White Pine Blister Rust in a Changing Climate in Mountain-Top Ecosystems: Taking the Long View and Acting Now

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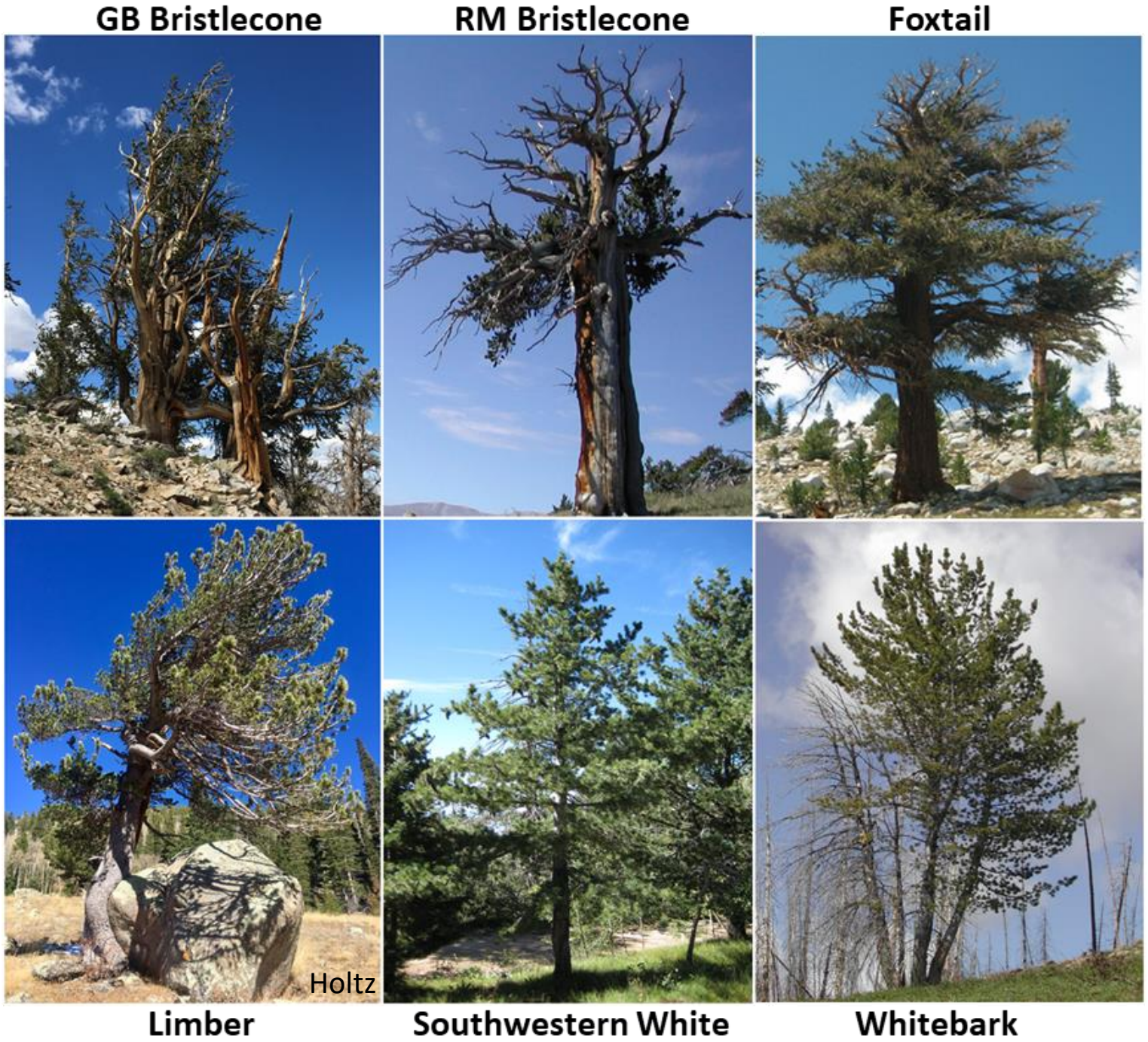
High Elevation 5-Needle White Pines

