# *What Can We Expect From Climate Change?*

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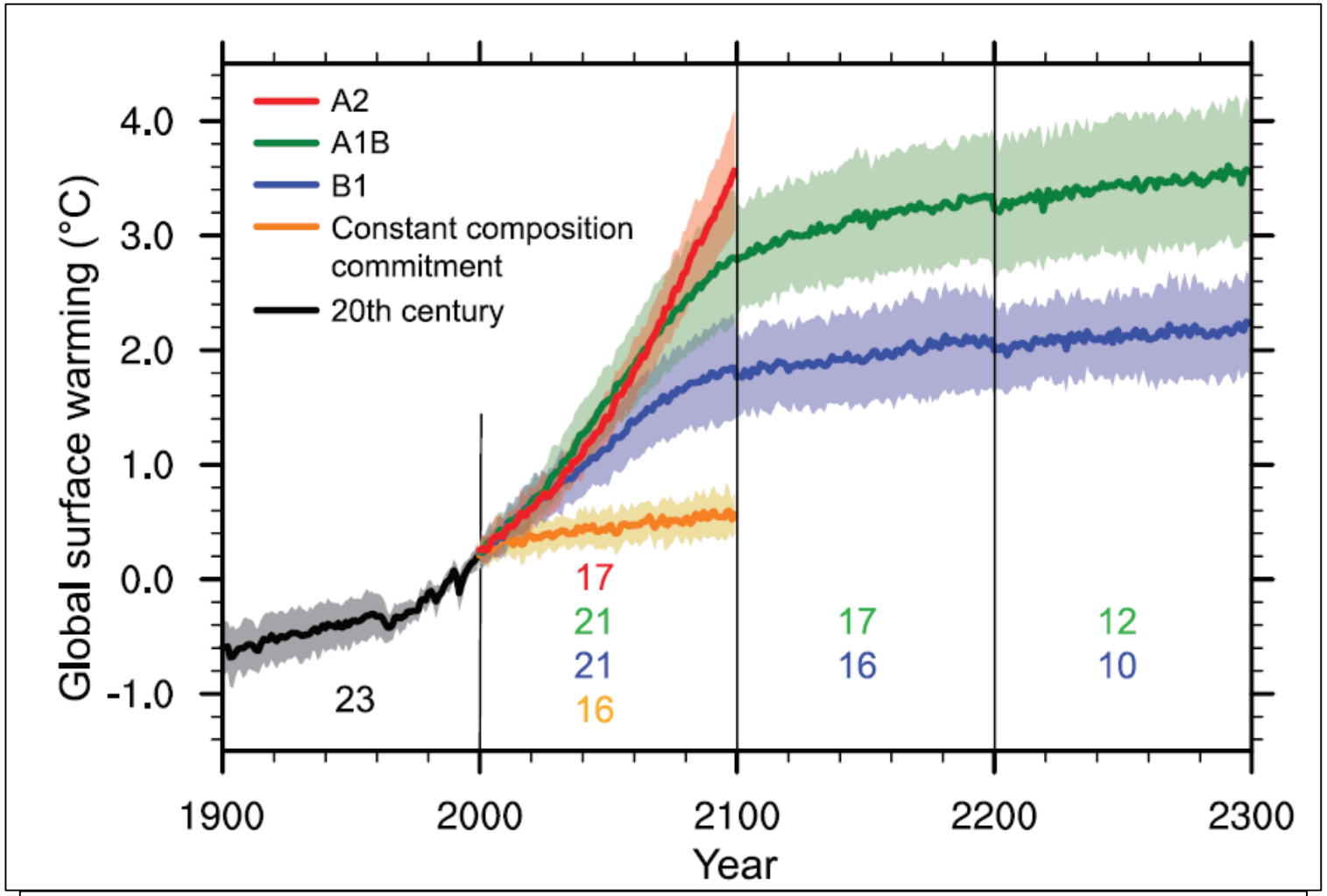
# What can we expect from climate change?

- Warmer
  - Warmer winters
  - Less snowpack
- Longer growing season
  - Longer fire season
  - Drier, hotter fall weather?
- Drought
  - Increased drought stress during growing season
  - Hotter drought
- Shift in precipitation patterns and snow?
- Migration of trees, vegetation, and pests!

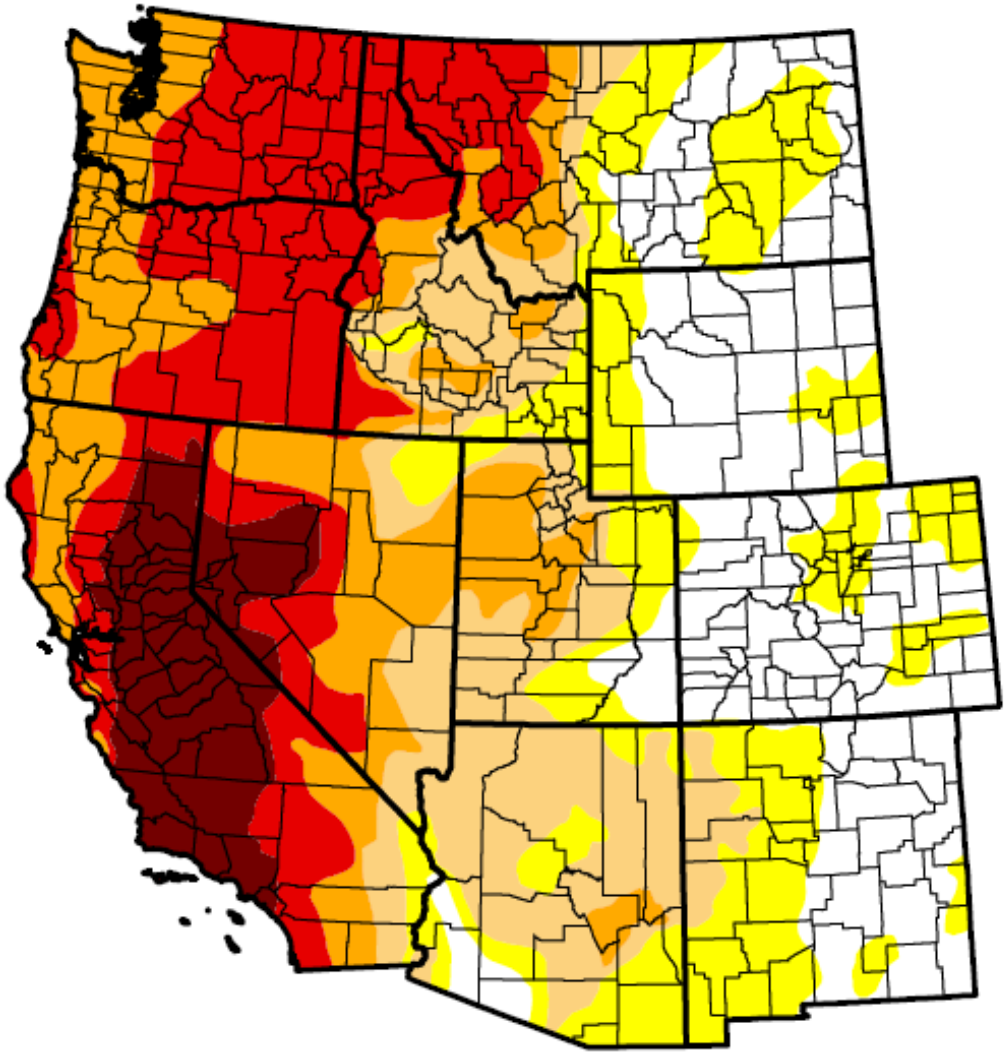



IPPC climate change projects.
Surface warming relative to 1980-1999.

# Drought and Climate Change

- September 2015!
- Severe droughts are anticipated, and have occurred in the past

## U.S. Drought Monitor
## West



**September 22, 2015**
*(Released Thursday, Sep. 24, 2015)*
**Valid 8 a.m. EDT**

*Drought Conditions (Percent Area)*

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|---|---|---|---|---|---|
| **Current** | 22.79 | 77.21 | 58.18 | 42.49 | 26.73 | 7.62 |
| **Last Week** *9/15/2015* | 24.68 | 75.32 | 59.66 | 42.69 | 26.73 | 7.62 |
| **3 Months Ago** *6/23/2015* | 23.93 | 76.07 | 57.86 | 35.88 | 17.13 | 7.26 |
| **Start of Calendar Year** *12/30/2014* | 34.76 | 65.24 | 54.48 | 33.50 | 18.68 | 5.40 |
| **Start of Water Year** *9/30/2014* | 31.48 | 68.52 | 55.57 | 35.65 | 19.95 | 8.90 |
| **One Year Ago** *9/23/2014* | 31.18 | 68.82 | 56.42 | 35.96 | 20.00 | 8.90 |

*Intensity:*

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

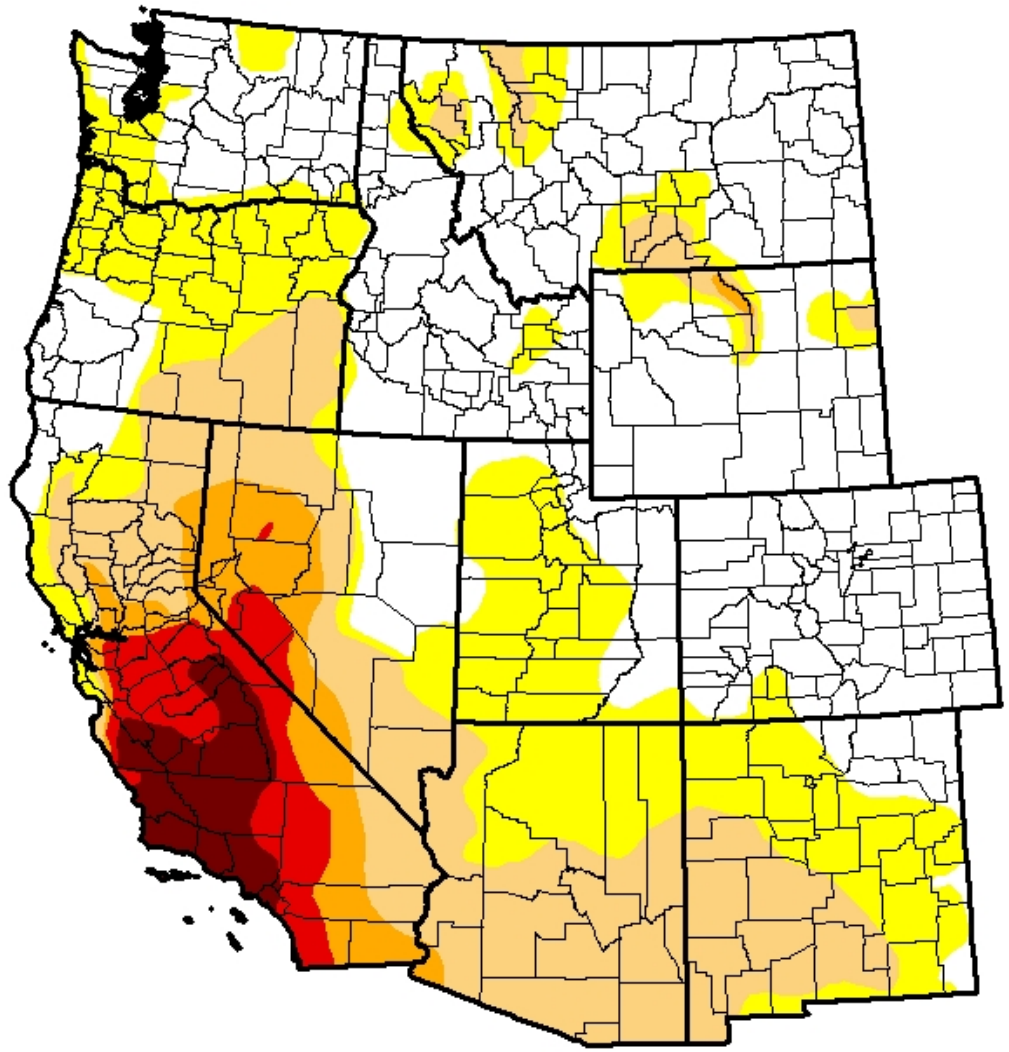
**Author:**
*Eric Luebehusen*
*U.S. Department of Agriculture*

