How Do Trees Know When to Stop Growing Each Year? And Will That Change in the Future?

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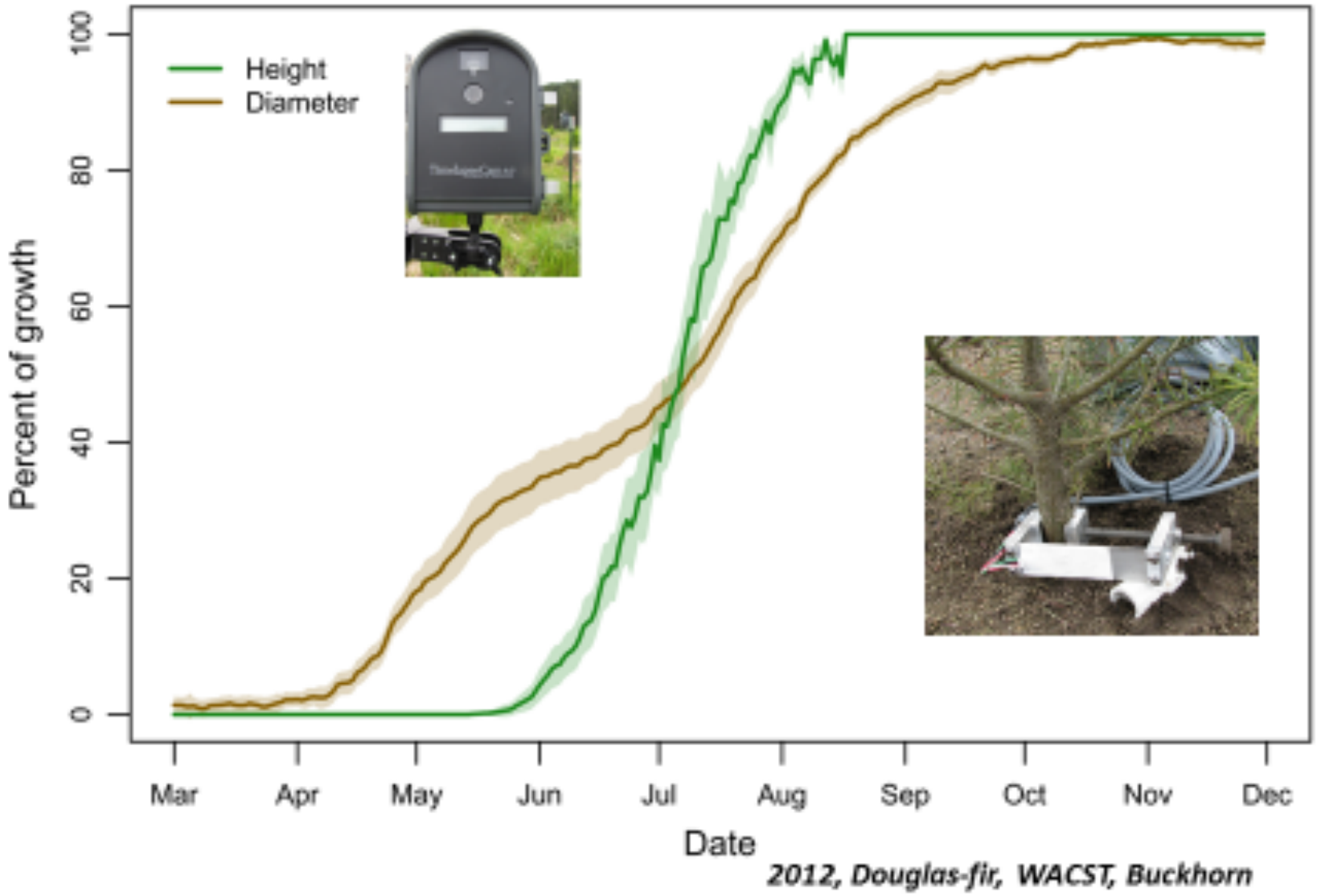
Phenology

The study of recurring biological events

- **Budburst (height growth initiation)**
- **Diameter growth initiation & cessation**
- **Flowering**
- **Insect hatches**
- **Bird migrations**
- **And many other events**

