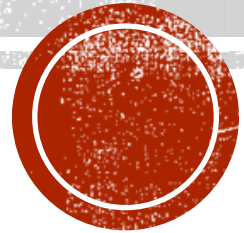
**Workshop on Summer Low Flows in Western Oregon:
Processes, Trends, Uncertainties, and Forest Management**

EVAPOTRANSPIRATION VARIABILITY ACROSS DOMINANT ECOSYSTEMS IN THE PNW



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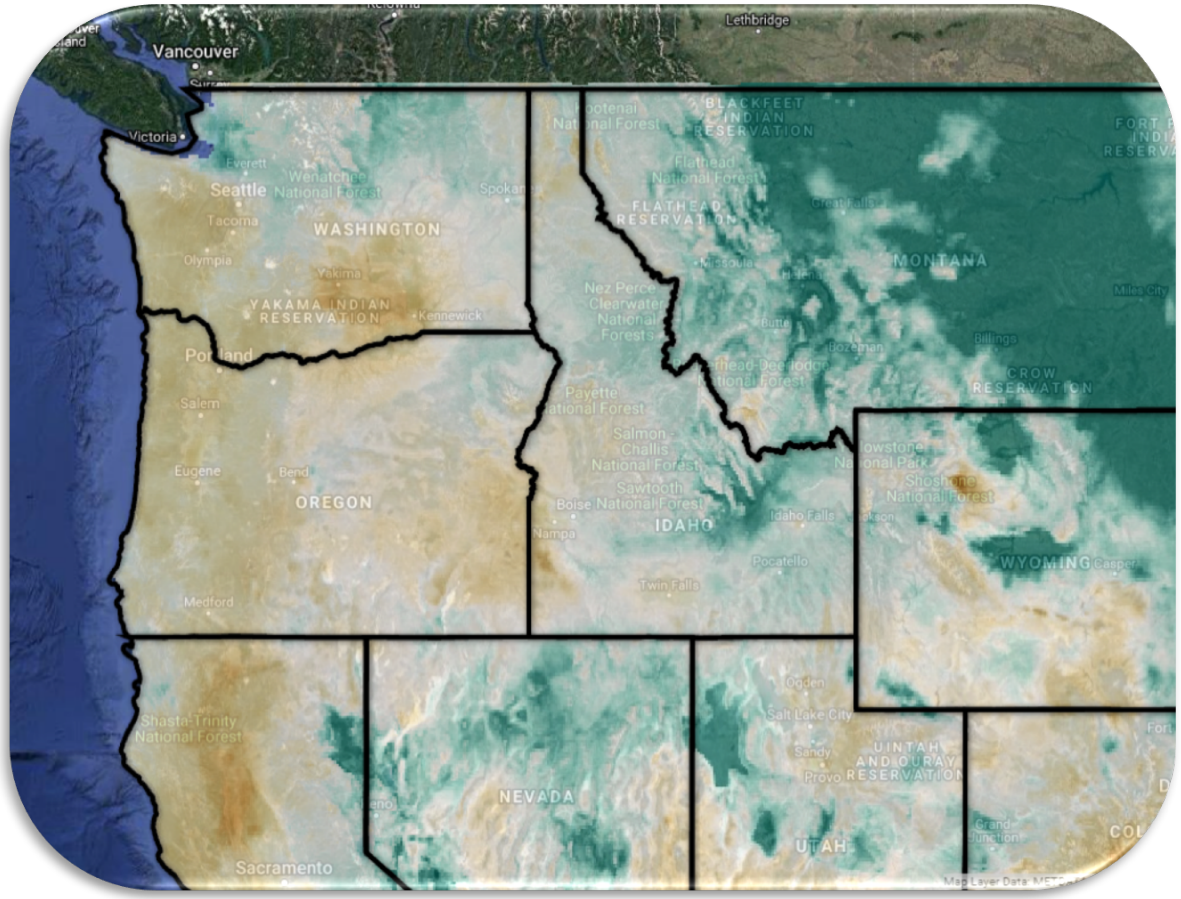
Oregon State University

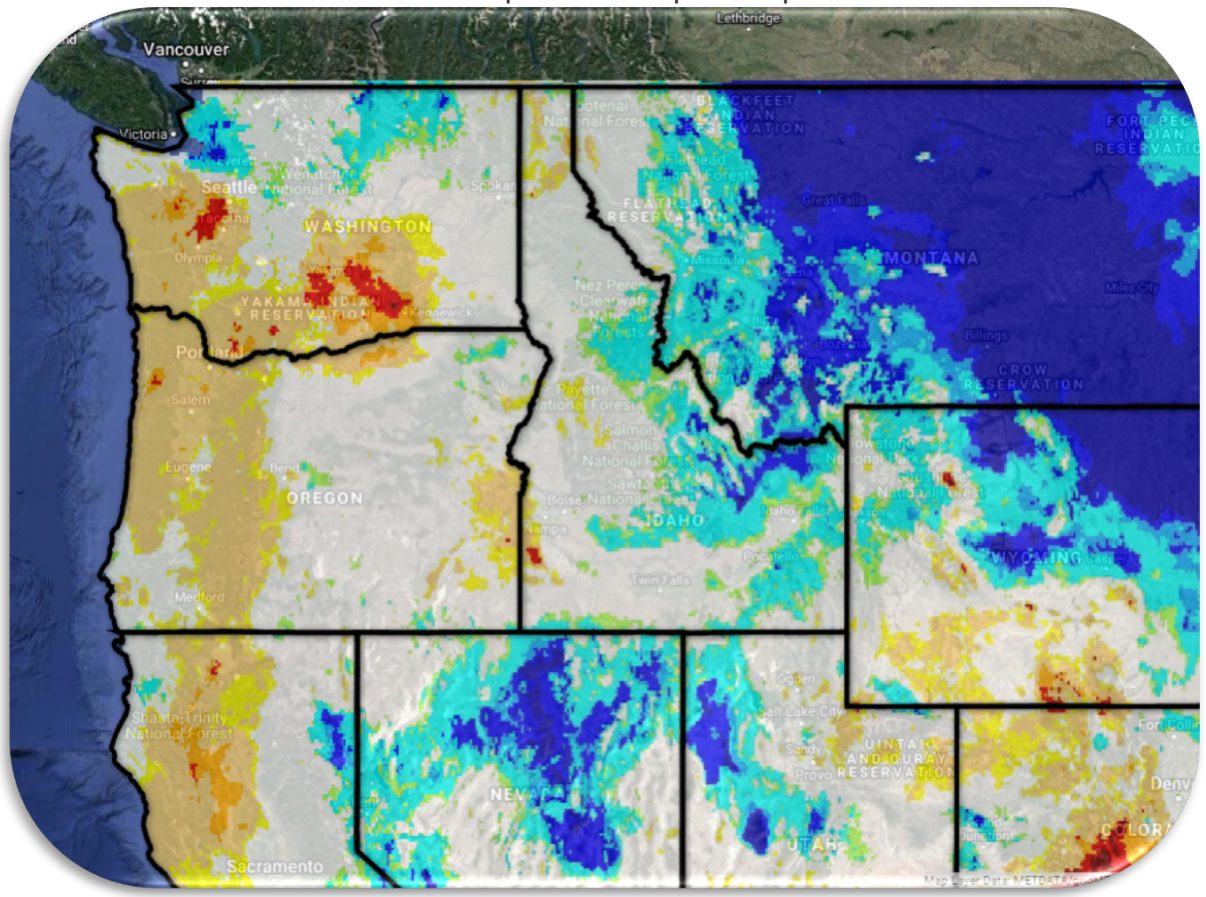
How Does Precipitation Look So Far This Year?