**http://droughtmonitor.unl.edu/**

# Today

(May 24, 2016)

## U.S. Drought Monitor
## West



**May 24, 2016**

*(Released Thursday, May. 26, 2016)*

Valid 8 a.m. EDT

*Drought Conditions (Percent Area)*

| | None | D0-D4 | D1-D4 | D2-D4 | D3-D4 | D4 |
|---|---|---|---|---|---|---|
| **Current** | 45.06 | 54.94 | 30.83 | 10.98 | 6.23 | 2.81 |
| **Last Week** 5/17/2016 | 45.83 | 54.17 | 31.19 | 12.13 | 6.23 | 2.81 |
| **3 Months Ago** 2/23/2016 | 37.06 | 62.94 | 36.25 | 19.70 | 10.28 | 5.55 |
| **Start of Calendar Year** 12/29/2015 | 33.17 | 66.83 | 45.07 | 29.30 | 15.92 | 6.85 |
| **Start of Water Year** 9/29/2015 | 22.77 | 77.23 | 57.81 | 42.42 | 26.50 | 7.62 |
| **One Year Ago** 5/26/2015 | 25.37 | 74.63 | 57.03 | 35.92 | 17.59 | 7.94 |

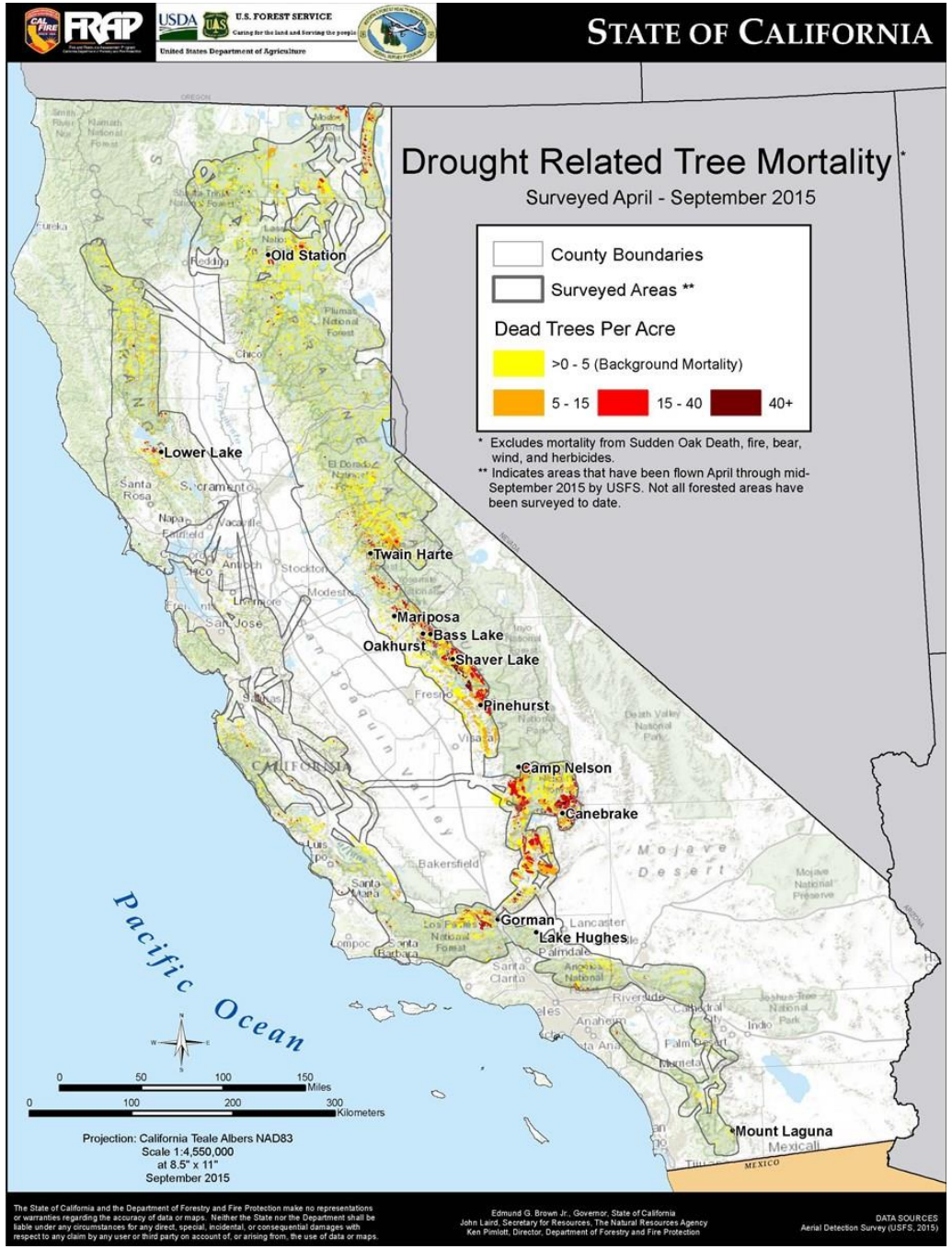
*Intensity:*

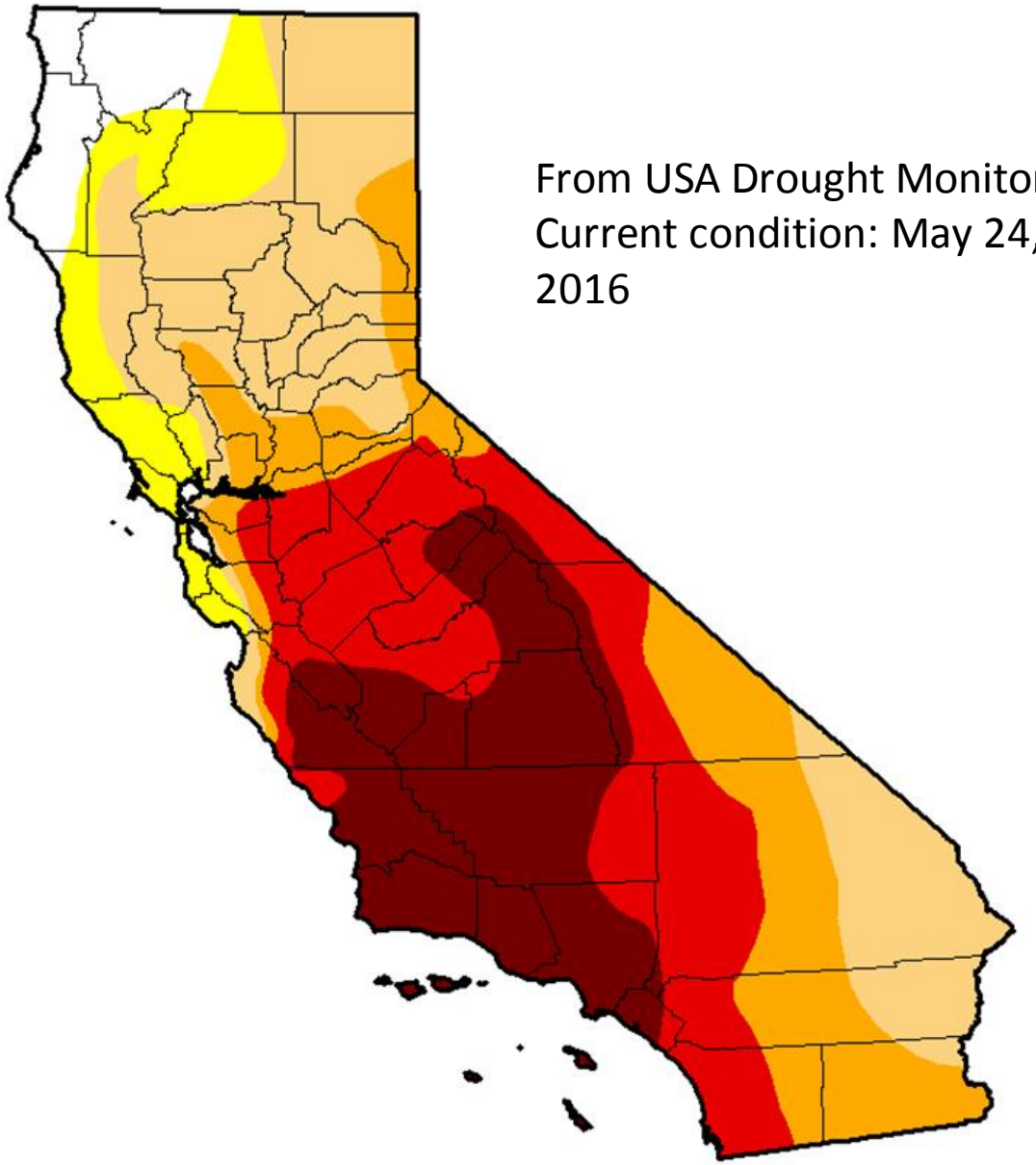
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

**Author:**
*David Simeral*
*Western Regional Climate Center*

**http://droughtmonitor.unl.edu/**

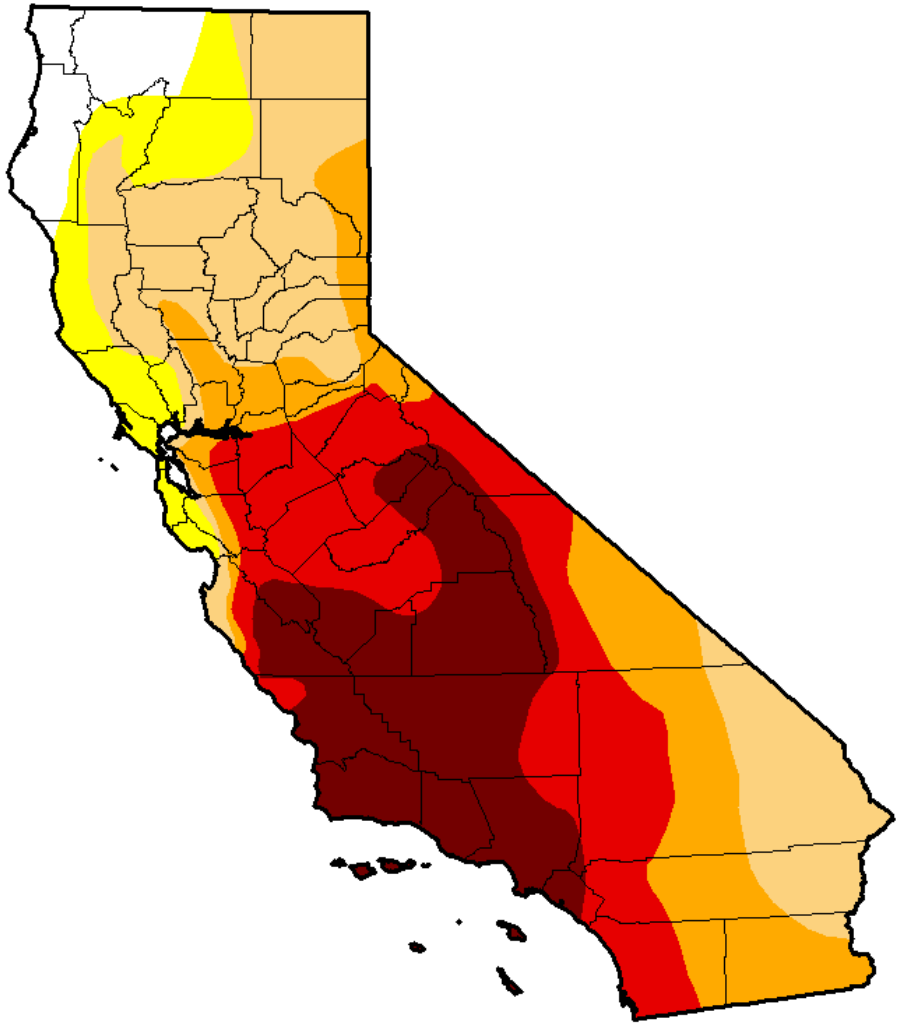


From USA Drought Monitor
Current condition: May 24, 2016

# S. California after drought… climate change effect?:

- From:http://www.fs.usda.gov/detail/catreemortality/toolkit/?cid=fseprd500165



Jeffrey Moore, Regional Aerial Survey Program Manager
Biological Scientist

Forest Service
R5 State and Private Forestry,
Forest Health Protection

From USA Drought Monitor
http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?CA
Current condition: May 24, 2016

