Climate Change Effects on Forest Insects and Diseases

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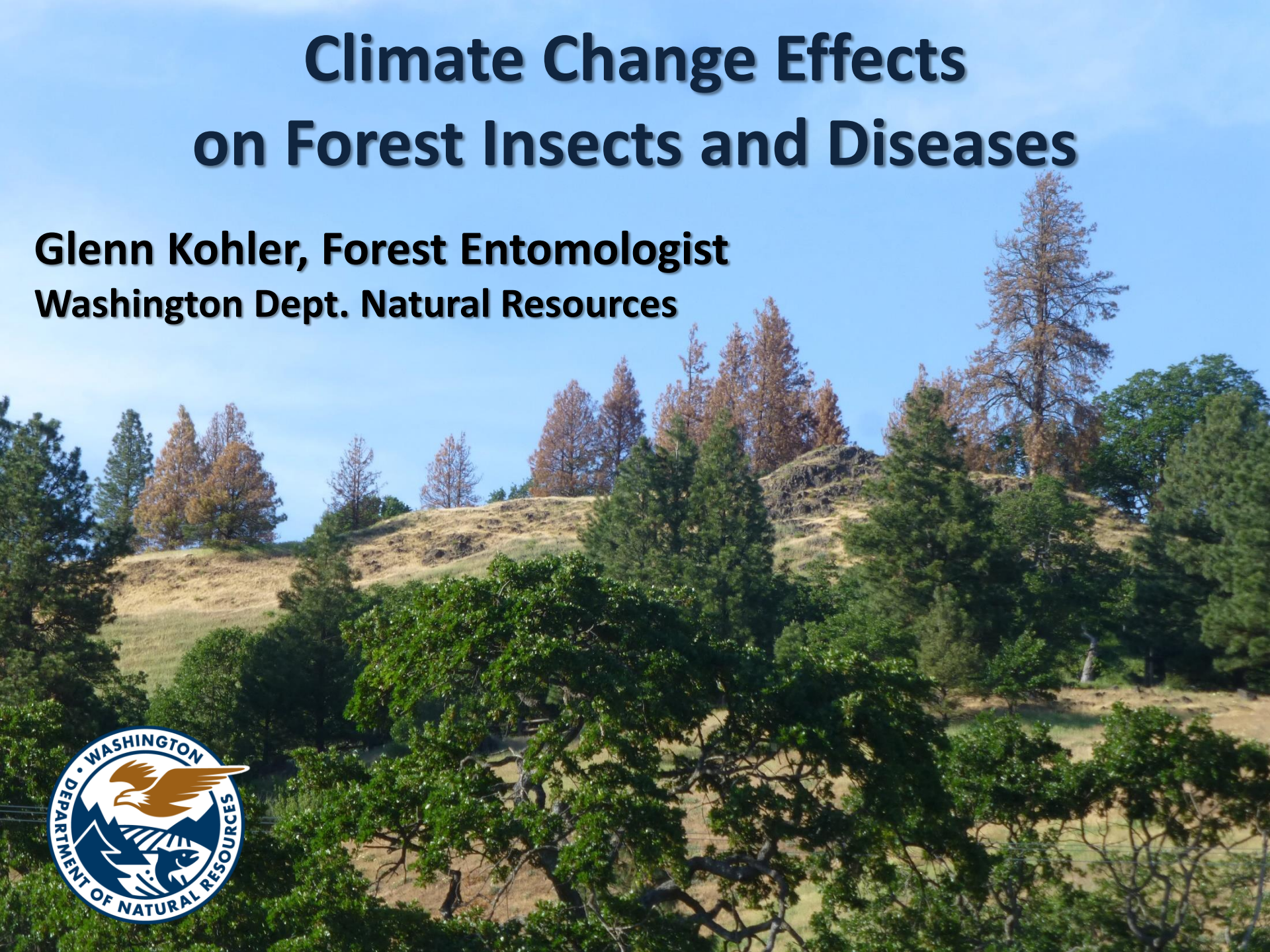
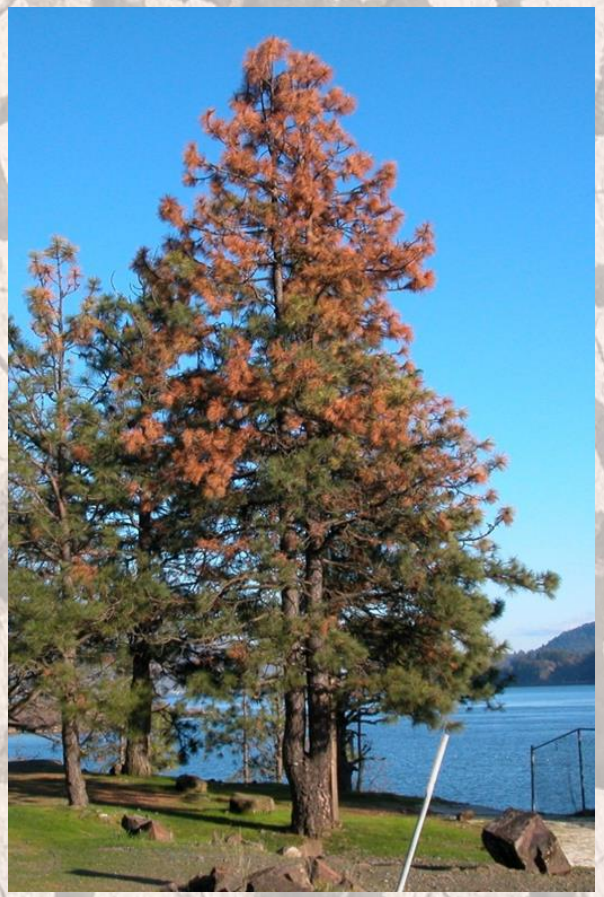


With climate change, we can expect more frequent and intense droughts

What is Drought?

