Whitebark Pine Ecosystem Foundation

www.whitebarkfound.org

Whitebark Pine and Climate Change: Compelling Reasons for Restoration

Diana F. Tomback

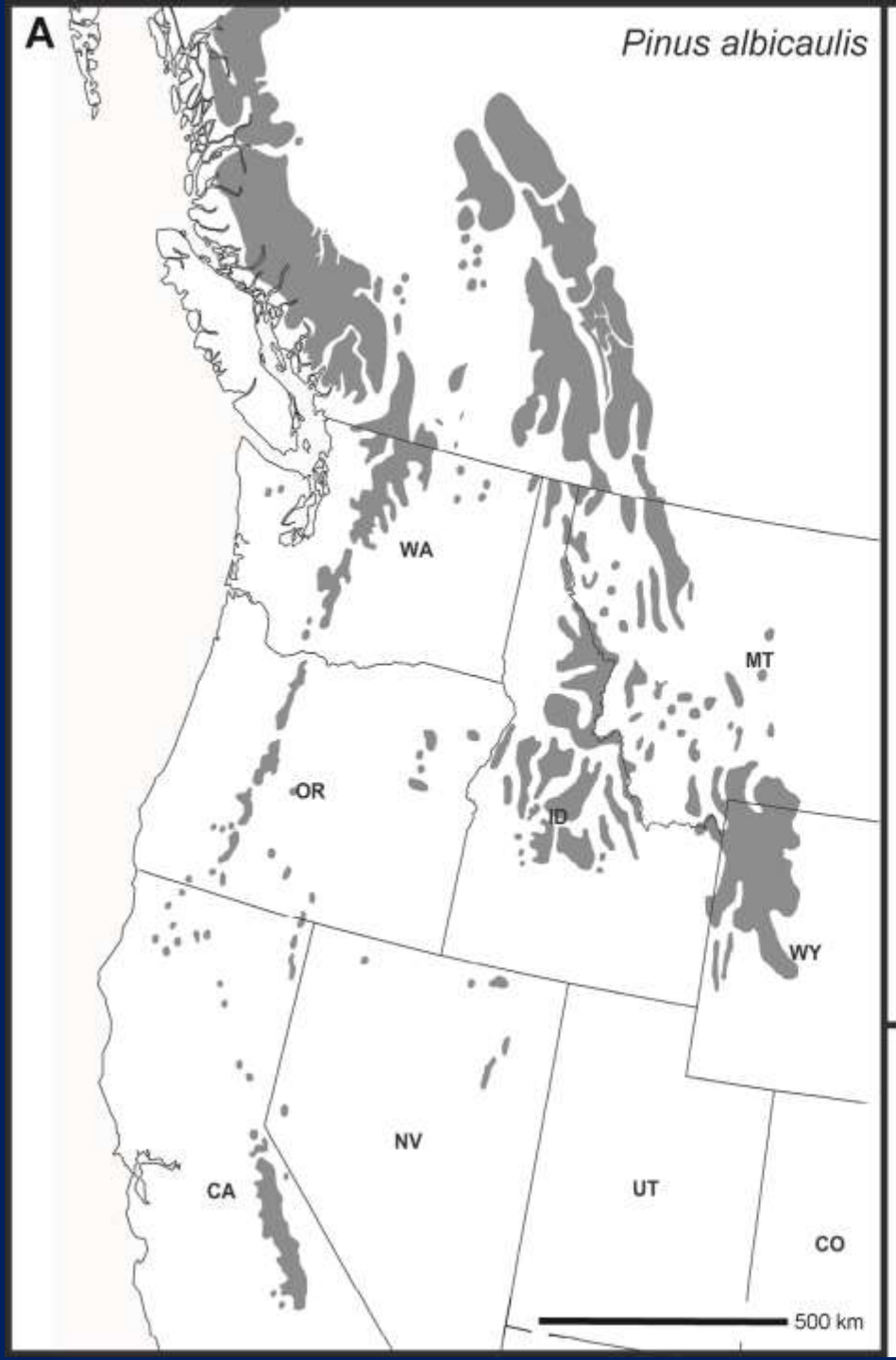
Diana.Tomback@ucdenver.edu

www.whitebarkfound.org

Willmore Wilderness Park

Whitebark pine (*Pinus albicaulis*)

- Upper subalpine and treeline conifer.
- Widely distributed throughout western North Amerca.
- 37° to 55° N lat.
- 107 to 128° W long.



