Anticipating fire-driven transformation of conifer forests and pathways for stewardship

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Co-authors: Sean Parks, Meade Krosby, and Solomon Dobrowski
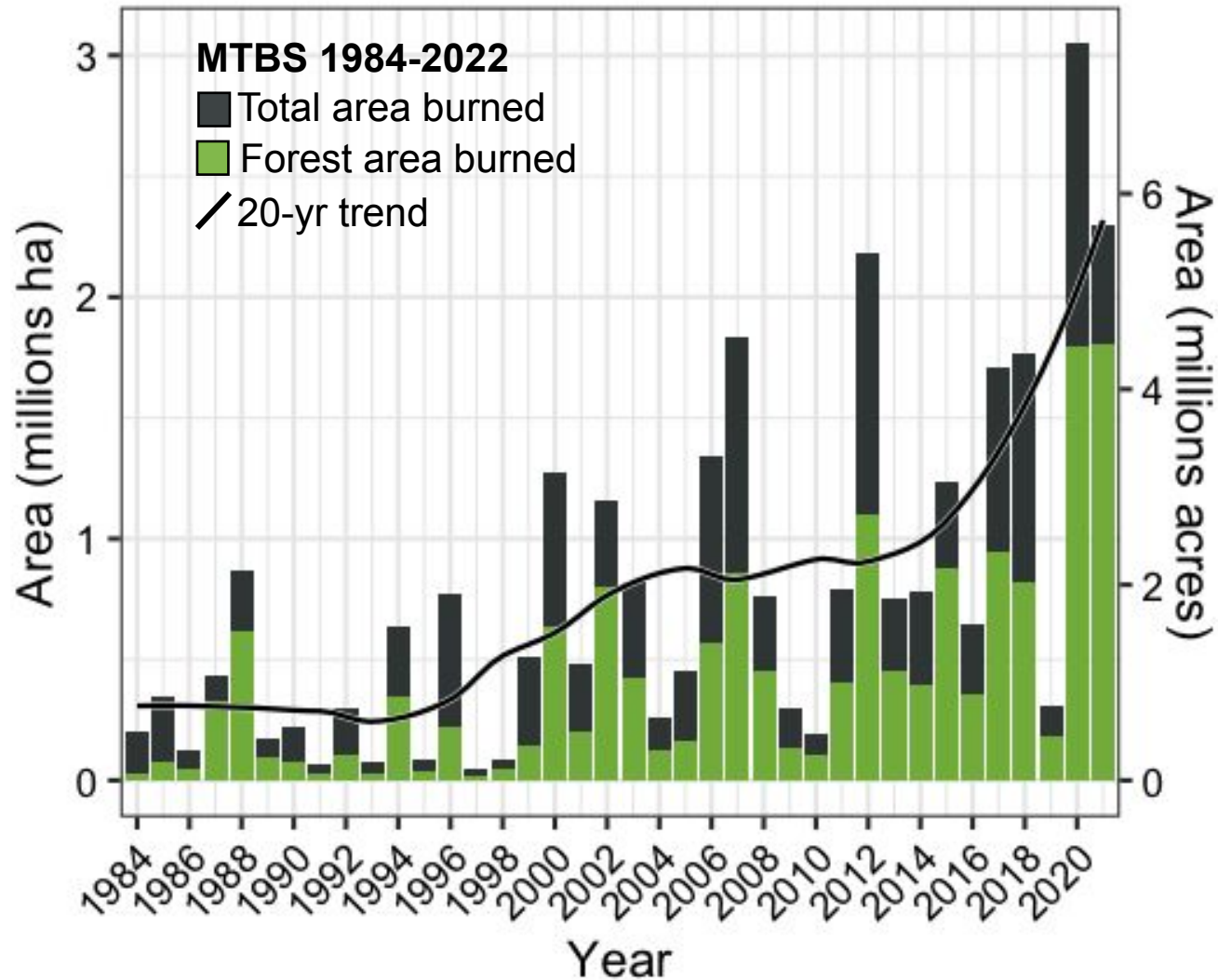
vibrant planet

UNIVERSITY OF
MONTANA

NORTHWEST
Climate Adaptation
Science Center

Photo: Brock Mickelsen

Annual area burned has increased significantly since 1984 (54% forest)

2017 Sprague Fire, looking towards continental divide in Glacier NP

The "wildfire crisis" is a social, technological, and ecological problem

Mitigating loss requires understanding forest-fire drivers and responses

The "wildfire crisis" is a social, technological, and ecological problem
Mitigating loss requires understanding forest-fire drivers and responses

WILDFIRE CRISIS
Landscape
Investments

CONFRONTING THE WILDFIRE CRISIS

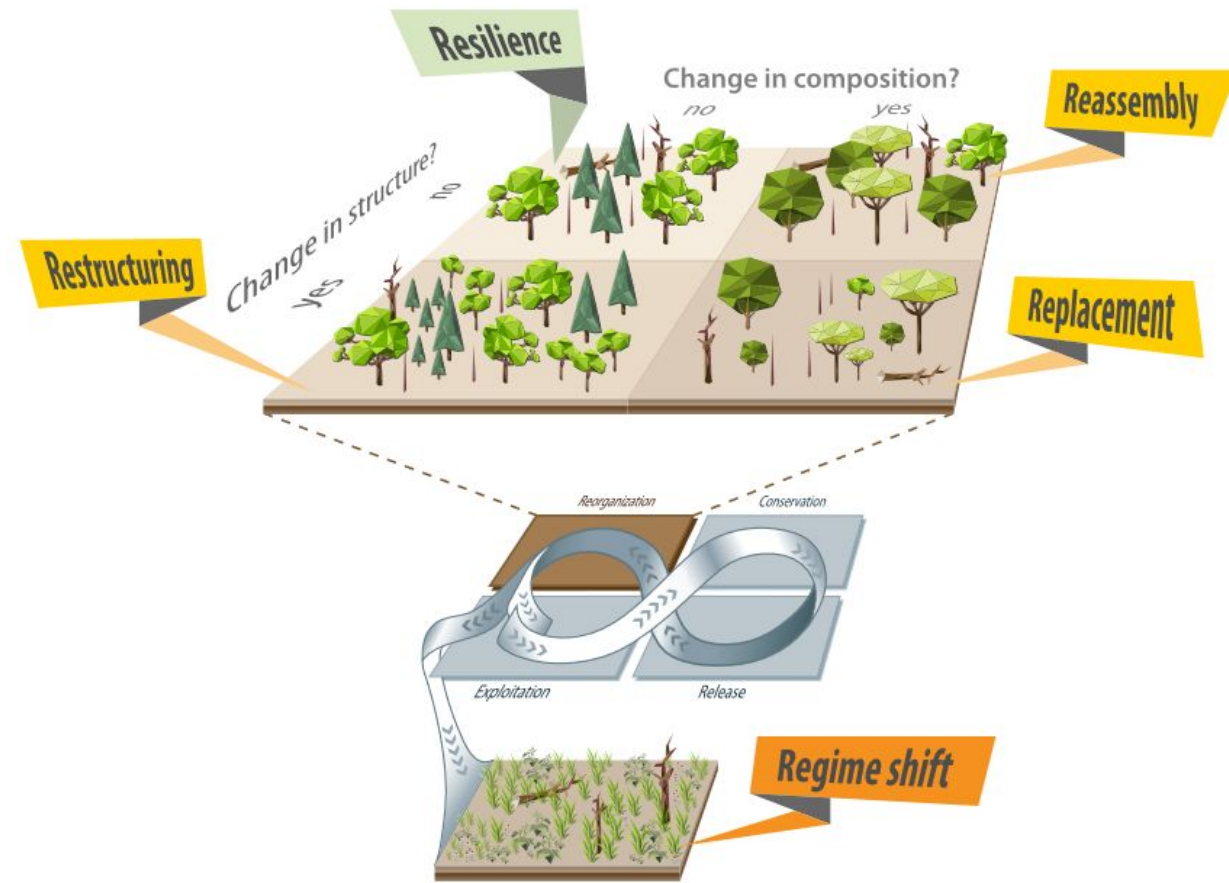Expanding efforts to deliver on the Wildfire Crisis Strategy
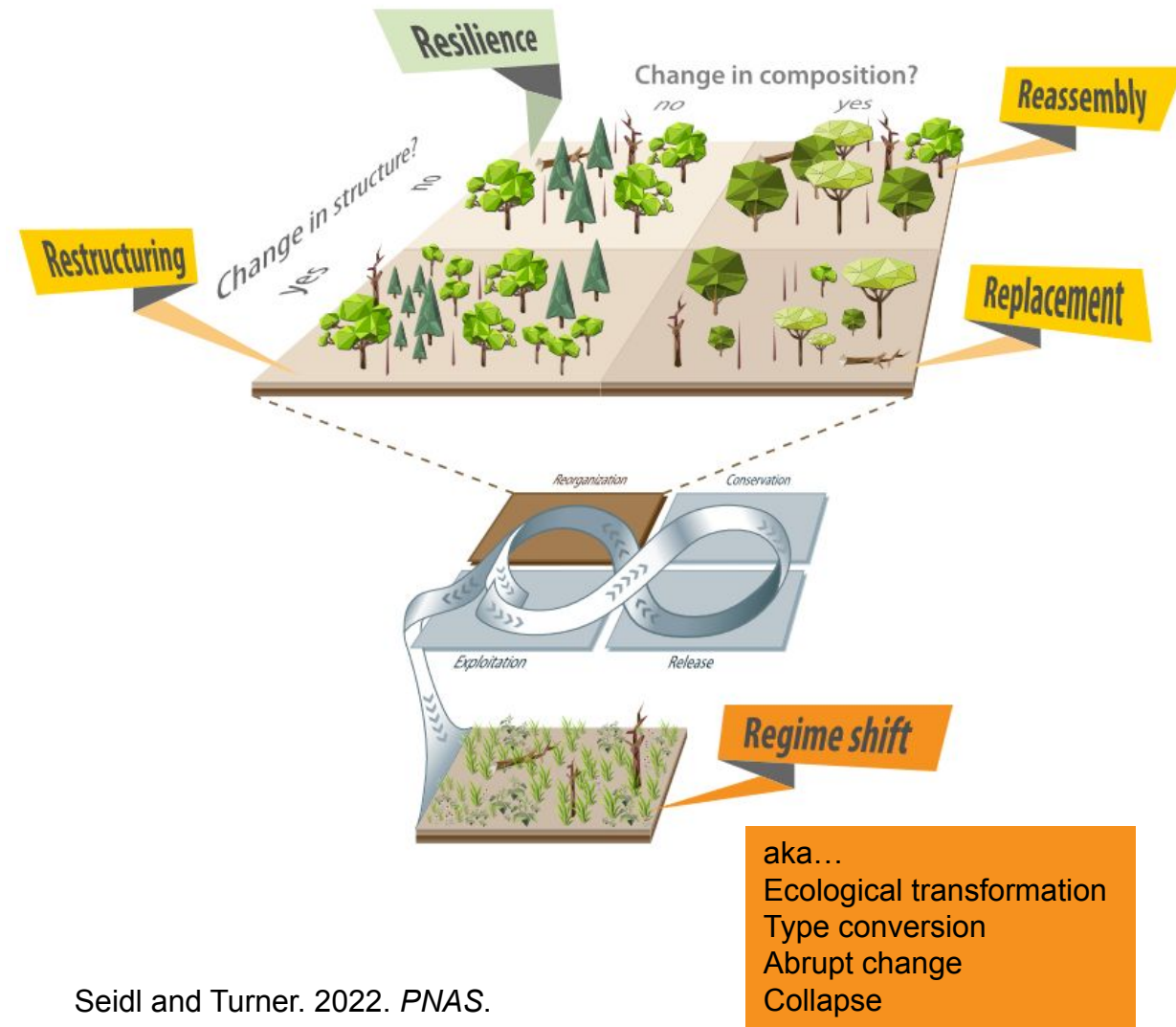
https://www.fs.usda.gov/managing-land/wildfire-crisis

USDA FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

Of $1.2T in BIL
$5 B for fire management over 5 years

sensu Iglesias, V., et al. 2022. *Environmental Research Letters*.

The "wildfire crisis" is a social, technological, and ecological problem
Mitigating loss requires understanding forest-fire drivers and responses

sensu Iglesias, V., et al. 2022. *Environmental Research Letters*.

Resilience and regime shift bracket possible responses to disturbance

Seidl and Turner. 2022. *PNAS*.

