

Climate Change and Forests — The Pacific Northwest and Beyond



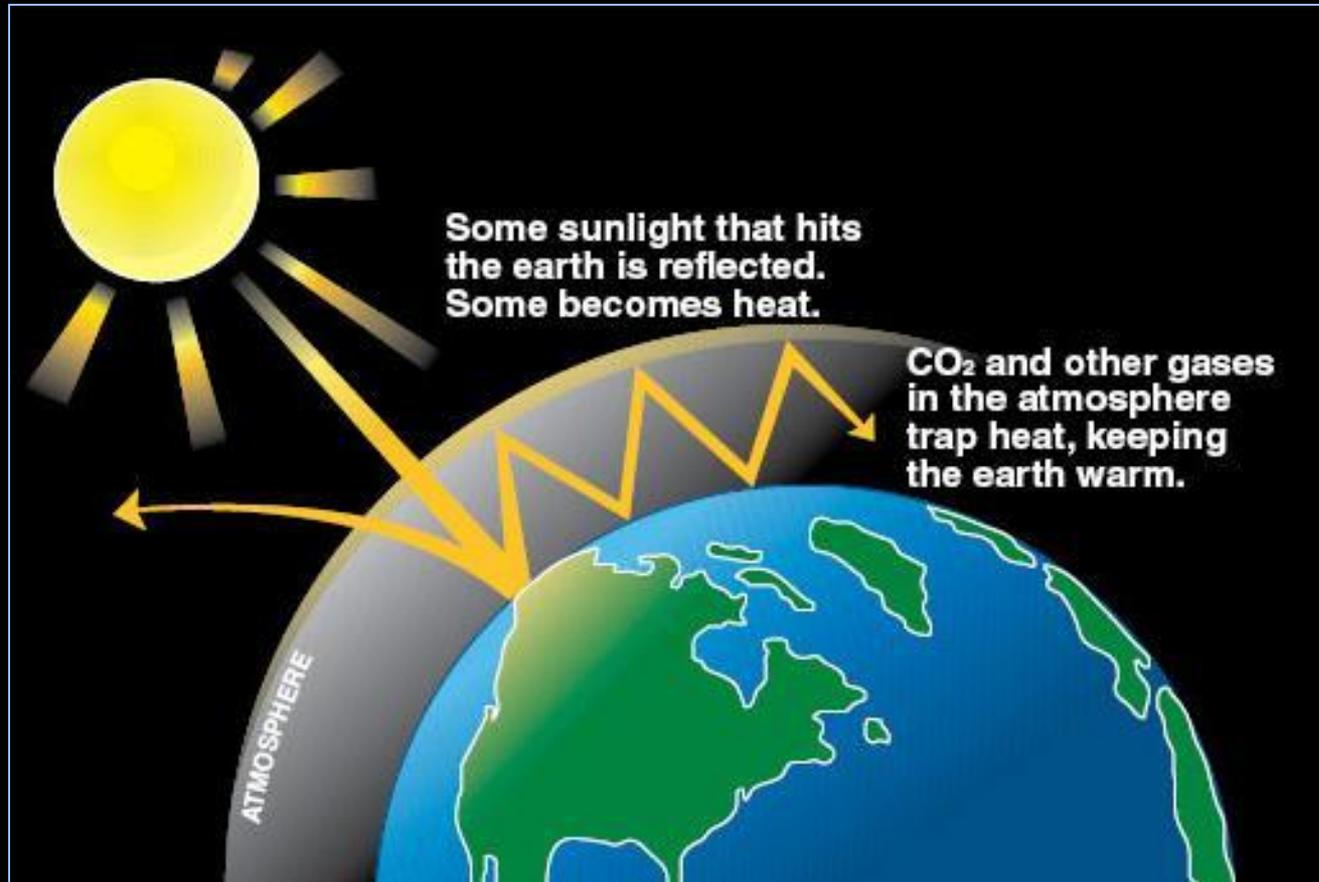
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University of Washington
School of Environmental and Forest Sciences



It's all about this
thin layer



Greenhouse gases (water vapor, CO₂, CH₄, N₂O) play a critical role in determining global temperature

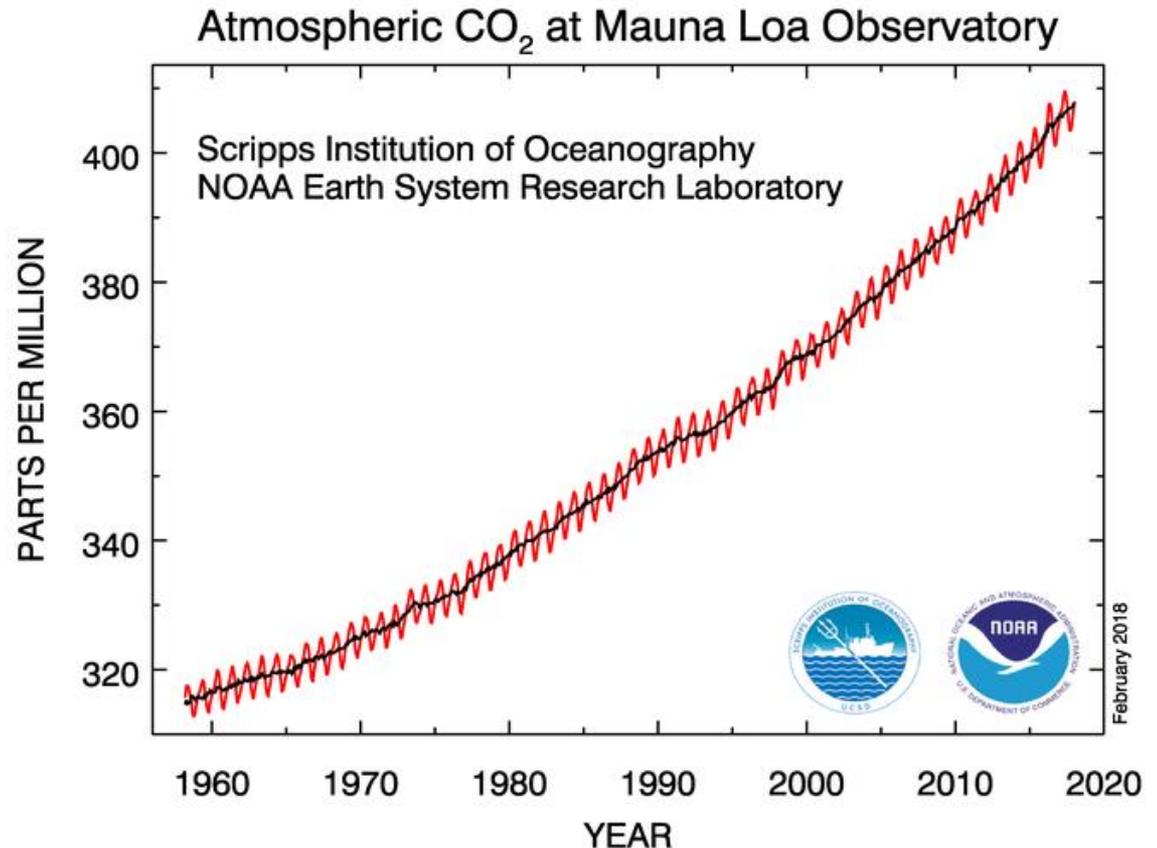


Rapid increases in greenhouse gases are changing this natural balance

Carbon dioxide is increasing

Atmospheric CO₂ is now **408 ppm**.

It was **260 ppm** in 1850.



Source: <https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html>



**Radiative
forcing**

1.5 Watts



----- 1 meter -----



----- 1 meter -----





1 meter

1 meter

X 500 trillion
for the entire Earth



In 2100?



