Post-fire regeneration in a changing climate

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UNIVERSITY OF MONTANA
W.A. FRANKE COLLEGE OF FORESTRY & CONSERVATION

North Central Climate Adaptation Science Center

USGS science for a changing world

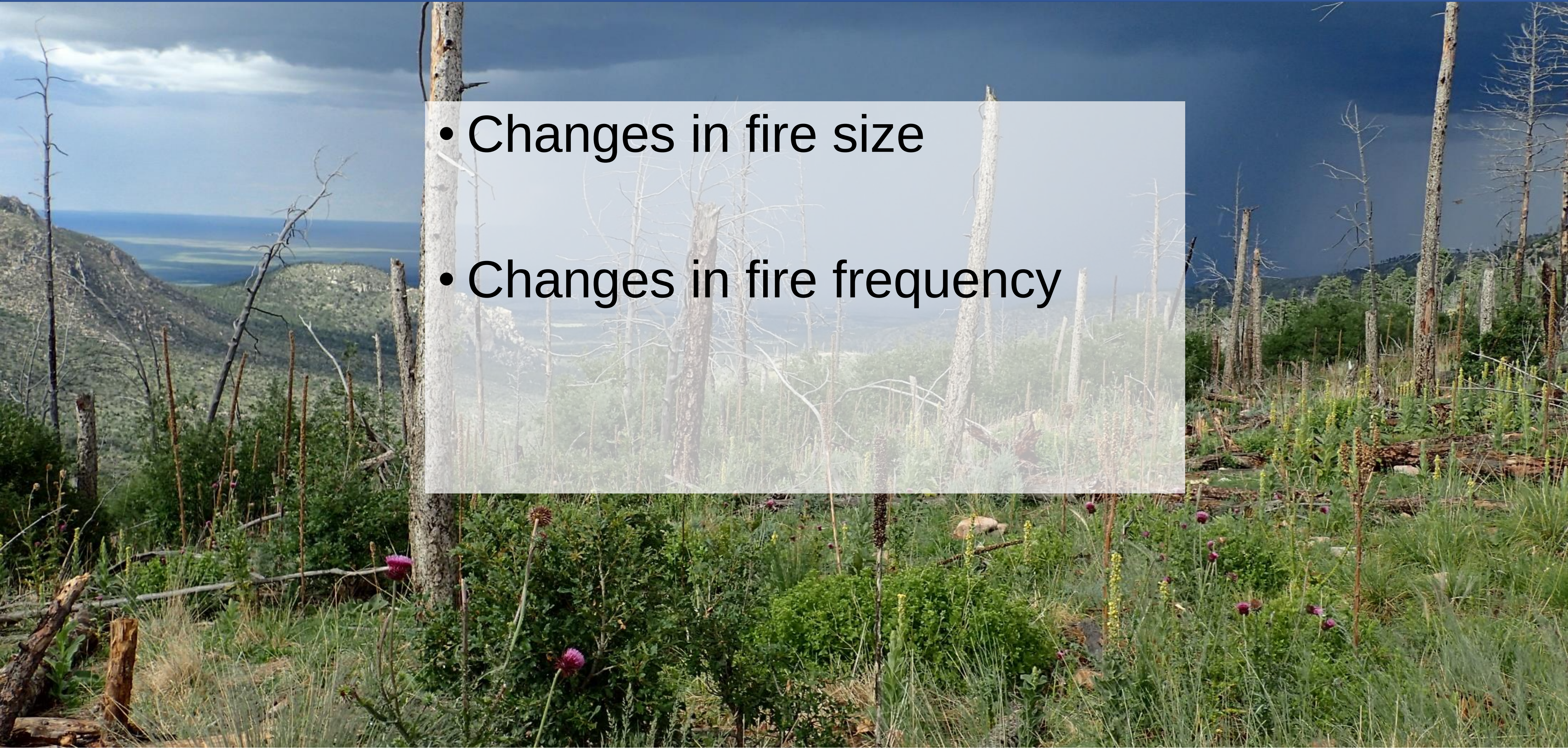
NSF

JOINT FIRE SCIENCE PROGRAM

How will climate change impact post-fire vegetation?

- Changes in fire size

How will climate change impact post-fire vegetation?



- Changes in fire size
- Changes in fire frequency

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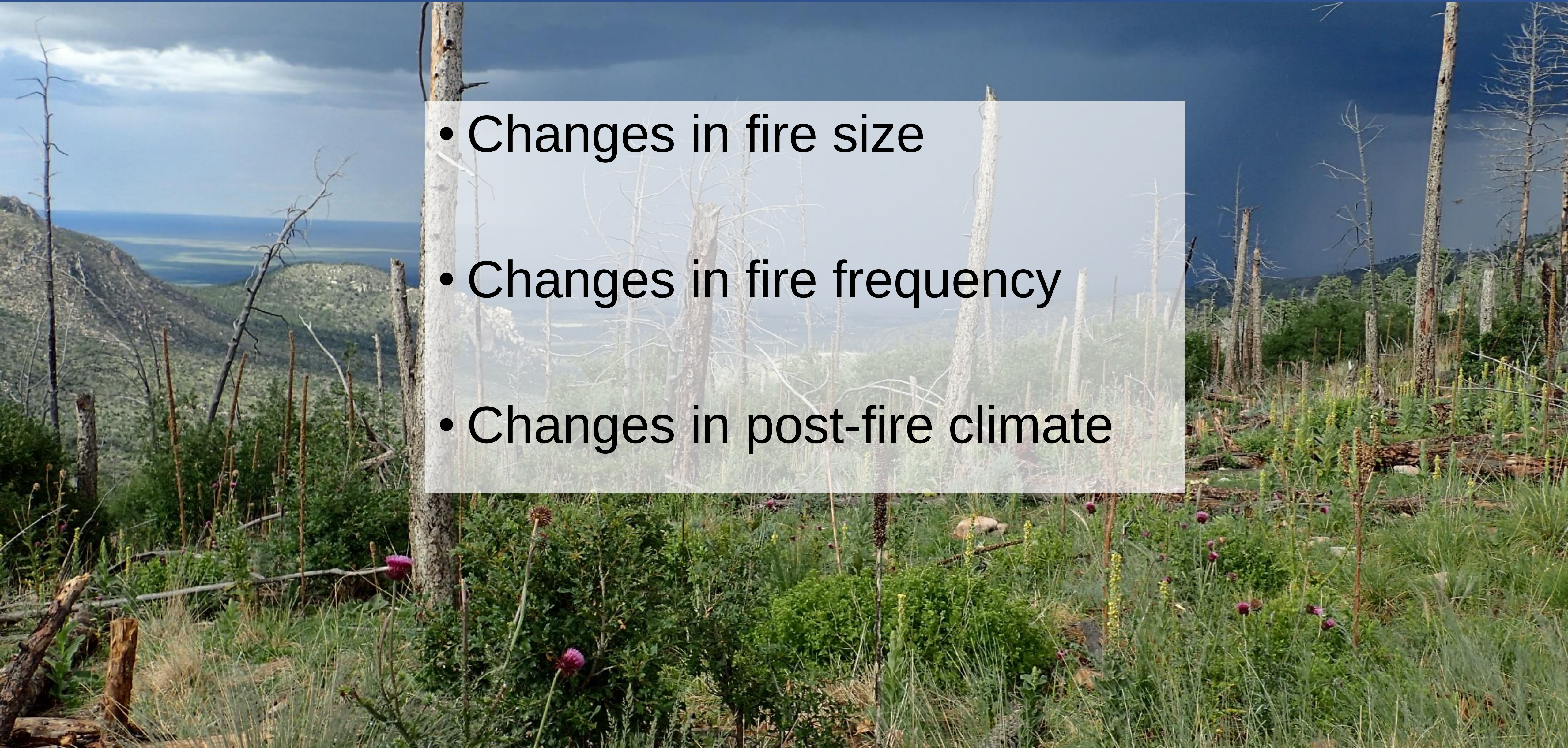

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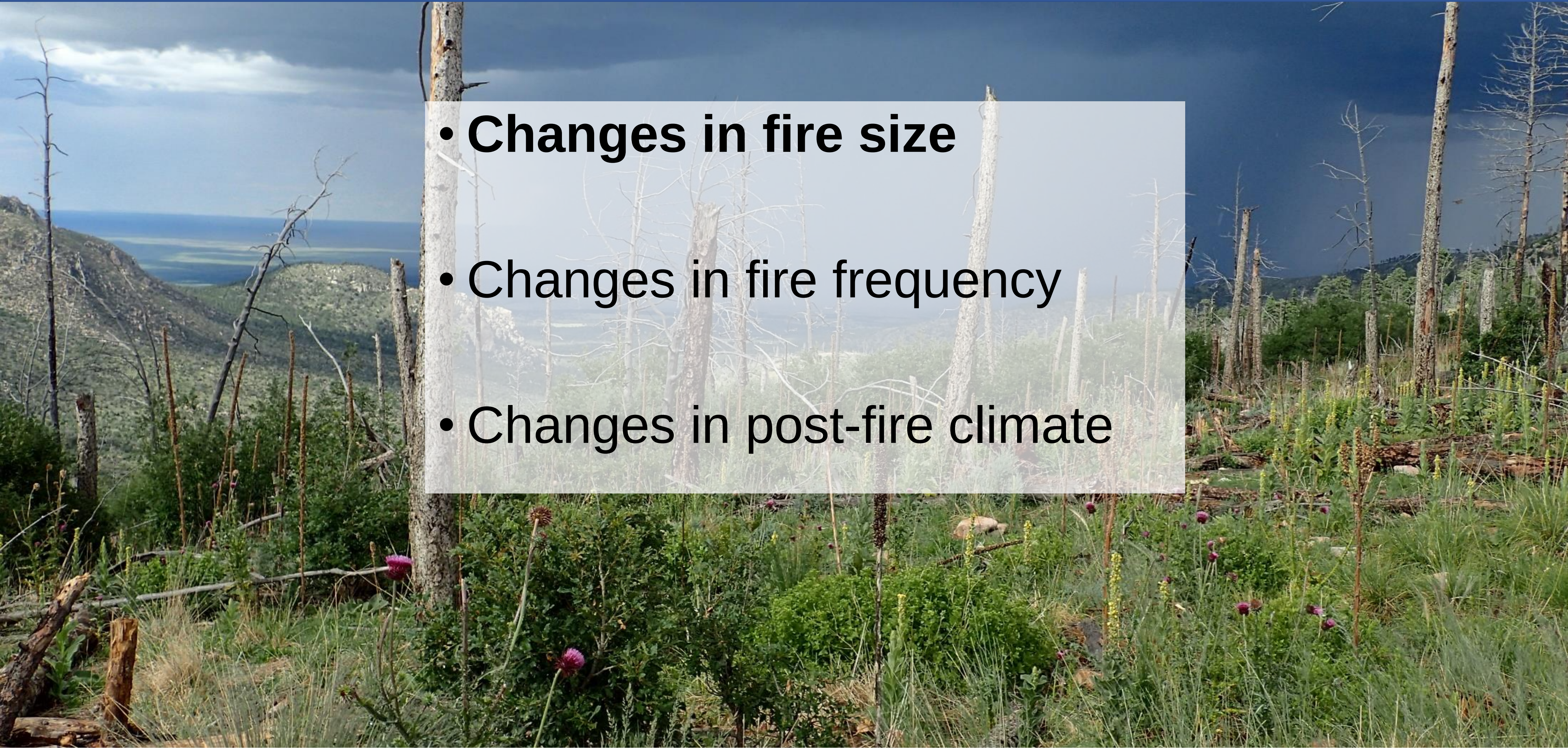