Seasonal Patterns of Height & Diameter Growth



Today's Roadmap

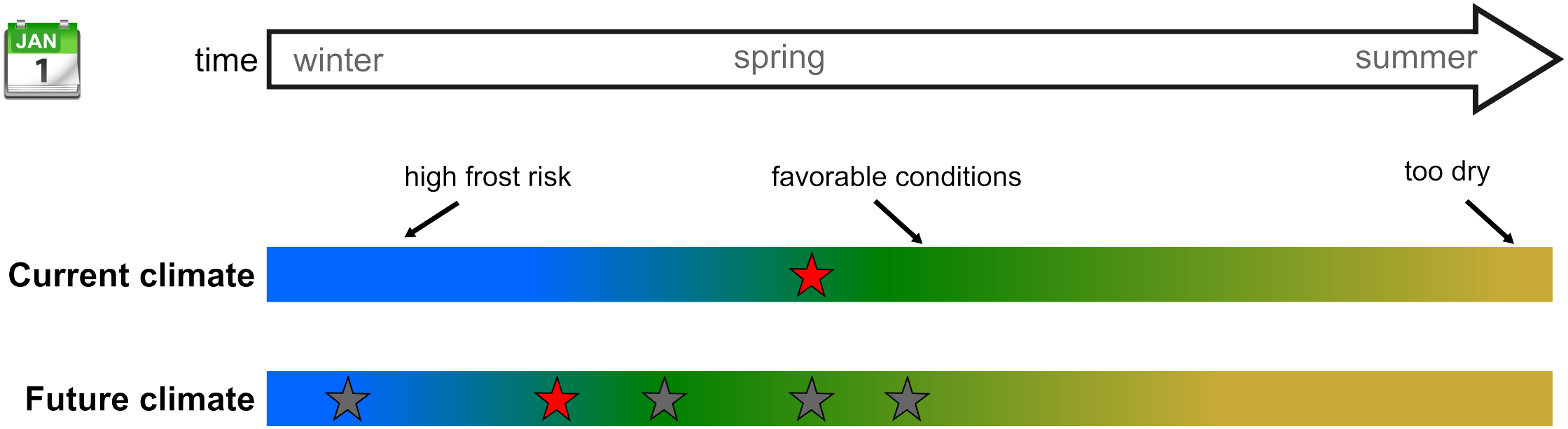
Review cues which start growth

Factors which stop tree growth

Predict future changes based on climate & our models

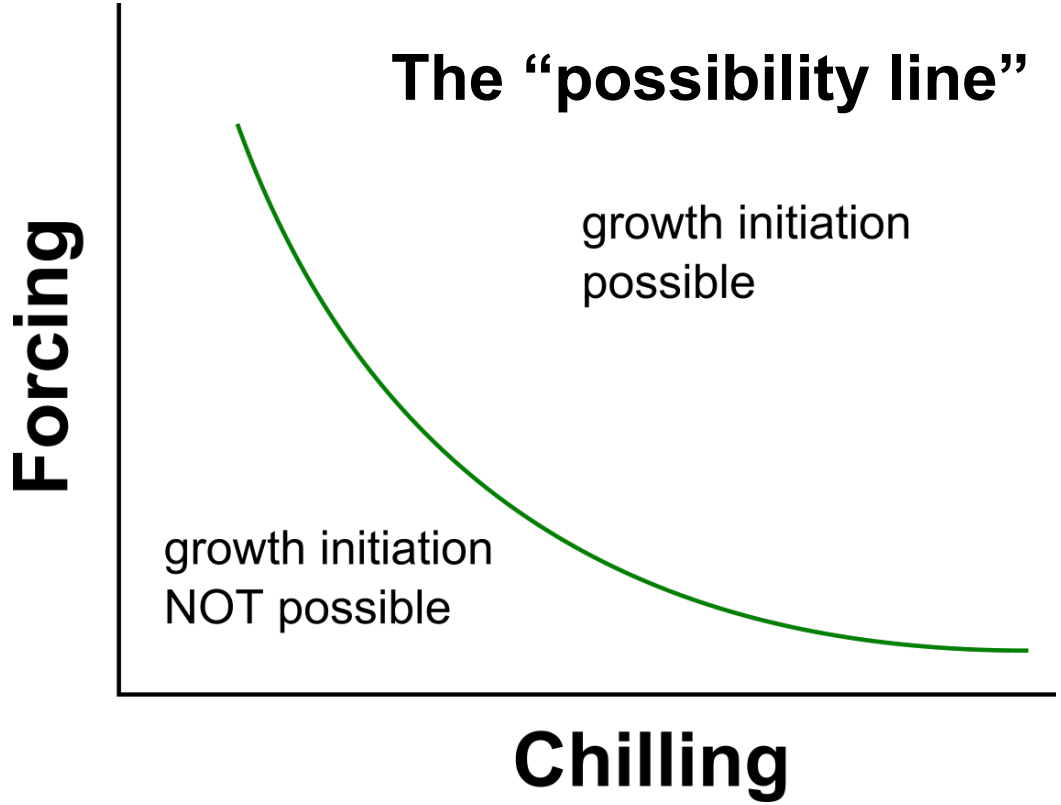
When should a tree start growing in the spring?

- Late enough to avoid frost
- Early enough to take advantage of favorable growing conditions



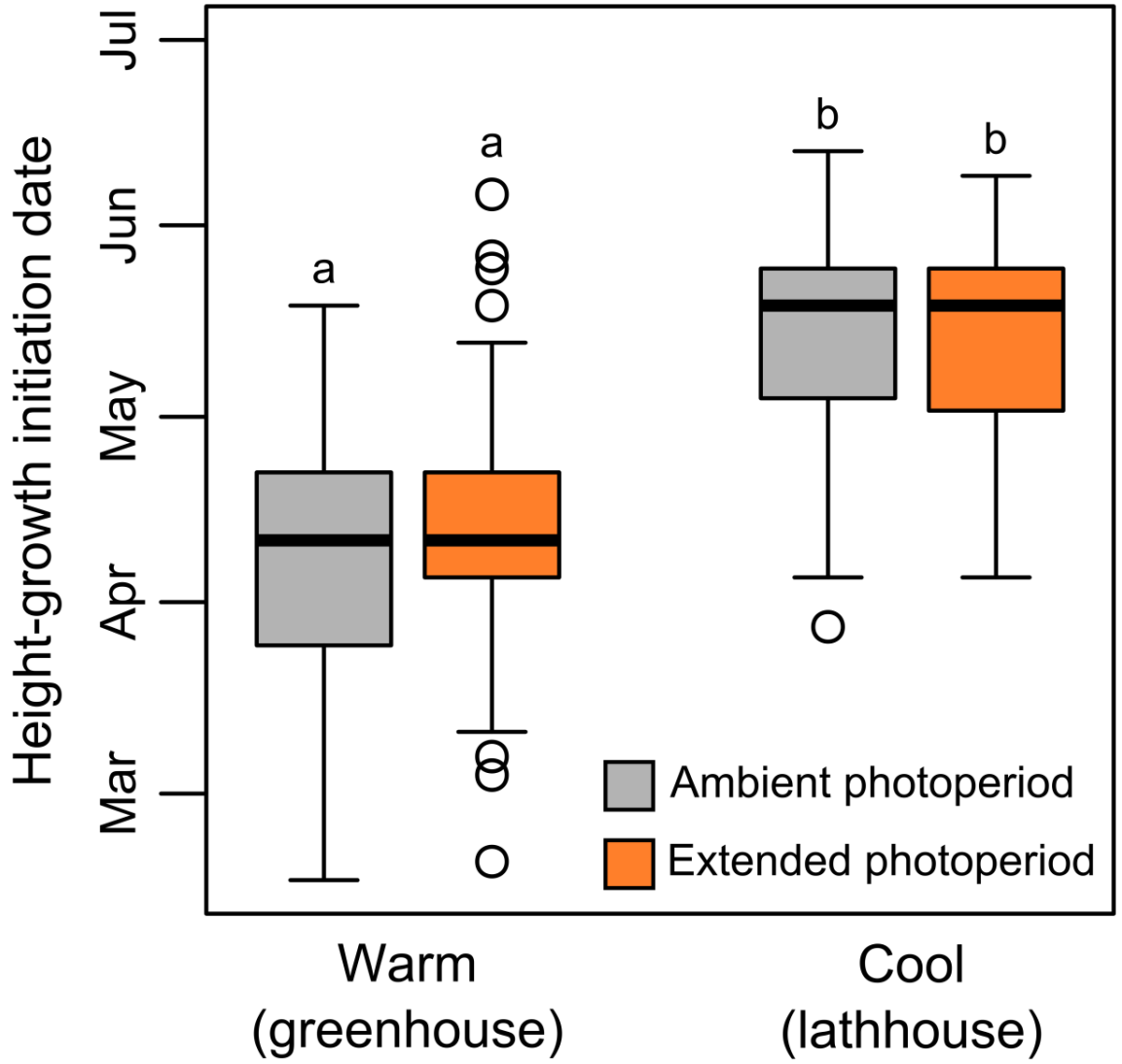
What's known about tree growth initiation – temperature cues

- Exposure to warm temperatures ("forcing")
- Amount of forcing required depends on exposure to cool temperatures ("chilling")



