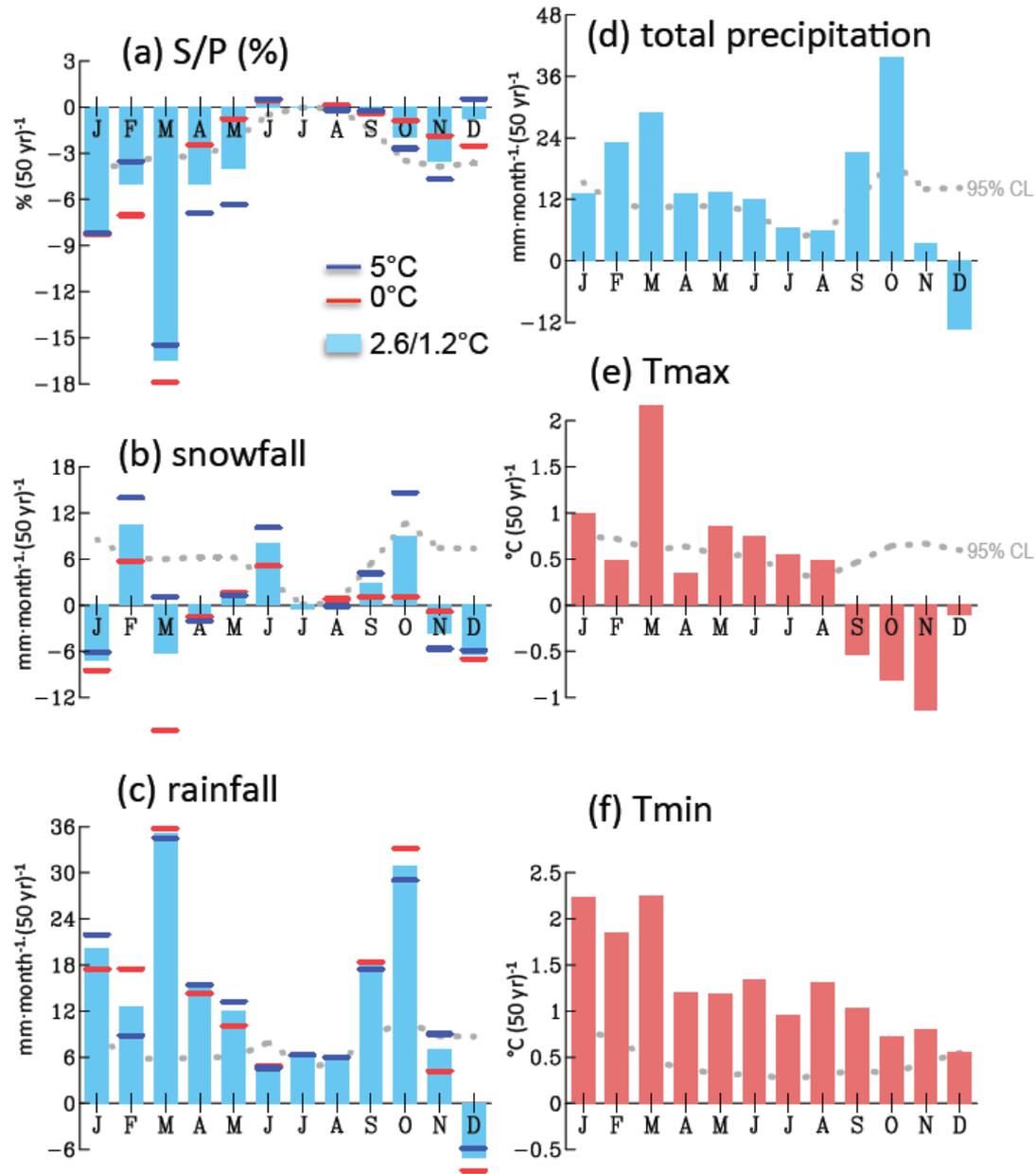




UTAH Observed monthly trends (1950-2010)



Barbara J. Bentz

Rocky Mountain Research Station
 USDA Forest Service, Logan UT
www.usu.edu/beetle

From: Gillies, Wang and Booth. In Press.

NATIVE Bark Beetle Species That Can Cause Landscape-Wide Tree Mortality in Northern Rocky Mountain Forests

SPRUCE



Spruce beetle
Dendroctonus rufipennis

DOUGLAS-FIR



Douglas fir beetle
Dendroctonus pseudotsugae

PINES



Mountain pine beetle
Dendroctonus ponderosae

TRUE FIRS



Fir engraver
Scolytus ventralis



Western balsam bark beetle
Droycoetes confusus

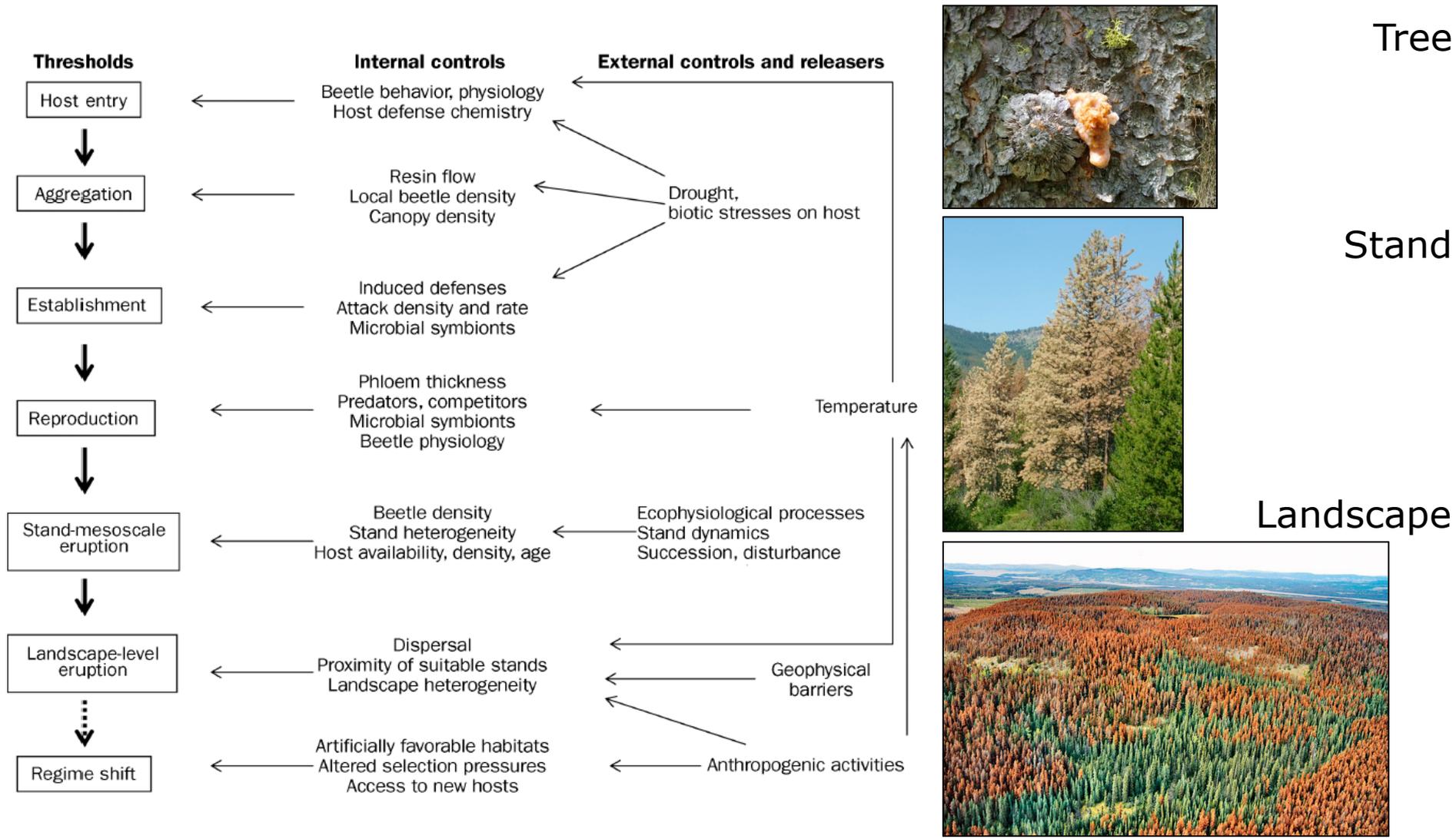


Pinyon ips
Ips confusus

Roundheaded pine beetle
Dendroctonus adjunctus

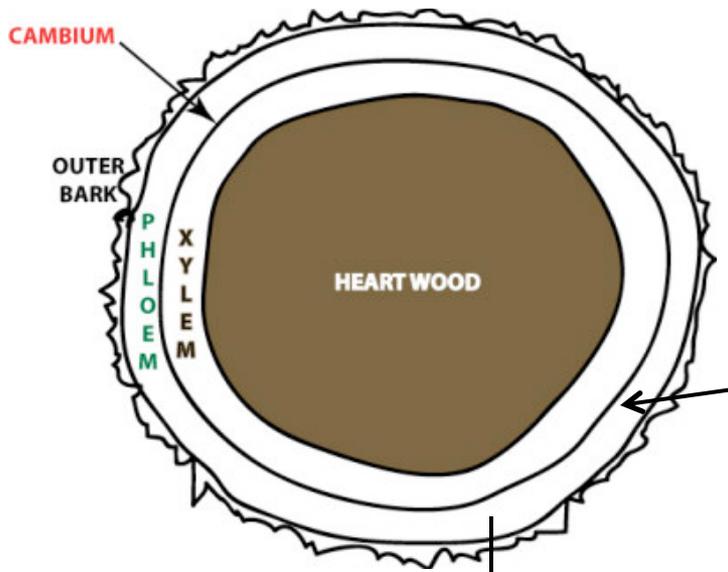


Western pine beetle
Dendroctonus brevicomis



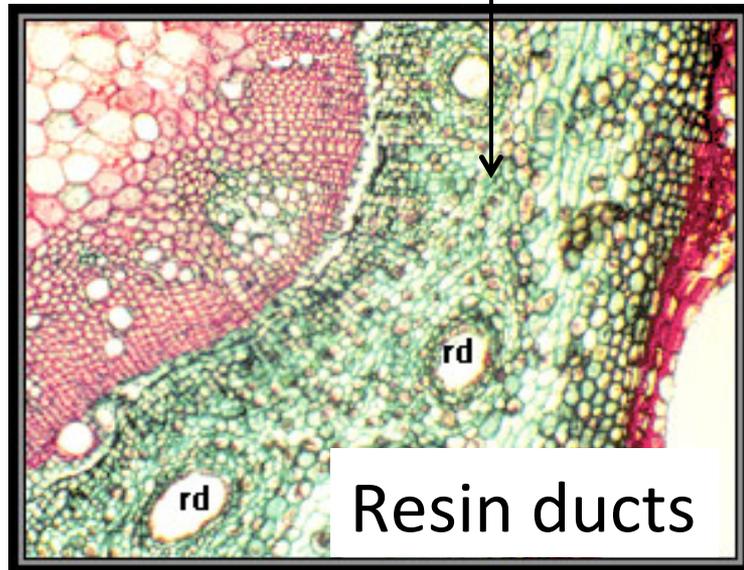
Thresholds and positive feedback processes at multiple scales contribute to the eruptive, outbreak nature of bark beetle populations. Climate can have direct and indirect effects on population success at multiple scales.





