PRELIMINARY RESULTS OF MONITORING MOUNTAIN PINE BEETLE LIFE CYCLE TIMING AND PHLOEM TEMPERATURES AT MULTIPLE ELEVATIONS AND LATITUDES IN CALIFORNIA

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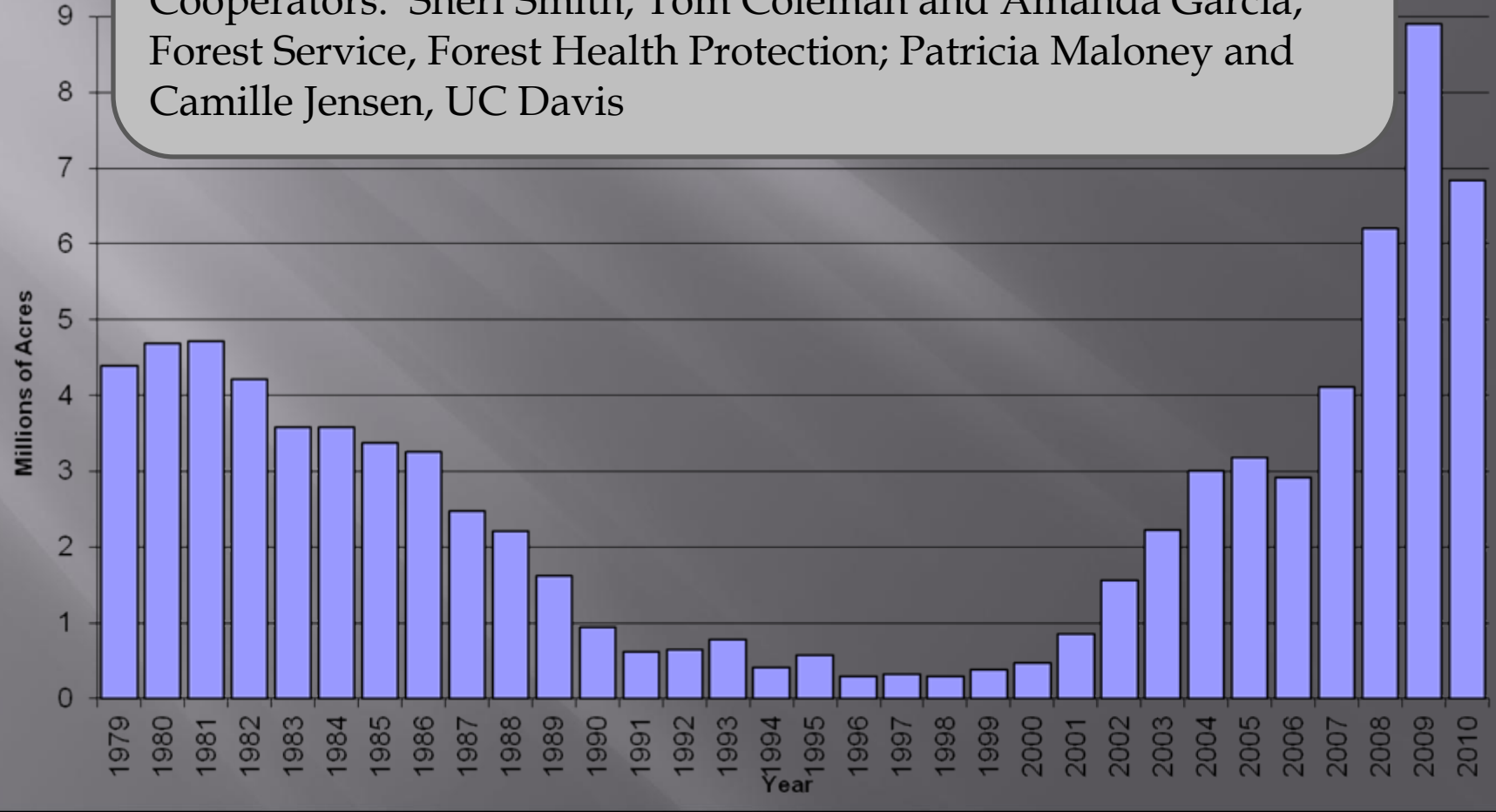
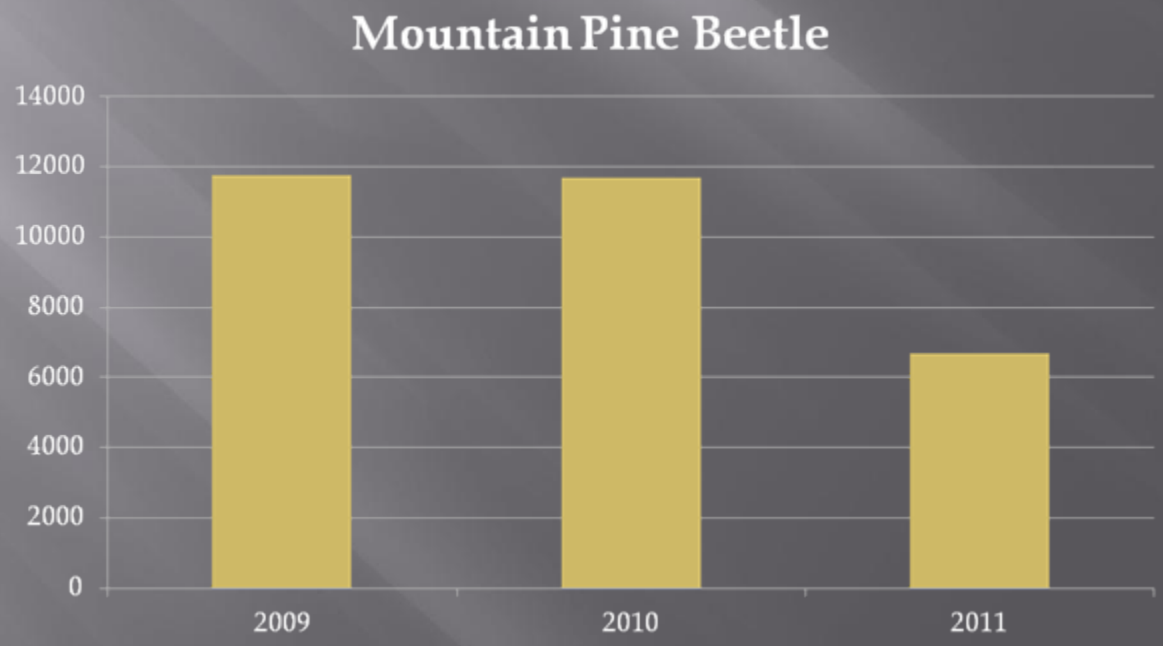
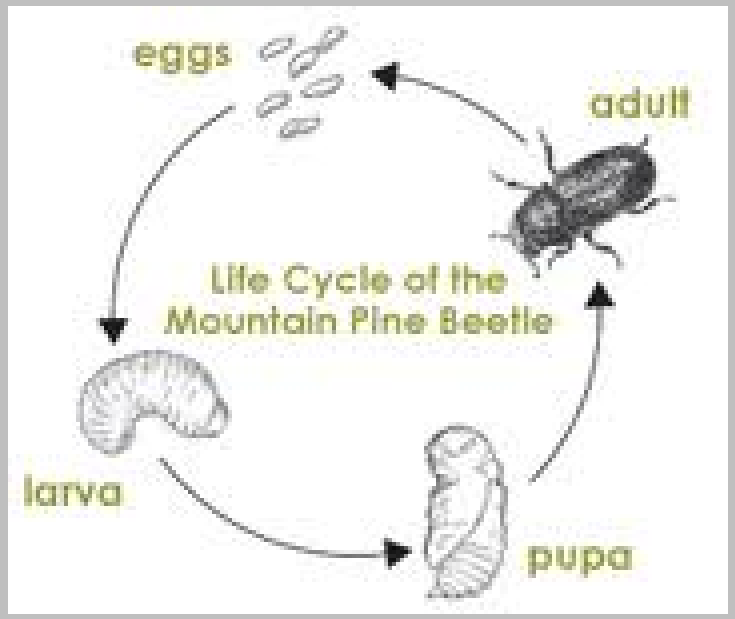