Precipitation



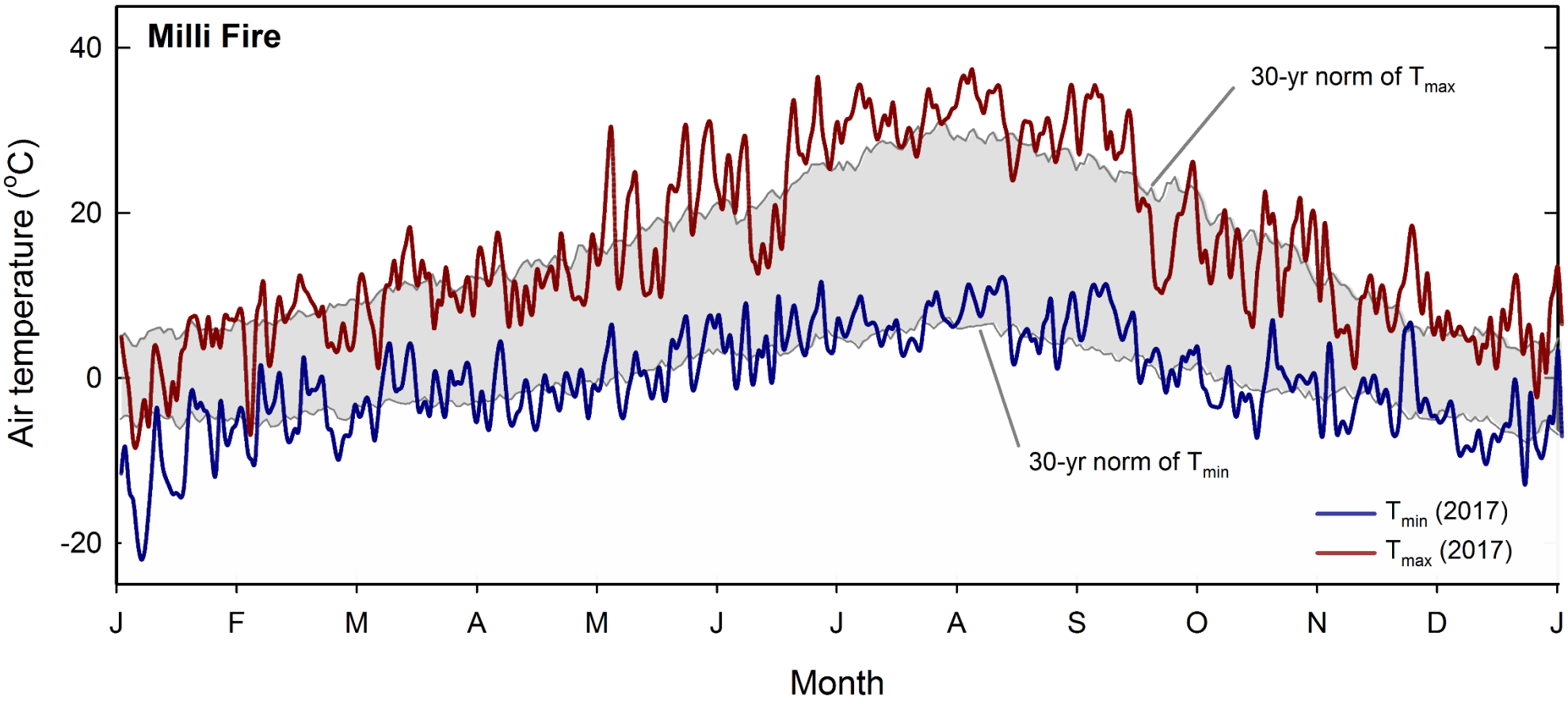
Drought Index (SPEI)

Standardized Precipitation Evapotranspiration Index

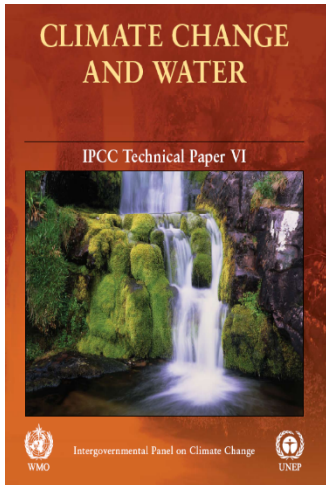


source: https://app.climateengine.org/

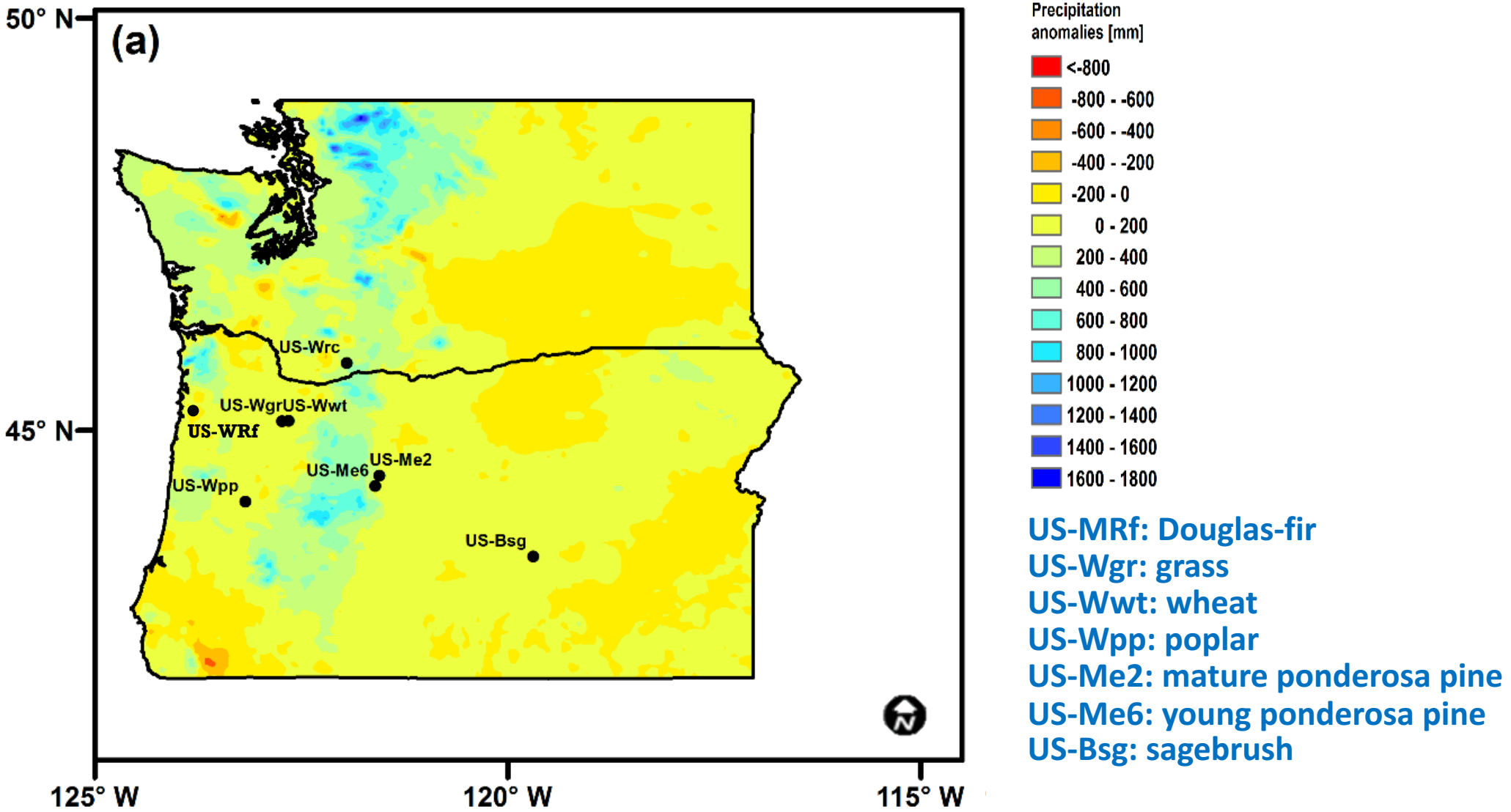
Increased T_{max} And T_{min}



Progress in knowledge depends on ***improved data availability*** *... Relatively short records may not reveal the full extent of natural variability and confound detection studies ...* ***Major gaps in observations*** *of climate change related to freshwater and hydrological cycles are:*



precipitation, streamflow, soil moisture, and ***actual evapotranspiration***



US-MRf: Douglas-fir
US-Wgr: grass
US-Wwt: wheat
US-Wpp: poplar
US-Me2: mature ponderosa pine
US-Me6: young ponderosa pine
US-Bsg: sagebrush

Strong gradient from the coast to the inland

Scientific Objectives

- Characterize and quantify evapotranspiration of different ecosystems (from high desert sagebrush steppe to ponderosa pine to Douglas-fir) across temperature and hydrological gradients
- Assess the mechanism (climatological and biological components) that controls evapotranspiration

Focus of the presentation are:

- on seasonal patterns and controlling mechanism of evapotranspiration at three forest sites

