Special Topics

Water and Fire

(The Cascading Effects of Drought, Wildfire, and Floods)

South Central Climate Science Center
LSU Louisiana State University
Flower Hill Institute

What Exactly is a Drought?

- Not enough water for needs.
  - Multi-faceted disaster with far-reaching consequences.
  - Slower, requiring different understanding than other natural phenomena (hurricanes, tornadoes, earthquakes, etc.).

https://en.wikipedia.org/wiki/Drought#/media/File:Drought.jpg

Types of Drought

- Meteorological drought
  - departures from "normal" precipitation
- Agricultural drought
  - soil/groundwater deficits that affect vegetation
- Hydrologic drought
  - deficiency of water in watersheds, rivers; often lags agriculture impacts
- Socio-economic drought
  - shortage of some item (water, food, fish, natural values) that affects the balance of supply and demand

Photo courtesy of Elephant Butte Irrigation District

How is Drought Monitored?

Rainfall Departures	• Measured virtually everywhere • Easy to calculate
Palmer Drought Severity Index	• Good for long-term drought in relatively uniform regions • Does not respond very rapidly
Standardized Precipitation Index	• Measures how "unusual" precipitation departures are • Calculated for different time scales
Keetch-Byrum Drought Index	• Used for fire potential • Responds quickly to weather conditions
Soil Moisture	• Water-balance approach • Tied closely to impacts
Evaporation	• Includes temperature, wind, humidity • Can be an early indicator
Reservoirs / Stream Flow	• Monitoring water supplies • Highly managed systems

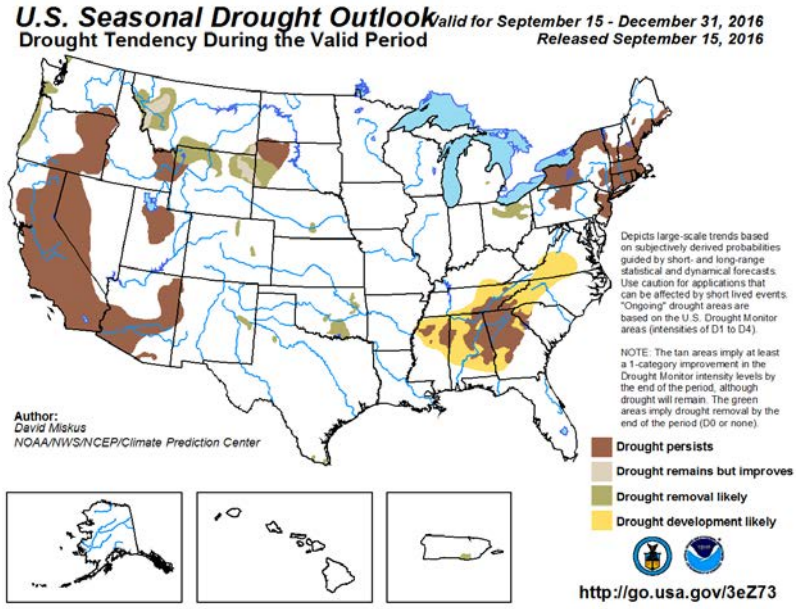
Consequences of Drought

- Loss of human life and property
  - Potential for socio-economic collapse.
- Loss of natural resources/environmental degradation
  - Death of animals, plants; loss of natural reservoirs and changes to hydrologic system.
- Increases risk of other disasters – wildfire and floods (i.e., cascading effects).

https://en.wikipedia.org/wiki/Drought#/media/File:FEMA_-_917__Photograph_by_Angel_Santiago_taken_on_04-03-1998_in_Marshall_Islands.jpg

What Causes Drought?