“The Hi-5” Pines

Western North America

Not timber species
Understudied species
Slow growing
Long-lived

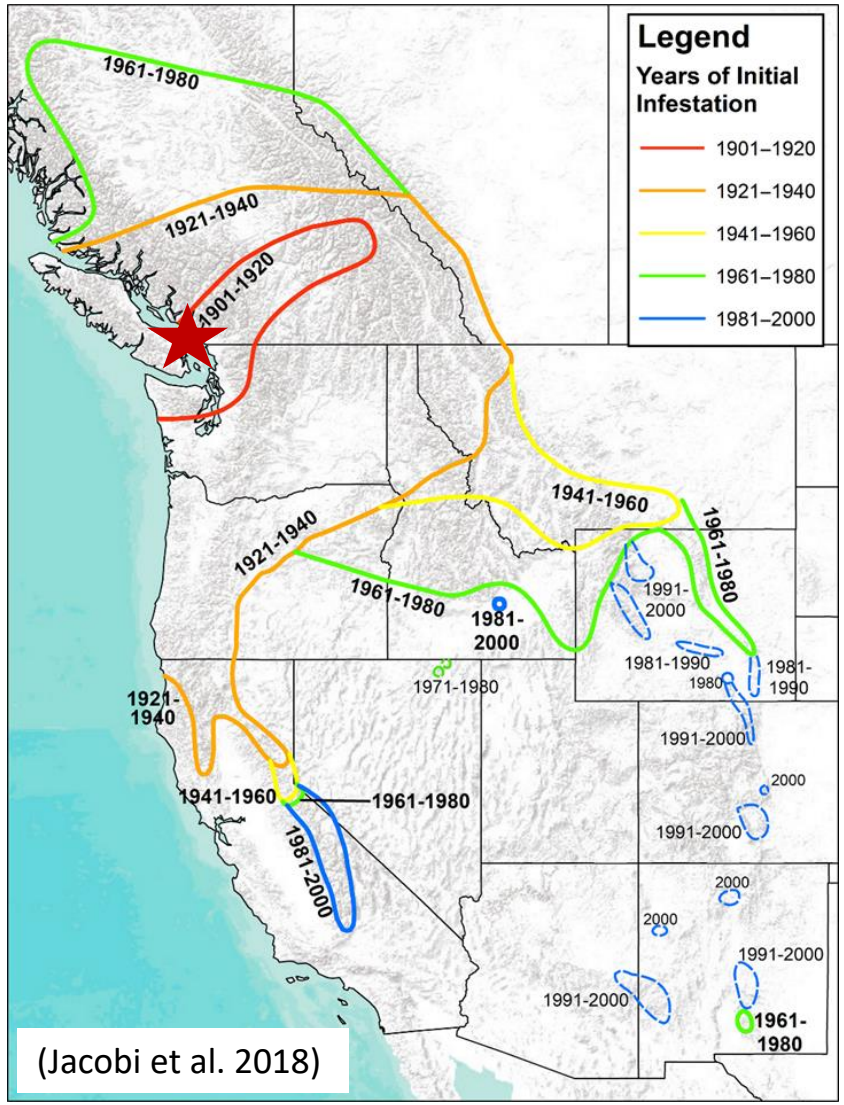


Ecological values

White Pine Blister Rust

Non-native pathogen *Cronartium ribicola*
Introduced into Western N. America ~1910
Threatens all Hi-5 species
Kills trees of all ages
High mortality

Still spreading
Spores spread in the air
Two obligate hosts
No tree-to-tree spread



(Jacobi et al. 2018)

Need for restoration: Whitebark pine is being listed as "threatened" under the ESA
Whitebark and limber pine are listed as endangered in Canada

Need for proactive treatments: increase resilience before or early in the invasion to prevent other Hi-5 Pines from following this same trajectory

Taking the Long View and Acting Now

No tools to stop the spread of WPBR at a forest scale

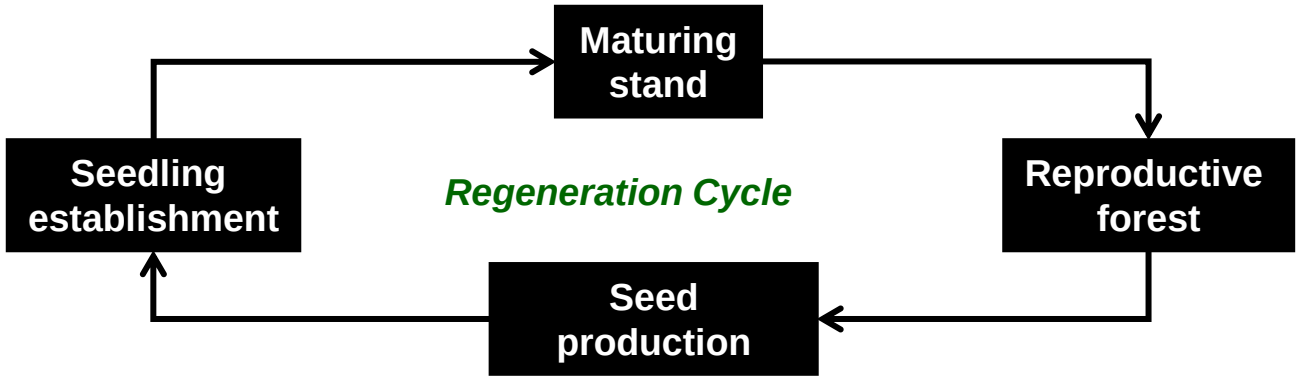
Interacting, intensifying and persistent threats
Hi-5 species are slow growing – not well suited for rapid adaptation to novel stresses

Population ecology and evolutionary approach

Build a Science Foundation to:

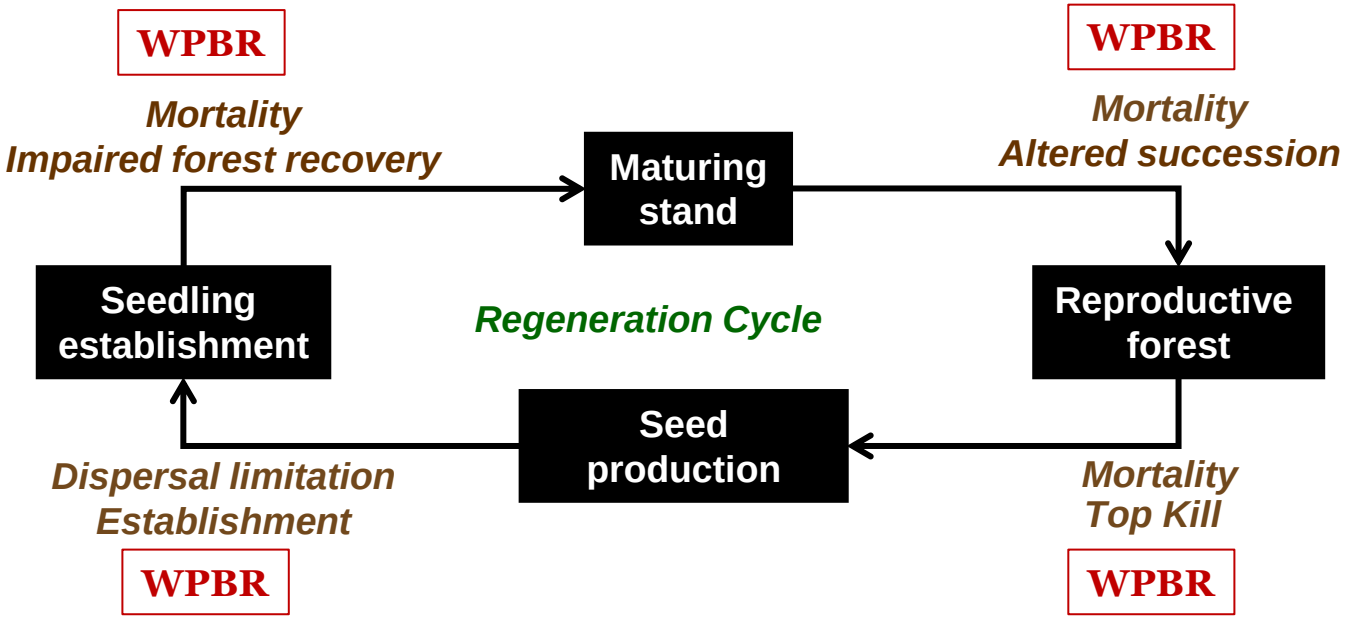
- Maintaining ecosystem function and mitigate impacts during WPBR naturalization
- Accelerate adaptive change to increase forest resilience