Resilience and transformation bracket possible responses to disturbance

Resilience

Change in composition?

no   yes

Reassembly

Change in structure?   no

Restructuring

Replacement

Reorganization   Conservation

Exploitation   Release

Regime shift

aka…
Ecological transformation
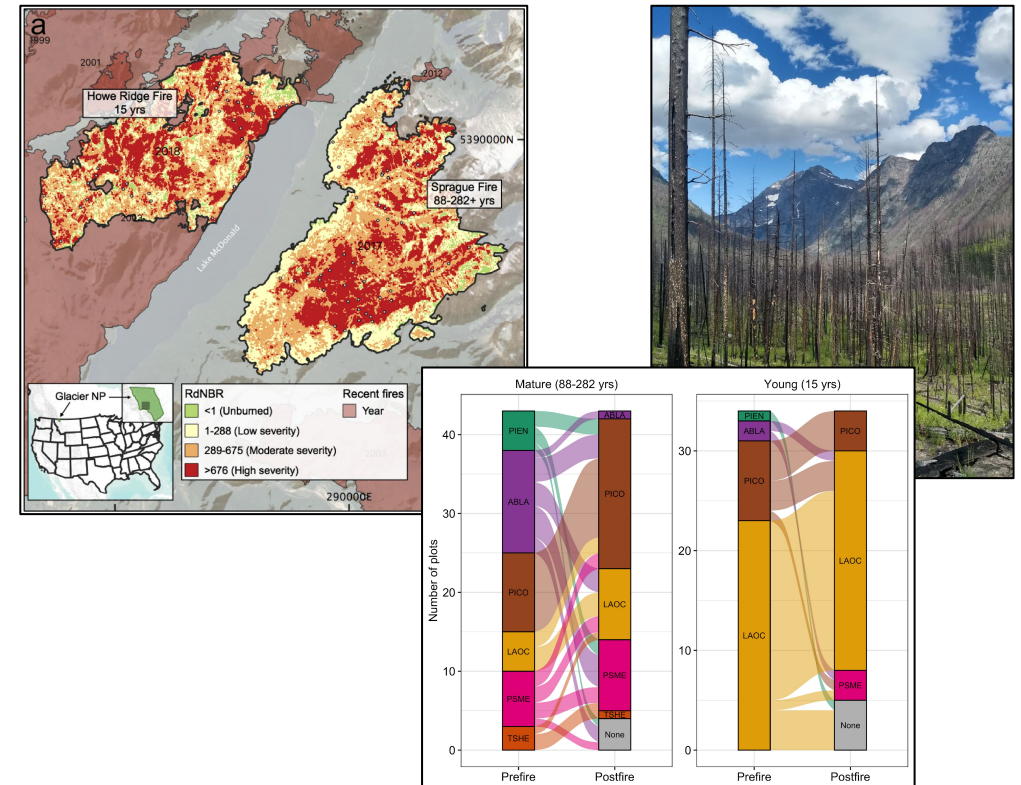Type conversion
Abrupt change
Collapse

Seidl and Turner. 2022. *PNAS*.

A short-interval reburn catalyzes departures from historical structure and composition in a mesic mixed-conifer forest
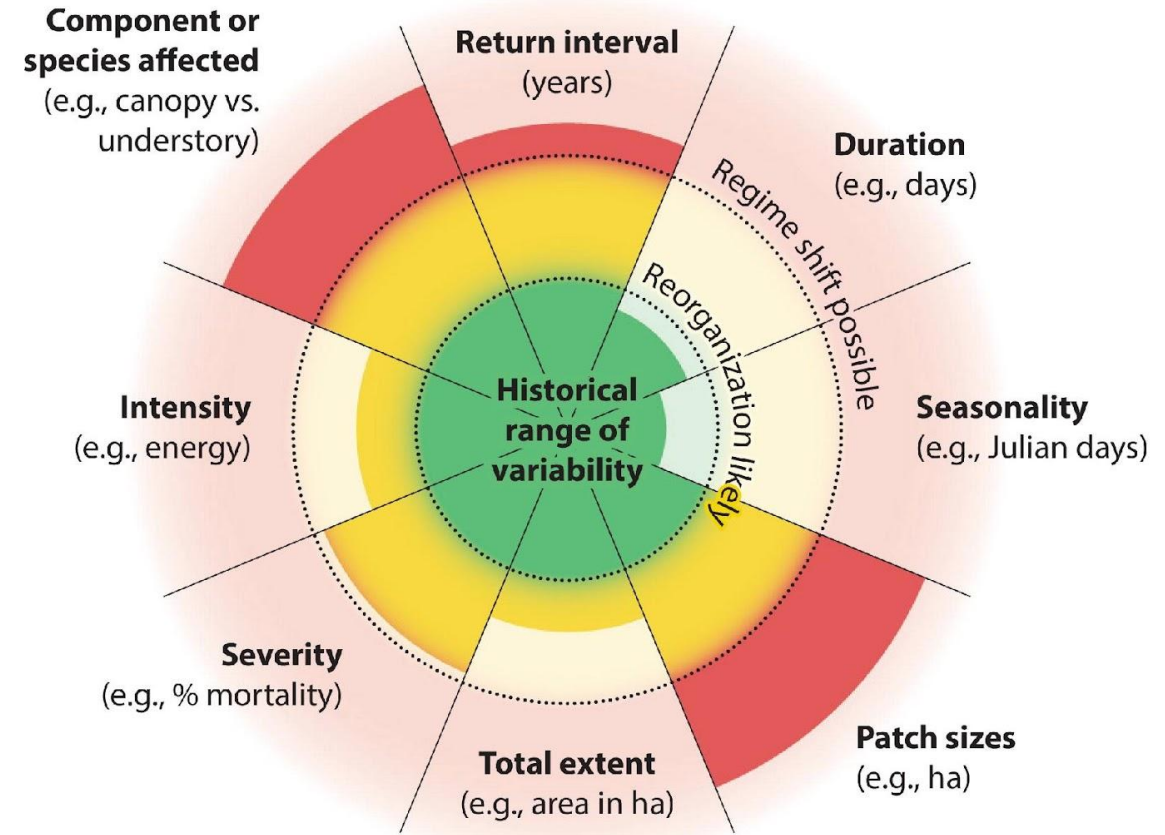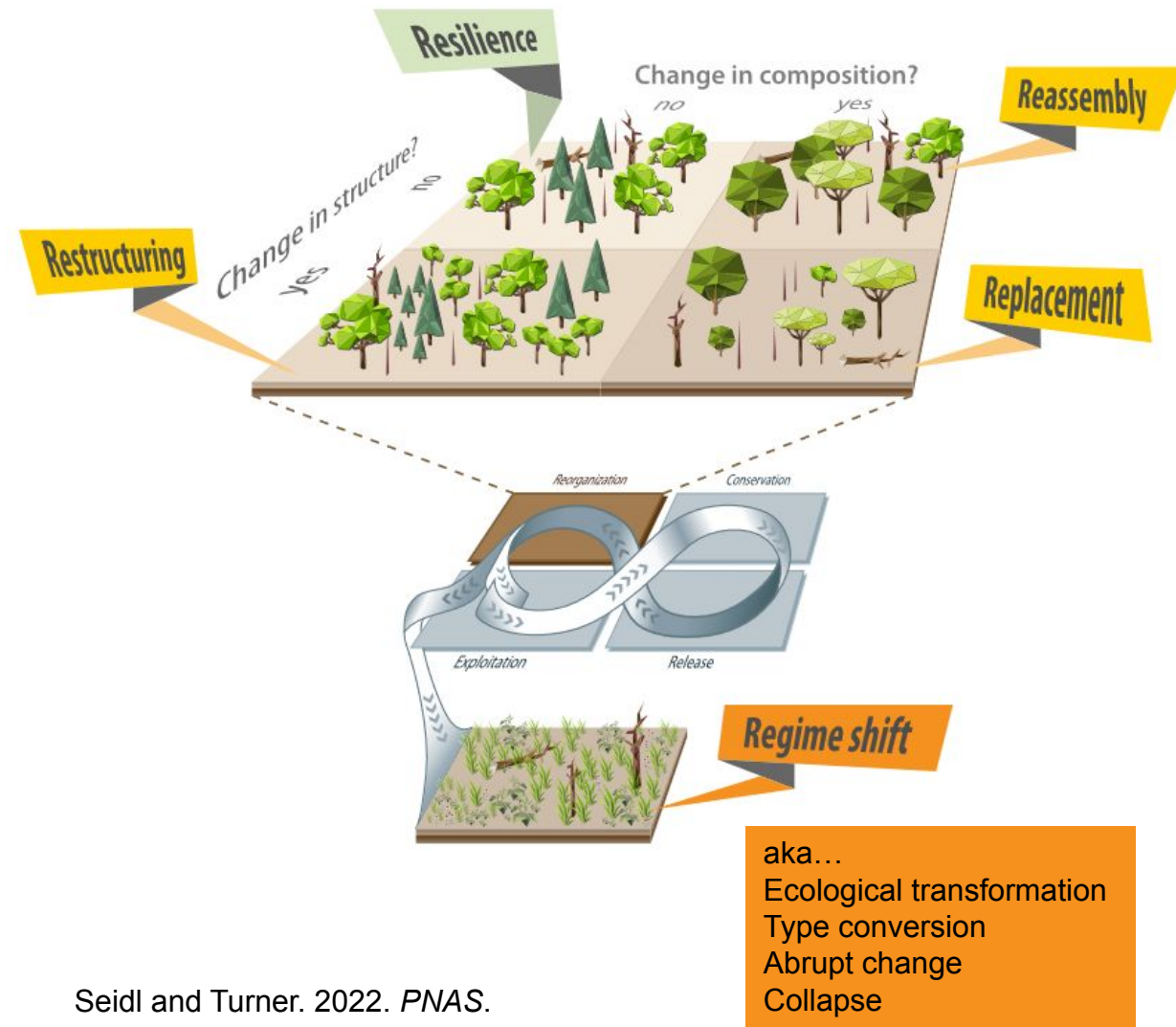
Tyler J. Hoecker [a,b,*], Monica G. Turner [a]

[a] Department of Integrative Biology, University of Wisconsin-Madison, Madison, WI 53706, United States
[b] Department of Forest Management, College of Forestry and Conservation, University of Montana, Missoula, MT 59812, United States

Howe Ridge Fire 15 yrs

Sprague Fire 88-282+ yrs

5390000N

Lake McDonald

Glacier NP

RdNBR
<1 (Unburned)
1-288 (Low severity)
289-675 (Moderate severity)
>676 (High severity)

Recent fires
Year

290000E

Mature (88-282 yrs)   Young (15 yrs)

PIEN   ABLA   PIEN   PICO
ABLA   PICO   ABLA
PICO   PICO   LAOC
LAOC   LAOC
PSME   PSME   PSME
TSHE   TSHE   None
None

Number of plots

Prefire   Postfire   Prefire   Postfire

Disturbances that exceed HRV in multiple dimensions catalyze transformation

aka…
Ecological transformation
Type conversion
Abrupt change
Collapse

Seidl and Turner. 2022. *PNAS*.

Turner MG, Seidl R. 2023
Annu. Rev. Ecol. Evol. Syst. 54:63–83

Where are post-resilience landscapes headed? Are we OK with that?

Resilience → **Adaptation**

Seidl and Turner. 2022. *PNAS*.