1 meter



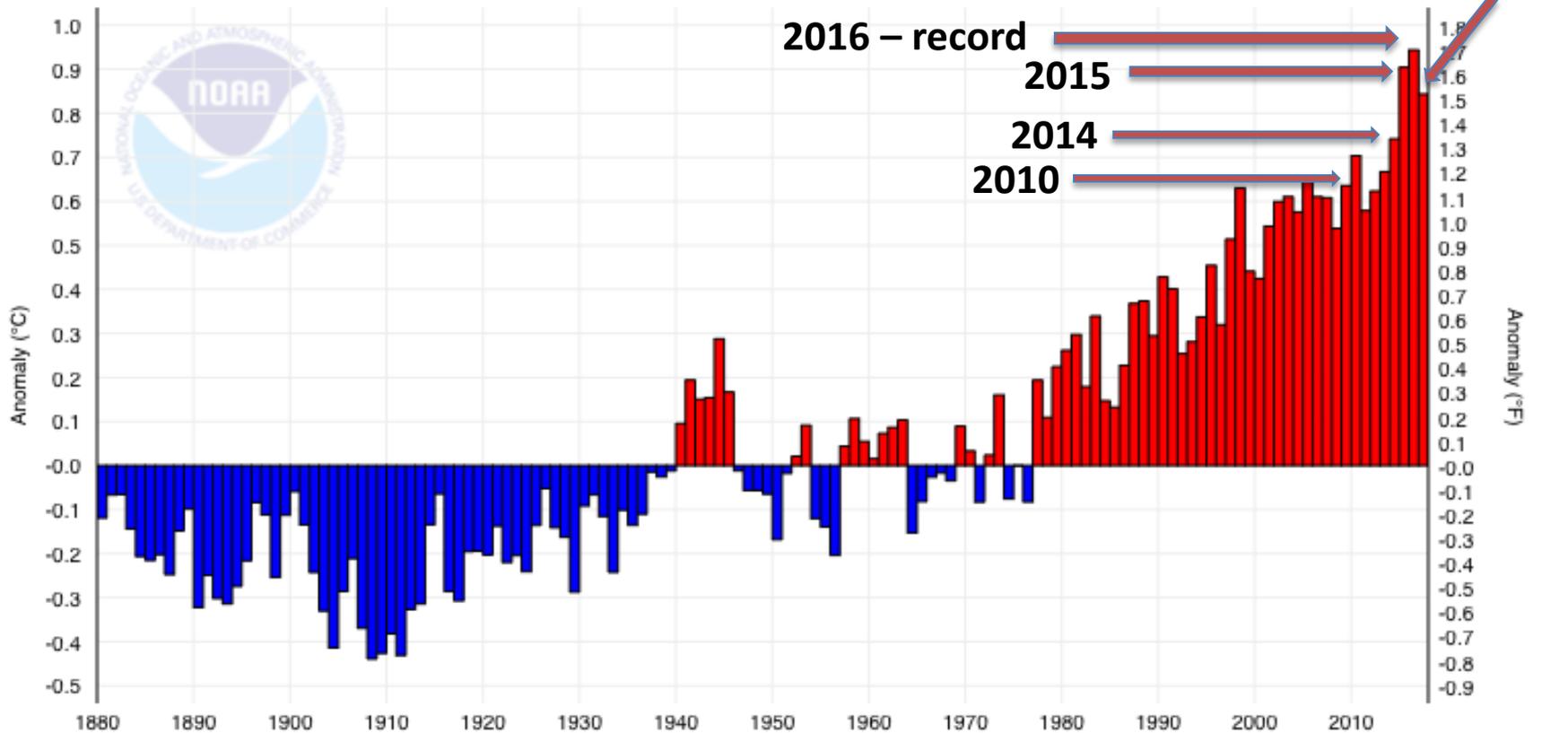
----- 1 meter -----

X 500 trillion



Global temperature trend

Global Land and Ocean Temperature Anomalies, January-December



Source: <https://www.ncdc.noaa.gov/cag/time-series/global>

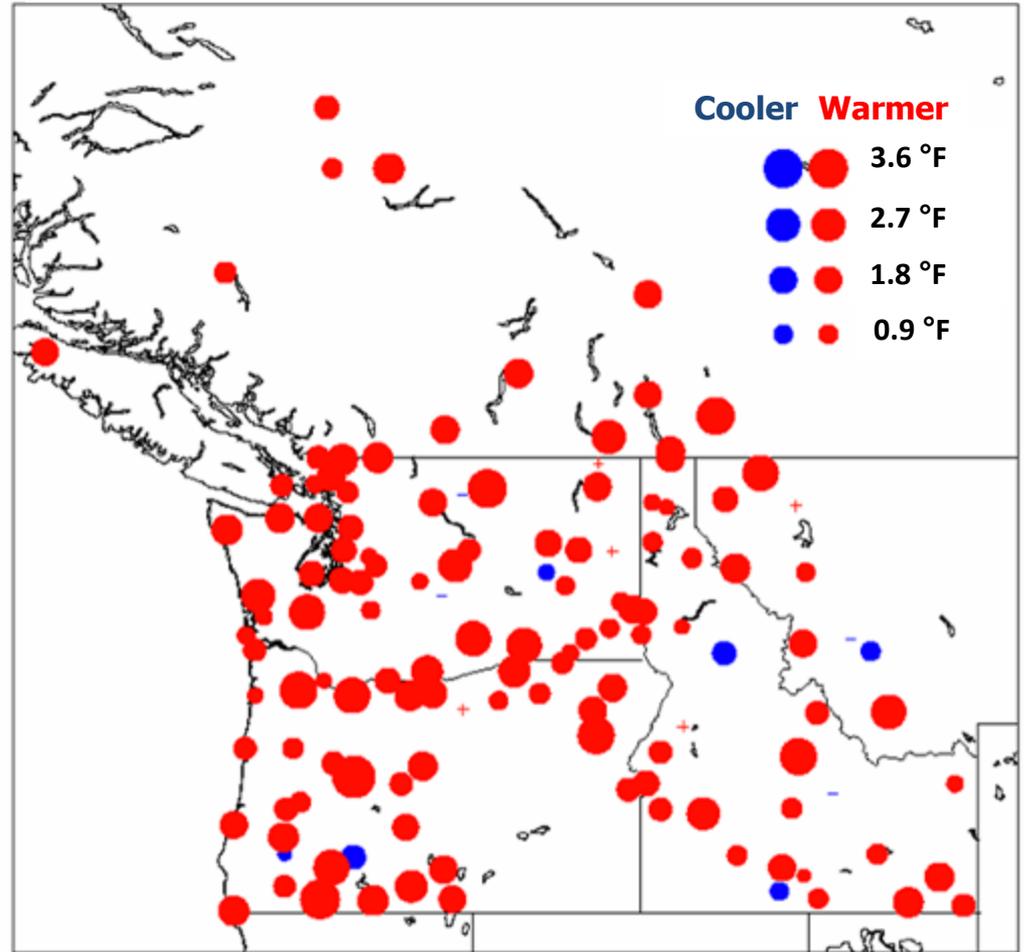
Temperature trends by station

Average annual temperature has increased $+1.6^{\circ}\text{F}$ since 1920.

Almost every station shows warming.

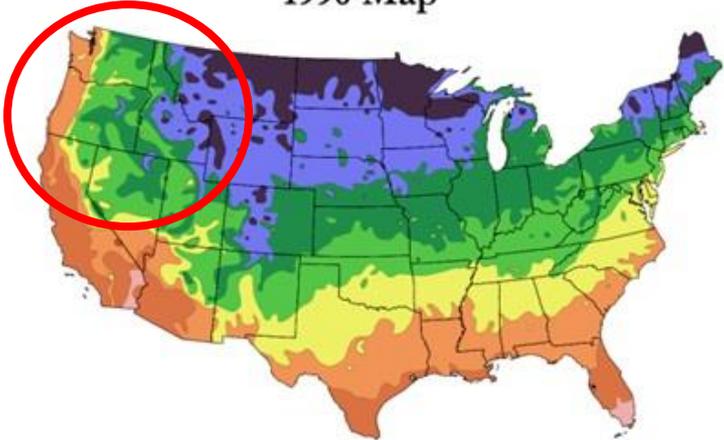
Extreme cold conditions have become rarer.

Minimum temperatures rose faster than maximum temperatures.



USDA plant hardiness zones

1990 Map



After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued January 1990

© 2006 by The National Arbor Day Foundation®

2012 Map

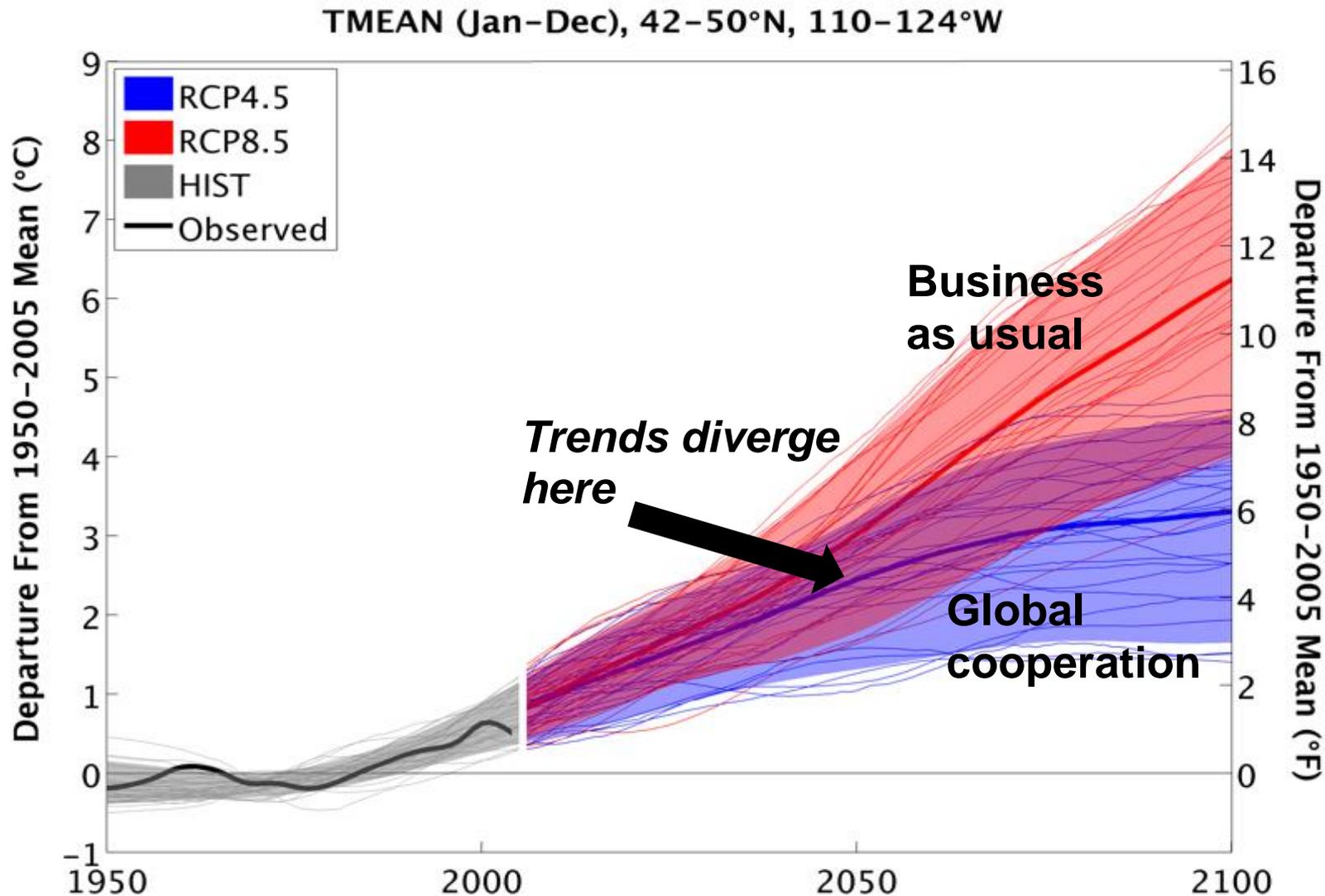


Re-colored version of the 2012 USDA Plant Hardiness Zone Map (available at: <http://planthardiness.ars.usda.gov/PHZMWeb/>)

Zone



Projected temperature in Pacific Northwest



What about precipitation?

Global climate models do not project precipitation reliably.

Most models project no change or a small increase in winter.



What will future climate feel like?



Mount Vernon, WA

What will future climate feel like?



Sacramento, CA

What will future climate feel like?