Whitebark Pine Growth forms

Wind River Mountains, WY

Banff National Park
Alberta, Canada

Rob Mutch Crater Lake National Park, OR

Banff National Park

Whitebark pine across its range


Crater Lake National Park OR


Grand Teton National Park, WY


Yosemite National Park, CA


Beartooth Plateau, MT


Blackfeet Indian Reservation, MT

Whitebark pine community types

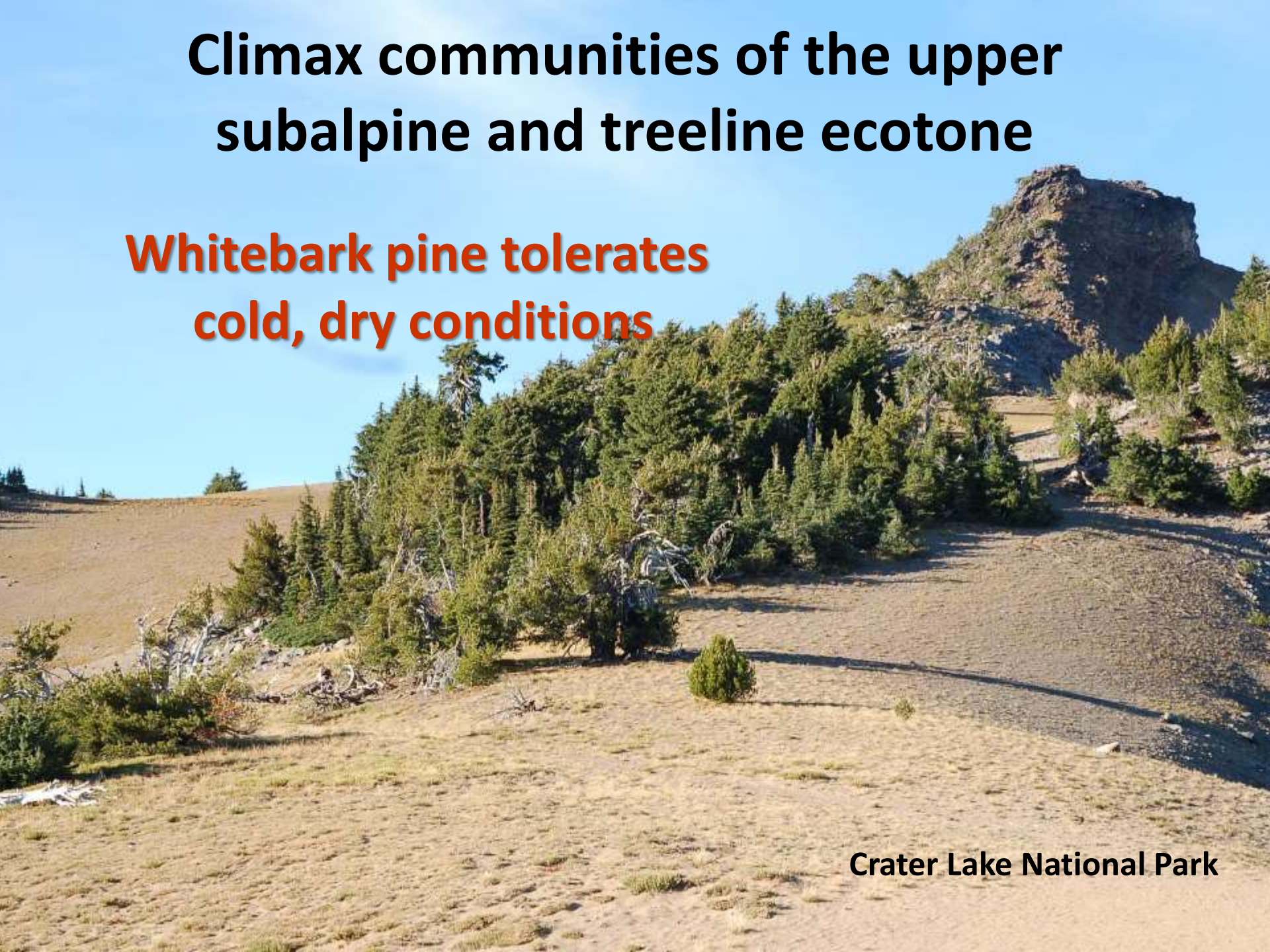
- ***Successional communities*** on favorable sites, upper subalpine zone (widespread in the Rocky Mountains).

- ***Climax communities*** on exposed upper subalpine sites and in treeline ecotone (most common community type.

Successional communities

- Over time, whitebark pine is largely replaced by shade-tolerant conifers.
- Succession is renewed by fire and other disturbances.

Climax communities of the upper subalpine and treeline ecotone



Clark's Nutcracker:
The primary seed disperser for whitebark pine

Adaptations of whitebark pine for seed dispersal by nutcrackers:

- Large, wingless seeds.
- Cones remain closed after seeds ripen.
- Horizontally-oriented cones on upswept branches.
- Seed morphology adapted for caching.