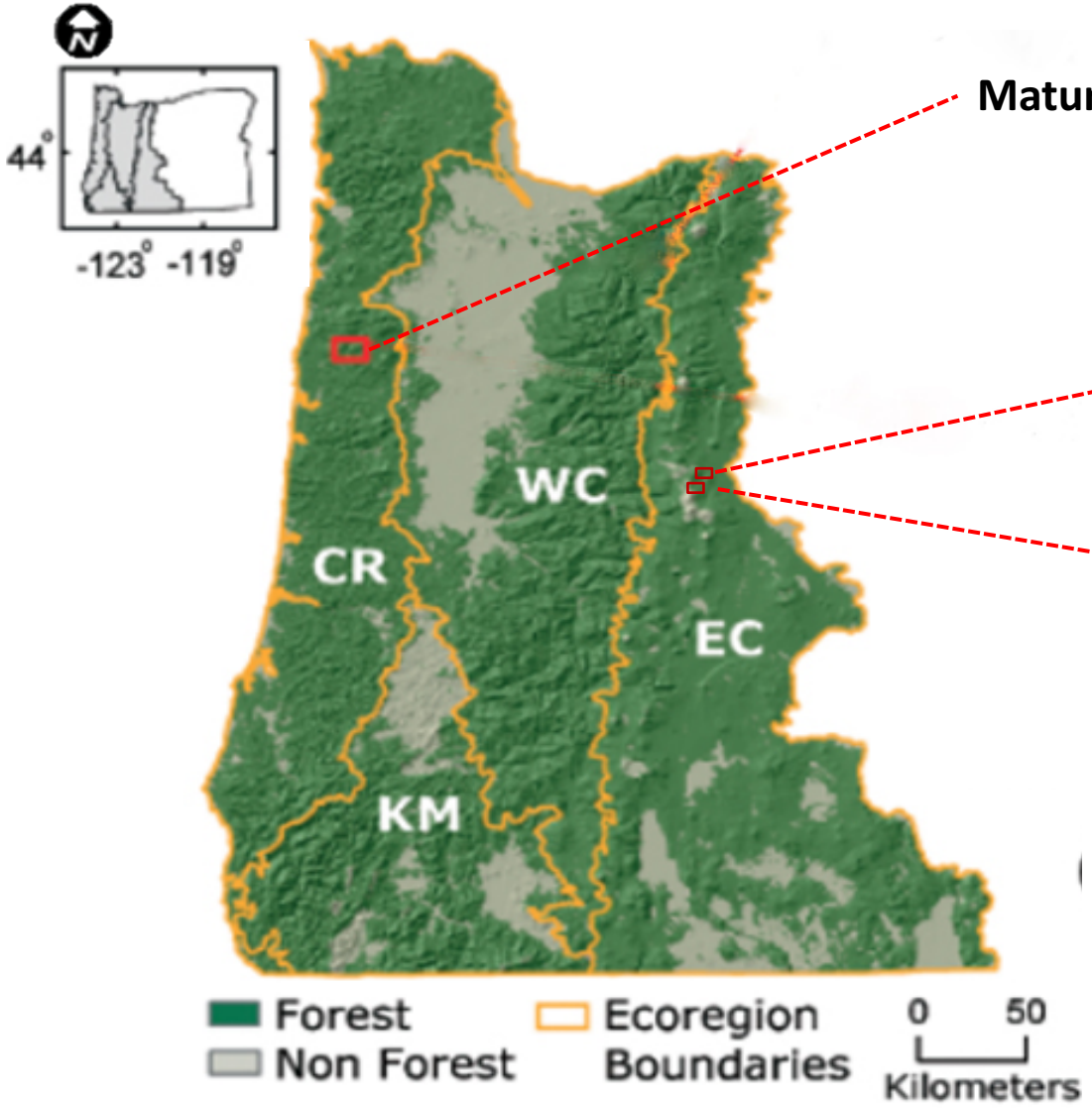
- on evapotranspiration variation at seven sites

$$\text{Evapotranspiration} = \text{Evaporation} + \text{Transpiration}$$

$$\text{Precipitation} = \text{ET} + \text{runoff} + \text{ground water} + \text{storage}$$

$$\text{Net radiation} = \lambda E + \text{sensible heat} + \text{ground heat} + \text{storage}$$

Study Sites

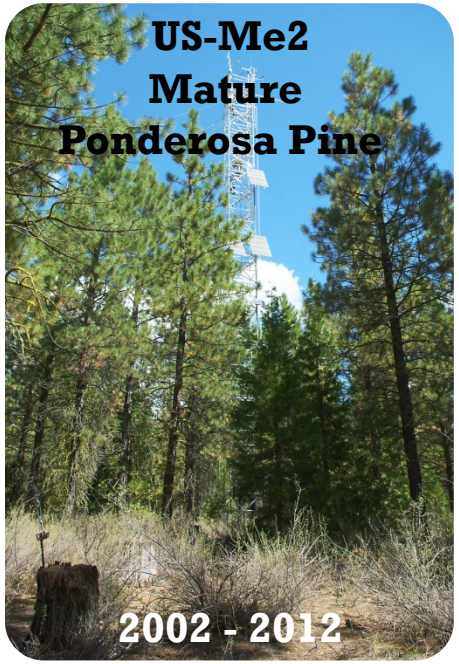


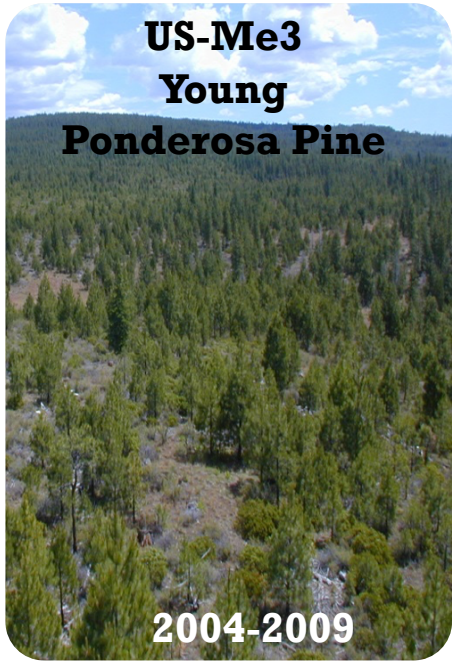
Mature Douglas-Fir (US-MRf)

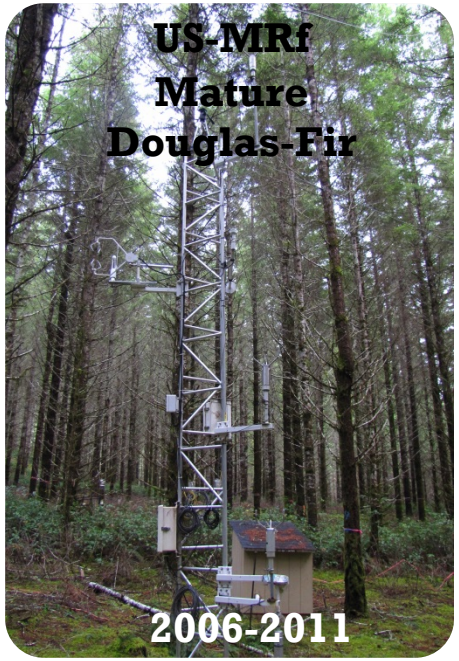
Mature Ponderosa Pine (US-Me2)

Young Ponderosa Pine (US-Me3)

CR: Costal Range WC: West Cascade EC: East Cascade



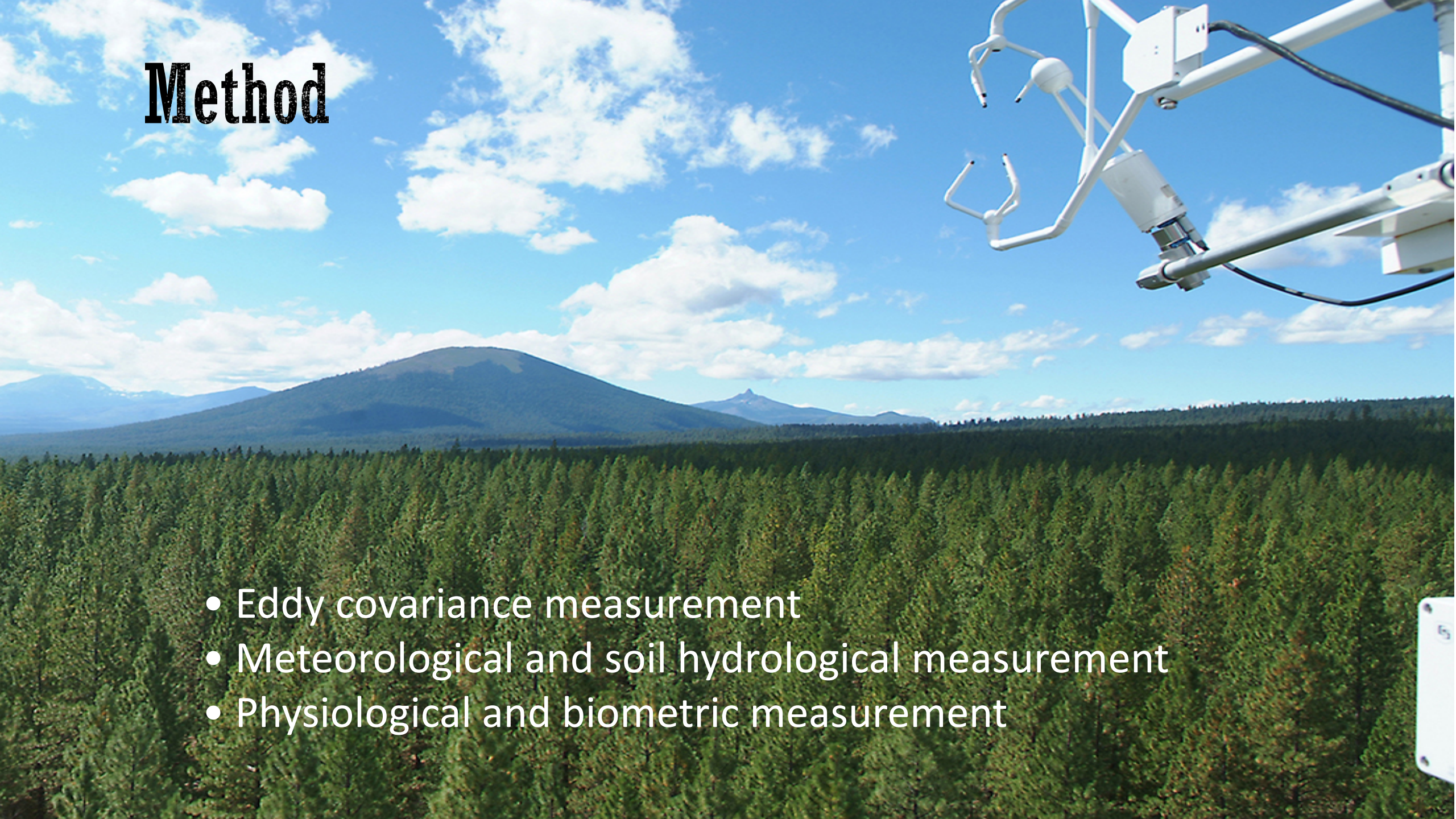




	US-Me2	US-Me3	US-MRf
Mean age (years)	64	16	58
Mean height (m)	22.0	3.3	34.0
Density (trees ha^{-1})	325	260	400
Maximum LAI	2.8	1.8	9.0
30-yr norm T_{air} (°C)	7.5	7.6	10.6
30-yr norm Prec (mm)	530	494	1820