Shurman et al. 2021. *Bioscience*.
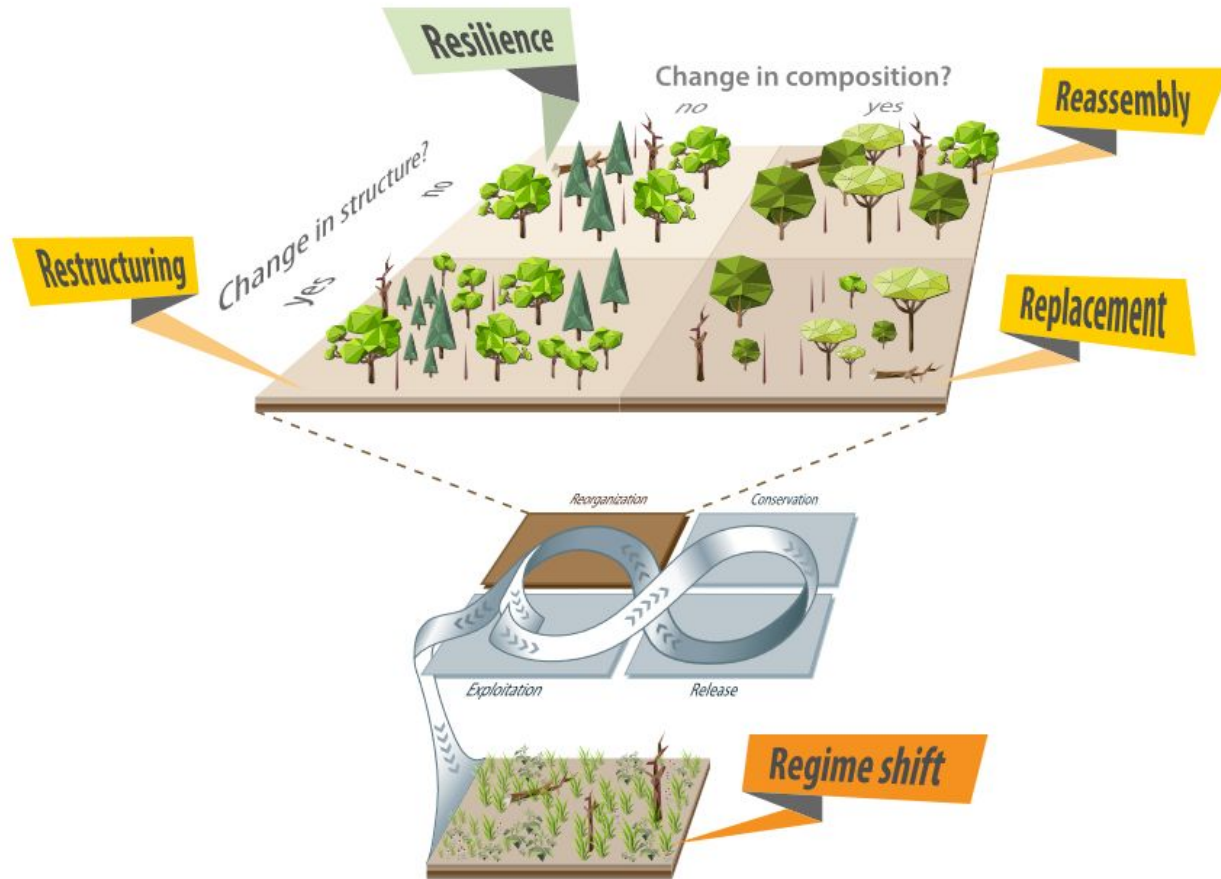
Managing post-fire, climate-induced vegetation transitions in the Northwest

A synthesis of existing knowledge and research needs
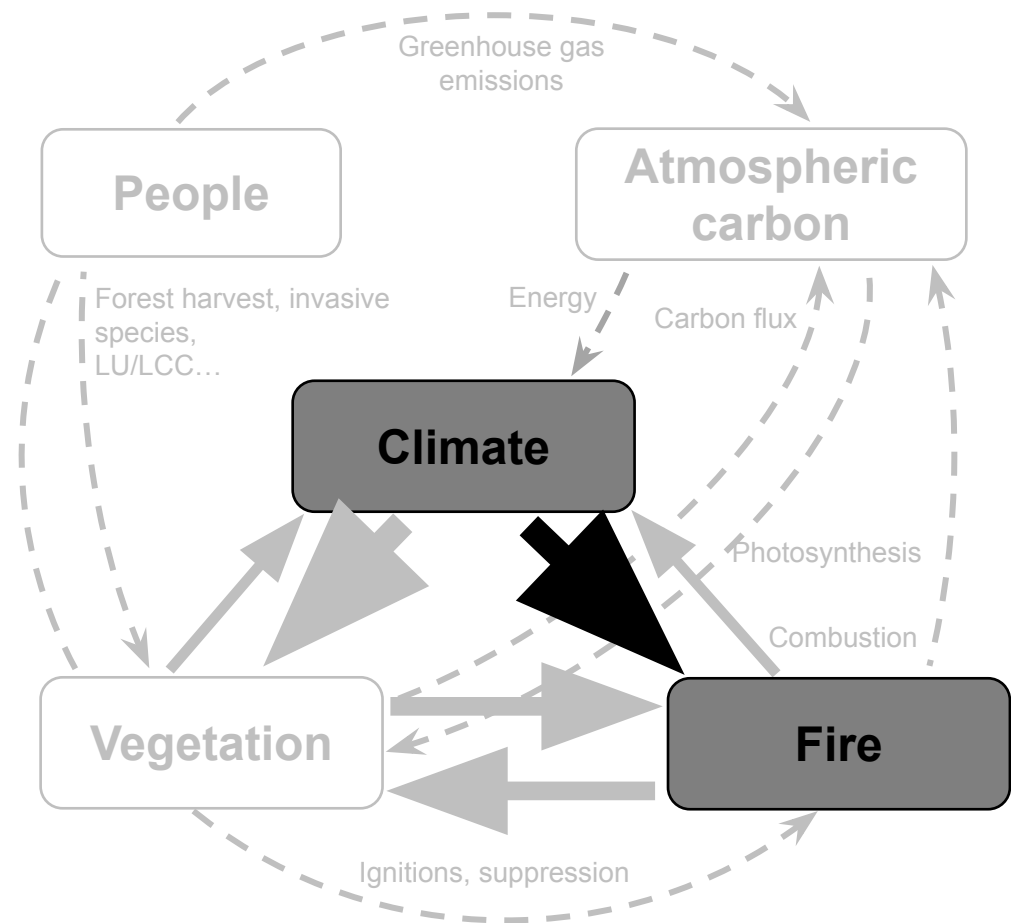
2020 Deep Dive Summary Report

NORTHWEST Climate Adaptation Science Center

CLIMATE IMPACTS GROUP

Krosby, et al. 2020.

The* Deep Dive *identified an actionable science agenda to address critical needs:

- Model plausible ecological futures

- Anticipate where and when post-fire transitions are expected to occur

- Develop predictions of future fire properties and novel processes

- Assess adaptive capacity of existing ecosystems to future conditions

Krosby et al. 2020.

How can we address these needs at management-relevant scales and across broad extents?

Recreated from Bowman et al. 2014

How can we address these needs at management-relevant scales and across broad extents?

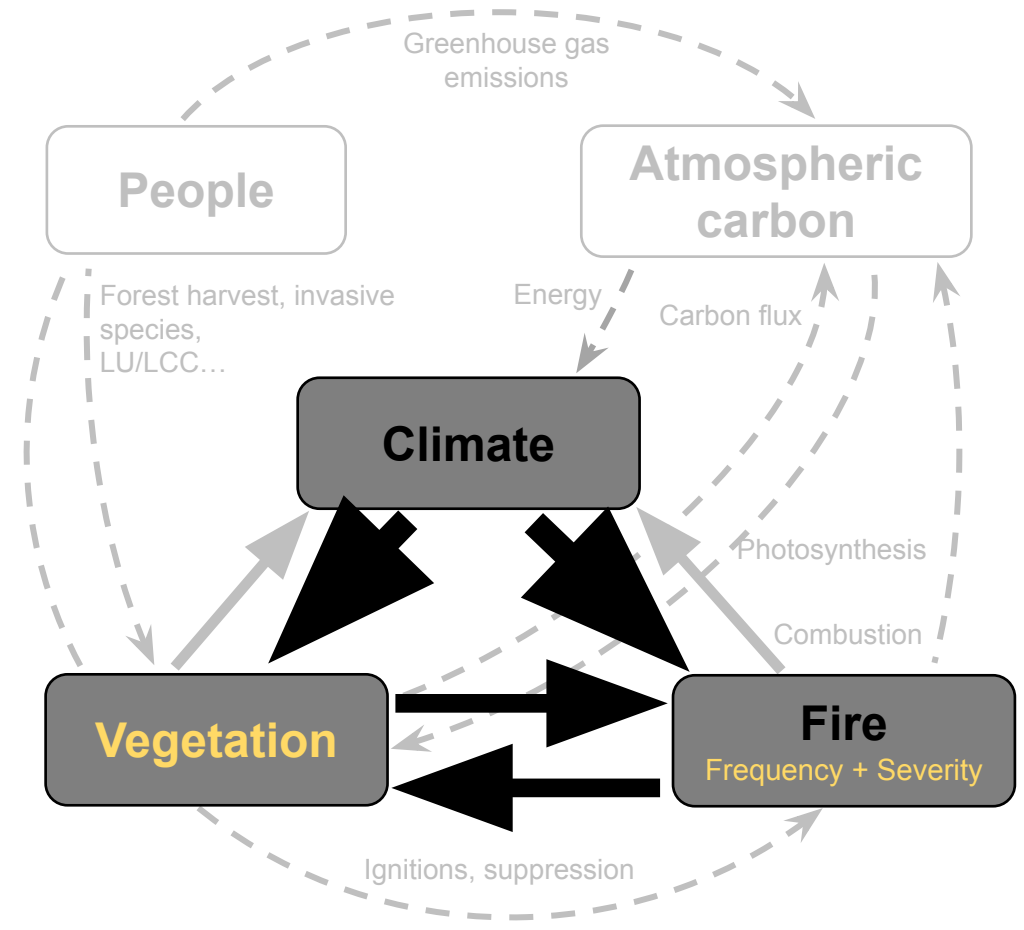Observed fire rotation periods (years to burn an area equal in size to a ~150 km^2 pixel)

Recreated from Bowman et al. 2014

A

How can we address these needs at management-relevant scales and across broad extents?

Recreated from Bowman et al. 2014
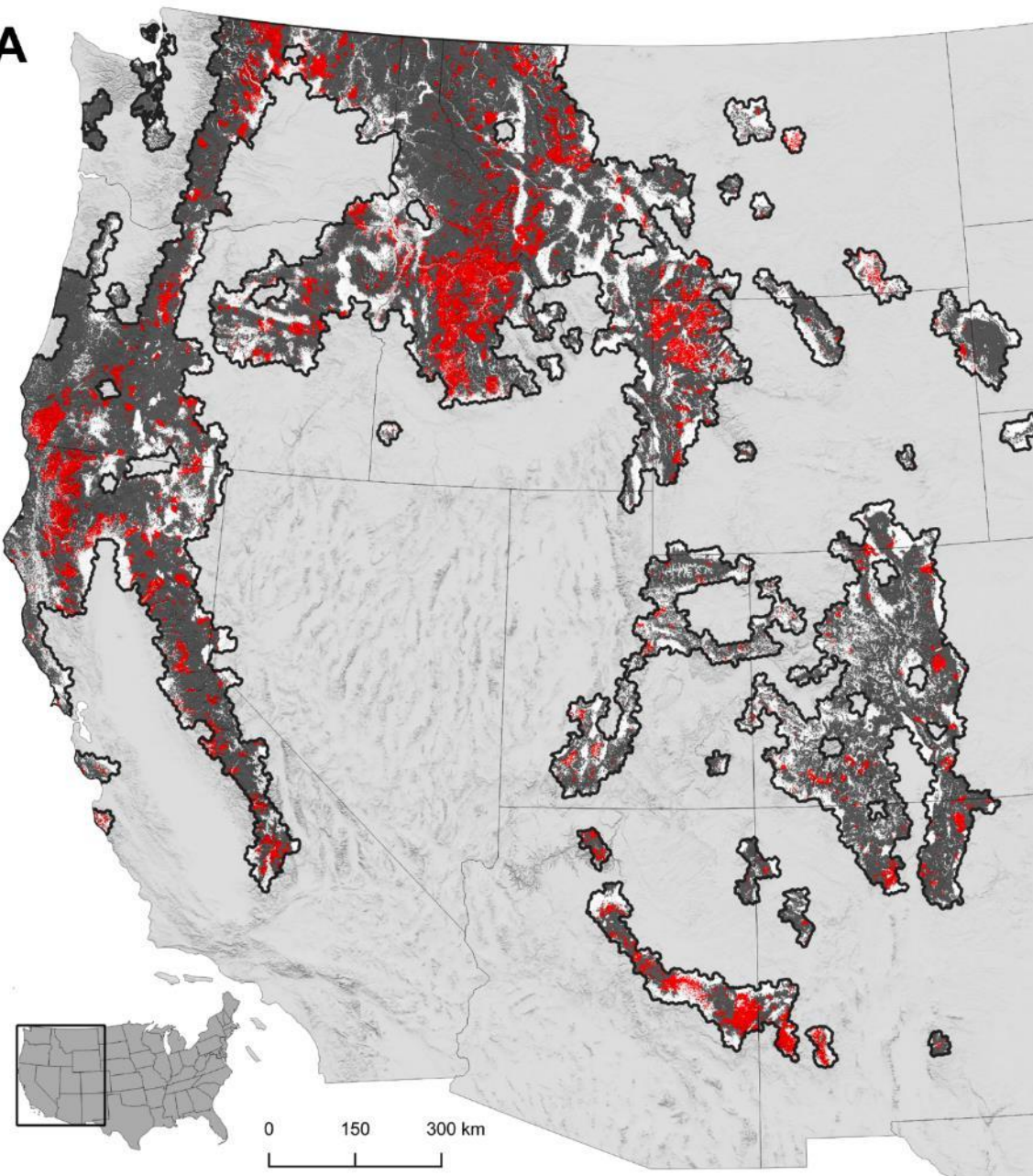
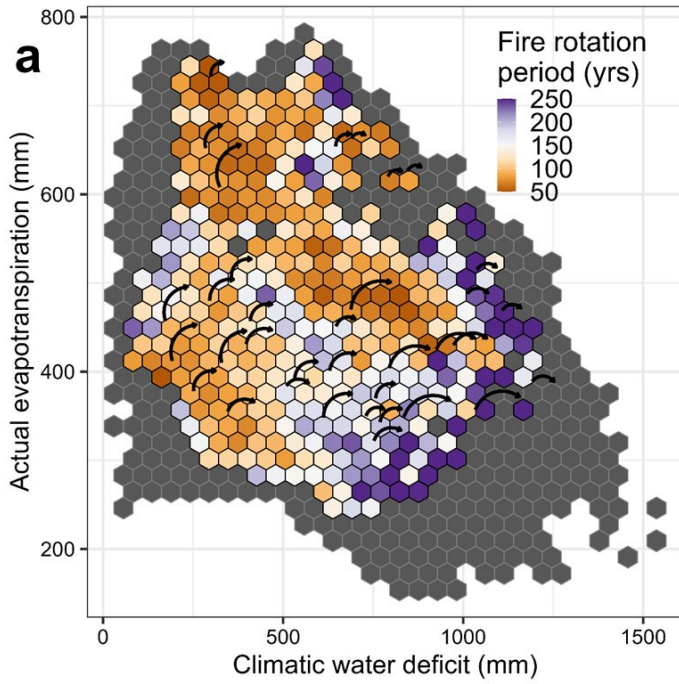**Conifer forests in geographic space**