Charleston, WV

This is what we know...

There is a natural greenhouse effect.

Humans are increasing the greenhouse effect by adding carbon dioxide and other gases to the atmosphere.

Effects of a changing climate are already apparent.

There will be more global warming to come.

**Nearly every glacier in the
Cascade Range has
retreated during the past
100 years**



***South Cascade Glacier,
1928 (top)
2016 (right)***



**Nearly every glacier in the
Cascade Range has
retreated during the past
100 years**

**Since 1900, glacial area in the North Cascades
has decreased by 46%**

***South Cascade Glacier,
1928 (top)
2016 (right)***



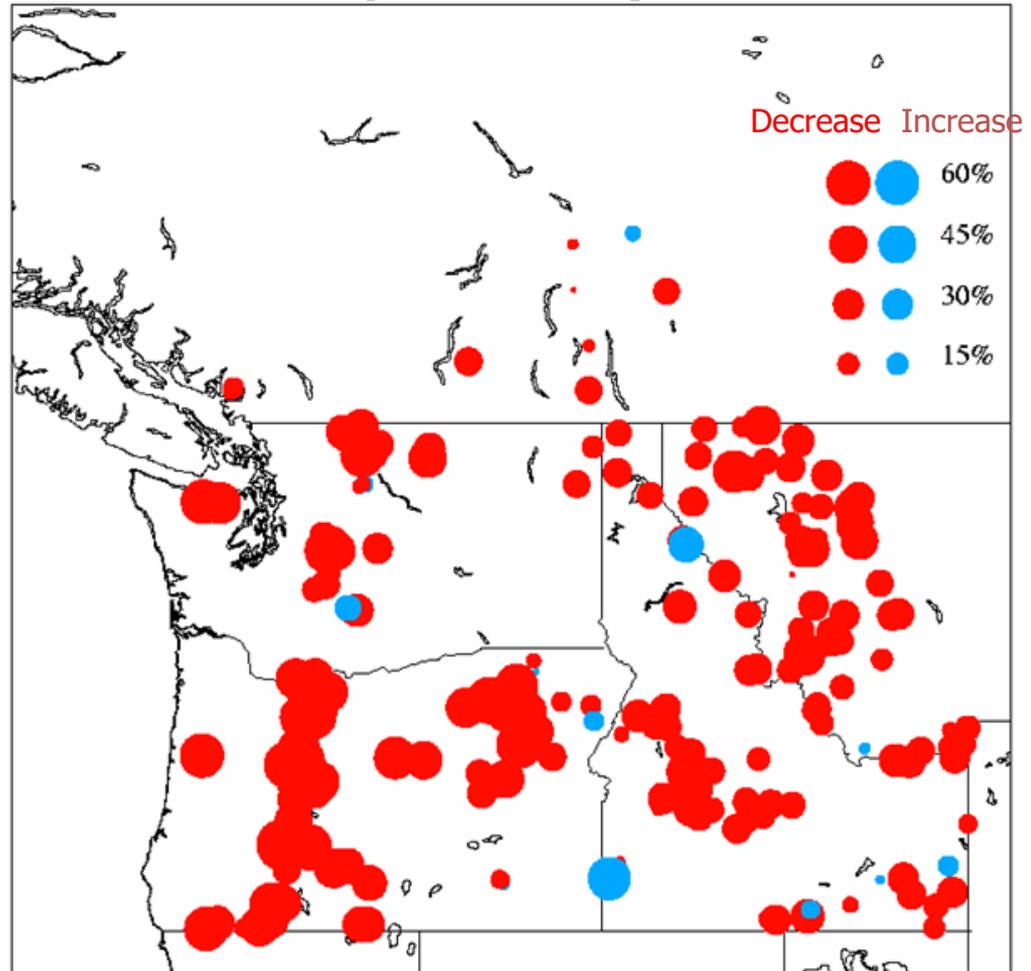
USGS

Snowpack is changing

Less snow in winter,
and more rain on snow

Watersheds that were
previously snow-
dominated are
changing to rain-
dominated

April 1 snow water equivalent, since 1950



How will trees grow in a warmer climate?

**Low elevation,
westside forest**

Moisture limited

Growth will decrease:

- Douglas-fir
- Western hemlock
- Western redcedar
- Sitka spruce



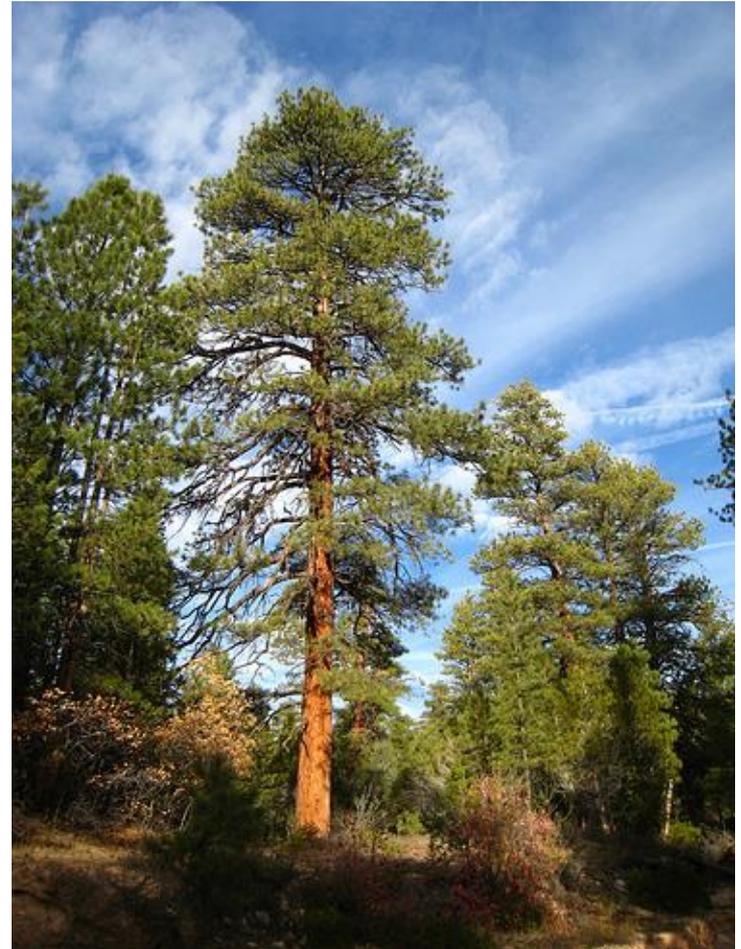
How will trees grow in a warmer climate?

Eastside coniferous forest

Moisture limited

Growth will decrease:

- Ponderosa pine
- Douglas-fir
- Western larch



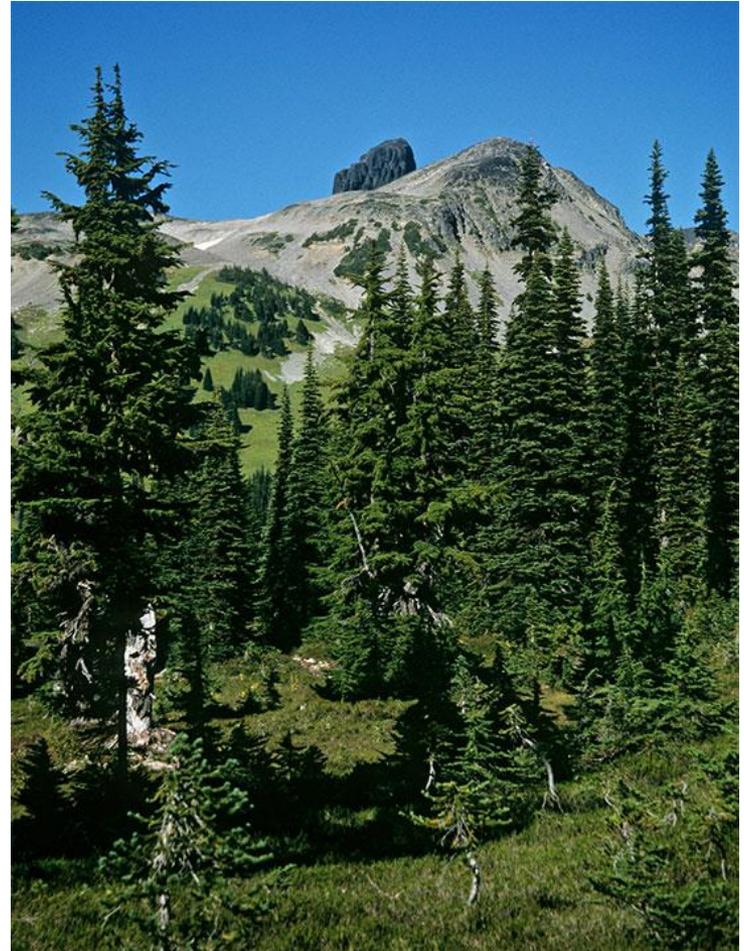
How will trees grow in a warmer climate?

High-elevation coniferous forest

Energy limited

Growth will increase:

- Subalpine fir
- Mountain hemlock
- Lodgepole pine



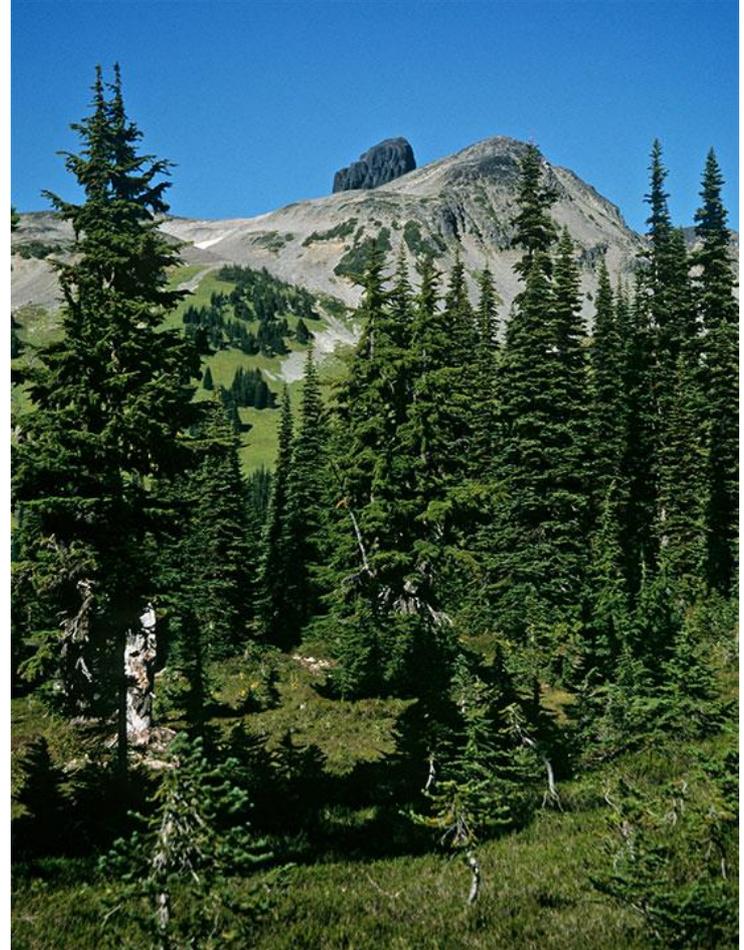
How will plants grow in a warmer climate?