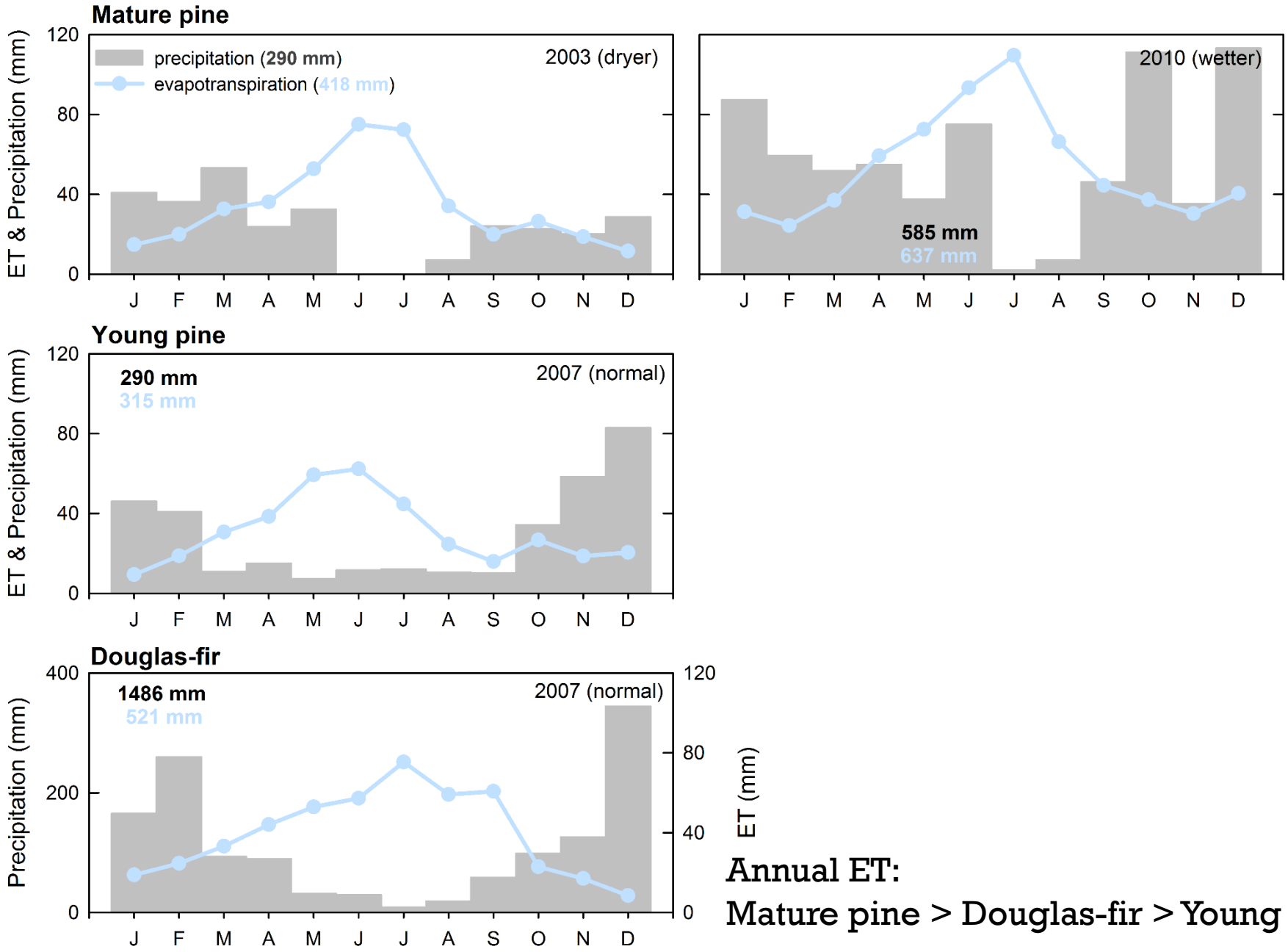
Source of 30-yr normal: PRISM (Parameter-elevation Regressions on Independent Slopes Model) data

Method



- Eddy covariance measurement
- Meteorological and soil hydrological measurement
- Physiological and biometric measurement

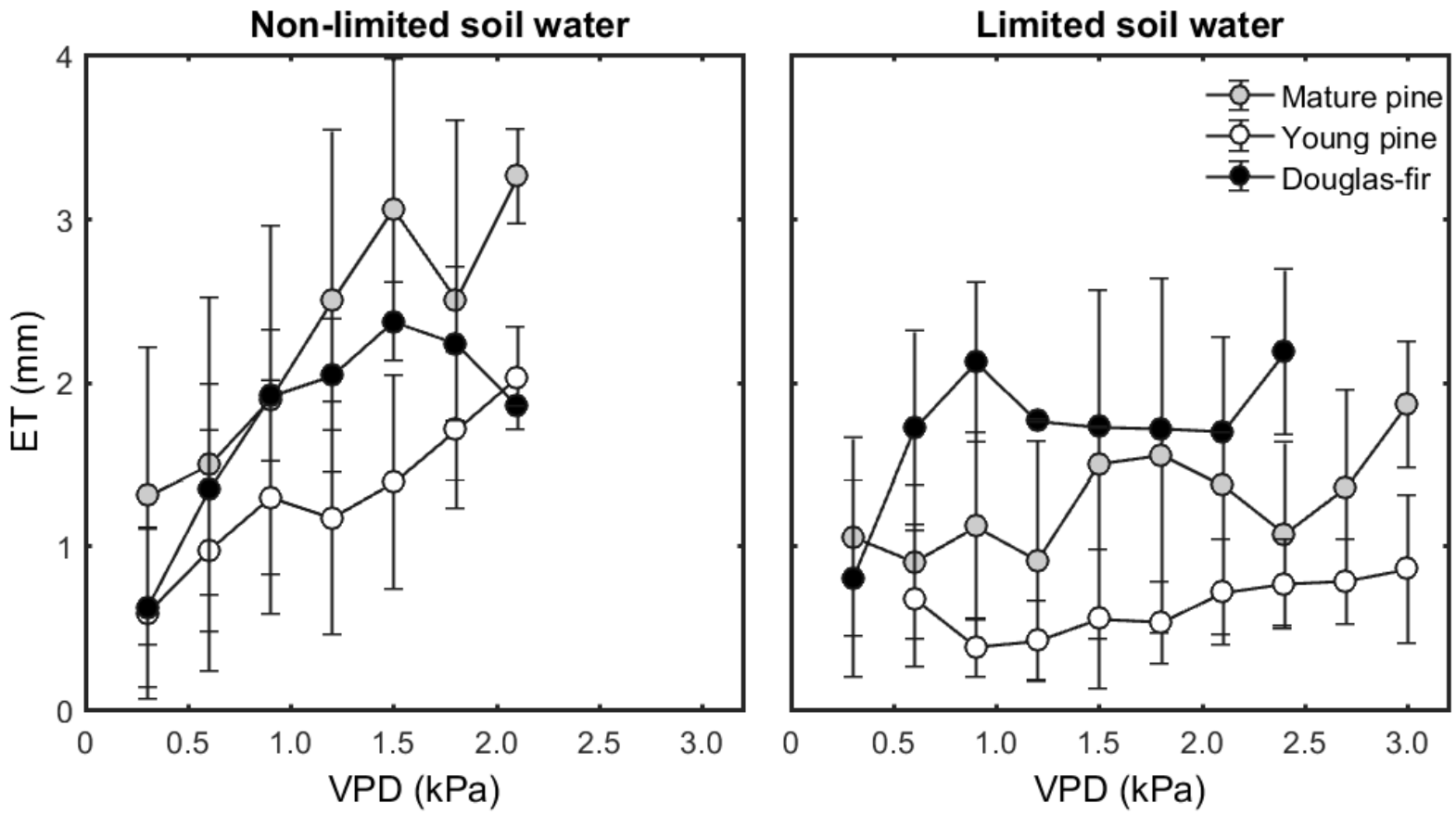
Seasonal Pattern



Annual ET:

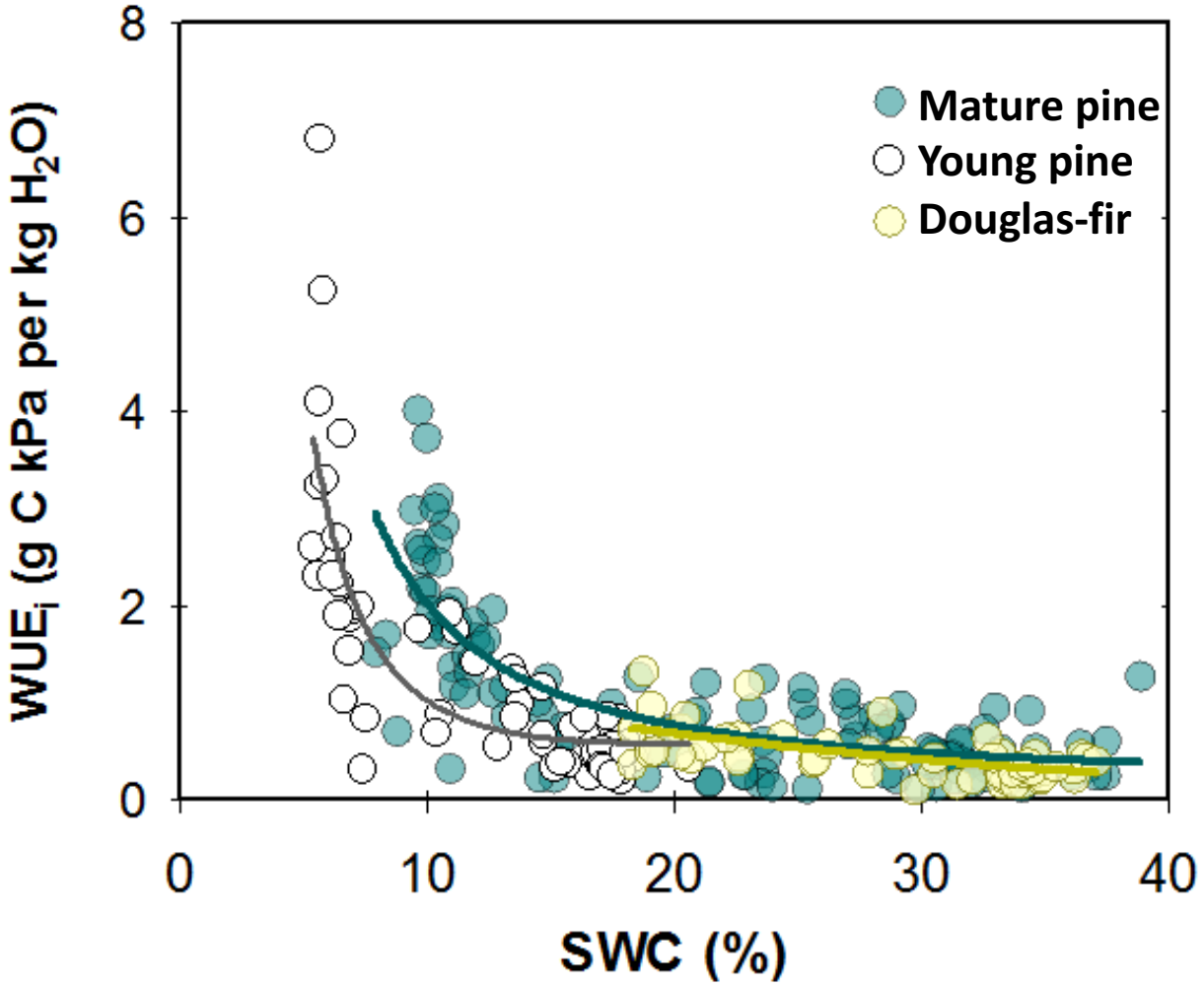
Mature pine > Douglas-fir > Young pine

Controlling Mechanism



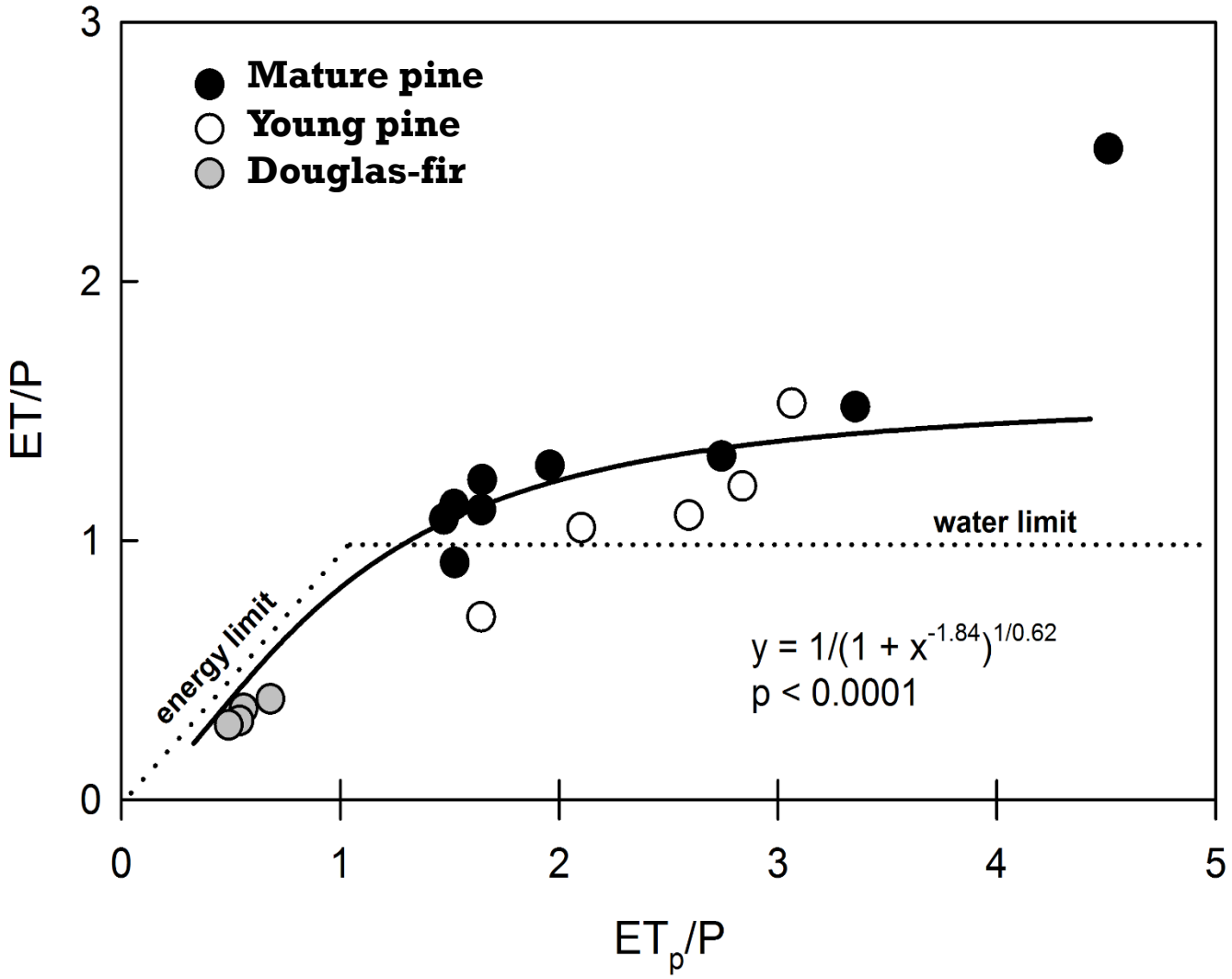
VPD: vapor pressure deficit

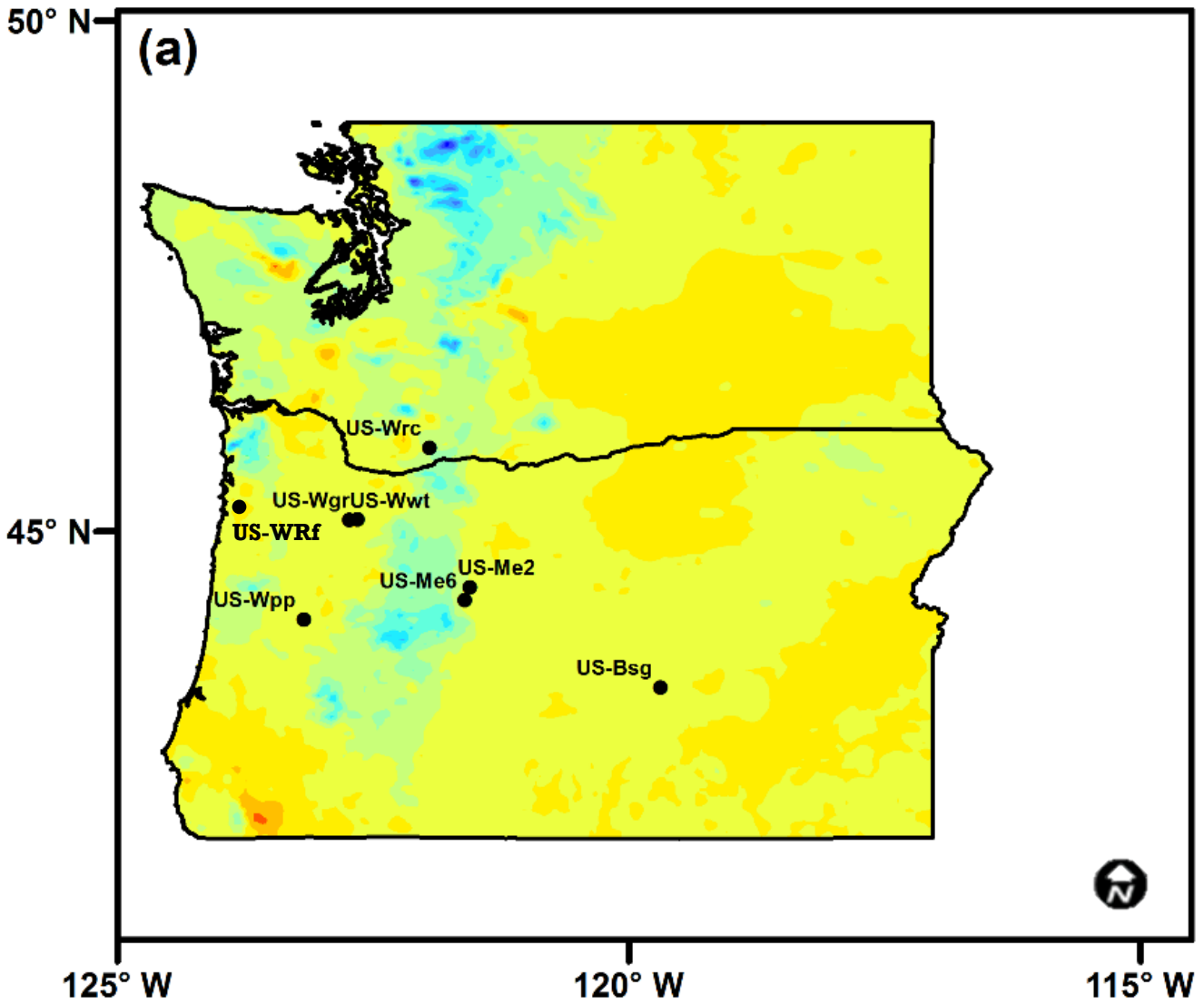
Inherent Water Use Efficiency, WUE_i = GPP*VPD/ET



GPP: gross primary production
VPD: vapor pressure deficit
ET: evapotranspiration

Water Vs. Energy-limited Conditions





