7th North American Forest Ecology Workshop, Utah State University, 22-26 June 2009

Whitebark Pine as a Foundation and Keystone Species: Functional Role and Community Interactions

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Classification

Price et al. 1998

Pinus albicaulis

Family Pinaceae

Subgenus *Strobus*

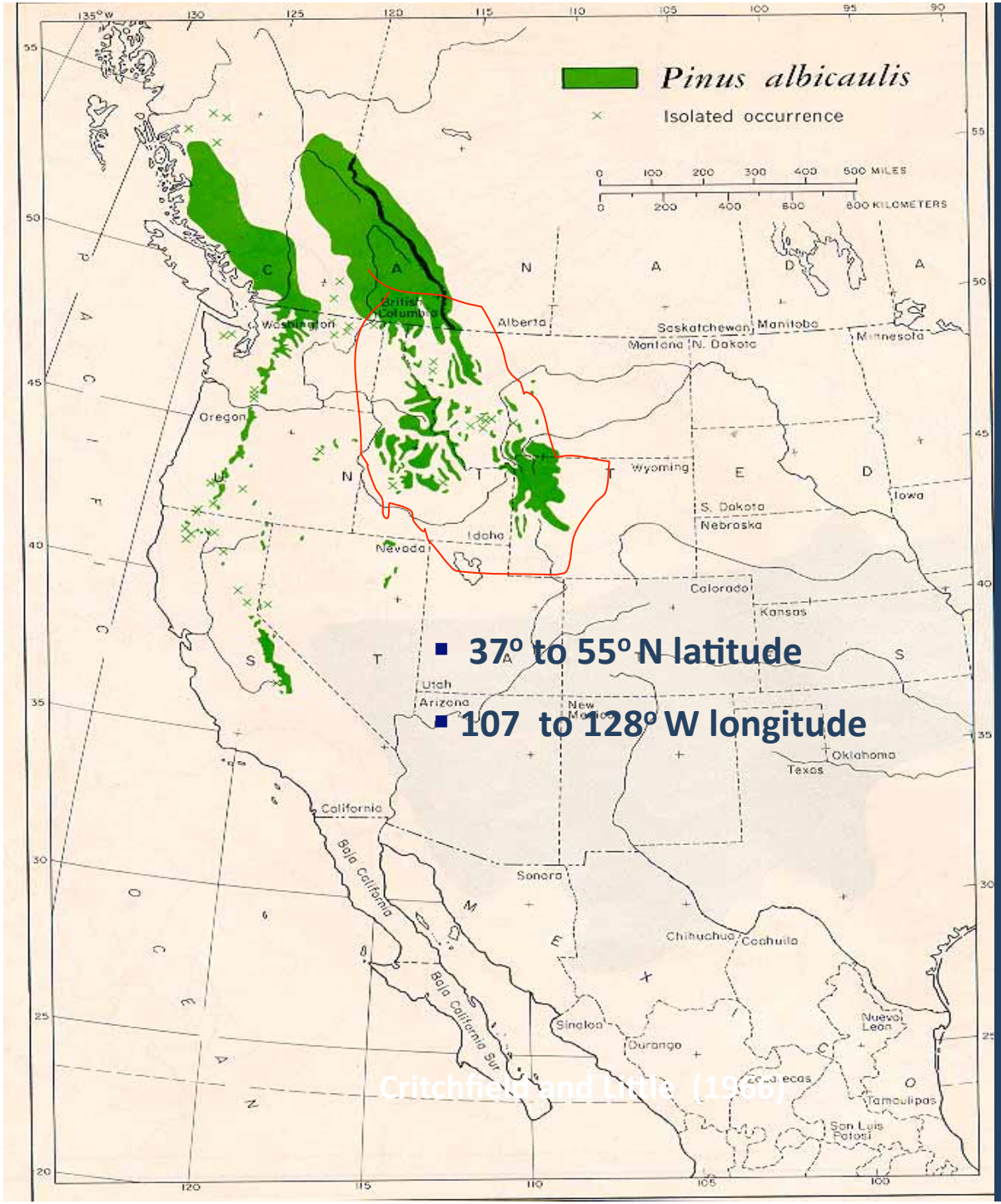
Section *Strobus*

Subsection *Cembrae*

Proposed: Gernandt et al. 2005

Section *Quinquefoliae*

Subsection *Strobus* (*Cembrae + Strobi*)



- 37º to 55º N latitude
- 107 to 128º W longitude

Whitebark Pine

Primarily grows in upper subalpine and treeline communities

Largest and most northern latitudinal distribution of any other five-needle white pine in the U.S. and Canada.