A lack of water…

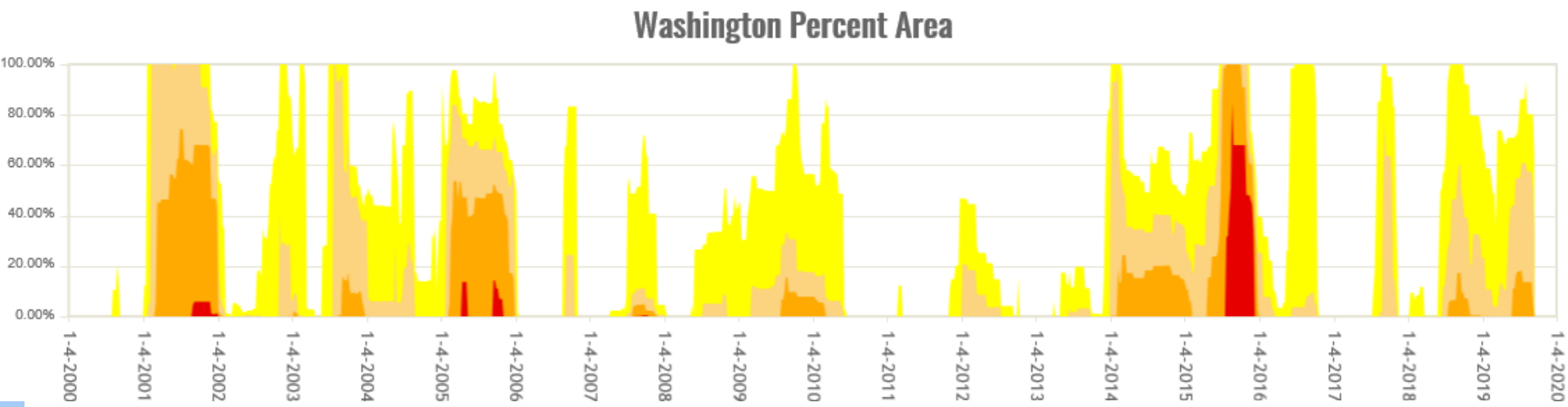
…but for <u>trees</u> many other factors determine drought effects:



Factors affecting drought damage to trees:

- Maximum temps during drought
- Season of drought
- Duration over the season/years
- Soil type
- Tree species (drought tolerance level)
- Tree size (leaf area, depth of root systems)
- Desiccating winds
- Competition
- Aspect, slope position (ridge vs valley)
- Position in tree's range (fringe or interior)
- **Presence of opportunistic insects & pathogens**

Summer drought often occurs somewhere in WA, but 2015 was an extreme drought year.



U.S. Drought Monitor
Washington

U.S. Drought Monitor
Washington

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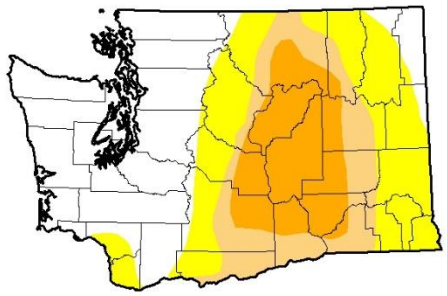
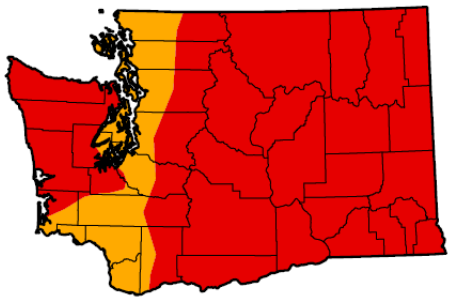
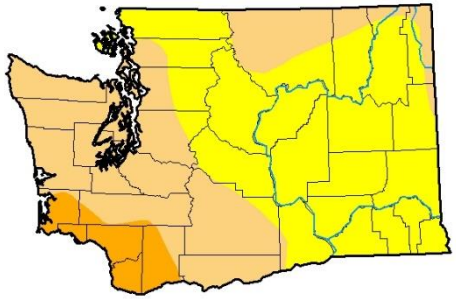


Summer 2014



Summer 2015



Summer 2018

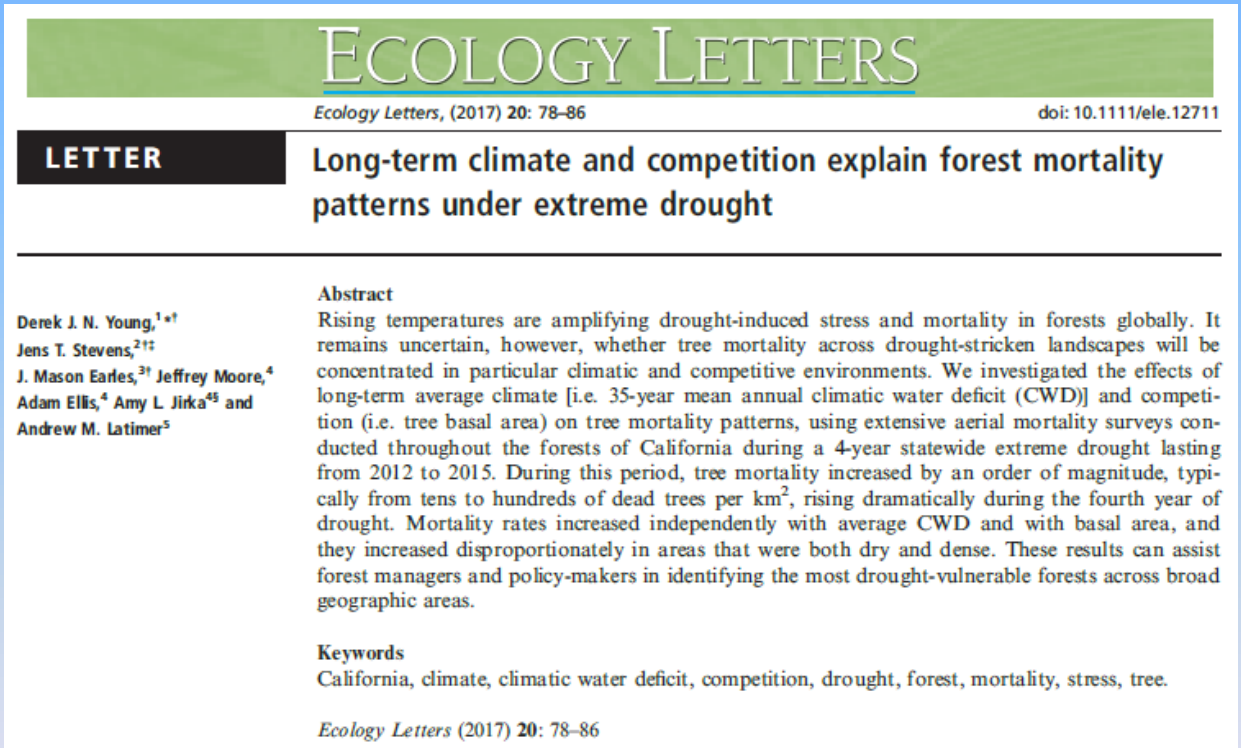
Normal droughts vs. “hotter droughts”

- Droughts are **natural** disturbances (many trees are adapted).
- **“Normal” droughts** have limited landscape level impacts, killing off younger, weak, vulnerable trees or damaging branches of mature trees.
- **Severe droughts** can cause widespread damage and contribute to insect outbreaks and fires, but the cumulative effect is reduced since they don’t occur that often.
- With climate change we’re experiencing **more frequent and intense droughts**, referred to by some as “hotter droughts” (Millar & Stephenson 2015).
- These have the potential to cause **significant landscape changes**, especially on the fringes of a tree’s range.

Millar, C.I., & N.L. Stephenson. 2015. Temperate forest health in an era of emerging megadisturbance. Science 349: 823-826.