- **Changes in fire size**
- Changes in fire frequency
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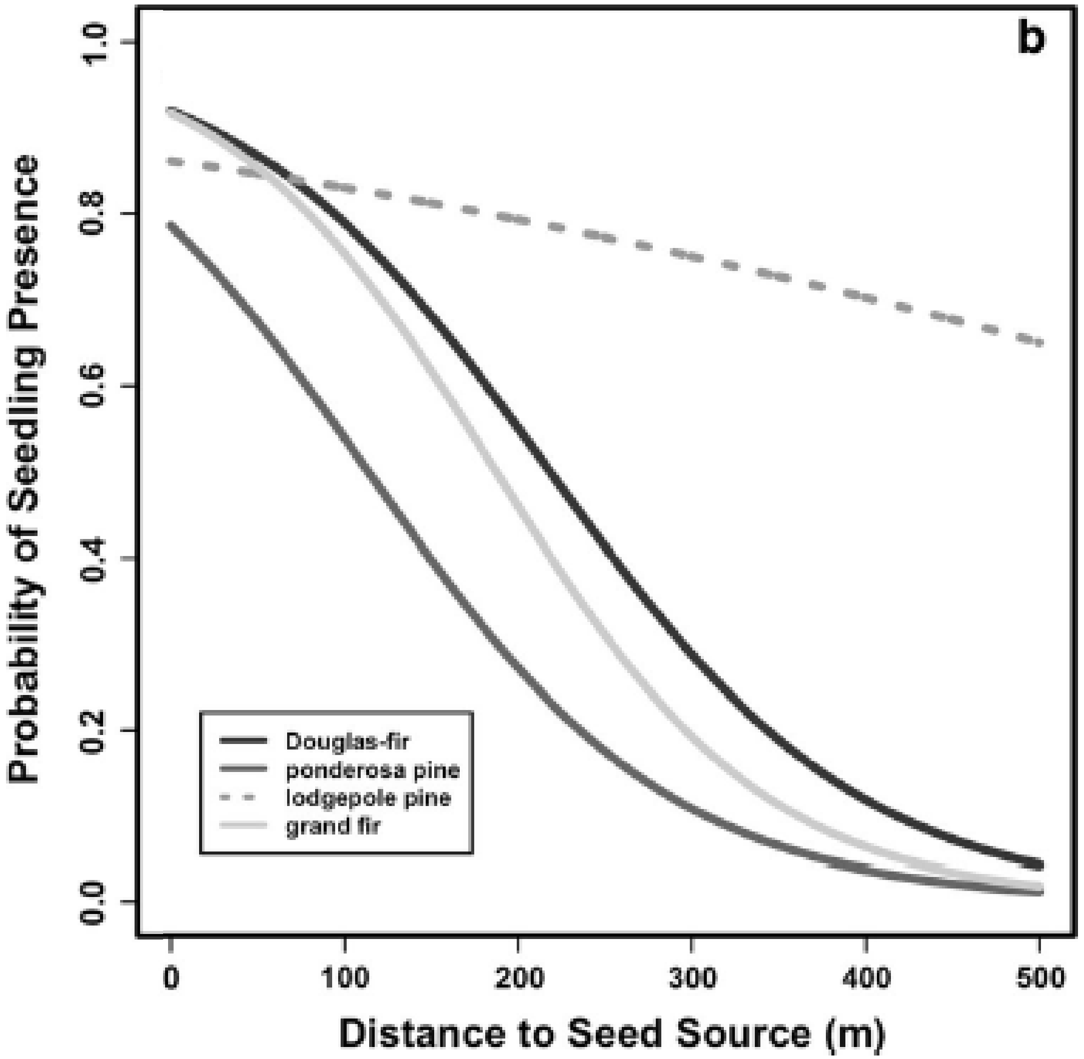
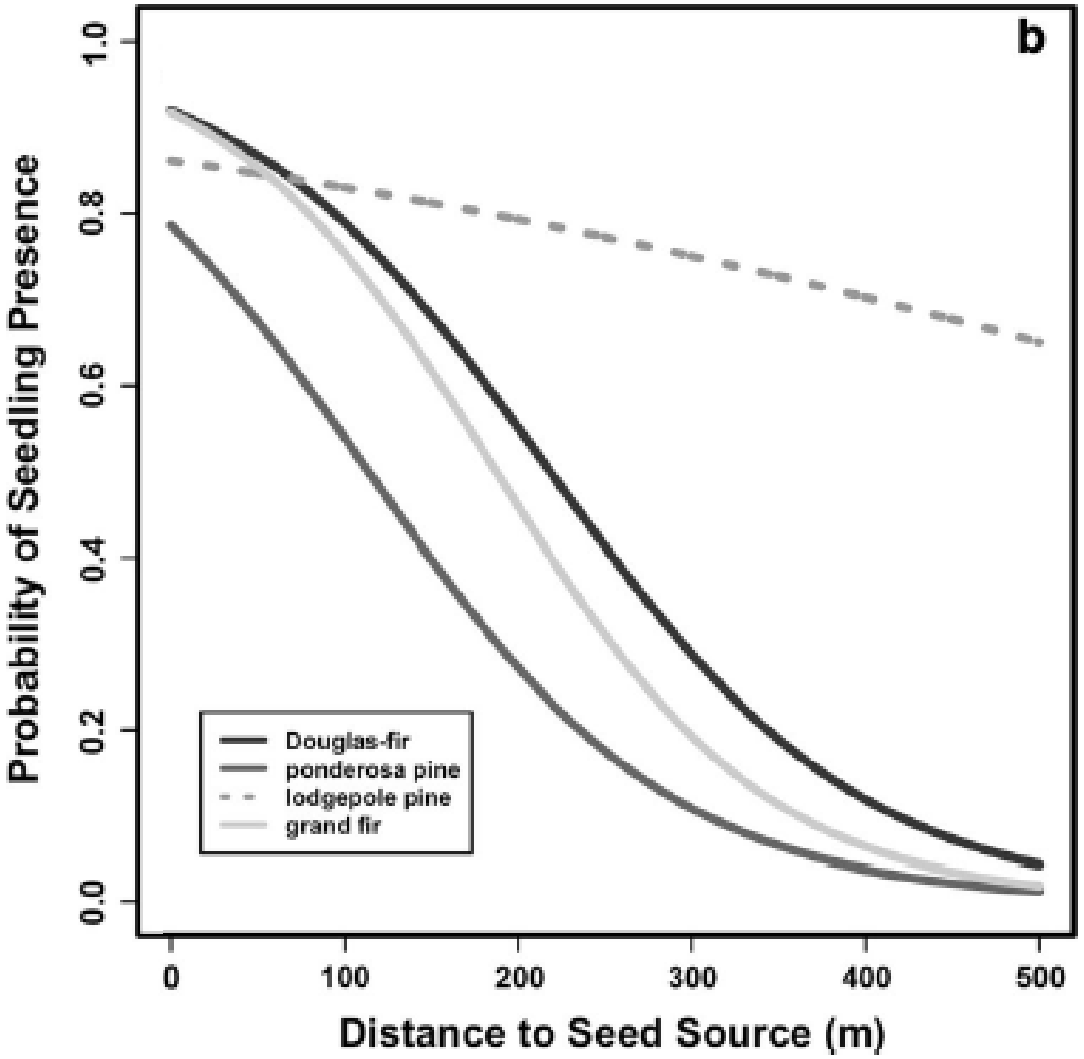
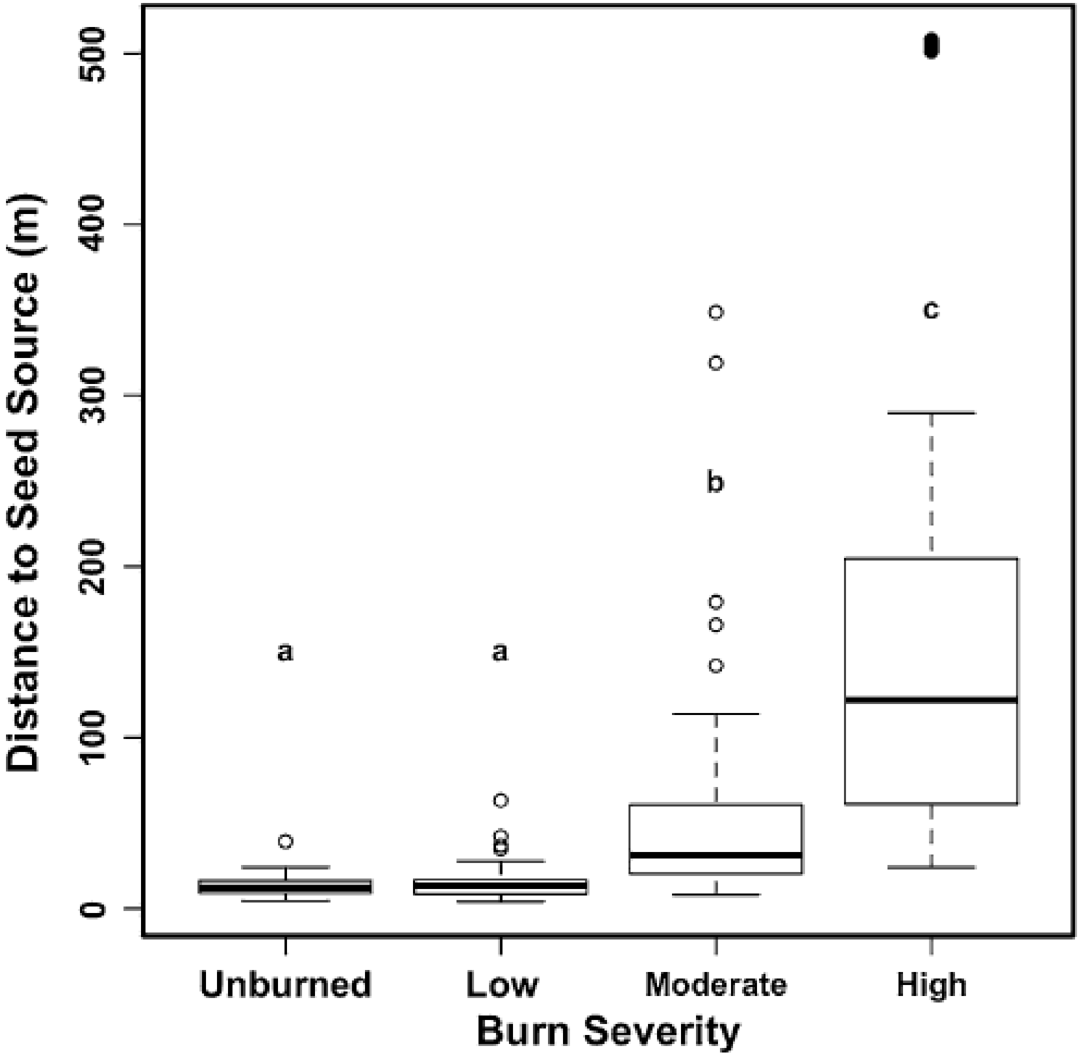
Changes in fire size: Distance to seed source



Kemp *et al.* 2016 *Landscape Ecology*

Changes in fire size: Distance to seed source



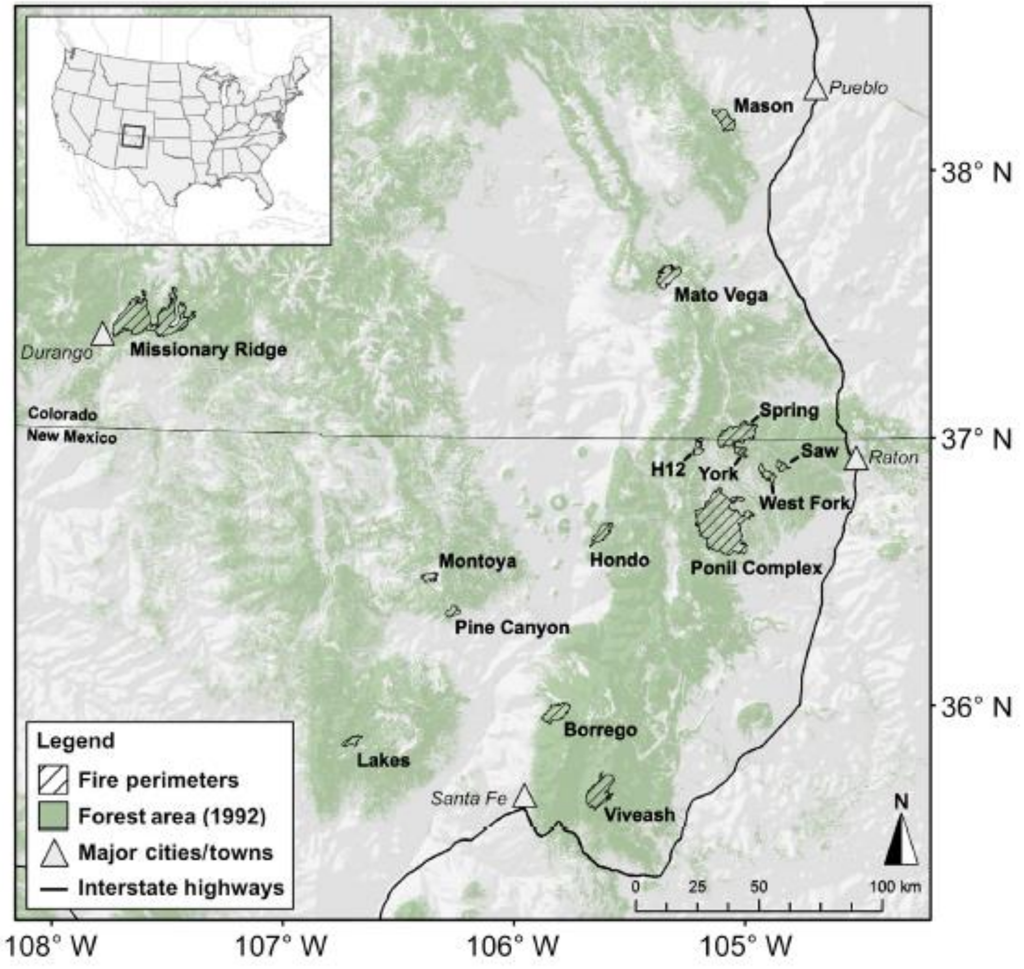


[Kemp *et al.* 2016 *Landscape Ecology*]

Changes in fire size: Seed availability

Limitations to recovery following wildfire in dry forests of southern Colorado and northern New Mexico, USA

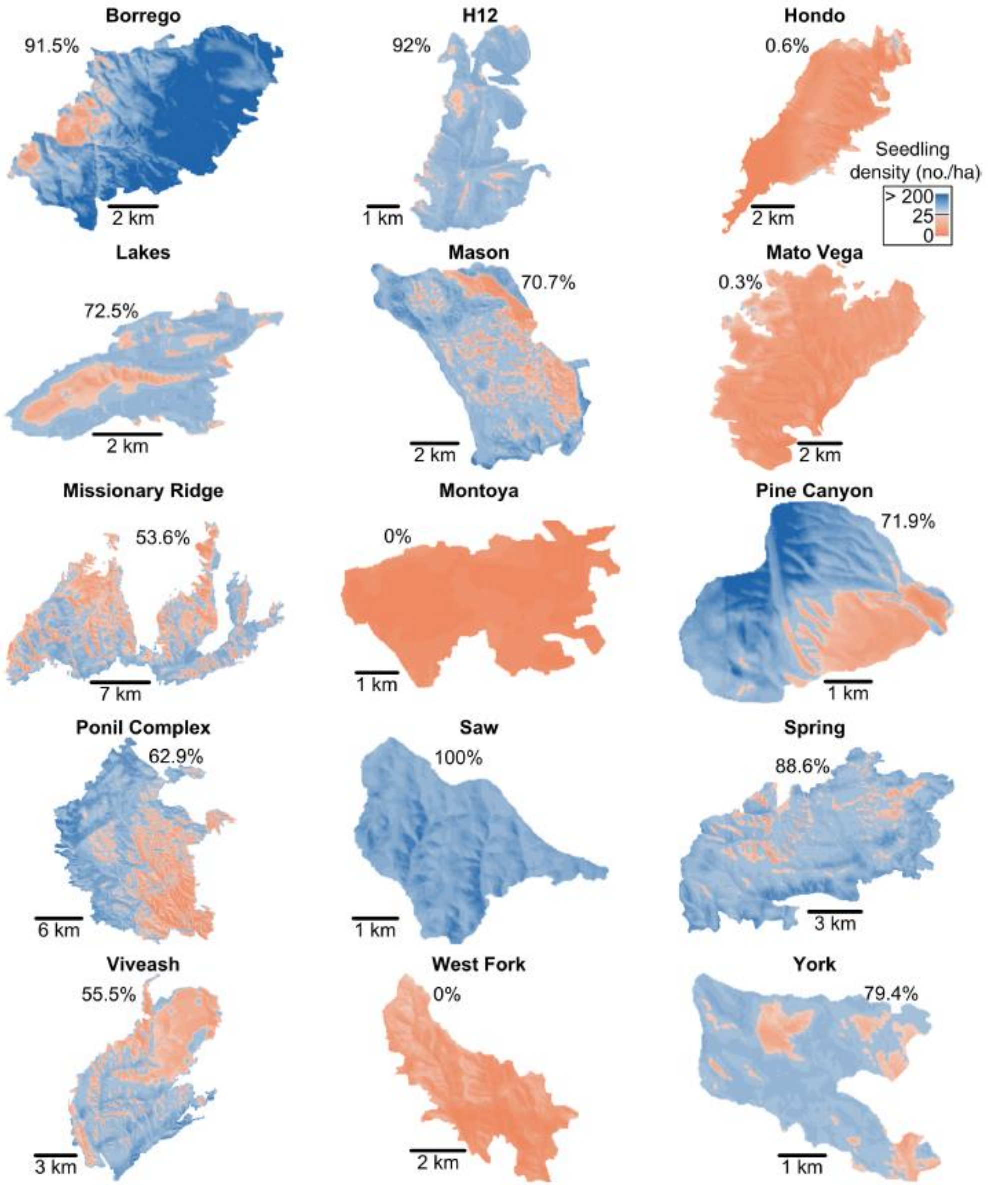
Kyle C. Rodman,[1,5] Thomas T. Veblen,[1] Teresa B. Chapman,[1,2] Monica T. Rother,[3] Andreas P. Wion,[4] and Miranda D. Redmond[4]



