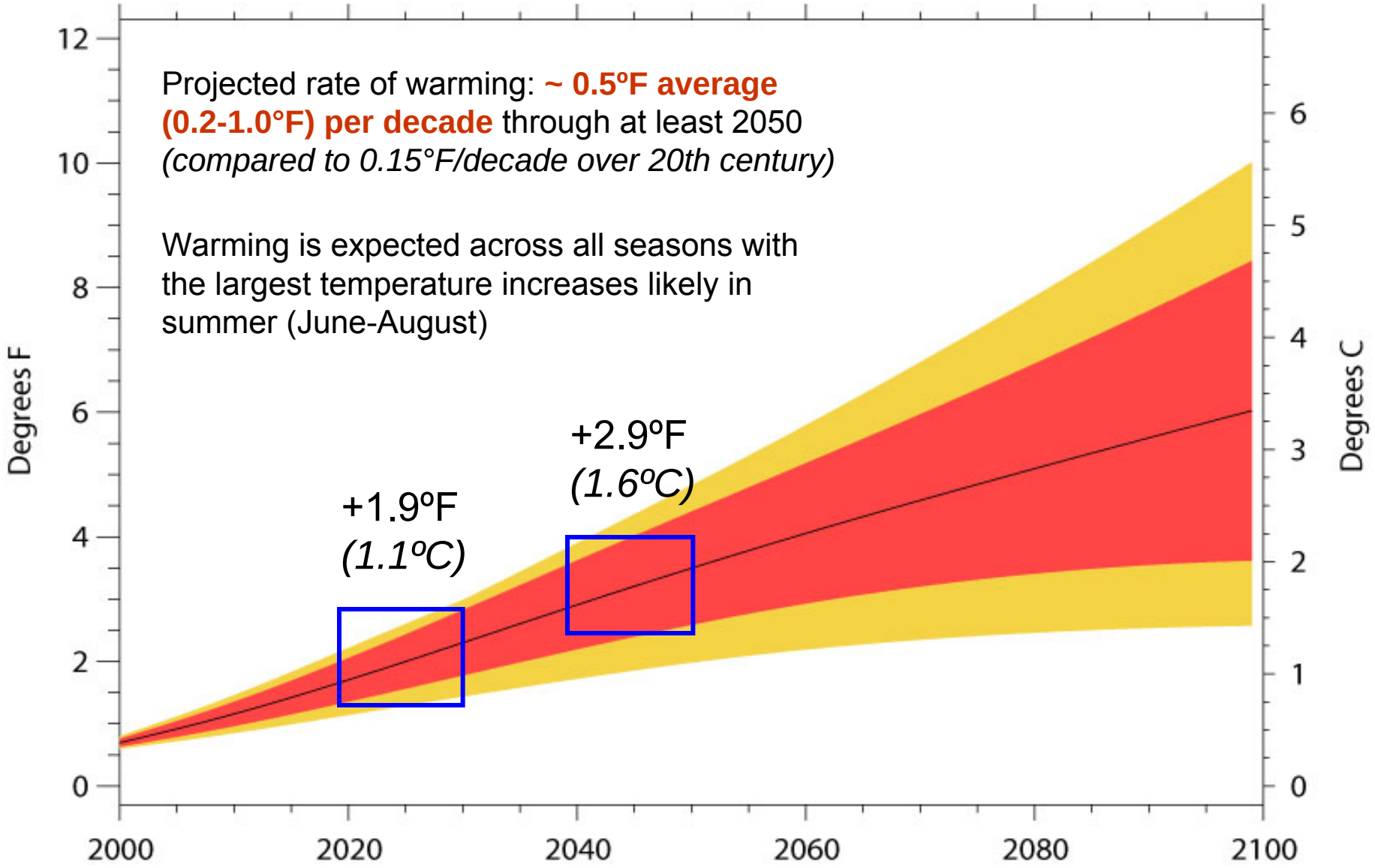




Have we seen changes in 20th century climate in the PNW?