- Can happen seasonally, but on longer scales is defined by several elements:
  - Climatic teleconnections and oscillations
  - Human activity
  - Climate change
- Combined high temperatures and low precipitation



http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php

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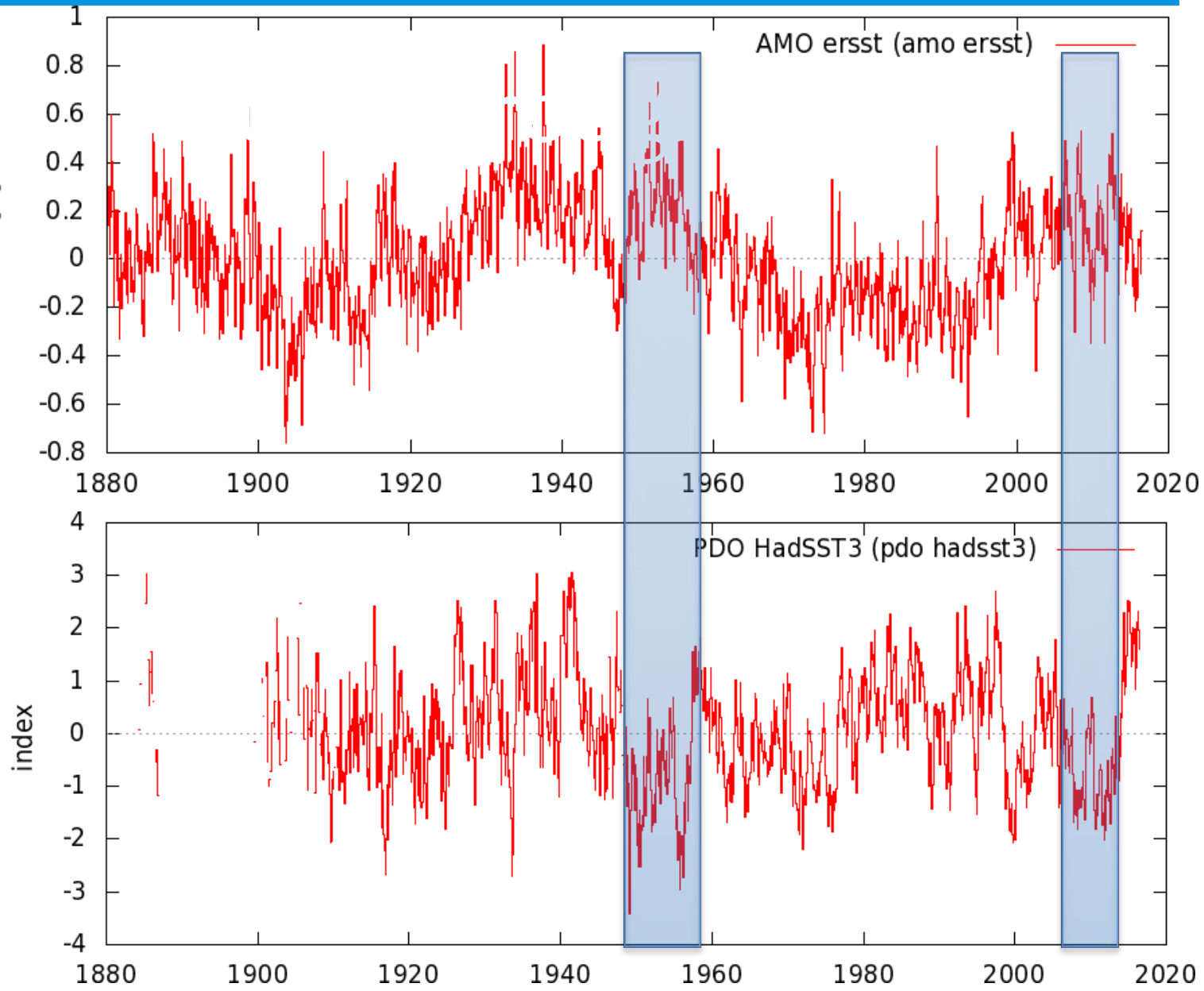
Years when climate conditions have aligned to produce extreme drought effects – most recently the 1950s and 2000s



