

The *Office of Sustainability and Climate and National Partnership Office* welcome you to our webinar on:

Climate, Megafires, and Conservation Finance



AUDIO CONNECTION

1. Phone: mute your computer speakers and call 1-877-369-5243; access code: 0290297##

OR

2. Audio through the computer: Make sure your computer speakers are on and listen with speakers or headphones.

Note: Phone audio will allow you to both listen and speak up with questions. *If you listen through the computer, you will not be able to speak up with questions, but will be able to type questions into the Q&A pod which will be answered by the appropriate speaker.*



Dr. Cynthia West
Director,
Office of
Sustainability and
Climate
U.S. Forest Service



Denise Blankenship
Deputy Director,
Fire and
Aviation
Management
U.S. Forest Service



Dr. Dixie Porter
Deputy Director,
Office of
Sustainability and
Climate
U.S. Forest Service



Shifts in severe wildland fire weather conditions across the United States

W. Matt Jolly

Research Ecologist,

US Forest Service, RMRS, Fire Sciences Lab

Mark Cochrane, Appalachian Laboratory, UMD Center for Environmental Science (UMCES)

Patrick Freeborn, USFS, Fire Lab

David Bowman and Grant Williamson, Univ of Tasmania

Tim Brown, Desert Research Institute

Zack Holden, USFS R1

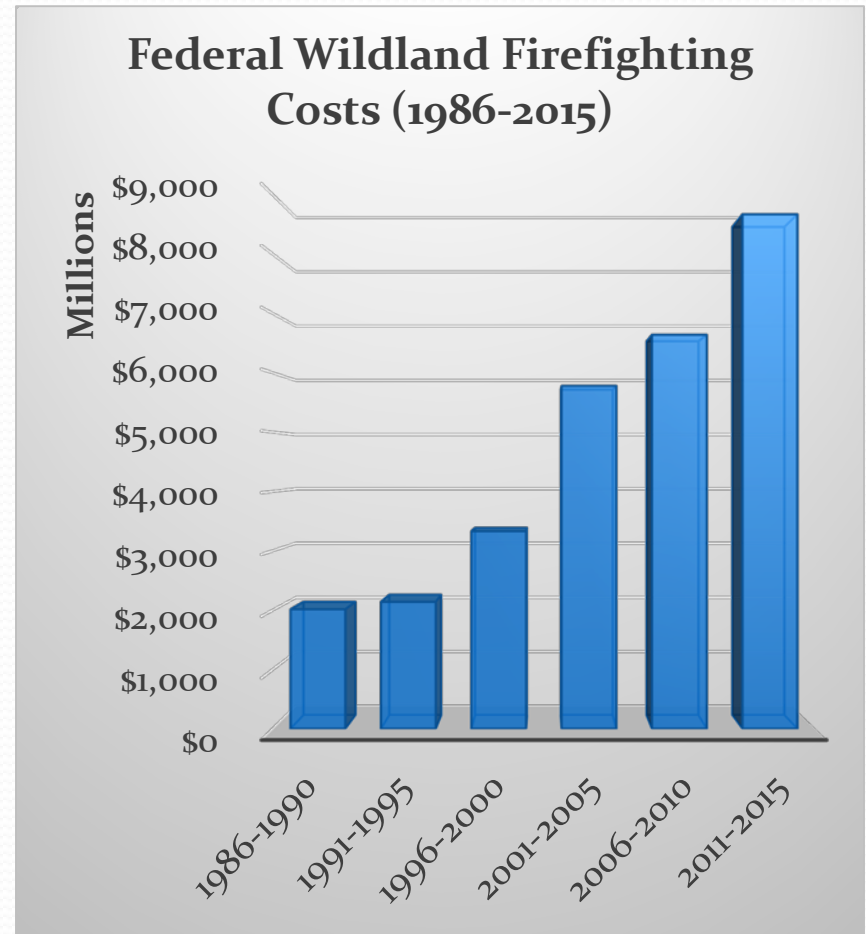


Roadmap

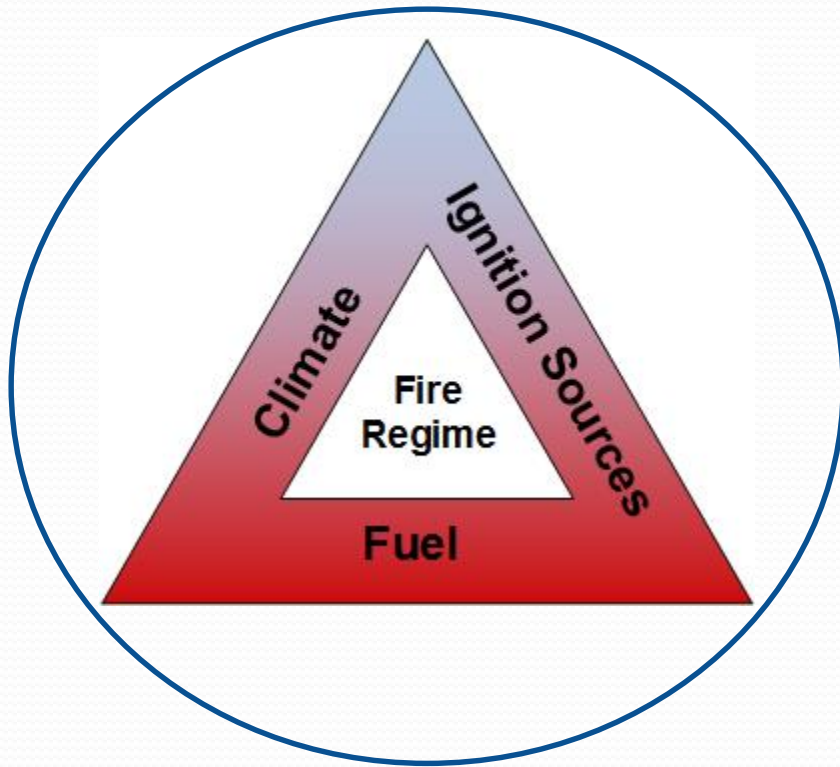
- Discuss climatic changes across the US over the last 40 years
- Explore climate-mediated shifts in fire weather regimes
 - Changes in fire season length
 - Changes in fire weather severity
- Implications for carbon cycle feedbacks

Why do we care?

- We must understand how climatic changes are affecting wildland fire activity across the US to identify areas where mitigation actions are most needed.
- Understanding climate / wildland fire relationships helps us to bracket uncertainty of expected outcomes.



What drives wildland fire regimes?



Wildfire activity and subsequent carbon feedbacks

- A fire regime shift can occur if:
 - Fire seasons get longer
 - Fire season weather gets more extreme
 - Fire seasons gets more variable
 - Extreme events become more frequent

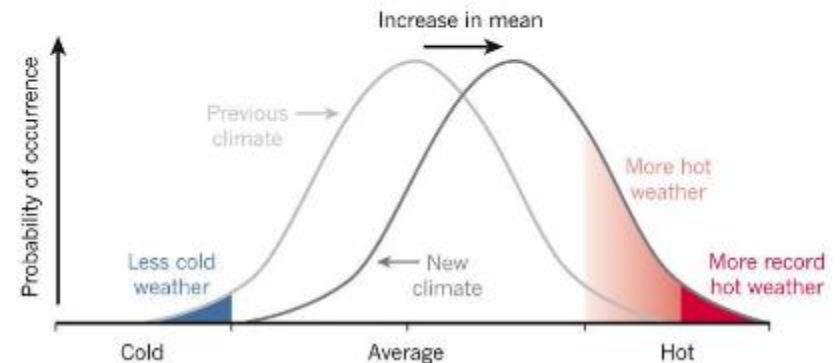
Our goal: *describe how weather changes may be influencing fire season duration*

Weather versus Climate

- Weather: Surface and upper atmospheric environmental conditions over very short time scales: hours, days
- Climate: Range of weather conditions common for a given place

CLIMATE SHIFT

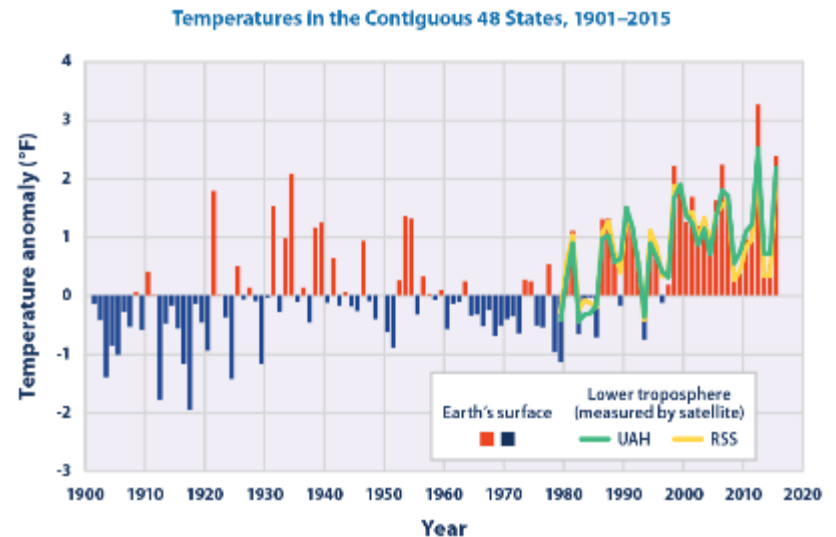
Extreme weather events — here, very hot or cold temperatures — are rare. But a small rise in the average temperature through greenhouse warming (right-hand curve) can radically increase their frequency. Attribution research tries to quantify this effect for specific events.



Schiermeier, Q. 2011. Climate and weather: Extreme measures. *Nature* 477, 148-149

Recent climatic changes across the United States and the World

- CONUS temperatures have risen on average 0.14°F per decade since 1901.
 - Average temperatures have risen 0.29 to 0.46°F per decade since 1979.
- Eight of the top 10 warmest years have occurred since 1998, and 2012 and 2015 were the two warmest years on record.
- Global average relative humidity is expected to remain but regional variations may be important
- Precipitation is stable but regional droughts may be more severe, even if the frequency of droughts remains constant
- **The ALIGNMENT of MULTIPLE weather drivers leads to the most severe wildfires**



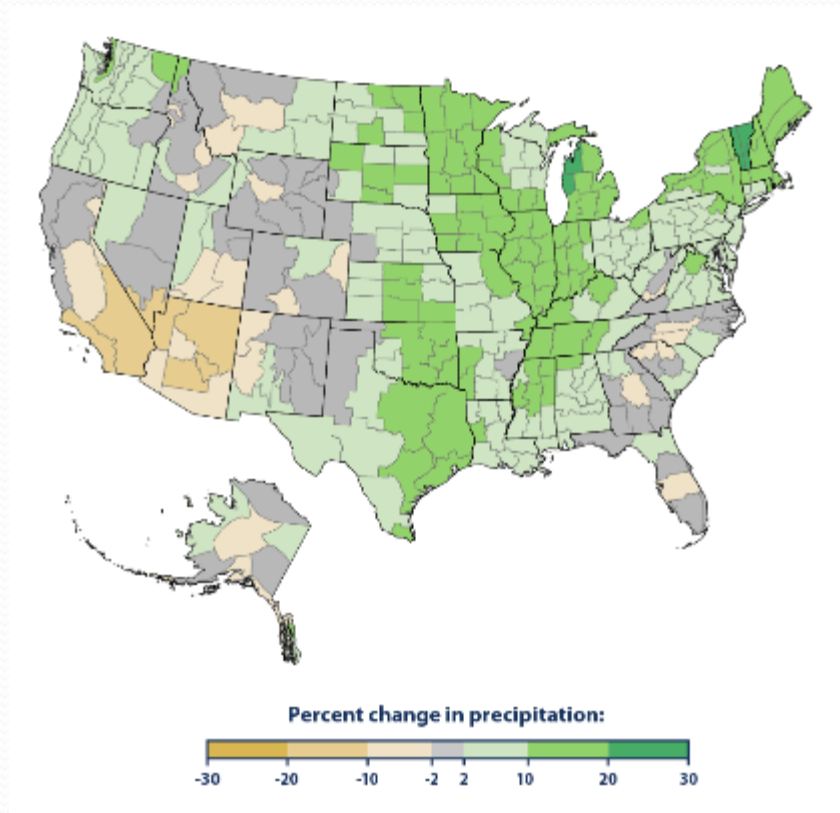
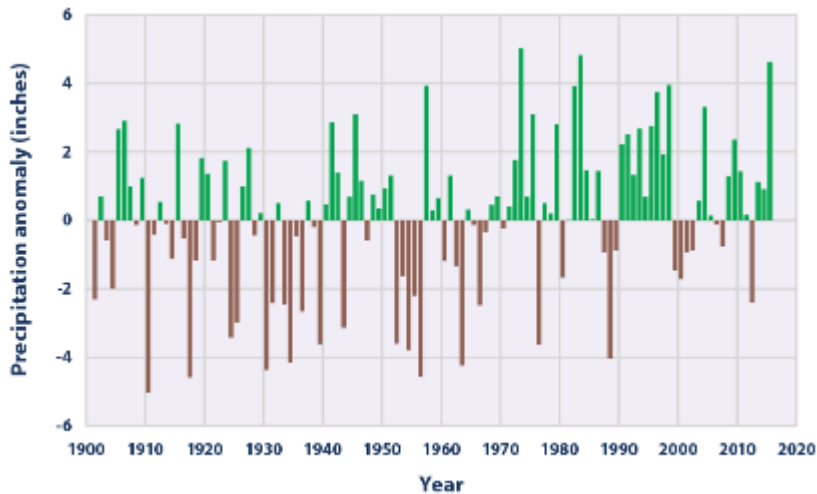
Data source: NOAA (National Oceanic and Atmospheric Administration). 2016. National Centers for Environmental Information. Accessed February 2016. www.ncei.noaa.gov.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

US Precipitation Changes

On average, precipitation has increased over land areas in the United States.