"Rising temperatures are amplifying drought-induced stress and mortality in forests globally."

"drought-induced mortality may increase at the hot, dry limit of an individual tree species' range"



ECOLOGY LETTERS

Ecology Letters, (2017) **20**: 78–86 doi: 10.1111/ele.12711

LETTER

Long-term climate and competition explain forest mortality patterns under extreme drought

Derek J. N. Young,[1]*† Jens T. Stevens,[2]†‡ J. Mason Earles,[3]† Jeffrey Moore,[4] Adam Ellis,[4] Amy L. Jirka[4,5] and Andrew M. Latimer[5]

Abstract

Rising temperatures are amplifying drought-induced stress and mortality in forests globally. It remains uncertain, however, whether tree mortality across drought-stricken landscapes will be concentrated in particular climatic and competitive environments. We investigated the effects of long-term average climate [i.e. 35-year mean annual climatic water deficit (CWD)] and competition (i.e. tree basal area) on tree mortality patterns, using extensive aerial mortality surveys conducted throughout the forests of California during a 4-year statewide extreme drought lasting from 2012 to 2015. During this period, tree mortality increased by an order of magnitude, typically from tens to hundreds of dead trees per km^2, rising dramatically during the fourth year of drought. Mortality rates increased independently with average CWD and with basal area, and they increased disproportionately in areas that were both dry and dense. These results can assist forest managers and policy-makers in identifying the most drought-vulnerable forests across broad geographic areas.

Keywords

California, climate, climatic water deficit, competition, drought, forest, mortality, stress, tree.

Young, D.J.N., J.T. Stevens, J.M. Earles, J. Moore, A. Ellis, A.L. Jirka and A.M. Latimer. 2017. Long-term climate and competition explain forest mortality patterns under extreme drought. Ecology Letters 20: 78-86.

Direct drought damage:

Symptoms

- Often more than one species affected
- Worse on marginal sites & well-drained soils
- Damage develops from top-down and outside-in

- Reduced shoot and root growth
- Wilting
- “Bleaching”
- Dropped needles
- Leaf scorch

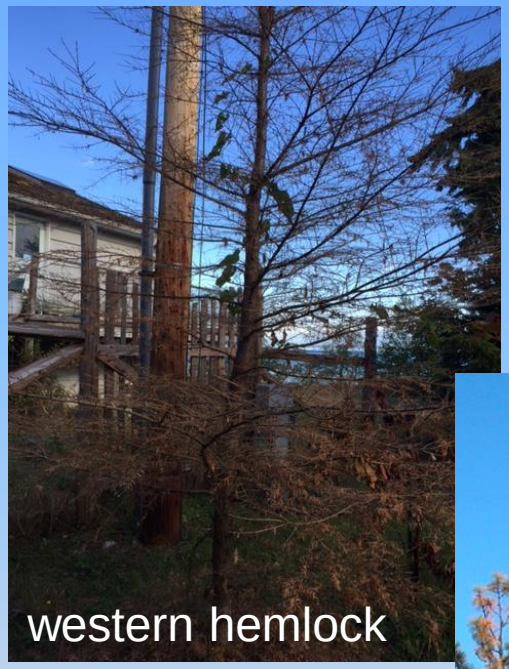
- Stress cone crop
- “Sunken” bark/cankers

Phomopsis canker

- Dead tops & branches (flagging)
- Whole-tree mortality without insect or pathogen signs

Tom Eckberg,
Idaho Dept lands

- All damage may not appear until following spring (starts late summer/fall with severe drought)



These are all likely to contain “secondary” bark beetles

Secondary bark beetles

- Breed in dead branches & slash (maintain low endemic populations)
- Infest small diameter, thinned-barked portions of trees that are stressed or dying
- Act as thinning agents of weakened, suppressed or diseased trees
- **Become opportunists after cumulative drought stress, then build populations**

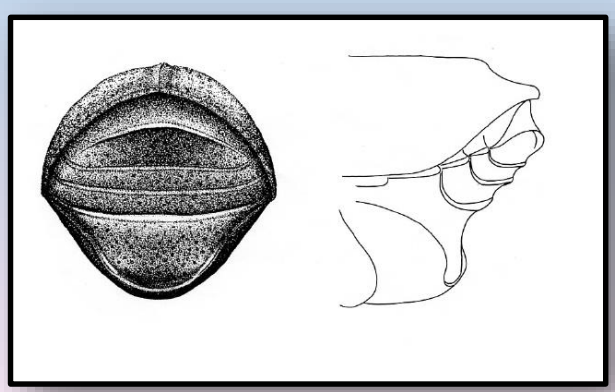
Secondary bark beetles that may outbreak in Douglas-fir after droughts

- **Douglas-fir pole beetle (*Pseudohylesinus nebulosus*)**

- **Douglas-fir engraver (*Scolytus unispinosus*)**

- **Another engraver (*Scolytus monticolae*)**

- Breed in dead branches & slash
- Usually not a problem until disturbance like drought



Ips beetles

- Multiple generations per year
- Broods build in green dead trees (slash, storms)
- Outbreaks typically collapse after one year (high overwintering mortality, less host material).
- Live trees at much higher risk during **drought**.

Damage in Columbia River Gorge area 2012.

Piles of boring dust are evidence of *Ips* attacks.

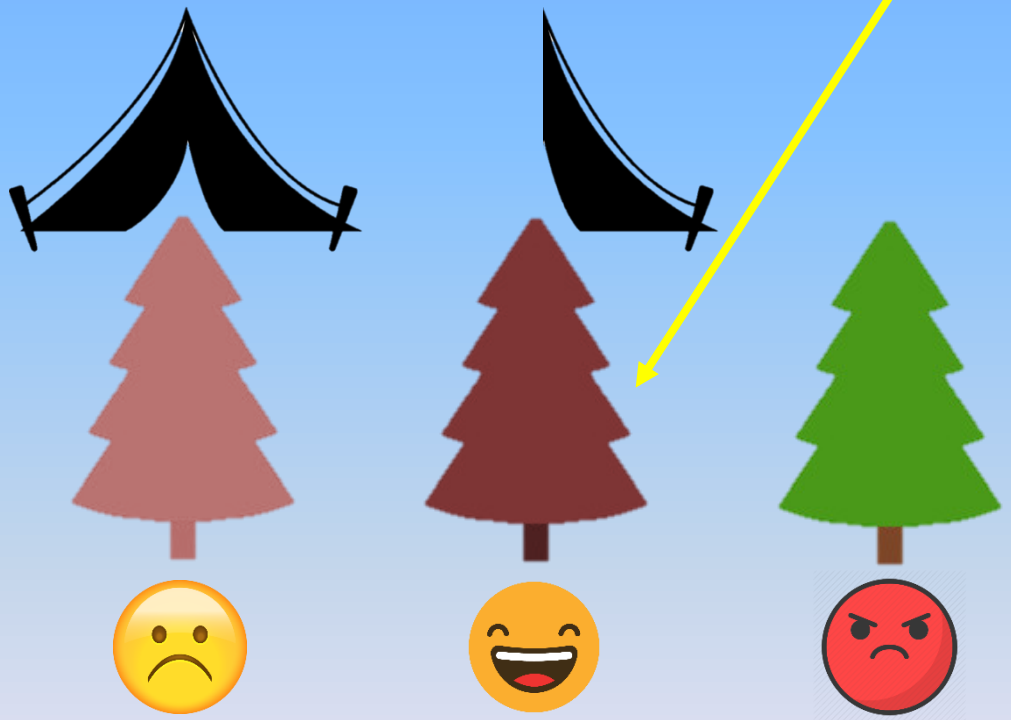
Other secondary bark beetles

- Silver fir beetle and hemlock; engraver in western hemlock
- *Phloeosinus* species in western redcedar
- *Pityokteines elegans* in noble fir
- *Pityophthorus* in pine

