

**TITLE:** Vulnerability of Great Basin Bristlecone Pine and Foxtail Pine to Mountain Pine Beetle

**LOCATION:** Utah, Nevada, and California

**DATE:** September 30, 2013

**DURATION:** Year 1 of 3-year project    **FUNDING SOURCE:** Base

**PROJECT LEADER:** Barbara J. Bentz, Rocky Mountain Research Station (RMRS), 435-755-3577, [bbentz@fs.fed.us](mailto:bbentz@fs.fed.us)

**COOPERATORS:** Sharon Hood, RMRS, University of Montana; Jim Vandygriff, RMRS; Matt Hansen, RMRS; Alison Macalady, University of Arizona.

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**PROJECT OBJECTIVES:** Our primary objective is to evaluate vulnerability of Great Basin bristlecone pine (*Pinus longaeva*) (GBBP) and foxtail pine (*P. balfouriana*) (FP) to mountain pine beetle (*Dendroctonus ponderosae*) (MPB) attack. We will also survey both species for presence of white pine blister rust (caused by the non-native *Cronartium ribicola*). Specifically we will:

- 1) Determine if MPB has previously (within the last 10 years) caused mortality of GBBP and FP in Utah, Nevada and California.
- 2) Monitor GBBP and FP stands for 3 years to determine if MPB activity begins or increases during that time period. Temperature will also be continuously monitored in select stands to provide a proxy for examining trends in historical and future conditions.
- 3) Compare constitutive and induced resin and wood characteristics between high elevation five-needle pine species with unclear vulnerability to MPB and known MPB hosts that co-occur in the same stand. Vulnerability of GBBP and FP is unclear, and limber pine (*P. flexilis*) (LP), and whitebark pine (*P. ablicaulis*) (WBP) are known hosts. Some combination of all these species co-occur in the same stands.
- 4) Determine if blister rust occurs in GBBP and FP stands, and quantify infection rates.

**JUSTIFICATION:**

- a. **Linkage to FHM program:** Aerial detection surveys (ADS) show a dramatic increase in the area affected by MPB from 2000 to 2012. Mortality of many high elevation five-needle pine species has increased due to a combination of climate change, MPB, and blister rust. ADS in Nevada indicated polygons of MPB-caused mortality of GBBP, although identification of tree species and causal agent from the air can be difficult. In 2012, we ground-checked ADS polygons in Great Basin National Park and found that MPB was attacking co-occurring LP within GBBP stands, but not GBBP. ADS from California suggest no acres of MPB impact in FP. This work compliments and greatly expands on previous EM funded work by Barbara Bentz and others, and Joan Dunlap and Patricia Maloney.
- b. **Significance/Impact of forest health issue:** GBBP is a long-lived species found at high elevations throughout the Great Basin in Utah (UT), Nevada (NV) and California (CA). FP, the sister species of GBBP, is found only in isolated areas of CA. 'Methuselah', a GBBP found in the White Mountains, CA, is the oldest known living non-clonal organism. GBBP has not been documented in written records as a host for MPB. FP is listed as a host, although vulnerability to MPB is unclear. Many high elevation five-needle white pine species, where MPB-caused tree mortality was previously recorded infrequently, have been significantly impacted by MPB and blister rust in the past decade. It is important to understand vulnerability of GBBP and FP to blister rust and MPB attack, and to identify

where mortality is occurring to increase efforts for protection and genetic conservation of these valuable species.

- c. **Scientific basis:** The PI and collaborators are experts in bark beetle identification and ecology, blister rust identification, and have worked extensively in subalpine systems. Collaborators Hood and Macalady have experience in analyses of terpenes and wood characteristics related to defense (e.g. resin ducts, density, storage tissue). In addition to recording basic mensurational data for GBBP and FP, we will follow established protocols for identifying causal agents of mortality (i.e., insect, disease, environmental).
- d. **Cost/Economic efficiency:** Minimal cost with substantial matching from RMRS and FHP in salary and RMRS in equipment.
- e. **Priority Issues:** This proposal directly addresses several FHM priority issues. Our results will provide information regarding the influence of climate change on the relationship between MPB and two long-lived high elevation five-needle pine species, GBBP and FP. Temperature measurements in GBBP and FP stands will allow us to estimate historical thermal trends and project potential future changes. Deviations from 'normal' weather that may be influencing GBBP and FP and potential MPB-caused tree mortality will be examined.