Interacting Impacts to Pine Host Population



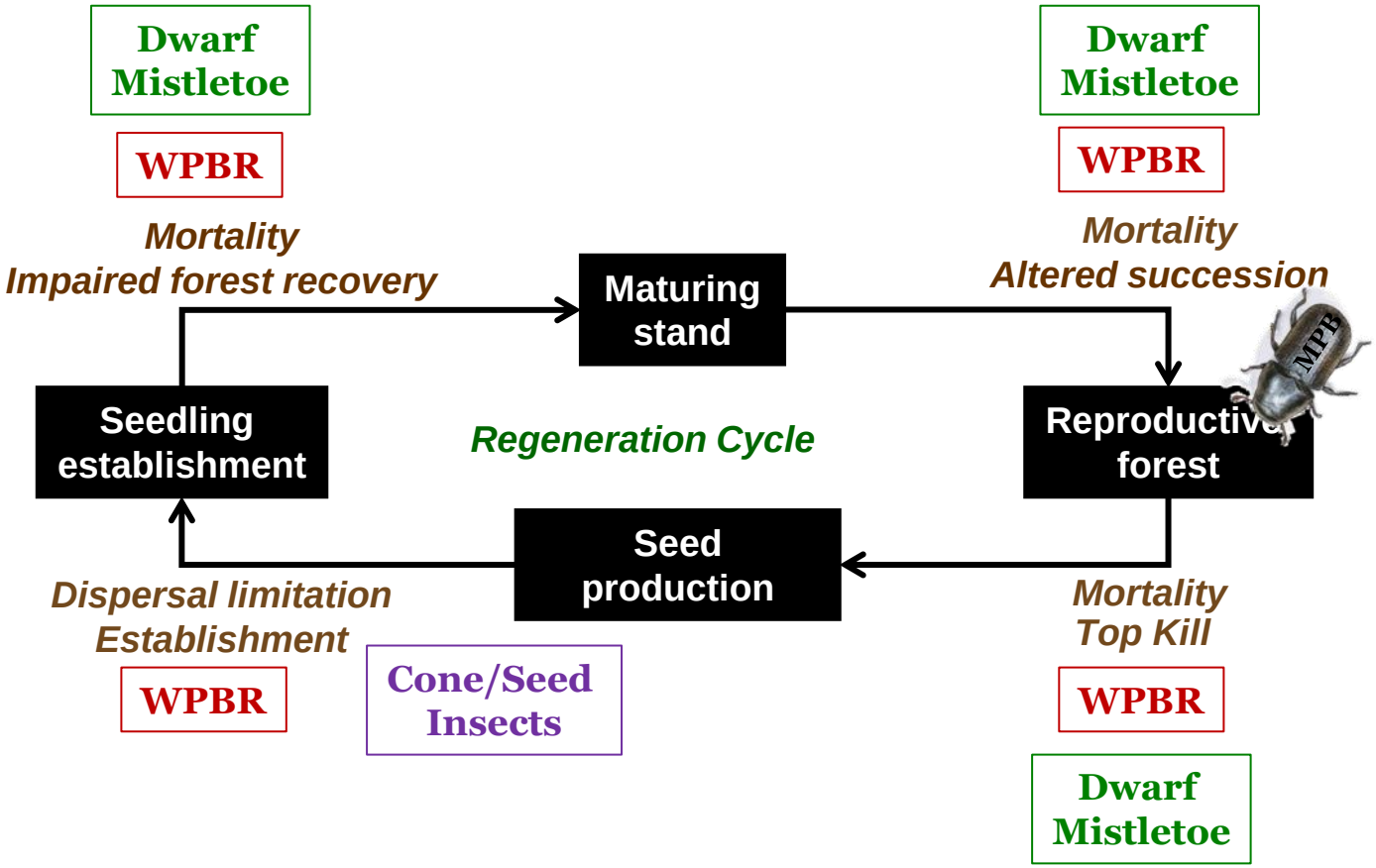
Interacting Impacts to Pine Host Population

