318,156 acres
Rock House	2011	314,444 acres

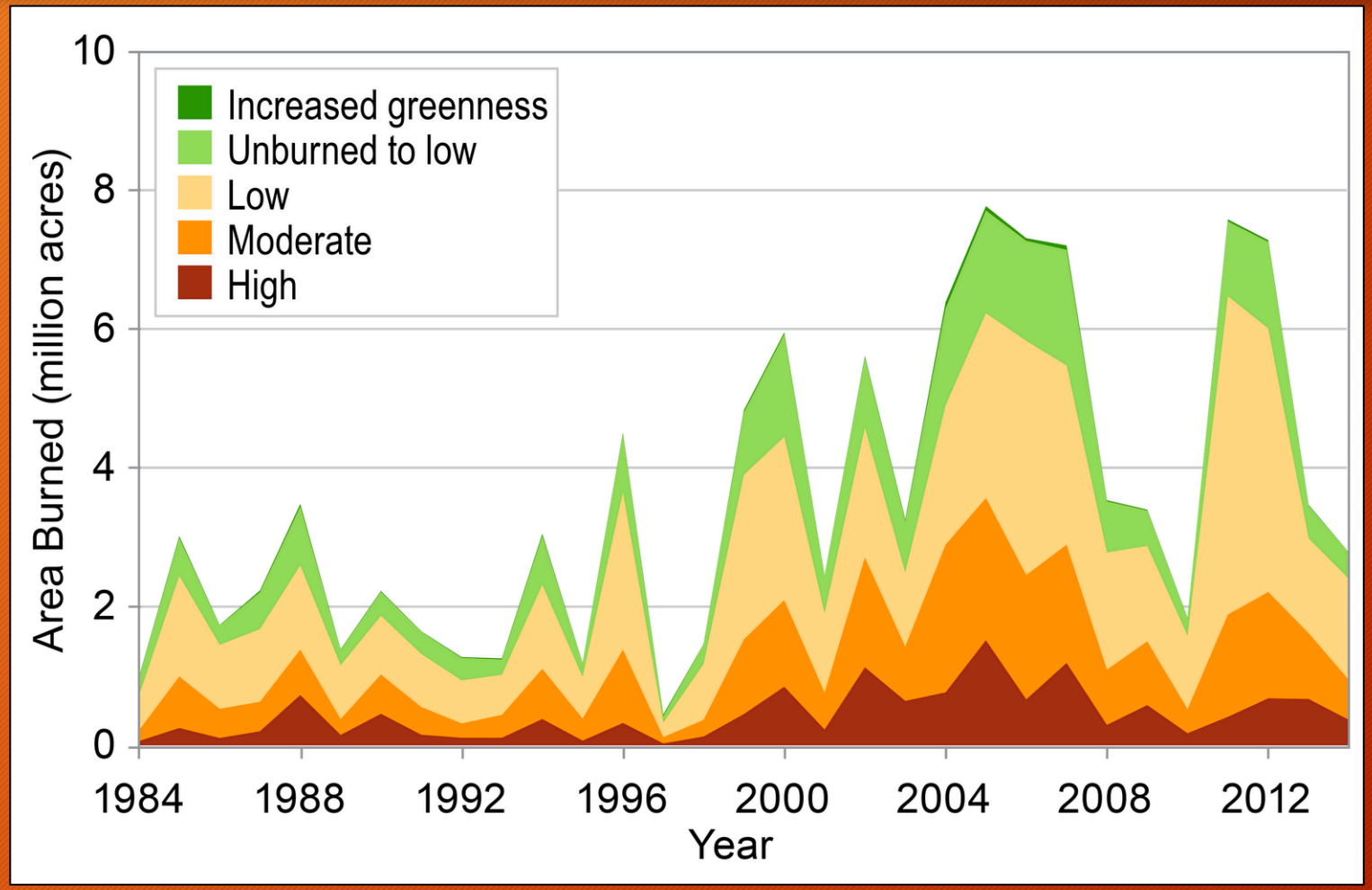
OKLAHOMA		
NW Oklahoma Complex (3 fires) *Starbuck Fire*	2017	779,292 acres *662,700 acres*
Anderson Creek	2016	367,740 acres
Rhea	2018	286,196 acres

NEW MEXICO		
Whitewater-Baldy	2012	297,845 acres
Las Conchas	2011	156,593 acres
Silver	2013	138,546 acres

Robin O'Shaugnessy, Amarillo Globe-News

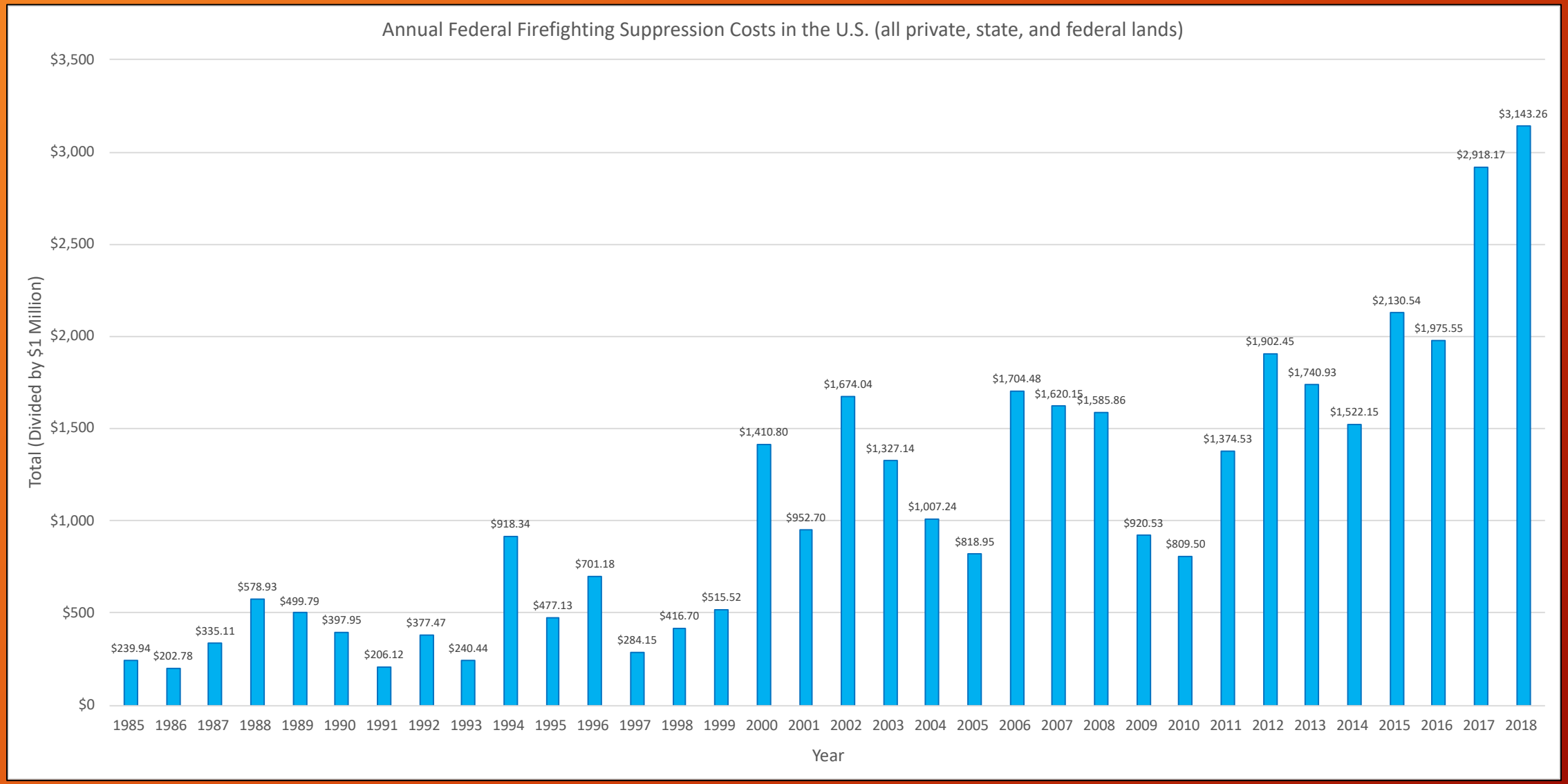
Mike Pearce, The Wichita Eagle via AP

Area Burned by Large Wildfires & Severity



4th National Climate Assessment:

- This figure shows area burned by large wildfires (>1,000 acres in the western US and >500 acres in the eastern US) from 1984–2014 and burn severity.
- Area with moderate-to-high burn severity has increased in recent decades, it has not changed as a proportion of the total area burned.



(National Interagency Fire Center, 2020)

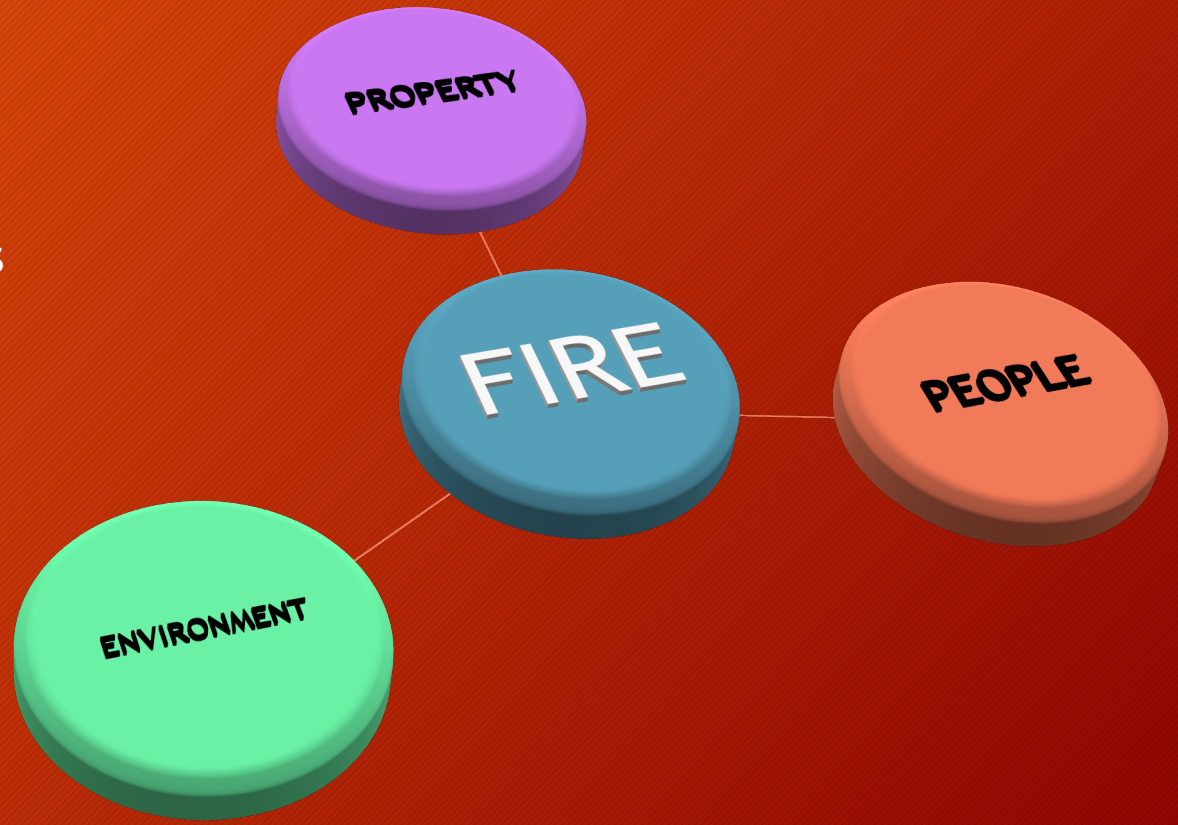
**The Department of Interior agencies include: Bureau of Indian Affairs, Bureau of Land Management; National Park Service; and U.S. Fish and Wildlife Service. The U.S. Forest Service is an agency of the Department of Agriculture.*

Annual fires and total acres include all private, state and federal lands in the United States.