- Since 1901, precipitation in the contiguous 48 states has increased at a rate of 0.17 inches per decade.

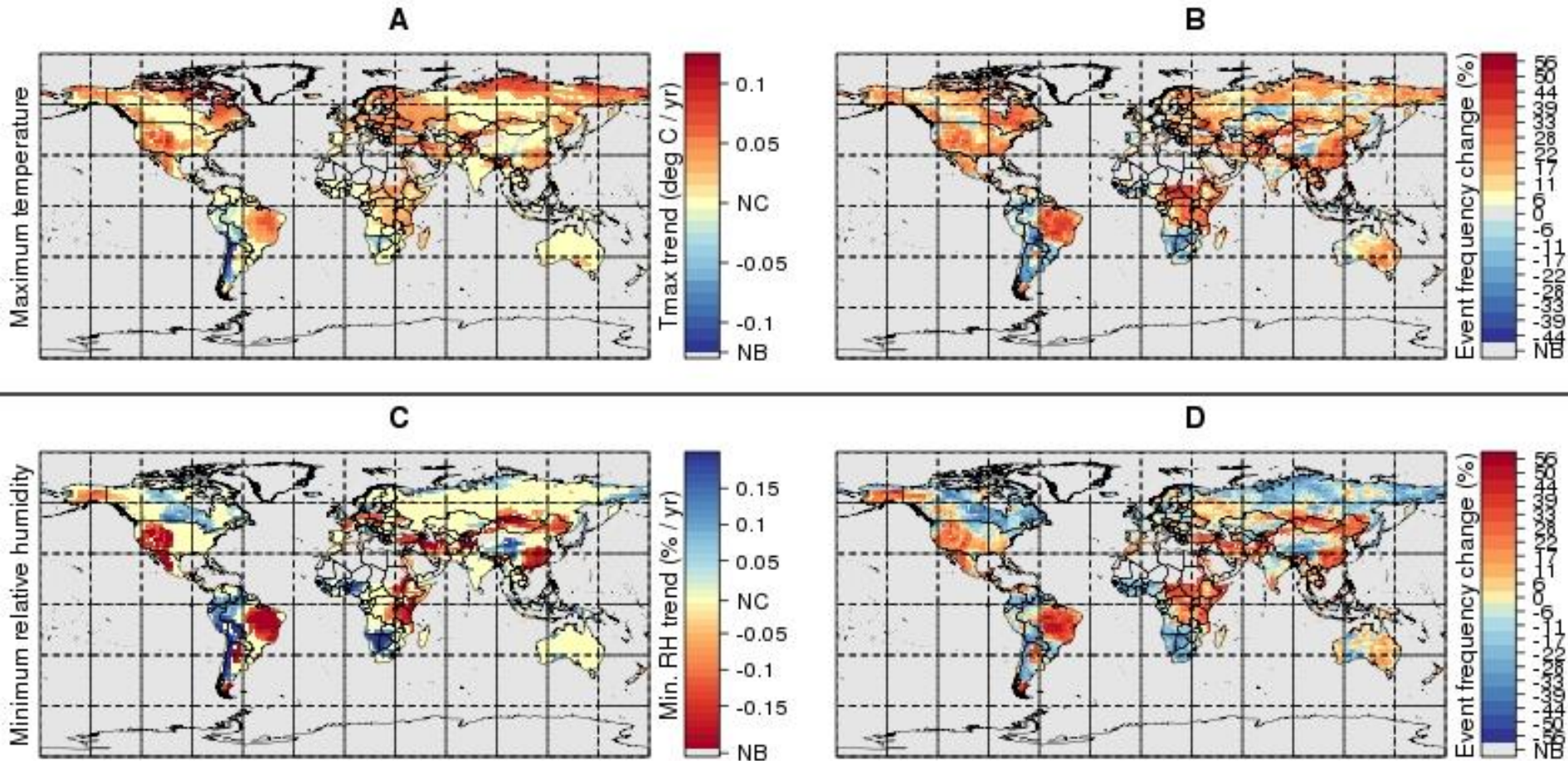


Trends in wildland fire weather

Gridded Global Surface Weather Reanalyses

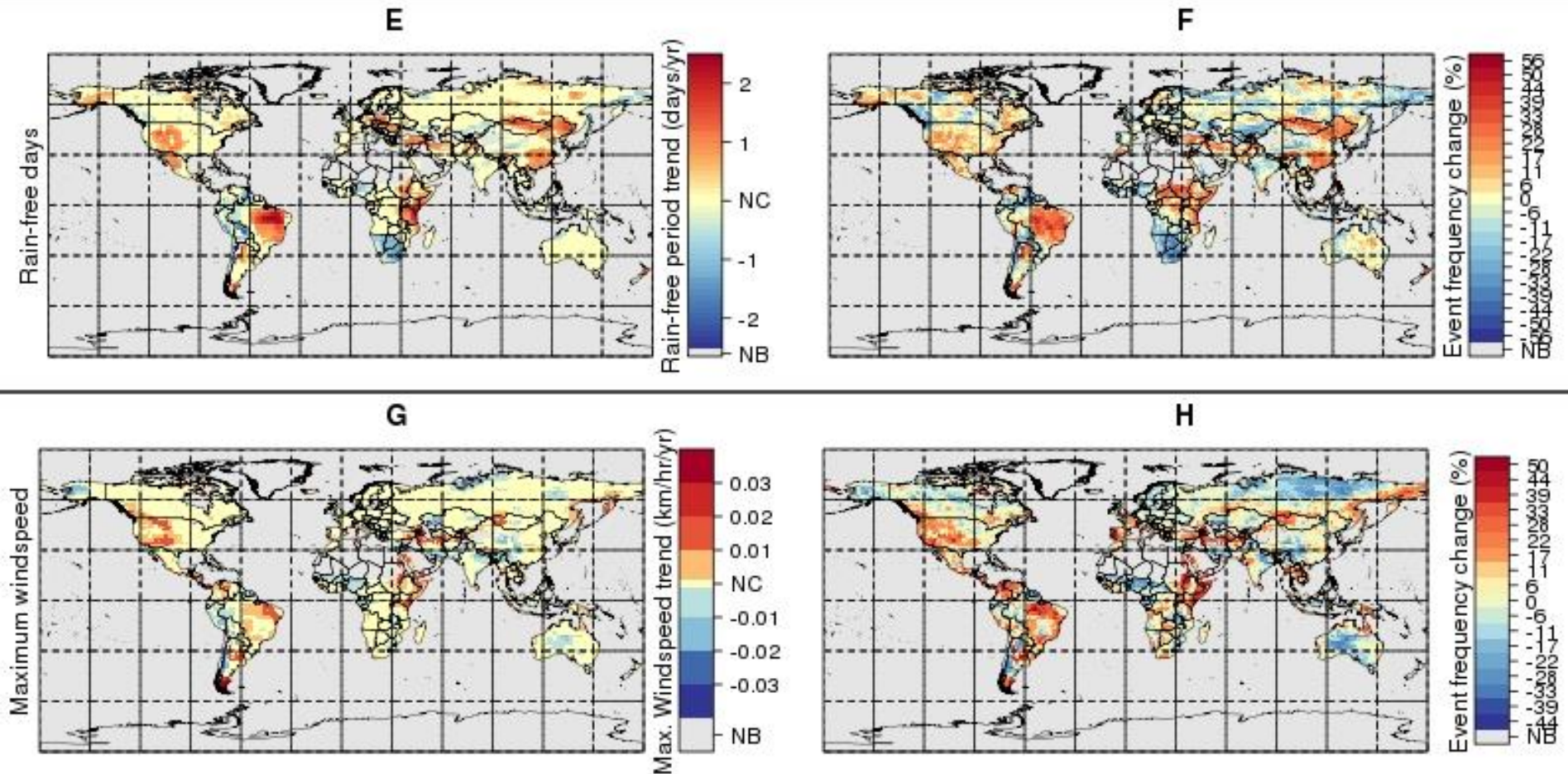
- NCEP Reanalysis, NCEP Reanalysis II and ECMWF Interim Reanalysis
- Coarse, continuous, sub-daily global surface weather data that were used to derive daily weather across the globe from 1979-2016
- How has global fire weather changed?

Maximum temperature and minimum relative humidity changes



Increased temperatures across much of the planet, but regional humidity variations

Rain-free days and maximum windspeed



If rainfall is stable, rainfall intensity is increasing

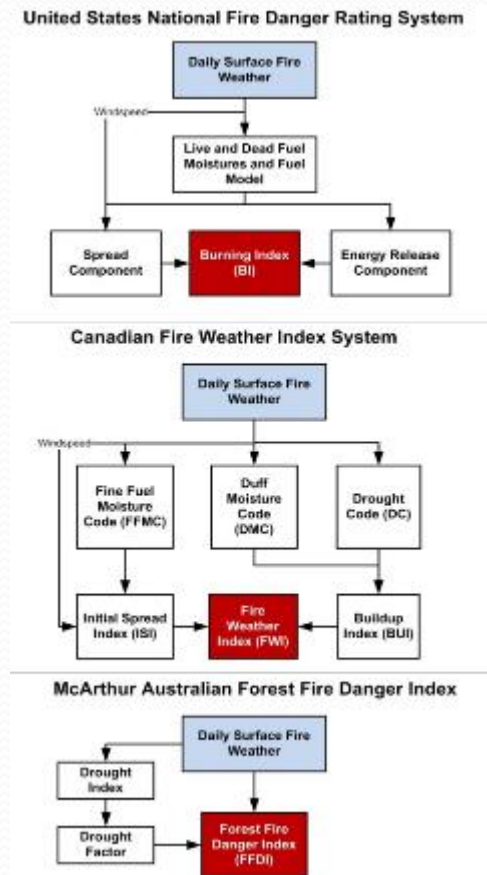
Quantifying fire weather season length

Hot

Dry

Windy

Calculating the Fire Danger Indices

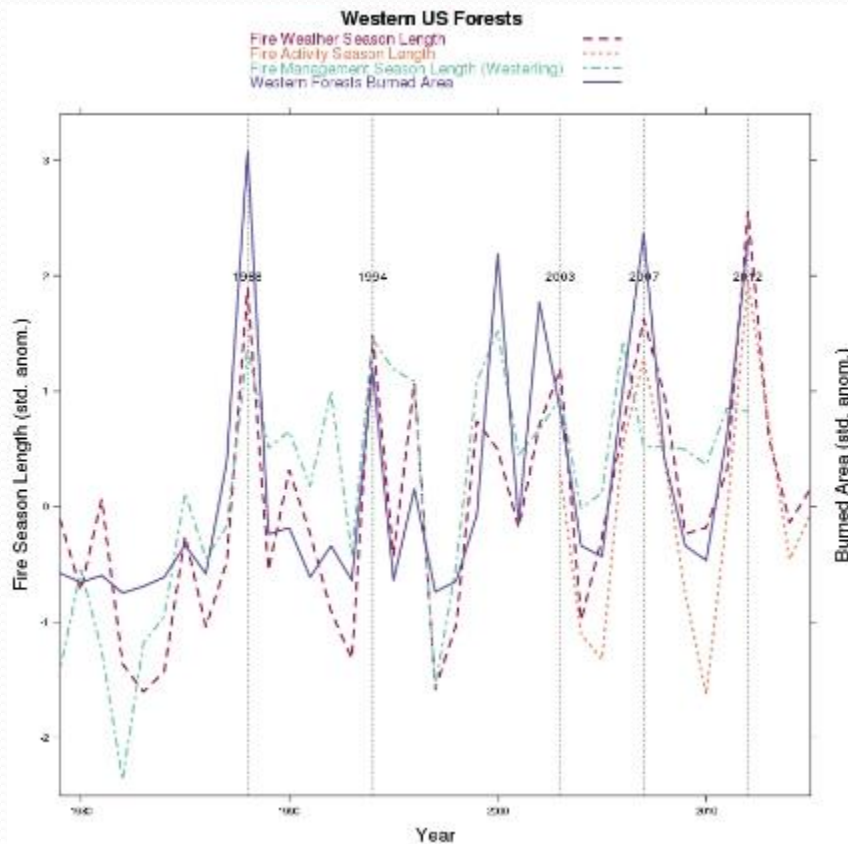


- We calculate the daily:
 - US Burning Index
 - Canadian Fire Weather Index
 - McArthur Forest Fire Danger Index
- However, the range of index values spanned two orders of magnitude
 - So all metrics were standardized over space and time to yield an annual metric of Fire Weather Season Length, or the number of days each year that wildfires are likely to burn

Nation-wide burned comparisons

Country	Year-to-year variation in burned area accounted for by FWSL	Source
United States	46% ^{***} (34)	US NIFC
Canada	9% [*] (34)	Canadian Forestry Database
Spain	49% ^{***} (33)	European Fire Database
Portugal	43% ^{***} (33)	
Italy	67% ^{***} (33)	
France	22% ^{***} (33)	
Greece	37% ^{***} (33)	
Latvia	48% ^{***} (33)	