Precipitation anomalies [mm]

- <-800
- -800 - -600
- -600 - -400
- -400 - -200
- -200 - 0
- 0 - 200
- 200 - 400
- 400 - 600
- 600 - 800
- 800 - 1000
- 1000 - 1200
- 1200 - 1400
- 1400 - 1600
- 1600 - 1800

US-MRf: Douglas-fir
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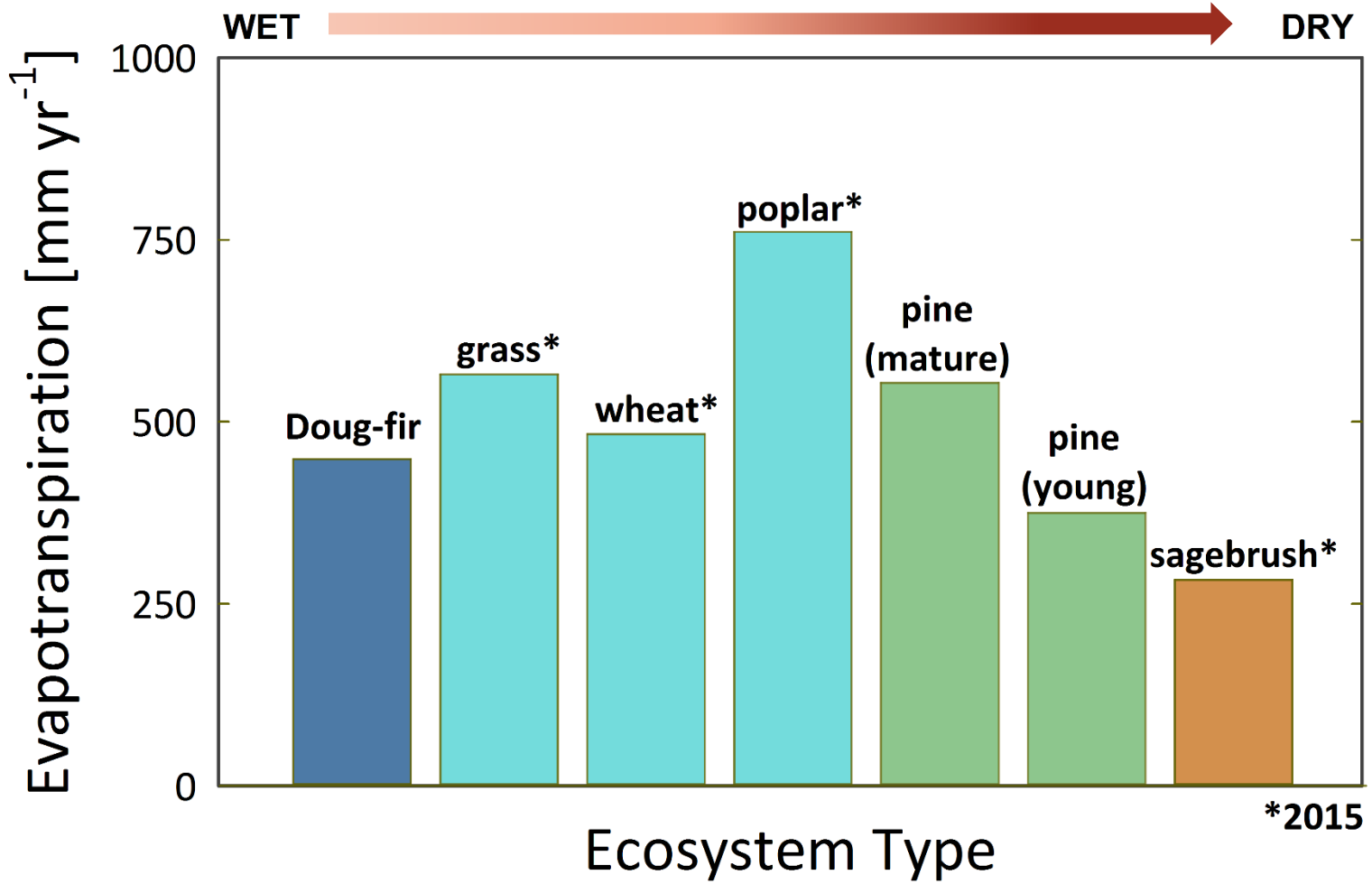
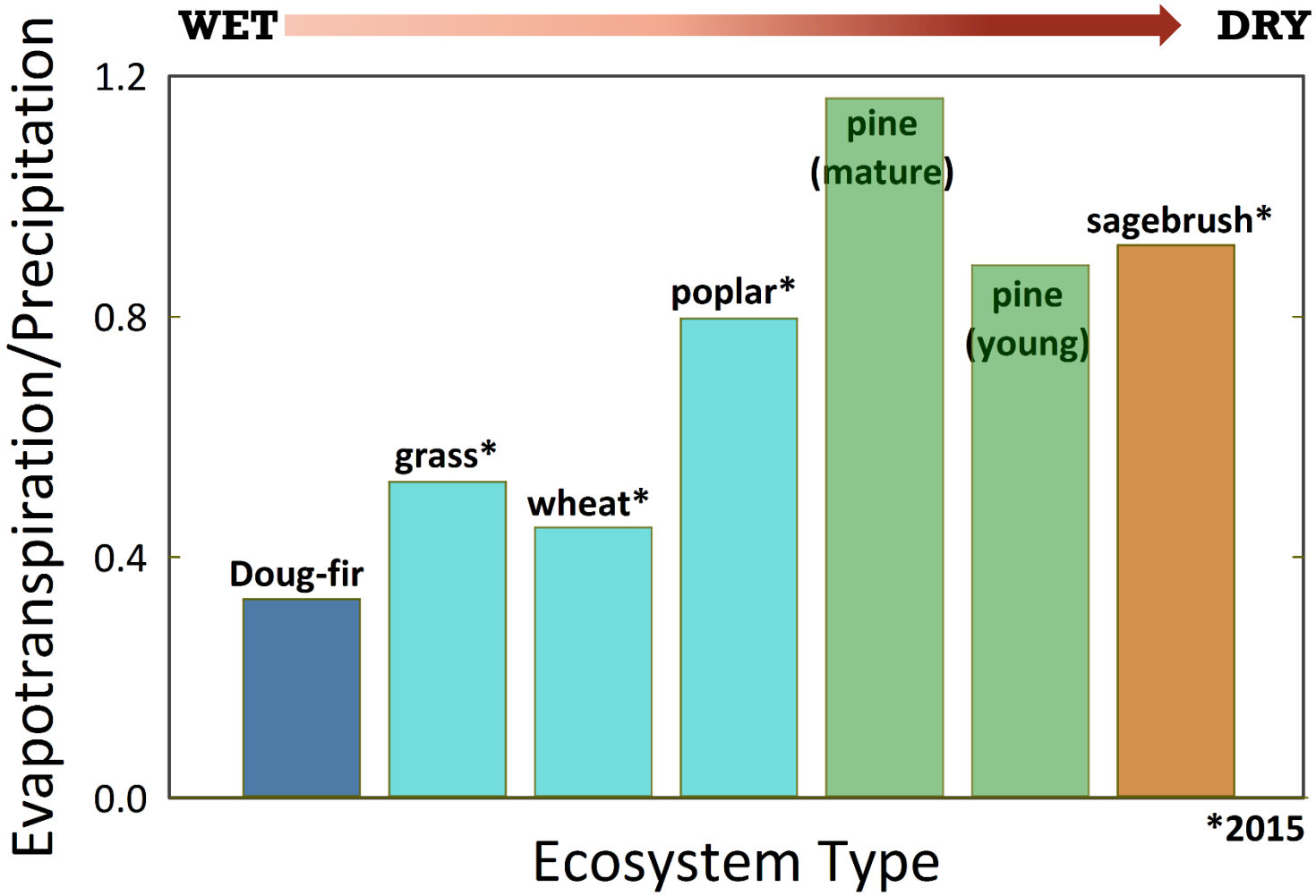