White Pine Blister Rust – kills trees of all ages



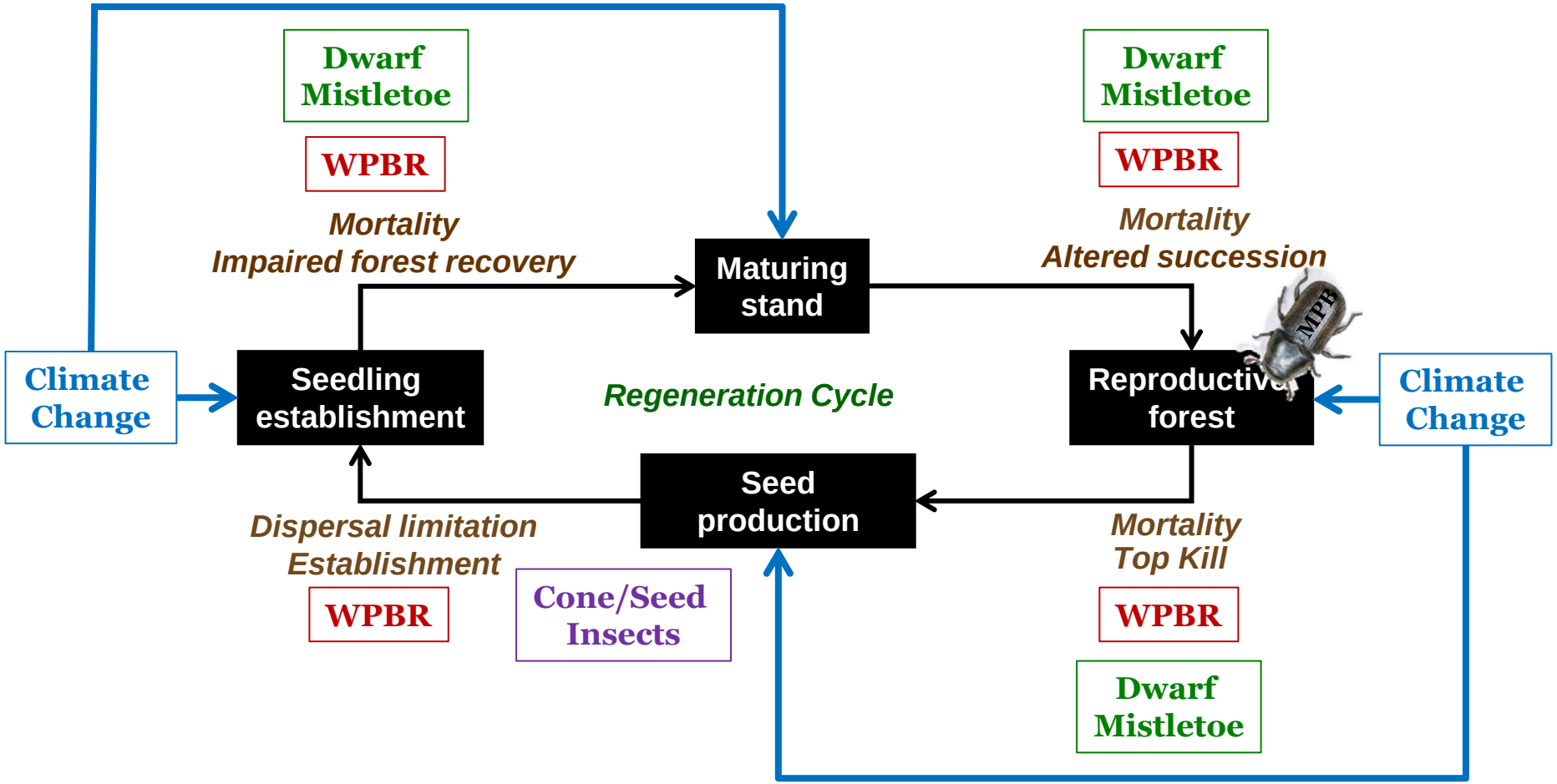
Interacting Impacts to Pine Host Population

Native Pests and Pathogens



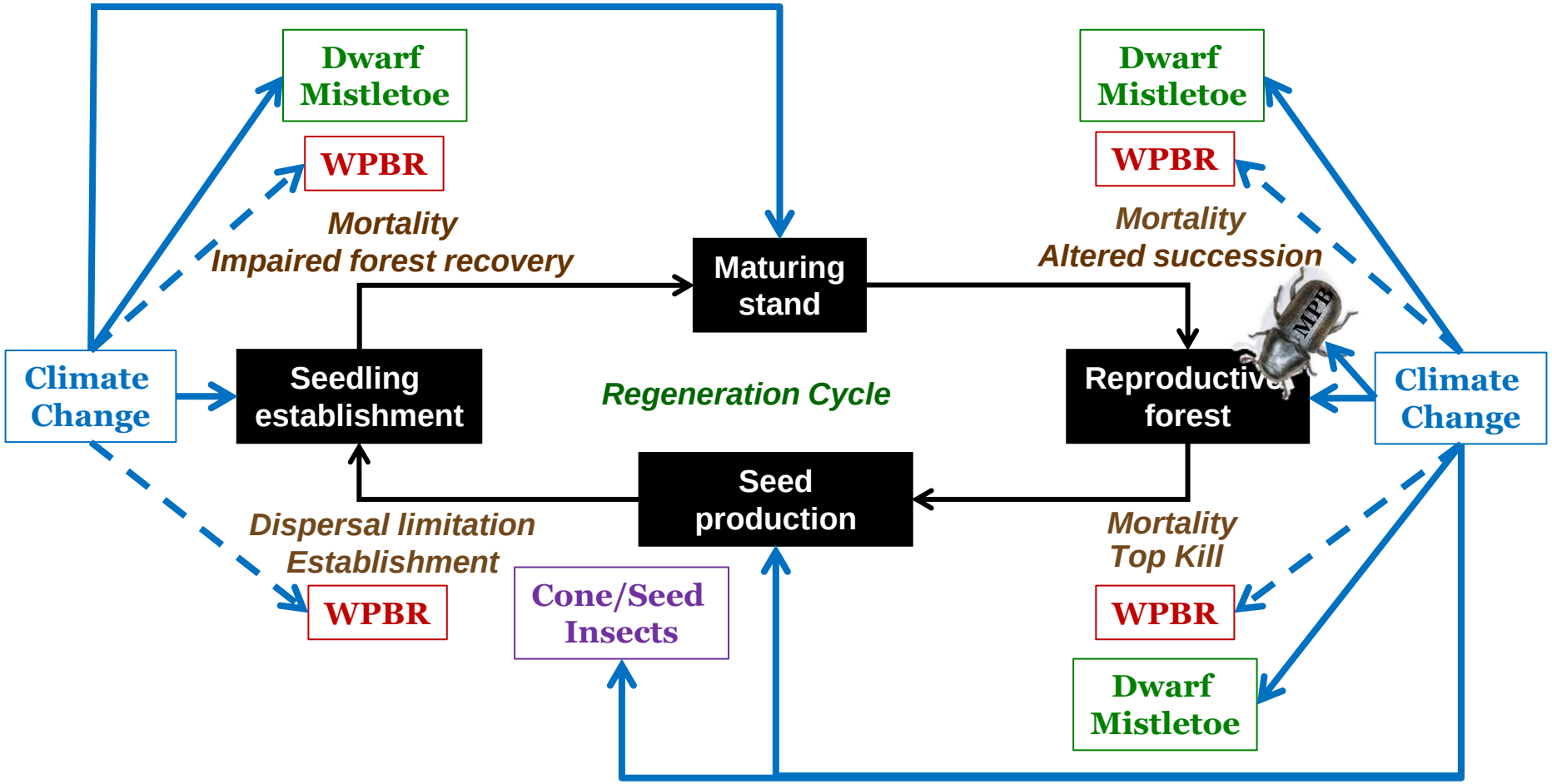
Interacting Impacts to Pine Host Population

