USDA United States Department of Agriculture

Office of Sustainability & Climate Change

# Welcome to the National Kickoff Meeting Responding to Drought and Water Challenges

October 4, 2016

Office of Sustainability and Climate Change

Forest Service Washington Office

## Introduction

Cynthia West, Ph.D

Executive Director

Office of Sustainability and Climate Change

USDA United States Department of Agriculture

Office of Sustainability & Climate Change

## Effects of Drought on Forests and Rangelands in the United States

James M. Vose
USDA Forest Service
Southern Research Station
Raleigh, NC

Forest Service Washington Office

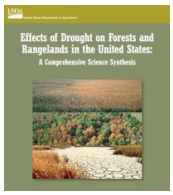
## An Overview of the Drought Science Synthesis

**Convening Lead Authors & Editors**

- **James M. Vose**, USFS R&D, Southern Research Station
- **James S. Clark**, Duke University
- **Charles H. Luce**, USFS R&D, Rocky Mountain Research Station
- **Toral Patel-Weynand**, USFS R&D, WO

- 77 additional lead chapter and co-authors from federal agencies, national labs, universities

## Published as a General Technical Report




Vose, J.M., J.S. Clark, C.H. Luce, and T. Patel-Weynand. 2016. Drought Impacts on U.S. Forests and Rangelands: A Comprehensive Science Synthesis. WO-GTR-93b.

**Topics Addressed in This Assessment**

- Characterizing Drought for Forested Landscapes and Streams
- Physiological Responses of Forests to Future Drought
- Impacts of Drought on Forest Dynamics, Structure, Diversity, and Management
- Forest Biogeochemistry in Response to Drought
- Insect and Pathogen Responses to Drought
- Fire and Drought
- Rangeland Drought: Effects, Restoration, and Adaptation
- Detecting and Monitoring Large-Scale Drought Effects on Forests: Toward an Integrated Approach
- Ecohydrological Implications of Drought
- Economics and Societal Considerations of Drought in Forests and Rangelands

## Published as Special Issues in Scientific Journals

### Global Change Biology[1]

- Forest Dynamics
- Fire
- Biogeochemical Cycling

[1]Clark, J.S., J.M. Vose, C.H. Luce. 2016. Forest drought as an emerging research priority (introduction to special issue). *Global Change Biology* 22(7): 2317-2317.

### Forest Ecology & Management[2]

- Ecohydrology
- Characterizing Drought
- Insects and Pathogens
  - Physiology
  - Monitoring Drought

[2]Vose, J.M., J.S. Clark, C.H. Luce. 2016. Drought impacts on forests in the United States (introduction to special issue). *Forest Ecology and Management*: Volume 380. (November issue)

## Forests and Drought

**Drought impacts….are in the news**

- Widespread forest mortality
- Increased costs of fighting large fires
- Water scarcity



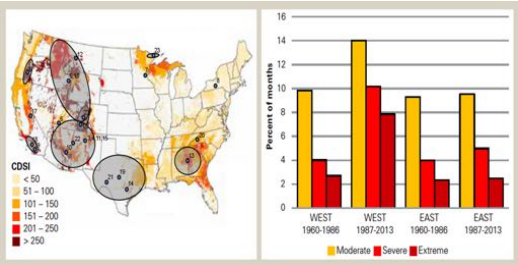
## Why a Synthesis?

- **Recent widespread drought, potentially getting worse**
- **Forest and rangeland responses differ from agriculture**
- **Scientific foundation needed to manage for resilience and adaptation**

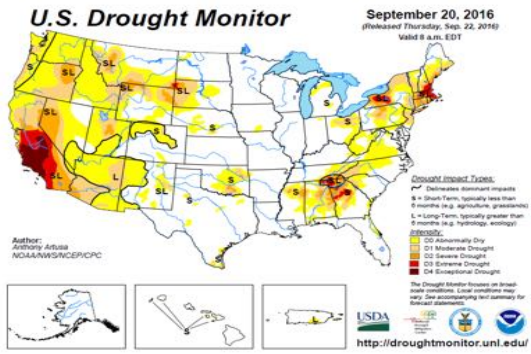
## Drought Definition

*"A period of uncharacteristically dry weather for a given location."*

## Droughts Occur Everywhere




Clark et al. 2016 – Chapter 4




## Drought Types

- **Meteorological**
  - Variations in Precipitation and Temperature imputing evaporation and soil moisture balance
- **Hydrological**
  - Outcome of a period of meteorological drought on streamflow or reservoir storage
- **Ecological**
  - Outcome of a period of meteorological drought on forest, rangeland, aquatic ecosystems.