- Average annual temperature increased +1.5°F in the PNW during the 20th century (warming greatest in spring and at night)
- Most PNW mountain stations show a decline in snow water equivalent (many up to 30-60%)
- Peak of runoff is moving earlier into the spring throughout western US and Canada (10-30 days)
- Fewer days below freezing in all seasons (12-40 days)
- No consistent trend in precipitation, but variability has increased since 1973 (more extremes … drought)

21st Century PNW Warming







Likely Implications for PNW Resources

- Continued declines in spring snowpack
- Further shifts in runoff timing and amounts
- Strains on water management systems
- Fisheries, especially salmon, effected across their full life cycle
- Forest productivity (↓↑) and ecosystem challenges (distribution, regeneration, fire and pest disturbance)
- Agricultural productivity (↓↑), phenology, drought stress, irrigation access, pests, shifts in suitable zones or crops
- Coastal zone stresses due to higher sea levels

Variety-Climate Thresholds

Too Cold Threshold
Lower sugar levels,
Unripe flavors,
Unbalanced

Too Warm Threshold
Lower retention of acids,
Overripe flavors,
Unbalanced

Plasticity – Adaptation
Management (short-term)
Varietal (long-term)

Optimum Zone
Consistent sugar levels,
Ripe flavors,
Generally balanced -
Vintage variations driven by seasonal climate factors
(frost, untimely rain, etc.)

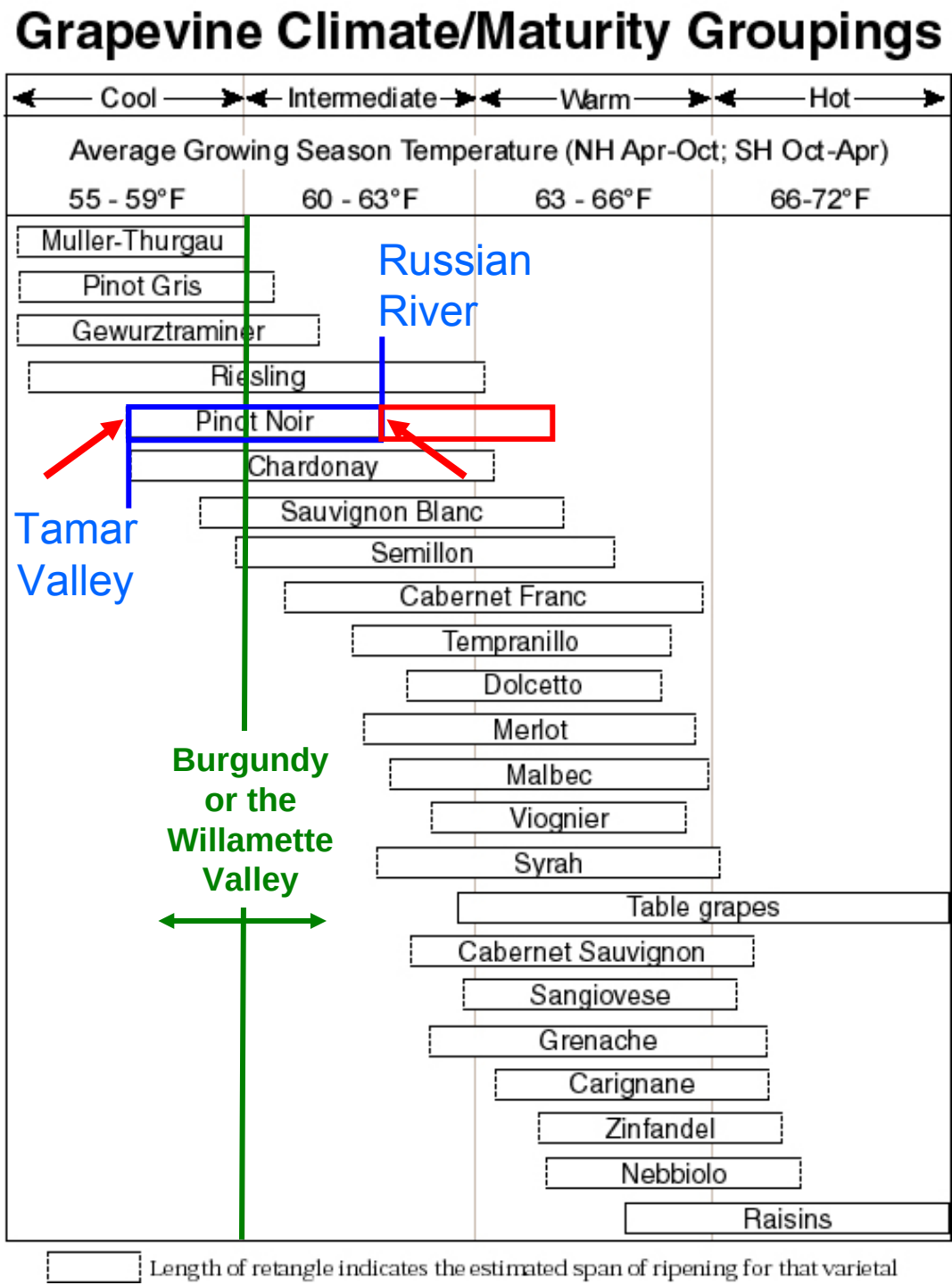
Wine Production and Quality Metrics
Yield/Production
Balanced Composition
Typical Varietal Flavors
Vintage Ratings/Price