#### **DESCRIPTION:**

**a. Background:** Several high elevation five-needle pines are known hosts to MPB, including LP and WBP. Warming in recent years has resulted in increased MPB activity at many high elevation sites. Despite the presence of MPB in areas where GBBP and FP are found, these species do not appear to be favored by MPB, and their suitability for MPB is unclear. GBBP and FP are sister species, likely evolved from an extinct species that diverged from Rocky Mountain bristlecone pine (*P. aristata*)<sup>1</sup>. FP is a rare pine endemic to high elevations in CA, and GBBP is restricted primarily to arid sites with limestone and dolomite soils at high elevations in UT, NV and southwestern CA. Both GBBP and FP can be found associated with other pines including LP and WBP. Maximum ages for GBBP and FP vary geographically and many ancient trees are between 3000 and 4000 years old. Based on the predominant key for bark beetles, GBBP is not a host for MPB, although FP is listed as a MPB host<sup>2</sup>. MPB can currently be found infesting LP and WBP across their distribution. ADS indicated polygons of MPB activity in GBBP in Great Basin National Park. In ground checks of several polygons we only found MPB attacking LP within GBBP stands. There is no record in ADS data of MPB attacking FP.

Resin chemistry can influence tree vulnerability to MPB attack<sup>3</sup>. Characteristics of wood including resin ducts, wood density and tracheids can also play a role in susceptibility to drought, mortality, and insect attack. We know of no published information on wood characteristics of GBBP, FP, LP or WBP, and therefore no information on potential differences among these species that may be influencing susceptibility to MPB-induced mortality. A recent study suggests differences in constitutive and induced terpene response between WPB and lodgepole pine<sup>4</sup>, and terpene differences were used to separate GBBP and *P. aristata* into 2 species. No comparative analyses of co-occurring high elevation five-needle pines has been conducted. Temperature and precipitation can also play a role in success of MPB at high elevations by directly influencing MPB and indirectly influencing the host tree<sup>5</sup>. The goal of this project is determine if GBBP and FP are potential hosts for MPB, if MPB is currently attacking these species, and physiological aspects of these tree species that may make them less vulnerable to attack. Blister rust, which has not been reported on GBBP but has been found infecting FP, will also be quantified. The potential role of MPB, blister rust, and climate in GBBP and FP persistence in a changing climate will be evaluated.

**b. Methods:** The location of GBBP and FP stands will be verified using several sources including 1) ADS, 2) FIA databases, 3) the Global Biodiversity Information Facility, 4) US Forest Service District and National Park Service vegetation maps and personal communication. A representative number of GBBP and FP stands (15-20) across the range of each species will be visited and surveyed in 2014, targeting areas with potential MPB activity based on ADS and discussions with USFS and NPS personnel. We will use a combination of line transects and variable radius plots, both permanently monumented using geo-referenced plot stakes. An automatic temperature recording device will be installed in each area, recording hourly temperatures for the

duration of the study (2014 – 2016). These data will be regressed with nearby permanent climate stations to estimate historical temperature in the GBBP and FP stands. Line transects will be used to survey larger areas of each stand to identify occurrences of GBBP and FP mortality and causal agents (presence/absence). Variable radius plots will be used to describe stand characteristics including tree species, tree size (DBH and height), slope, aspect, elevation, and slope position. All pine species found on plots will be evaluated for signs of MPB (based on gallery patterns and insect specimens) and blister rust. Stem and branch canker locations and number will be recorded for each infected tree. Year of death will be estimated based on foliage color and dendrochronology. The first year, GBBP and FP seedlings and saplings will also be recorded using recruitment subplots. All transects and plots will be revisited in 2015 and 2016 and new MPB attacks and blister rust infection will be recorded.

