

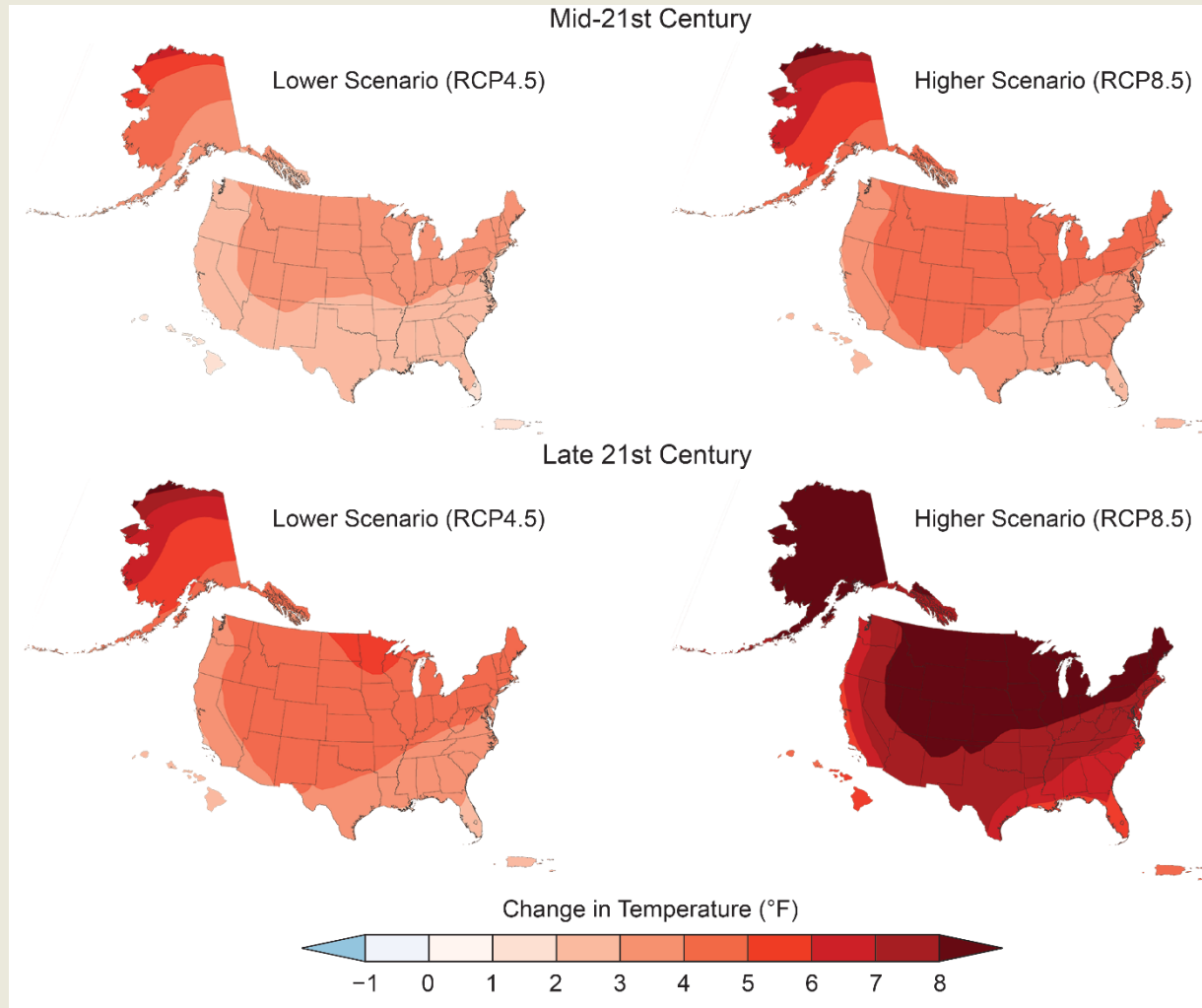
Effects of climate change and shifting disturbance regimes on wildlife habitat in the western United States



Jessica E. Halofsky

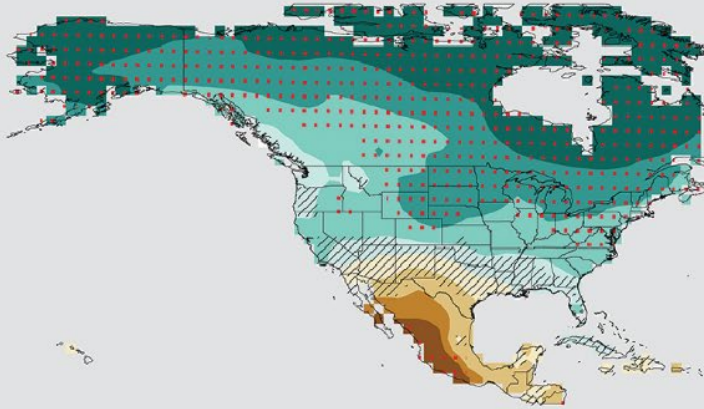
*USDA Forest Service, Northwest Climate Hub and
Western Wildland Environmental Threat Assessment
Center*

Temperatures will continue to increase in the coming century

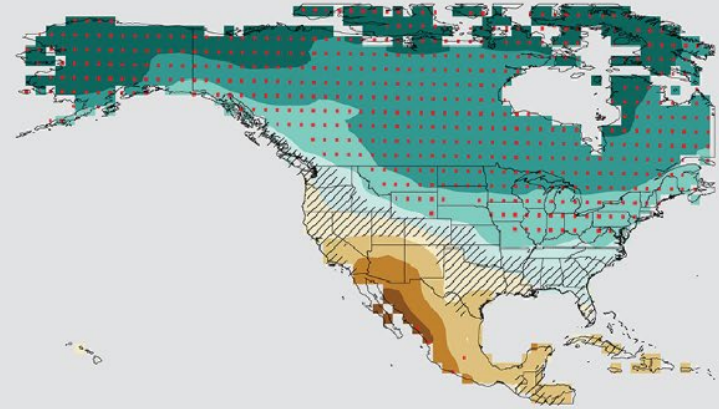


Projected Change (%) in Seasonal Precipitation

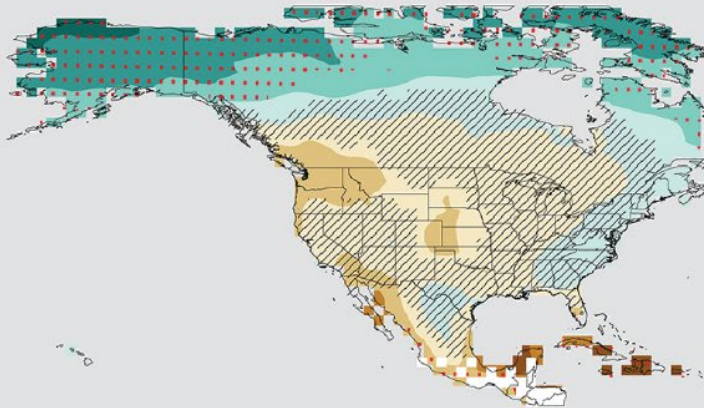
Winter



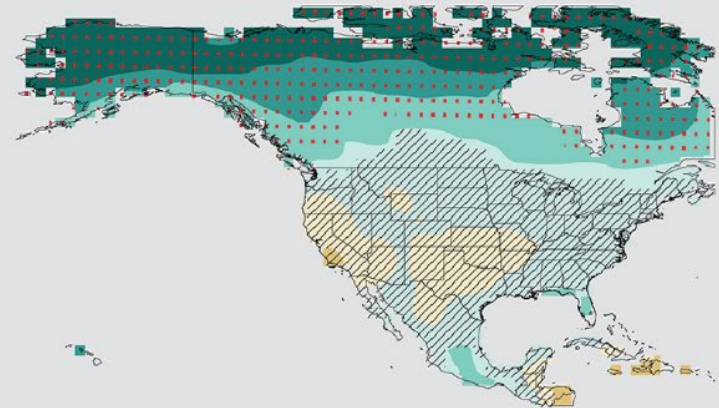
Spring



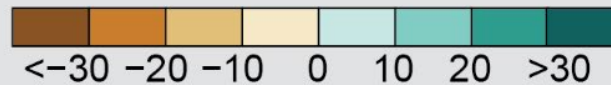
Summer



Fall

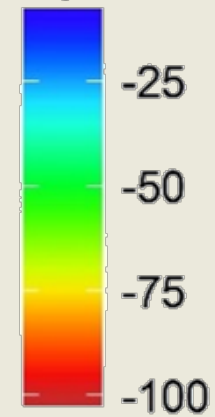


Change (%)