Acres with mortality



Source: ADS 2009-2011



- **Females initiate attack**
- **Mating occurs under bark**
- **Eggs – 10-14 days**
- **Four larval instars**
- **Pupal stage – ~14 to 30 days**

Optimum temperature for development: 23-25° C.
No diapause; rely on direct temperature control for seasonality

Hosts:
lodgepole pine
ponderosa pine
whitebark pine
western white pine
sugar pine
limber pine
Coulter pine
foxtail pine
pinyon pine
bristlecone pine
(successful in 22 species)

Sandy Kegley

Factors that influence mountain pine beetle phenology:

- Food availability
- Resin pressure
- Moisture
- Predator/parasite complexes
- Temperature

Successful across a broad spectrum of latitude and temperature regimes .

Numerous outbreaks recorded the past 100-150 years across western North America


Erich Vallery

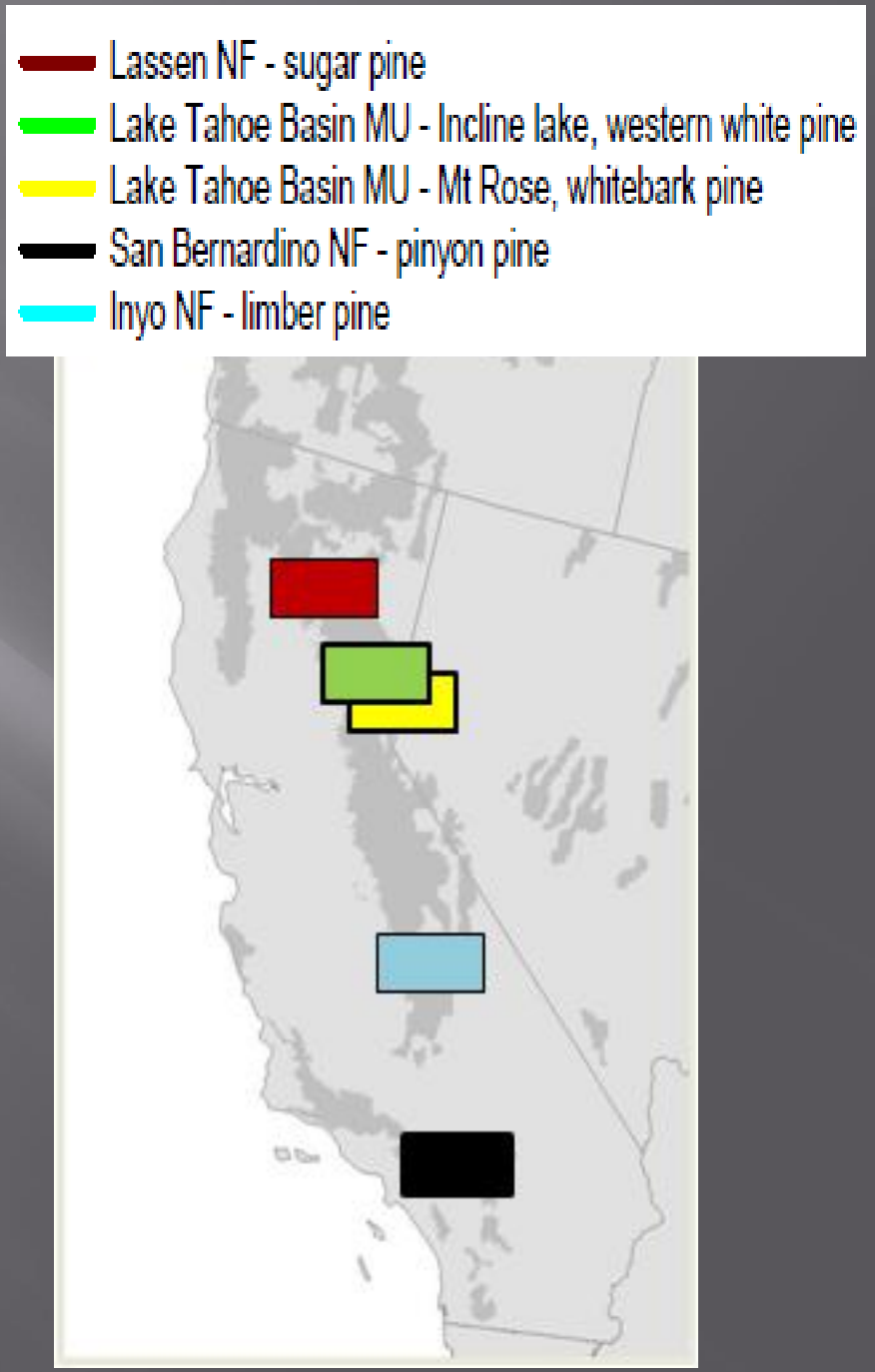
PROJECT OBJECTIVES

- develop a baseline database of mountain pine beetle life cycle timing and associated phloem temperatures in several host trees at multiple elevations and latitudes