Direct Effect of Climate Change on Pines



Interacting Impacts to Pine Host Population

Direct Effect of Climate Change on Pests and Pathogen



Indirect Effect of Climate Change on Pines through Altered Pest/Pathogen/Pine interactions

Adapted from Schoettle et al. 2019b

The Good News - Genetic Resistance to WPBR

- WPBR is a novel stress to the Hi-5 pines
- The pines and WPBR did not co-evolve
- Resistance to WPBR can help trees survive

→ reduce mortality

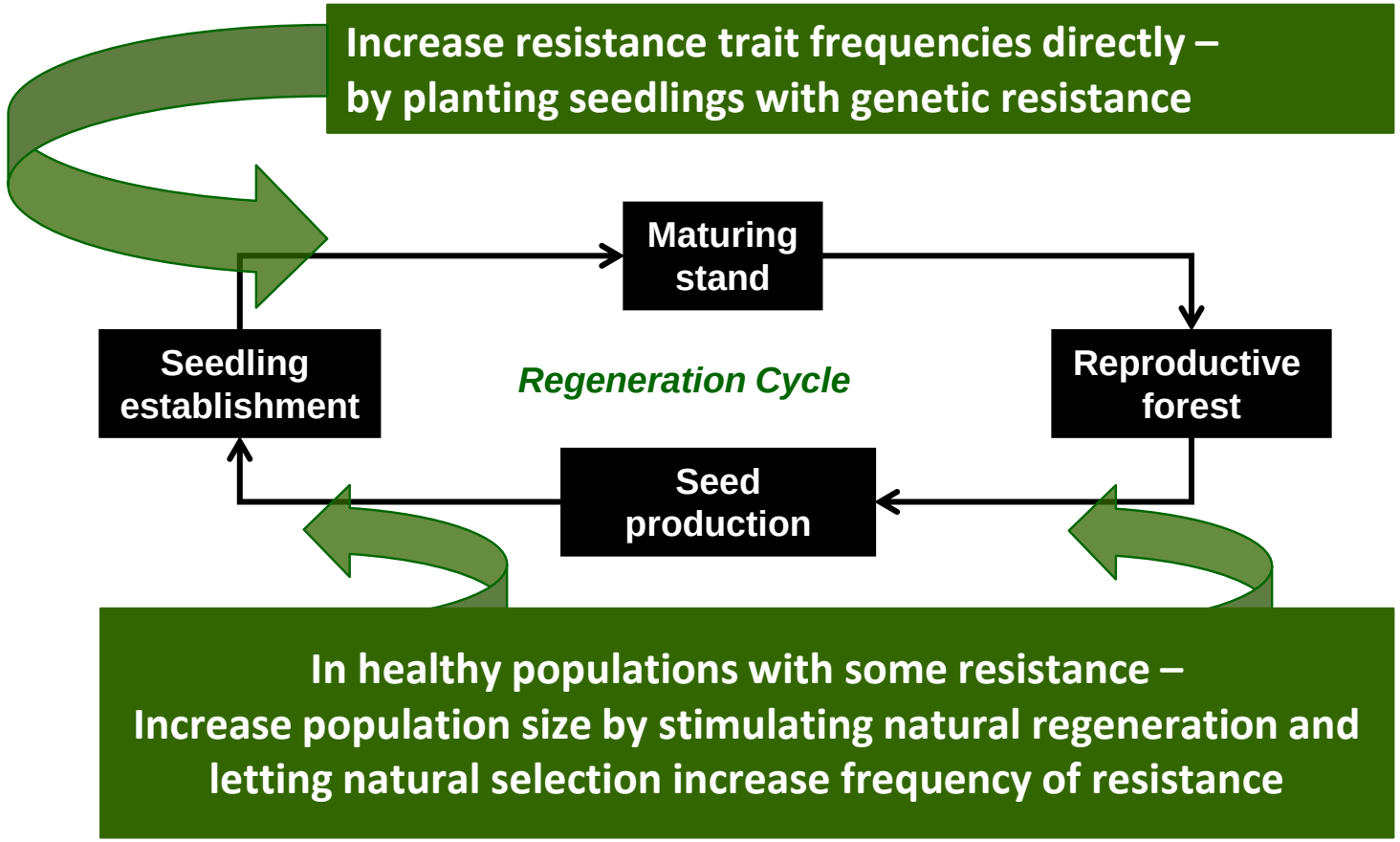
Artificial Inoculation at Dorena GRC

Genetic resistance to WPBR exists at <u>low frequency</u> in the Hi-5 Pines

Types and durability vary geographically and by species

My focus: Limber pine, RM bristlecone, GB bristlecone

Increasing the Frequency of Genetic Resistance in Populations



Option for impacted or threatened populations

Option only for threatened populations

Research foci:

Understand natural regeneration dynamics

Develop techniques for successful artificial regeneration

Characterize resistance traits, define their distributions, develop genomic tools for their detection