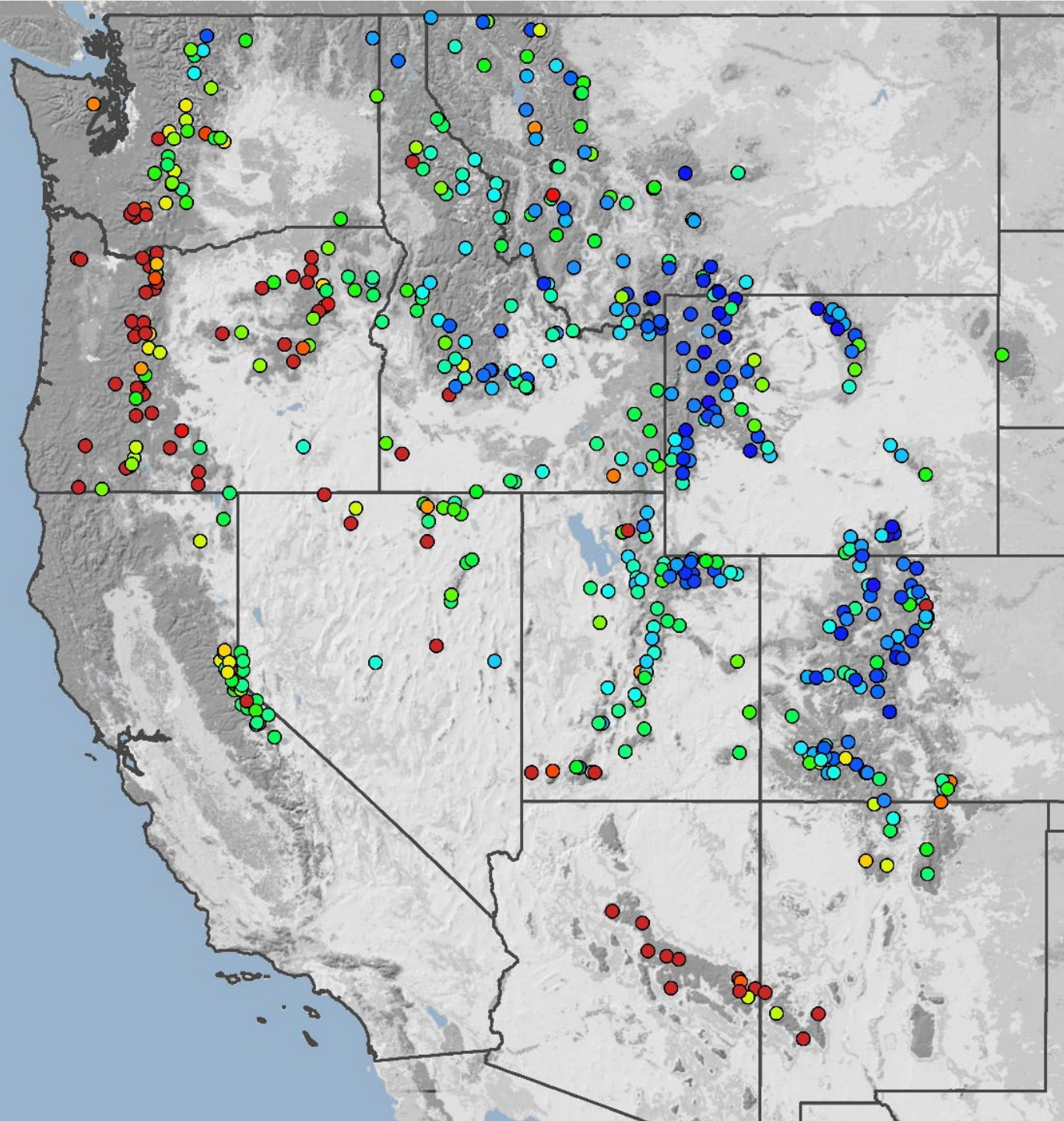
Snowpack Sensitivity

Percent Change
April 1 SWE

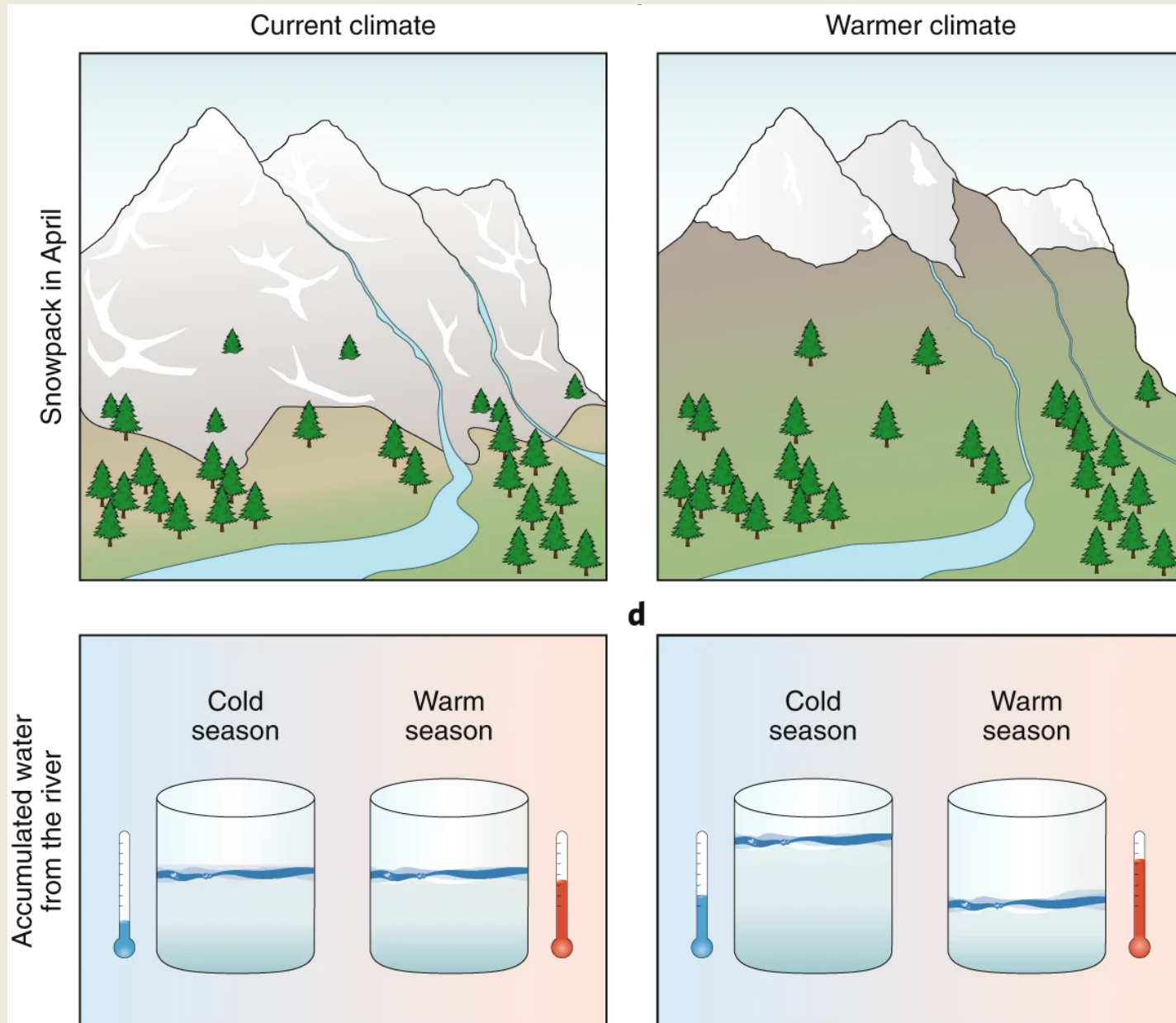


3°C
Temperature
Increase

Data from C. Luce



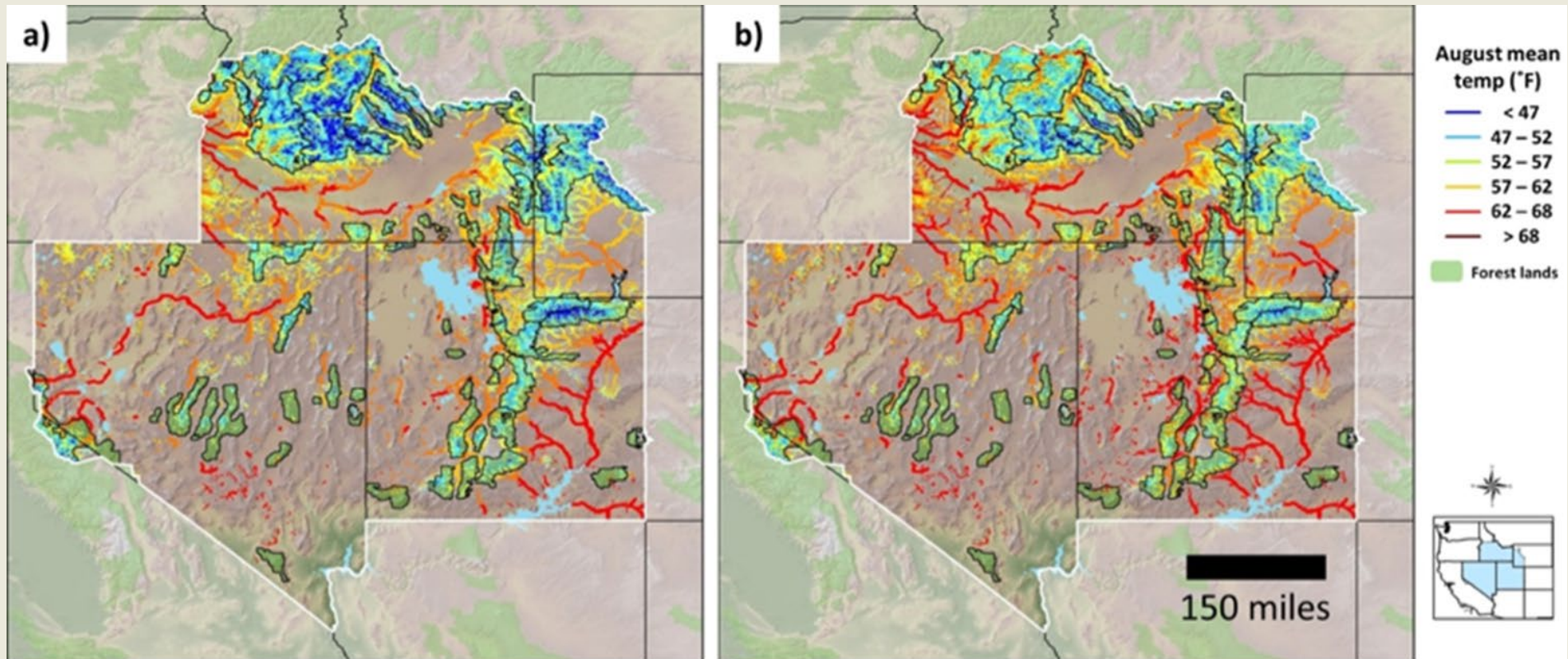
Effects of snowpack loss on streamflow



Higher temperatures will stress cold-water adapted fish

Historical (2000s)

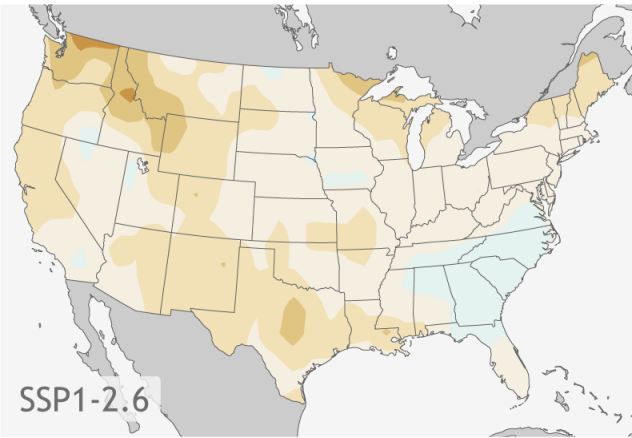
Projected future (2080s)



Risk of drought will increase

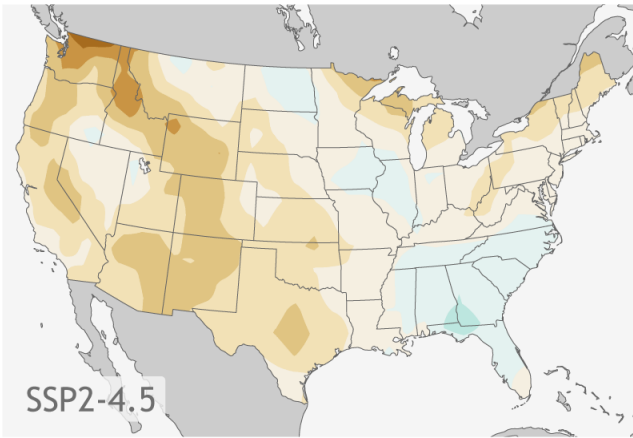
Change in summer soil moisture, late 21st century

