# Bringing Fire and Soil Moisture Worlds Together, Together

**Timothy Brown**

Desert Research Institute, Reno, Nevada

Soil Moisture and Wildfire Prediction Workshop     Albuquerque, NM     29 Apr 2019

Desert Research Institute

Western Regional Climate Center

Climate Ecosystem Fire / Applications

California-Nevada Climate Applications Program

A NOAA RISA team

# The water and fire cycle


The Spokesman-Review: Crews battle a wildfire in the Palomino Valley, on Wednesday, July 5, 2017, near Reno, Nev. (Jason Bean / AP)

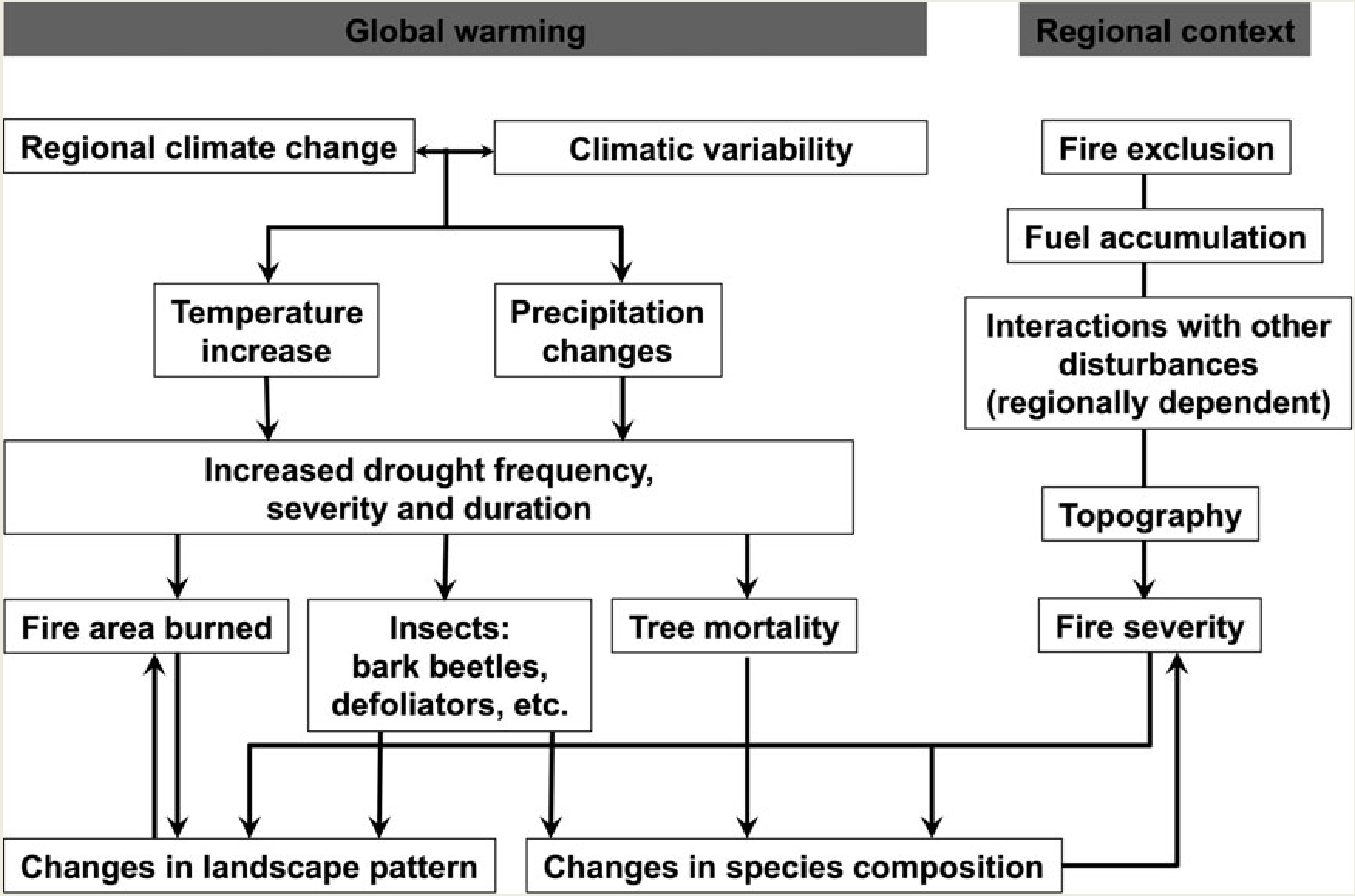
# The water and fire cycle

Buffelgrass green-up and curing

https://www.nps.gov/sagu/learn/nature/buffelgrass.htm

https://www.usgs.gov/centers/wgsc/science/buffelgrass?qt-science_center_objects=0#qt-science_center_objects