Conifer forests in a climate space

Fires observed
150
100
50
10

Actual evapotranspiration (mm)

Climatic water deficit (mm)

Burned conifer forest w/ sufficient sample   Burned conifer forest w/ insufficient sample   Unburned conifer forest
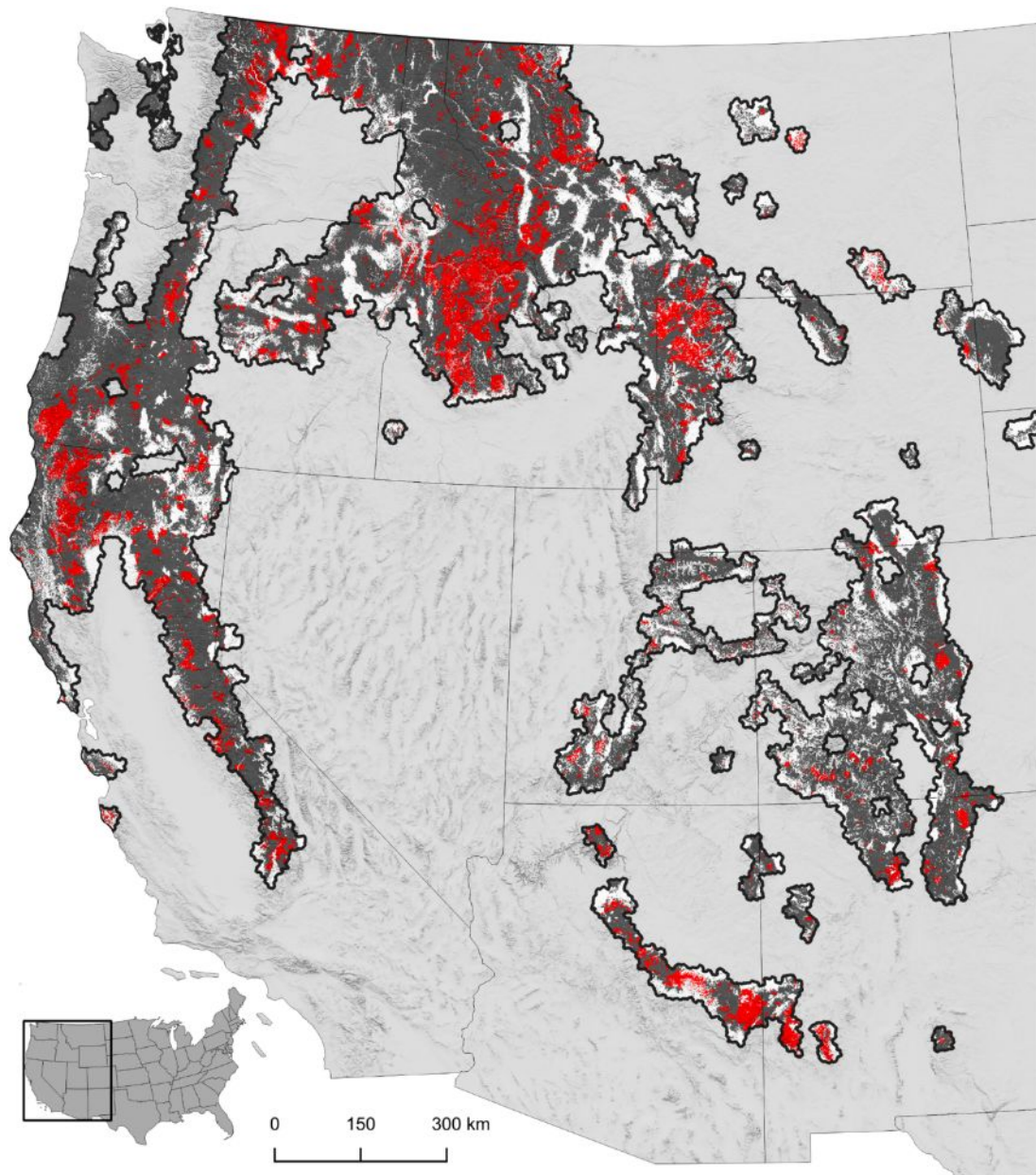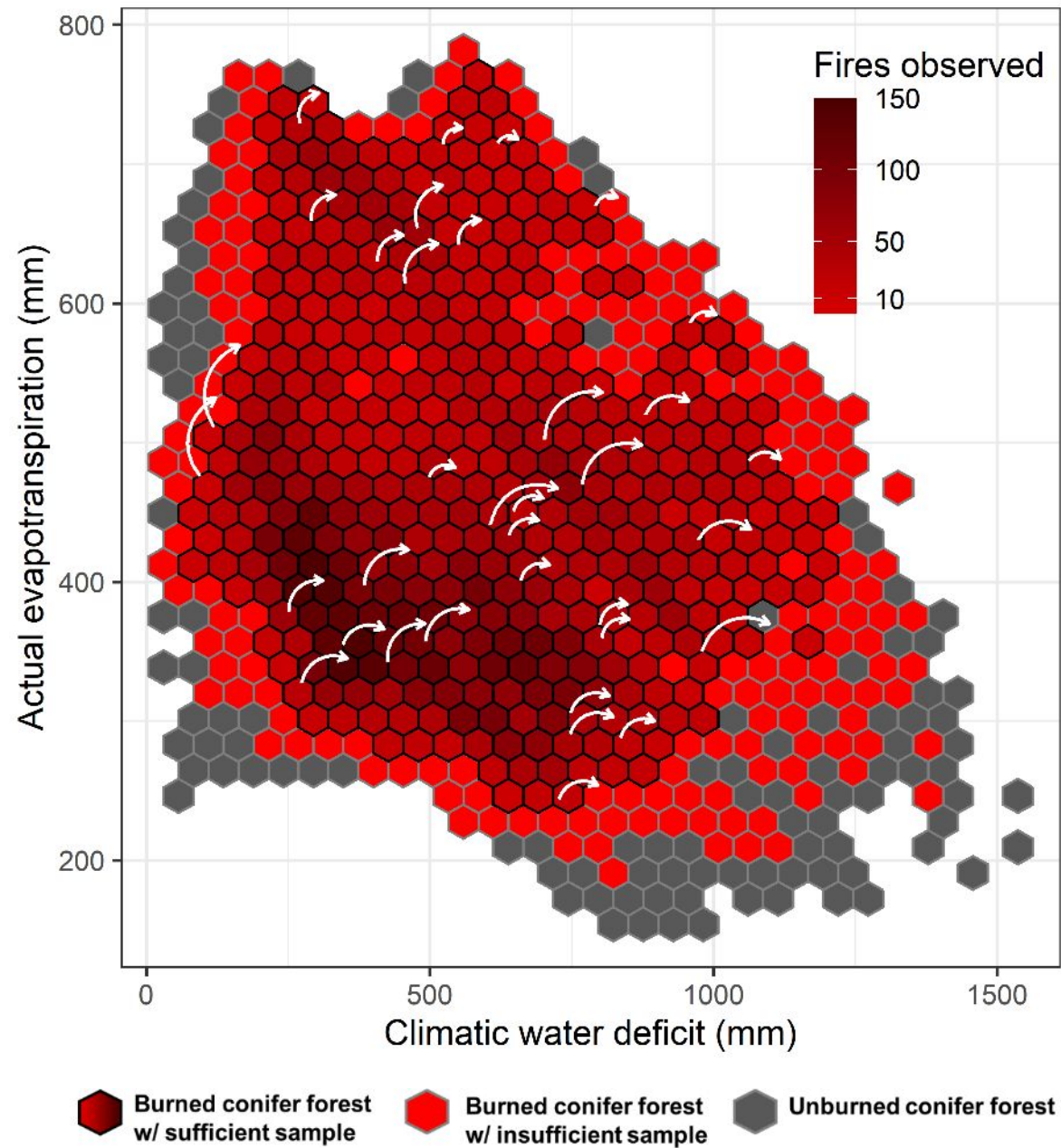
Fire & vegetation information from thousands of points within dozens of fires that share climate