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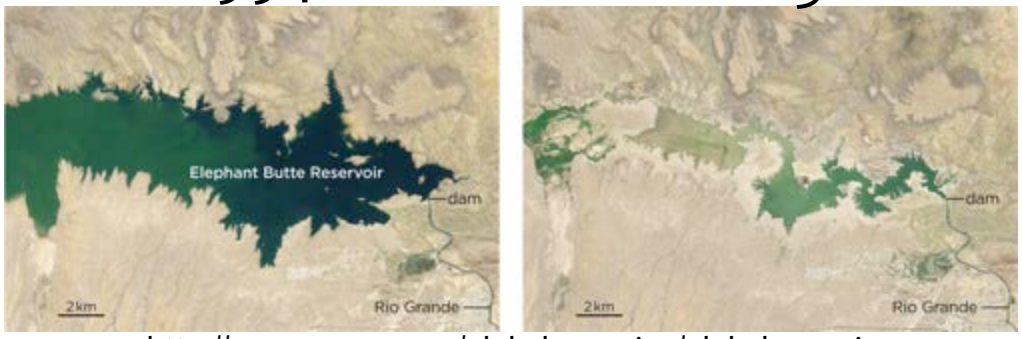
Human Activity

- Humans have been managing water all over the world for thousands of years.
- More recent activity (last few hundred years) has dramatically changed flow of water in western US.
- Water often does not get where it is needed or is wasted.

1994 2013



http://www.ucsusa.org/global-warming/global-warming-impacts/confronting-climate-change-impacts-new-mexico#.V8m5-yMrIy4

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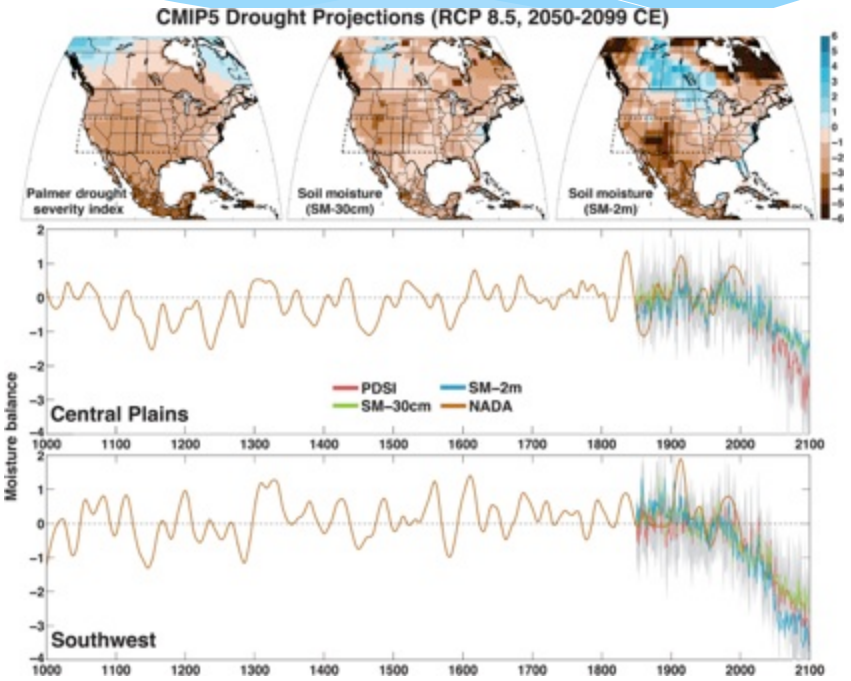
Drought and Climate Change

- July 2016 was hottest month recorded by instruments – 10th in a row!
- Climate change means increased heat and CO_2 in atmosphere and oceans
  - Both contributing factors to drought.
- Higher temperatures cause feedback effect – drier soils, less retention of water.