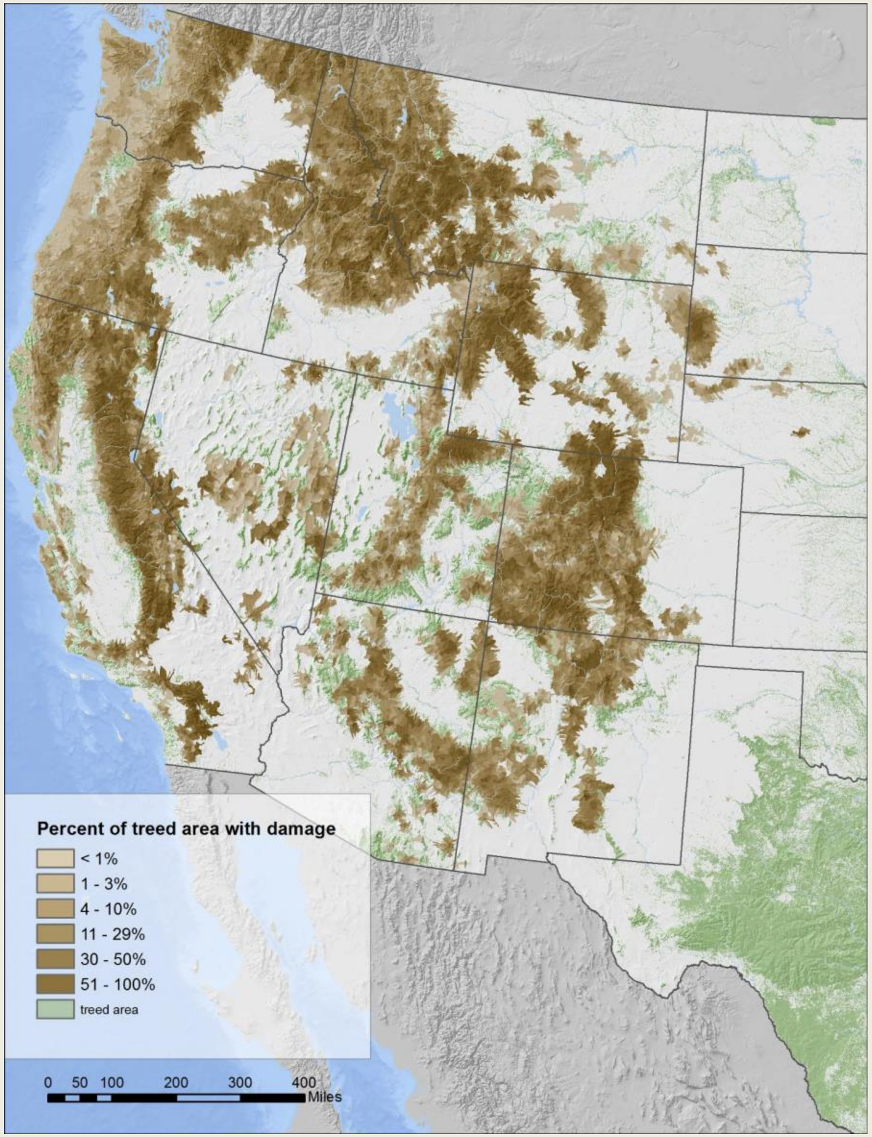
# Forest stressor complex




Source: Littell et al. 2016

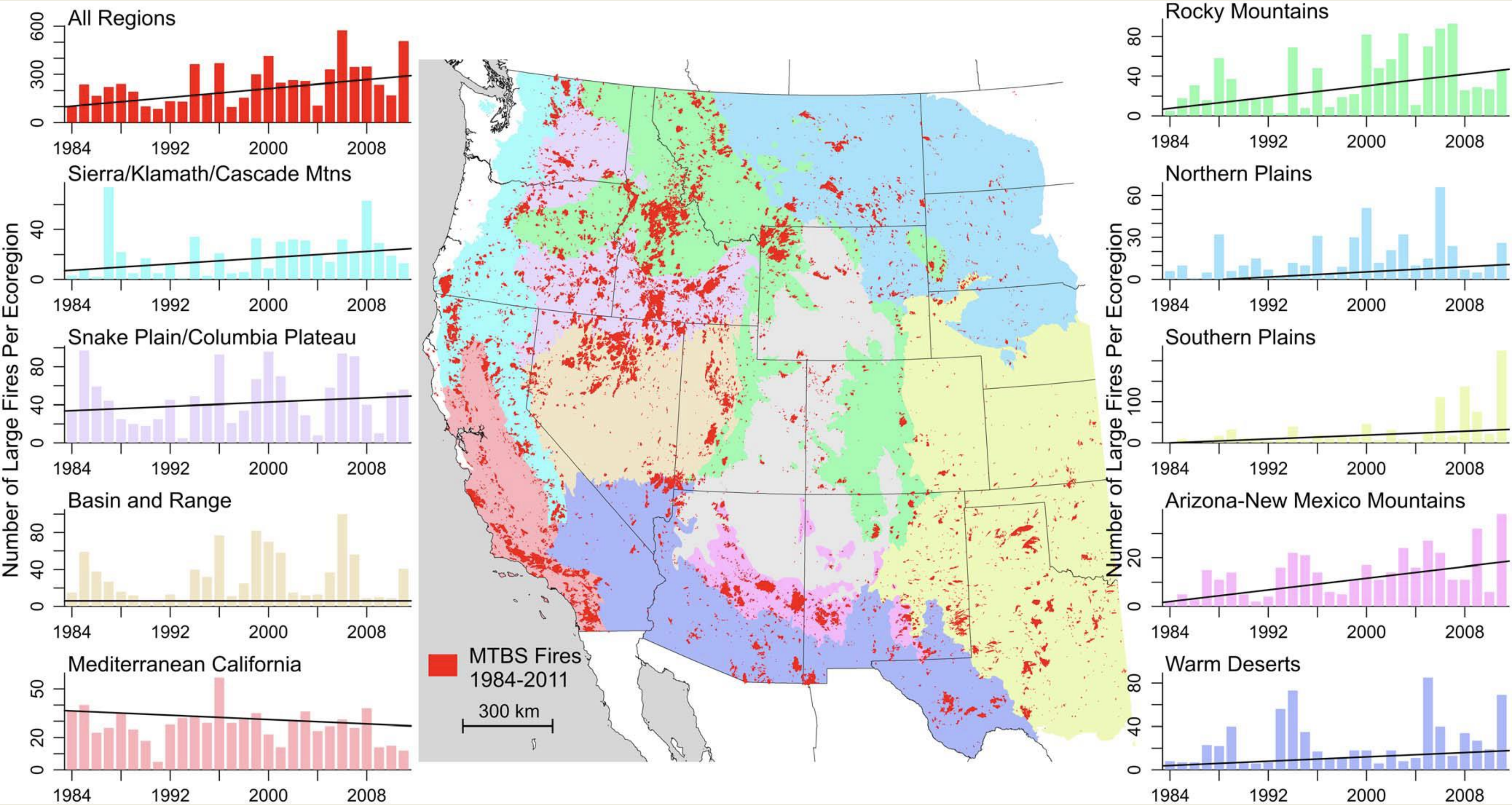
# Climate-fire trend

AREA WITH TREE MORTALITY FROM ALL WESTERN BARK BEETLES 2000 – 2016



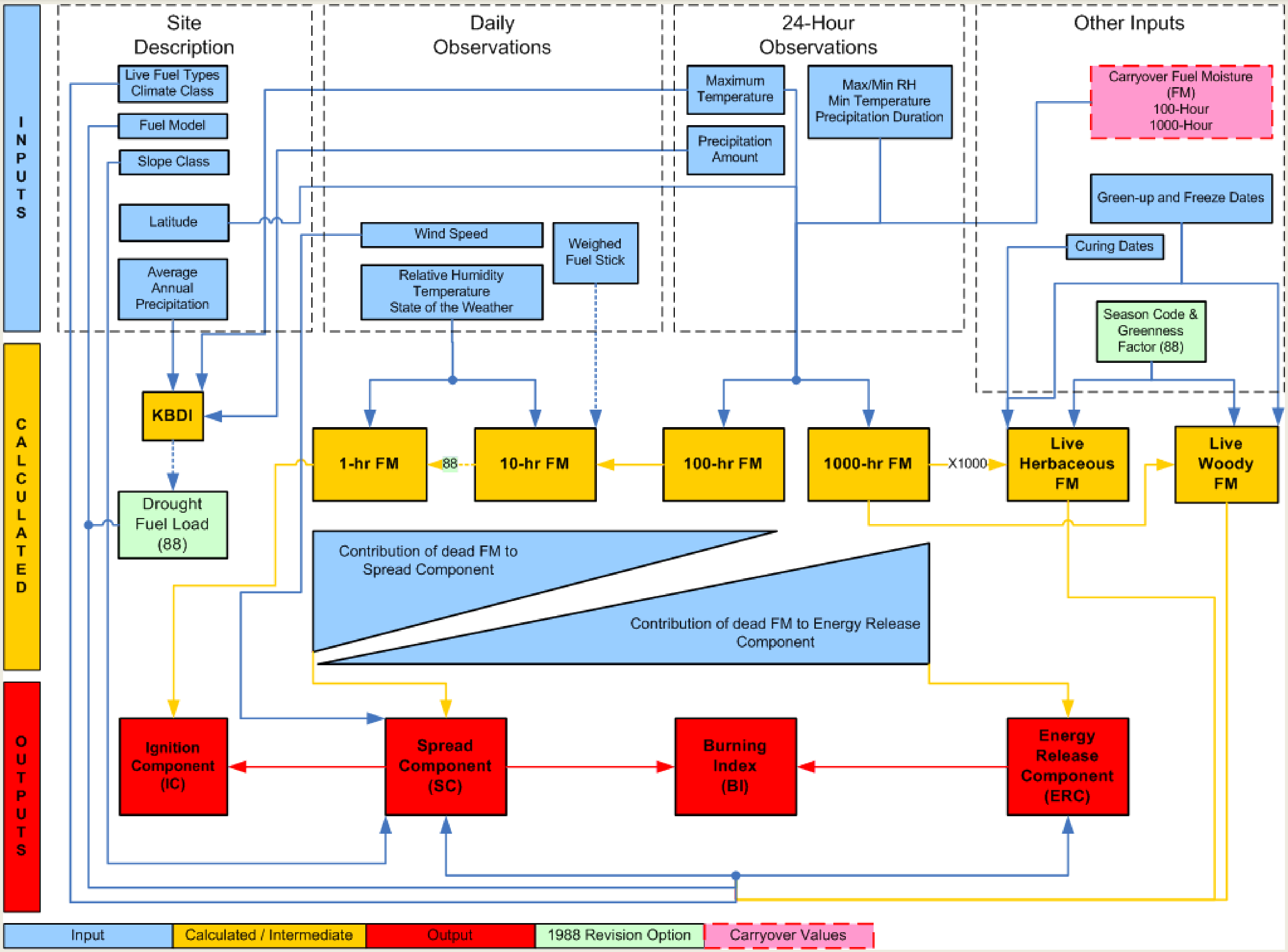

Source: US Forest Service

# Climate-fire trend




Source: Dennison et al. GRL 2014

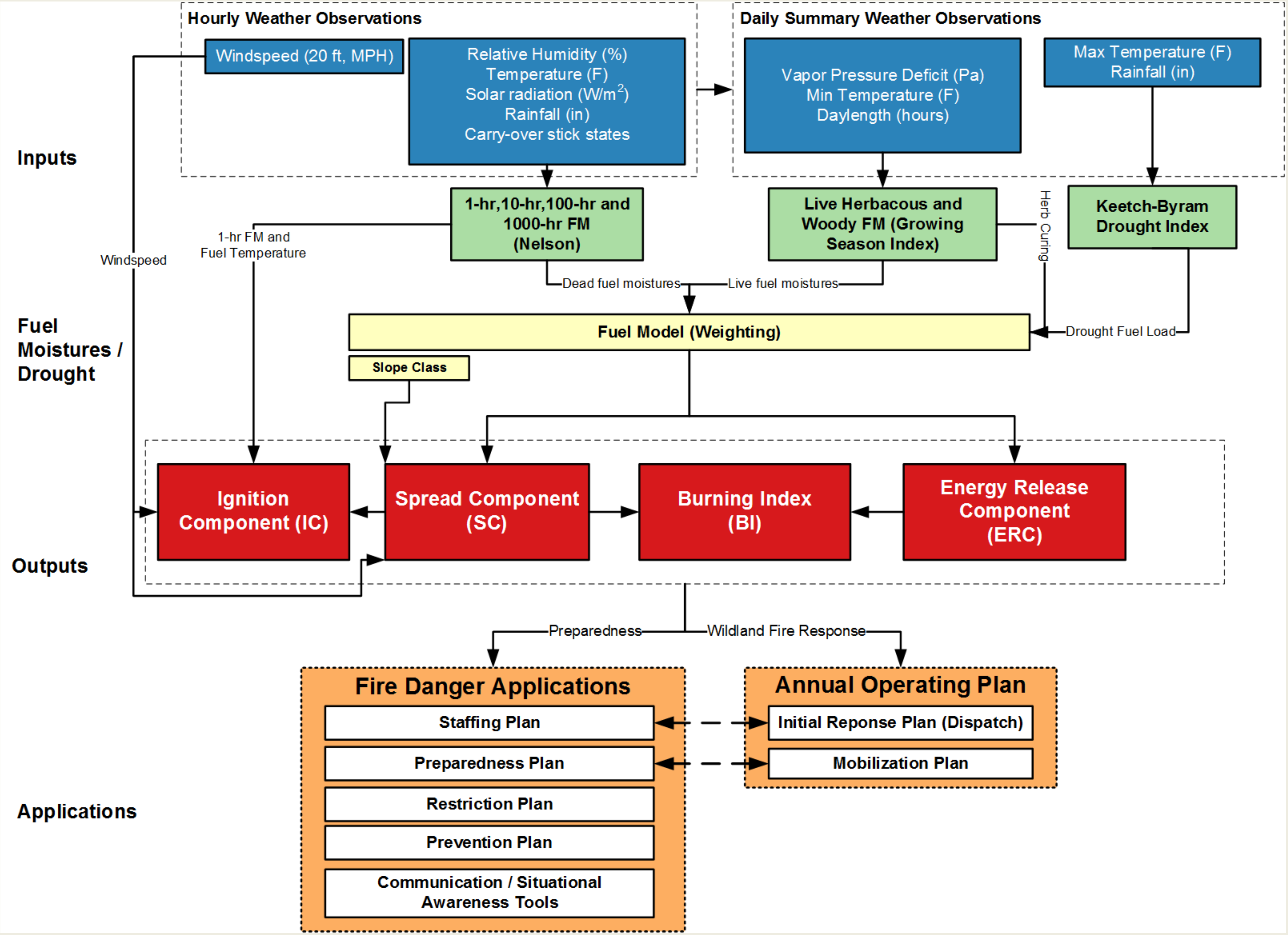
# National Fire Danger Rating System




The National Fire Danger Rating System 1978/88 version

Source: Matt Jolly, USFS

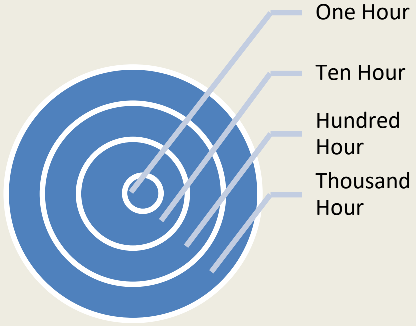
# National Fire Danger Rating System




The National Fire Danger Rating System 2016 version

Source: Matt Jolly, USFS

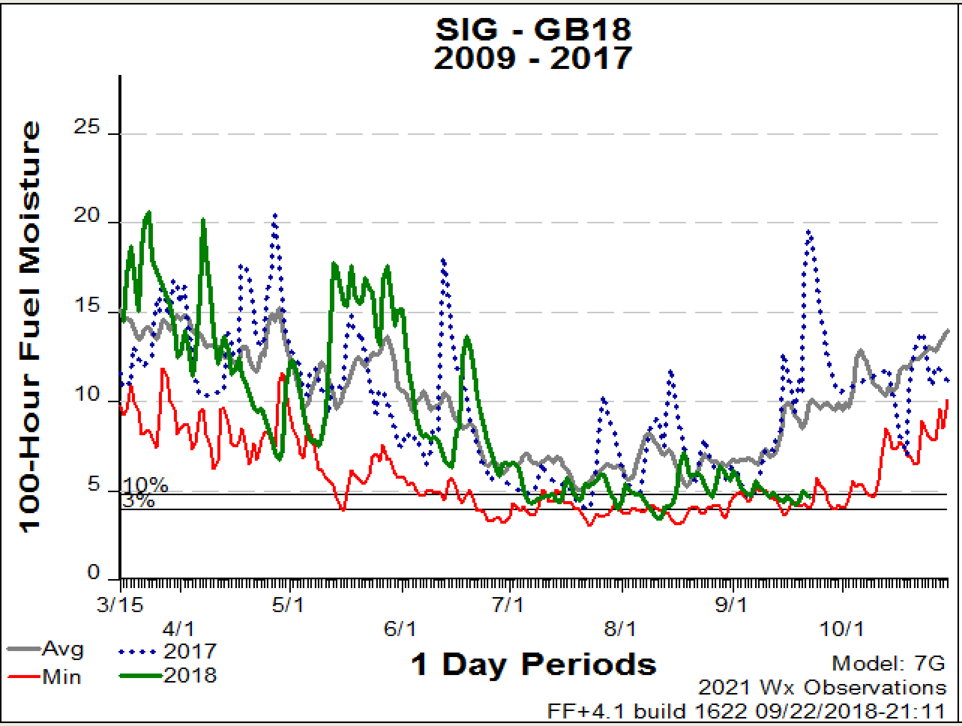
# National Fire Danger Rating System

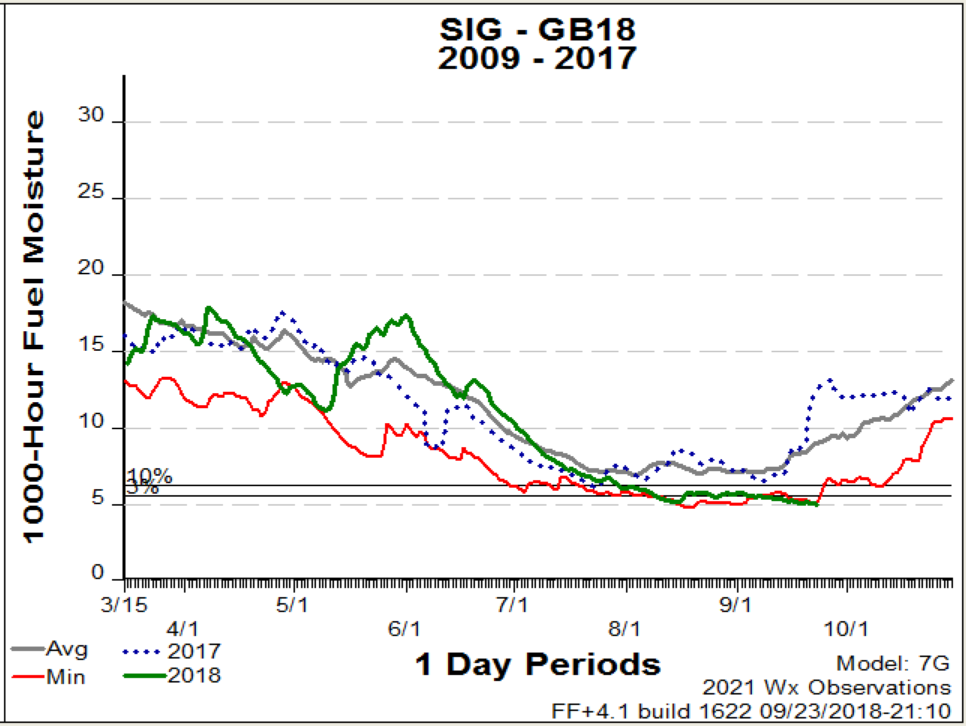



| Time Lag | Stick Diameter (inches/cm) |
|---|---|
| 1 hour | 0.16 in / 0.4 cm |
| 10 hour | 0.5 in / 1.28 cm |
| 100 hour | 1.6 in / 4.0 cm |
| 1000 hour | 3 in / 7.62 cm |