Rodman et al. 2020 *Ecological Applications*

Changes in fire size: Seed availability

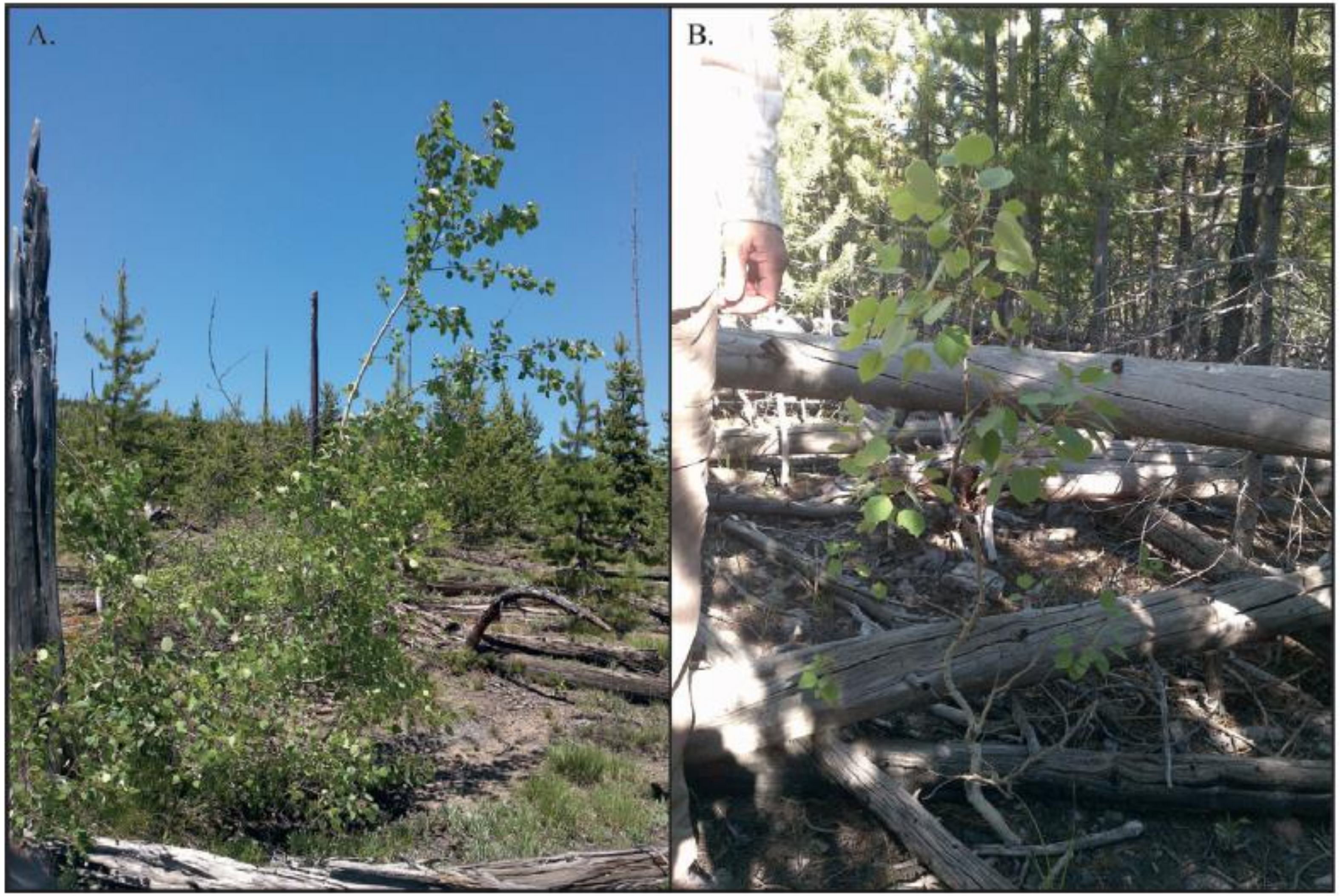
- Lack of live mature trees limited regeneration potential in many areas
- Moisture limited regeneration in marginal sites



Rodman et al. 2020 *Ecological Applications*

Larger fires may benefit serotinous or seedbank species

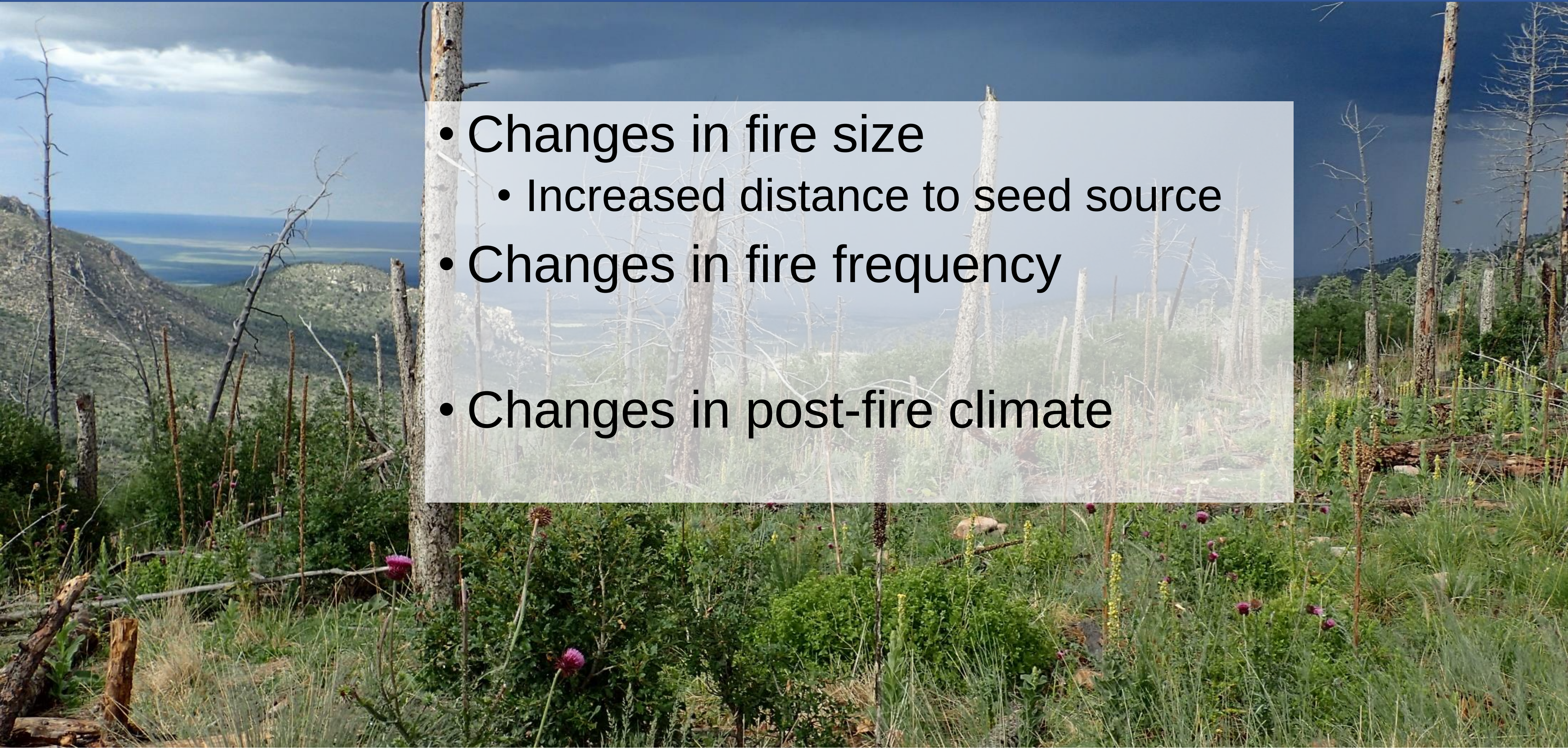
Larger fires may benefit species with long dispersal distances



- Aspen has effective very long distance dispersal
- Dispersal capability will determine ability of plants to move to areas with more suitable climate post-fire

Hansen et al. 2016 *Forest Ecology & Management*

How will climate change impact post-fire vegetation?



- Changes in fire size
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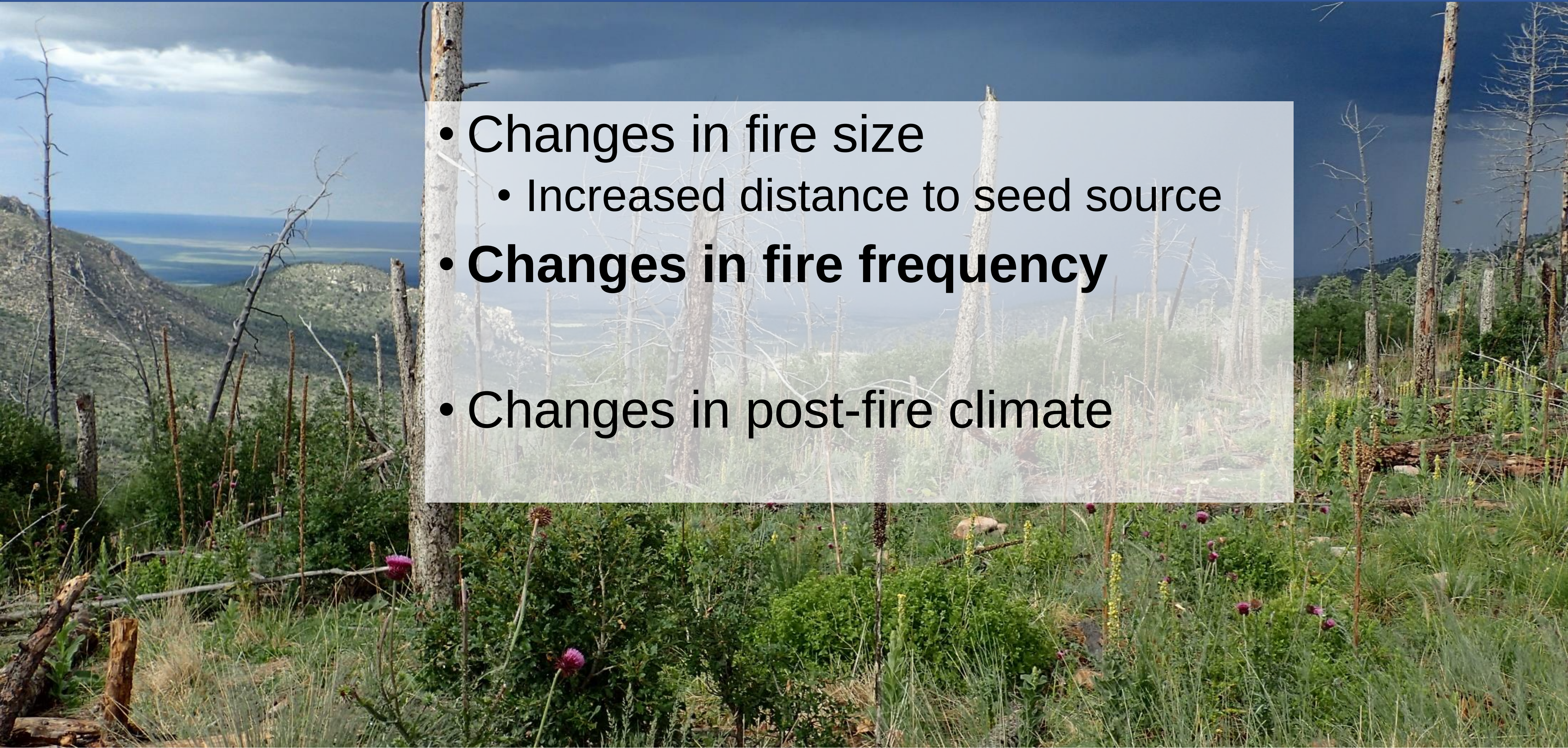

- Changes in fire size
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- **Changes in fire frequency**
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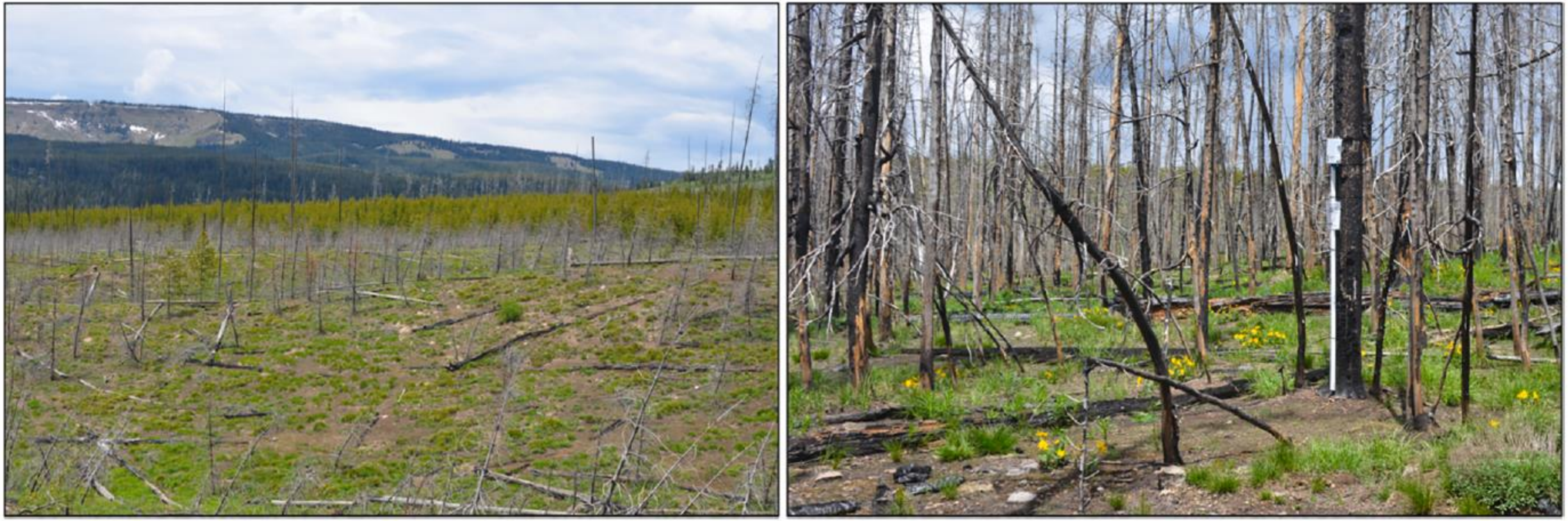
Changes in fire frequency: Short-interval fires