Seed dispersal by nutcrackers

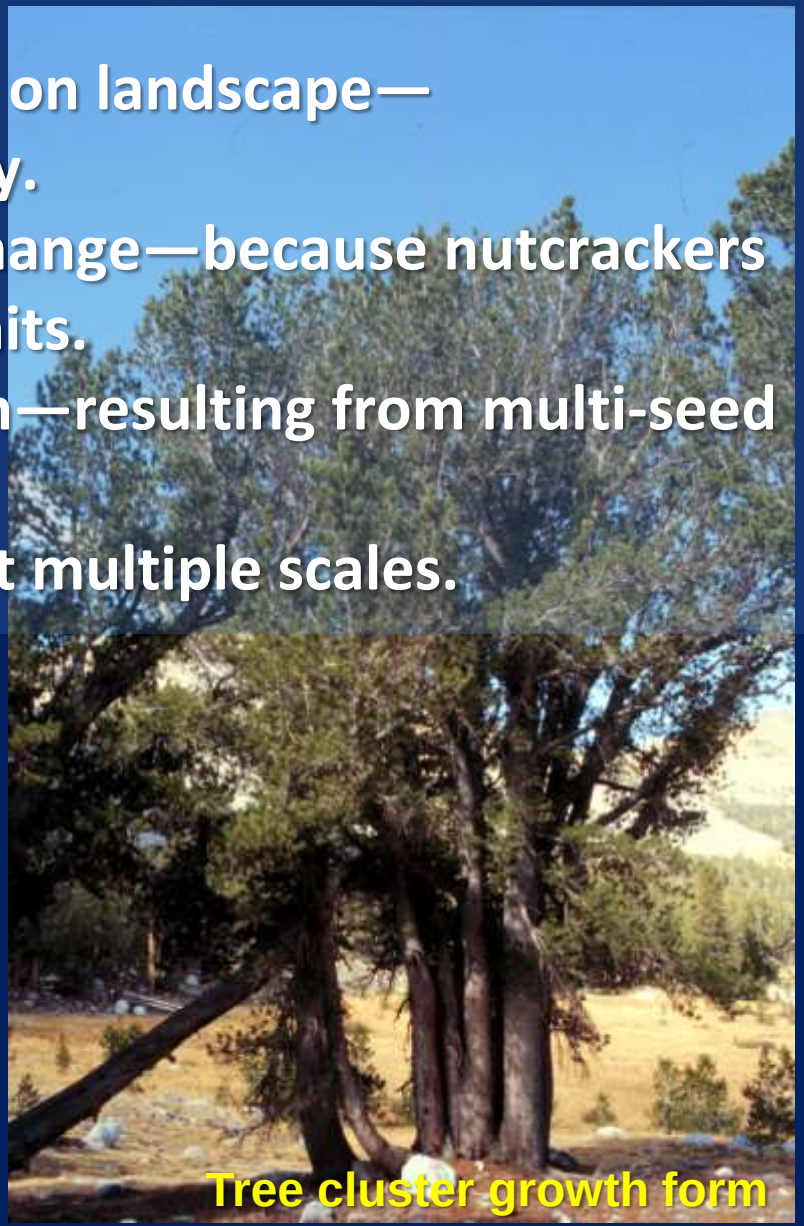
Nutcrackers

- Bury seeds in caches of 1-15 seeds, typically 3 or 4.
- Seeds cached 1 to 3 cm under soil, needle litter, or gravel.
- Seeds cached at distances of a few meters to 35 km from source trees.
- Unretrieved caches germinate, leading to regeneration.

Seed dispersal by nutcrackers

Responsible for

- Distribution of whitebark pine on landscape—both elevation and topography.
- Rise in treeline with climate change—because nutcrackers cache seeds above treeline limits.
- The "tree cluster" growth form—resulting from multi-seed caches.
- Population genetic structure at multiple scales.



Tree cluster growth form

Whitebark pine seeds are an important wildlife food

- Birds: 7 families, 13 species.
- Mice and squirrels: 2 families, 8+ species.
- Pine squirrels compete with nutcrackers for seeds.
- Bears and foxes.
- When seeds are ripe, canopies busy with foraging birds and chipmunks and squirrels.

Whitebark pine—
keystone and foundation species
Promotes biodiversity

- Wide spectrum of community types.
- Provides wildlife habitat, shelter, and nest sites.
- Seeds are important wildlife food.

Stanley Glacier , Kootenay NP

Ecosystem services:
Community development and stability; protects our "water towers"

- Regulates snow melt and downstream flow.
- Reduces soil erosion; stabilizes snow--- avalanche control.
- Fosters community development after disturbance.
- Nurse tree on harsh sites.
- Tree island initiator and component.
- Rapid response to warming or cooling at treeline.

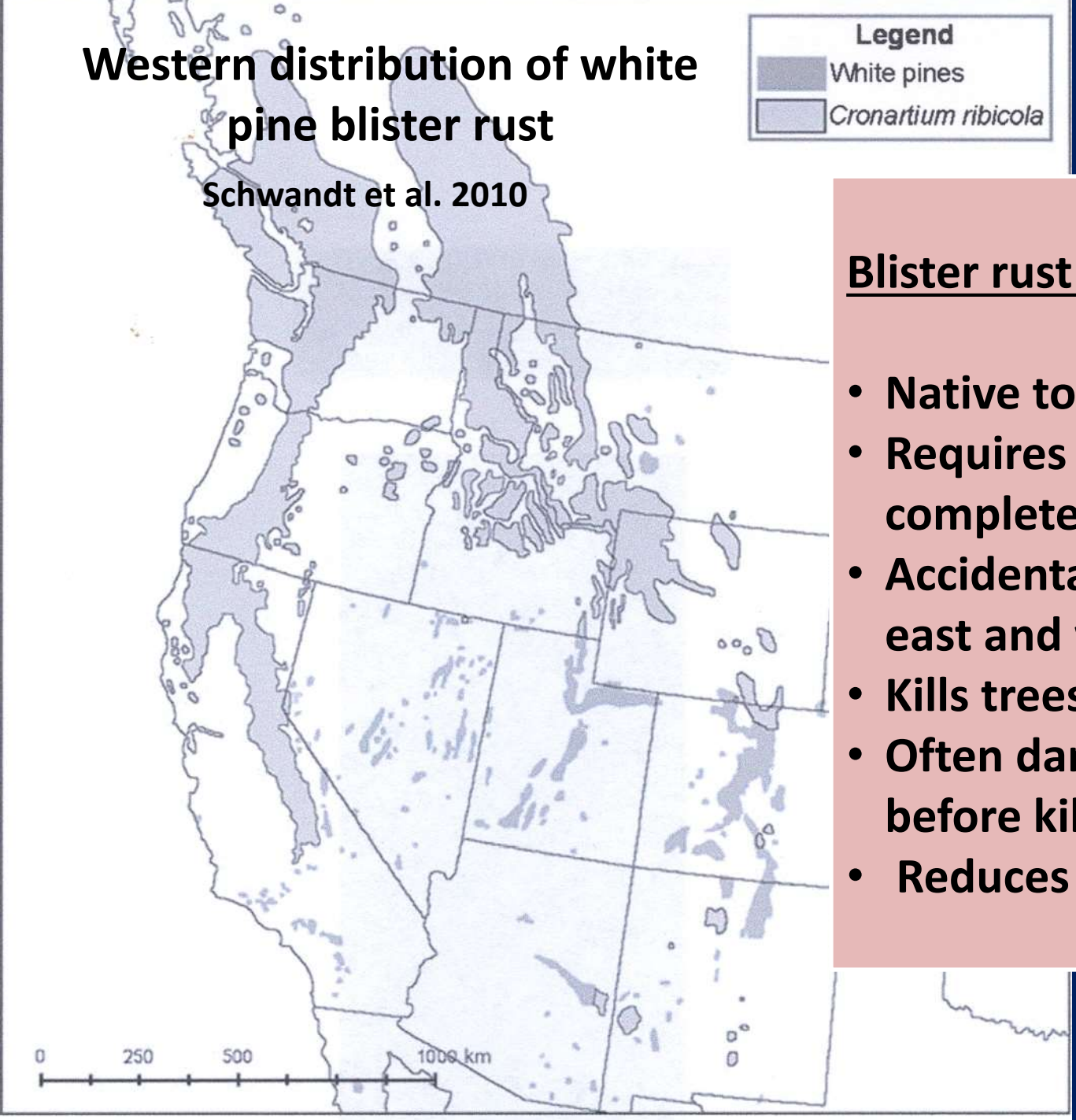
Grand Teton National Park

Whitebark pine “in peril”

