Drought, Water Extremes, and Infrastructure

AUDIO CONNECTION

1. Phone: mute your computer speakers and call 1-877-369-5243; access code: 0337996#

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.

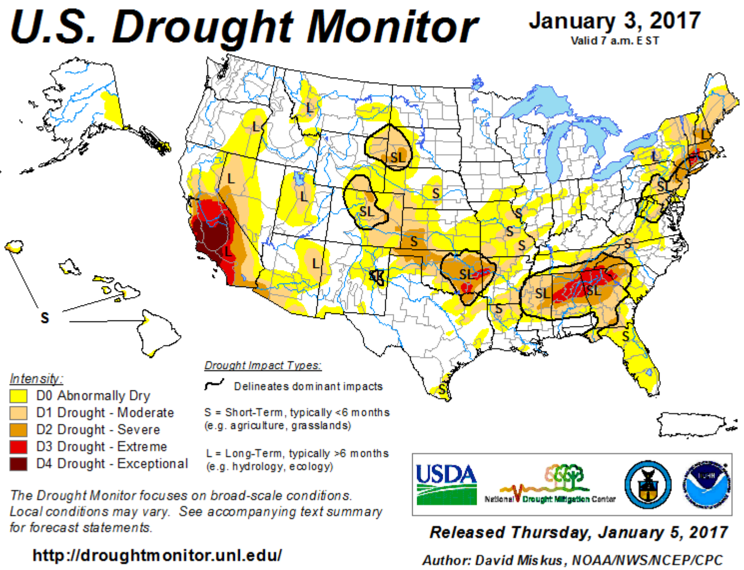
How much water will we have?

Rising global temperatures.

Changing precipitation patterns

Increasing natural disturbance

Increasing water use and demand


U.S. Drought Monitor
January 3, 2017
Valid 7 a.m. EST
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically <6 months (e.g. agriculture, grasslands)
L = Long-Term, typically >6 months (e.g. hydrology, ecology)
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.
http://droughtmonitor.unl.edu/
USDA
National Drought Mitigation Center
Released Thursday, January 5, 2017
Author: David Miskus, NOAA/NWS/NCEP/CPC

Drought, Water Extremes, and Infrastructure - Overview

Sarah H. Baker, PE

Engineering, Technology, and Geospatial Services, WO

What we're discussing

What kinds of infrastructure do we have?

What kinds of events are we talking about?

What kinds of risks should we consider?

Infrastructure

- Roads – 370,581 miles
- Trails – 157,348 miles
- Bridges (road and trail) – 13,006
- Buildings – 39,826
- Dams – 1,700 (460 FS-owned)
- Drinking water (4,779) and wastewater systems (4,764)
- Developed Recreation sites - 27,849

Drought and Extreme Water Events

- Too little water
  - Drying out
  - Fire
- Too much water
  - Flooding

Connections:

Drought → Fire → Flooding from Intense Storms

Las Conchas Fire

- 2011
- 150,000 acres

Los Alamos Reservoir

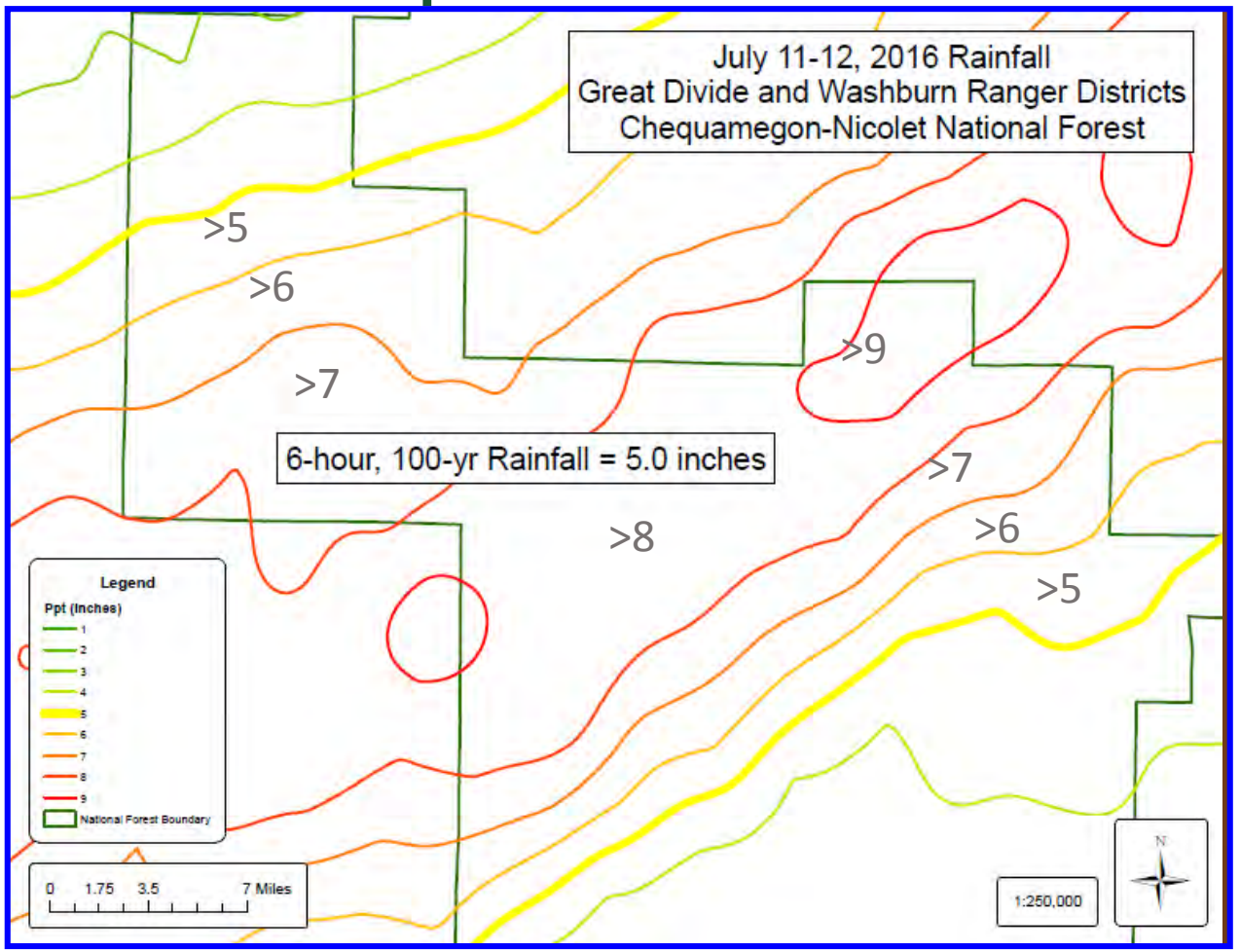
Defining Extreme: Rainfall

Chequamegon-Nicolet NF Example

Duration

- 6-hours
- Magnitude
- 5 - 9 inches of rain
- 100- to 1,000-yr RI

From Dale Higgins, Hydrologist.



