Forest tree species restoration – where and why. The importance of integrating ecological and genetic approaches in forest ecosystem science

Patricia Maloney[1], Detlev Vogler[2], Camille Jensen[1], Annette Delfino Mix[2], Andrew Eckert[3], David Neale[4]

[1]*University of California – Davis, Department of Plant Pathology & Tahoe Environmental Research Center*

[2]*USDA Forest Service, PSW Research Station, Institute of Forest Genetics*

[3]*Department of Biology, Virginia Commonwealth University*

[4]*Department of Plant Sciences, University of California – Davis*

Forest restoration versus Species restoration

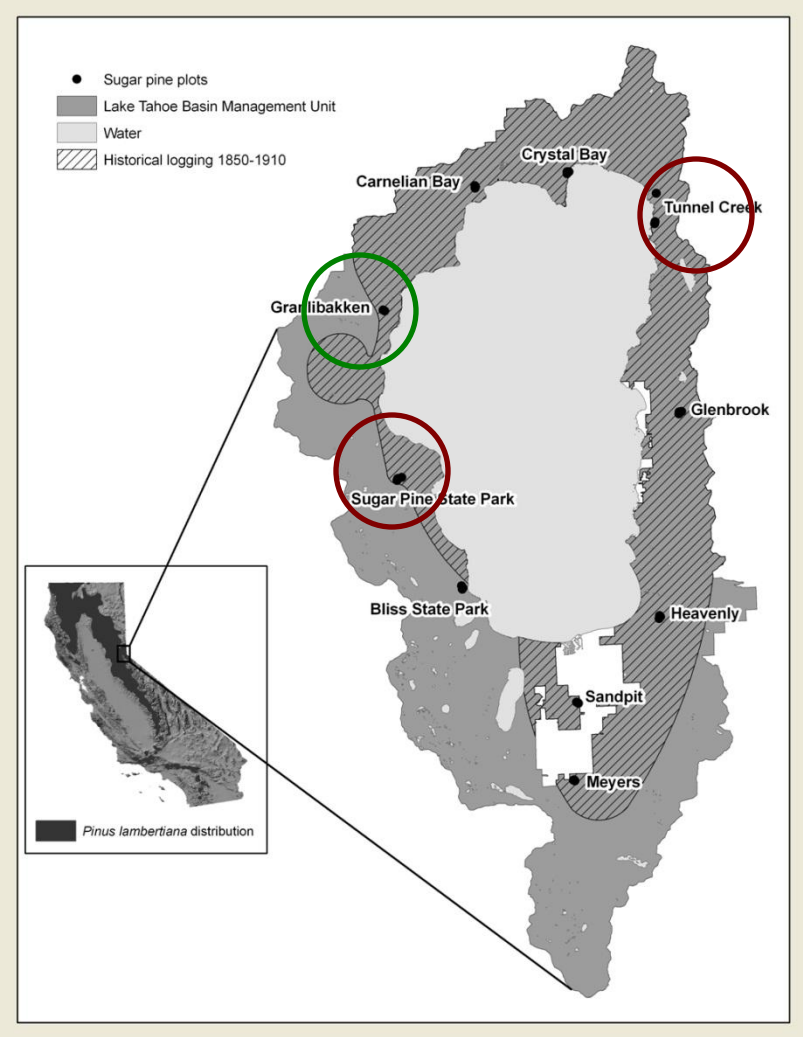
- Prescription burning, thinning
- Structural shifts (mixed size structure)
- Compositional shifts

- Restore population numbers – facilitate recruitment
- Enhance genetic diversity
- Deploy disease resistance (if warranted)
- Deploy drought tolerant phenotypes