Why are there no bark beetles in this perfectly acceptable-looking tree?

Drought experiment in Austria (European spruce bark beetle):

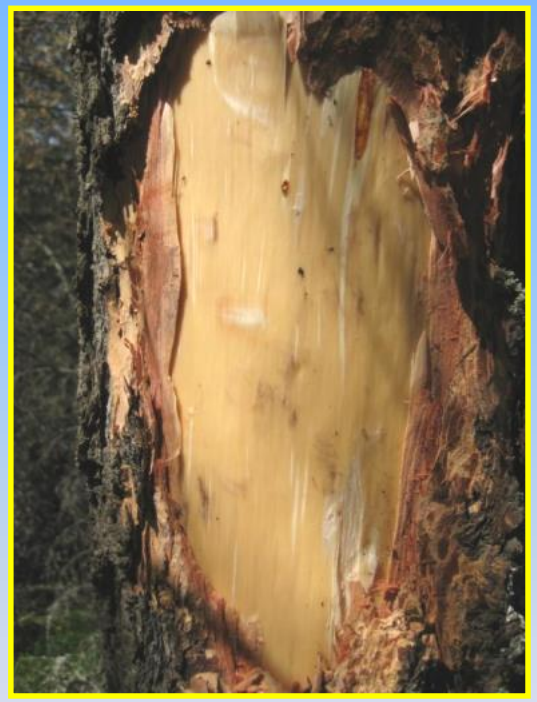
- Less resin for pitch-out during attack
- Less resin and toxic compounds = higher brood survival



TOO DRY!

JUST RIGHT!

TOO PITCHY!



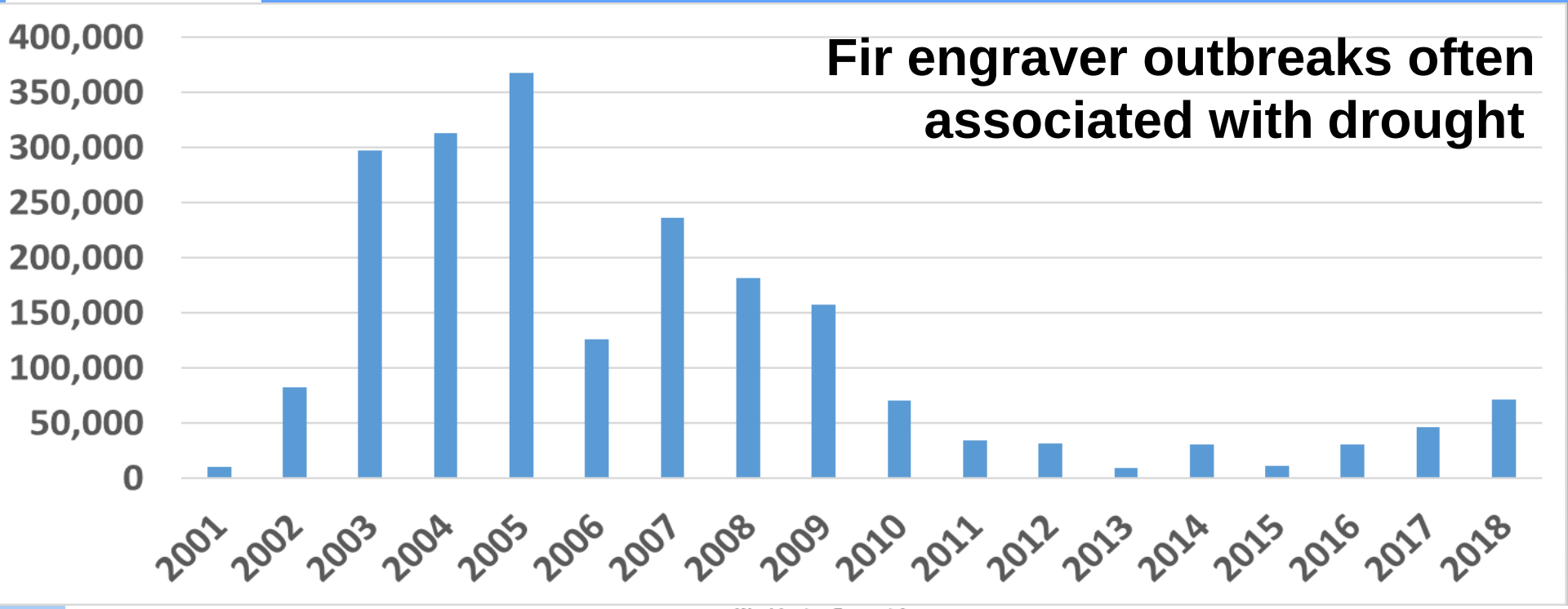
Netherer S. et al. 2015. Do water-limiting conditions predispose Norway spruce to bark beetle attack? New Phytologist 205: 1128-1141

