

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

A Comprehensive Science Synthesis

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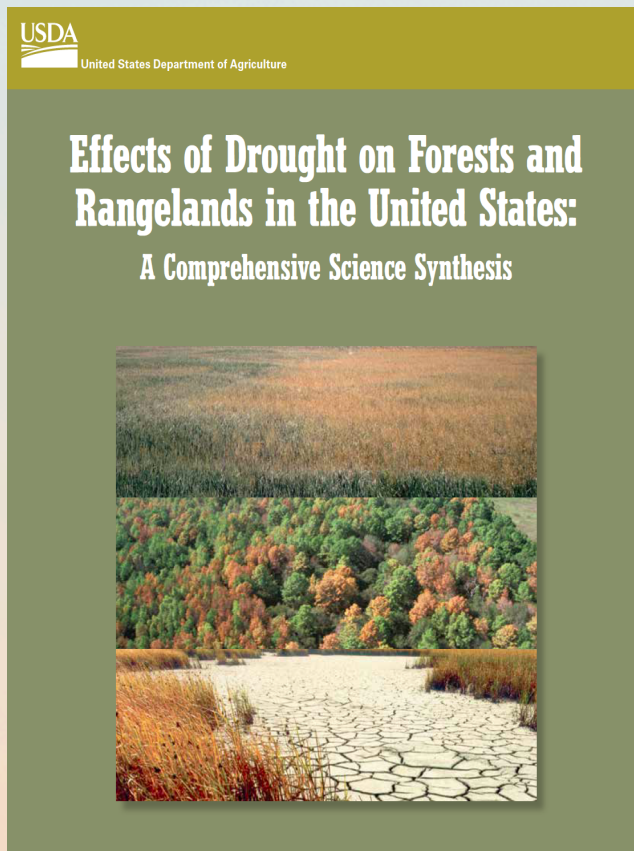
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Report for National Climate Assessment paralleling IPCC process

77 authors from federal agencies,
national labs, & universities



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

Chapters also Published in Special Issues of Refereed Scientific Journals

Global Change Biology

Forest Dynamics

Fire

Biogeochemical Cycling

Forest Ecology & Management

Water Supply and Drought

(aka Ecohydrology)

Characterizing Drought

Insects and Pathogens

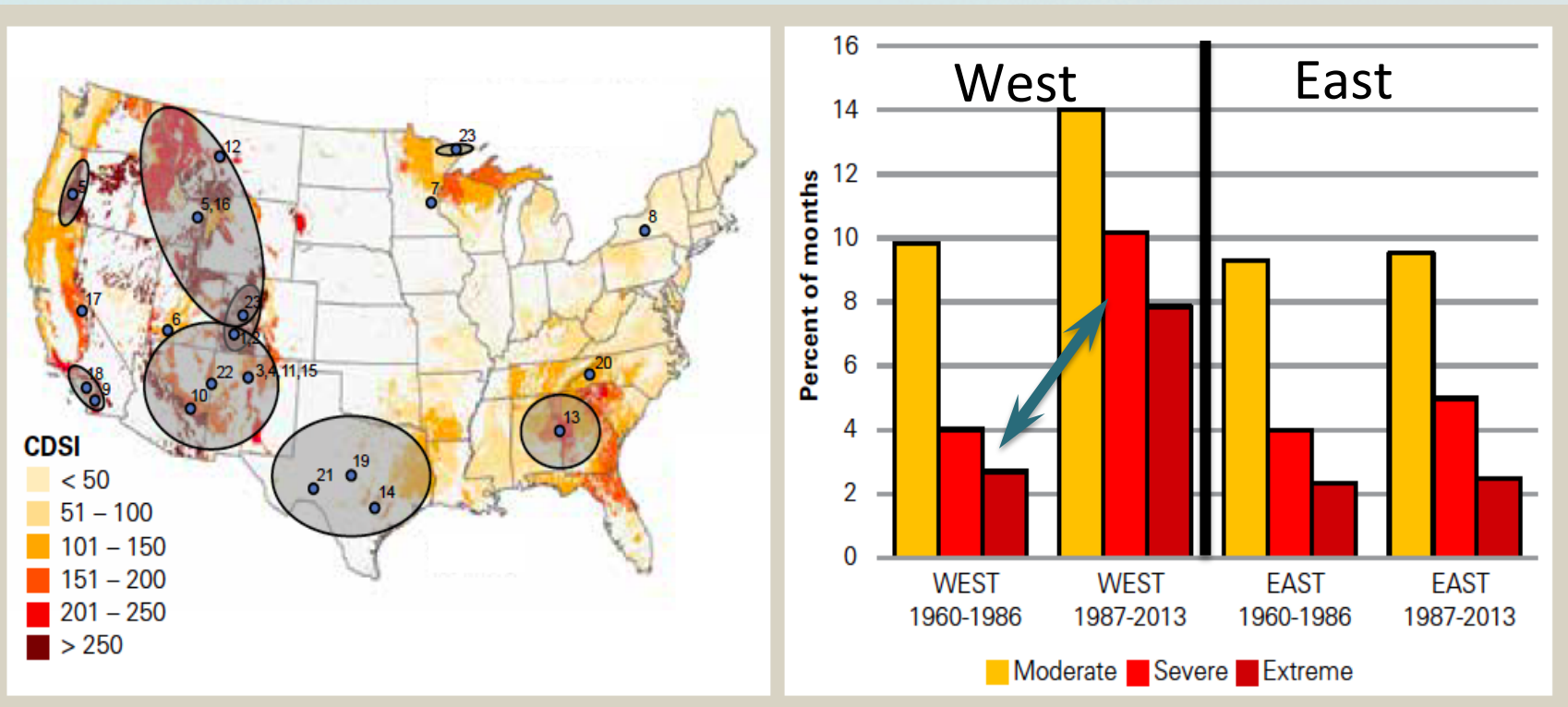
Physiology

Monitoring Drought

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*

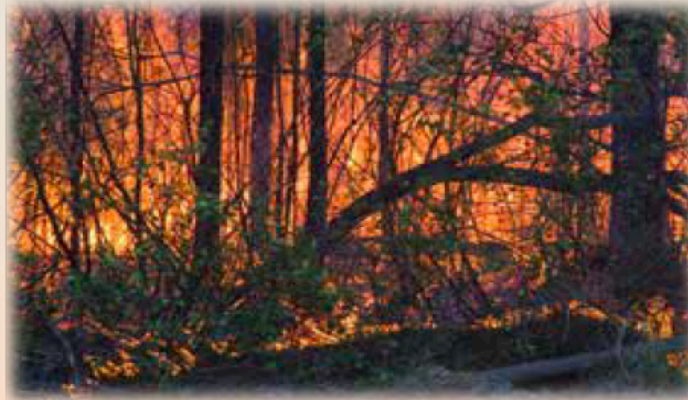
Major increases in western wildfire



Forests and Drought

Drought impacts....

- *Widespread forest mortality – especially the west*
- *Increased costs of fighting large fires*
- *Water scarcity*



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
 - *Plant stress, drought-tolerant species*
 - *Habitat shifts*
 - *Some invasive species can benefit*
 - *Reduced carbon storage and water supplies*
- Manage to increase resiliency and resistance

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.

