Washington's Future Forests

Christopher Earle
Gymnosperm Database
address to WNPS, April 2, 2022

Overview

- Principles
- Baseline
- Climate Change
- Humans and the Forest
- Shaping the Future Forest

Principles

- Ecosystems are composed of species and plant species primarily respond to *climate*.
- Dominant trees are *keystone species*.
- The major forest *stressors* are: drought, fire, pests, pathogens, climate change, invasives, and exploitation.
- Environment and ecosystem *change never ends*; there has never been a "once upon a time."

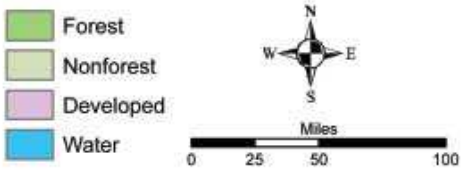
Baseline: Past Forests

Keystone Tree Species

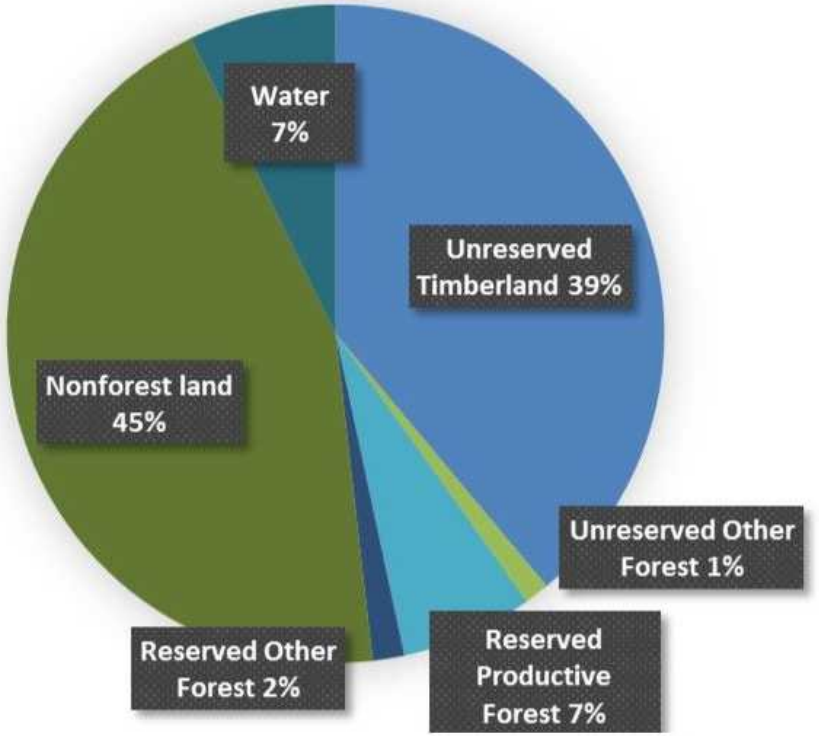
- Douglas-fir (33)
- Black cottonwood (31)
- Lodgepole pine (28)
- Western redcedar (25)
- Western hemlock (22)
- Bigleaf maple (21)
- Red alder (21)
- Ponderosa pine (19)
- Oregon white oak (14)
- Sitka spruce (13)

(Parentheses) = No. of Washington's 39 counties where found (USDA PLANTS).

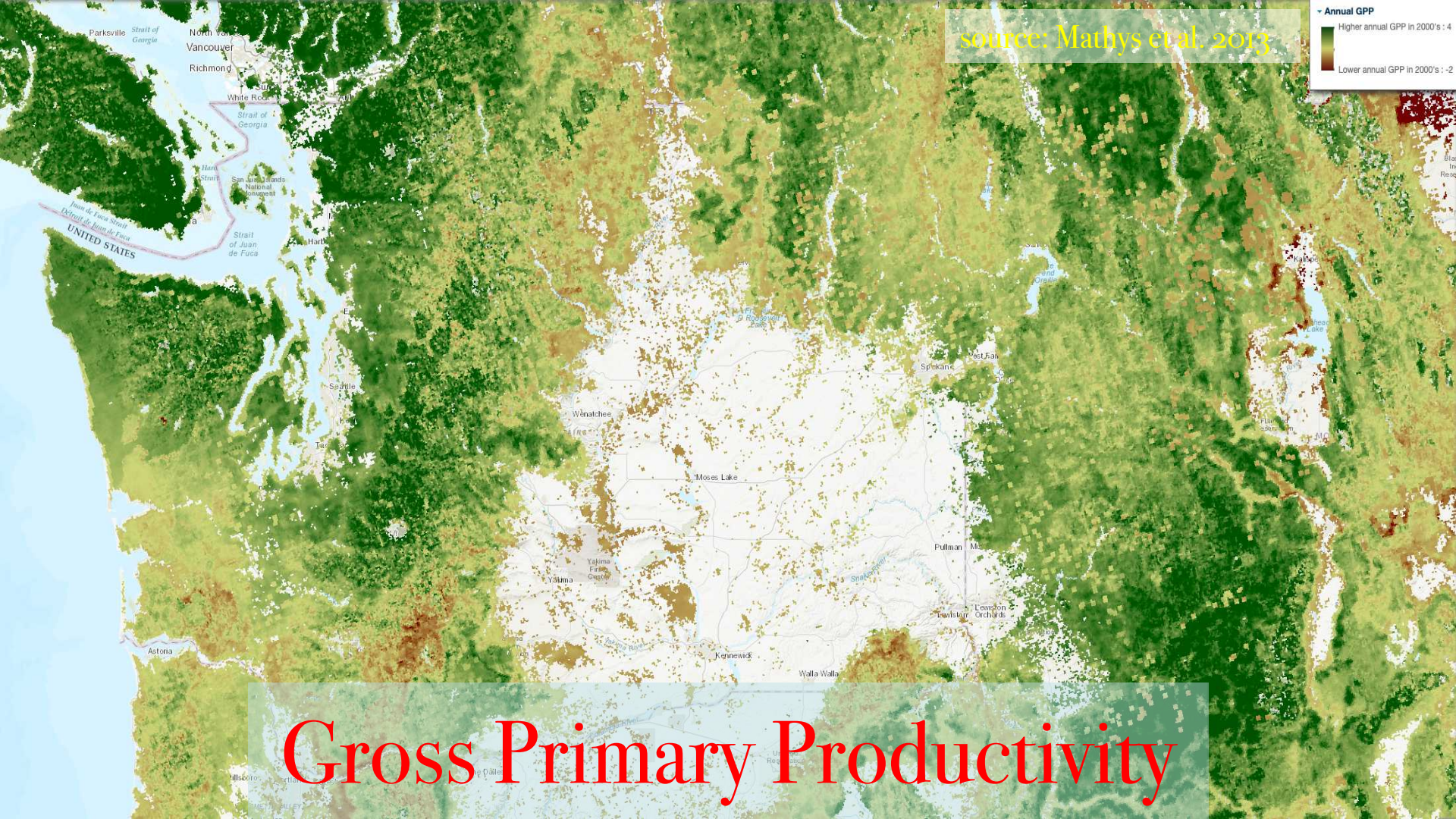
source: USDA Forest Service (2017a, 2017b)



Source: US Forest Service
biomass map forest/nonforest mask,
USGS MRLC-NLCD 2001.