Source: Matt Jolly, USFS

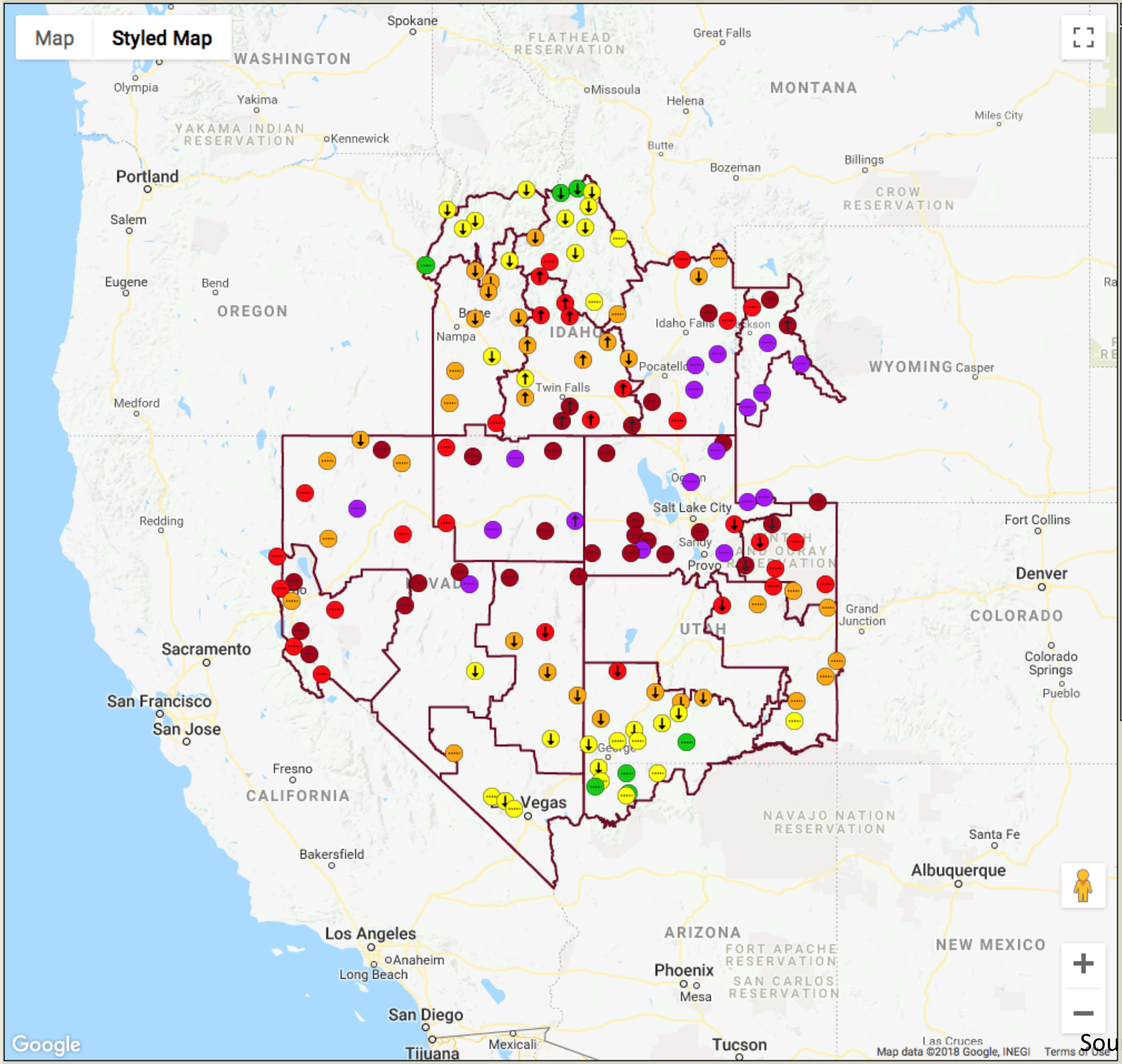
# National Fire Danger Rating System




Source: Great Basin Predictive Services

# Nevada fuels status 9/23/18




RAWS observations from: 09/23/18

**ERC Percentile:**

- : below 50th
- : 50th to 69th
- : 70th to 79th
- : 80th to 89th
- : 90th to 96th
- : 97th and above

**3-day ERC Trend:**

- : increase of 3 or greater
- : decrease of 3 or greater
- : change of less than 3

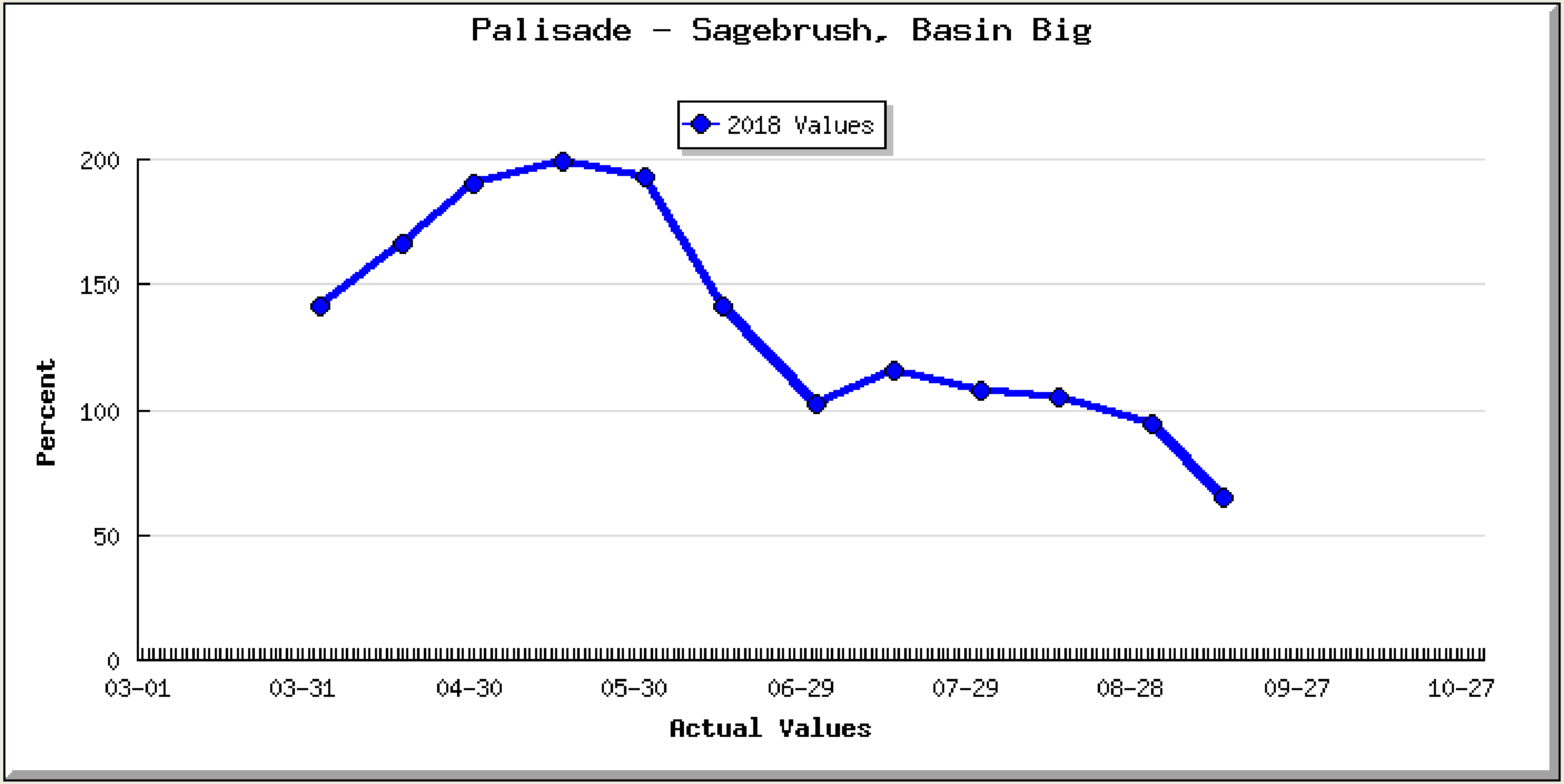
Missing a station? Stations will only appear on the map if the 13:00 observation was submitted by the dispatch center the previous afternoon.

The Energy Release Component (ERC) is an NFDRS (National Fire Danger Rating System) index related to how hot a fire could burn. It is directly related to the 24-hour, potential worst case, total available energy (BTUs) per unit area (in square feet) within the flaming front at the head of a fire.