Costs are not adjusted for inflation.

Fire is a huge part of the human experience

- Fate of fire and changes in fire patterns will affect you in many ways
- Direct and indirect effects
  - Economic
    - Structures
    - Ecosystem services
  - Agriculture
    - Lands
    - Livestock
  - Cultural and indigenous traditions
    - Access to traditionally significant plants and animals
    - Spiritual practices
  - Ecological
    - Habitat disruption
    - Migration patterns
  - Health and safety
    - Loss of life
    - Air quality
- Relationship status with fire: **It's complicated**



Environmental Factors Attributed to Increased Fire Threat:

Increased population/human activity → Heightened likelihood of ignition

Long-term drought
+
Seasonal variability
+
Fire-conducive Weather Systems

Change in land use practices → Resurgence of native grasslands and fuel

Population and Land-Use

- Fire helped create the plains and was used to modify habitats and aid in hunting activities in the past.
- Since the early 1900s there has been a reduction in prescribed burning.

→ Increase in native vegetation growth (e.g. grasses and shrubs)

→ Increase in invasive species (e.g. Eastern Red Cedar and Mesquite)

➔ An increase in vegetative fuels available for burning, especially Red Cedars which have large diameters and create high intensity fires

(Great Plains Nature Center, Photo: Jim Mason)

Increasing human activity + an increase in vegetation = higher chances of ignition and fuel, making the region vulnerable to fire

Meteorological Fire Ingredients

1. **Precipitation**
   - April showers bring May FUEL!
   - Tough to get a fire when it's raining…
   - Affects soil moisture and dead vegetative fuel moisture
2. **Temperature**
   - Warmer temperatures can ↑ evapotranspiration and ↓ relative humidity, reducing moisture for fuels
   - Warmer fuels are closer to their ignition point
3. **Relative Humidity (RH)**
   - Impacts moisture content of fuels
4. **Wind Speed and Direction**
   - Impacts containment and spread

Suggested Thresholds by the Oklahoma Mesonet's OKFire Program:

Weather Variable	Value	Fire Danger Expected
Relative Humidity	35- 85%	Increasing fire danger as relative humidity decreases
	20- 35%	Containment becomes difficult; quick ignition; spot fires increase
	< 20%	Extreme fire behavior; spot fires frequent
Wind Speed	> 20 mph	Higher speeds cause increased fire danger and spread rates; winds and gusts over 20 mph become increasingly problematic
Temperature		In general, higher temperatures increase fire danger

(Thresholds from OKFire)

Climatological Fire Drivers

- **Seasonality/Dipole Events**
  - **Drought**
  - **Heavy rainfall events**

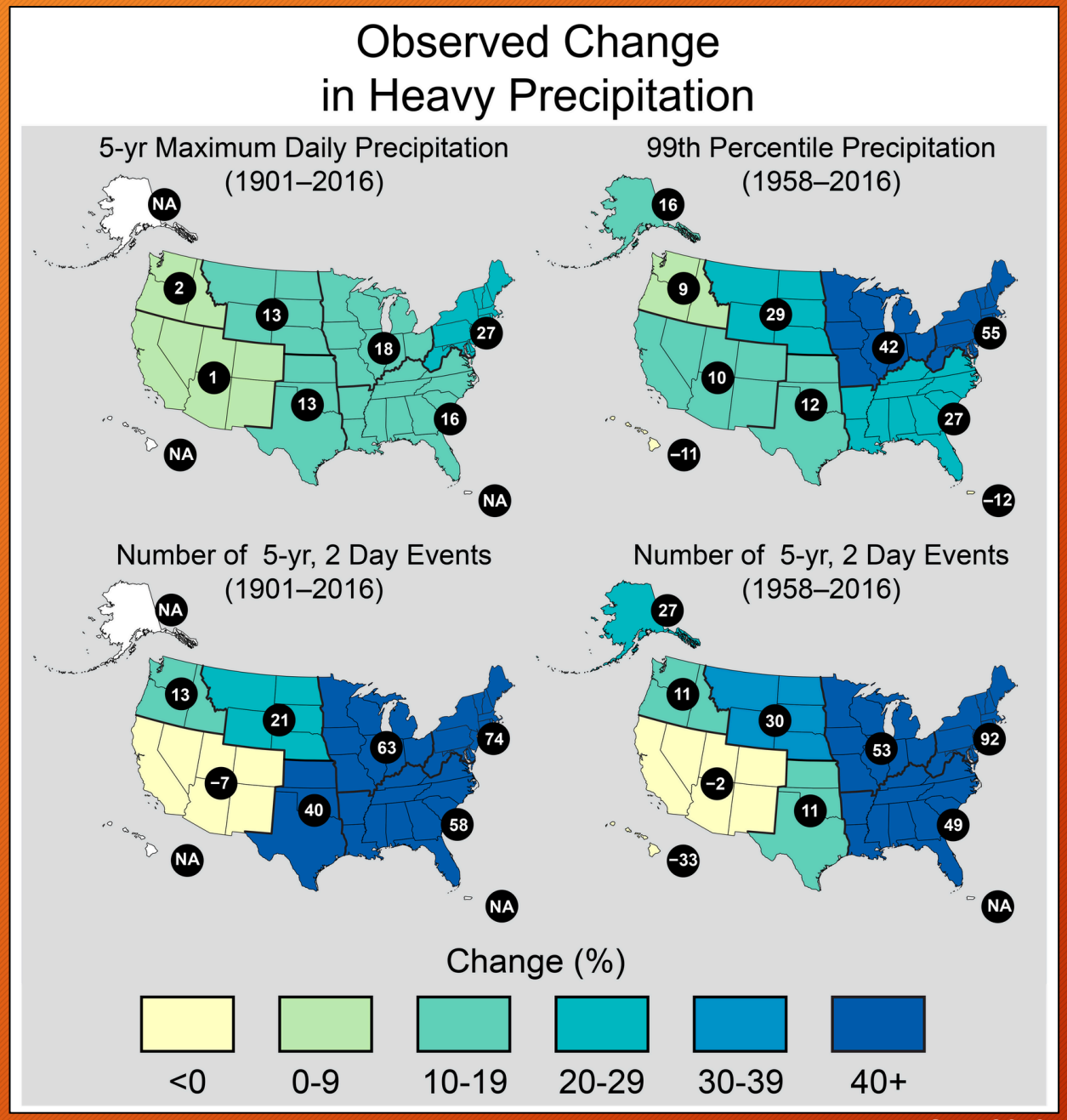
These climate drivers demonstrate shifts in wet and dry periods and can act as predictors for the fire season.

Seasonality/Dipole Events

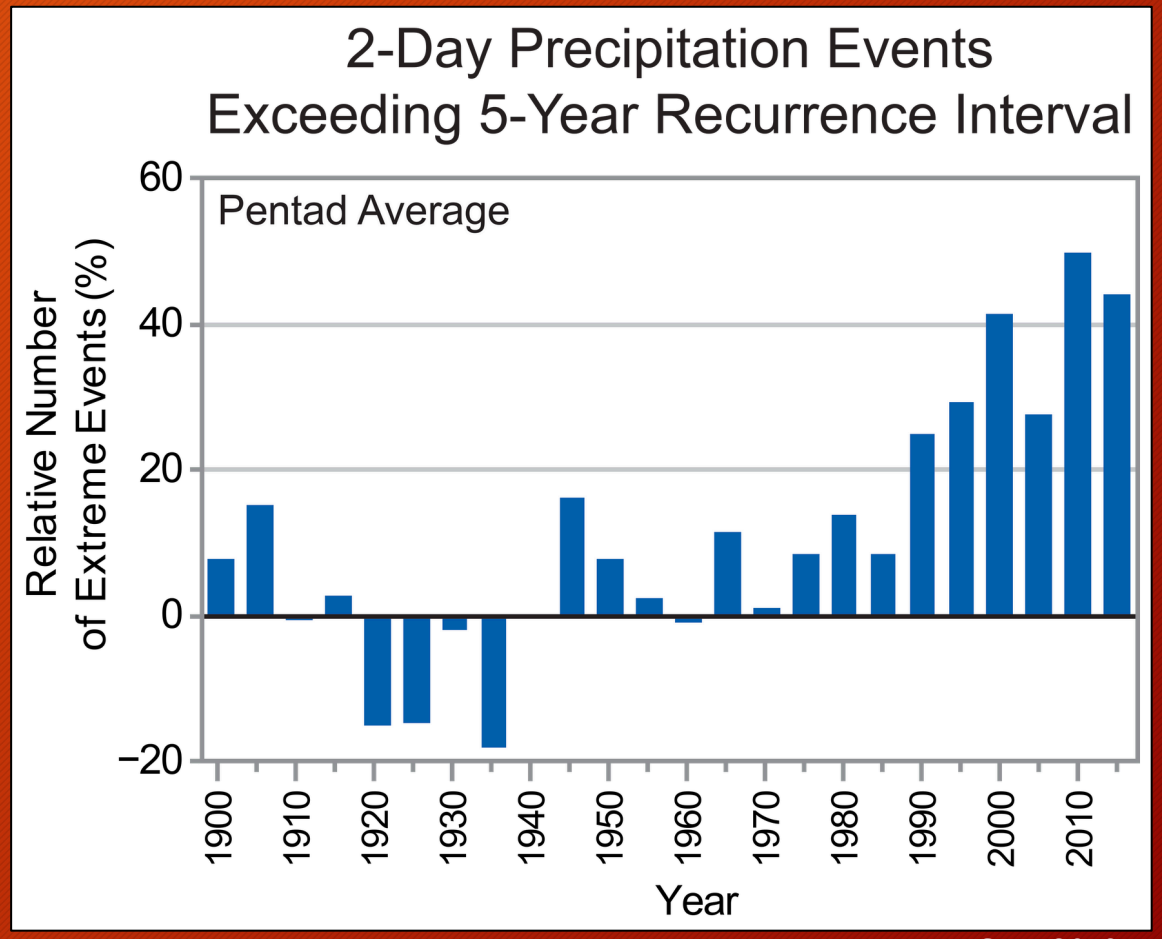
- Dipole Events- Alternating periods of significant drought and rainfall.
- All about seasonal shifts from wet → dry that creates fuel




