

National Whitebark Pine Summit, Missoula, MT, Nov. 7-9, 2017

Introduction to Whitebark Pine



WHITEBARK PINE
ECOSYSTEM FOUNDATION

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White Calf Mountain, Glacier National Park, MT

Glacier National Park, MT—overlooking Blackfeet Reservation



WHITEBARK PINE
— ECOSYSTEM FOUNDATION —

Mission:

501 (c)(3) science-based organization dedicated to promoting the conservation of whitebark pine ecosystems through:

- **Education**
- **Restoration and management**
- **Research and development**

**Established in 2001. Volunteer director and board.
Visit us at www.whitebarkfound.org**

Outline of presentation

- Taxonomy
- Distribution
- Ecology
- Foundation and keystone roles
- Ecosystem services
- Historical and traditional significance
- Threats, status, and trends
- How dependence on a bird complicates restoration
- Definition of restoration
- Conservation and restoration: call to action
- Summary statements

Willmore Wilderness Park, Alberta, Canada

Whitebark Pine

across its range



Banff National Park, AB



Wind River Mountains, WY



Crater Lake NP,
Cascades, OR



Sierra Nevada, CA

Taxonomy: *Pinus albicaulis* Engelm.

Formally described by George Engelmann in 1863

Family Pinaceae

Genus *Pinus*

Subgenus *Strobus*: “White” pines or “soft” pines, haploxylon

Section *Quinquefoliae*

Subsect. *Strobus* -“five-needle pines” (revised)*

- *subsect. *Strobus* from combined subsects. *Strobus* and *Cembrae*
Gernandt et al. 2005; Syring et al. 2007
- Phylogeny unresolved for many five-needle white pines.
- Hao et al. (2015)—“...ancient and relatively recent introgressive hybridization events...particularly in northeastern Asia and northwestern North America.”

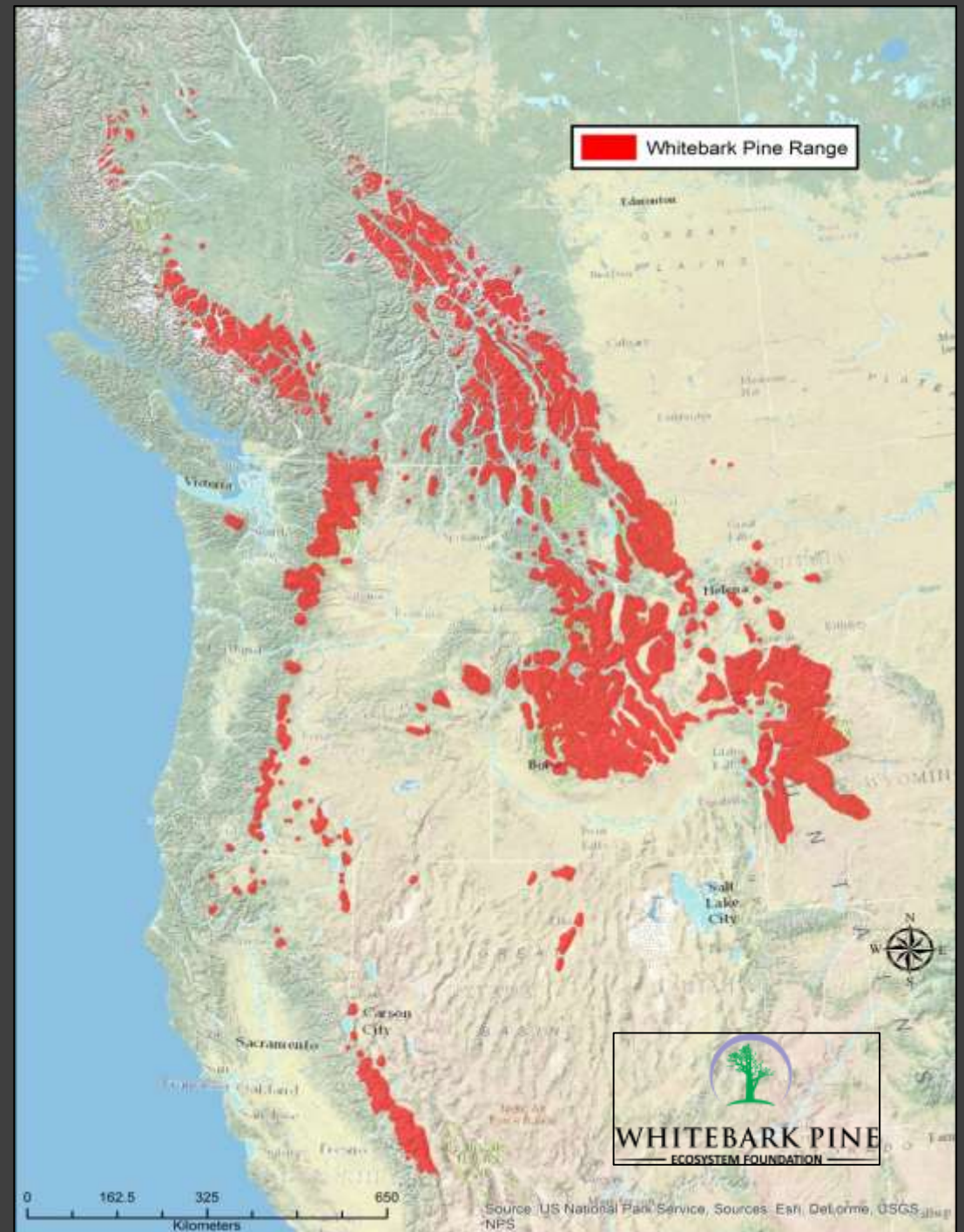
Whitebark pine range

- Upper subalpine and treeline forest zones.
- Western U.S. and Canada.
- 37° to 55° N lat.
- 107° to 128° W long.
- Elevation: 900-3,660 m
- Estimated areal coverage:

Keane et al. 2012, Table 4.1

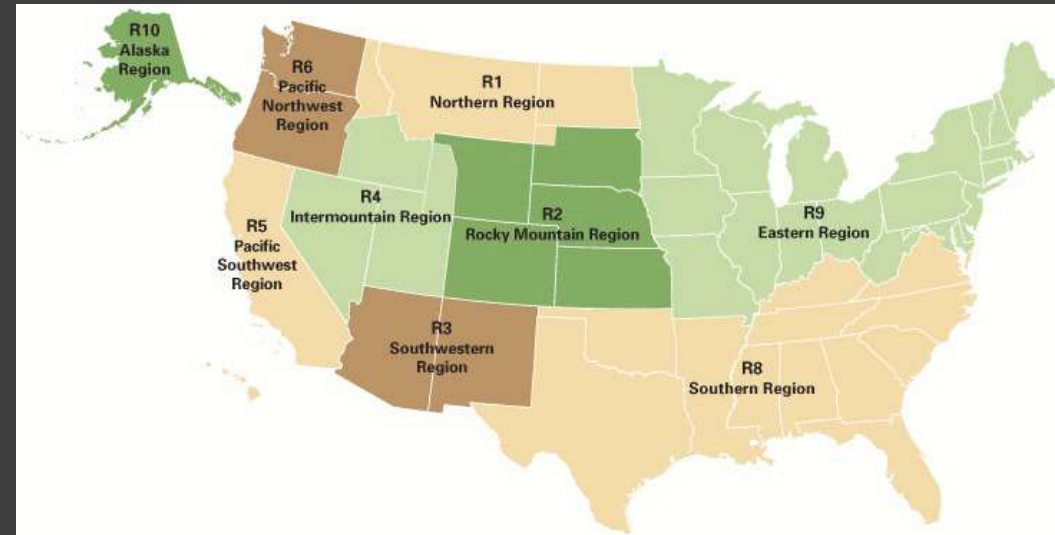
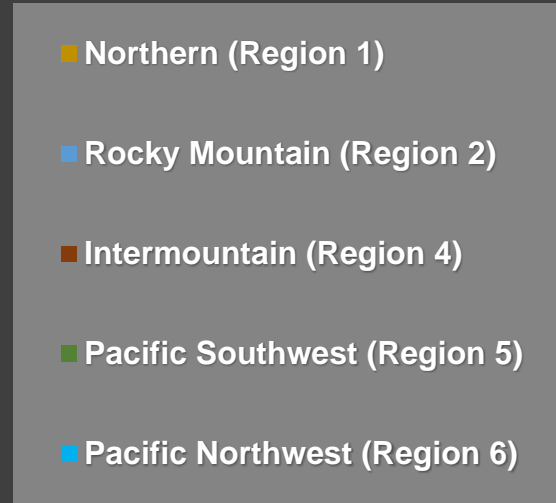
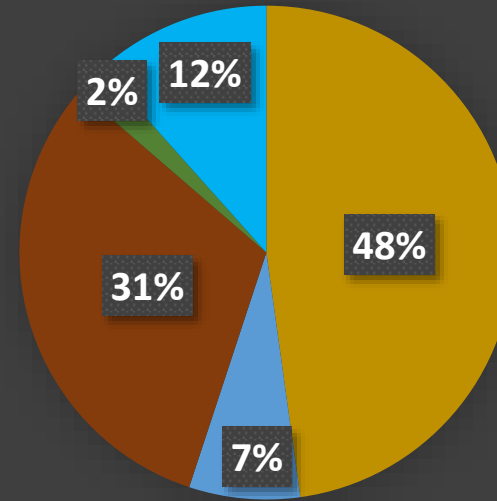
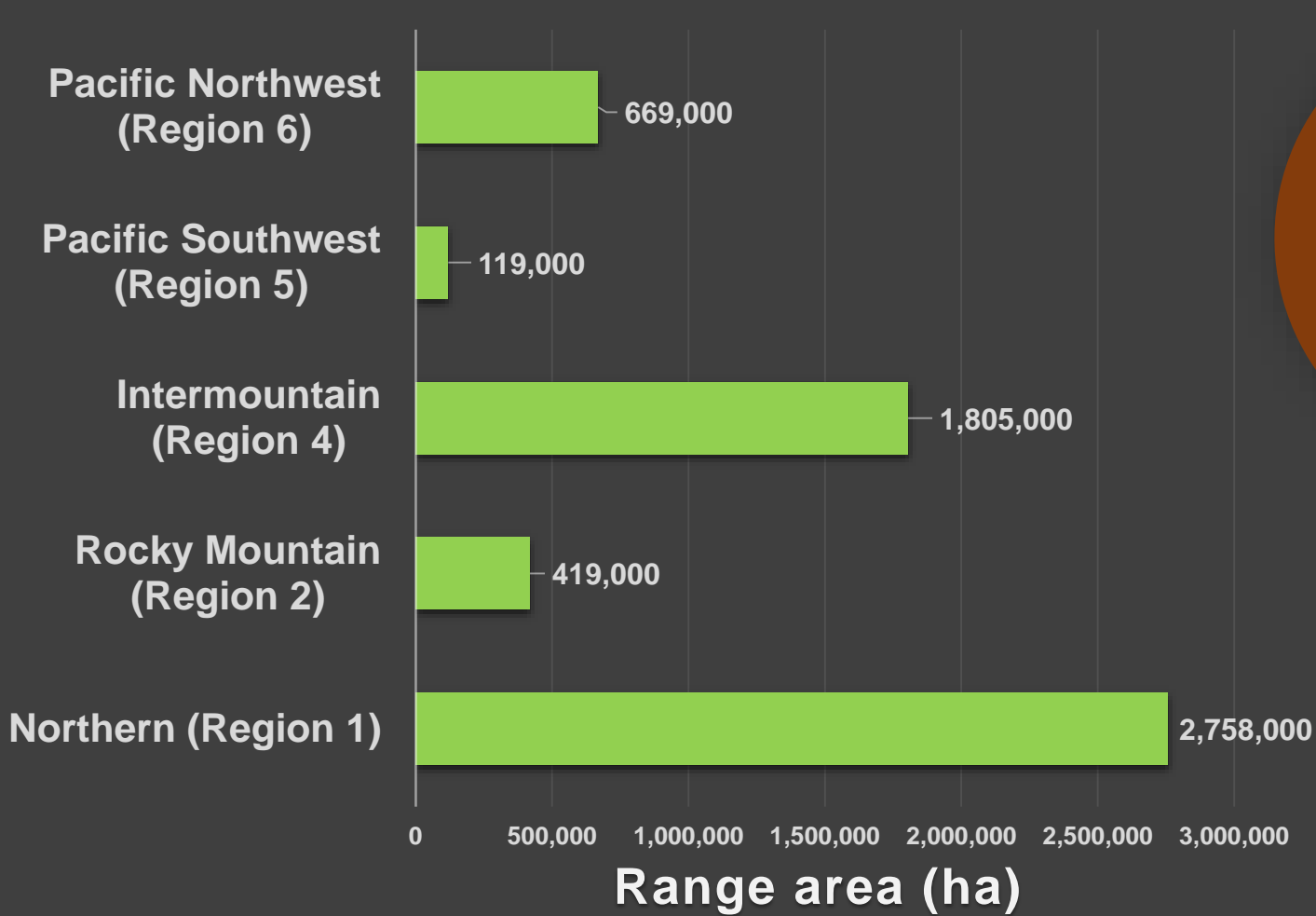
-ca. 5,770,000 ha