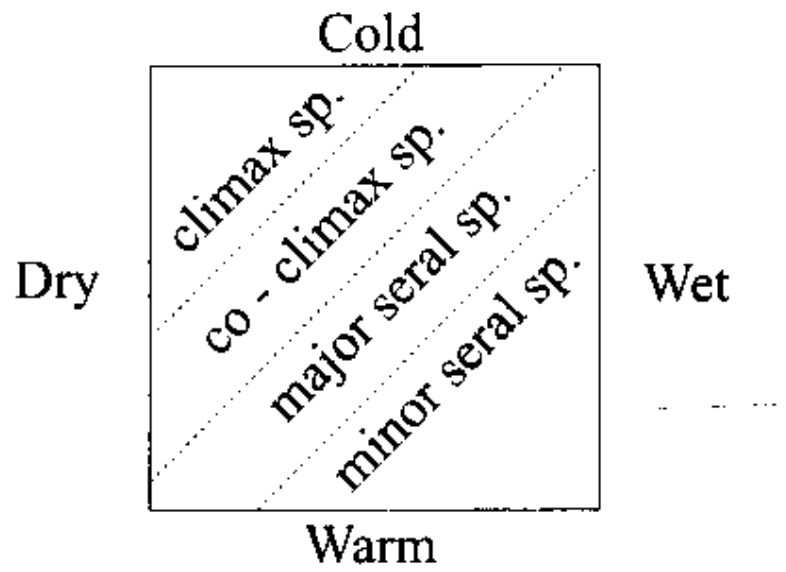
- 18° range of latitude
- 21° range of longitude

Whitebark pine community types

- *Successional communities* on favorable sites, upper subalpine zone

- *Climax communities* on exposed upper subalpine sites and in treeline ecotone

Whitebark pine communities: abundance vs. temp & moisture



- Minor to major component of successional communities
- Outcompeted by shade-tolerant conifers over time
- Pioneer and long-lived seral species

Successional communities on favorable sites: renewed by fire

- Intermountain Region
- Northern Rocky Mountains
- Coastal and Cascades ranges
- Long-lived seral species


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

Adaptations of whitebark pine for seed dispersal by nutcrackers

- Large, wingless seeds
- Cones remain closed (indehiscent)
- Seed morphology adapted for caching mode of dispersal