## Drought is More Than Just Abnormally Low Rainfall

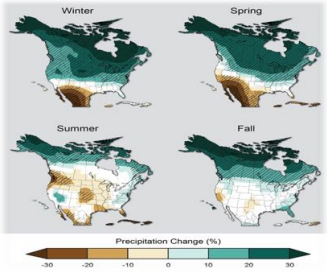
**Lower rainfall, but also…**

- Less snow
- Dry air (low humidity)
- Longer dry spells
- Higher temperatures during droughts

**How will drought regimes change in the future?**

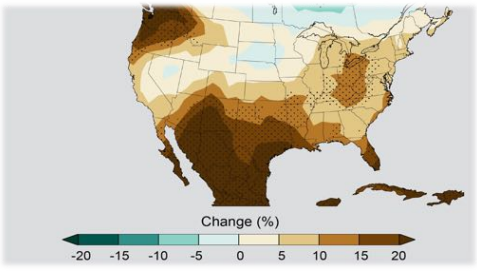
## Seasonal Precipitation Projections

- **White = models disagree**
- **Hatched = models agree**




GCRP 2014, Our Changing Climate

## Change in the Maximum Number of Consecutive Dry Days




GCRP 2014, Our Changing Climate

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## Key Messages

- **Drought is now affecting all ecosystems, could get worse**
  - changes most obvious in the west, impacts in eastern forests through morbidity, slow decline
- **Impacts both immediate and long-lasting**
  - fire and Insects
  - plant stress, favors drought-tolerant species
  - habitat shifts
  - some invasive species can benefit
  - reduced carbon storage and water supplies
- **Manage to increase resilience and resistance**

## Challenges for the Future

- **Detection** – where is it going to happen and how can we detect areas under drought stress?
- **Predicting impacts** – how will forests and rangelands respond to drought?
- **Managing for drought** – what can we do to make forests and rangelands more resilient?

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# Drought, Forests, and Water Resources

Charles Luce and Jim Vose
US Forest Service Research

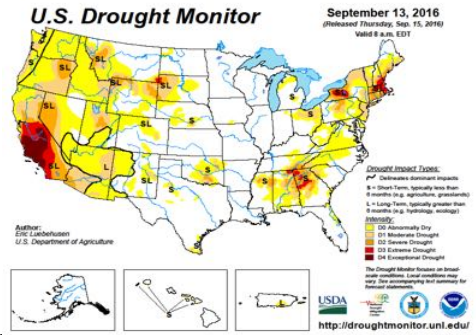
Forest Service Washington Office



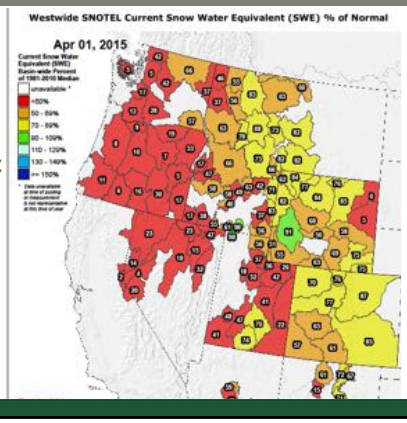

## Links Between Forest Service and Water Resources

- Questions about forest management for water yield
- Permitting (diversions, reservoirs, grazing & watering)
- Endangered Species Act Responsibilities
  - Water rights controlled by states
  - Permits for equipment and operations by FS
- Weather Data to Assist Water Resource Management