-ca. 14,252,000 acres



Whitebark Pine Area within U.S. Forest Service Regions

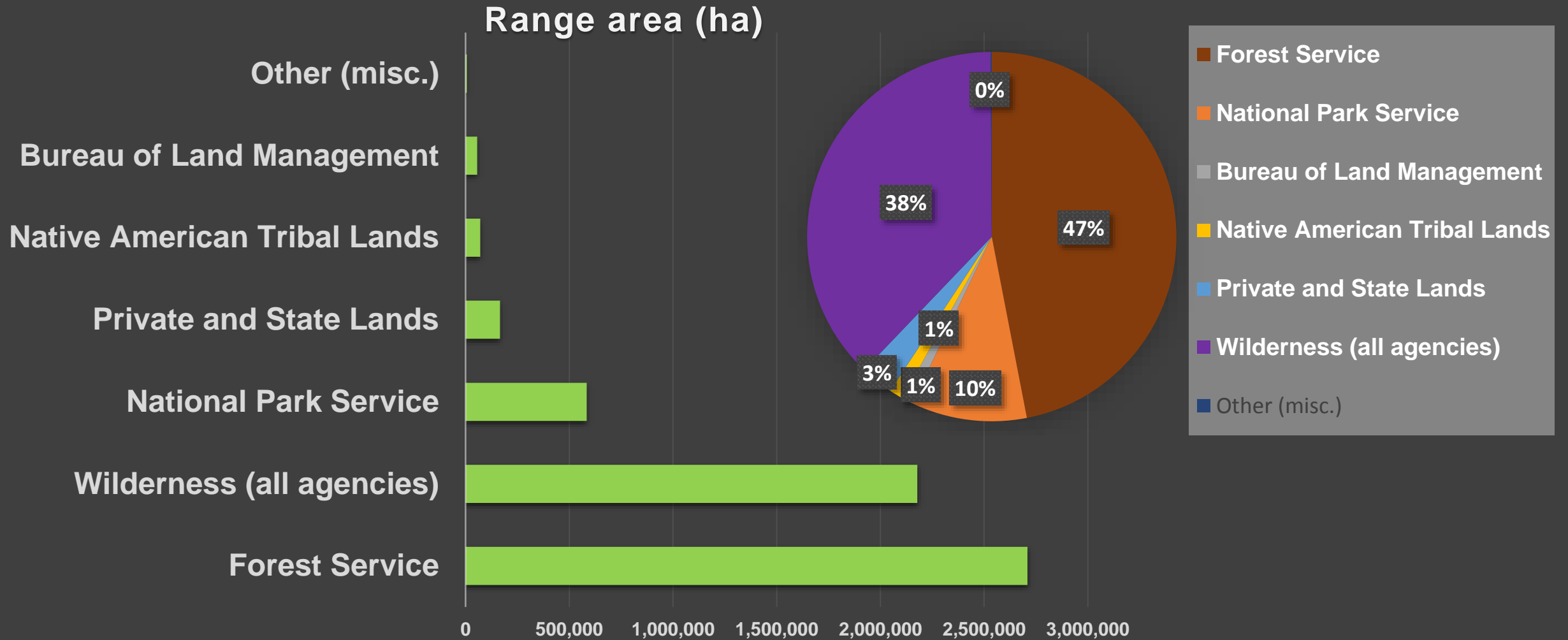
Total estimated area ~ 5,770,000 ha



Data from Keane et al. 2012, Table 4.1

Whitebark Pine Area by Government Jurisdiction

Total estimated area ~ 5,770,000 ha



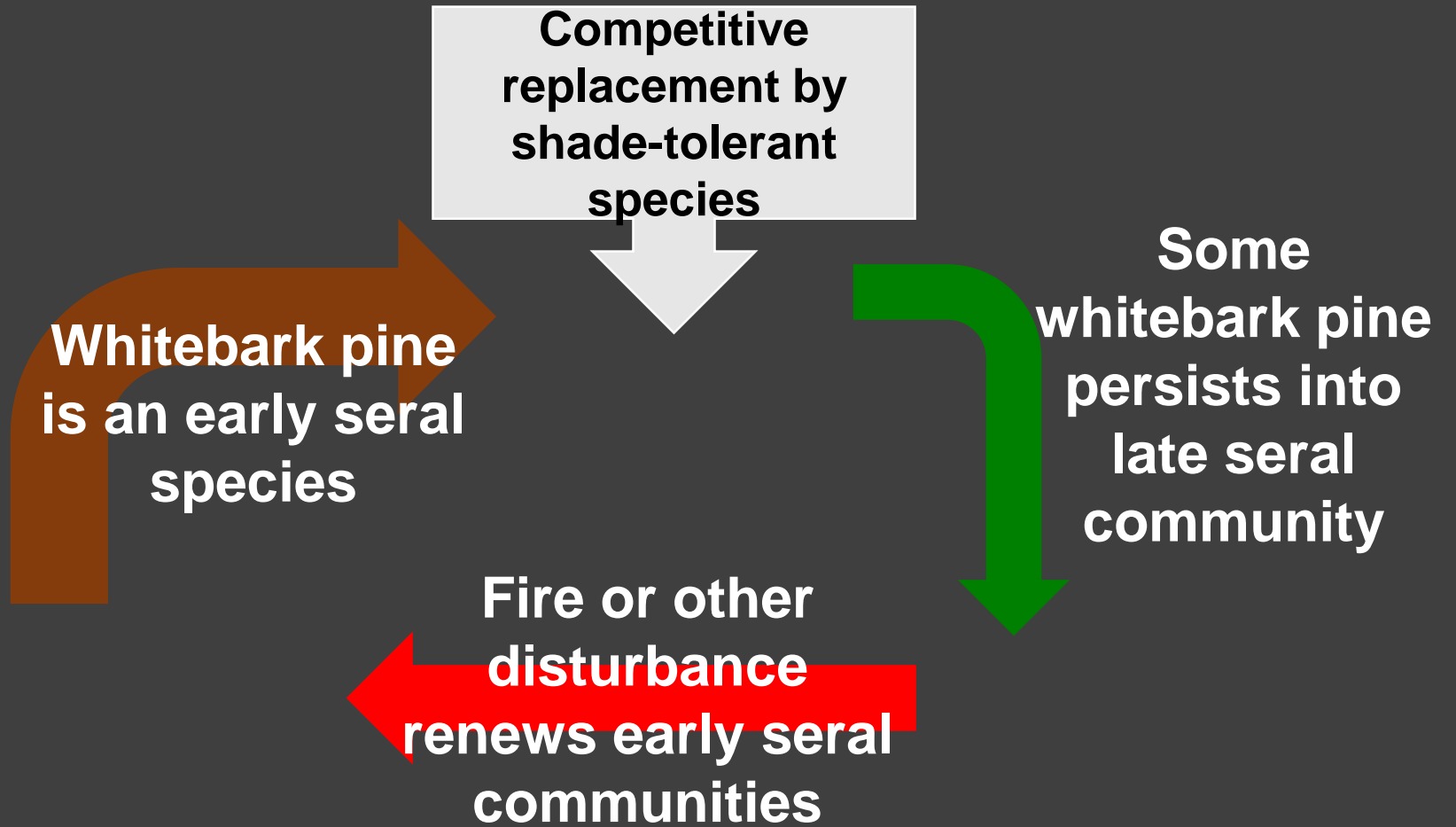
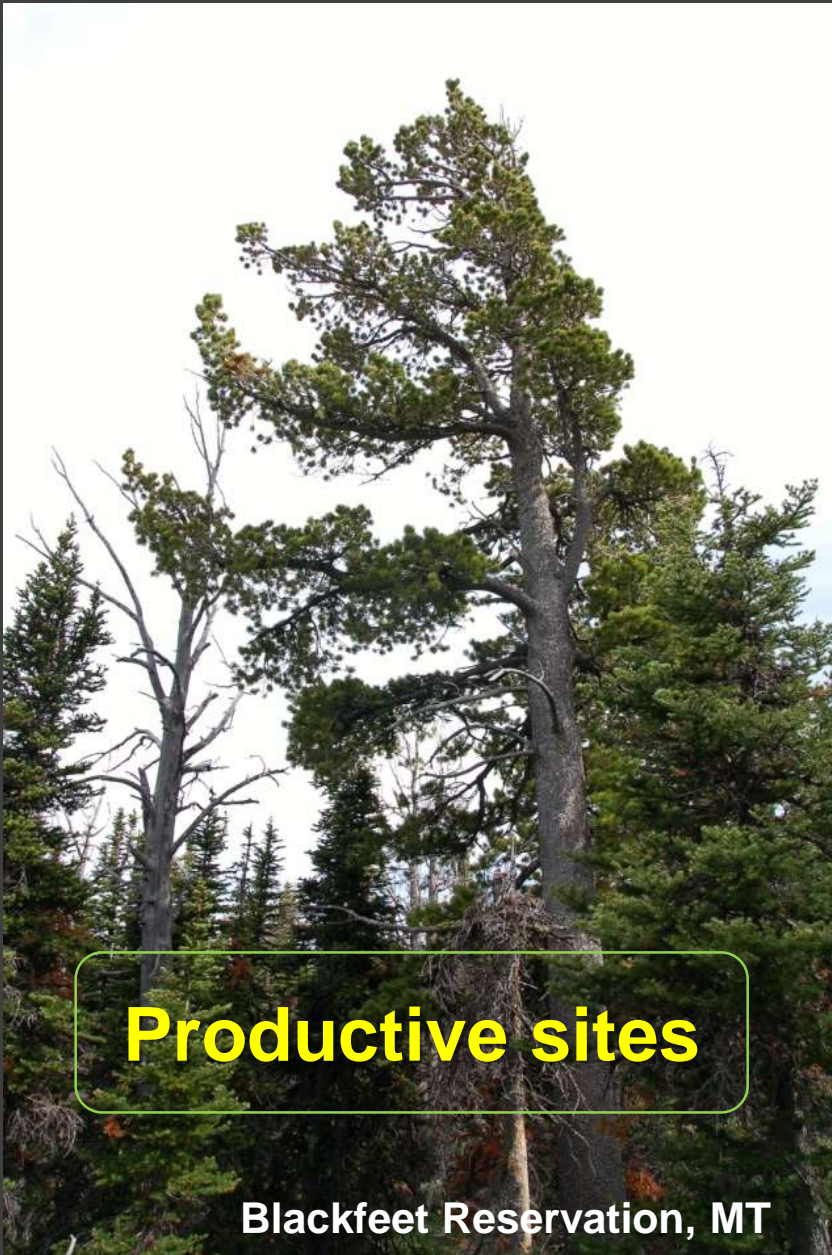
Data from Keane et al. 2012, Table 4.1

Whitebark pine community types

- ***Successional communities*** on favorable sites, upper subalpine zone.
- ***Climax communities*** on exposed upper subalpine sites.
- ***Treeline communities*** on cold sites in the alpine treeline ecotone.



Community types vary with site conditions: successional communities



Climax or self-replacing communities



Crater Lake NP, OR

**Arid, wind-swept sites,
nutrient-poor soils**

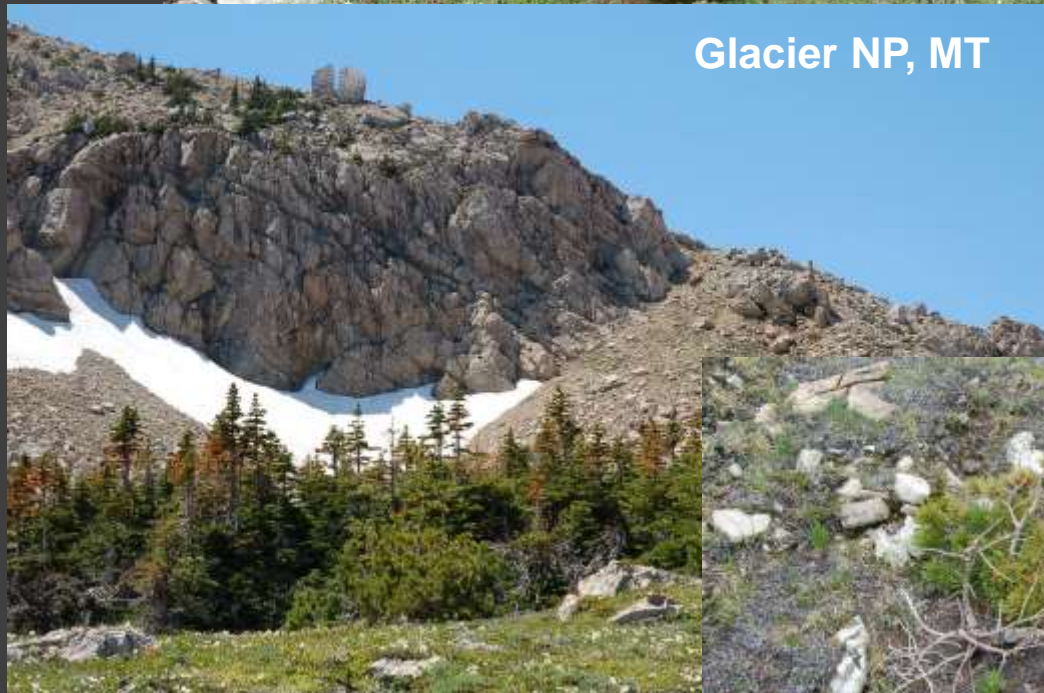
**Continuous but
sparse regeneration
over time**

**Whitebark pine co-
dominates or
dominates the
community**

Whitebark Pine treeline communities



Glacier NP, MT



- At upper forest edge-- *alpine-treeline ecotone*.
- Krummholz (dwarf) and flagged growth forms
- Dominant component of treeline communities on dry, windswept slopes.
- Prevalent along eastern slopes, e.g., Rocky Mountains, Cascades, Sierra Nevada.
- Whitebark pine is often a tree island “initiator.”

**Clark's Nutcracker is the
primary seed disperser for whitebark pine**

Coevolved mutualism



Jasper National Park

Adaptations of whitebark pine for seed dispersal by nutcrackers

- Large, wingless seeds.
- Cones remain closed after seeds ripen: obligate mutualism.
- Horizontally-oriented cones on upswept branches.
- Seeds adapted for caching: viable for several years under soil.



Seed dispersal by nutcrackers

Nutcrackers

- May carry 100 or more whitebark pine seeds in their throat pouch .
- Place seeds in caches of 1 to 15 seeds.
- Bury seed caches 1 to 3 cm under substrate.
- Carry seeds from a few meters to >32 km.
- Store >35,000 whitebark pine seeds per year per bird.
- Retrieve caches using highly accurate spatial memory.

Unretrieved caches germinate, leading to regeneration.





