Searching for Sanctuary

Lining up old-growth forest and carbon reserves with fire refugia in a changing climate

Raymond Davis
Zhiqiang Yang

Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan

A geographical context

Northern spotted owl
(Strix occidentalis caurina)

Northwest Forest Plan
Interagency Monitoring Program

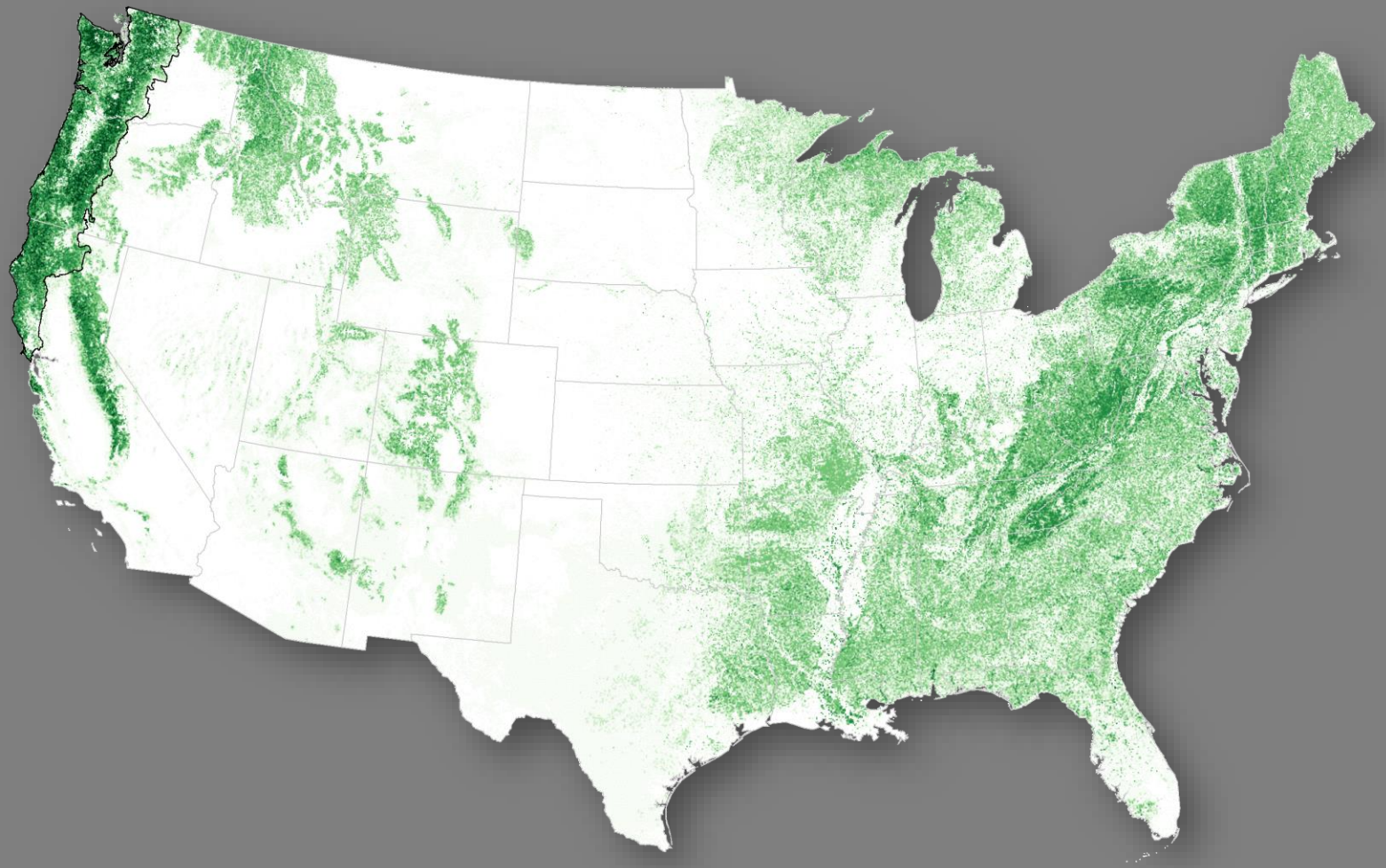
The Northwest Forest Plan

A geographical context

Aboveground Forest Biomass

high

low

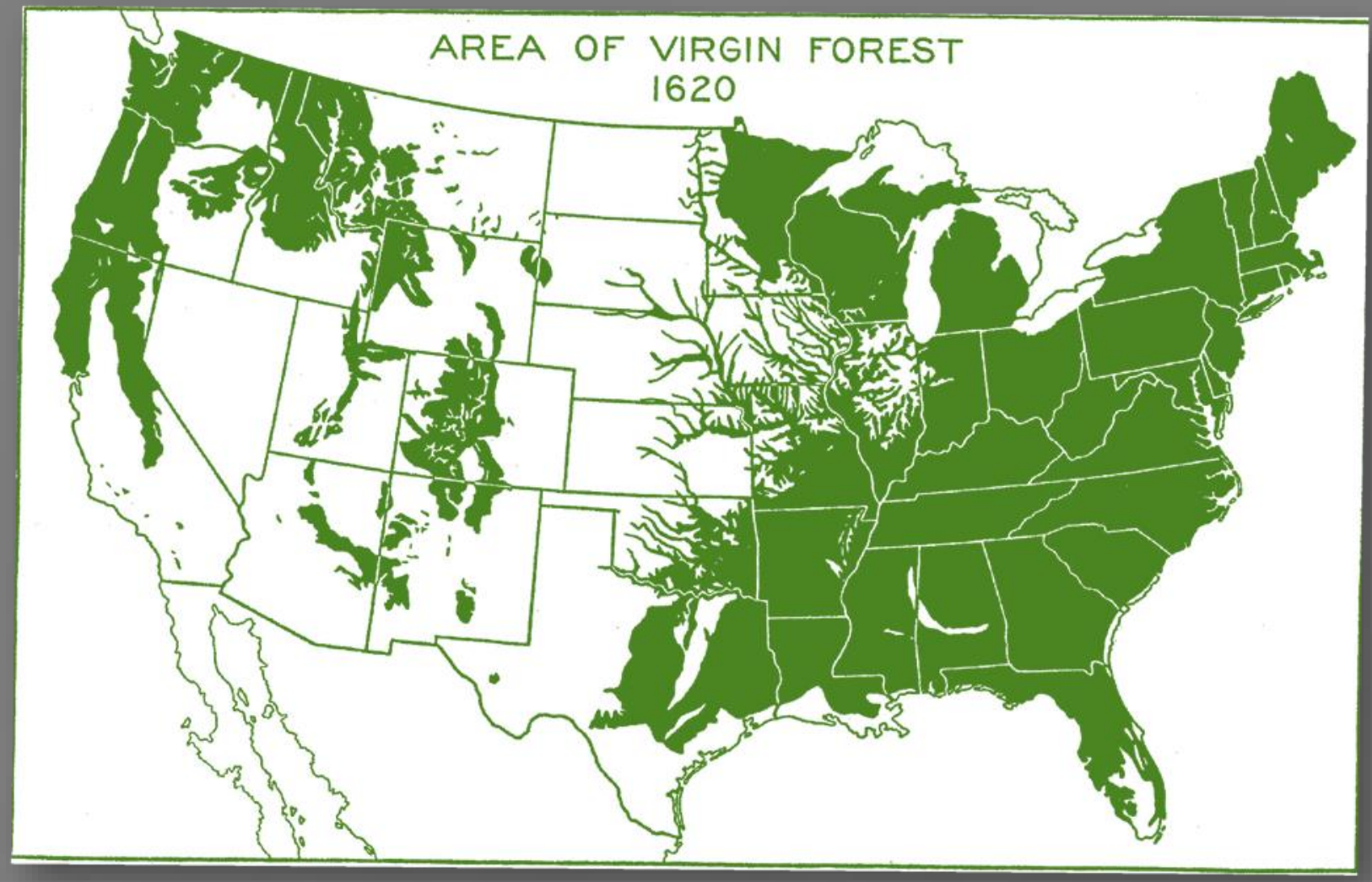


Wilson, B. Tyler; Lister, Andrew J.; Riemann, Rachel I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182-198. DOI: https://doi.org/10.1016/j.foreco.2012.02.002

Northwest Forest Plan
Interagency Monitoring Program

US Forest Geography

The first forest time series maps

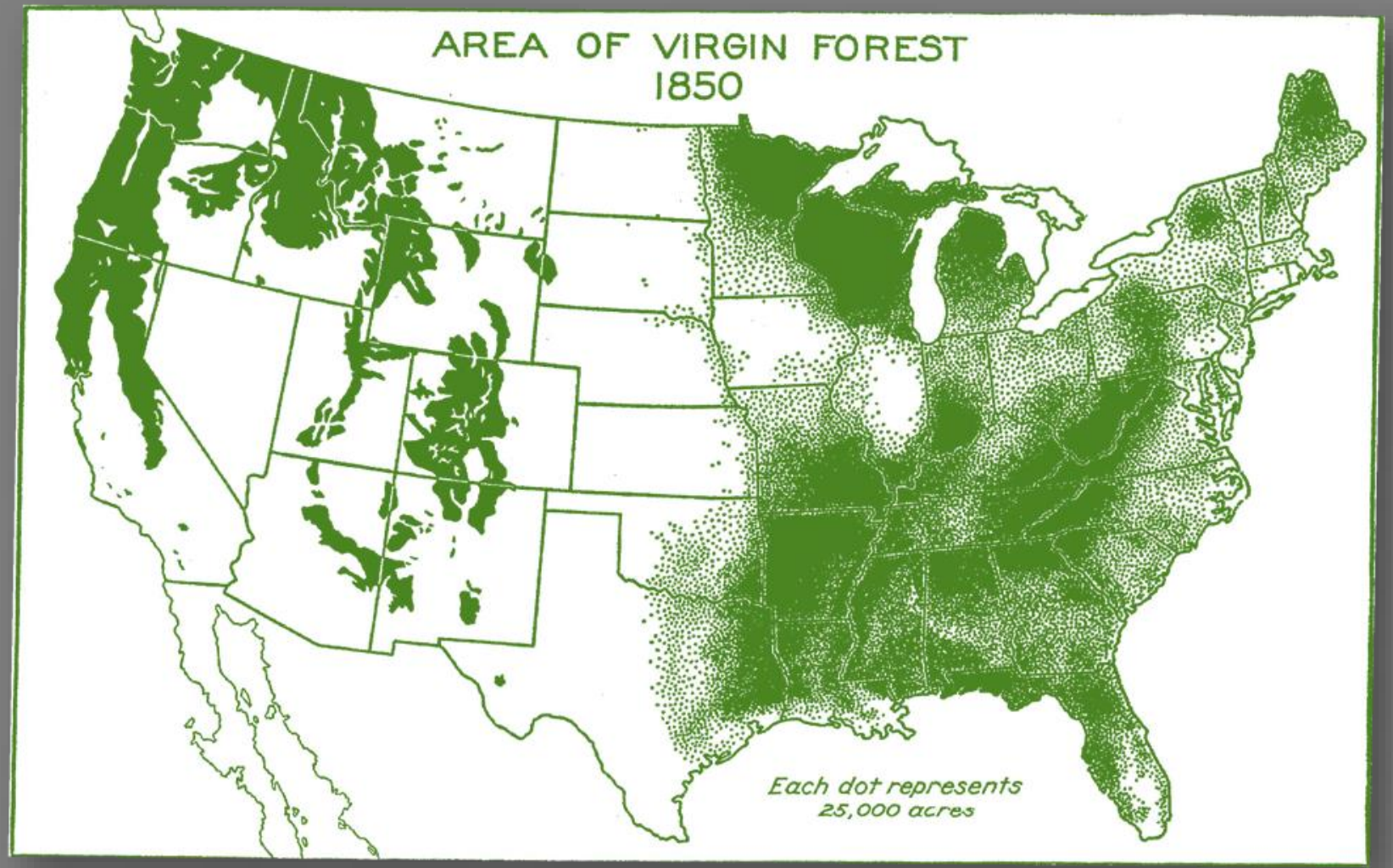


Greeley, William B. 1925. The relation of geography to timber supply. Economic Geography 1:1, pp. 1–14

Northwest Forest Plan
Interagency Monitoring Program

US Forest Geography

The first forest time series maps

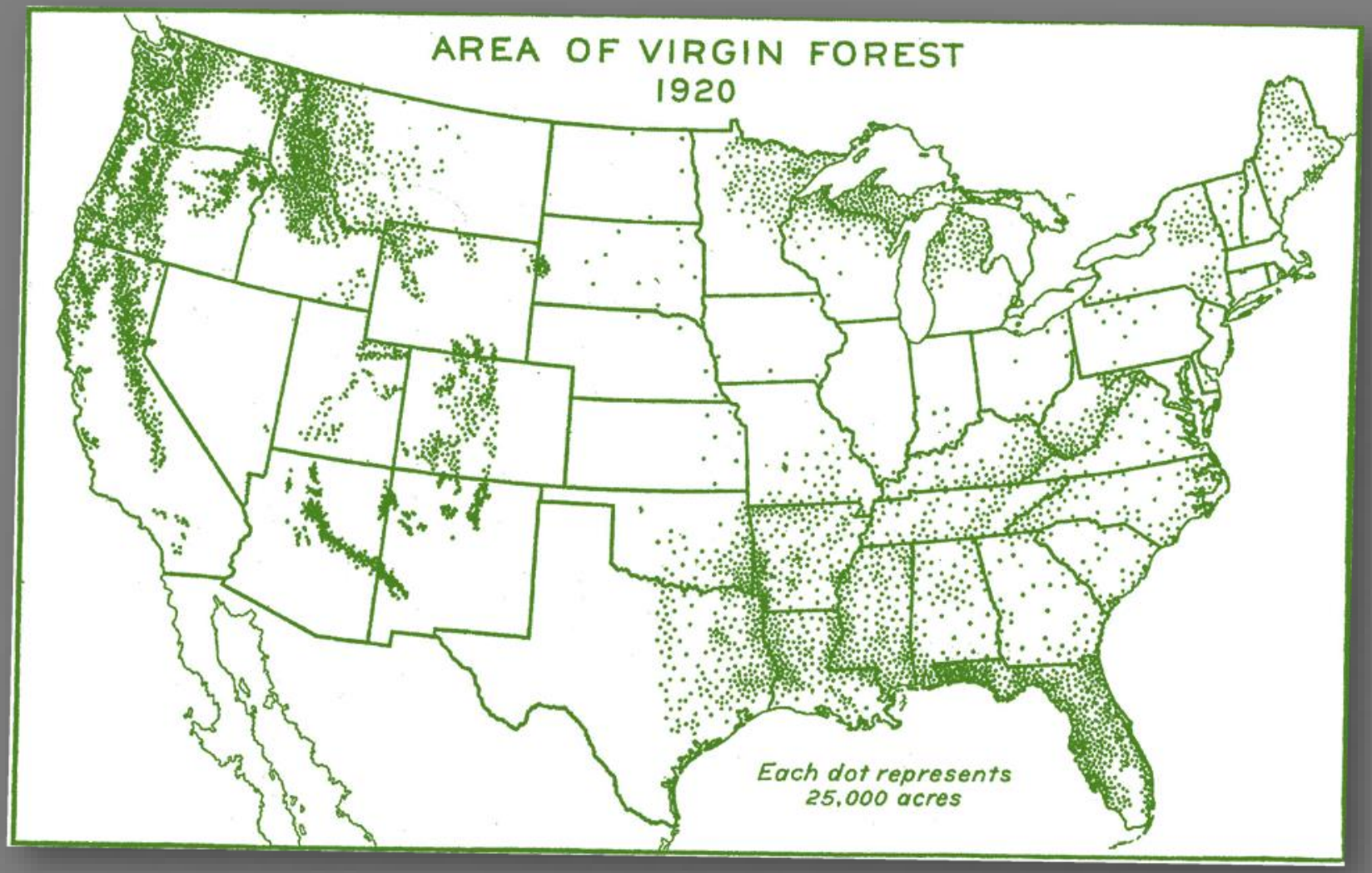


Greeley, William B. 1925. The relation of geography to timber supply. Economic Geography 1:1, pp. 1–14