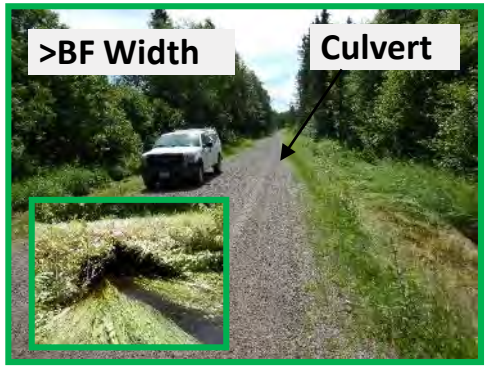
Reference: Huff, Floyd A., and James R. Angel. Rainfall Frequency Atlas of the Midwest. Illinois State Water Survey, Champaign, Bulletin 71, 1992.

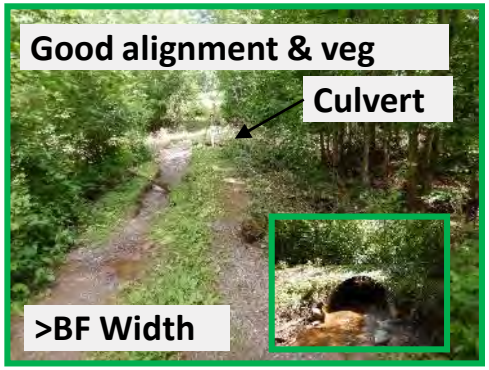
What Failed? Why?

- Extreme flood
  - (>500-yr, <0.2%)
- Undersized
  - < bankfull width
- Entrenched
- Poor alignment
- Debris
- Poor condition

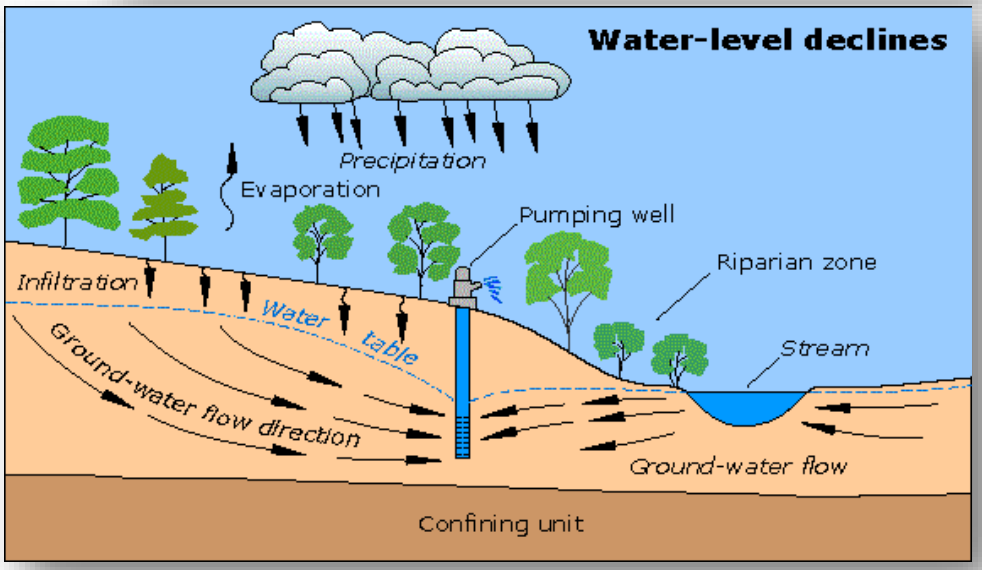
What Survived? Why?

- > BF Width
- Slightly entrenched w/ overflow
- Good alignment
- Riprap/veg
- Large key pieces
- Concrete



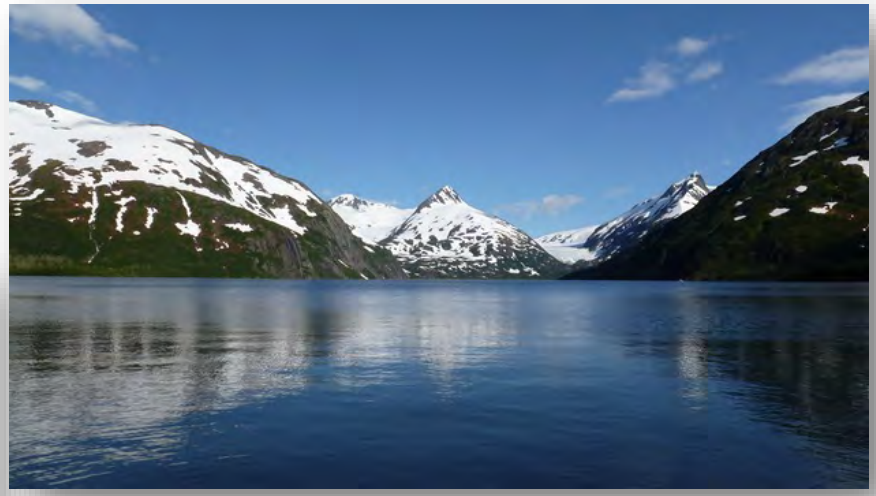


Too little water



Too much water

Think about Systems and Share Information!



Questions & Answers

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- **On your computer:** Type your question into the Q & A pod on the left side of your screen.

Vulnerability Assessments as an Integration Point
Intermountain Region – Drought and Infrastructure

February 7, 2017

Natalie Little, PE - Ogden, Utah
R4 Sustainability and Climate Change Coordinator

We have lots of information!
What is important? What isn't?
Who decides?

Important:

- Multi-perspective
- Structured

Climate Change Performance Scorecard
FY11 – FY16

Organizational Capacity	
1	Employee Education
2	Designated Climate Change Coordinators
3	Program Guidance
Engagement	
4	Science and Management Partnerships
5	Other Partnerships
Adaptation	
6	Assessing Vulnerability
7	Adaptation Actions
8	Monitoring
Mitigation and Sustainable Consumption	
9	Carbon Assessment & Stewardship
10	Sustainable Operations

The Intermountain Adaptation Partnership (IAP)

Goals for the science-management partnership:

- Increase climate change awareness
- Assess vulnerability of natural resources
- Develop adaptation strategies and tactics

http://adaptationpartners.org/iap

Two-Day Workshops

Dates	Location	Total Attendees	Forest Service	Partners
May 4-5	Ogden, Utah	50	41	9
May 11-12	Boise, Idaho	53	32	21
May 18-19	Salt Lake City, Utah	54	37	17
May 25-26	Reno, Nevada	43	28	15
June 1-2	Idaho Falls, Idaho	51	37	14