- using the field-collected data, evaluate current models of mountain pine beetle phenology

Plots established: 2009

1.*Lassen NF*: sugar pine near Elam Creek (5364 ft)
2.*Tahoe NF:* lodgepole pine near Prosser Creek (5847 ft)
3.*Lake Tahoe Basin Management Unit:* western white pine and lodgepole pine near Incline Lake (8540 ft), and whitebark pine near Mt. Rose (9619 ft)
4.3) *Inyo NF:* limber pine on Granite Pass near Horseshoe Meadow (9600 ft)
5.4) *San Bernardino NF:* ***piñon*** pine near Big Bear Lake (6822 ft)

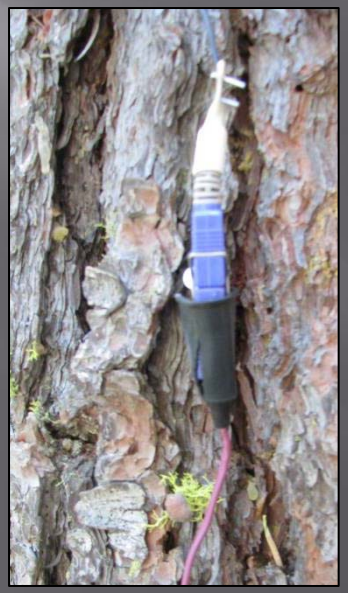


Temperature probes were installed into the phloem on 3 to 5 trees on the north and south bole aspect at DBH.

Temperature probes were attached to dataloggers that allow for continual recording of temperatures every minute.

MPB tree baits were placed on each tree to initiate attack.

Baits pulled after ~20 MPB attacks.



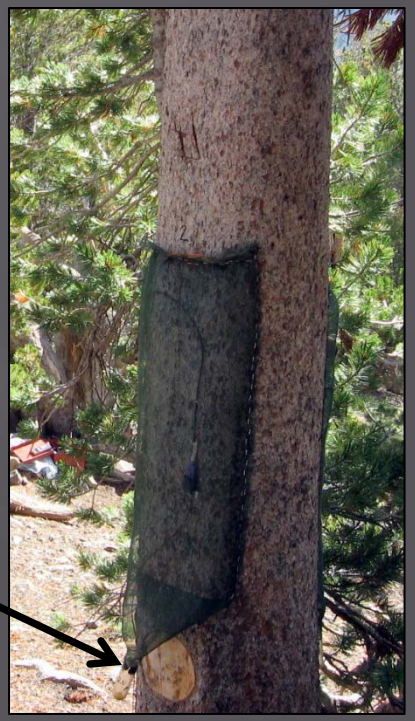
Ambient temperatures recorded at each site.

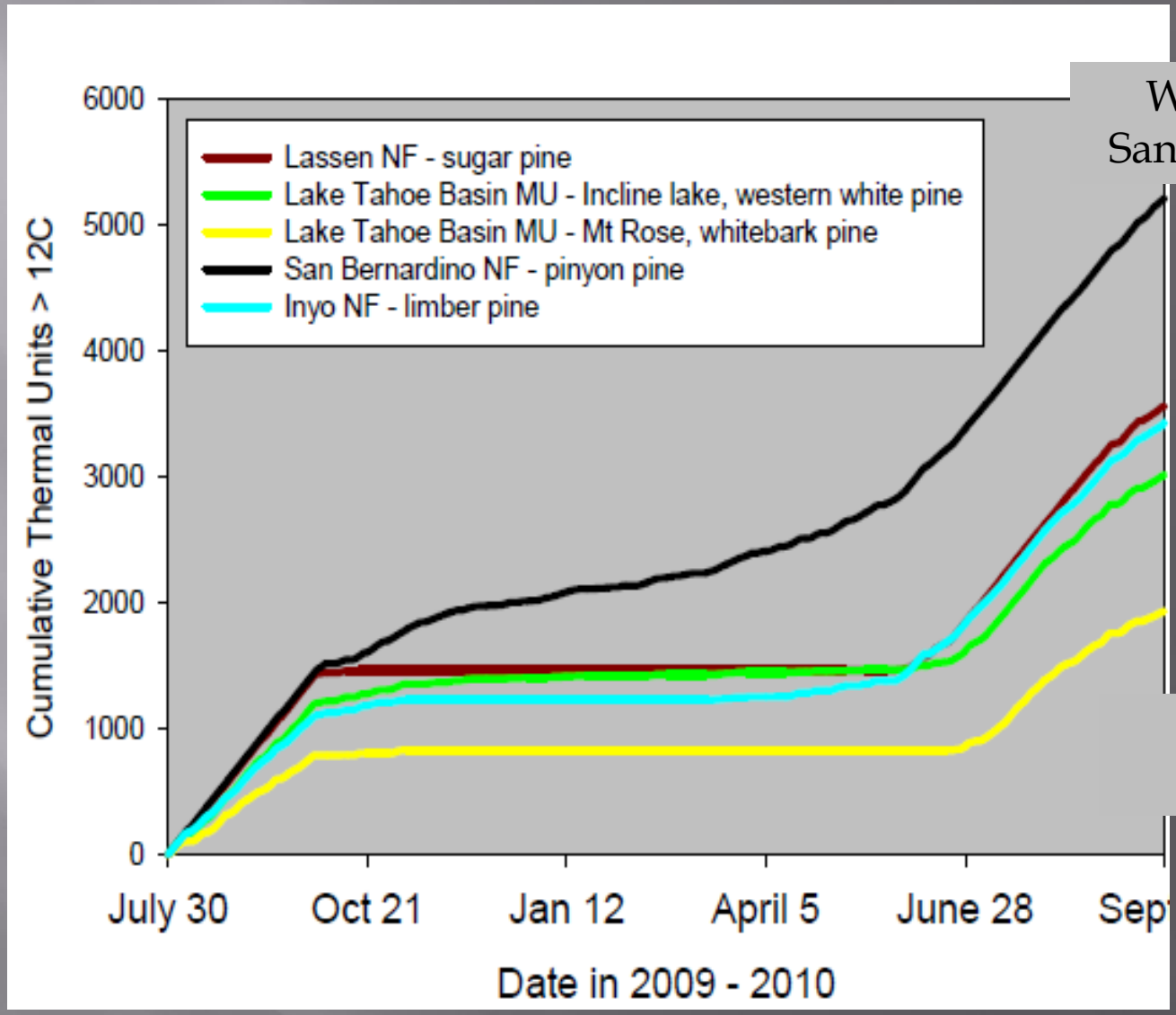
MPB attacks were monitored on each tree (between 1 ft and 5 ft) on a daily or weekly basis depending on site.