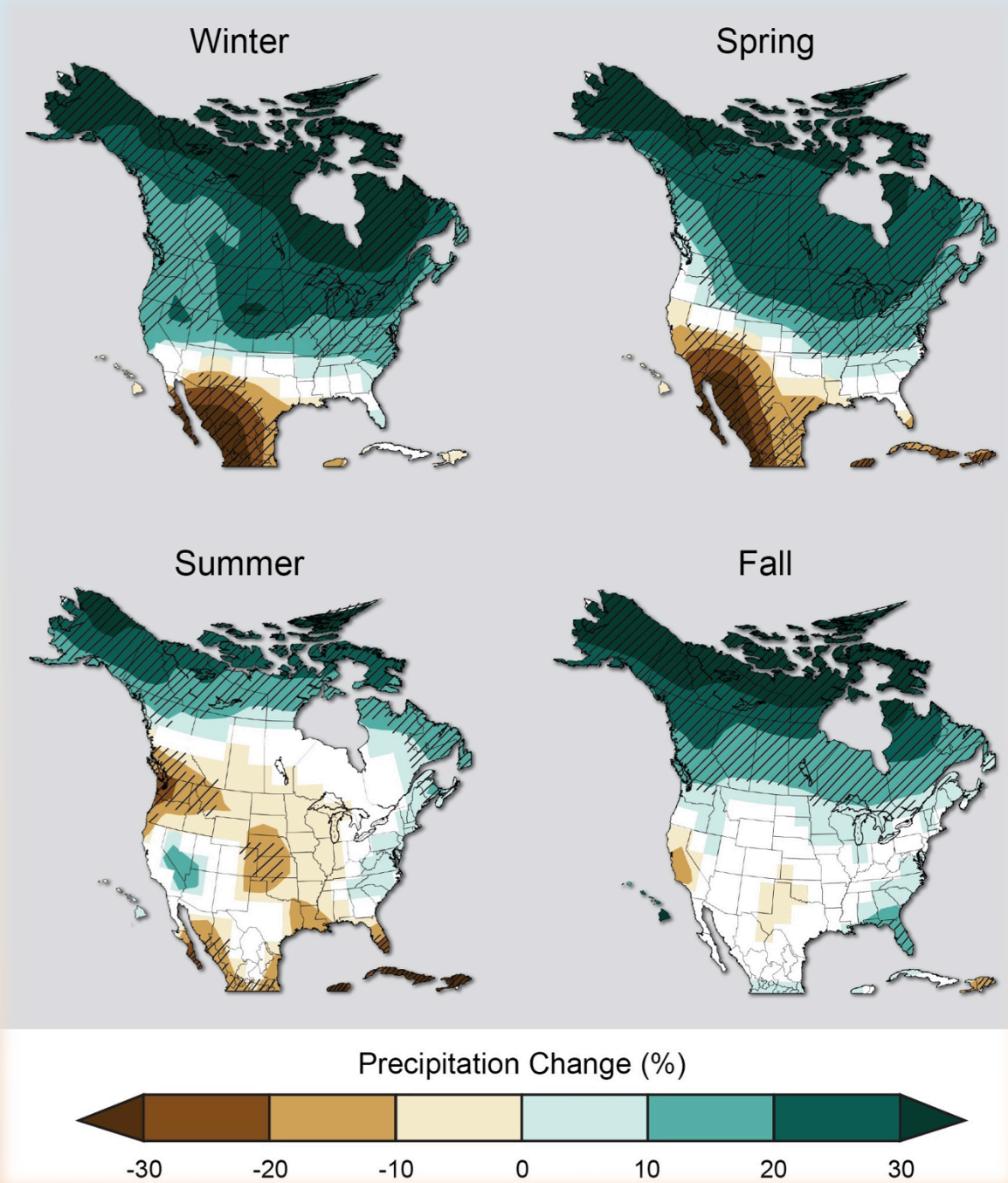
Drought and associated weather characteristics important for forests and rangelands

Lower rainfall, but also...

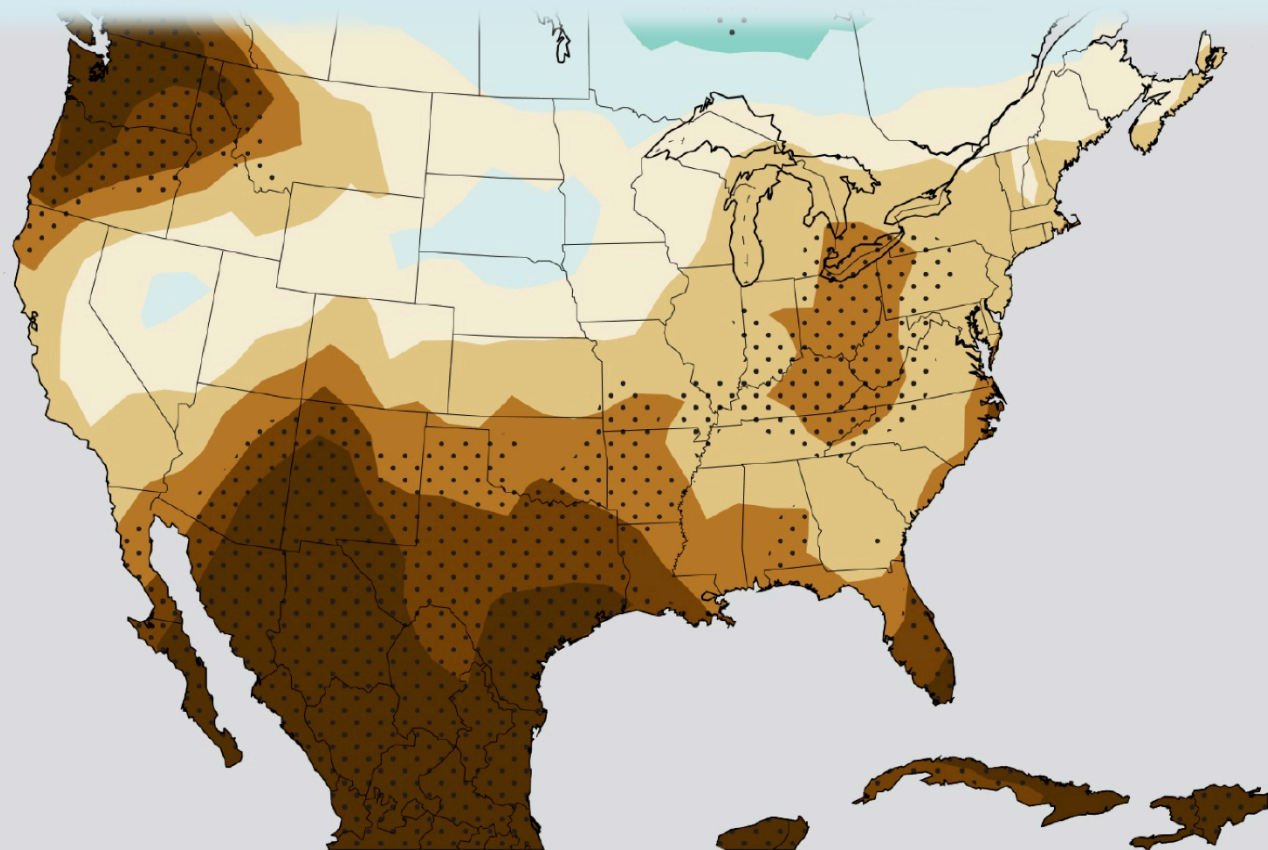
- Less snow
- Drier air (low humidity)
- Longer dry spells
- Higher temperatures during droughts