IAP Focus Areas

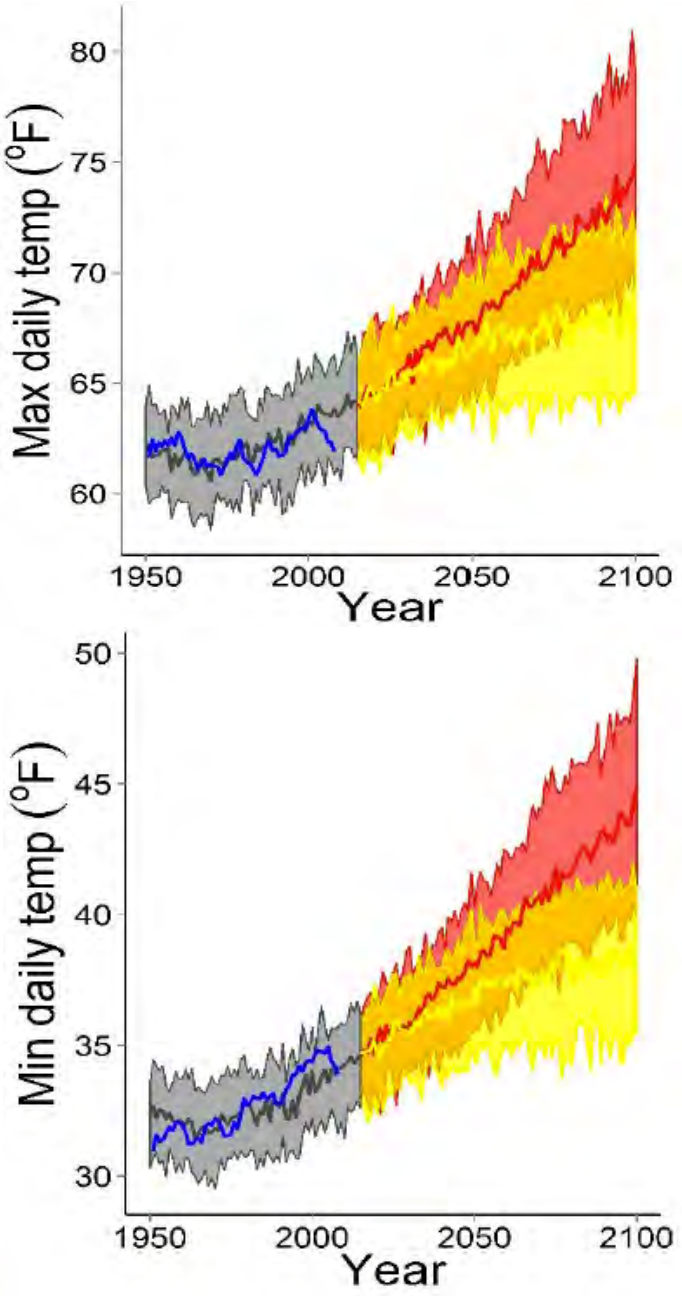
- Climate
- Hydrology, Soil, and Water
- Aquatic Species
- Vegetation
- Disturbance
- Terrestrial Animals
- Recreation
- Infrastructure
- Cultural Heritage
- Ecosystem Services

Why assess infrastructure?

- $$$$$ - lots of money used to develop and maintain infrastructure
- Ecosystem protection
- *** Human safety ***

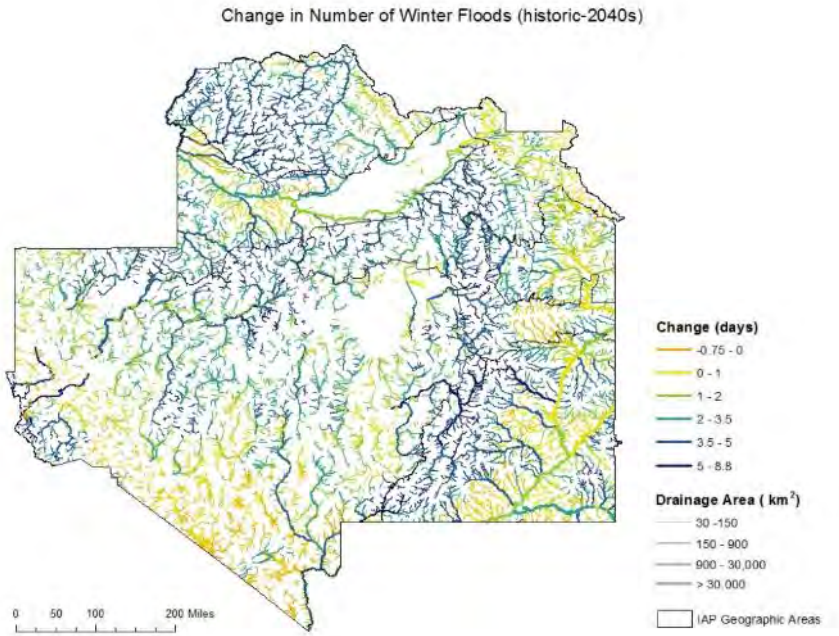
Climate

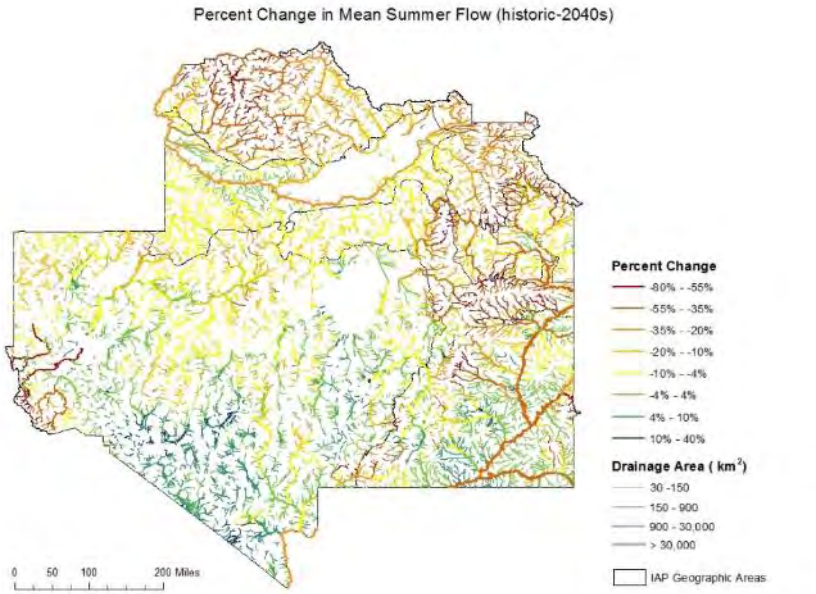
- Average temperature has increased 1.5F in the past 50 years.
- Average temperature will increase 3-4F by 2050, 7-10F by 2100.
- Precipitation may increase slightly in winter (uncertain)



Hydrology, soil, water

- Snowpack will become intermittent at low-mid elevations
- Reduced snowpack will cause (1) higher winter peak flows, (2) lower streamflows and higher stream temp. in summer
- Groundwater and water supplies will decrease





Aquatic species

- Higher stream temps. will reduce habitat for cold-water fish, especially bull trout, cutthroat trout
- Less water & higher temp will stress amphibians, mussels, & springsnails
- Habitat for most species will be retained at higher elevations