Current Forests



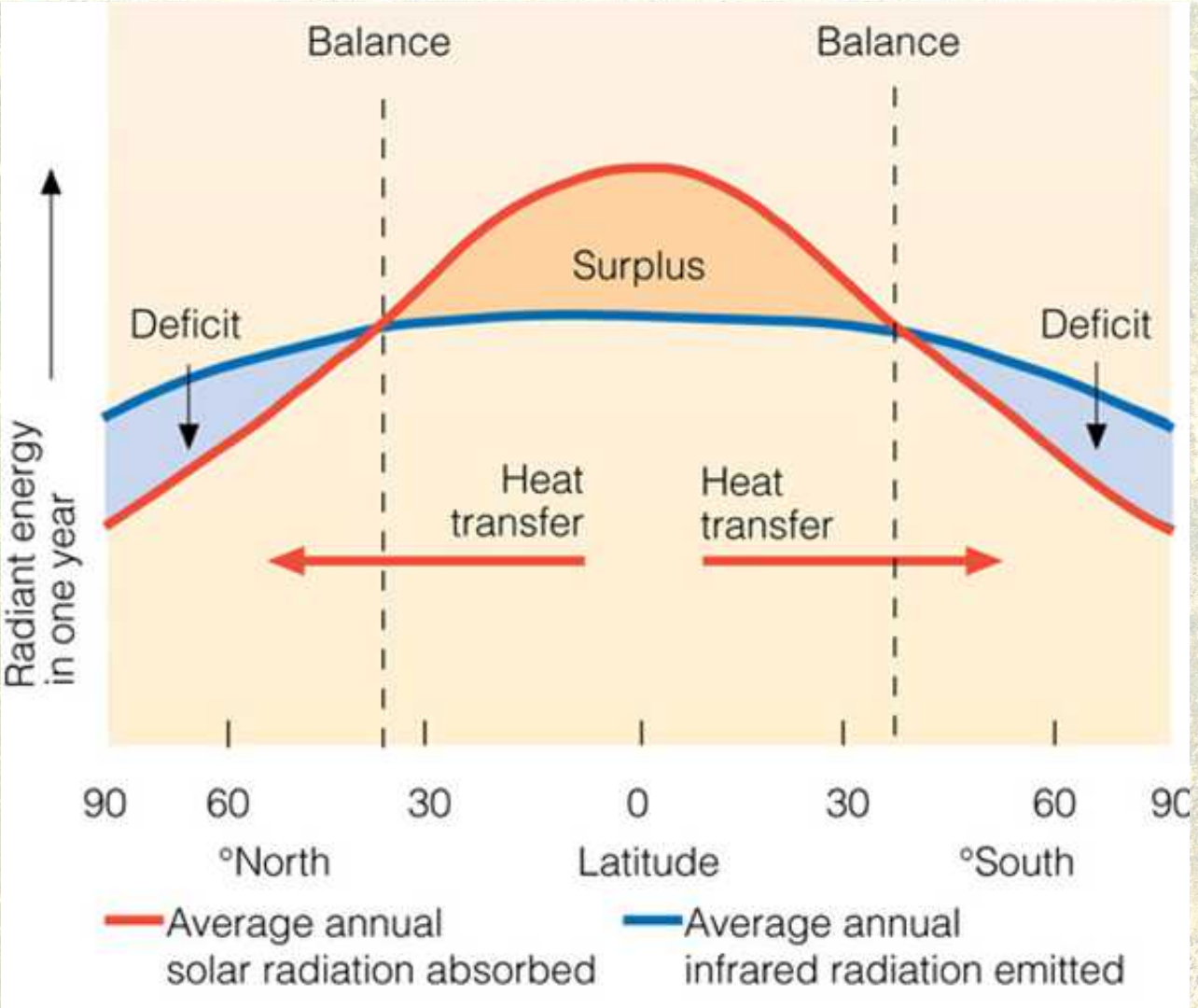
Gross Primary Productivity

Climate Change

Principles

- *Greenhouse gases* change the amount of sunlight absorbed by the atmosphere, changing the weather, which has always been driven by the *transport of heat from the equatorial towards the polar regions*.
- Climate scenarios are based on science, data, and *computer models*.
- Scenarios depend on certain assumptions about *human behavior*, mainly, how rapidly greenhouse gases accumulate.
- Climate change is effectively *irreversible* at human timescales.

Transport of Heat



source: NASA

Principles

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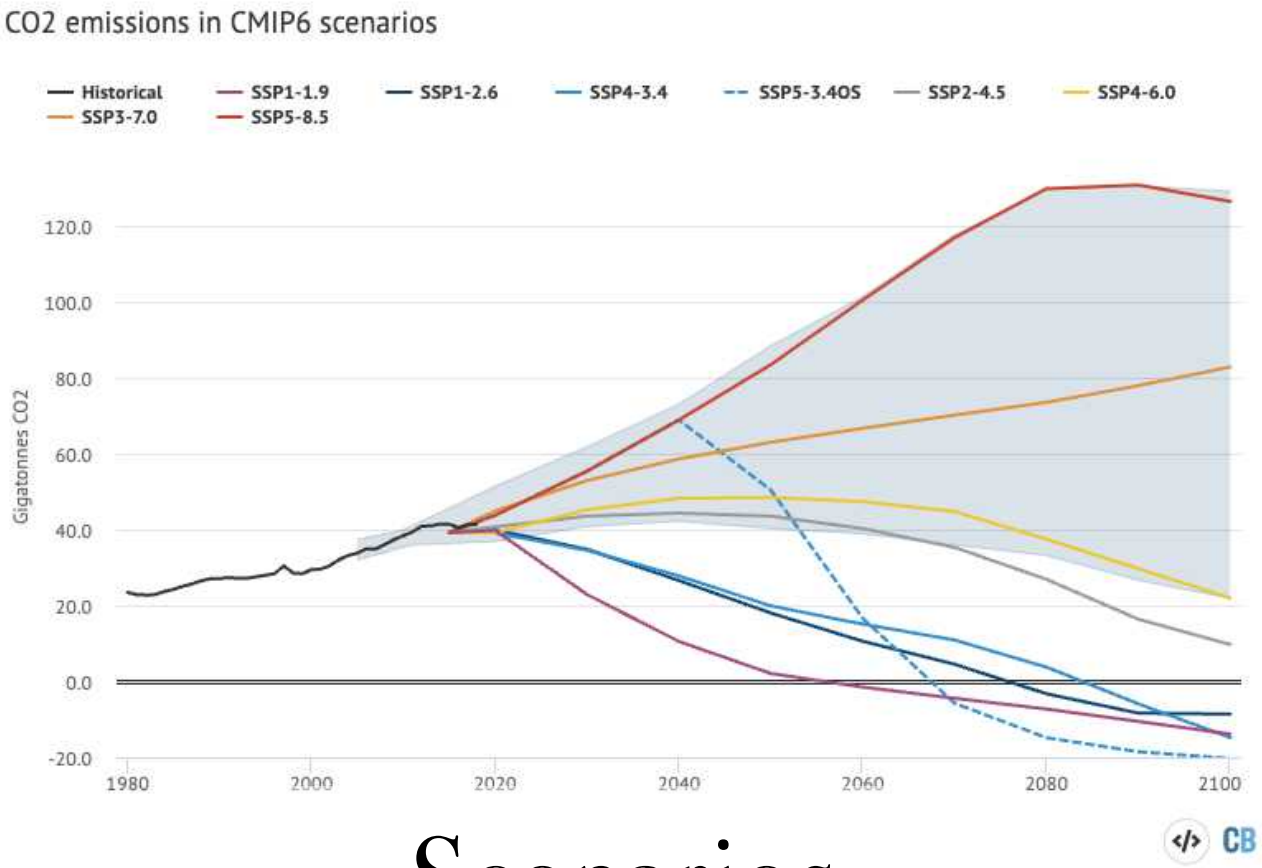

Scenarios

Future CO2 emissions scenarios featured in CMIP6, as well as historical CO2 emissions (in black). The shaded area represents the range of no-policy baseline scenarios. Data from the SSP database; chart by Carbon Brief using Highcharts.

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CLIMATE CHANGE SUMMARY (CMIP6)

Variable	WESTERN WASHINGTON				EASTERN WASHINGTON			
	Baseline	2040	2060	2100	**Baseline**	2040	2060	2100
Summer temperature	59° F	up 3° F	up 5° F	up 9° F	59° F	up 4° F	up 5° F	up 9° F
Days above 95°F	2	7	11	18	1	7	10	17
Summer rainfall	5.1 in.	down 8%	down 11%	down 17%	5.5 in.	down 8%	down 10%	down 15%
Annual precipitation	65 in.	down 2%	down 3%	down 5%	40 in.	down 2%	down 3%	down 6%
Annual snowfall	11 in.	down 20%	down 31%	down 56%	22 in.	down 10%	down 18%	down 25%

Baseline era is 1981 to 2010

W WA = Average of Snohomish and Olympics grid cells

E WA = Average of Spokane and Okanogan grid cells

Source: https://www.ipcc.ch/assessment-report/ar6/

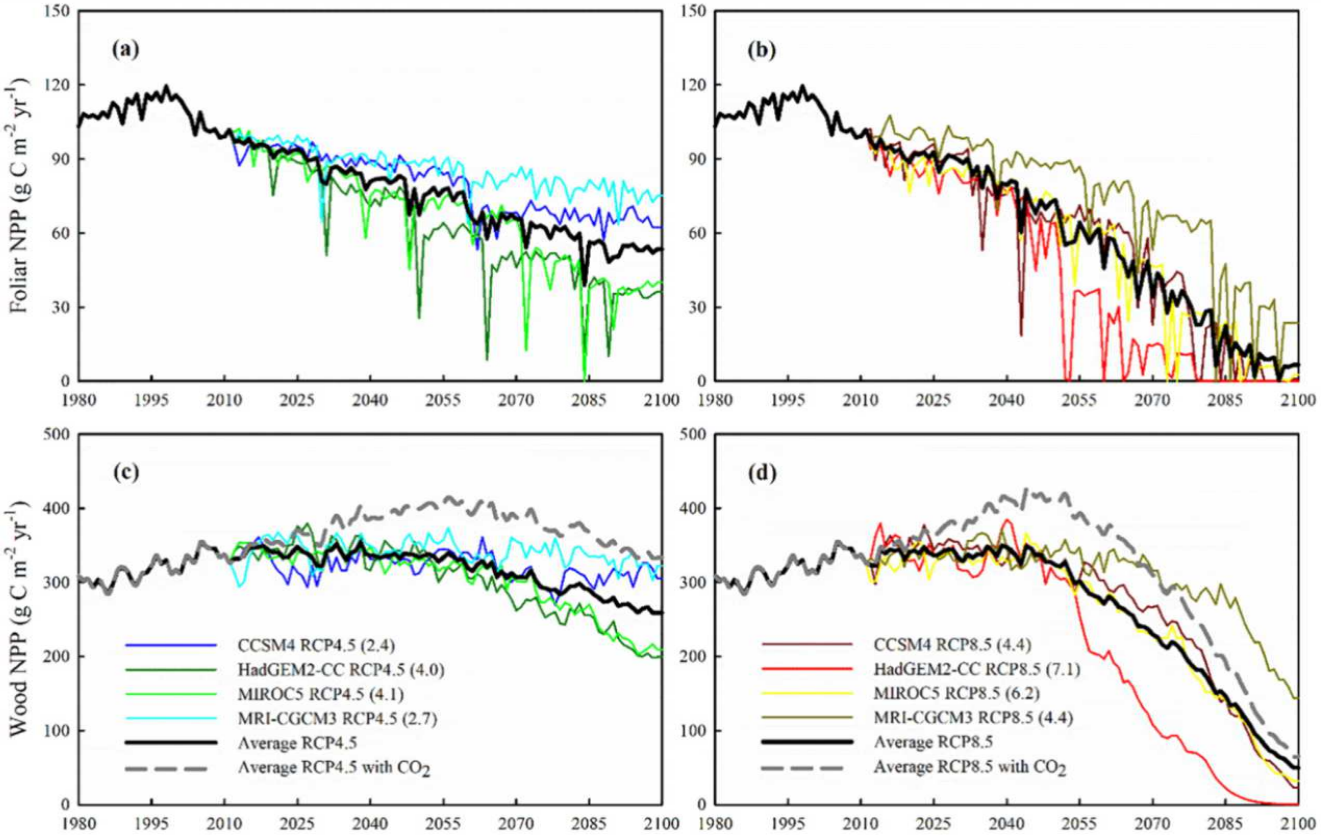
Values based on SSP2 and SSP3 scenarios, i.e. small GHG emission reductions