Northwest Forest Plan
Interagency Monitoring Program

US Forest Geography

The first forest time series maps

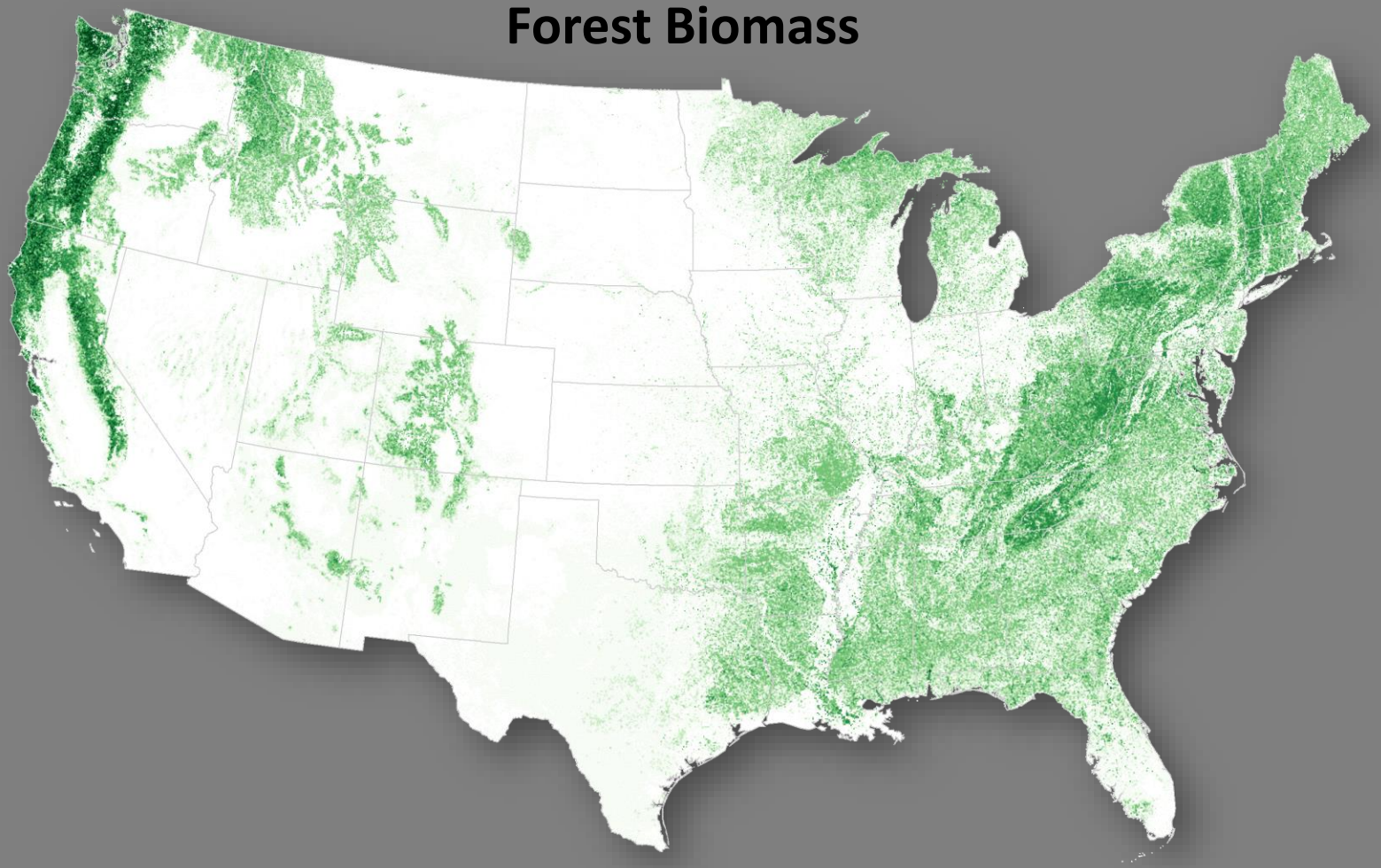


Greeley, William B. 1925. The relation of geography to timber supply. Economic Geography 1:1, pp. 1–14

Northwest Forest Plan
Interagency Monitoring Program

US Forest Geography

Current condition



Wilson, B. Tyler; Lister, Andrew J.; Riemann, Rachel I. 2012. A nearest-neighbor imputation approach to mapping tree species over large areas using forest inventory plots and moderate resolution raster data. Forest Ecology and Management. 271: 182-198. DOI: https://doi.org/10.1016/j.foreco.2012.02.002

Northwest Forest Plan
Interagency Monitoring Program

US Forest Fire Geography

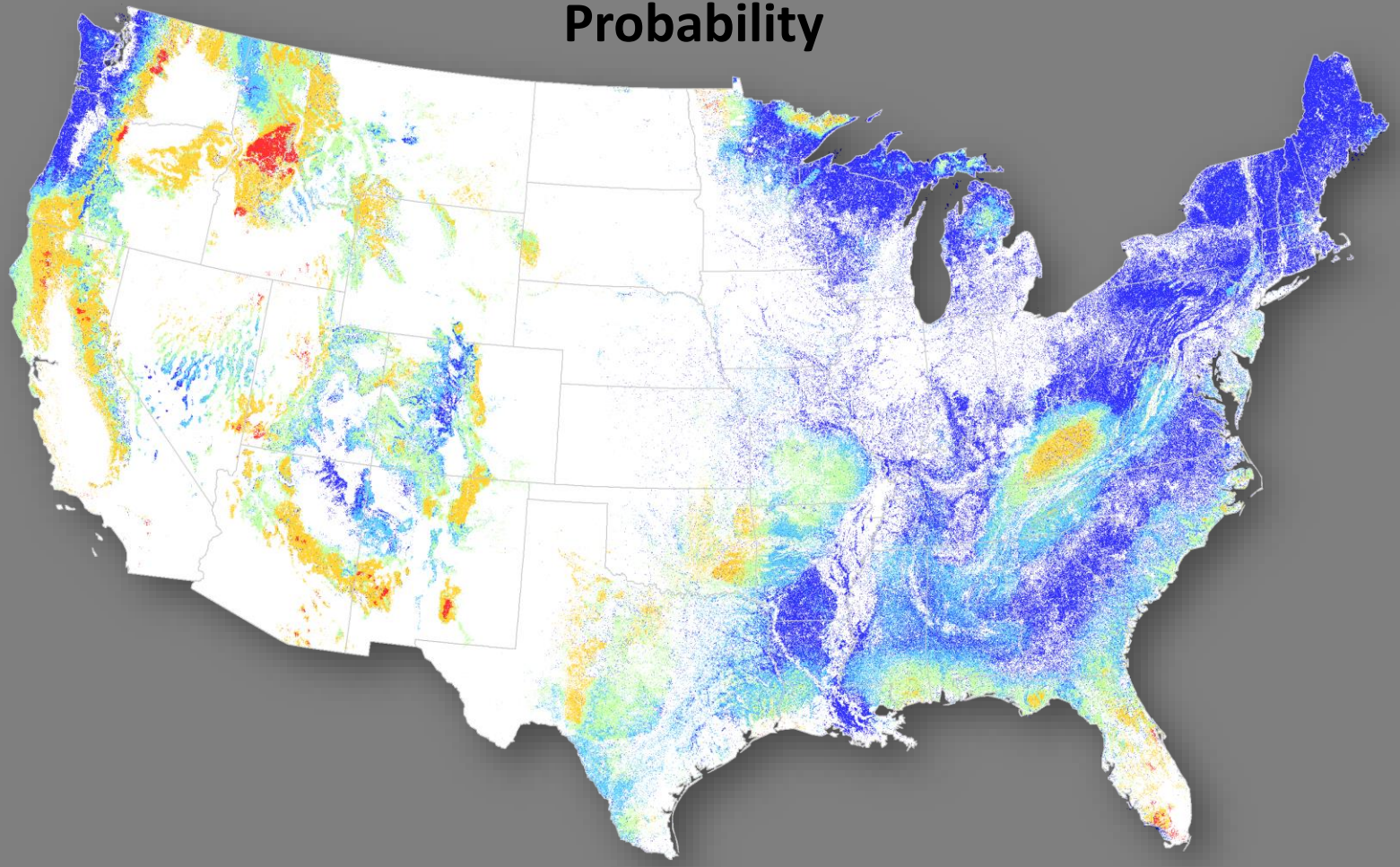
Current climate

Wildfire Probability

high

low

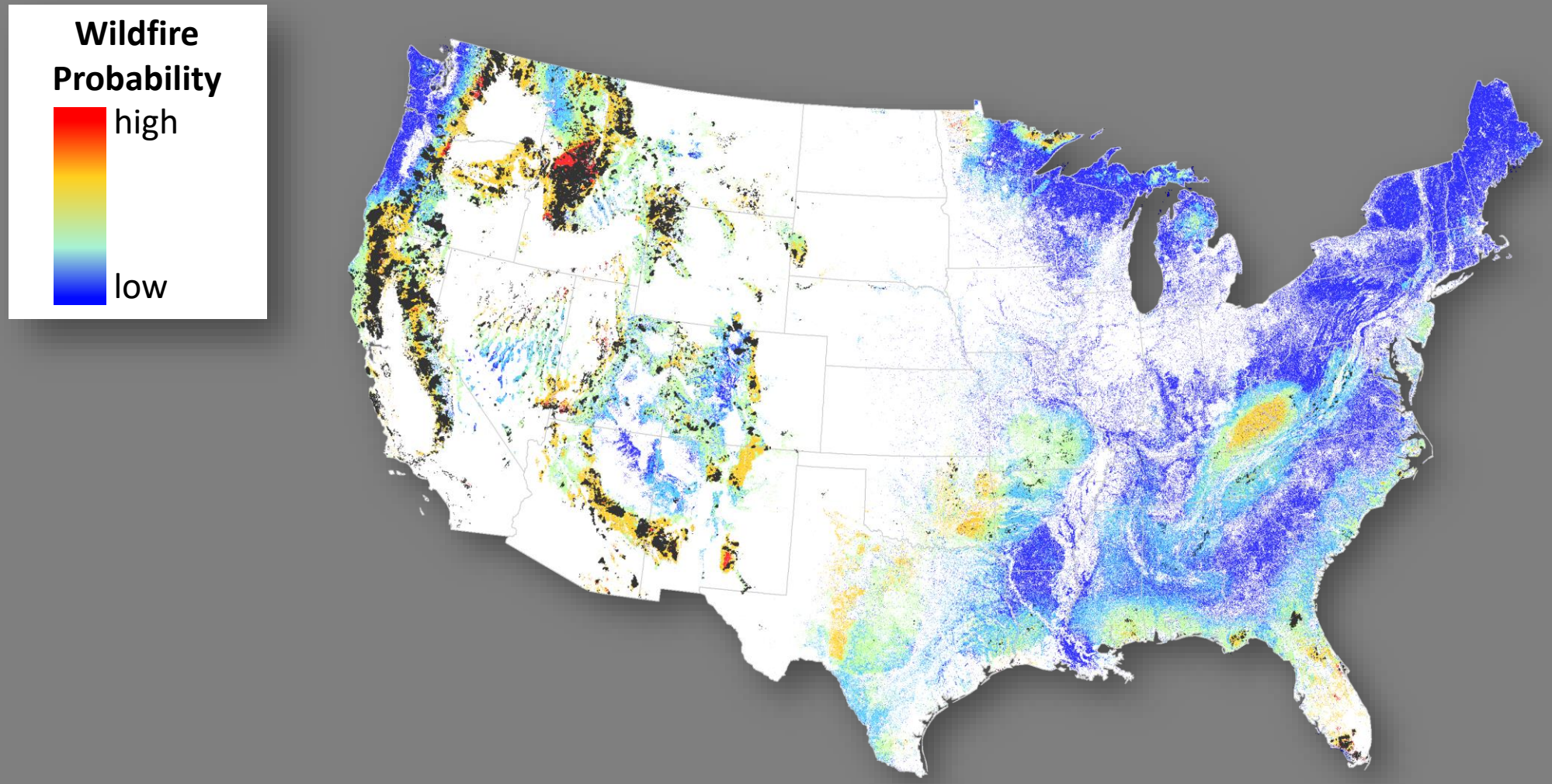
Wildfire (Burn) Probability



Short, Karen C.; Finney, Mark A.; Vogler, Kevin C.; Scott, Joe H.; Gilbertson-Day, Julie W.; Grenfell, Isaac C. 2020. Spatial datasets of probabilistic wildfire risk components for the United States (270m). 2nd Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0034-2

Northwest Forest Plan
Interagency Monitoring Program

US Forest Wildfires
(1970–2021)



Short, Karen C.; Finney, Mark A.; Vogler, Kevin C.; Scott, Joe H.; Gilbertson-Day, Julie W.; Grenfell, Isaac C. 2020. Spatial datasets of probabilistic wildfire risk components for the United States (270m). 2nd Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0034-2

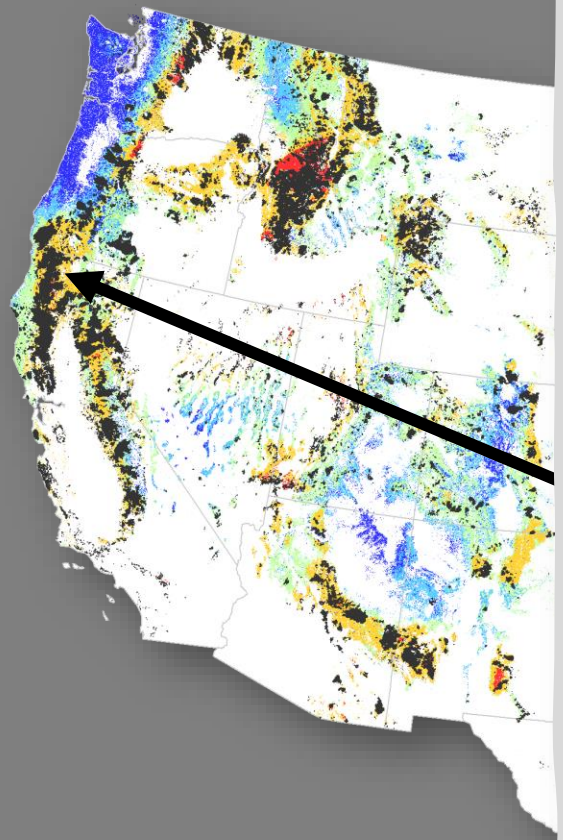
Where is the Focus?

Recent headlines

Wildfire Probability

high

low



BREAKING NEWS

Forest fires burn millions of acres in the west!

Northwest Forest Plan
Interagency Monitoring Program

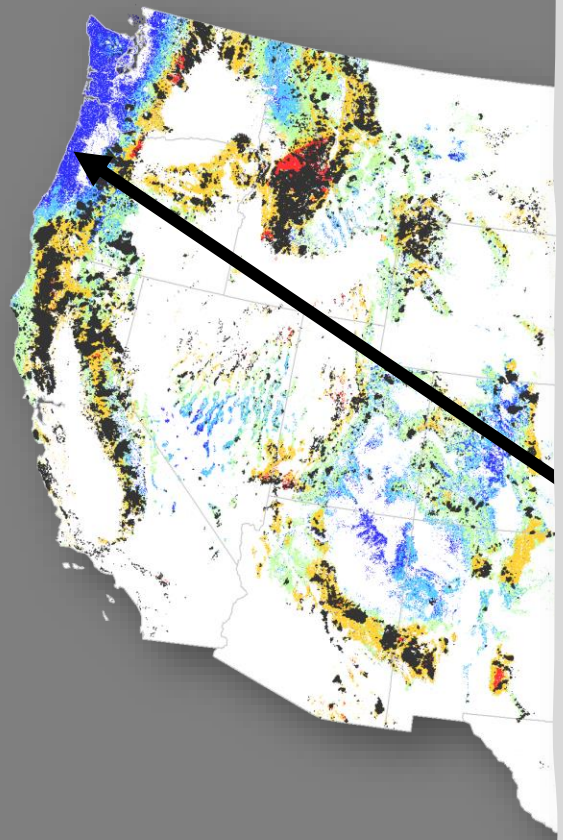
Where is the Focus?

Never a headline

Wildfire Probability

high

low



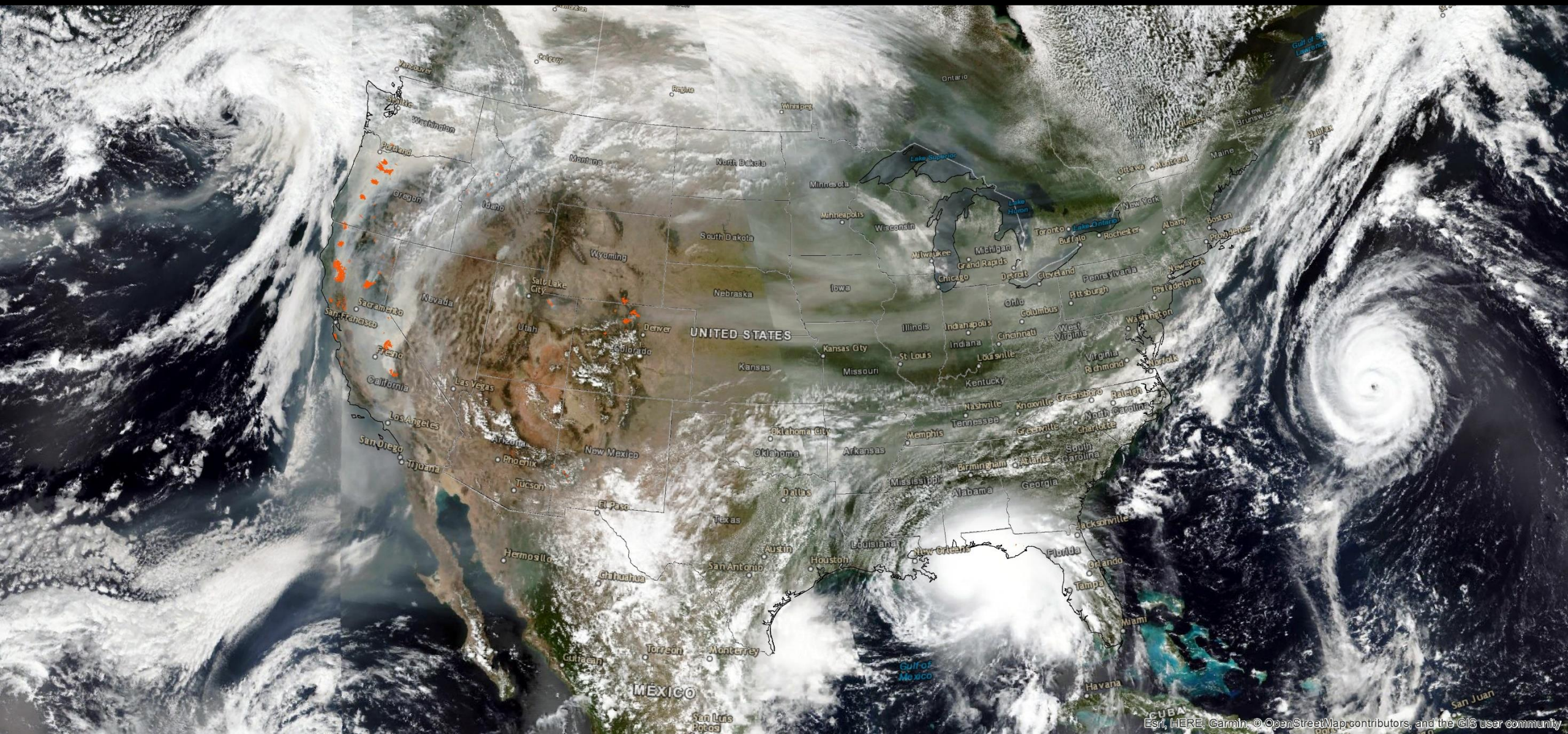
BREAKING NEWS

Forest continues to sequester carbon in the west!