PRECIPITATION



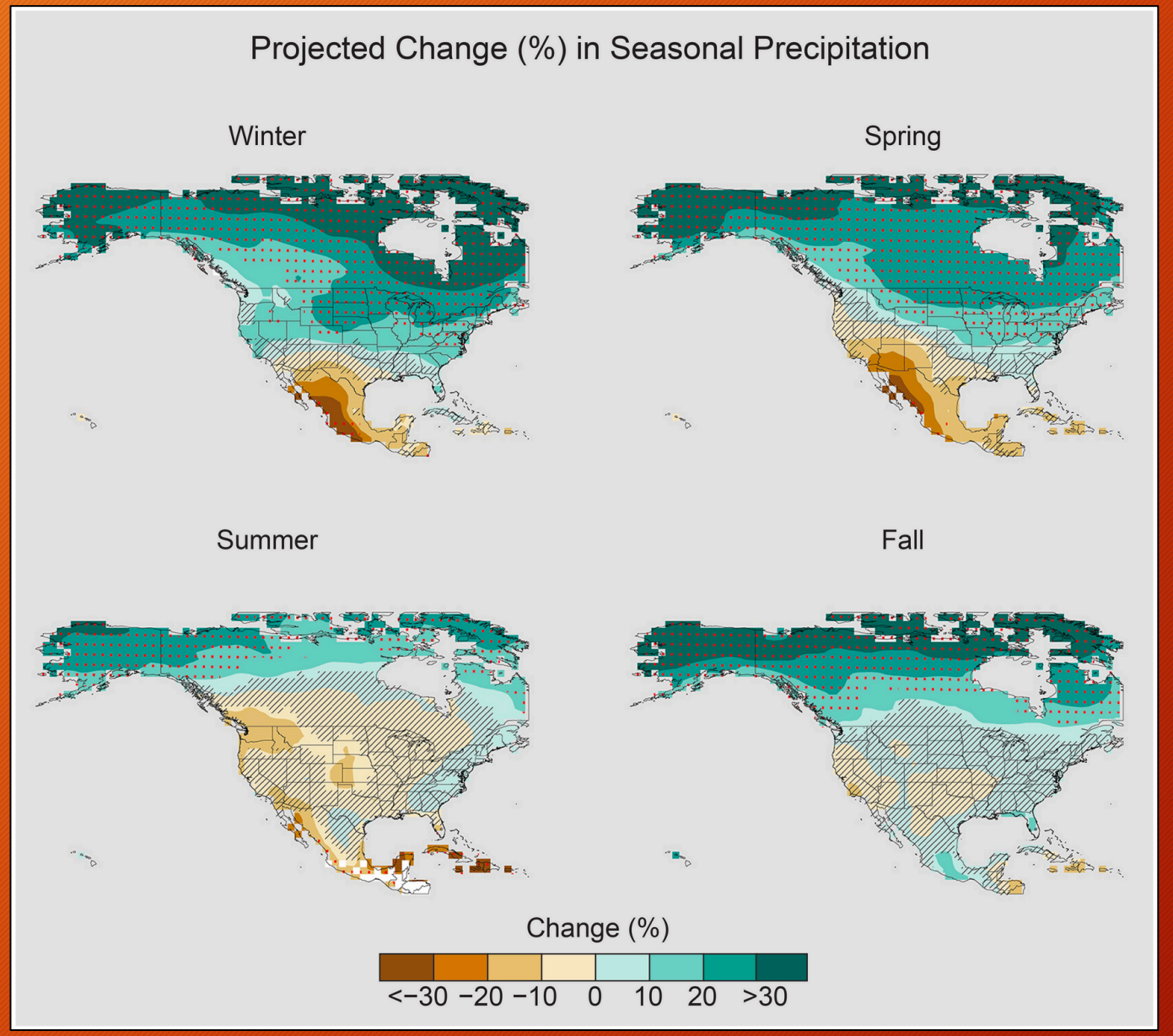
(NCA4, 2018)



(NCA4, 2018)

Precipitation projections

PRECIPITATION



(NCA4 CSSR, 2017)

Drought

- La Nina favors drought
  - ➔ Warm and dry conditions
- Leads to dry soils and stressed vegetation
  - ➔ Makes vegetation more flammable
- Drought has been linked to a higher potential for ignition, fire spread, and large fire events (Vose *et al.*, 2018)

West Texas Drought 2011 (http://bit.ly/2DTJChm)

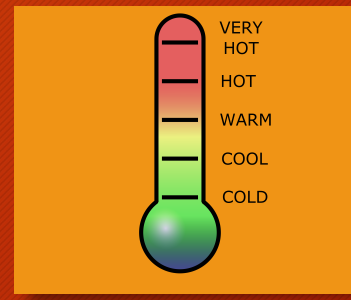
Drought PSA

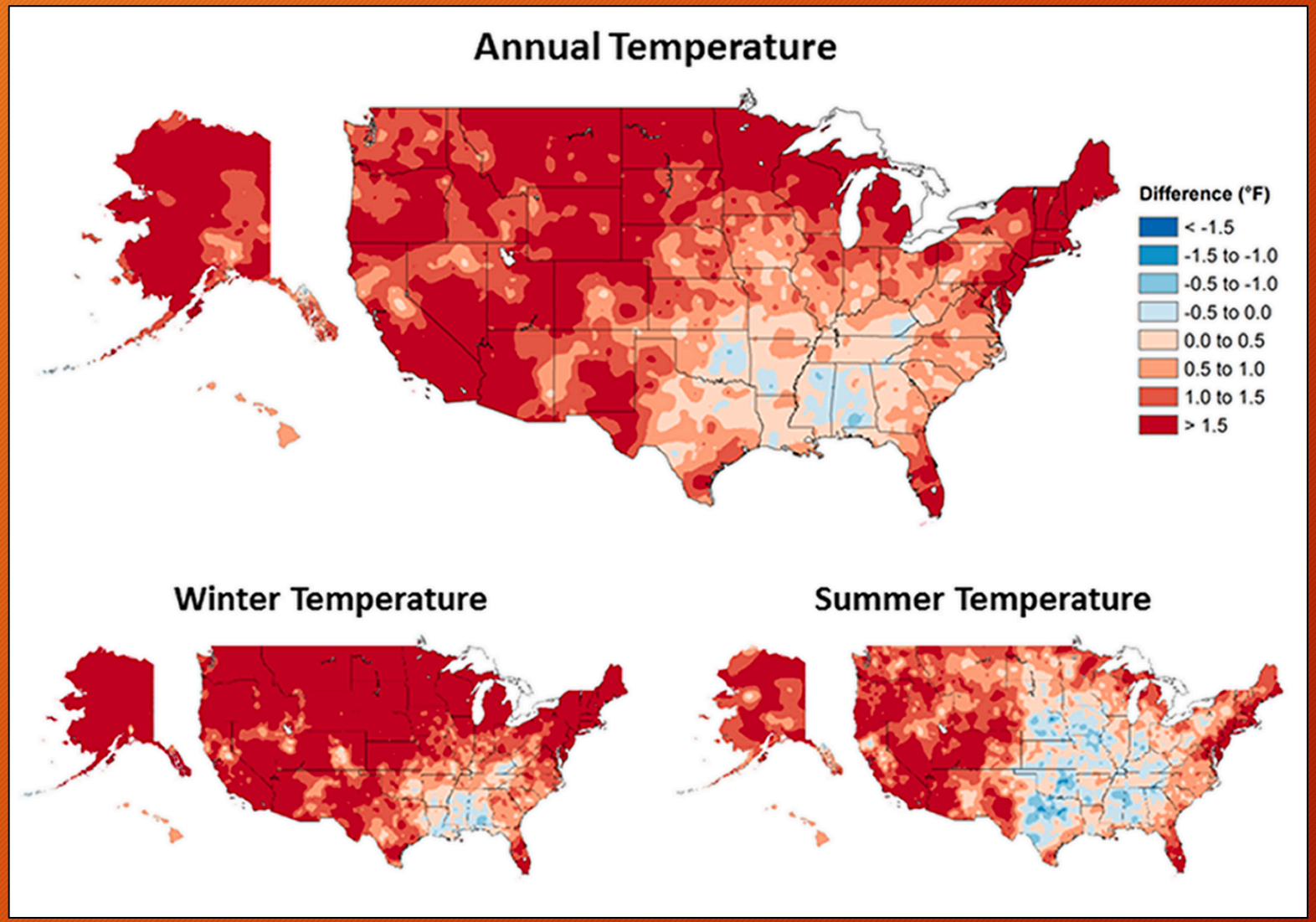
This is your pond.

This is your pond on drought.

Any questions?