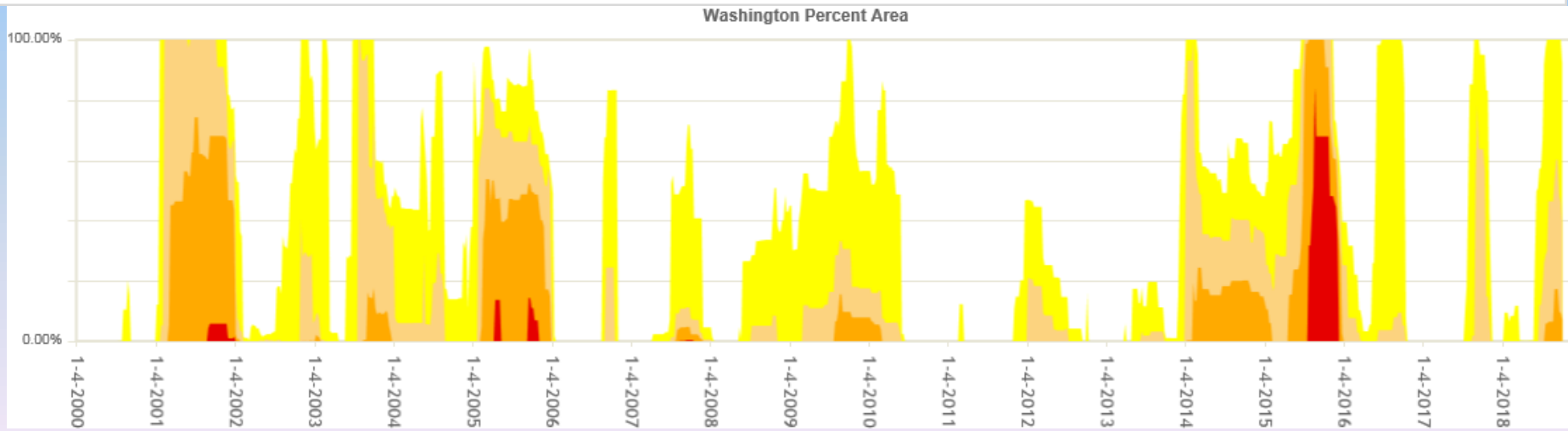
Major bark beetles associated with drought

- **Fir engraver (*Scolytus ventralis*)**

- **Hosts:** True firs (Abies), primarily grand fir

Acres in WA

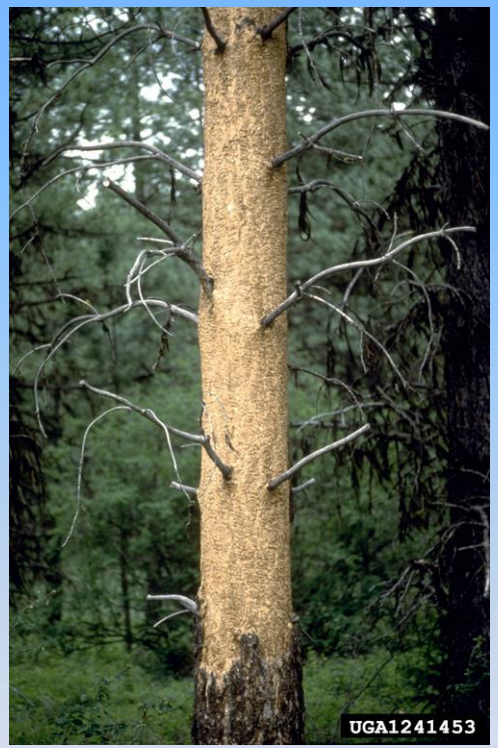




US Drought Monitor for WA state

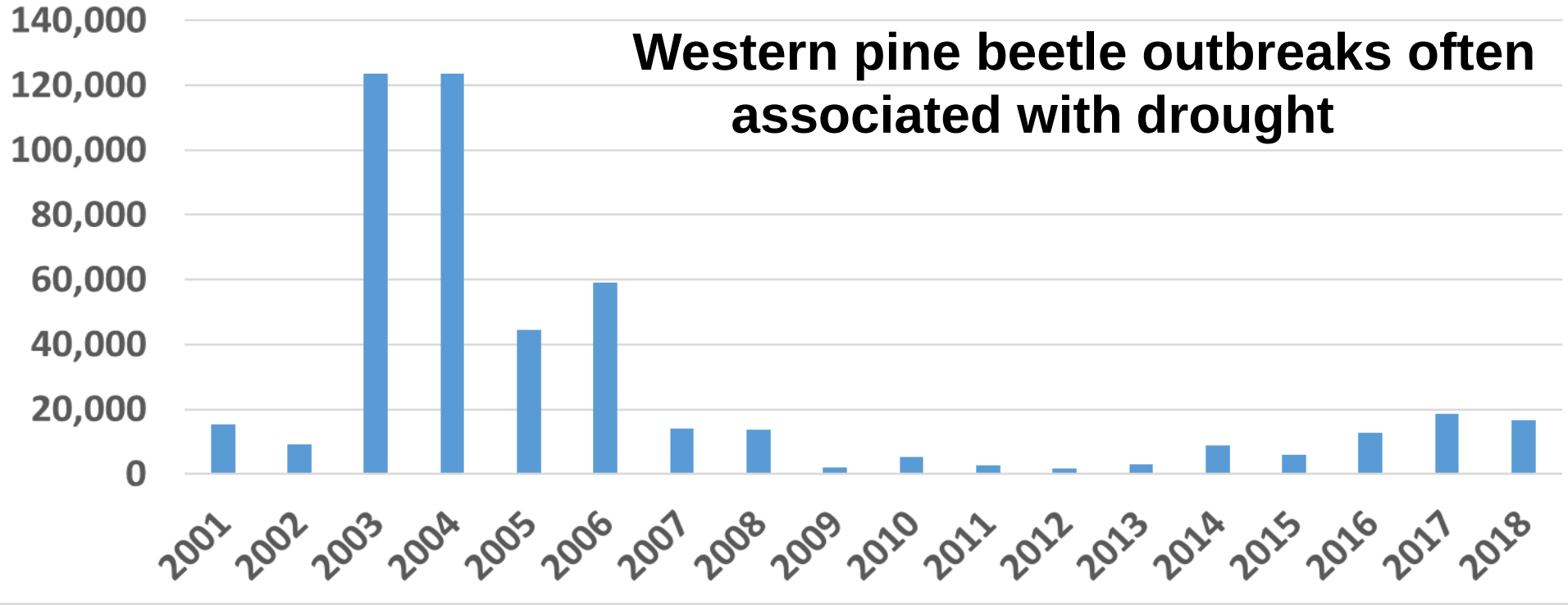
Major bark beetles associated with drought

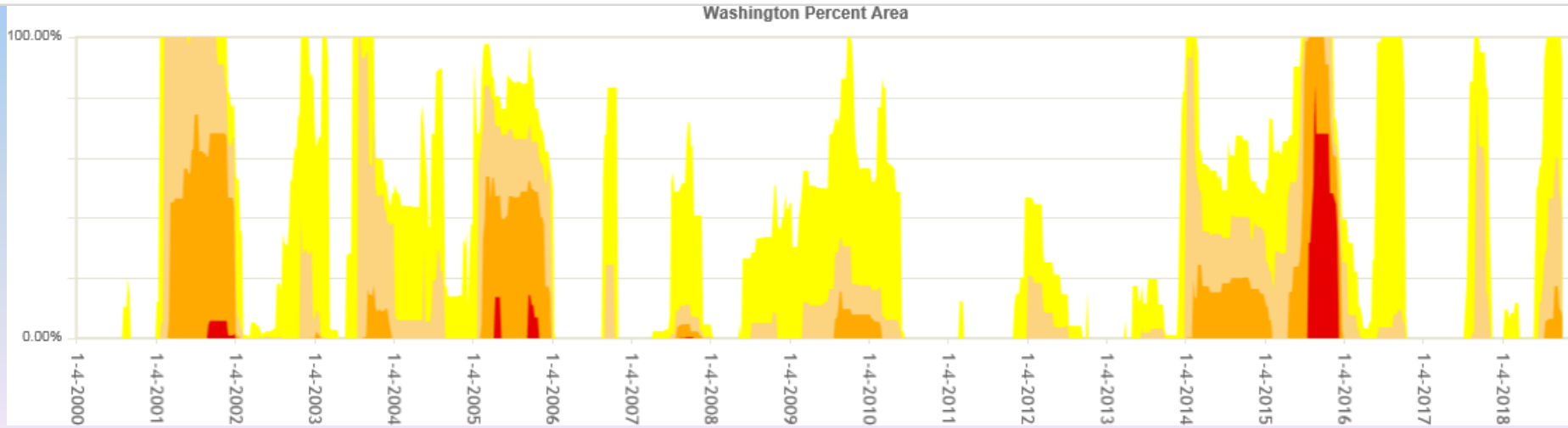
- **Western pine beetle (*Dendroctonus brevicomis*)**