Northwest Forest Plan
Interagency Monitoring Program

A Year for the Books

2020

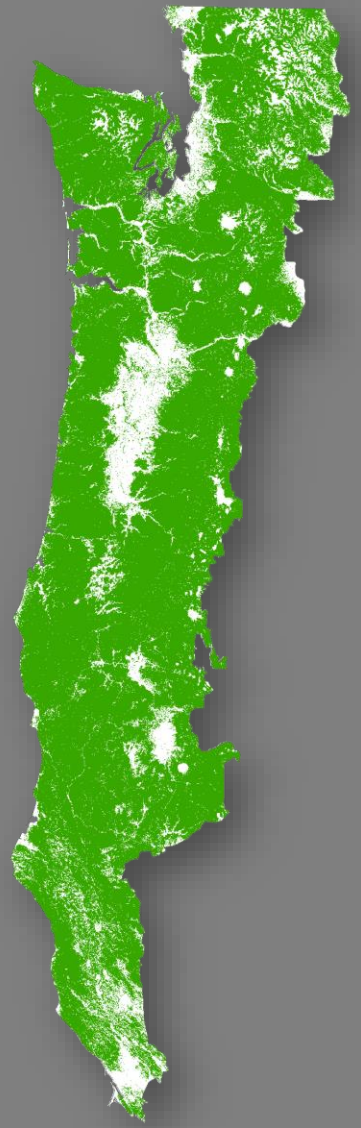


Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan

A closer look

forests

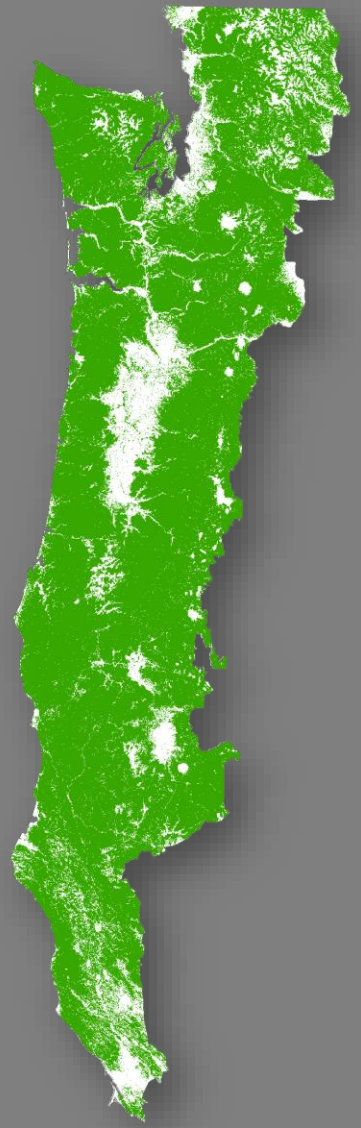


Northwest Forest Plan
Interagency Monitoring Program

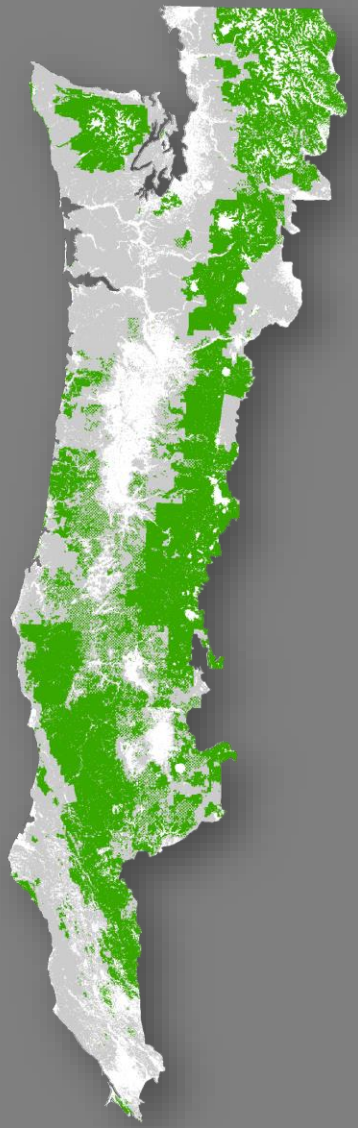
The Northwest Forest Plan

A closer look

forests



federal forests

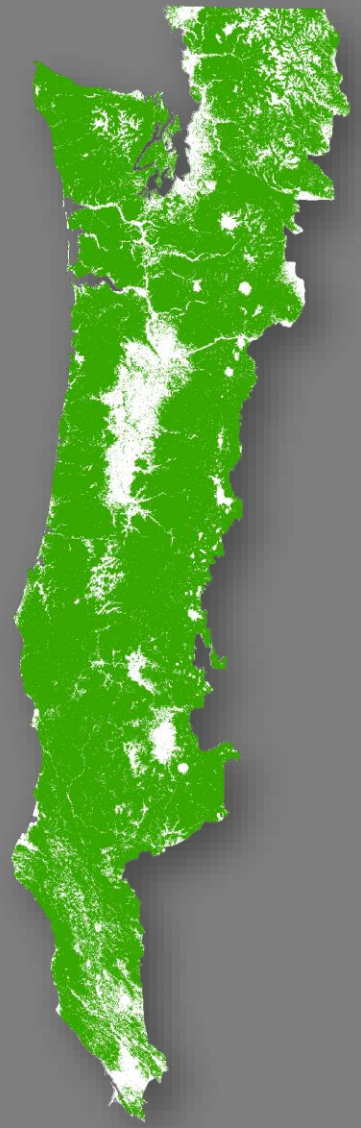


Northwest Forest Plan
Interagency Monitoring Program

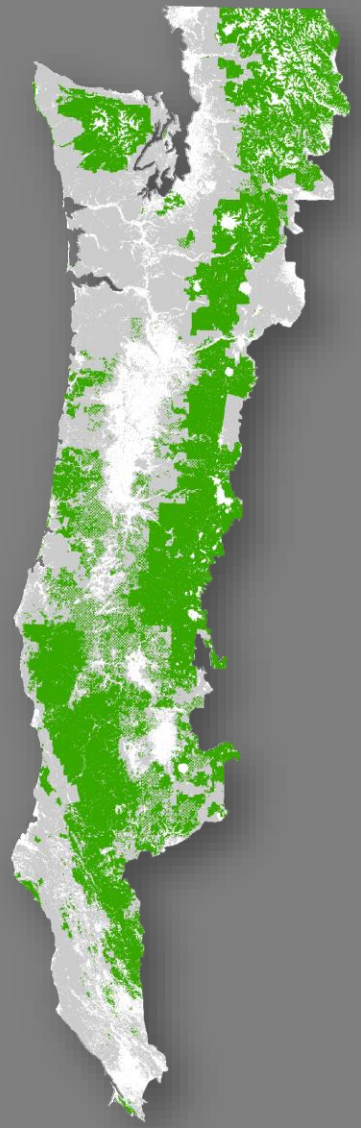
The Northwest Forest Plan

A closer look

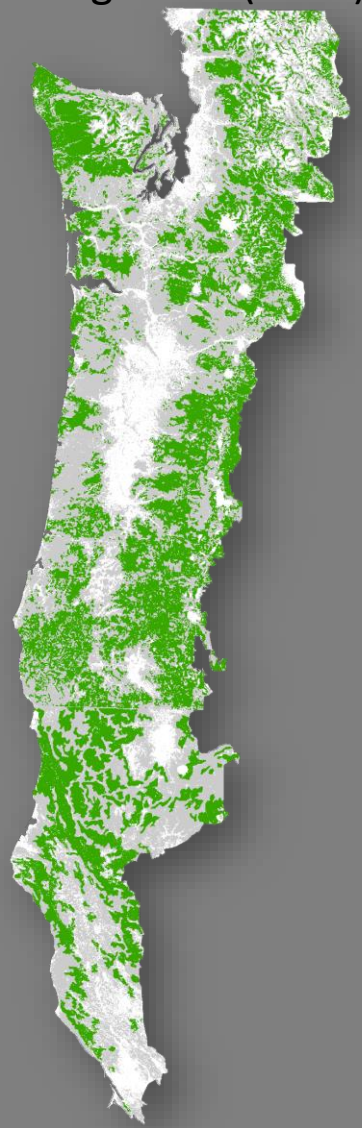
forests



federal forests



old growth (1940)

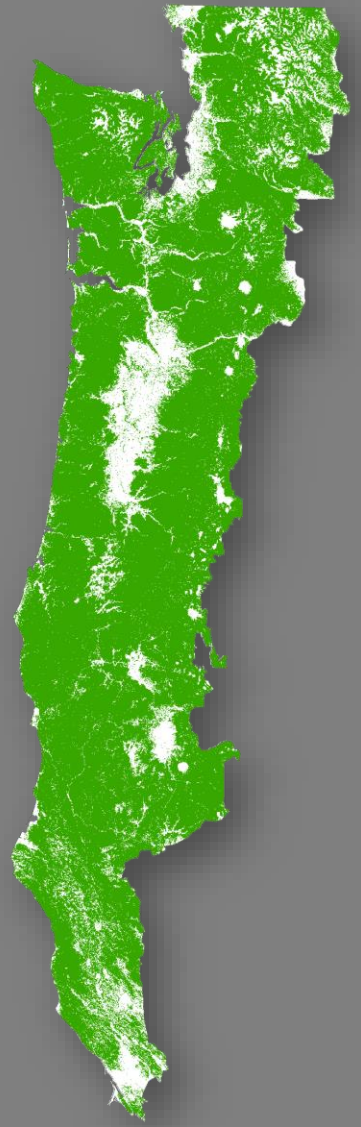


Northwest Forest Plan
Interagency Monitoring Program

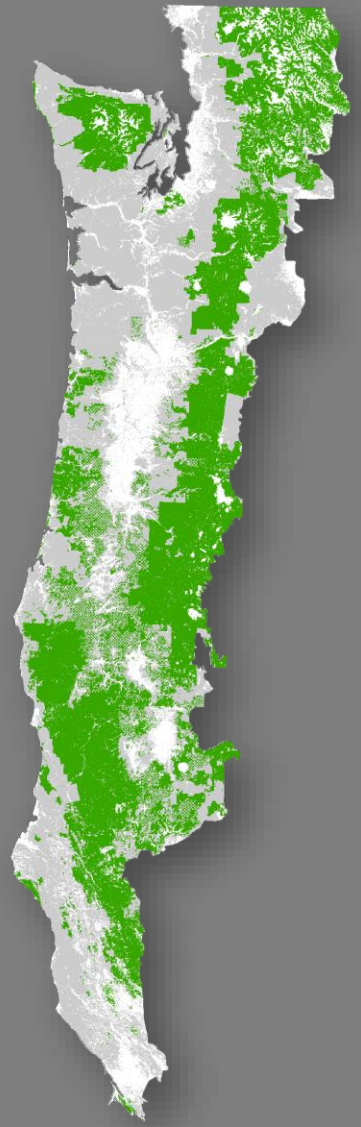
The Northwest Forest Plan

A closer look

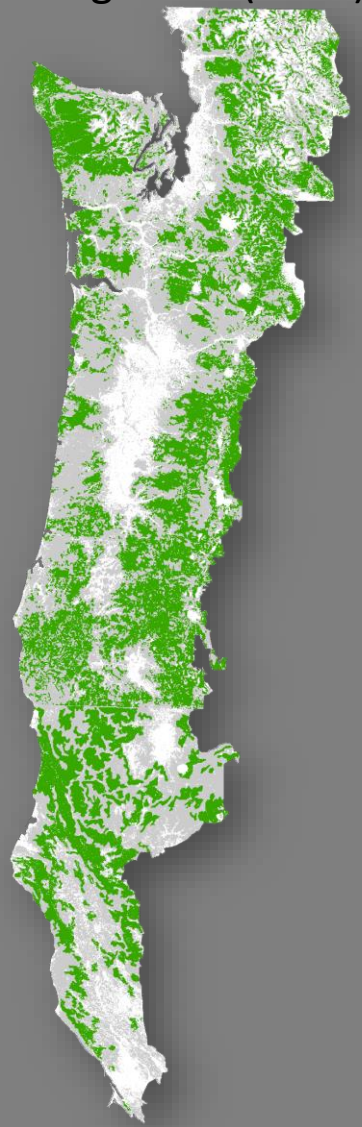
forests



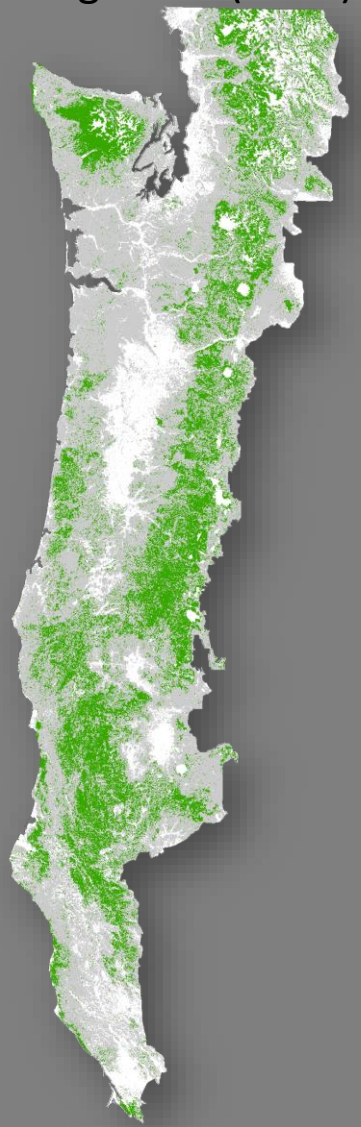
federal forests



old growth (1940)



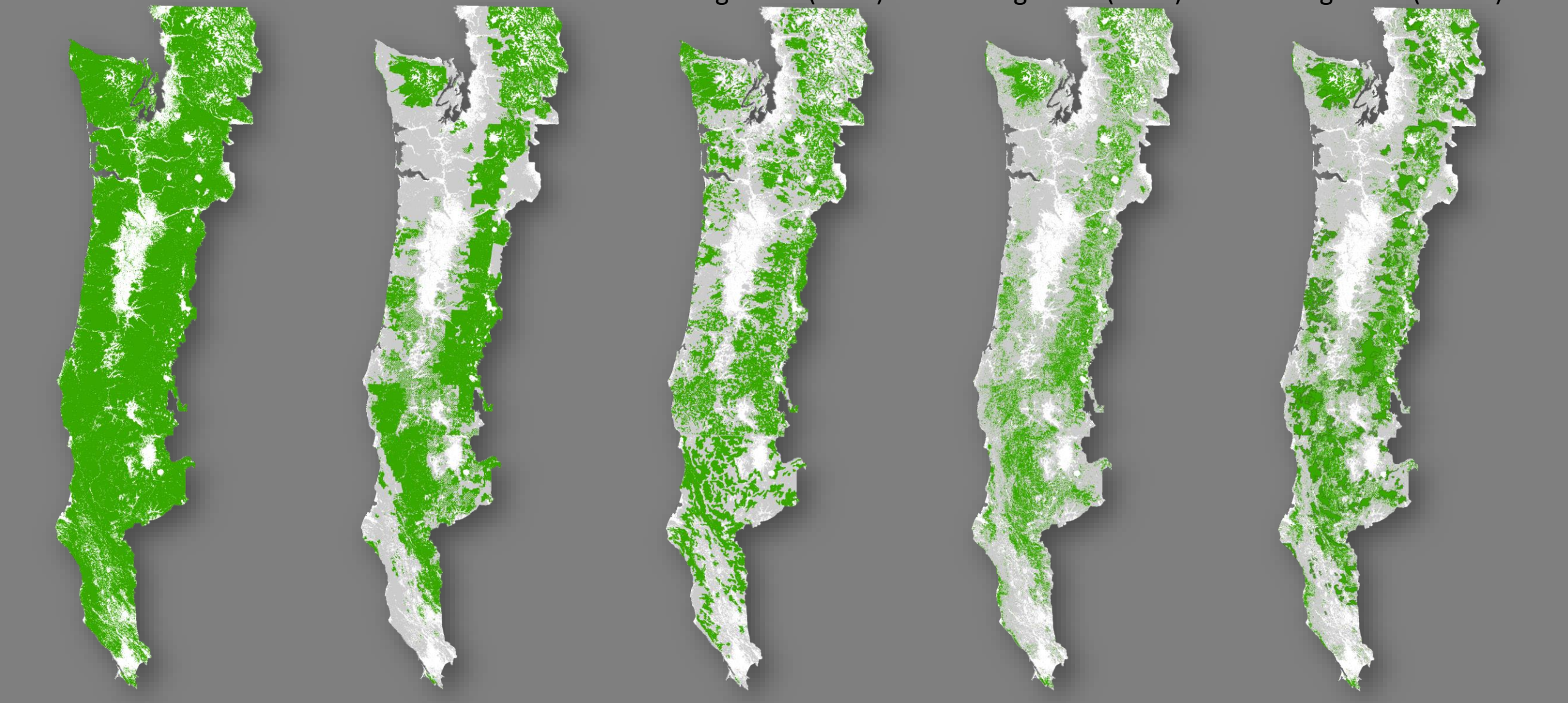
old growth (1993)



Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan

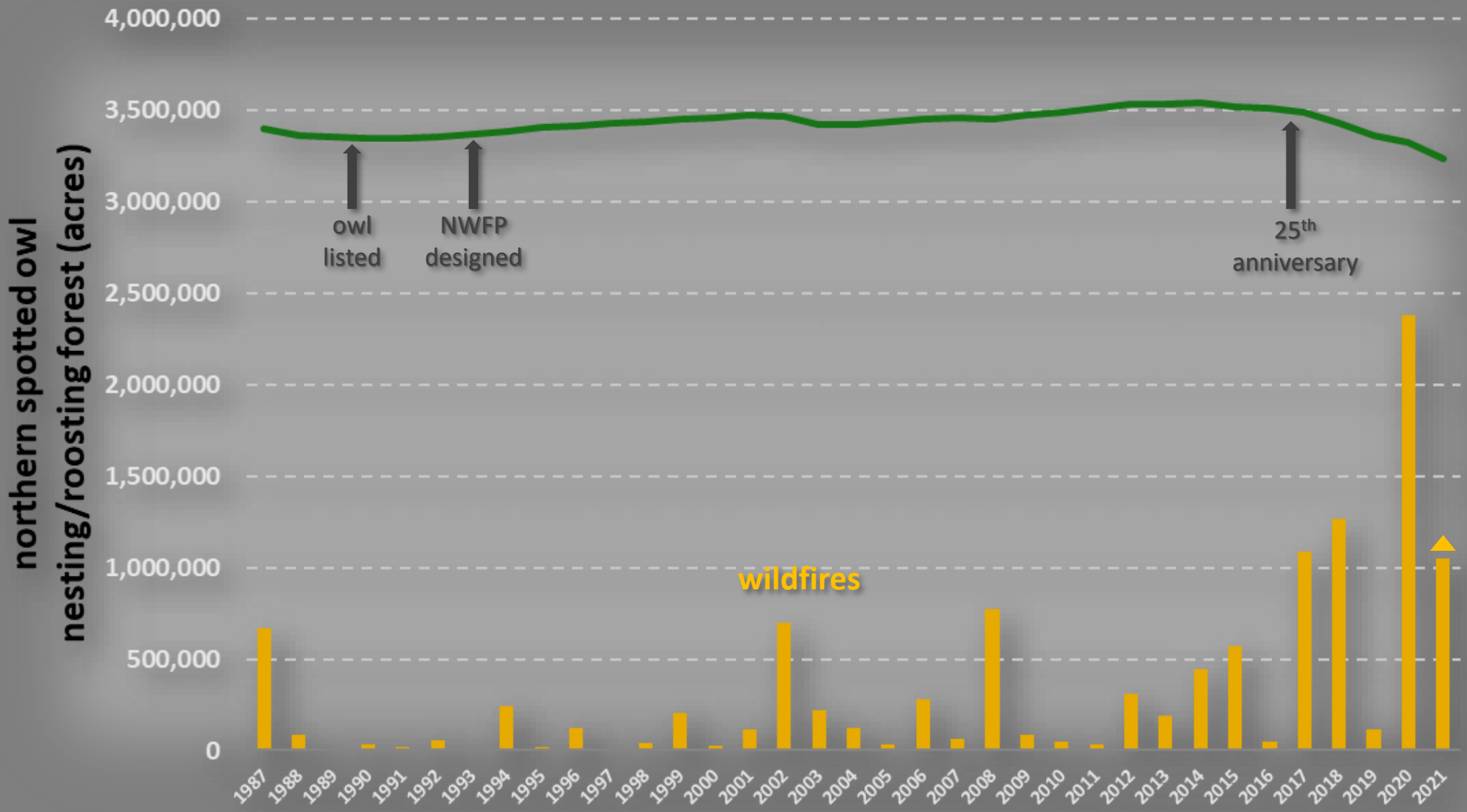
A closer look



Northwest Forest Plan
Interagency Monitoring Program

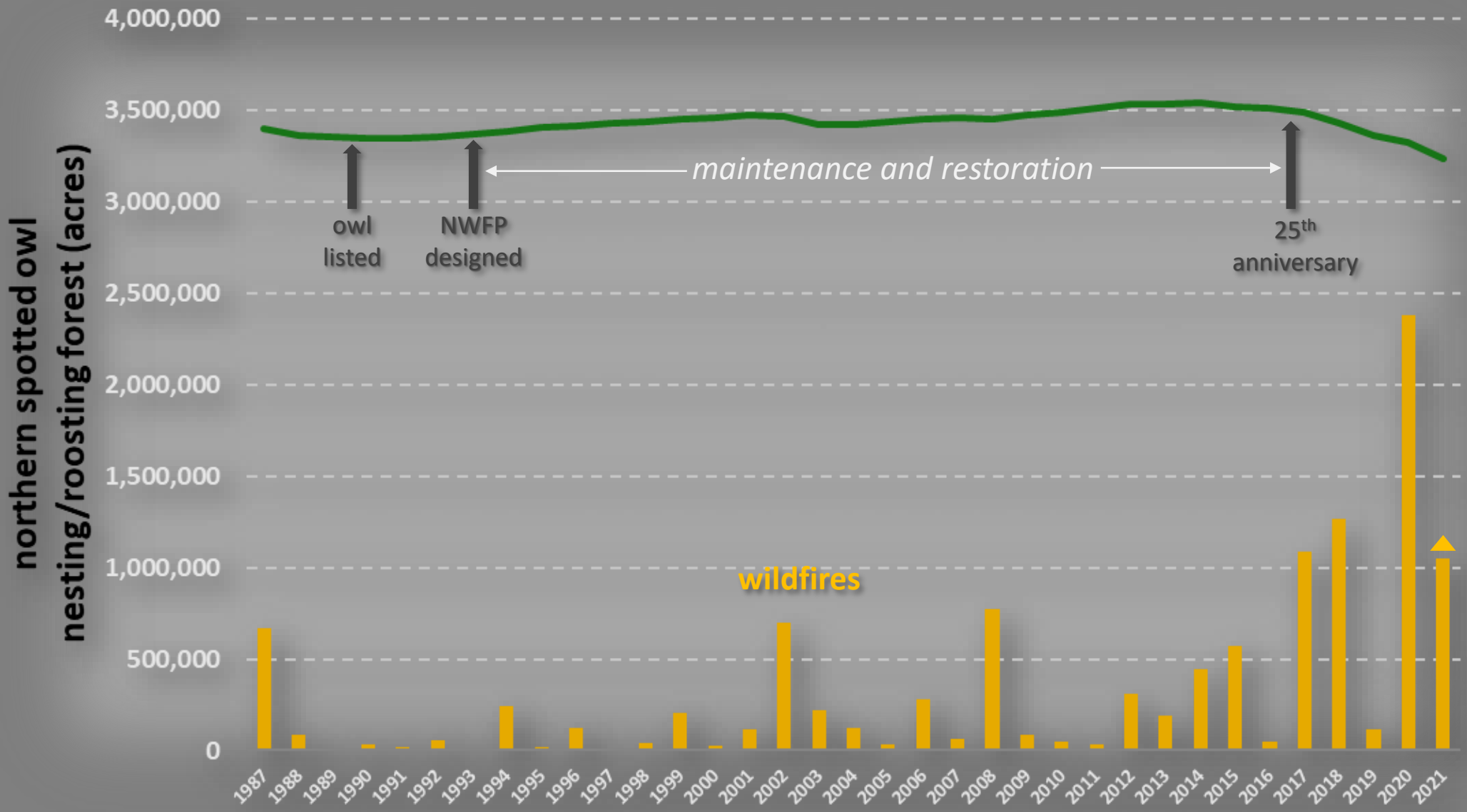
The Northwest Forest Plan

Monitoring the reserves



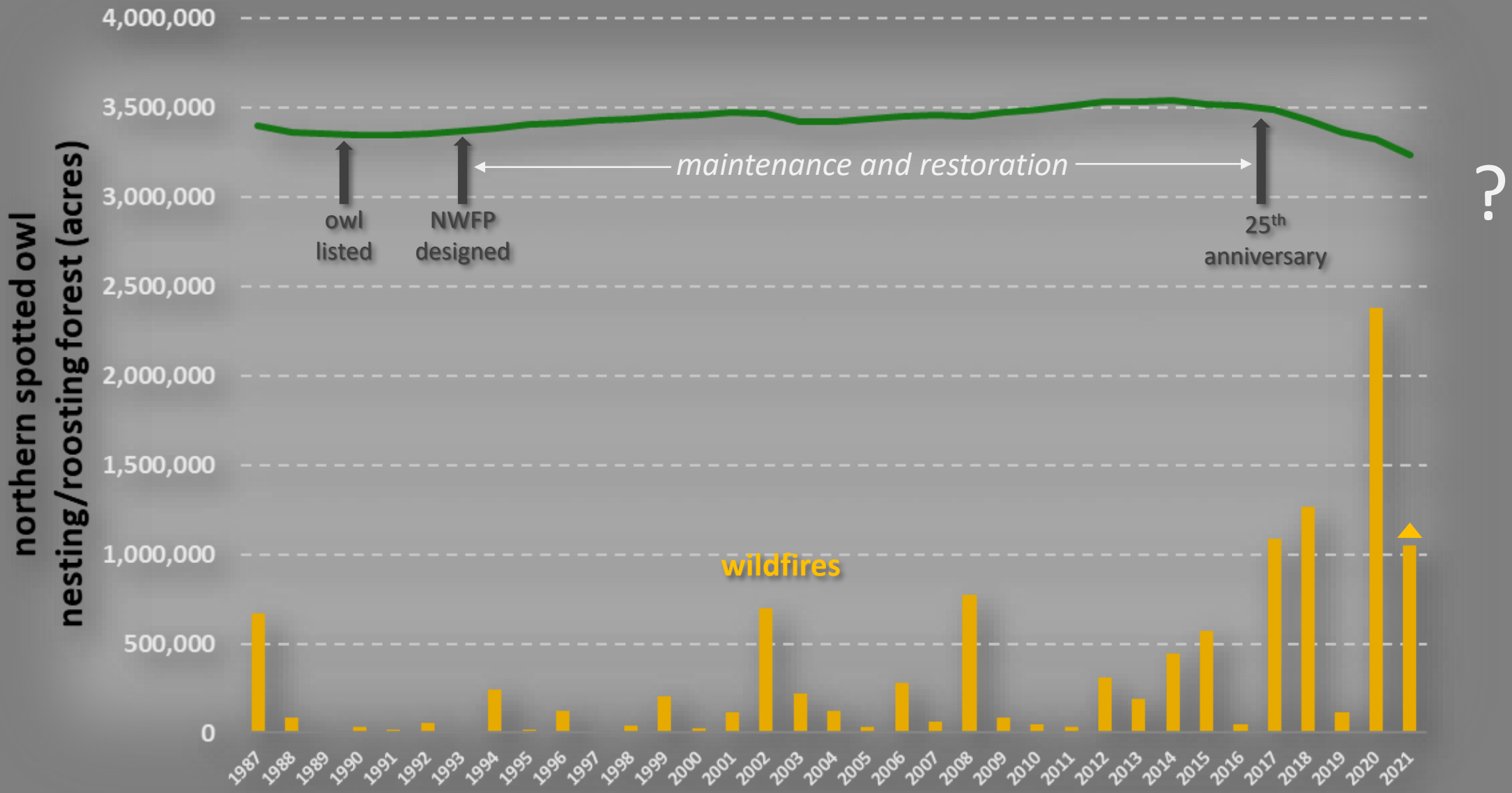
Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan
Monitoring the reserves



Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan
Monitoring the reserves

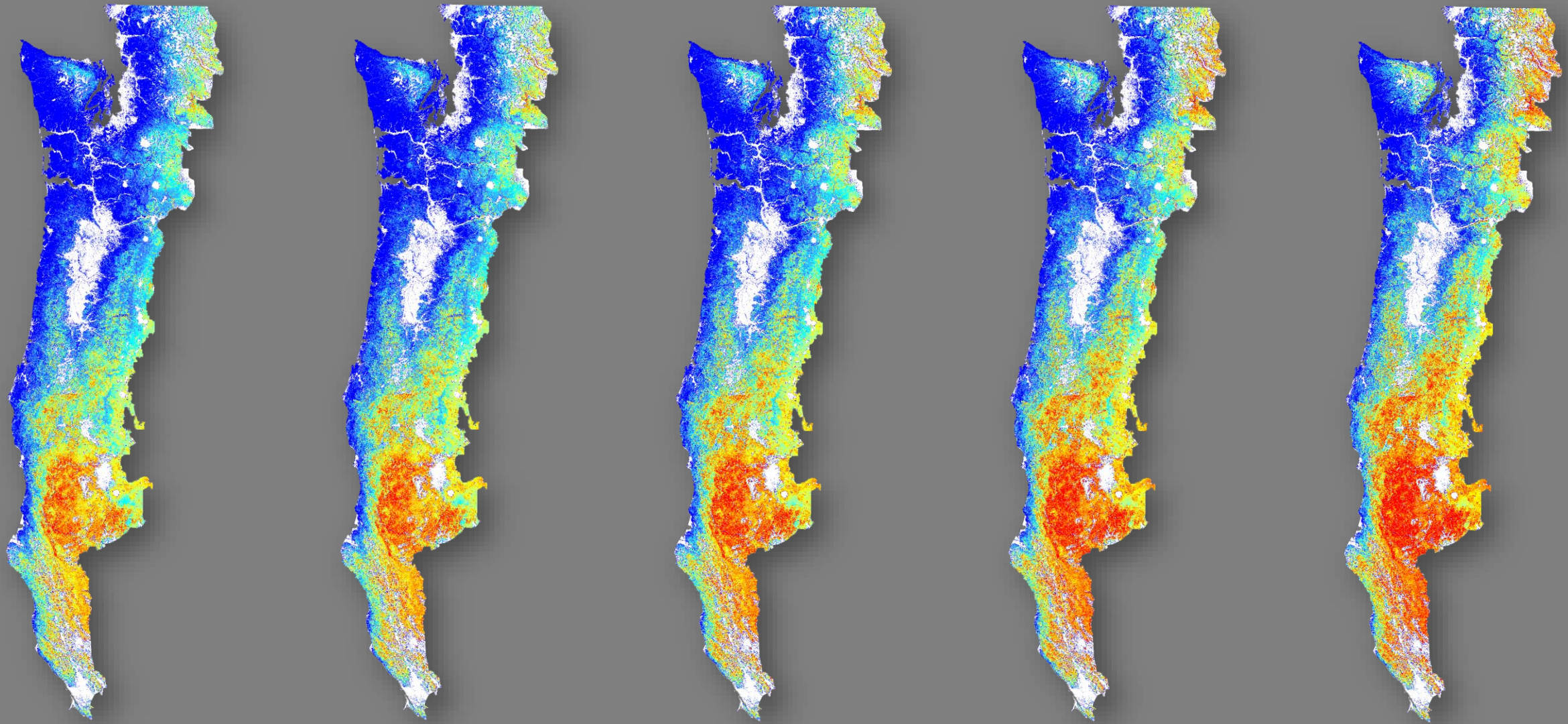


?

Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan

The normal fire environment(s)

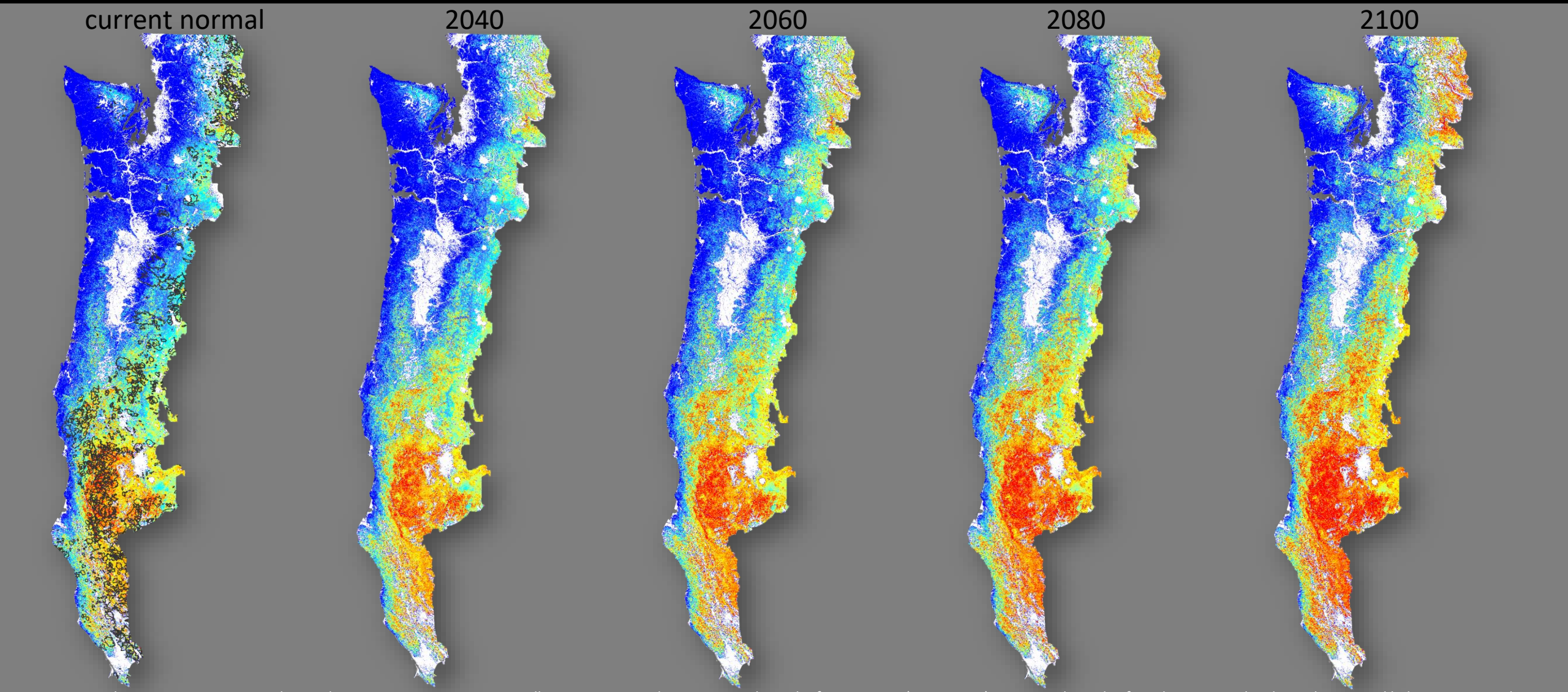


Davis, Raymond J.; Dugger, Katie M.; Mohoric, Shawne; Evers, Louisa; Aney, William C. 2011. Northwest Forest Plan—the first 15 years (1994–2008): status and trends of northern spotted owl populations and habitats. Gen. Tech. Rep. PNWGTR- 850. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 147 p. https://www.fs.fed.us/pnw/pubs/pnw_gtr850.pdf

Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan

The normal fire environment(s)

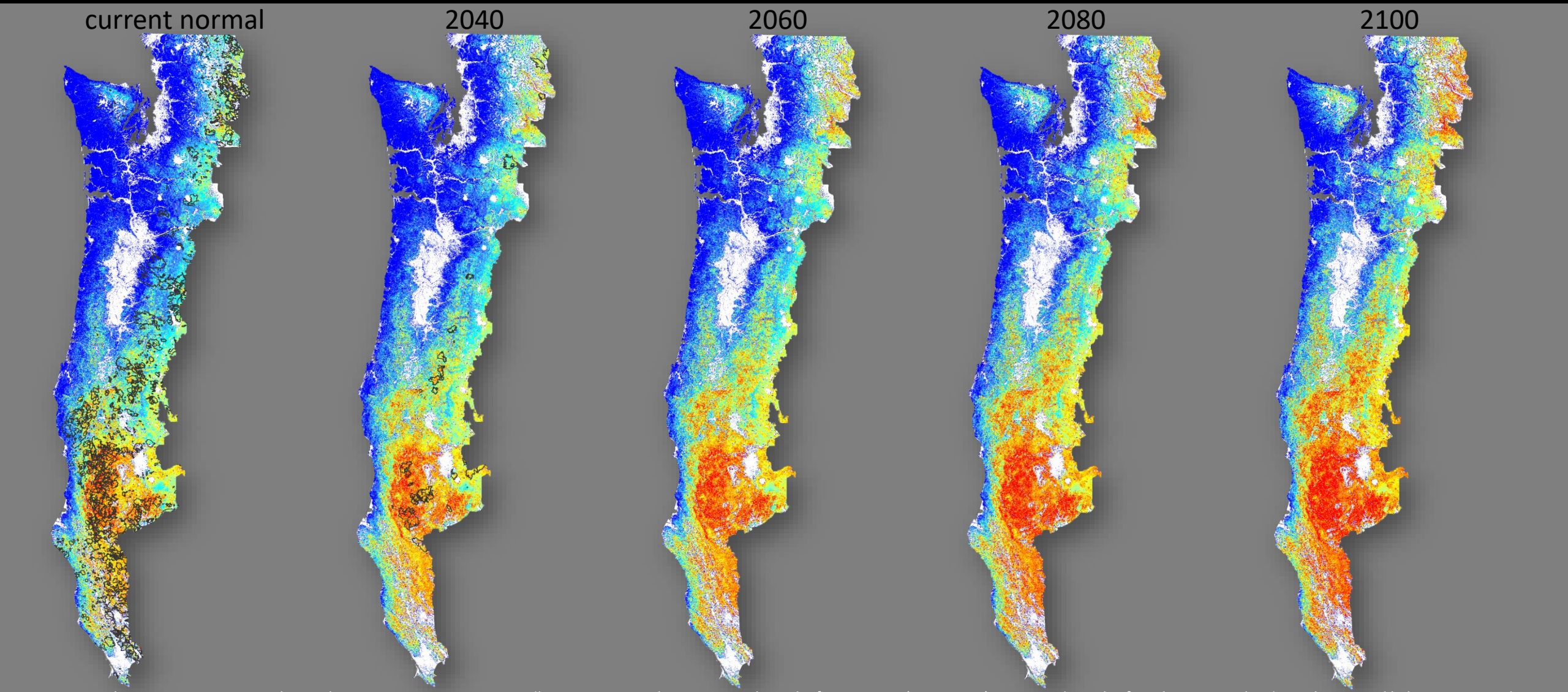


Davis, Raymond J.; Dugger, Katie M.; Mohoric, Shawne; Evers, Louisa; Aney, William C. 2011. Northwest Forest Plan—the first 15 years (1994–2008): status and trends of northern spotted owl populations and habitats. Gen. Tech. Rep. PNWGTR- 850. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 147 p. https://www.fs.fed.us/pnw/pubs/pnw_gtr850.pdf

Northwest Forest Plan
Interagency Monitoring Program

The Northwest Forest Plan

The normal fire environment(s)



Davis, Raymond J.; Dugger, Katie M.; Mohoric, Shawne; Evers, Louisa; Aney, William C. 2011. Northwest Forest Plan—the first 15 years (1994–2008): status and trends of northern spotted owl populations and habitats. Gen. Tech. Rep. PNWGTR- 850. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 147 p. https://www.fs.fed.us/pnw/pubs/pnw_gtr850.pdf

Northwest Forest Plan
Interagency Monitoring Program

Finding Sanctuary
In partnership with

Oregon State University
College of Forestry

Fire Refugia Project

USGS
NW climate adaptation
science center


Gnarl Ridge Fire, OR (photo: Garrett Meigs 2012)

Contact Us

Person/Role	Organization	Expertise on Project
Cameron Naficy Lead Analyst	Oregon State University, College of Forestry	Disturbance ecology, geospatial analysis, stakeholder engagement
Meg Krawchuk	Oregon State University, College of Forestry	Fire ecology, landscape ecology, conservation science
Garrett Meigs	Washington Department of Natural Resources	Disturbance ecology, geospatial analysis
David Bell	US Forest Service, Pacific Northwest Research Station	Vegetation mapping and landscape change; stakeholder engagement
Raymond Davis	US Forest Service, Pacific Northwest Region	LSOG and owl monitoring; liaison to managers
Katie Dugger	USGS, Oregon Cooperative Fish and Wildlife Research Unit	Northern spotted owl and barred owl demography
Matthew Gregory	Oregon State University, College of Forestry	Vegetation mapping and technology transfer
David Wiens	USGS, Forest and Rangeland Ecosystem Science Center	Northern spotted owl and barred owl ecology and management

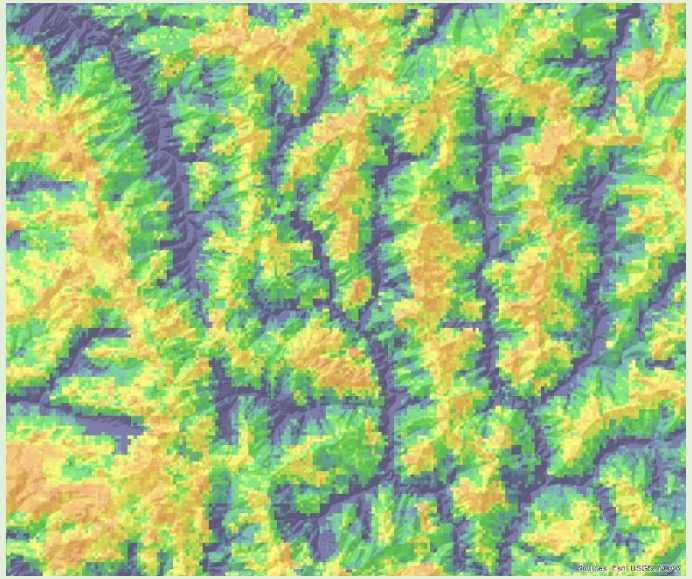
Northwest Forest Plan
Interagency Monitoring Program

Finding Sanctuary
In partnership with

Oregon Department of Forestry

Oregon forest carbon policy

Andrew Yost – Forest Ecologist



fire refugia model

owl nesting forest

Northwest Forest Plan
Interagency Monitoring Program

Finding Sanctuary

In partnership with

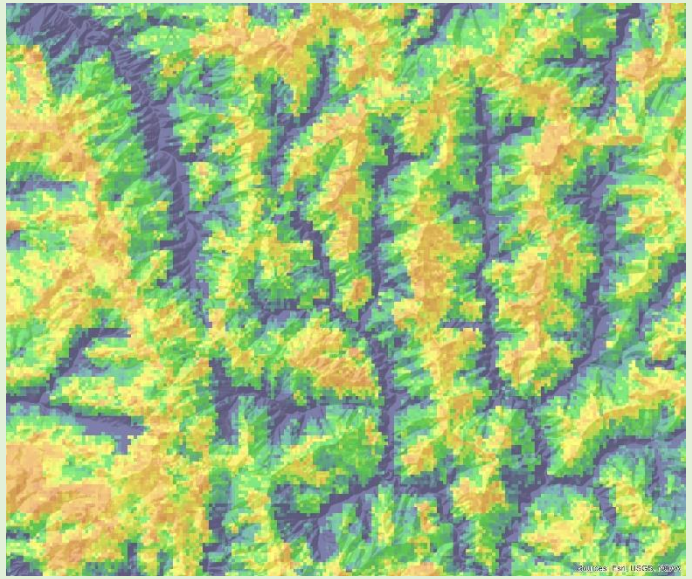
Rocky Mountain Research Station

Inventory and Monitoring Program

Andrew Yost – Forest Ecologist

Sean Healey – Research Ecologist

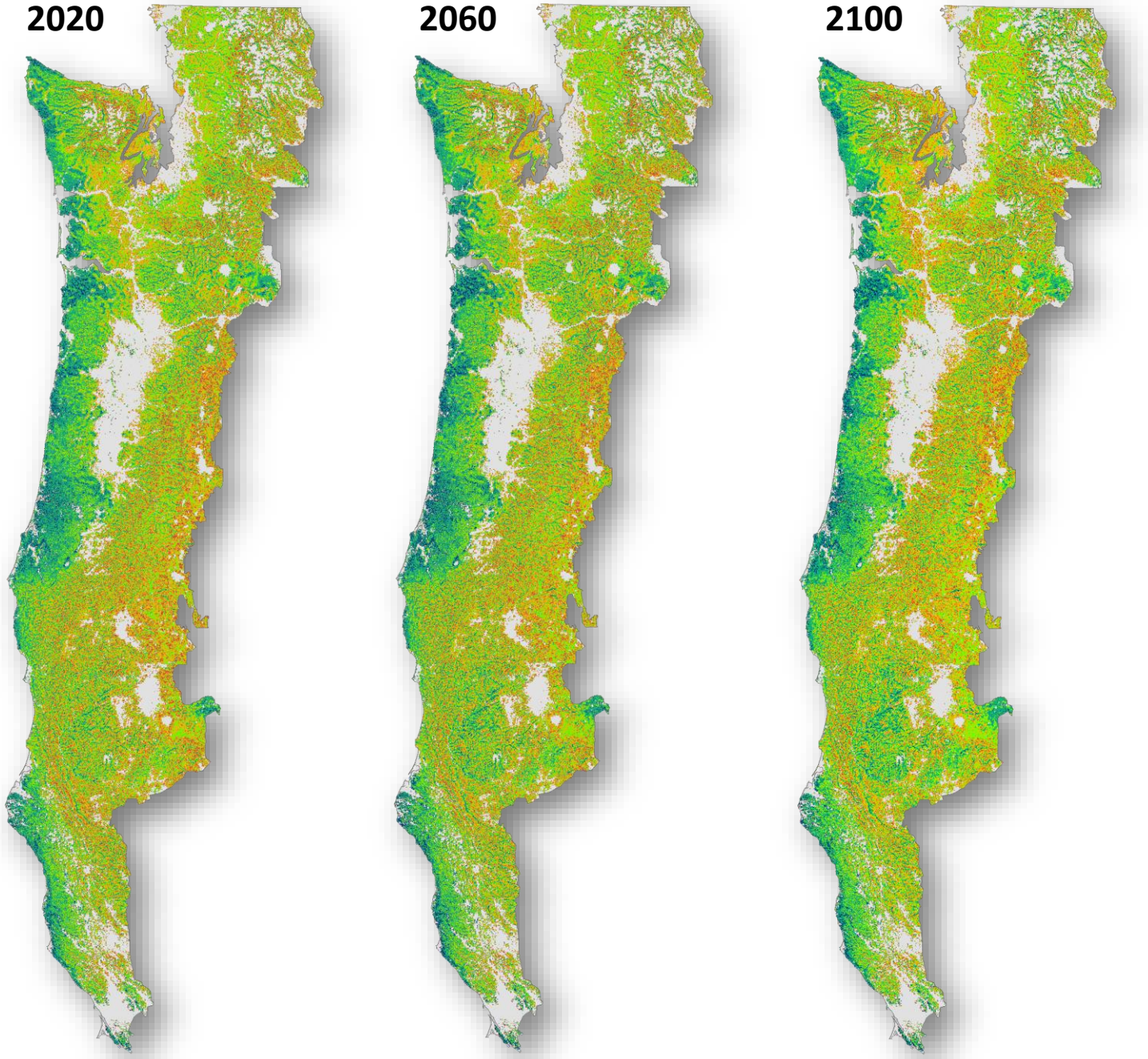
Zhiqiang Yang – Computer Scientist



fire refugia model

owl nesting forest

Finding Fire Refugia



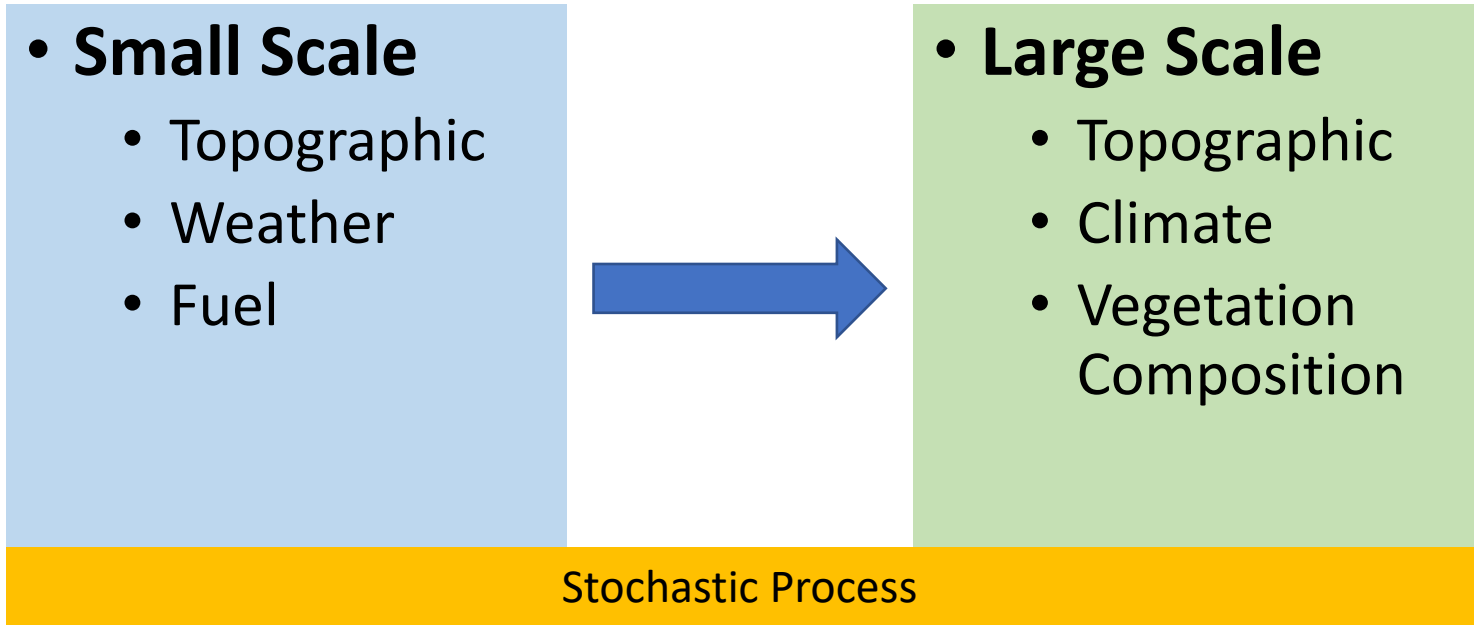
What is fire refugia?