Observed data from locations that share a climate

+2 deg. C

Observed data from locations that share a climate

Mean 1961-1990

Conifer forests in a climate space
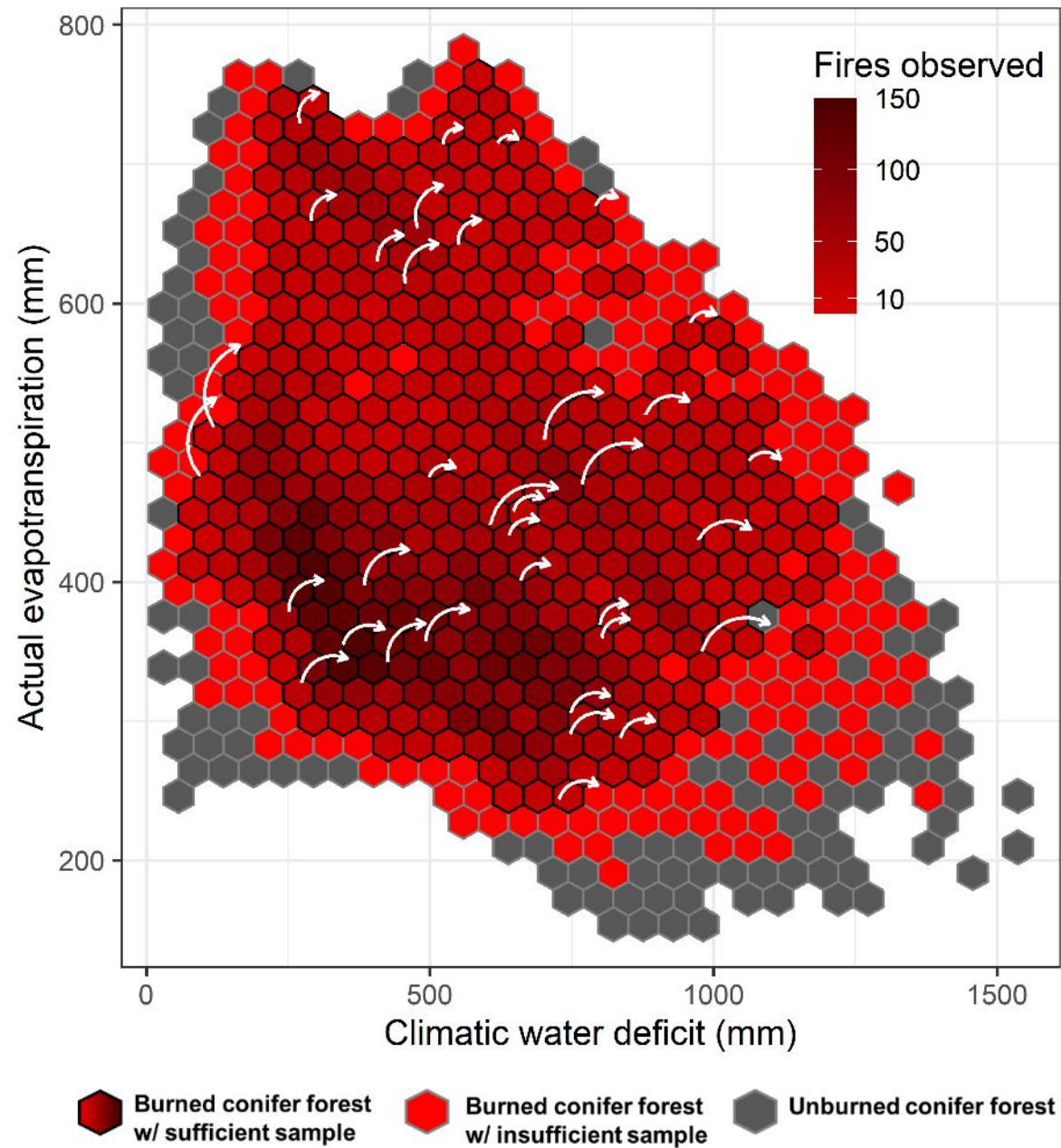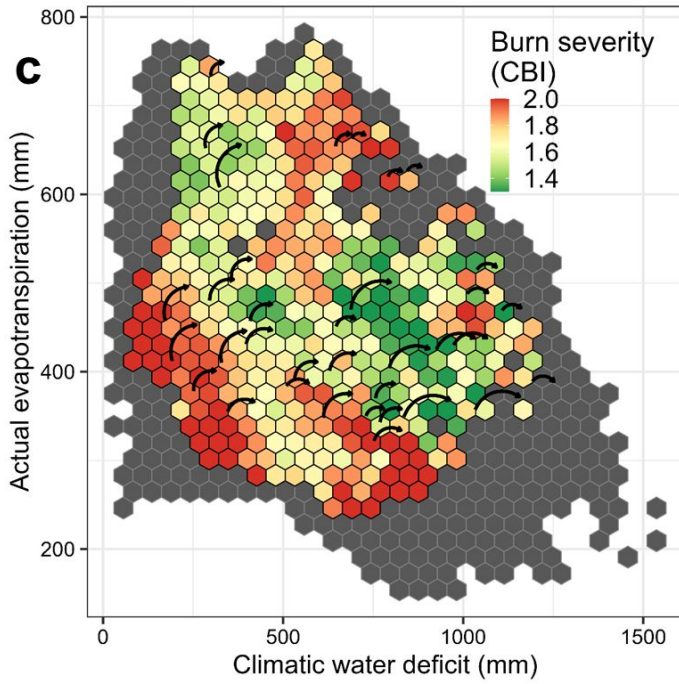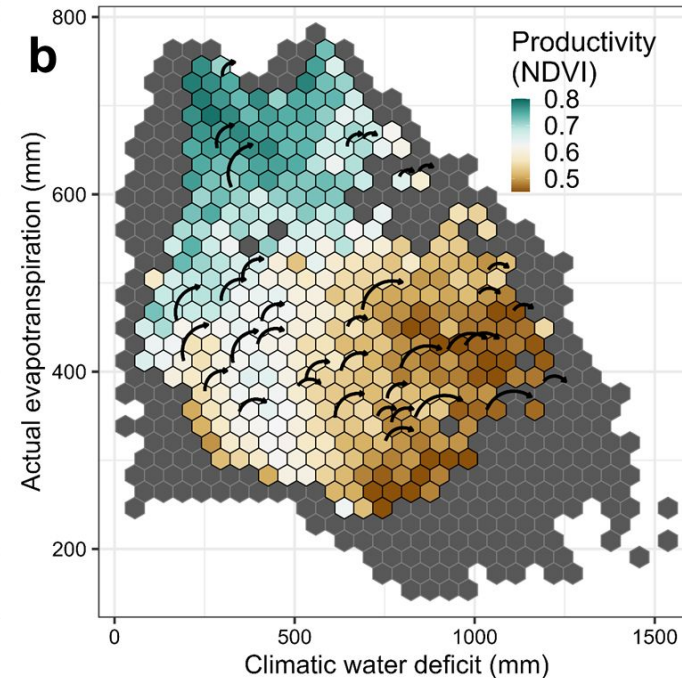
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Burned conifer forest w/ sufficient sample   Burned conifer forest w/ insufficient sample   Unburned conifer forest
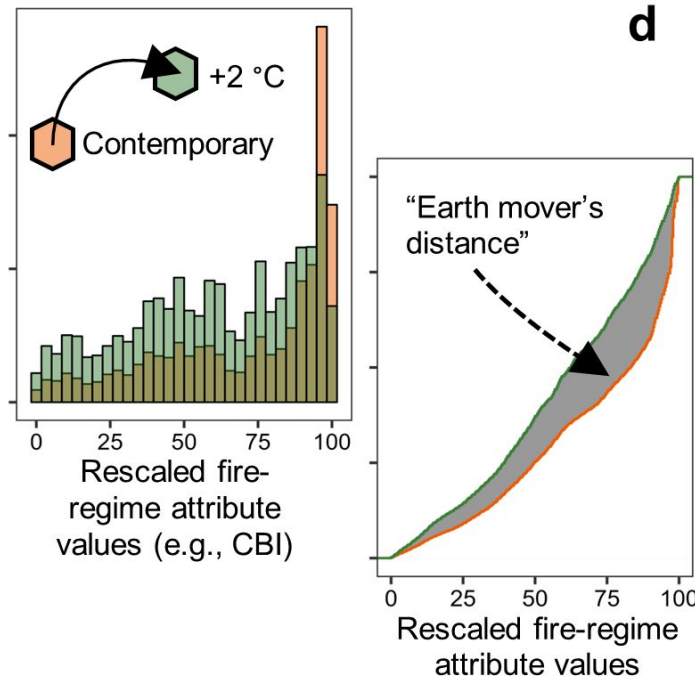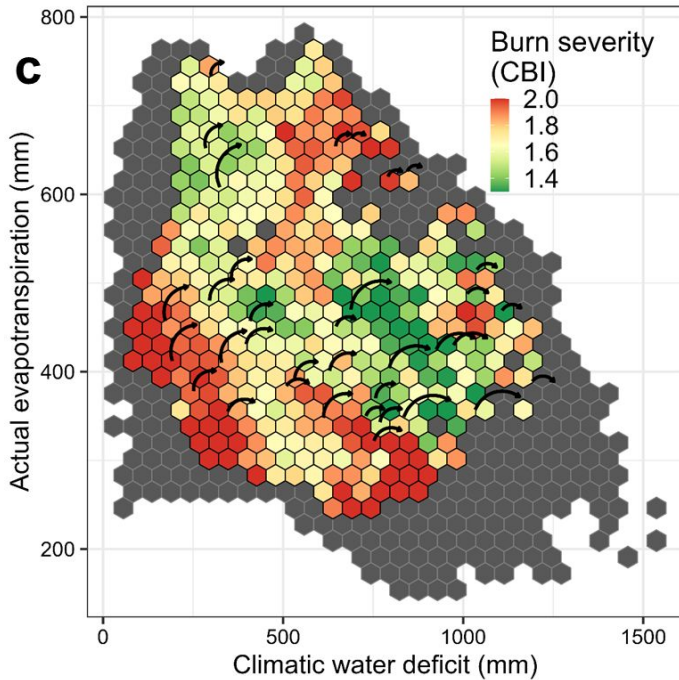
Patterns of fire frequency and burn severity are complex across gradients in climate and productivity
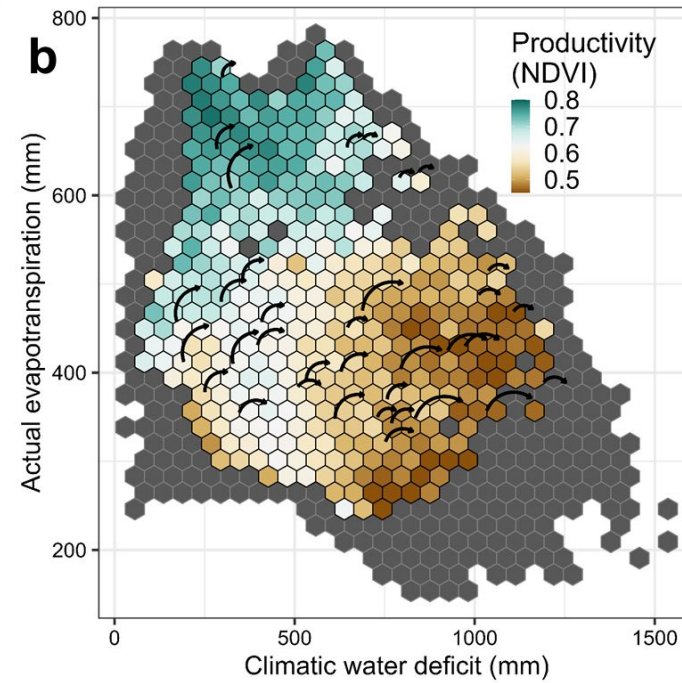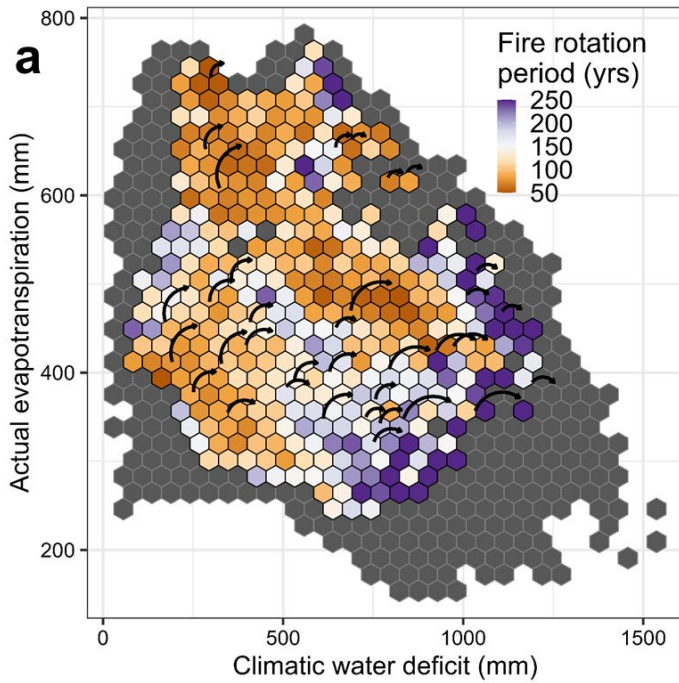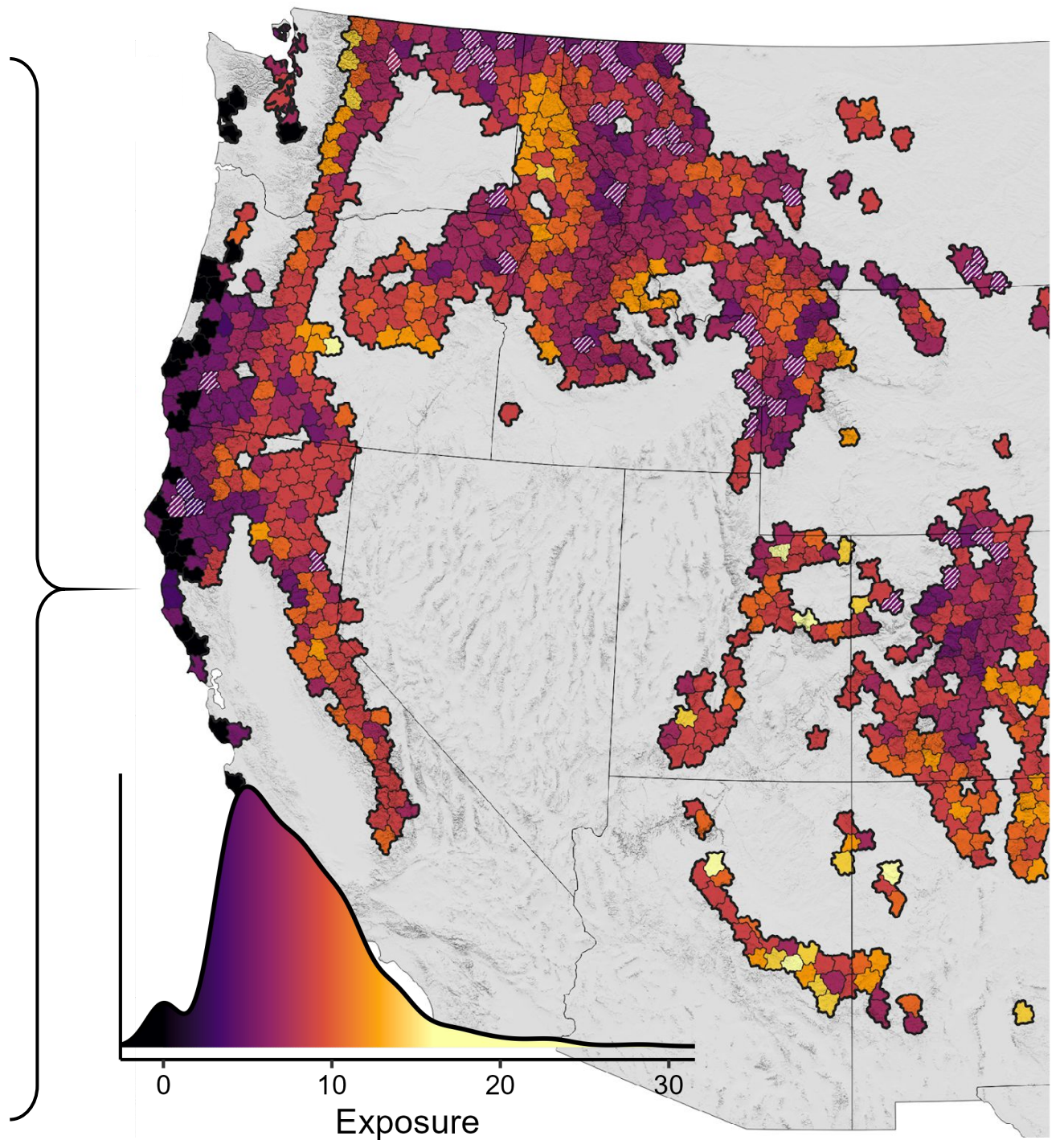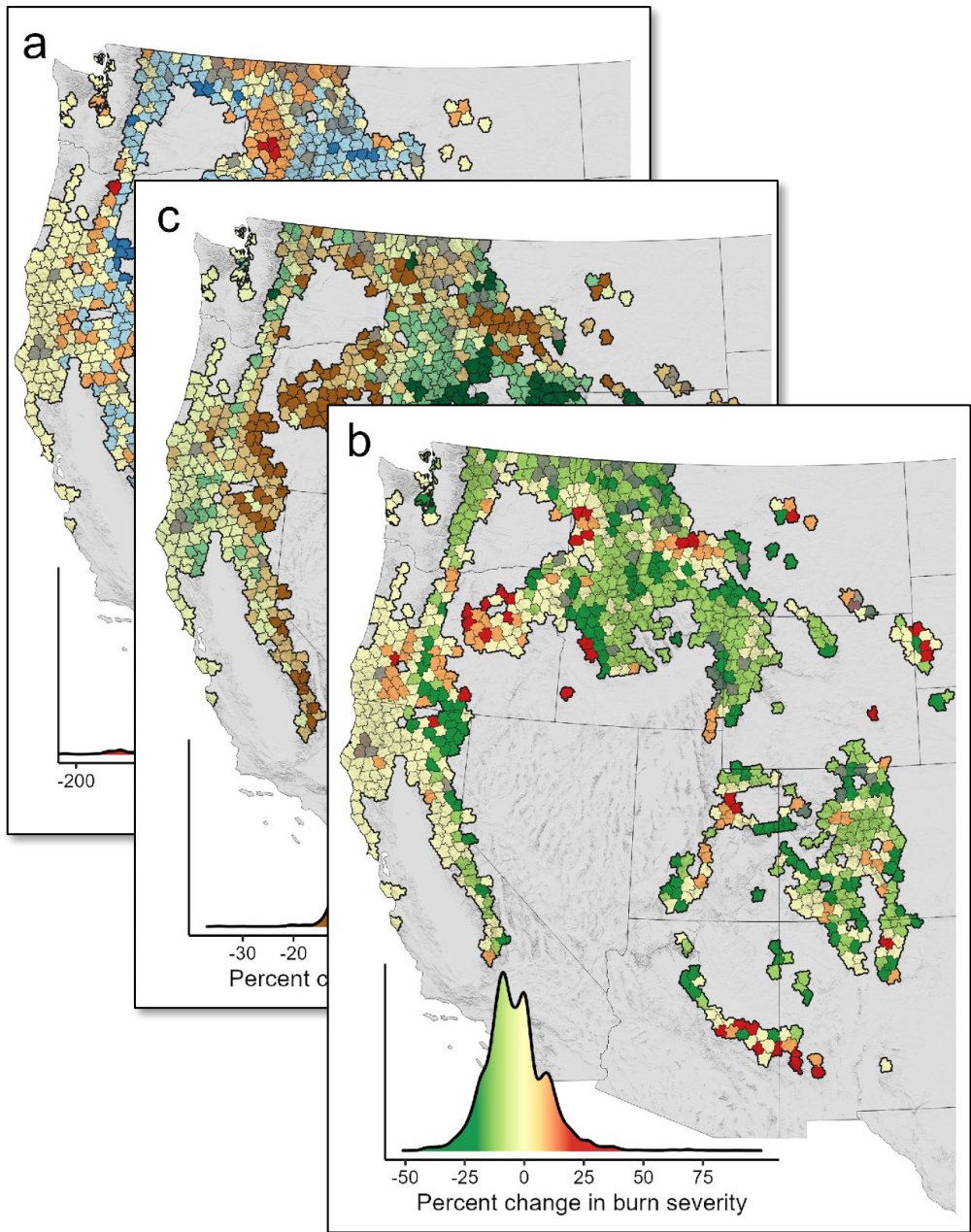
Patterns of fire frequency and burn severity are complex across gradients in climate and productivity