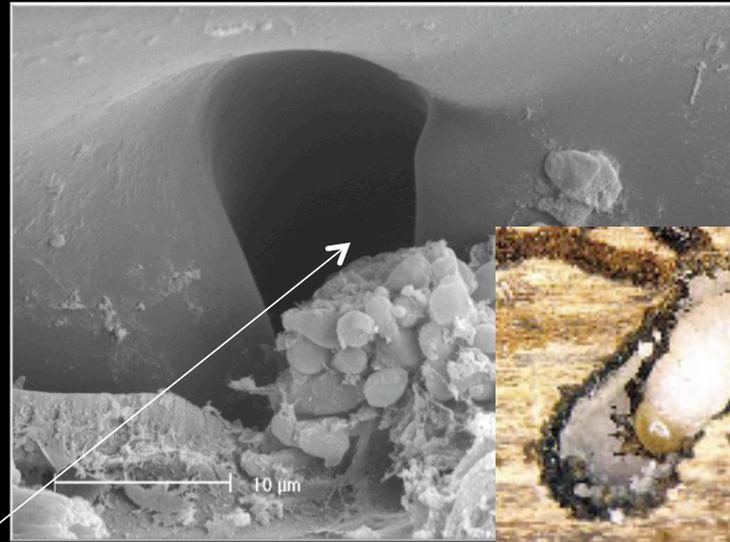
Climate directly affects host tree physiology and distribution, thereby indirectly affecting bark beetle population success -

Phloem tissue of living trees is the main food source.

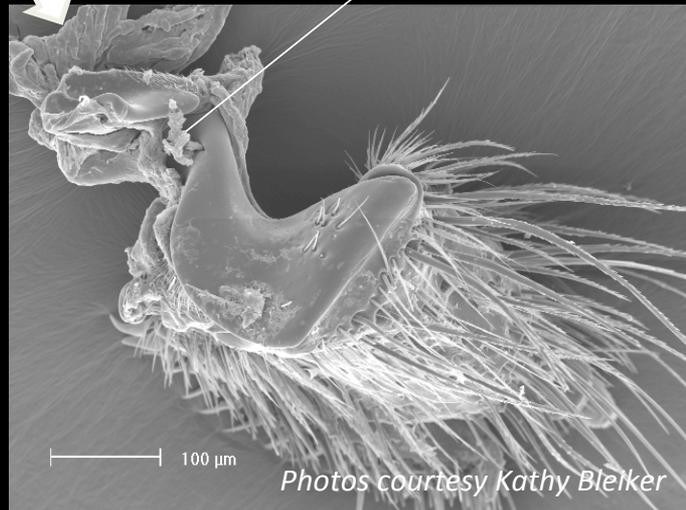


"Pitch out"

Increased water deficits and drought stress ↑ tree susceptibility to bark beetles.



*fungi
spores*

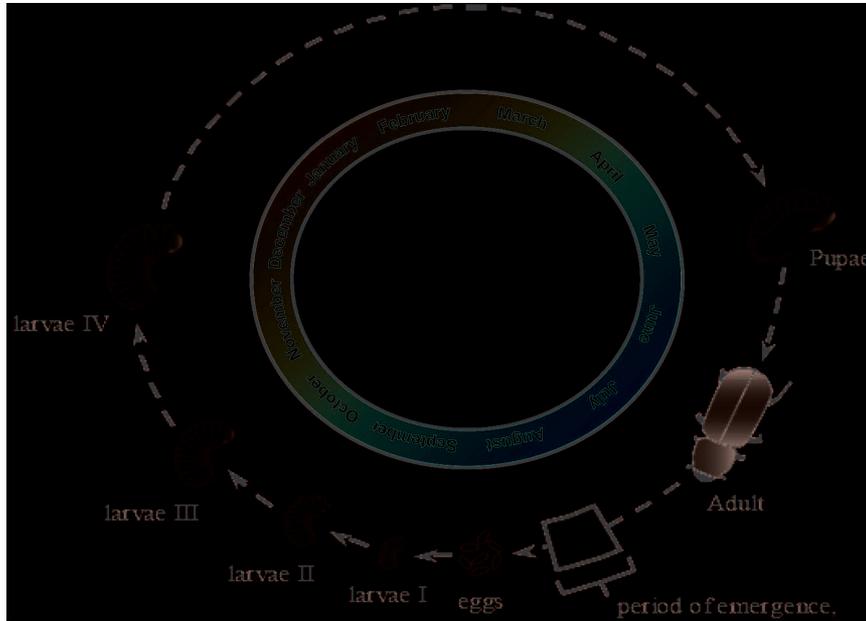


*fungi
hyphae*



'Blue - staining' fungi provide vital nutrients to developing mountain pine beetle. Fungi will be influenced by changing climate.

Temperature can directly influence bark beetle success -



Seasonality – appropriately timed phenology that is synchronized among individuals to facilitate a mass attack on host trees.

Mountain pine beetle Phenology

Development time and rate are related by:

$$\tau(T, \mathbf{A}) = \frac{1}{r(T, \mathbf{A})}$$

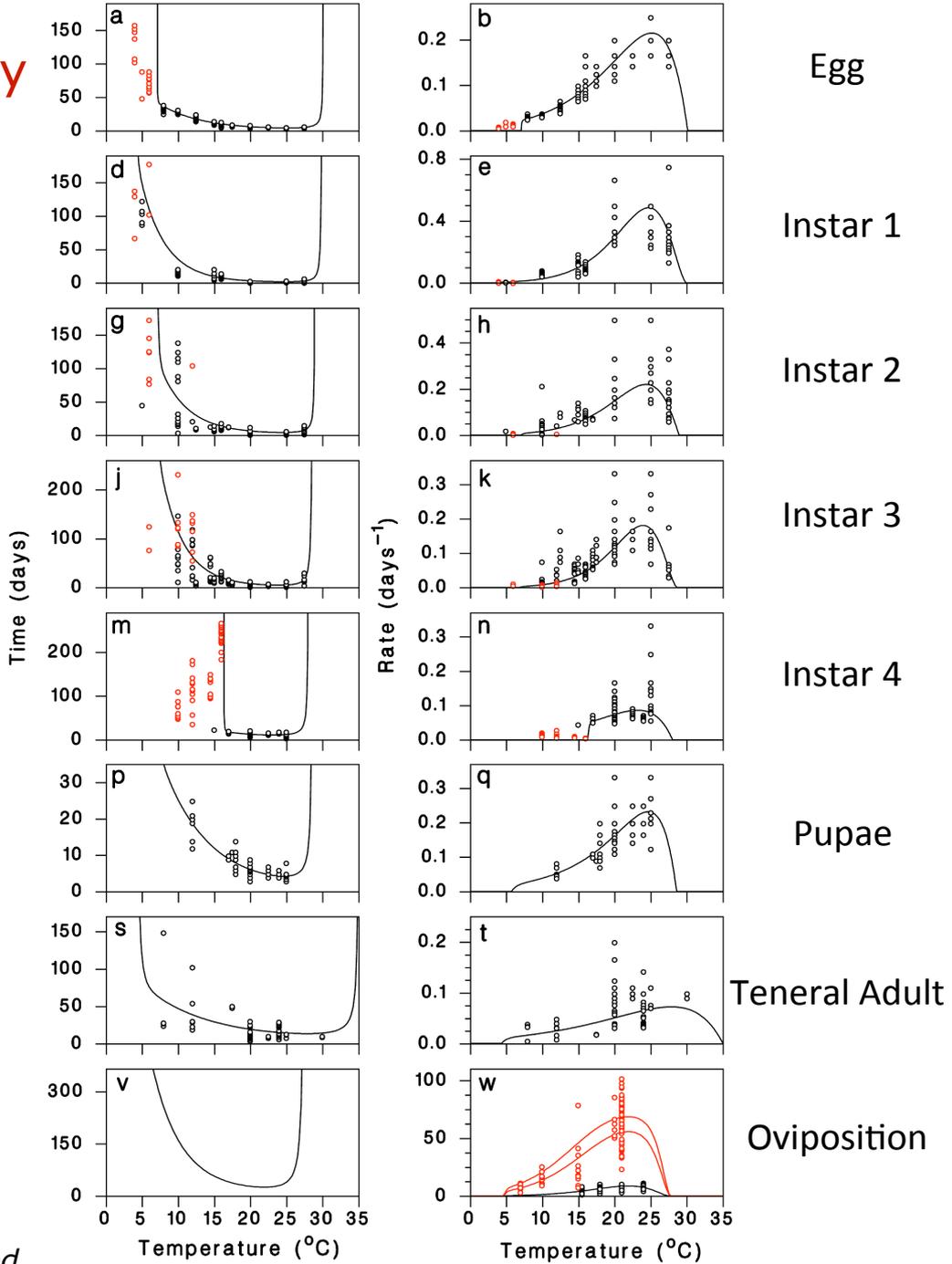
Where $\tau(T, \mathbf{A})$ = the modeled average time to complete the life stage at temperature T.

A = a vector of parameter values of development rate function $r(T, \mathbf{A})$.

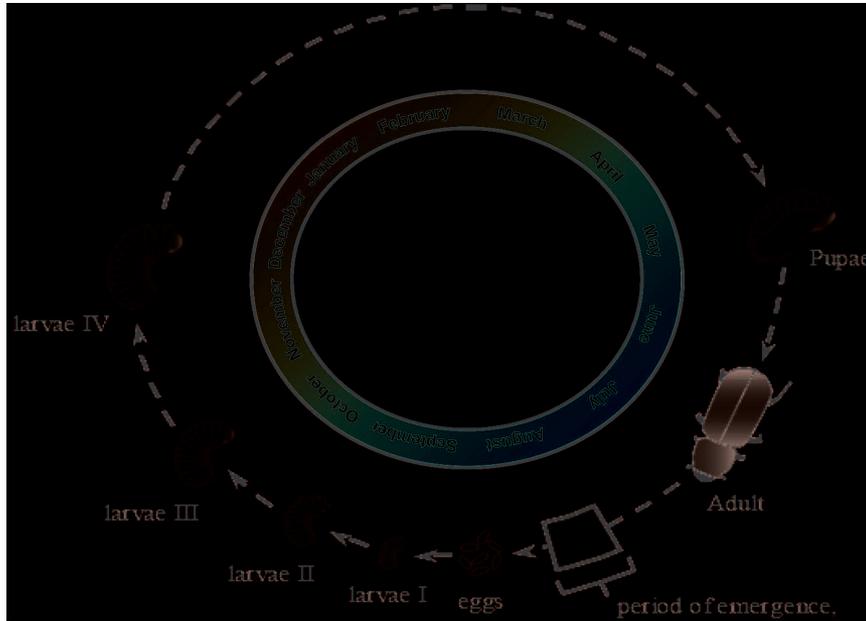
Development rates are summed (integrated) over short time steps Δt .