- Locations
  - Unlikely to burn (*low fire frequency*)

  AND/OR

  - When burned, it is more tolerant of fire (*low fire severity*)

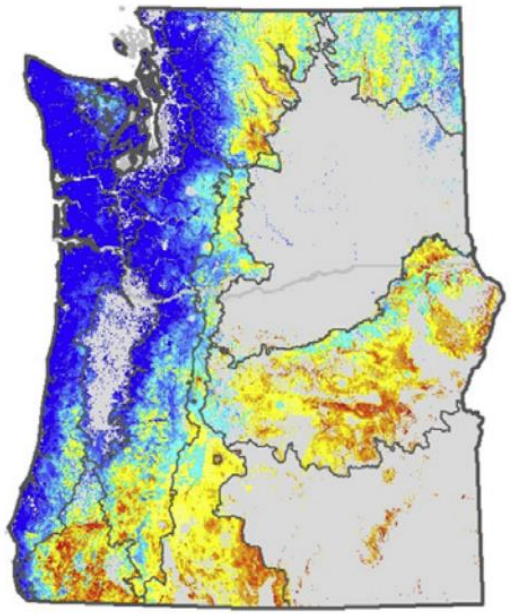
Potential Factors for Fire Refugia



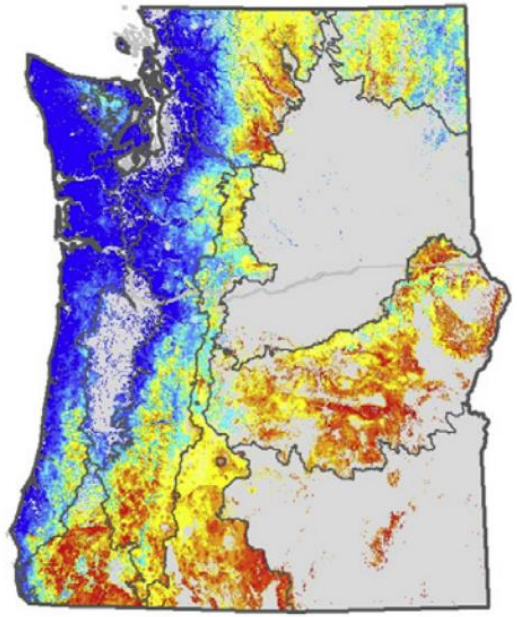
P(refugia) = *f(topographic, Climate, Vegetation)*

P(fire|climate)

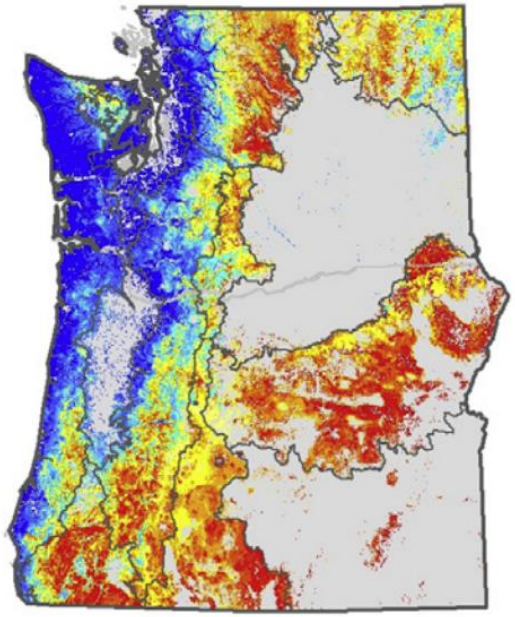
1991–2020 Normal



2031–2060 Normal



2071–2100 Normal



Davis, Raymond, Zhiqiang Yang, Andrew Yost, Cole Belongie, and Warren Cohen. “The Normal Fire Environment—Modeling Environmental Suitability for Large Forest Wildfires Using Past, Present, and Future Climate Normals.” *Forest Ecology and Management* 390 (April 15, 2017): 173–86. https://doi.org/10.1016/j.foreco.2017.01.027.

P(vegetation)

Is it forest? What type of forest?

P(fire|topographic)

Objective:

- Develop a topographic template for fire refugia

Method:

- Bootstrapping from historical fire severity
- Create relative probability of low severity
- Create relative probability of high severity

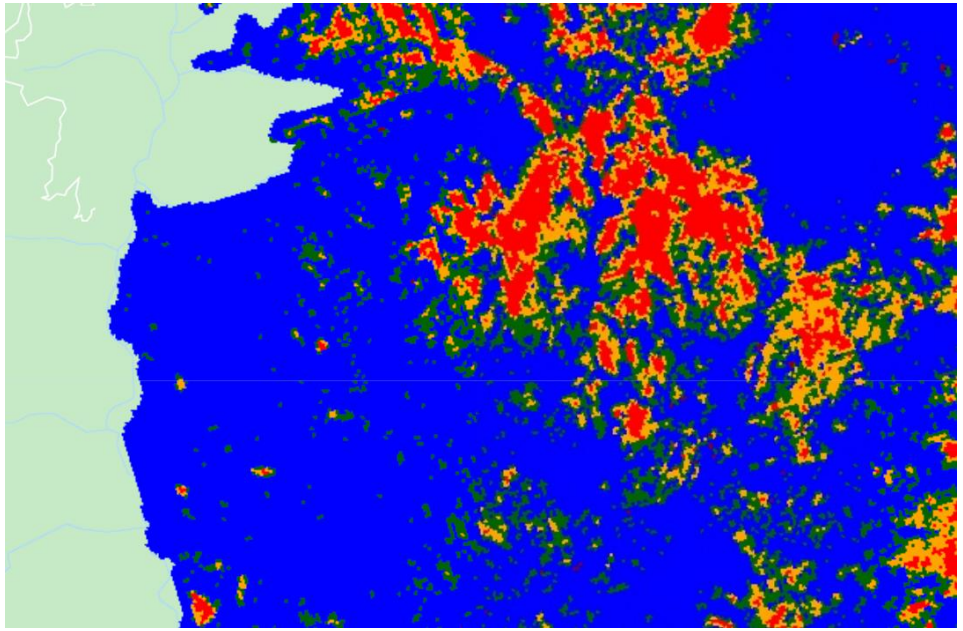
Reference Data (MTBS)

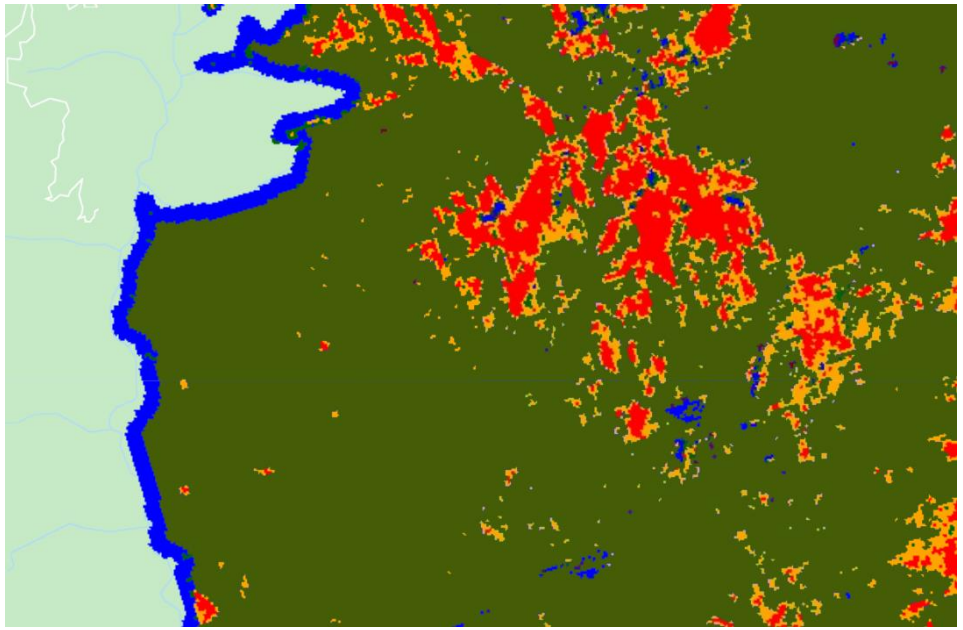
Population

- Forest land only
- Exclude 5 pixels from fire perimeter

Severity Class of Interest

- Model 1: low severity vs other
- Model 2: high severity vs other



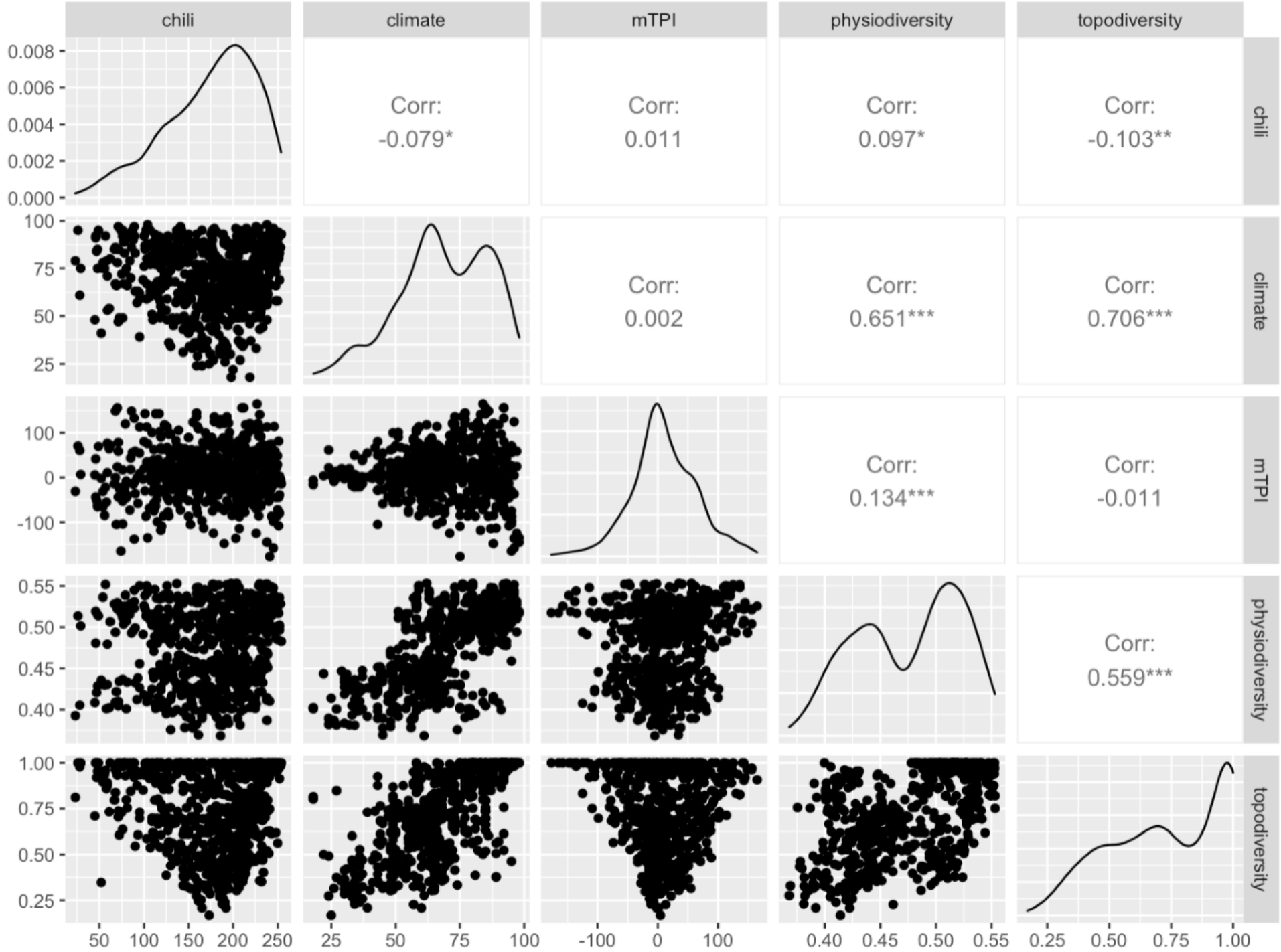


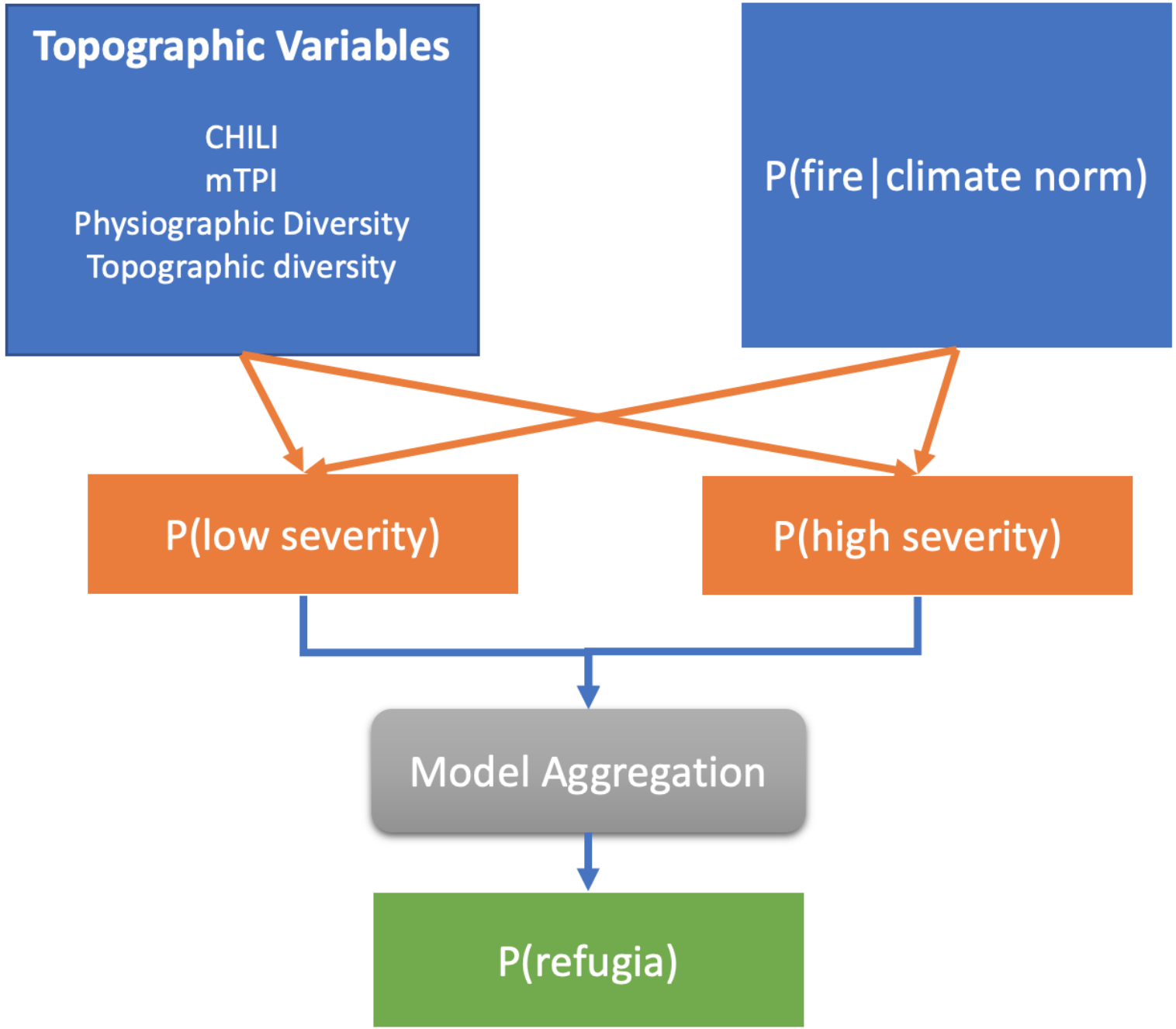
Modeling

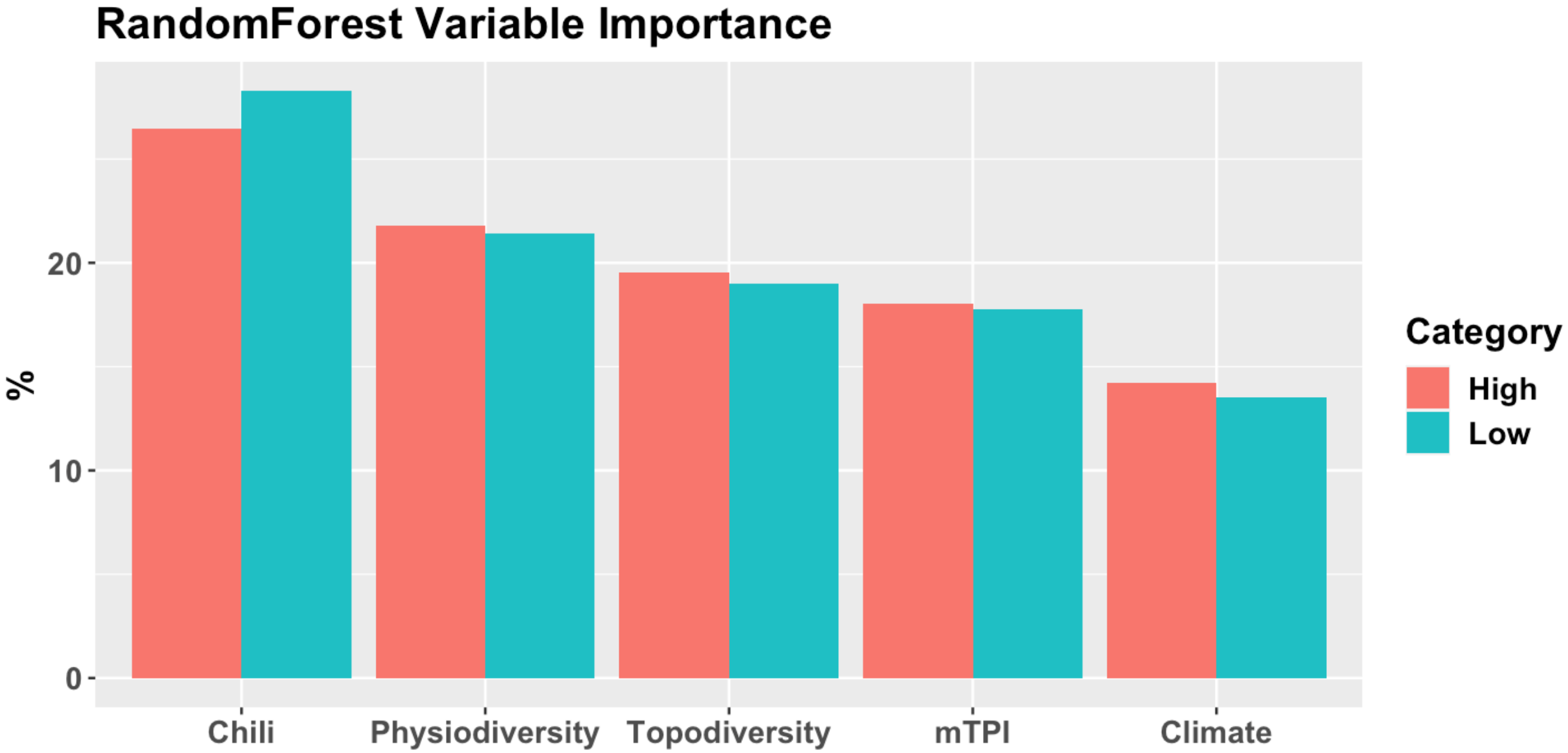
- Modeling each year separately
- Random forest
- 5000 random samples of each class
- 50 replicates for each year
- Aggregate to yearly output
- Stack predictions from 1985 to 2019