Vegetation

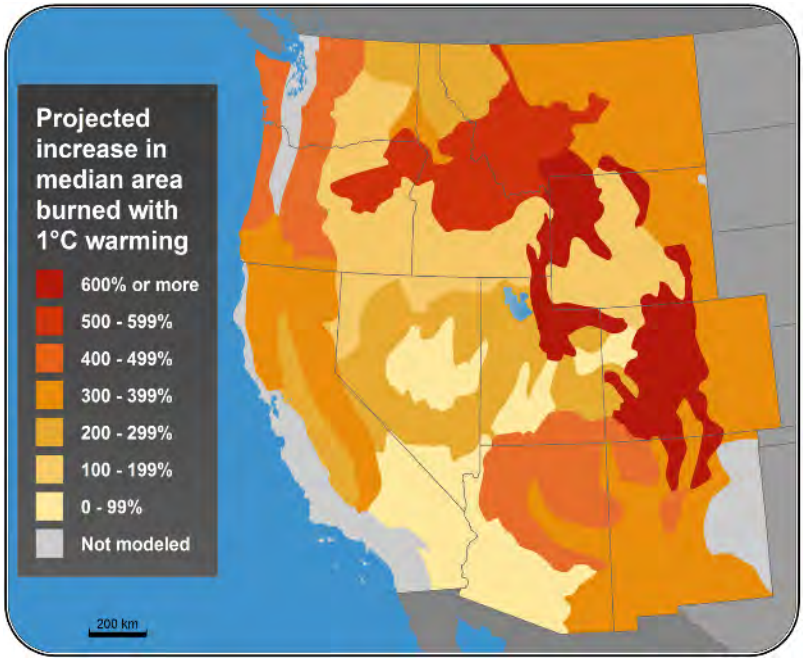
- Most low-mid elevation forests will grow slower; some high-elevation forests will grow faster

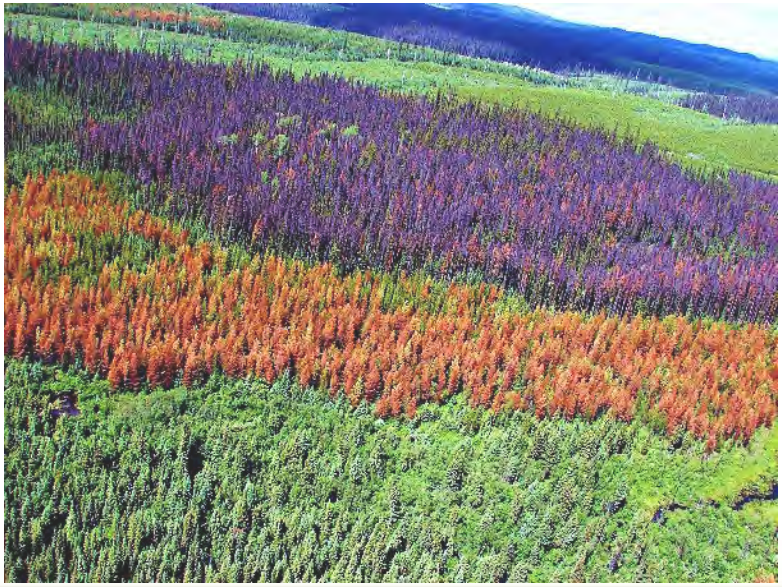
- Distribution & abundance of species will shift
- Increasing fire & insects will reduce dominance of susceptible species

Disturbance

- Area burned by wildfire will increase 200-300% by mid-21st century
- Bark beetle outbreaks will be more common in lodgepole pine & ponderosa pine
- Mass wasting & flooding will be more common in some areas

Wildfire area burned, 2050





Terrestrial animals

- Snow-dependent mammals (wolverine, lynx) will be especially vulnerable
- Amphibian species will be vulnerable to changes in ponds & riparian areas
- Animal species that require specific vegetation (e.g., sage-grouse) may be vulnerable

Recreation

- Warm-weather activities will expand (esp. shoulder seasons)
- Winter activities will decrease, especially at low-mid elevations
- Water-based activities will probably increase, as recreationists avoid heat

Cultural heritage

- Increased fire & flooding will threaten the integrity of artifacts
- Increased aridity & erosion will make artifacts more vulnerable to illegal collecting
- Altered vegetation may affect some cultural sites & landscapes

Ecosystem services

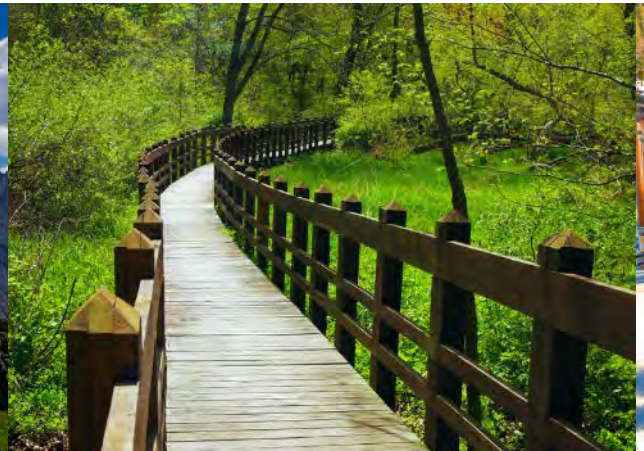
- Less productive range & altered land use will reduce grazing values
- Less snow, more drought, & more fire will reduce water supplies & quality
- Ranges of native pollinators may decrease
- Increased disturbance will reduce carbon storage

Infrastructure

- Increased flooding will damage roads, culverts, & bridges
- Increased flooding & avalanche hazard will reduce visitor safety
- Increased tree mortality will reduce safety

Assessment Approach – Three Levels

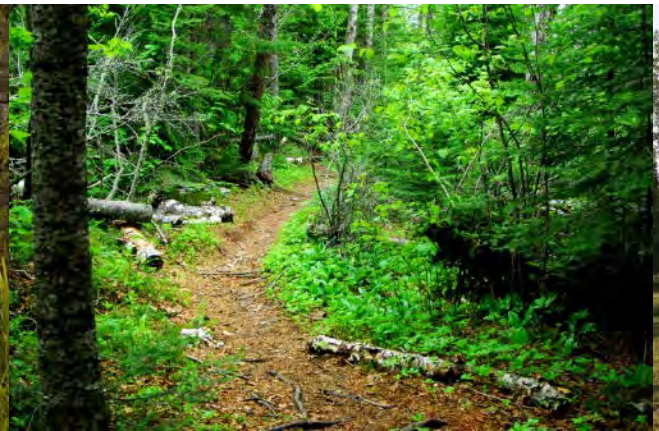
- Assessment Level 1 – Infrastructure presence
  - Know what infrastructure exists – how much of each type and where
- Assessment Level 2 – Regional scales of analyses
  - National Forests
  - Proximity to streams
  - For roads and streams in particular, road-stream intersections
  - Slope steepness
  - Soil type
- Assessment Level 3 – Smaller scales of analysis
  - Watersheds
  - Past ERFO sites
  - Areas of high human presence
  - High infrastructure values