## Drought Affects Eastern and Western Forests



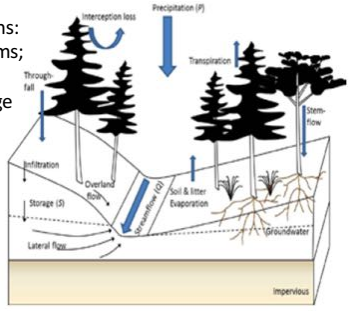

## Snow Drought

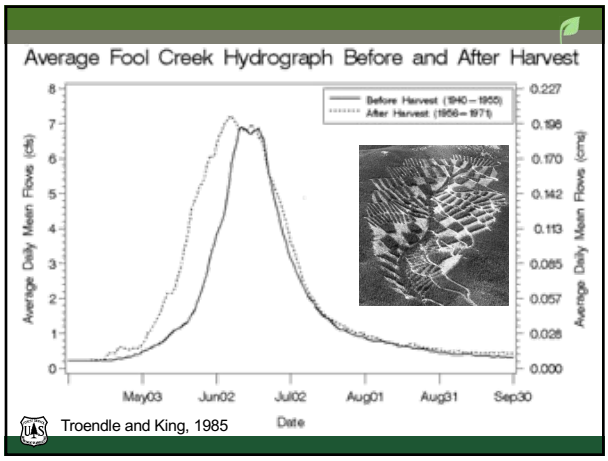


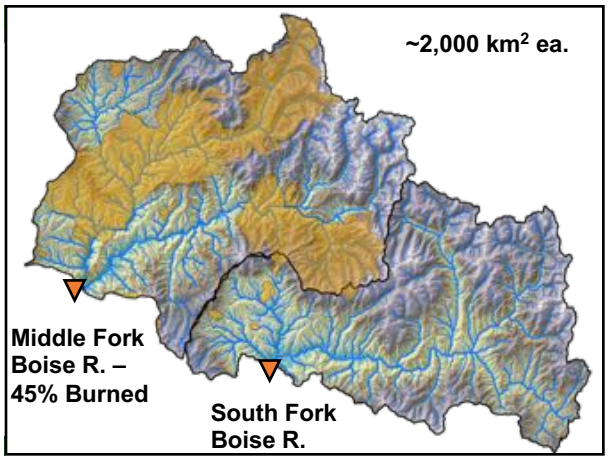

## Water Cycle

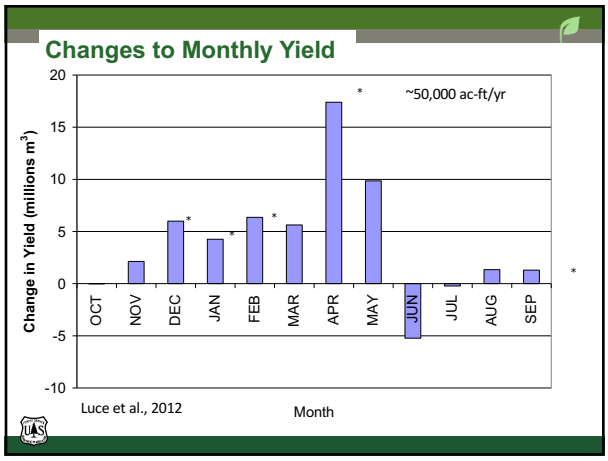
Precipitation = Streamflow + ET + ΔStorage

Less Precipitation means:
1) Less water for streams;
2) Less water for trees;
3) Decline in soil storage

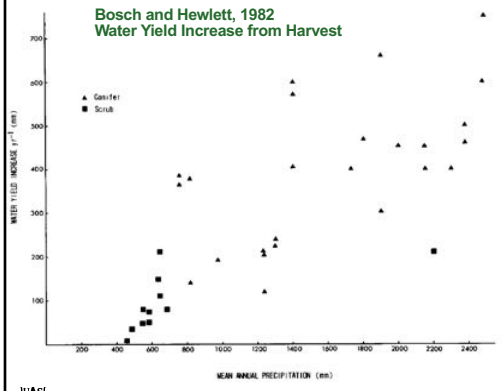



Average Fool Creek Hydrograph Before and After Harvest
Before Harvest (1940 – 1955)
After Harvest (1956 – 1971)
Average Daily Mean Flows (cfs)
Average Daily Mean Flows (cms)
0
1
2
3
4
5
6
7
8
0.000
0.028
0.057
0.085
0.113
0.142
0.170
0.198
0.227
May03
Jun02
Jul02
Aug01
Aug31
Sep30
Date
Troendle and King, 1985


~2,000 km² ea.
Middle Fork Boise R. – 45% Burned
South Fork Boise R.

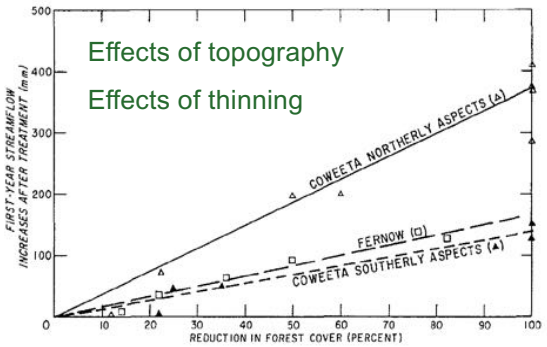

Changes to Monthly Yield
~50,000 ac-ft/yr
Change in Yield (millions m³)
20
15
10
5
0
-5
-10
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Month
Luce et al., 2012

**Bosch and Hewlett, 1982**
**Water Yield Increase from Harvest**

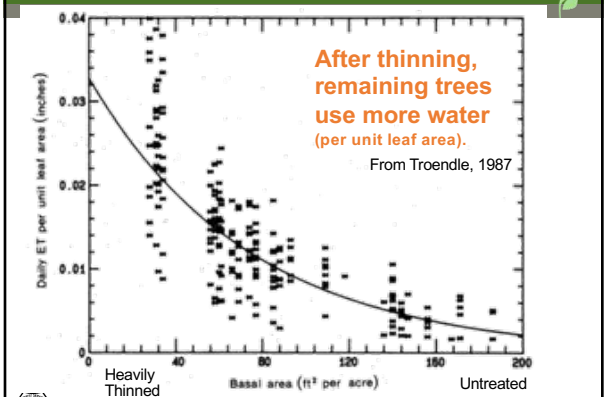



Effects of topography

Effects of thinning

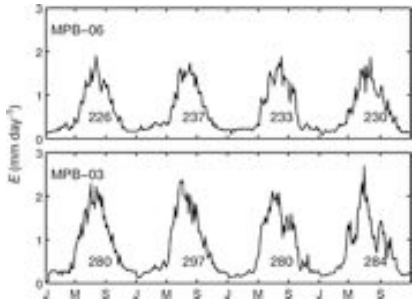



From Hibbert, 1965




**After thinning, remaining trees use more water**
**(per unit leaf area).**

From Troendle, 1987

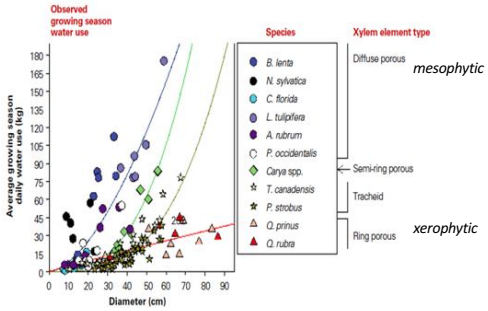



#'s are annual ET

Evapotranspiration during 4 years after Bark Beetle outbreak in British Columbia

Brown et al., 2013

## Large differences in water use requirements among species




## Non-Intuitive Outcomes

- Beetle Kill in AZ
  - Post-mortality flow declines
  - Temporary spp shift
- Woolly Adelgid in East
  - Riparian Hemlock die-off
  - Initial reduction in ET
  - Replacement with hardwoods with higher ET rate in longer term

## Value of Biodiversity!!

- Large scale drought related die-off in mixed stands (many in the eastern US) less likely
  - Buffer hydrologic swings?
- Consistently increasing drought favors xerophytic species in the long run
  - Create drought resilient and low water use forests?