Published by AAAS **Benjamin I. Cook et al. Sci Adv 2015;1:e1400082**

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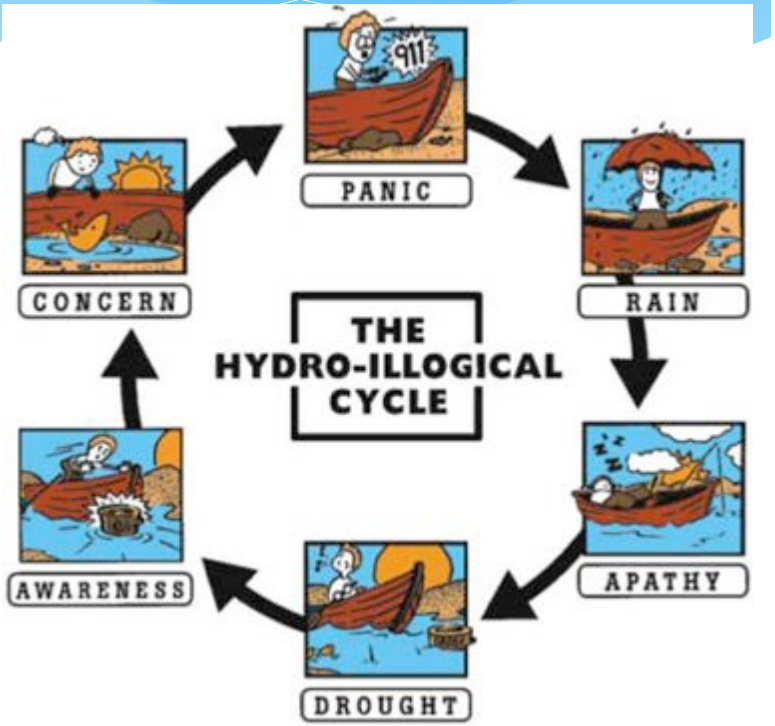
Mitigation and Adaptation

- Most current drought response is reactive
  - However, drought is inevitable, and longer droughts are becoming more common
  - Planning is crucial
- ABCs of drought preparation
  - Assess Conditions
  - Be Prepared
  - Communicate



https://www.ihs.gov/california/tasks/sites/default/assets/FileDroughtContingencyPlanTemplate.docx

Examples: Navajo and Hopi Drought Plans

- Navajo developed their plan in 2003
  - Includes vulnerability assessments, drought monitoring and mitigation guidelines, and response procedures
  - http://drought.unl.edu/archive/plans/drought/tribal/NavajoNation_2003.pdf
- Hopi developed their plan in 2000
  - Part of the mission of their Department of Natural Resources
  - http://www.hopi-nsn.gov/tribal-services/department-natural-resources-2/


NAVAJO NATION
DROUGHT CONTINGENCY PLAN
2003

GREAT SEAL OF THE NAVAJO NATION

PREPARED BY:

NAVAJO NATION
DEPARTMENT OF WATER RESOURCES

IN COOPERATION WITH:
U.S. Bureau of Reclamation
U.S. Bureau of Indian Affairs
Navajo Nation Department of Emergency Management