Cages were placed on trees to monitor emergence.

Adult emergence was monitored in the spring, summer and fall (2010 and 2011) on a weekly or bi-weekly interval.

Size and sex of emerging adults were also recorded.





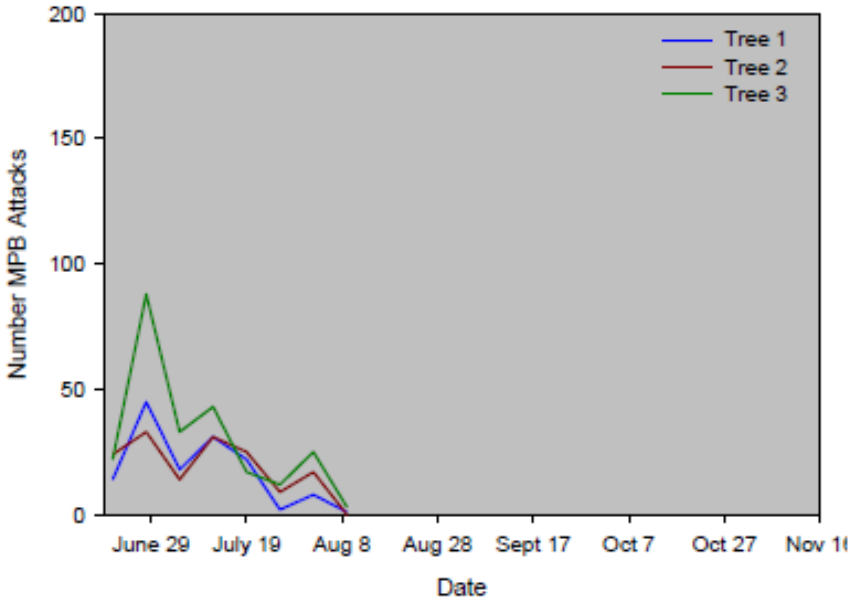
WARMEST
San Bernardino

COOLEST
Mt. Rose

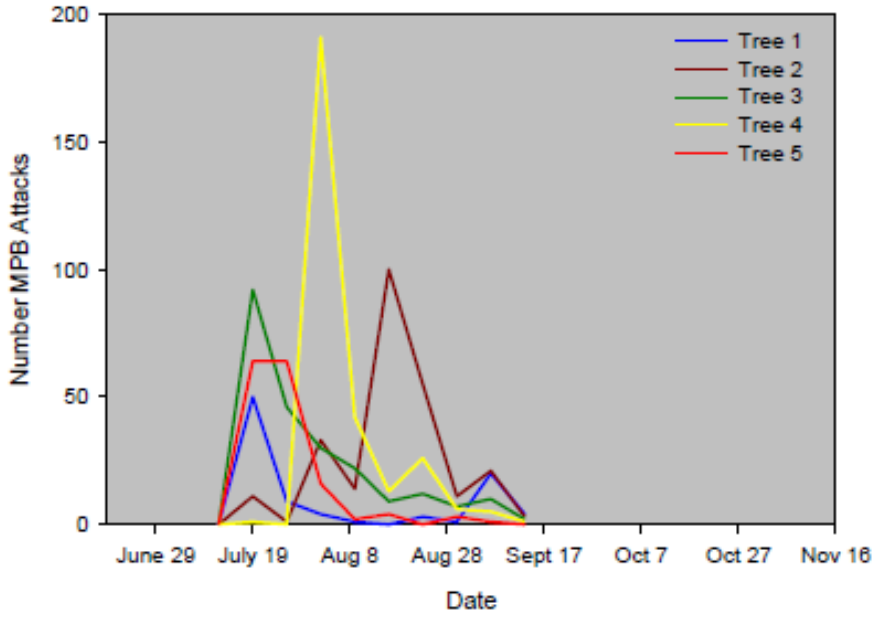
Thermal patterns varied significantly among the sites and between years.

Variability in MPB flight timing and number of attacks on trees among and within trees at each site.