Physiological age, a_t , proportion of the stage completed from 0 at the onset to 1 at completion -

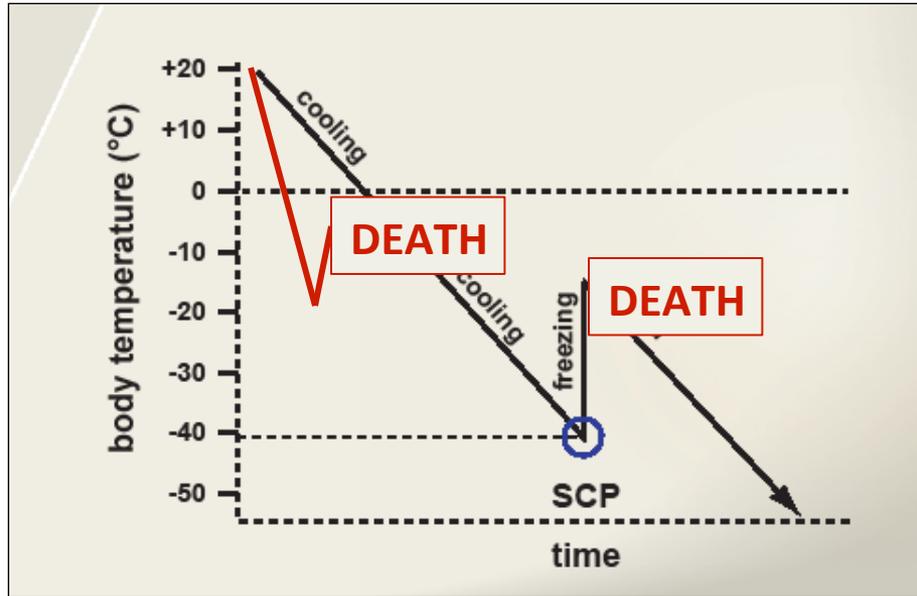
$$a_t = \int_0^t r(T_t, \mathbf{A}) dt \approx \sum_0^t r(T_t, \mathbf{A}) \Delta t$$



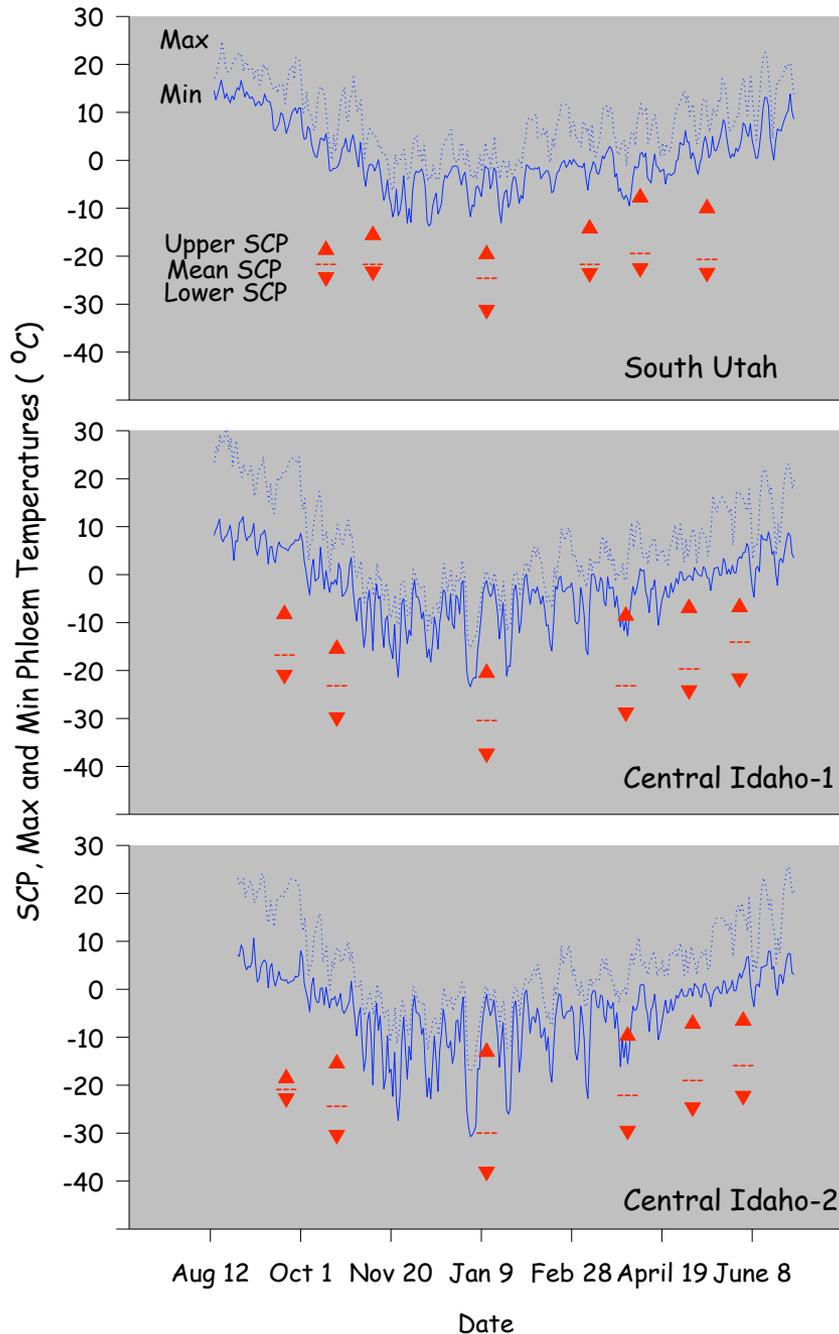
Temperature can directly influence bark beetle success -



Seasonality – appropriately timed phenology that is synchronized among individuals to facilitate a mass attack on host trees.



Mortality due to cold temperatures

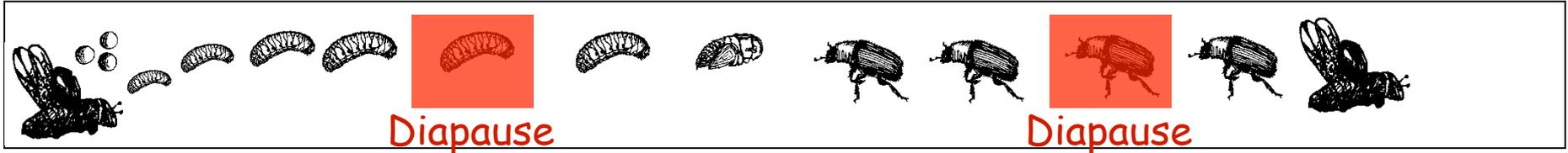


Mountain pine beetle tolerance to cold is dynamically dependent on temperature regime experienced.

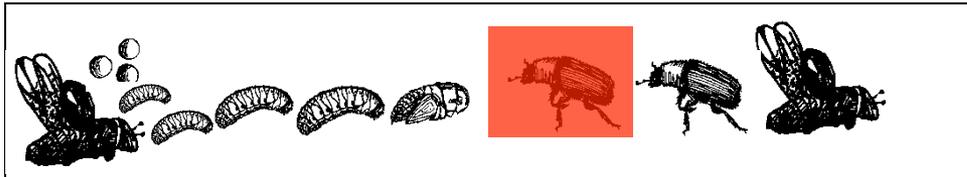
Simple low temperature threshold can not explain the role of temperature in mountain pine beetle survival/mortality.

Spruce beetle

Semivoltine



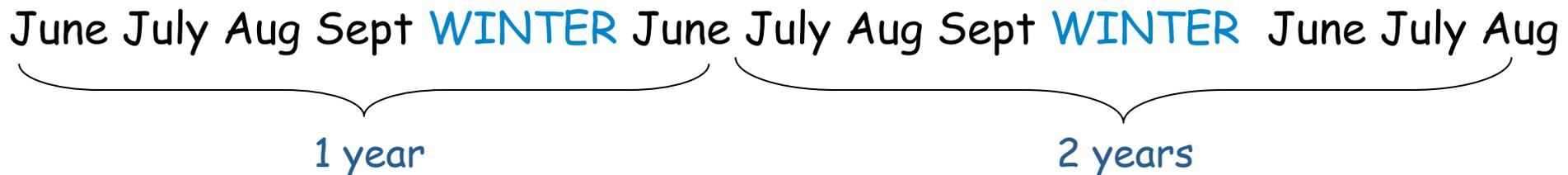
Univoltine



Reproductive Capacity of a

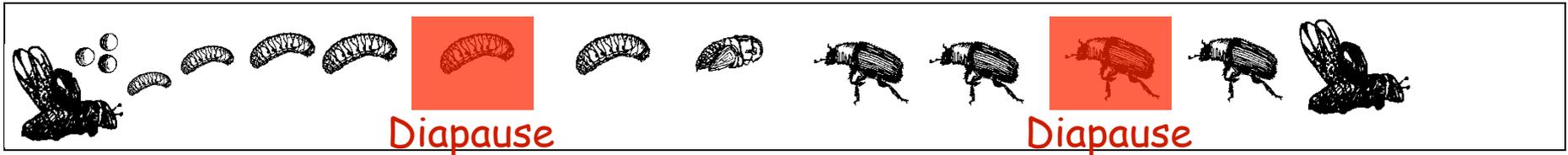
1 year (univoltine) beetle = 2 year (semivoltine) beetle

(Hansen & Bentz 2003)

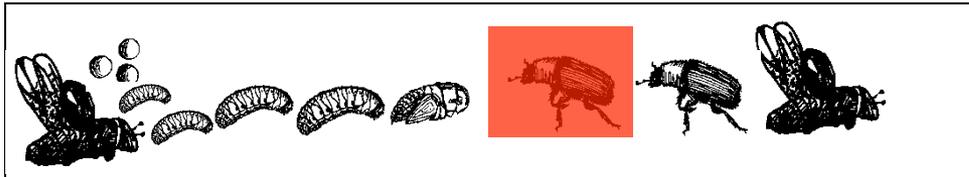


Spruce beetle

Semivoltine



Univoltine

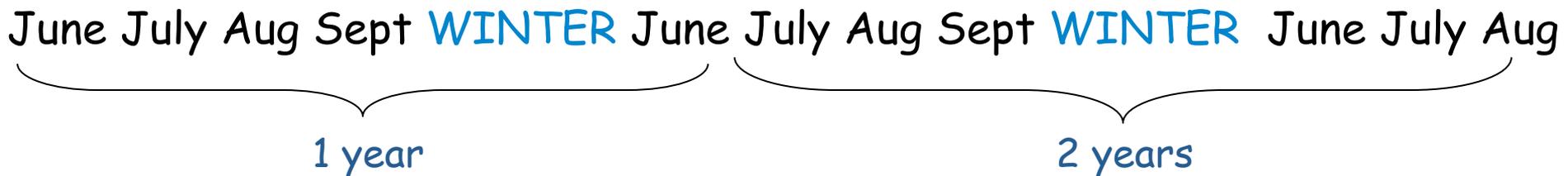


NO-larval diapause YES-adult diapause

Proportion Univoltine brood =

f (cumulative hours above 17°C following *peak flight biofix*)

(Hansen et al. In prep.)