We will use a comparative approach to investigate tree chemistry and wood characteristics. Resin and wood characteristics of LP and WBP, known hosts to MPB, will be determined and compared with GBBP or FP growing in the same stands. We will choose 2 stands (identified above) for each comparison. Within each stand, 15 healthy trees of each species that are of similar DBH will be sampled for constitutive monoterpene chemistry and wood characteristics. We will collect a 2x5 cm phloem sample, measure thickness, and place sample immediately on dry ice. Samples will be stored at -80 °C until monoterpene extraction. We will collect two cores/tree to determine resin duct characteristics, wood density, growth, and ray parenchyma tissue. To measure induced resin response, we will apply methyl jasmonate to the tree bole adjacent to the constitutive phloem sample area. One week following application, a phloem sample will be removed from within the induced reaction site as described above. Monoterpenes from constitutive and induced phloem samples will be extracted in hexane and analyzed by gas chromatography. Wood density will be calculated using the water displacement method, and cores mounted and sanded for growth and resin duct measurements.

**c. Products:** Presentations at local and national meetings and technical and peer-review publications.

**d. Schedule of Activities:** In spring 2014 we will evaluate existing databases to determine locations of GBBP and FP stands and possible MPB activity. Initial surveys of stands, with permanent plot establishment, will occur during the summer 2014. Sampling for resin and wood characteristics will also occur in 2014, with lab analyses in 2014 and 2015. Each permanent plot and transect will be re-visited in 2015 and 2016.

**e. Progress/Accomplishments:** na

**f. Relevant Citations:** <sup>1</sup>Eckert, A and B Hall. 2006. Phylogeny, historical biogeography, and patterns of diversification for Pinus: Phylogenetic tests of fossil-based hypotheses. *Mol Phylog Evol* 40:166-182. <sup>2</sup>Wood SE. 1982. The bark and ambrosia beetles of North and Central America, a taxonomic monograph. *Great Basin Nat.* 6:1-1359. <sup>3</sup>Franceschi, V R, P Krokene, E Christiansen, and T Krekling. 2005. Anatomical and chemical defenses of conifer bark against bark beetles and other pests. *New Phytologist* 167:353-376; <sup>4</sup>Raffa, KF, EN Powell and PA Townsend. 2013. Temperature driven range expansion of an irruptive insect heightened by weakly co-evolved plant defenses. *PNAS*; <sup>5</sup> Bentz, BJ, JC Vandygriff, C Jensen, P Maloney, S Smith, A Grady and G Langenheim. In Press. Mountain pine beetle voltinism and life history characteristics across latitudinal and elevational gradients in the western United States. *For. Science*.

**COSTS:**

*Salaries: MS student at Utah State University (USU) (\$60,000) and SH 8 pp (\$29100). Travel is for 2 people, plus vehicle. RMRS overhead 2%. RMRS contributing 14 Hobo dataloggers. RMRS and FHP contributing salary for field work and data analyses.*

	Item	Requested FHM EM Funding	Other-Source Funding	Source

<b>YEAR – 2014</b>				
<b>Administration</b>	Salary	34500	27000 6000	RMRS FHP
	Overhead	900		
	Travel	10000		
<b>Procurements</b>	Contracting			
	Equipment		6000	RMRS
	Supplies	500		
<b>Total</b>		45900	32000	

	<b>Item</b>	<b>Requested FHM EM Funding</b>	<b>Other- Source Funding</b>	<b>Source</b>
<b>YEAR – 2015</b>				
<b>Administration</b>	Salary	27300	20000 6000	RMRS, FHP
	Overhead	708		
	Travel	8000		
<b>Procurements</b>	Contracting			
	Equipment			
	Supplies	100		
<b>Total</b>		36108	26000	

	<b>Item</b>	<b>Requested FHM EM Funding</b>	<b>Other- Source Funding</b>	<b>Source</b>
<b>YEAR - 2015</b>				
<b>Administration</b>	Salary	27300	23500 6000	RMRS, FHP
	Overhead	708		
	Travel	8000		
<b>Procurements</b>	Contracting			
	Equipment			
	Supplies	100		
<b>Total</b>		36108	29500	