Photo: Brian Harvey

Changes in fire frequency: microclimate

A Short-interval fire **16 years** **B** Long-interval fire **>150 years**

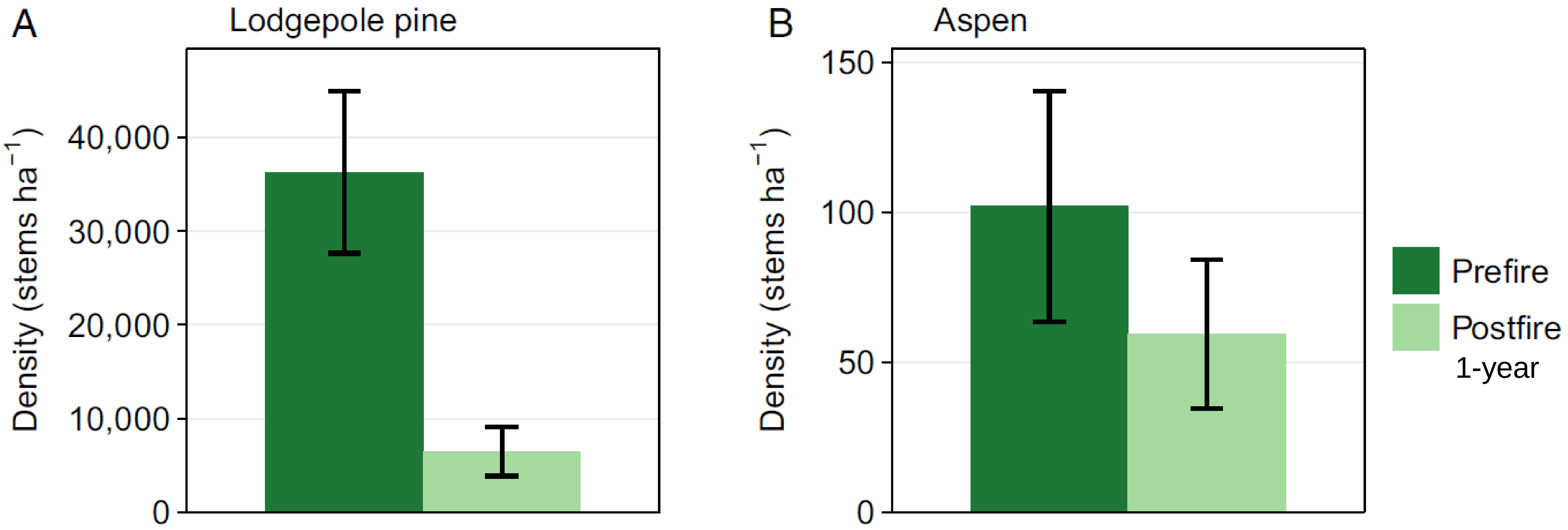


Temperature 2° C warmer and soil moisture 25% lower in short-interval compared to long-interval fires.

Hoecker et al. 2020 *Forest Ecology & Management*

Changes in fire frequency: tree regeneration

Effects of short-interval fires (16-28 years) on postfire tree density in Yellowstone NP

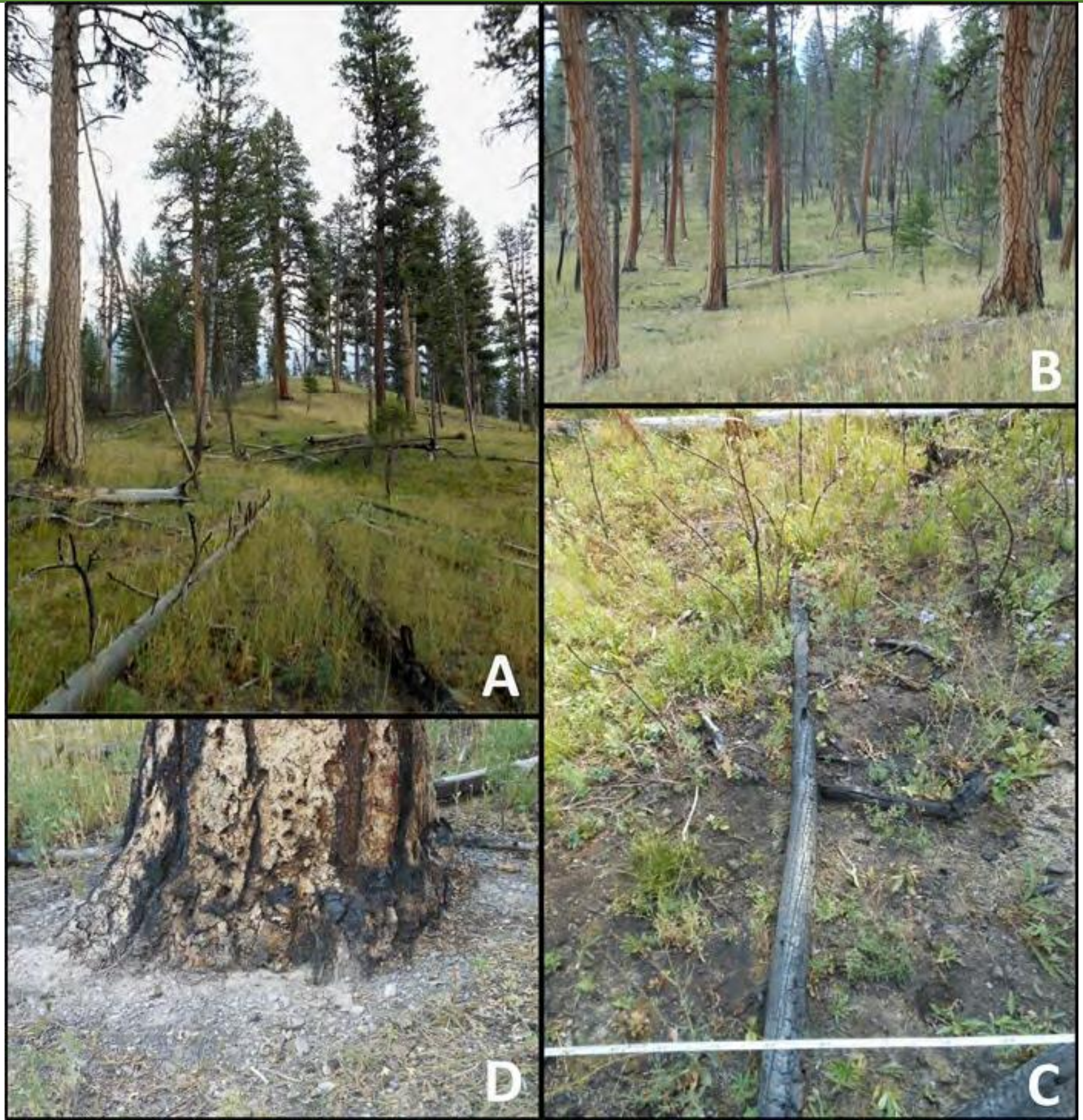


Turner et al. 2019 *PNAS*

Changes in fire frequency: stand structure

Effects of short-interval fire (8 years) in Bob Marshall Wilderness

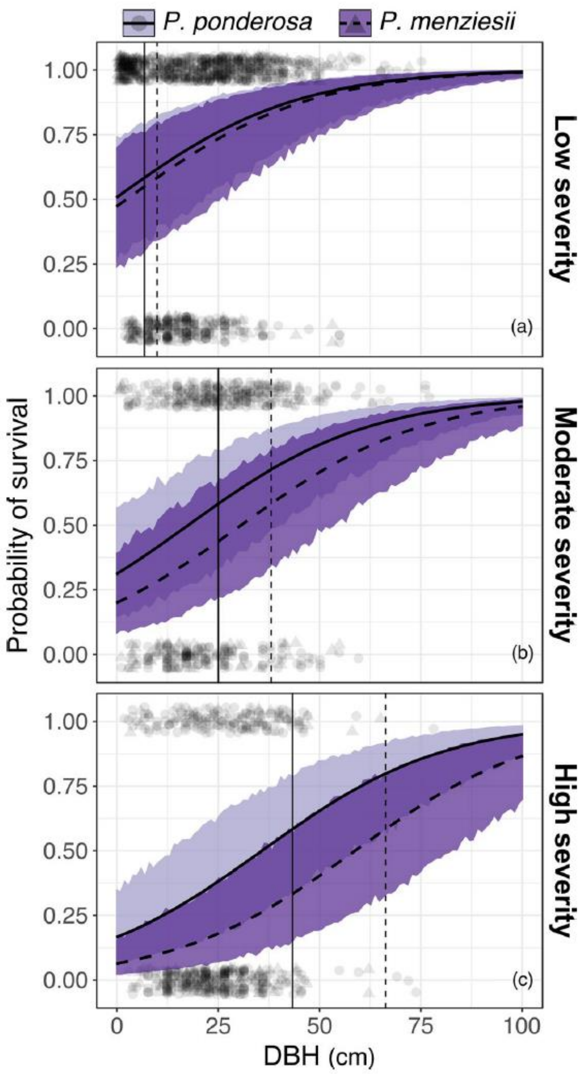
- Mortality of small diameter lodgepole & Doug-fir
- Consumption of coarse woody fuels from first fire
- Reduced duff mounds at base of large ponderosa



Larson et al. 2013
Ecological Applications

Increased fire frequency may favor certain species

Age to survival



Rodman et al. 2020 *J. of Ecology*

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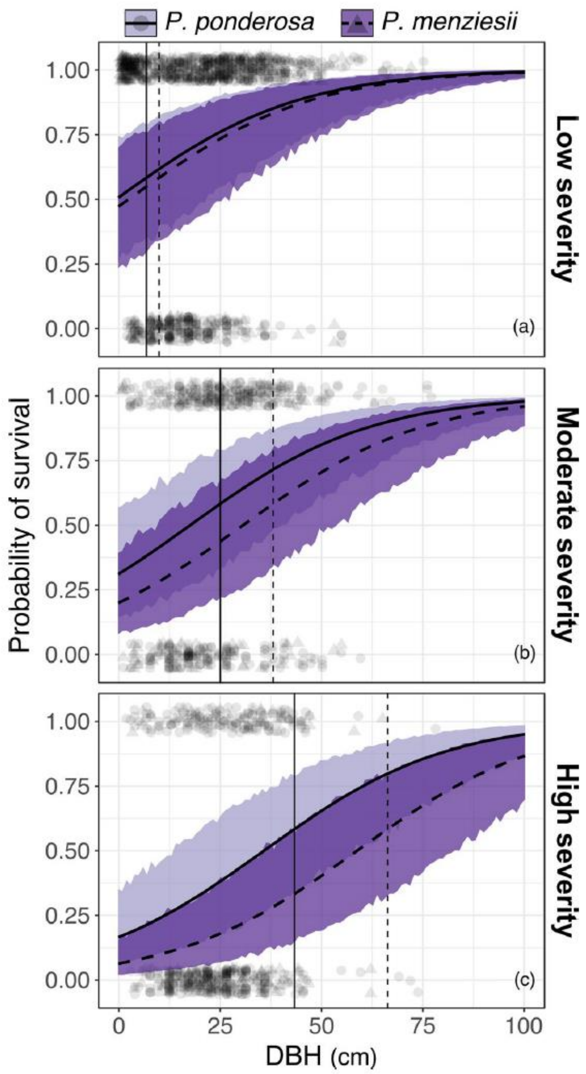

Age to maturity

Species	Age to maturity
Whitebark pine	20-30
Lodgepole pine	5-15
Limber pine	20-40
Rocky Mountain bristlecone pine	10-40
Western hemlock	25-30
Engelmann spruce	15-40
Blue spruce	20
Subalpine fir	20
Gambel oak	3-5
Aspen	2-3

Rodman et al. 2020 *J. of Ecology*

Hood et al. In Press

Changes in fire frequency

Photo: Brian Harvey

Short-interval fires

- Can affect microclimate, seed availability, tree regeneration
- Forest to non-forest conversions in some cases
- Less dense forests, potentially more resilient to future conditions in other cases
- Favor species that are quick to reproductive maturity

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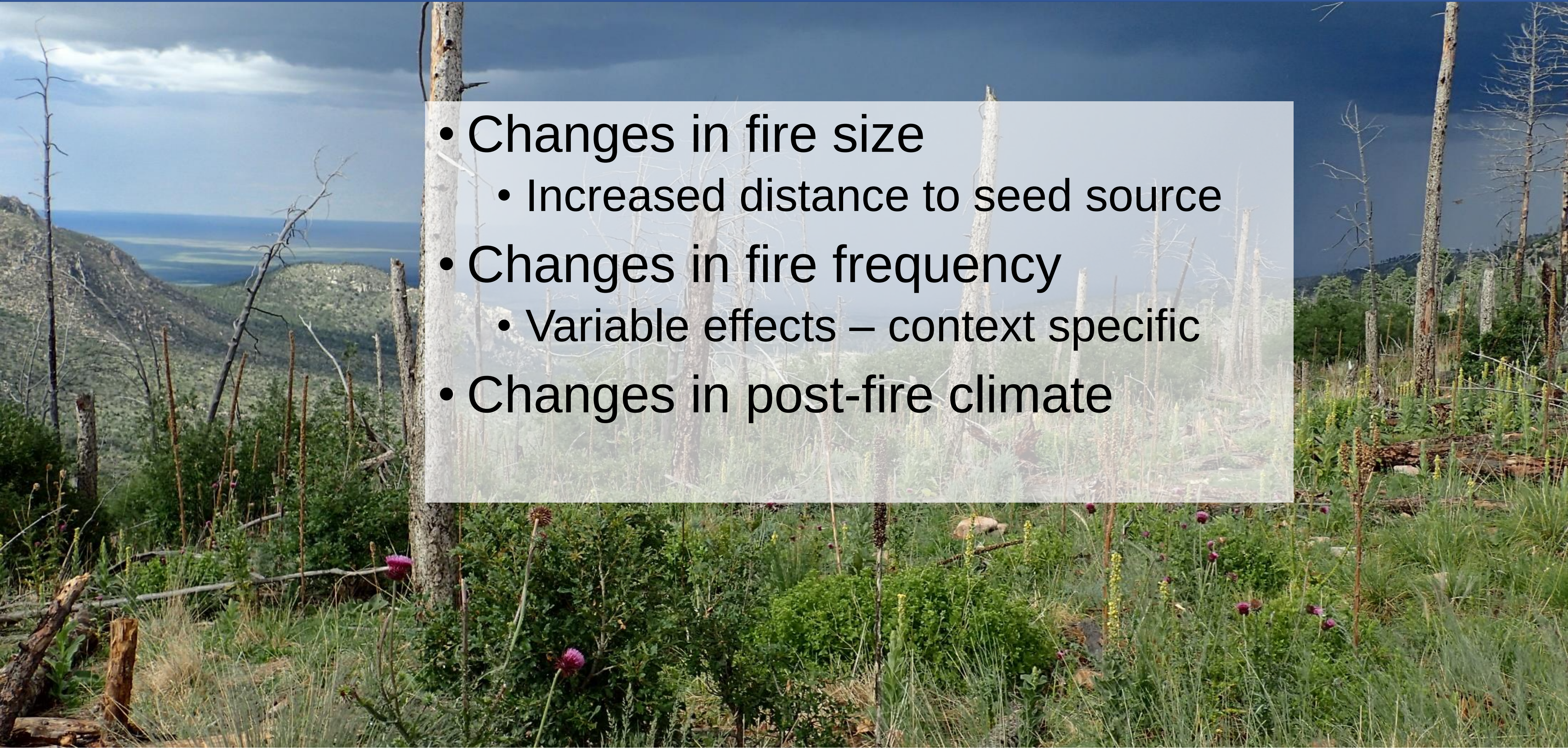