Seed dispersal by nutcrackers determines:

- The distribution of whitebark pine on the landscape—elevation and topography.
- Where whitebark pine grows locally—nutcracker cache site selection and environmental suitability.
- Rise of treeline with climate change—because nutcrackers cache seeds above tree limits.



Tomback and Linhart 1990

Tomback 2001

Tomback 2005

Seed dispersal by nutcrackers results in:

- The “tree cluster” growth form—from multi-seed caches.
- Fine-scale population genetic structure.
- Watershed and regional population structure.



A scenic view of a mountain valley with a waterfall and snow-capped peaks. The foreground shows a rocky, gravelly slope with sparse green vegetation. In the middle ground, a waterfall cascades down a dark, layered rock face. The background features rugged, snow-dusted mountain peaks under a clear sky.

Whitebark pine

Keystone species

Promotes biodiversity

- **Wide spectrum of community types.**
- **7 recognized SAF cover types.**
- **High elevation wildlife habitat, shelter, and nest sites.**
- **Seeds provide wildlife food.**

Stanley Glacier, Kootenay NP, BC, CA

Seeds as a wildlife food: birds

Birds: 8 families

Songbirds:

- Corvids
- Chickadees
- Nuthatches
- Crossbills
- Cassin's finches
- Pine grosbeaks

Other birds:

- Woodpeckers
- Grouse



visitwesterniowa.com



lbc.lynxed.com



Google.com



Imgarcade.com

Seeds as a wildlife food: small mammals

**Small Mammals: 2 families
many species, examples:**

- Pine squirrels
- Chipmunks
- Deer mice
- Red-backed voles



S. McKinney



greatlakesecho.org



<http://www.bentler.us/eastern-washington/animals/mammals/rodents/douglas-squirrel-lodgepole-pine-cone.jpg>

Seeds eaten by carnivores

Large Mammals: 2 families

- Grizzly and black bears
(Seeds obtained from pine squirrel middens.)
- Red fox



S. Wirt



P. Hartop



Wildlifeanimalz.blogspot.com



animalsadda.co,

Whitebark pine communities as wildlife habitat



Birds of prey:

- Great horned owls
- Red-tail hawks
- Goshawks
- Cooper's hawks
- Peregrine falcons

Ungulates:

- Bighorn sheep
- Mountain goats
- Bison
- Elk
- Mule deer
- Moose

Misc.

- Pine martens
- Weasels
- Snowshoe hares
- Pika
- Marmots
- Coyotes
- Wolves
- Mountain lions
- Canada lynx
- Wolverines



Yellowstone National Park, WY

Whitebark pine Foundation species

(Dayton 1972)

“...a single species that defines much of the structure of a community by creating locally stable conditions for other species and by modulating and stabilizing fundamental ecosystem processes.”

Defines ecosystem structure and function

- Early establishment after disturbance.
- Fosters community development through mitigation of harsh conditions and facilitation.
- Nurse tree on harsh sites (facilitation).
- Tree island initiator (facilitation).

Whitebark Pine Ecosystem Services

- High elevation forests and treeline communities redistribute and retain snow.
- Shade from these forests slows summer snowmelt, regulating downstream flow.
- Roots stabilize soil, reducing soil erosion.
- Trees stabilize snow, reducing avalanche hazard.

Role of treeline communities in snow redistribution and retention (Fig. 6 from Tomback et al. 2016)



Historical and spiritual significance

Whitebark pine and Clark's nutcracker not known to European settlers until the Lewis and Clark Expedition, 1803-1806.

- September 6, 1805: Expedition (Clark) observed "whitebark pine" within a high elevation mixed coniferous forest, as the men struggled to cross the Bitterroot Mountains into Idaho during an early season snowstorm.
- August 22, 1805: Clark first observed the Clark's nutcracker. He wrote a brief description. "I Saw to day Bird of the wood pecker kind which fed on Pine burs its Bill and tale white the wings black every other part of a light brown, and about the Size of a robin."
- May 28, 1806: Lewis shot a nutcracker on the return trip. He described it in some detail. The specimen later was formally named for Clark by Alexander Wilson.

There is an especially powerful symbolism associated with trees:

- Whitebark pine signifies endurance, stoicism, timelessness to mountain visitors.



Traditional and cultural significance

(Moerman 1998, 2009)

Provisioning services: Native American/First Nations use of whitebark pine as a food resource

Seeds

- Cooked in hot ashes or roasted, eaten or stored.
- Dried seeds mixed with serviceberries & stored.
- Ground to make mush.

Inner bark as food

- Roasted or raw.
- Probably under-reported for all pines.



D. Pigott

Threats, status, and trends

Henderson Mtn., Custer Gallatin NF, MT

The four major threats to whitebark pine



<https://imgur.com/gallery/OPa7e>



- ***Cronartium ribicola***—fungal pathogen that causes white pine blister rust.
- **Mountain pine beetle (*Dendroctonus ponderosae*)** outbreaks.
- **Altered fire regimes**—successional replacement from fire exclusion actions.
- **Climate warming**—driving bark beetle outbreaks, drought stress and mortality, larger, more frequent, and severe fires.



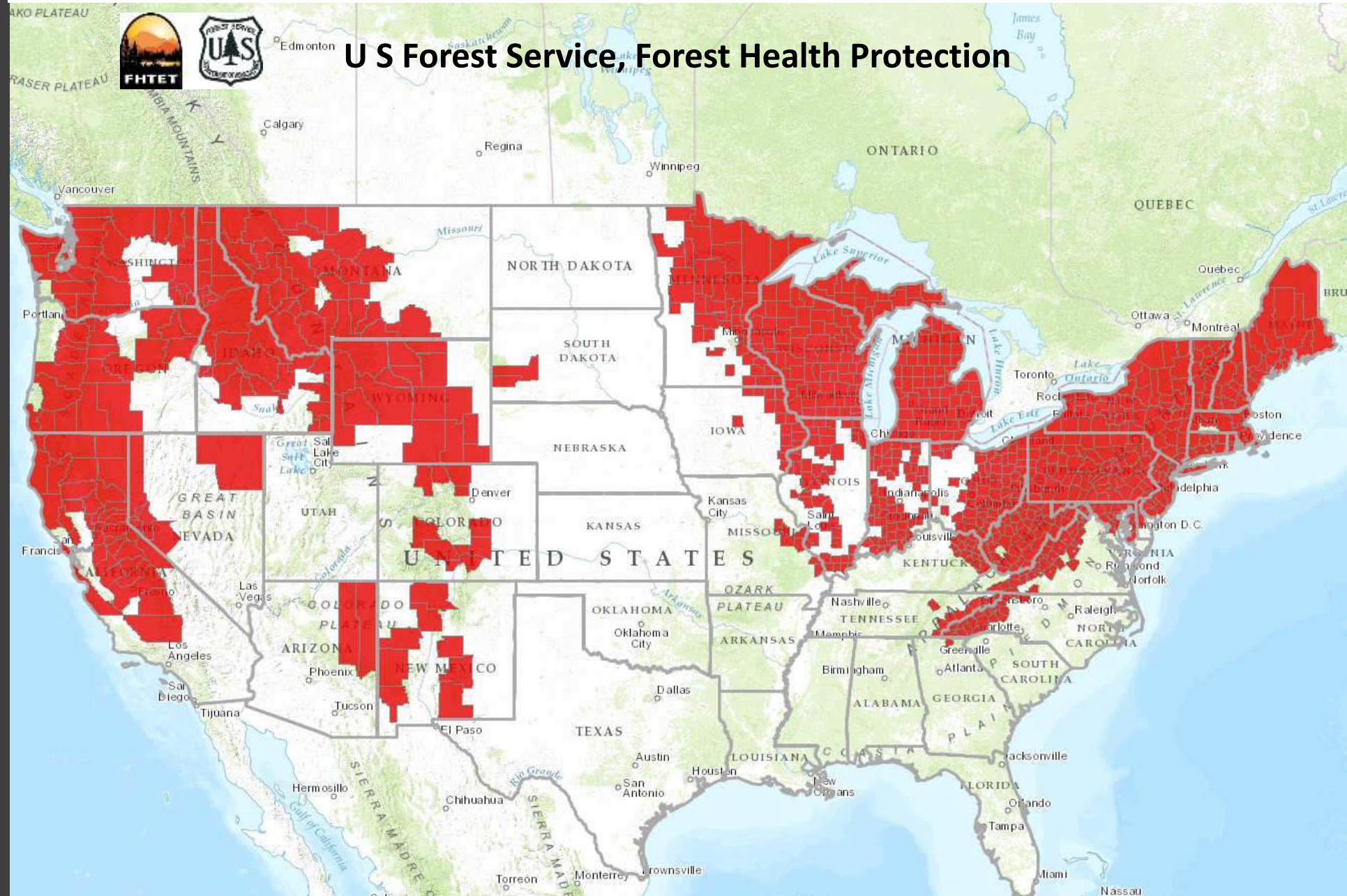
https://en.wikipedia.org/wiki/Mountain_pine_beetle

White Pine Blister rust (WPBR): an exotic disease naturalized to North America

- Accidental introduction(s) to the Northwest around 1910.
- First detected in PNW in 1921.
- Conditions (pine hosts, alternate host *Ribes* spp., and climate) highly favorable to its spread.
- Continues to spread geographically and intensify locally.
- Now in regions once believed to be too cold, warm, or dry.
- Spread facilitated by *wave years*.