## Permitting

- When Drought Happens –
  - Responses needed
  - Emergencies and exigencies may dictate water reallocation
  - May want to clarify ESA obligations with everyone beforehand!
- Reservoir expansion requests … changing drought risk
- Well drilling for cattle as preparation
  - Groundwater not independent of surface water

## Information

- Can we help the states with their drought detection and planning?
  - Forest Service is a big blank spot on the map!
- Can we operate water storage and distribution systems more efficiently with better data from National Forests?
  - Unequivocal, resounding yes in many western forests
- What is FS Role in providing/encouraging information?

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## Summary Points

- Forest harvest and thinning unreliable source for water during drought -- but, thinning might be important for keeping trees alive during and after drought!
- Ecological biodiversity buffers effects on forests … may help with water yield.
- To play well with others, it is important to be prepared.

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## Drought issues and management challenges in forest and rangeland vegetation

**Matt Reeves**

*USDA Forest Service, Rocky Mountain Research Station*

**Jessica Halofsky**

*University of Washington, School of Environmental and Forest Sciences*

Forest Service Washington Office



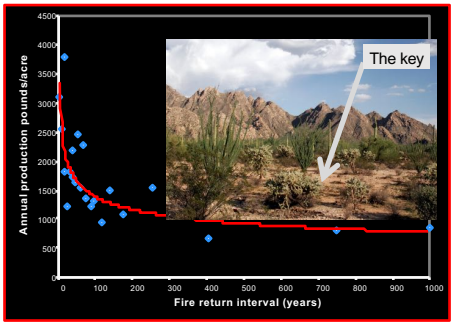
## Drought is:

- not uncommon in the arid west
- increasing in frequency with respect to recent history
- "an inevitable part of normal climatic fluctuation…" (Thurow and Taylor)
- among the most costly disasters

## Drought effects on vegetation

- Vegetation production decreases
- Plant mortality increases
- Plant cover reduced
- Bare ground increases
- Soil erosion more prevalent
- Habitat for wildlife reduced
- Fires may increase **(maybe not)**

## Vegetation productivity and fire

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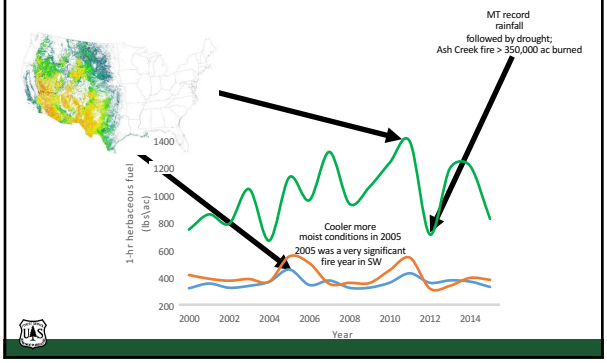
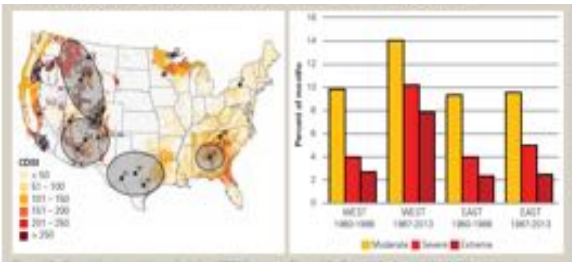


## Drought effects on vegetation

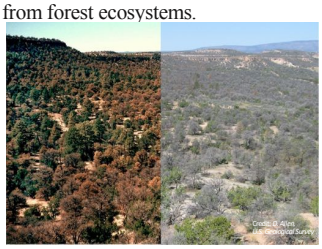
- Vegetation production reduced
- Plant mortality increases
- Plant cover reduced
- Bare ground increases
- Soil erosion more prevalent
- Habitat for wildlife reduced
- Rangeland fires may increase **(maybe not)**
- Some pests and weeds may increase
- Forage value and carrying capacity decreases

## Drought in the U.S.



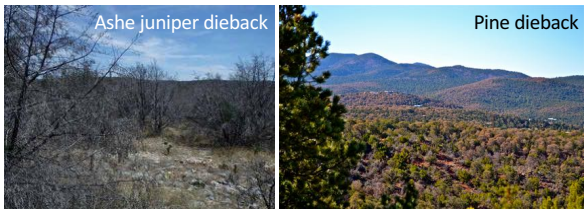
## Drought and forests

In extreme droughts, trees are increasingly susceptible to attack by pests and pathogens, which can lead to major changes in nutrient flux to the soil. Extreme droughts often lead to more common and more intense forest fires, causing dramatic changes in the nutrient storage and loss from forest ecosystems.