Source: Great Basin Predictive Services

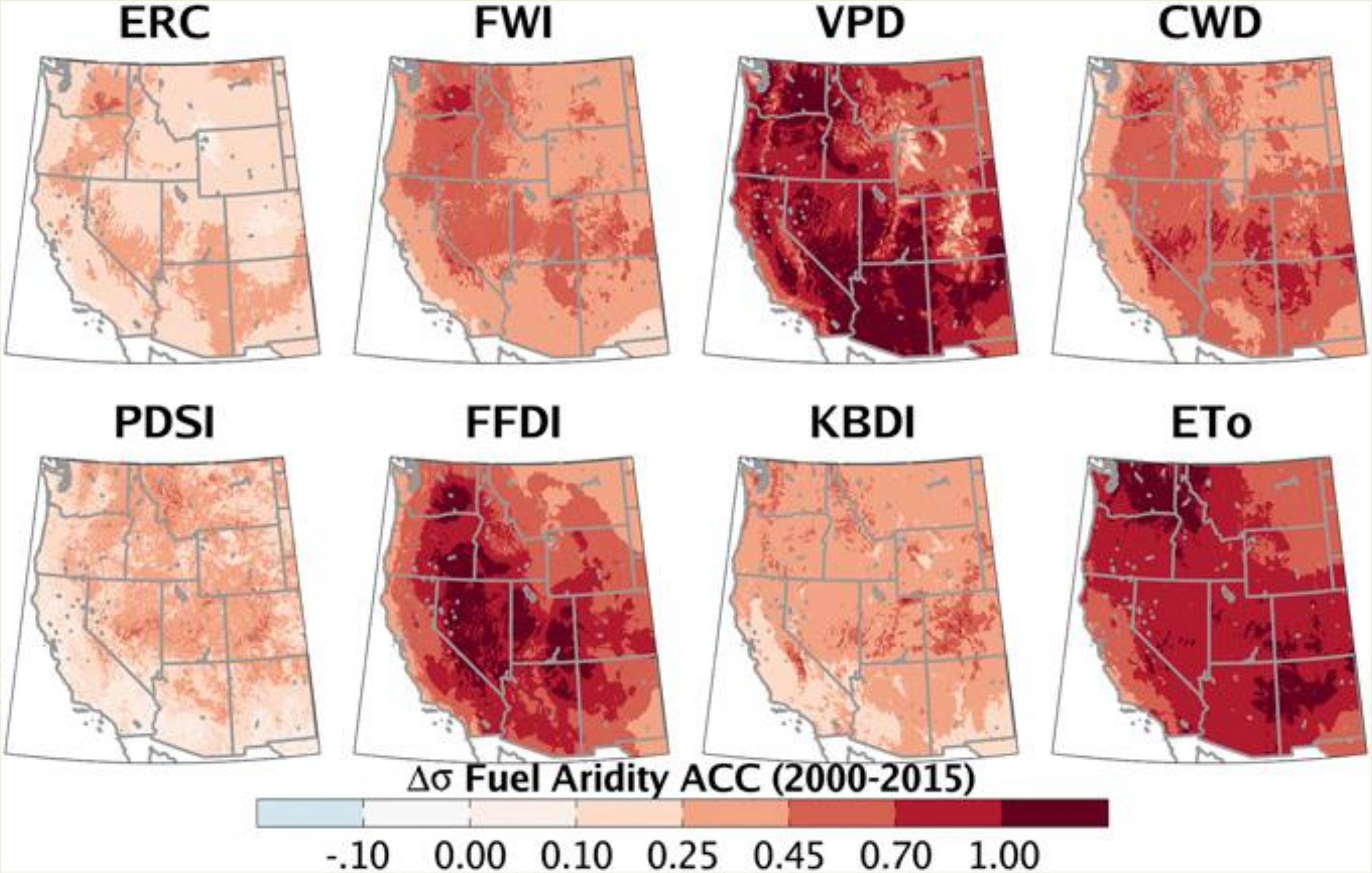
# Nevada fuels 9/23/18 status

Live fuel moisture



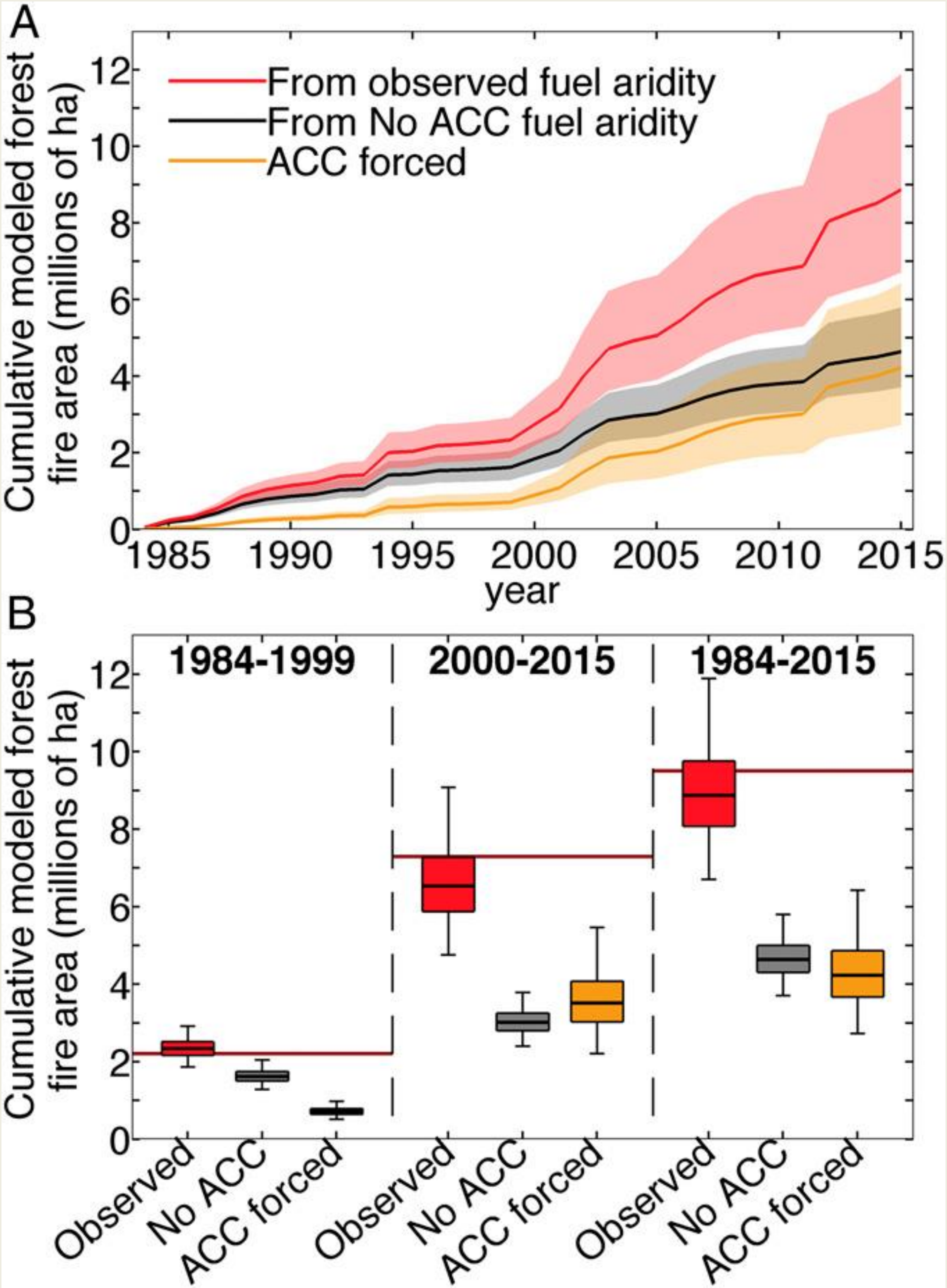

Source: Great Basin Predictive Services

# Climate-fire trend



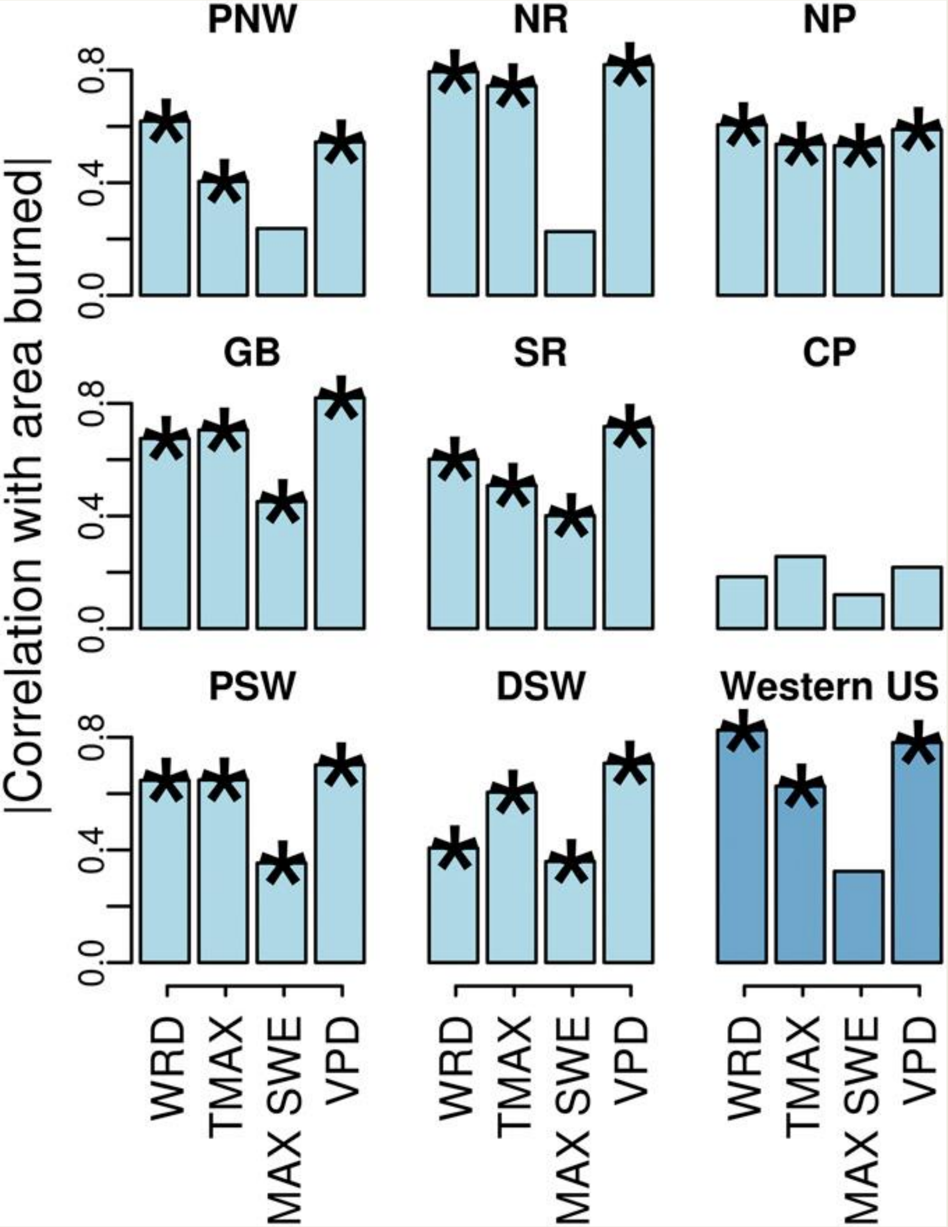

Source: Abatzoglou and Williams, PNAS 2016

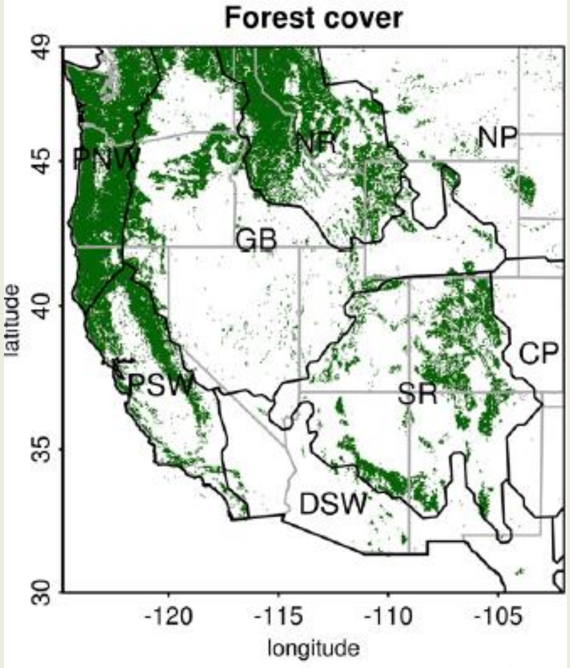
# Climate-fire trend




Source: Abatzoglou and Williams, PNAS 2016

# Climate-fire trend

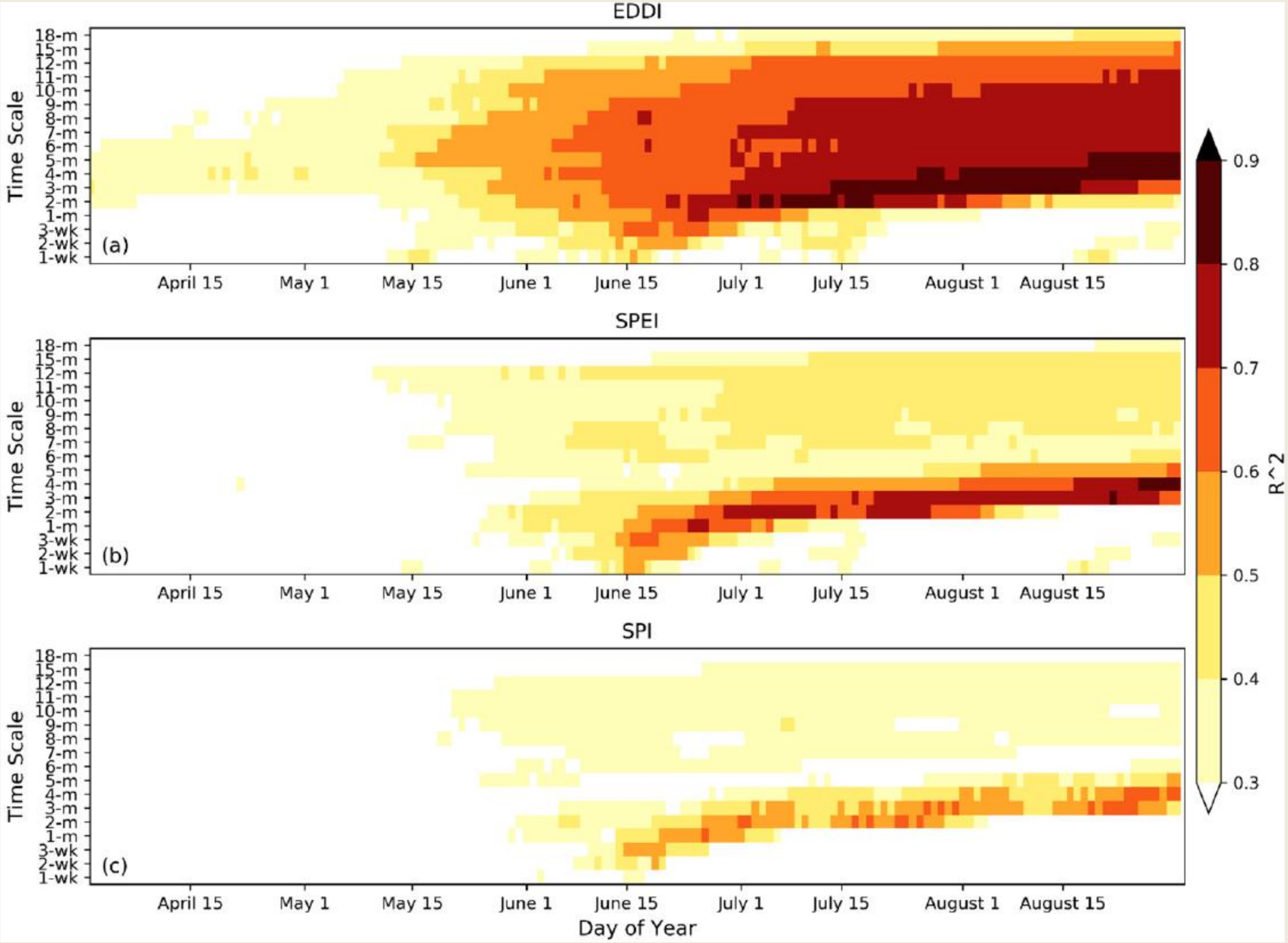