U. S. distribution of WPBR



U S Forest Service, Forest Health Protection

Key points concerning WPBR

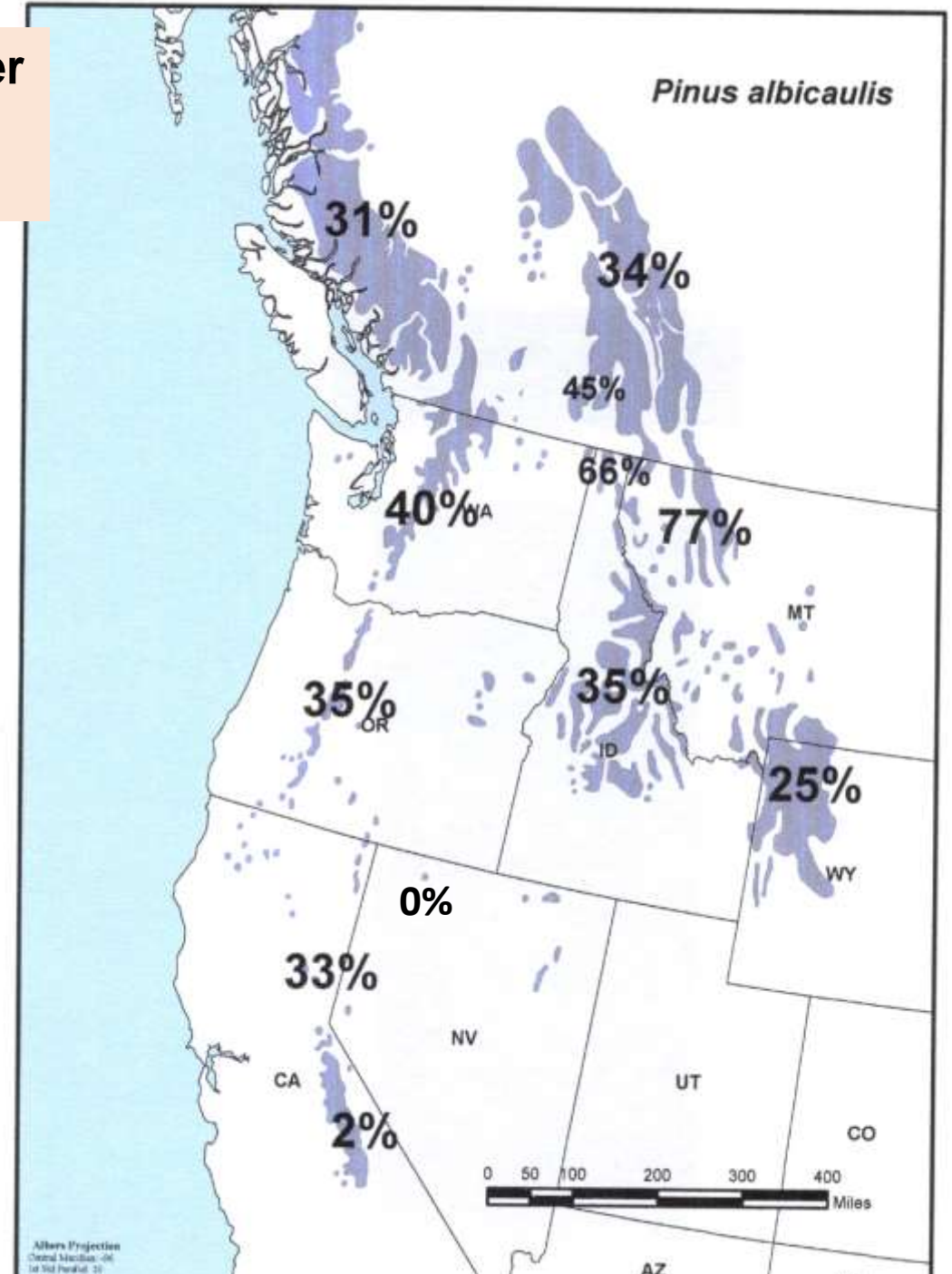
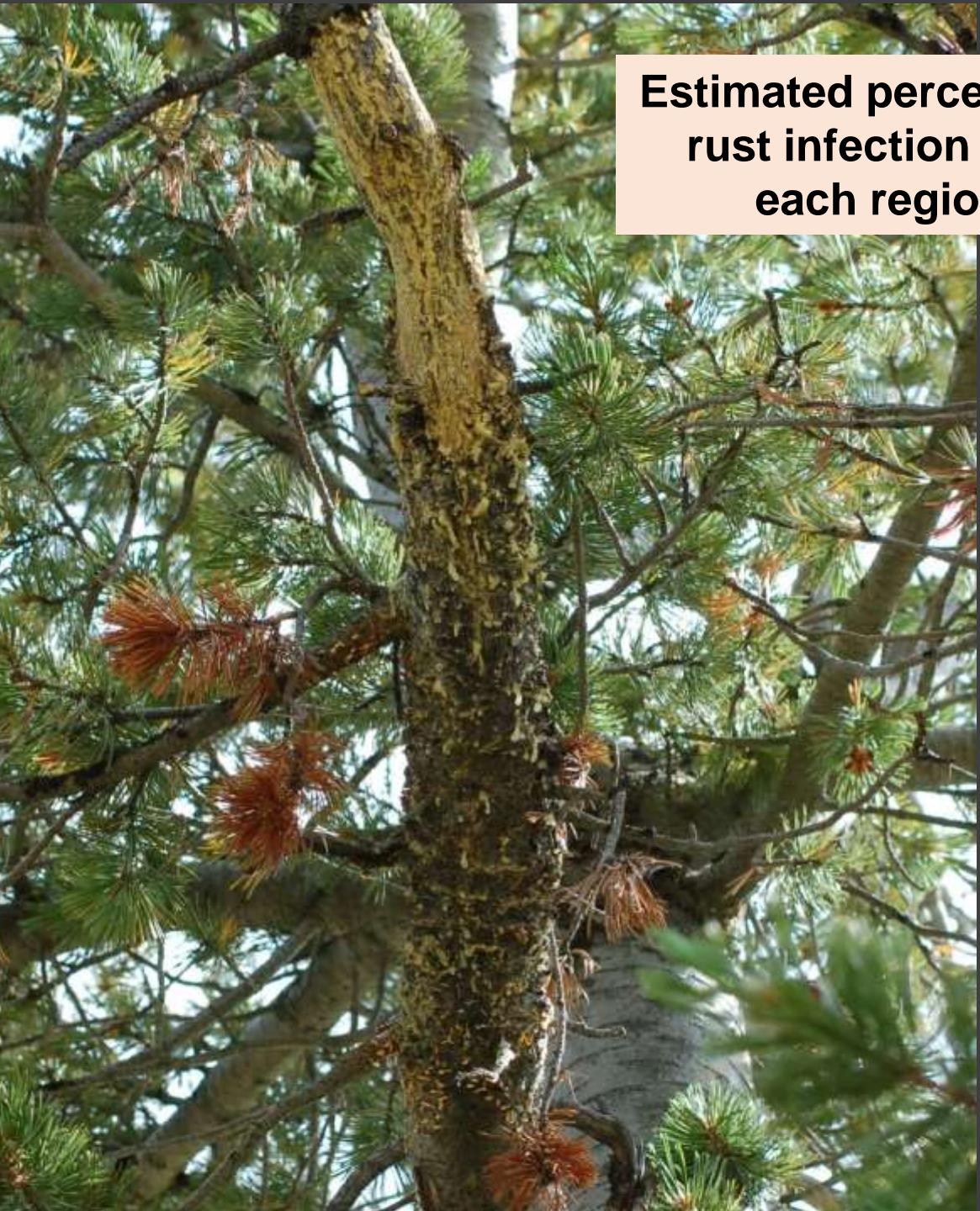
Geils et al. 2010, Benedict 1981, Kendall and Asebrok 1998

- All age classes vulnerable to WPBR, seedlings to mature trees.
- Sporulating cankers in branches kill branches and reduce cone production and photosynthetic biomass; cankers in stems usually kill trees.
- Whitebark pine populations are very susceptible; frequency of genetic resistance varies geographically.

Effort to control early in process through removal of alternate host *Ribes* spp. USDA Office of Blister Rust control created in 1916; later administered within the U.S. Forest Service.