- The introduced, invasive pathogen *Cronartium ribicola*—white pine blister rust.
- Mountain pine beetle outbreaks.
- Altered fire regimes—successional replacement.
- Climate warming—sustaining pine beetle outbreaks, producing drought stress and mortality, and altering pine distributions.

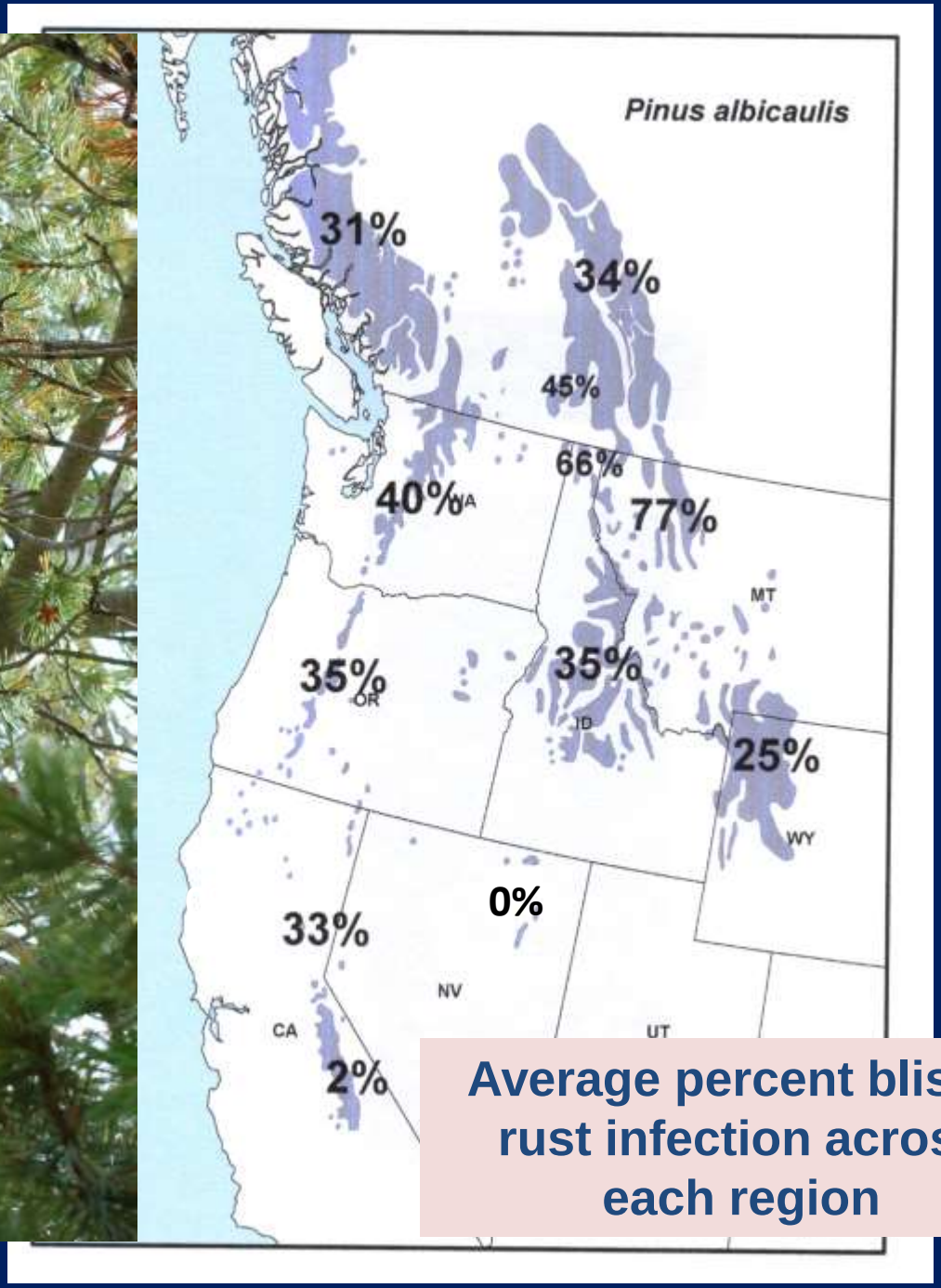
Western distribution of white pine blister rust

Schwandt et al. 2010



Blister rust facts

- Native to Asia.
- Requires alternate hosts to complete life cycle.
- Accidental introductions to east and west 1890s-1900s.
- Kills trees of all age classes.
- Often damages canopy before killing trees.
- Reduces cone production.