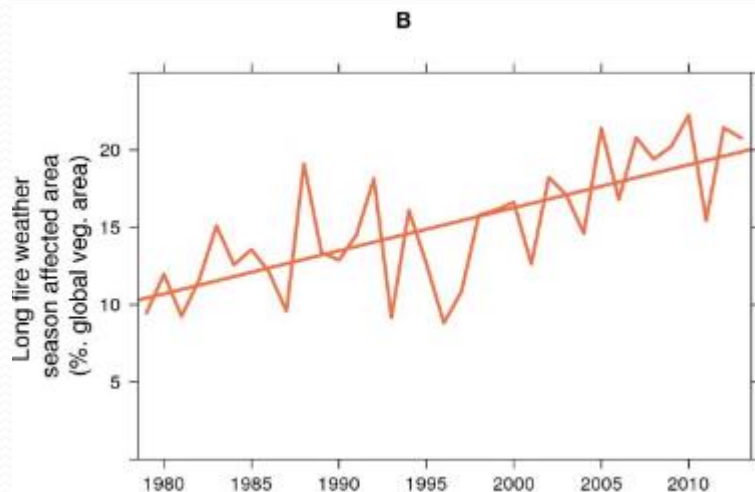
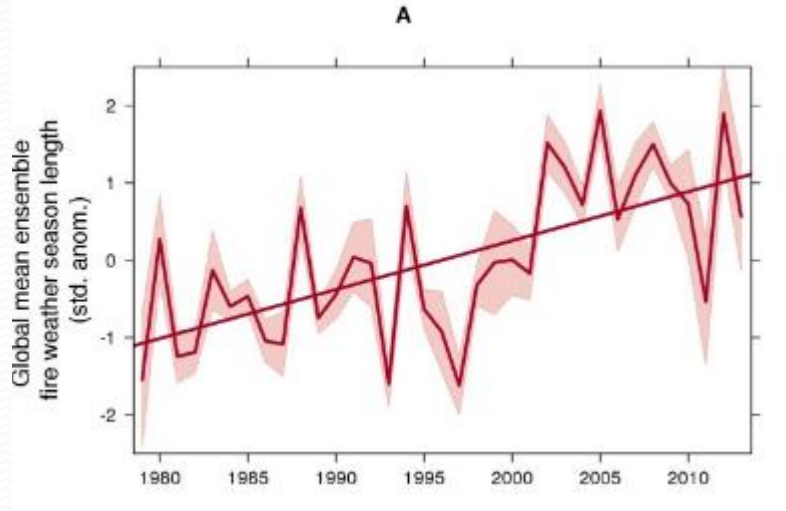
Relationships between fire weather season length and burned area across Western forests



- Correlations between Fire Weather Season length and western forests burned area are high ($r^2=0.71$)

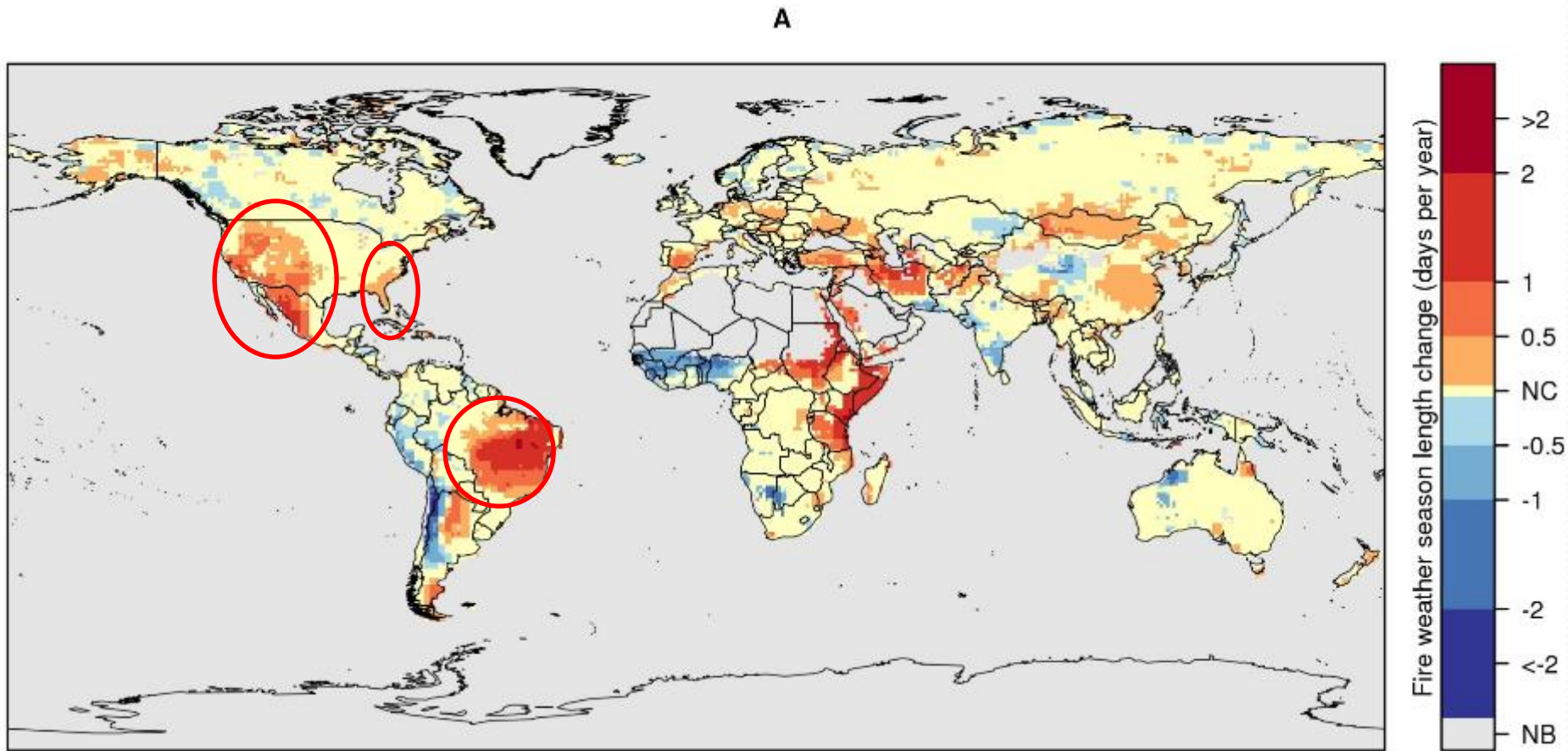
Changes in fire weather season length

Global season length trend



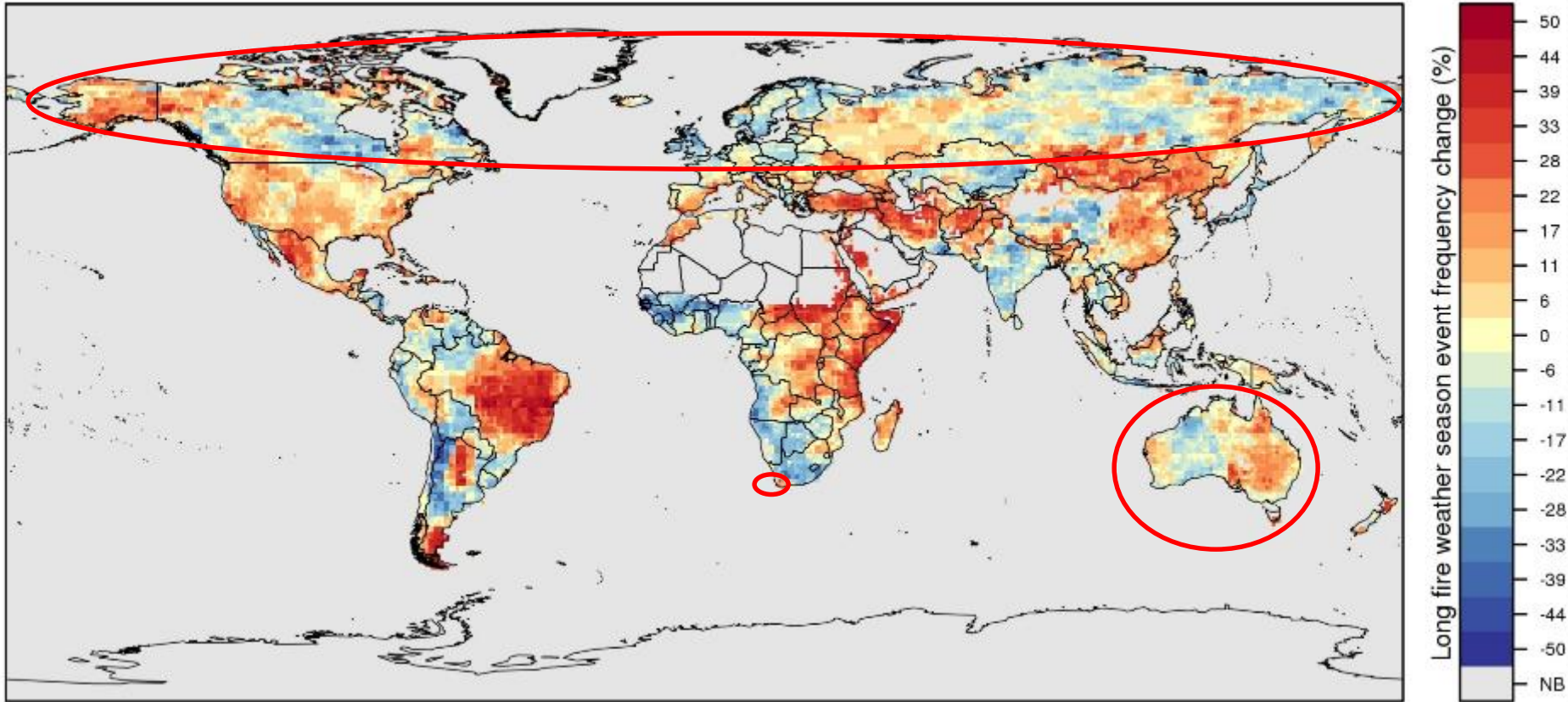
- 18.7% increase in global fire weather season length from 1979-2013
 - Represents an increase in the mean global fire season length from 18 to 22 days
- Global burnable area affected by anomalously long fire weather seasons ($>1.0 \sigma$ above historical mean) has doubled (108.1%)