- **Host:** Only ponderosa pine in our area

Acres in WA



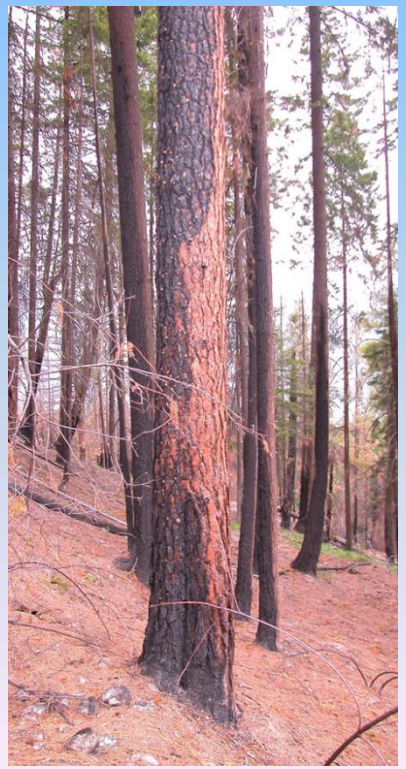


US Drought Monitor for WA state

Other factors that can lead to bark beetle outbreaks:

- Wildfire damage
- Windstorms
- Overmature and/or overstocked stands
- Logging slash (eastside)

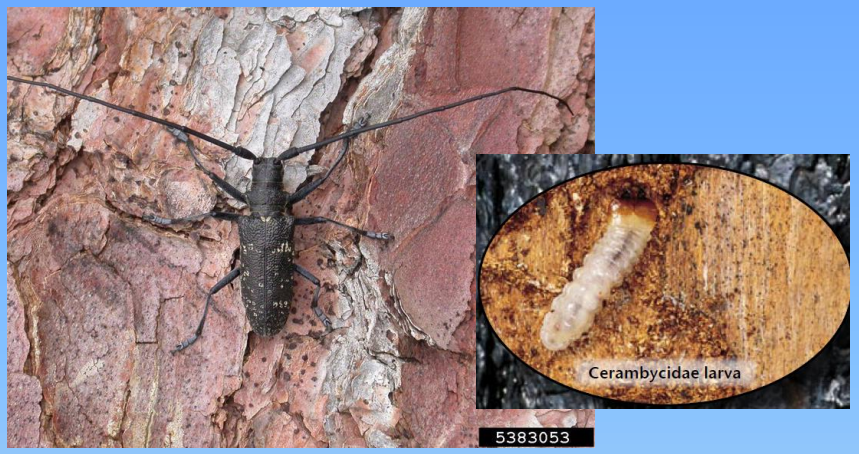

mountain pine beetle




Douglas-fir beetle

Wood borers associated with drought

Metallic wood borers
Flat-headed wood borers
Family Buprestidae



Long-horned wood borers
Round-headed wood borers
Family Cerambycidae

Woodwasps
Other colorful names
Family Siricidae

Bark beetle larva

Wood Borers

Bark Beetles

Flatheaded fir borer

Buprestidae: *Phaenops drummondi*

- Primarily in Douglas-fir and grand fir
- Capable of killing drought-stressed trees
- Acts like bark beetles in SW Oregon
- No external signs of attack
- Sometimes top-kill

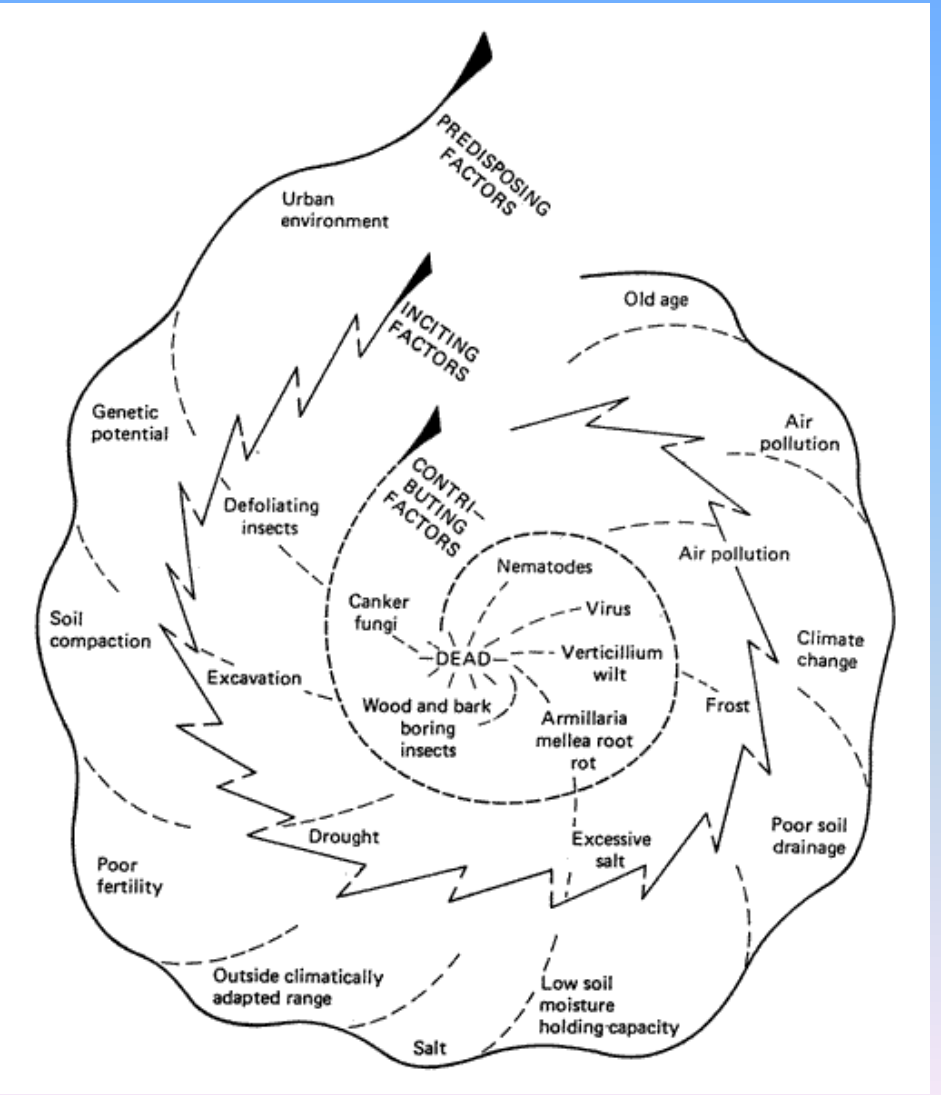
Root diseases and canker fungi can increase on drought stressed trees