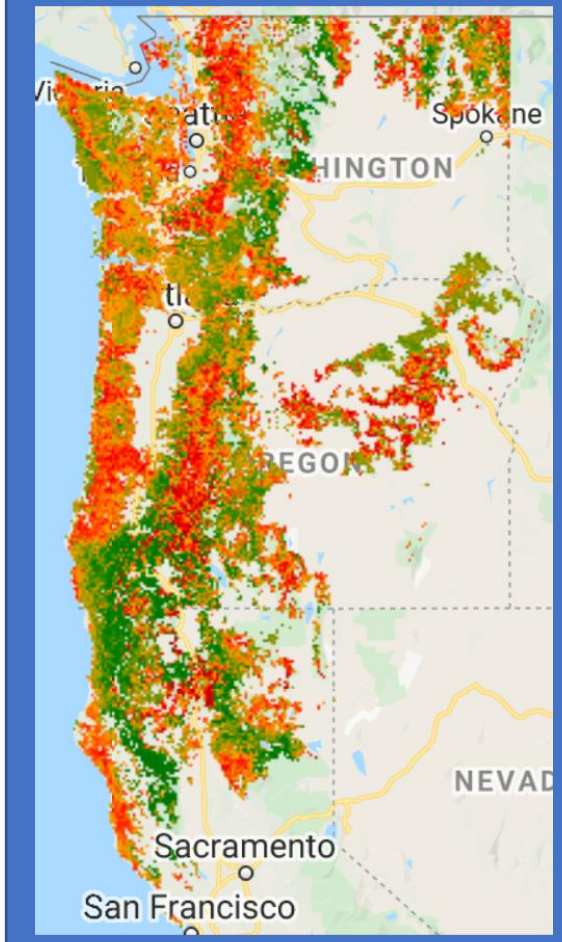
Topographic Variables

- **Continuous Heat-Insolation Load Index (CHILI)**
  - a surrogate for effects of insolation and topographic shading on evapotranspiration represented by calculating insolation at early afternoon, sun altitude equivalent to equinox.
- **Multiscale Topographic Position Index (mTPI)**
  - The mTPI distinguishes ridges from valley forms
- **Physiographic Diversity**
  - an index of the diversity of physiographic types. It was calculated using the Shannon diversity index at multiple-scales (km): 115.8, 89.9, 35.5, 13.1, 5.6, 2.8, and 1.2.
- **Topographic diversity**
  - a surrogate variable that represents the variety of temperature and moisture conditions available to species as local habitats.

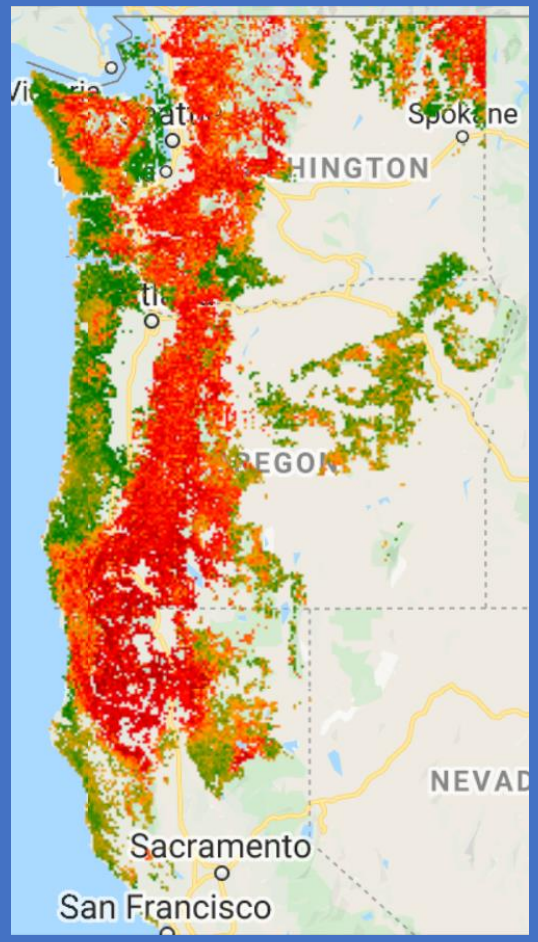

chili
climate
mTPI
physiodiversity
topodiversity
Corr:
-0.079*
Corr:
0.011
Corr:
0.097*
Corr:
-0.103**
Corr:
0.002
Corr:
0.651***
Corr:
0.706***
Corr:
0.134***
Corr:
-0.011
Corr:
0.559***
0.008
0.006
0.004
0.002
0.000
100
75
50
25
100
0
-100
0.55
0.50
0.45
0.40
1.00
0.75
0.50
0.25
50
100
150
200
250
25
50
75
100
-100
0
100
0.40
0.45
0.50
0.55
0.25
0.50
0.75
1.00


Topographic Variables
CHILI
mTPI
Physiographic Diversity
Topographic diversity
P(fire|climate norm)
P(low severity)
P(high severity)
Model Aggregation
P(refugia)

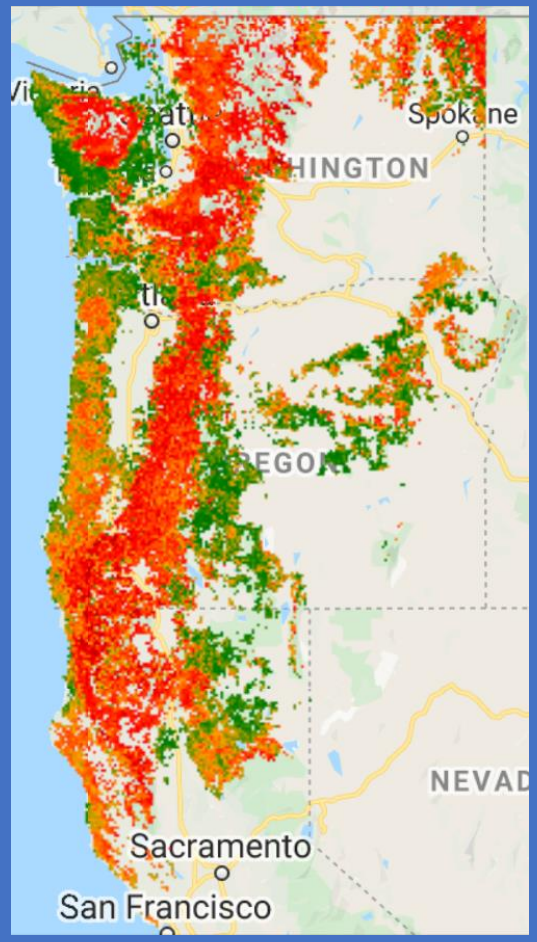

RandomForest Variable Importance
%
20
10
0
Chili
Physiodiversity
Topodiversity
mTPI
Climate
Category
High
Low



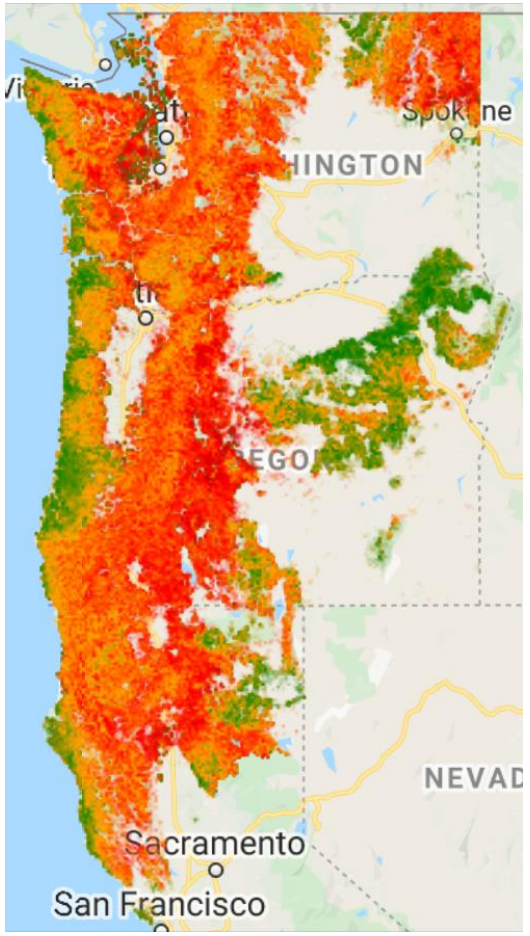
...



...