Significant trends in global ensemble fire weather season

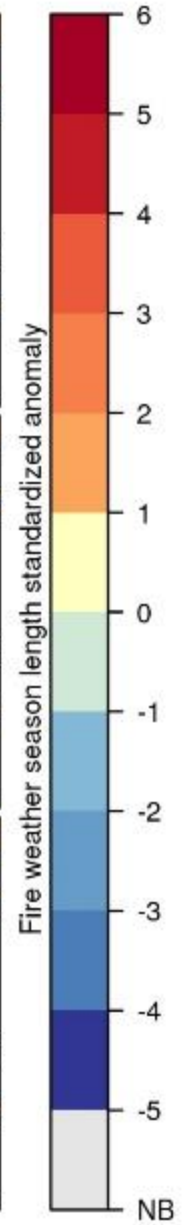
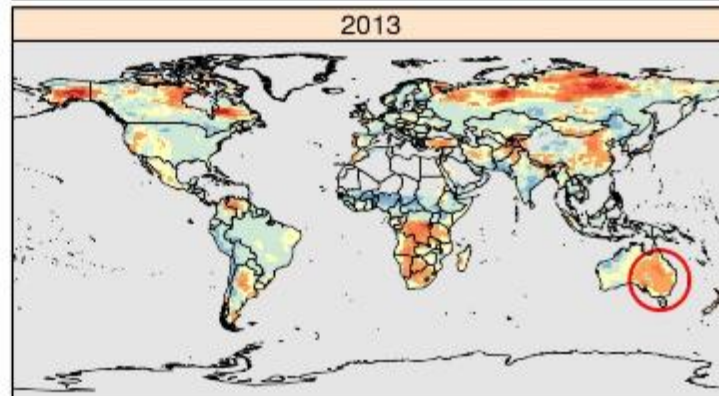
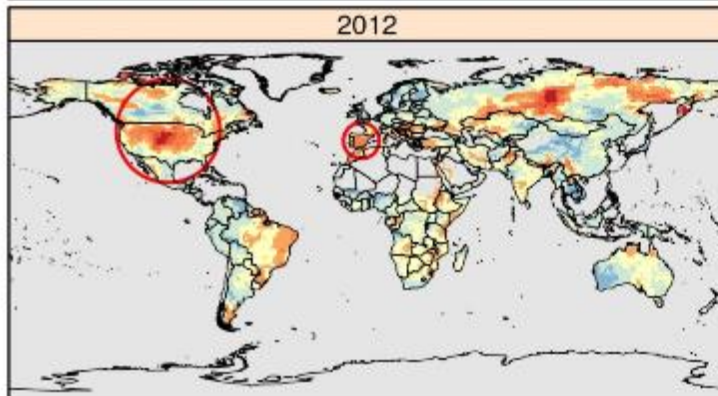
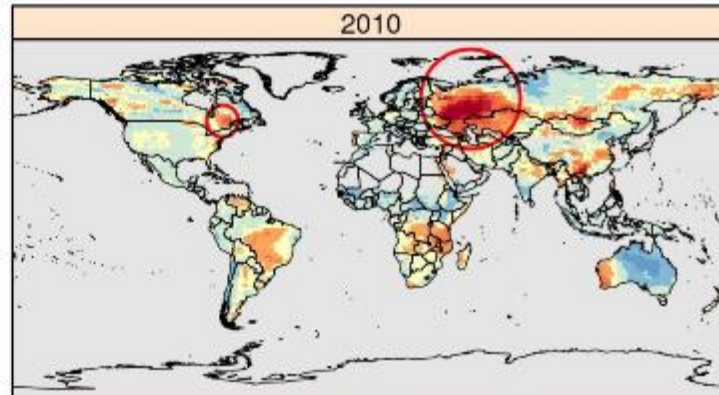
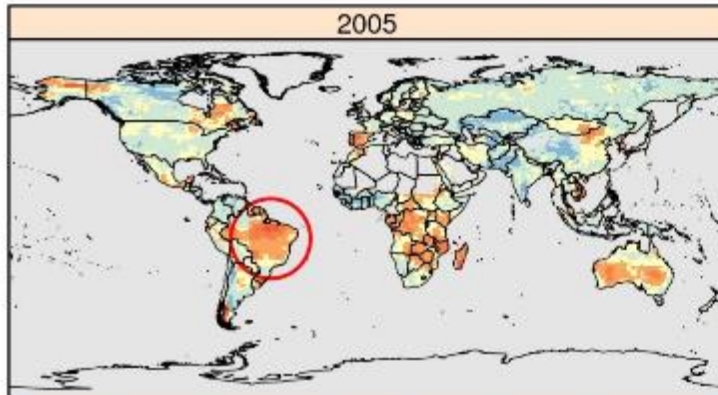
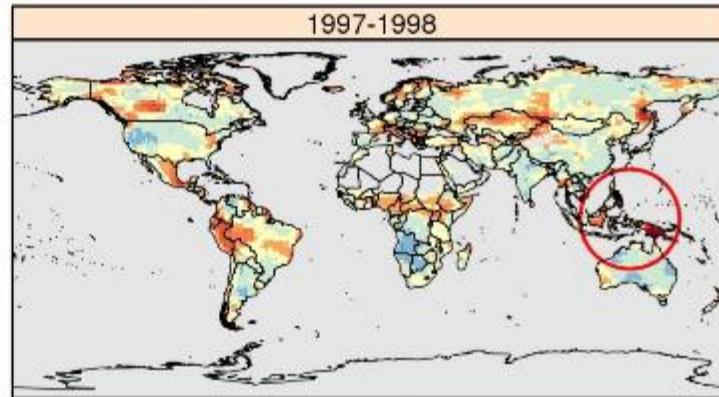
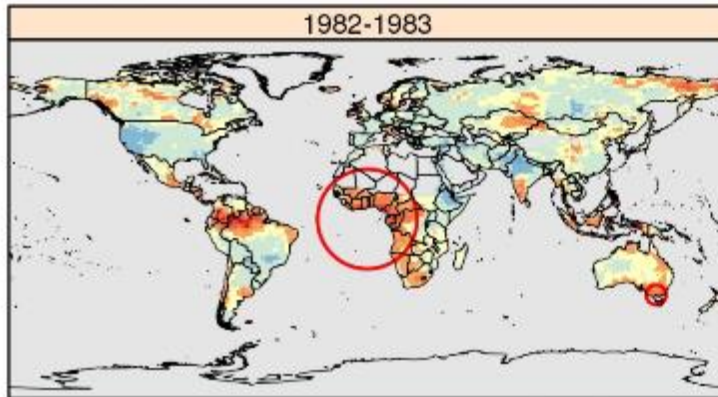


Fire weather seasons have lengthened across 29.6M km² (25.3%) of the Earth's vegetated surface.

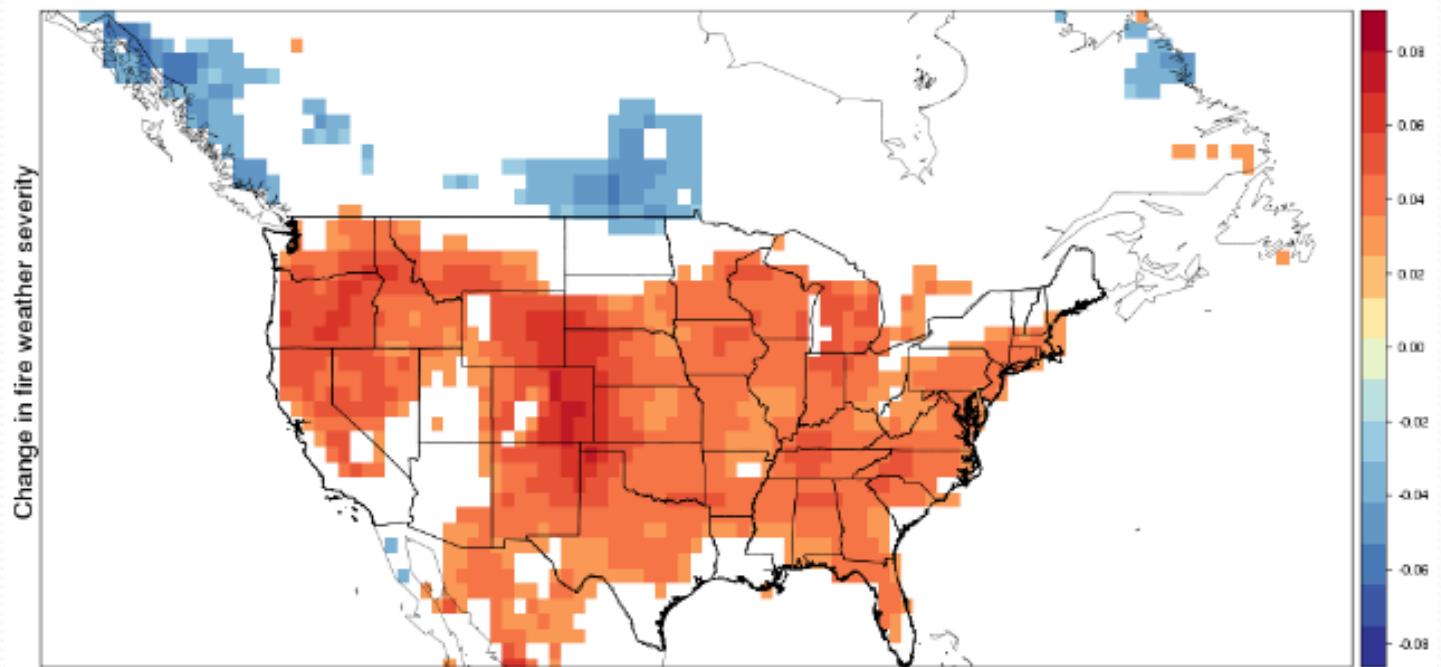
B



and an increased frequency of long fire weather seasons across 62.4M km² (53.4%) of the globe's vegetated areas during the second half of the study period.



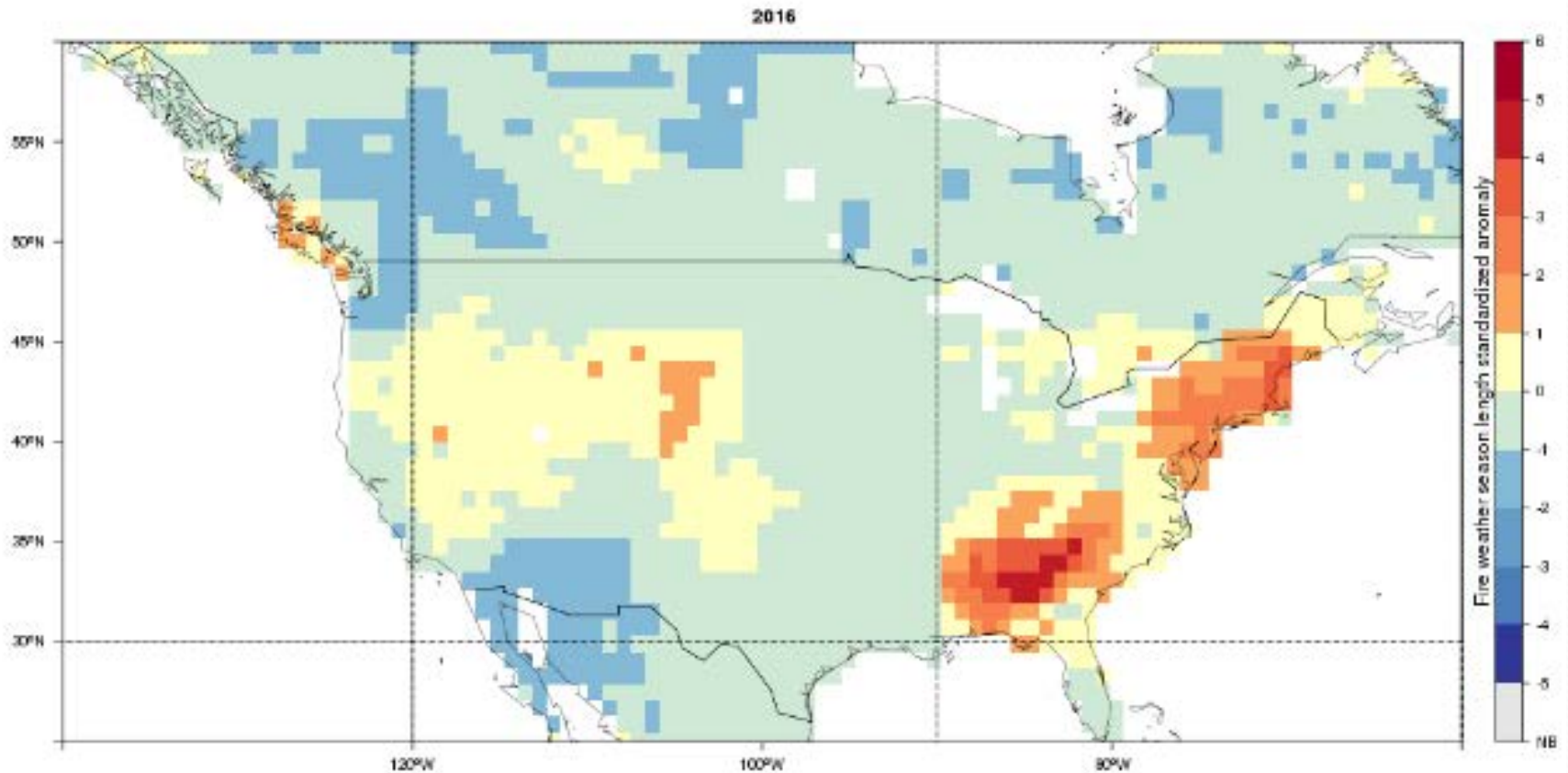
Fire season severity is increasing across the US



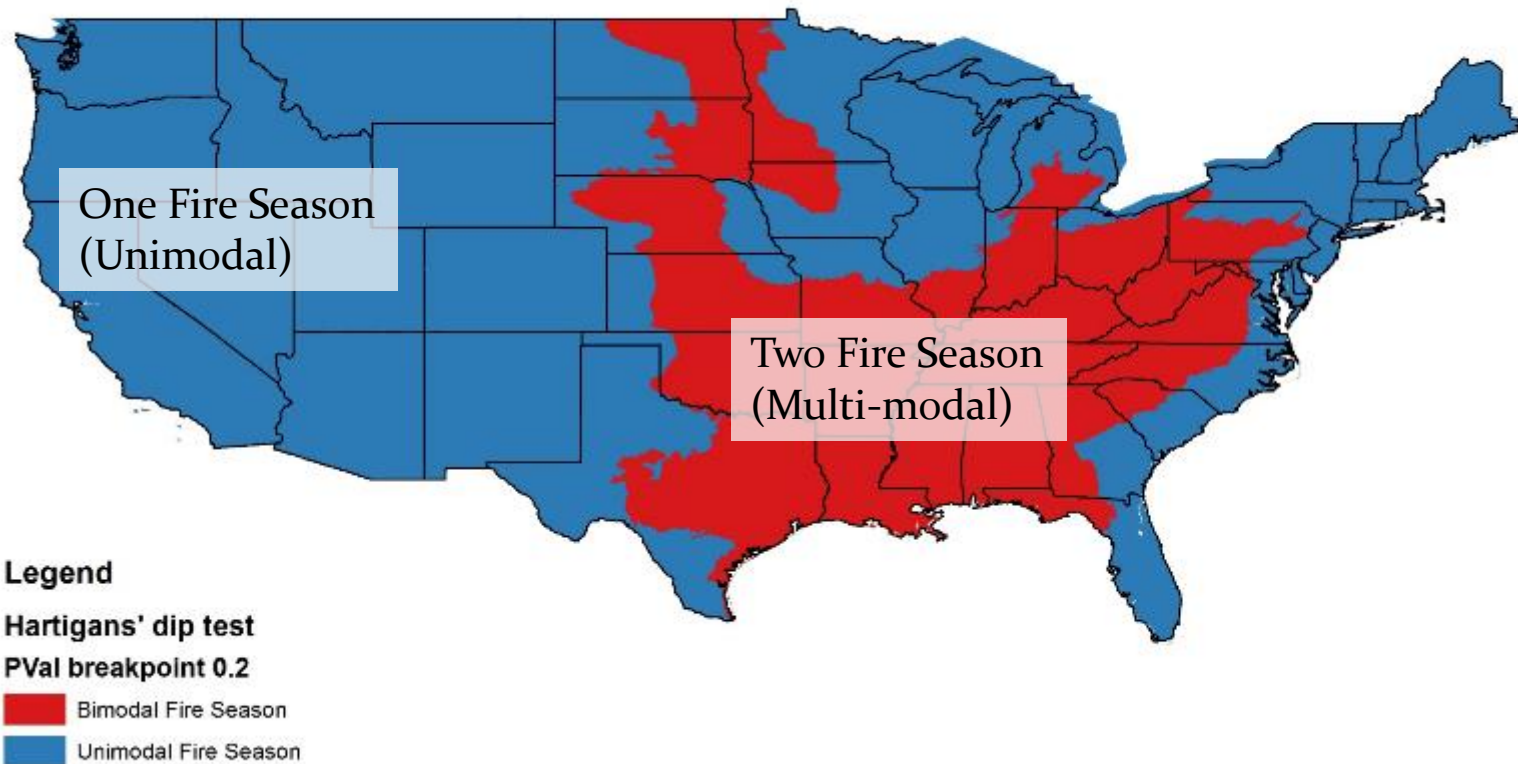
When fire season length is held constant, most of US shows increases in the within-season fire weather severity as measured by fire danger indices