We measured multivariate dissimilarity between contemporary fire regimes and those supported by future climates

a

c

b

Percent change in burn severity
-50   -25   0   25   50   75

Exposure
0   10   20   30

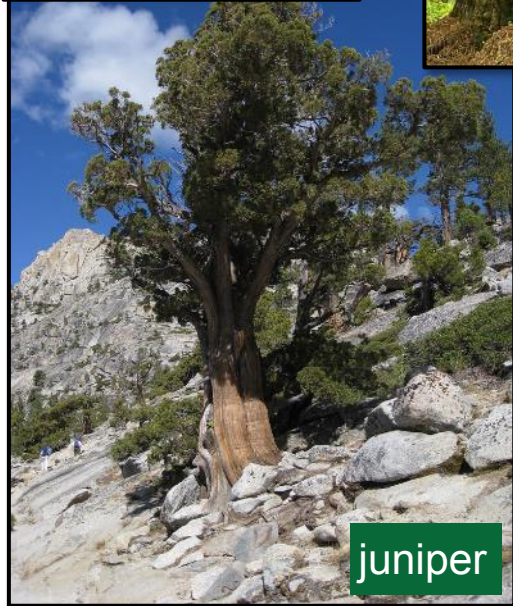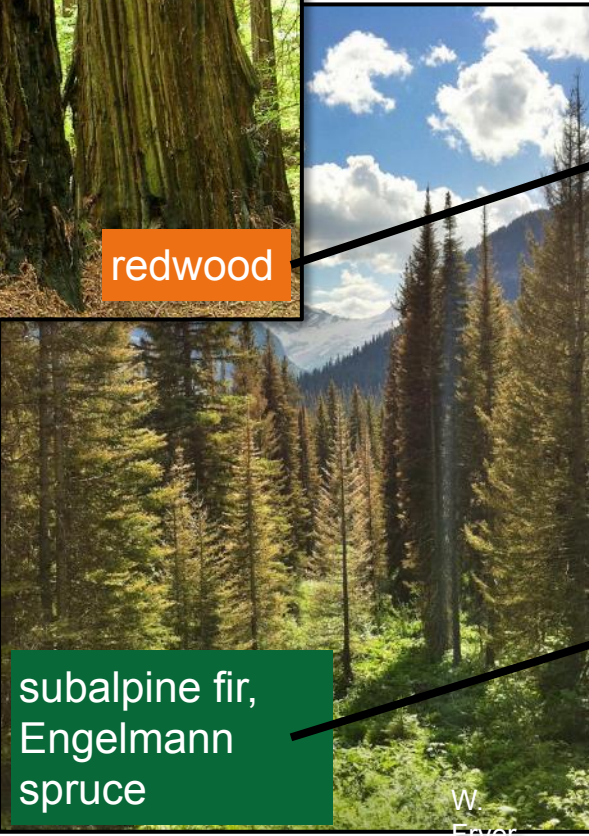# Information about the distribution of fire-relevant traits provides key context
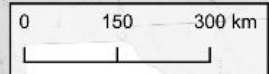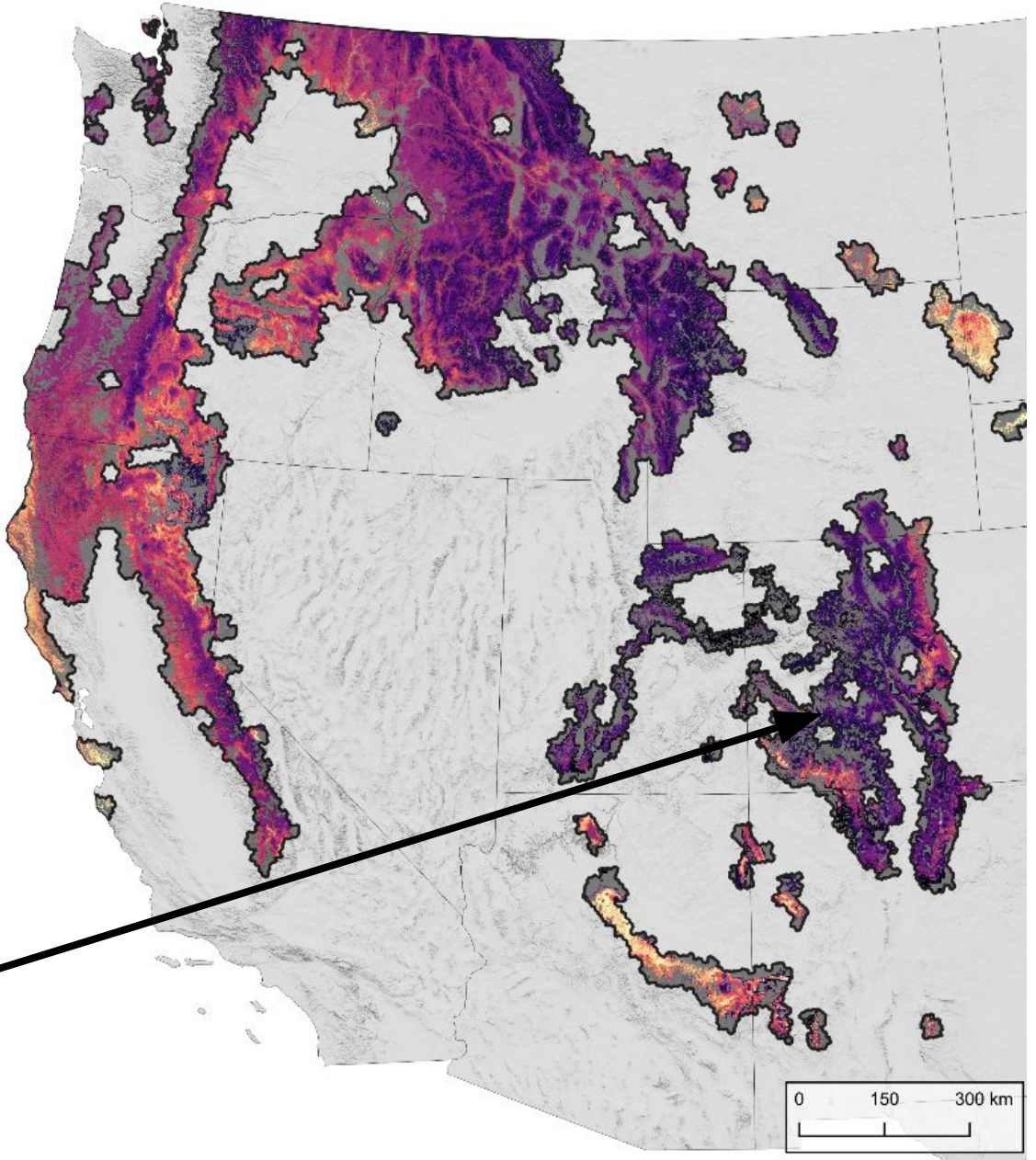