TEMPERATURE

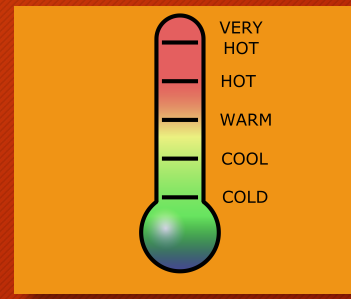


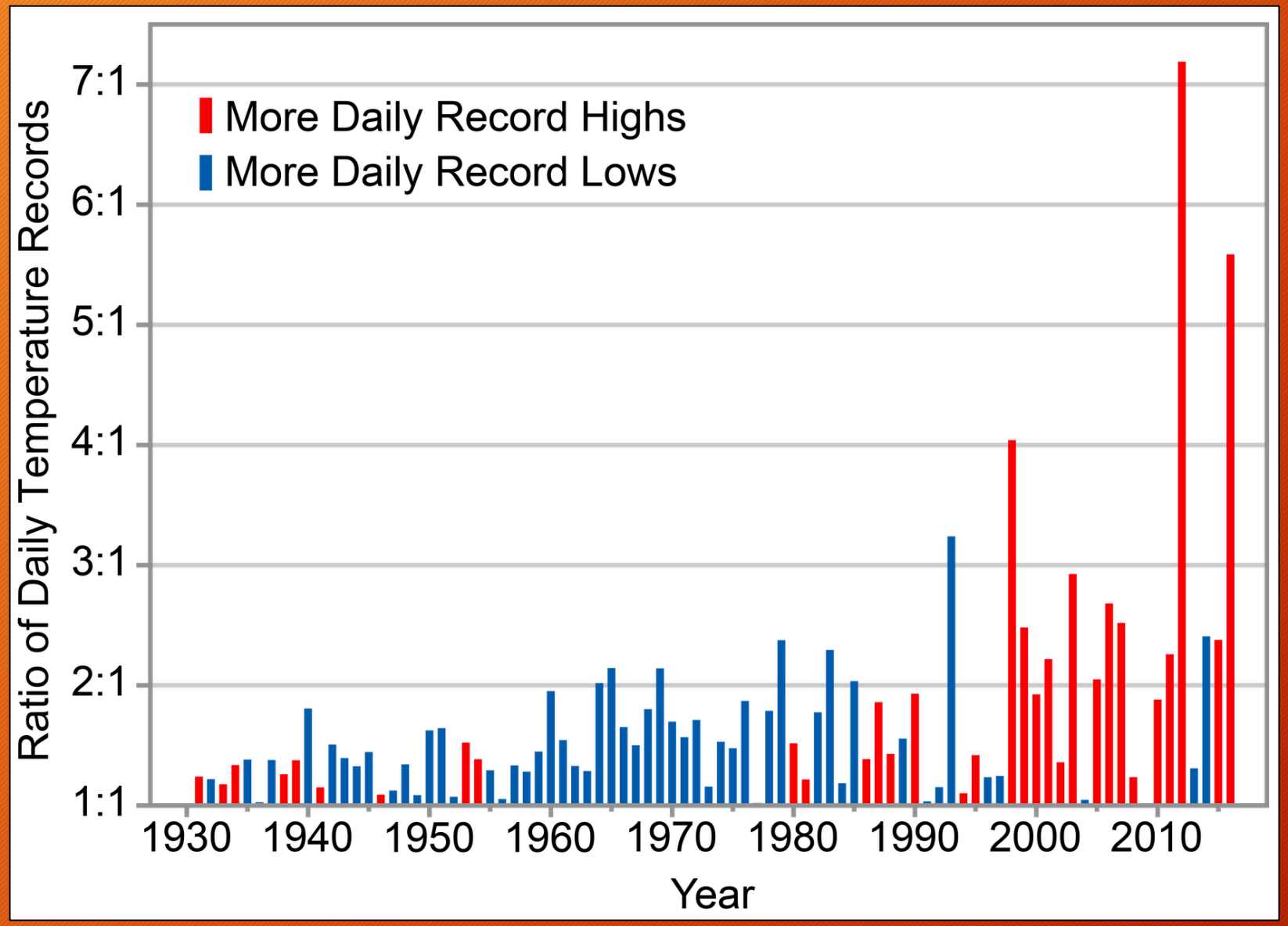


(NCA4 CSSR, 2017)

Changes in average annual temperatures by comparing the 1986–2016 values to the first half of the last century.

TEMPERATURE





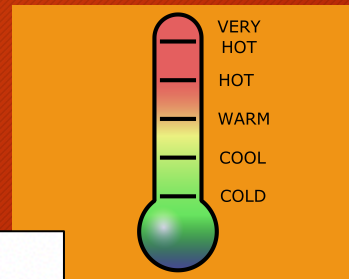
(NCA4 CSSR, 2017)

"Observed changes in the occurrence of record-setting daily temperatures in the contiguous United States.

Red bars indicate a year with more daily record highs than daily record lows, while blue bars indicate a year with more record lows than highs."

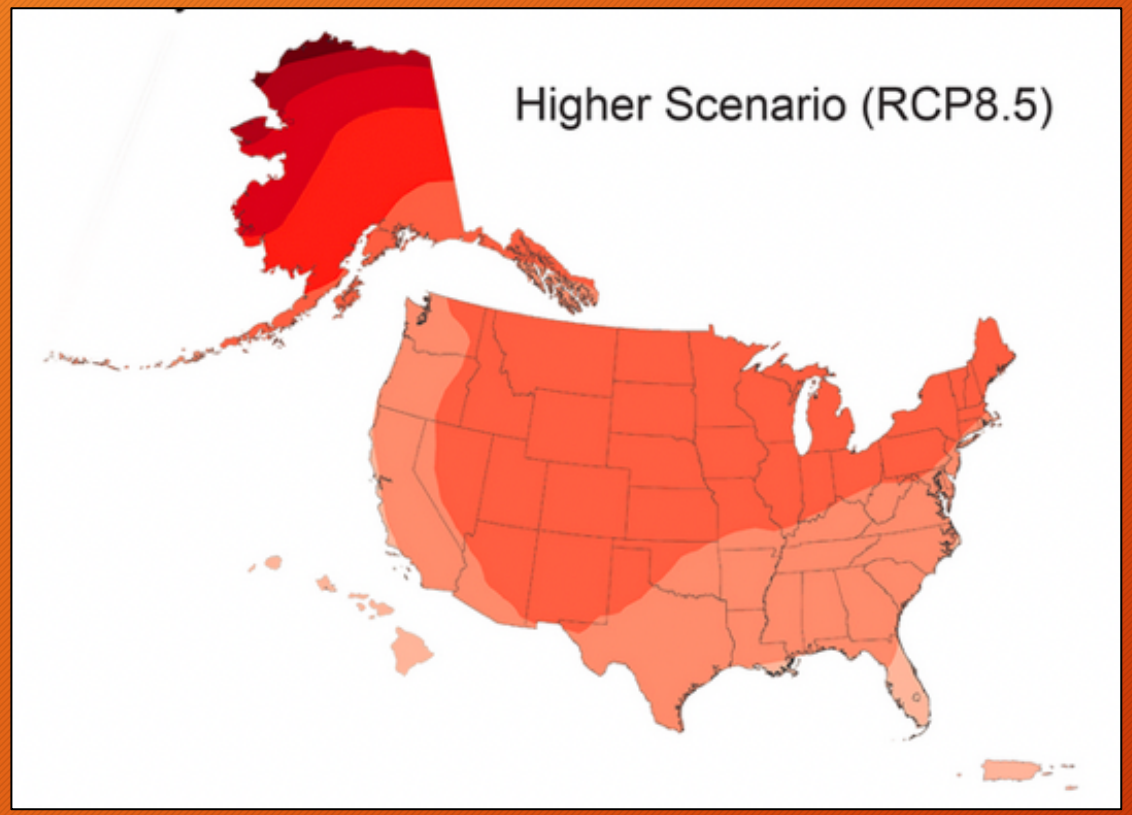
How will temperatures look moving forward?