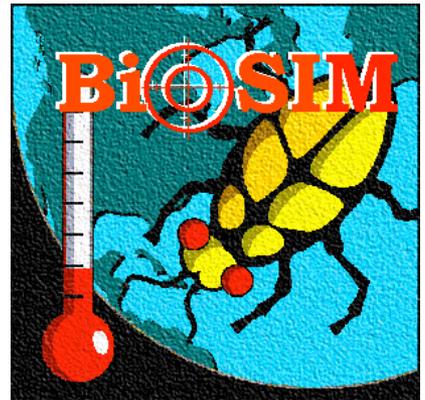


Future Predictions

Spruce Beetle
Proportion Univoltine

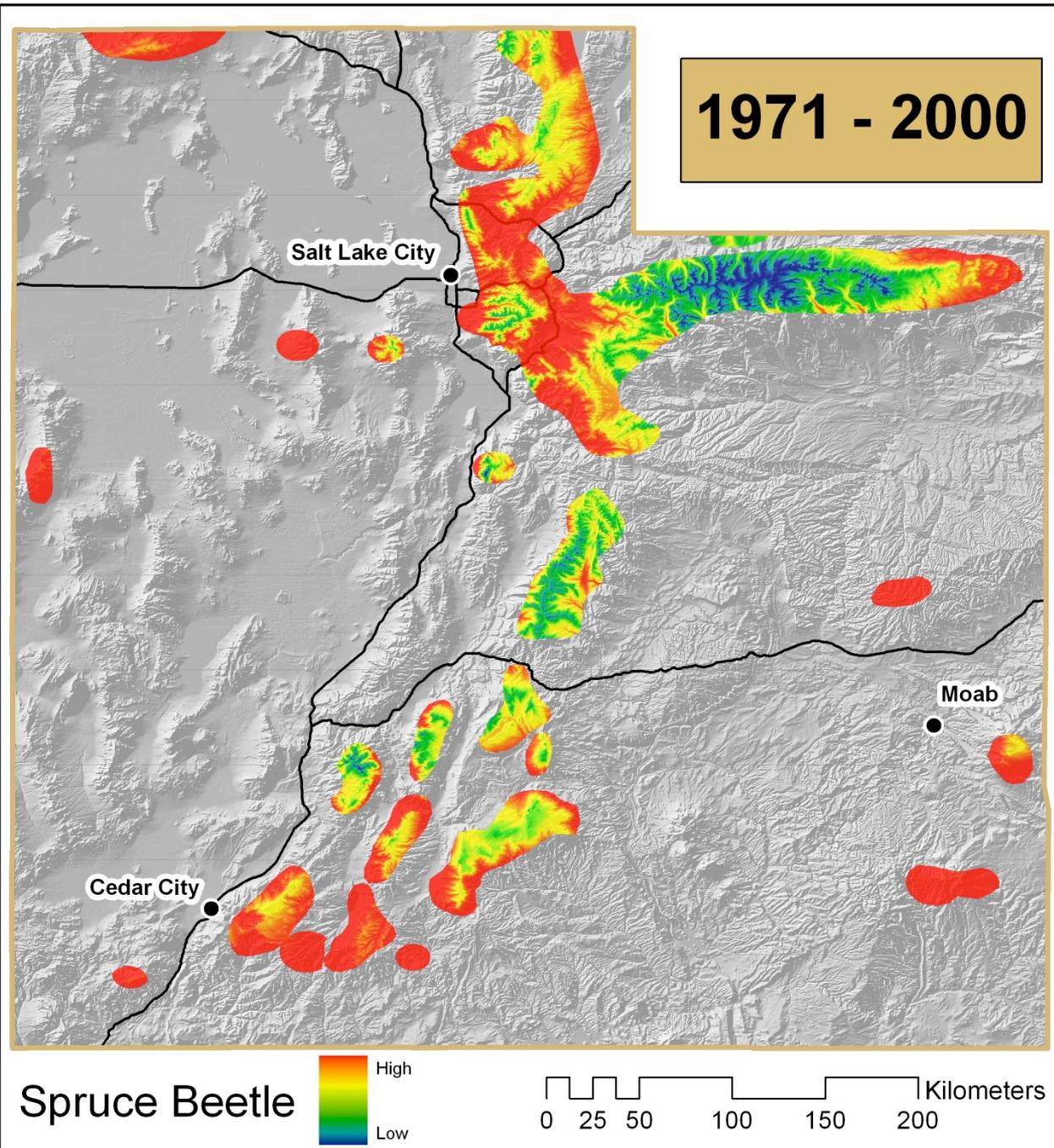
1971-2000

Normals,
CRCM v. 4.2.0
IPPC A2 scenario



Régnière & St-Amant. 2007

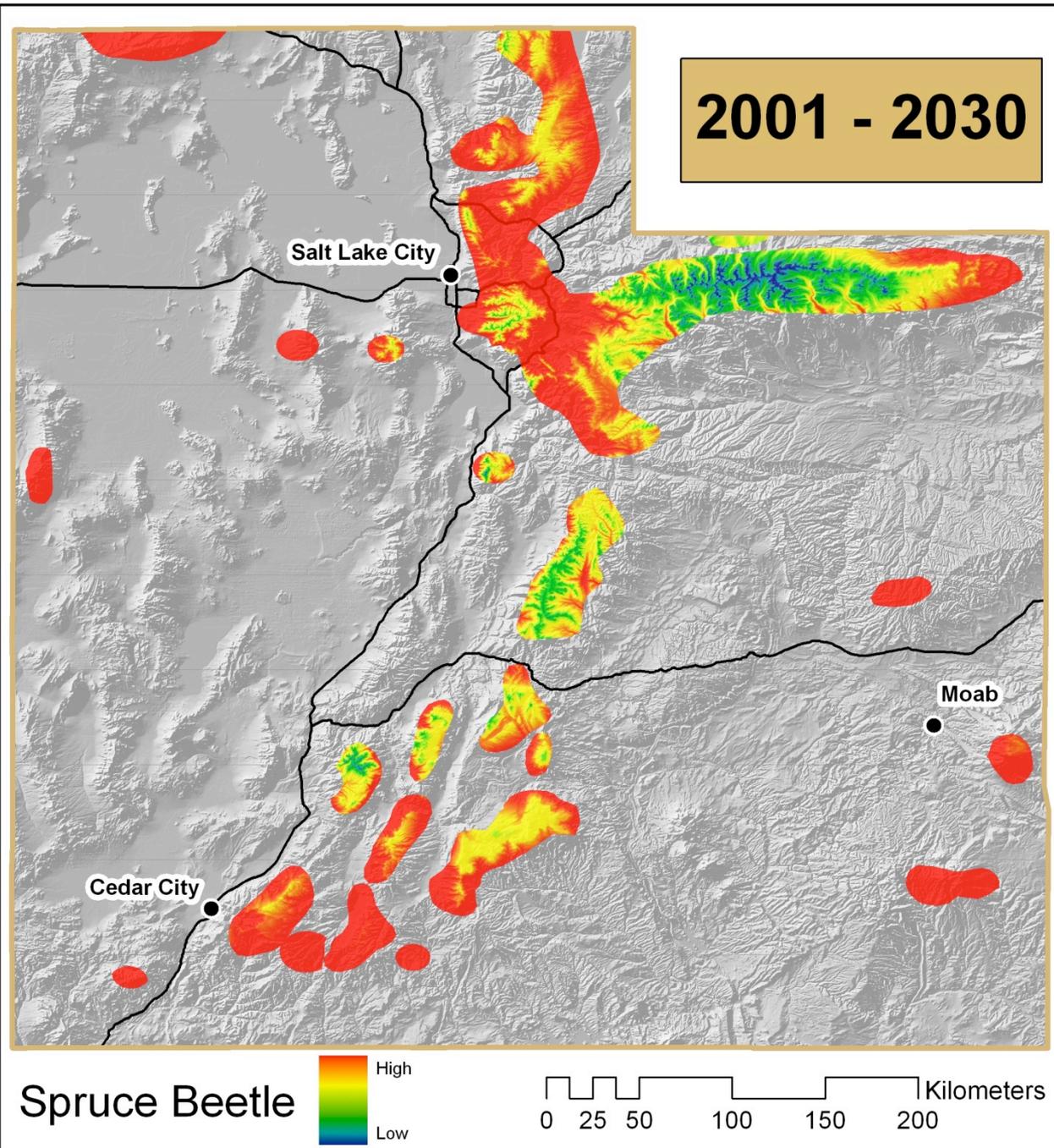
Bentz et al 2010, Bioscience



Future Predictions

Spruce Beetle
Proportion Univoltine

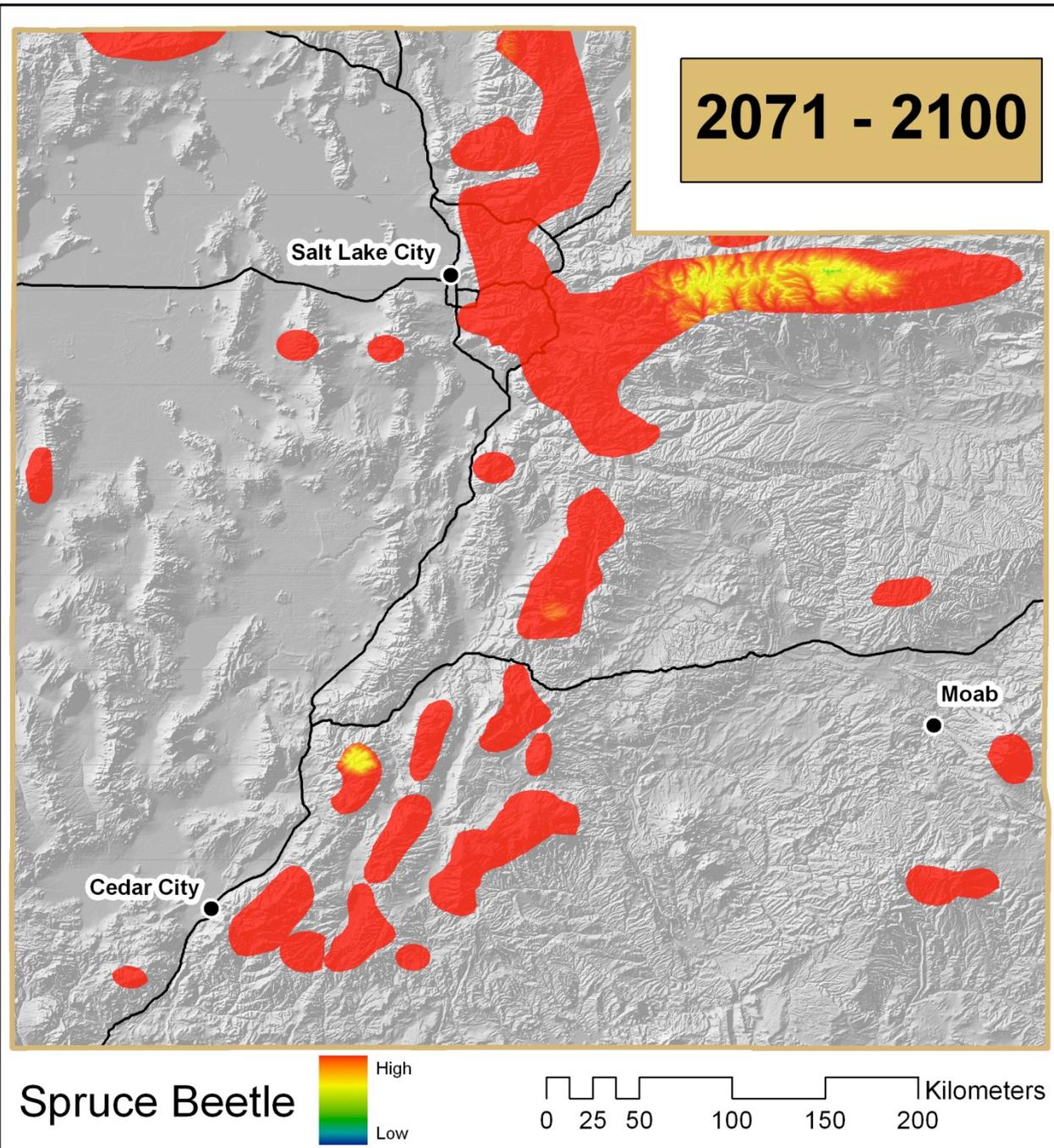
2001-2030



Future Predictions

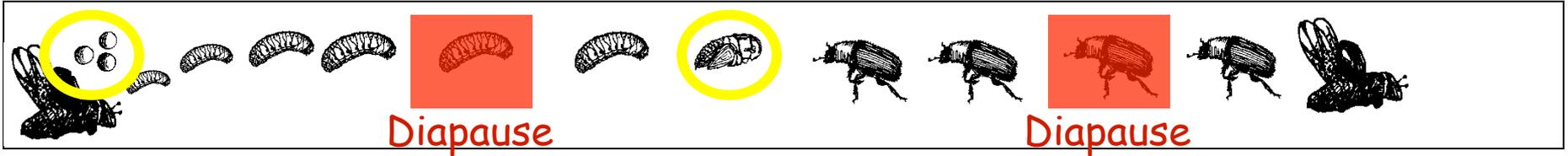
Spruce Beetle
Proportion Univoltine

2071-2100

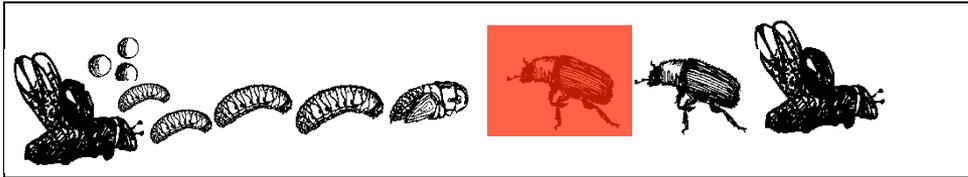


Spruce beetle

Semivoltine



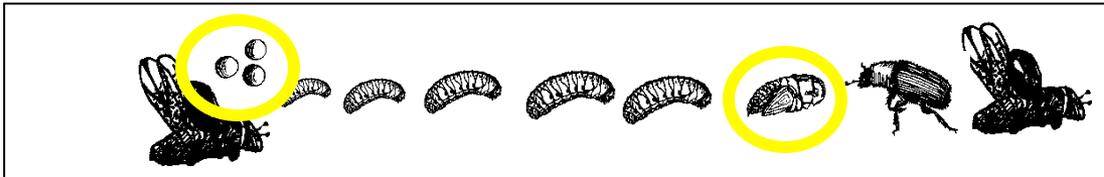
Univoltine



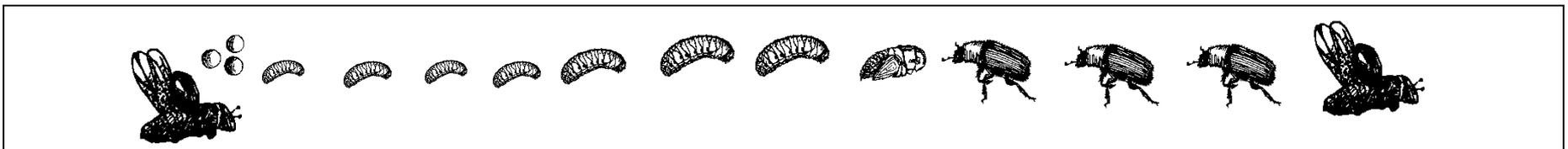
NO-larval diapause YES-adult diapause

Mountain pine beetle

Univoltine



Semivoltine



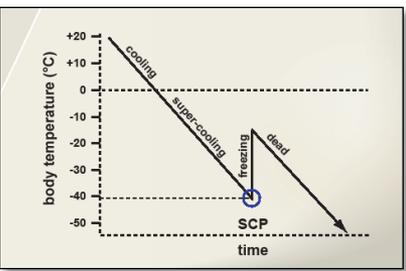
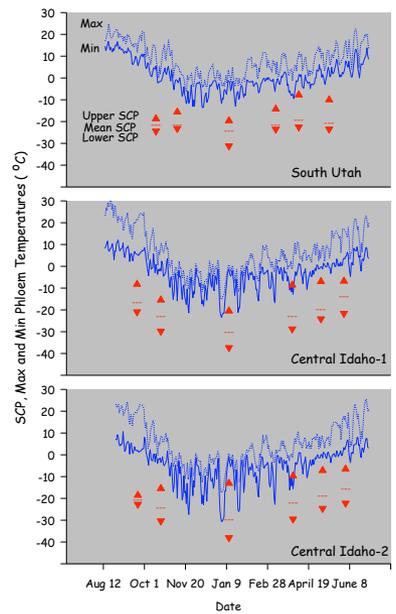
June July Aug Sept WINTER June July Aug Sept WINTER June July Aug

1 year

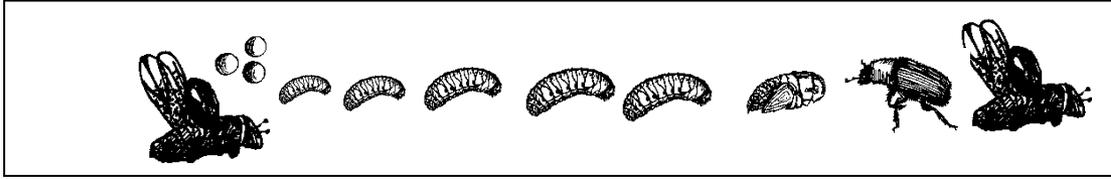
2 years

Cold Tolerance Model -

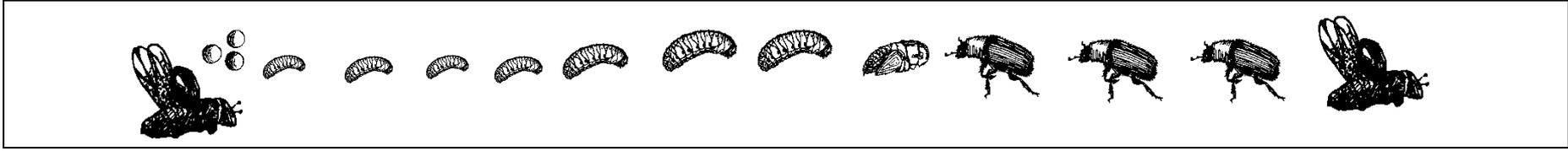
- Based on lab and field data
- Driven by hourly temperatures