Riparian areas, wetlands,
groundwater-dep. systems

Water controlled

Growth and regeneration
will change:

- Bogs, fens
- Species composition
- Fire susceptibility

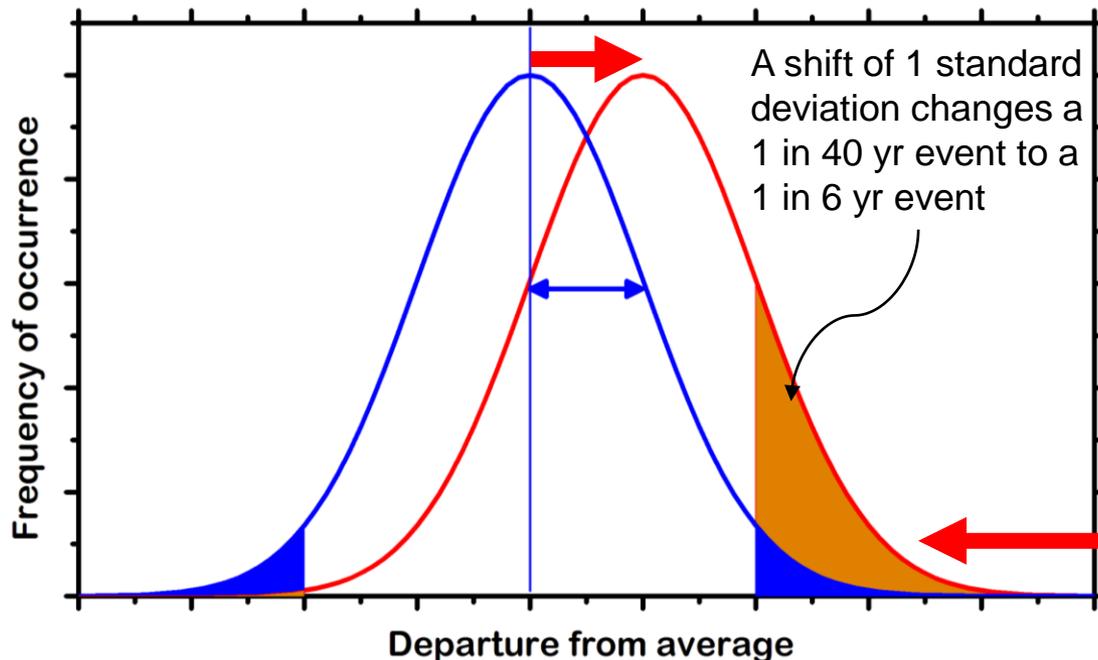


Extreme weather + increased disturbance: Our primary challenge



Extremes matter

Frequency, extent, and severity of disturbances may be affected by climate change, altering the mean and *variability* of disturbance properties.



A shift in *distribution* of disturbance properties has a larger relative effect at the *extremes* than near the mean.

It's all about the tail!

Climate change affects insects

Mountain pine beetle



Warmer temperature has favored MPB by:

- Increasing its reproductive rate
- Allowing an expanded geographic range

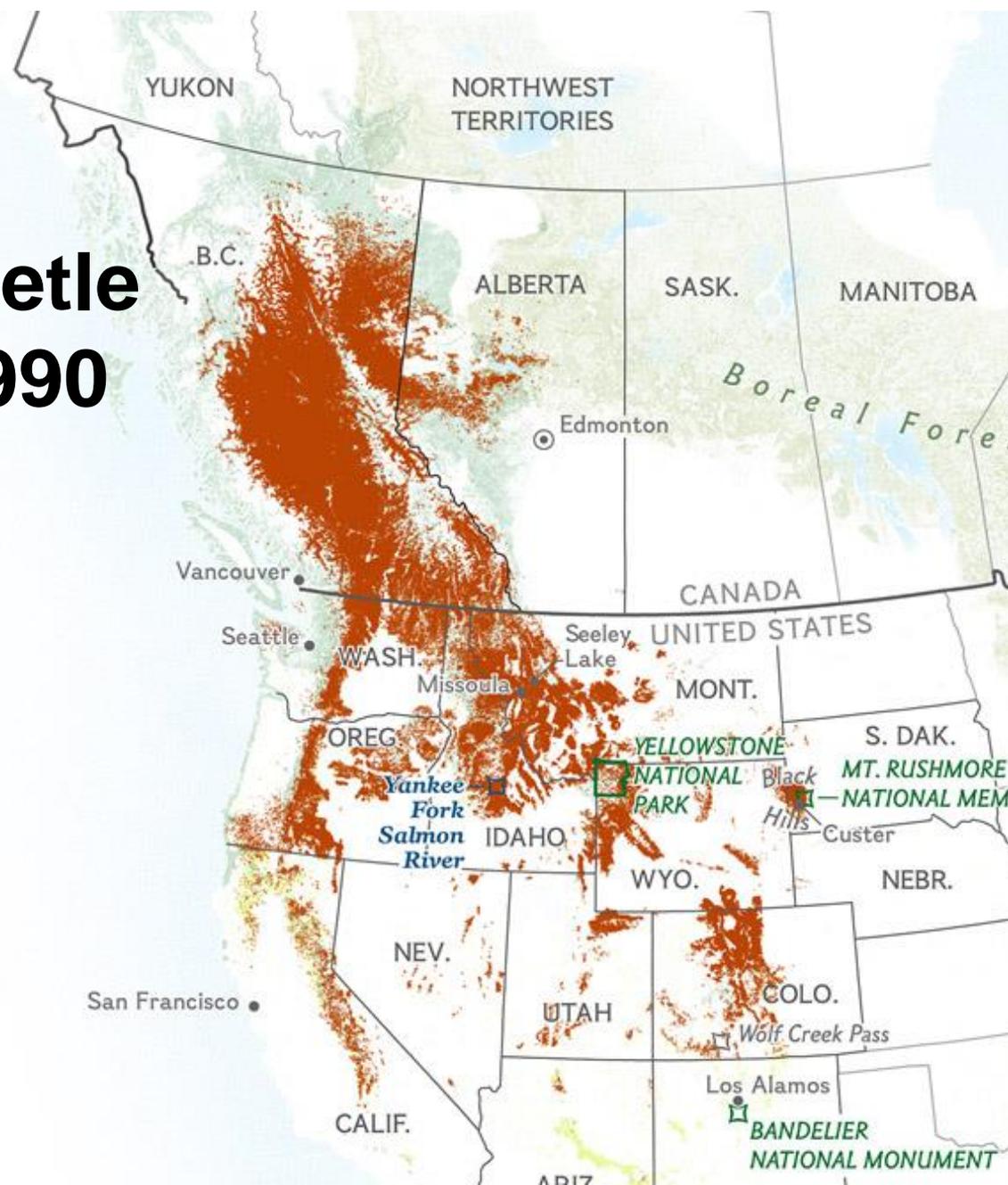


Mountain pine beetle outbreak since 1990

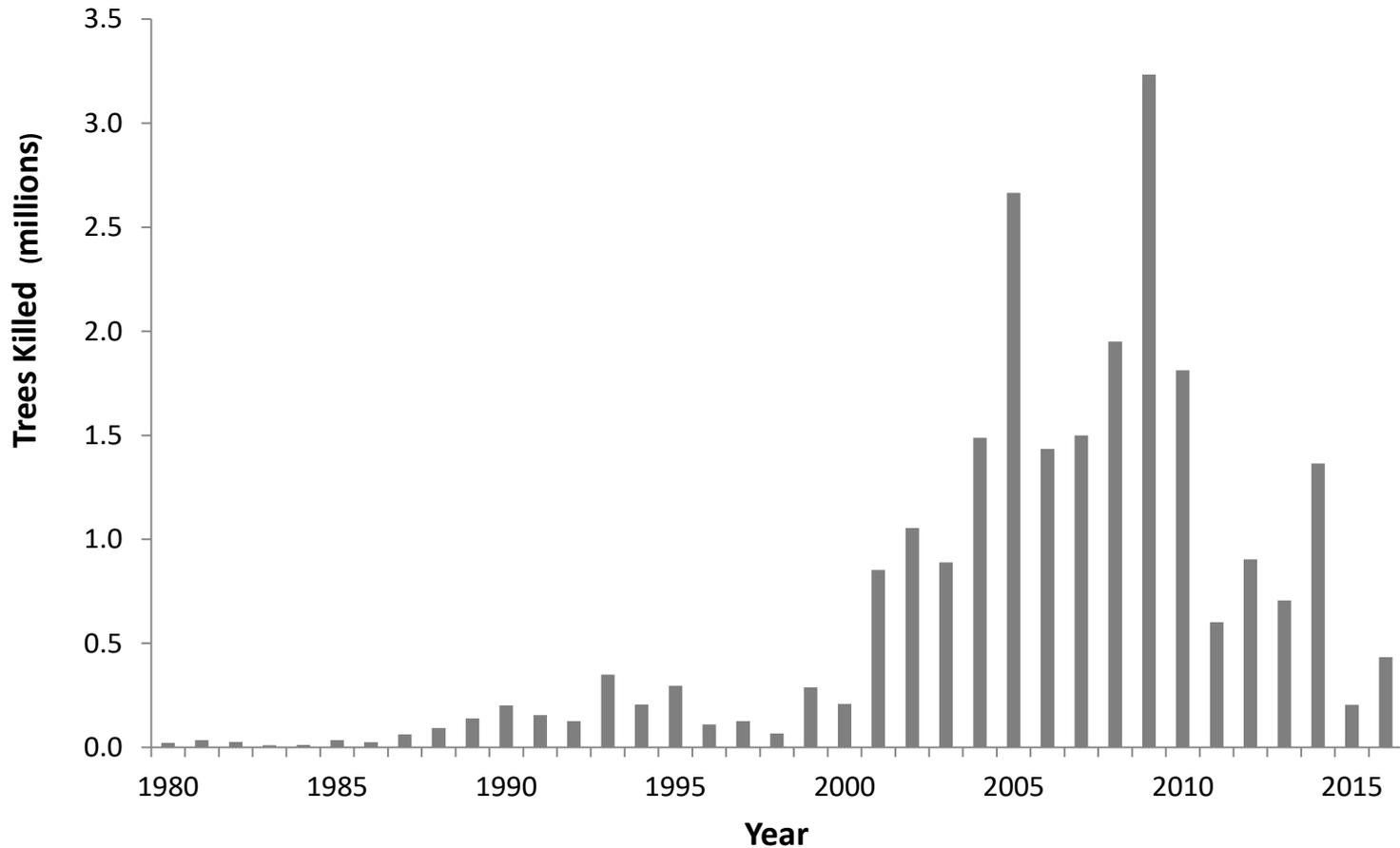
50 million acres

THE BEETLE AND ITS HOSTS

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



Trees killed by mountain pine beetles (Okanogan-Wenatchee NF)



How will climate change affect wildfire?



How will climate change affect wildfire?



Anacortes – August 26, 2016

How will climate change affect wildfire?



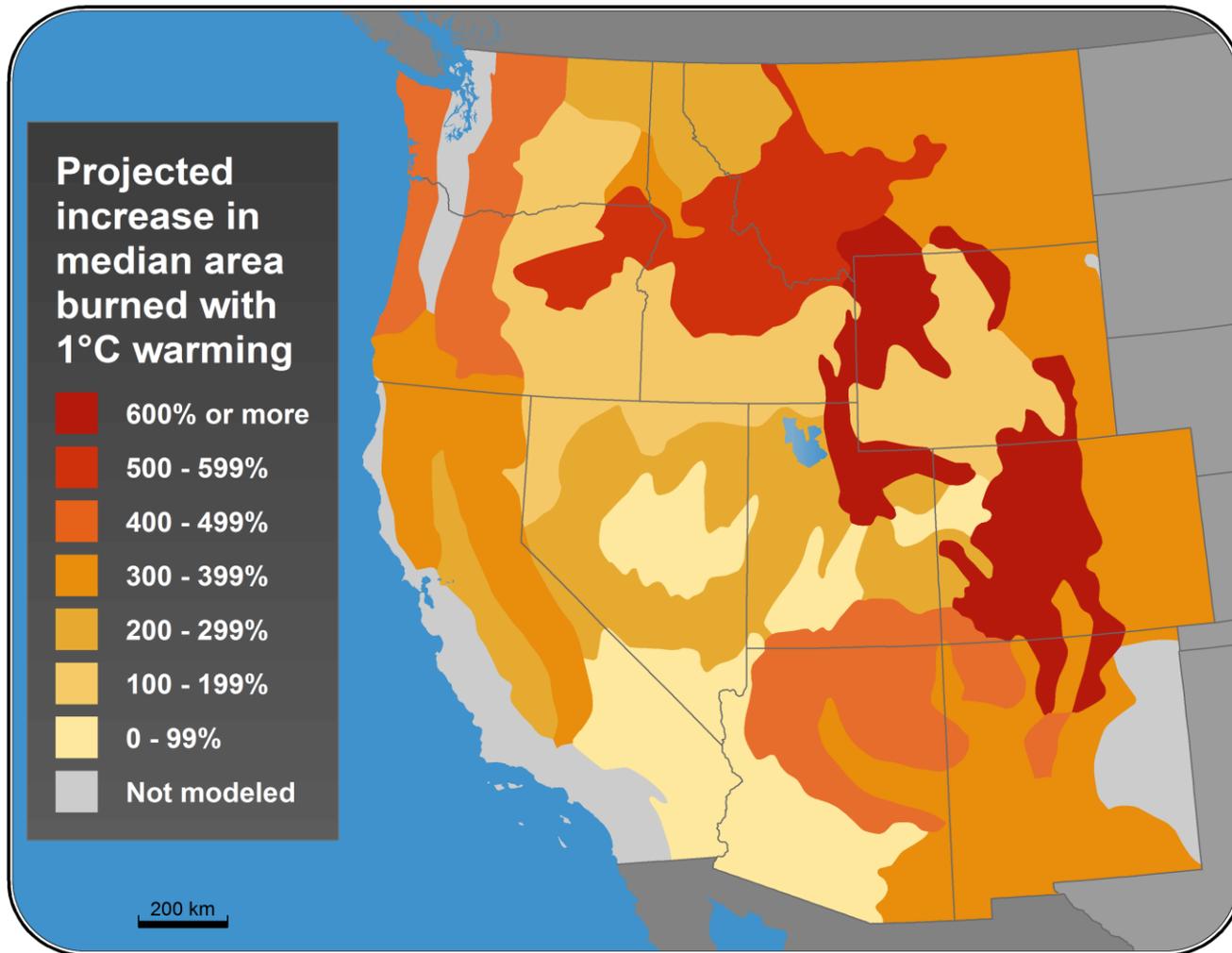
Anacortes – August 26, 2016

Washington wildfires — 2015

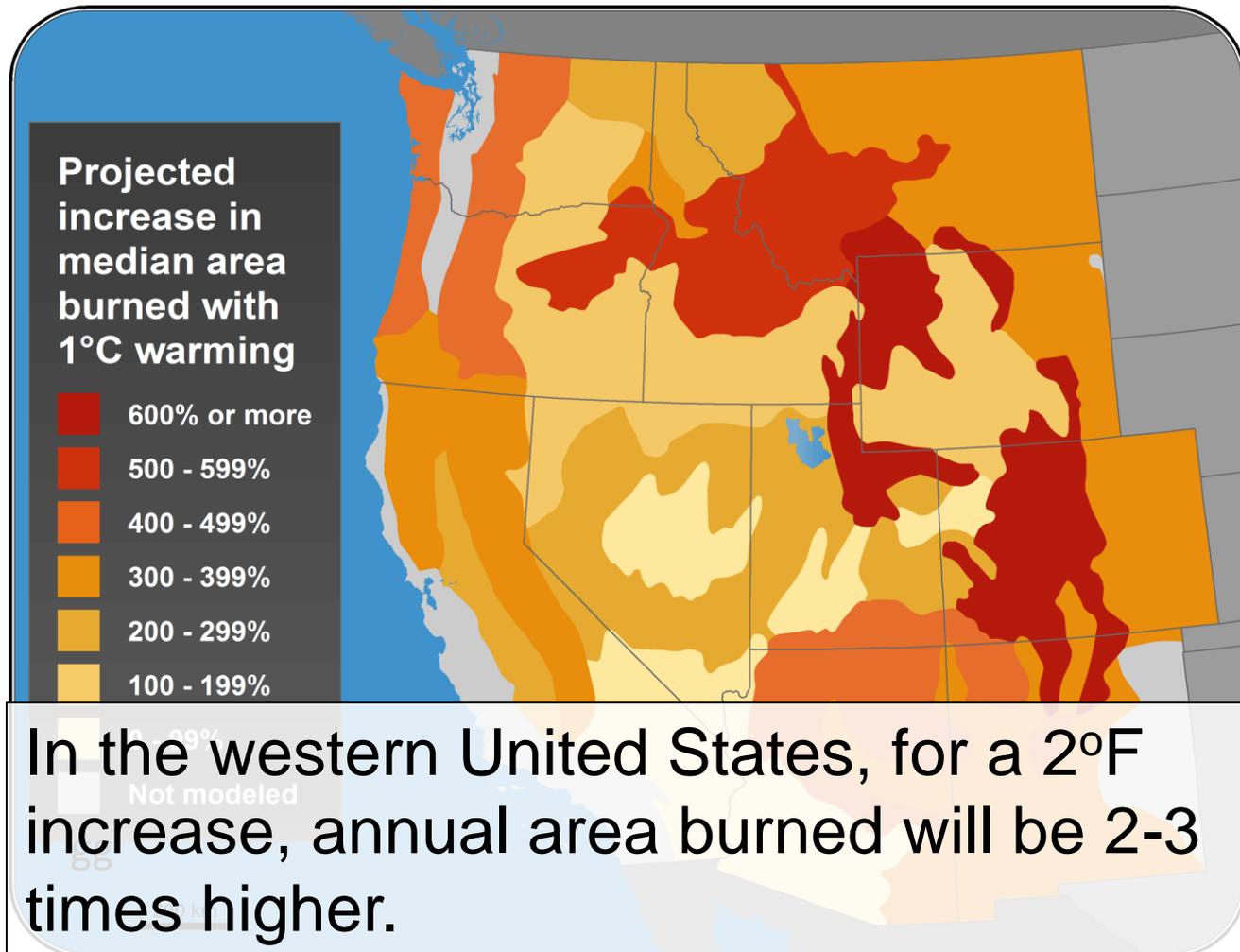
- 1,541 fires
- 1 million acres burned (387,000 acres in 2014)
- \$253 million fire suppression cost
- Large economic losses in rural communities