Sugar pine restoration

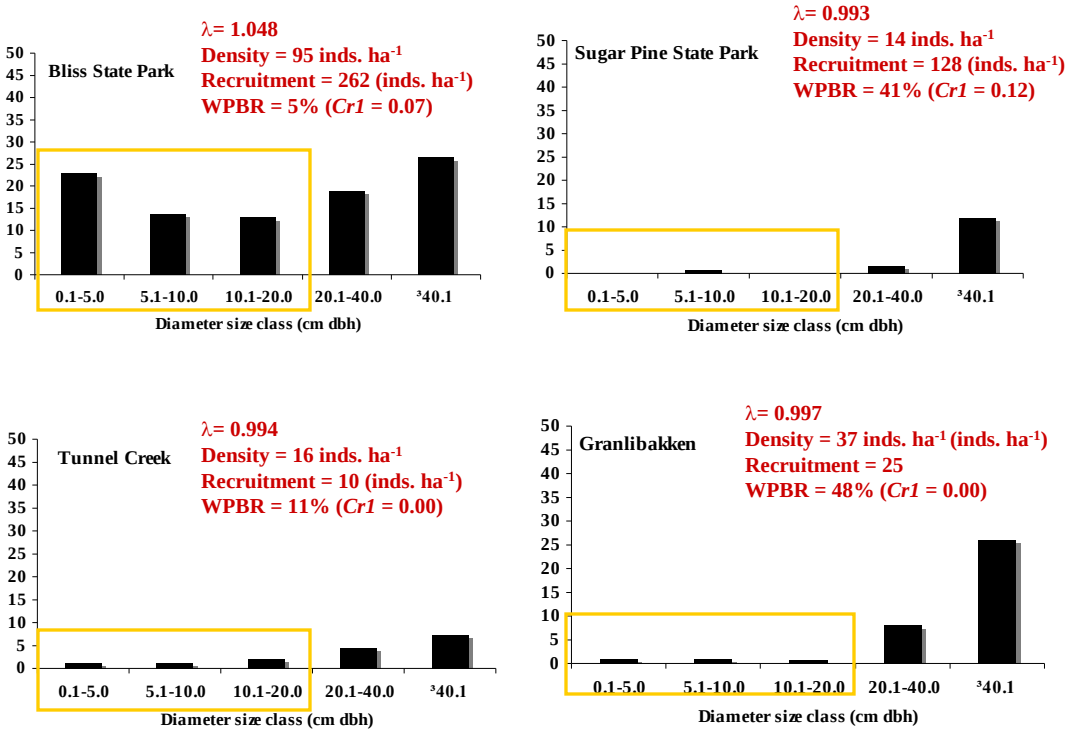
- **Extensive logging and fire suppression policies** have changed the structure & composition in lower montane forests (Lindstrom et al. 2000; Manley et al.2000).
- **Historical composition**: 20–25%, in some locations (Lindstrom et al. 2000).
- **Present–day composition**: 1–6% (Barbour et al. 2002; Lindstrom et al. 2000).
- **Population & genetic consequences**: Effects on population structure and dynamics, but also genetic structure and diversity. Population and genetic losses.
- **Non-native pathogen introduction**: *Cronartium ribicola*, cause of white pine blister rust (WPBR)
- **Such losses could affect sugar pine's resilience** to disturbances and environmental change (e.g., WPBR, MPB, climate).

Sugar pine restoration – Where?



