Annotated Bibliography for Whitebark Pine Ecology

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1. **Notes:**
   - **a.** Using the most recent science contributes to the successful conservation of whitebark pine. This bibliography has become my annual contribution to this objective. Enjoy!
   - **b.** The majority of recent research is presented in the Proceedings of the High Five Symposium, published in June 2011. Because the proceedings publication is such an amazing resource of extended abstracts, the 2011 annotated bibliography is short. Please take advantage of this resource.
   - **c.** Instead of an annotation for each paper, I have made a list here of the topic areas covered by the Proceedings of the High Five Symposium.
   - **d.** If I missed any key work or if you have additional interpretations from any given paper, please let me know.

2. **Keane, R.E., Tomback, D. F., Murray, M.P., & Smith, C.M. eds. 2011. The future of high-elevation, five-needle white pines in Western North America: Proceedings of the High Five Symposium. 28-30 June 2010; Missoula, MT. Proceedings RMRS-P-63. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Research Station. 376 p.**
   - **a.** You can obtain a pdf or hard copy of this document at: http://www.fs.fed.us/rm/pubs/rmrs_p063.html
   - **b. Topics Covered**
     - **I. Ecology**
       - ✓ Treeline dynamics
       - ✓ Native ectomycorrhizal fungi
       - ✓ Whitebark health, cone production, and nutcracker occurrence
       - ✓ Long-term monitoring
       - ✓ Species interactions and implications for natural regeneration
       - ✓ Regeneration and survival after the Yellowstone fires
       - ✓ Seed Dispersal
       - ✓ Limber pine health
       - ✓ Seed predator dynamics
       - ✓ Clark's nutcracker demography and habitat-use
     - **II. Mountain Pine Beetle Dynamics**
       - ✓ Mountain pine beetle in whitebark forests
       - ✓ Health of whitebark forests after MPB outbreaks
       - ✓ Protecting whitebark with verbenone
     - **III. Genetics**
       - ✓ Conservation genetics
       - ✓ Genetic variation in height growth and needle color
       - ✓ Population genetic model: projecting population outcomes
       - ✓ Ex Situ gene conservation
       - ✓ Comparison of genetic diversity and population structure
       - ✓ The US Forest Service's renewed focus on gene conservation of five-needled pines
       - ✓ Geographic patterns of genetic variation, population structure, and adaptive traits
     - **IV. Disturbance Ecology & Climate Change**
       - ✓ Disturbance ecology of high elevation pines in Western North America
       - ✓ Fire and high elevation pines in the Southern Rocky Mountains
       - ✓ Modeling climate changes and wildfire interactions: effects on whitebark pine
       - ✓ Fuel and fire behavior in five-needle pines affected by mountain pine beetle
       - ✓ Influence of fire on mycorrhizal colonization of planted and natural whitebark seedlings
       - ✓ Climate change response of Great Basin Bristlecone pine
       - ✓ Whitebark pine assisted migration trial
       - ✓ Whitebark pine: a climate change prognosis
       - ✓ Establishment patterns of whitebark following fire in Canadian Rockies
     - **V. Blister Rust: Ecology & Assessment**
       - ✓ A natural history of *Cronartium ribicola*
       - ✓ Monitoring blister rust infection and mortality in the GYE
       - ✓ Limber pine forests and blister rust in northern Colorado
       - ✓ Willingness to pay for white pine blister rust management
       - ✓ Annual observations of canker activity on whitebark pine
       - ✓ Re-measurement of whitebark pine infection and mortality in the Canadian Rockies

- ✓ Can microscale meteorological conditions predict the impact of blister rust in Colorado and Wyoming?
- ✓ Histological observations on needle colonization by *Cronartium ribicola* in susceptible and resistant seedlings

VI. Genetic Resistance to Blister Rust

- ✓ Past and current investigations of genetic resistance to blister rust
- ✓ Preliminary overview of the first extensive rust resistance screening
- ✓ Status of blister rust and seed collections in California's high-elevation pines
- ✓ Polymerase chain reaction applications in rust resistance screening
- ✓ Molecular dissection of white pine genetic resistance to blister rust
- ✓ Rust resistance in seedling families and implications for restoration

VII. Restoration & Management

- ✓ Strategies, tools, and challenges for sustaining and restoring high elevation five-needle white pine forests in Western North America
- ✓ Investigating the optimality of proactive management of an invasive forest pest
- ✓ Exploring whitebark pine resilience in the Crown of the Continent
- ✓ Inoculation and successful colonization of whitebark seedlings with native mycorrhizal fungi
- ✓ The proactive strategy for sustaining five-needle pine populations: an example of implementation
- ✓ Whitebark and limber pine restoration and monitoring in Glacier National Park
- ✓ Restoration of whitebark in the northern Rocky Mountains
- ✓ Observations on seed predation, cone collection and controlled germination
- ✓ Highlights of Forest Health Protection whitebark restoration program
- ✓ Whitebark pine direct seedling trials in the Pacific Northwest
- ✓ Guidelines for whitebark pine planting prescriptions
- ✓ Limber pine seed and seedling planting experiment in Waterton Lakes, Canada
- ✓ Restoration planting options for limber pines in southern Rocky Mountains
- ✓ High elevation white pines educational website

3. Hatala, J.A, Dietze, M.C., Crabtree, R. L., Kendall, K., Six, D., & Moorcroft, P.R. 2011. An ecosystem-scale model for the spread of a host-specific forest pathogen in the Greater Yellowstone Ecosystem. Ecological Applications. 21(4): 1138-1153.