TEMPERATURE

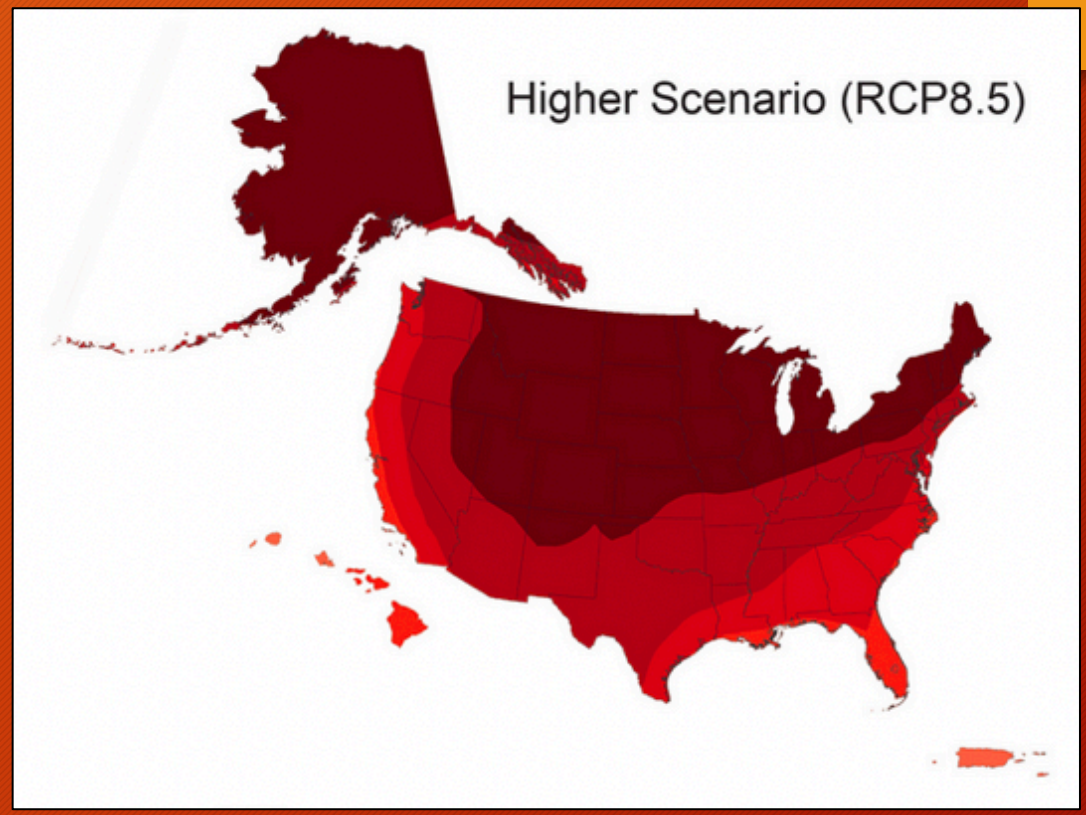


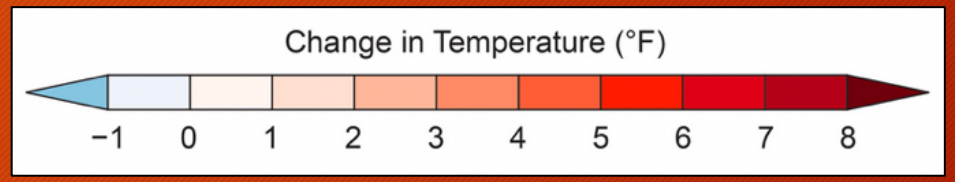
Annual Average Temperature Projections

Mid-21st Century



Late-21st Century

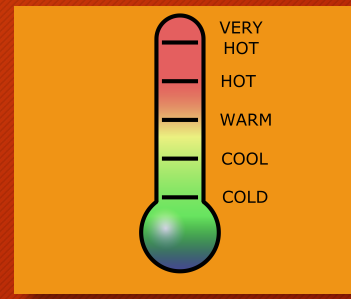




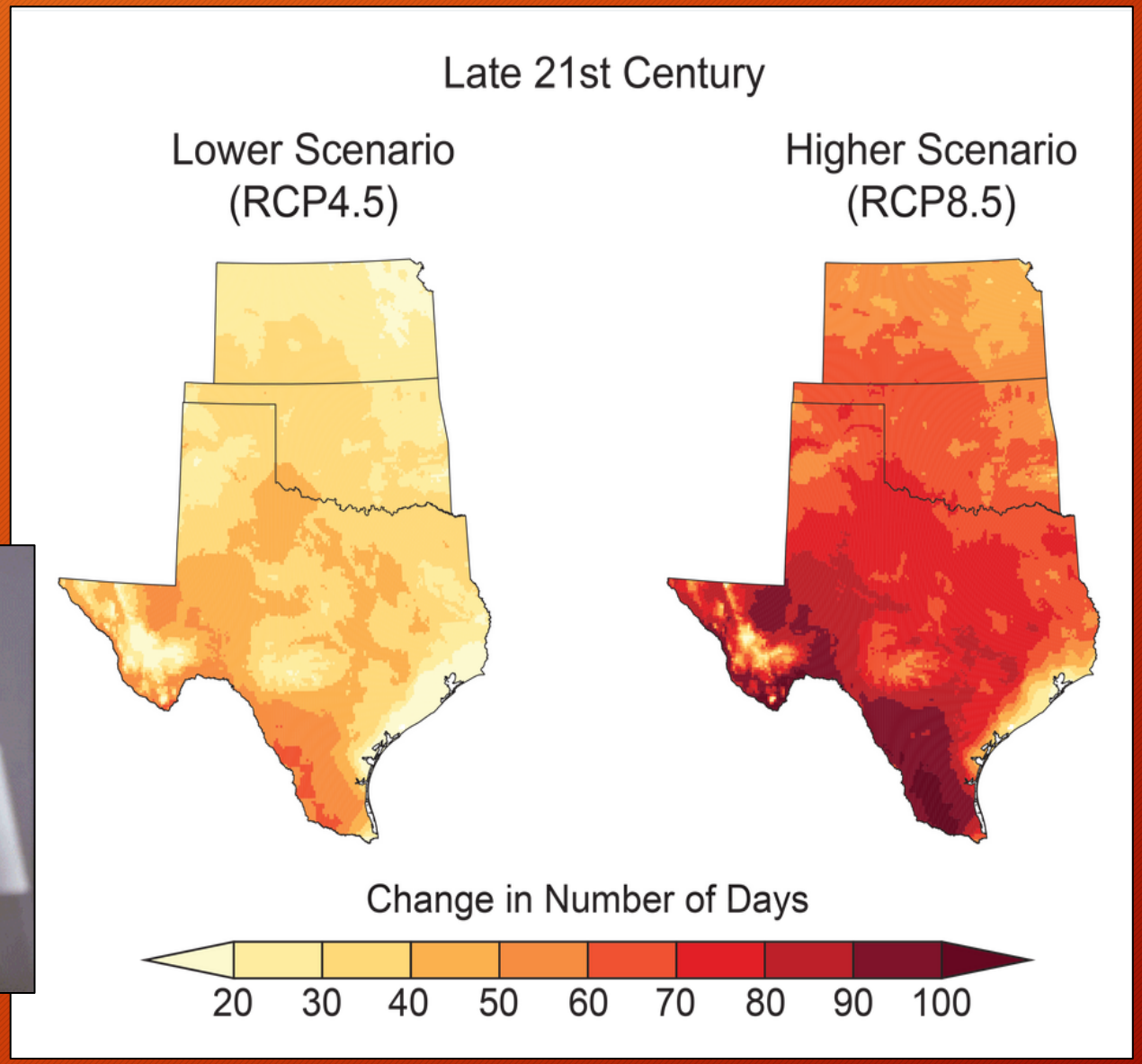
(NCA4, 2018)

Projected number of days above 100ºF

TEMPERATURE



By late in the 21st century, if no reductions in emissions take place, the region is projected to experience an **additional 30-60 days per year above 100°F** than it does now



(NCA4, 2018)

~Recipe~

SIMPLE DROUGHT TACO

Combine:
- Vegetation (shredded)
- 2 cups of Heat
- 1 cup of rainfall & soil moisture reduction sauce
- Bacon

Evapotranspiration

(Oklahoma Farm Report, 2011)

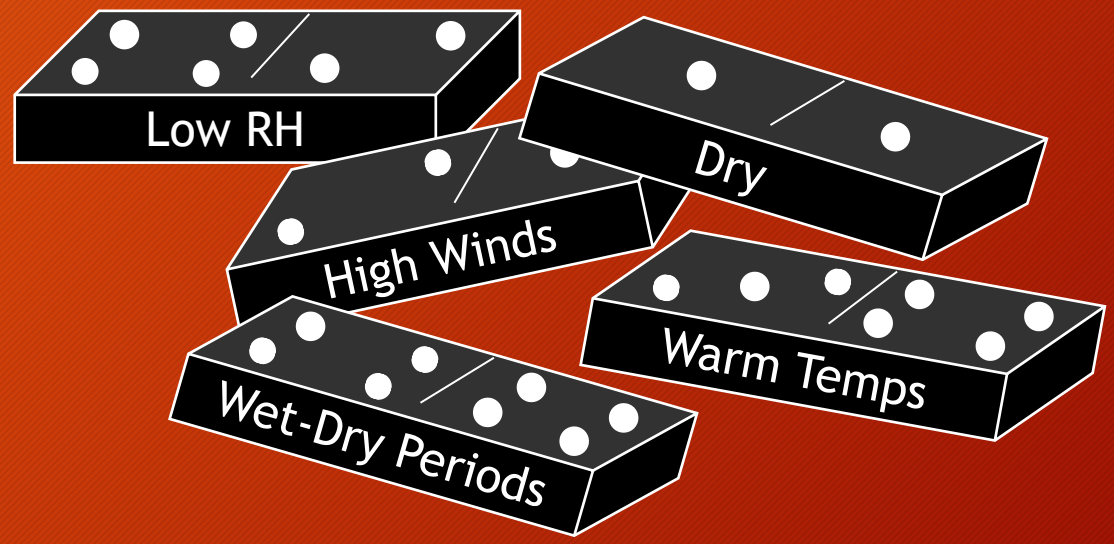
"Climate change is likely to exacerbate aridity in the Southern Great Plains, largely associated with drying soils due to increased evapotranspiration caused by higher temperatures (NCA4, 2018)."

Let’s Recap

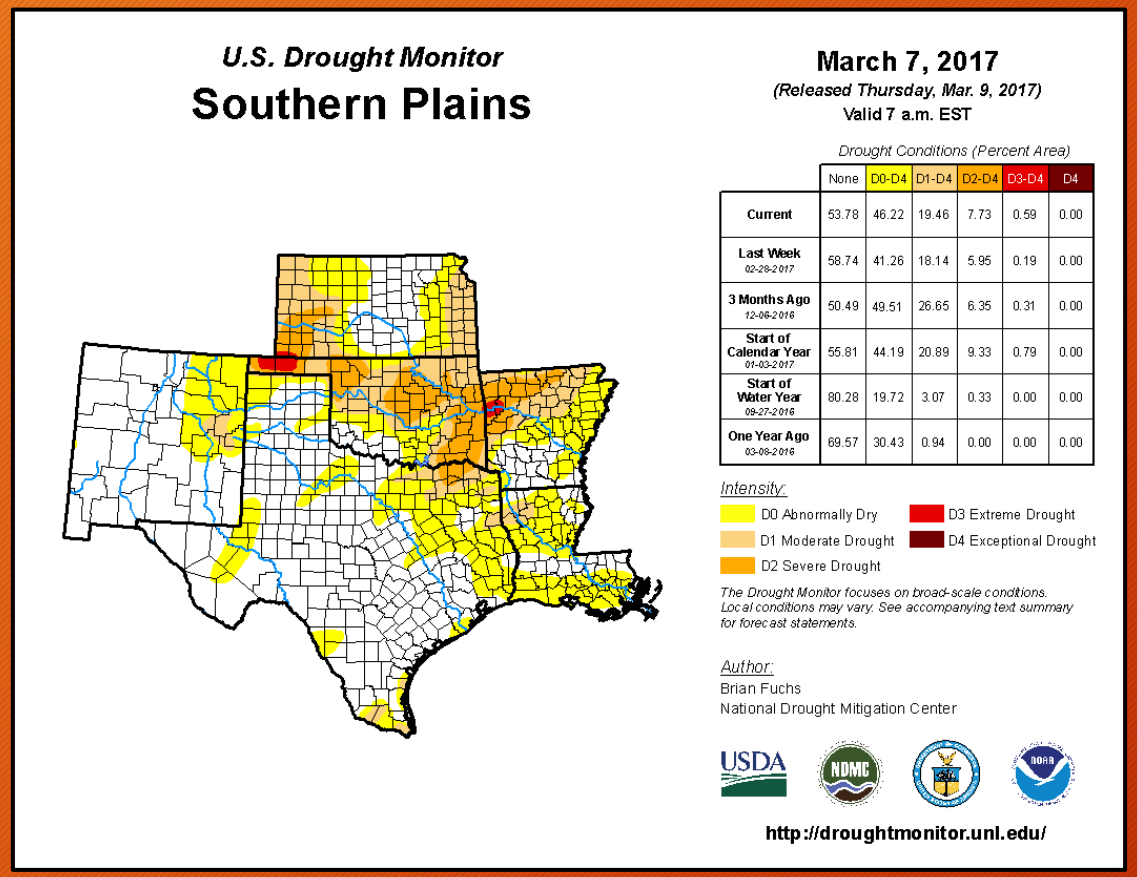
- Dipole events
- Extreme rainfall is increasing
- Temperatures are increasing
- Drought events may become more common