Fire weather conditions in the Southern Area fall 2016

Fire weather season length anomalies for 2016

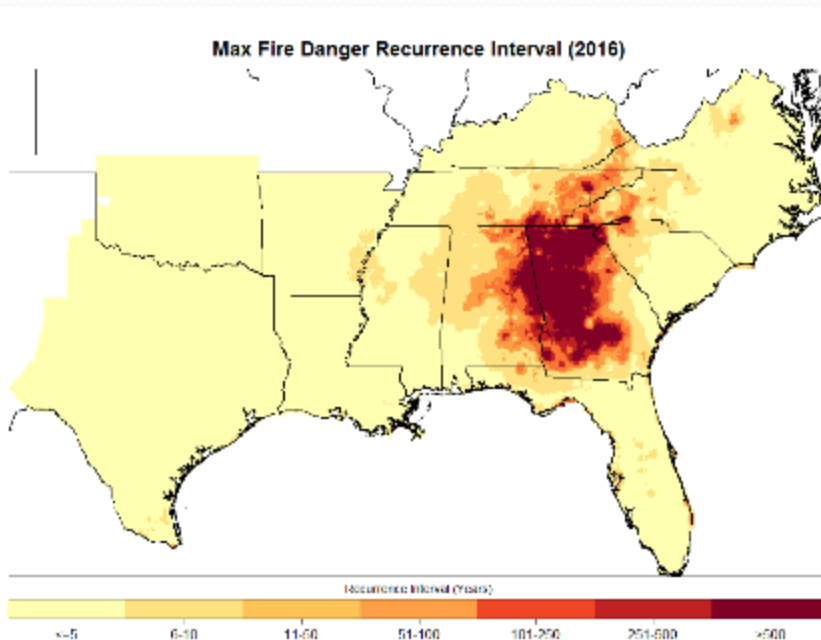


Not all fire seasons occur during the summer

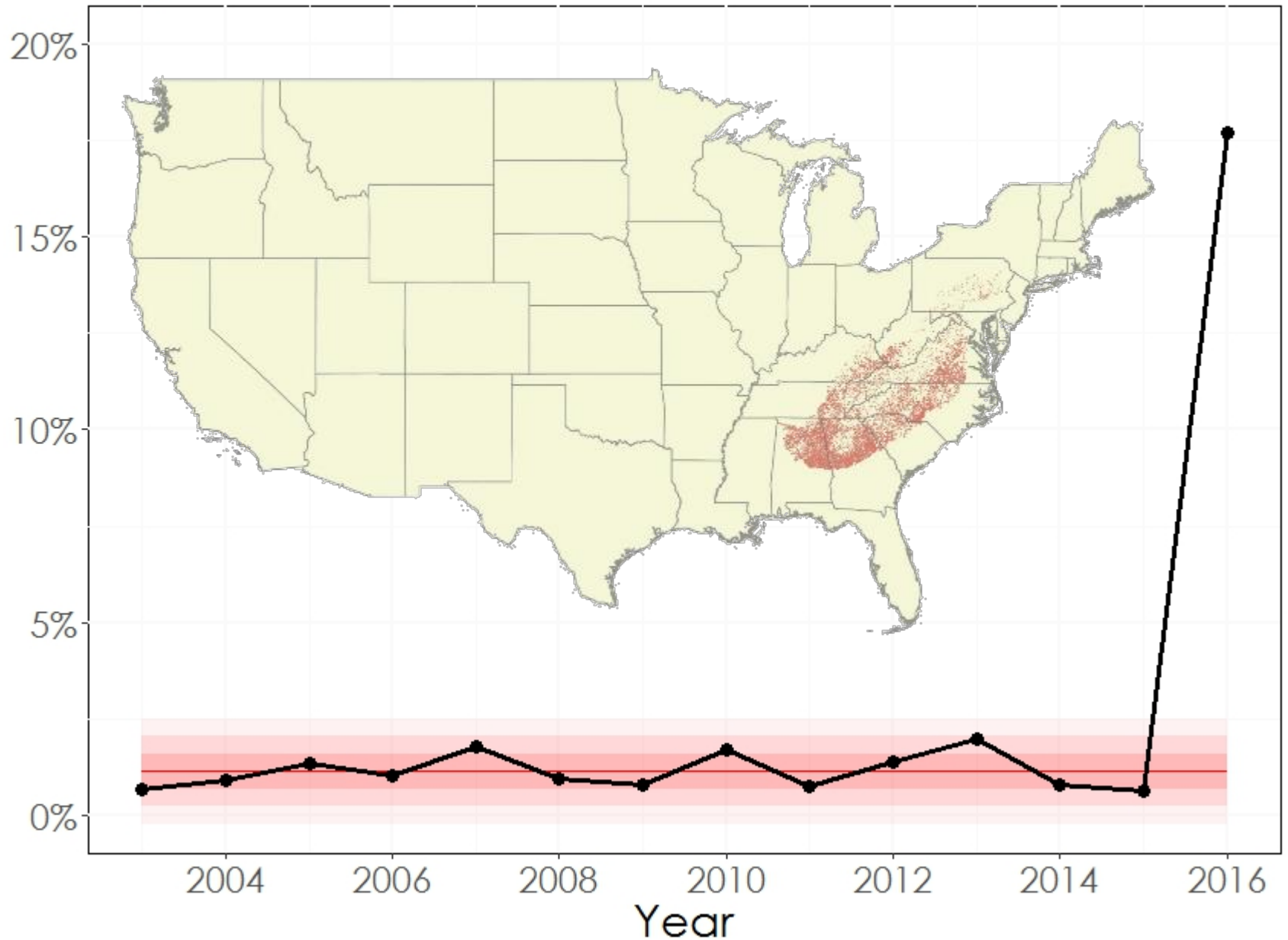


Fire Return Interval for fall 2016 fire season

- Many areas witnessed fire danger conditions in fall of 2016 that exceeded 500 year return intervals



Nighttime Proportion of Heat Detected By Satellites



Wildland fire and the global carbon cycle

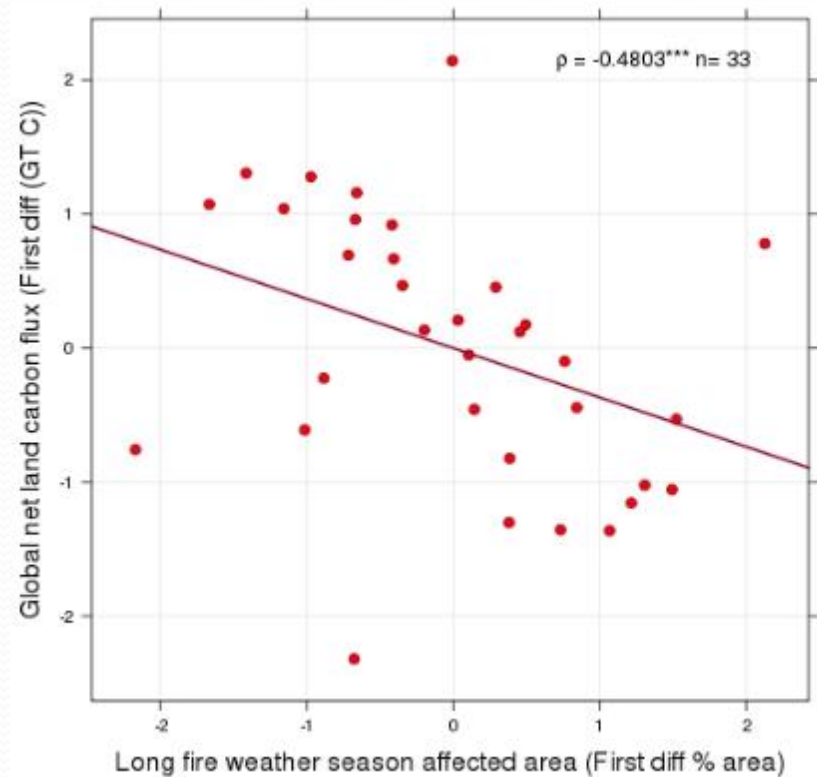
Implications for the global carbon cycle

We compared mean annual global FWSL to global net land carbon flux

Net Land Carbon Flux = Land Carbon Sink – Land Use Change Emissions

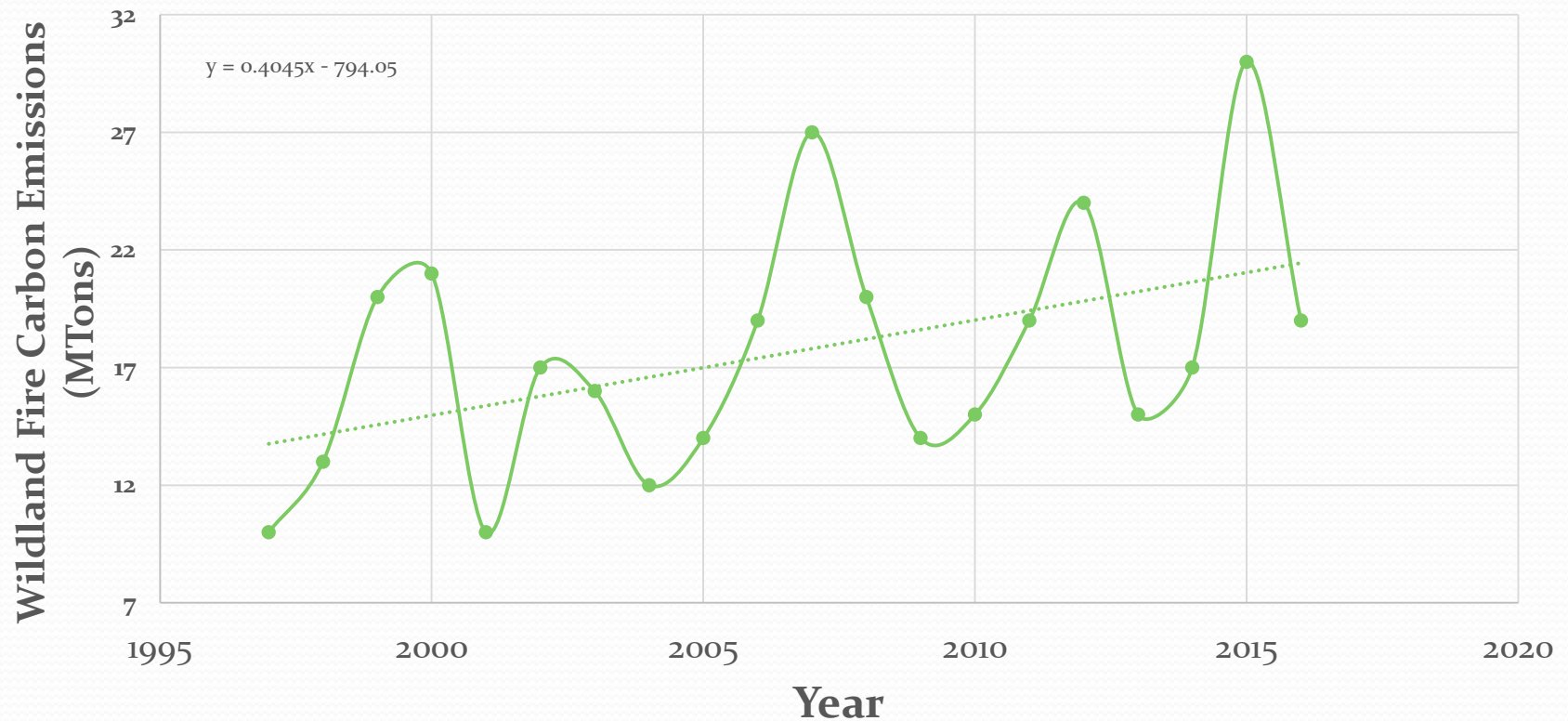
Mean global FWSL accounted for over 23% of the inter-annual variation global net land carbon uptake

Longer fire weather seasons -> more wildfire carbon loss -> less net carbon uptake by the vegetated surface



US Wildland Fire Carbon Emissions (1997-2016)

Carbon Emissions (Continental US)



Source: Global Fire Emissions Database (GFED) V. 4.1,
Temperate North America TENA

Summary

- Global fire weather season lengths have increase by 18.7% and global burnable area affected doubled from 1979-2013
- Regional trends across the US were more pronounced
 - Significant trends across California, the Great Basin, Rocky Mountains and part of the Southeastern US
- Observed extreme events like those in the Southeast are far outside historical ranges
- **If changes continue, *and they are coupled with ignition sources and available fuel*, we can expect more burned area and higher intensity fires that foster direct global carbon cycle feedbacks**

Publication

- Jolly, W.M., Cochrane, M.A., Freeborn, P.H., Holden, Z.A., Brown, T.J., Williamson, G.J., Bowman, D.M.J.S., 2015. Climate-induced variations in global wildfire danger from 1979 to 2013. *Nature Communications* 6: 7537.