Forecast: Drought

- *Increased atmospheric drought*: less rain, less snow, warmer thus higher vapor pressure deficit
- *Increased soil drought*: less summer rain, less snow, earlier snowmelt
- *Heat stress*: higher vapor pressure deficit, increased but also impaired plant metabolism

Foliage

Wood



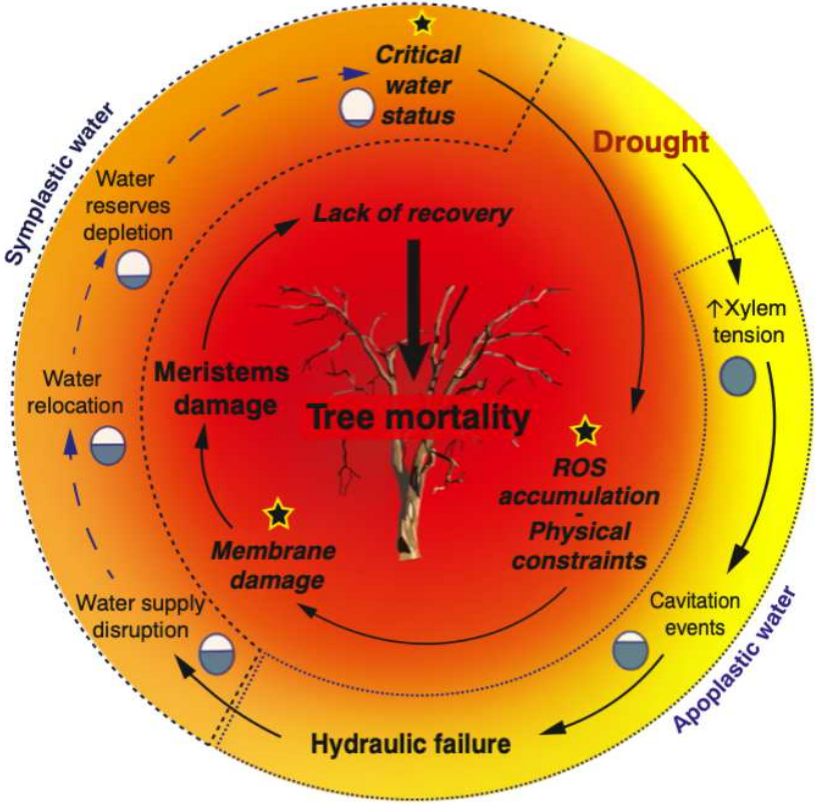
RCP4.5

RCP8.5

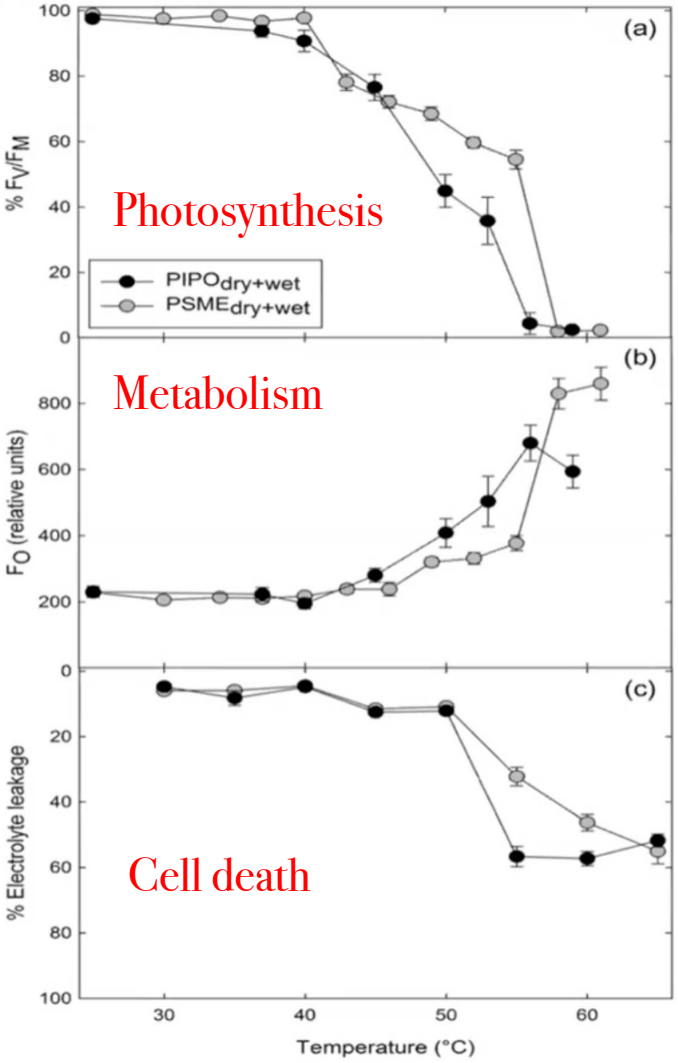
Source: Dong et al. 2019, modeling responses of an old-growth DF forest in W WA

Forests, Drought, and the 2021 Heat Wave

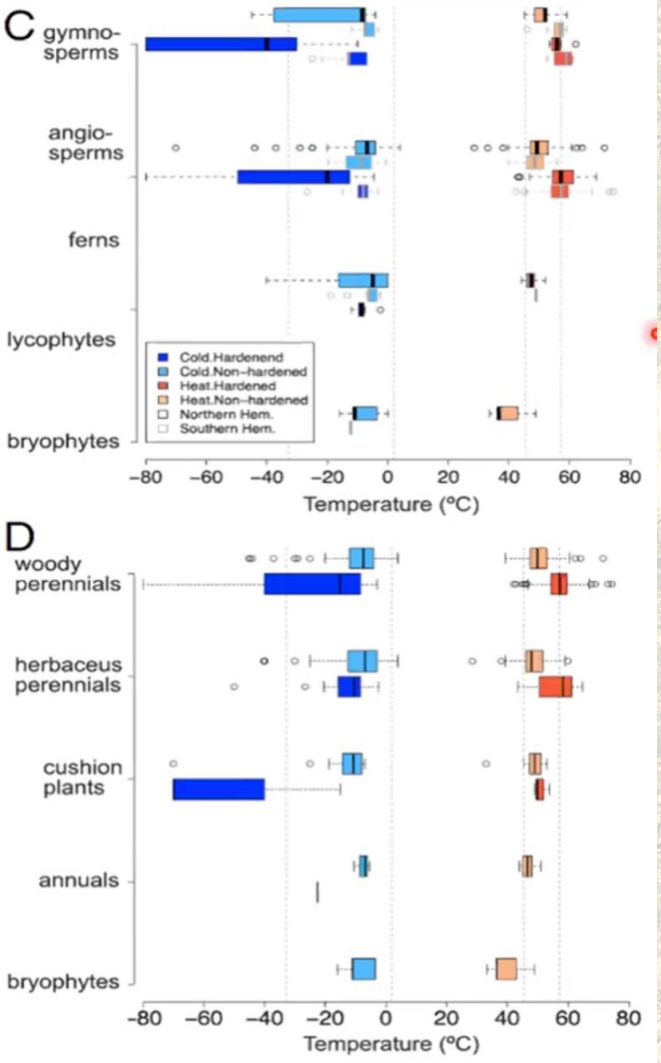
- Heat wave in late June 2021
- Many locations over 108°F (42°C); maxima 118°F (48°C)
- Widespread foliage death in W OR and WA
- Multiple conifer species