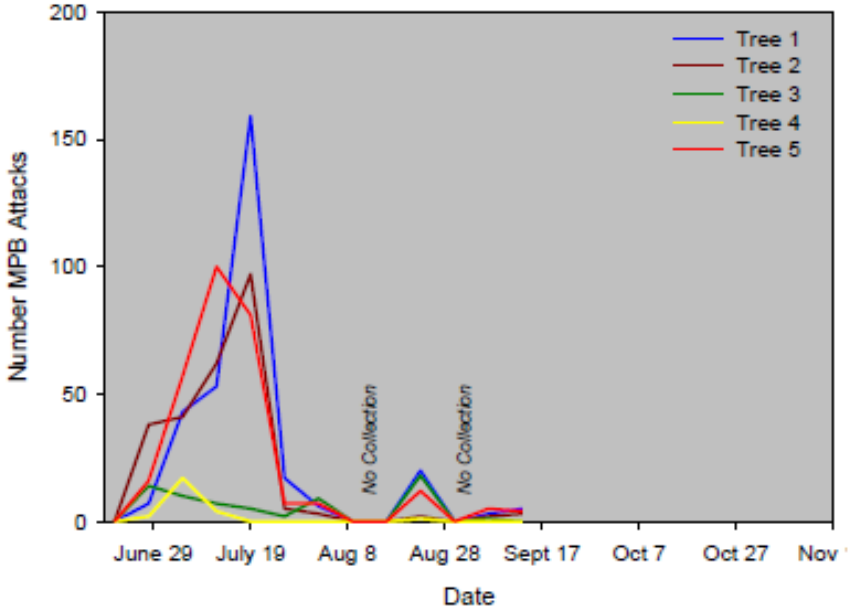
Lassen NF - Sugar pine - 1635 m



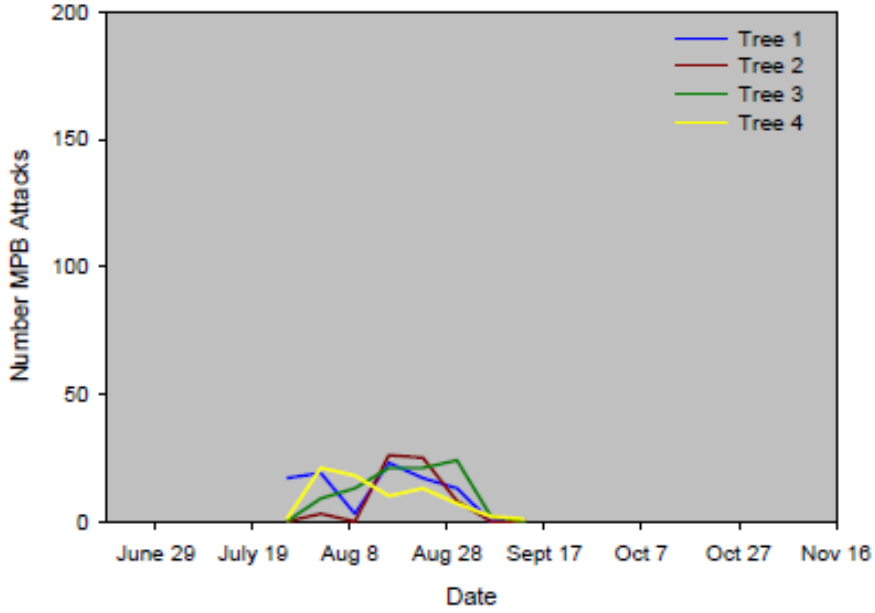
Lake Tahoe Basin NF - Western White & Lodgepole pine - 2603 m