Seasonal precipitation projections

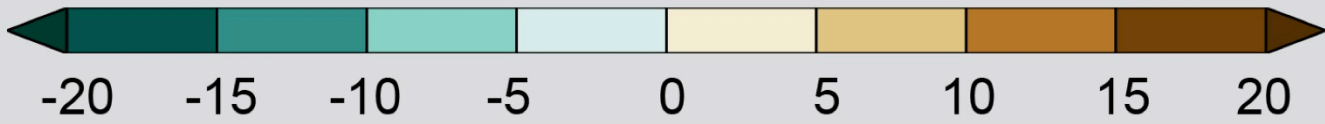
White = models disagree
Hatched = models agree



Change in Maximum Number of Consecutive Dry Days

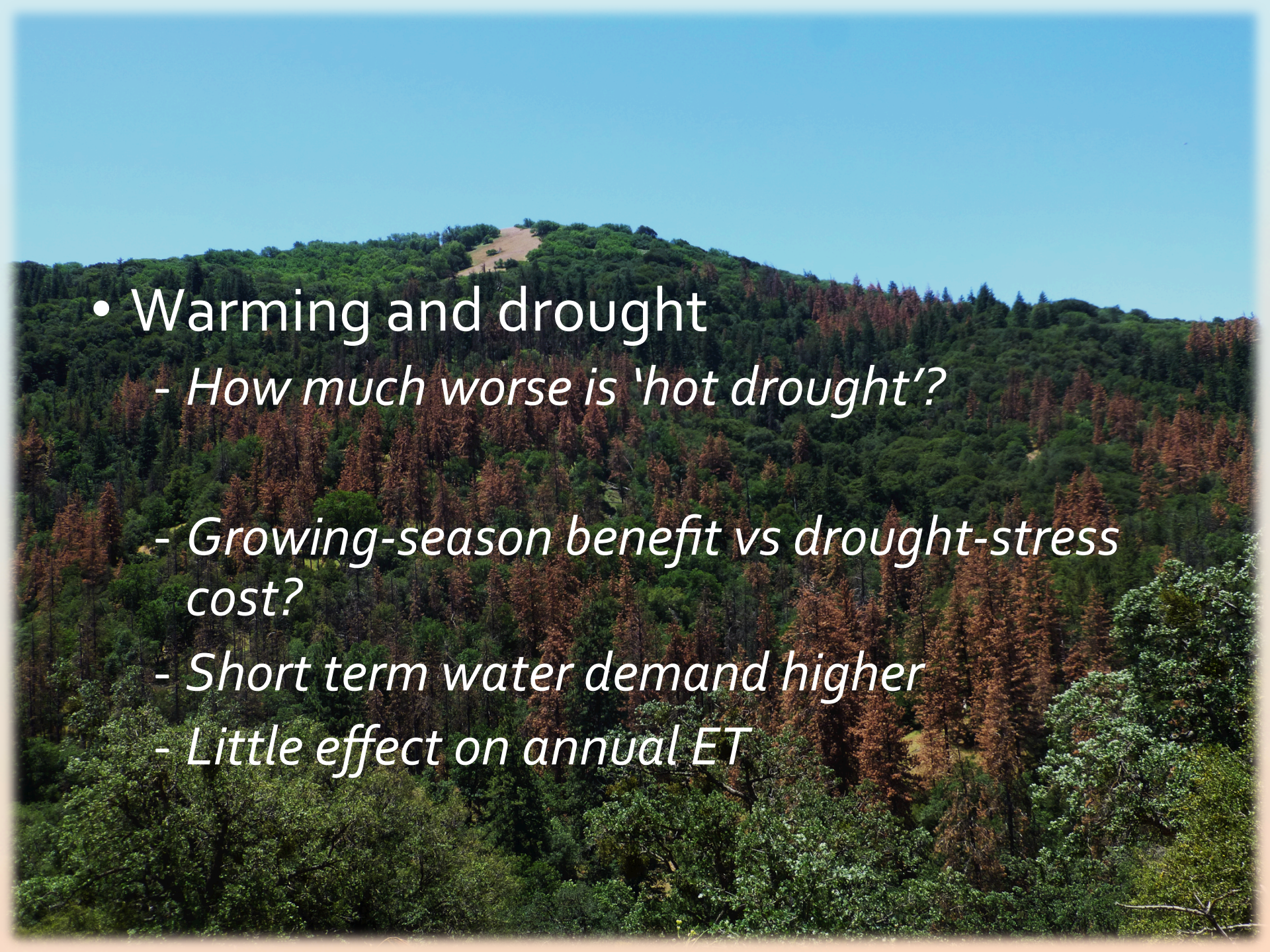


Change (%)



Effects of Drought on Trees and Forests

- Changing biodiversity
 - *Species differences in drought effects*
- Forest productivity
 - *Balance of effects on growth, survival, reproduction*
 - *differs for each species*

- 
- Warming and drought
 - *How much worse is 'hot drought'?*
 - *Growing-season benefit vs drought-stress cost?*
 - *Short term water demand higher*
 - *Little effect on annual ET*

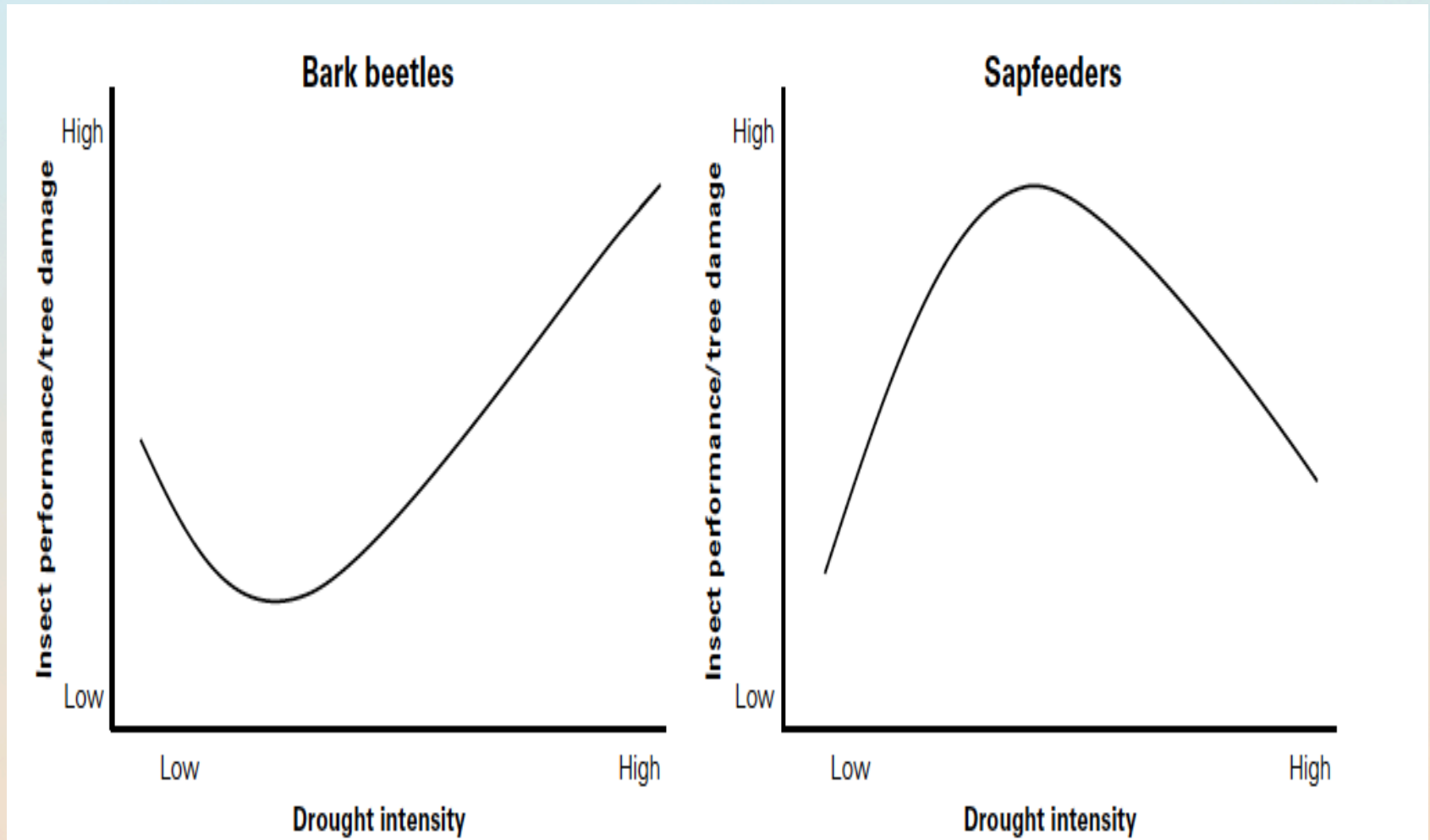
Effects of Drought on Forests – Indirect Effects