Climate Metrics
Growing Season Temperatures, Heat Accumulation

Jones, 2006

- All varieties have inherent climatic thresholds for optimum quality and production characteristics
- Pinot Noir exhibits one of the most narrow climatic niches for premium quality production
- From what we know about today's Pinot Noir regions, growing season average temperatures range from ~57-61°F, or ~ a 4°F climatic niche

Jones, 2006

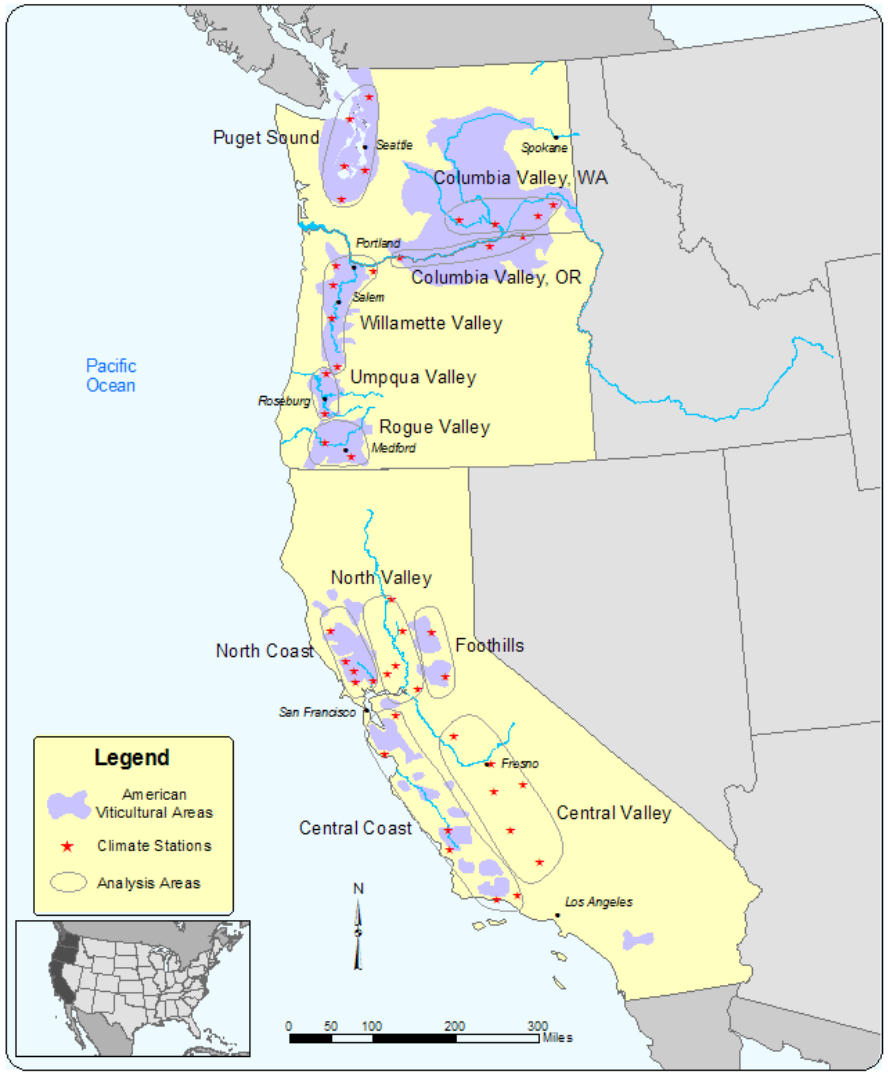


Climate Change Effects on Viticulture/Wine

- Changes in average climate structure and variability
- Warmer and longer growing seasons
- Warmer dormant periods
- Reduced frost damage (in some areas)
- Altered ripening profiles
- Earlier phenology (plant growth events)
- Altered/new disease/pest timing and severity
- Changes in soil fertility and erosion
- CO_2 fertilization … but wine effects?
- Water availability and timing of irrigation (some places drier, some wetter)

Jones, 2006

Observed Changes in the Western U.S.