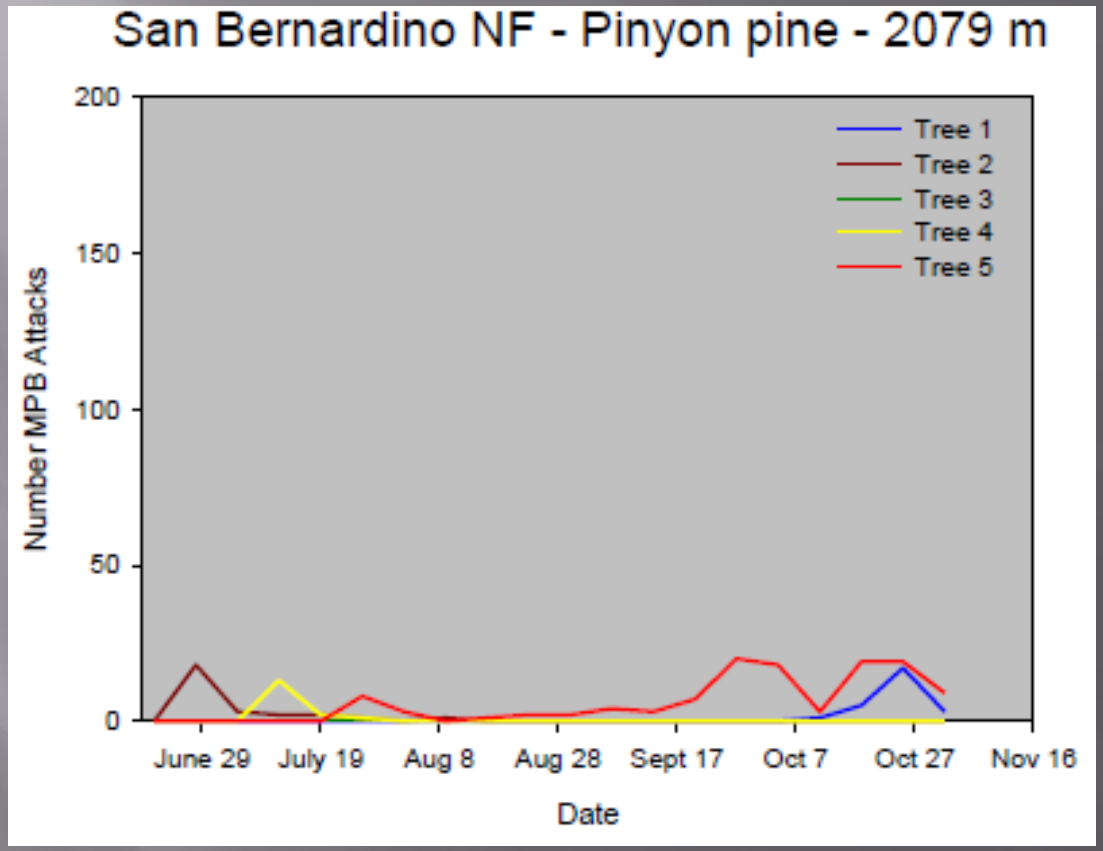


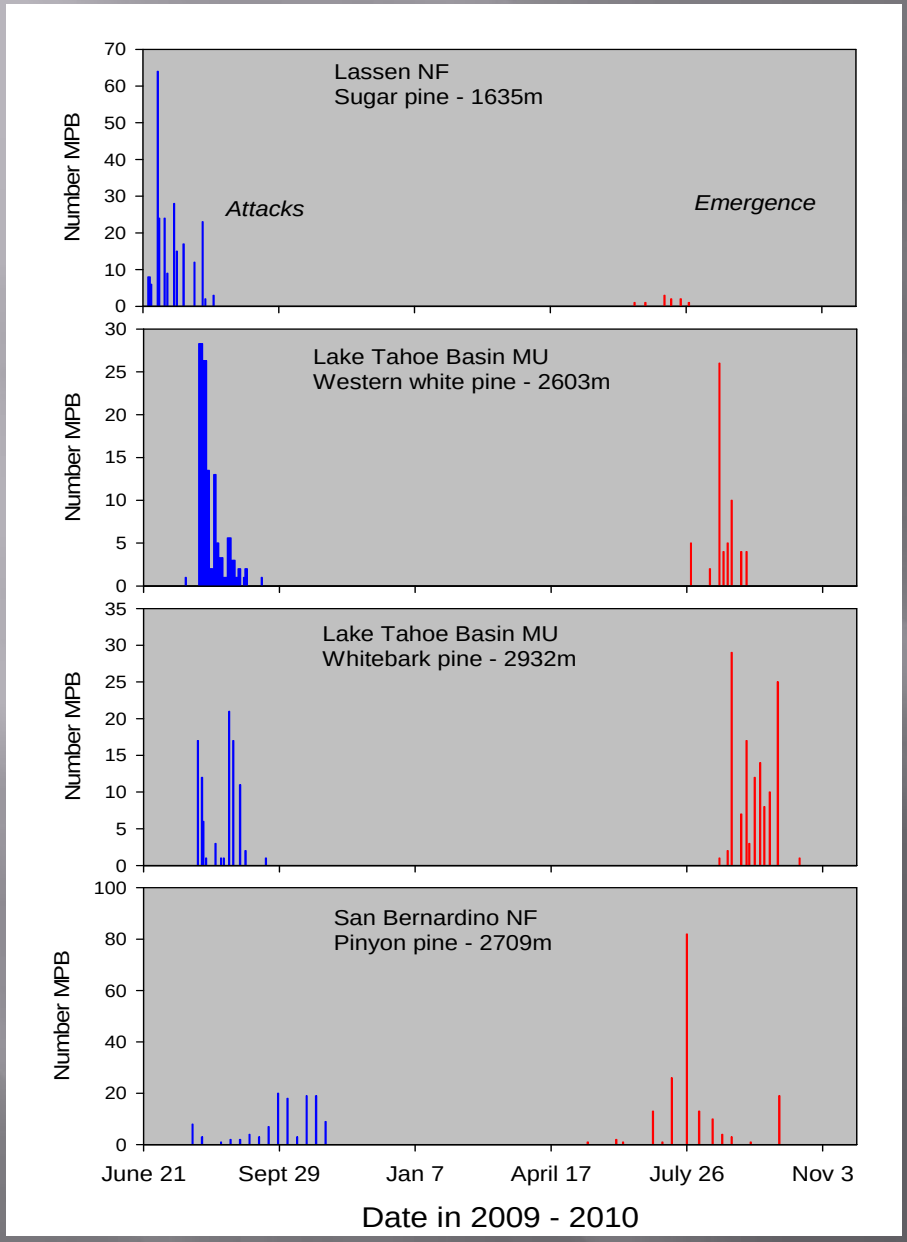
Tahoe NF - Lodgepole pine - 1782 m



Lake Tahoe Basin NF - Whitebark pine - 2932 m



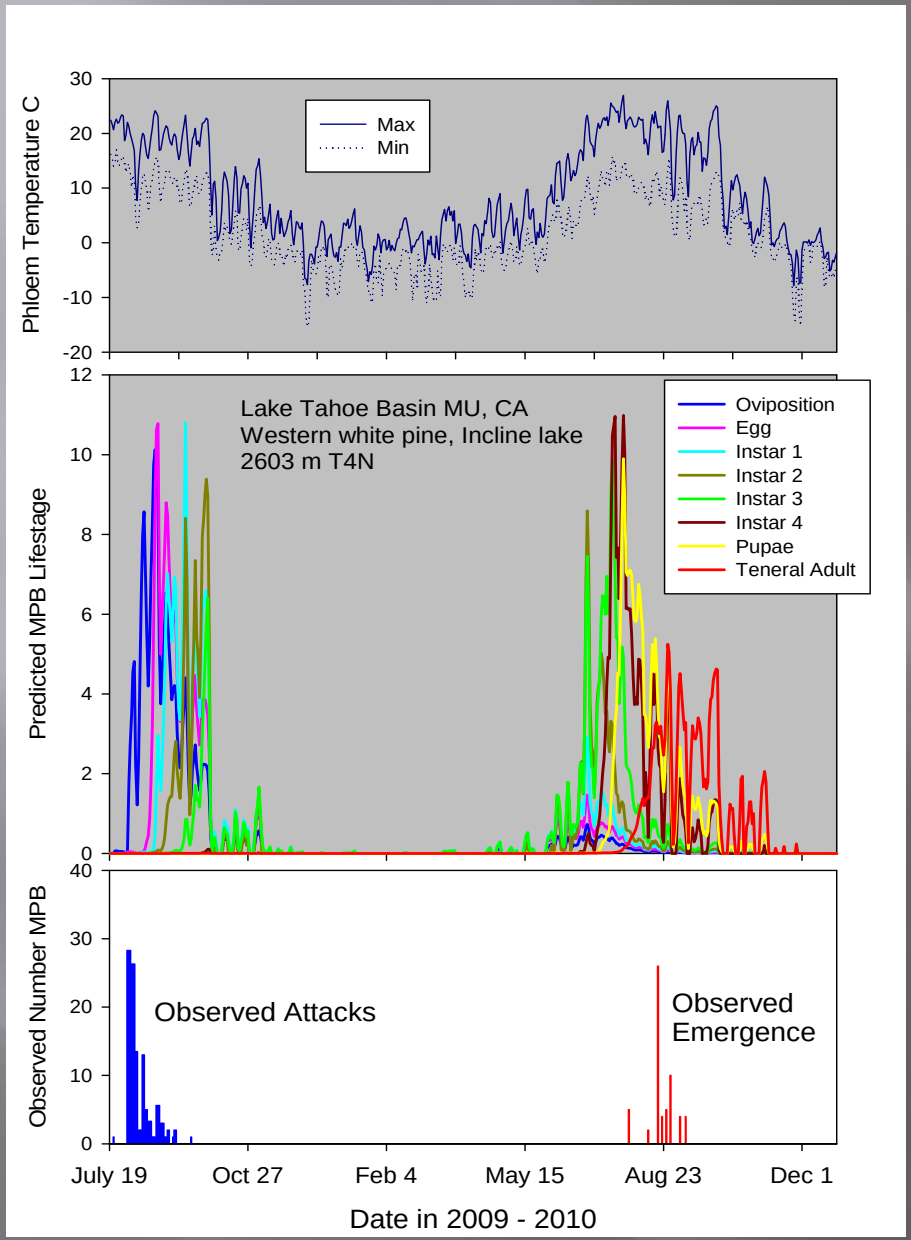

San Bernardino NF - Pinyon pine - 2079 m
Number MPB Attacks
200
150
100
50
0
Tree 1
Tree 2
Tree 3
Tree 4
Tree 5
June 29
July 19
Aug 8
Aug 28
Sept 17
Oct 7
Oct 27
Nov 16
Date



MPB attacks in 2009 resulted in development in a single year at the majority of the sites.

A proportion of the population at the highest elevation site took two years to develop.