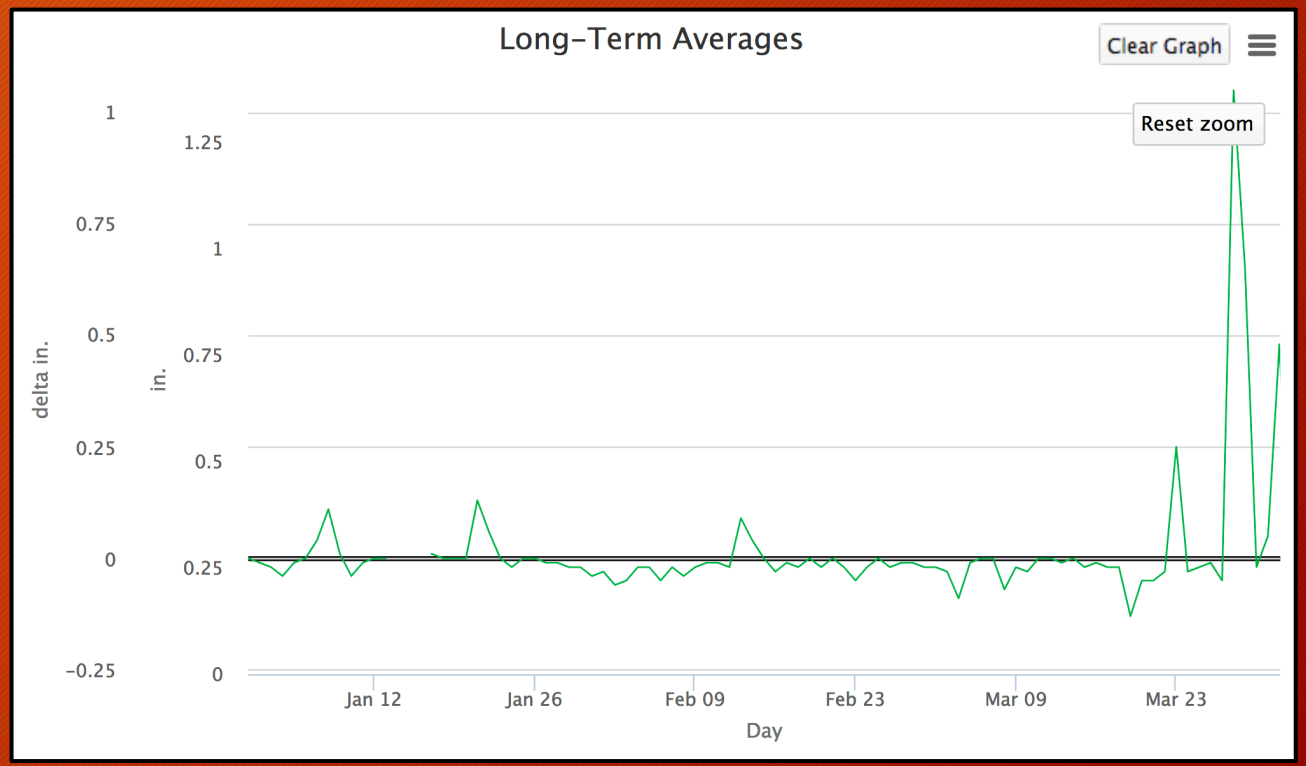
March 6, 2017: A Case Study

- ☐ Low Relative Humidity
- ☐ High Winds
- ☐ Warm Temperatures
- ☐ Low Precipitation/Drought
- ☐ Wet → Dry Period Shifts



Dry?

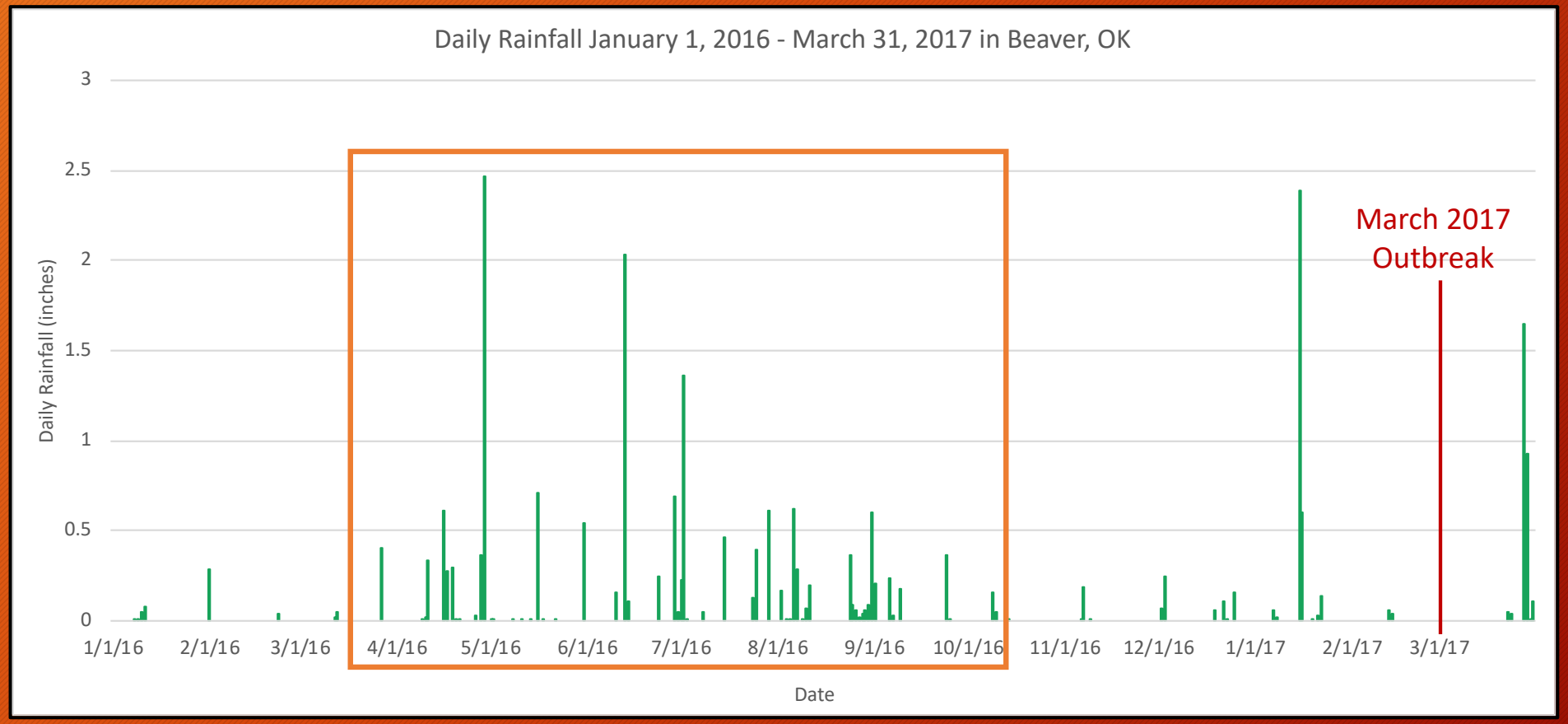




Oklahoma Panhandle Departure from Average Rainfall

(Data Source: OK Mesonet)

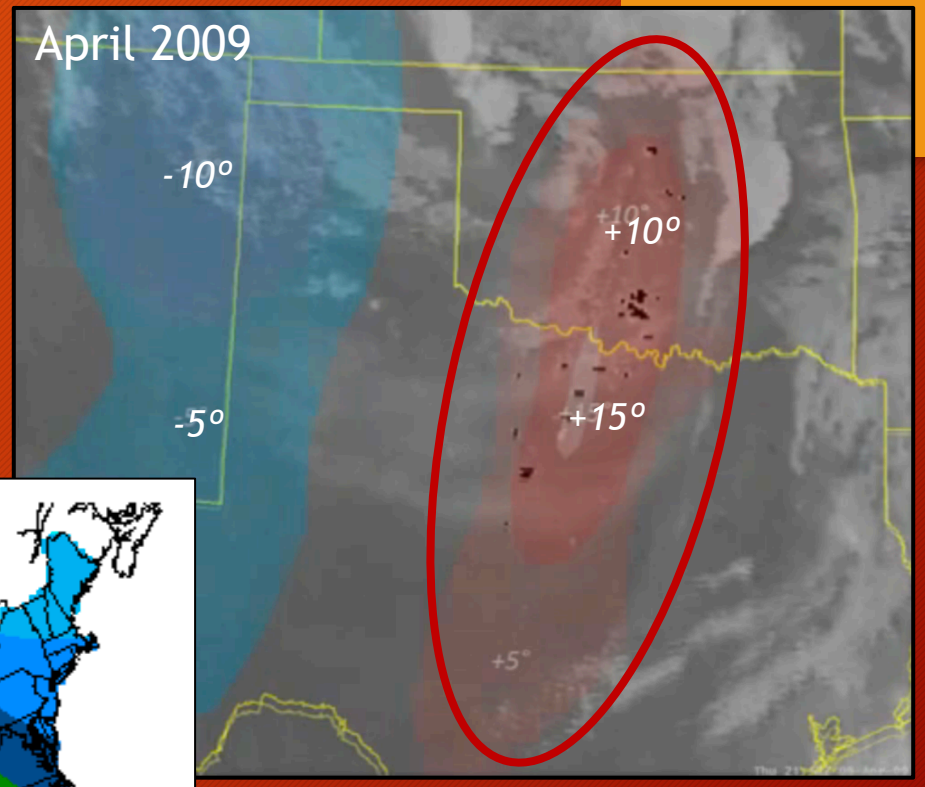
Dipole?



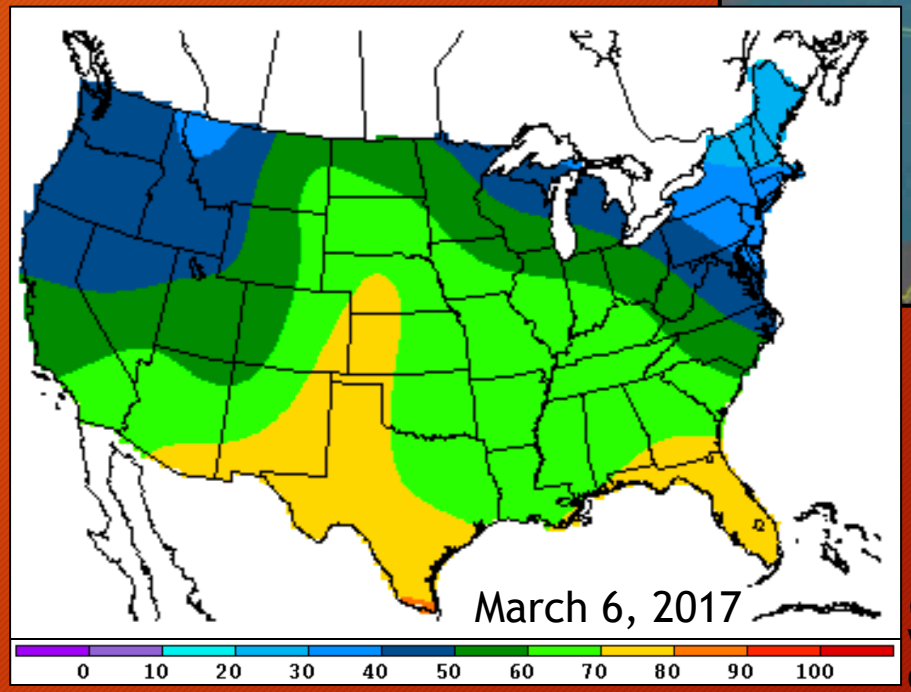
(Data Source: OK Mesonet)

Warm?