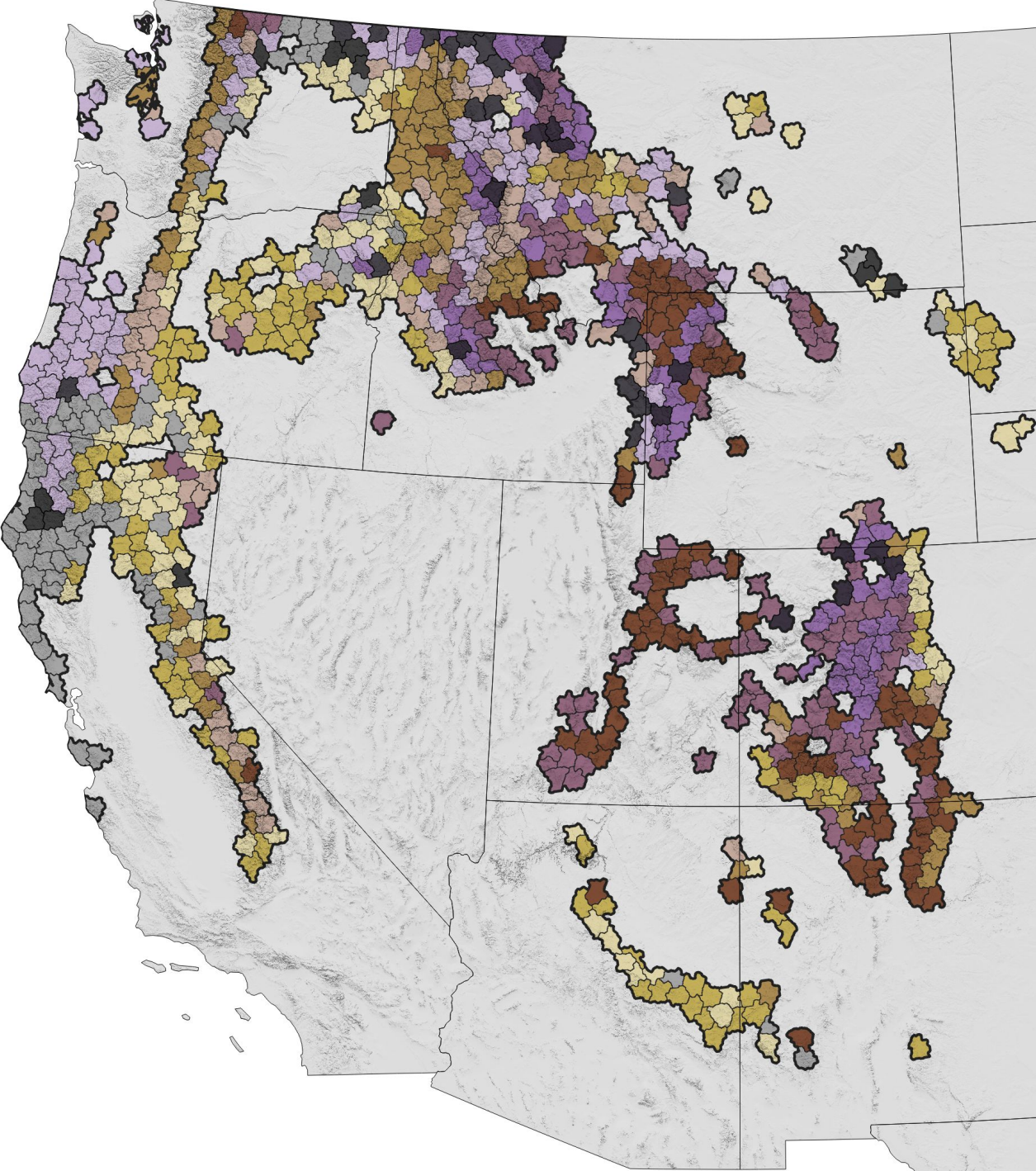**Fire-resistance trait index**

ponderosa pine

redwood

juniper

subalpine fir, Engelmann spruce

W. Fryer

Stevens et al. 2020. Global Ecology and Biogeography.

Low exposure to fire-regime change and low fire resistance

High exposure to fire-regime change and high fire resistance

Fire resistance

Low

High

Exposure to fire-regime change

Low

High

Low exposure to fire-regime change and high fire resistance

Low exposure to fire-regime change and high fire resistance
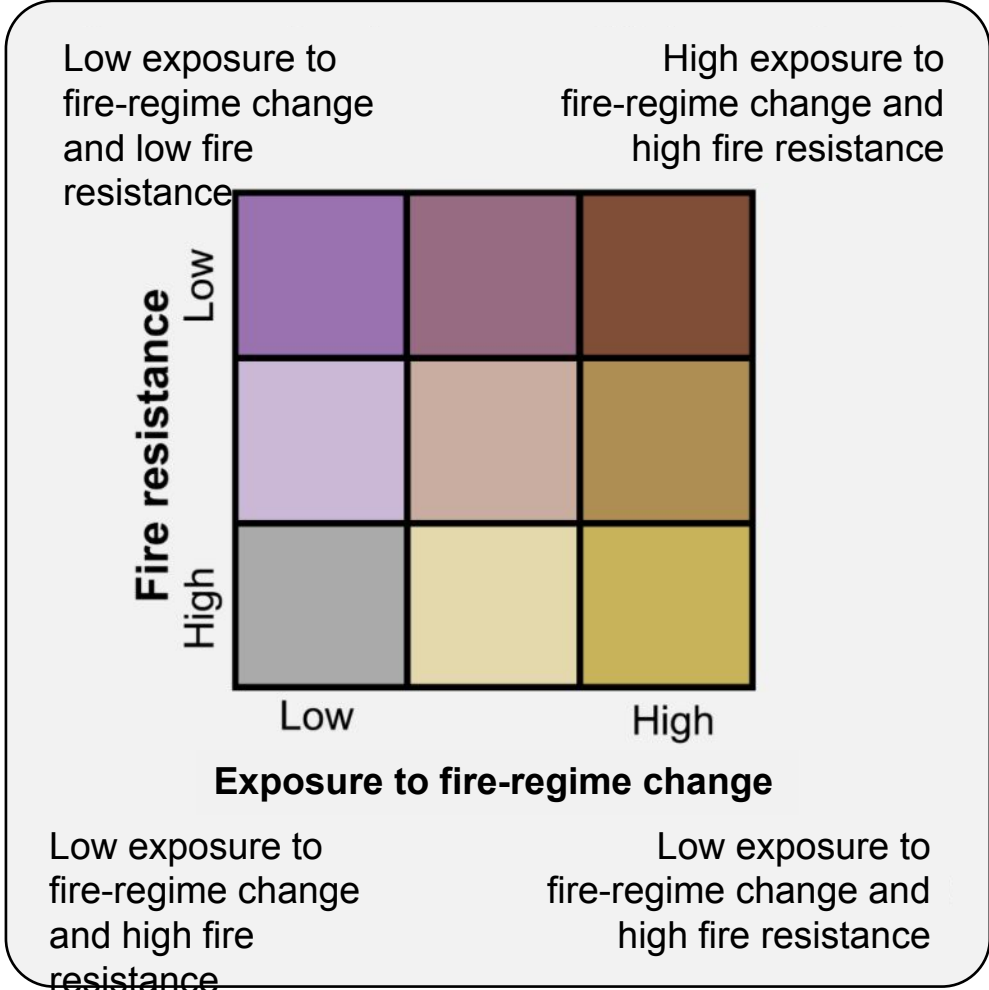
**Fire-resistant forests,** *where exposure is low,* **could** *adapt to future regimes and* **persist**

*Exposure is high and adaptive capacity is low (**vulnerability is high**) in warm-dry **'trailing edge' forests** and cool-wet **subalpine forests***

**communications** earth & environment

Widespread exposure to altered fire regimes under 2 °C warming is projected to transform conifer forests of the Western United States

Tyler J. Hoecker ✉, Sean A. Parks, Meade Krosby & Solomon Z. Dobrowski
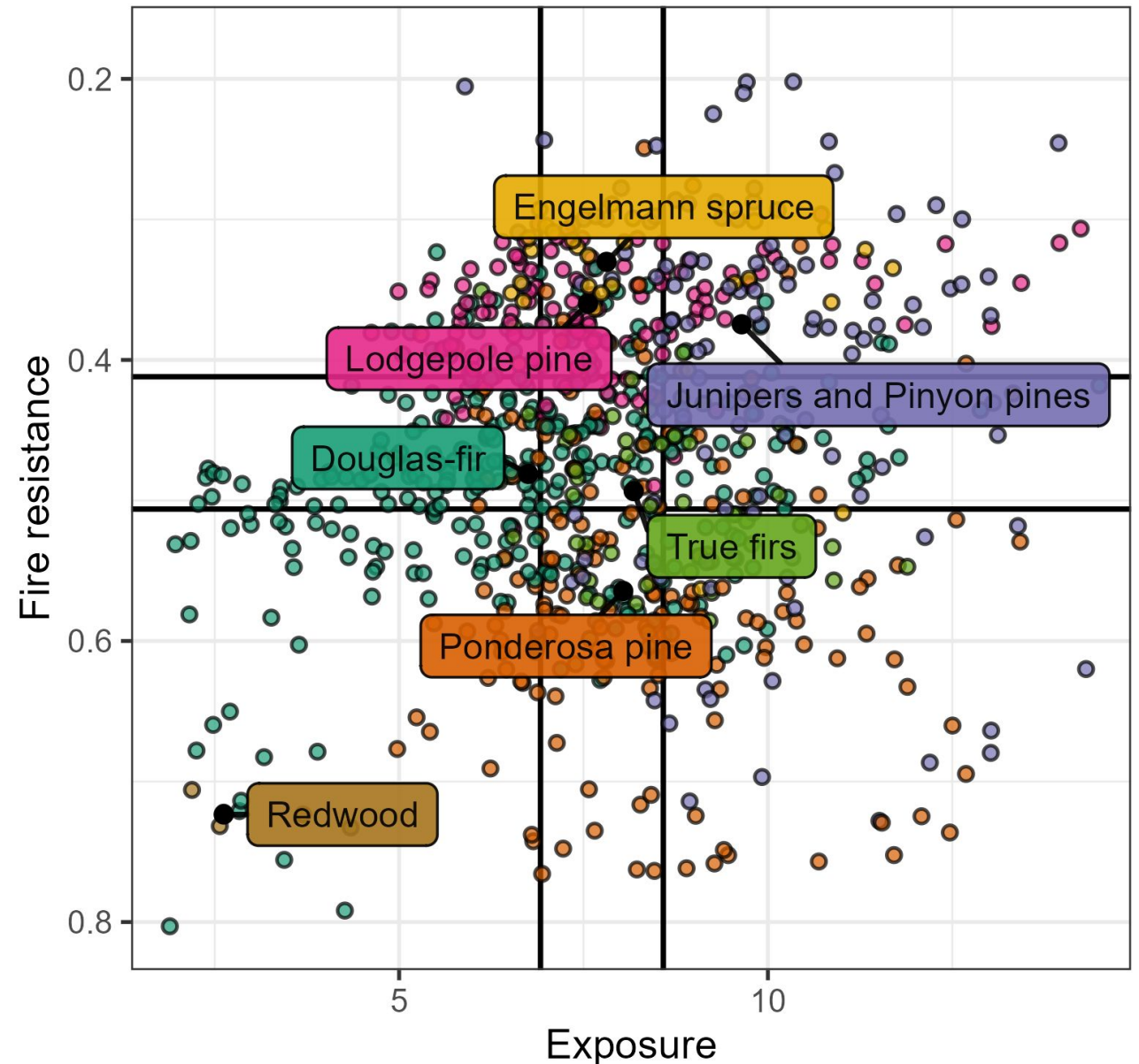
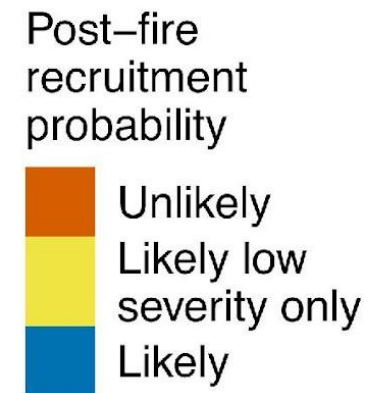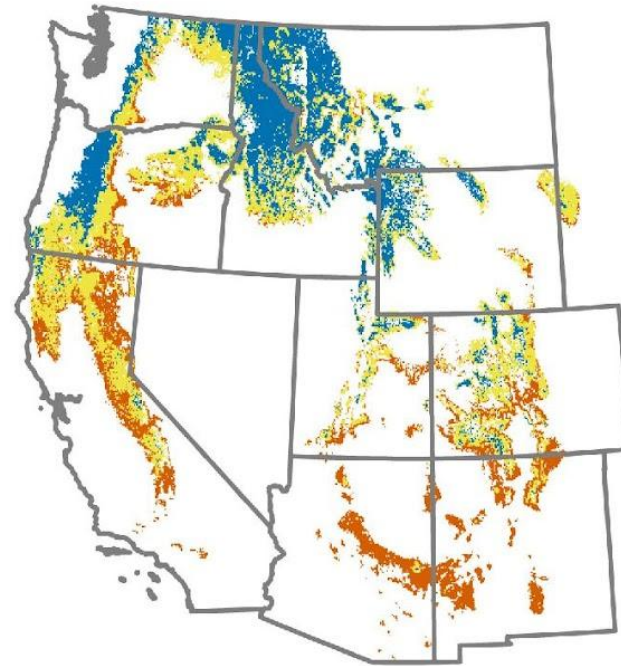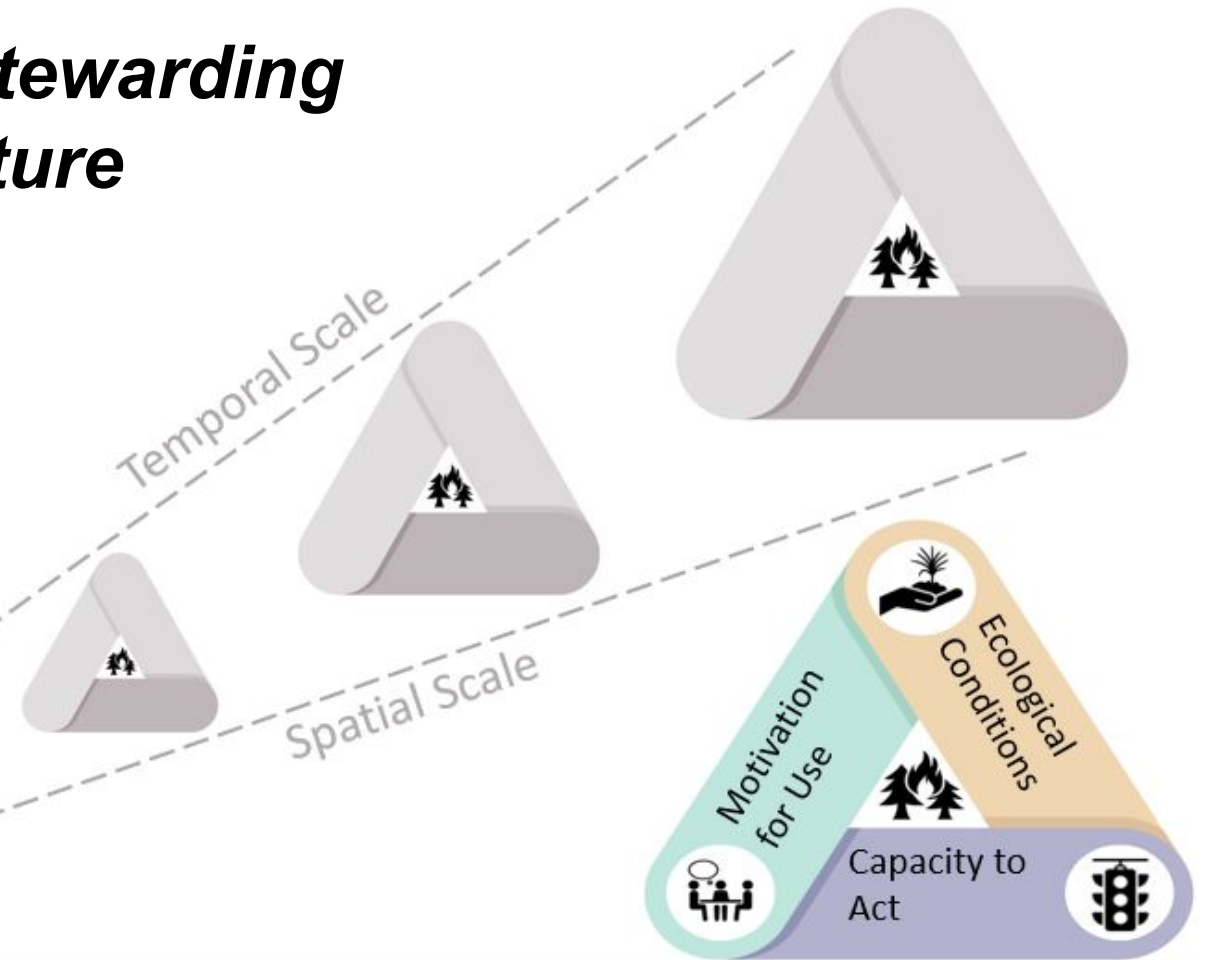*Multiple lines of evidence suggest* **post-fire regeneration, supported by mature tree survival, is possible under low burn severity**