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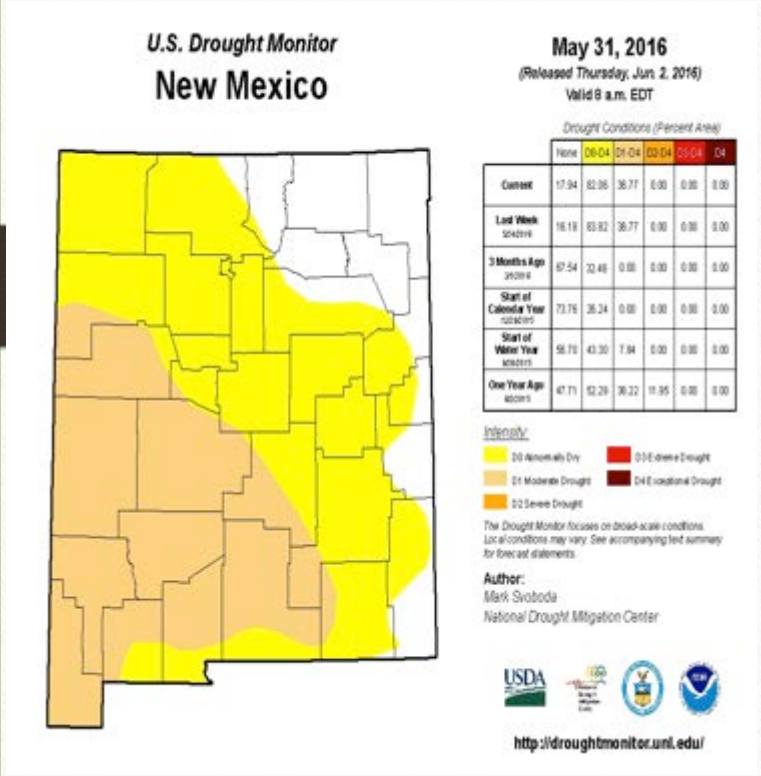
How is Climate Change affecting Fires?

- **Western States-Longer fire season**
  - T ↟ 1.9º annually since 1970 in Western States
  - Fire seasons 78 days longer than they were in 1970

More frequent and severe droughts and floods



Gila River at Red Rock

Santa Clara Pueblo flooding July 2013

More fuel for fires

- **Large Scale Forest Die back**
- **More frequent Bark Beetle Infestations**

Less snow and more rain

Snowpack stores moisture from winter to release slowly in late spring and early summer. Higher temperature-melts earlier.
Hot, dry summer, no extra moisture

Los Conchas Fire

- Second Largest wildfire in NM history
- Began June 26, 2011
- Contained August 1, 2011
- Burned over 156,000 acres

Pueblos Affected

- Burned 145 square miles of pueblo land, over 16,000 acres of Santa Clara Pueblo
- Santa Clara, San Ildelfonso, Pojoaque, Jemez, Cochiti, Kewa

Tribes and Las Conchas Fire

Over the years, devastating fires have not only wiped out wildlife, vegetation and landscapes but, they have also changed and challenged the environments and cultures of many tribes.

Fire and a healthy forest

Before the fire:

- Ponderosa Pine trees, Pinon trees, Juniper and other Evergreens, native grasses and shrubs
- Important for cultural practices

Alamogordo, NM

Invasive Species and Changing Pinon-Juniper woodlands

- Tamasisk (Saltcedar)
  - 1 Million acres or more along streambanks
- Western Juniper
  - Invading new areas pushing out native plants
  - HIGH fuel intensity, burns everything