- 1948-2004
- Growing Season Temperatures +1.6°F
- Driven by changes in minimum temperatures not maximum temperatures
- Decline in the # of days below freezing in all seasons (9-35 days)
- Earlier last spring frost (12-52 days)
- Later first fall frost (6-22 days)
- Longer frost-free period (18-65 days)
- Annual and seasonal precipitation levels are highly variable (no trends)
- Phenology trends range 6-20 days earlier over numerous varieties and locations

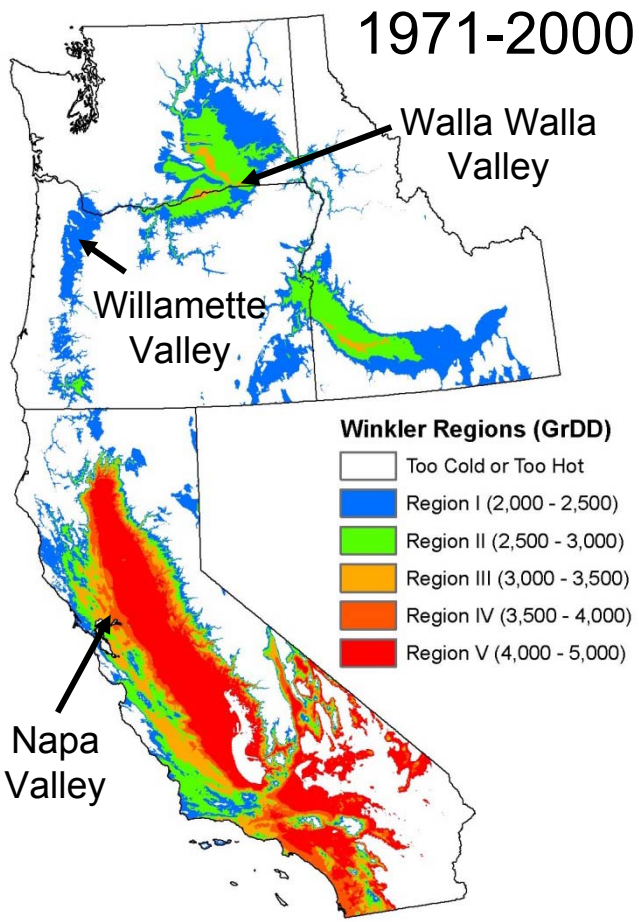
Jones (2005) Acta Horticulturae; Jones and Goodrich (2008) Climate Research

Observed Climate Trends for the Western U.S. during 1948-2004

Variable	Willamette Valley	Average Change across all regions
Growing Degree-Days (Apr-Oct, base 50°F)	380	326
Growing Season Average Temperatures	2.0°F	1.6°F
Growing Season Maximum Temperatures	**1.6°F**	**Mixed, 1.6°F**
Growing Season Minimum Temperatures	**2.5°F**	2.4°F
Ripening Period Average Temperatures (8/15-10/15)	2.1°F	1.8°F
Growing Season Number of Days >95°F	NS	Mixed, Most NS
Number of Days below Freezing – Annually	-23 days	-18 days
Number of Days below Freezing – Spring (Mar-May)	-9 days	-7 days
Number of Days below Freezing – Fall (Sept-Nov)	-4 days	-3 days
Date of Last Spring Frost (32°F)	19 days earlier	24 days earlier
Date of Last Fall Frost (32°F)	14 days later	10 days later
Frost-Free Period	32 days longer	34 days longer
Winter Precipitation (Nov-Mar)	NS	Mixed, Most NS
Growing Season Precipitation (Apr-Oct)	NS	Mixed, Most NS
Bloom Period Precipitation (May 15-June 15)	NS	+, Most S
Ripening Period Precipitation (Aug 15-Oct 15)	-1.88"	-, Most NS