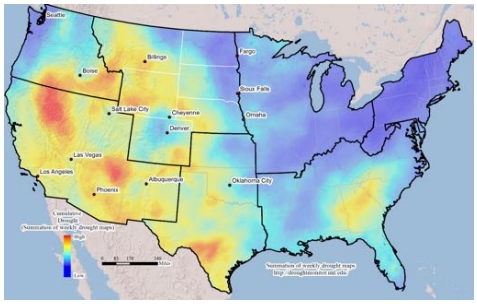


Pinyon ~ 90% dieback

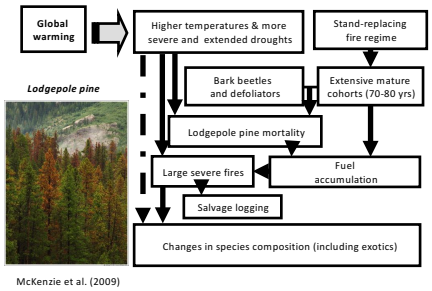
## Drought and forests




## Drought in the U.S.




## Warming affects stress complexes




McKenzie et al. (2009)

## Drought Adaptation Strategies for Forest Vegetation

- Decrease forest stand density
- Plant drought-tolerant species and genotypes
- Maintain a tree seed inventory with high-quality seed for a range of species
- Protect trees that exhibit adaptation to water stress
- Promote age class and structural diversity across the landscape

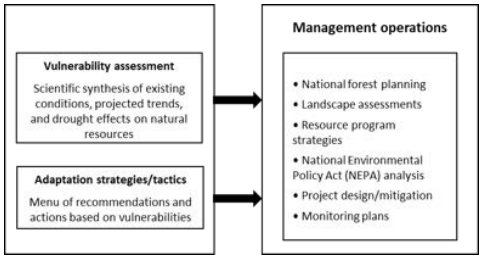
## Drought Adaptation Strategies for Rangeland Vegetation

- Maintain integrity of native plant populations
  - Prevent establishment of invasive species
  - Actively restore less resilient sites
- Mitigate consequences of large disturbances by planning ahead
- Develop adaptive grazing management plans

## Drought Adaptation Strategies for Vegetation

- Work across jurisdictions at larger scales
  - Align budgets and priorities for work with neighboring lands
  - Communicate about projects adjacent to other lands, and coordinate on the ground
  - Work across boundaries to preserve roads, trails, and access with increasing fire and flood events
- Conduct integrated and consistent inventory and monitoring of vegetation

## Applications in planning and project management




## Ways to Move the Needle

- The Forest Service can conduct proactive drought management planning.
- Agencies and organizations will likely be better prepared for drought if they work together and pool information and resources.

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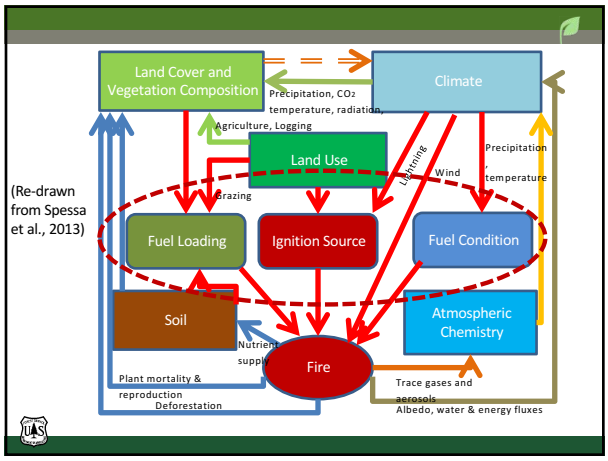
## Drought and Fire: Issues and Management Challenges

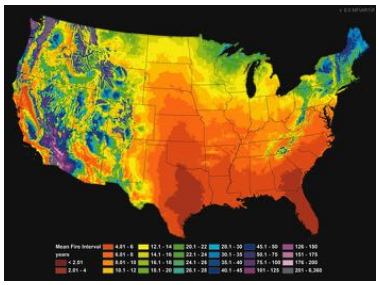
John A. Stanturf
Center for Forest Disturbance Science
Southern Research Station
Athens, GA