- Cultivated currant (*Ribes nigrum*) banned.
- Cost of *Ribes* removal in 1916 was 0\$0.42/acre.
- Federal funds were \$400,000/yr from 1916-1939.
- *Ribes* control began around 1924 in the West. Later, fungicides tried.
- Realization that the program was non-effective in the West by the 1940's.
- Yellowstone among the last regions to apply control, 1945-1978.
- **Most extensive disease control effort in American forestry: Total cost of effort was about \$100 million. (about \$60 million in the West).**
- \$150 million in 1994 dollars

Estimated percent blister rust infection across each region in



Mountain Pine Beetle 20 year outbreak

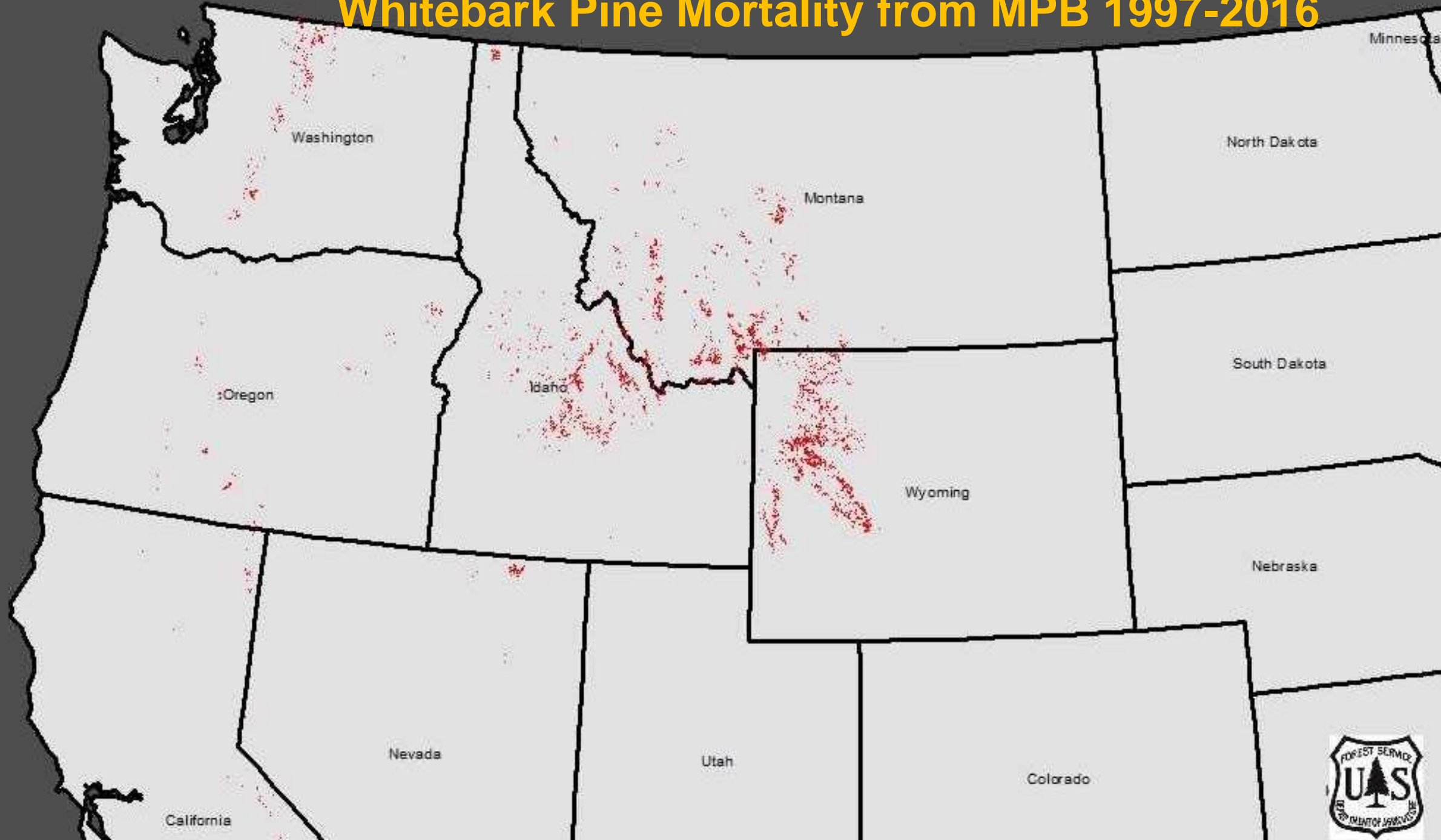


Mountain pine beetle MPB mortality in whitebark pine

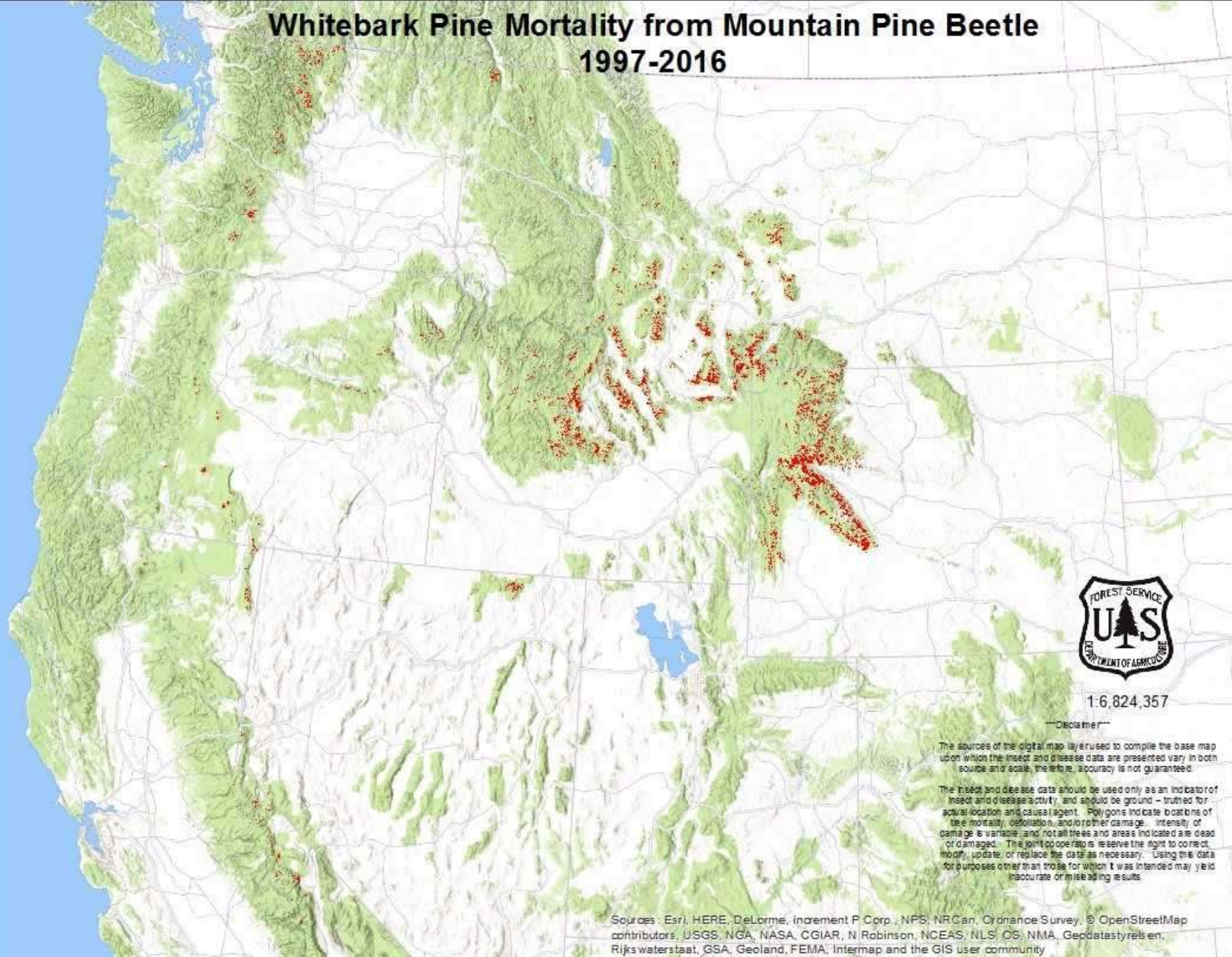
- Major losses of mature, cone-bearing trees over two decades.
- Loss of trees resistant to WPBR.
- Some research shows preference by MPB for trees weakened by WPBR.
- Outbreak still active: diminishing in Rockies, active in Pacific distribution.