Insect outbreaks and drought... complex

*Moderate drought can
increase resistance to some,
decrease resistance to
others*

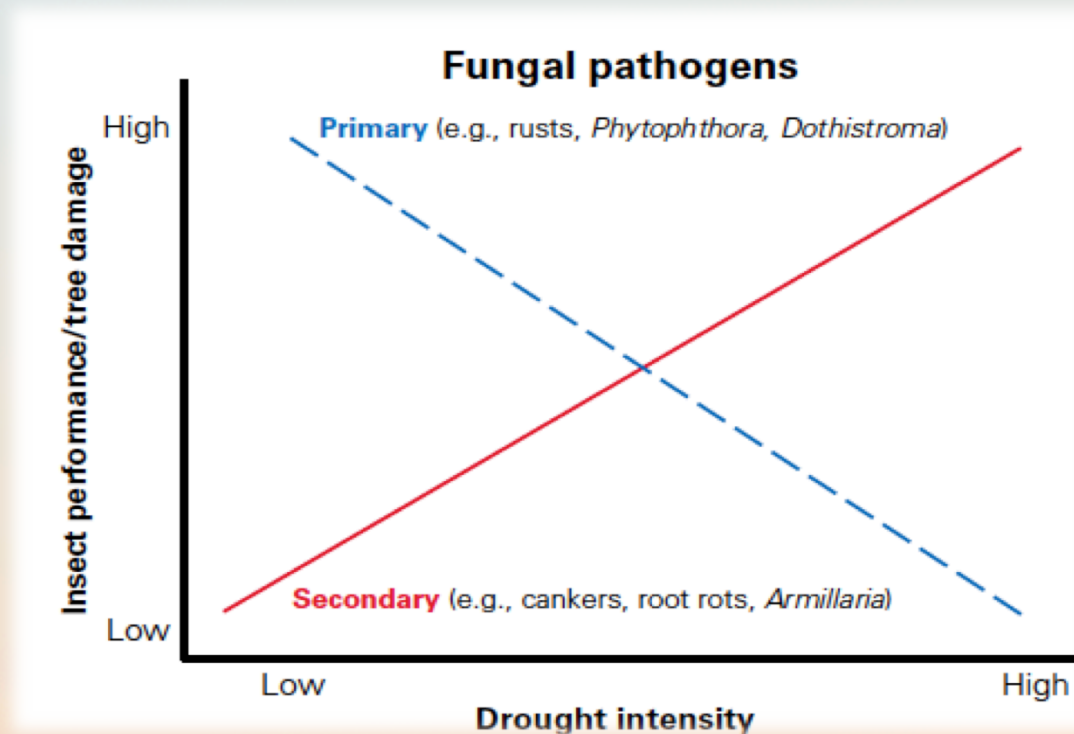
*Severe drought can
promote widespread
outbreaks*

Response varies by insect type.....



Effects of Drought on Forests – Indirect Effects

Pathogens.... *some more harmful under drought, others less*



Effects of Drought on Forests – Indirect Effects

Wildfire... increase frequency, size, severity

Sensitive to moisture supply & timing

- *Annual area burned projected to increase by >200% in much of western US*
 - *Substantial uncertainty!!*
 - *Suppression costs, wildland urban interface*

Effects of Drought on Ecosystem Processes

Nutrient Cycling.... water stress = nutrient stress

- *reduced nutrient uptake*
- *premature leaf loss*
- *declining microbial activity*
- *losses to due to fire and postfire erosion*