**Vapor pressure deficit = difference b/w amount of moisture in the air and how much moisture the air can hold**

**Big influence on tree water relations because the higher the VPD, the more pull on water from the plant.**

**Temperature increase will increase VPD even if precip stays the same because warmer air can hold more water**

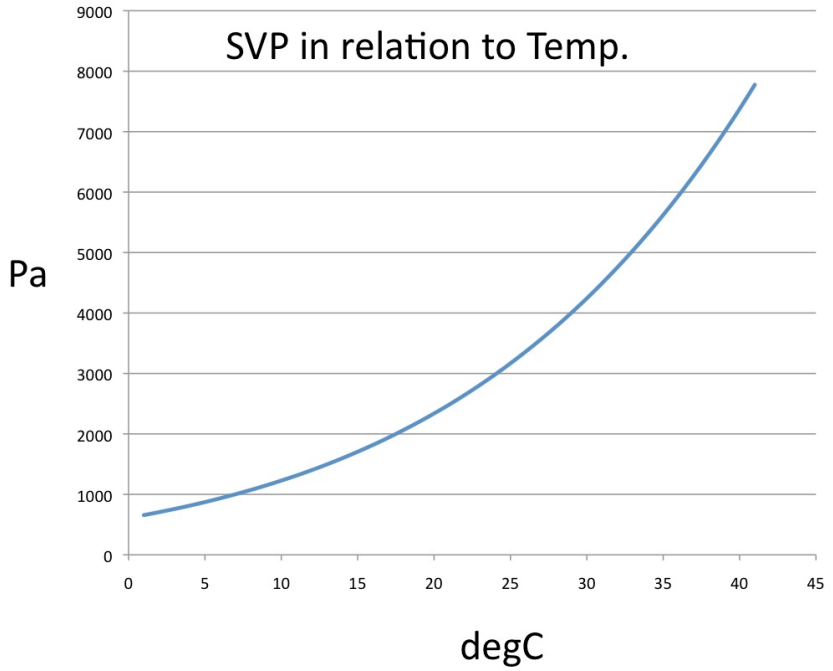
**If it is hotter during droughts…then impacts of drought are greater on plants.**

esa 2015 ECOSPHERE

**ESA CENTENNIAL PAPER**

# On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene

CRAIG D. ALLEN,[1,]† DAVID D. BRESHEARS,[2] AND NATE G. MCDOWELL[3]




Source: http://physics.holsoft.nl/physics/ocmain.htm

2015

Remote Sensing of Environment xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Remote Sensing of Environment

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

Full length article

# A forest vulnerability index based on drought and high temperatures

David Mildrexler [a,*], Zhiqiang Yang [a], Warren B. Cohen [b], David M. Bell [b]

Forest Vulnerability Index = Land surface temperature – Water Balance

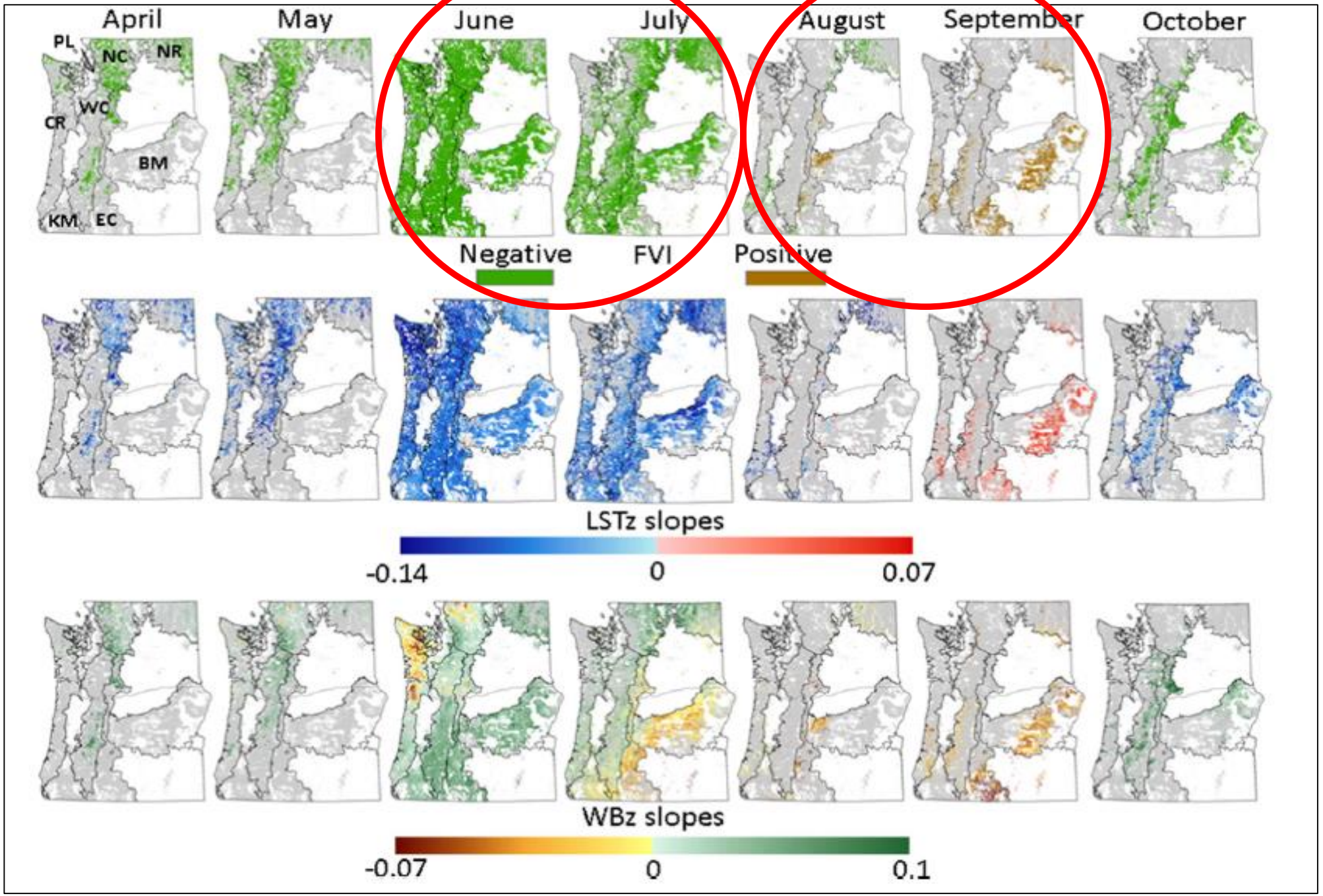
Water balance = Precipitation – Evapotranspiration

**2003 – 2012**
**RECENT**

FVI = Forest Stress Index

LSTz = Land surface temperature

WBz = Water balance



# Douglas-fir
# Western Oregon

Western Oregon

Western Oregon

# Western Oregon

Diplodia

NE Oregon

ODF Photos

# Diplodia

Paul Oester Photos

# Diplodia

# Gall rust

Both Diplodia and Gall Rust

# Rust Incidence in central interior British Columbia

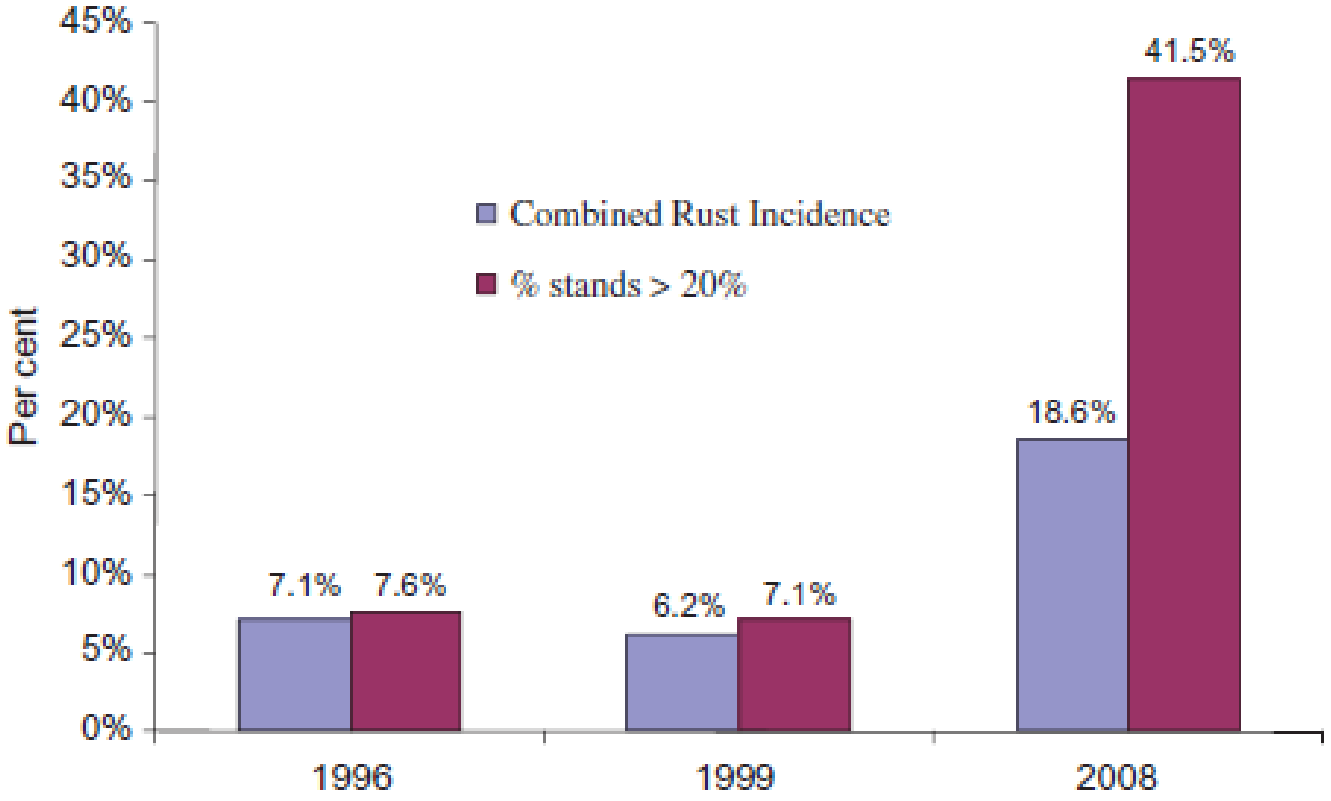
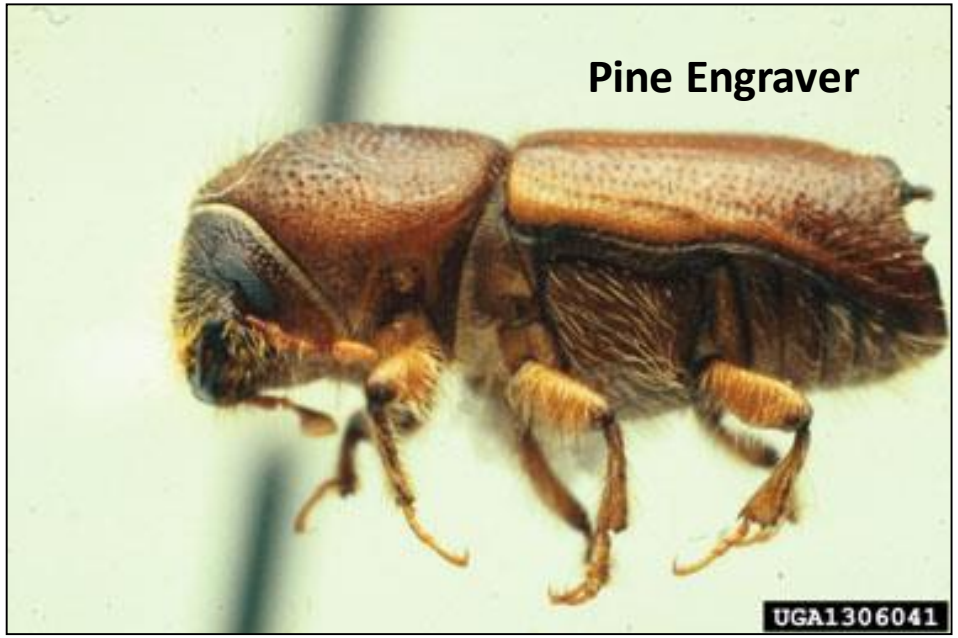



**Fig. 5.** Evidence of increasing landscape level hard pine rust incidence in the central interior of BC based on three similar operational surveys conducted in 1996 (67), 1998 (98) and 2008 (82) in the Morice Timber Supply Area. Numbers in parentheses are the sample size of randomly selected stands for each survey. Data courtesy of T. Coombes, Nadina Forest District.