Mountain pine beetle *Univoltine*



Semivoltine



June July Aug Sept **WINTER** June July Aug Sept **WINTER** June July Aug

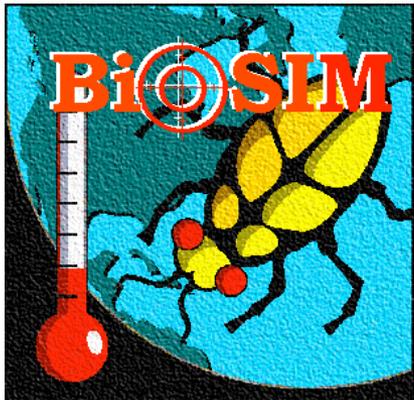
1 year

2 years

Future Predictions

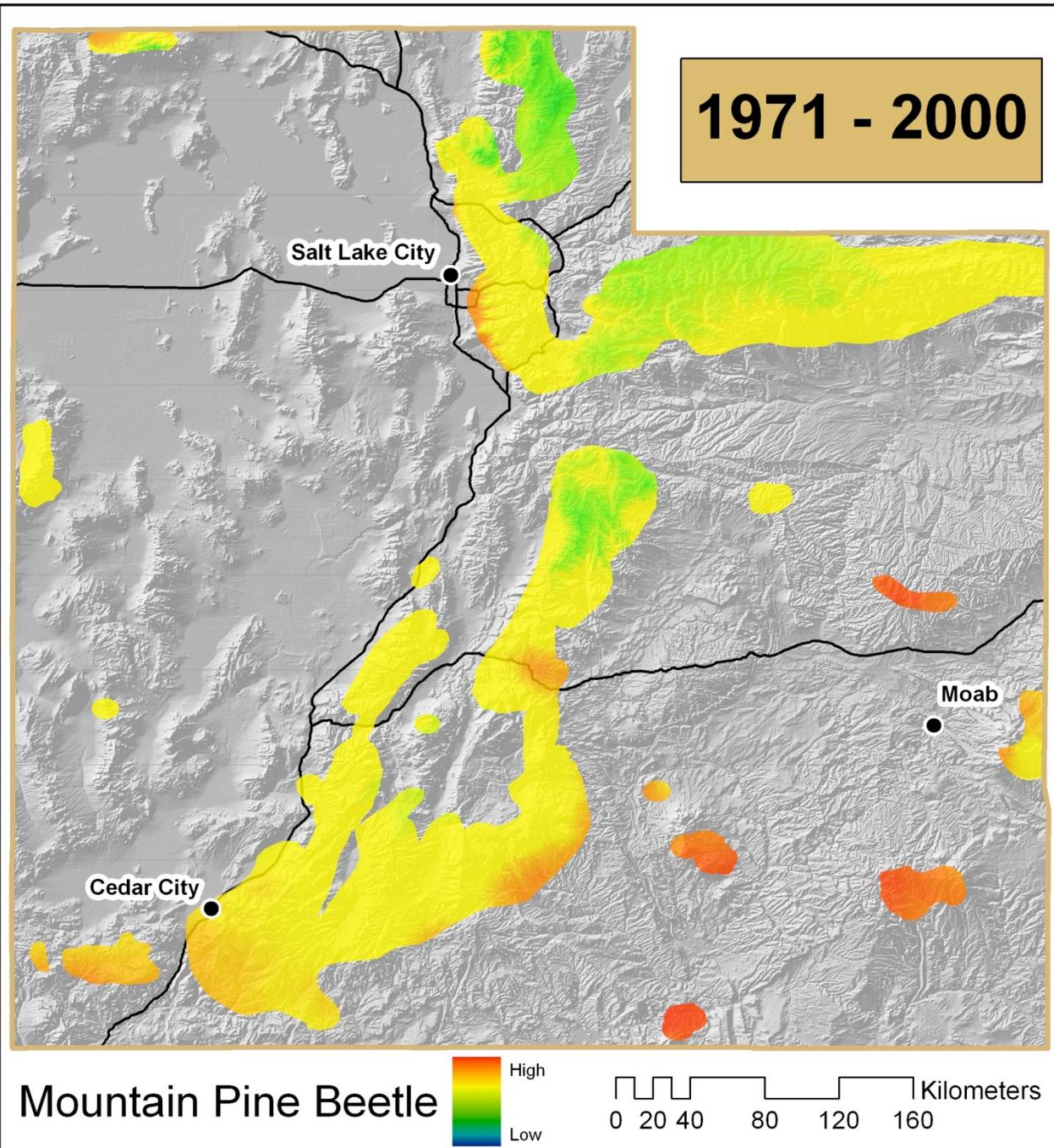
Mountain pine beetle
Probability of Survival
Cold Tolerance Model
1971-2000

Normals,
CRCM v. 4.2.0
IPPC A2 scenario

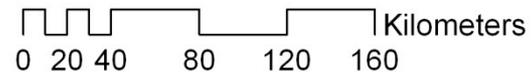
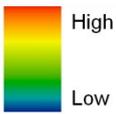