WET
DRY
Evapotranspiration [mm yr-1]
1000
750
500
250
0
Doug-fir
grass*
wheat*
poplar*
pine (mature)
pine (young)
sagebrush*
*2015
Ecosystem Type


WET
DRY
Evapotranspiration/Precipitation
1.2
0.8
0.4
0.0
Doug-fir
grass*
wheat*
poplar*
pine (mature)
pine (young)
sagebrush*
*2015
Ecosystem Type

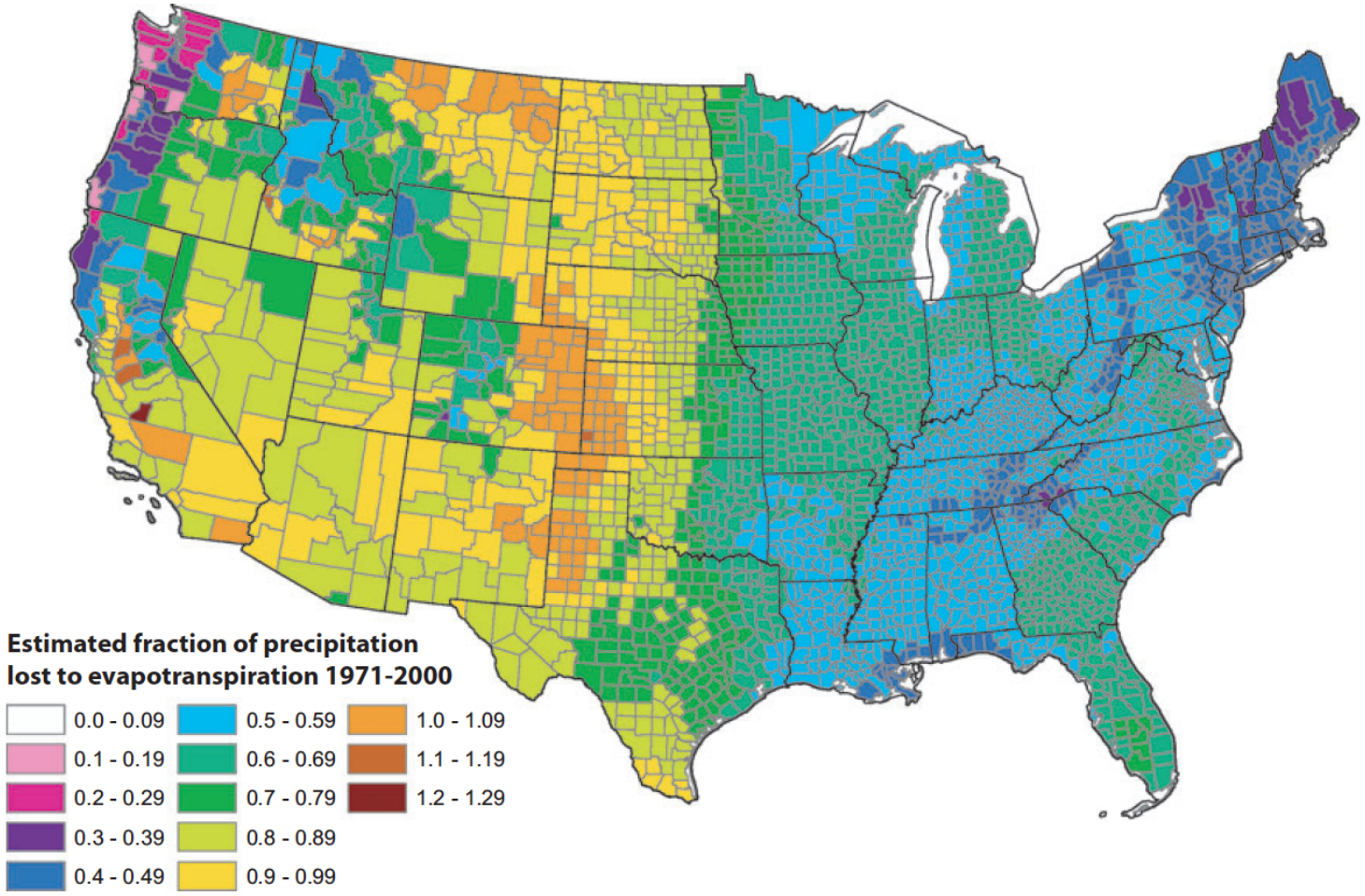
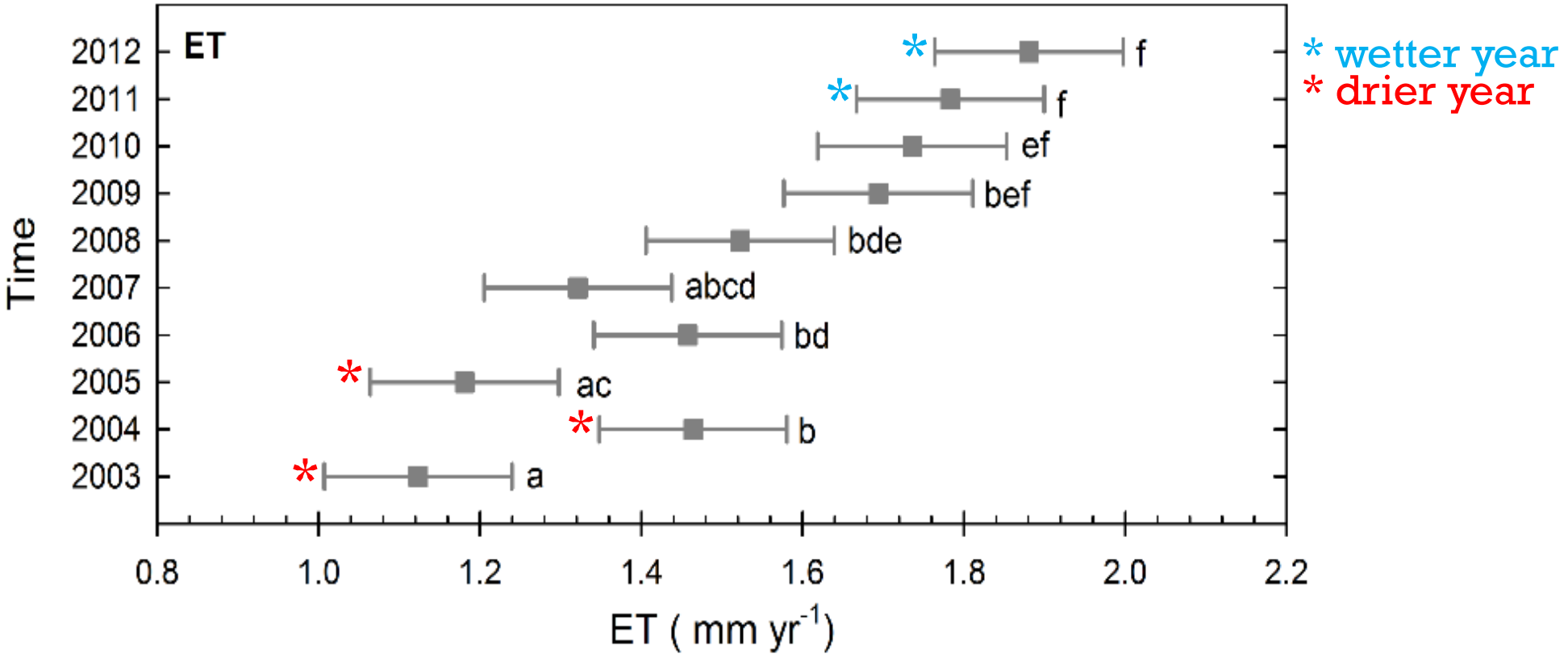


FIGURE 13. Estimated Mean Annual Ratio of Actual Evapotranspiration (ET) to Precipitation (P) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation in Table 1 that includes land cover. Calculations of ET/P were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county. Areas with fractions >1 are agricultural counties that either import surface water or mine deep groundwater.