- Changes in fire size
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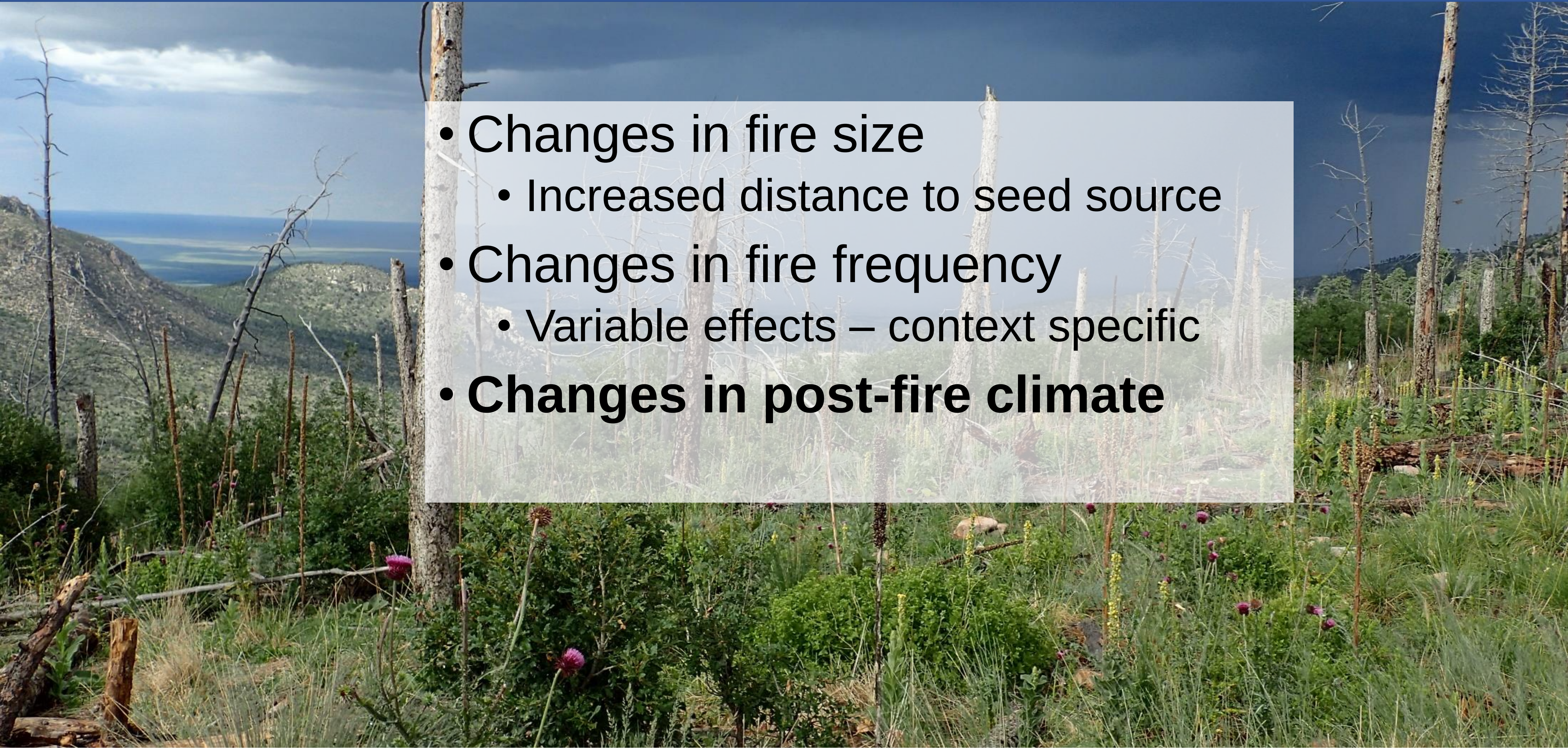
  - Variable effects – context specific
- Changes in post-fire climate

How will climate change impact post-fire vegetation?



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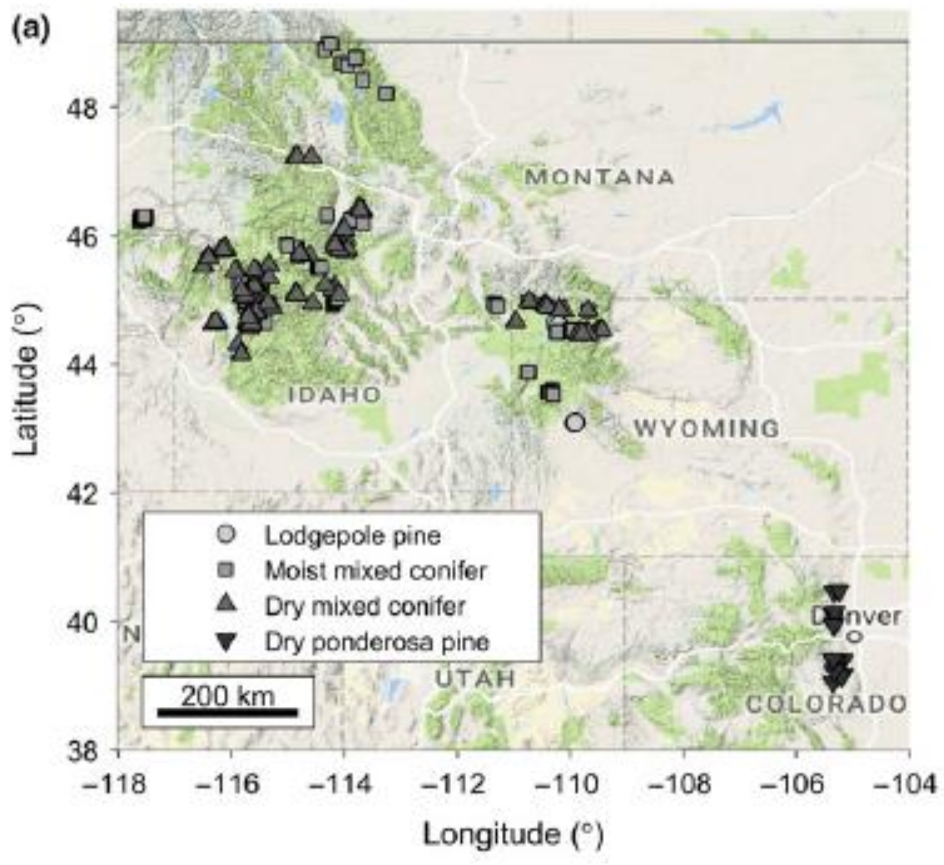
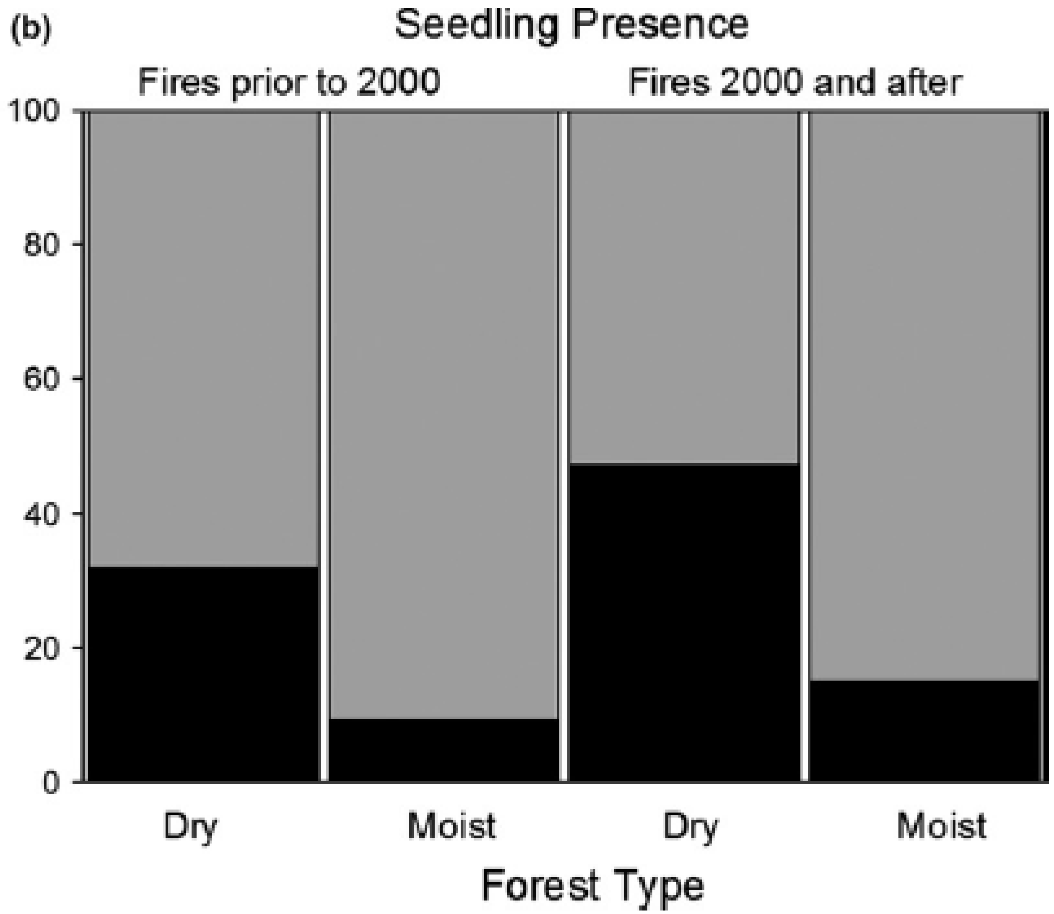
- **Changes in post-fire climate**

Dry forests less likely to have regeneration than moist forests





Stevens-Rumann et al. 2018 *Ecology Letters*

Climate will be increasingly important in N. Rockies

Climate will increasingly determine post-fire tree regeneration success in low-elevation forests, Northern Rockies, USA

Kerry B. Kemp,[1,4,†] Philip E. Higuera,[2] Penelope Morgan,[1] and John T. Abatzoglou[3]

- Hot summer temperatures and distance to seed source limit post-fire ponderosa pine and Douglas-fir regeneration.
- Post-fire regeneration densities are predicted to decline in future with warmer summer temperatures.

Kemp et al. 2019 *Ecosphere*

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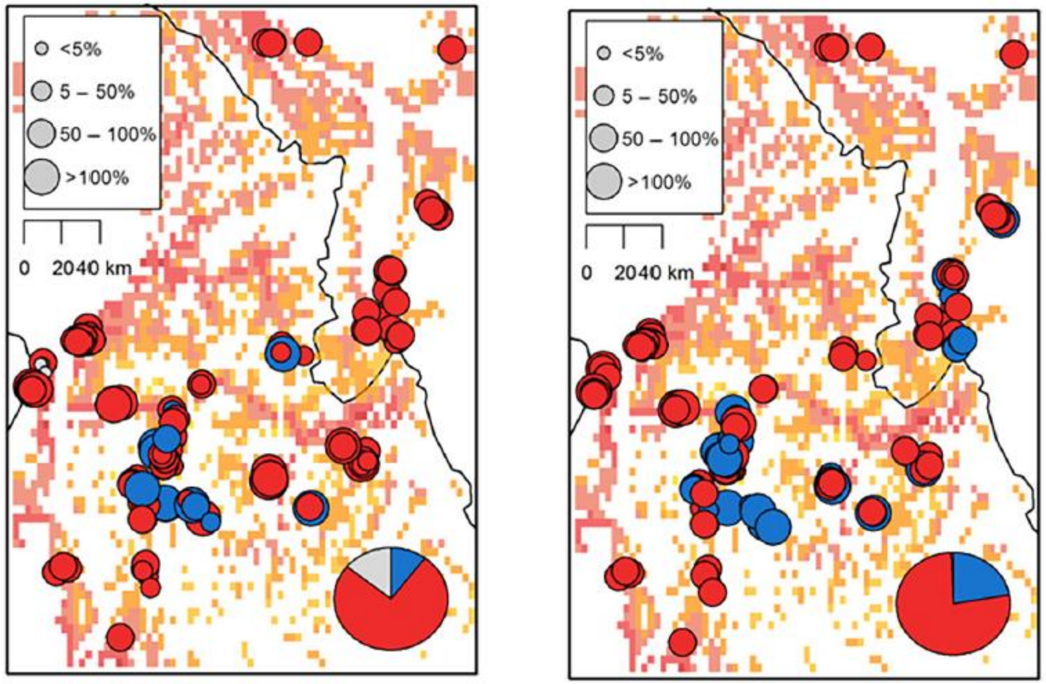
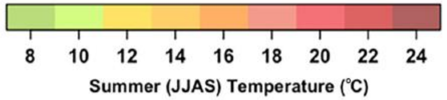
Change in recruitment densities
1981-2010 to 2041-2070 (RCP 8.5)