Sustain and advance adaptive capacity for the future

Adapted from Schoettle et al. 2019a

Increase Frequency of Genetic Resistance through Regeneration

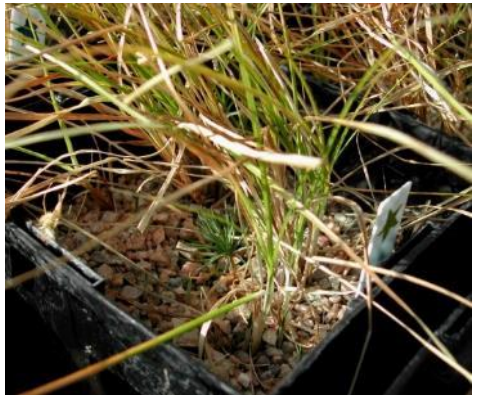
- Study natural patterns
- Sustain viable populations – offset mortality
- Supplement natural population with natural regeneration or planted seedling with resistance traits

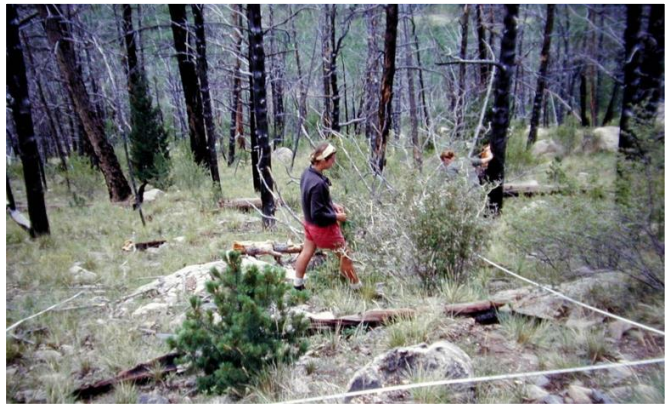
Spatial and temporal patterns of natural regeneration

Microsite characterization

Planting Trials

Experiments studies





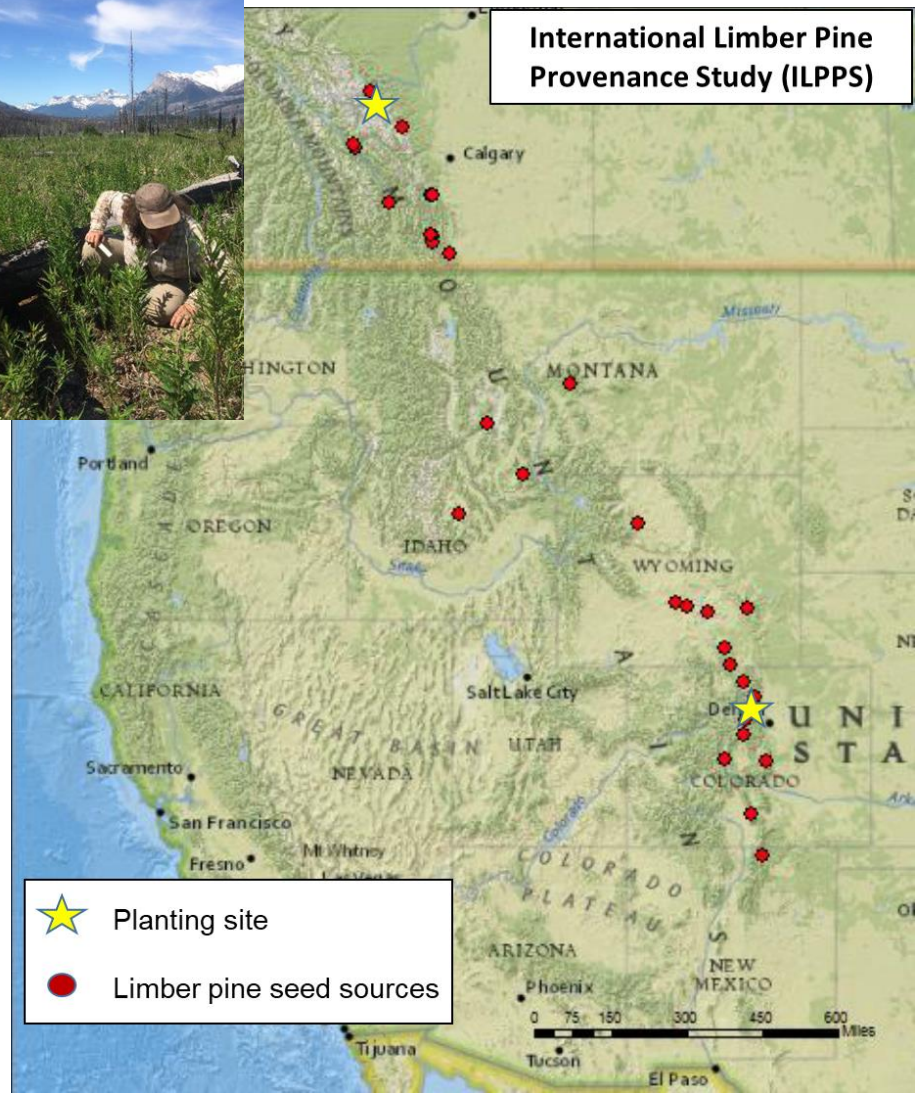
Post-fire patterns

- **Silvicultural treatments can increase natural regeneration**
- **Planting guidelines**

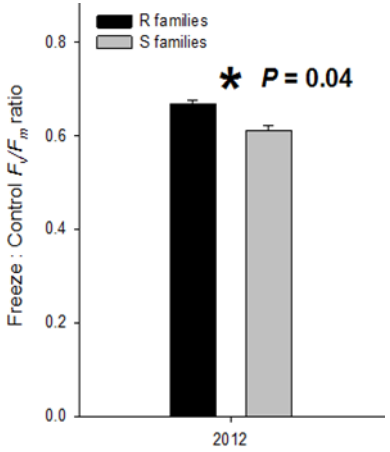
Supporting adaptive capacity for the future

