This tree's not big enough for the both of us: Symptoms of Sudden Oak Death on California Bay Laurel are lower when insect herbivores are abundant

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Abstract

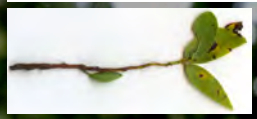
Leaves of California bay laurel (*Umbellularia californica*) are considered the primary natural source of inoculum for the devastating forest disease sudden oak death (*Phytophthora ramorum*), and yet this plant & insects associated with its leaves remain understudied. This is unfortunate due to the role herbivorous insects may play in disease transmission and alterations to plant disease susceptibility. There is also a deficit of knowledge on how landscape level variability or the effect of microclimate may influence insect presence, and about systems involving both a plant's pathogen and insect herbivores. 200 woodland plots within a 275 km2 region of Sonoma county have been assessed since 2003 for disease progression. Insect diversity and abundance on leaves of bay have been monitored since April 2014, with species appearing most often from the suborder Sternorrhyncha, which includes aphids, scale, and whiteflies. We have found a negative relationship between insect and pathogen presence on the tree level for California laurel aphid ($p = 0.04$) and one species of armored scale insect ($p = 0.004$). We will investigate these interactions on a finer scale, including direction of correlation and across two microclimates, in 10 plots at Fairfield Osborn Preserve December 2015 - May 2016, using both an observational and experimental approach. We hope this may inform management strategies to slow spread and cope with this disease threatening to unhinge native Northern California ecosystems.

Questions

1. What is the natural diversity and abundance of insects on leaves of California bay laurel?
2. Does insect presence relate to symptom levels of *P.* ramorum on bay laurel, and what is the direction of this relationship?
3. How does disease progression on bay influence insect presence?
4. How do landscape, environmental, and microclimate factors, such as sunlight and temperature, affect these interactions?

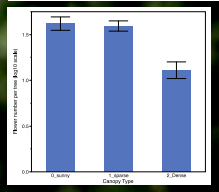
Background

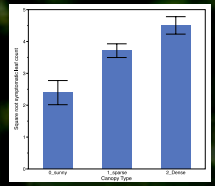
P. ramorum is a water mold discovered in the mid 1990's known to infect over 100 plants in California, with Sonoma county affected most. It is the primary cause of mortality for five native trees, including *Notholithocarpus densiflorus* (Tanoak) and *Quercus agrifolia* with 1 million trees already dead & 1 million more infected. This loss of these keystone species is causing sweeping ecological disruption in addition to concern of negative cultural, economic, and safety impacts. Oak conservation efforts depend heavily on gaining a deeper understanding about this destructive forest pathogen .



P. ramorum causes foliar damage to bay, but not significant systemic injury. Bay is therefore expected to persist as a foliar host (Dileo et al. 2009).

California bay trees in sunny areas produce more flowers and fruit than those under forest canopy cover.





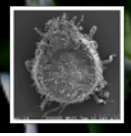
Conversely, prevalence of infection is greater in areas with more canopy (Mike Carlson, 2012 SSU thesis).

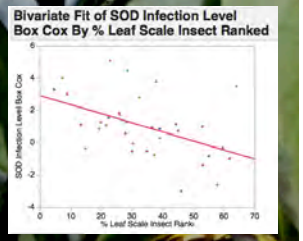
Scale insects and SOD 2013

We visited 4 plots at SSU's Fairfield Osborn Preserve in Spring 2013 to asses disease and insect level on 35 bay trees.

Both infection and scale insect levels were far from normally distributed so transformations (Box Cox and Ranked) were performed.

Stationary herbivores were most common, such as California Laurel Aphid (*at right & left*), armored scale (*above*), and white fly larvae. These are tightly associated with host tissue, unable to flee a mounted defense, and therefore ideal for our study.

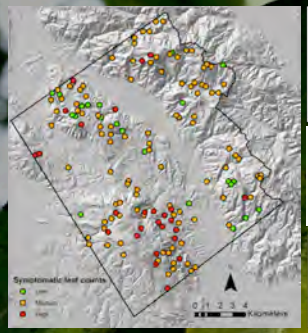




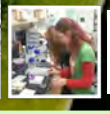
After excluding a single outlier, linear regression shows a negative relationship between each tree's SOD level and scale insect level, for both scale transformation types ($F = 9.40$, $p = 0.004$, *Ranked at left*), ($F = 6.71$, $p = 0.01$, *Box Cox at right*).