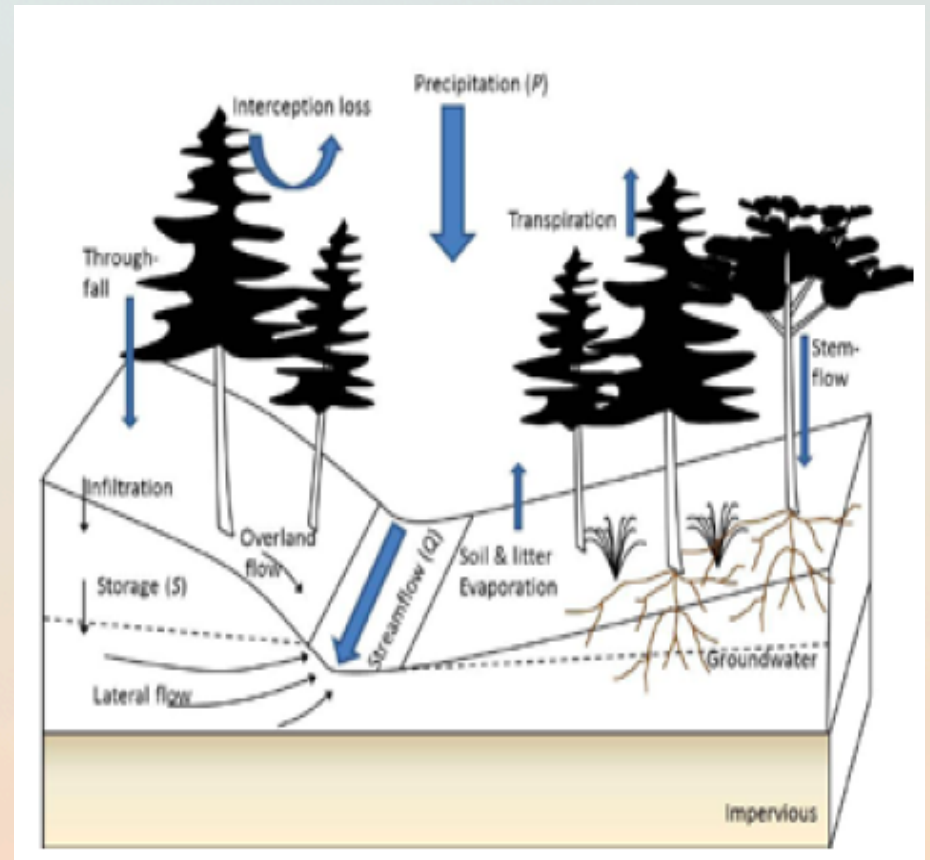
Effects of Drought on Streamflow

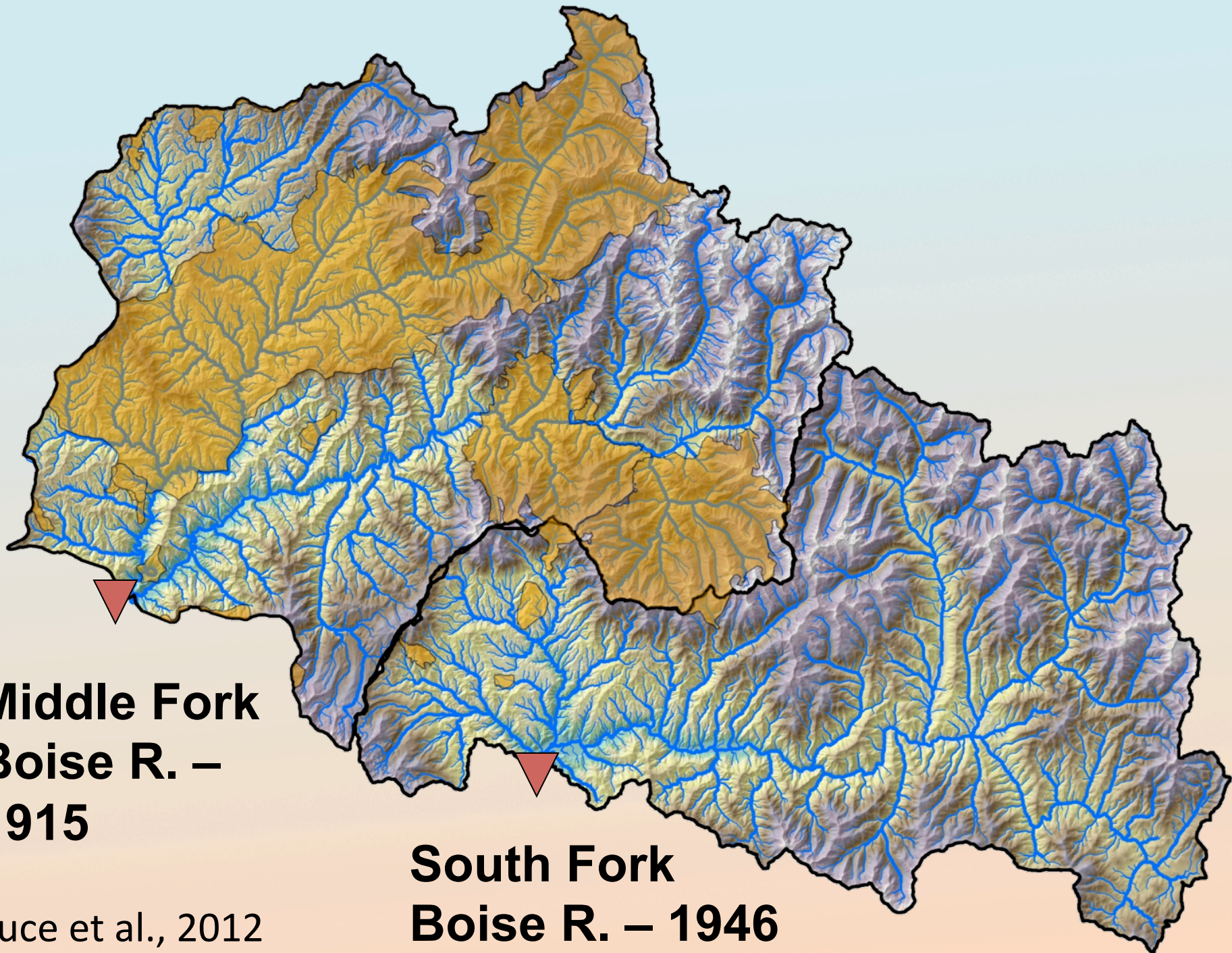
Hydrologic Cycling.... Declining streamflow, reservoir storage