Based on published work for PNW species

No evidence for photoperiod on DF initiation

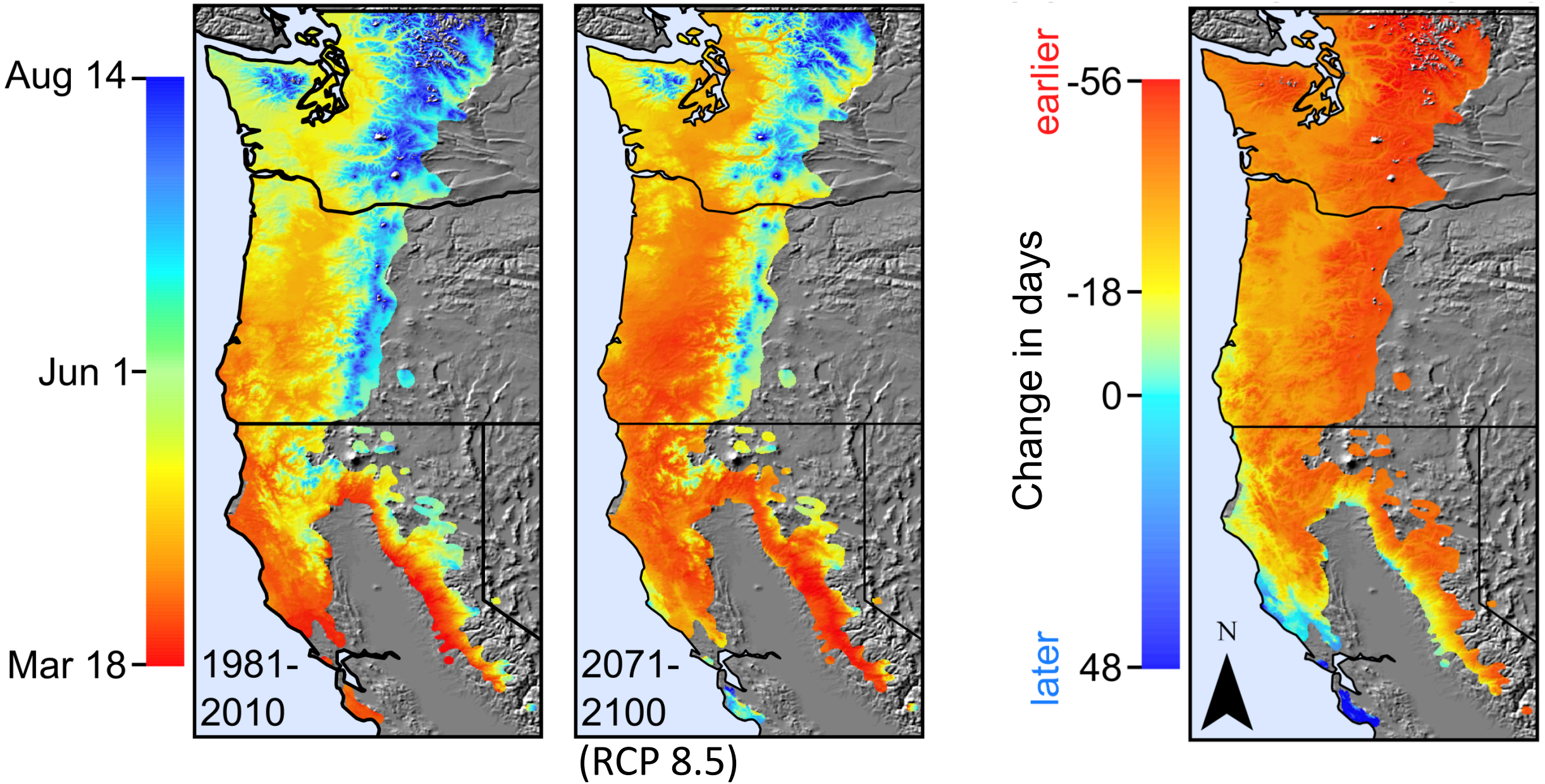


Most trees do NOT use calendars!

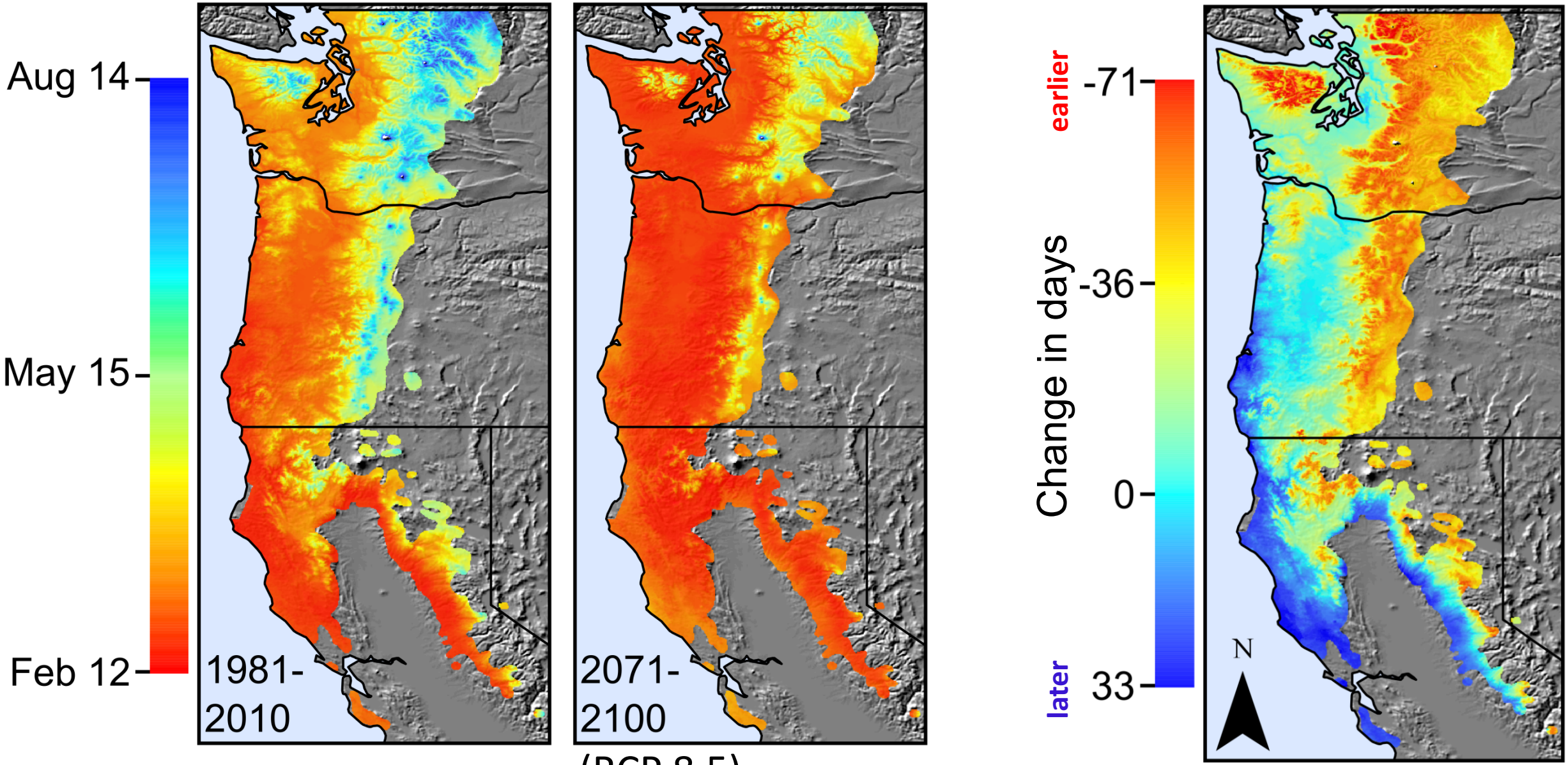
Some will respond to long photoperiod if not chilled (don't know of any PNW species that do tho)