=



OOB: 0.193

1985

OOB: 0.264

2000

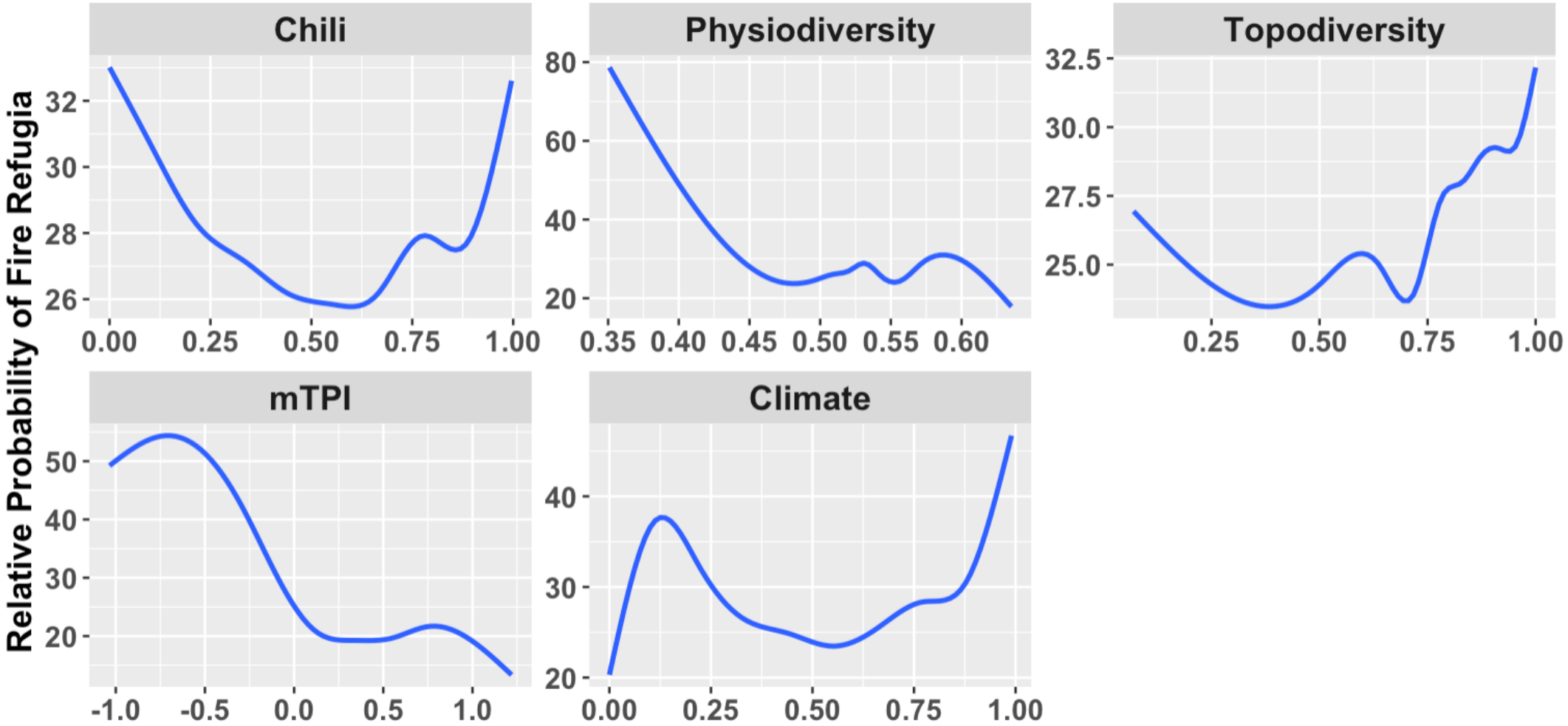
OOB: 0.237

2019

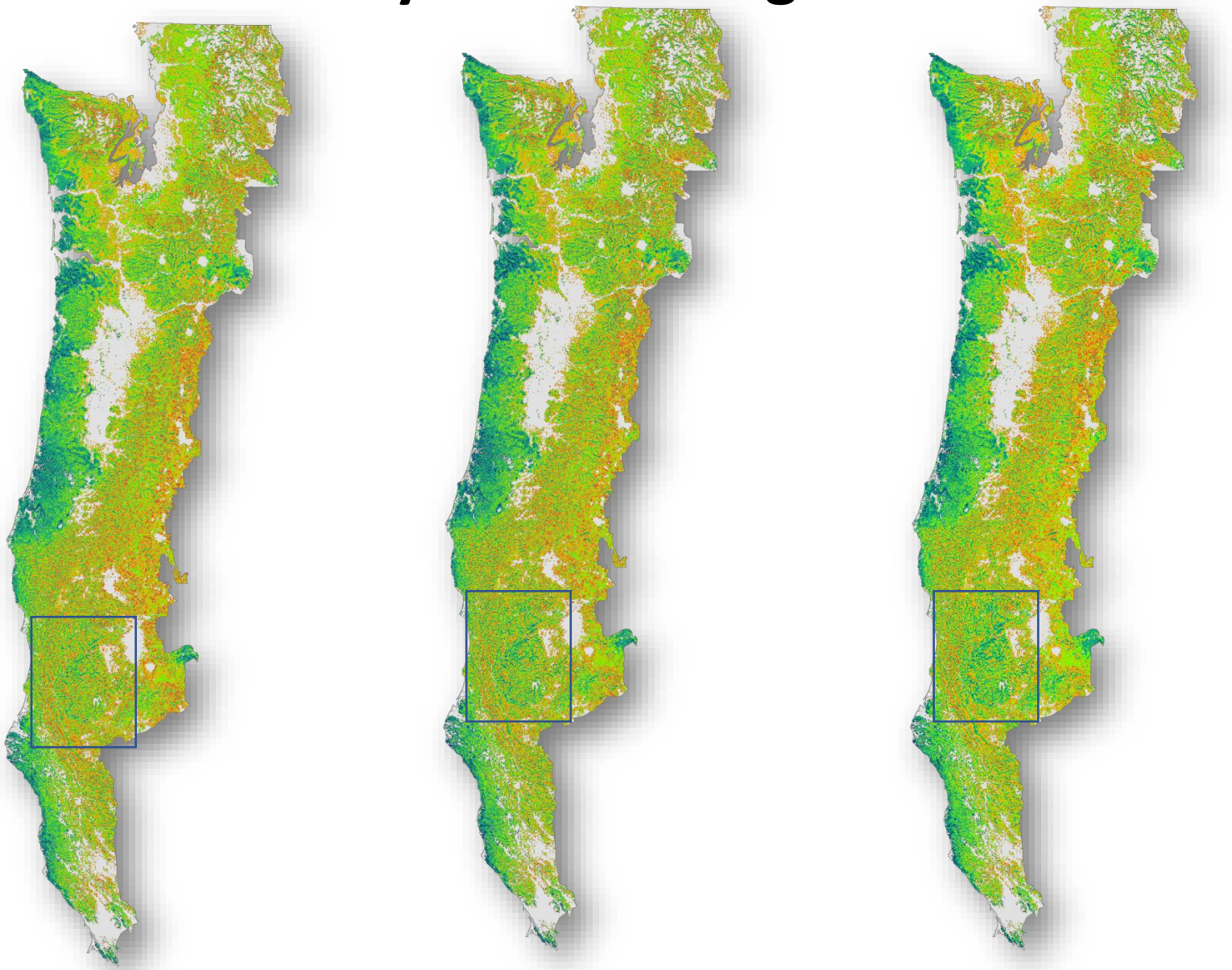
Aggregation of Annual Prediction

Relative Probability

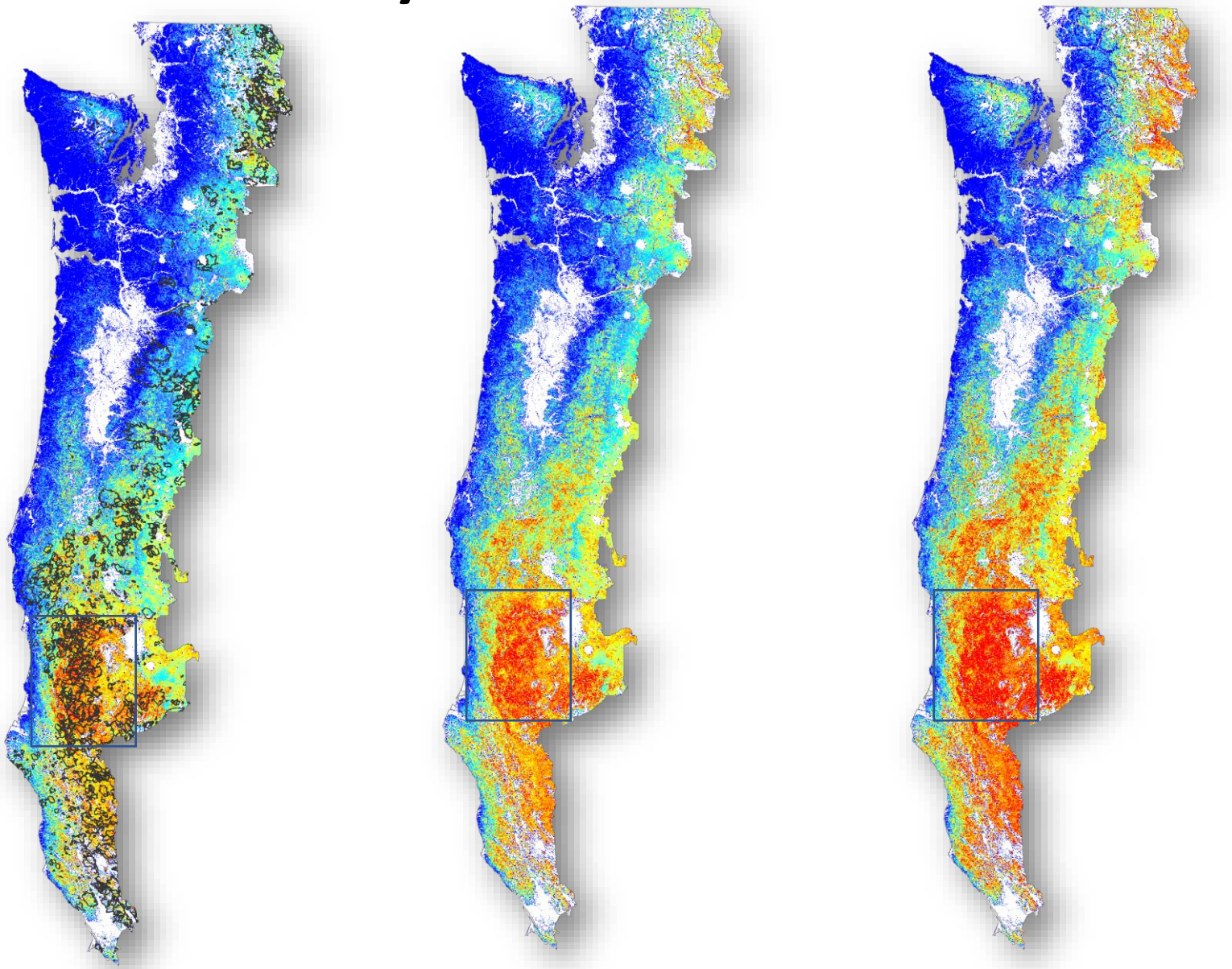
Response Curve



Relative Probability of Fire Refugia

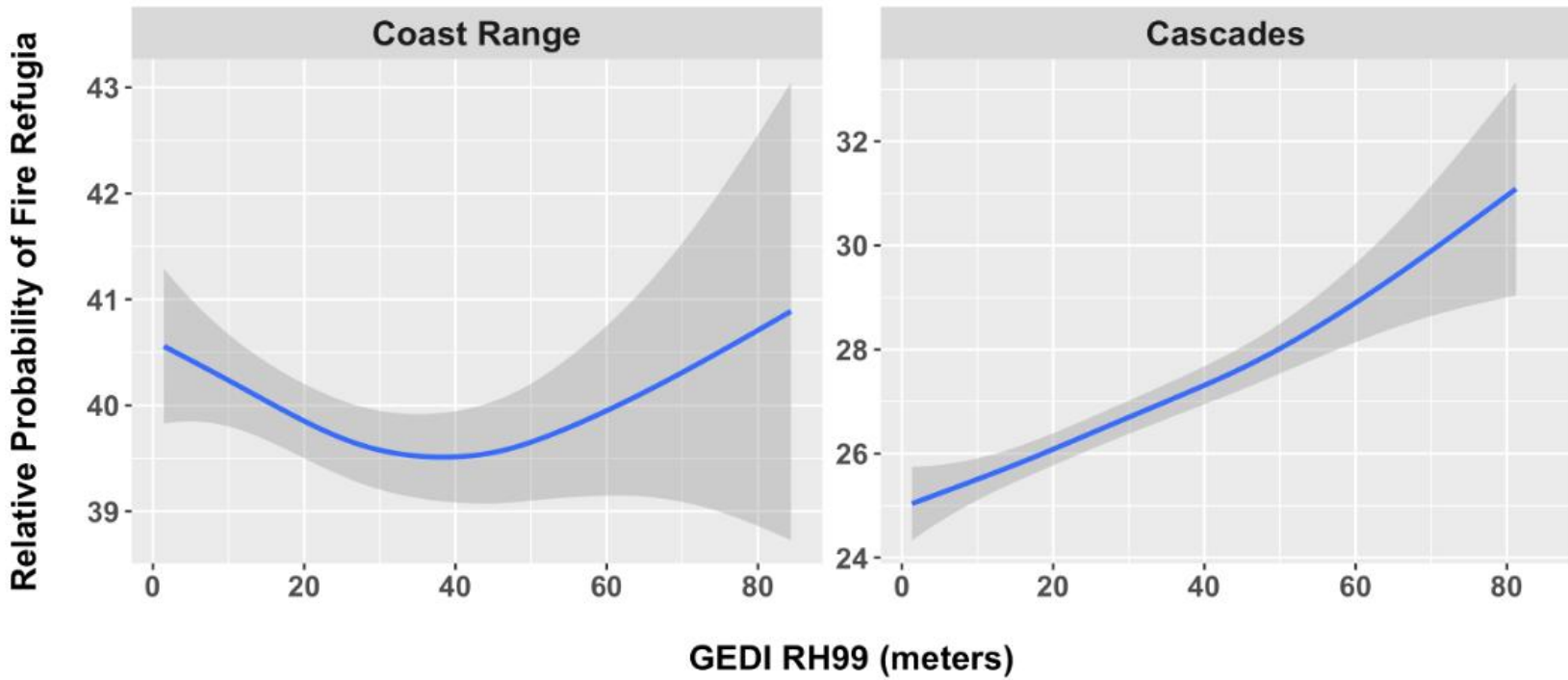


Relative Probability of Fire Occurrence

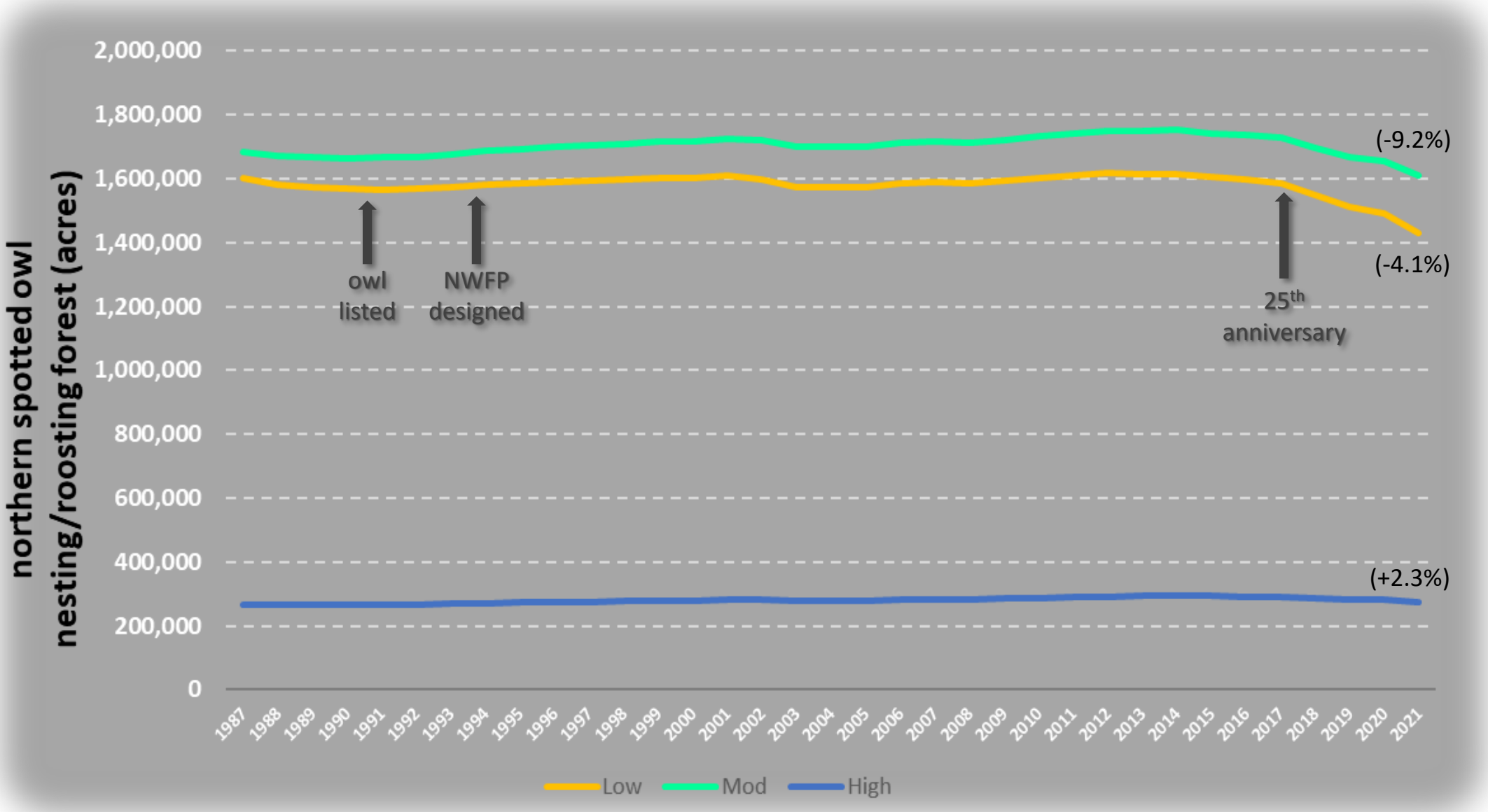


2020 2060 2100

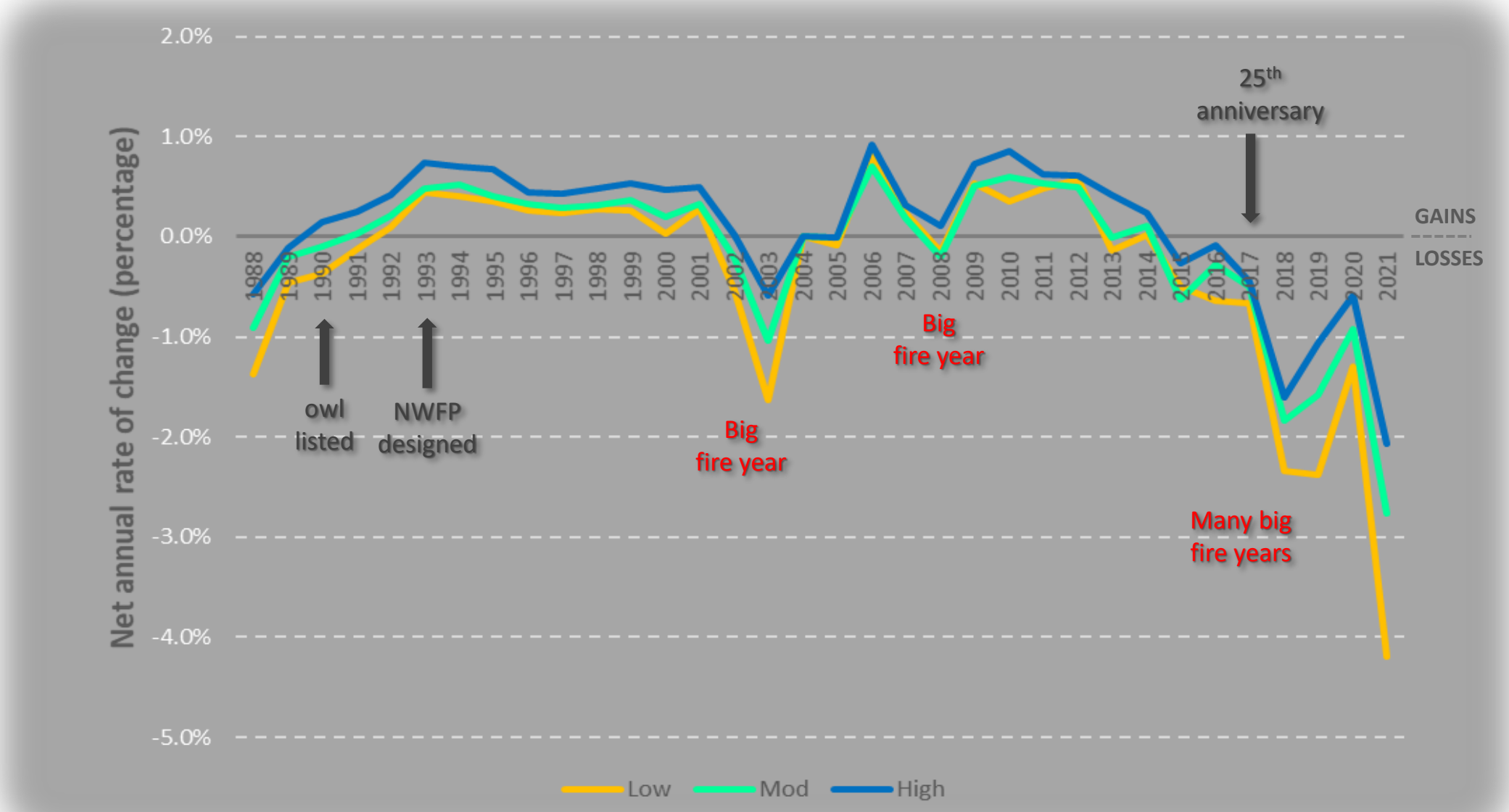
Refugia Structure



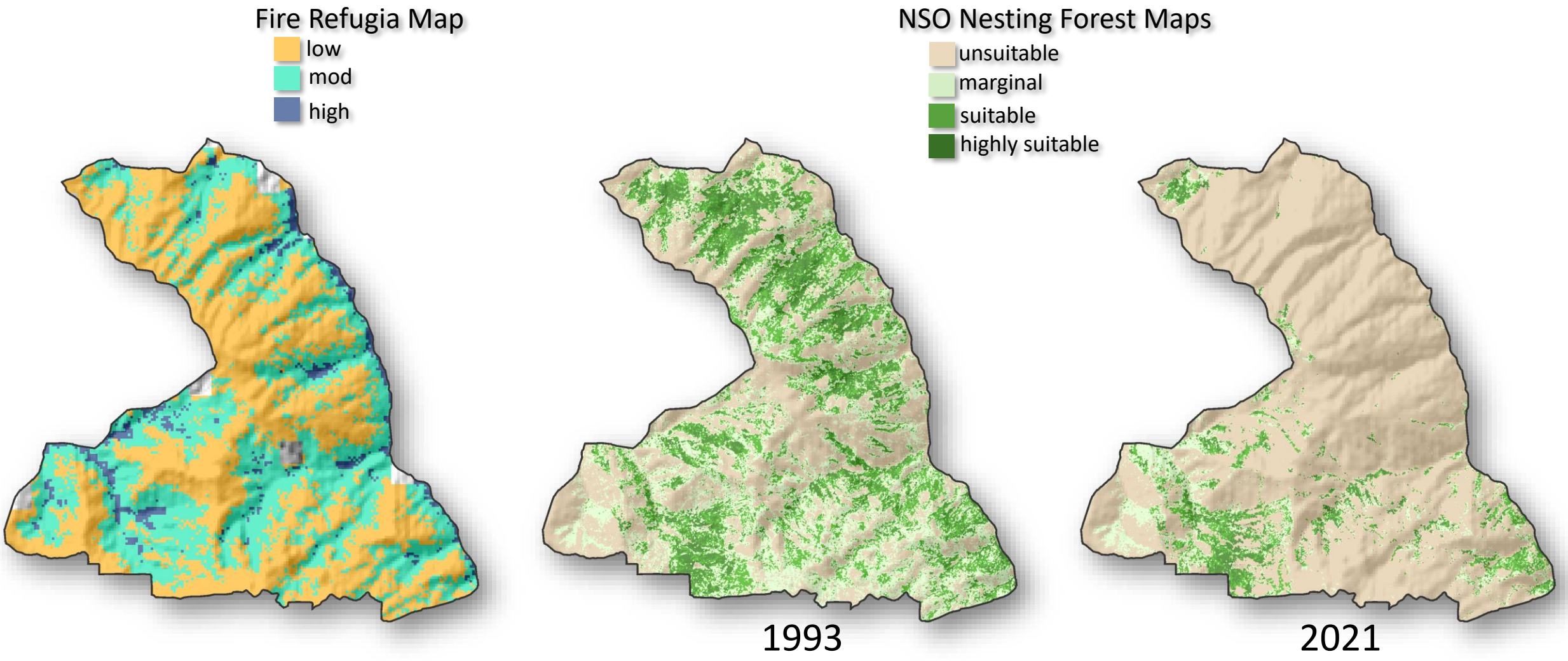
Temporal Trend Refugia for NSO (Δ_{net} since 1993)



Annual Rate of Change for NSO



Late-Successional Forest Reserve (LSR-310)



Thank You!
Questions?