Average percent blister rust infection across each region

Mountain pine beetle in whitebark pine

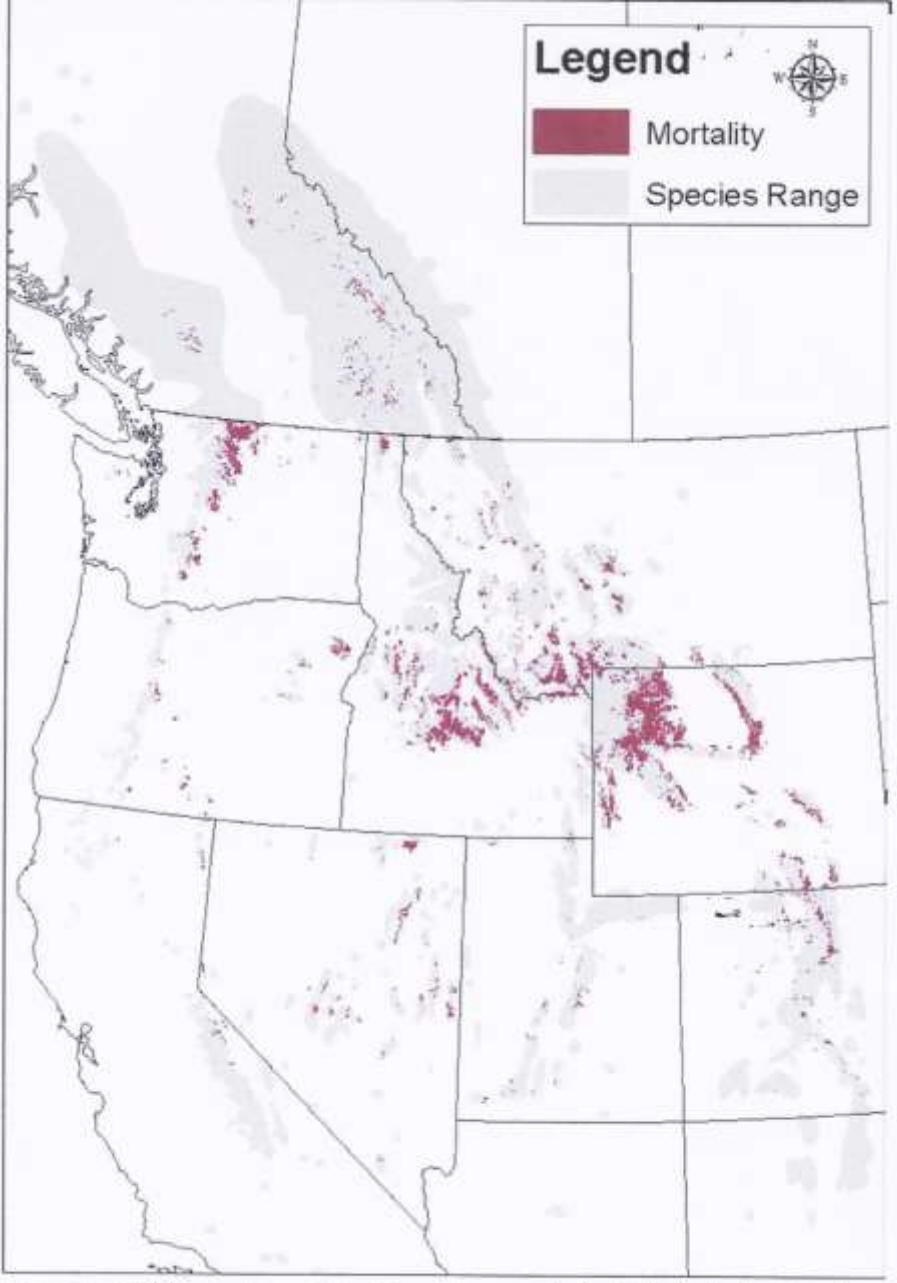


Figure 7. MPB-caused mortality of four pine species (whitebark, limber, Rocky Mountain bristlecone, and Great Basin bristlecone) in the western United States (1998-2007 ADS) and British Columbia (2006-2007) throughout the distributions of these tree species (United States Geological Survey).

Mountain Pine Beetle

Map of mortality in whitebark, limber, Rocky Mountain, and Great Basin bristlecone pines, 1998-2007.

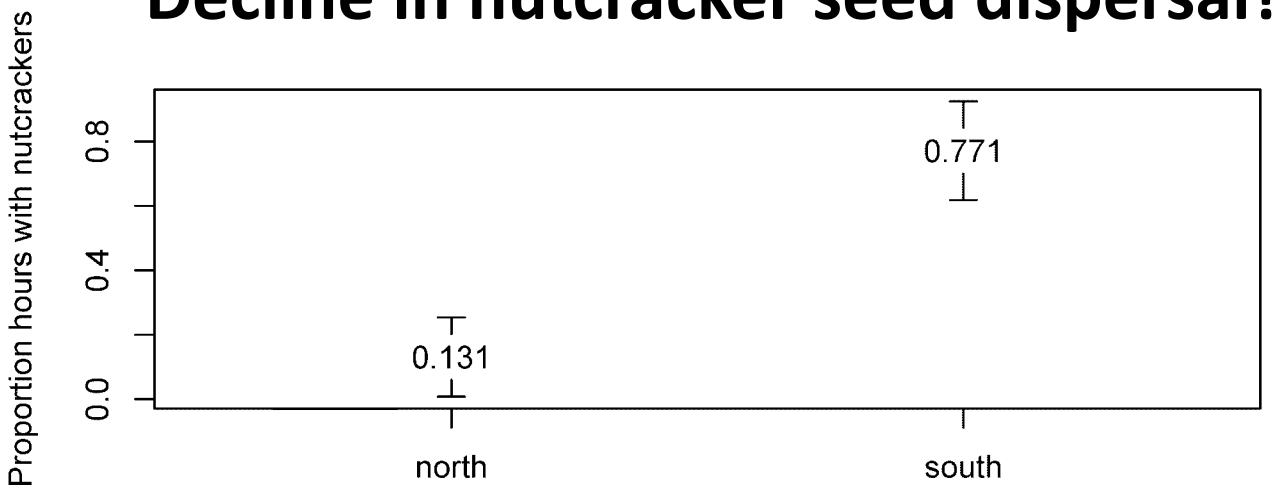
- Based on aerial detection surveys.
- Total mpb-killed whitebark pine estimated to be ~ 470,000 .
- As great as 90% mortality in some stands.