Background & Objectives

This study integrates field data from five projects conducted in the GYE from 1968 to 2008 to create a blister rust infection model for the GYE. The model specifically tested whether rust infection is independent of infected tree density or rust infection is proportional to local infected tree density.

Main Findings

- Compiled data indicated a rapidly accelerating transition rate between uninfected and infected sites.
- Predicted infection ranged among the four models.
- The most rapid infection rates predict 90% infection by 2013; the slowest indicate 90% infection by 2033.
- Comparison among models indicates that rust infection is dependent on the density of local infection.
- Infection data lacked spatial autocorrelation, resulting in uncertainty in initial conditions of rust distribution.

Implications

- This model can be used to track the rated of infection within sites and rust progression throughout the GYE.
- Model predictions of slow rust progression may indicate sites with greater genetic resistance to rust.
- Sites identified as those with rapid progression may be high priorities for restoration.

4. Kelgley, S., Schwandt, J., Gibson, K., & Perkins, D. 2011. Health of whitebark pine forests after mountain pine beetle outbreaks. USDA, Northern Region, Report 11-03.

Background & Objectives

This paper reports on MPB severity recorded in 2008-09 in 42 whitebark stands in Idaho, Wyoming, and Montana in order to describe stand conditions following MPB outbreaks. Documentation included the condition of regeneration and remaining mature whitebark, blister rust infection levels, and abundance of other tree species.

Main Findings

- Mean MPB mortality was 72%.
- 76% of sites have less than 50ft^2/acre live whitebark
- Note: sites where MPB activity had peaked were chosen for this study.
- 10% of 2473 whitebark tallied had severe blister rust resulting in loss of cone production.

- Low severity blister rust was present on 54% of 2473 whitebark tallied
- Mean rust infection of whitebark regeneration was 23%
- On 69% of study sites, tree species other than whitebark were dominant in the understory.

Implications

- The authors predict, based on species-specific density regeneration, that 57% of their study sites will convert away from whitebark cover types.
- Stands that fall in the above mentioned category should be considered higher priority for restoration.

5. Larson, E.R. 2011. Influences of the biophysical environment on blister rust and mountain pine beetle, and their interactions, on whitebark pine. Journal of Biogeography. 38:453-470.

Background & Objectives

This research seeks to understand biophysical influences on patterns of infection by blister rust and mountain pine beetle, whether these disturbances interact, and how they are influenced by climate change. Surveys took place in the following mountain ranges: Cascade, Wallowa, Pioneer, Paulina, Salmon River, and Gravelly.

Main Findings

- Whitebark decline was relatively similar among sites.
- Blister rust incidence varied significantly among mountain ranges.
- 37% of 2666 whitebark inventoried had blister rust.
  - Rust infection was more common in less dense forests on steeper slopes, cooler, moister aspects.
  - At stand-scale, rust affects trees of all sizes and ages.
- 33% of 2666 whitebark inventoried were dead – 83% of this mortality was MPB-caused.
  - MPB killed trees were more frequent at sites with cooler June temps, higher August temps, and drier springs.
  - MPB distribution is dictated by proximity to food sources and topographic barriers.
- Evidence of past fire (fire scars or post-fire cohorts) was found on 35% of sites.
- Whitebark regenerates well under beetle-killed canopy.

Implications

- Combined effects of rust and beetles significantly lower cone production.
- Prolific regeneration in areas with remaining healthy seed trees may accelerate the development of rust resistance.

6. Lorenz, T.J., Sullivan, K.A., Bakian, A.V., & Aubry, C.A. 2011. Cache-site selection in Clark's Nutcracker (*Nucifraga columbiana*). The Auk. 128(2): 237-247.

Background & Objectives

Radio telemetry used to determine the proportion of whitebark seeds placed by the Clark's Nutcracker in sites suitable versus unsuitable for germination.

Main Findings

- 97% of seeds were cached within the nutcracker's home range.
- Some seeds were harvested >30 km away from home range and transported back.
- 59% of seeds cached in high elevation sites were cached above ground, mostly in living trees.
- 15% of all cached whitebark seeds were placed in sites suitable for germination.
- Nutcracker's cached more seeds at low-elevation sites, likely to facilitate access to caches during winter.
- Nutcracker's preferred to cache near base of trees in their below ground caches.

Implications

- Information will assist managers when assessing a specific site for potential restoration by nutcracker caching versus direct planting.
- Nutcrackers forgo caching in habitat types preferred for whitebark germination when they are outside their home range.
- Management techniques designed to alter caching habitats may not affect seed caching behaviors of resident nutcrackers.
- Snow accumulation and rate of melt likely influences Nutcracker's cache site choice.

7. Shoal, R. & Aubry, C. 2006. Core data attributes for whitebark pine surveys. USDA, Pacific Northwest Region.

Background & Objectives

The purpose of this document was to standardize whitebark pine data collection. The survey methods outlined are peer-reviewed and inclusive of existing methods.

Main Findings

- This document contains recommendations for data collection and reporting to describe whitebark stand characteristics and whitebark demographics, to assess whitebark health, and to describe cone production and regeneration.

Implications

- Excellent resource for whitebark surveys.