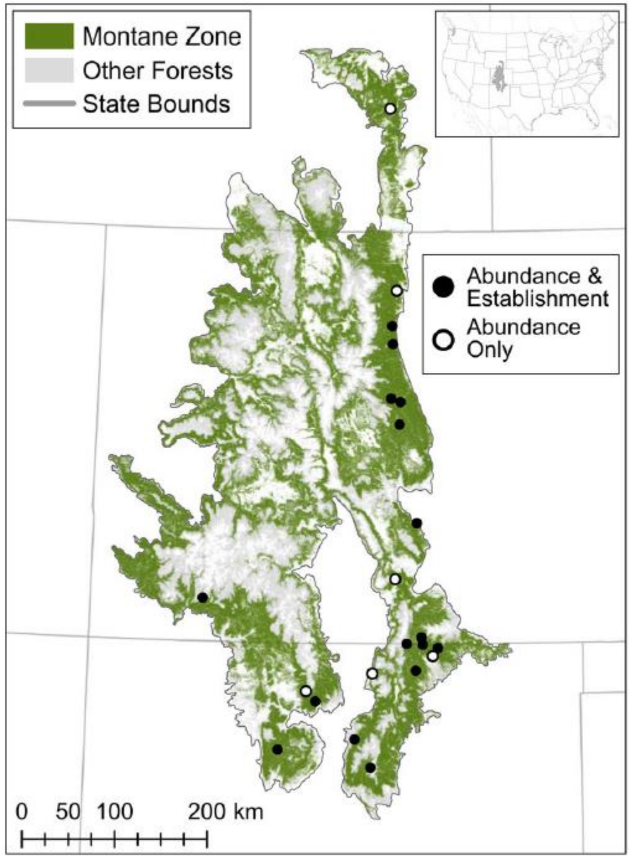
Ponderosa Doug-fir

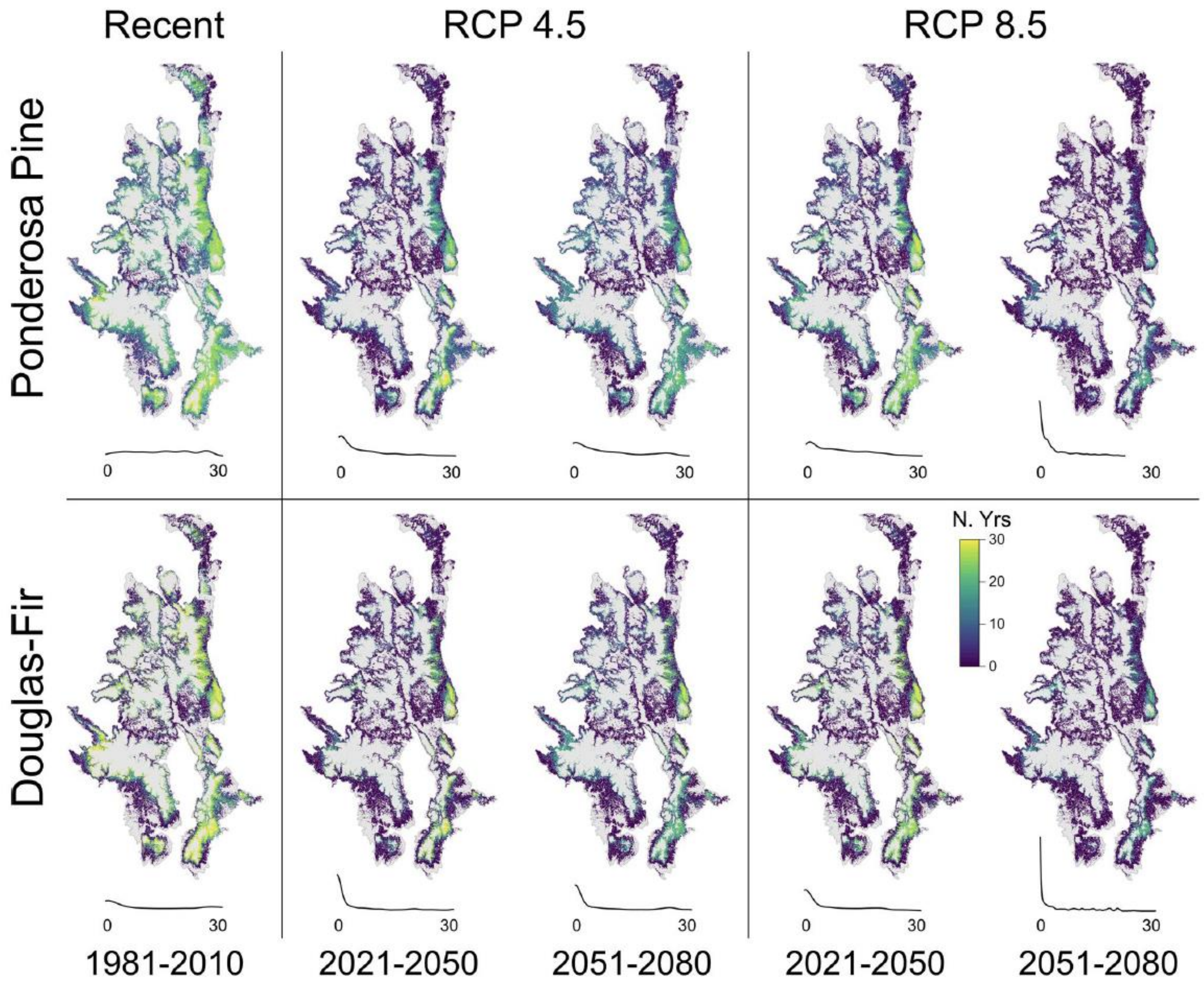


Kemp et al. 2019 *Ecosphere*

Climate will limit regeneration in S. Rockies

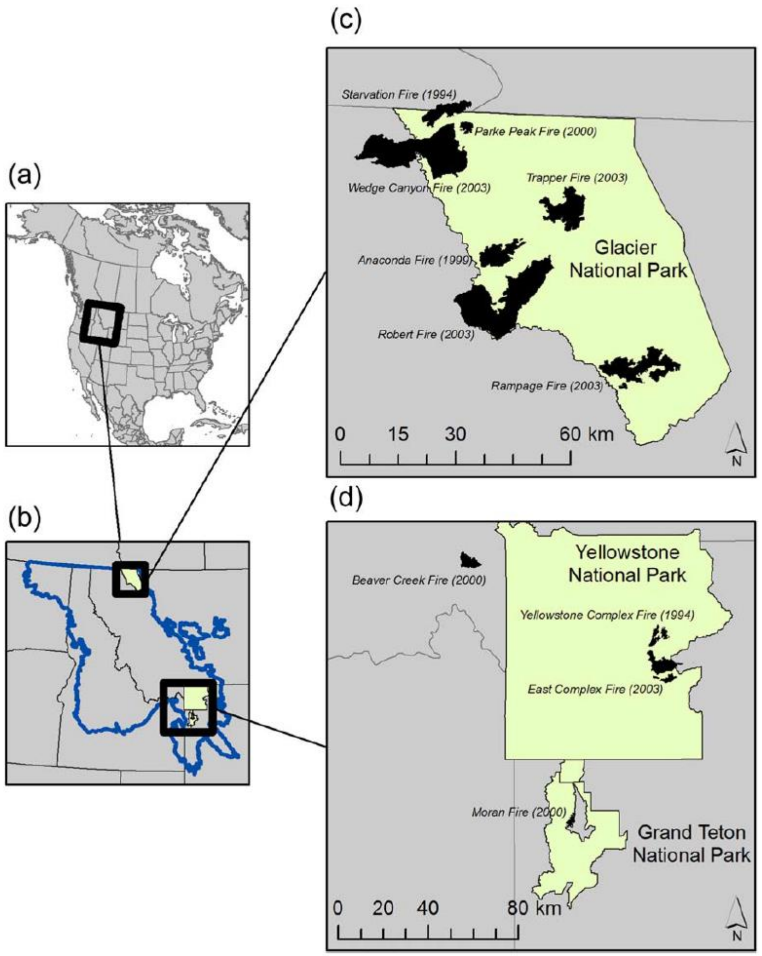
Number of years that exceed 19th-century tree density thresholds (50 PIPO/ha; 15 PSME/ha)

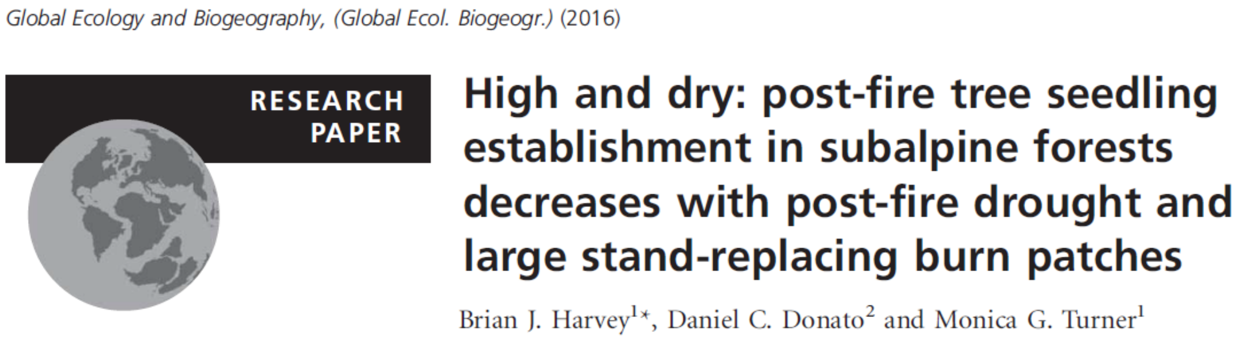




Rodman et al. 2020 *Global Ecology and Biogeography*

Climate impacts on subalpine forest regeneration




Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2016)

RESEARCH PAPER

High and dry: post-fire tree seedling establishment in subalpine forests decreases with post-fire drought and large stand-replacing burn patches

Brian J. Harvey[1]*, Daniel C. Donato[2] and Monica G. Turner[1]

- Post-fire subalpine fir and Engelmann spruce regeneration declined with increased post-fire drought

Harvey et al. 2016 *Global Ecology and Biogeography*

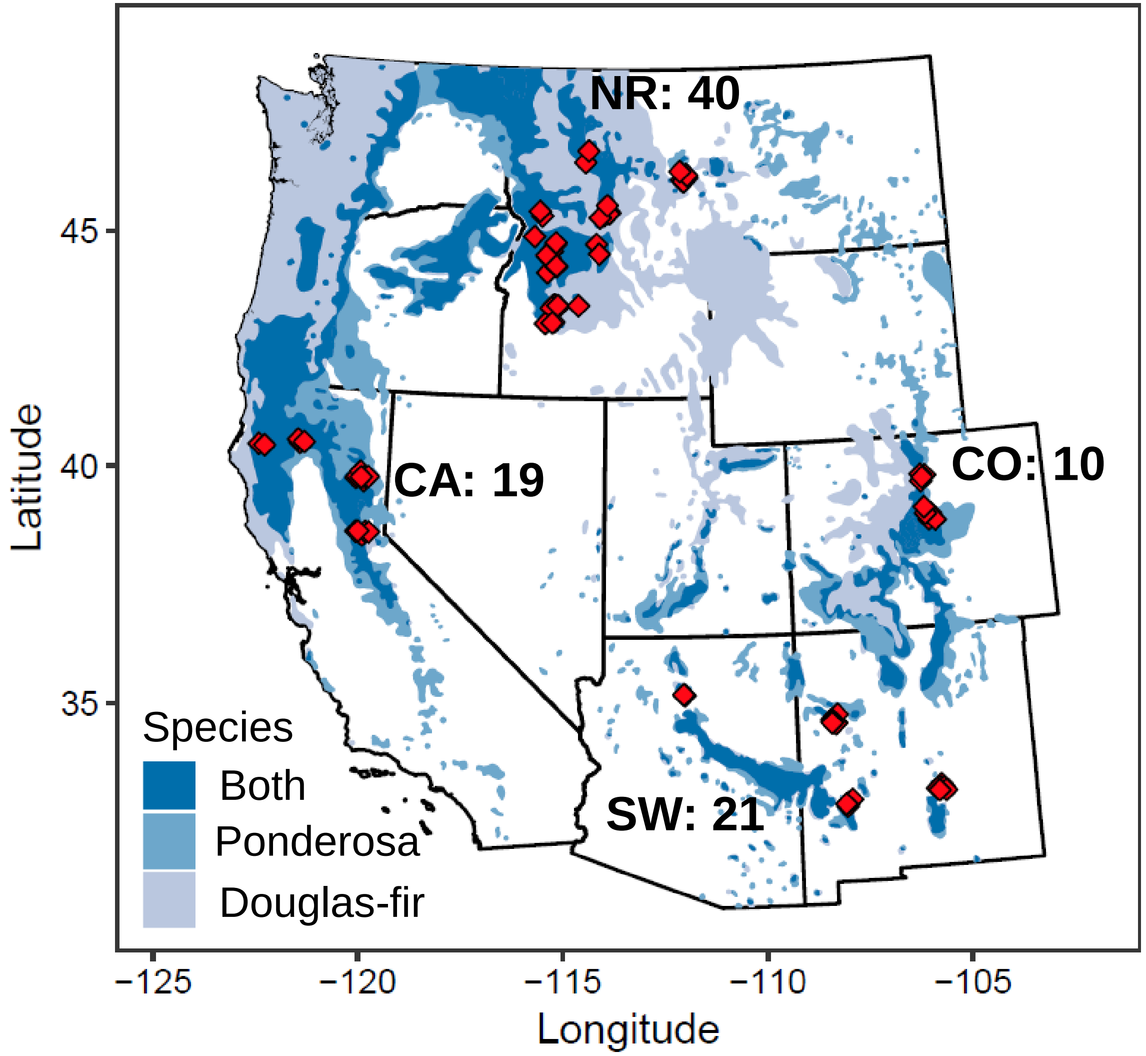
Climate impacts: experimental evidence


Open topped chambers (OTCs) in Colorado Front Range (Monica Rother)

- Reduced regeneration seen in warming treatments for ponderosa pine, Douglas fir, lodgepole pine, Engelmann spruce.

Rother et al. 2015; Kueppers et al. 2016; Conlisk et al. 2017; Hansen & Turner 2018

Annual climate & post-fire regeneration study

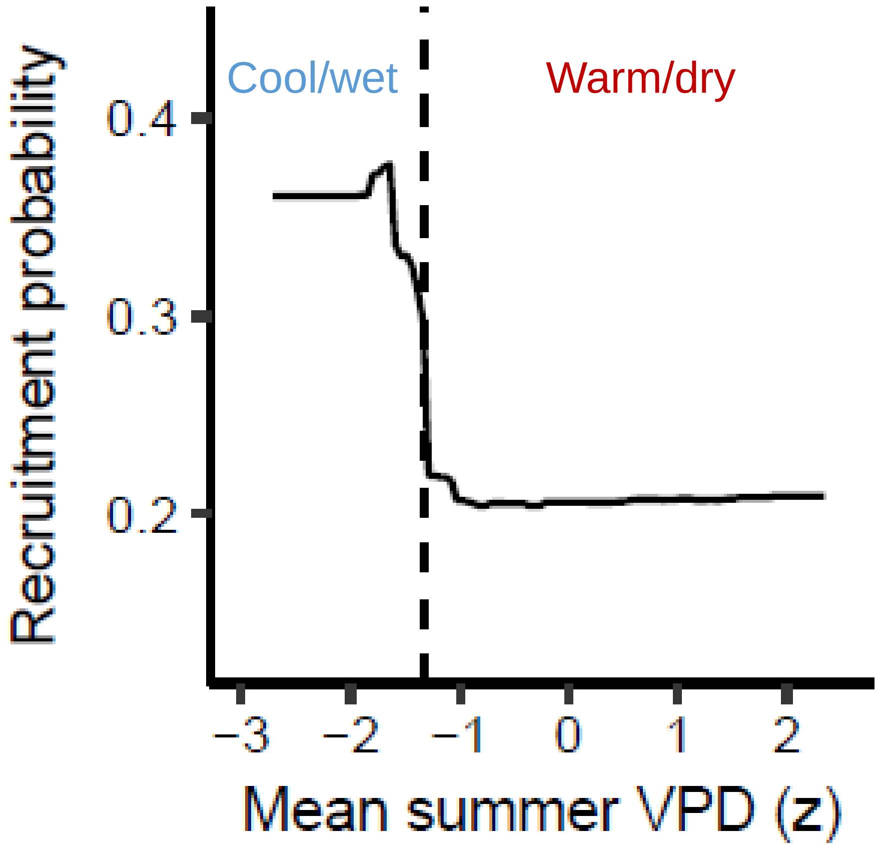





CO data: [Rother & Veblen 2017]
[Davis et al. 2019 *PNAS*]