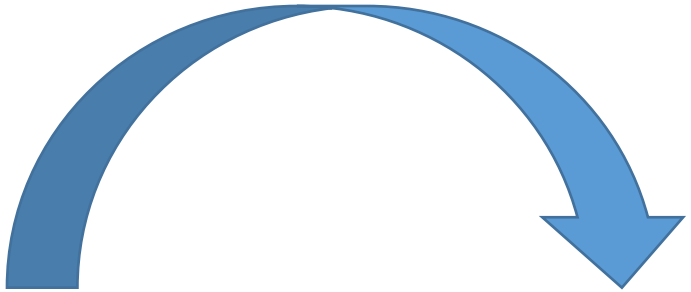
Also see Laube et al. 2014, *Global Change Biology*

DF height-growth initiation



DF diameter-growth initiation





When should a tree stop growing in the fall?

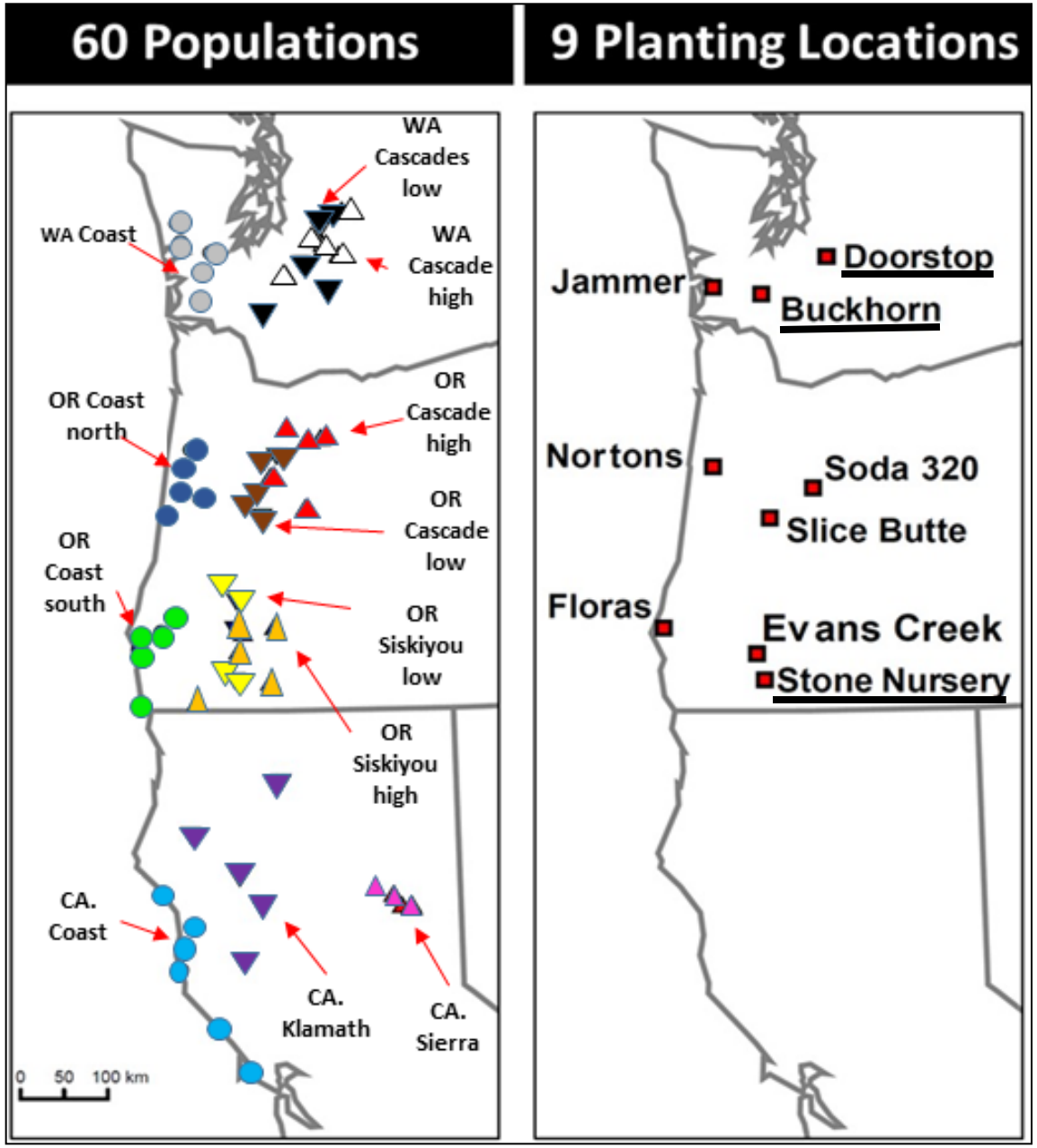
- **Late enough to take advantage of favorable growing conditions**
- **Early enough to avoid frost**
  - **Some plants conservative – stop well before typical frost**
  - **Others aggressive and will grow until frost**