Forest Service Washington Office

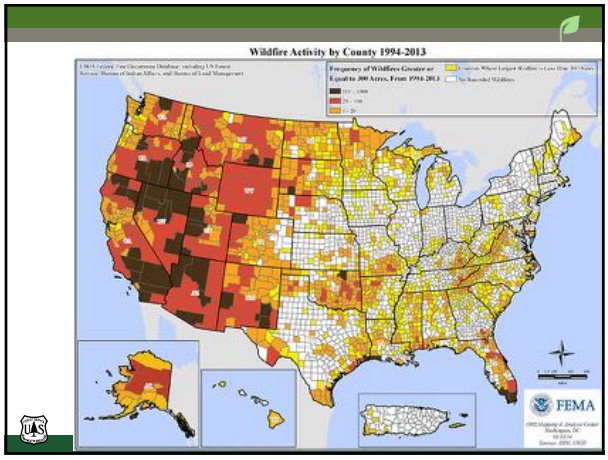


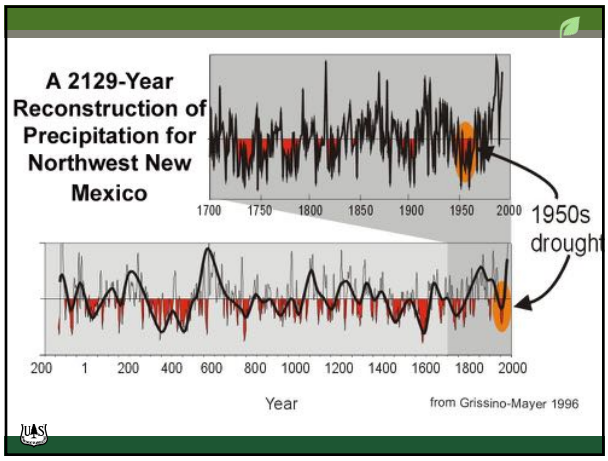

(Re-drawn from Spessa et al., 2013)

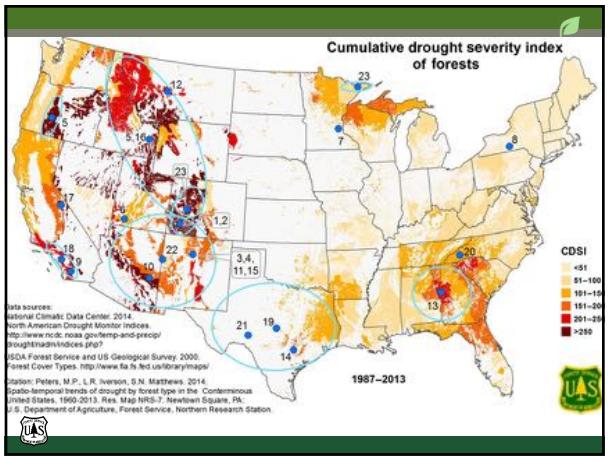
## Historic Fire Frequency 1650-1850

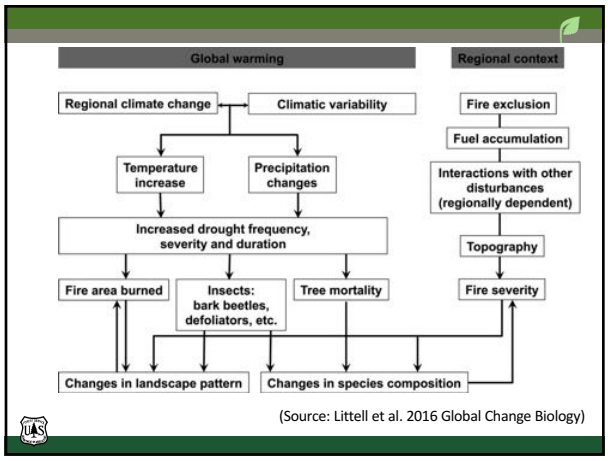


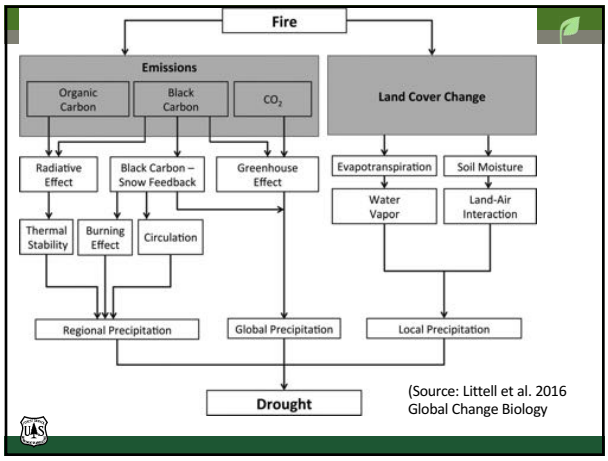
Guyette, R.P., Stambaugh, M.C., Dey, D.C. et al. Ecosystems (2012) 15: 322.




A 2129-Year Reconstruction of Precipitation for Northwest New Mexico
1700 1750 1800 1850 1900 1950 2000
1950s drought
200 1 200 400 600 800 1000 1200 1400 1600 1800 2000
Year
from Grissino-Mayer 1996


Cumulative drought severity index of forests
CDSI
1987–2013


Global warming
Regional context
Regional climate change
Climatic variability
Fire exclusion
Fuel accumulation
Temperature increase
Precipitation changes
Interactions with other disturbances (regionally dependent)
Increased drought frequency, severity and duration
Topography
Fire area burned
Insects: bark beetles, defoliators, etc.
Tree mortality
Fire severity
Changes in landscape pattern
Changes in species composition
(Source: Littell et al. 2016 Global Change Biology)




(Source: Littell et al. 2016 Global Change Biology

## Other Fire Challenges

- Land use change
- Smoke management
- Fire management constrained by other regulations (egs., regional air quality, ESA, public acceptance)
- Carbon storage effects
- Mega-fires and suppression costs

## Regional Assessments

- Southwest: Pinyon-Juniper
  - Water-limited system
  - Recent dieback (low precip, high temp, Ips)
  - Large-scale, severe fires inhibit regeneration
  - More severe drought, fire likely
- Sierra Nevada and Southern California
  - Long, hot and dry summers
  - Fire exclusion
  - Ozone
  - Native and non-native pathogens
  - Protracted drought, Large fires
  - More severe drought, fire likely