Low emissions

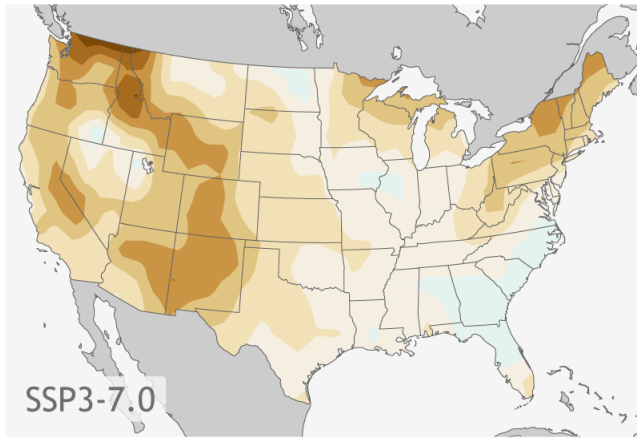


2071-2100
compared to 1971-2000

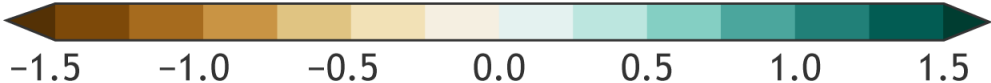
Intermediate emissions



High emissions



difference from average (z-score)
drier *wetter*



NOAA Climate Program Office
Data: Cook et al. 2021

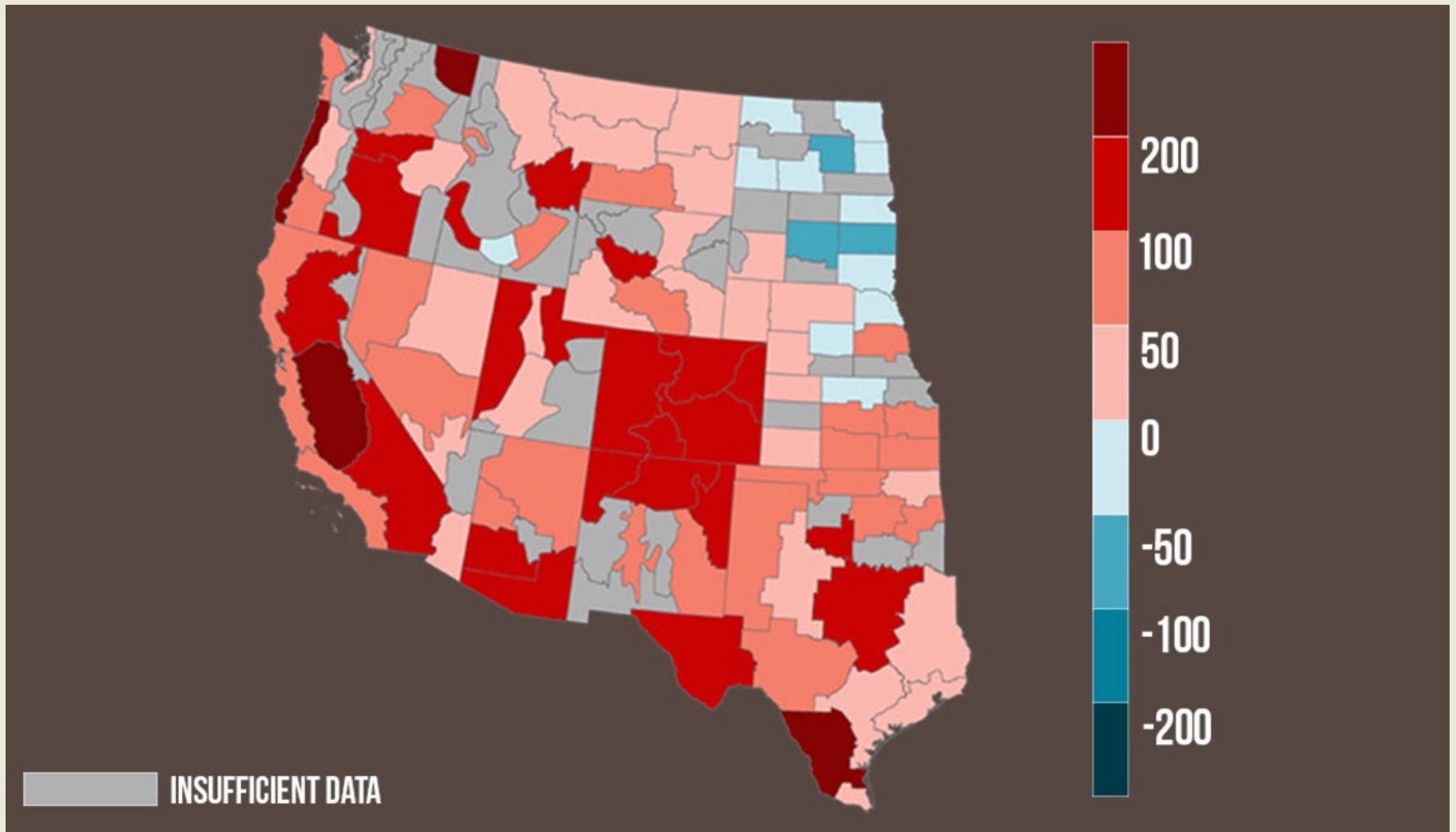
Several weeks of high temperature and low rainfall are sufficient to dry fuels and cause extreme fire hazard.



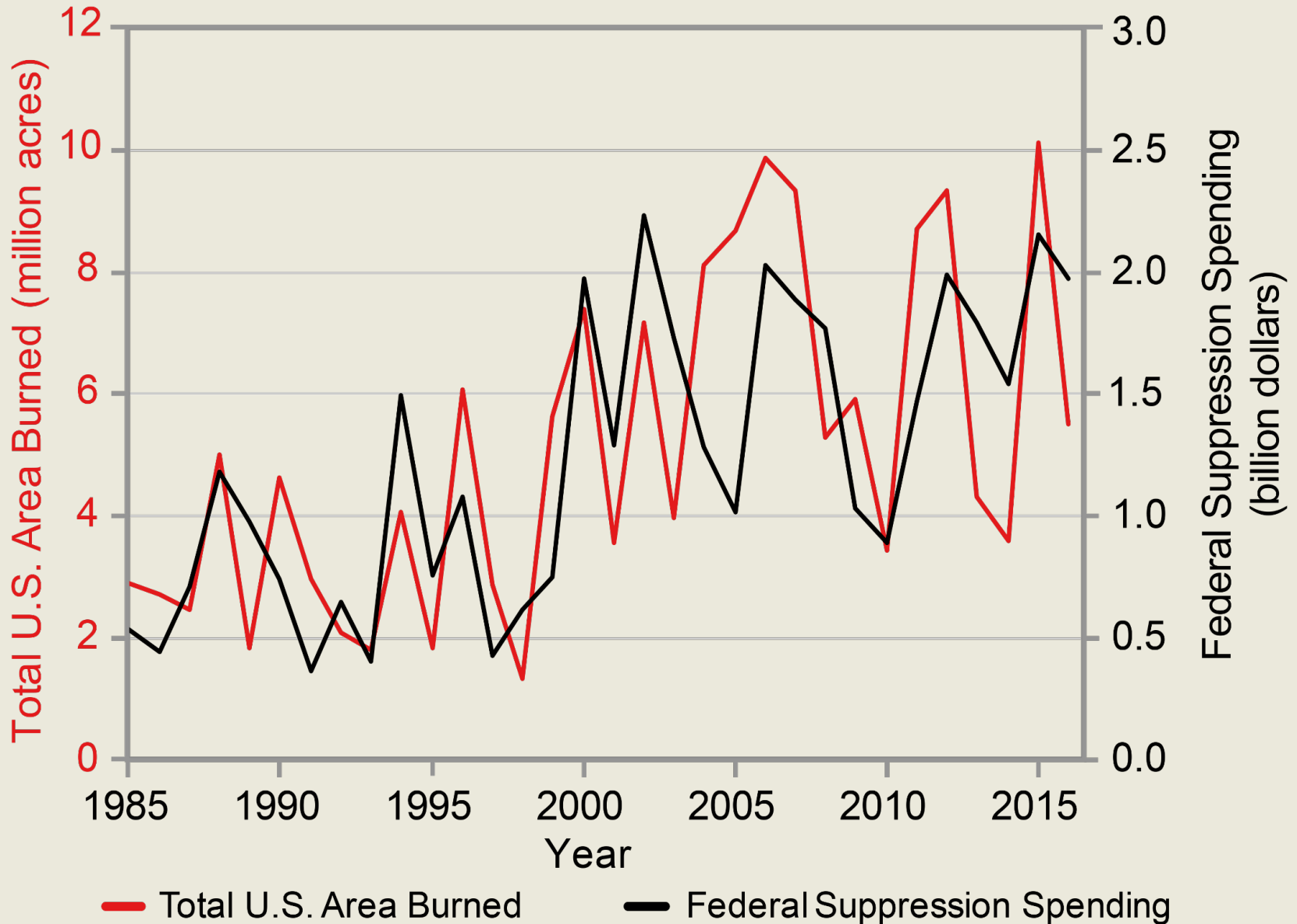
Earlier and longer periods of dry fuels are affected by multiple factors

Change in fire weather days

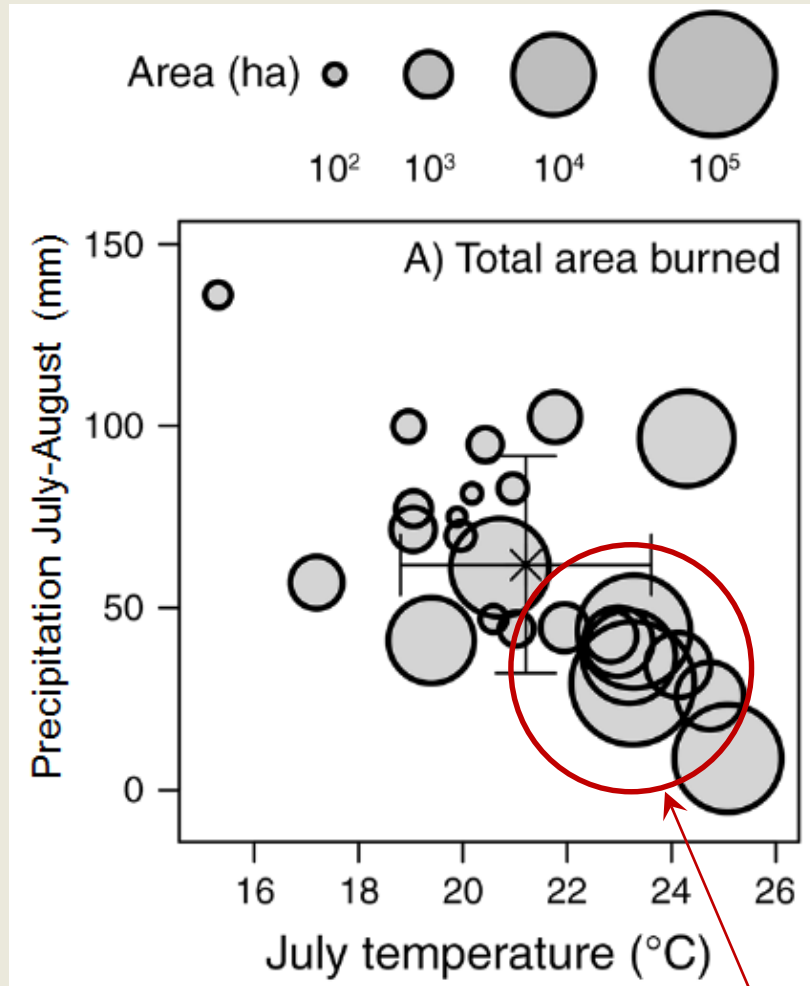
(% change from 1973 to 2020)