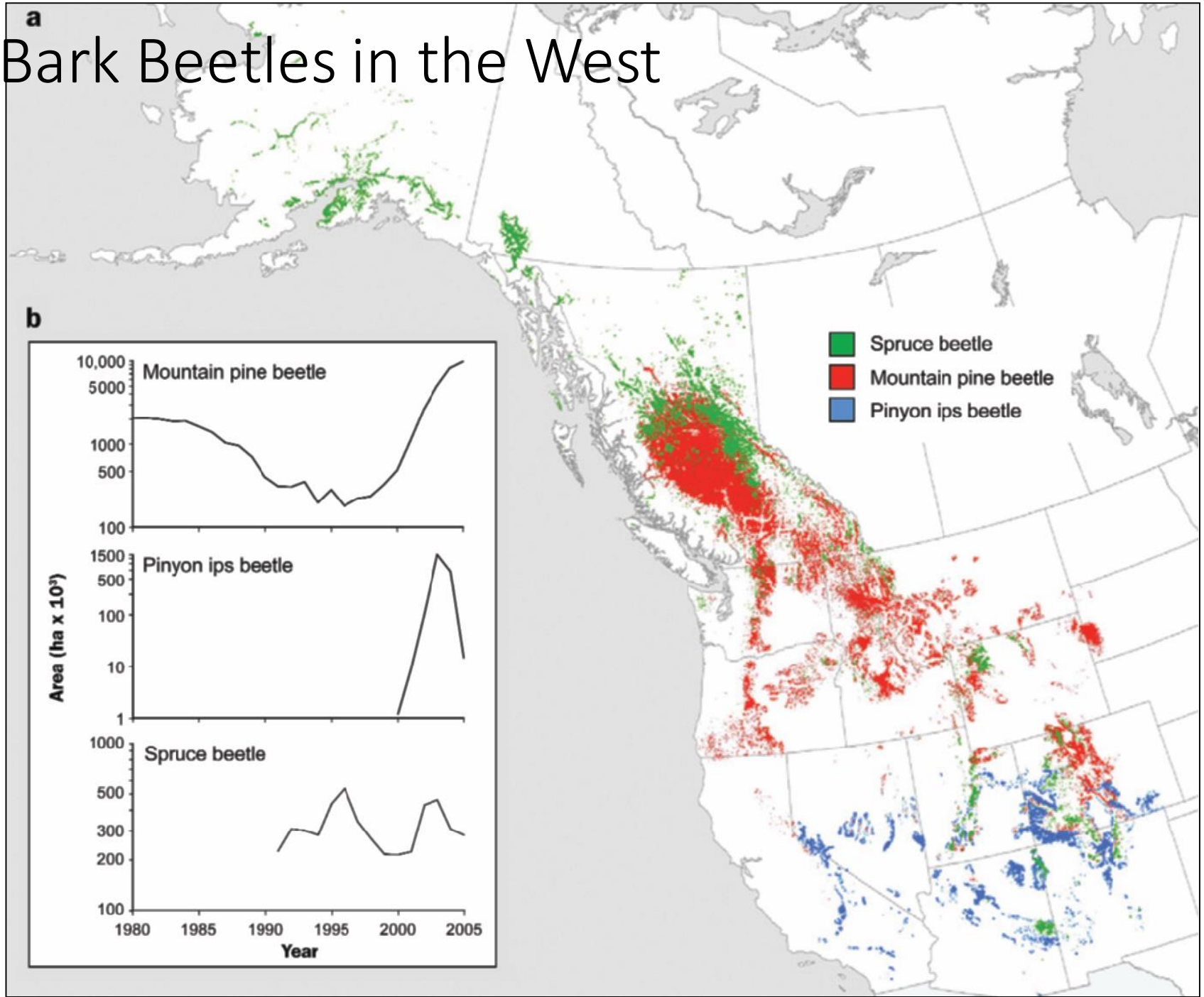
Woods et al. Can. J. Plant Path. 2011.

