Assessing the Relative Importance of Radial Growth and Resin Duct Density in Ponderosa Pine Resistance to Bark Beetle Attack

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Introduction

In numerous montane conifer ecosytems, such as the Rocky Mountains, insect outbreaks are a regularly reoccurring disturbance factor that maintains species diversity and forest health; however the intensity and severity of insect outbreaks has been intensifying under climate change (Logan et al. 2004, Logan and Powell 2001). Drought, hot growing seasons, and shorter winters brought on by climate change may increase ponderosa pine stress and influence how trees invest in growth, defense, and other essential processes. Furthermore, climate change has the potential to alter bark beetle's life history traits, including its distribution, its population levels, and its synchrony. The impacts of climate change coupled with fire suppression policies that result in unnaturally dense stands have the potential to lead to beetle outbreaks of unprecedented severity, which has implications for ecosystem dynamics, forest carbon balance, and the economic and recreational value of these forests.

Ponderosa pines employ numerous strategies to defend against bark beetles, other insects, and pathogens. Resin ducts are one defense conifers maintain to be able to deter a variety of insects. Resin ducts enable pines to exude resin, which can encase and trap or expel beetles. The greater the density of resin ducts, the greater the flow of resin (Blanche et al. 1992, Lombardero et al. 2000). Kane and Kolb found that resin duct density is a more reliable indicator of resistance to bark beetle attack than growth measurements (2010).

Given the potential for climate change to exacerbate the severity of bark beetle attacks, it is imperative that more research be done to elucidate mechanisms of tree resistance and defense. This research aimed to address two components of ponderosa pine resistance to bark beetle attack: the relative importance of radial growth and resin duct density in fending off bark beetle attacks and how climate affects tree investment in these two processes. Developing a better understanding of both tree defense strategies and how climate alters tree physiology will be essential to predicting the consequences of climate change for ponderosa pine and developing appropriate management strategies.

Objectives & Hypotheses

This research had two objectives: (1) to address differential investment in growth and defense in ponderosa pine and the implications of preferential investment in either of these processes for defense against bark beetle attack and (2) to examine how resin duct density and radial growth are affected by climate. In order to investigate these issues, I formulated three hypotheses and corresponding predictions:

H1: Resource limitation necessitates a trade-off between growth and defense in conifers; specifically, resin duct density will be negatively correlated with radial growth.

H2: Investment in defense makes conifers more resistance to bark beetle attack than investment in growth; therefore resin duct density will be a better indicator of attack success than radial growth.

H3: The most important climatic factor influencing duct formation is temperature whereas for radial growth, it is precipitation; therefore duct density will be positively correlated with growing season temperatures whereas radial growth will be positively correlated with spring precipitation.

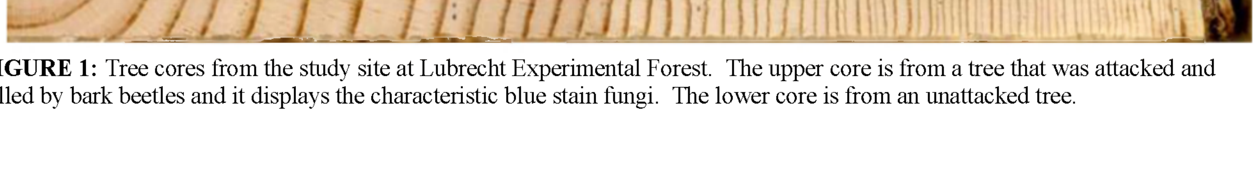

FIGURE 1: Tree cores from the study site at Lubrecht Experimental Forest. The upper core is from a tree that was attacked and killed by bark beetles and it displays the characteristic blue stain fungi. The lower core is from an unattacked tree.

Study Area

The study site for this research was the Fire-Fire Surrogate Study located in Lubrecht Experimental Forest. The dominant tree species at the site are ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii)*. The majority of the trees at the site are between 80 and 90 years of age. The site consists of three randomized 36-ha blocks. Each of these blocks is broken into four 9-ha units; one unit has been thinned, one unit has been burned, one unit has been thinned and burned, and the final unit has been left unaltered (the control). In 2010, the site began to see high levels of bark beetle attacks, particularly in the control treatment units and the burn-only units.

Methods

Fifteen pairs of attacked and unattacked trees were selected from the control units. The trees were selected based on the following criteria: (1) attacked and unattacked trees are no farther than 6 meters apart, and (2) diameter at breast height for the paired trees is within +/- 2.5 cm. Two cores from bark to pith were taken from each individual.

After collection, cores were left in the lab to dry for two weeks, sanded, mounted, and turned into high- resolution images using CDendro. These images were used to determine ring widths and delineate annual ring boundaries. The data from this analysis was cross-dated, with the strength of cross-dating being assessed with COFECHA. Resin ducts were identified and measured using ImageJ. Climate data was obtained from Greenough Hill DOT weather station as well as data from the regional Palmer Drought Severity Index (PDSI). Statistical analysis, including assessing the relationship between resin duct density, radial growth, and attack status and comparing resin duct density and radial growth to climatic factors, was done primarily in JMP.

Results & Discussion

Data analysis is still ongoing, so I do not have result yet. However, on a personal level this project has enabled me to learn innumerable valuable skills that I believe will help me in the future. Working with two researchers enabled me to learn research skills, including how to do literature reviews, improve my scientific writing skills, how to core trees and analyze resin ducts and growth, and conduct statistical analyses.

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