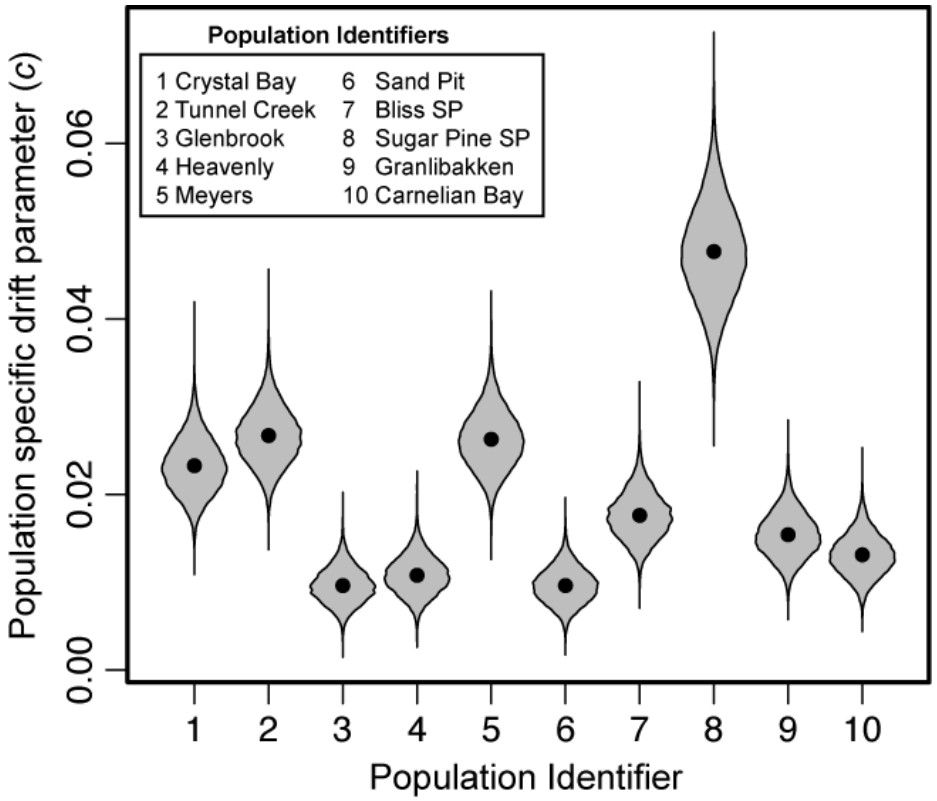
- Sugar Pine Point State Park
- Tunnel Creek – Sand Harbor
- Granlibakken – 3rd candidate site

Sugar pine restoration – Why?



- Reduced population sizes
- Low lambda (λ) – low survival of small– and intermediate–sized individuals
- Low recruitment
- High levels of WPBR
- Low frequency of *Cr1*

Sugar pine restoration, cont.
Consequences of historical logging



- High genetic drift in some populations
- Effects of genetic drift are greater in small populations
- In small populations drift can act faster to reduce genetic variation