# Bark beetles of pine


Western Pine Beetle




# Bark Beetles in the West



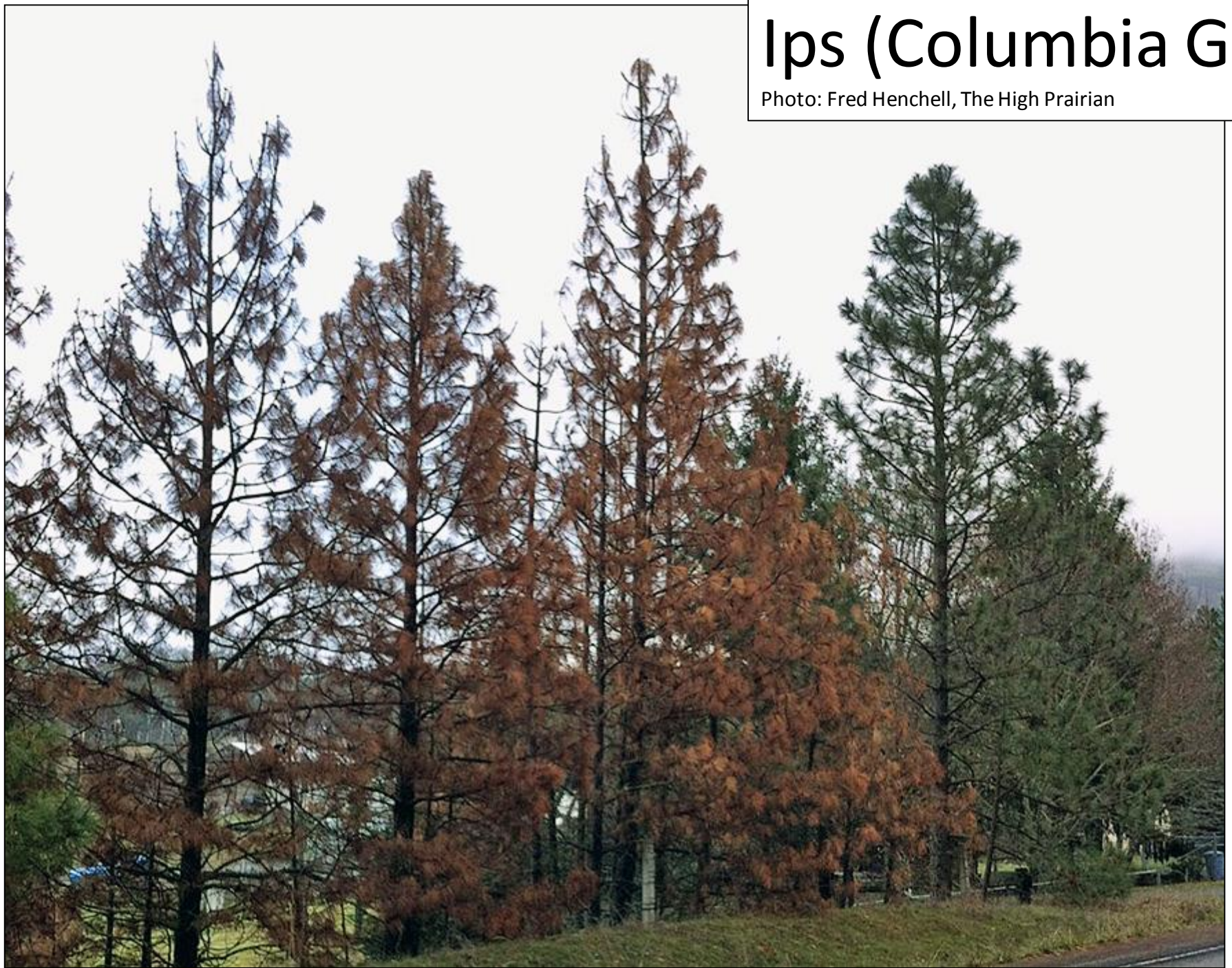
# Mt. Pine Beetle Epidemic in BC


MPB Outbreak gray stage

# Ips killed pine WV, USFS photo

# Ips (Columbia Gorge)

Photo: Fred Henchell, The High Prairian



Ips

Douglas-fir Beetle

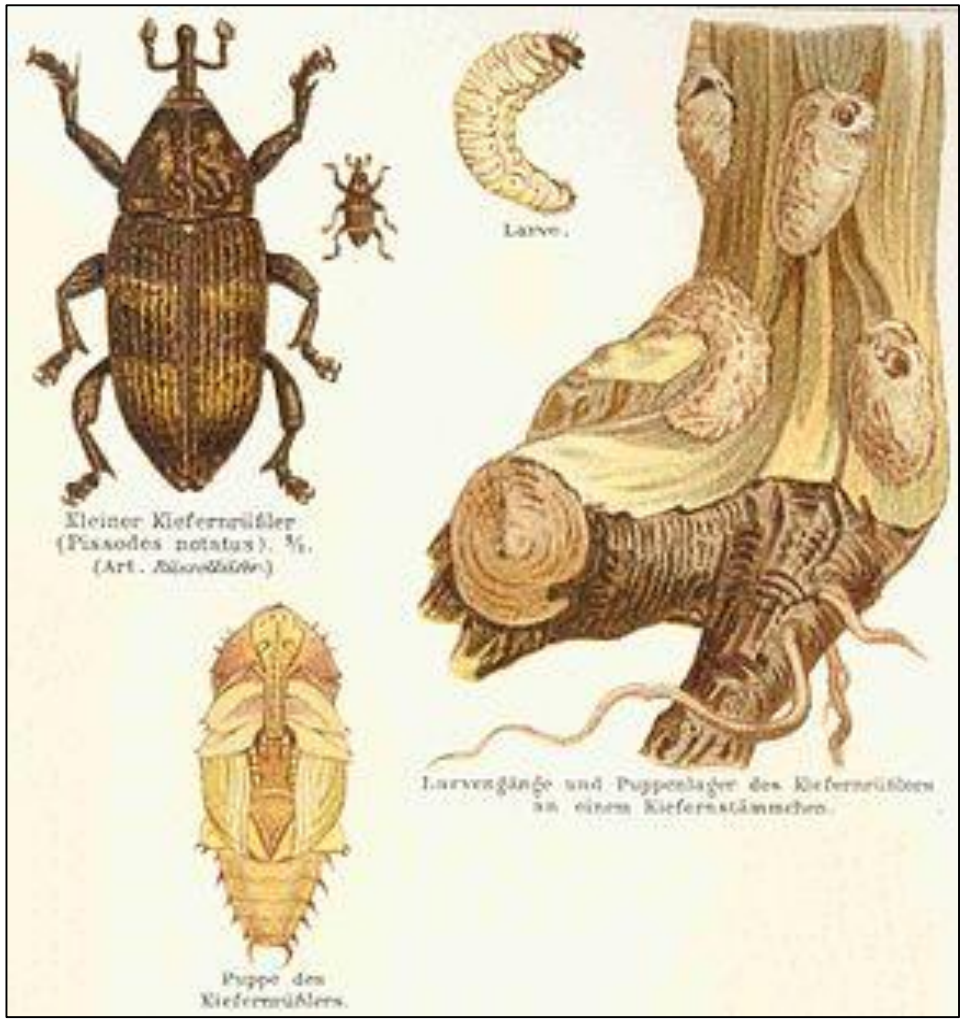
# Fir engraver

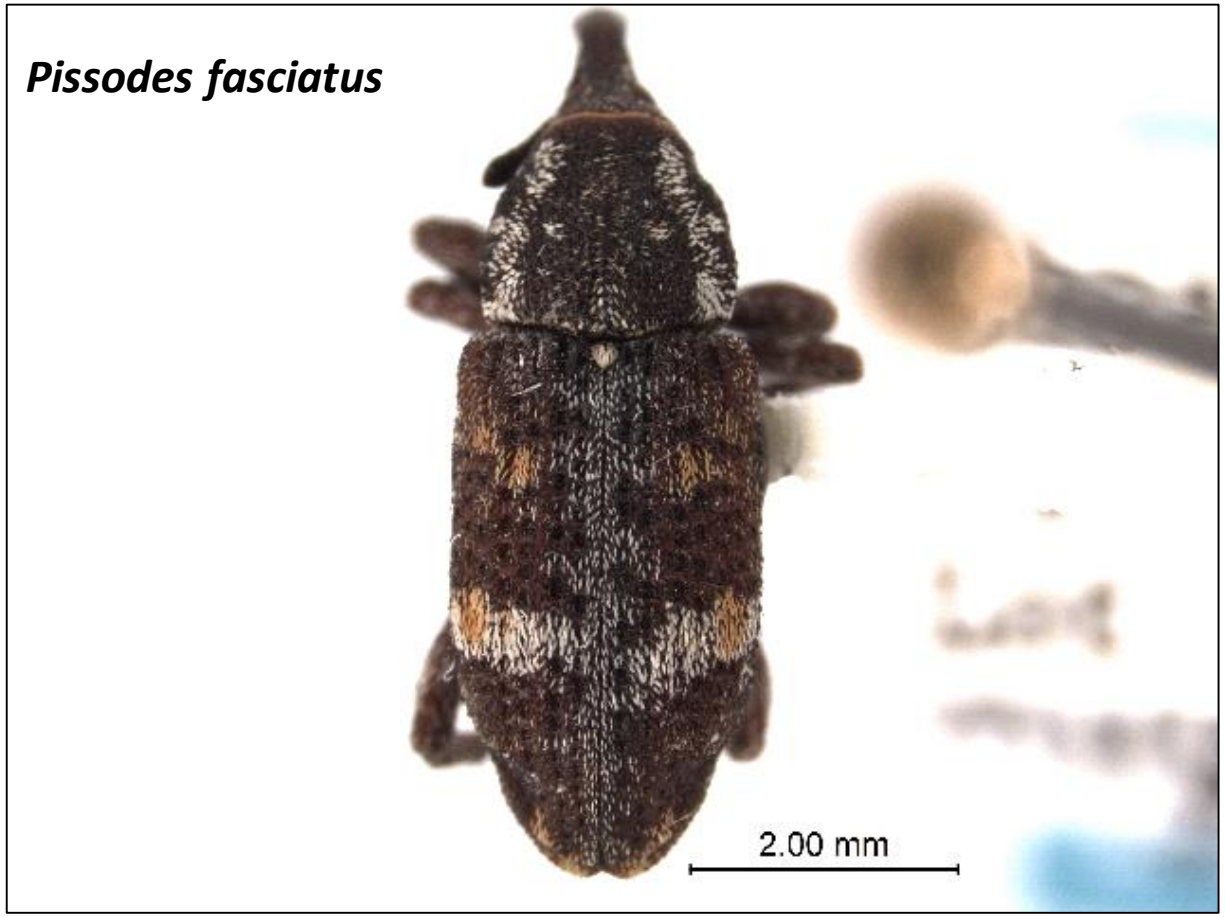
# Weevils/Black Stain Root Disease

Black Stain Root Disease

photo LeBoldus

# *Hylastes nigrinus* (Coleoptera: Scolytidae), *Pissodes fasciatus,* and *Steremnius carinatus* (Coleoptera: Curculionidae) as vectors of black-stain root disease of Douglas-fir.




CNC/BIO Photography Group, Biodiversity Institute of Ontario

# *Steremnius carinatus* (Coleoptera: Curculionidae) Conifer seedling weevil or root collar weevil


USDA Forest Service - Northeastern Area ,
USDA Forest Service, Bugwood.org

# *Hylastes nigrinus* (Coleoptera: Cuculionidae: Scolytinae), Douglas-fir root beetle

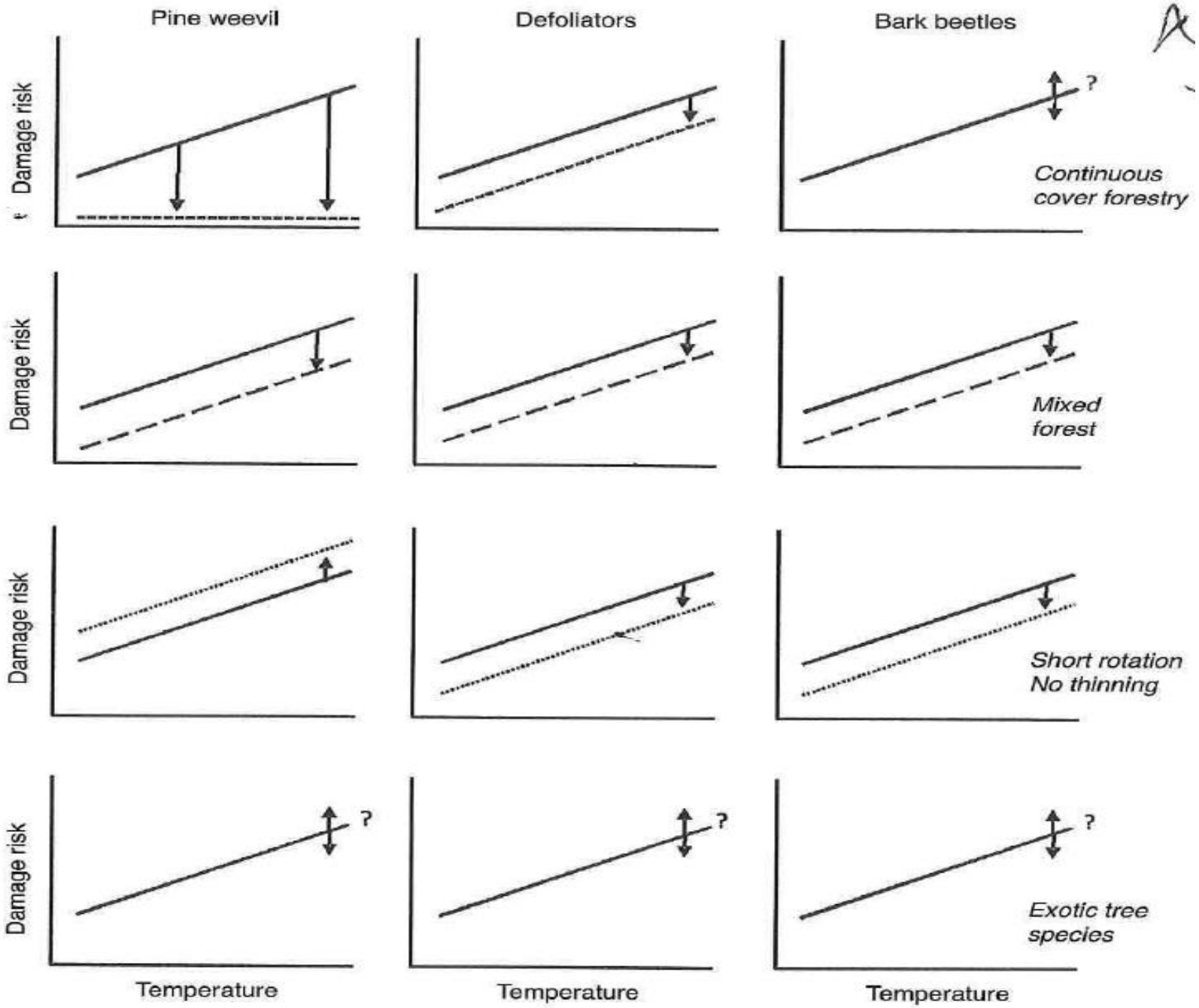



Defoliators

Don’t really know the connection to climate change.

*Phenology
*CO2
*Foliage C/N

Pine butterfly in Ponderosa pine, Oregon




# Projected changes with increasing temperature

# N. Europe example.

Björkman et al. 2015. Chap 14 in: Climate Change and Insect Pests. CABI.

# Changes in Precipitation

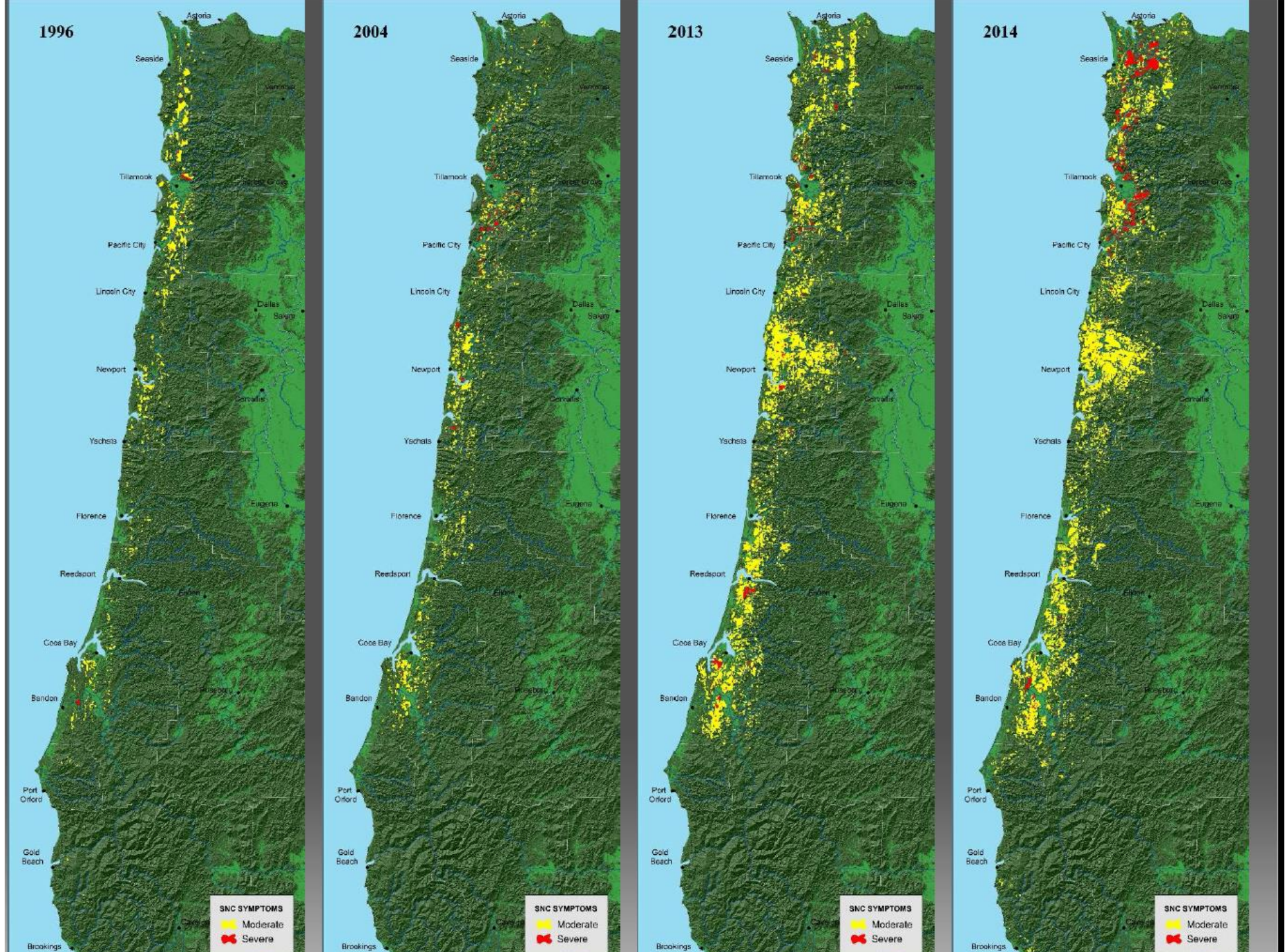
- Seasonal changes in precipitation can change dynamics of foliage disease.
- Especially coupled with warmer winters.
- Dothistroma needle blight in pines.
- Swiss needle cast in Douglas-fir.