1984-2015

Source: Holden et al., PNAS 2018

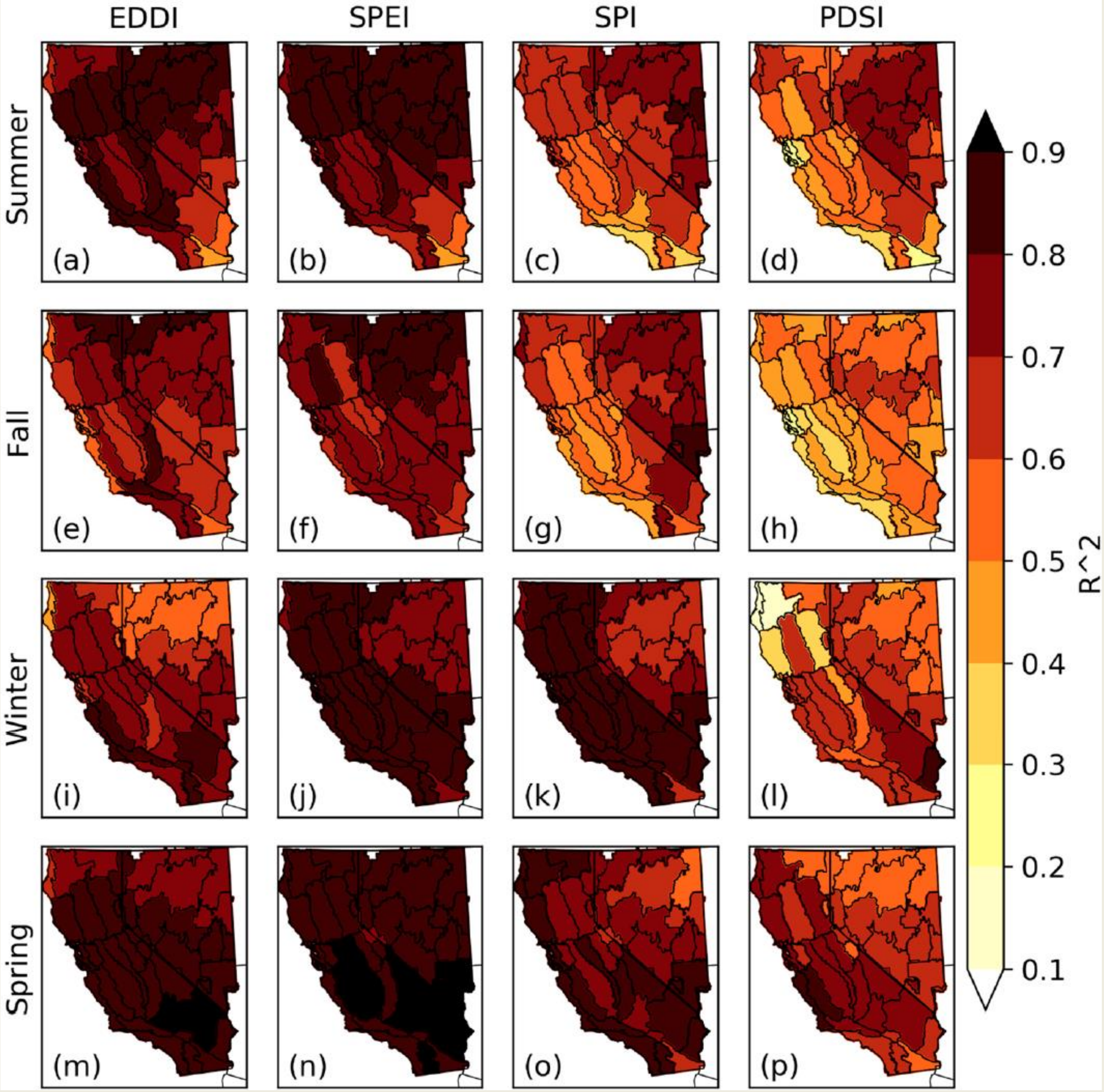
# Drought and fire




1000-hour dead fuel moisture

Source: McEvoy et al. 2019

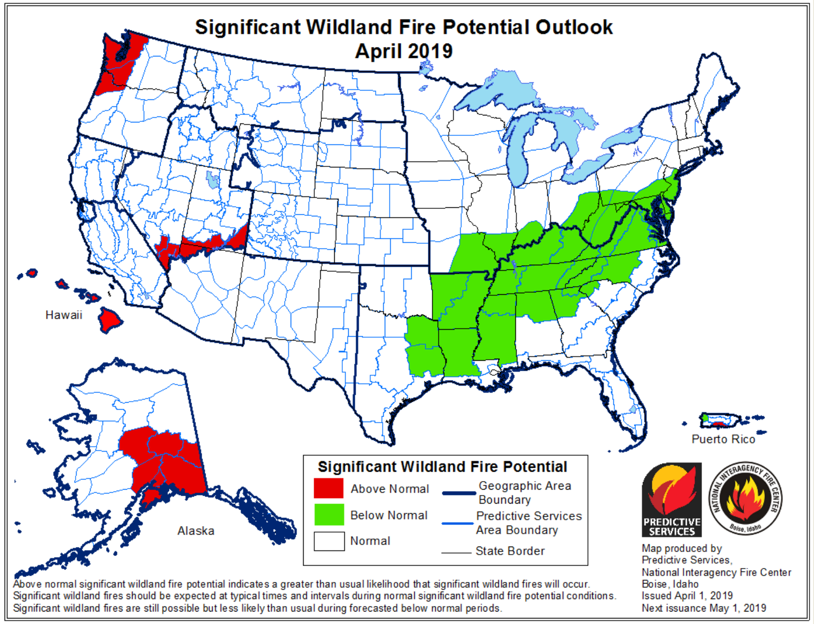
# Drought and fire

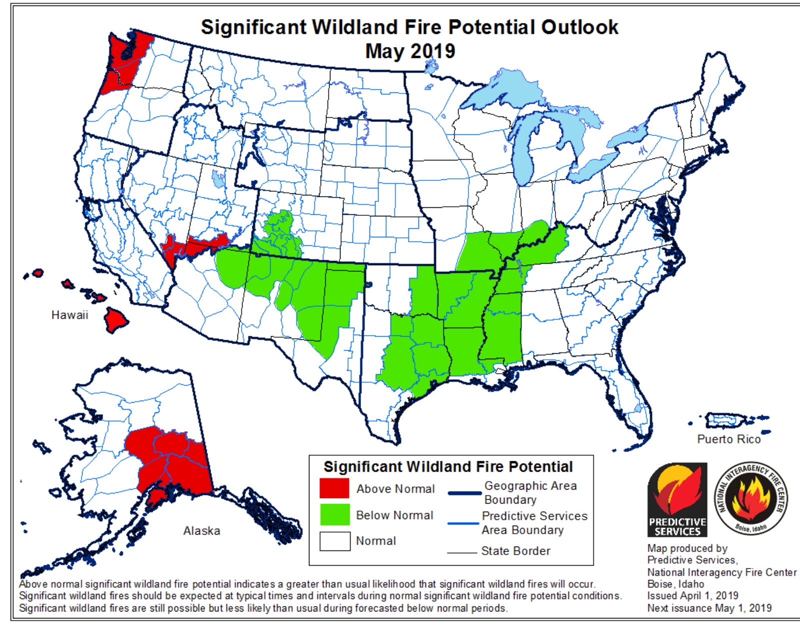


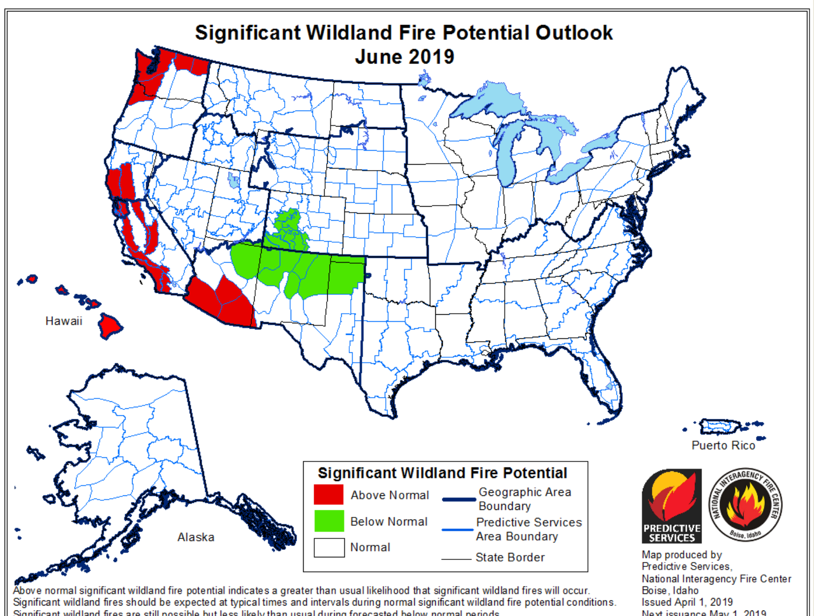

1000-hour dead fuel moisture

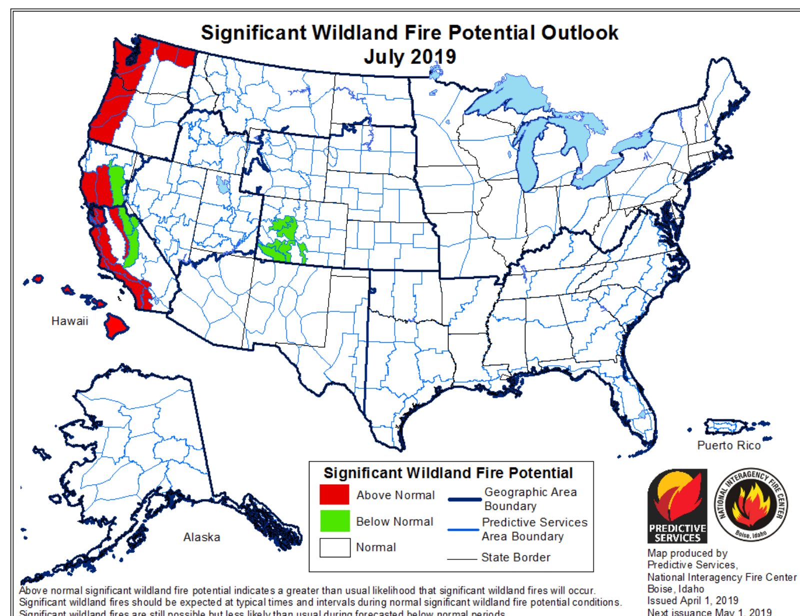
Source: McEvoy et al. 2019

# Seasonal fire outlooks



# Predictive Services

Soil moisture proxy for:

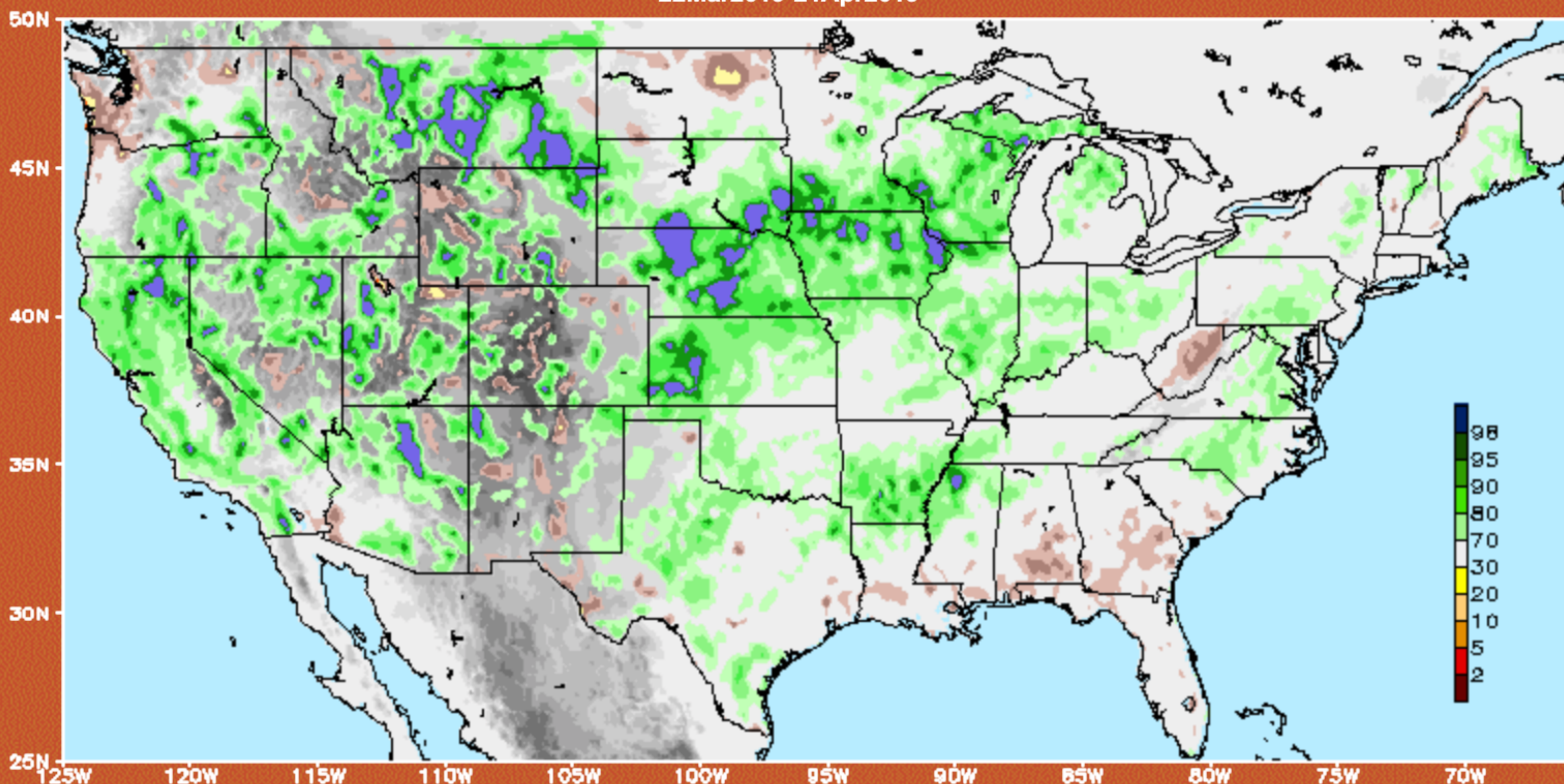
- Fine fuel growth
- Fine fuel curing and accelerated drying
- Heavy fuel vegetation stress and drying

# Seasonal fire outlooks

**Drought Indices**
**Soil Moisture Percentiles**

**Recent Analyses**

**22Mar2019-21Apr2019**




☑ Topo ☑ Ensemble ☐ MOSAIC ☐ NOAH ☐ SAC ☐ VIC ☑ Boundaries ☐ Rivers ☑ Legend

Notes about this product:

- Drought classification: D1 10-20%; D2 5-10%; D3 2-5%; D4 less than 2%;
- Data source: North American Land Data Assimilation System (NLDAS)
- GeoTIFF: Undefined value is -999.

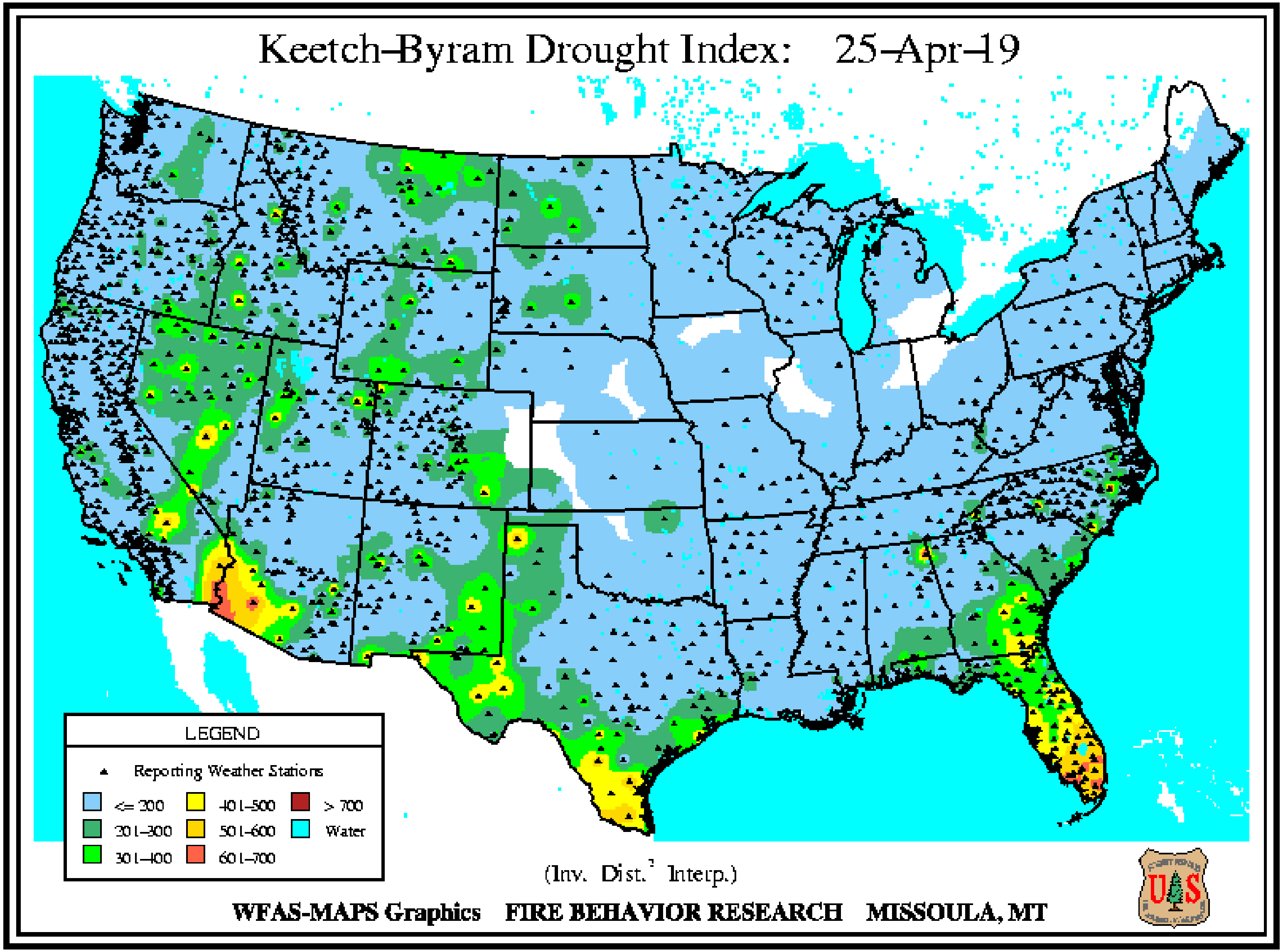
Related Links:

- 5-panel SMP (Ensemble,MOSAIC,NOAH,VIC & SAC) graphic
- GeoTIFF

Contacts: Kingtse Mo (Kingtse.Mo@noaa.gov) & Li Xu (li.xu@noaa.gov)

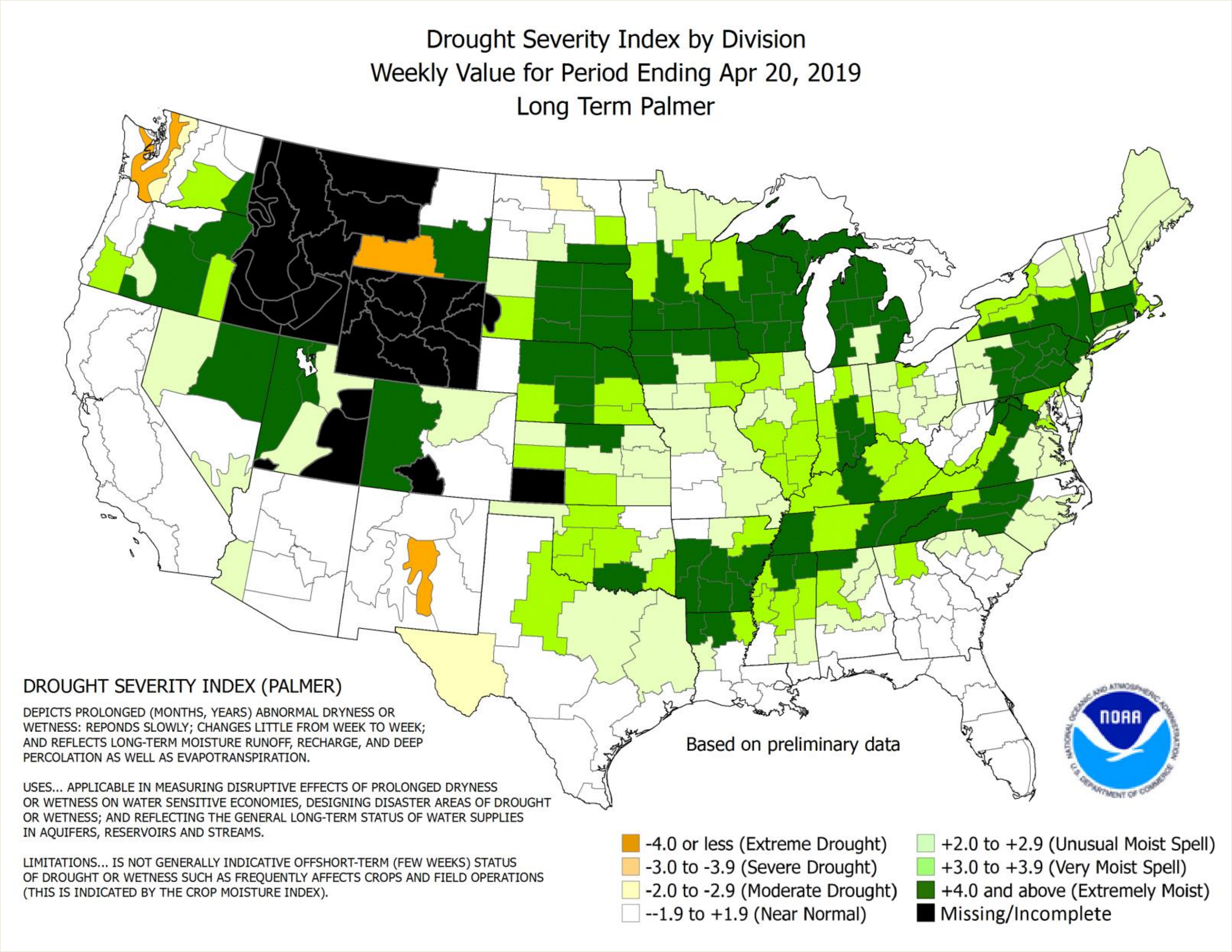
https://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/smp.shtml