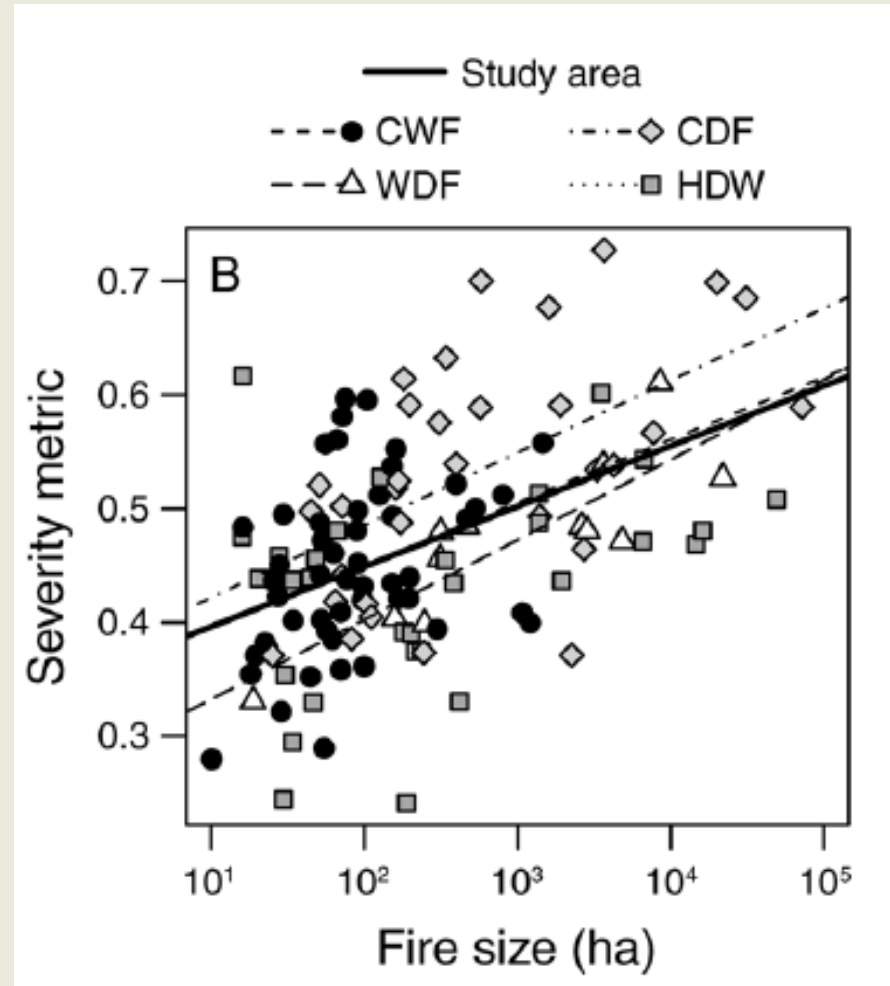
Total area burned and suppression spending have increased in the U.S.



Increasing fire size with warmer, drier summers, and increasing severity with fire size



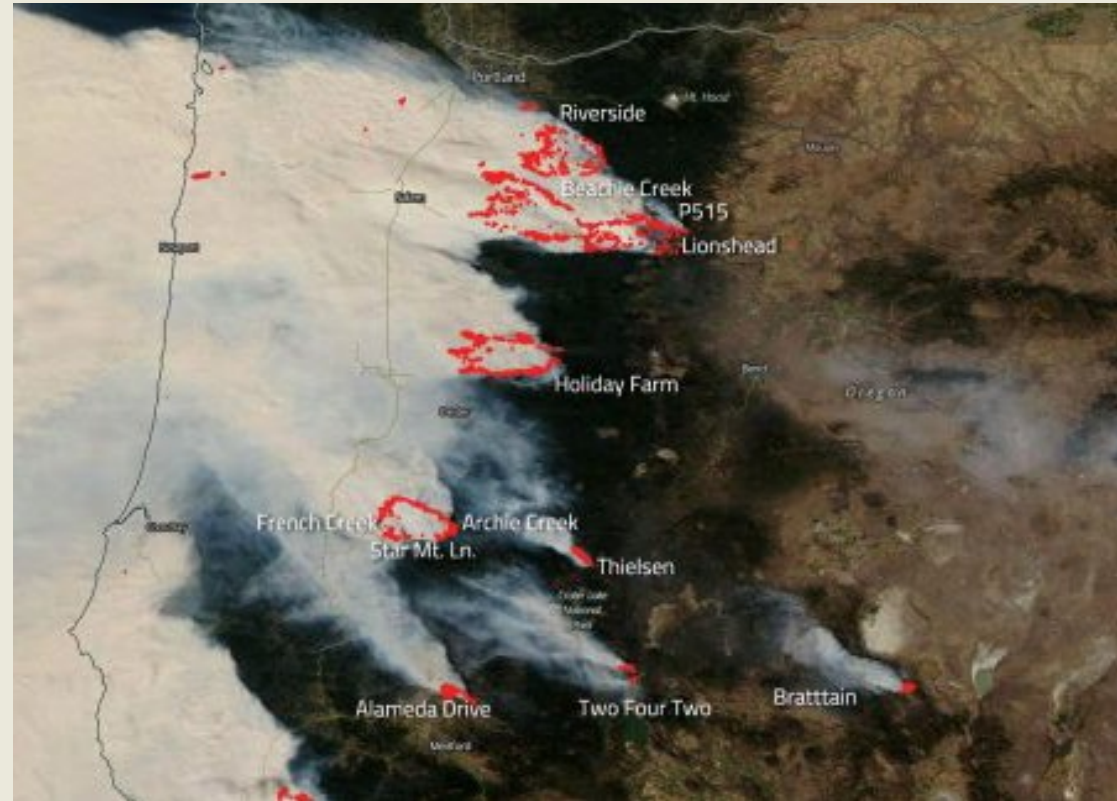
Larger fires



Climatic change and regional wildfires

Oregon, September, 2020

- As temperature increases, more water evaporates from the landscape and plant tissues
- Larger areas of low fuel moisture
- Regional synchronization of fires occurs