The "Death Spiral" of drought
source: Mantova et al. 2021



source: OSU 2021



Heat Wave Findings

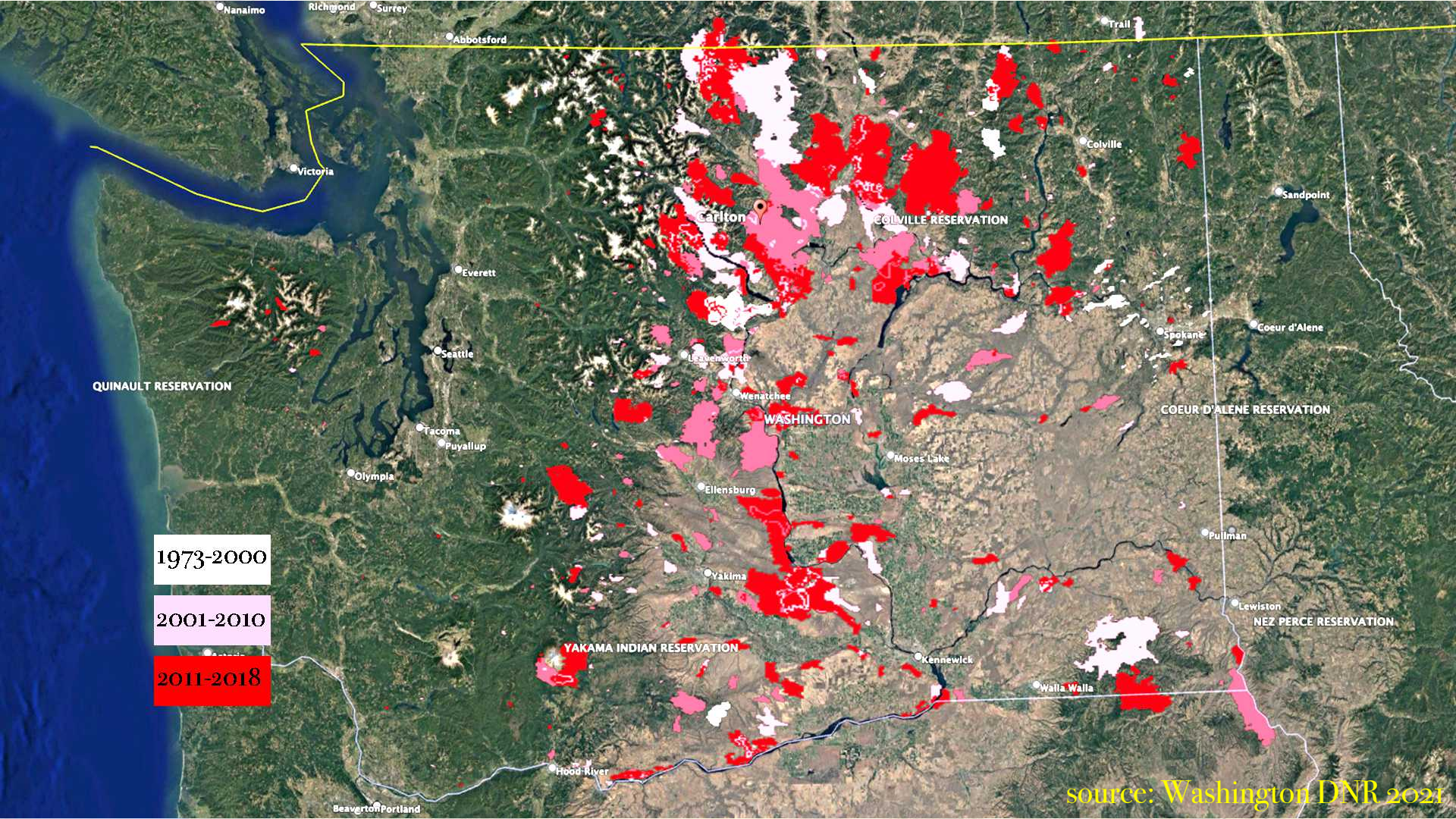
- Heat waves comparable to the 2021 event are likely under all climate change scenarios
- All our forests are vulnerable, especially ponderosa and Douglas-fir dominated forests
- Risk factors include species, drought, duration, slope/aspect, and phenology

Biotic Effects of Climate Change

- Pests and pathogens
  - Trees more vulnerable when stressed by heat, drought, etc.
  - Disease may move into areas with previously unsuitable climate
- Altered phenology

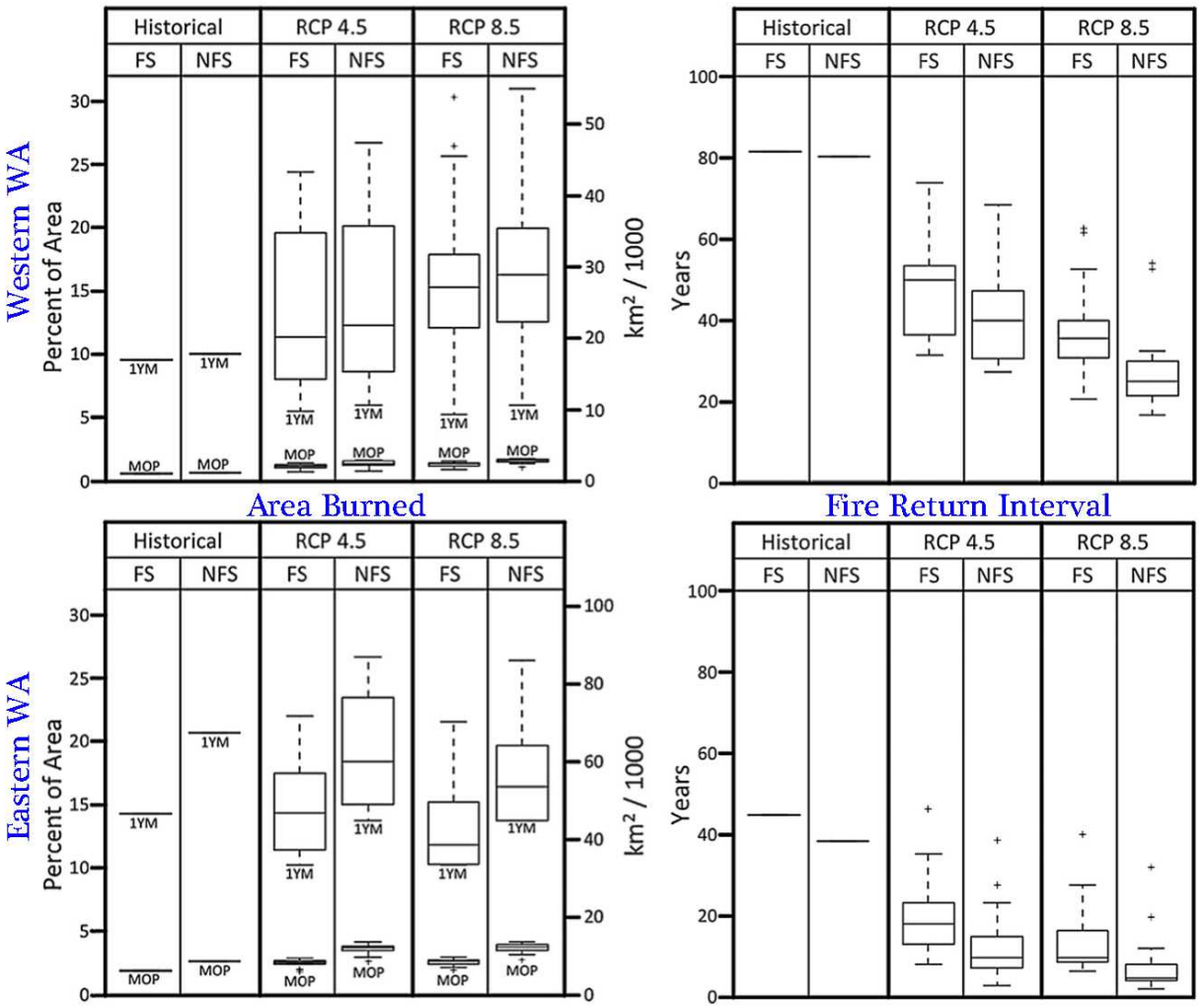
Future Forest Fire Forecasts

- Effects related to climate change: hotter, drier
- Effects related to management: suppression
- Derivative ecological effects: productivity, mortality, competition
- Forecasts are based on modeling of these effects