The screenshot shows the top portion of a web page for a Nature Communications article. At the top left is the 'nature COMMUNICATIONS' logo with a stylized orange and yellow wave graphic. Below the logo is a navigation bar with buttons for 'Home', 'About the journal', 'Authors and referees', 'Browse archive', and 'Search'. A breadcrumb trail reads 'nature.com > journal home > archive by date > july > full text'. Below this is the text 'NATURE COMMUNICATIONS | ARTICLE OPEN' with a share icon to the right. The article title 'Climate-induced variations in global wildfire danger from 1979 to 2013' is prominently displayed. Below the title, the authors are listed: 'W. Matt Jolly, Mark A. Cochrane, Patrick H. Freeborn, Zachary A. Holden, Timothy J. Brown, Grant J. Williamson & David M. J. S. Bowman'. There are links for 'Affiliations', 'Contributions', and 'Corresponding author'. At the bottom, the article details are provided: 'Nature Communications 6, Article number: 7537 | doi:10.1038/ncomms8537' and 'Received 24 November 2014 | Accepted 15 May 2015 | Published 14 July 2015'.

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Thank You

This work was supported by NASA Headquarters under the Terrestrial Ecology Program (NNX11AB89G) of the NASA Science Mission Directorate's Earth Science Division.



Questions & Answers

- **By phone: Dial #2 to enter the queue.**
- **On your computer: Type your question into the Q & A pod on the left side of your screen.**



Introduction to the Forest Resilience Bond (FRB)

Prepared for the US Forest Service

December 11th, 2017

Goals of the Forest Resilience Bond

**Provide
resources to
support
collaboration**

**Accelerate
pace and
scale of
restoration**

**Support
public land
management**

SOCIAL

- Rural job creation & community development
- Community resilience
- Protected lives & homes

ENVIRONMENTAL

- Reduced fire severity
- Protected water resources
- Carbon storage
- Protected habitat

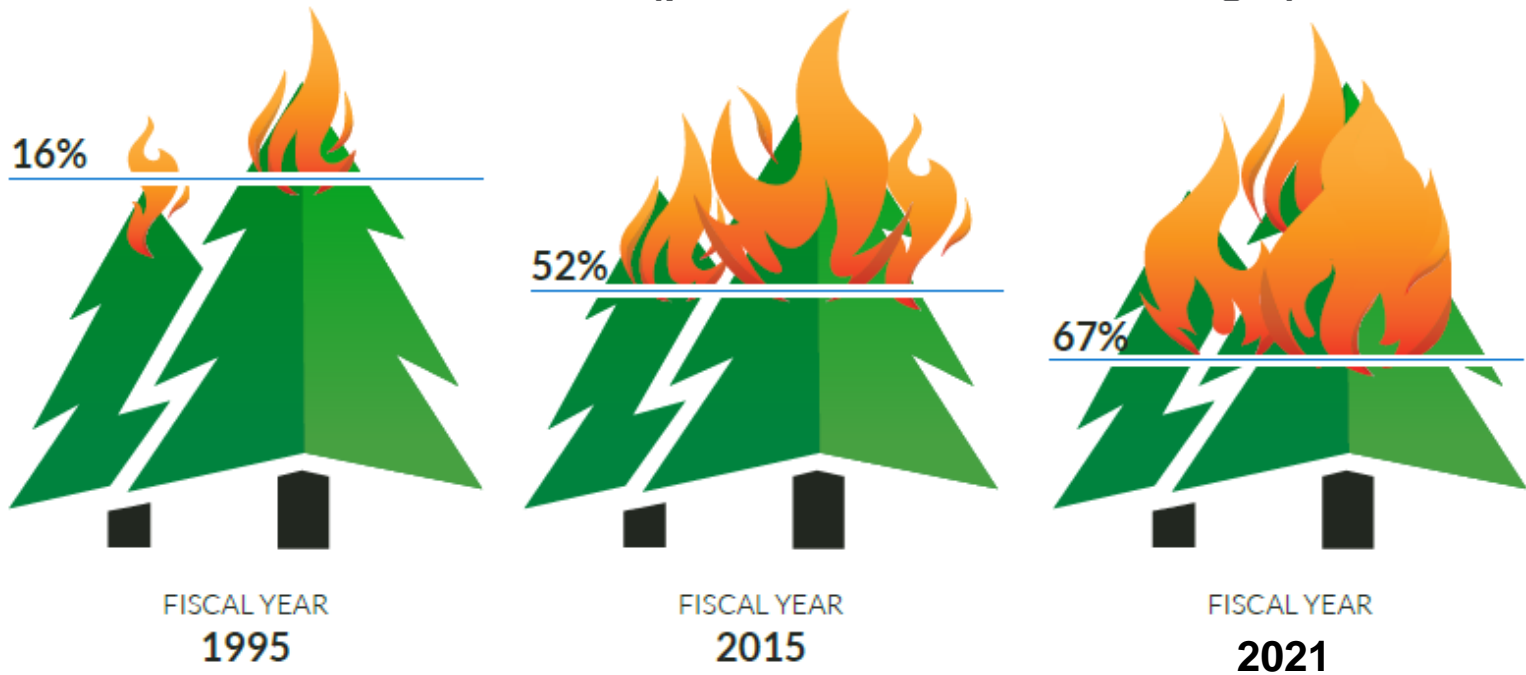
FINANCIAL

- Value for beneficiaries
- Taxpayer and ratepayer savings
- Investor returns

USFS: Rising Cost of Fire Suppression

Vicious cycle in which USFS is forced to pay for today's fires out of the funds designed to prevent tomorrow's

Cost of Wildland Fire (percent of USFS Annual Budget)¹



1. [The Rising Cost of Wildfire Operations](#), USDA Forest Service

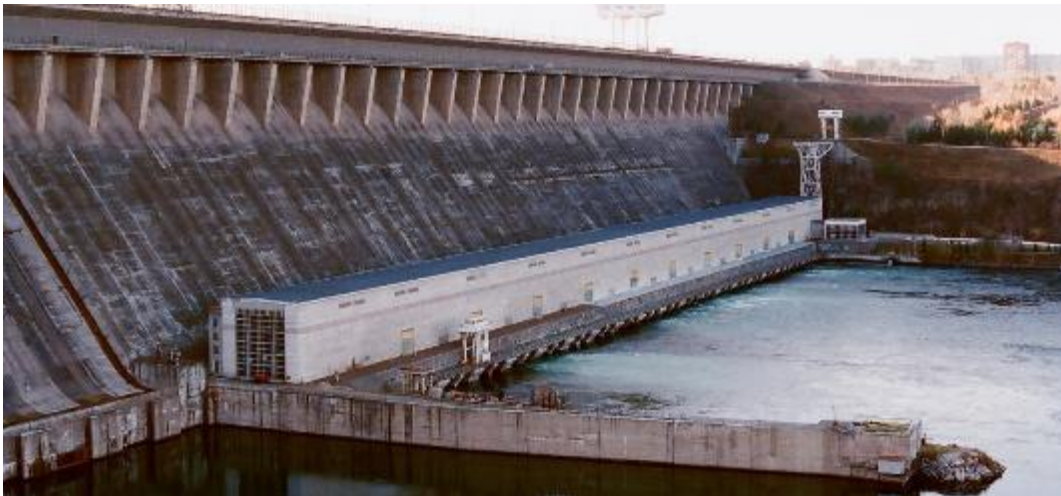
Utility Benefits of Forest Restoration

Water Utilities

- Reduces fire risk to water quality
- Potential to increase water quantity

Common Watershed Challenges

- Water quality
- Infrastructure damage
- Instream flow protection
- Sedimentation
- Declining yield
- Endangered species
- Climate resilience
- Insect and disease
- Timing of flows/runoff
- Flood control



- Protects against reservoir sedimentation
- Potential to increase utilization of cheap, carbon-free hydropower