Wildland Urban Interface

Cascading Events leading to fire

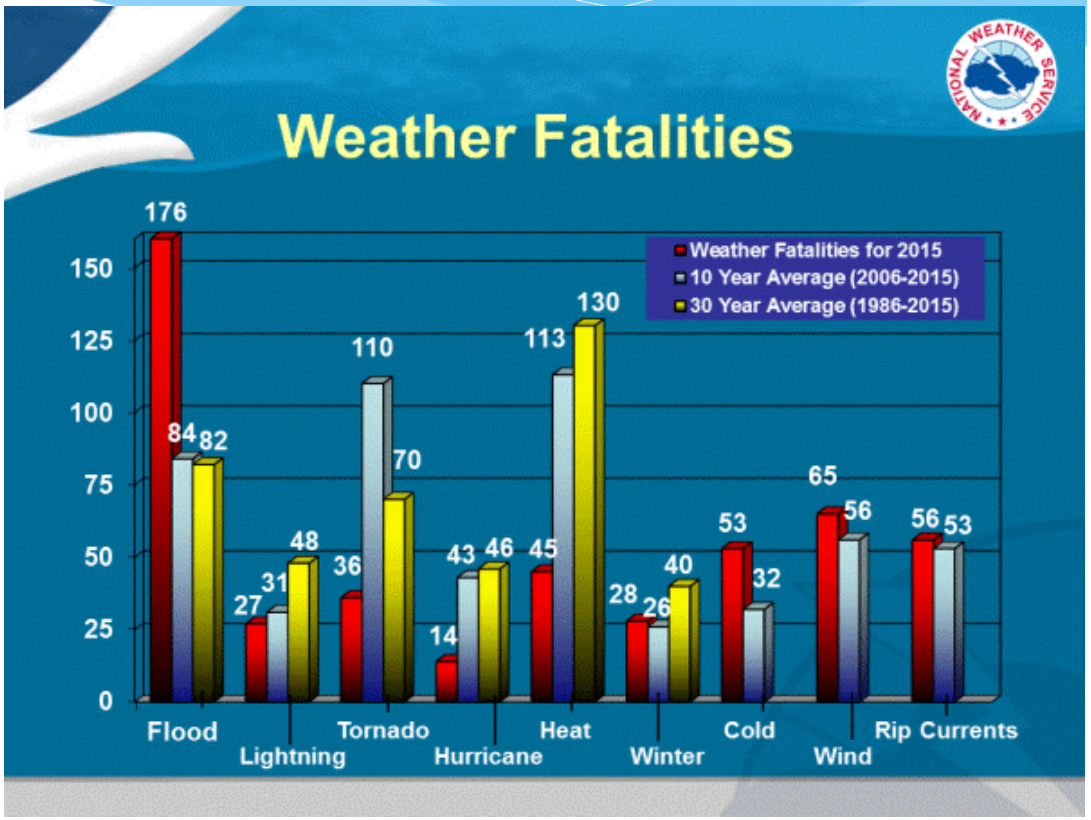
We have had:

- Drought
- Floods
- Fires
- Increased Debris buildup
- New vegetation
- Earlier Spring
- Fire season starts sooner
- Changing monsoon season

Flooding

Flash Floods

- Flash floods are rapid floods of low-lying areas typically caused by excessive rainfall
  - Time scale of less than six hours.
- Flooding in general kills 176 people last year in the US, making it the most common form of weather-related fatality.



http://www.nws.noaa.gov/om/hazstats.shtml

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What Causes Flash Floods?

http://www.blm.gov/style/medialib/blm/nv/field_offices/las_vegas_field_office/red_rock/redesign_photos.Par.7985.File.150.113.1.gif

- Often follow drought and wild fire
  - Dry soil cannot retain moisture
  - Vegetation overwhelmed – can't absorb water in time
  - Rainy season follows dry season and brings sudden, intense rainfall

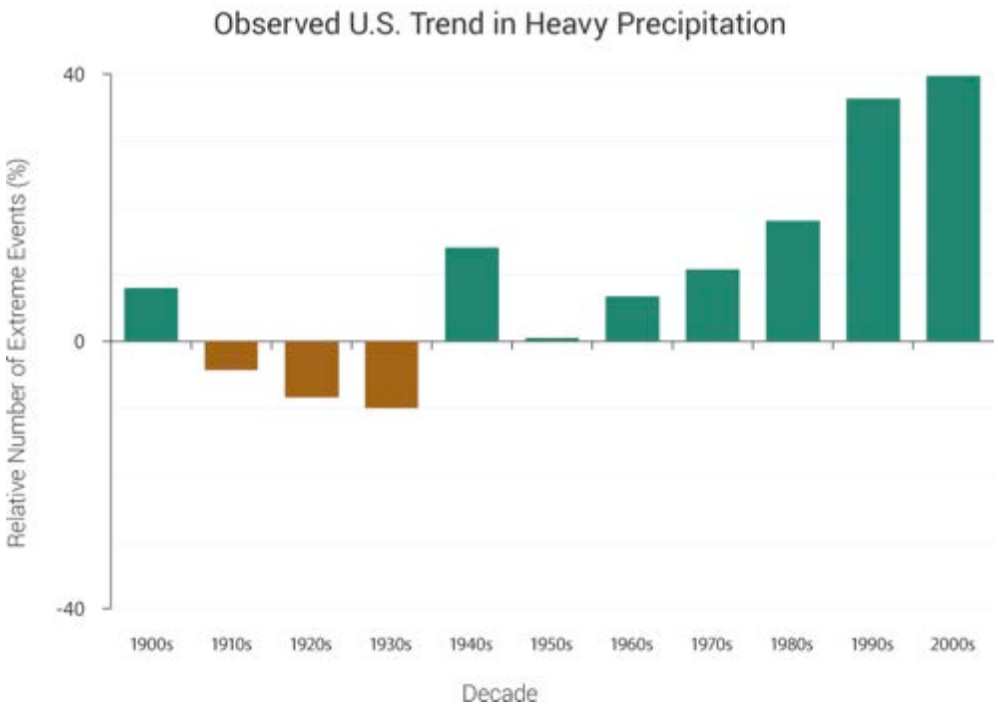
How Does Climate Relate?