Gibson et al. (2008).

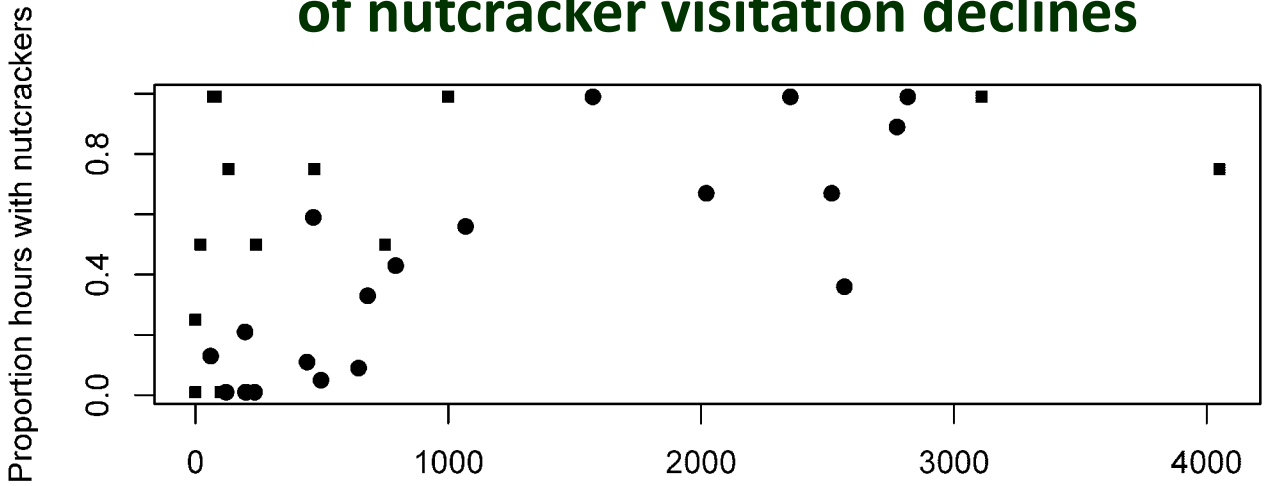
Mountain pine beetle

Avalanche Peak, Yellowstone National Park, EcoFlight

Decline in nutcracker seed dispersal?



As cone production declines,the likelihood of nutcracker visitation declines



Barringer et al. 2012

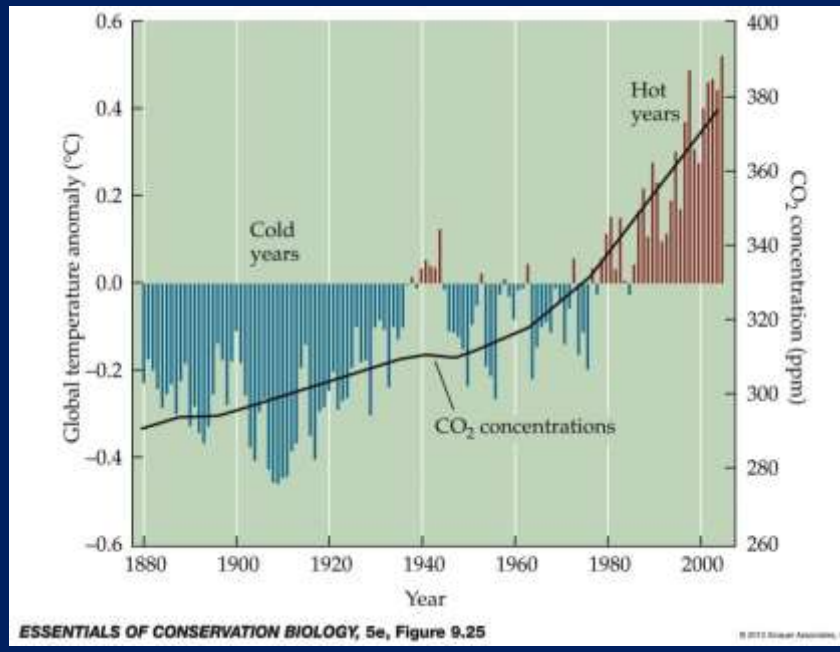
Fire suppression and succession

Fire suppression in the western U.S. began 1850 to 1904, with aggressive suppression as of 1905-1910.

- Long fire return intervals at high elevations, so effects are not always evident at the stand level; need to be examined at the landscape level.
- Effects of fire suppression have been documented for whitebark pine in some Rocky Mountain regions, the Inland Northwest, and the Cascades.
- Fire creates favorable conditions for seed caching by nutcrackers and whitebark pine establishment.
- The combination of whitebark pine mortality from blister rust and fire suppression hastens succession and the loss of whitebark pine.

Climate Change

- CO_2 has increased from 290 ppm to 387 ppm over the last century.
- Projected to double this century.
- Believed that global surface temperatures have increased about 0.6^0C this past century.
- Consensus among climatologists that world temperature will increase 2^0 to 4^0 C by 2100.
- The distributions of many forest trees are expected to shift independently, resulting in new forest associations.
- Fire frequency and severity are projected to increase.



Distributional shifts

Bioclimatic models (niche-based models) used to predict distributional shifts under different climate scenarios. Generally predict that whitebark pine will shift to higher elevations and more northern latitudes.