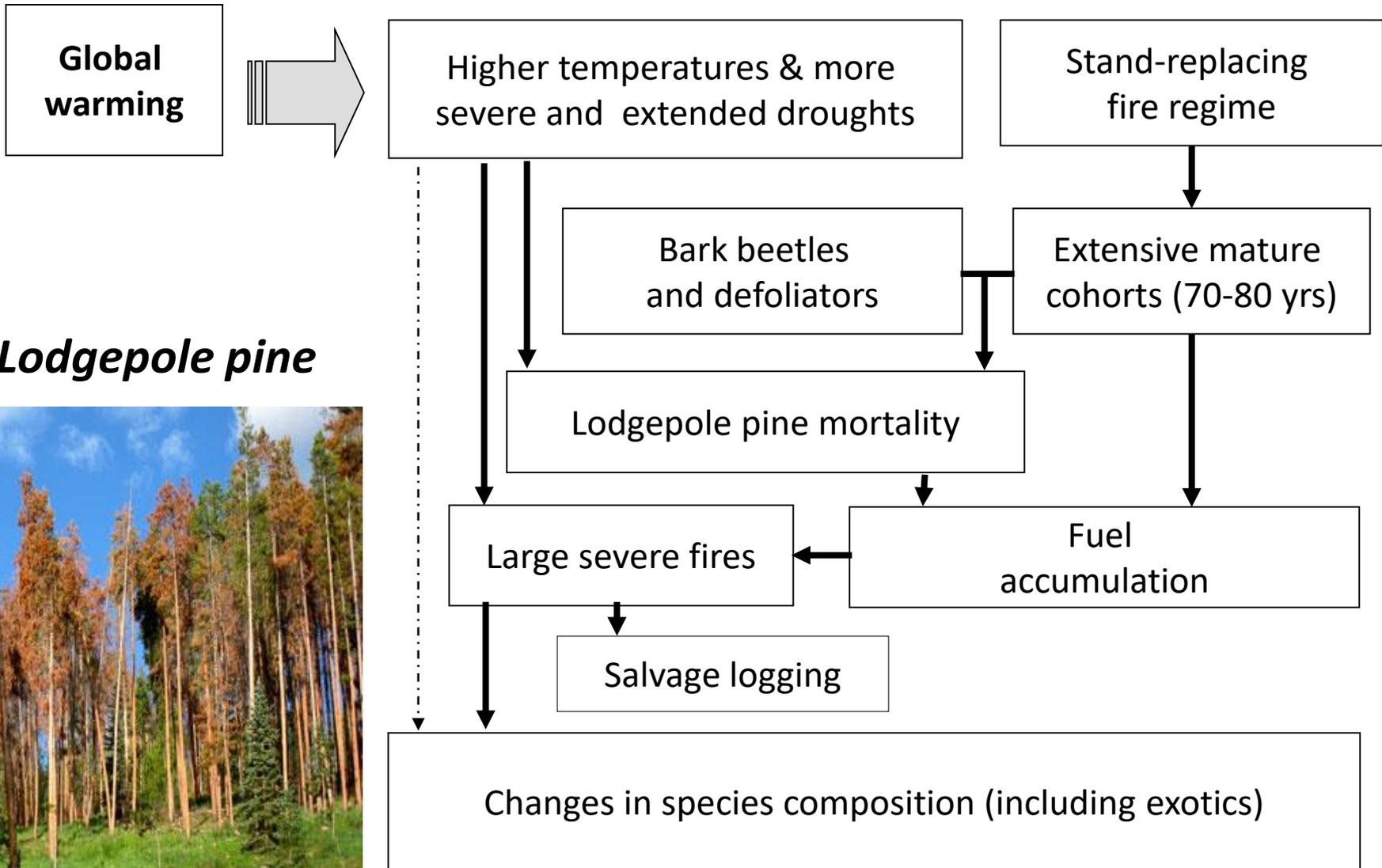
Wildfire area burned, 2050



Wildfire area burned, 2050

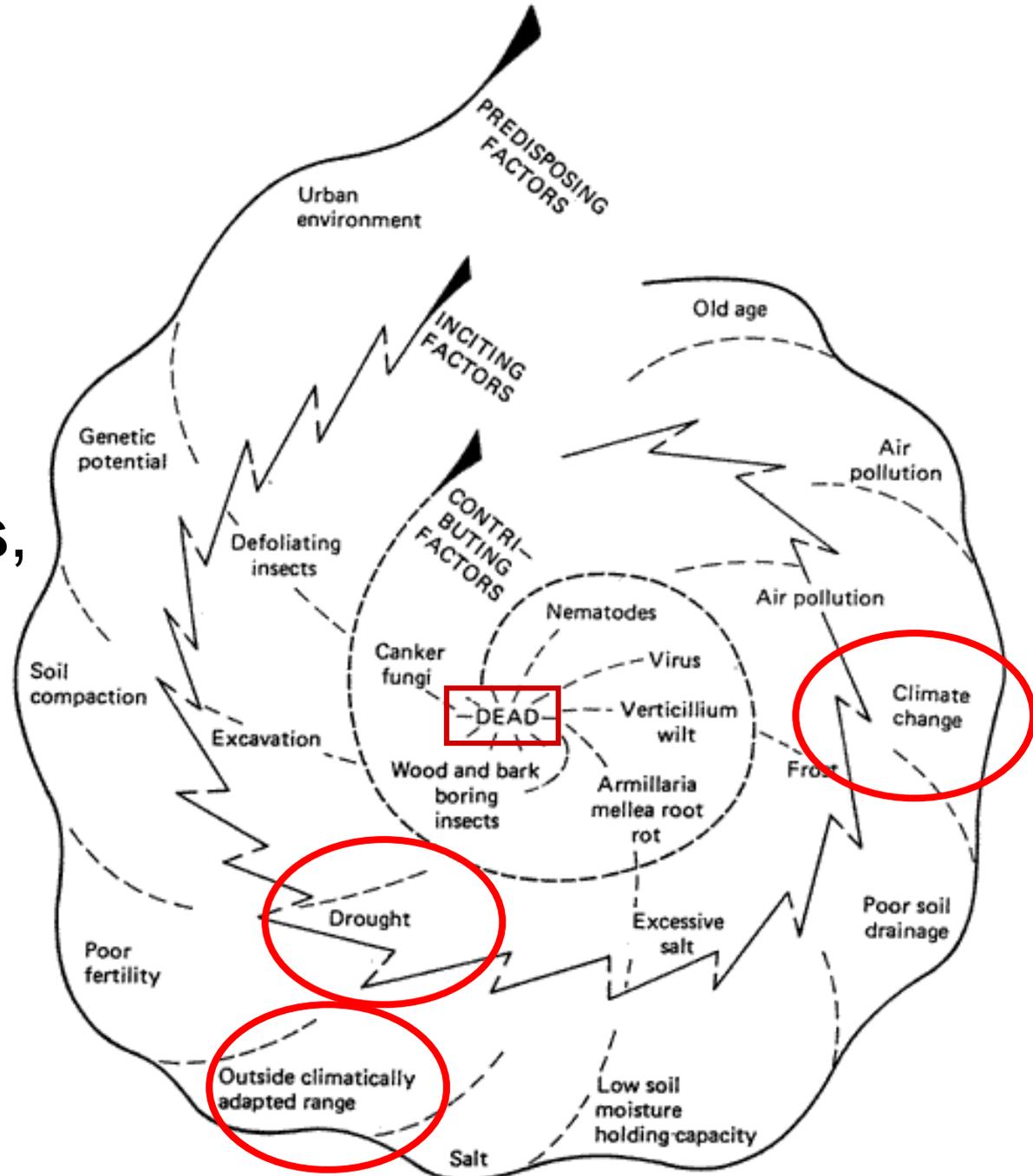


Warming affects stress complexes



The Disease Spiral

Stress complexes, mediated by climate, lead to plant mortality and other changes.

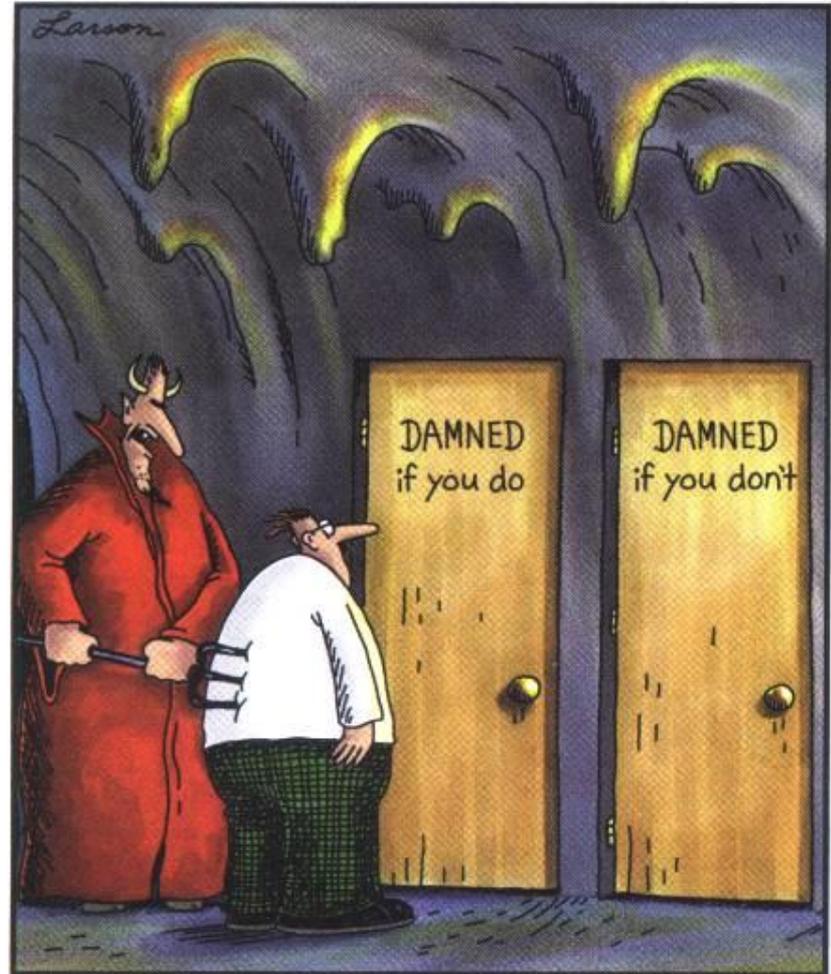


From Manion (1991)

What is climate change adaptation?