# Seasonal fire outlooks



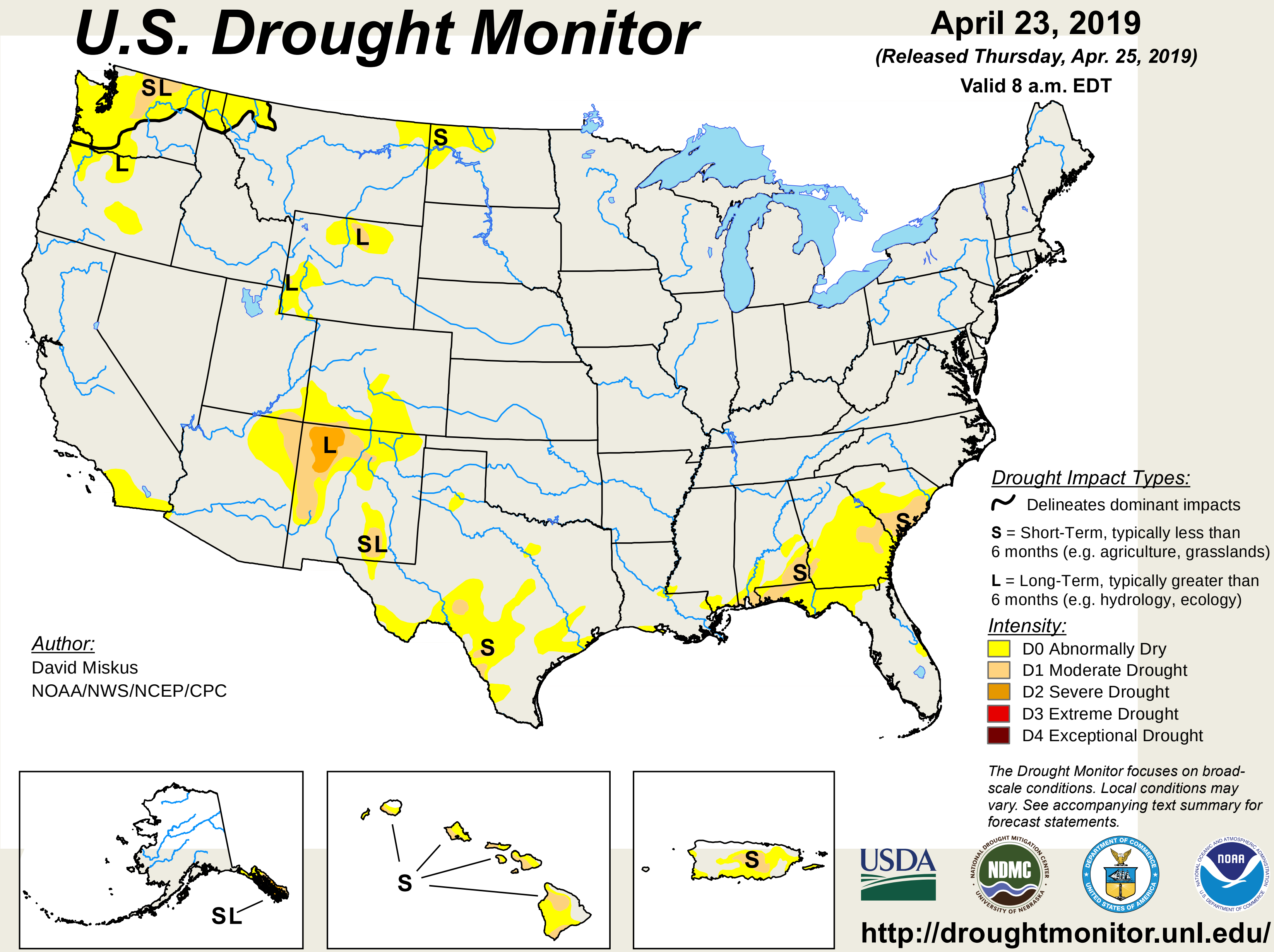

https://www.wfas.net/images/firedanger/kbdi.png

# Seasonal fire outlooks

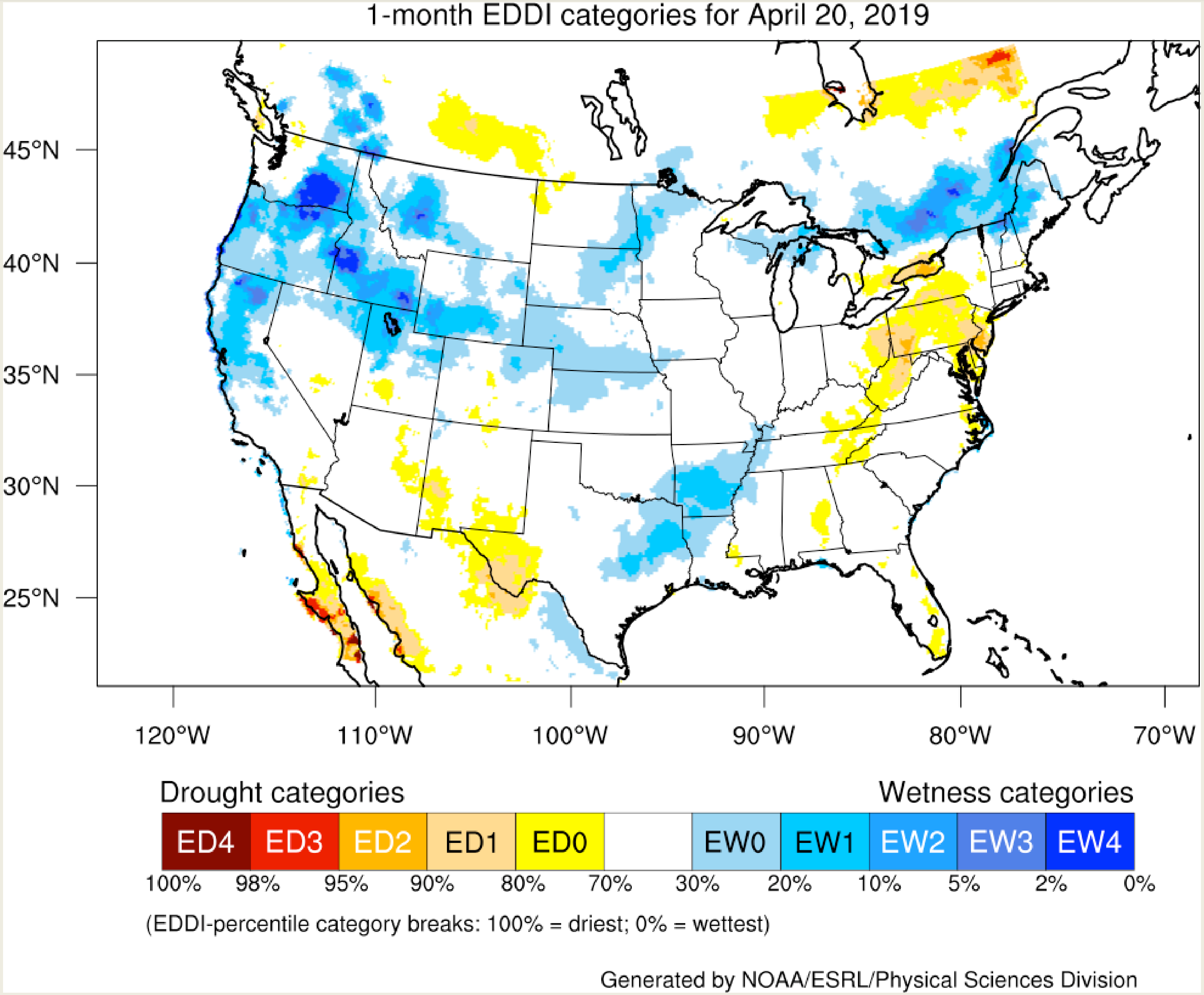



https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/palmer.gif

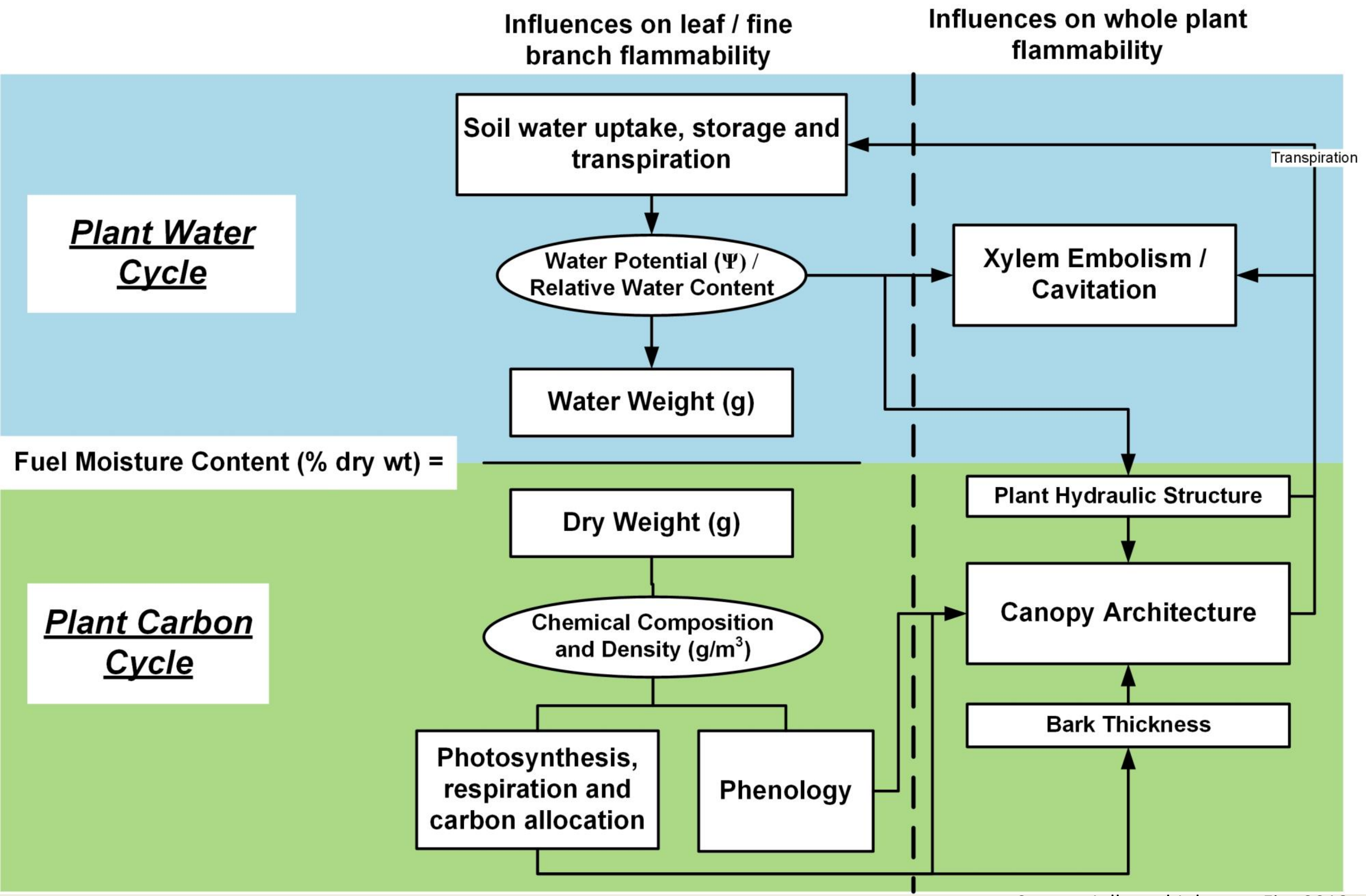
# Seasonal fire outlooks



# Seasonal fire outlooks



# Water relation to fuel flammability




Source: Jolly and Johnson, Fire 2018

# Water relation to fuel flammability

Fuel Moisture Content (FMC) = Water Weight/Dry Weight

Dead fuels: dry weight is relatively constant, but does change slowly as a function of decomposition