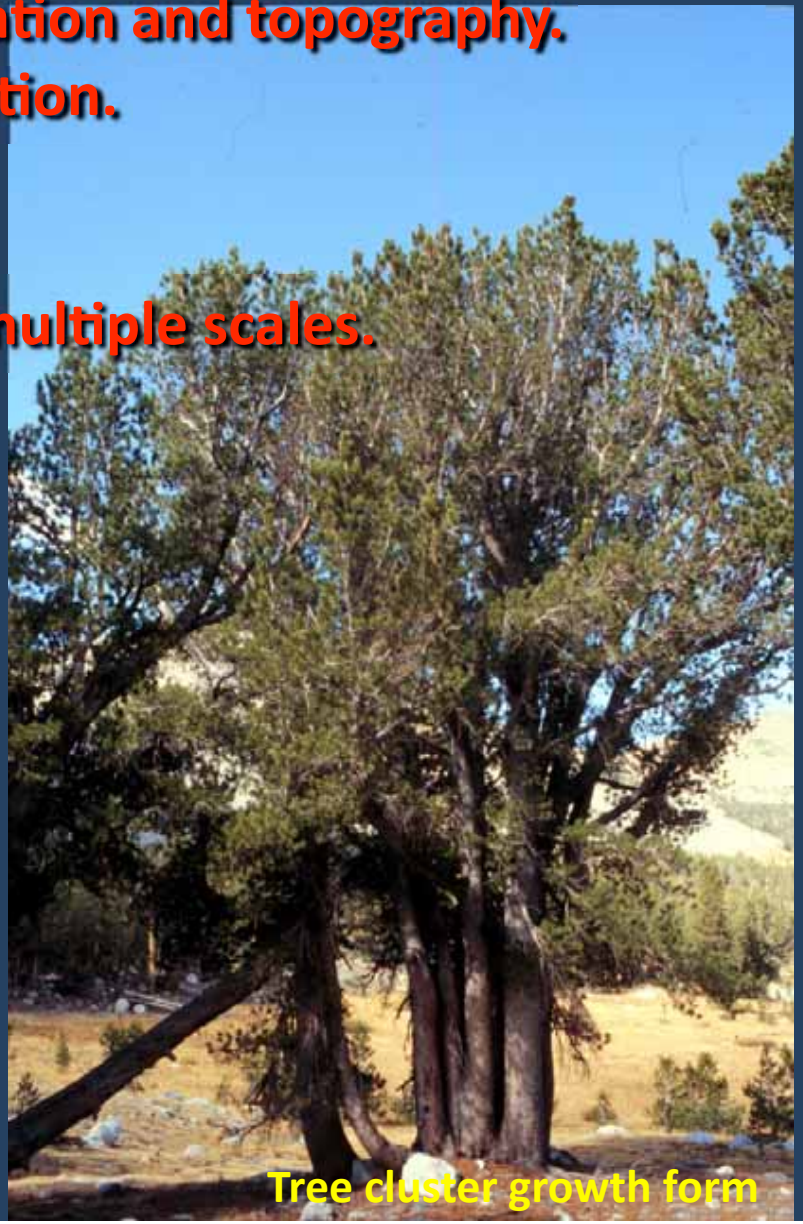
Krugman & Jenkinson 1974

Seed dispersal

- Carry up to 150 seeds in sublingual pouch.
- Bury seeds in caches of 1-15 seeds, typically 3 or 4.
- Carry seeds a few meters to 12 km (max. known 30 km).
- Stored per bird: 35,000 to 98,000 seeds.
- Unretrieved caches germinate, leading to regeneration

Impact of seed dispersal by nutcrackers

Distribution on landscape—elevation and topography.
Rapid post-disturbance regeneration.
Climate change—treeline.
The "tree cluster" growth form.
Population genetic structure at multiple scales.



Tree cluster growth form

Whitebark pine: Foundation and Keystone Species

Foundation species-"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."

Dayton (1972) in Ellison et al. (2005)

Keystone species –These influence community diversity to a far greater extent than predicted by the number of individuals or the biomass of the keystone species.

Power et al. (1996)

Functional roles and interactions

Interactions

- Food source for wildlife
- Distribution by nutcrackers
- Facilitation: nurse tree on harsh sites

Functional roles

- Wide spectrum of community types; biodiversity
- Community development after disturbance
- High elevation hydrology and downstream flow
- Reduces soil erosion; avalanche control
- Tree island initiator: response to climate warming
- Rapid response to warming or cooling

Community diversity

- **Latitudinal, topographic, structural variation:** successional to late seral to climax; open parkland forest to closed forest; mesic to xeric; maritime to continental—tremendous species diversity.

- **Forest associates:** subalpine fir, Engelmann spruce, foxtail pine, lodgepole pine, limber pine, western white pine, Douglas fir, mountain hemlock, alpine larch.

- **Wildlife habitat:** elk, deer, small mammals, large carnivores; resident and migratory songbirds, grouse, raptors, hummingbirds.

- **Early successional post-fire communities:** black-backed and three-toed woodpeckers, olive-sided flycatchers, mountain bluebirds.