(Hamann and Wang 2006, McKenney et al. (2007), Warwell et al. (2007), Schrag et al. (2008)

- According to Aitken et al. (2008), forest trees have three possible responses to climate change:
- adapt in current distribution
- migrate following their niche
- extirpation

Climate warming and whitebark pine

Predicted distributional changes depend on tracking ability (e.g., McKenney et al. 2007)

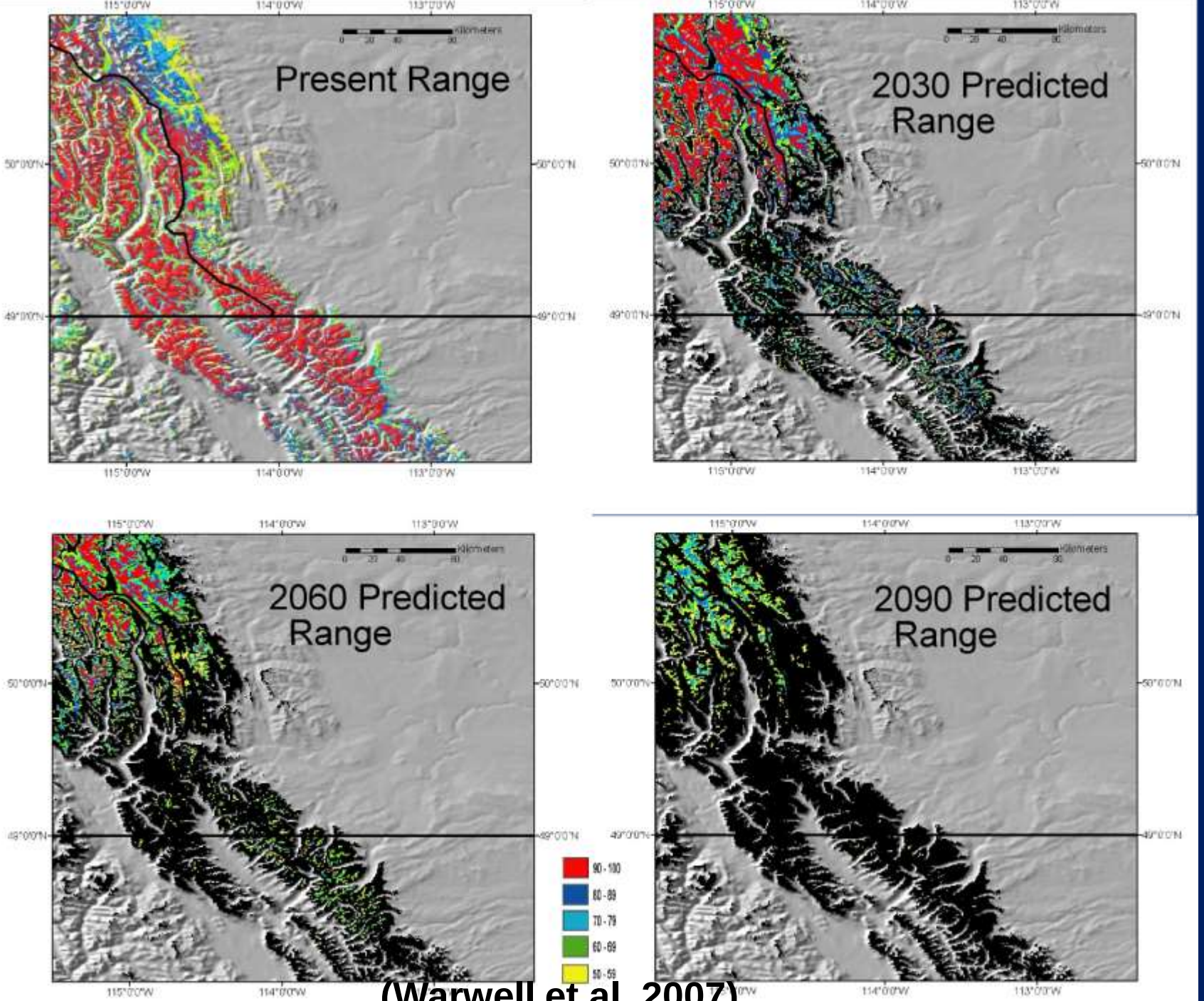
- **If full tracking, whitebark pine moves north and gains area.**
- **If no tracking, it loses area.**

Climate change complicates management:

- **Which seed provenances/transfer zones to plant?**
- **Will continuing warming accelerate pine beetle outbreaks?**
- **What effects will warming have on *C. ribicola* spread?**
- **How will more frequent fires affect succession and stand composition?**