Vegetation

Infiltration rate & soil storage

Groundwater access

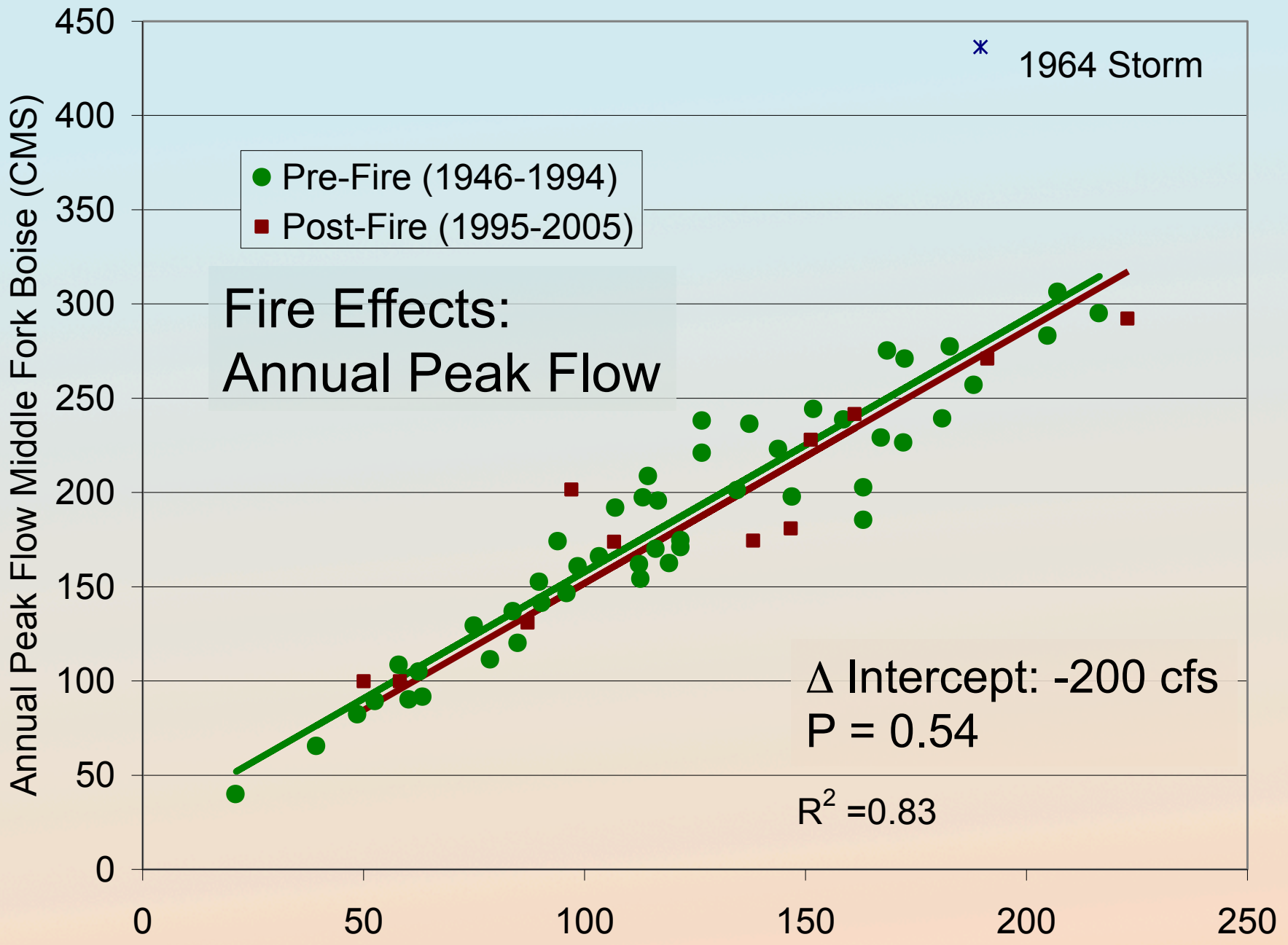


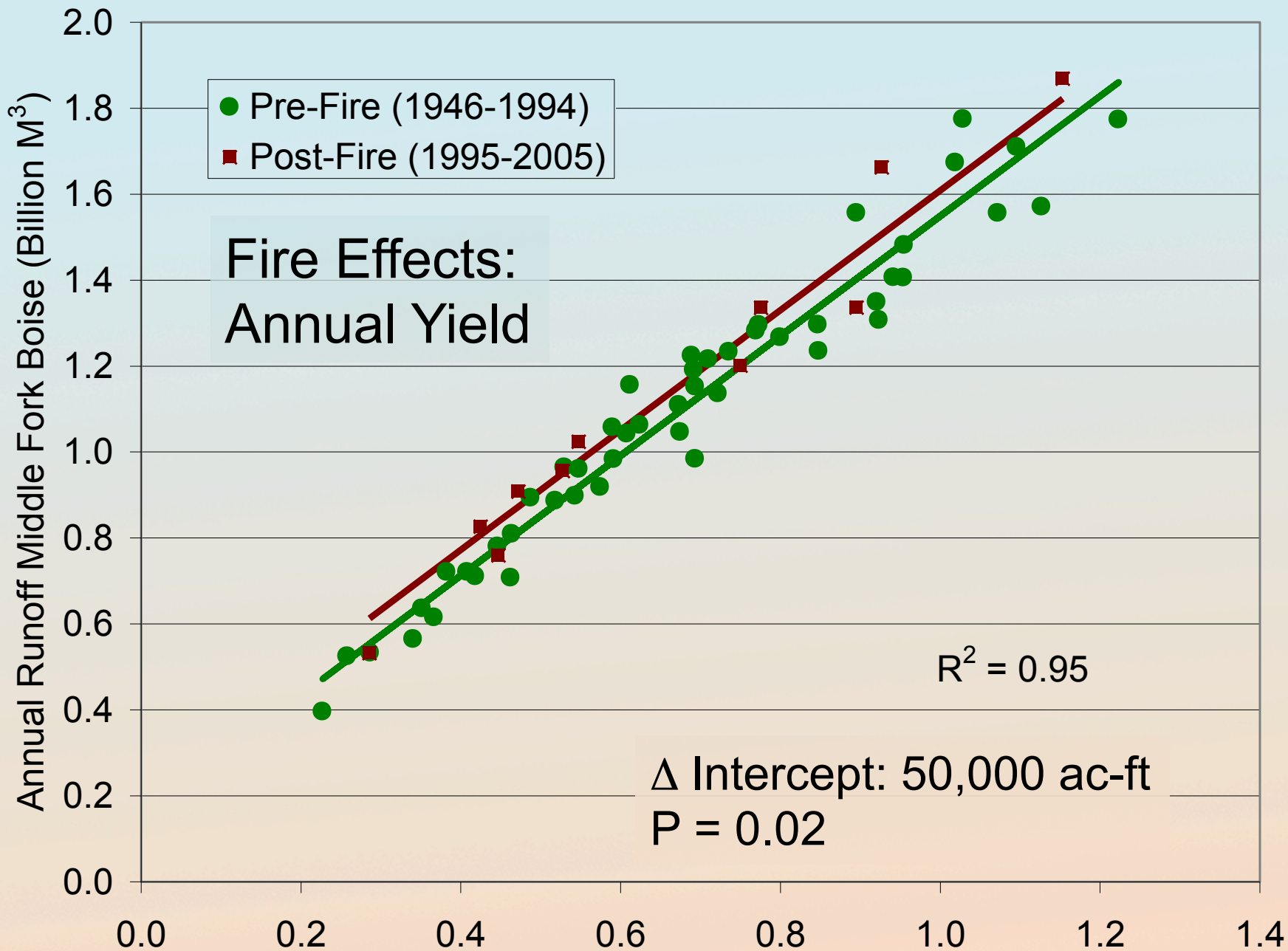


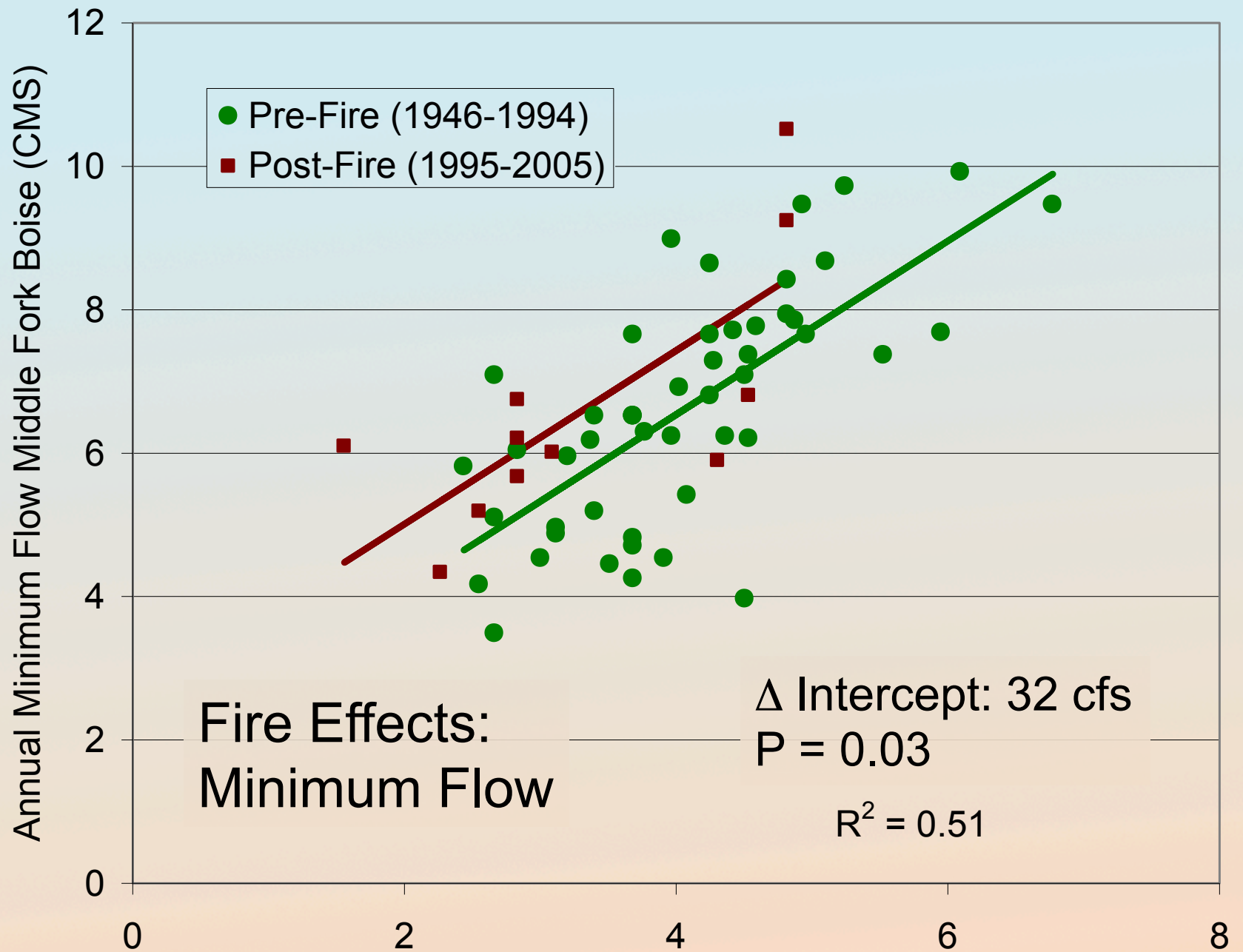
**Middle Fork
Boise R. –
1915**

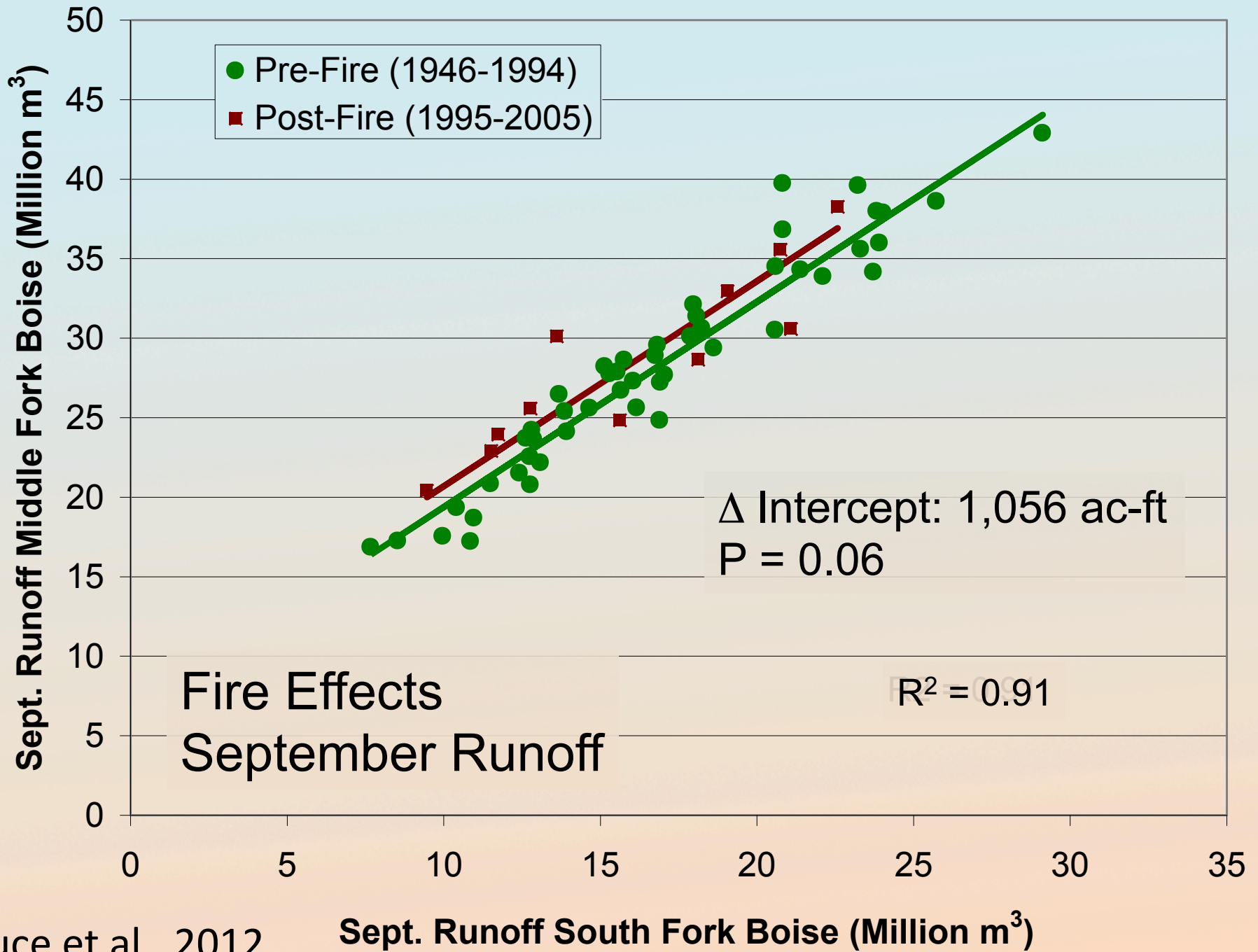
**South Fork
Boise R. – 1946**

Luce et al., 2012

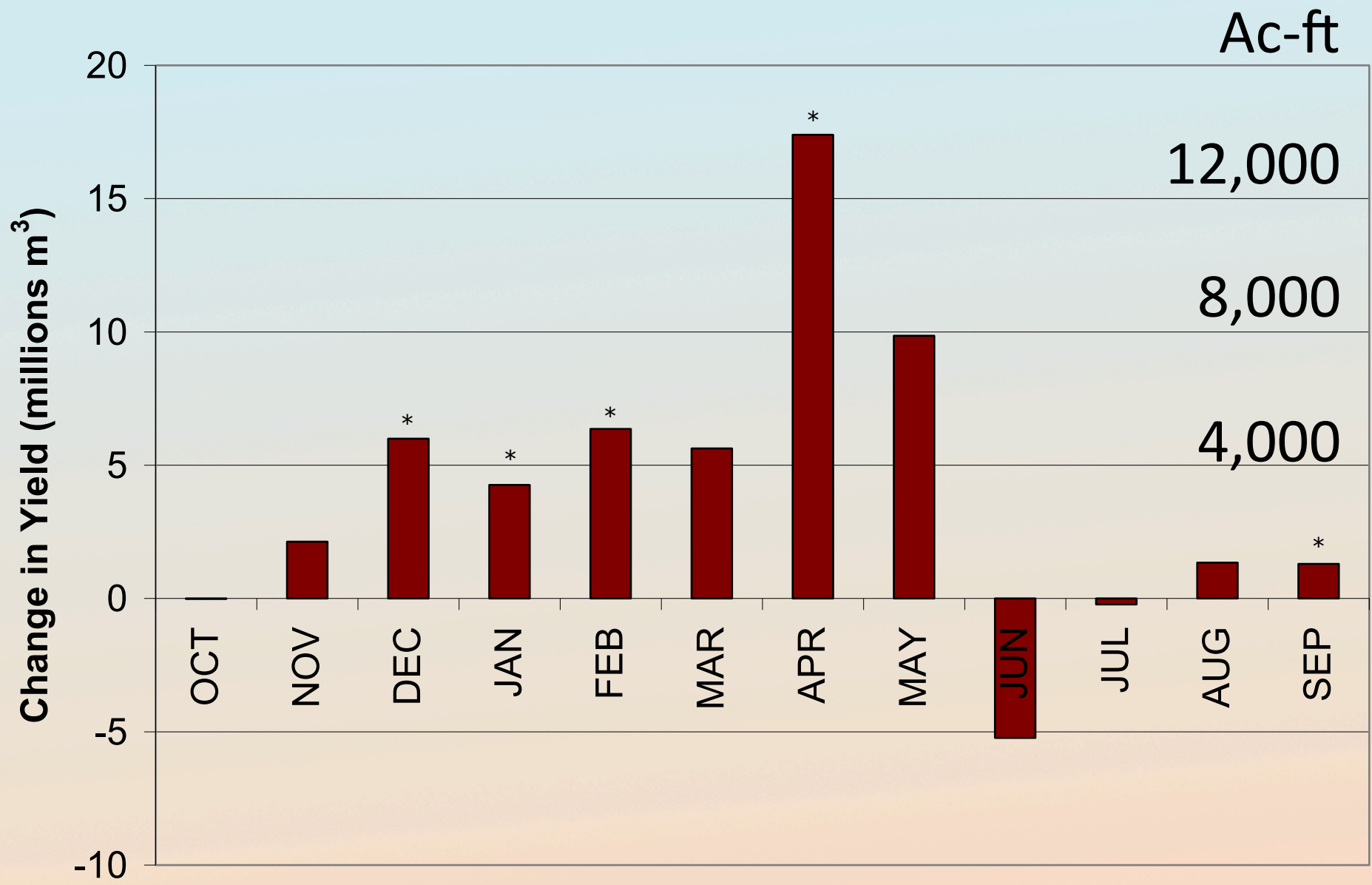








Changes to Monthly Yield – MFB



Rangeland impacts

- *Reduced vegetation, increased erosion*
- *Loss of moist microsites*