Jones (2005) Acta Horticulturae; Jones and Goodrich (2008) Climate Research

Temporal & Spatial Changes in Growing Degree-Days



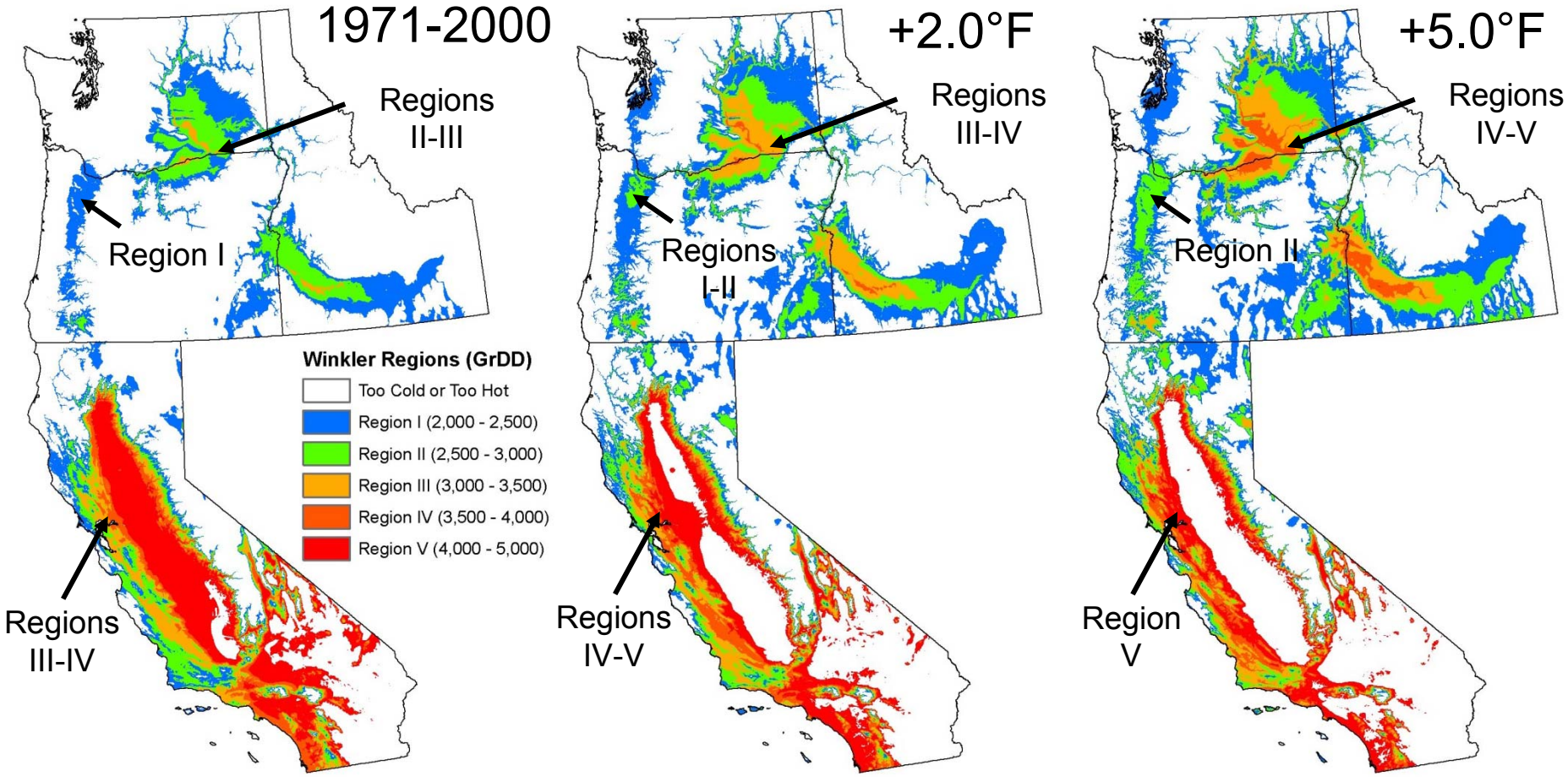
Blue – Cool climate varieties such as Pinot Noir, Chardonnay

Orange – Warm climate varieties such as Merlot, Cabernet Sauvignon

Red – Hot climates for bulk wine and table grapes

Jones, 2007

Temporal & Spatial Changes in Growing Degree-Days



Blue – Cool climate varieties such as Pinot Noir, Chardonnay

Orange – Warm climate varieties such as Merlot, Cabernet Sauvignon

Red – Hot climates for bulk wine and table grapes

Jones, 2007

Wine Production in Oregon

- Ramifications of the predicted warming are evident as shifts in climate may produce shifts in varietal maturity viability
- Cooler regions should benefit more than warm regions with the ability to shift to a wider range of varieties
- Some regions, near their optimum, may no longer be able to produce the same wines without changes in production technologies

Jones, 2006