Régnière & St-Amant. 2007

Bentz et al 2010, Bioscience



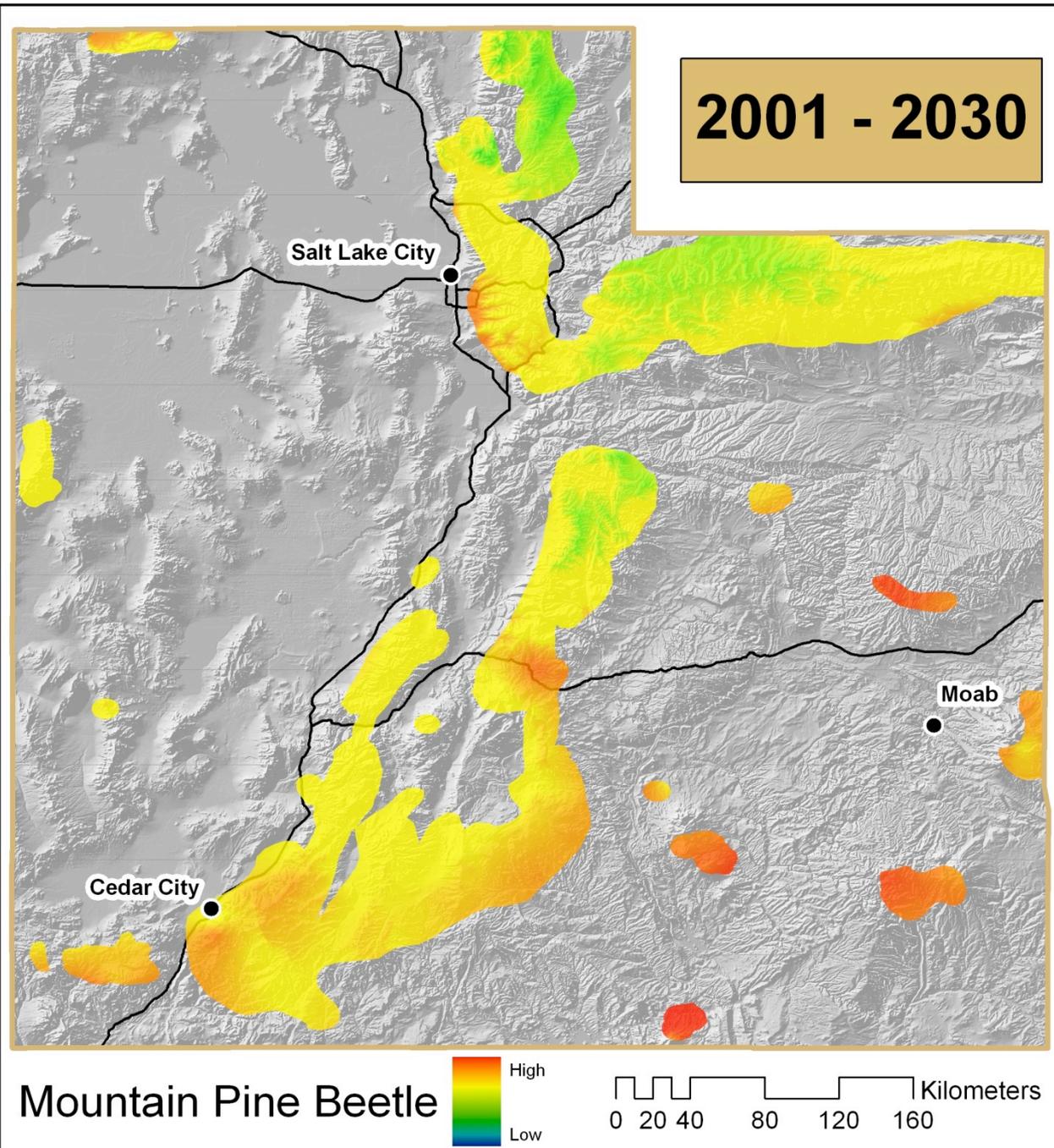
Mountain Pine Beetle



Future Predictions

Mountain pine beetle
Probability of Survival
Cold Tolerance Model
2001-2030

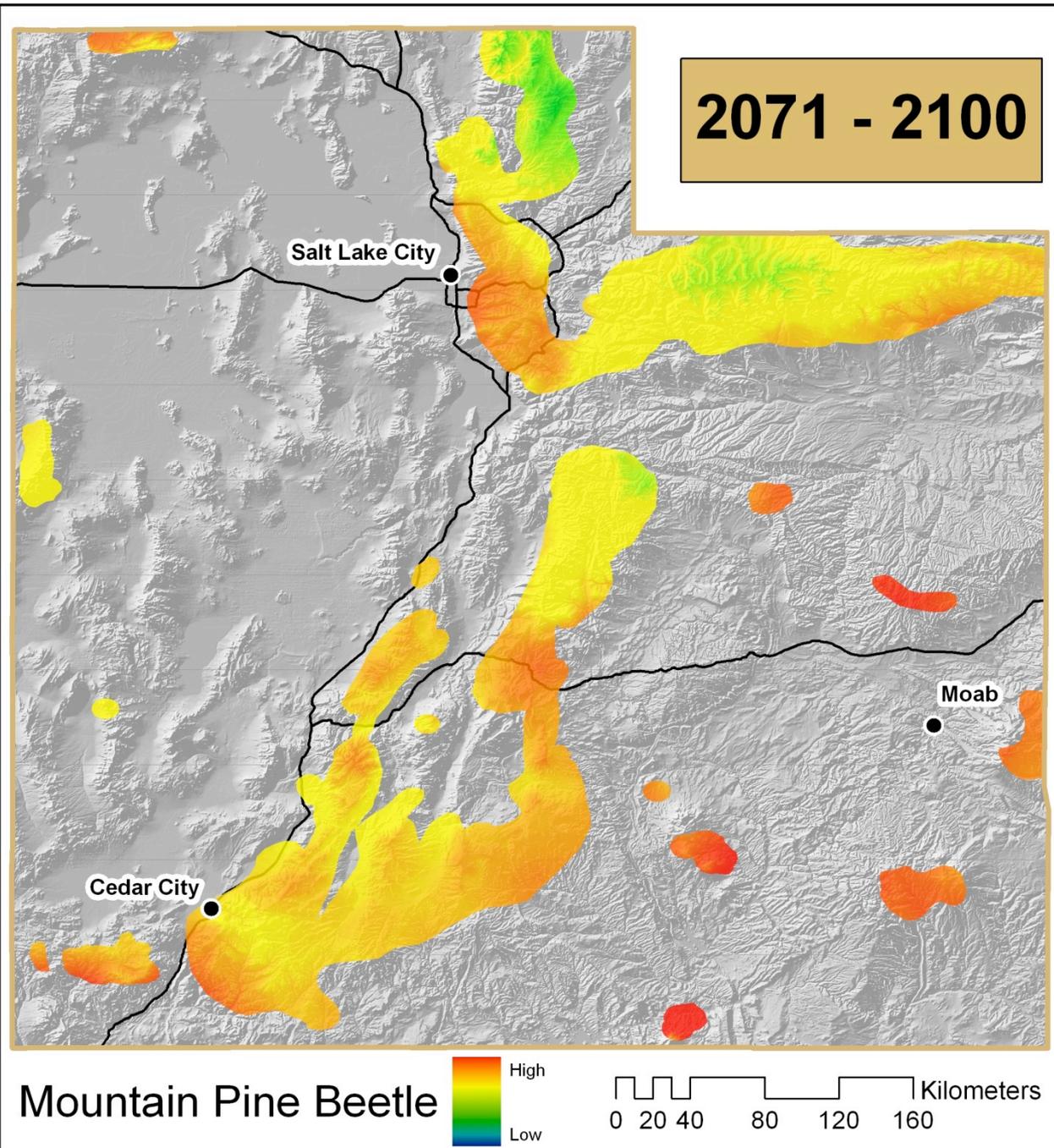
Normals,
CRCM v. 4.2.0
IPPC A2 scenario



Future Predictions

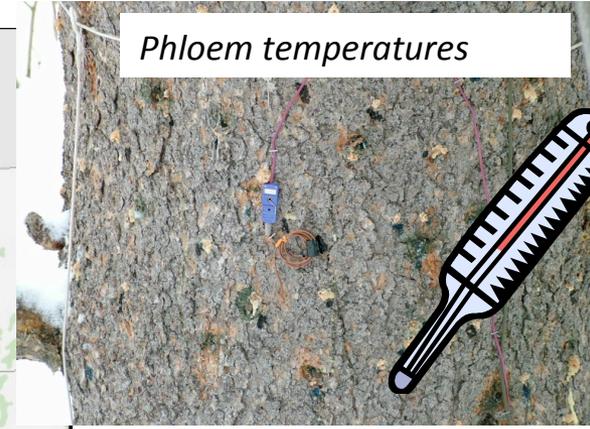