source: Washington DNR 2021

Fire Model Forecasts

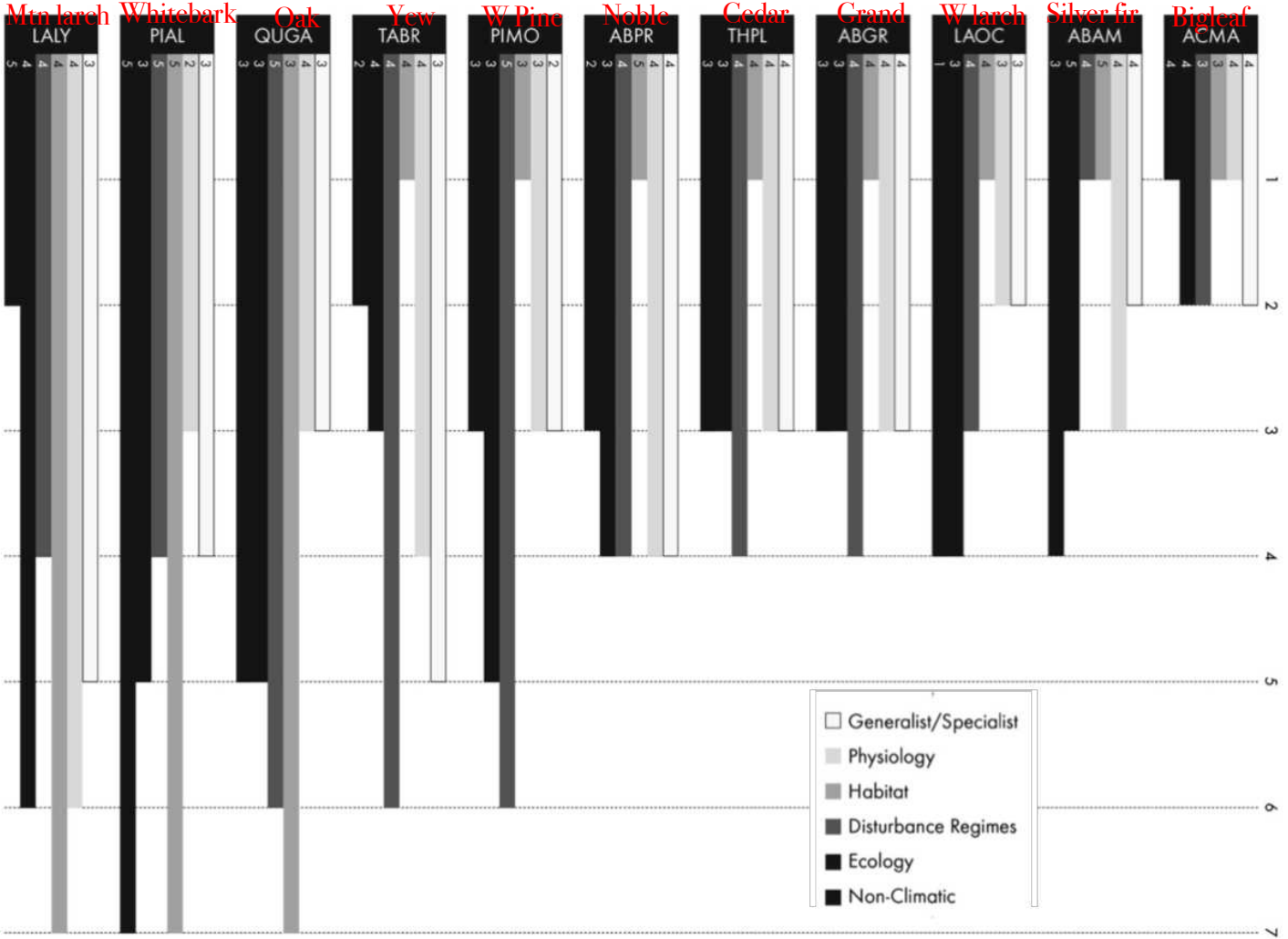


source: Sheehan et al. 2015

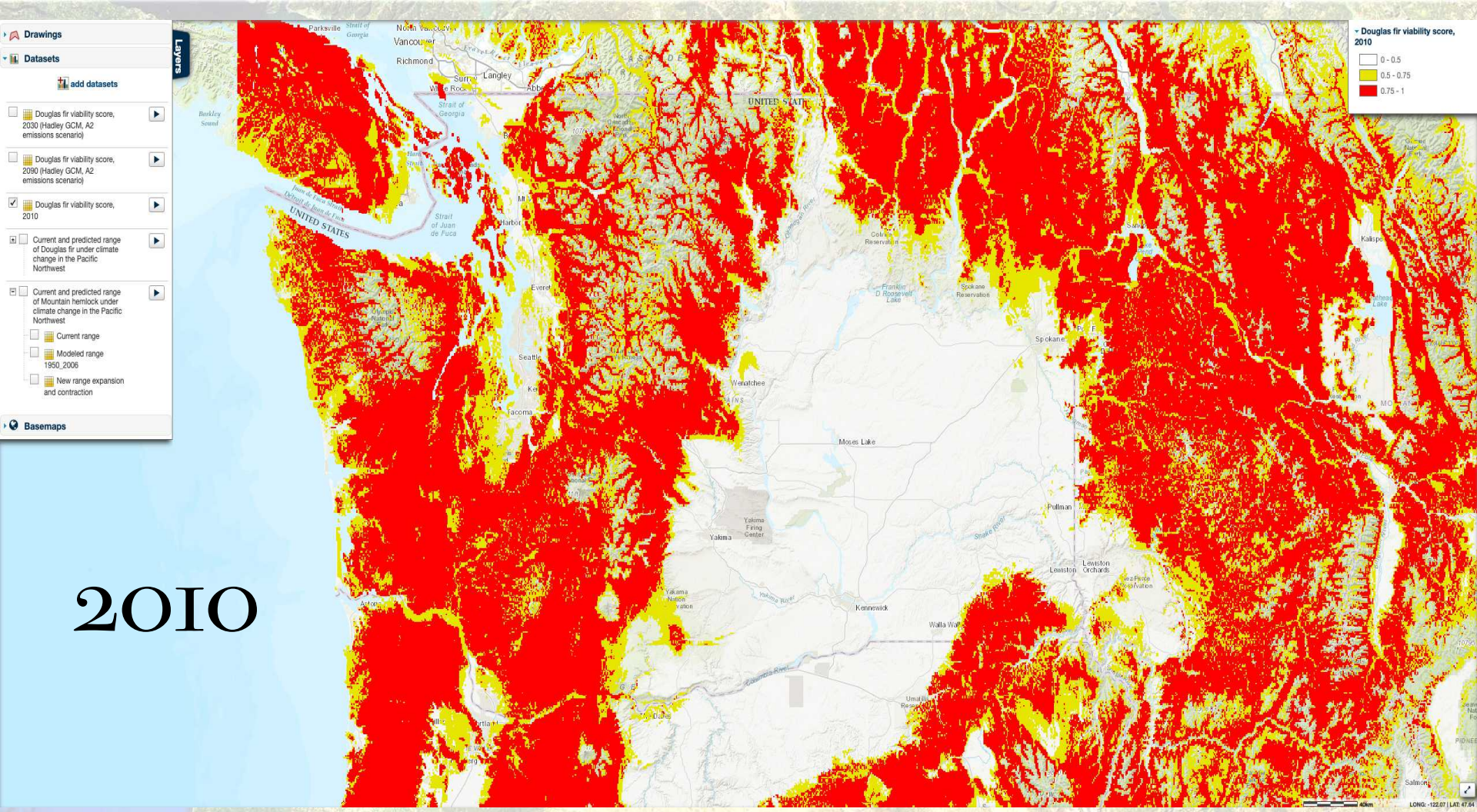
Habitat Suitability for Major Trees

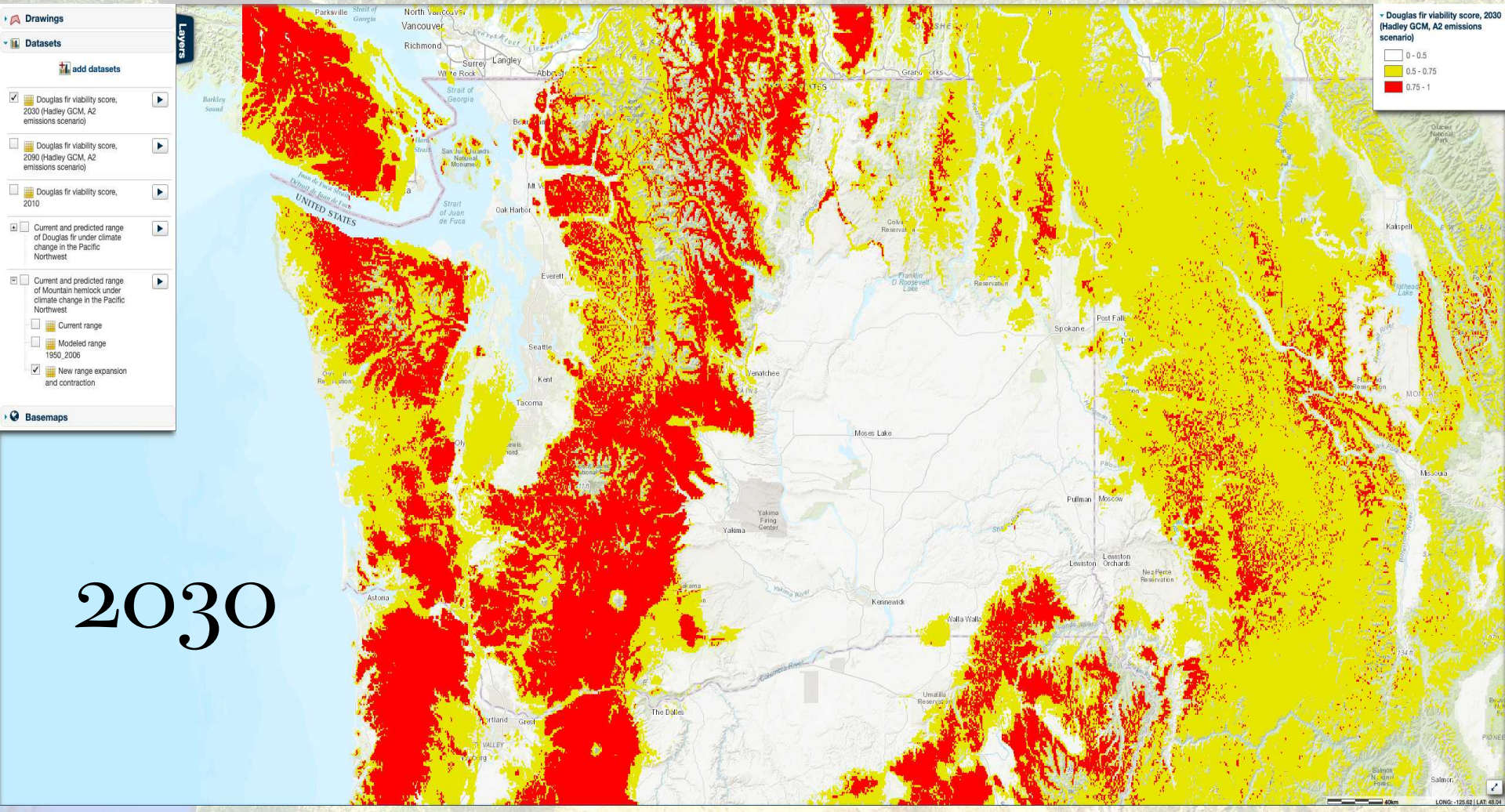
- Altered suitability for all dominant species
- Changes are species-specific
  - Responses related to climate, physiology, ecological relationships, disturbance regimes
- Spatial scale exceeds seed dispersal distances