What is known about cessation

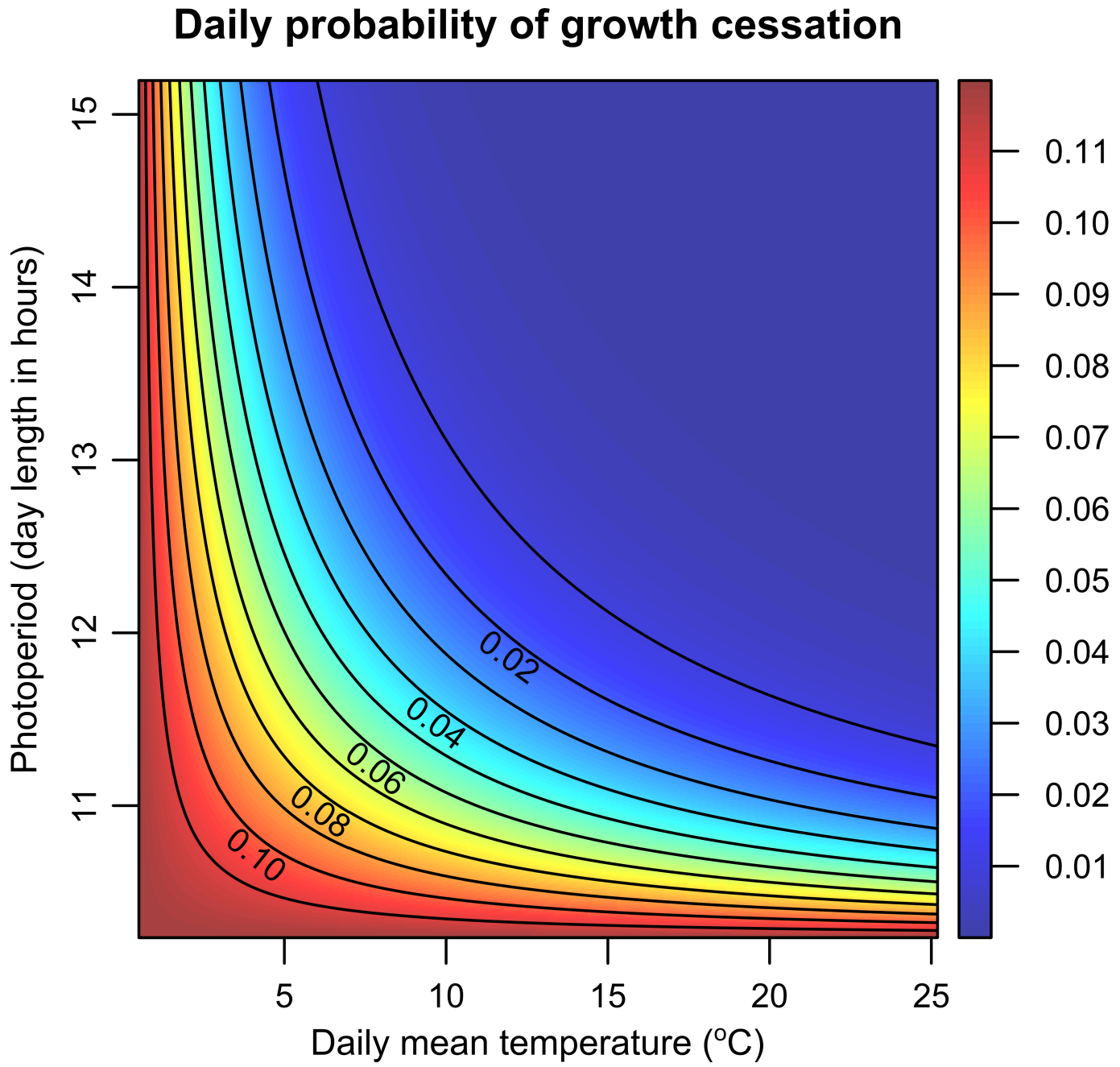
Generally assumed to rely on photoperiod and temperature – but not well modeled

Tree phenology mostly studied in spring events

Douglas-fir Seed-Source Movement Trial



Electronic dendrometers measure tree size every 30 min



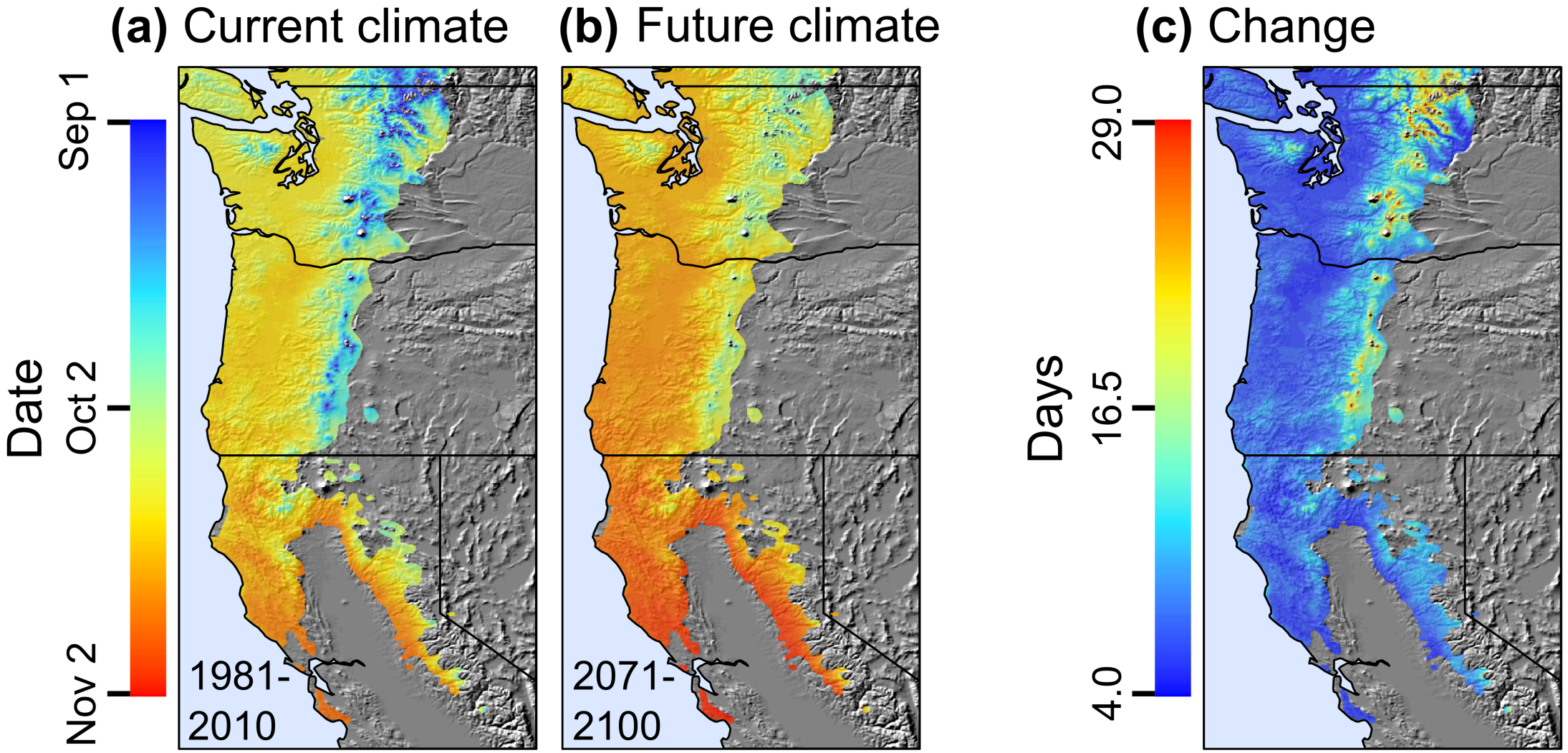
Fall Diameter-growth Cessation

Short photoperiods and low mean temperatures both increase likelihood of diameter shutdown

Based on >40 site x year field combinations for DF

Ford et al. 2017 DOI: 10.1111.gcb.13690

Diameter-growth cessation date



(RCP8.5)