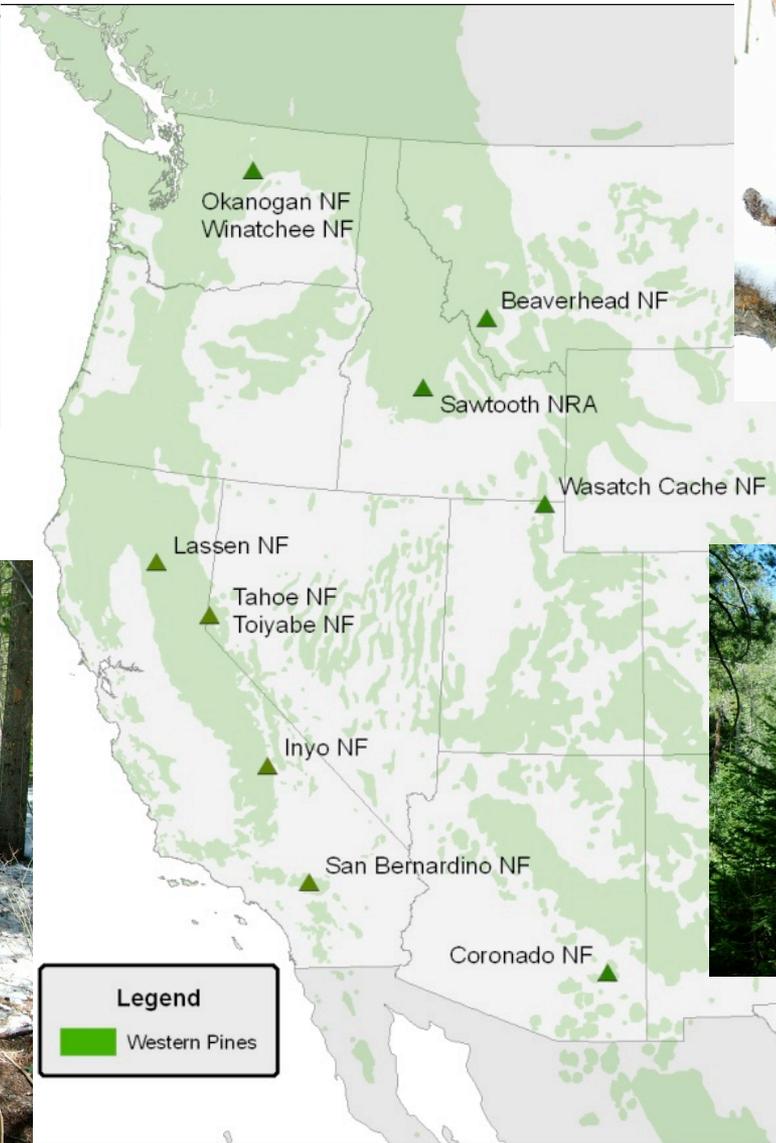
Mountain pine beetle
Probability of Survival
Cold Tolerance Model
2071-2100

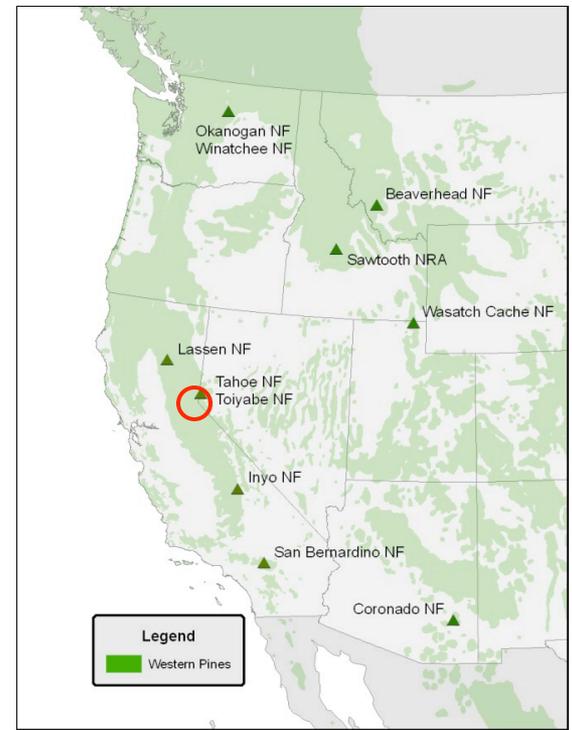
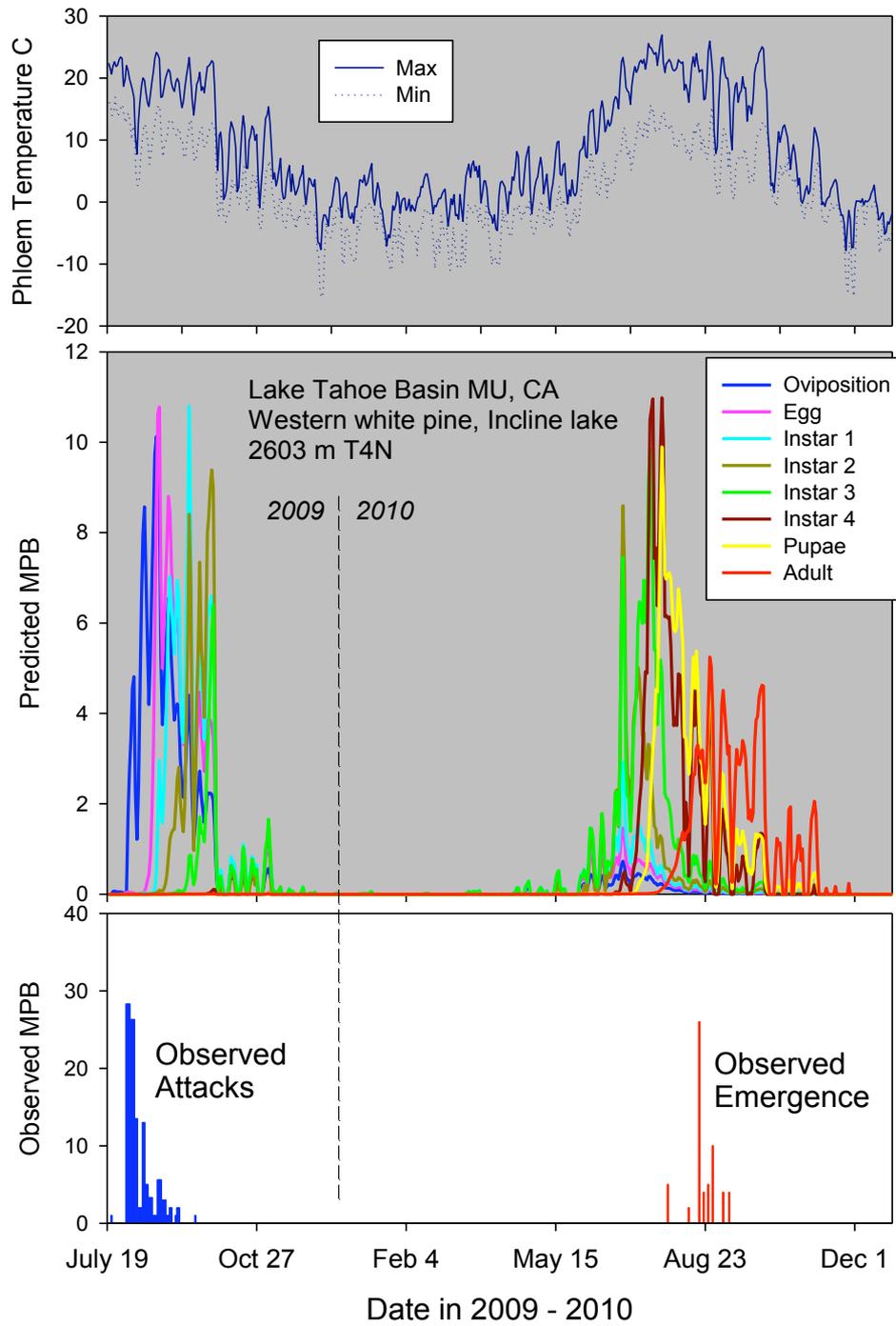
Normals,
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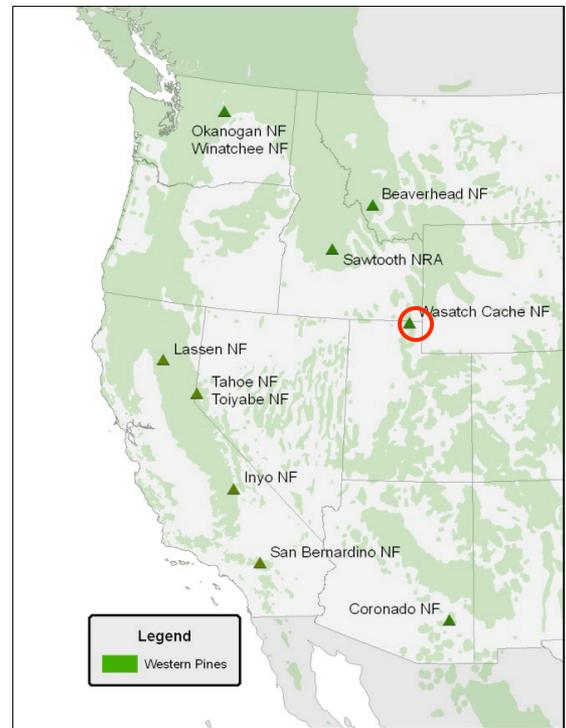
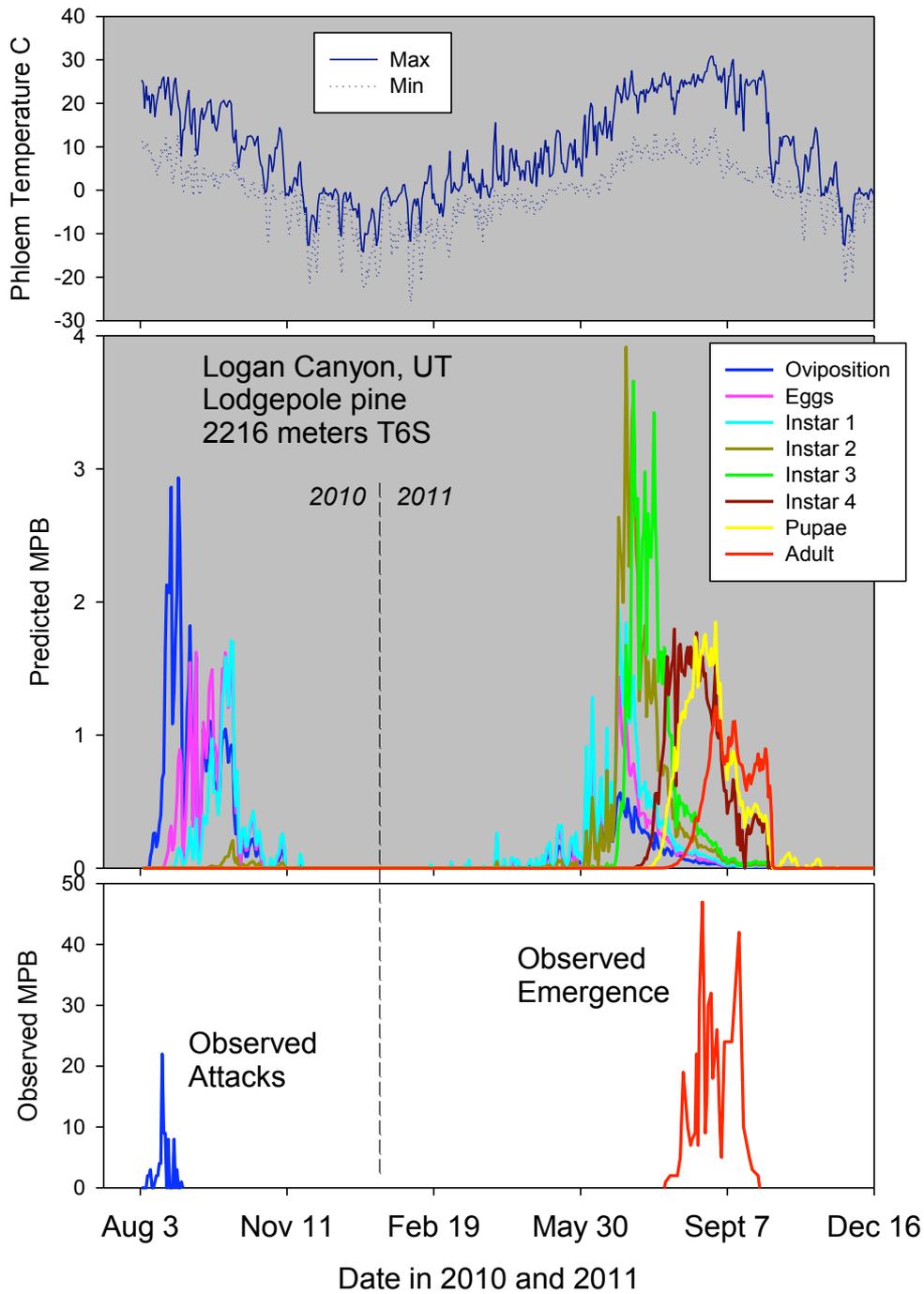