Sugar pine restoration strategies

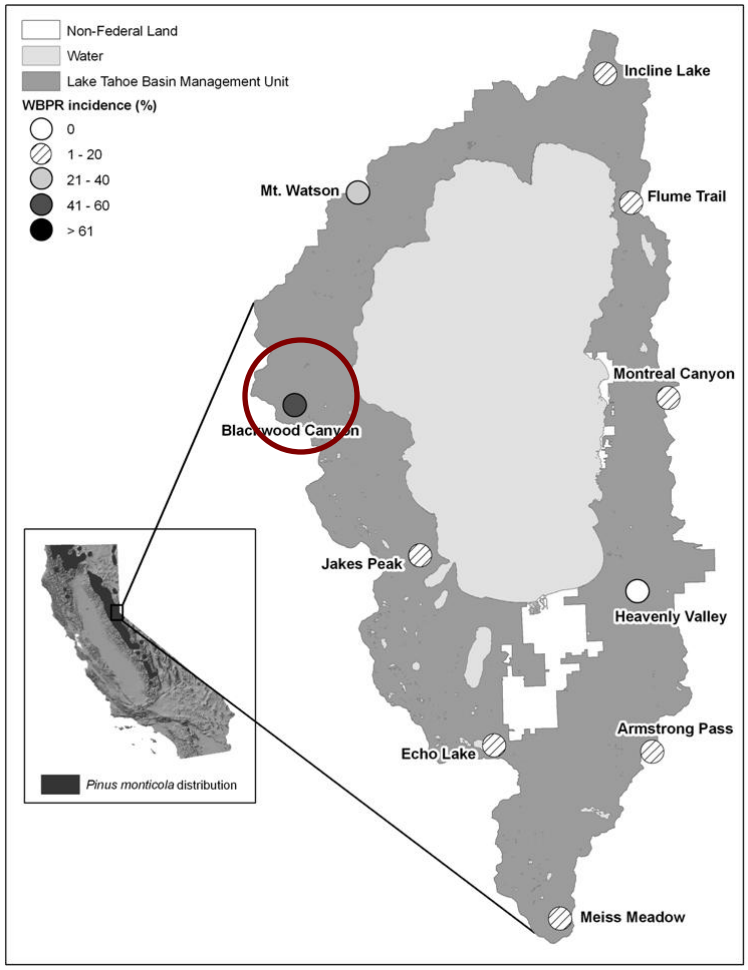
Sugar Pine Point SP

- Increase population size
- Deploy WPBR resistance (≤ 0.20)
- Enhance genetic diversity

Tunnel Creek/Sand Harbor

- Facilitate recruitment
- Increase sugar pine numbers – population size
- Enhance genetic diversity

Western white pine restoration – Where?



- Blackwood Canyon

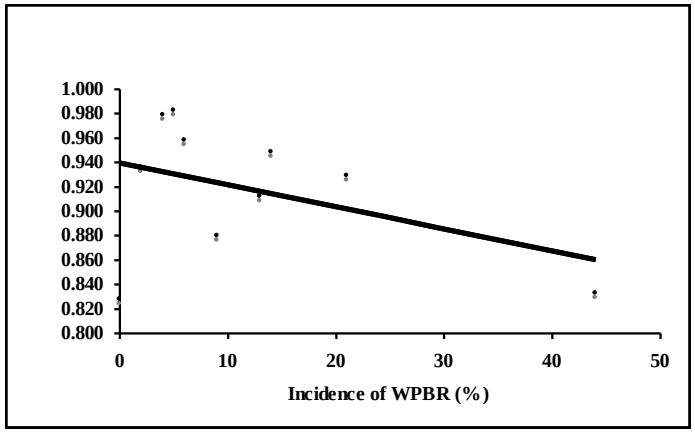
Western white pine restoration – Why?

- Highest disease pressure by WPBR in upper montane forests – 44%
- Moderate levels of MPB – 15%
- Relatively low mean survivorship across diameter classes (0.833), with the lowest for trees 5.1–10.0 cm dbh (0.700)
- Most mesic upper montane location in study – Average annual ppt = 1472 mm

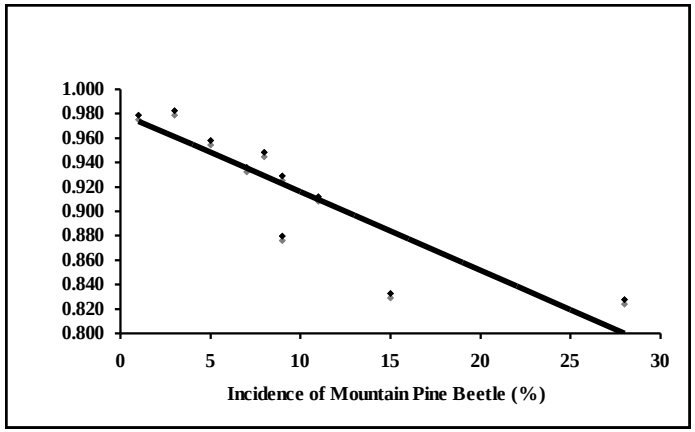
  1.Mesic adapted?