- Occur in areas where soil does not handle moisture well
  - Arid or super saturated regions
- Areas of sudden, intense rainfall
- Also areas where vegetation is vulnerable – post-wildfire and drought
- Lots of low-lying areas (i.e., canyons, riverbeds)
- The Southwest US meets all of these criteria.

https://www.nps.gov/glca/planyourvisit/images/flash_flood_1.jpg

Flash Flooding and Climate Change

- Increased drought length/severity mean less moisture
  - Dryer soils and fewer plants
- More heat in atmosphere means stronger thunderstorms more often



http://nca2014.globalchange.gov/highlights/report-findings/extreme-weather

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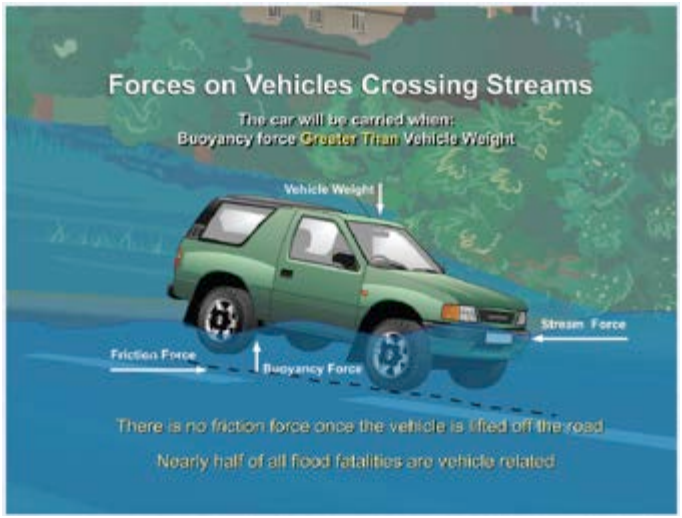
Mitigation and Adaptation

- Planning
  - Build away from rivers
  - Prepare for increase in winter rainfall and decrease in summer
- Infrastructure – culverts, storm drains, retention basins
  - Especially near roads
- Timely response
  - Evacuation routes
  - "Turn Around, Don't Drown" – National Weather Service



https://www.youtube.com/watch?v=UbiPT5VMo8E

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Example: Ghost Ranch Flood of 2015

- Prime example of how climate change can cause more intense flooding
  - NWS had no record of flooding this intense in this area before 2015
- 27 feet of water at highest, possibly over in less than an hour!

http://krqe.com/2015/07/09/flooding-destroys-parts-of-new-mexico-ghost-ranch/#jp-carousel-175001

Tying it all together

- Climate influences each of these events, and they can cascade together to make each event more intense.
  - Droughts make an already arid area drier.
  - Fire can disrupt what vegetation and soil moisture remain.
  - Floods intensify as a direct result of previous two conditions plus sudden rainfall.

- By planning for all three together, adaptation and mitigation is possible. All of these events will become more of an issue with climate change.