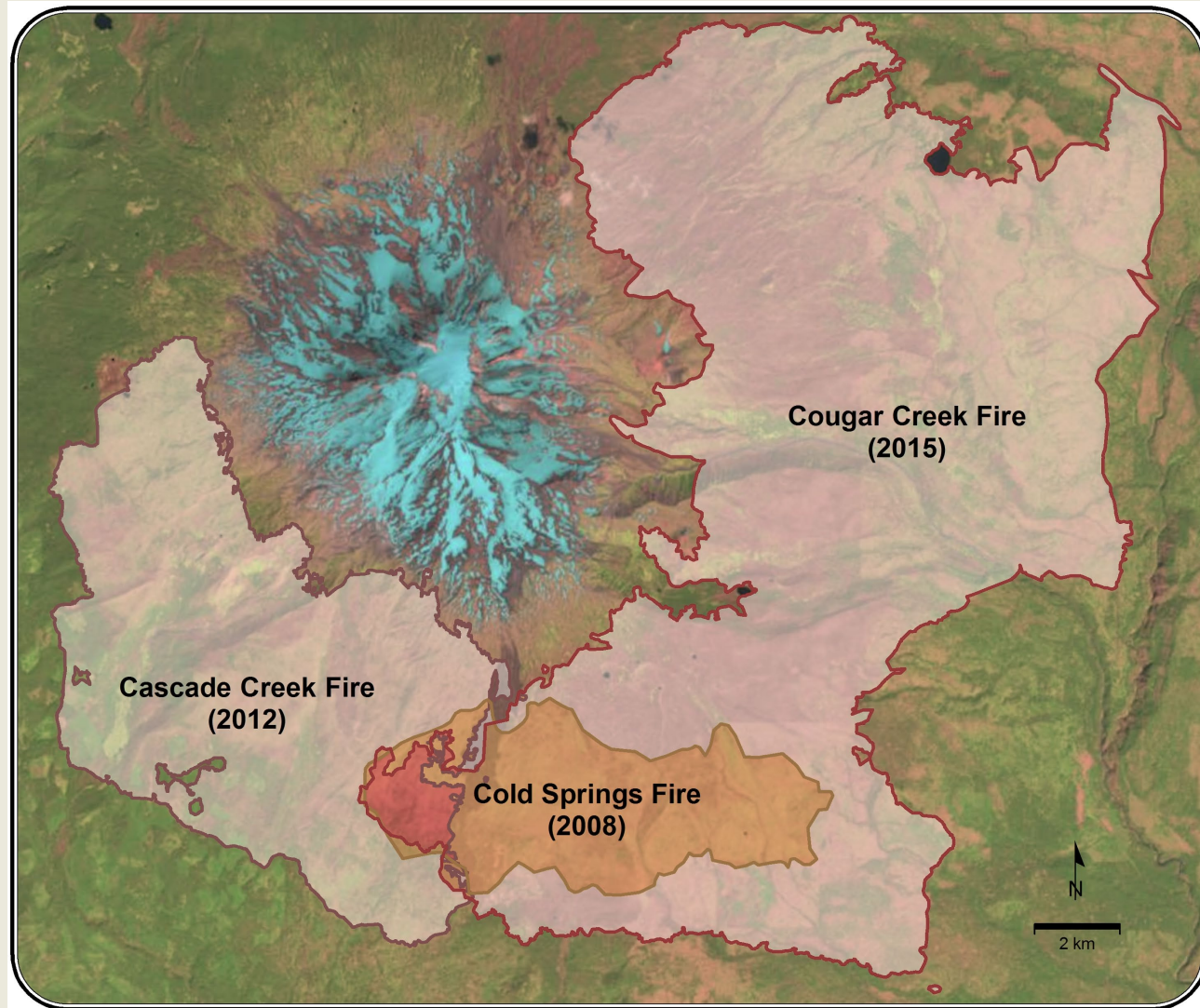


MODIS, NASA

Wildfires are colliding

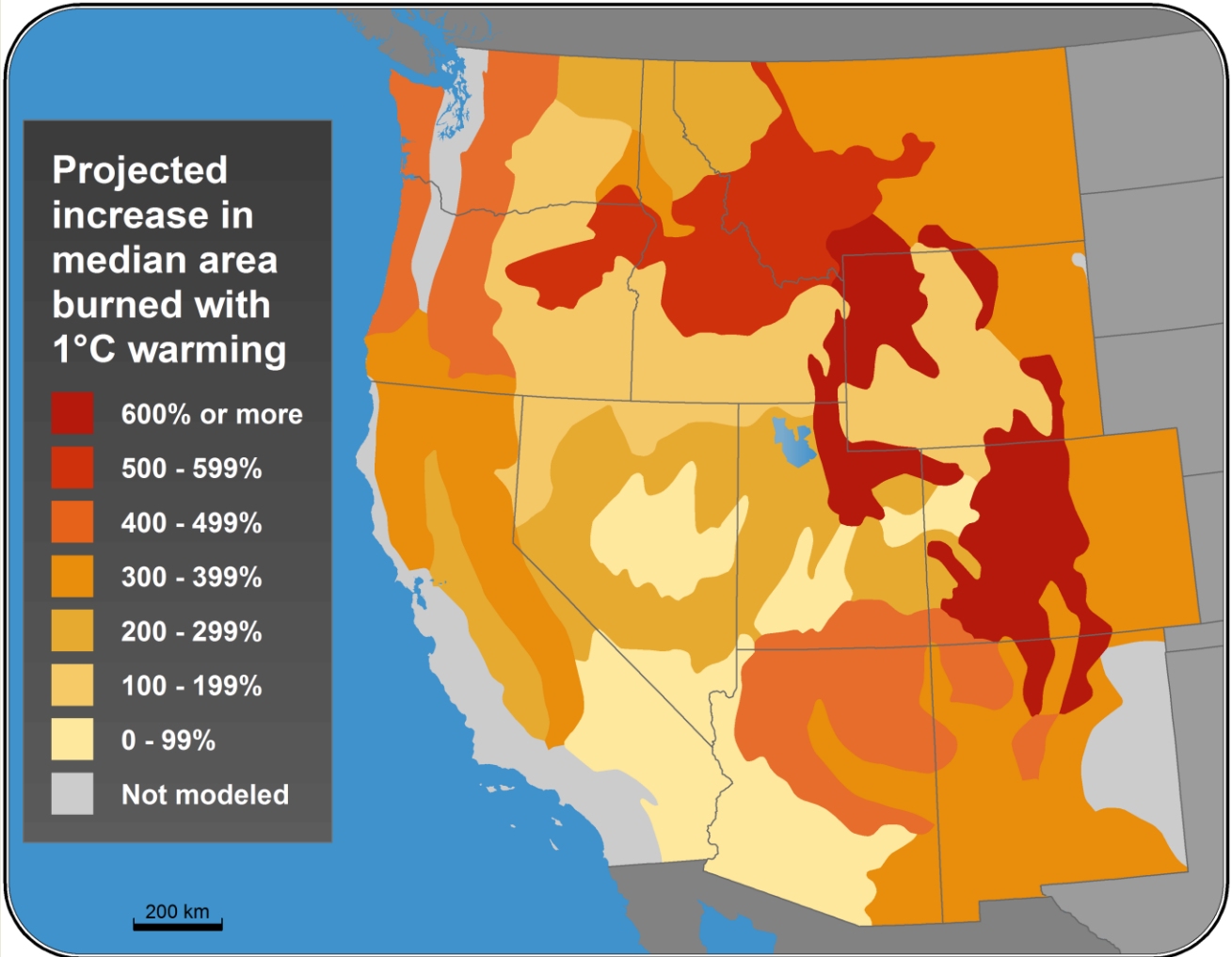
Southwest Washington

Fires have
burned some
areas 3 times
since 2008

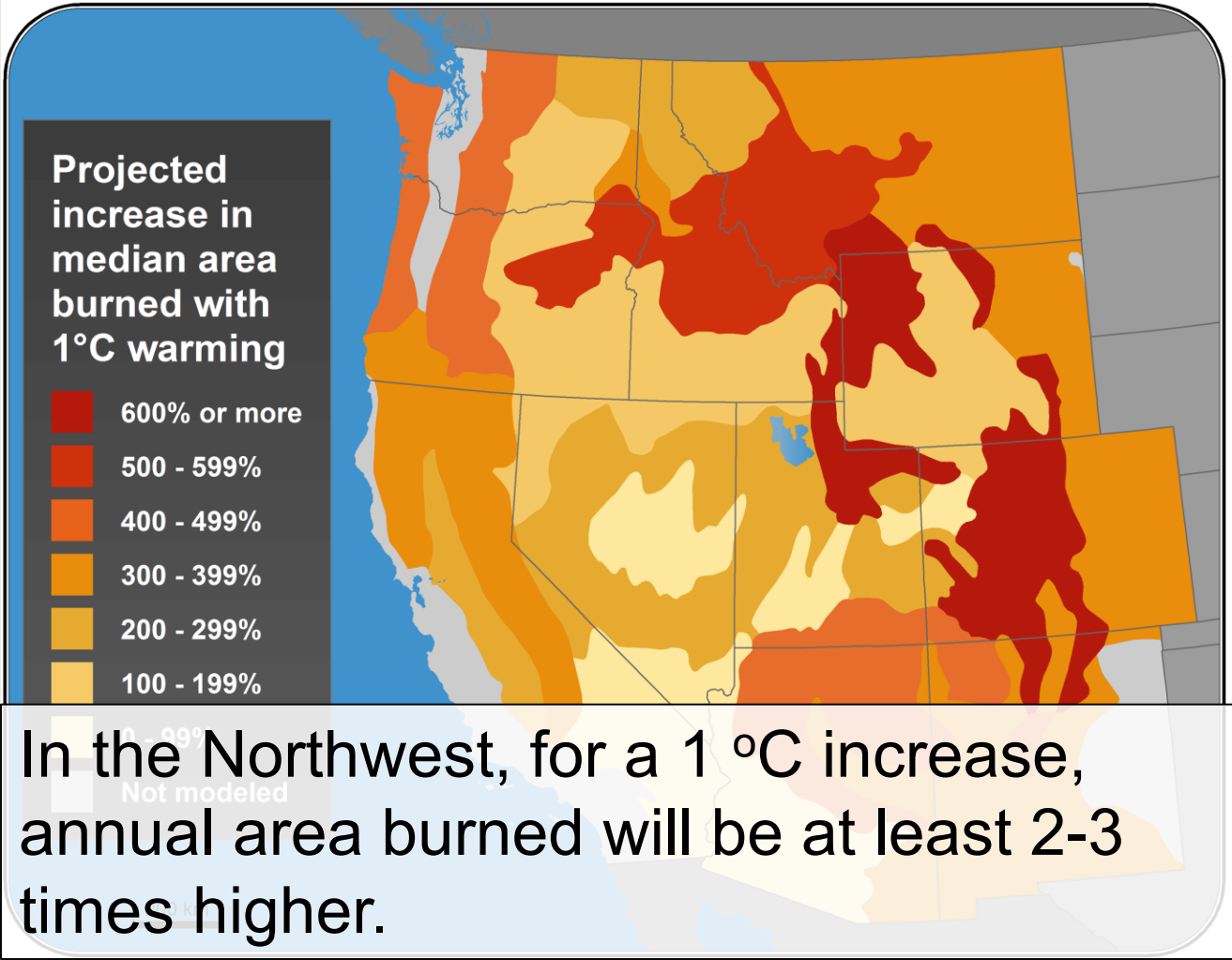


Map by R. Norheim

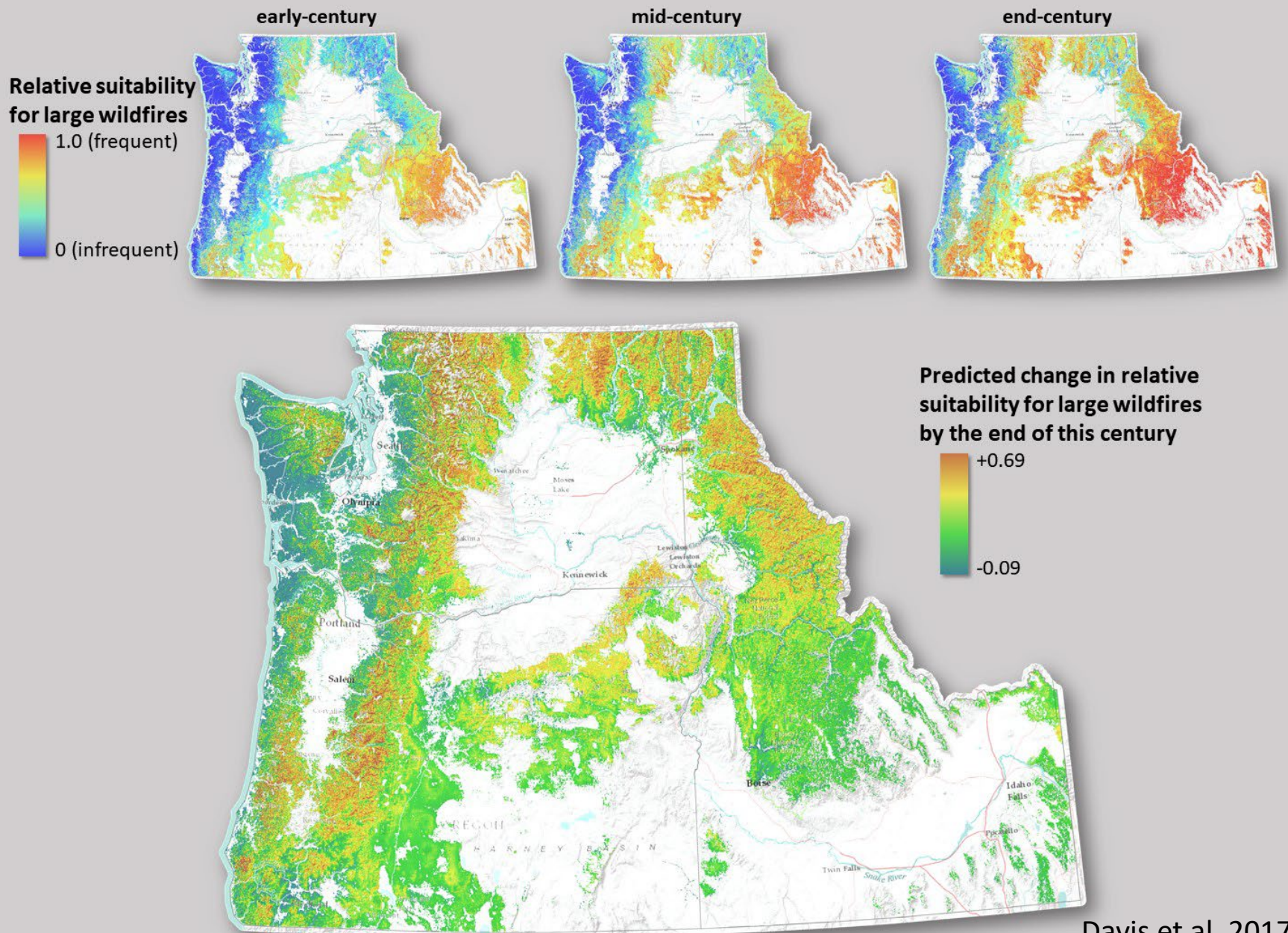
Wildfire area burned, 2050



Wildfire area burned, 2050



Suitability of large forest fires



Climate change affects insects

Mountain pine beetle



Warmer temperature has favored MPB by:

- Increasing its reproductive rate
- Allowing an expanded geographic range

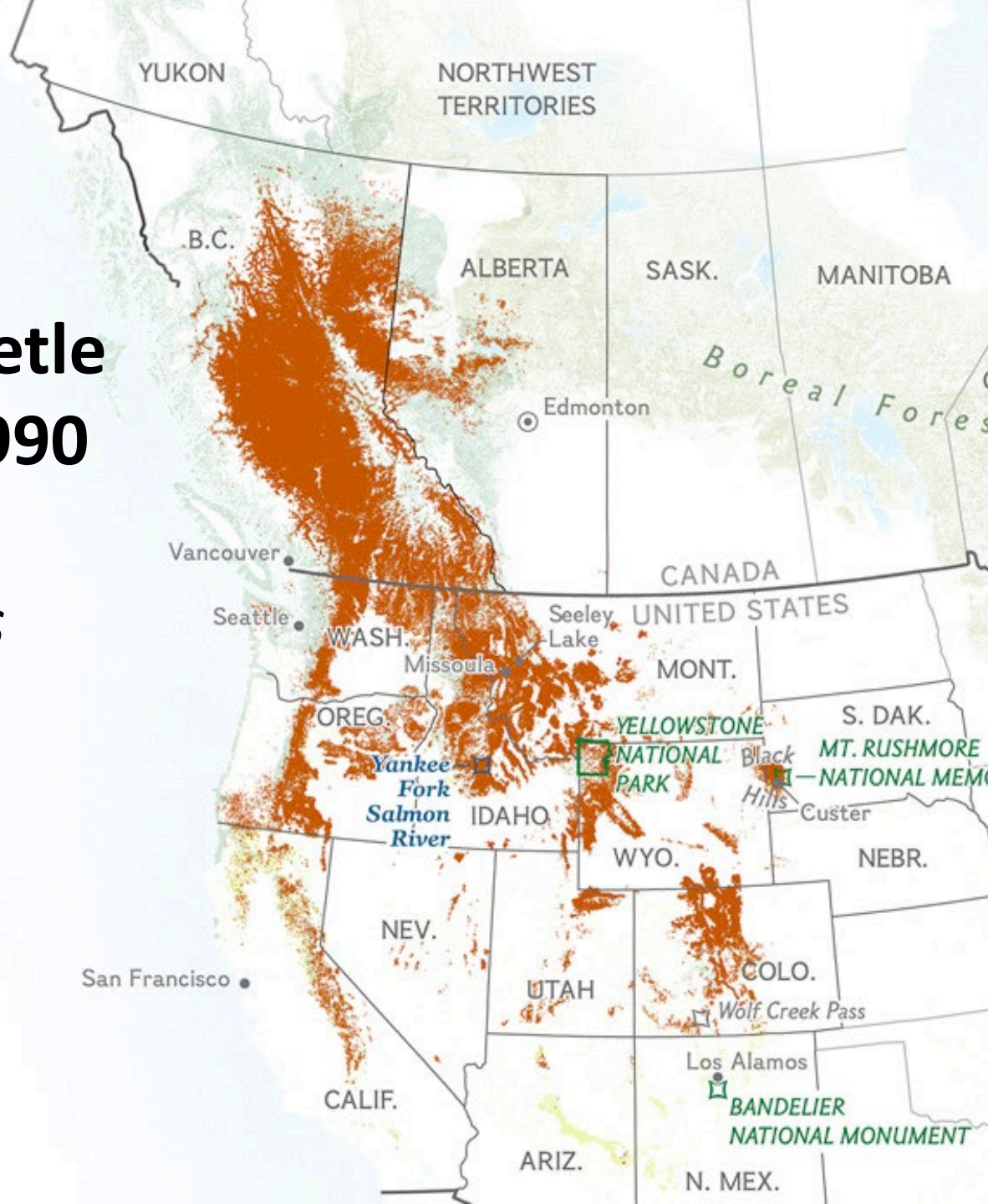


Mountain pine beetle outbreaks since 1990

20 million hectares

THE BEETLE AND ITS HOSTS

- Mountain pine beetle occurrence
- Lodgepole pine range
- Jack pine range
- Other pine species



Potential Future Insect Issues of Concern

Stress-induced “secondary” insects becoming primary tree killers

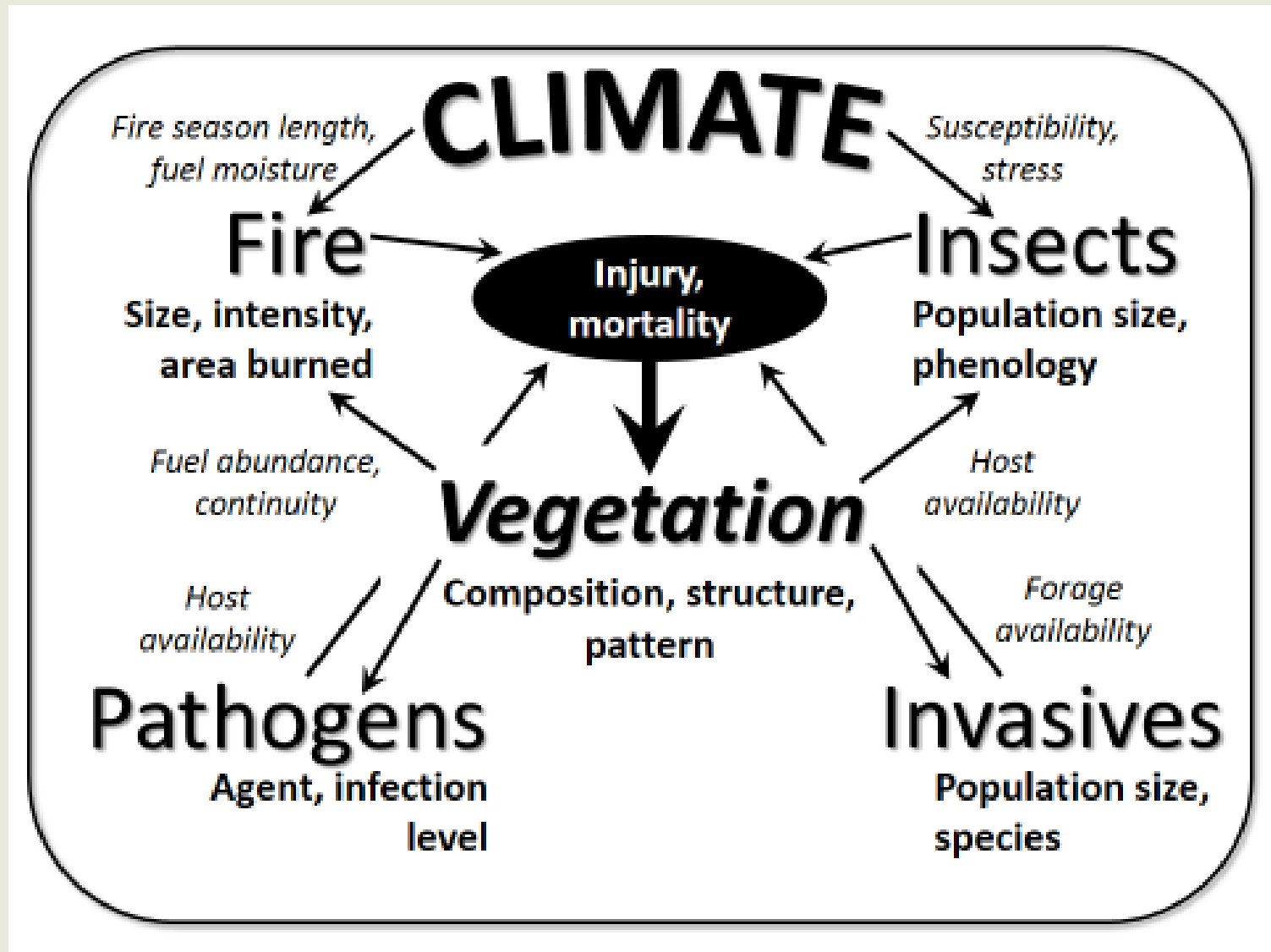


- Flatheaded fir borer on Douglas-fir



- Douglas-fir mortality complex on smaller trees (fungi, twig weevil, Douglas-fir engraver, Douglas-fir pole beetle)

Disturbances will interact



What does this mean for forests in the West?



High severity “reburns” may occur before forests recover from the most recent high-severity fire



Large fires are creating larger and more homogeneous patches of stand-replacing fire



Post-fire regeneration is very sensitive to climate

3-yr old Douglas-fir



350-yr old Douglas-fir



Drought, bark beetle outbreaks, and fires will likely interact



**Forests will
change in
species
composition
and structure,
and in some
places will
transition to
non-forest.**



What does this mean for wildlife habitat in the West?