Climate Change Sensitivity of Dominant Trees



source: Case and Lawler 2016


Drawings
Datasets
add datasets
Douglas fir viability score, 2030 (Hadley GCM, A2 emissions scenario)
Douglas fir viability score, 2090 (Hadley GCM, A2 emissions scenario)
Douglas fir viability score, 2010
Current and predicted range of Douglas fir under climate change in the Pacific Northwest
Current and predicted range of Mountain hemlock under climate change in the Pacific Northwest
Current range
Modeled range 1950_2006
New range expansion and contraction
Basemaps
Layers
Douglas fir viability score, 2010
0 - 0.5
0.5 - 0.75
0.75 - 1
Vancouver
Richmond
Langley
Seattle
Tacoma
Spokane
Wenatchee
Moses Lake
Pullman
Yakima
Kennewick
Lewiston
UNITED STATES
2010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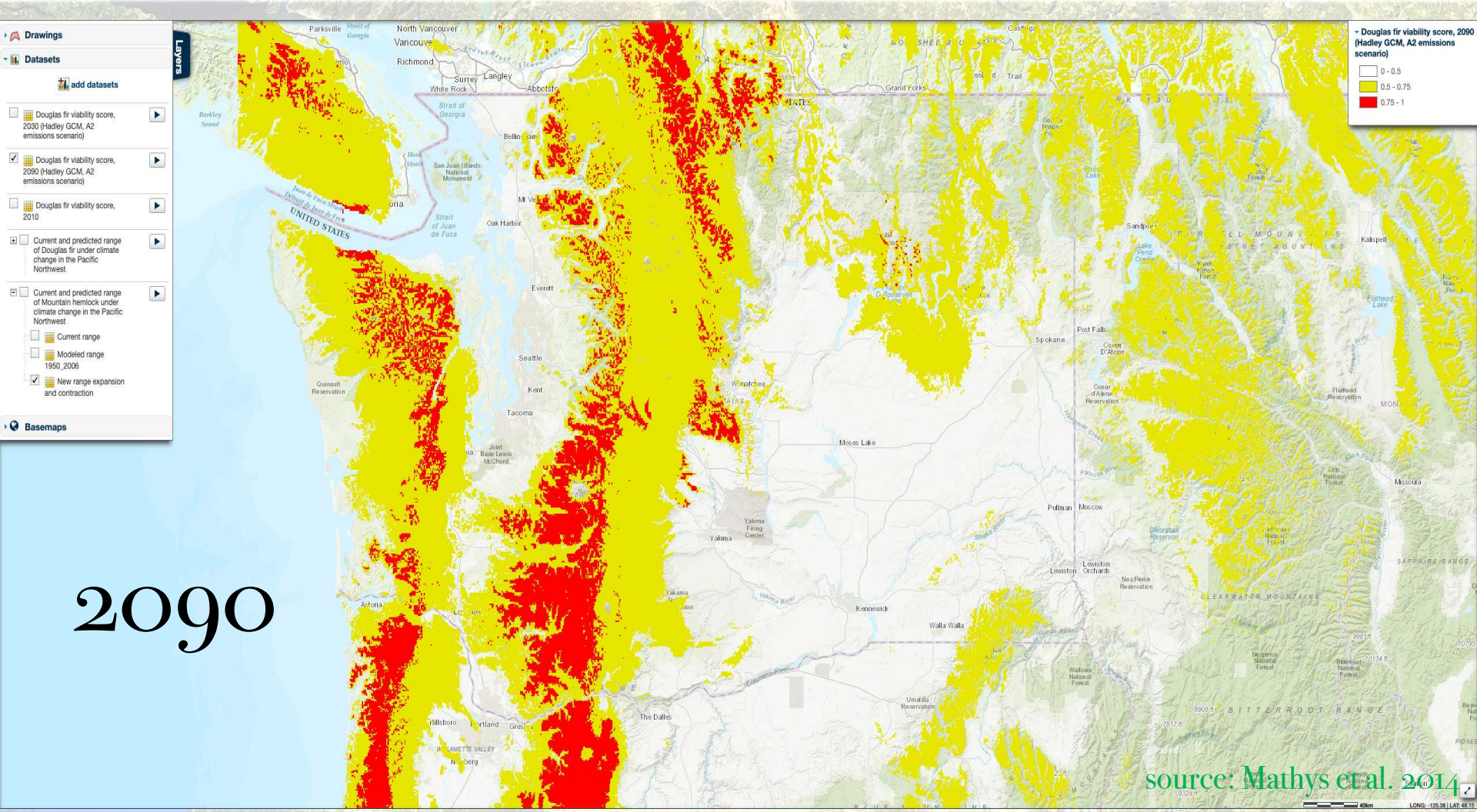
0 - 0.5
0.5 - 0.75
0.75 - 1
Vancouver
Seattle
Spokane
Tacoma
Yakima
Kennewick
Walla Walla
Moses Lake
Pullman
Moscow
Lewiston
Everett
Kent
Venatchee
Kalispell
Missoula
Astoria
The Dalles
UNITED STATES
2030