The Forest Resilience Bond Ecosystem



Project Partners



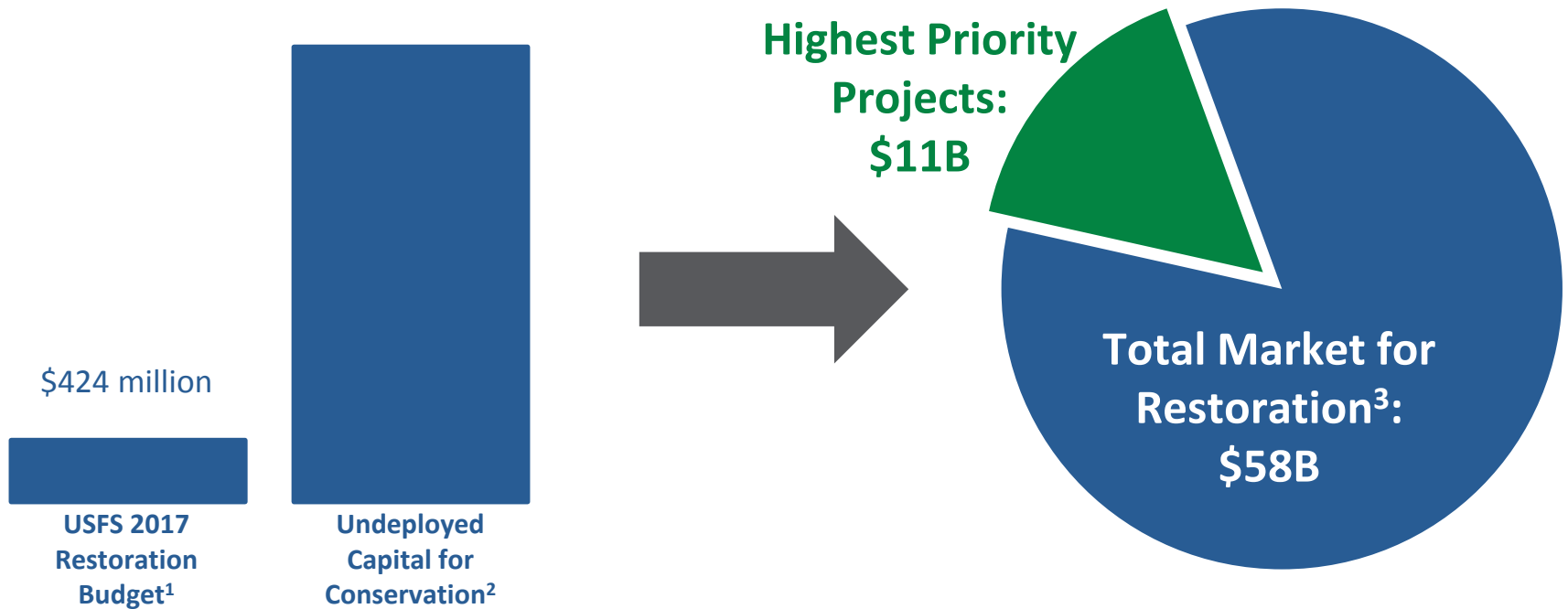
Research Partners



Grant & In-Kind Funders



Opportunity for Private Capital



Advantages of Private Capital

Infusion of capital

Cost sharing

Larger projects

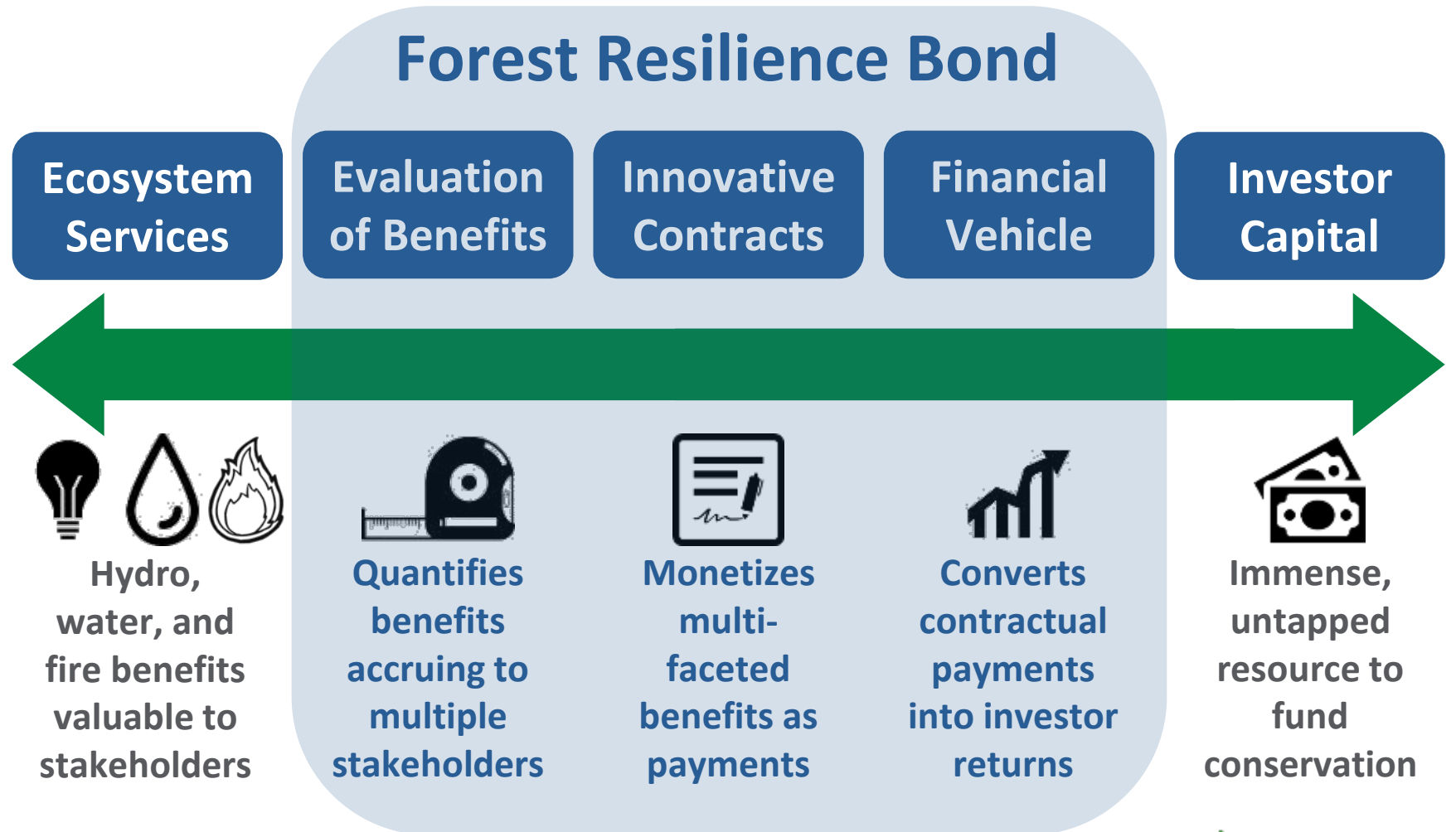
Project catalyst

Ex-post payments

1. [USFS Fiscal Year 2017 Budget Overview](#) (\$40 million for CFLRP and \$384.1 million for hazardous fuel reduction)
2. [State of Private Investment in Conservation 2016](#) (\$3.1 billion of investor capital undeployed at end of 2015)
3. [USFS Fiscal Year 2017 Budget Overview](#) (58 million acres at "high or very high risk of severe fire" @ \$1,000/acre)



Connecting Investor Capital to Conservation



Ecosystem Services of Forest Restoration

Ecosystem Services

Evaluation of Benefits

Innovative Contracts

Financial Vehicle

Investor Capital



Fire Severity



Water Quantity & Quality



Hydropower Generation



Air Quality & Emissions



Job Creation

Community Resilience

Recreation & Habitat

Measurement and Evaluation

Ecosystem Services

Evaluation of Benefits

Innovative Contracts

Financial Vehicle

Investor Capital

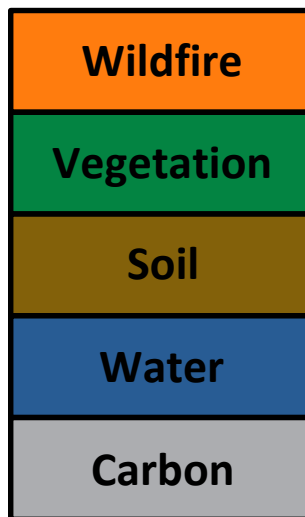
Field-Based Sensors



Remote Sensing



Ecosystem Modeling



Fire Risk Reduction

Water Quantity & Quality

Hydropower Generation

UC MERCED SNRI
SIERRA NEVADA RESEARCH INSTITUTE

natural capital PROJECT

WORLD RESOURCES INSTITUTE

Contracting with Utilities

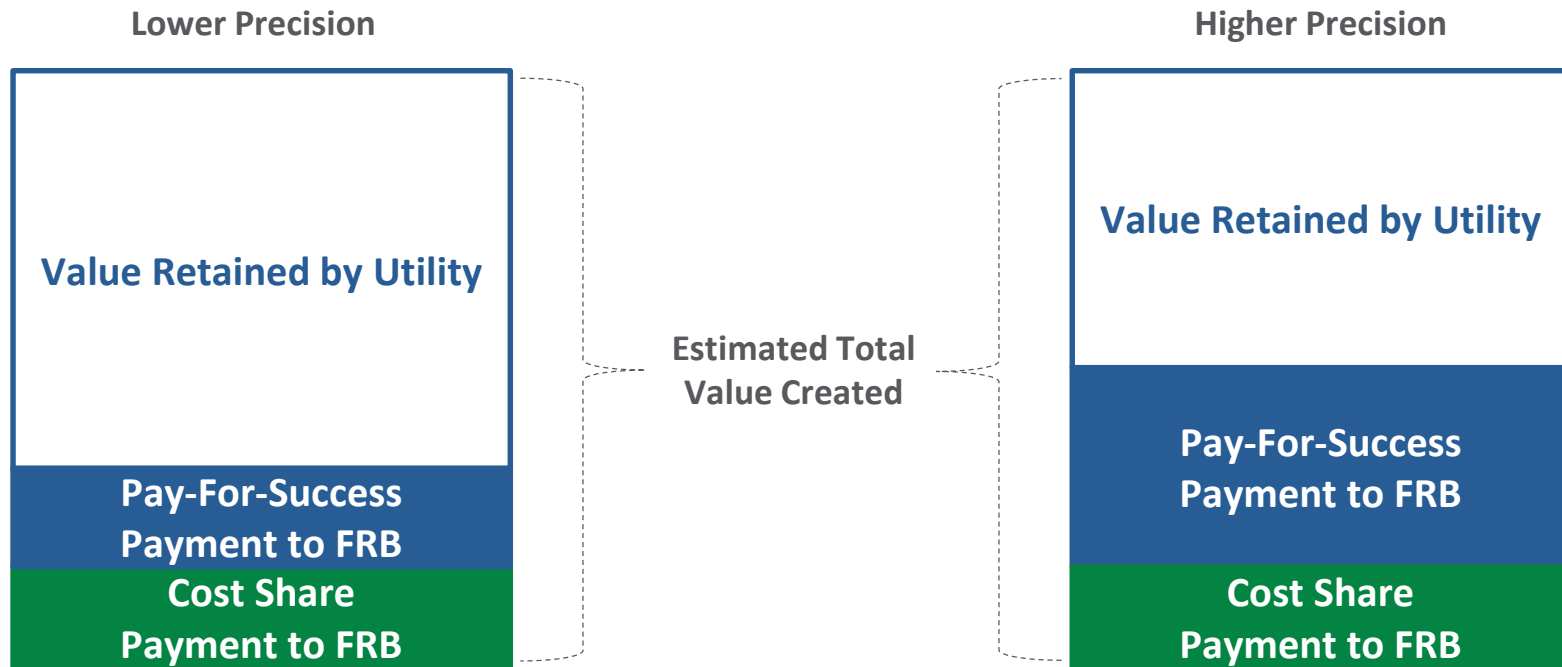
Ecosystem Services

Evaluation of Benefits

Innovative Contracts

Financial Vehicle

Investor Capital



Contracting with USFS




Ecosystem Services

Evaluation of Benefits

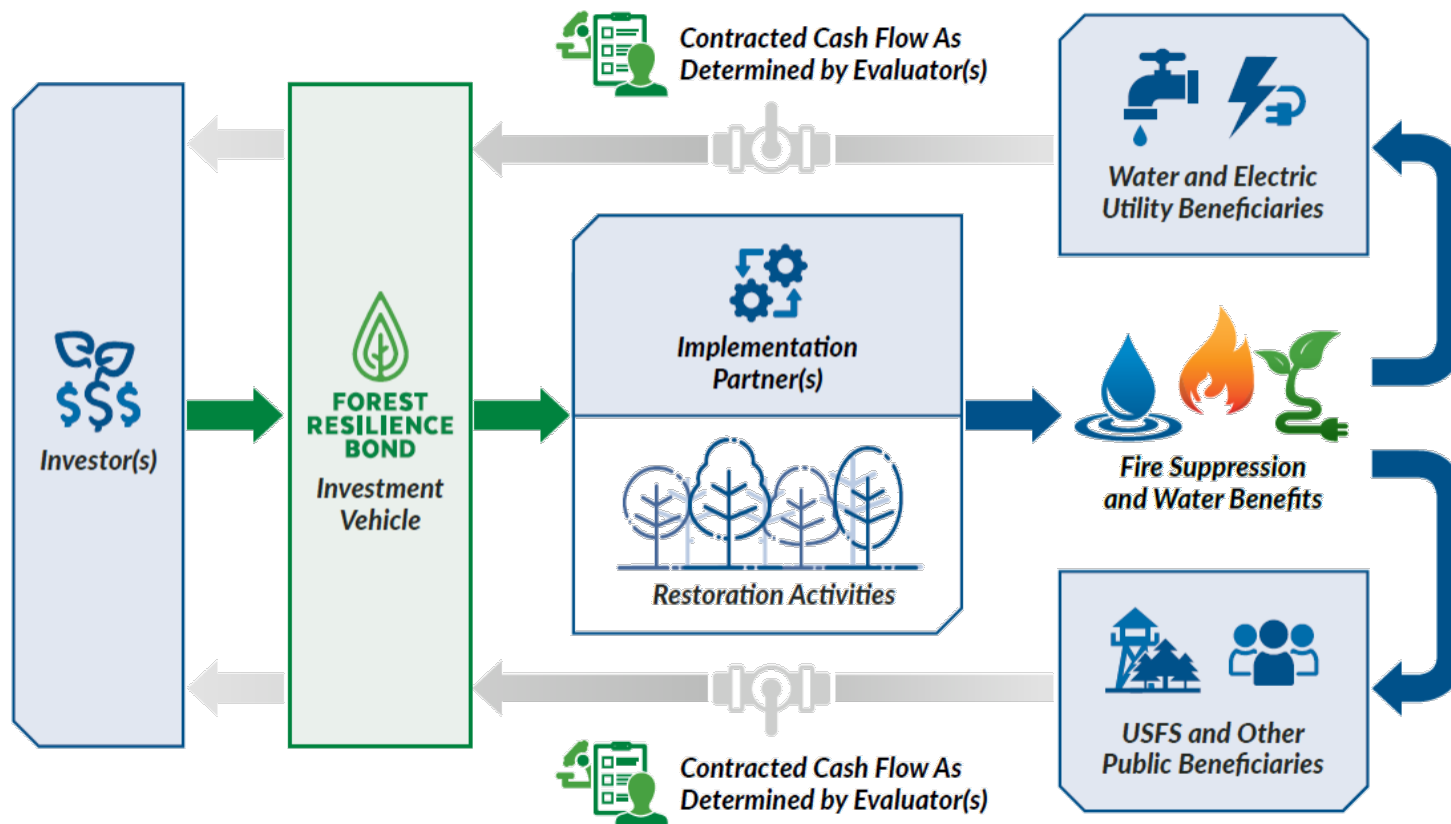
Innovative Contracts

Financial Vehicle

Investor Capital

		
<ul style="list-style-type: none"> • Restoration funding at a discount due to matching funds • Involvement in other workstreams determined by USFS staff 	<ul style="list-style-type: none"> • Project specific financing vehicle • Utilizes Cooperative Agreements (e.g. Stewardship or Challenge Cost Share) • Implementation partner can handle contracting and project management, as necessary 	<ul style="list-style-type: none"> • <u>Engagement</u> –beneficiaries, investors, communities, etc. • <u>Contracting</u> – utilities, investors, state, etc. • <u>Science</u> – robust ecosystem service measurement • <u>Financing</u> – deal structuring, fund management