# Dothistroma needl blight: Lodgepole in BC

Photo Credit: Harry Kope (MFR)

PNW Plant Disease Management Handbook

# Swiss Needle Cast in W. Oregon/Washington(photo Rob Flowers, ODF)


1996
2004
2013
2014
Astoria
Seaside
Tillamook
Pacific City
Lincoln City
Newport
Yachats
Florence
Reedsport
Coos Bay
Bandon
Port Orford
Gold Beach
Brookings
Dallas
Salem
Corvallis
Eugene
Roseburg
Elkton
SNC SYMPTOMS
Moderate
Severe

Swiss Needle Cast in Oregon
2015 = 238,360 ha
(589,851 acres)

From Alan Kanaskie,
Danny Norlander
Oregon Dept Forestry

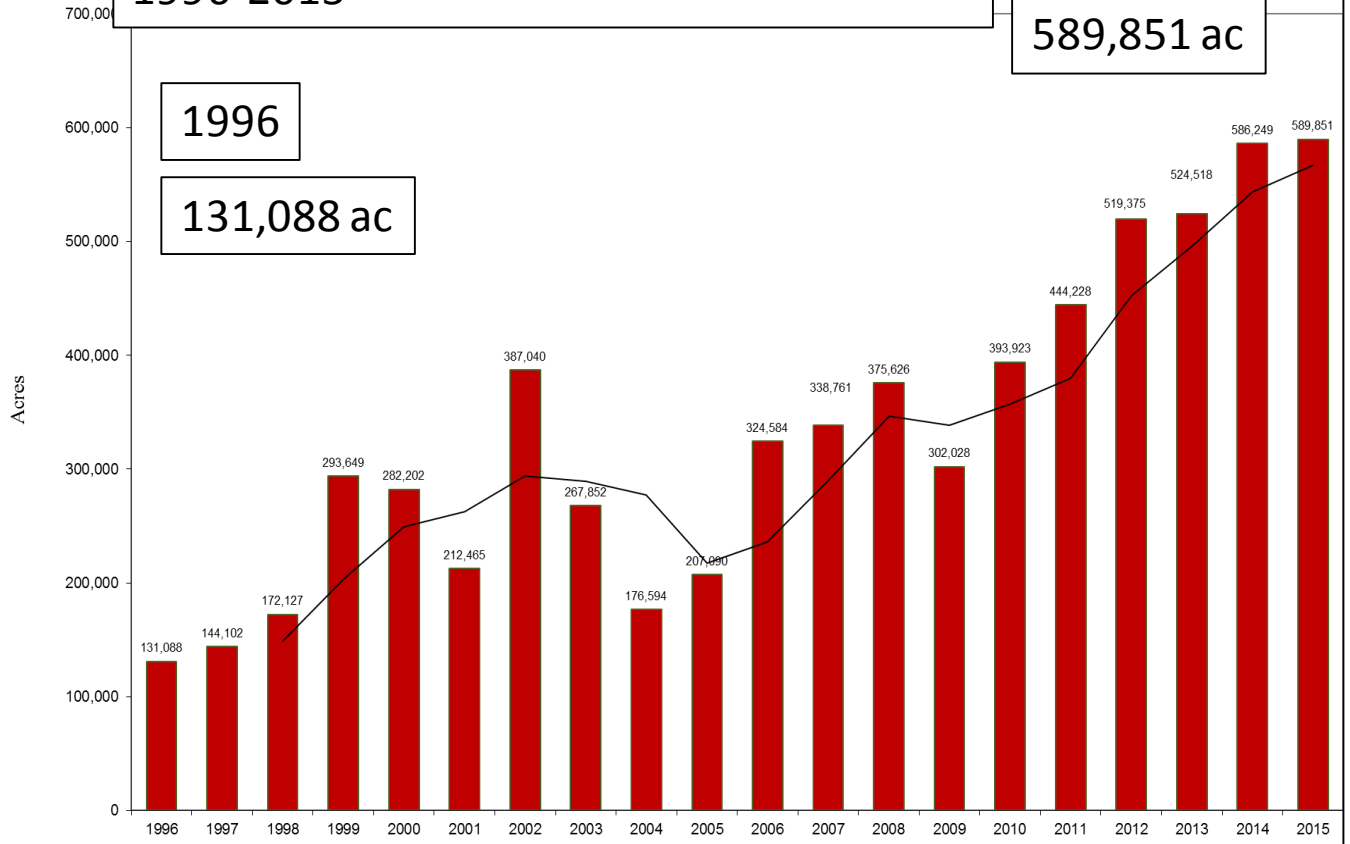
Cooperative Aerial Survey ODF/USFS FHP
1996-2015