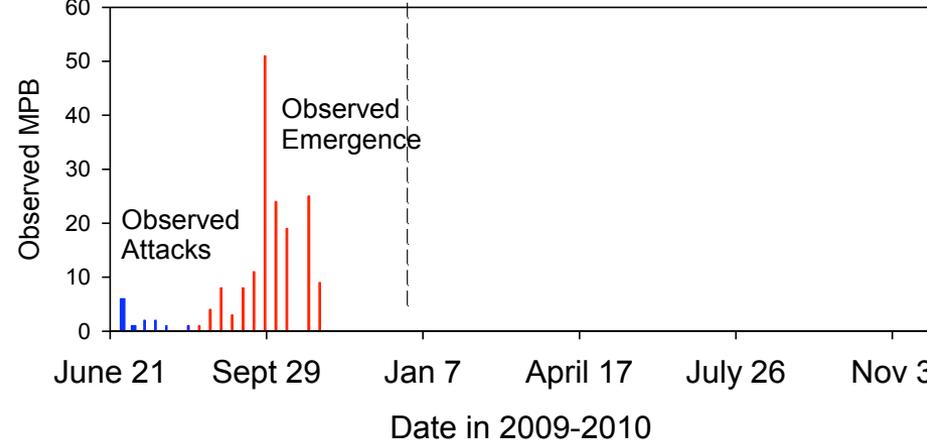
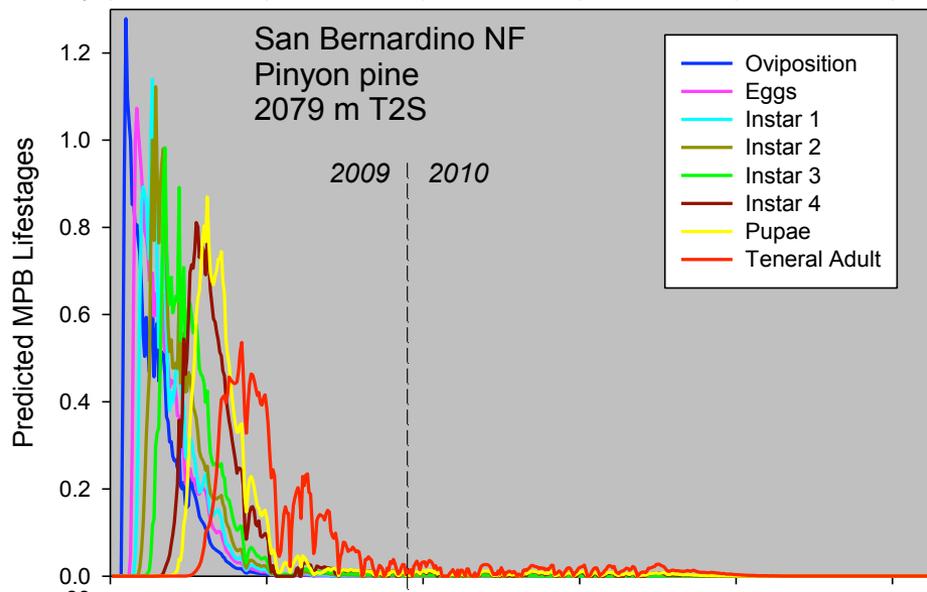
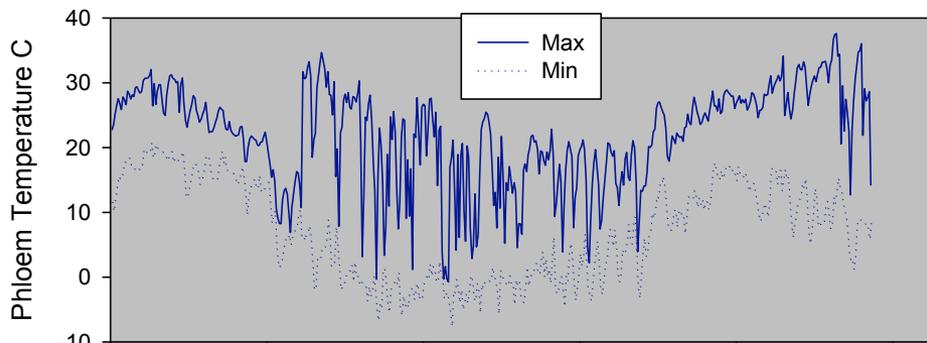
West-wide monitoring of mountain pine beetle and weather –

- Set benchmarks for future climate changes
- Evaluate temperature-dependent phenology models

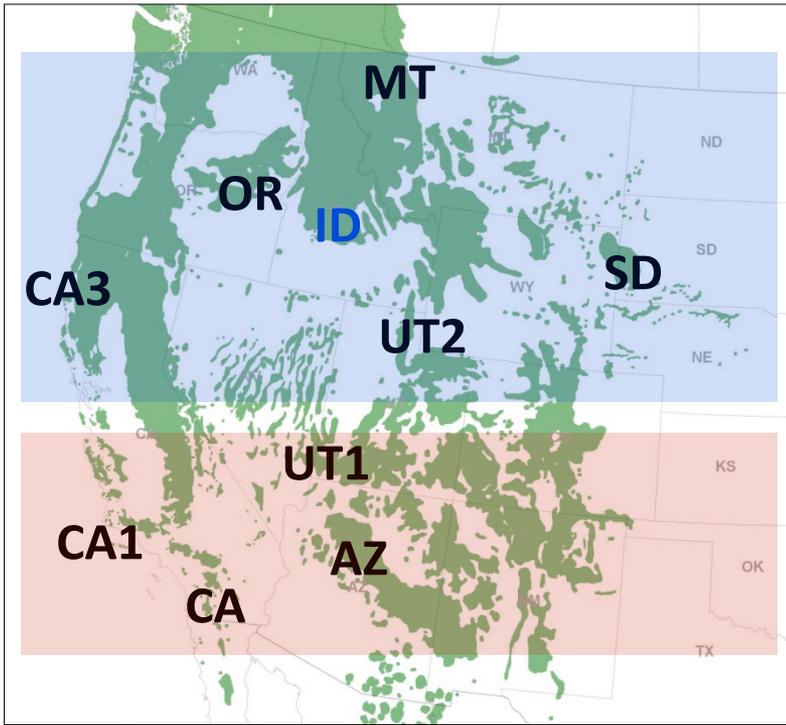








Common Garden Rearing Experiments



- **Slower** total development at more southern latitudes (warmer) and **faster** development at more northern latitudes (colder) potentially facilitate the same strategy, univoltinism.

- Strong local selection among geographically-separated MPB populations. Phenotypic plasticity and genetic variability in thermal development thresholds are influencing latitudinal differences.

- **Response to climate change will differ geographically.**