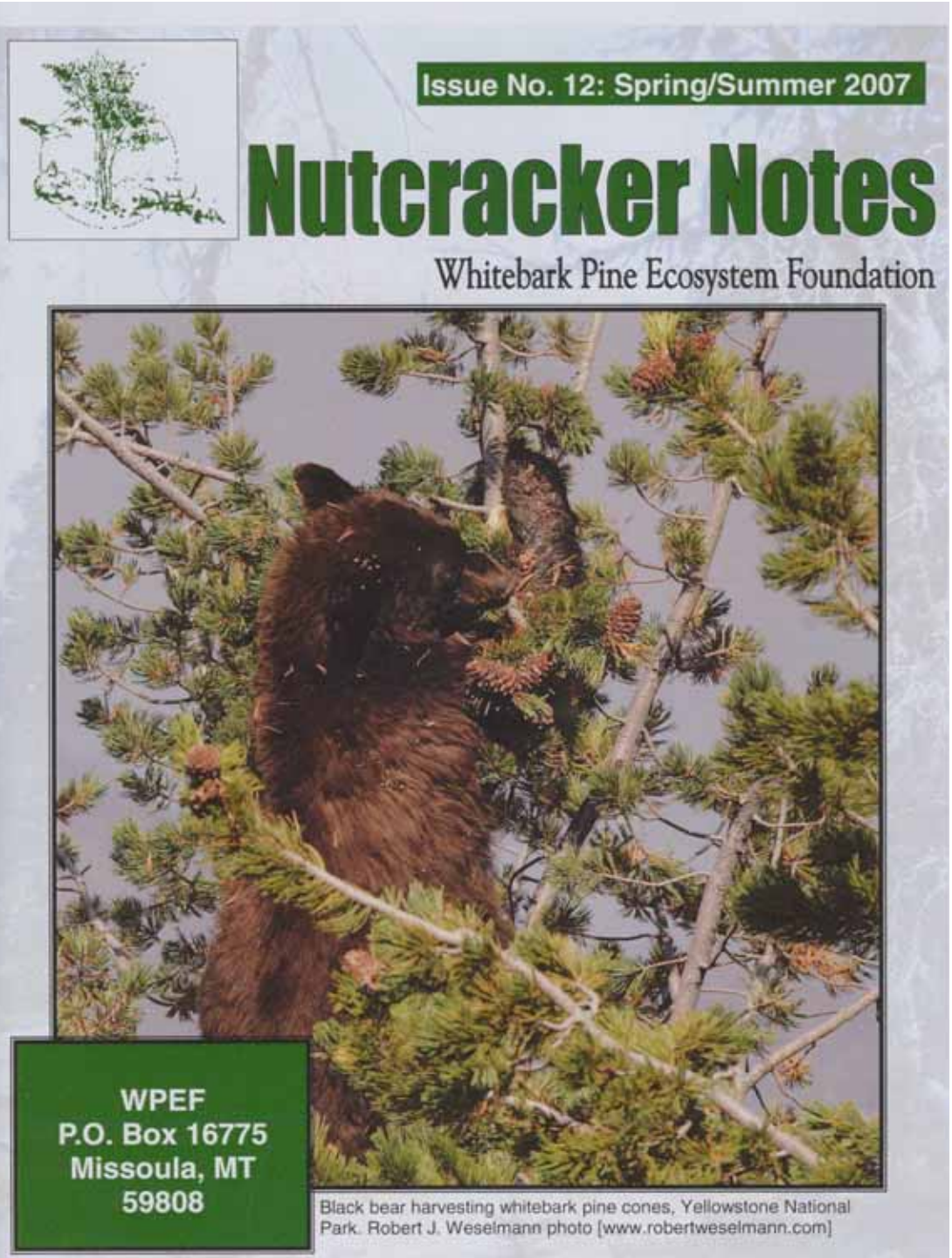
Whitebark pine seeds are an important wildlife food

- Birds: 7 families, 14 species
- Small Mammals: 2 families, 8+ species
- Large Mammals: 1 family, 2 species: Grizzly and black bears
- When seeds are ripe, good cone crop, canopies active with foraging species

Black bear feeding on whitebark pine seeds in Yellowstone National Park

Photo: R. J. Weselmann

Whitebark pine nuts: highly important grizzly and black bear food in the Greater Yellowstone Area, Rocky Mountain Front, and possibly in the Willmore Wilderness Park, Canada