RM Adaptive Variation (G x E) Experiment

Seed Transfer Distance



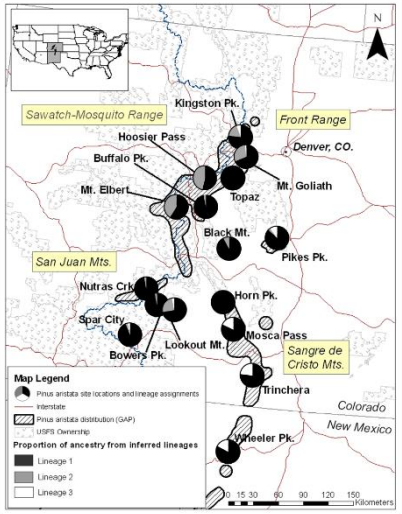
Cost of WPBR resistance to other traits



Selection for WPBR resistance may not be neutral with respect to other traits (Vogan and Schoettle 2015)

May be a shift in the fundamental niche of the pine species after WPBR selection

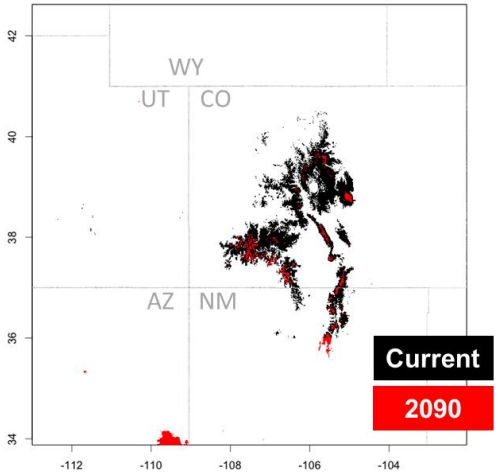
Modeling – infection and climate change



Schoettle et al. 2012

RM Bristlecone Genetic structure;

Climate change projections of lineages



Malone et al. 2018

Restoration Strategies

Crown of the Continent Whitebark Pine

WHITEBARK PINE RESTORATION STRATEGY
2019 PILOT
Project Summary
Crown of the Continent High Five Working Group Tech Team

BACKGROUND

Whitebark pine (*Pinus albicaulis*; WBP) is dramatically declining in the Crown of the Continent Ecosystem (CCE) due to a combination of mountain pine beetle (MPB, *Dendroctonus ponderosae*), effects of fire suppression, and the nonnative pathogen *Cronartium ribicola*, which causes white pine blister

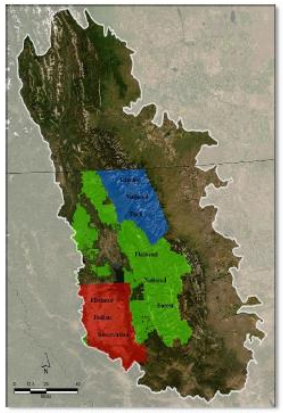


Figure 1. The Pilot area was composed of three Units in the Crown of the Continent Ecosystem: Flathead NF, Flathead Indian Reservation, and Glacier National Park.

[1] Shepherd, B.; Jones, B.; Sissons, R.; Cochrane, J.; Park, J.; Smith, C.M.; Stafl, N. Ten Years of Monitoring Illustrates a Cascade of Effects of White Pine Blister Rust and Focuses Whitebark Pine Restoration in the Canadian Rocky and Columbia Mountains. Forests 2018, 9, 138.

Strategies, Tools, and Challenges for Sustaining and Restoring High Elevation Five-Needle White Pine Forests in Western North America

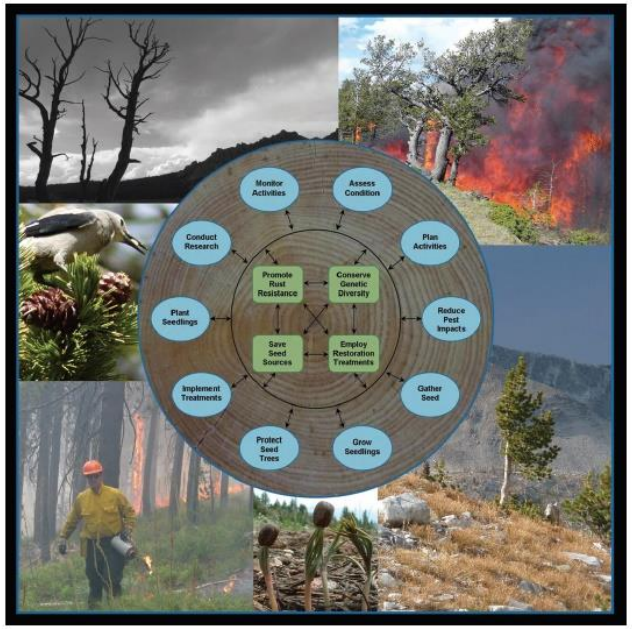
Plenary Paper

Robert E. Keane, USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, Missoula, MT; **Anna W. Schoettle,** USDA Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory, 240 W. Prospect Rd., Ft. Collins, CO