- Yes! In fact, a Low-Level Thermal Ridge played a major role
- Low-Level Thermal Ridge (LLTR)- a region of warm temperatures near the surface that often experiences warm air moving in ahead of a cold front
- Fire activity often occurs along thermal ridges where there are warm temperature anomalies
- LLTR was in place



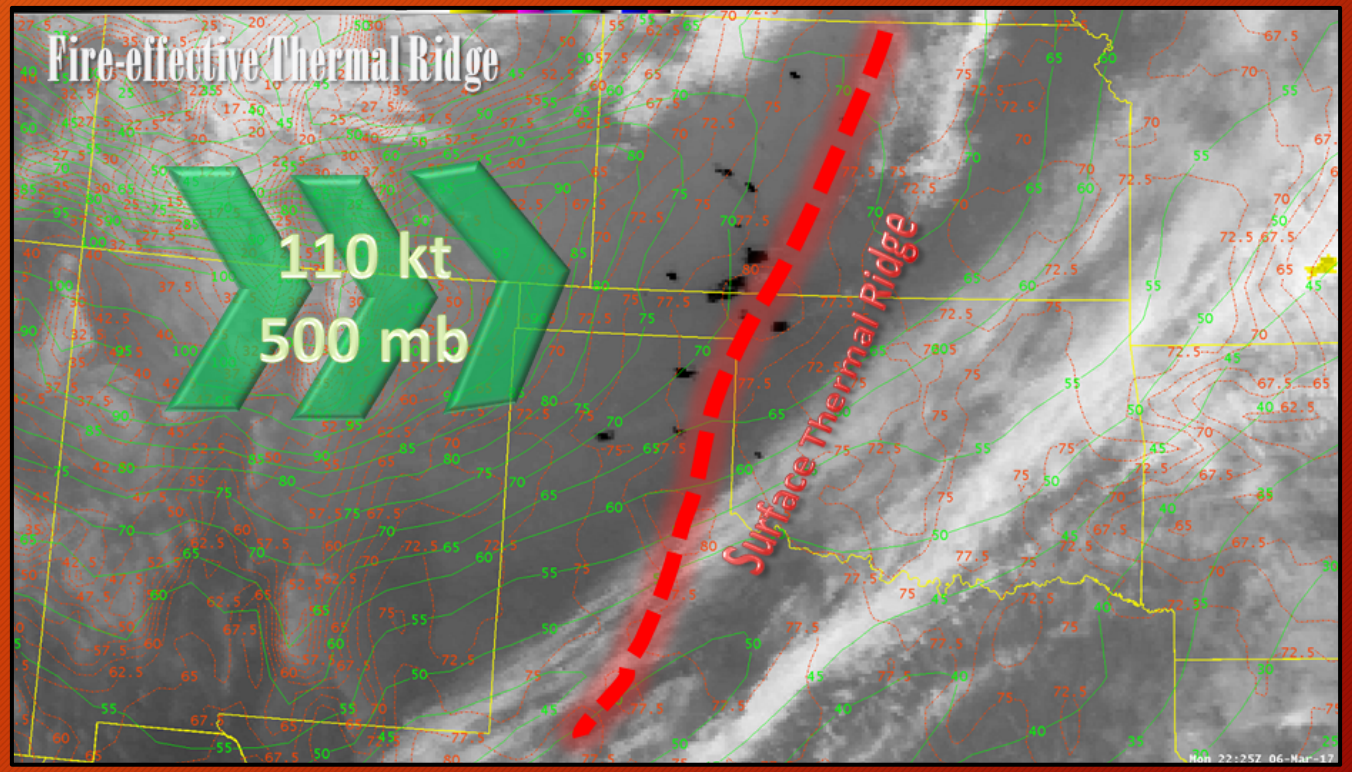
(Lindley et al. 2017)



(Data Source: Weather Prediction Center)

Windy?

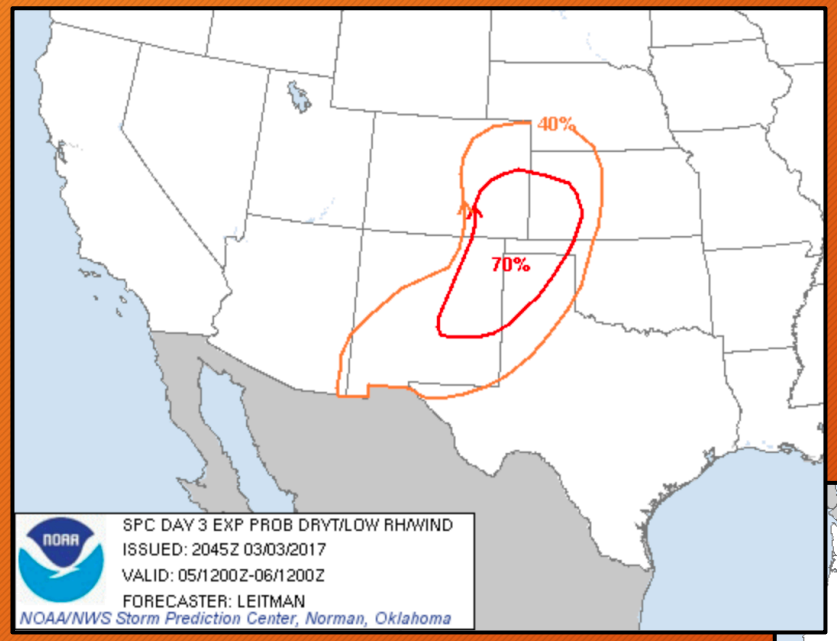
- Mid-level wind speed maximum was in place and it overlapped the thermal ridge
- Mid-level wind maxima + thermal ridge = typically most significant fire activity
- Fires generally occur in an area bounded by the wind maxima to the west and the thermal ridge to the east



(Lindley et al. 2017)

Outlooks:

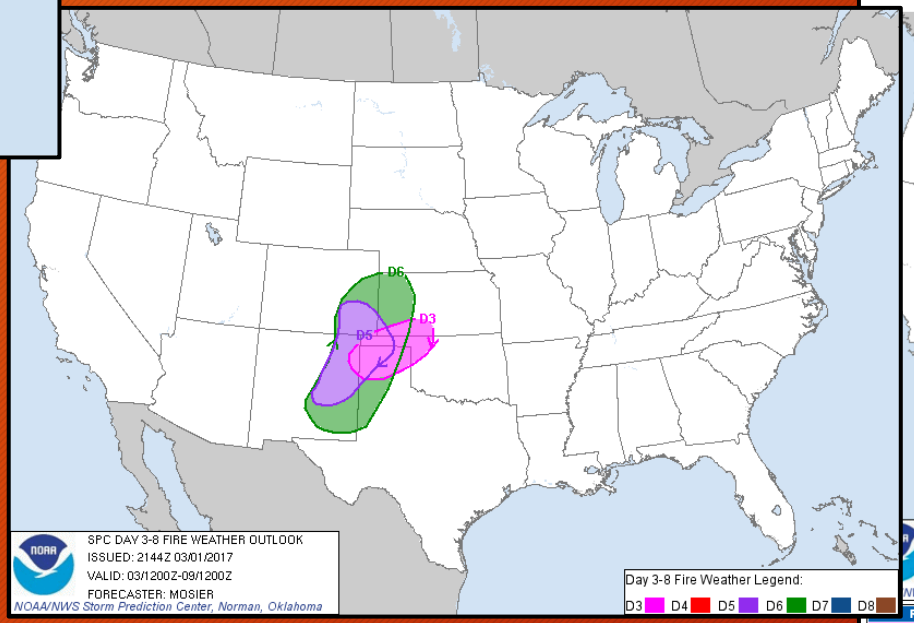
11:58pm March 5:
"…The region of greatest concern remains located along an axis from southeastern Nebraska southwestward into west-central Kansas, portions of the Oklahoma and Texas Panhandles, and eastern New Mexico. Here, 30-45 mph westerly surface winds will become common as temperatures rise into the 70s and RH values fall to between 5and 15%..."

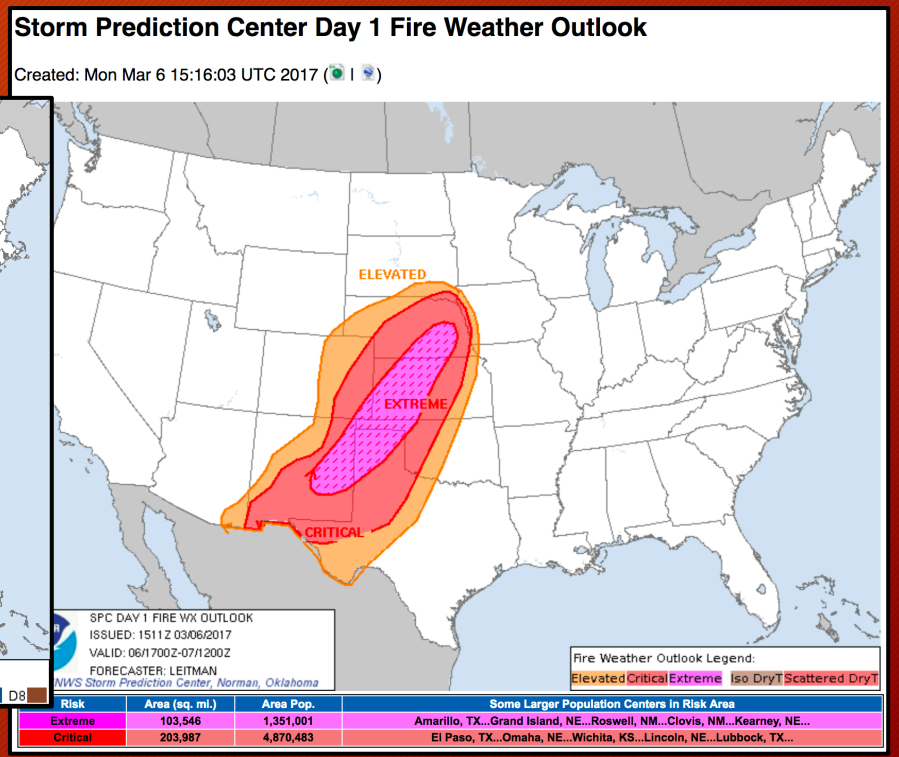


Day 3 Fire Outlook:

Probability of strong winds, low RH, and warm temperatures concurrent for at least 3 hours with dry fuels within 12 miles of a point
- Critical Area - 70% (red)
- Marginal Area - 40% (orange)

~1 Week Outlook:





(Data Sources: Storm Prediction Center)

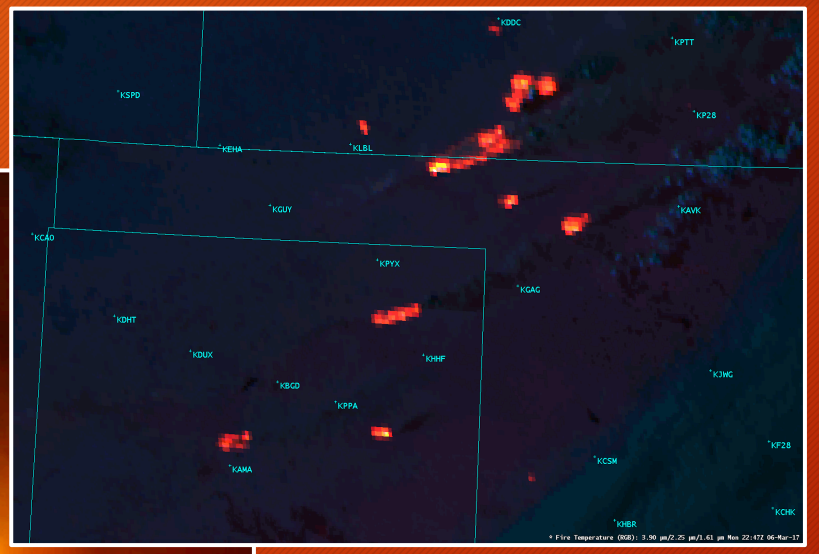
The Ingredients Coming Together…

Ingredients came together and the dominos fell…

- According to the Weather Forecast Office, fuel loading had been building over time
- Drought was impacting the area
- Combination of the thermal ridge and wind maxima created ideal fire conditions

