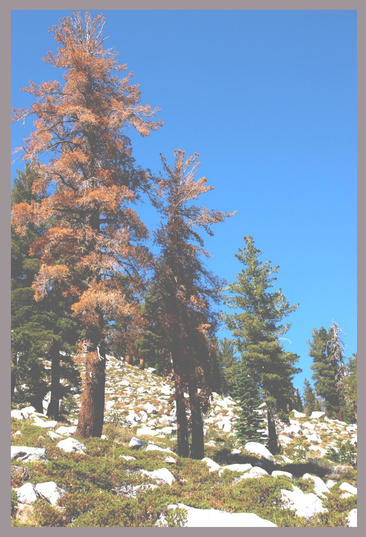

Monitoring Mountain Pine Beetle Life Cycle Timing and Phloem Temperatures at Multiple Elevations and Latitudes in California

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Introduction

The geographic distribution of mountain pine beetle (*Dendroctonus ponderosae*) (MPB) is extensive, encompassing all pine ecosystems from southern California to central British Columbia. In recent years, MPB outbreaks have become more intense and of longer duration, killing pines over millions of acres. This increase in, and expansion of, MPB activity is thought to be a direct result of warming temperatures and reduced precipitation as well as changing stand conditions. MPB fitness and population success are directly related to temperature as it affects multiple life history strategies and community associates. Future distributions of MPB (both expansions and contractions) will be dictated by climate regimes in susceptible pine forests as well as the ability of MPB to migrate and/or adapt to novel environments.

To describe and predict future trends in population success as a function of temperature, models describing MPB phenology have been developed using data derived from populations in central Idaho. However, little data is available on MPB population dynamics in the southern part of its range, including many areas in California, to evaluate the adequacy of current models. Constant temperature laboratory experiments and range-wide genetic analyses have demonstrated significant genetic and quantitative trait variation among MPB populations from different latitudes, but how this variation relates to population success throughout California is unclear. For example, the potential for MPB populations to successfully complete two generations in a single year in current or predicted climate regimes of California has not been investigated. California is home to six of the nine white pine species native to the US. Many of these are keystone, long-lived species growing at high elevations and are threatened by MPB and white pine blister rust. **Baseline data is needed on MPB temperature-dependent lifecycle timing to assess potential impacts to high-value pine species caused by current and changing climates throughout California.**

Methods

In 2009, four areas were selected in California to monitor MPB lifecycle timing in conjunction with air and phloem temperatures of MPB-infested host trees. The four areas had current MPB activity, and were chosen to provide a gradient of elevation with multiple host tree species from northern to southern California: 1) Lassen NF, *Pinus lambertiana (*sugar pine) ; 2) Tahoe NF and Lake Tahoe Basin Management Unit (MU), including three elevation zones with *P. contorta* (lodgepole pine), *P. monticola* (western white pine), and *P. albicaulis* (whitebark pine); 3) Inyo NF, *P. flexilis (*limber pine); and 4) San Bernardino NF, *P. monophylla* (pinyon pine) (Fig. 1). Data were collected over a three year period (two complete MPB life cycles from attack in 2009 through emergence in 2011).

At each site, for two years, air and under-bark temperature probes were attached to 3-5 trees to monitor hourly averaged phloem temperatures for the duration of the MPB lifecycle. To ensure MPB attacks within plots, a single attractant bait was placed on appropriate plot trees for just long enough to initiate beetle attack. The timing of MPB attacks was then monitored and recorded on the lower bole of each sample tree at each site on at least a weekly basis. After the completion of MPB attack at a site, 1x2 ft emergence cages were attached to north and south sides of each sample tree. Brood samples were taken periodically from infested trees within plots. MPB emergence timing was monitored on each tree beginning spring 2010. Coincident with emergence from 2009 attacked trees, new plots were established in 2010 and monitored through 2011.

Figure 1. CA Site locations

Results

Mountain pine beetle Summer development

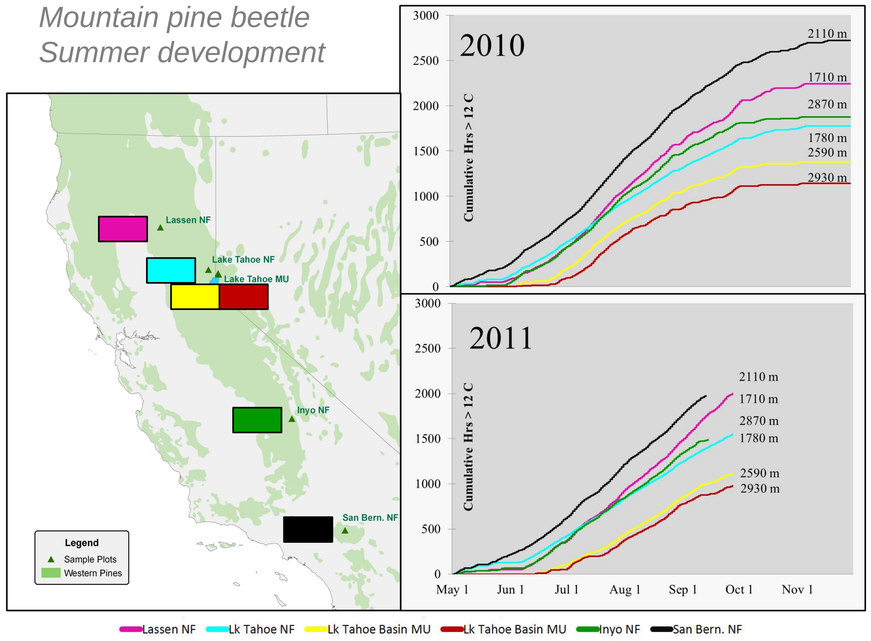

Figure 2. Cumulative number of hours with temperatures ≥ 12˚C at each site.