2090

source: Mathys et al. 2014

Humans and the Forest

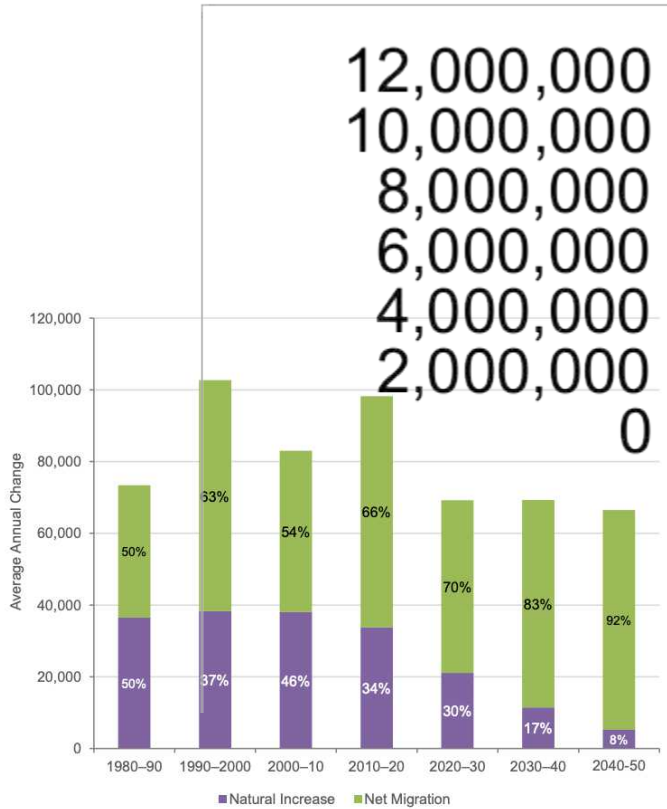
Principles: History

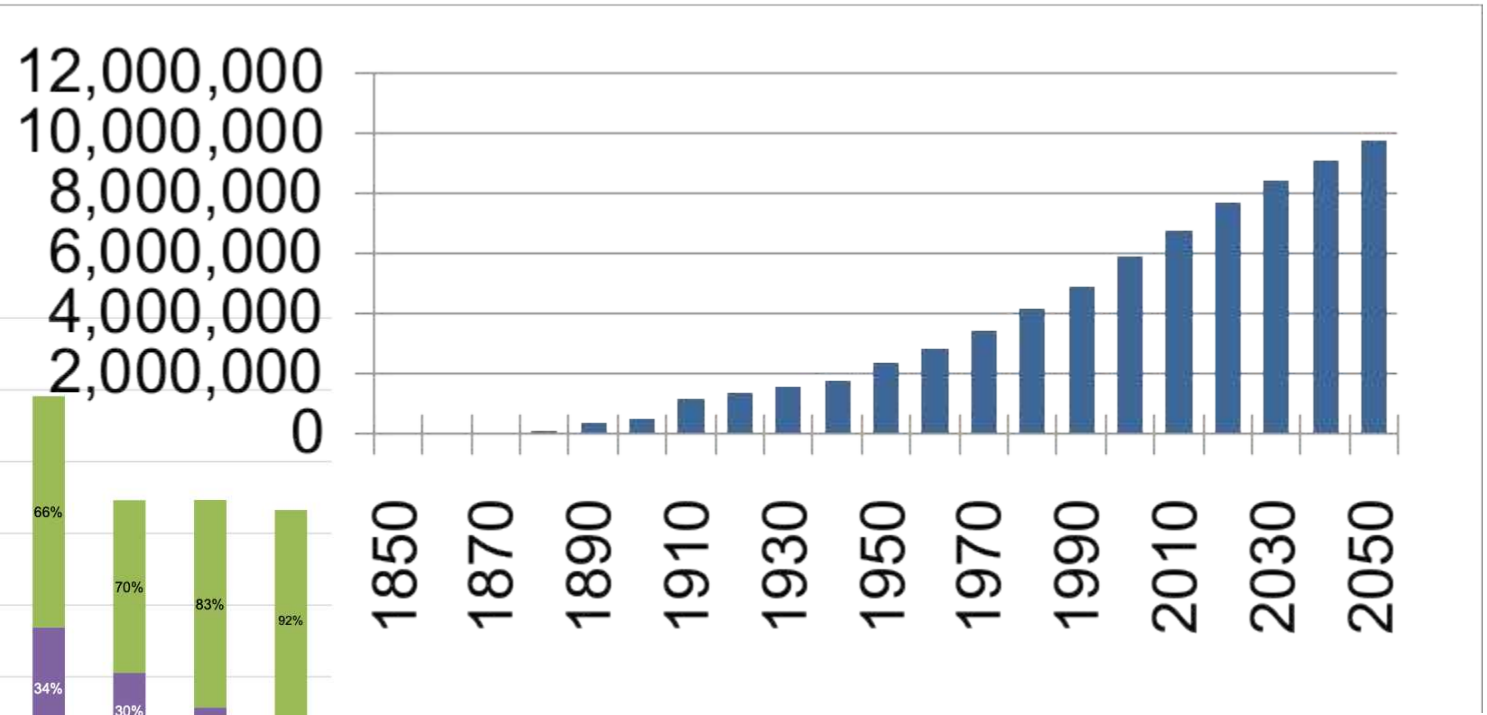
- The human relationship to the forest has historically been one of exploitation or neglect
- Exploitation has focused on harvest, neglect has focused on preserves
- Neglect has become harmful; the future requires ecosystem management in all forests

Source of Future Impacts

- Climate change, as discussed earlier
- Changes in forest landscape pattern and age structure due to
  - Land conversion
  - Timber harvest
  - Fire suppression
- New, non-native pests and pathogens