- *Seasonal changes affect species composition/ productivity*
- *Advantages for invasives*
- *Increased wildfire*
- *Reduced tree cover*

Challenges for the Future

- Detection
 - Remote sensing more difficult than for crops
 - Ground detection requires intensive monitoring
- Predicting impacts
 - Future precipitation uncertain
 - Limited understanding of physiology, species interactions, and stress complexes
- Managing for drought

Managing for Drought

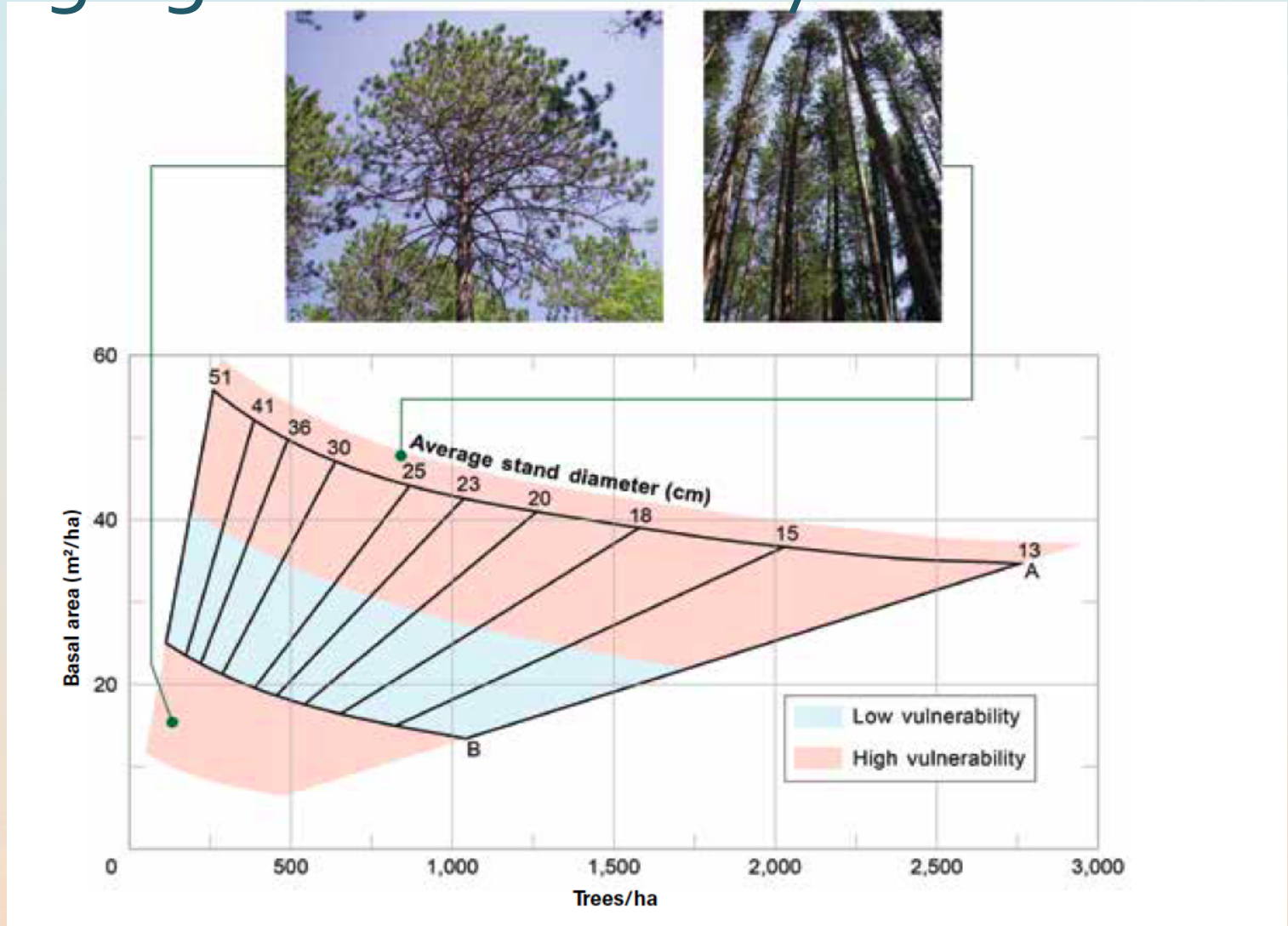
Can we make forests less vulnerable?

direct effects – growth, reproduction, mortality

indirect effects – fire, insects, pathogens

Can we reduce impacts on water supply?

Different ways to think about managing size and density



Managing for Droughts

Impacts on stream water quality and quantity...

- *Reduce fire risk in those areas where WQ critical*
- *Maintain riparian ecology*
- *Avoid compensating for flow loss through harvest*
- *Resilience through information and intelligent response*

Priorities: where to focus effort?