Abstract—Many ecologically i
forests that historically dominat
western North America are now
tain pine beetle (*Dendroctonus*
white pine blister rust (WPBR
regimes. Management interven
tegic treatments will be needed
The goal of this intervention is to
dle white pine ecosystems that h
and genetic resistance to white
methods are available for land
line important steps for implem
in declining high elevation whi
ber of proactive treatments in t
adverse impacts of rust, beetles
restoration include (1) create a s
tiple scales, (2) develop materia
restoration treatments, such as
assessments of the genetic mate
scapes by integrating the strate
administrative barriers, climate
cal concerns, (4) implement silv
fire according to landscape and
activities and assessments to enh
ments are effective including pla
and protecting valuable seed-
treated landscape and stands f
future treatment designs accor
pine ecosystems in the norther
sented to demonstrate this proce
pine ecosystems that are threat
mountain pine beetle, there are
tively to gain necessary informa
landscapes for invasion to mitig
strategy includes: (1) educate a
ers to shift from crisis managem
(2) conserve genetic diversity fr
are impacted by WPBR or othe
patterns, processes and respons
process level understanding of e
and conduct appropriate manag
siliency of high elevation five-n
them for change. Whether it is
interventions to mitigate the d
ened landscapes, there are two
the success of these species ev
tive rangewide strategies: (1) th
over time to conduct restoration
natural resource agencies to con
long term, most likely for many

USDA
United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-279
June 2012

A Range-Wide Restoration Strategy for Whitebark Pine (*Pinus albicaulis*)



Ongoing:
National Whitebark Plan

Proactive Conservation Strategies

USDA
United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-206
March 2008

Options for the Management of White Pine Blister Rust in the Rocky Mountain Region

CrossMark

Regeneration for resilience framework to support regeneration decisions for species with populations at risk of extirpation by white pine blister rust

Anna W. Schoettle[1] · William R. Jacobi[2] · Kristen M. Waring[3] · Kelly S. Burns[4]

Received: 13 November 2017 / Acc
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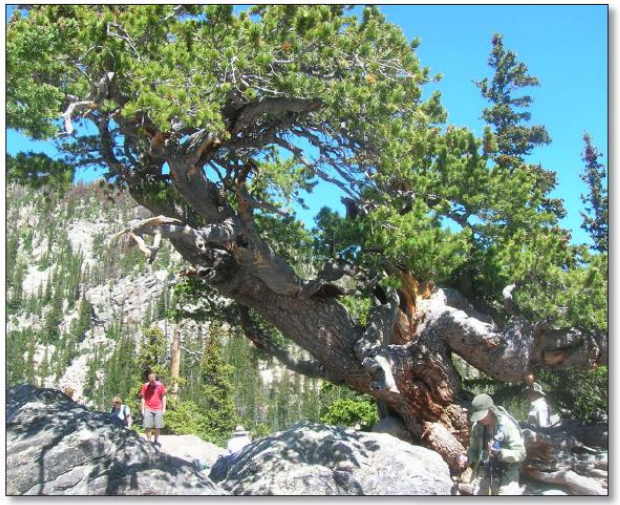
Abstract
Natural forests are increasi
host species with populati
eration for resilience (R4R
resources and utilize artifici
hood of success in position
sustaining host populations
population size to offset inv
resistance traits in host popu
retard future mortality and
tain host genetic diversity, a
is designed for conditions w
the host species naturally ha
host populations are integra
framework has been develo
tems of North America im
ribicola that causes the let
using the R4R framework t
or hazard, genetic resistanc
itize areas and design inter
eration dynamics can increa
invasive species.

Keywords *Pinus albicaulis*
needle pine · White pine bli
regeneration · Invasive spec

USDA
United States Department of Agriculture

Proactive Limber Pine Conservation Strategy for the Greater Rocky Mountain National Park Area

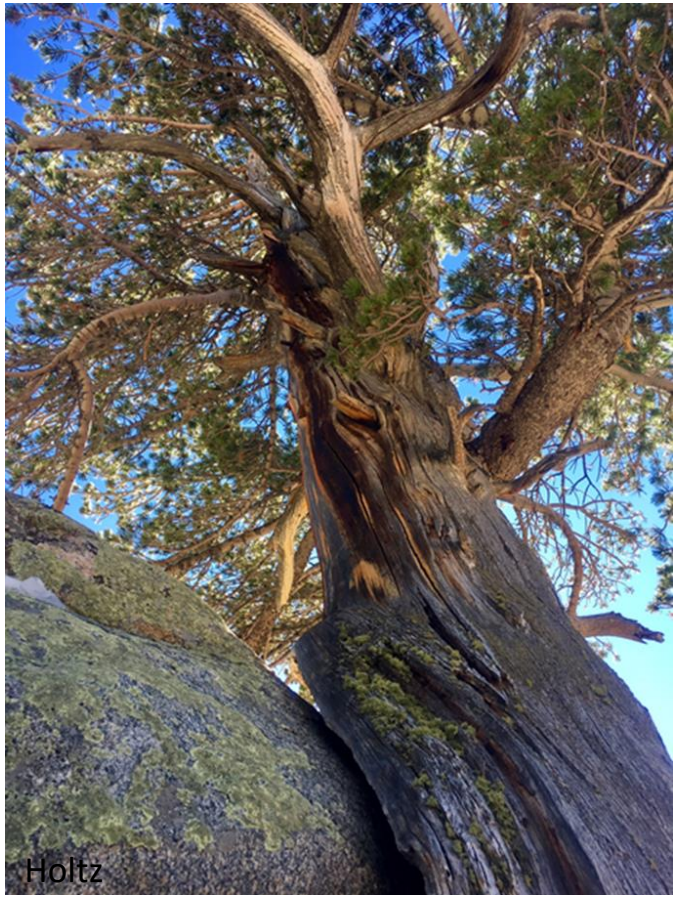
Anna W. Schoettle, Kelly S. Burns, Christy M. Cleaver, J. Jeff Connor



Forest Service | Rocky Mountain Research Station | General Technical Report RMRS-GTR-379 | February 2019

Ongoing:
Great Basin Strategy

Summary



An evolutionary approach in an ecological context can be effective at addressing invasive species impacts and developing management tools

Working with research and manager partners – made progress in developing restoration strategies and the first proactive conservation strategies

Keep in mind:
Treatment options and probability of success depends on the stage of invasion and forest condition

Timing of intervention is important – act sooner than later!

Look beyond the crisis areas

Find opportunities to mitigate the development of impacts in threatened areas - prepare the landscape for invasion

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Resources

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