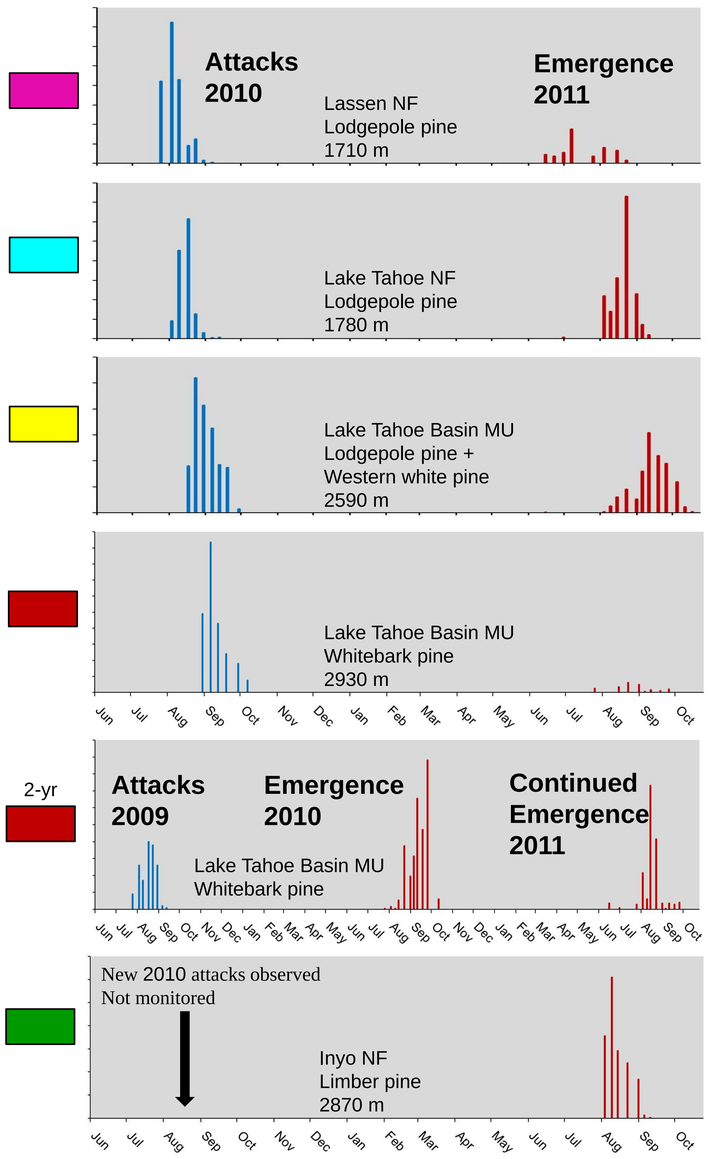

Figure 3. Attack and emergence at each site.

Results, cont.

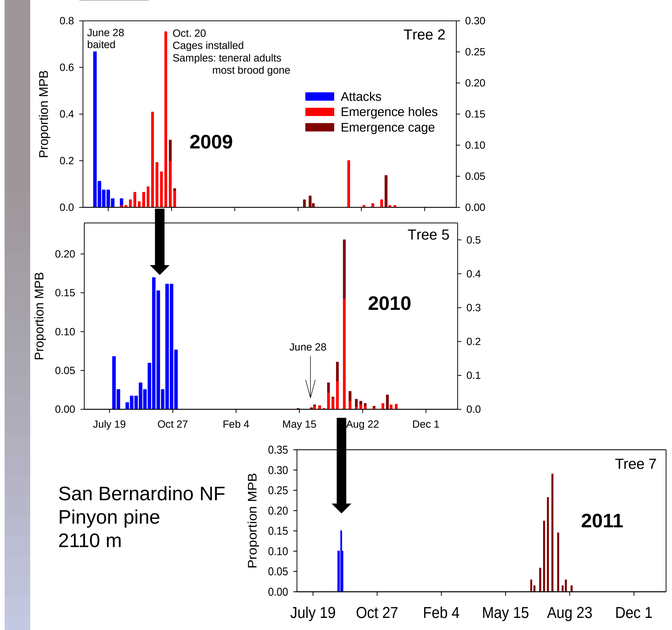

Figure 4. Emergence ➡ Attack at hottest temperature site indicating "Fractional Voltinism".

3 generations in ~2½ years.
NOT Bivoltine!

Summary

- MPB is predominantly univoltine .
- Temperature is warmest at the San Bernardino NF pinyon pine site, and coolest at the Lake Tahoe Basin NF whitebark pine site (Figs. 2).
- At the extreme temperature sites, MPB shows sign of fractional voltinism and semivoltinism in their development. At the warmest site, San Bernardino NF, MPB developed 3 generations in approximately 2½ years (Fig. 4). At the coldest site, Lake Tahoe whitebark pine, a proportion of the population required 2-years to complete development (Fig. 3).
- At all other sites, results suggest that MPB completed a single lifecycle between early July and early October (Fig. 3).
- Continued MPB emergence and temperature data will be collected thru summer 2012 at the coolest Lake Tahoe sites. This will provide a complete emergence record for MPB lifecycle timing in sites with potential semivoltinism due to cool summer temperatures.
- Data from multiple trees, sites, and years will be used to evaluate our MPB phenology model for use in predicting susceptibility of California pine forests to MPB outbreaks and to develop management strategies and prioritize cone collection for gene conservation.

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