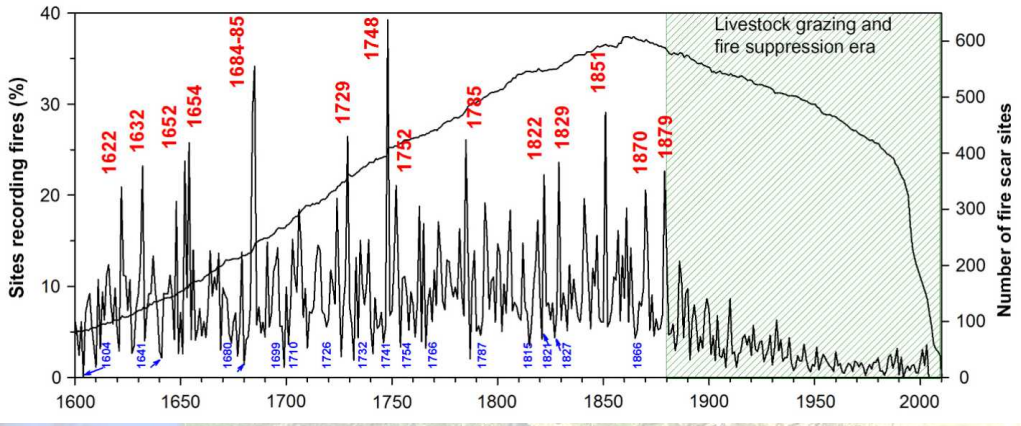
More People - Land Use Change

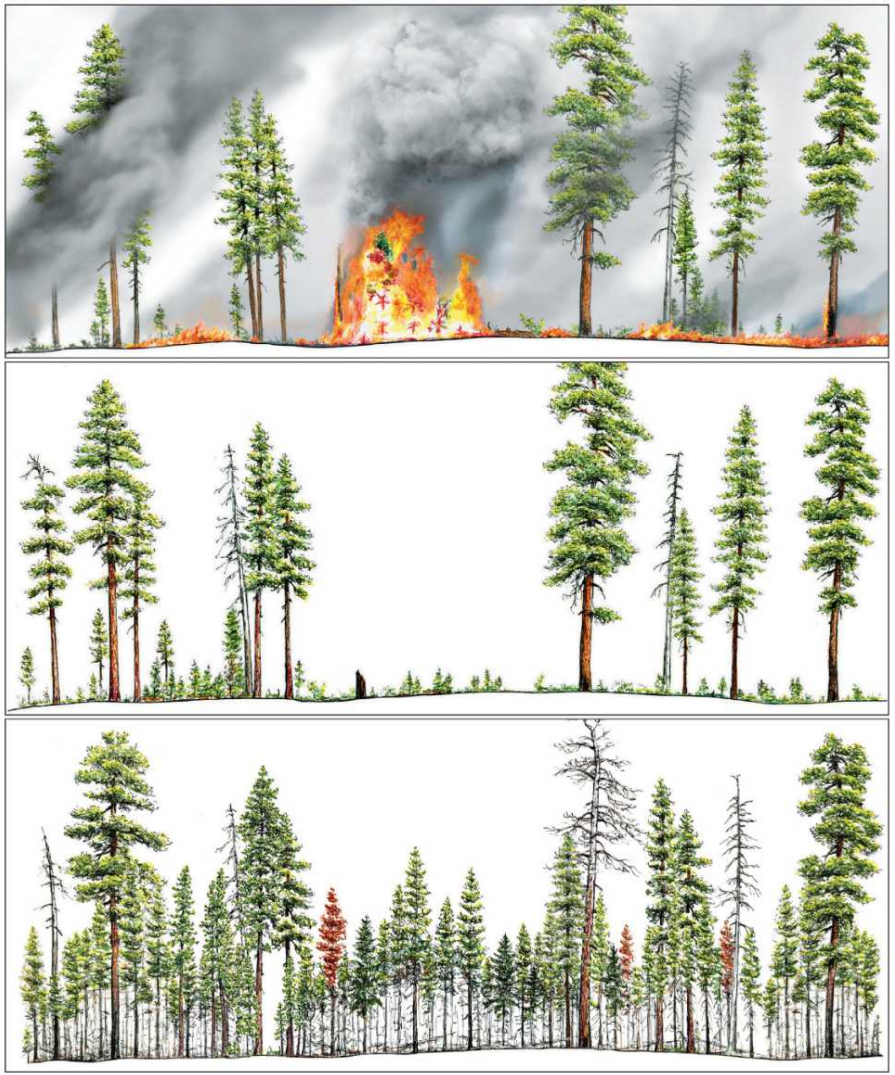




source: US Census Bureau


Timberland
Neglect
Development
Agriculture

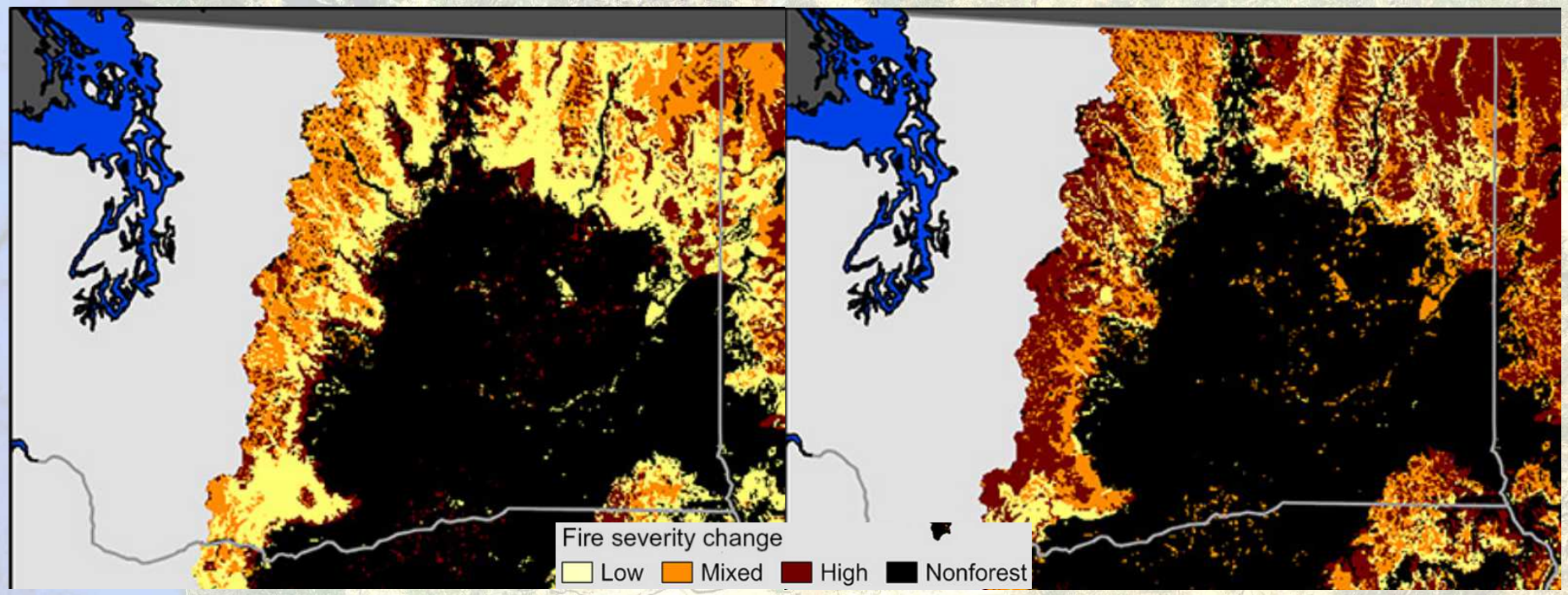




Fire Suppression: Evidence and Results

sources: Swetnam et al. 2016; Hagmann et al. 2021 (Van Pelt)

Fire Severity Changes

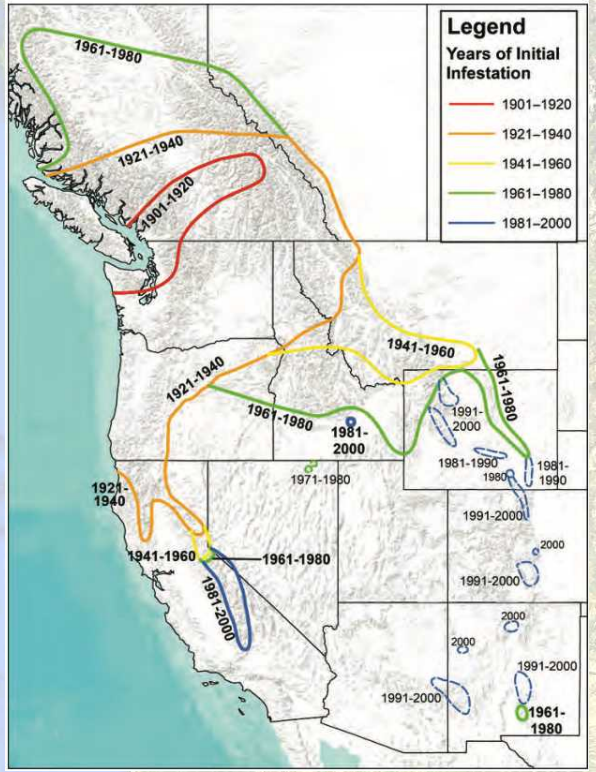


ca. 1800

Modern

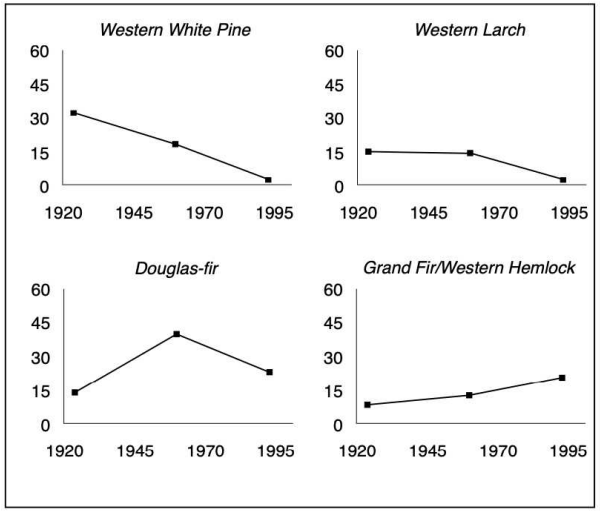
source: Hagmann et al. 2021 after Hessburg et al. 2005

Pests & Pathogens



White pine blister rust impacts on all 5-needle pines of western North America (except *P. longaeva*)

Tree inventory data taken from the Panhandle National Forests (Idaho) illustrates the decline of white pine relative to its companion species.

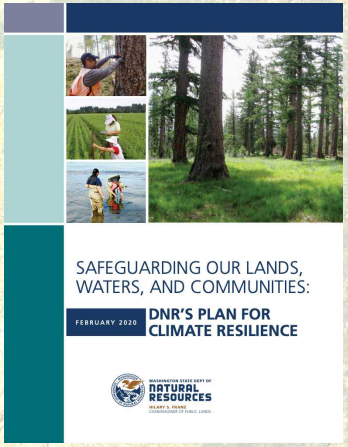


sources: Schoettle 2019, Neuenschwander et al. 1998

Shaping the Future Forest

Climate Change Adaptation

- The most promising programs include vision, goals, and tactics
  - Vision defines the problem
  - Goals define a desired future condition (a constantly changing target)
  - Tactics are tools especially useful for achieving goals



Vision

Manage forests to optimize ecological services

- Priority One: Minimize risks of catastrophic failure
- Create habitat connectivity on the landscape
- Designate and defend ecological refugia
- Leverage disturbance! That is the best time to realign vegetation with climate

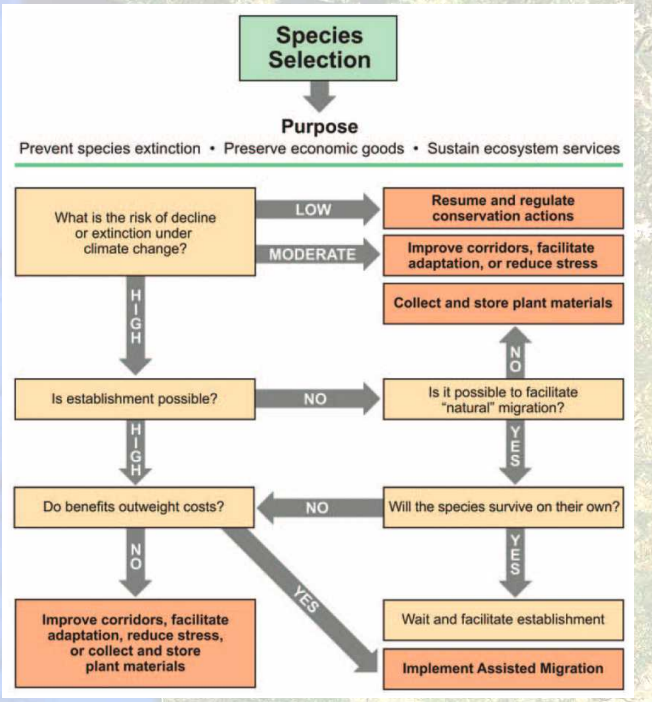
Goals

- Retain biological diversity (species, genetic, structural)
- Protect special ecosystems (aquatic, talus, etc.)
- Maintain habitat (fish, game, threatened species)
- Provide timber
- Control fire (e.g., WUI)
- Preserve hydrologic functions
- Provide for recreational use
- others?

Tactics

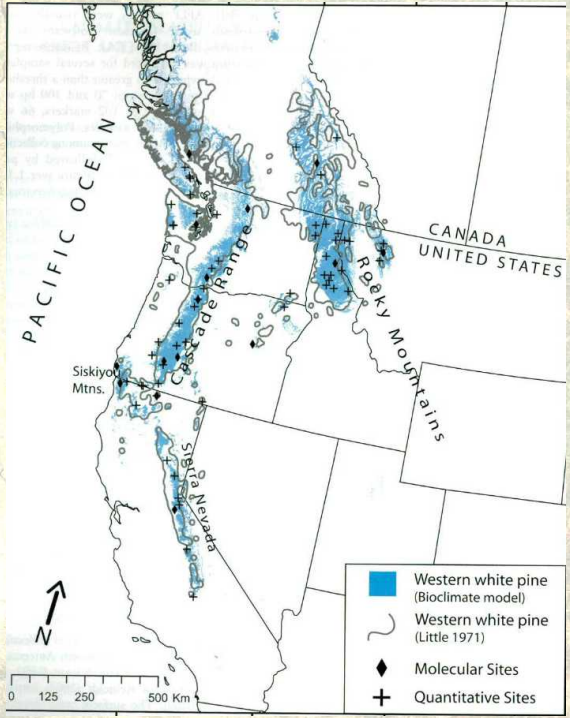
- Scientific, e.g. geospatial data and modeling to evaluate the alternatives and track progress
- Law, policy, and society, e.g.
  - Forest thinning programs
  - Assisted migration programs
  - Conservation reserve designation and management
- Existing laws provide for most tactical approaches, but funding is scarce.

Assisted Migration



We can do it with trees.

What about the species that depend on those trees?



sources: Williams and Dumroese 2013, Richardson et al.2009

Conclusions

- Washington's future forests will be much different from those we have known
- They will be hotter, drier, and support less biomass
- We have options to manage the changes and minimize their harm
- We have a limited time to develop the science, policies, regulations, and funding structures to meet this challenge

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