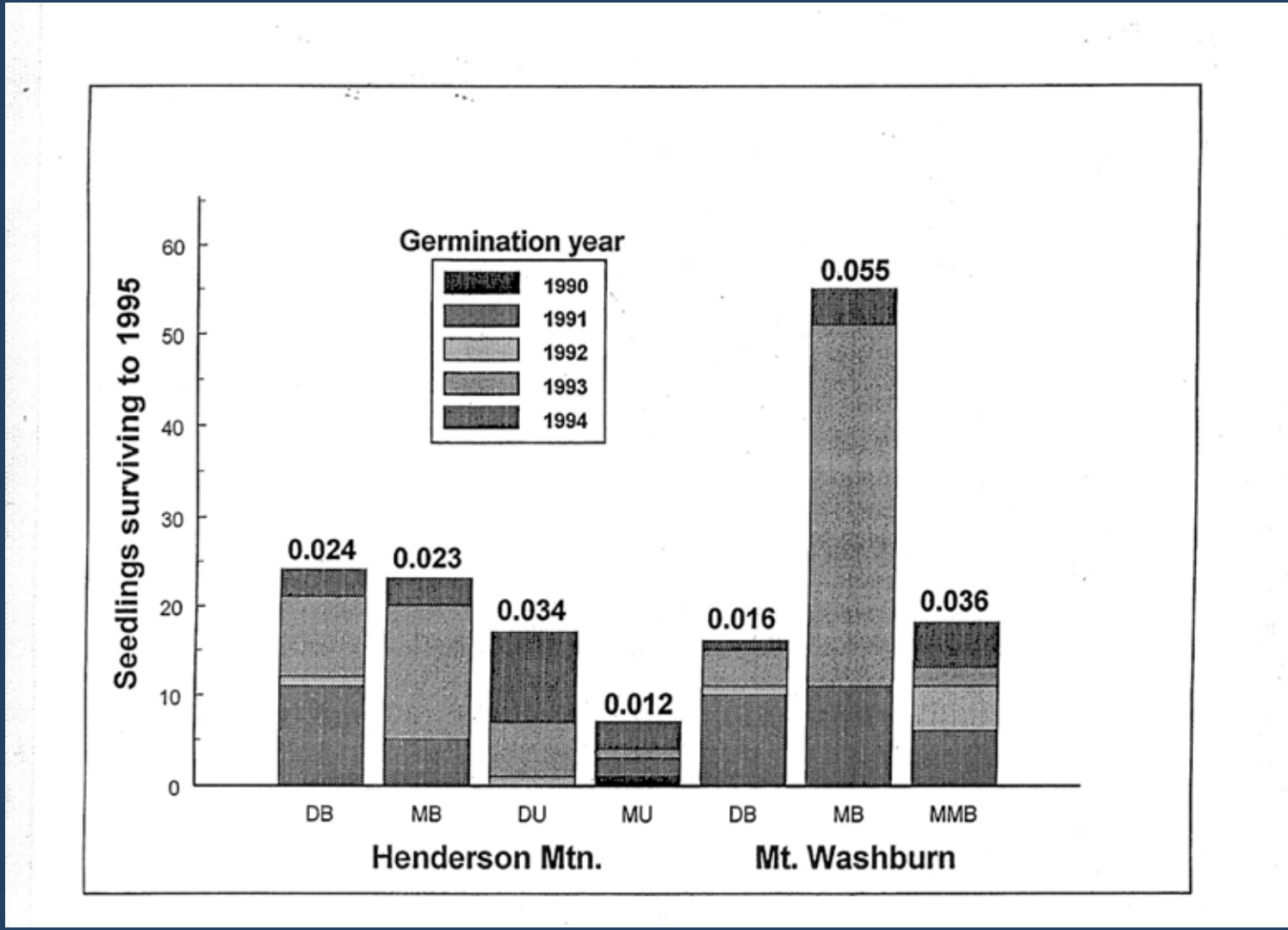


Community development

- Whitebark pine pioneers after fire.
- Hardy survivor on harsh, arid sites.
- Provides shelter for undergrowth and conifers.
- Nutcracker caches form a soil seed bank—remain viable for several years.