An effort to reduce the potentially negative consequences of climate change

AND transition species and ecosystems to a warmer climate.



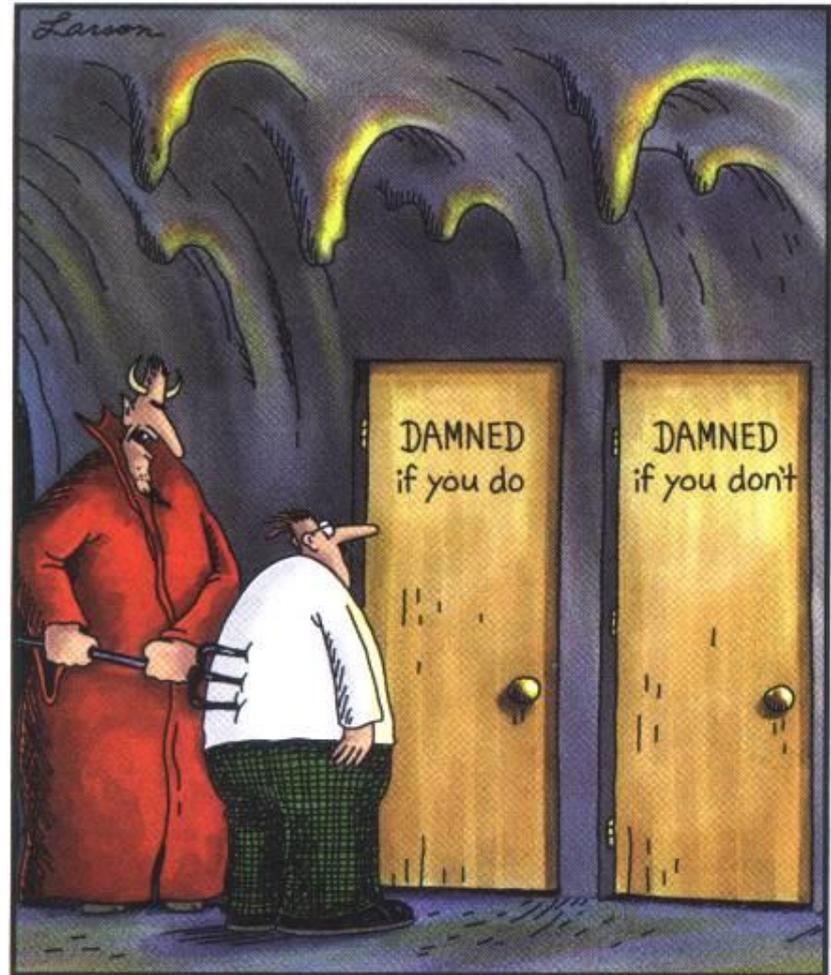
“C’mon, c’mon – it’s either one or the other.”

What is climate change adaptation?

Fine tuning and prioritizing current planning and management

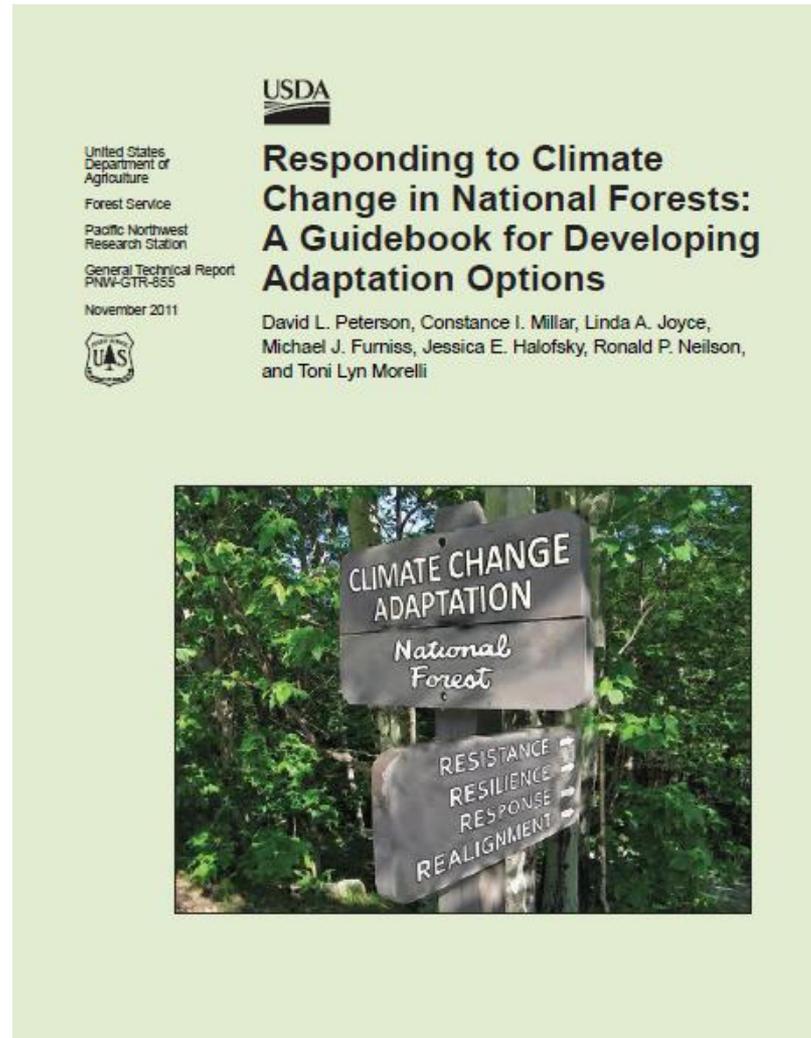
Component of *sustainable resource management*

A form of *risk management*



“C’mon, c’mon – it’s either one or the other.”

Adapting to climate change – Information & tools



Adapting to climate change – Information & tools



Climate Change Vulnerability and Adaptation in the North Cascades Region, Washington



Forest
Service

Pacific Northwest
Research Station

General Technical Report
PNW-GTR-892

September
2014

How do we manage for resilient landscapes in a warmer climate?



Adaptation strategy

Reduce non-climatic stressors

Detect and eradicate non-native plant species.

Encourage rapid tree establishment after wildfire.

Manage roads to reduce erosion.

Minimize incursion of structures in riparian areas.



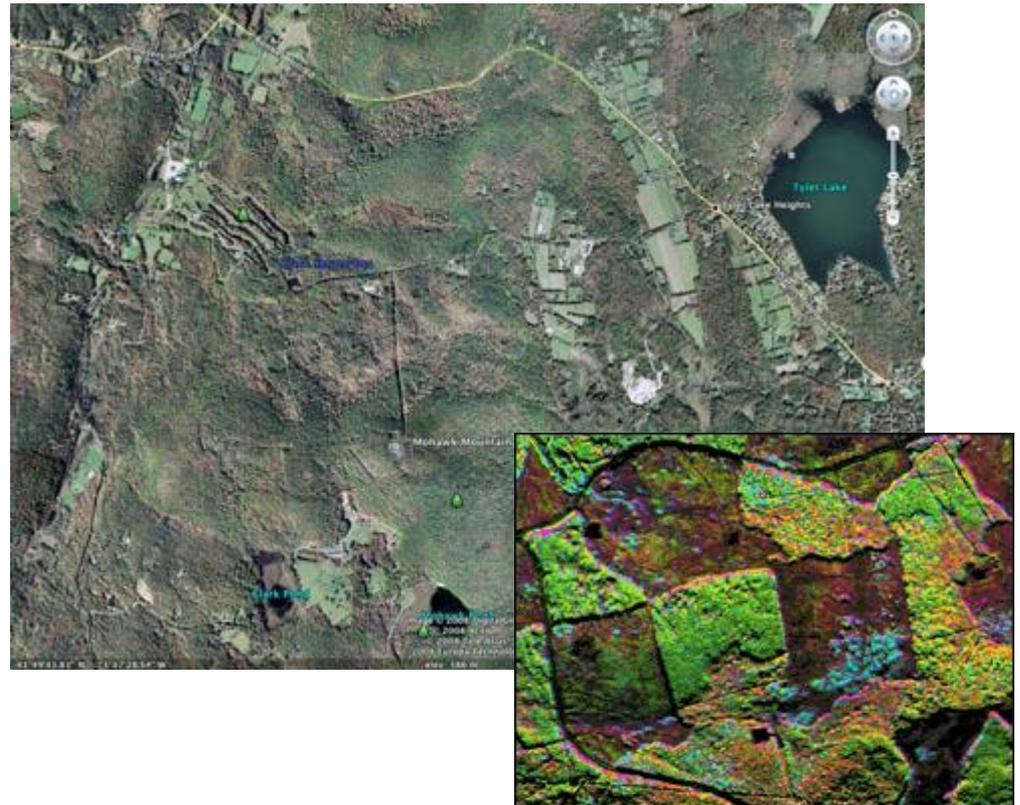
Adaptation strategy

Increase landscape diversity

Diversify spatial distribution of species, ages, and structures.

Manage forest stand densities and fuels across landscapes.

Orient the location of treatments in large blocks to increase resilience to disturbance.



MANAGING PLANTS AND LANDSCAPES IN A WARMER CLIMATE

Which characteristics do climate-sensitive species have?

Low production of seeds and other propagules

Low seed dispersal or vegetative propagation

Intolerant of low soil moisture

Intolerant of high air temperature

Intolerant of wildfire

Low competitive ability

Narrow environmental tolerance

Low genetic diversity

Which characteristics do climate-tolerant species have?