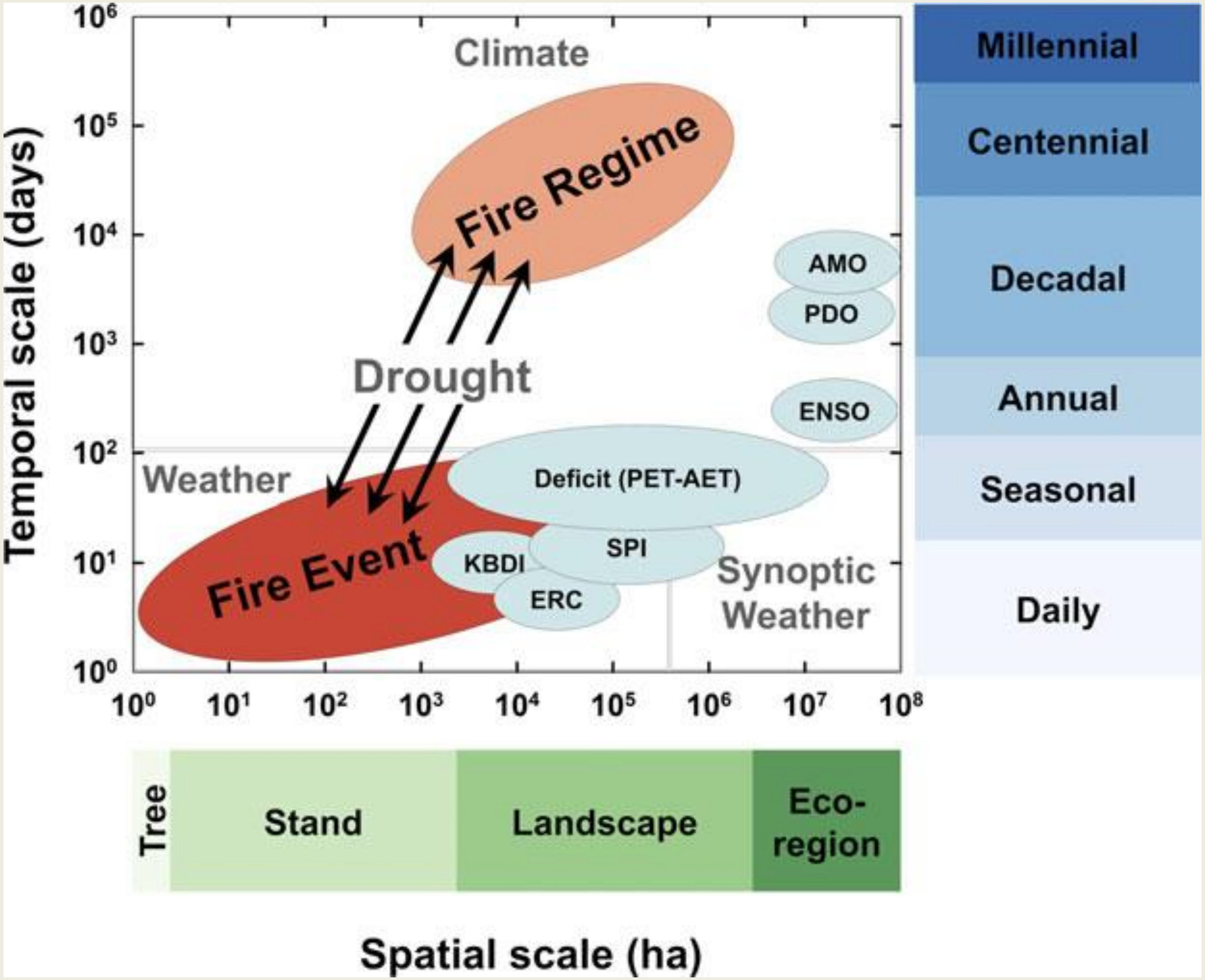
Live fuels: Both the water weight and dry weight changes diurnally, seasonally, and inter-annually

Both quantities of FMC can contribute to flammability and both vary independently over space and time

Drought preconditions fuel flammability

Source: Jolly and Johnson, Fire 2018

# Drought and fire




Source: Littell et al. 2016

# For consideration

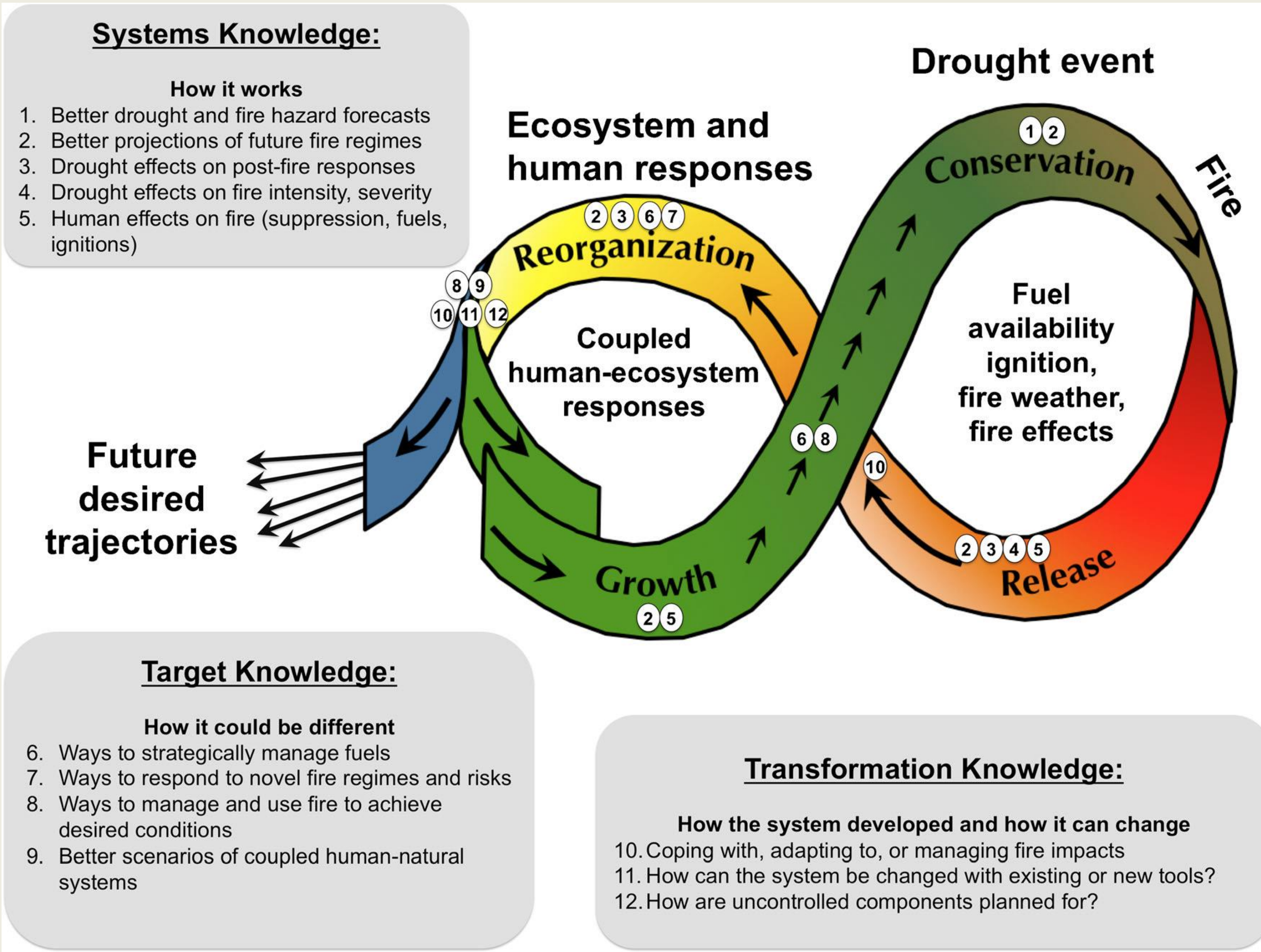
Curr Clim Change Rep (2018) 4:396–406 

**Table 1** Temporal scale and mechanisms of fire-related drought

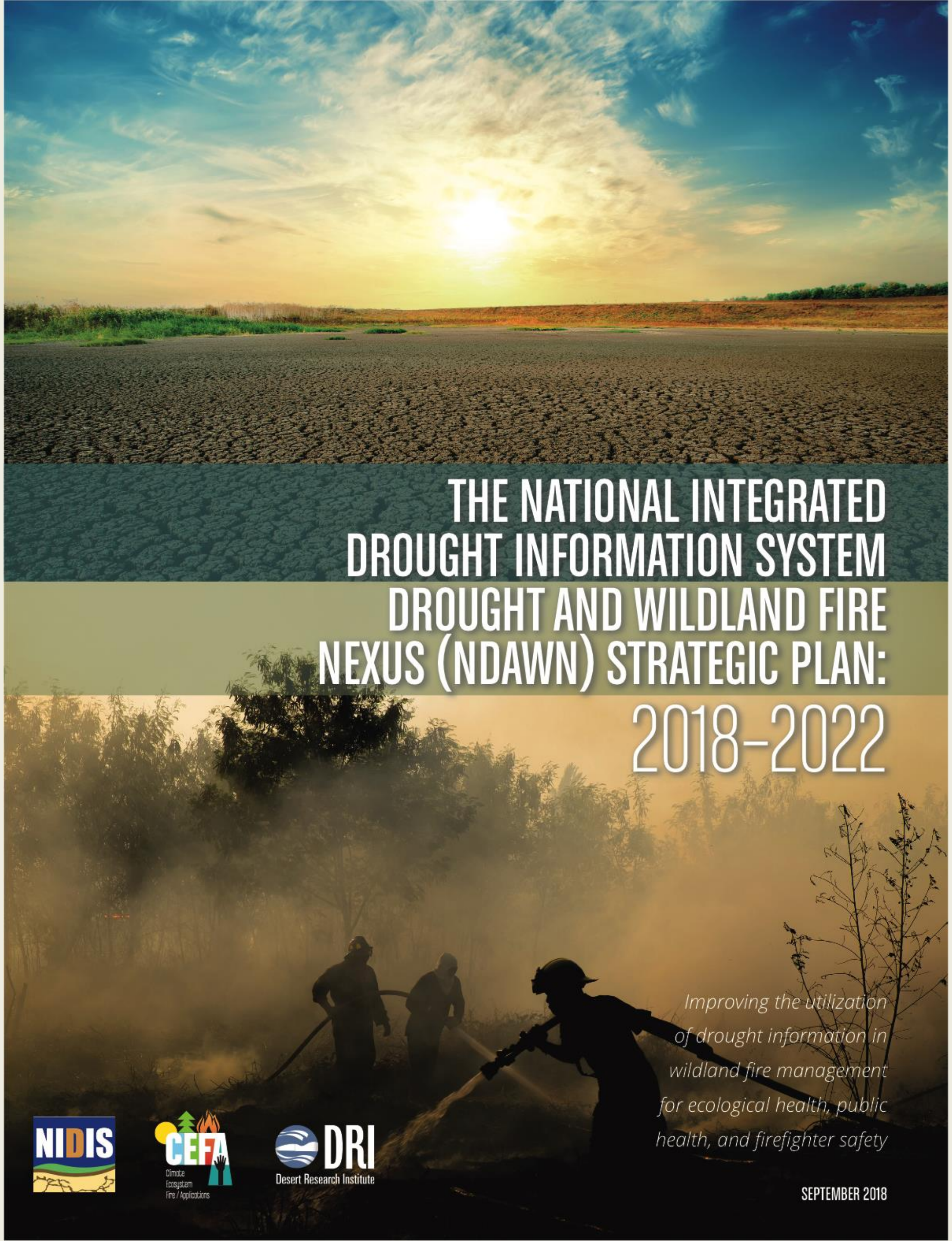
| Temporal scale | Drought indicator/variable | Physical mechanism | Fire response mechanism(s) |
|---|---|---|---|
| Days | Synoptic meteorology | Atmospheric pressure: blocking ridges | Increased PET, VPD: decreased foliar and dead fuel moisture, increased fuel flammability |
| | | Atmospheric pressure: ridge-trough interactions | Lightning, ignition potential; Foehn winds |
| | Flash drought | Low precipitation | Decreased soil moisture: decreased foliar and dead fuel moisture, increased fuel flammability |
| | | High temperature | Increased PET, VPD: decreased foliar and dead fuel moisture, increased fuel flammability |
| | Fire weather | High surface winds | Increased PET: decreased foliar and dead fuel moisture, increased fuel flammability |
| | | | Increased fire spread |
| | | Low relative humidity | Increased PET, VPD: decreased foliar and dead fuel moisture, increased fuel flammability |
| | Meteorological drought | Low precipitation | Decreased soil moisture: decreased foliar and dead fuel moisture, Increased fuel flammability |
| | Hydrological drought | Low runoff | Correlation with decreased soil moisture: decreased foliar and dead fuel moisture, increased fuel flammability |
| Seasons | Snow drought | Low winter precipitation as snow | Longer snow-free season, decreased soil moisture: decreased foliar and dead fuel moisture, increased fuel flammability |
| | | Early snow melt | Longer snow-free season, decreased soil moisture: decreased foliar and dead fuel moisture, increased fuel flammability |
| | Global-change-type drought | High temperature for given low precipitation anomaly | Decreased soil moisture: decreased foliar and dead fuel moisture, increased fuel flammability |
| | | | Increased PET, VPD: decreased foliar and dead fuel moisture, increased fuel flammability |
| Years | Ecological drought | Water availability deficit | Drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedbacks in natural and/or human systems |
| Decades to centuries | Persistent or frequent seasonal and interannual droughts | Atmosphere/ocean interactions: ENSO, PDO, etc. | Increased (drier) or decreased (wetter) frequency of above events; long term changes in fuel availability and distribution |

Source: Littell 2018

# For consideration




Source: Littell 2018


THE NATIONAL INTEGRATED
DROUGHT INFORMATION SYSTEM
DROUGHT AND WILDLAND FIRE
NEXUS (NDAWN) STRATEGIC PLAN:
2018–2022
Improving the utilization
of drought information in
wildland fire management
for ecological health, public
health, and firefighter safety
NIDIS
CEFA
Climate
Ecosystem
Fire / Applications
DRI
Desert Research Institute
SEPTEMBER 2018

# Greetings From Reno!

*Fire near Tim's house*