## Regional Assessments

- Interior lodgepole pine
  - Mature forests, vulnerable to beetle outbreaks
  - Warmer temps
    - lower tree vigor, accelerated pest reproduction
    - high flammability dead biomass, mortality, higher crown fire potential for 3 yrs, surface fire longer
    - More severe drought, fire likely
- South-central and interior Alaska
  - Large crown fires, spruce bark beetle
  - Higher temps
  - Conversion to less flammable deciduous species

## Regional Assessments

- Eastern mesic deciduous forest
  - Disturbance including drought more common before European settlement
  - Spatial continuity and scale of disturbance smaller than the West
  - Wind disturbance common, may interact with other stressors
  - Locally, longer fire season
- Southern pines
  - Frequent fires, much prescribed burning
  - Interact with wind storms (hurricanes)
  - Expected increase in drought frequency and severity
  - Flammable invasive species (cogongrass)
  - Smoke restrictions on prescribed burning
  - More drought, longer fire season

## Management Options

- Reduce stand density
- Develop complex stand structures
- Reduce fuels, aggressive prescribed burning program
- Artificial regeneration to overcome barriers, capture site and sequester carbon
- Select/favor drought tolerant species and genotypes

## Knowledge Gaps

- Stand-level effects of drought; delayed mortality and species shifts
- Uncertainty of climate projections
- Novelty of projected new climates
- Novel combinations of drought frequency, intensity, and seasonality

## Conclusion

- Paleo evidence for megadroughts of severity and duration not experienced by modern society
- Increasing drought and heat-induced tree mortality means drought is more than a western problem
- Fire feedbacks to climate can prolong and intensify droughts
- Climate models show summer (June to Aug) water balance deficit increasing in much of the West
- Fire hazard increases in most seasons and regions of continental US; largest increases in SW, RM, northern Great Plains, SE, and Pac coast, caused by higher temps
- Interactions of warming and drying climate with increased fire hazard challenges our ability to maintain carbon storage in forests

USDA United States Department of Agriculture

Office of Sustainability & Climate Change

# Recreation and Ecosystem Services

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## Overview

- Context for recreation, amenities, and human values
- Interaction of drought and other water challenges with recreation and ecosystem services
- Projected future conditions
- Potential management solutions and directions

## Recreation is a growing economic driver

- Recreation and tourism are displacing extractive resources
- Visitation in Intermountain Region (USFS=$1 billion)
  National Forests – 19 million
  National Parks – 24 million
- The Old West has evolved in response to changing environmental values and resource demands

## Ecosystem services are a growing management issue

- Presidential memorandum (Oct. 7, 2015): *develop and institutionalize policies to promote consideration of ecosystem services*
- Ecosystem services are a component of forest plan revisions and climate change assessments
- Important connection with carbon management

## Drought effects on recreation

**Cold Weather Recreation**

- Reduced snowpack will have negative impacts on skiing, snowmobiling, etc.
- Shorter recreation season
- Activities will move to higher elevations
- Ski resorts in national forests will face major economic and management challenges

## Drought effects on recreation

**Warm Weather Recreation**

- Reduced snowpack will have positive impacts on timing and location of hiking, camping, sightseeing, etc.
- Longer recreation season, especially in shoulder seasons
- Major challenges in managing facilities and recreation opportunities

## Drought effects on recreation

**Hunting, fishing, water recreation, special products**

- Reduced snowpack will provide a longer recreation season
- Low streamflows will have negative impacts on fishing
- Effects on hunting are uncertain, probably neutral
- More wildfire may reduce quality of recreation experience

## Effects of flooding, variable water supply on recreation

- Safety hazards for recreationists
- Potential losses in fish habitat and populations
- Negative impacts on roads and other infrastructure
- Potential closure of recreation facilities and access routes

## Current management guidance —Recreation

- Access to recreation sites and facilities is managed both actively and passively
- Popular recreation corridors are critical
- USFS Travel Analysis Process considers sustainability issues
- Most recreation is <1 day

## Current management guidance —Recreation

- Management of recreation is relatively inflexible
- Depends heavily on seasonal workforce
- Greatly underfunded compared to participation and economic value
- Not much interaction with other resources, except roads and infrastructure

## Current management guidance —Ecosystem Services

- ES is starting to be explicitly addressed in public and private lands
- ES is a major consideration in forest planning
- ES covers many resources, each of which has existing guidance, BMPs, etc.
- Structure and process for quantitative and qualitative valuation lacking – but are they necessary?