Phytochromes - Pigments sense light quality/quantity

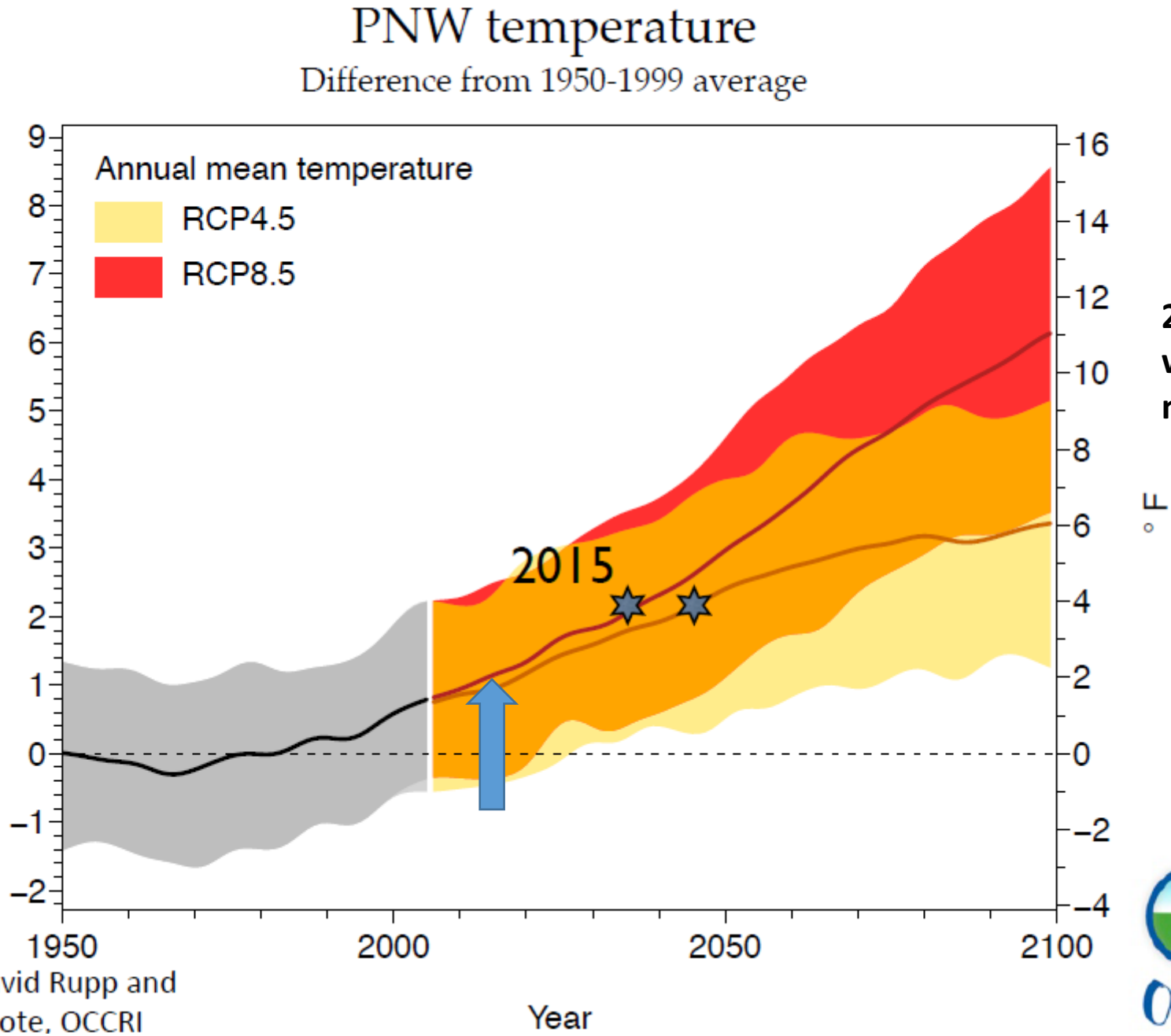
Trigger changes:

- **Seed & bud dormancy**
- **Stem elongation**
- **Flowering**

Rate of change from one phytochrome form to another is TEMPERATURE dependent. Thus, PCs could account for both daylength and temperature effects.

Legris et al 2016, Jung et al. 2016

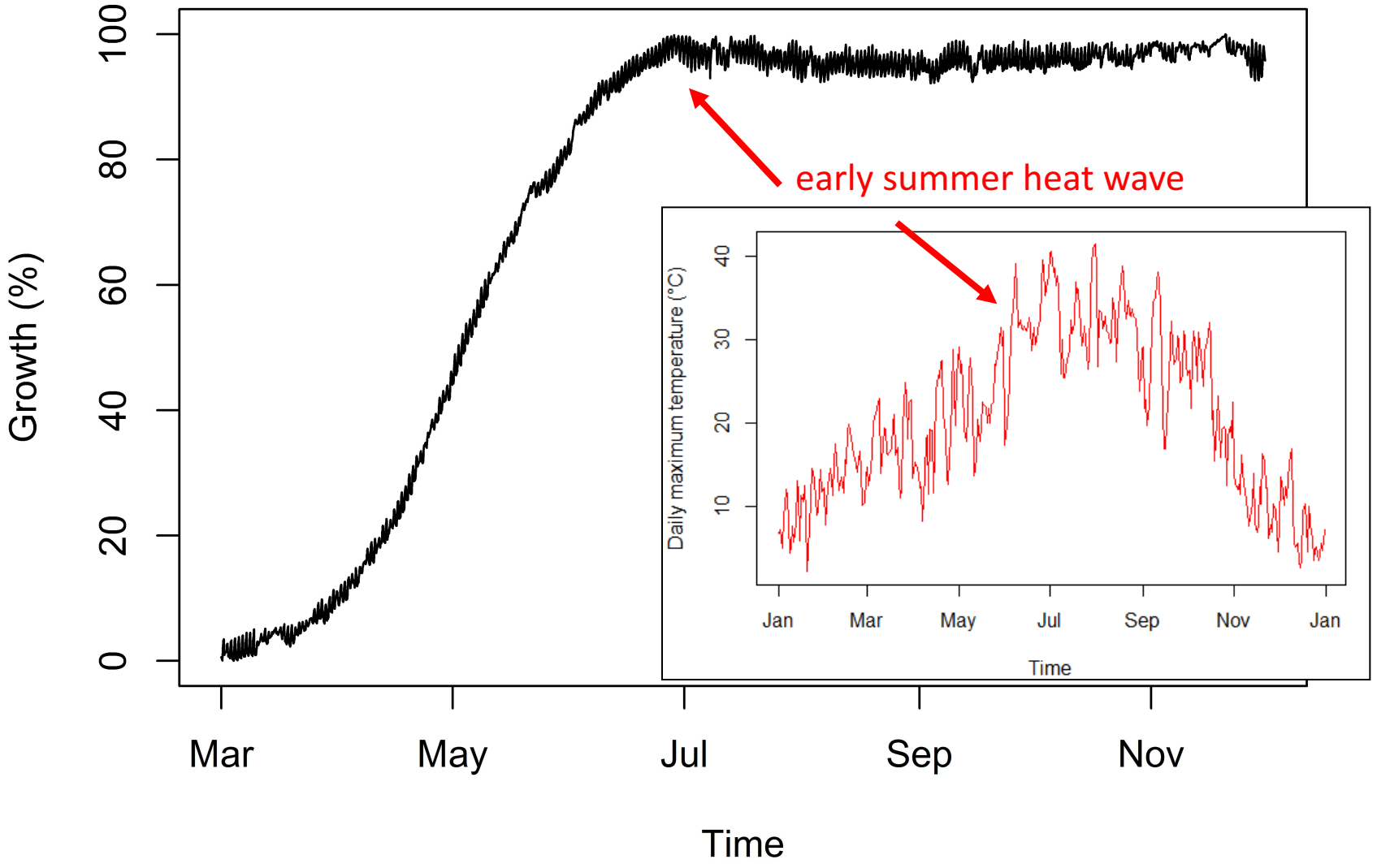
RCP = Representative Concentration Pathways
We appear to be on the 8.5 line (emissions continue to rise all century)