- Pathogens more successful in low vigor hosts
- Slower wound healing and compartmentalization
- Higher concentrations of nitrogen and sugars

What leads trees to decline?

The Manion Spiral:

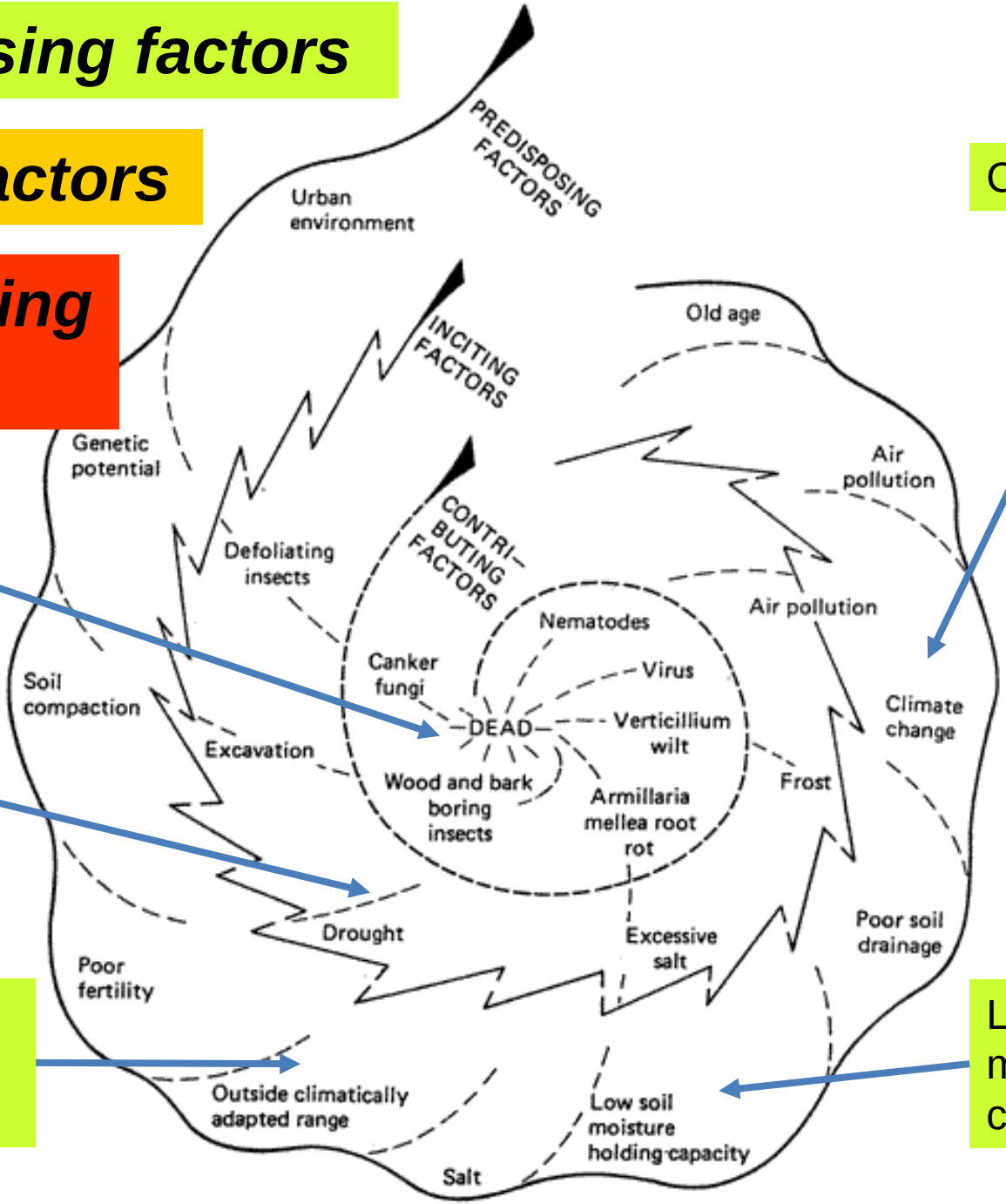
- Trees can go into a decline if there is first a factor that will predispose the tree to decline, followed by an inciting factor to trigger the decline and, finally a contributing factor that could eventually kill the tree
- In most documented decline examples there have been several factors from each of the sets acting upon the declining trees



Predisposing factors

Inciting factors

Contributing factors



Climate change

Insects & Disease

Drought

Outside climatically adapted range

Low soil moisture holding capacity

Decline diseases incited by drought
An example: Bigleaf maple decline

- Since 2010; symptoms include crown dieback, discoloration, and reduced leaf size
- Previous investigations focused on specific pathogens, but there was no “smoking gun”
- Starting in 2017, Univ. Washington study plots found correlations between declines and higher summer temps, more extreme summer droughts, and human development

Defoliating insects have higher fitness on drought-stressed trees

- Higher concentrations of nitrogen and sugars
- Western spruce budworm (WSB) and Douglas-fir tussock moth (DFTM) do not typically outbreak west of Cascades
- WSB outbreaks may develop after drought periods
- DFTM is more successful on fringes of hosts range

Sucking insects (aphids, adelgids, scales)

- More successful in wet years
- Hosts usually resilient
- Can be severely damaged if predisposed by prior drought

Oak pit scales, Columbia River Gorge 2011

Spruce aphid damage on OR and WA coast 2019

Foliar Diseases and Climate

- "New" foliar diseases being discovered as weather conditions change
- Greater incidence of some foliar diseases due to weather favoring the fungi and ability to infect host
- drought stress will likely influence symptom expression and premature foliage loss

Phytophthora pluvialis on Douglas-fir

Potential effects of climate change on insect and pathogen development and success

- Shifts in timing of host budbreak could negatively affect defoliators
- Natural enemies of defoliators could also shift timing
- Shifts in rainfall season and amounts could mean more impacts from otherwise minor foliar diseases