Whitebark Pine Mortality from MPB 1997-2016



Whitebark Pine Mortality from Mountain Pine Beetle 1997-2016



1:6,824,357

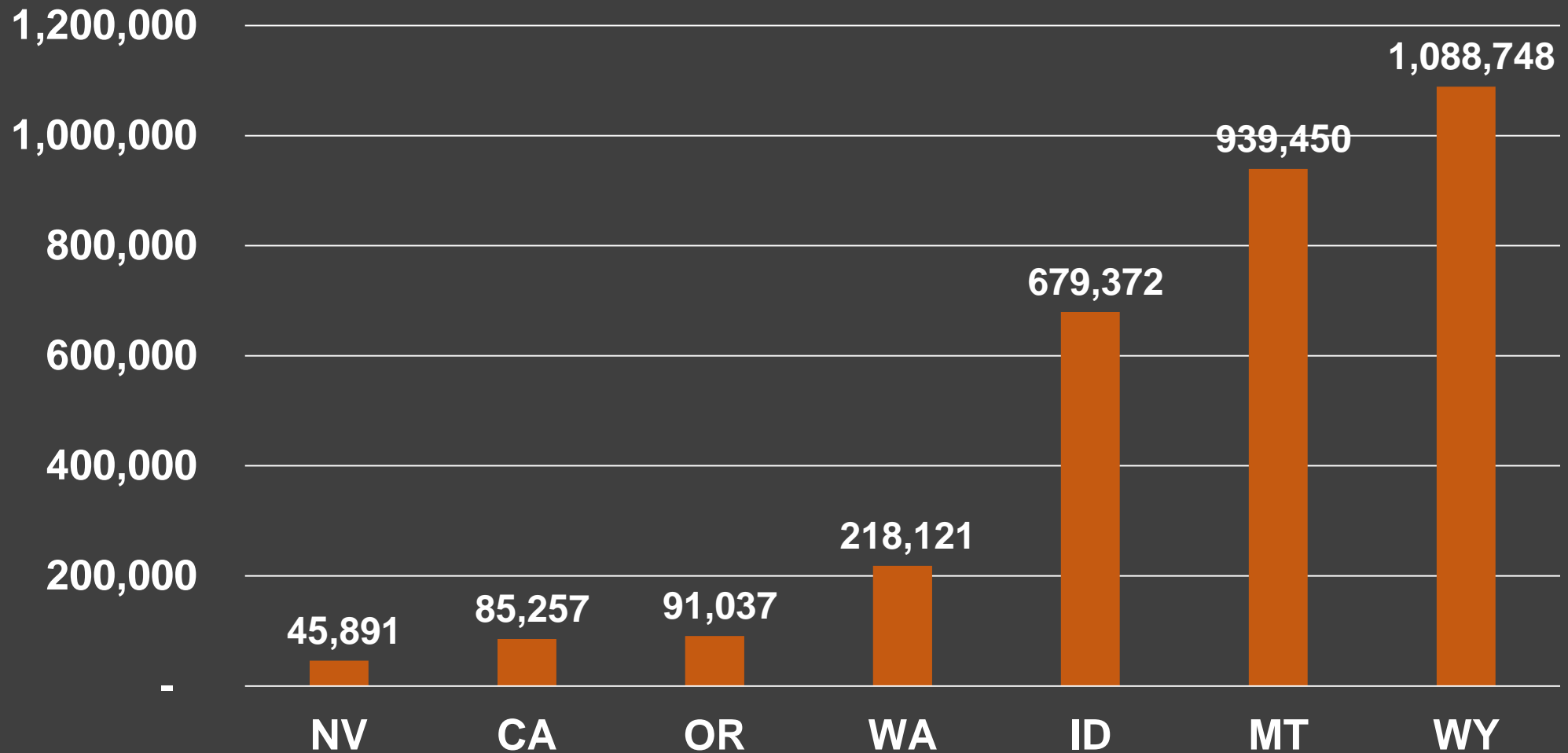
---Disclaimer---

The sources of the digital map layers used to compile the base map upon which the insect and disease data are presented vary in both source and scale, therefore, accuracy is not guaranteed.

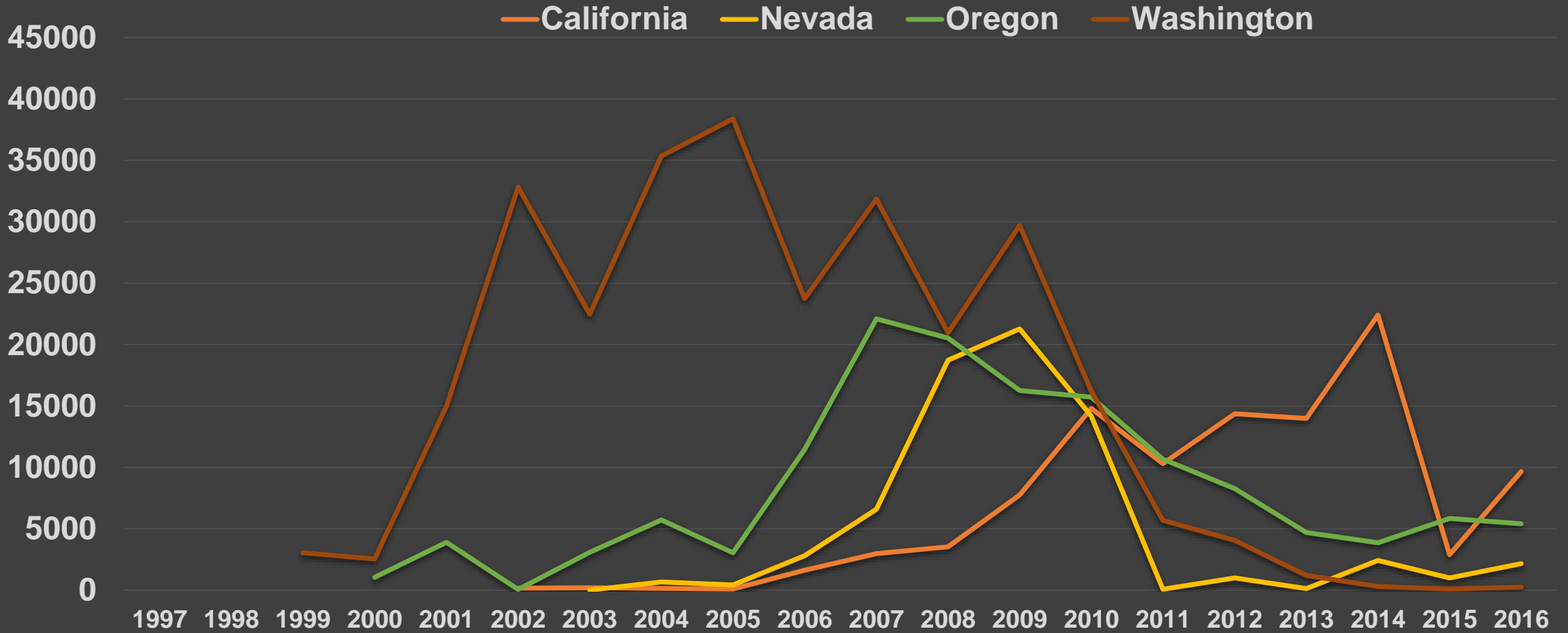
The insect and disease data should be used only as an indicator of insect and disease activity, and should be ground-truthed for actual location and causal agent. Polygons indicate location of tree mortality, defoliation, and/or other damage. Intensity of damage is variable, and not all trees and areas indicated are dead or damaged. The joint operators reserve the right to correct, modify, update, or replace the data as necessary. Using this data for purposes other than those for which it was intended may yield inaccurate or misleading results.

Sources: Esri, HERE, DeLorme, InCREMENT P Corp., NPS, NRCAN, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, CG, NMA, Geodatastyrelsen, Rijks waterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community

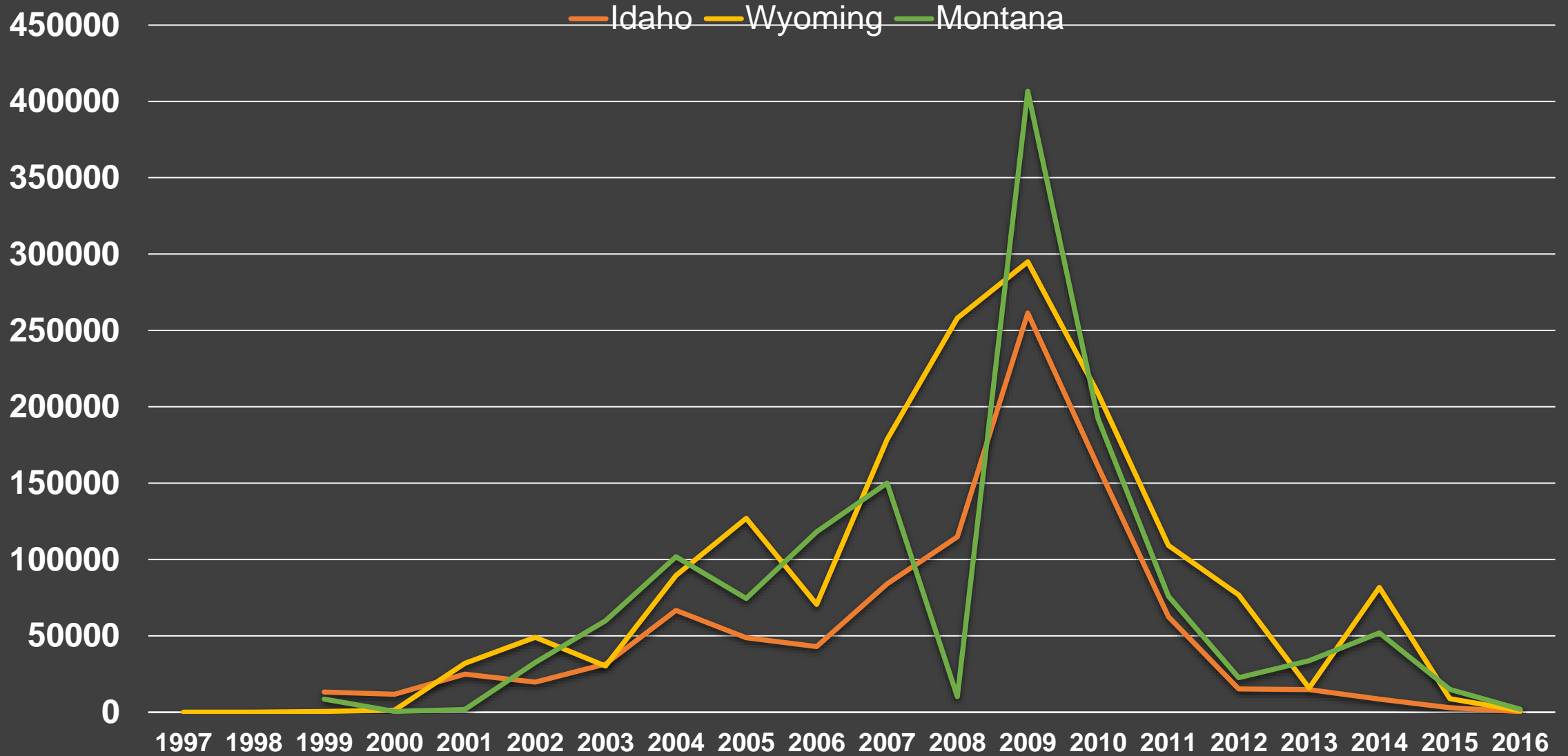
1997-2016 Cumulative Whitebark Pine MPB Footprint: Total 3,147,876 Acres (~25% range)