slide by David Rupp and Philip Mote, OCCRI

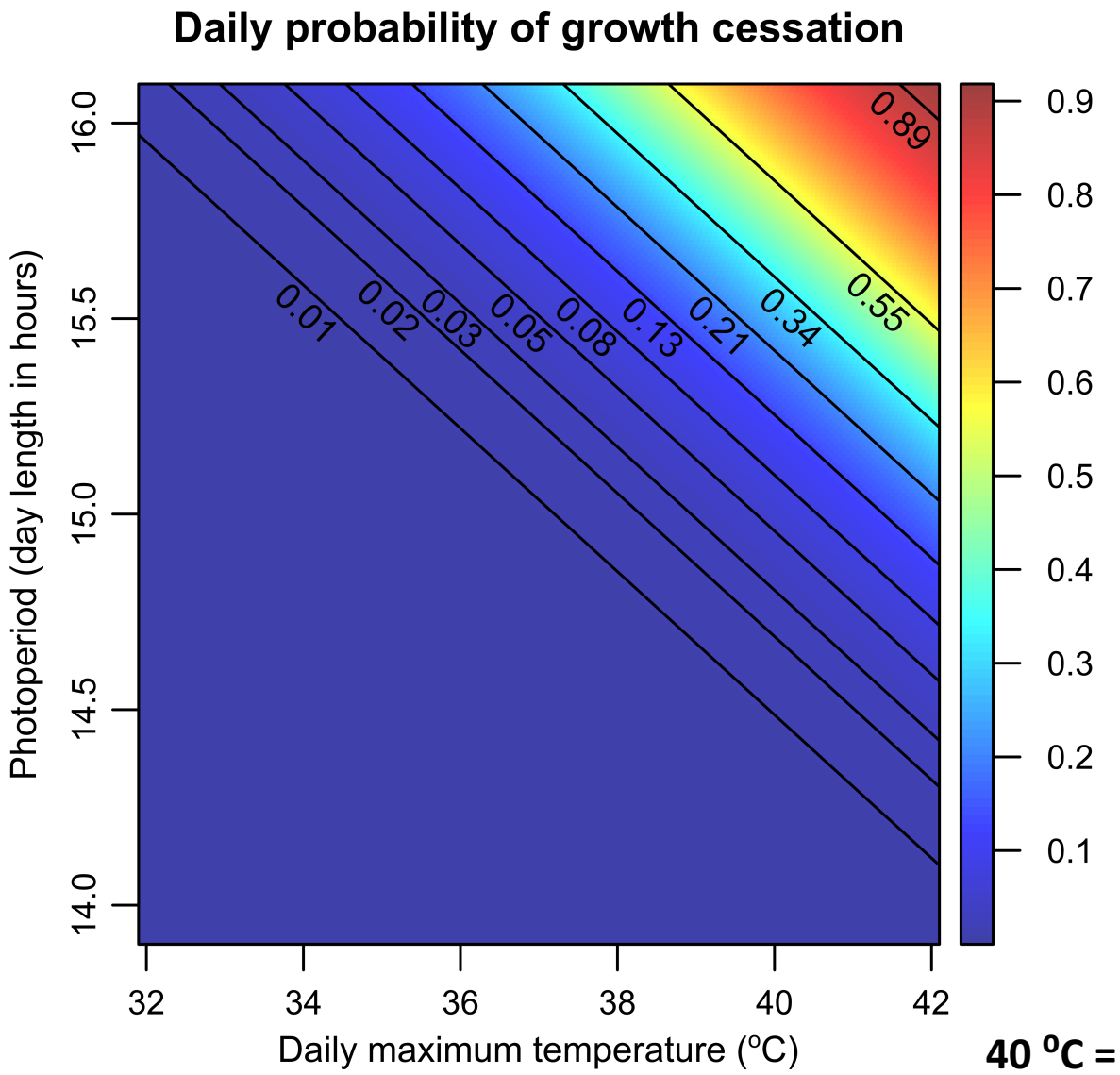
2015 was 3.9 °F (2 °C) warmer than 1950-2000 mean

Summer cessation of diameter growth Stone (Medford) 2015



40 °C = 104 °F

Summer diameter-growth Cessation



40 °C = 104 °F

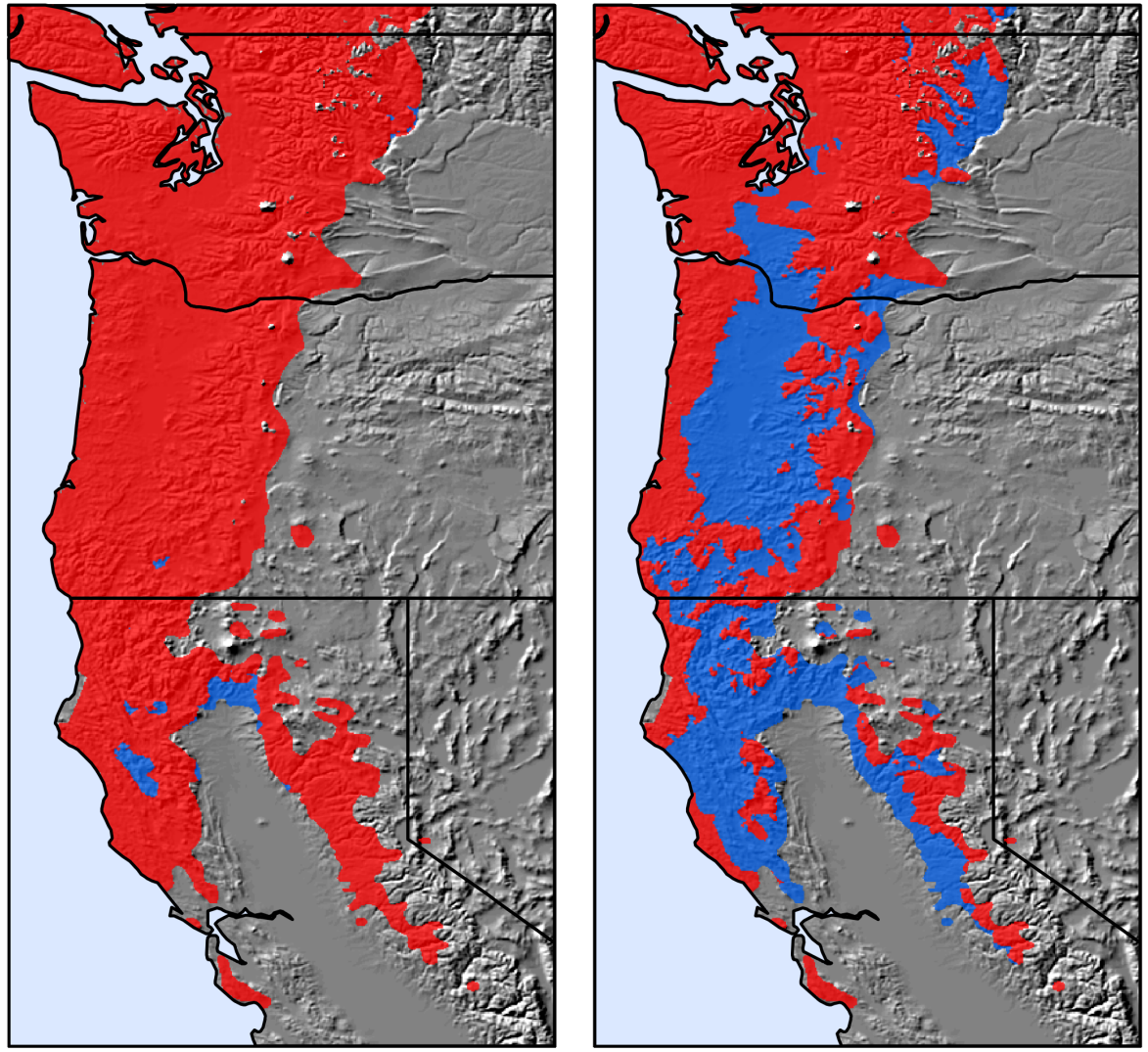
Long days and high daily max temperature can trigger early cessation