2015

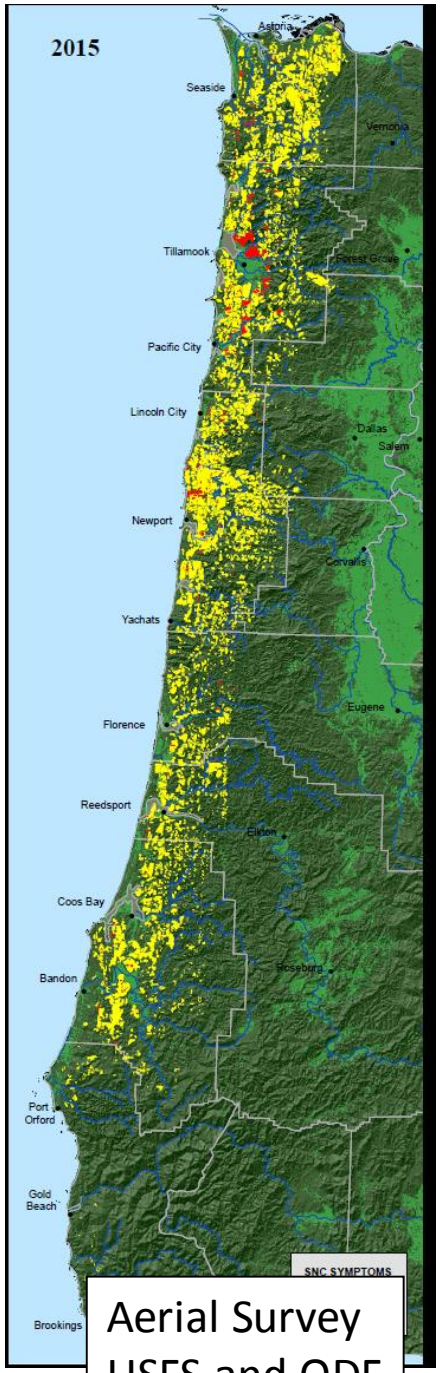
589,851 ac

1996

131,088 ac




SNCC Website: http://sncc.forestry.oregonstate.edu/

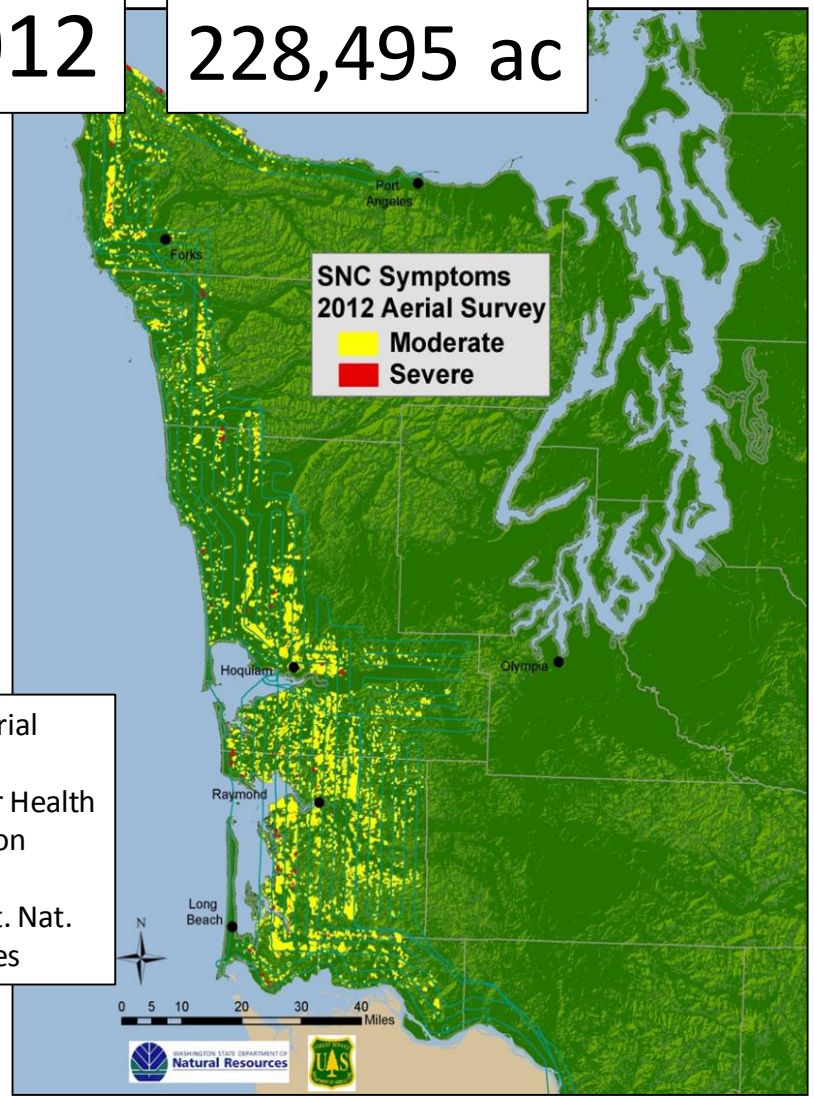



Aerial Survey
USFS and ODF

# Disease Distribution from Aerial Survey: SW Washington State and Olympic Peninsula

2012

228,495 ac

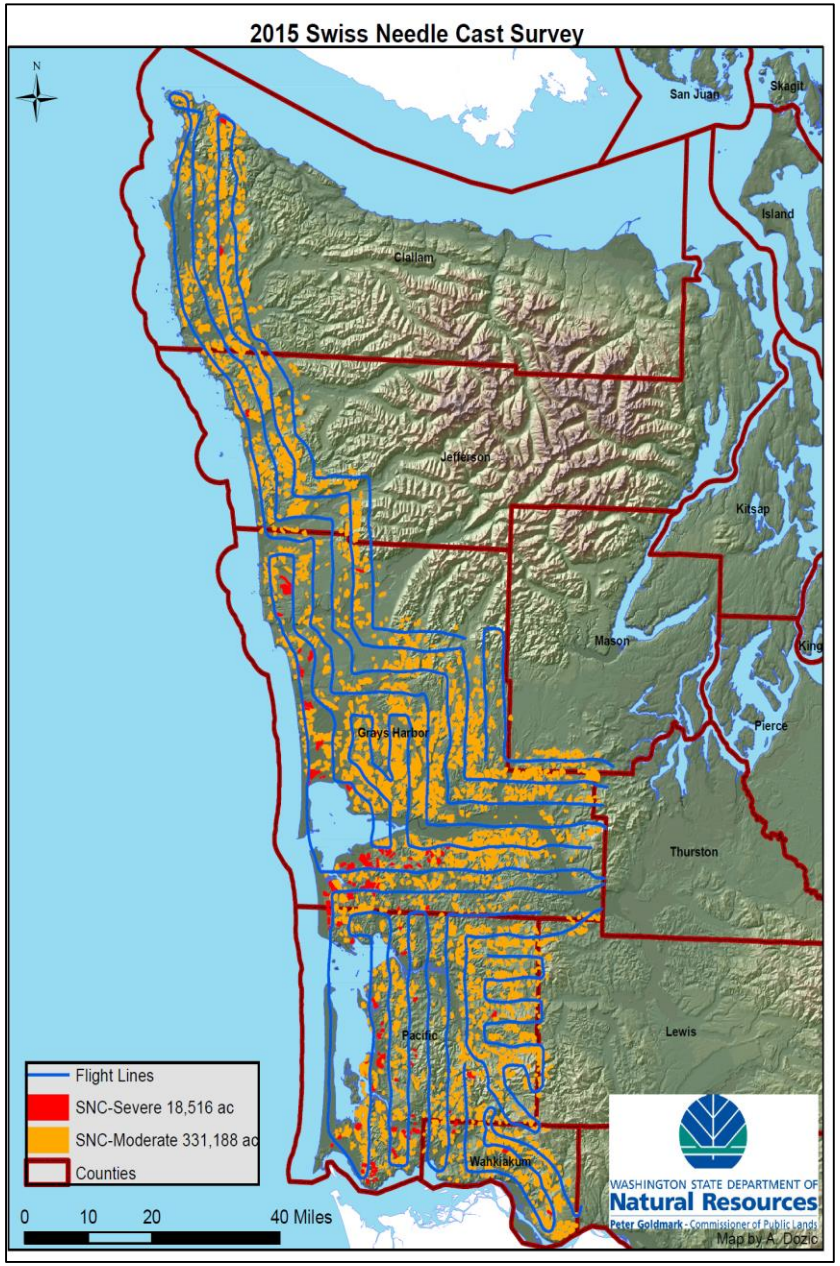



Coop Aerial Survey
USFS For Health Protection

WA Dept. Nat. Resources

2015

349,703 ac



2016

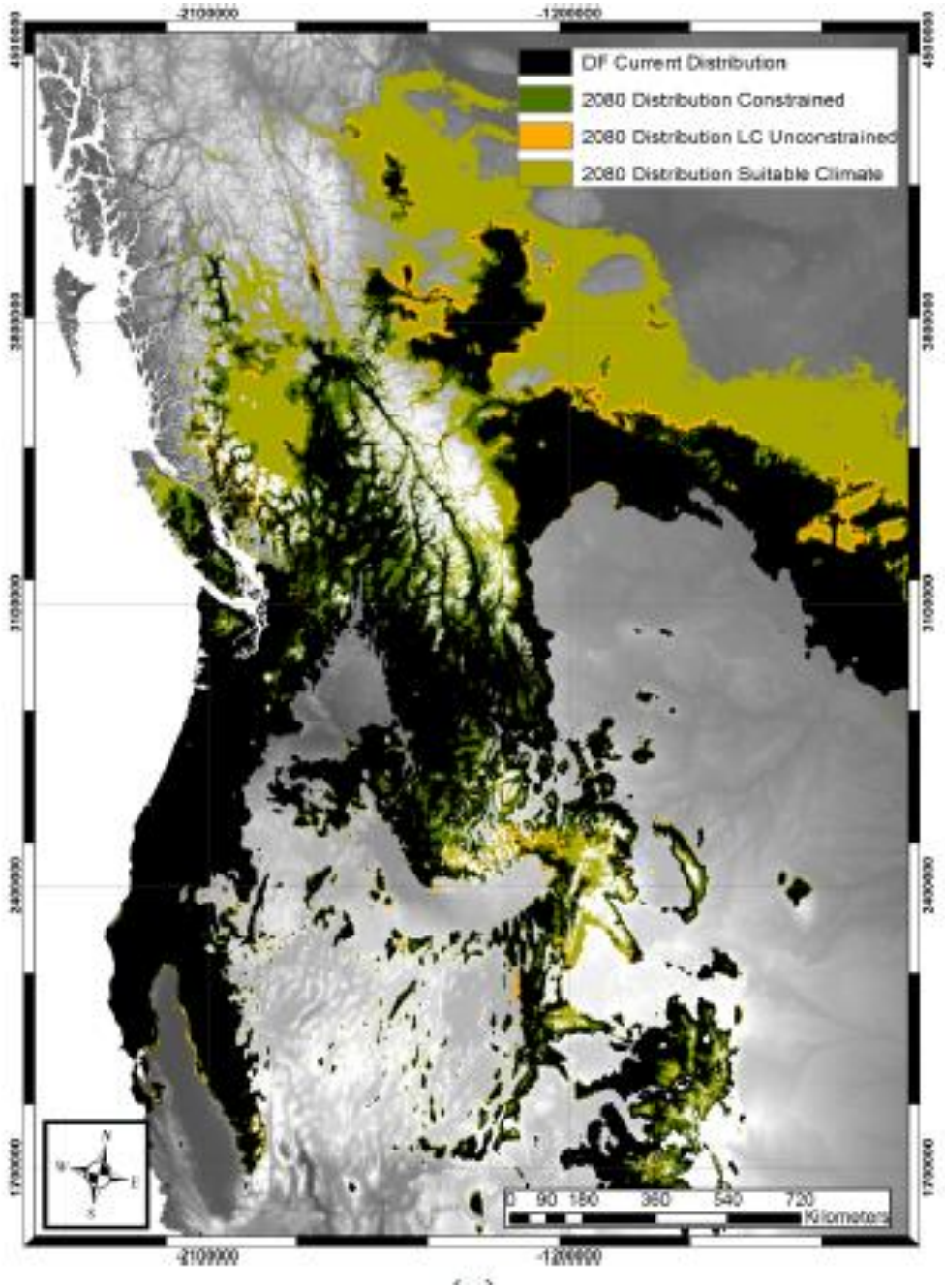
*remote sensing*

MDPI

*Article*

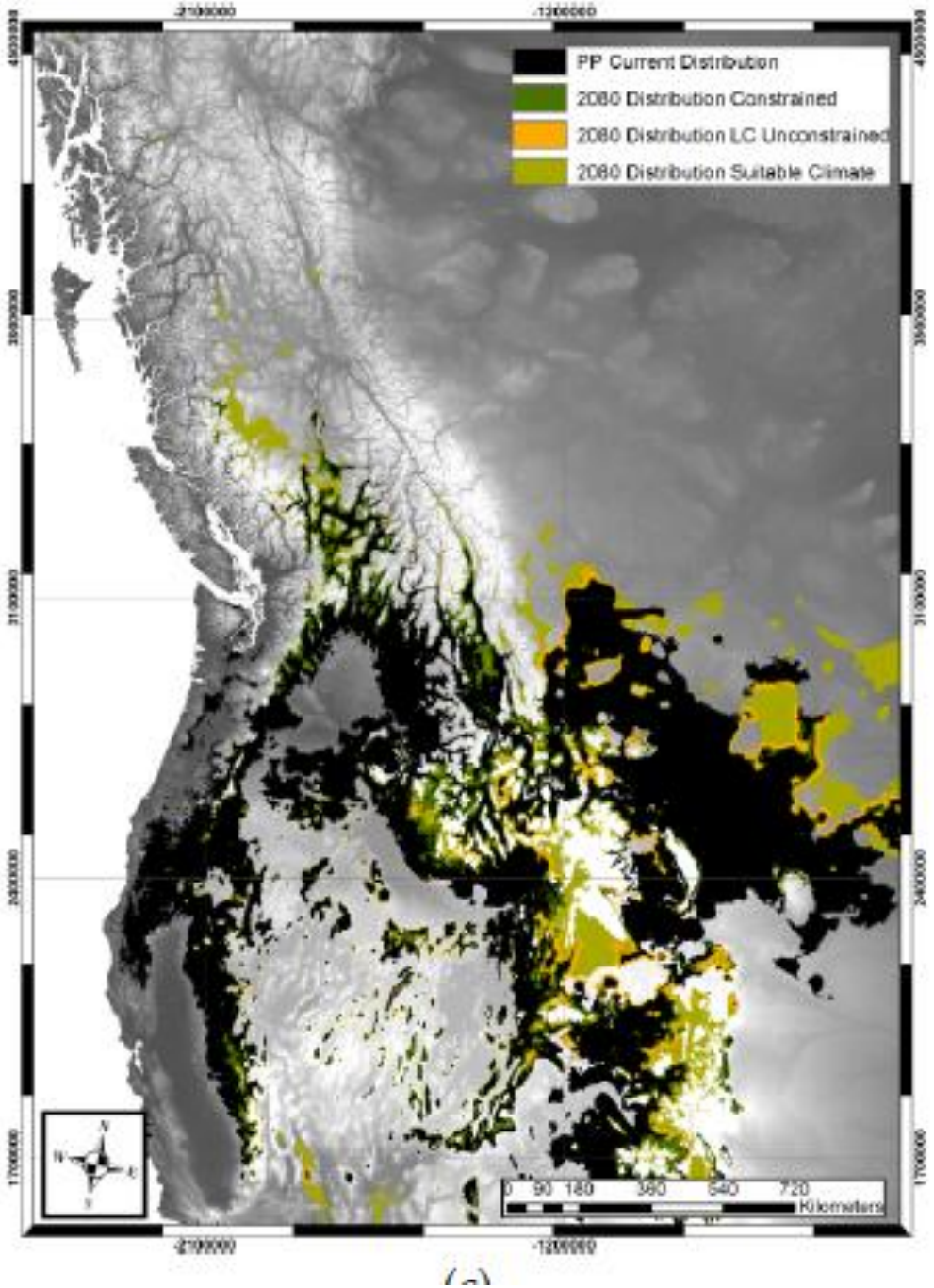
# Using Remotely-Sensed Land Cover and Distribution Modeling to Estimate Tree Species Migration in the Pacific Northwest Region of North America

Nicholas C. Coops [1,*], Richard H. Waring [2,†], Andrew Plowright [1,†], Joanna Lee [1,†] and Thomas E. Dilts [3,†]