High production of seeds and other propagules

High seed dispersal or vegetative propagation

Tolerant of low soil moisture

Tolerant of high air temperature

Tolerant of wildfire

High competitive ability

Broad environmental tolerance

High genetic diversity

THE RIGHT PLANT

IN THE RIGHT PLACE

FOR THE RIGHT REASON

PROBLEM

Summers will be hotter and drier

SOLUTION

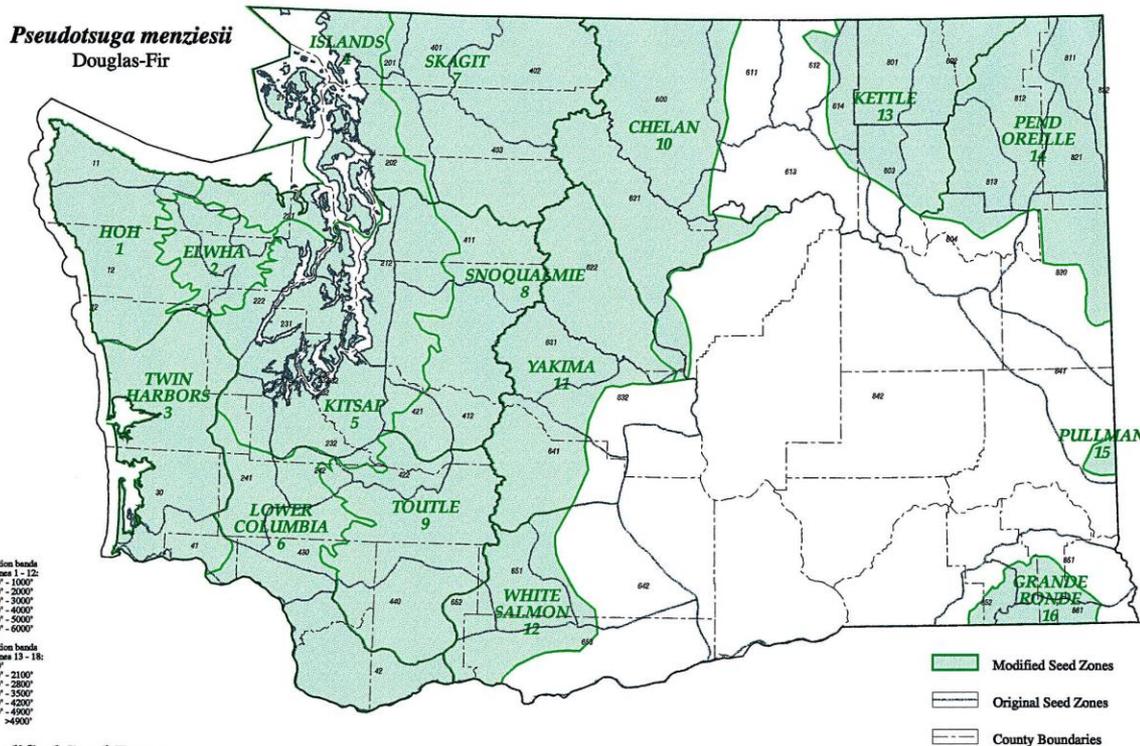
**Select drought tolerant plants
where possible**



Ponderosa pine

SOLUTION

Be more flexible with seed zones



Modified Seed Zones

Douglas-fir seed zone map

PROBLEM

**High temperature and
moisture variability**

SOLUTION

**Select plants that tolerate
extremes**



Willows

PROBLEM

**There will be surprises:
insects, fungi, non-natives,...**

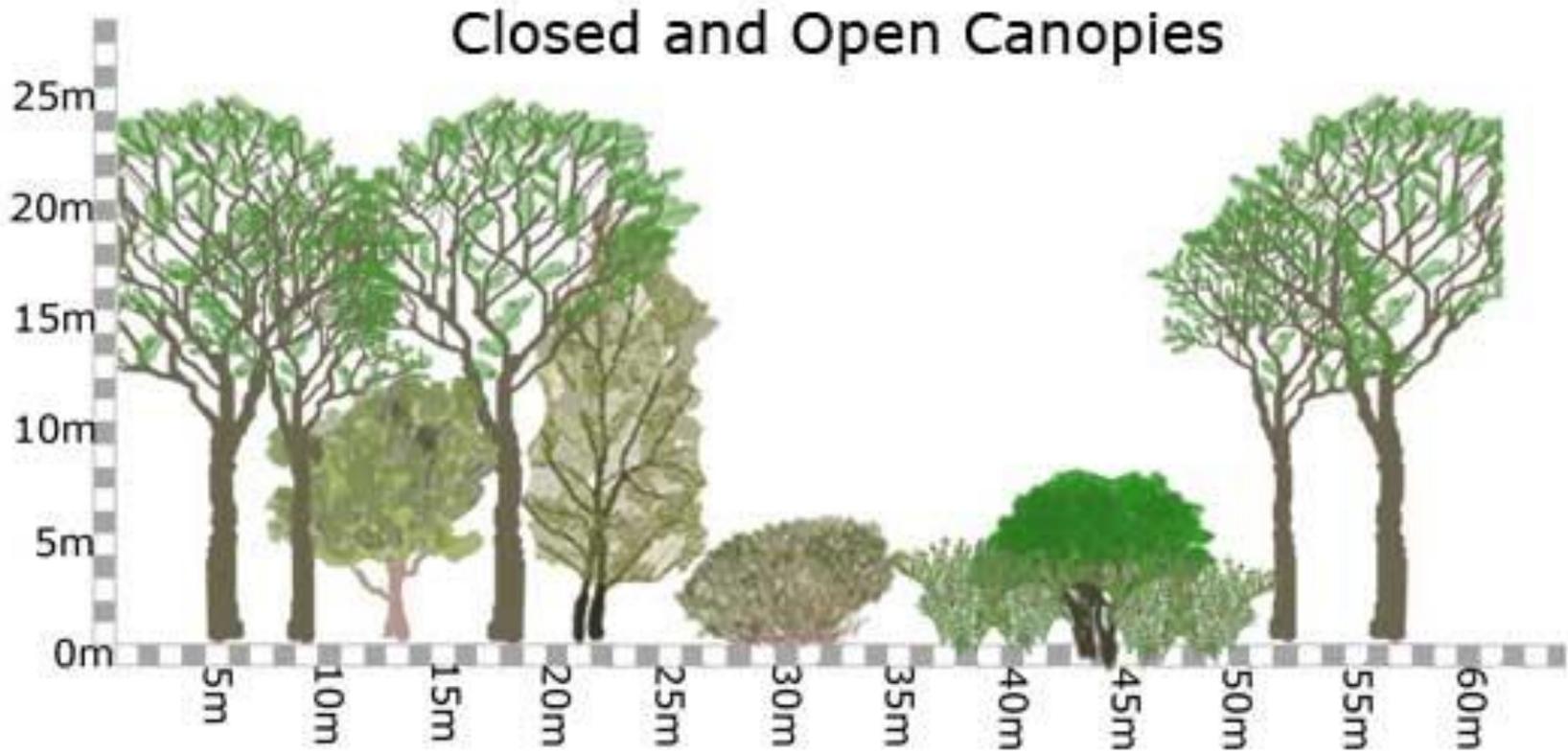
SOLUTION

**Keep vegetation healthy,
remove stressors quickly**



GOOD PRACTICE

Maximize plant species diversity



GOOD PRACTICE

**Diversify landscape pattern:
partition species by water needs**



GOOD PRACTICE

**Diversify landscape pattern:
partition species by water needs**



GOOD PRACTICE

Mulch and water efficiently



GOOD PRACTICE

Mulch and water efficiently



Natives to the rescue?



Natives to the rescue?



Shore pine

Natives to the rescue?



Oregon grape

Natives to the rescue?



Salal

Natives to the rescue?



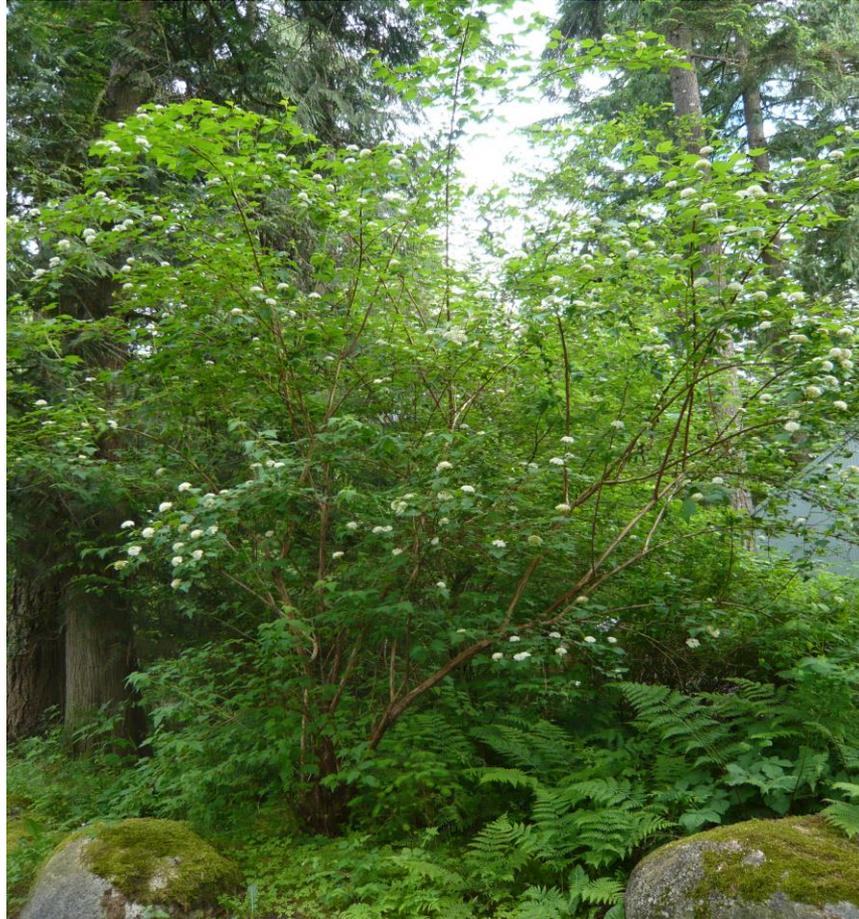
Mock orange

Natives to the rescue?



Chokecherry

Natives to the rescue?



Ninebark

Natives to the rescue?



Kinnikinnick

In summary...

- Manage for 30 years from now: warmer temperatures, higher extremes.
- Reduce non-climatic stress.
- Consider future maintenance requirements.
- Diversify plant species and patterns.
- Partition vegetation by water needs.
- Monitor, learn, and adjust as needed.

The best time to plant a tree was 20 years ago



The second best time is today

**The best time to start planning for climate change
was 20 years ago**



The second best time is today