Whitebark Pine MPB ADS Acres by Year 1997-2016



Whitebark Pine MPB ADS Acres by Year 1997-2016

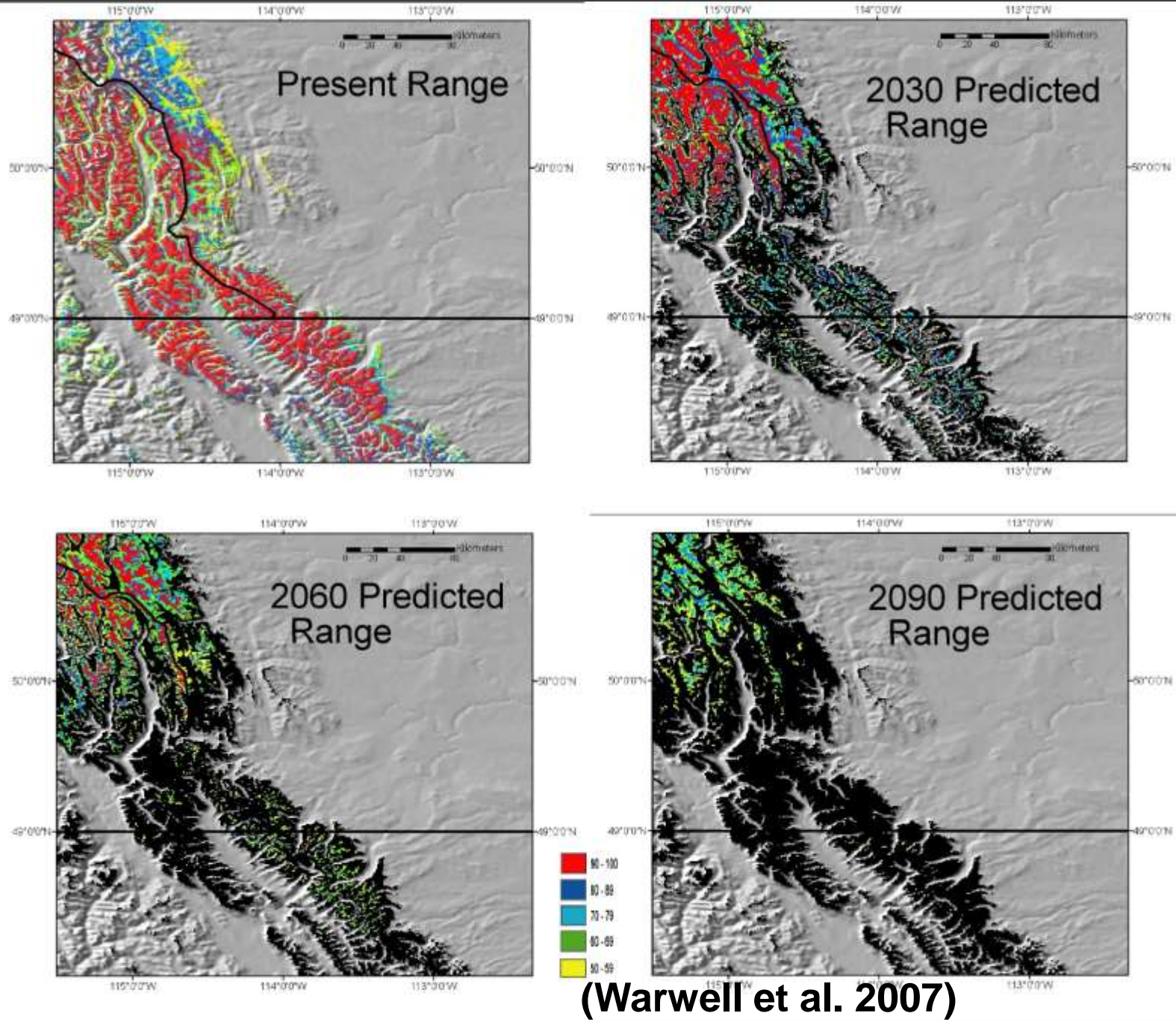


Fire exclusion leads to advancing succession

- Aggressive fire exclusion since early 20th century.
- Altered fire regimes have led to successional replacement of whitebark pine in several regions.



Climate change and whitebark pine



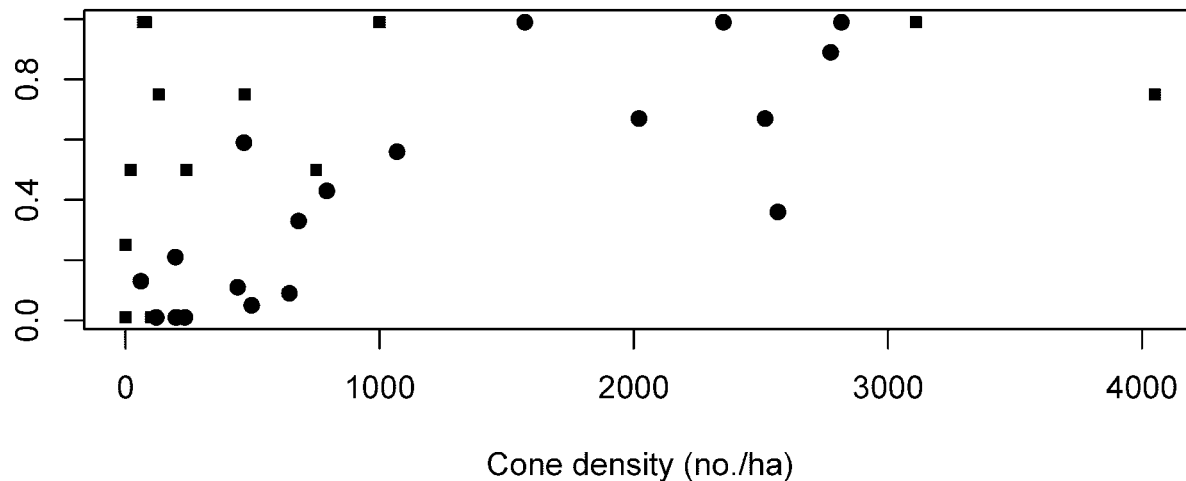
(Warwell et al. 2007)

- Predictions based on Species Distribution Models (Bioclimatic Envelope Models): WP upwards and northwards.
- We do need to consider climate change in restoration actions. We need to add cc mitigation to restoration:
- Rely on resilience in established whitebark pine.
- Find local refugia.
- Use genetic diversity.

Probability of nutcracker visitation vs. cone production: Consequences of an obligate mutualism



Combined data: McKinney et al. 2009
Barringer et al. 2012



McKinney and Tomback 2007, McKinney et al. 2009, Barringer et al. 2012

Summary points:

- Nutcrackers are energy-sensitive foragers.
- As whitebark pine health declines, cone production declines.
- Leads to disproportionate loss of seeds to pre-dispersal seed predation (red squirrels and nutcrackers).
- The probability of nutcracker stand visitation declines rapidly below ~1000 cones per ha (but at a landscape scale).

This is why genetic resistance in whitebark pine cannot spread without management intervention.

What do we stand to lose?

- Whitebark pine, the high elevation keystone and foundation species, is declining rapidly from a convergence of threats.
- There is no evidence to indicate that in the few areas where whitebark pine is relatively healthy, it will stay healthy. WPBR is spreading = fact.
- The loss of whitebark pine has immense implications for high elevation biodiversity and ecosystem services—and our country's natural heritage.
- **In July 2011, whitebark pine was named a Candidate Species for listing under the Endangered Species Act. Cited: blister rust, mountain pine beetles, fire exclusion, climate change.**
- In June 2012, whitebark pine was listed as endangered in Canada under the Species at Risk Act with the same factors cited.

Hope: Whitebark pine restoration

- Speed up natural selection by developing and planting blister-rust resistant seedlings.
- Replace the seed dispersal services of nutcrackers.
- Protect against MPB; reset succession; mitigate climate change.



The National Whitebark Pine Restoration Plan

The overarching goal of whitebark pine conservation and restoration is to develop and sustain healthy and resilient whitebark pine communities in the face of current and future challenges.

We have the knowledge and the tools:

- This restoration plan will take more than a year to assemble.
- It can provide a blueprint for restoration that accommodates change and new information.
- It can guide restoration until the job is done.

Two key statements (see Restoration Management Actions for Whitebark Pine Ecosystems: Best Management Practices)

- *Cronartium ribicola*, infectious only to five-needle white pines and its alternate hosts, is currently and potentially the most persistent and widely distributed threat to whitebark pine populations, affecting seedlings, saplings and mature trees. The combination of WPBR and MPB reduces seed production and accelerates population losses.
- In stands where genetic resistance has increased through planting, direct seed sowing, or natural regeneration, and trees reach maturity, potentially nutcrackers will spread resistance by caching seeds in adjacent areas and to distances as great as 30 km. **This concept is fundamental to devising a core area restoration plan.**

Thanks to

- Gregg DeNitto, Annalisa Ingegno - R1 Forest Health Protection
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- WPEF BOD members for their help and support.
- Many research colleagues and students over the years.

Thanks to you all for your support for whitebark pine!