2031–2050 RCP 4.5

Post–fire recruitment probability

- Unlikely
- Likely low severity only
- Likely
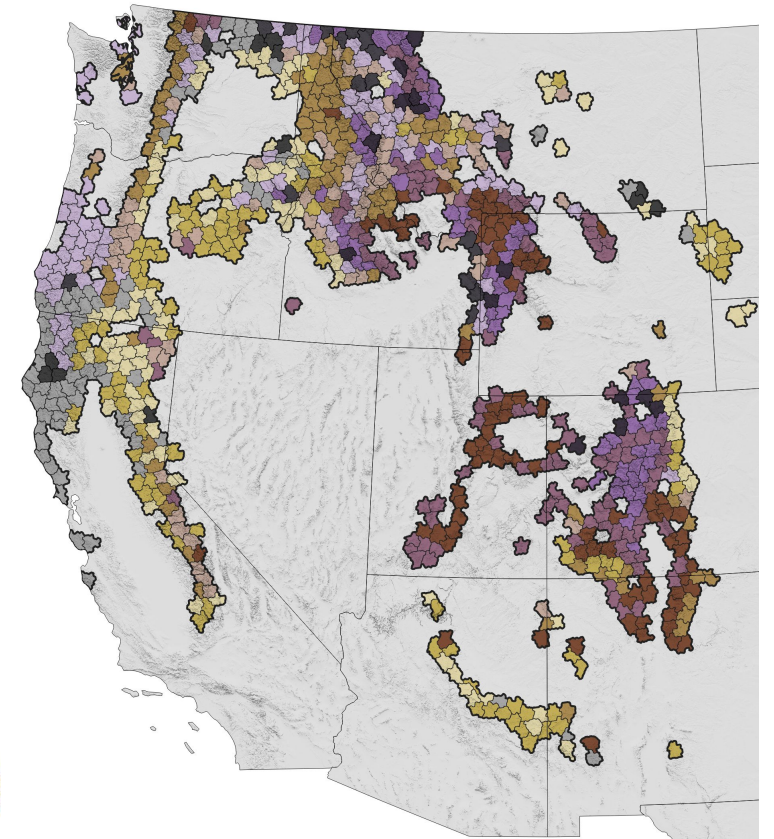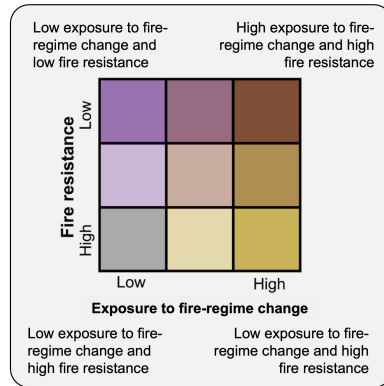
Intentional fire use is central to stewarding fire-prone landscapes into the future

A social-ecological fire-use decision space

How can information about likely future conditions inform risk analysis and pre-fire planning?

- Pre-fire planning supports beneficial fire use by identifying response scenarios before incidents unfold

- Strategic prioritization of fuel treatments and Rx fire

- Assessments should be scenario-based and future-proof; account for restoration and adaptation value and avoided loss

WILDFIRE CRISIS
Landscape Investments

CENTRAL WASHINGTON INITIATIVE

FOREST SERVICE REGION
Pacific Northwest

NATIONAL FOREST
Okanogan-Wenatchee
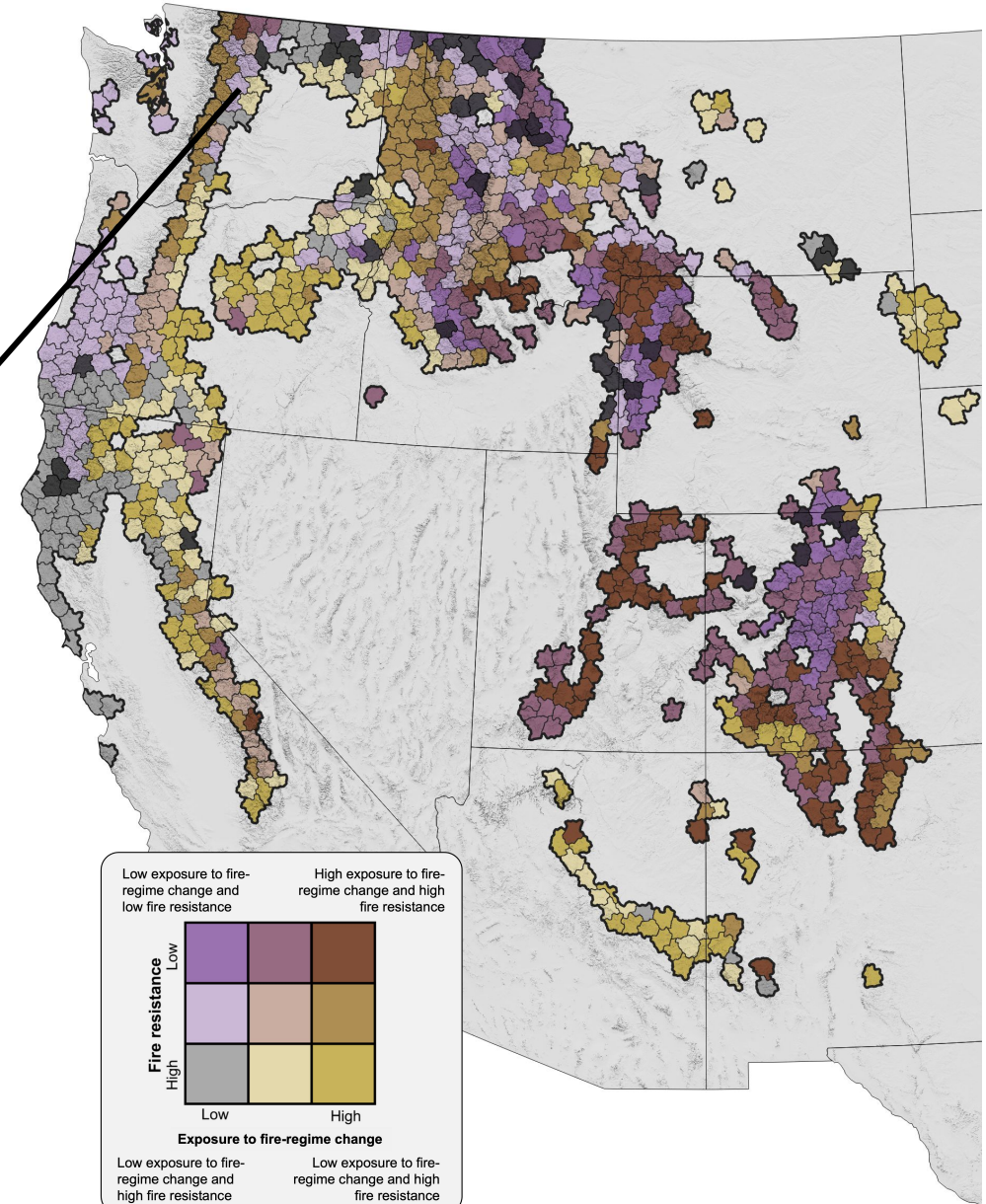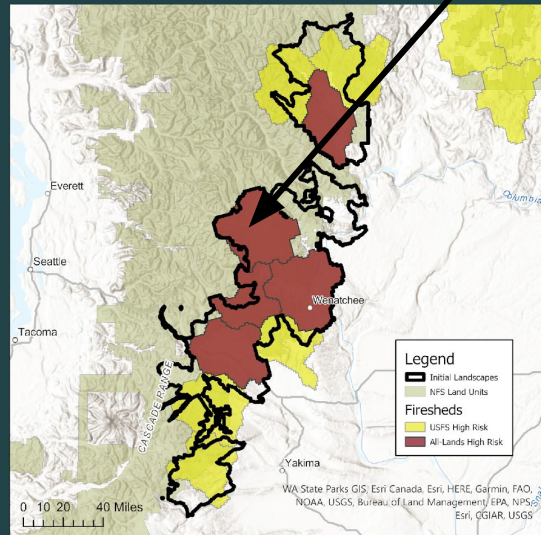National Forest

STATE
Washington

LANDSCAPE SIZE
2,450,000 acres

EXPECTED FUNDING, FY 2023
$39,910,598

2022-2024 >$100 million

USDA

Thank you!
Questions?

Scan to read the OA paper ⤴

a

b

c

d

Fire rotation period (yrs)
250
200
150
100
50

Productivity (NDVI)
0.8
0.7
0.6
0.5

Burn severity (CBI)
2.0
1.8
1.6
1.4

+2 °C

Contemporary

"Earth mover's distance"

Rescaled fire-regime attribute values (e.g., CBI)

Rescaled fire-regime attribute values

Fire-regime comparison

Contemporary-Contemporary (null model)

Contemporary-Future

Actual evapotranspiration (mm)

Climatic water deficit (mm)

Fireshed ID

Dissimilarity (Earth mover's distance)