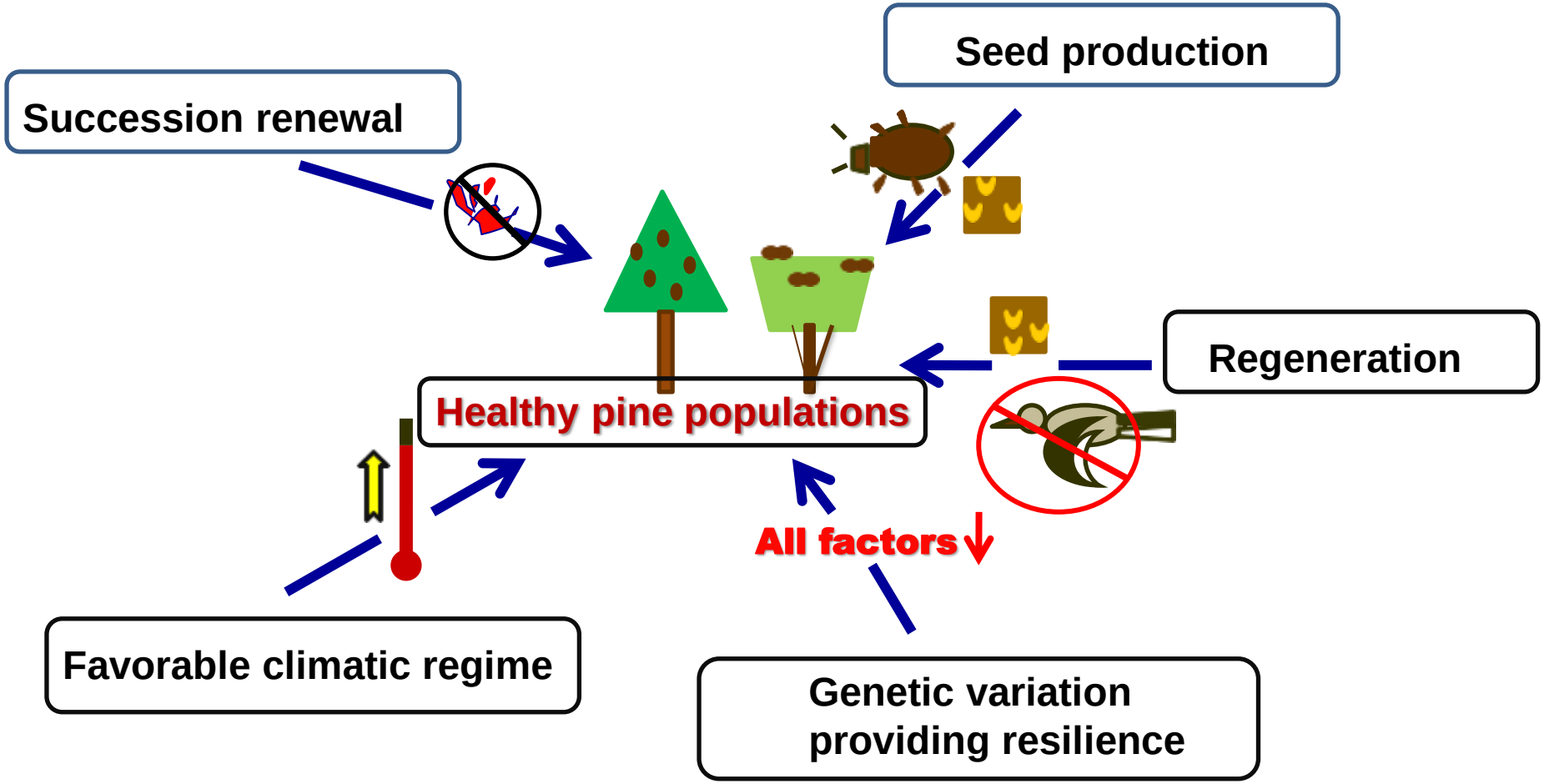
Climate warming “fronts” for whitebark pine

- Treeline in the higher mountains of the west.
- Northern-most limits to distribution.
- Blister rust is present in both situations.



(Warwell et al. 2007)

Challenges to maintaining viable populations of whitebark pine



Whitebark pine restoration

- Strategy: speed up natural selection by developing and planting blister-rust resistant seedlings.
- Replace the seed dispersal services of nutcrackers.
- Plant seedlings or seeds where whitebark pine has the best chance to become established.

Restoration approaches

Genetic resistance:

- Genetic resistance program: seek out trees potentially resistant to blister rust.
- Collect cones, screen seedlings, and test for resistance.
- Protect resistant trees from mountain pine beetles and fire.
- Plant seedlings or direct seed in suitable sites.

Steps in restoration by planting

Protect ripening cones.
Harvest cones.

Grow seedlings

Screen seedlings for resistance.

R. Sniezko

Protect resistant seed sources against mountain pine beetles.

Plant seedlings.

Other restoration approaches

- Protect cone-bearing trees by removing competition through silvicultural thinning.
- Use prescribed burns to open successionally advanced stands for planting and natural regeneration.

Strategize

Hedge bets—restoration should include a mixed approach of:

- "Reactive restoration" of stands that have nearly lost whitebark pine and its ecological function.
- "Proactive restoration" of stands that still have good cone production and some level of resistance. These may be less costly to restore with higher probabilities of success.
- Promote natural regeneration but also plant to spread resistance.
- Has the time come to use direct seeding? This would allow large-scale efforts at spreading resistance.

Restoration under climate change

The best strategy is restore healthy populations of whitebark pine to provide “seeds for change.”

Bet-hedging strategies:

- Plant resistant seedlings or seeds representing a mix of seed zones, especially more southern seed zones.
- Plant on north aspects and colder topography, including valley bottoms.
- Manage forests for mountain pine beetle, which means a mosaic of communities of different ages.

More frequent fires in general should favor whitebark pine establishment.

Common misbeliefs about climate change

All of whitebark pine will march northwards or upwards and off the mountains.

- It is far more complex: topography varies, aspect varies, climate varies locally. Whitebark pine will be retained in patchier distributions for a long time.

The Species Distributional Models tell it all.

- These models have a high degree of uncertainty, exceeding the range of predictions.
- They do not consider life stage or processes of cone production , pollination, seed dispersal, tree growth, species interactions, and effects on phenology.
- Whitebark pine is long-lived and once established, endures changes in climate over time.

Modelling restoration techniques under climate change

Bob Keane is currently evaluating each restoration technique in the "range-wide strategy" using modeling (Keane, Loehman, Holsinger 2012). Findings to date:

- Restoration activities are somewhat more effective at higher elevations.
- Management of entire landscapes, especially lower elevation forests, dictates the fate of whitebark pine above.
- Planting rust-resistant seedlings translates to healthy cone-producing trees in about 80 years.
- Wildfires create the same stands as mechanical treatments, except there is higher whitebark pine mortality.
- Genetic resistance takes about two centuries to spread throughout a stand, but only if there are enough cone-producing trees.
- It takes 80 to 120 years to spread resistance by planting.

Responsibility for whitebark pine restoration will be most effective as a partnership among:

- **the public**
- **non-profit organizations**
- **the federal government**

Whitebark pine restoration requires a multi-generational commitment. We need to recruit new generations of forest managers and researchers to this cause.

Whitebark Pine Ecosystem Foundation