Water



Food



Security



Space

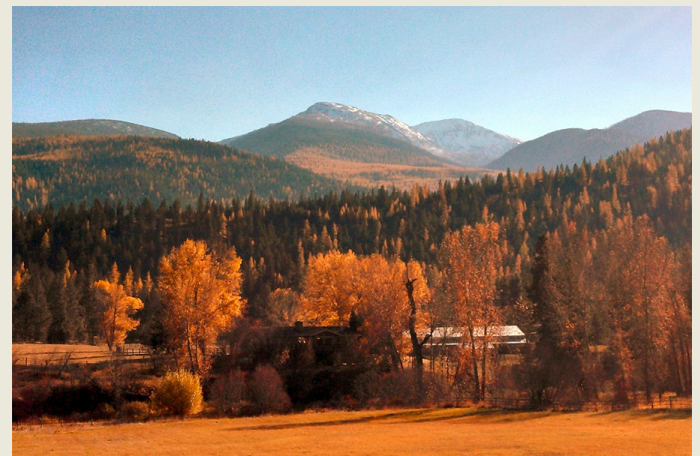


Shelter

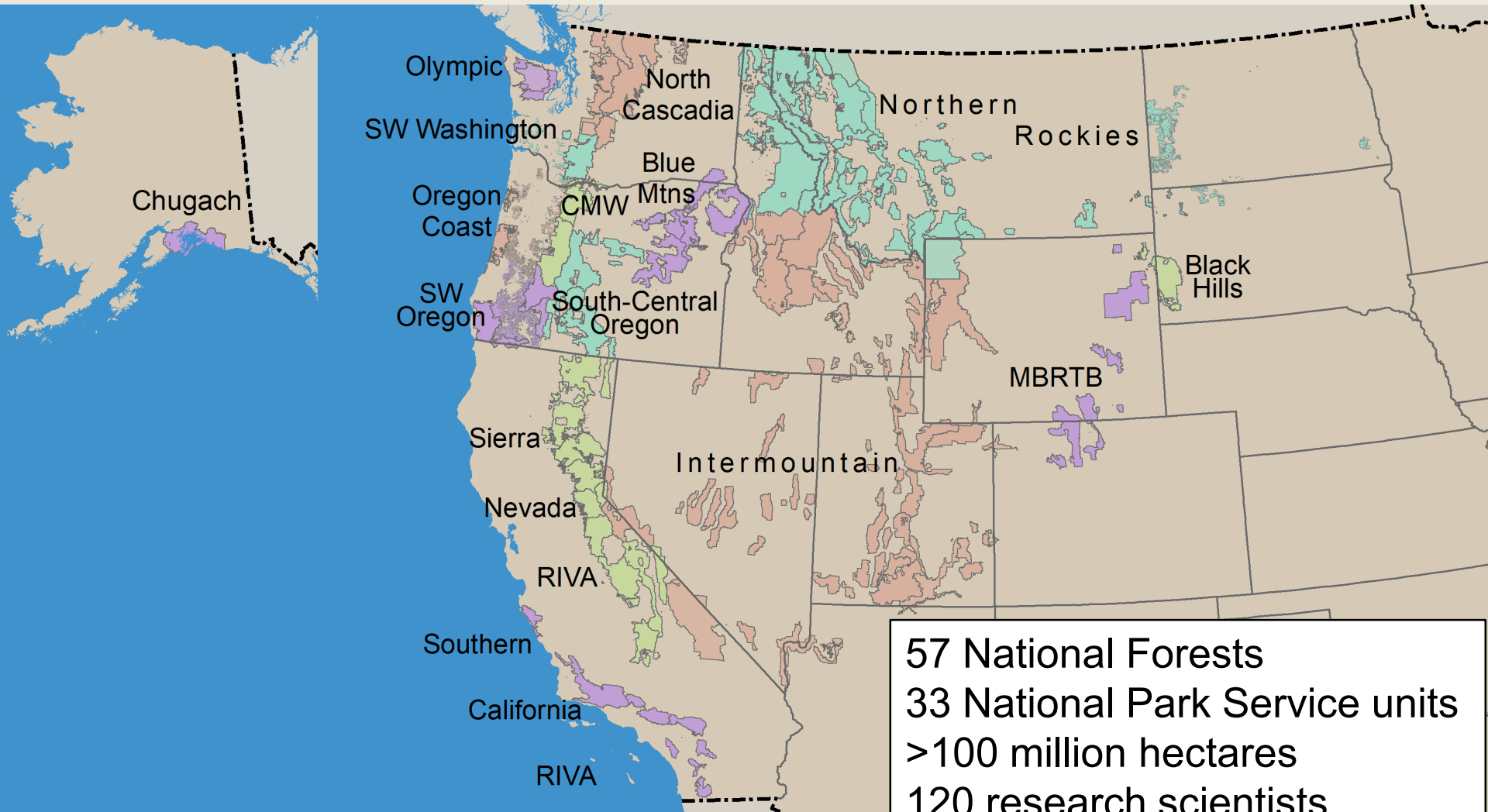


Adaptation Partnership Goals

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



Adaptation Partnership Locations



57 National Forests
33 National Park Service units
>100 million hectares
120 research scientists
1,400 resource managers

General approach

Establish a science-
management partnership



Conduct a vulnerability
assessment



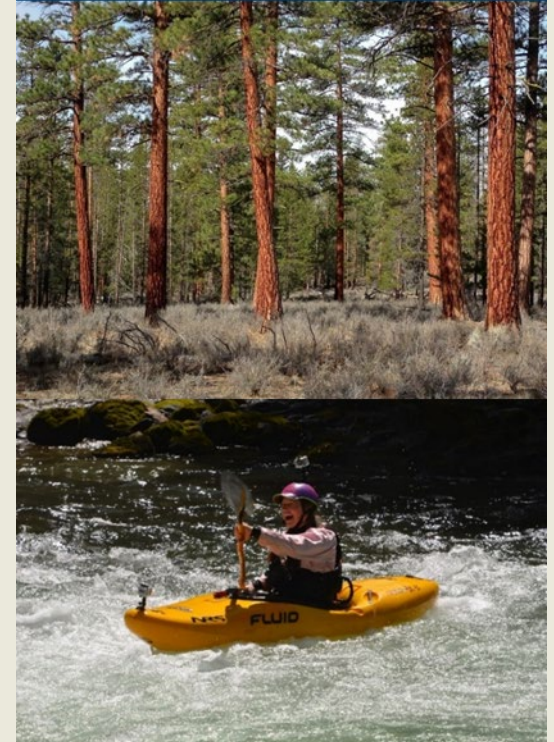
Identify adaptation strategies
& tactics



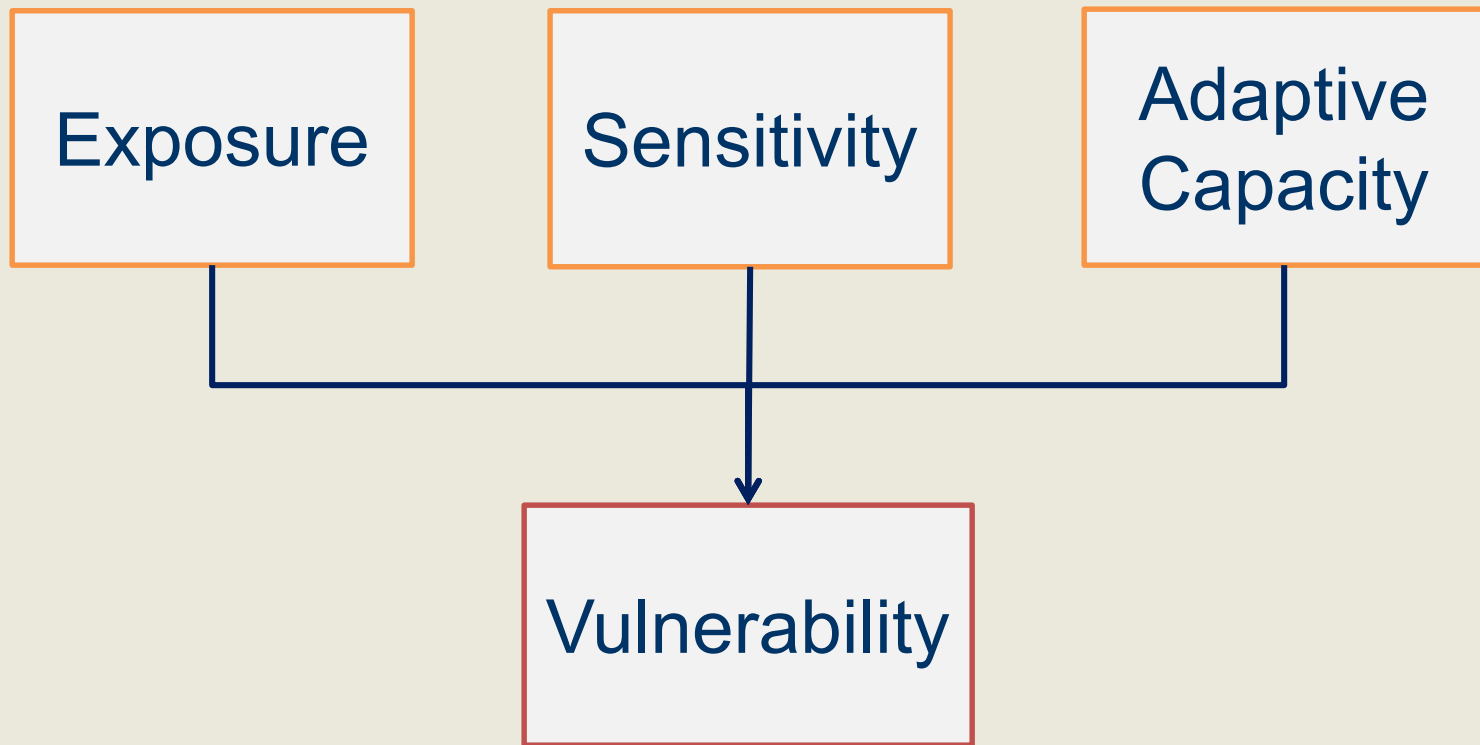
Develop & publish a peer-
reviewed report

Core topics addressed in vulnerability assessments

- Climate
- Water resources and infrastructure
- Fisheries
- Vegetation and disturbance
- Wildlife
- Recreation
- Cultural heritage
- Ecosystem services



Assessing Climate Change Vulnerability



Grassland / Shrubland / Woodland



Habitat Features:

- Mix of grasses, shrubs & pinyon/juniper
- Rocks, cliffs & talus
- Deep soils for burrows

Grassland / Shrubland / Woodland

- Sensitivity
 - Species are adapted to hot, dry conditions, but extreme summer temperatures could exceed physiological thresholds.
 - Water availability may become more limiting.
 - Increased fire severity & frequency may contribute to loss of habitat structure and food availability.
- Adaptive Capacity
 - Opportunities for seasonal movements and range-shifts are likely to be important for species trying to adapt to hotter and drier conditions.
 - Thermal refugia (e.g. burrows, cliffs, talus) may become more important for behavioral responses to increased temperatures.



Greater Sage Grouse



Pygmy Rabbit



Townsend's Solitaire

Wetland, Riparian, & Open Water



Habitat Features:

- Moving & still water
- Riparian vegetation, particularly deciduous trees & shrubs
- Woody debris
- Abundant plant & insect foods
- Cool, moist microclimate
- Linear, connected pattern



Wetland, Riparian, & Open Water

- Sensitivity
 - Decreased summer stream flows & decreased groundwater availability may contribute to seasonal or permanent drying.
 - More frequent & severe flood events may damage riparian habitat values.
 - Distribution of cold-moving-water streams is likely to decrease.
 - Riparian areas are vulnerable to large-scale high-intensity fire.
- Adaptive Capacity
 - Adaptive capacity is limited by hydrologic and topographic context in which these habitats exist.



Beaver



Oregon Spotted Frog



Yellow Warbler



Black-crowned Night-Heron

Ponderosa Pine Forest

Habitat Features:

- Large, unevenly spaced ponderosa pine or Douglas-fir trees (early-seral, fire-resilient species)
- Diverse herb & shrub understory
- Large snags & logs
- Spatial complexity, including treeless openings & closed-canopy patches



Ponderosa Pine Forest

- Sensitivity
 - Spatial arrangement may change with disturbance and loss of dry forest.
 - Wildlife habitat outcomes will depend on broad-scale disturbance processes, particularly fire. Low- & mixed-severity fire can contribute to spatial and structural complexity, large-scale high-intensity fire can simplify landscapes.
 - Summer drought stress may increase tree mortality, particularly in overstocked stands.
- Adaptive Capacity
 - Many associated wildlife are adapted to relatively warm, dry conditions.
 - Good opportunities for upward range shifts & seasonal movements.



White-headed
Woodpecker



Pygmy Nuthatch



Flammulated
Owl

Mid-elevation Old Forest

Habitat Features:

- Structural & spatial complexity
- Moderate to closed canopy
- Multiple tree size classes, including some large old trees
- Snags & logs (especially hollow ones)
- “Messiness...”



Mid-elevation Old Forest

- Sensitivity
 - Wildlife habitat outcomes will depend on broad-scale disturbance processes, particularly fire. Low- & mixed-severity fire can contribute to spatial and structural complexity, large-scale high-intensity fire can simplify landscapes.
 - Summer drought stress may increase tree mortality, particularly in overstocked stands.
- Adaptive Capacity
 - Good opportunities for upward range shift...
 - But old forest habitat characteristics take many decades to develop and may not keep up with rapidly changing climatic conditions.