Types of Infrastructure

- Road transportation system: roads, bridges, culverts
- Trails, trail bridges
- Buildings
- Developed Recreation Sites
- Dams

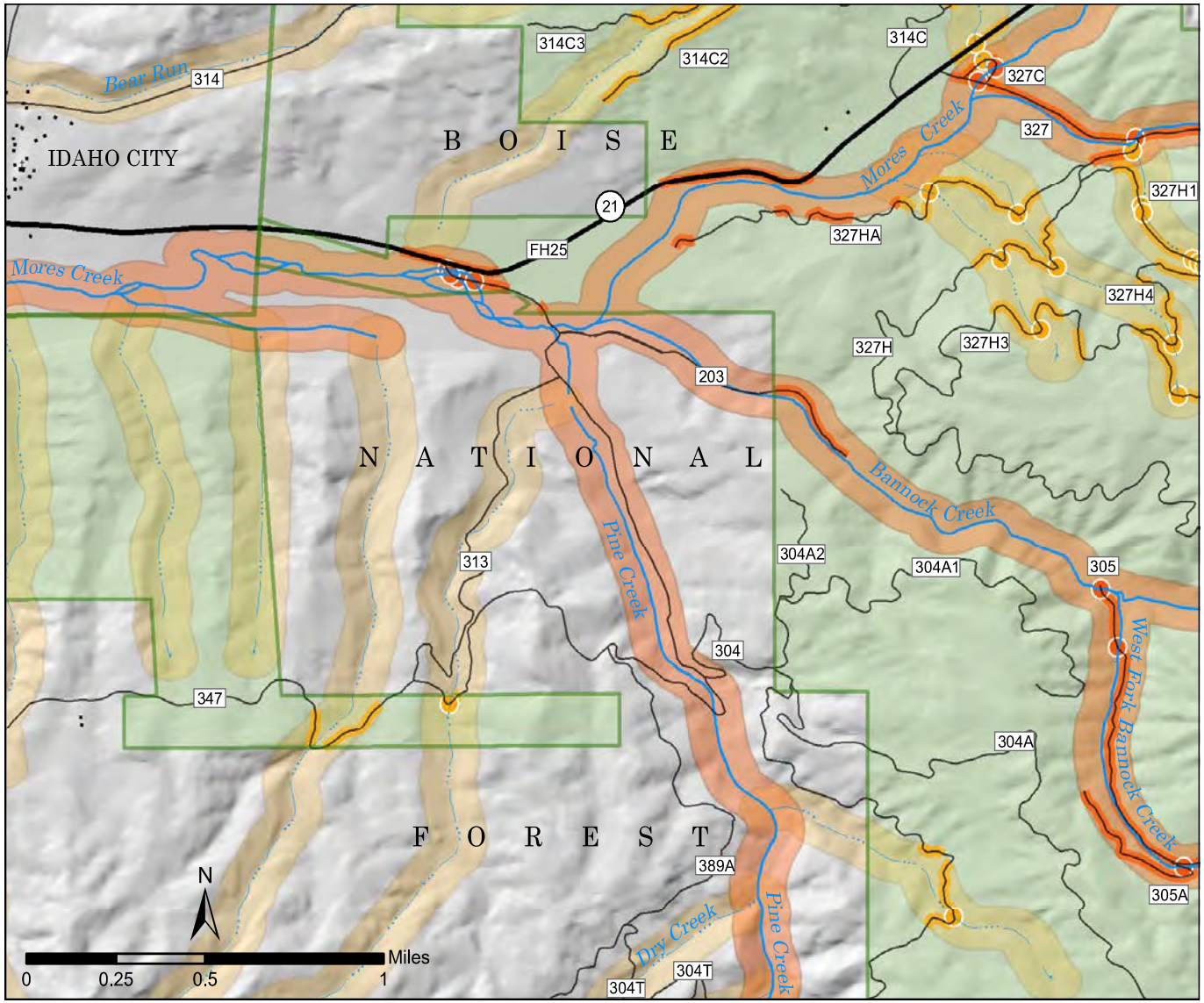
Roads, ML 1-5	35,778 miles
Bridges	850
Trails	29,622 miles
FA&O Buildings	2,133
Dams	347
Campgrounds	618


Higher Risk Infrastructure

- Communities that rely on road access
- Steep terrain and erosive soil types
- Stream channels with high avulsion
- Sensitive ecosystems
- Inadequate safety provisions
- Areas that have failed before
- Aging and deteriorating infrastructure
- High risk of wildfire, landslides, flooding