Recruitment-climate relationships have thresholds

Ponderosa pine



Davis et al. 2019 *PNAS*

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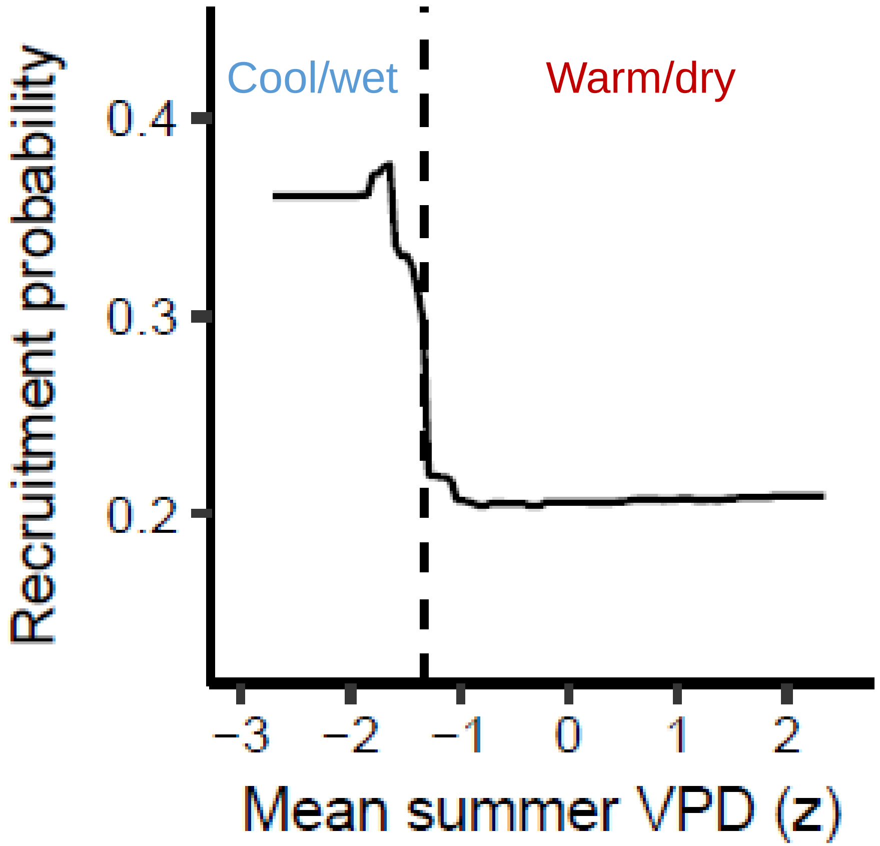
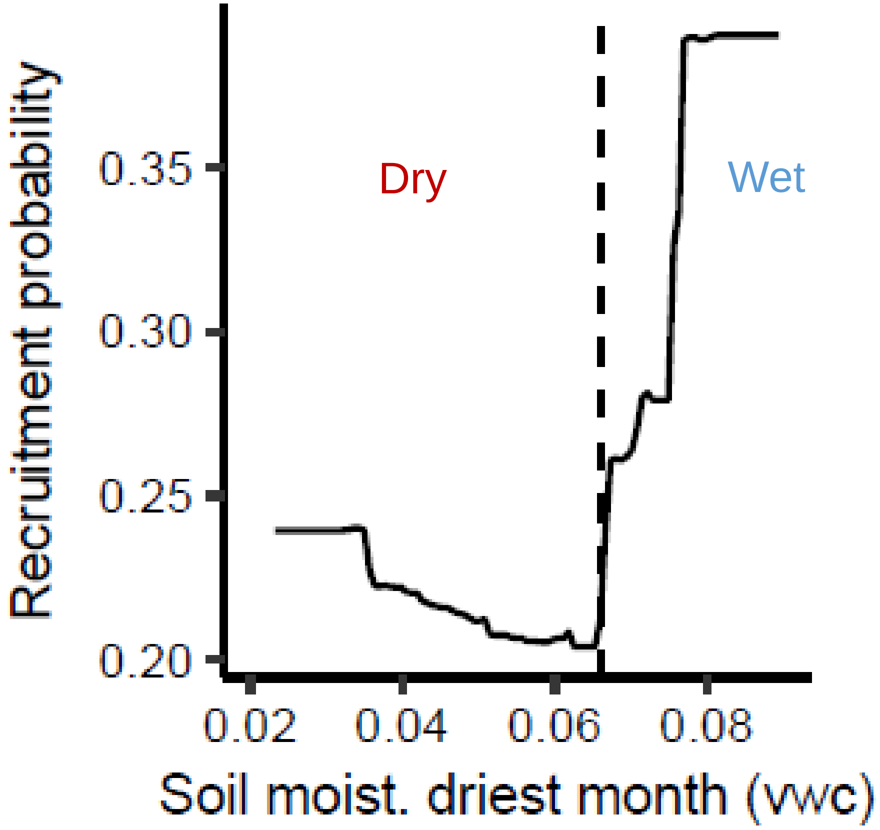
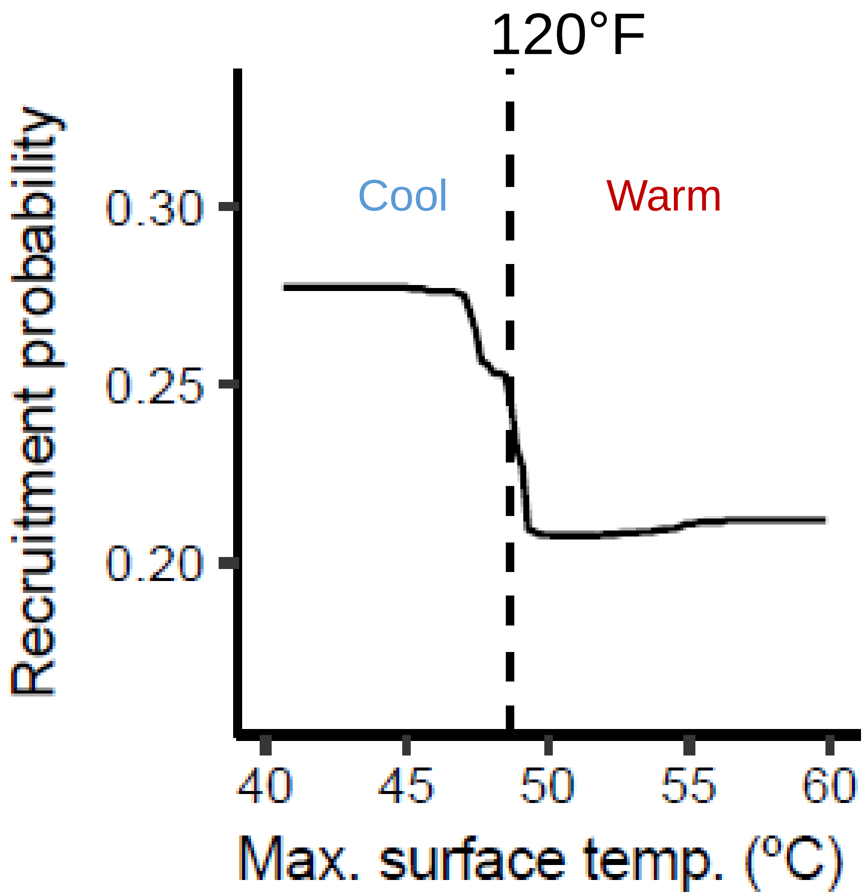