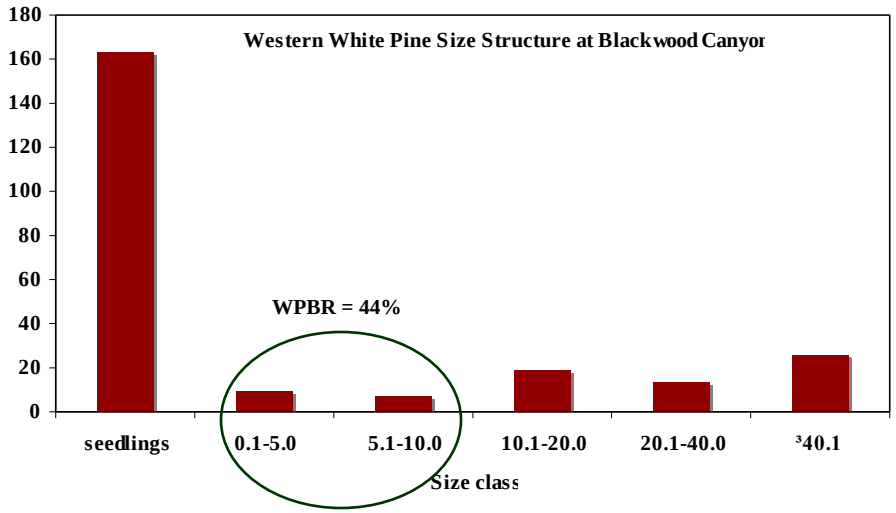
  2. Favorable conditions for WPBR infection

Western white pine restoration, cont.



WPBR is known to be a predisposing agent to MPB attack





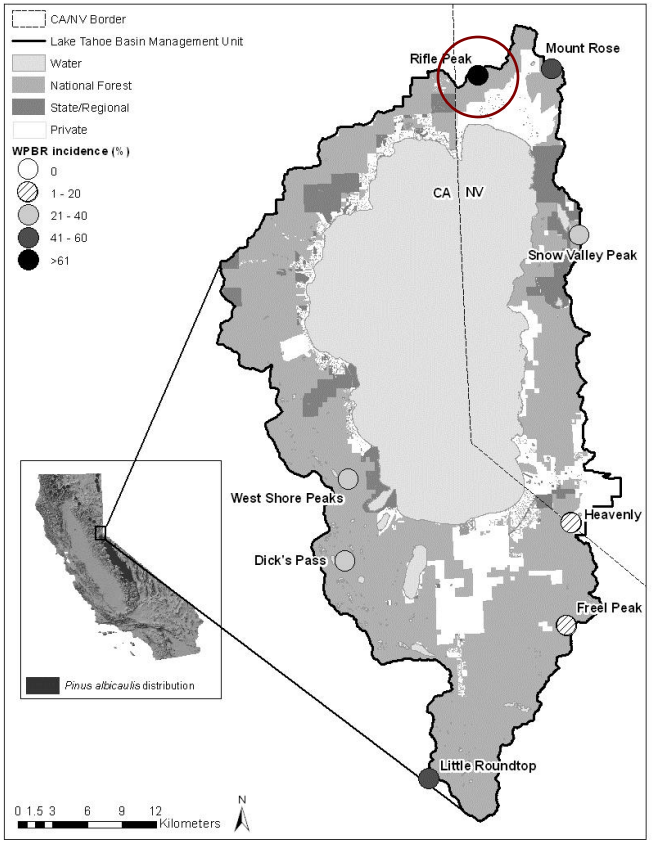
Western white pine restoration strategies at Blackwood Canyon

- A diversity of seedling material will be planted as well as WPBR – resistant genotypes – to increase small tree survival (*Cr2* is found in WWP at 2 locations in the Lake Tahoe Basin – Armstrong Pass and Meiss Meadow).

- Given the local environmental conditions at Blackwood Canyon the tree species here may be more mesic-adapted and less drought tolerant than species growing in more xeric conditions (i.e., east side locations, granitic soil types).

- Next year common garden studies will be completed for WWP and drought tolerant families & populations will be identified. Out–planted seedlings will include drought tolerant phenotypes.

Whitebark pine restoration – Where?