From RYM Oy http://rym.fi

## What we learned in 2014-15 (the winter without snow)

Recreationists are highly adaptable

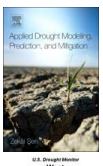
- They found snow
- They switched to summer activities

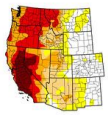
Capacity of agencies to adapt was minimal

- But they understand how climate affects recreation patterns
- They have ideas for adapting to a warmer climate in the future

## Building resilience

- Develop scenarios for future increases in drought and other extreme events
- Manage proactively—not reactively—to build resilience in ecosystems and organizations
- Incorporate “drought thinking” in climate-smart management



## Building resilience—Recreation

EXAMPLES

- Adjust capacity of recreation sites as needed
- Develop flexibility in hiring seasonal workforce
- Adjust timing of road and trail closures
- Develop multi-season recreation at ski resorts

## Building resilience—Ecosystem Services

EXAMPLES

- Manage for diversity of vegetation structures across the landscape
- Include carbon dynamics in vegetation and fire management and planning
- Work with local partners to identify ecosystem services values and risks
- Work with local communities to manage water quantity and quality

## Conclusions

- **Recreationists will adapt** to droughts and other challenges by changing behavior and preferences (definitely in short term, probably in long term)
- **Agencies are generally inflexible** in responding to short-term drought and extreme events
- **Many options exist for building resilience** in recreation and in responding to drought
- **Many options exist for ecosystem services**, but are highly specific to individual landscapes and local values

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# The Business of Sustainability

## *Walking the Talk* of our Conservation Ethic

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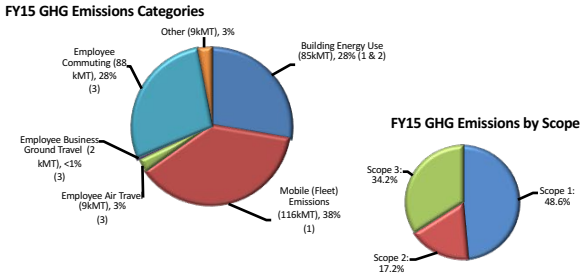
## Walking the Talk…

- Consider how we show up
- Understand and share—
  - How climate change impacts our infrastructure
  - Our consumption
  - Mandates related to our consumption
  - How managing our infrastructure impacts resource management
- Share our next steps

## Showing up

## GHG Emissions from Operations




## Impacts to Infrastructure

## Impacts to Water Systems

We manage 4,800 Drinking Water Systems

- Doesn't include paid utilities
- Administration and Recreation sites
- Safe Drinking Water Act

Water table drop or flooding can lead to:

- Wellhead damage and/or well contamination
- Costs to deepen, repair, or close wells
- Rise in water utility costs

## Consumption of Water

| Entity | Annual Potable Water Use (gallons) | Annual Cost ($) |
|---|---|---|
| Federal Government (FY14) | 131,100,000,000 | 515,200,000 |
| Forest Service | 526,082,000 | 2,041,000 |
| Average US Person (indoor water) | 36,500 | 90 (in Albuquerque) |
| Average US Diet (per person)* | 365,000 | ?? |

(*source: National Geographic)

- Water Footprint: http://www.watercalculator.org/

## Consumption Mandates

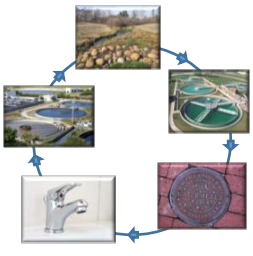
EO 13693, *Planning for Federal Sustainability in the Next Decade*:

- "Federal leadership…will **continue to drive national greenhouse gas reductions and support preparations for the impacts of climate change**…"
- "…It therefore continues to be the policy of the United States that agencies shall **increase efficiency and improve their environmental performance**."

**Reduce water intensity by 36% by FY25 from FY07 baseline**

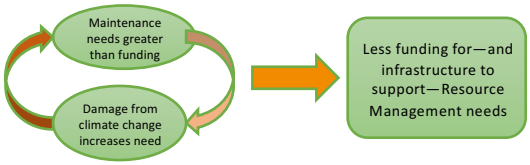
## Looking at Systems

- Reducing water –
  - Reduces use of energy
  - Reduces use of treatment chemicals
  - Reduces wastewater to treat
  - Supports our resource management goals



## Infrastructure management impacts resource management

- Current deferred maintenance needs:
  - $92 million in drinking water systems
  - $5.2 billion total for infrastructure




## Next Steps: OSCC Operations in FY17

- Corporate Priority Action Item: **W**ater **A**ssessment and **T**ools for **E**fficiencies and **R**eductions
  - Water system leaks (~14%)
  - Outdoor water use (up to 50%)
  - FY17 – FY19
  - Expect up to 40% reduction in potable water consumption
  - Mandate: 36% reduction in water consumption intensity by FY2025

## Next Steps

**Steps for WATER:**

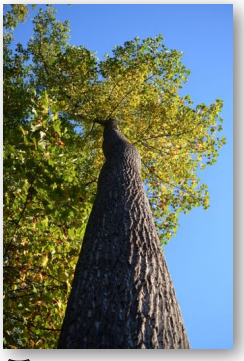
- Comparing water use to use estimates
- Assessing outdoor water use
- Prioritizing water leaks and outdoor watering by site

**FY18 and FY19 –**

- Working on priority sites
- Identifying funding and resources to help the field

## Challenges

- How do we help others connect the dots so we show up as responsible when managing resources?
- **How do we move the discussions we're having from several to many?**
- How do we make our own infrastructure resilient in the face of droughts, floods, and other climate change impacts with limited resources? *(How do we prioritize this work?)*



## From our founder…

"The vast possibilities of our great future will become realities only if we make ourselves responsible for that future." ~Gifford Pinchot