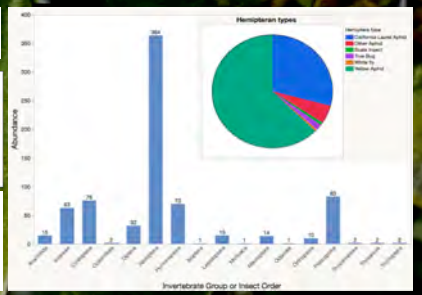
Insect Diversity and Abundance 2014

Woodland plots 15 m² within a 275 km² region of Sonoma county have been monitored since 2003 for disease, debris, plant growth & topography. Disease levels vary across landscape (*below*).



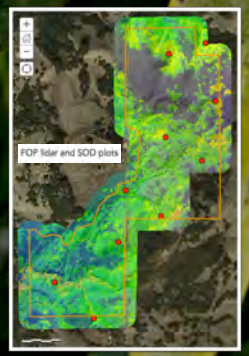
Collected insects are taken to lab for identification, cataloguing & preservation.





Two types of aphids (*right*) were most prevalent, followed by booklice (*right*) , beetles, ants, and spiders. This data shows the diversity of resident insects as well as a number of infrequent visitors.

Microclimate 2015-2016



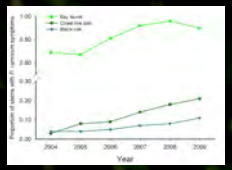
10 plots at Fairfield Osborn Preserve (*left*) are visited every 3-4 weeks December 2015 – May 2016 to follow progression of disease and insects on leaves of 40 trees.

Trees are located in both sunny and shady areas in order to investigate the role of microclimate on this interaction. Loggers record temperature and light levels (*left*).

To examine direction of correlation, insects are removed & excluded using a factorial design. Treatments include Tanglefoot & pyrethrin, horticultural oil, or both.

Unusual disease lesions that are colonized by scale insects are cultured for pathogen presence (*right*).

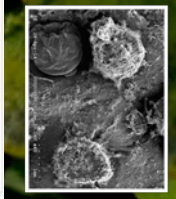
LiDAR and GIS are used to quantify microenvironment variability and geolocate trees (*left*).



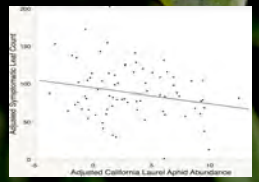
Current data are correlated and compared to historical disease information (*above*).

Discussion

- Previous studies have identified climatic, vegetation, and topographic factors influencing establishment of *P. ramorum* in California woodlands. As yet, no study relates disease prevalence to insect presence, of which we know little about landscape level variability.
- Insect damage may create a route through which pathogens enter a host plant's tissues. Conversely, our preliminary study suggests that attack by pathogen or insect herbivore may lead to lowered susceptibility to the next.
- A change in disease susceptibility of bay laurel in response to insect attack could have implications for both spread prediction and management strategies in communities that are losing oak keystone species.
- For example, if allocation of physiological resources to defense against insects makes bay laurel more susceptible to disease, new management strategies may focus on insect removal. In contrast, if insects prime a plants immune system such that their presence lowers disease susceptibility, as is being suggested by the data, insect introduction or other strategies might be considered.
- Repetitive infection by *P. ramorum* over years may lead to a type of systemic injury or protection not previously considered – changes in susceptibility to insect herbivores. Analyzing historical data from the plot network provides a unique opportunity to explore this question.
- Parsing out the direction and strength of these variables in a landscape-level context is crucial due to the large influence environmental factors have on these components.



Summary



2014 data show that California Laurel Aphid abundance is negatively related to field counts of SOD symptomatic leaves ($m = -2.1 \pm 1.0$, $n = 75$ plots, $p = 0.04$, *left*)

We aim to shed light on the relationship between insect prevalence and *P. ramorum* infection, in a landscape-level context, with hopes to inform management strategies that may slow spread and cope with this disease that threatens to unhinge native California ecosystems.

Acknowledgements

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