ational Forest System (NFS) Land

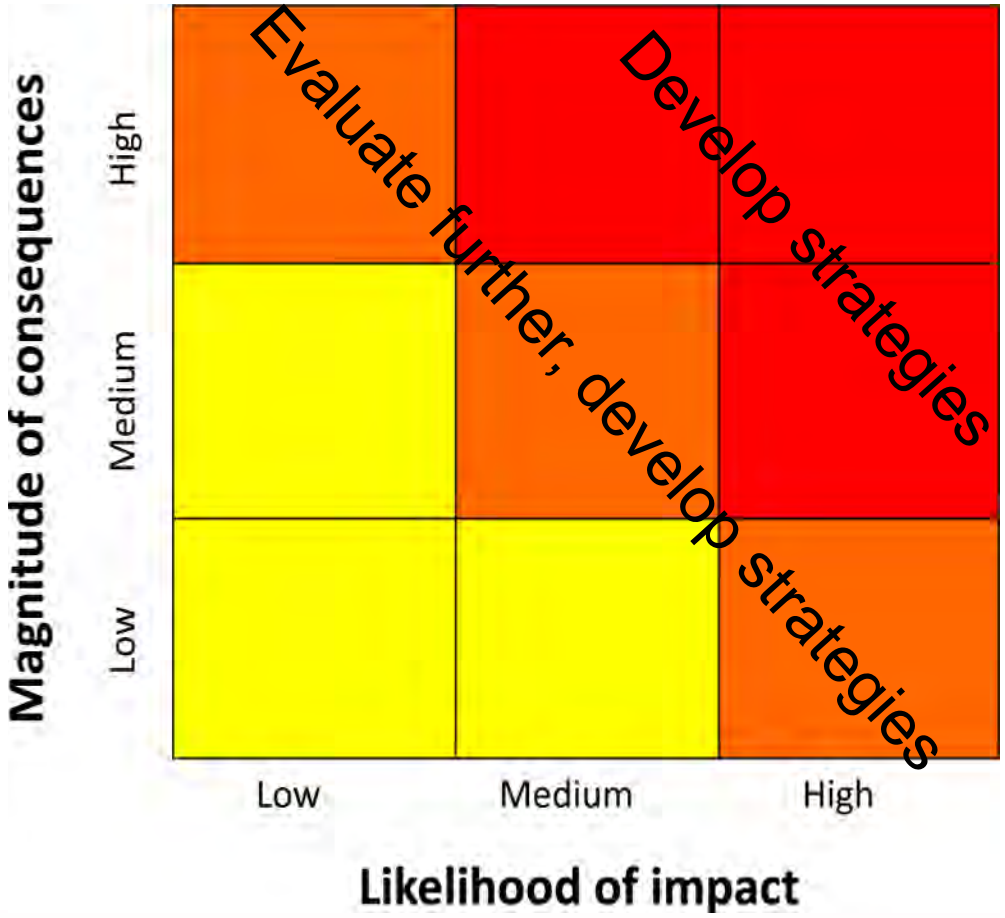
ADAPTATION SYNTHESIS: WATER RESOURCES

Sensitivity to Climate Change	Adaptation Strategy	Adaptation Tactic
Higher peak flows will lead to increased road damage at stream crossings	Increase resilience of stream crossings, culverts, and bridges to higher peak flows	• Continue to replace culverts with higher capacity culverts • Complete unit-wide inventory of culverts and bridges, including GPS locations of structures and accurate culvert data • Consider a process for replacing culverts based on projected future, rather than historical, peak flows • Consider prioritizing structure replacement in high-risk (mixed-rain-and-snow) watersheds • Reroute roads out of flood plains
	Increase resistance of road surfaces to higher peak flows at stream crossings	• Install hardened stream crossings • Perform a basin-wide assessment of current hydrological interactions with roads • Continue to use grade control structures, humps, and water bars to reduce velocity and redirect flow

Future Possible Developments Incorporate Risk Assessments

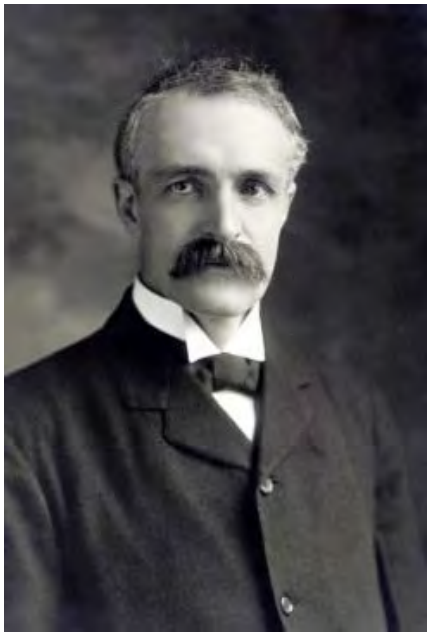
Quantify or at least estimate the risk of climate change effects on infrastructure

Use risk assessment to guide and prioritize adaptation responses.



"Where conflicting interests must be reconciled, the question shall always be answered from the standpoint of greatest good for the greatest number in the long run."

- Gifford Pinchot



Questions & Answers

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Natural Disturbances and Transportation Resiliency

By: RE Pablo Cruz, PE

Context/Goals/Big WHY

USDA Strategic Plan for 2014-2018 departmental goal:

"Ensure our national forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing our water resources."

FS's National Roadmap for Responding to Climate Change calls for:

"Protecting infrastructure by modifying or relocating roads, culverts, trails, campgrounds, and other facilities to resist floods and other major disturbances."

Investment Strategy

Guidebook Purpose and Audience

- ❑ To support FS and USDA goals
- ❑ To provide the field with a process to assess and address climate change impacts on FS transportation assets at the local and regional levels
- ❑ Intention is to be specific enough to be implementable and flexible enough to accommodate a variety of needs and challenges
- ❑ Audience is Forest-level staff who work on transportation assets
  - ❖ Offers tools and resources to integrate resilience into current practices
  - ❖ Acknowledges existing staff and funding constraints with “short-cuts”

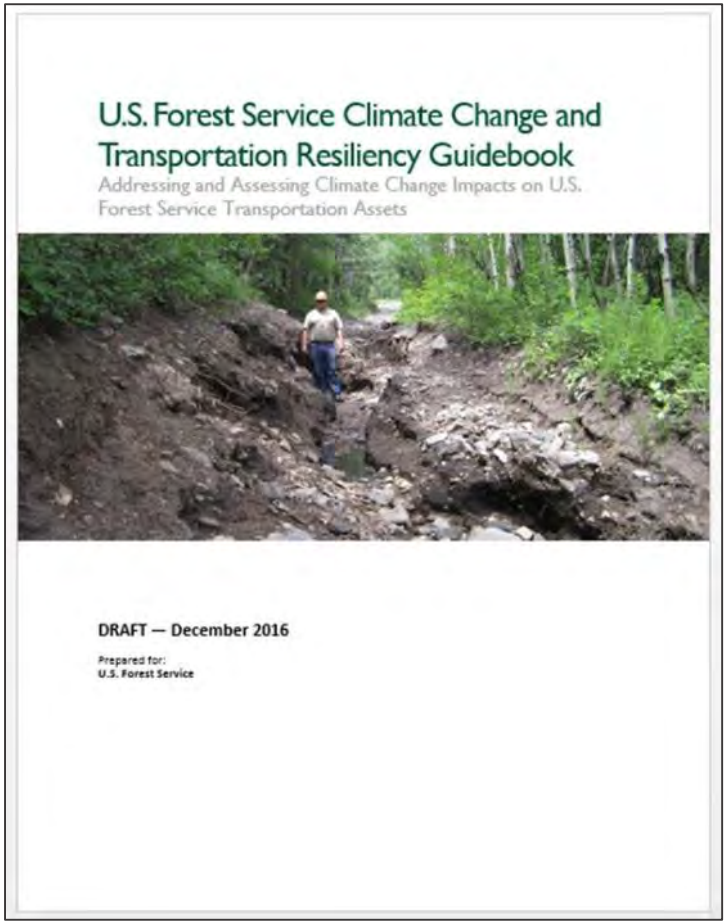
Guide Development

- **Funded by WO Engineering**
- **Advisory group**
  - Composed of diverse staff from NFS & Research
  - Development facilitated by Ben Rasmussen (Volpe)
  - Provided input and reviewed drafts
- **Field conversations**
  - Talked with staff from several Forests about current impacts and practices
- **Coordinated with Office of Sustainability and Climate Change and Regional Sustainability and Climate Change Coordinators**

Overview of Guidebook

Three Sections:

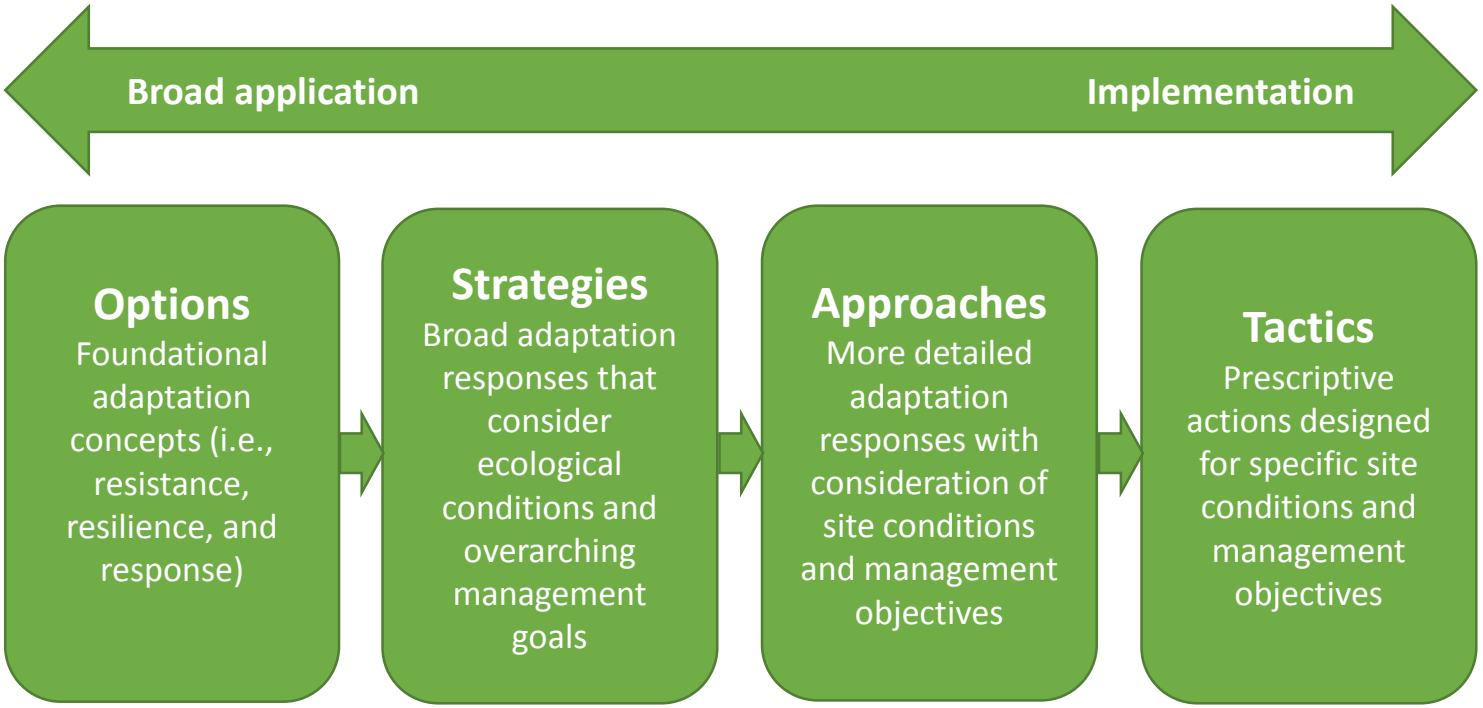
1. Identify Vulnerabilities within the FS Transportation Network
2. Reducing Transportation Vulnerability to Climate Change
3. Implementation Opportunities: Linking to FS Plans and Programs



Components of Vulnerability for Transportation Infrastructure

1. **Exposure**:	2. **Sensitivity**:	3. **Adaptive Capacity:**
Whether a transportation system could be adversely impacted by a climate stressor. (For example, how likely is it that a road could be flooded, under current or future climate conditions?)	The degree to which a system would be impacted by climate stressors, if exposed. (For example, if a road were exposed to flooding, how much damage would it experience?)	A system's ability to adjust to or cope with potential impacts from a climate stressor. (For example, if a road is damaged from flooding, what is the agency's ability to withstand the damage or repair the system?)

Reducing Transportation Vulnerability to Climate Change



Role of Adaptation Strategies in Reducing Impacts and Consequence

Stressor	Impacts on Transportation	Example Strategies to Reduce Impacts	Consequences of Impacts on Transportation	Example Strategies to Reduce Consequences
Heavy Precipitation / Flooding	• Flooded roadways interrupting service • Damage/destruction of roads and bridges • Pavement buckling • Erosion comprising underlying soil stability and associated transportation assets • Slope failures • Landslides damaging and disrupting transportation routes • Plugged or blown out culverts	• Retrofit facilities • Relocate facilities • Upgrade culverts and storm water drainage facilities • Build new facilities to climate ready standards • Protect existing infrastructure	• Safety risk for transportation users • Disrupted access to critical emergency routes • Disrupted public access to Forests for recreation and other purposes • Disrupted access for Forest Service personnel for forest management activities • Higher transportation costs for Forest Service	• Reroute passenger flows • Evacuation strategies • Build in network flexibilities • Rapid rebuilding of damaged facilities
Wildfires	• Additional woody debris that plug culverts • Reduced slope stability causing increased risk of landslides • Increased heavy vehicle traffic wear and tear on Forest Service roadways	• Sustain forest ecology • Protect forests from severe fire and wind disturbance • Facilitate forest community adjustments through species transitions		
Tree Mortality	• Fallen trees disrupt access along transportation routes • Increased need for clearing hazard trees along roadways • Provide forest fuel for wildfire			

Implementation Opportunities

Natural Disturbance Responses

- Building resilient landscapes to disturbances
- Inventory and Monitoring Assessment Coordinators

Planning Processes

- Collaborative Long-Range Transportation Plans (CLRTPs)
- Forest Plans
- Travel Analysis Reports

Potential Funding Sources

- Federal Lands Transportation Program (FLTP)
- Federal Lands Access Program (FLAP)
- Emergency Relief for Federally Owned Roads (ERFO)
- Other Forest Service funding sources

Climate Change Stressors Considered and Their Subsequent Road Impact

- **Heavy precipitation** || Washing out roads and plugging or blowing out culverts.
- **Sea level rise** || Flooding and erosion of coastal infrastructure.
- **Tree mortality** || Hazard trees along roadways and waterways (leads to debris plugging drainage structures). ((Southern Pine beetle infestations and drought conditions))
- **Extreme heat waves** || Buckling of paved roadways.
- **Wildfires** || Wooden bridges, potentially vulnerable culvert materials and wear and tear on roads from fire response.
- We understand that tree mortality and wildfires are the consequence of long periods of precipitation deficits or droughts. In addition, there is the possibility of movement of unstable soils once vegetation is lost and rain events may either return to normal or intensify.