The Perfect Firestorm

Firefighters from across Kansas and Oklahoma battle a wildfire near Protection, Kansas, Monday, March 6, 2017. *(Bo Rader/The Wichita Eagle via AP)*

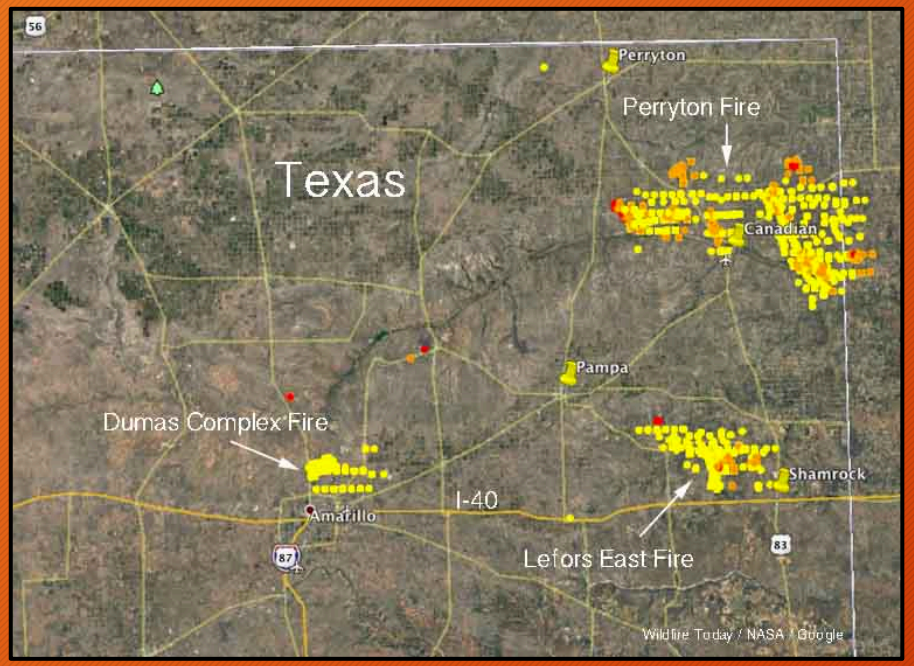


GOES-16 satellite image March 6, 2017

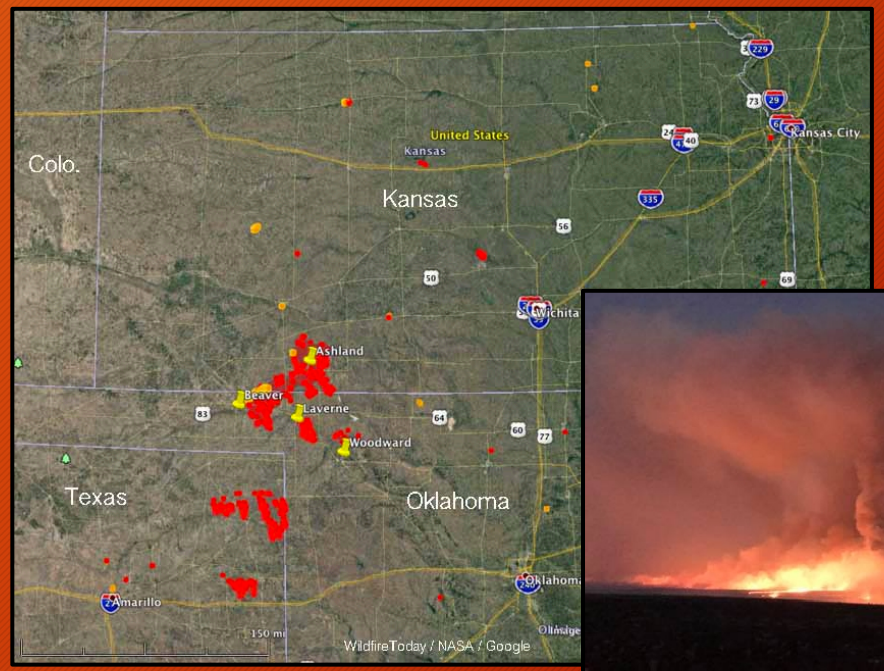
- 32 major fires
- 1,257,336 acres burned
- 87 structures destroyed
- 7 fatalities; 5 injuries

(Lindley, 2017)

- Largest individual Plains fire outbreak in modern history
- Unique: Multiple **megafires** occurred (>100,000 acres burned)
  - Megafires are high intensity fires that can cause immense damage and extremely poor air-quality
  - “Commonly understood to be very large, intense, and uncontrollable fires (Larkin *et al.*, 2015)”

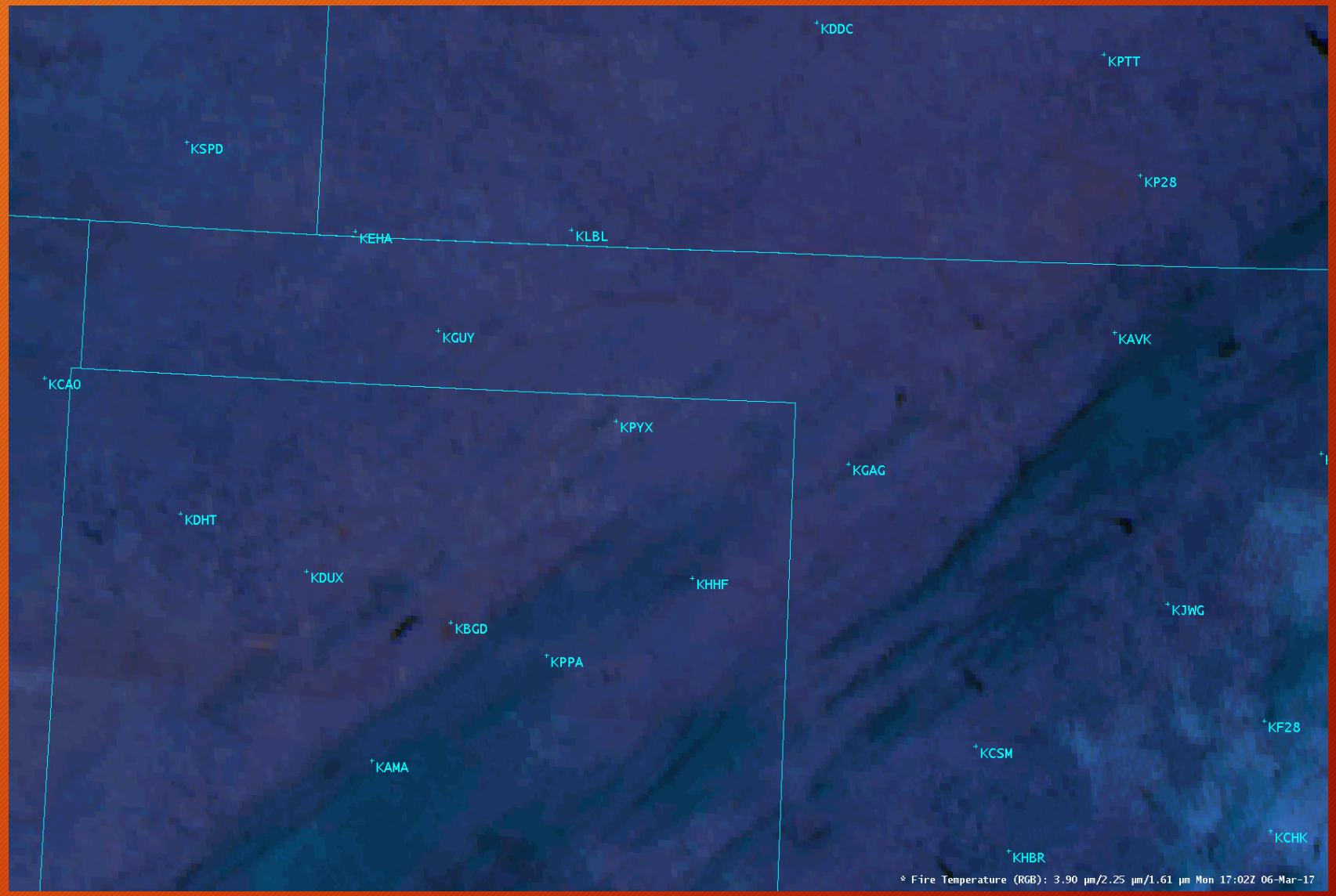


(Gabbert, 2017)



Perryton Fire March 8, 2017, Perryton, TX (abc Amarillo)

GOES-16 Satellite March 6, 2017



Dominoes Stacked

- ☑ Low Relative Humidity
- ☑ High Winds
- ☑ Warm Temperatures
- ☑ Low Precipitation/Drought
- ☑ Wet → Dry Period Shifts

Climate change is expected to…

- Increase average temperatures
- Increase frequency, duration, and intensity of extreme heat events and a reduction in extreme cold events
- Increase drought duration and severity
- Small changes to average annual precipitation in the region, with slightly wetter winters and drier summers
  - → Increase in frequency and intensity of heavy precipitation
  - → Implies fewer soaking rains and more time to dry out between events, with an increase in soil moisture stress
  - → Less future soil moisture, with future <u>conditions possibly drier than anything experienced by the region during at least the past 1,000 years</u>

What does this mean for future wildfires?

- “Increased frequency and size of large, severe forest fires are expected in the United States (Stephens et al., 2013).”
- In the western U.S., this is exacerbated by increased temperatures, earlier spring snow melt, and a longer fire season
- In the Southern Plains, wildfire risk will increase throughout the region as temperatures rise, particularly in the summer, and as the duration of the fire season increases (NCA4, 2018).
- Forest fire extent, frequency, and intensity will still also depend strongly on local ecosystem properties, which will vary across the country.

As decision-makers and resource managers:

- Recognize these fire ingredients, as well as factors that impact other climate-related hazards you may face
- Consider how land management may play a role in fuel load
- Knowing how conditions are projected to change can help you plan for the future
- Continue to grow awareness, educate yourself, and be a perpetual student

Thank you!

We got this!

Contact:
Monica Mattox
mmattox@mesonet.org