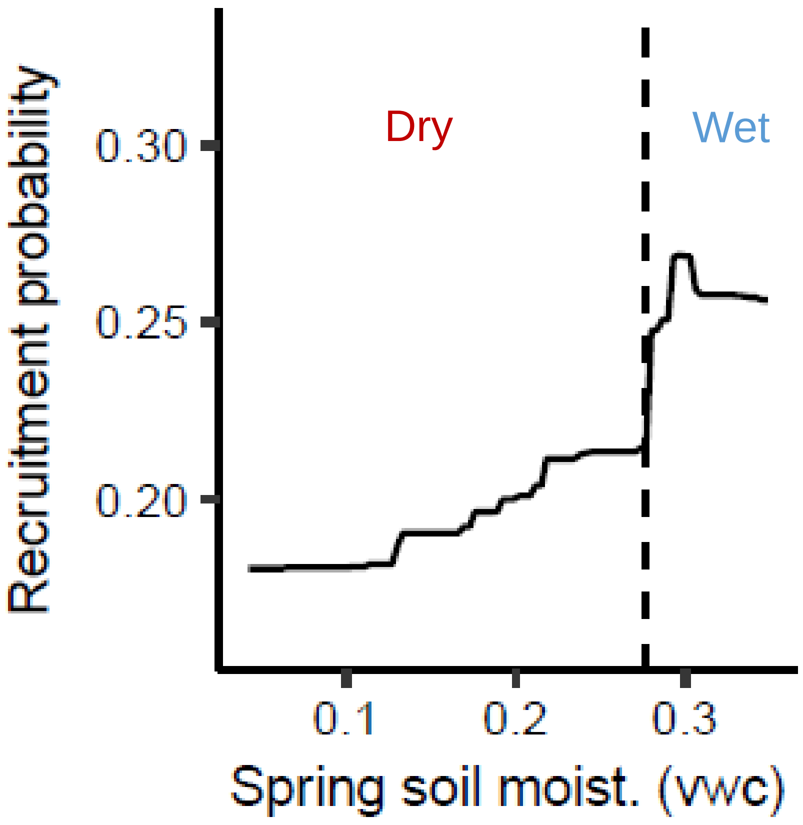


Davis et al. 2019 *PNAS*

Recruitment-climate relationships have thresholds

Douglas-fir

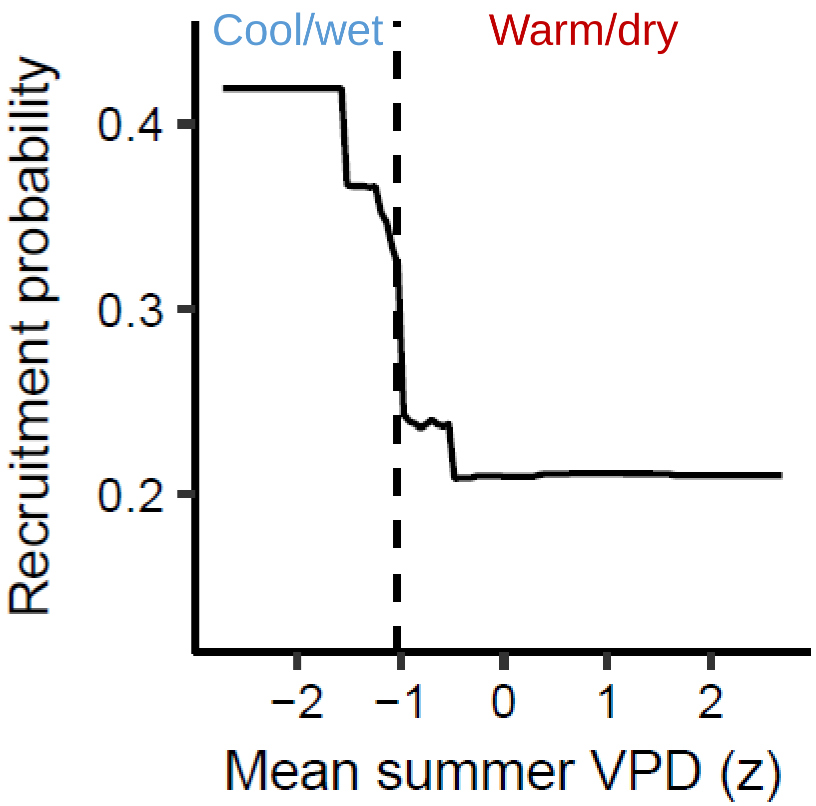


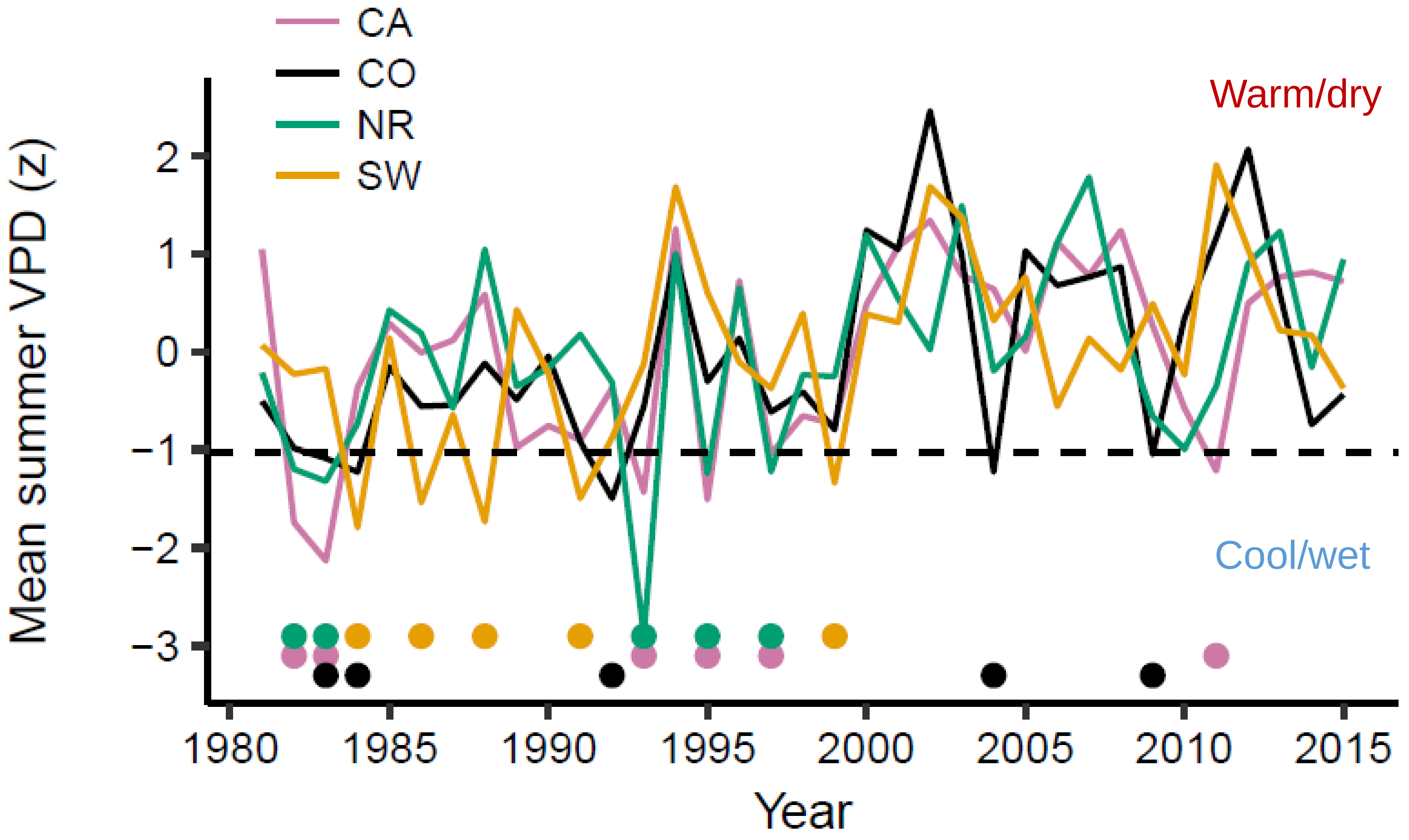


Davis et al. 2019 *PNAS*

Climatic thresholds crossed in recent decades

Ponderosa pine

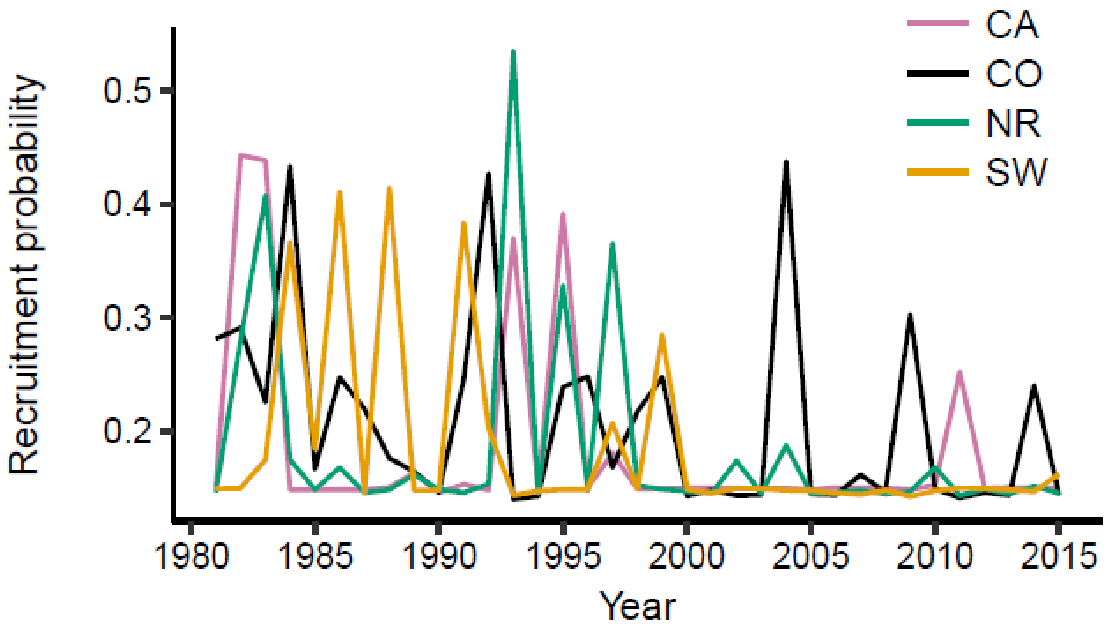




Davis et al. 2019 *PNAS*

Recruitment probability declined in recent decades

Ponderosa pine



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Davis et al. 2019 *PNAS*

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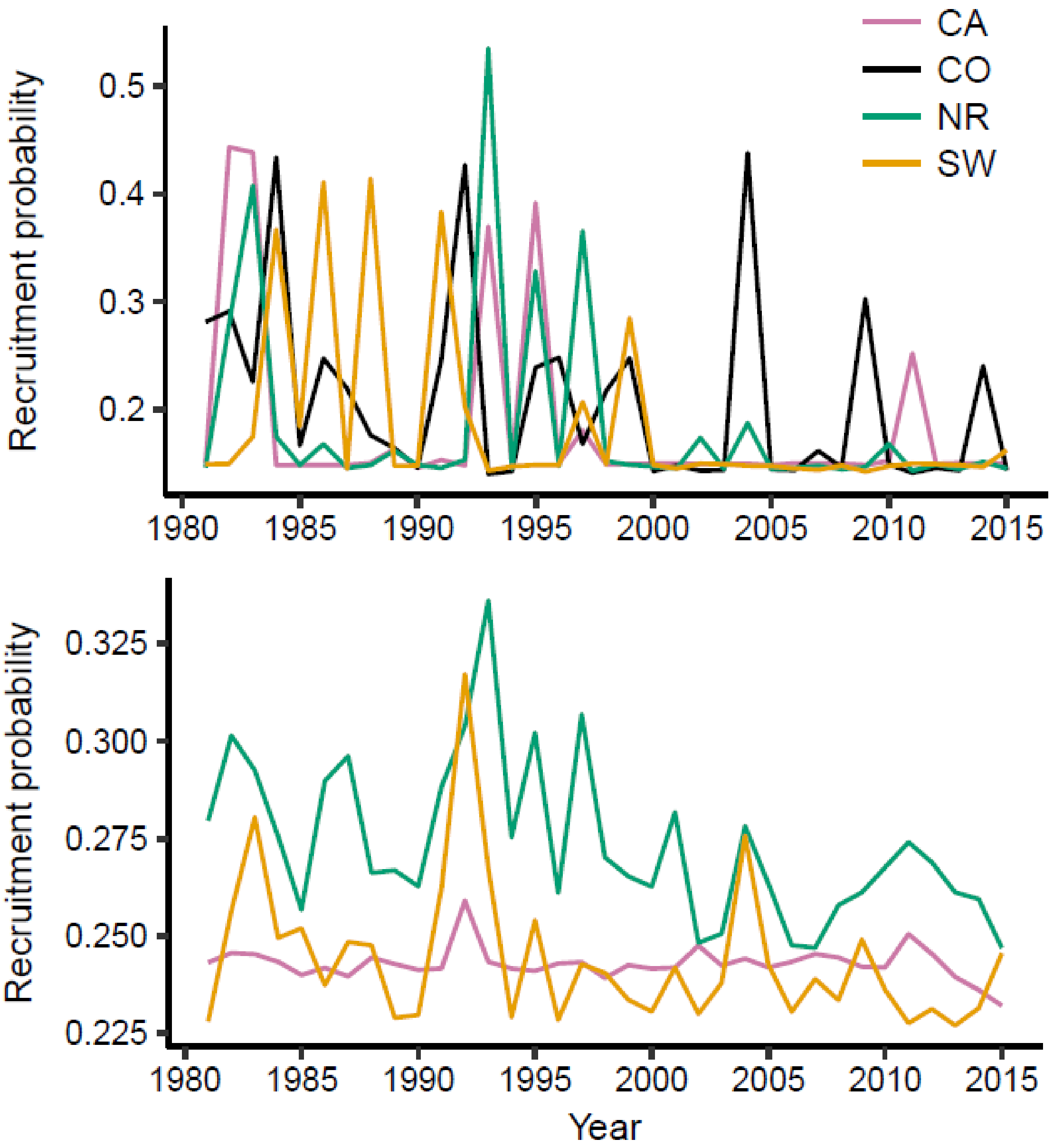
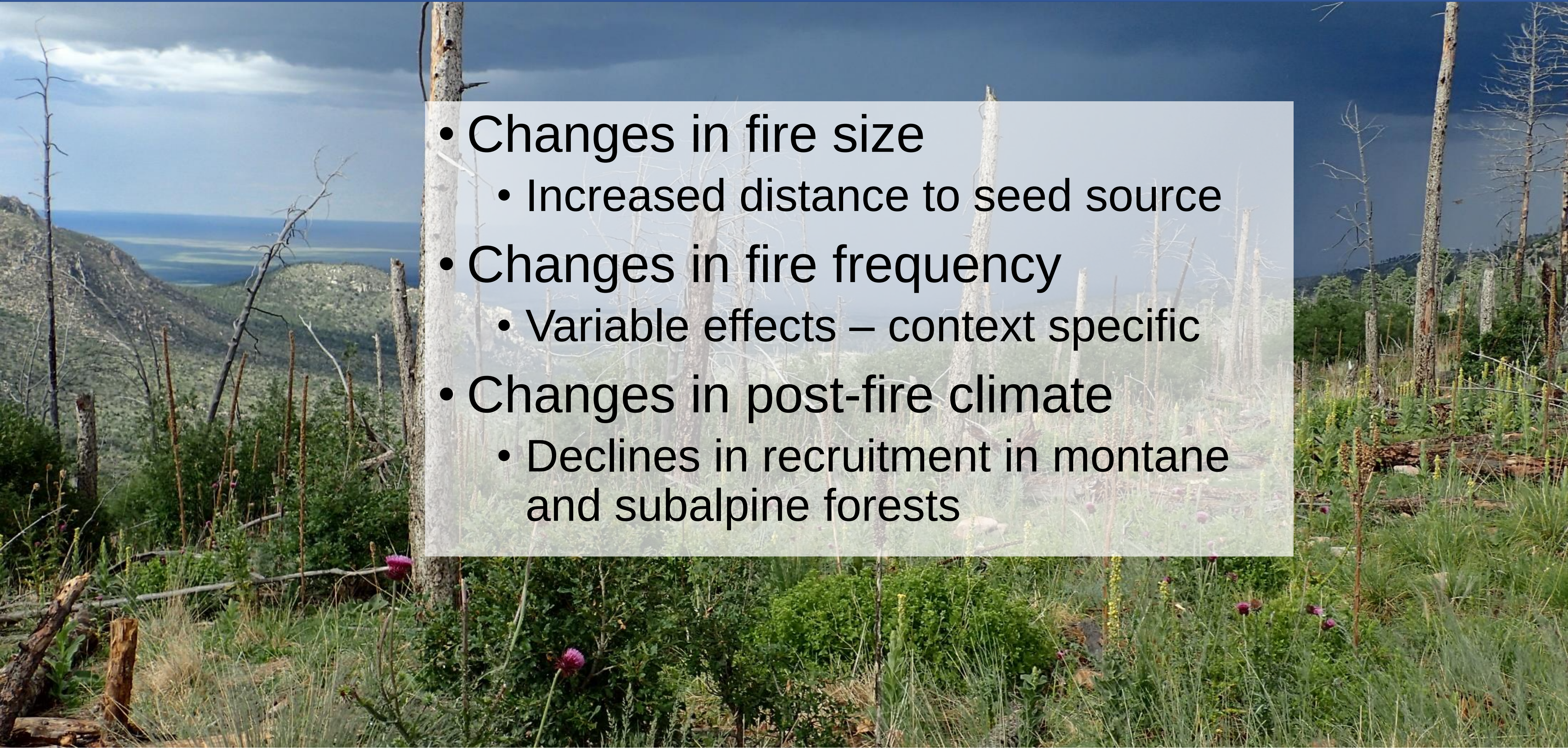


Davis et al. 2019 *PNAS*

How will climate change impact post-fire vegetation?

- Changes in fire size
  - Increased distance to seed source
- Changes in fire frequency
  - Variable effects – context specific
- Changes in post-fire climate
  - Declines in recruitment in montane and subalpine forests



How will climate change impact post-fire vegetation?

- Other disturbances – insects, drought, blowdown

Populus tremuloides seedling establishment: An underexplored vector for forest type conversion after multiple disturbances

Nathan S. Gill[a,b,*], Florencia Sangermano[a,c], Brian Buma[d], Dominik Kulakowski[a]

esa ECOSPHERE

Future dominance by quaking aspen expected following short-interval, compounded disturbance interaction

Robert A. Andrus[1,2,†], Sarah J. Hart[2], Niko Tutland,[2] and Thomas T. Veblen[1]

Journal of Vegetation Science **24** (2013) 168–176

Compounded disturbances in sub-alpine forests in western Colorado favour future dominance by quaking aspen (*Populus tremuloides*)

Dominik Kulakowski, Carolyn Matthews, Daniel Jarvis & Thomas T. Veblen

Future conditions will favor species that:

- Resprout following fire

Davis et al. 2018 *Functional Ecology*

Future conditions will favor species that:

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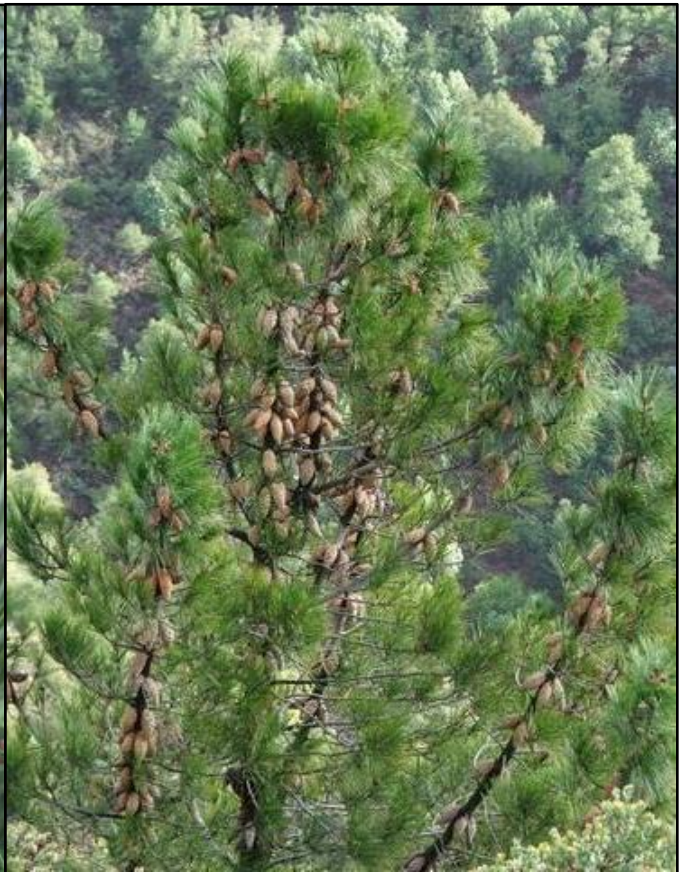
- Maintain canopy or soil seedbanks



Davis et al. 2018

Future conditions will favor species that:

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Davis et al. 2018 *Functional Ecology*

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- Resprout following fire
- Maintain canopy or soil seedbanks
- Have long distance seed dispersal
- Produce drought-tolerant seedlings

Davis et al. 2018 *Functional Ecology*

Future conditions will favor species that:

- Resprout following fire
- Maintain canopy or soil seedbanks
- Have long distance seed dispersal
- Produce drought-tolerant seedlings
- Reach reproductive maturity quickly

Davis et al. 2018 *Functional Ecology*

Questions?

Canyon Ferry Complex Fire, 2000
Helena National Forest, MT
Photo year : 2017