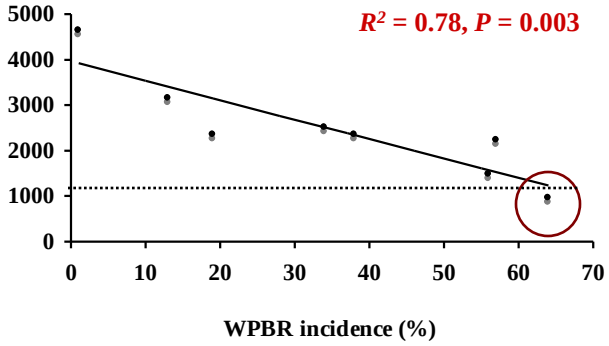


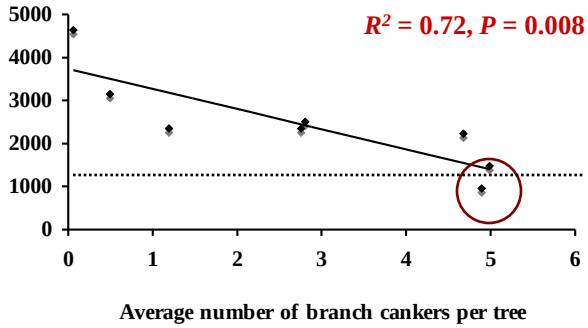
- Rifle Peak area – Ridge from Mt Baldy, Rifle Peak to east of Rose Knob Peak

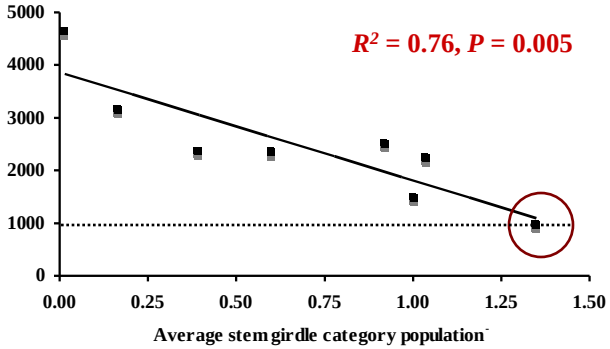
Whitebark pine restoration – Why?

- Very high disease pressure by WPBR – 65%
- Most critical effect of WPBR is infection and mortality of cone-bearing branches.
- Low cone production and recruitment

Whitebark pine restoration, cont.







- Negative relationships between cone production and WPBR incidence and severity.

- Percent of individuals infected (incidence), average number of infected branches per population, and severity of stem girdling are all negatively related with cone production.

- Whitebark pine at Rifle Peak has the lowest female cone numbers [960 cones ha^{-1} (mean across sites = 2,456)], lowest recruitment numbers [44 seedlings/saplings ha^{-1} (mean across sites = 139)], and the highest incidence of WPBR (65%) of all whitebark pine populations surveyed in the Lake Tahoe Basin.

- A threshold number of $\geq$ 1,000 cones ha^{-1} has been estimated to maintain seed dispersal within a forest stand by Clark's nutcracker (McKinney et al., 2009). Whitebark pine cone production at Rifle Peak falls below this threshold.

Whitebark pine restoration strategies

- Facilitate whitebark pine recruitment to maintain adequate species numbers
- Deploy WPBR resistant and/or tolerant phenotypes
- Diverse seedling material

Testing white pine restoration protocols

- Will use 2-year old seedlings
- Planting season (spring vs fall)
- Microhabitat (closed canopy, open canopy, log/litter debris, rock shelter)
- Protective enclosures (above and belowground herbivore pressure)

Acknowledgements

- Tom Burt, Martin Frye
- CA State Parks: Tamara Sasaki, Rich Adams
- LTBMU: David Fournier, Cheryl Beyer, Joey Keeley
- NDF & NV State Parks: Roland Shaw, Bill Champion

- Funding sources:
- Southern Nevada Public Lands Management Act – Sponsored by the USDA FS Pacific Southwest Research Station
- NVDSL Lake Tahoe License Plate Program