Financial Structuring



Benefits of FRB for Investors

Ecosystem
Services

Evaluation
of Benefits

Beneficiary
Contracting

Financial
Vehicle

Investor
Capital

Stable, annual cash flows

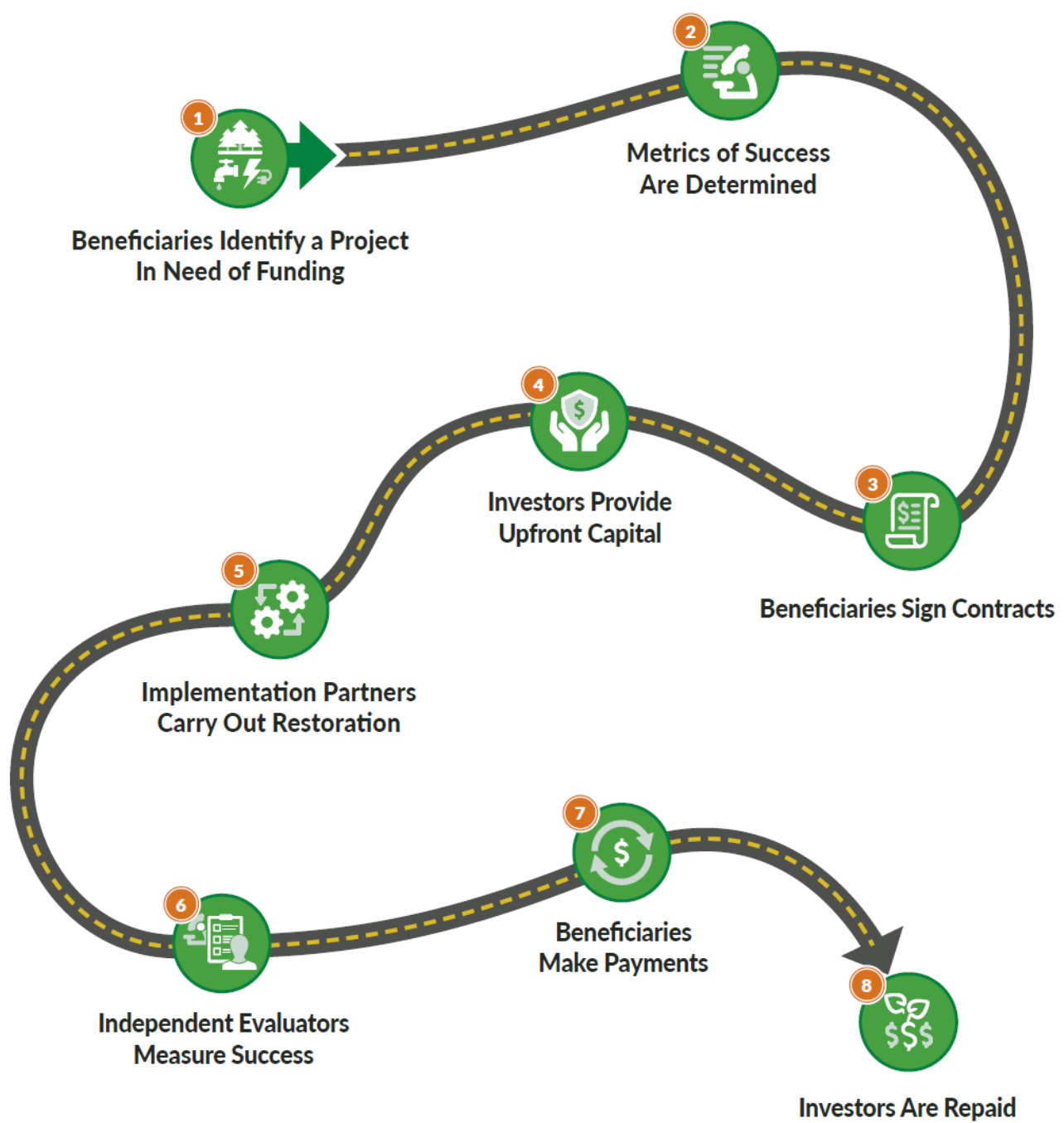
Expressed investor demand

Sizeable investment opportunity

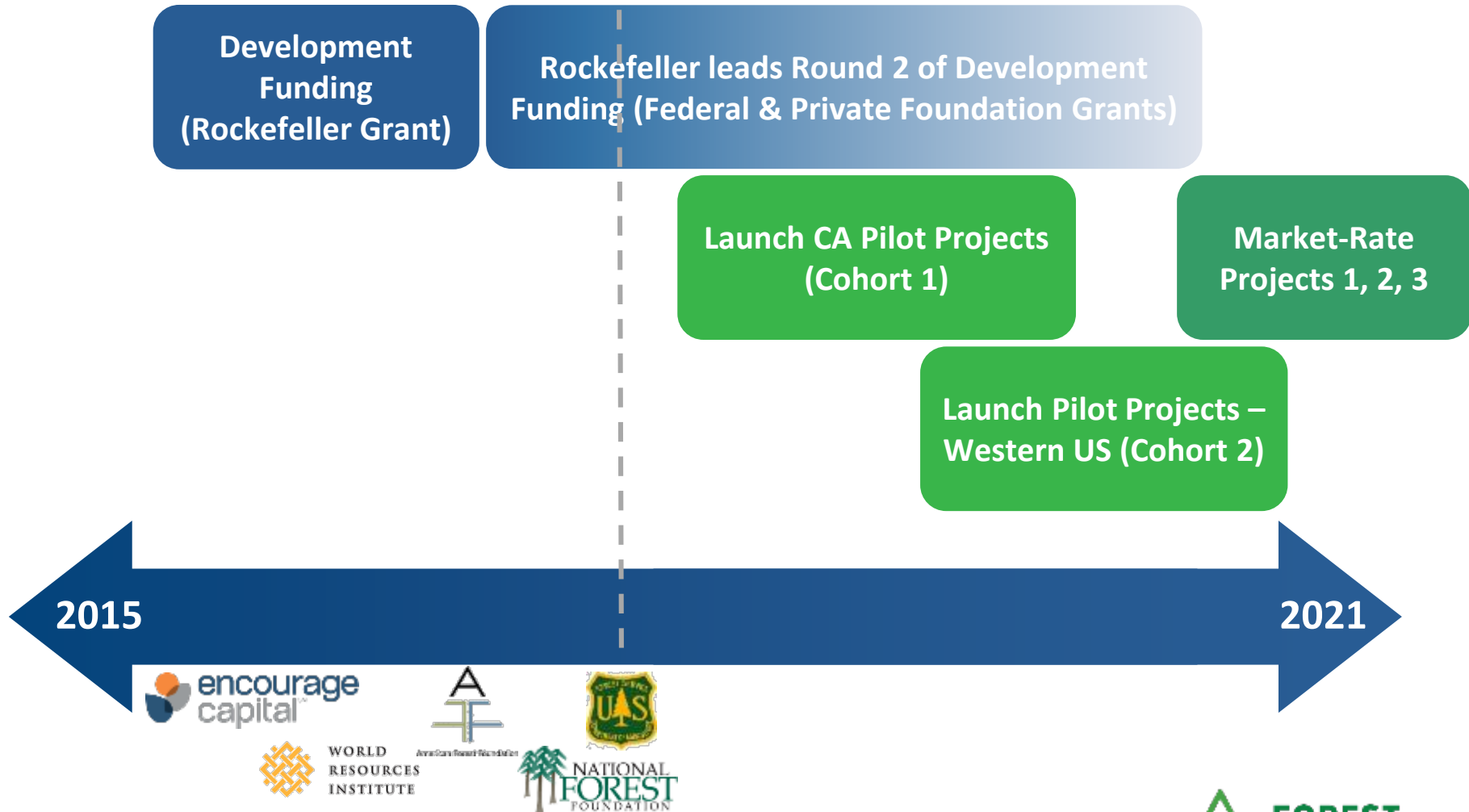
Portfolio diversification benefits

Multiple cash flow sources from low-risk counterparties

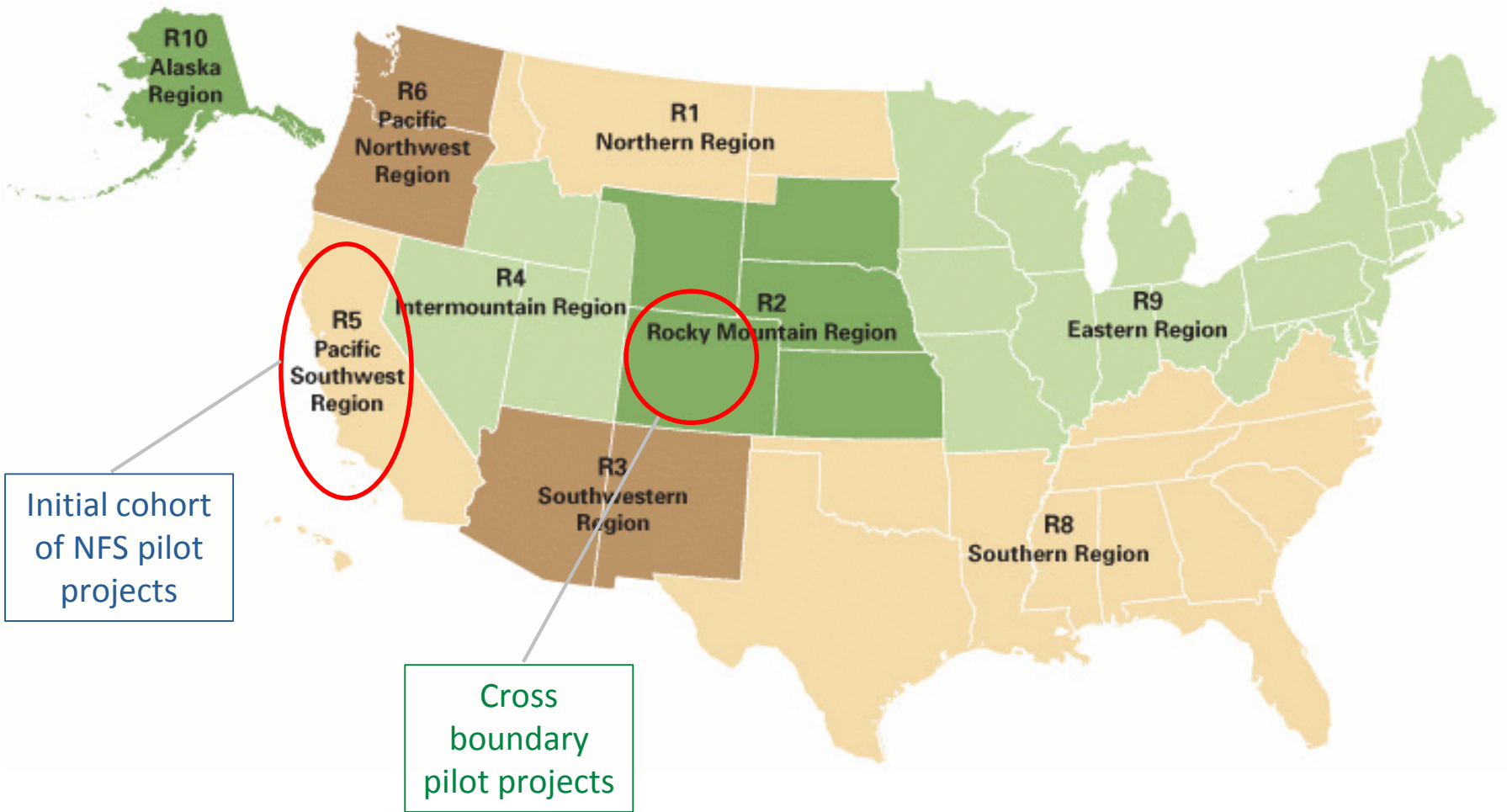
How the FRB Works



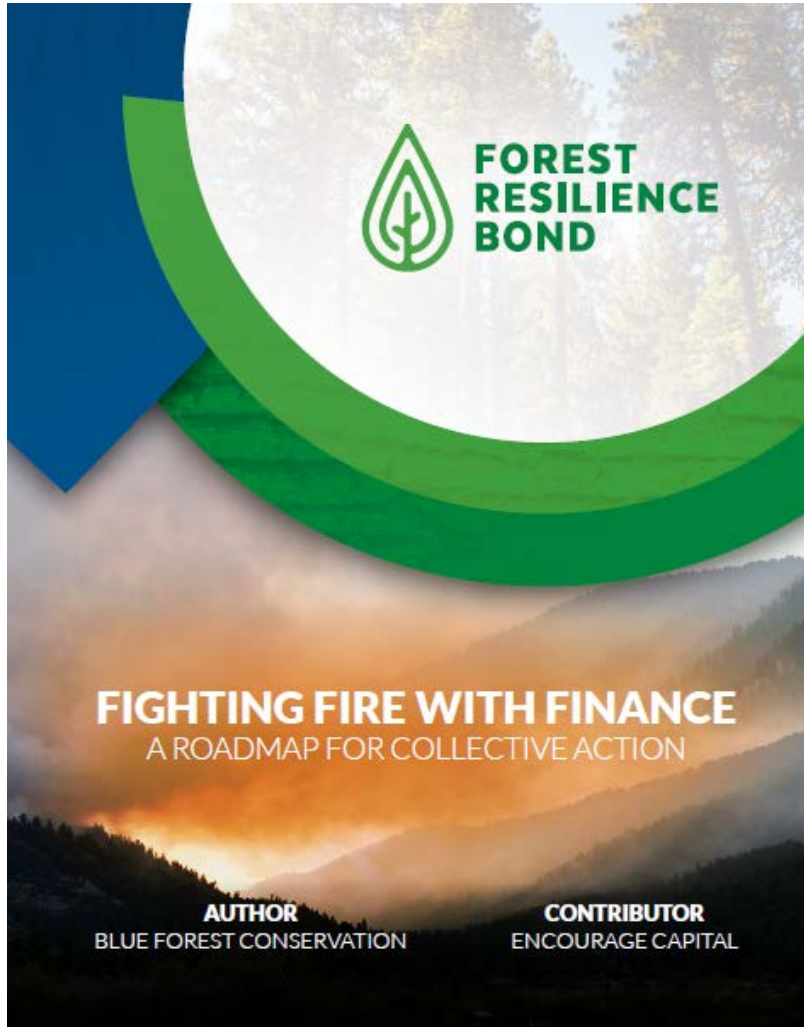
Timeline to Market



Proposed Pilot Projects



Additional Resources



Explore and download the [Roadmap Report](http://www.forestresiliencebond.com):
www.forestresiliencebond.com

Learn more about [Blue Forest Conservation](http://www.blueforestconservation.com):
www.blueforestconservation.com

Learn more about [Encourage Capital](http://www.encouragecap.com):
www.encouragecap.com



BLUE FOREST
CONSERVATION

Financial Innovation for Sustainable Solutions



**FOREST
RESILIENCE
BOND**

Zach Knight

Co-Founder and Managing Partner
zach@blueforestconservation.com

Questions & Answers

- **By phone: Dial #2 to enter the queue.**
- **On your computer: Type your question into the Q & A pod on the left side of your screen.**



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<http://www.climatewebinars.net/webinars/climate-megafires>