Western spruce budworm larva mining in swelling buds

Stand scale needle cast disease damage

Potential effects of climate change on insect and pathogen development and success

- Warmer winters could increase overwintering insect survival (for those exposed or active)
- Fewer late spring frosts could increase survival of some defoliators

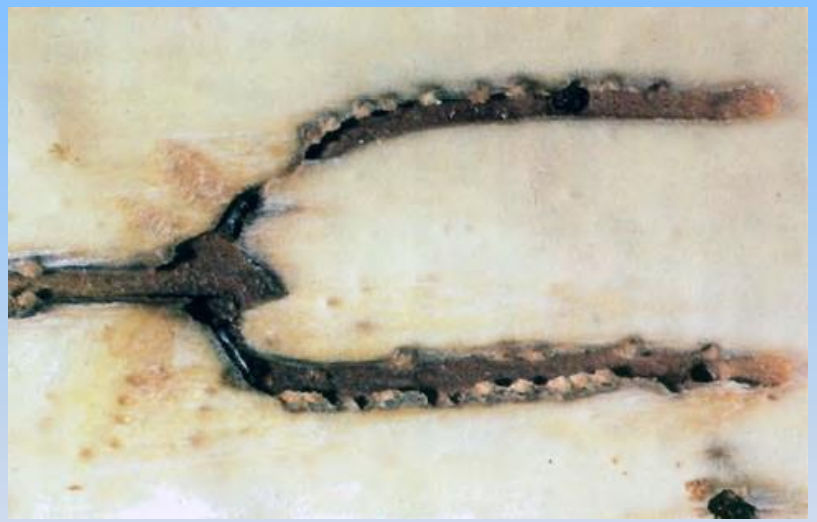
Spruce aphid is active in the winter, outbreaks can occur during mild winters

Ips pine engravers overwinter, outbreaks can occur during mild winters

Potential effects of climate change on insect and pathogen development and success

- Longer warm season could increase number of generations per year (more likely for insects with short generation times)

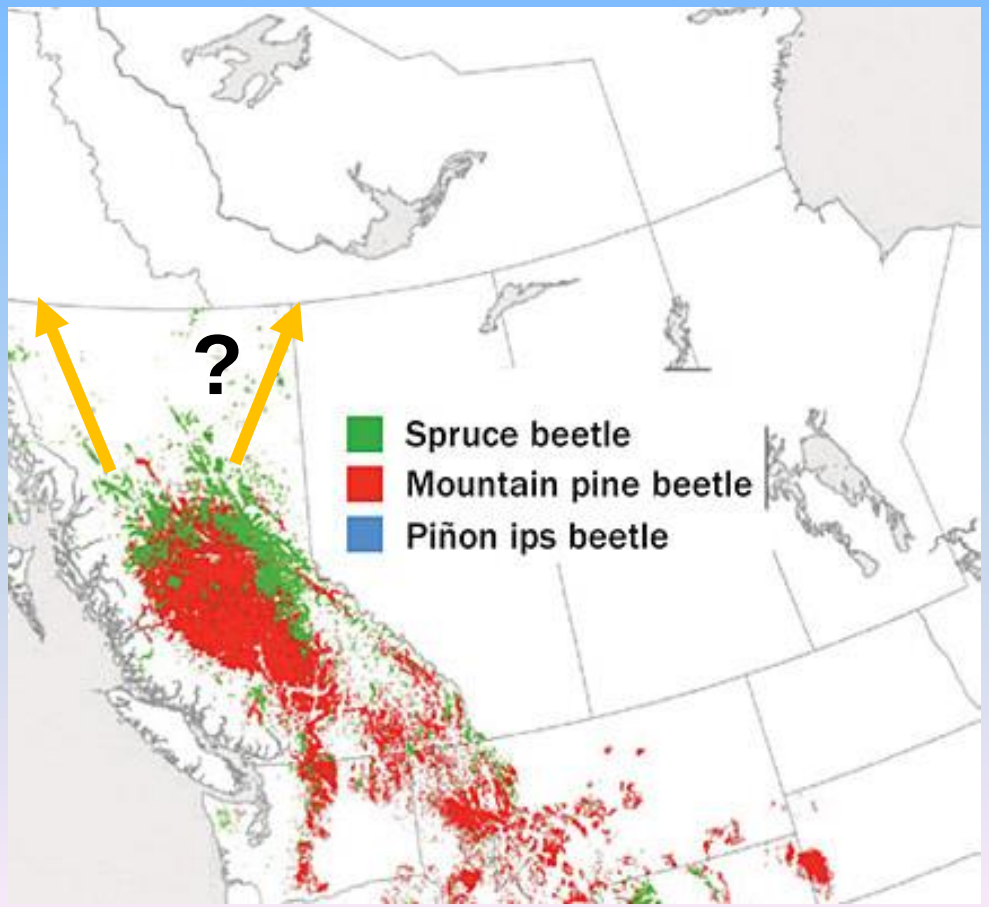
Western pine beetle has 1-2 generations/year in Washington; 3-4 in California



Ips pine engravers have 2 generations/year in WA; up to 5/yr in CA

Potential effects of climate change on insect and pathogen development and success

- Range expansions into higher latitudes and elevations could expose new hosts



- In fall, bark beetle larvae build up antifreeze compounds like **glycerol**.
- This allows them to **supercool** down to as low as -40 F.

When Washington freezes, so do invasive bugs

By PAIGE BROWNING • JAN 3, 2017

Mountain pine beetles will be challenged by the current cold weather.

FLICKR PHOTO/GOVERNMENT OF ALBERTA (CC BY-NC-ND 2.0) HTTPS://FLIC.KR/P/O3U8AX

You can thank this cold weather for making Washington's forests healthier in the new year. Forests, and backyard gardens, rely on bouts of cold weather to kill off invasive pests.

[redacted] climatologist [redacted] has one particular bug in mind: the bark beetle. They take advantage of mild conditions, like Washington experienced the past two winters in a row.

[redacted]: "Lack of cold weather has helped promote infestations of bark beetles that do real damage to forests. And so, these kind of cold air outbreaks can knock back those populations and keep our ecosystem healthier."

Native insect

Weather station in outbreak area (4,650 ft) ranged from -6 to 2 F for one week in Dec, 2016

Management approaches to reduce or prevent drought damage

- Thinning increases vigor and host defenses, reduces competition stress
- Avoid thinning during drought and mechanical damage
- Manage pine slash and blowdown (Doug-fir also)
- Address understory vegetation
- Retain or plant native & local drought-tolerant species suited for site
- Monitor surviving trees for signs of bark beetles
- Sanitation salvage if currently infested trees can be identified

Management approaches to reduce or prevent drought damage

- Landscape/ornamental trees
  - Water if possible, slowly
  - Mulch to retain soil moisture
  - Don’t fertilize during drought
  - Monitor for bud survival before removal
  - Address hazard trees
  - Avoid root damage and wounding