Incline Lake (8540 ft), western white pine

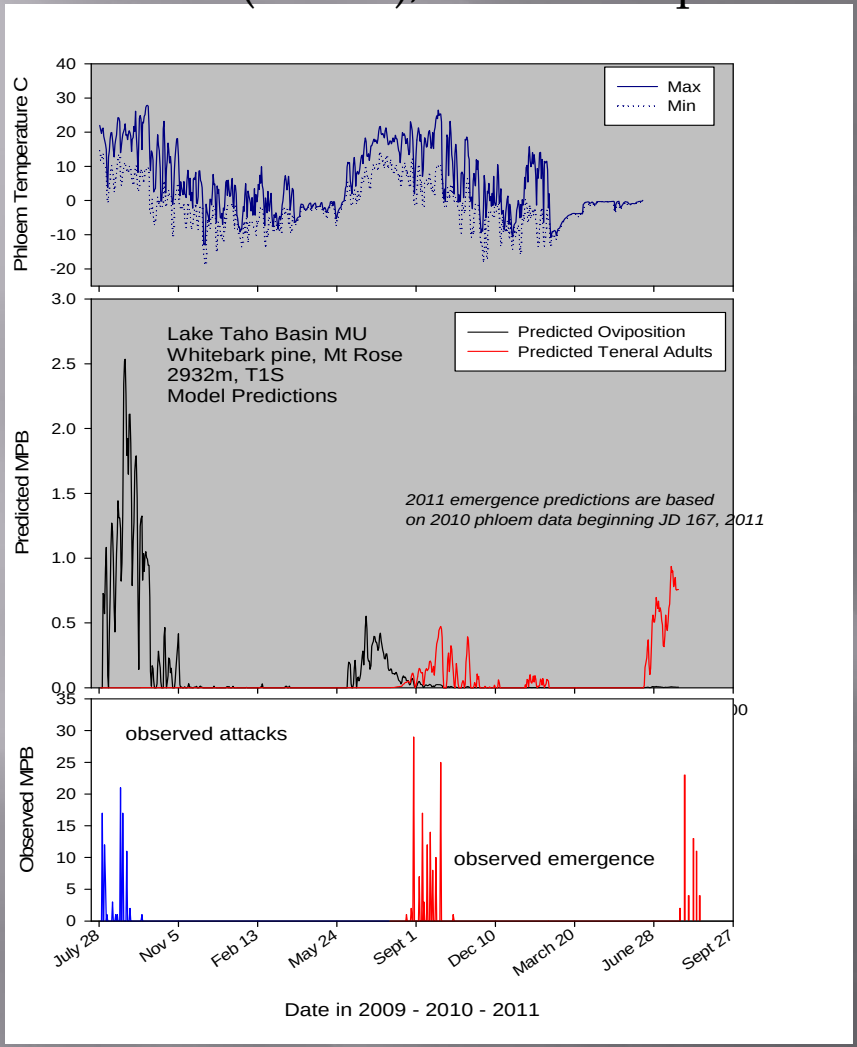


Observed phloem temperatures

Model predictions

MPB attacks and emergence

Mt. Rose (9619 ft), whitebark pine

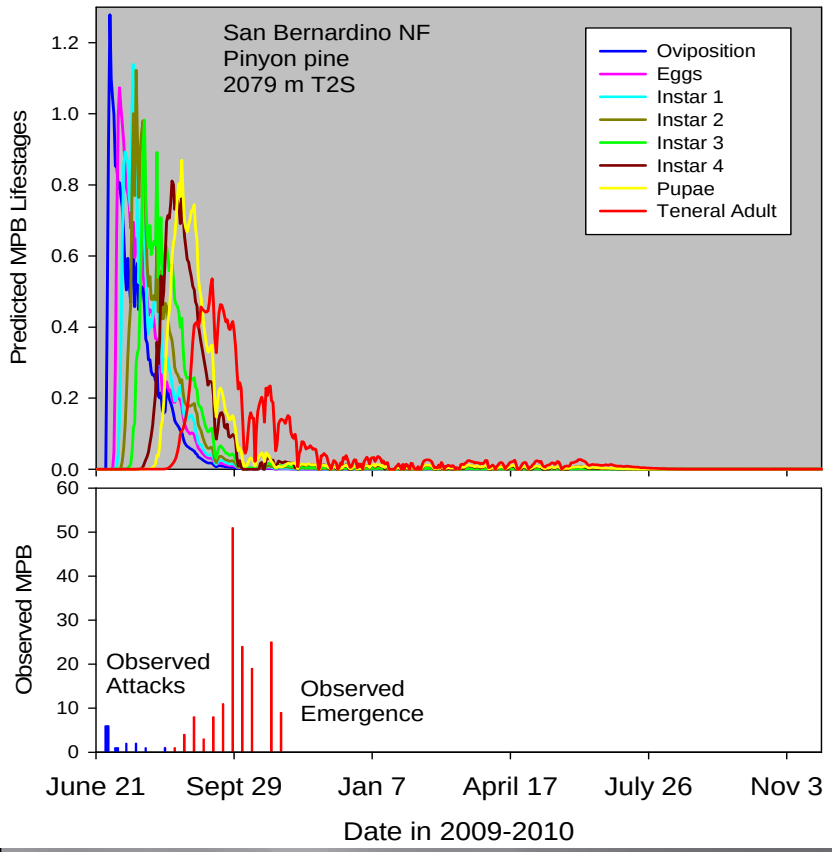


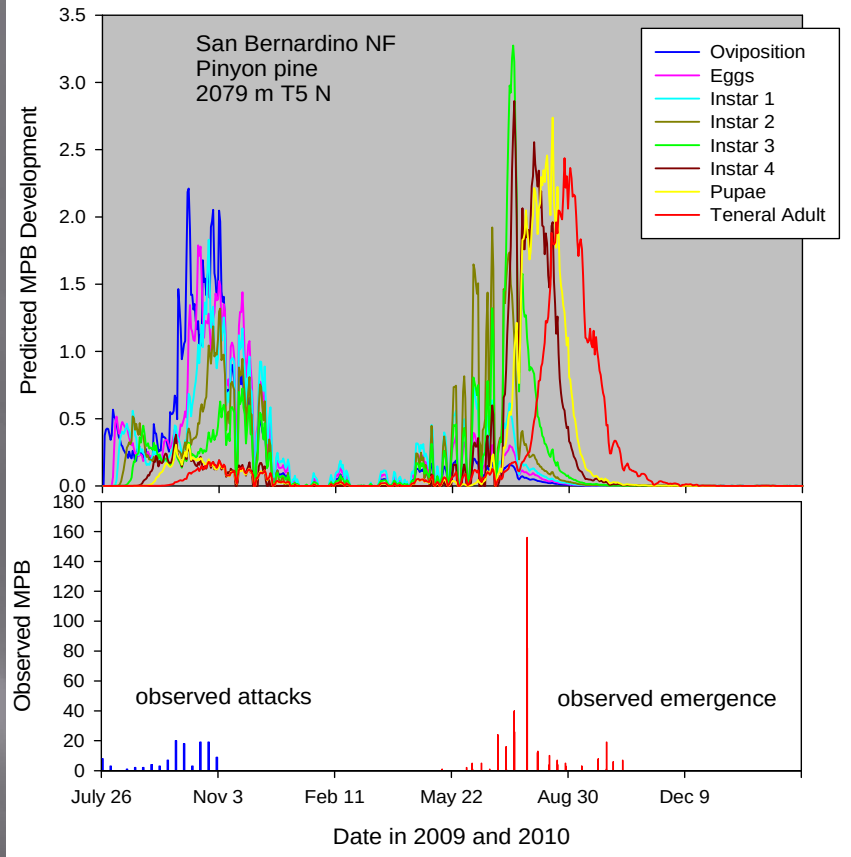
Observed phloem temperatures

Model predictions

MPB attacks and emergence

- 2009 attacks = some proportion of beetles that developed in a single year and beetles that required 2 years in the same trees.
- This pattern was predicted by the MPB phenology model.
- Preliminary 2011 field data indicates >90% of brood at the Mt. Rose site will require 2 years to complete a generation.





south side

north side

San Bernardino

Forced attacks on trees in early June resulted in completion of a MPB lifecycle in less than a year.

Brood in trees at the same site required a full year to complete their development with emergence the following summer.

Preliminary information

- **Thermal patterns varied significantly among the sites and between years.**

- **MPB attacks in 2009 resulted in a univoltine lifecycle at the majority of the sites; a proportion of the population at Mt. Rose developed on a semivoltine lifecycle.**

- **Completion of a MPB lifecycle on the San Bernardino NF occurred in less than a year in 1 tree; beetles in other trees at the same site required a year.**

- **The MPB model appears to do well at predicting lifecycle timing in CA.**
  - **Predict developmental timing and # generations/year.**
  - **Determine how the interaction between beetle, stand and temperature influence population dynamics.**
  - **Predict areas where univoltine/bivoltine/semivoltine populations are possible under historic, current and predicted climate regimes.**

Eggs and small larvae are most susceptible to winter kill.

Eggs and pupae typically do not make it through winter.

Young brood from fall attacks
Young brood at the end of larval galleries
Young brood of occasional 2nd attacks
are usually more adversely affected than older larvae.

Large larvae are more susceptible to cold temperatures in early spring after feeding has resumed.

Sudden freezing can cause larval mortality at any time.

High temperatures are not likely to cause mortality (>110°F).

- The MPB phenology model will be an additional tool for predicting susceptibility of pine forests to MPB outbreaks across California.
- Development of management strategies.
- Prioritize gene conservation efforts (e.g., cone collections, seed-banking, genetic studies).

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Sandy Kegley

In recent years, mountain pine beetle populations have been found further north into British Columbia and east into Alberta than had been observed in historical records, including an outbreak in 1985.

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Funding: Evaluation monitoring, Forest Health Monitoring program, WO

References: Bentz et al. 1991; Gibson et al. 2009; Logan and Bentz 1999; Powell and Bentz 2009; Amman and Cole 1983.

MPB Model:

Regniere, J., J Powell, B. Bentz and V. Nealis. Temperature responses of insects: Design of Experiments, data analyses and Modeling. *In Review*. Journal of Insect Physiology.

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Erich Vallery