An Application Business Case for Future Investment towards Resiliency (ERFO)

1. Conclusions of R8 flood events during a 14 month period.
2. Financial subsidy by USDOT (ERFO).
3. Investment towards resiliency

2015-2016 Rain Events

Date	Forest	State	Description
May 2015	NF in Texas	TX	Heavy Rains
May 2015	Ozark-St. Francis	AR	Heavy Rains
May 2015	Ouachita	AR	Hurricane Joaquin
May 2015	NF in FL	FL	Heavy Rains
May 2015	George Washington-Jefferson	VA	Heavy Rains
October 2015	Francis Marion & Sumter	SC	Hurricane Joaquin
October 2015	George Washington-Jefferson	VA	Winter Storm Goliath
December 2015	Chattahoochee-Ocoee	GA	Winter Storm Goliath
December 2015	NF in North Carolina	NC	Winter Storm Goliath
December 2015	Daniel Boone	KY	Winter Storm Goliath
December 2015	Cherokee	TN	Winter Storm Goliath
December 2015	NF in FL	FL	Winter Storm Goliath
December 2015	NF in MS	MS	Winter Storm Goliath
December 2015	NF in AL	AL	Winter Storm Goliath
December 2015	Land Between the Lakes	KY, TN	Winter Storm Goliath
December 2015	Ouachita	AR	Winter Storm Goliath
January 2016	George Washington-Jefferson	VA	Winter Storm Jonas
March 2016	NF in Texas	TX	Heavy Rains
March 2016	Kisatchie	LA	Heavy Rains
May 2016	NF in Texas	TX	Heavy Rains
May 2016	Cherokee	TN	Heavy Rains
May 2016	El Yunque	PR	Heavy Rains
July 2016	Land Between the Lakes	KY, TN	Heavy Rains
July 2016	Cherokee	TN	Heavy Rains

Interpretation and Conclusions of the Rain Events

- It is a year round problem.
- These floods are becoming more frequent and with increased severity.
- Within the 14 month period analyzed, nine forests were impacted by one event, four were impacted by two, and two were impacted by three. Total cost for basic repairs exceeded $43 million dollars.
- Twelve of twenty-three flood events in the table above have qualified for ERFO funds totaling almost $23 million, which is only a portion (53%) of the repairs needed.
- We have ERFO ineligible damages due to these floods that we are unable to fund $18 million (42%) . We obtained and used about $2 million (5%) of other funds such as stewardship grants where appropriate (i.e., improve fish passages).

Financial Subsidy by USDOT (ERFO)

- ERFO funds cannot be obtained for damage that was exacerbated by an existing lack of maintenance. For this reason alone, much of the damage repairs we must complete will not be covered by ERFO.
- Once a segment of road qualifies for ERFO subsidy, it is only to restore what was there prior to the event, and betterments are difficult to justify with forests lacking capacity to adequately investigate and design with incredibly short ERFO program timelines.

Investment towards RESILIENCY

- As we face increasing floods and damage, we need to anticipate extreme events in order to design and build a more sustainable road system. To proactively address the increasing impacts of climate change on our transportation system, we will be analyzing how and where extreme events may cause critical infrastructure damage throughout the region. This will help us develop options for increasing the resilience of new investments in our infrastructure.
- Facilitated by the USDOT Volpe Center, we developed a guide to conduct such vulnerability analysis in our NFS lands.
    - *The guide is in draft and will be pilot tested in the Southern Region in FY17*.
- We had conversations with FHWA in order to ascertain their willingness to allow us to improve rather than rebuild what was there before for those ERFO qualifying damaged road segments in identified vulnerable zones. They are in favor of this proposal.

Resiliency

Questions & Answers

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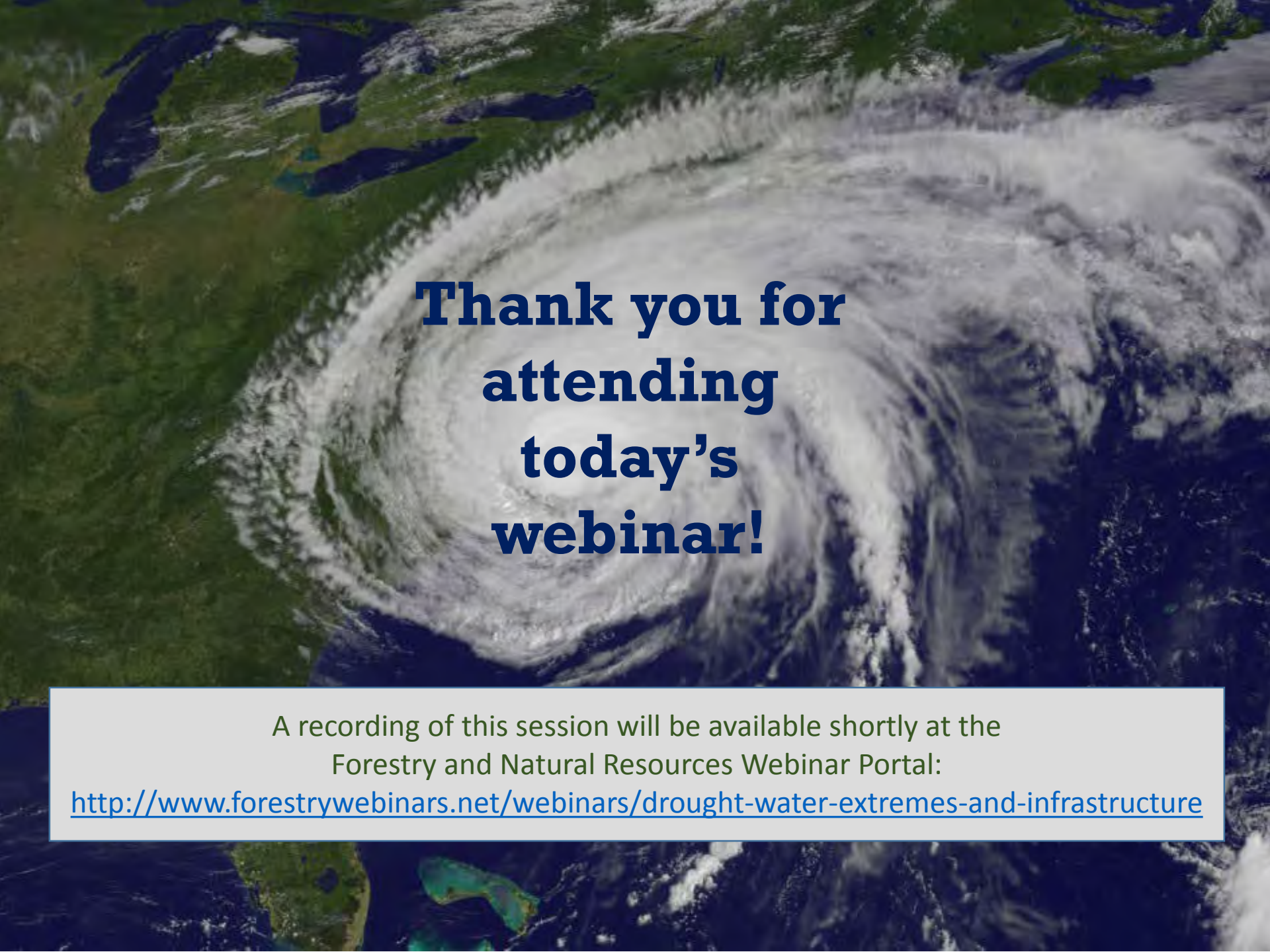

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Forestry and Natural Resources Webinar Portal:
http://www.forestrywebinars.net/webinars/drought-water-extremes-and-infrastructure