Long days = short nights to allow recovery

Model based on 1 years data only

Type of Growth-Cessation

(a) Current climate **(b)** Future climate



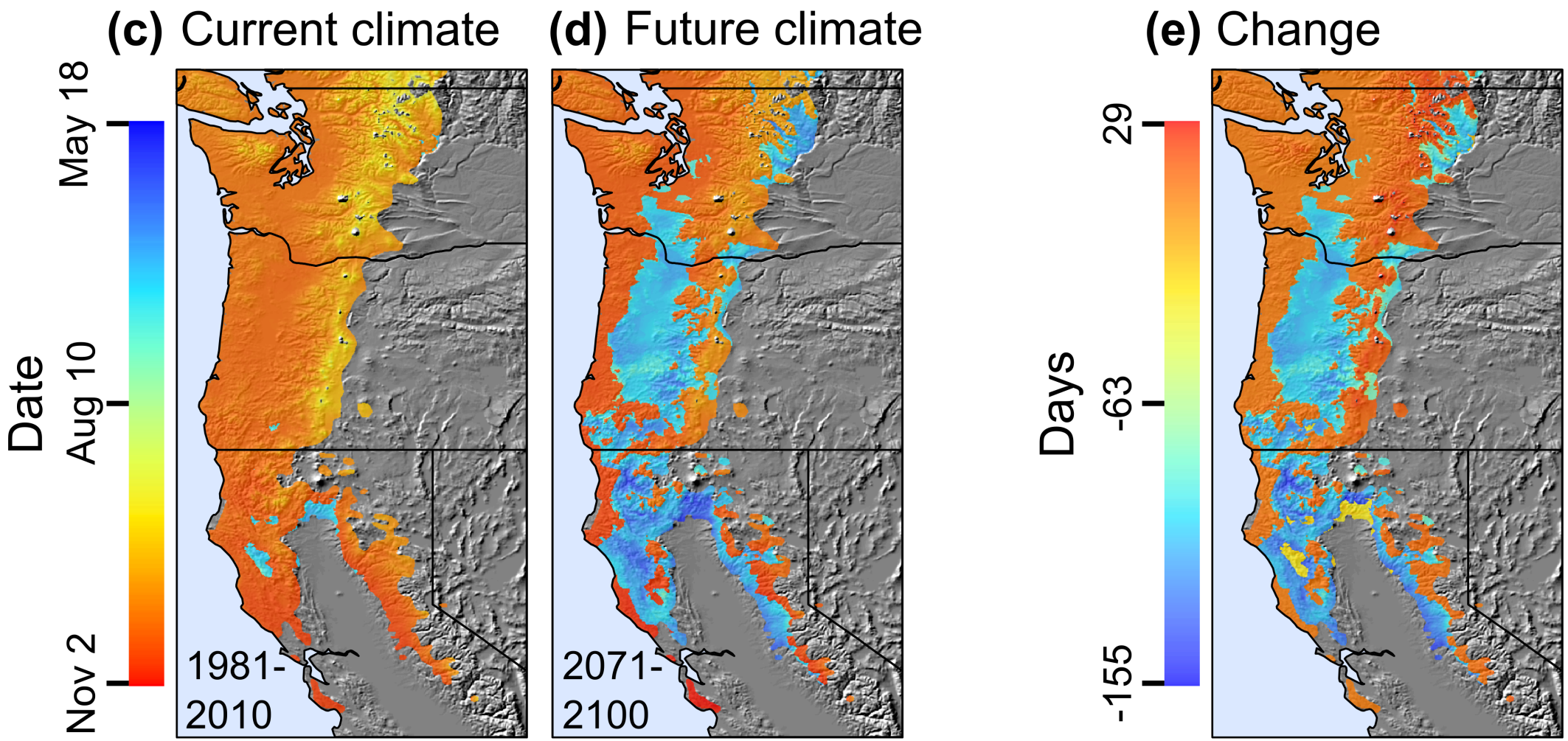
Modeling “summer” cessation based on limited data but important topic

Working on controlled environment study now

Could also study tree rings

summer
autumn

Growth-Cessation Date



Mechanisms for Summer Cessation

Reduction/cessation mitosis > 40^{o}C

Production heat shock proteins in leaves on days with high thermal stress

Reduce transport of plant hormones

Long days = fewer hours to recover

May induce cambial dormancy similar to heat-induced dormancy in seeds

Diameter growth

Cessation - Ends later at high latitudes, cool climates

Limited by photoperiod at low latitudes

May TIP to summer cessation with very high temperatures

Final Thoughts

Modeling of precip & extreme temps less developed than for mean temp

Insects, diseases, fires interact/alter tree responses

Final Thoughts

Future responses could be incremental or have tipping points (e.g., diameter growth cessation)

Earlier cessation could alter not just diameter growth but also future drought resistance if less latewood

Height Cessation - Next research topic

Bud set and cessation of height growth are not the same as substantial growth can occur after bud scales are formed and a bud is set

Data from repeated measurements or TL cameras look at cessation – but not budset

Acknowledgements

Supporters

- **Bureau of Land Management**
- **USDA Forest Service PNW Res. Station**
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- **Roseburg Resources**
- **Starker Forests**
- **USFS Stone Nursery**
- **Washington DNR**

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Northwest Science annual meeting Evergreen State College, Olympia, WA March 27-30, 2018

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Questions?
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