Fisher



Northern Spotted Owl



Black Bear

Early-seral Forest

Habitat Features:

- Productive herb & shrub understory
- Abundant food resources (insects, small mammals & plants)
- Legacy structures: snags, logs, & remnant live trees with defects
- Lots of spatial diversity, particularly after mixed-severity disturbances



Early-seral Forest

- Sensitivity
 - Distribution of early-seral habitats will depend on future disturbance regimes.
 - Abundance could increase with increasing fire frequency & severity.
 - Biological legacies may be lost with repeated high-severity fires.
- Adaptive Capacity
 - Wildlife associated with early-seral habitats probably have high adaptive capacity compared to species associated with other focal habitats.
 - Early-seral species tend to be good dispersers with high reproductive rates.
 - Post-disturbance habitats are created quickly, and abundance will likely increase in the future.



Pocket Gopher



Elk



Black-backed Woodpecker



Gray Flycatcher

High-Elevation Cold Forest



Habitat Features:

- Structural & spatial complexity
- Moderate to closed canopy
- Multiple tree size classes, including some large old trees
- Snags & logs
- Deep, persistent snowpack

High-Elevation Cold Forest

- Sensitivity
 - Cold forest & subalpine conditions are projected to decrease substantially.
 - Loss of winter snowpack will limit subnival thermal & predation refugia.
 - Winter warming may produce changes in thermoregulatory behaviors.
 - Large-scale forest structure loss could result from large, high-intensity fires.
 - Recreation pressures on higher elevation areas could increase as people seek cooler settings for recreation throughout the year.
- Adaptive Capacity
 - No opportunities for upward range shift.
 - Wildlife better adapted to cold than warm extremes.
 - Availability of thermal micro-refugia (e.g., burrows, cavities, large logs, or shading vegetation) may be particularly important for short-term species persistence



Snowshoe Hare



Great Grey Owl



American Marten

Synthesis of Sensitivity

- **Food:** There will be changes in seasonal plant & prey food availability.
- **Water:** Snowmelt dominated sub-basins will experience the greatest degree of hydrologic change. Arid areas are also likely to experience more seasonal drying.
- **Shelter:** Habitat structure will be determined by disturbance processes, particularly fire.
- **Space:** Habitat configuration will be determined by fire & human land uses.
- **Security:** Interactions with competitors & predators will change.



Synthesis of Adaptive Capacity

- Species currently adapted to warm, dry conditions may have opportunities for range expansion.
- Species currently adapted to cold, snowy conditions will have limited opportunities for range shift.
- Opportunities for changes in behavioral thermoregulation will depend on availability of thermal refugia at multiple scales.
- Opportunities for animal movement to track seasonal resource availability & facilitate shift ranges will be important.
- Species with good dispersal capability & high reproductive rates may be best prepared for change.



Principles for Adaptation

- **Food:** Provide abundant & diverse plant & prey food resources.
- **Water:** Identify & enhance or protect critical water / wetland features.
- **Shelter:** Retain & recruit diverse habitat structures (e.g. big trees, snags, logs, cliffs, talus, deep soils, etc.).
- **Space:** Provide heterogeneous landscape patterns that are permeable for animal movement.
- **Security:** Monitor species interactions (competitors & predators).

Climate change vulnerability: Fire and drought in dry forests

Adaptation strategy

- Increase resilience to disturbance.

Adaptation tactics

- Conduct more intensive thinning.
- Conduct prescribed burns and allow frequent fire.
- Promote persistence of healthy trees.
- Promote drought- and disturbance-tolerant species.



Climate change vulnerability: Loss of habitat with disturbance

Adaptation strategy

- Increase resilience of late-successional habitat and vegetation structure.

Adaptation tactics

- Protect, maintain, and recruit legacy structures (e.g., large trees, snags, downed wood).



Climate change vulnerability: Increased stream temperatures

Adaptation strategy

- Restore and maintain cold-water habitat

Adaptation tactics

- Decrease fragmentation of stream networks
- Restore and maintain natural flow regimes
- Increase shade in riparian areas



Climate change vulnerability: Low flows and disturbance

Adaptation strategy

- Increase resilience to drought and disturbance

Adaptation tactics

- Promote drought-tolerant native species
- Reduce existing stressors (e.g., invasives, intensive grazing, conifer encroachment)
- Protect wetlands and groundwater-dependent ecosystems



Products

USDA
United States Department of Agriculture

Climate Change Vulnerability and Adaptation in the Intermountain Region Part 1



Forest
Service

Rocky Mountain
Research Station

General Technical Report
RMRS-GTR-375

April 2018

Advances in Global Change Research 63

Jessica E. Halofsky^{a,*}
David L. Peterson^b *Editors*

Climate Change and Rocky Mountain Ecosystems

 Springer

Climate Services 10 (2018) 1–8

Contents lists available at ScienceDirect

Climate Services

journal homepage: www.elsevier.com/locate/cliser



Assessing and adapting to climate change in the Blue Mountains, Oregon
(USA): Overview, biogeography, and climate

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Resource management
Vulnerability assessment
Blue Mountains

ABSTRACT

The Blue Mountains Adaptation Partnership (BMAP) was established to increase climate change awareness, assess vulnerability to climate change, and develop science-based adaptation strategies for national forest lands in the Blue Mountains region of northeast Oregon and southeast Washington (USA). The BMAP process included (1) development of a science-management partnership, (2) a vulnerability assessment of the effects of climate change on natural resources and infrastructure, (3) development of adaptation options that will help reduce negative effects of climate change and assist the transition of biological systems and management to a changing climate, and (4) ongoing dialogue and activities related to climate change in the Blue Mountains region. This special issue of *Climate Services* describes social context and climate change vulnerability assessments for water use and infrastructure, vegetation, and riparian ecosystems of the Blue Mountains region, as well as adaptation options for natural resource management. This manuscript introduces the special issue, describing the management, biogeographic, and climatic context for the Blue Mountains region; the climate change vulnerability assessment and adaptation process used in BMAP; and the potential applications of the information described in the special issue. Although the institutional focus of information in the special issue is U.S. Forest Service lands (Malheur, Umatilla, and Wallowa-Whitman National Forests), the broader social context and adaptation options should be applicable to other lands throughout this region and the Pacific Northwest.

Practical Implications

The vulnerability assessment described in this special issue of *Climate Services* is the first step in understanding how climate change may affect climate, natural resources, and ecosystem services in the Blue Mountains of northeast Oregon and southeast Washington (USA). Although uncertainty exists in the likelihood, magnitude, and timing of future changes in aquatic and terrestrial ecosystems, the information provided a basis for development of adaptation options that managers can choose from and utilize in the future.

Climate change effects in the semiarid Blue Mountains are a particular concern, because much of the landscape has already been greatly altered by land-use activities—timber harvesting, livestock grazing, water diversions—that have in

many cases affected the functionality of systems and the distribution and abundance of species. These stressors provide an important context for considering how to adapt to climate change in the context of current land uses and policies. Infrequent, extreme events such as drought and wildfire will be a driving force for both ecological and social change, as they combine with existing stressors and interact with demands for ecosystem services (water, fish, timber, recreation, etc.).

Changes in hydrology and water availability will be major issues for the Blue Mountains region in a warmer climate. Lower snowpack and higher peak flows in winter will cause more damage to infrastructure. Upgrading engineering standards for roads and infrastructure (e.g., increasing culvert size) will likely help to minimize damage and repair costs. Lower stream flows in summer will reduce water supply for agriculture, municipal uses (drinking water), industrial uses,

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<http://www.adaptationpartners.org/>

Climate Change Adaptation Library

<http://www.adaptationpartners.org/library.php>

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CLIMATE CHANGE ADAPTATION LIBRARY FOR THE WESTERN UNITED STATES



Information in the Library is derived from climate change vulnerability assessments conducted by Adaptation Partners (adaptationpartners.org), which collaborates with a diversity of organizations and stakeholders to develop multi-resource assessments. A science-management partnership including research scientists and natural resource specialists provides a foundation for all projects. Adaptation options are intended to inform sustainable management of natural resources, reduce the negative effects of climate change, transition ecosystems to a warmer climate, and help integrate climate change in natural resource management, planning, and business operations of federal land management agencies.

Adaptation Partners has elicited expertise on management responses to climate change from land managers in the U.S. Forest Service, National Park Service, and other organizations throughout the western United States. Specifically, adaptation options in the Library were developed by resource specialists during workshops convened to examine climate change vulnerability assessments. These climate change adaptation actions are organized by categories of 1) sensitivity to a particular climate change effect, 2) corresponding strategies to mitigate the impacts of this climate change effect, and 3) specific tactical actions that can take place as an implementation of that particular strategy. We have also provided citations of general technical reports that either originated or include these strategies and tactics.

[Adaptation Partners Library](#) | [AP Library References](#)

[Download Entire Library \(MS Excel\)](#) (Updated 11/2019)

Filter summaries by:

USFS Region [Map]

- Region 1: Northern
- Region 2: Rocky Mountain
- Region 3: Southwestern
- Region 4: Intermountain
- Region 5: Pacific Southwest
- Region 6: Pacific Northwest
- Region 10: Alaska

Resource Area

- Cultural
- Ecosystem Services
- Fish
- Forest Vegetation
- Non-Forest Vegetation
- Recreation
- Riparian Areas/Wetlands/GDEs
- Soils
- Water Resources/Infrastructure
- Wildlife

Climate Change Effect

- Altered distribution and abundance of fish species
- Altered distribution and abundance of plant species
- Altered distribution and abundance of wildlife species
- Altered hydrologic regime
- Altered precipitation patterns
- Changes in ecosystem services
- Changes in phenology
- Changing fish habitat suitability
- Changing habitat suitability
- Changing plant habitat suitability
- Changing wildlife habitat suitability
- Enhanced disturbance

Keyword

- Alpine
- Aquatic
- Aspen
- Beavers
- Beetles
- Biodiversity
- Birds
- Bridges
- Campgrounds
- Carbon
- Conifers
- Connectivity

APPLY FILTER

RESET

National Compendium for Climate Change Adaptation Actions



U.S. FOREST SERVICE
Caring for the land and serving people

United States Department of Agriculture

CLIMATE CHANGE RESOURCE CENTER



EDUCATION TOPICS TOOLS ADAPTATION LIBRARY

Compendium of Adaptation Approaches

- Adaptation Approaches
- Adaptation Examples
- Featured Stories

 The Adaptation Approaches help natural resource managers and landowners identify actions for responding to climate change. It provides a curated list of adaptation actions that helps you move from broad ideas to specific actions. Many illustrative examples of adaptation actions are included in this tool, but it is not a comprehensive list of all available options. [Learn more about adaptation actions.](#)

 The collection is organized by adaptation approach – click on each approach for more information on how the idea links to broader adaptation strategies and more specific management tactics. You can browse by resource area, region, or climate change impact.

 We created this tool to inspire thinking and spur brainstorming for adaptation planning. It can also be used to link a specific management action to a broader adaptation approach in order to show how management is intentionally addressing climate change concerns. As you do this, it is important to consider your own management goals and local climate change impacts before selecting actions for implementation. We strongly encourage you to use a structured process to intentionally consider climate change in your planning and project development.

Find Approaches For Your Project

Resource Area:

Climate Change Effect:

Region:

<https://www.fs.usda.gov/ccrc/>

Thank you

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<https://www.climatehubs.usda.gov/hubs/northwest>

<https://www.fs.fed.us/wwetac/>

<http://adaptationpartners.org/>