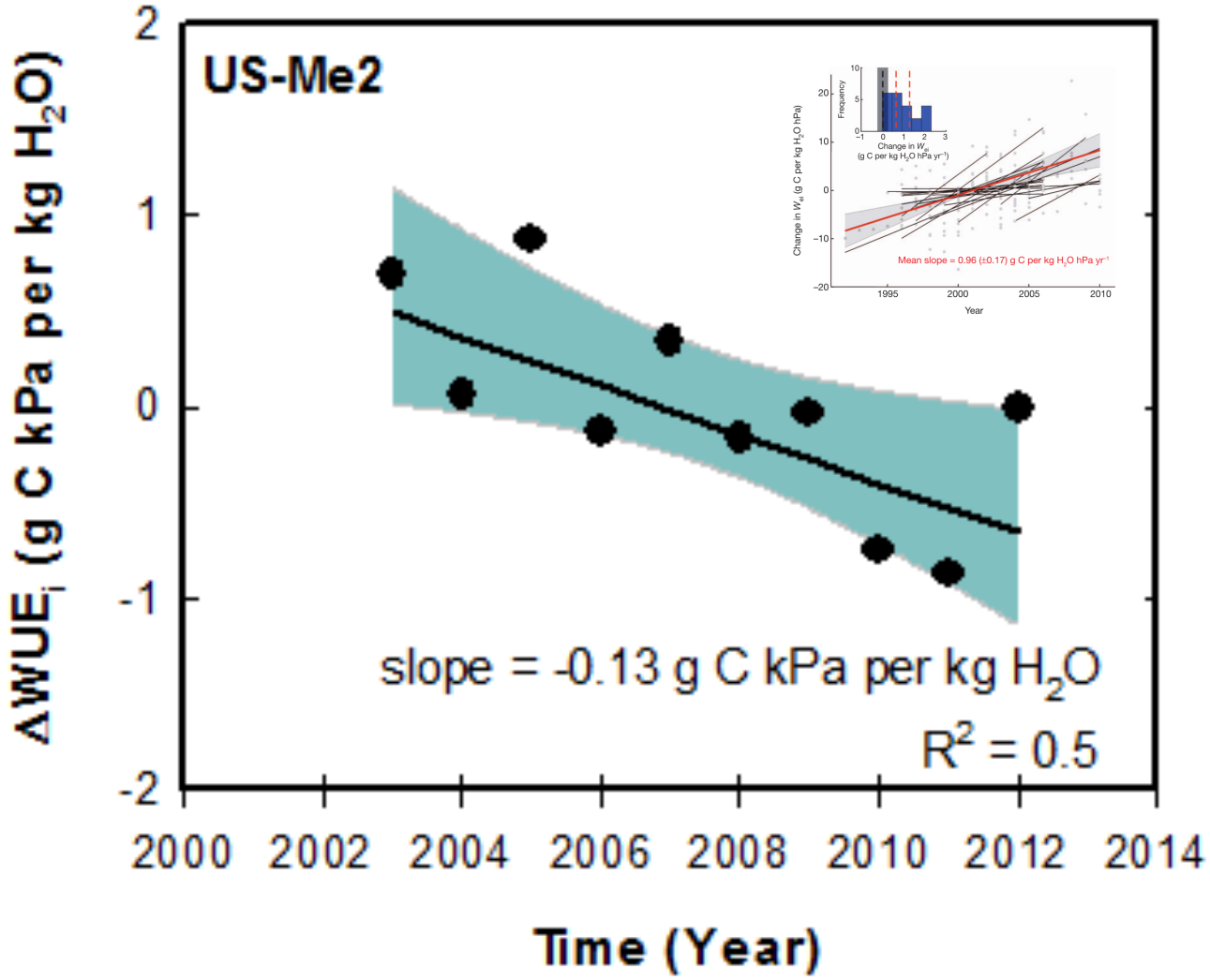
Conclusion

- Individuals of different ages can have markedly different trends in evapotranspiration
- Douglas-fir and ponderosa pine are different enough that sub-plant functional type classes, such as genera, would be a reasonable classification for land system modeling
- Influence of climate and hydrological gradient on evapotranspiration across different land covers is non-linear and often counter-intuitive.

Long-term Variation Of ET



Annual Anomaly Of WUE_i



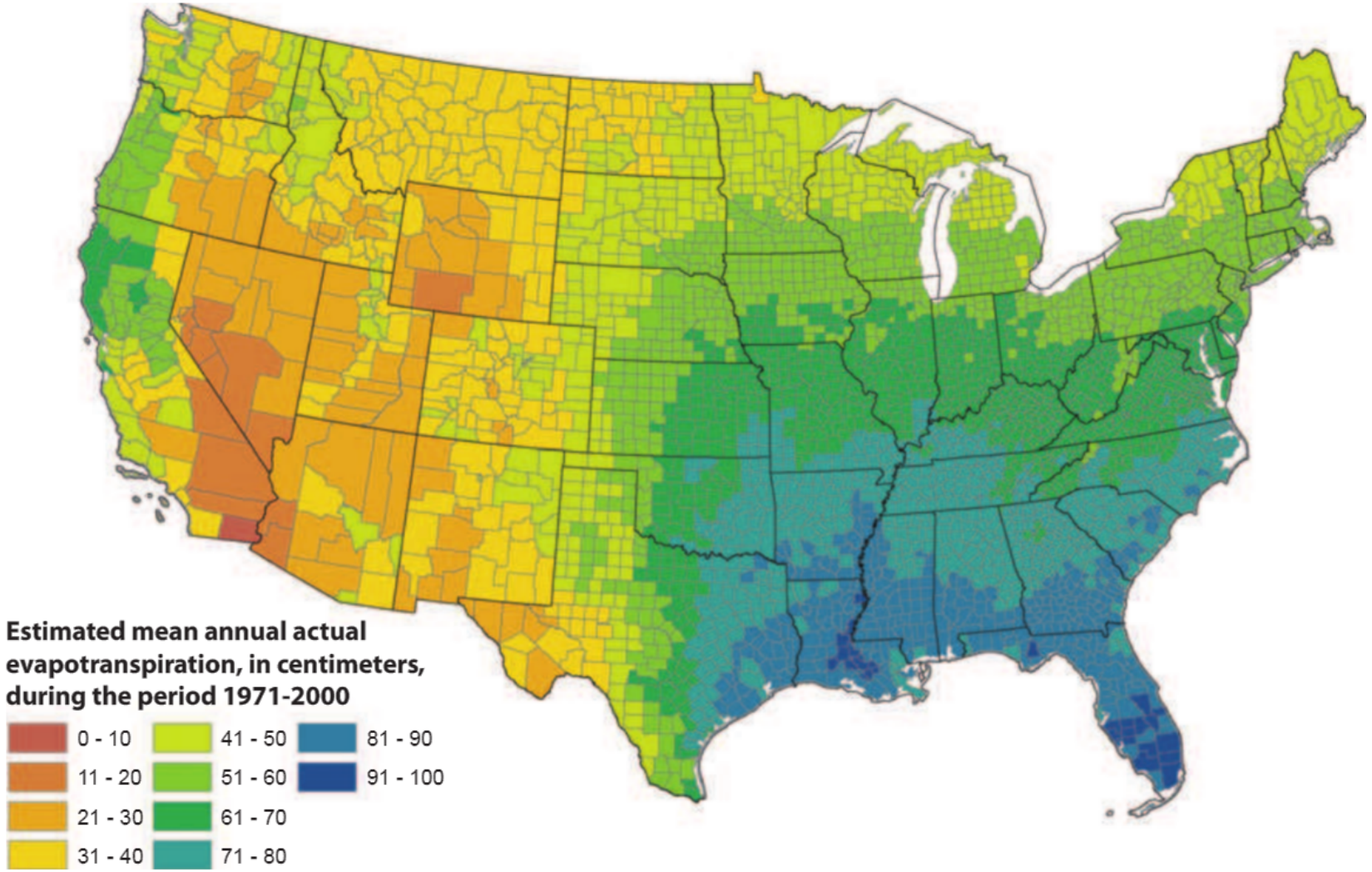


FIGURE 14. Map of Estimated Mean Annual Actual Evapotranspiration (ET) for the Conterminous U.S. for the Period 1971-2000. Estimates are based on the regression equation of ET/*P* in Table 1 that includes land cover multiplied by the mean annual precipitation from the PRISM climate data for the same period. Calculations of ET were made first at the 800-m resolution of the PRISM climate data. The mean values for the counties (shown) were then calculated by averaging the 800-m values within each county.