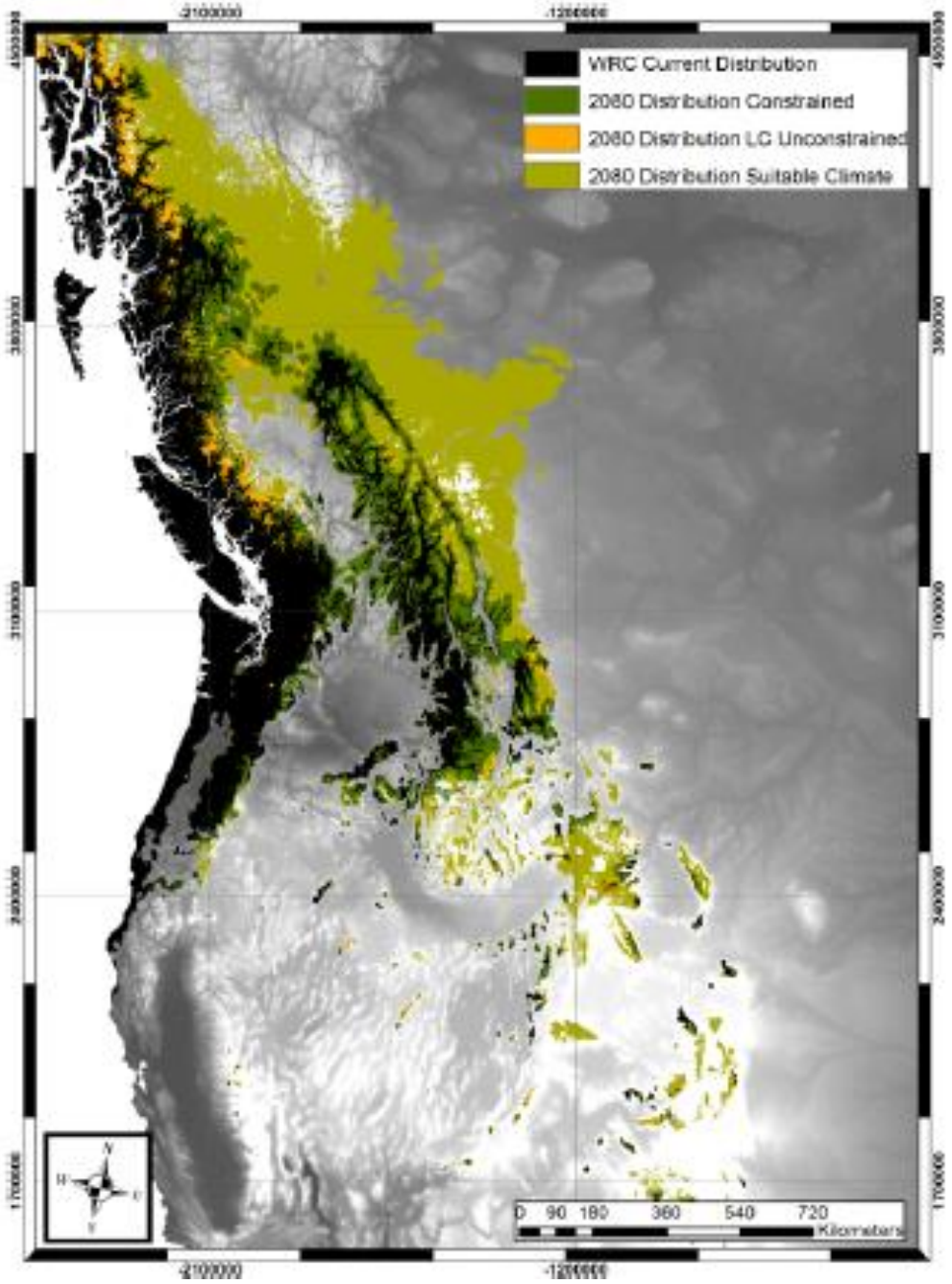

# Douglas-fir in 2080

- Black: current distribution
- Dark green: 2080 distributions with climate and landscape barriers imposed
- Tan/yellow: Distributions with maximum 200-meter/yr limit constraint
- Light green: 2080 suitable climate




# Ponderosa Pine

- Black: current distribution
- Dark green: 2080 distributions with climate and landscape barriers imposed
- Tan/yellow: Distributions with maximum 200-meter/yr limit constraint
- Light green: 2080 suitable climate




# Western redcedar

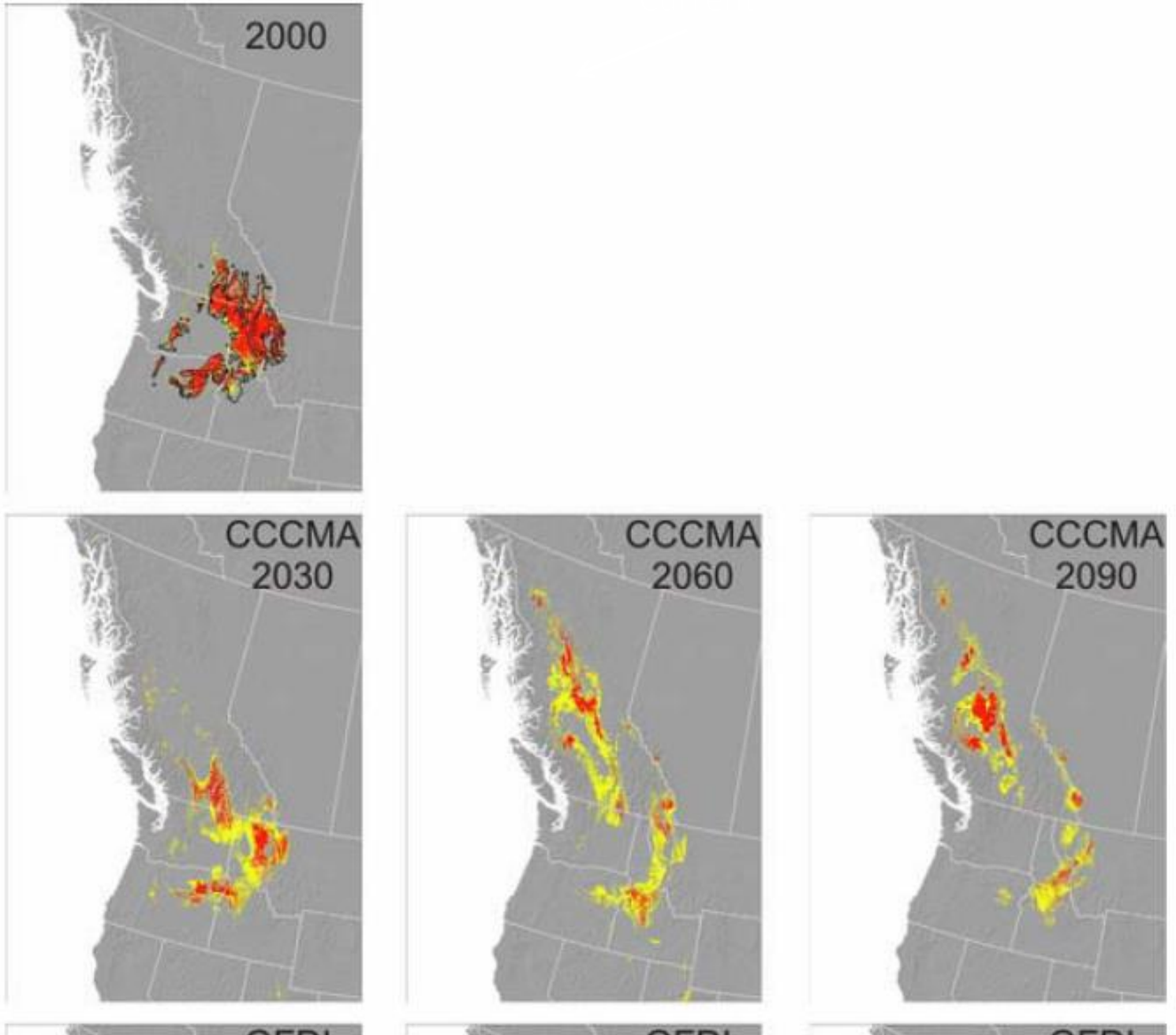
- Black: current distribution
- Dark green: 2080 distributions with climate and landscape barriers imposed
- Tan/yellow: Distributions with maximum 200-meter/yr limit constraint
- Light green: 2080 suitable climate

# W. Larch

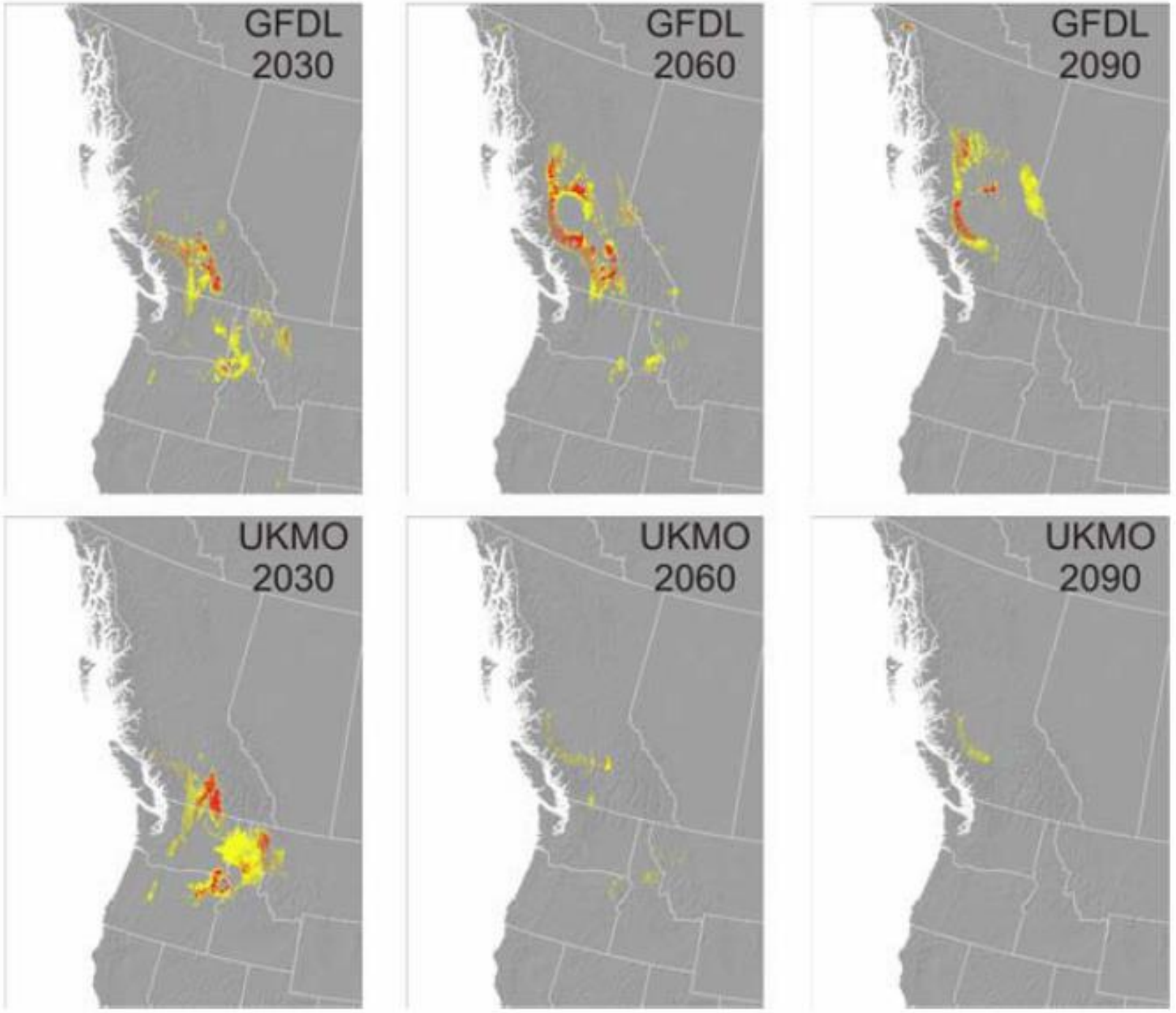
- G. Rehfeldt and B Janquish. Mitig. Adapt. Strateg. Glob. Change (2010) 15: 283-306.

- Models predict changes in western larch environment.





# Western Larch



# Forest Pathogens and Insect Pests will migrate too

- Bark beetles, defoliators and sapsuckers (adelgids) have been documented.
- Pathogens can easily move, especially if human assisted.

# Conclusions: We Should Expect Changes

- Trees
- Insects and Pathogens
- Fire
- Drought
- Seasons