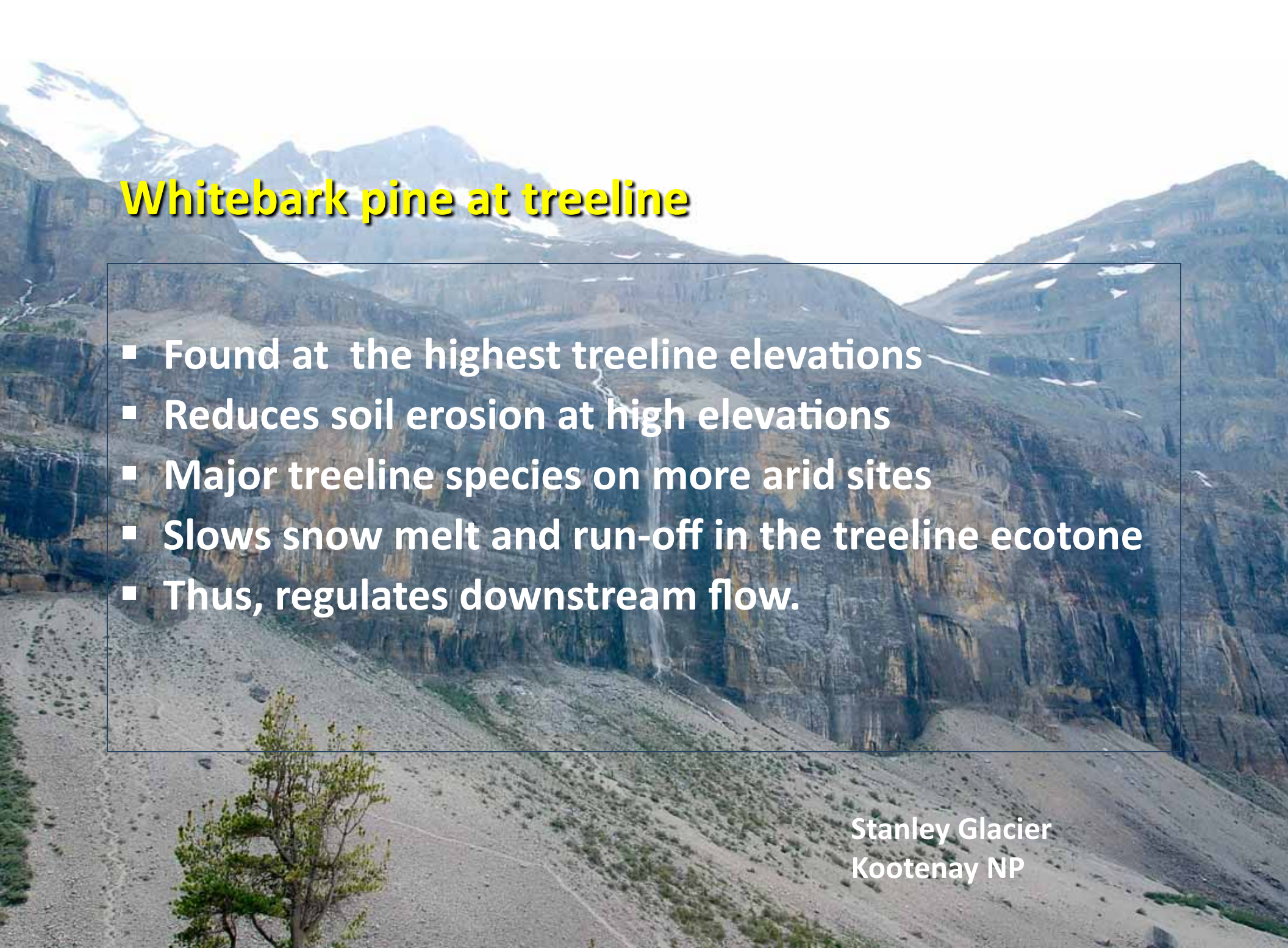
Serves as a nurse tree on harsh sites for spruce and fir (Calaway 1998)

Whitebark pine regeneration densities by 1995 after the 1988 Yellowstone Fires (seedlings per m^2)



Whitebark pine at treeline

- Found at the highest treeline elevations
- Reduces soil erosion at high elevations
- Major treeline species on more arid sites
- Slows snow melt and run-off in the treeline ecotone
- Thus, regulates downstream flow.



Stanley Glacier
Kootenay NP

Whitebark pine and tree island formation

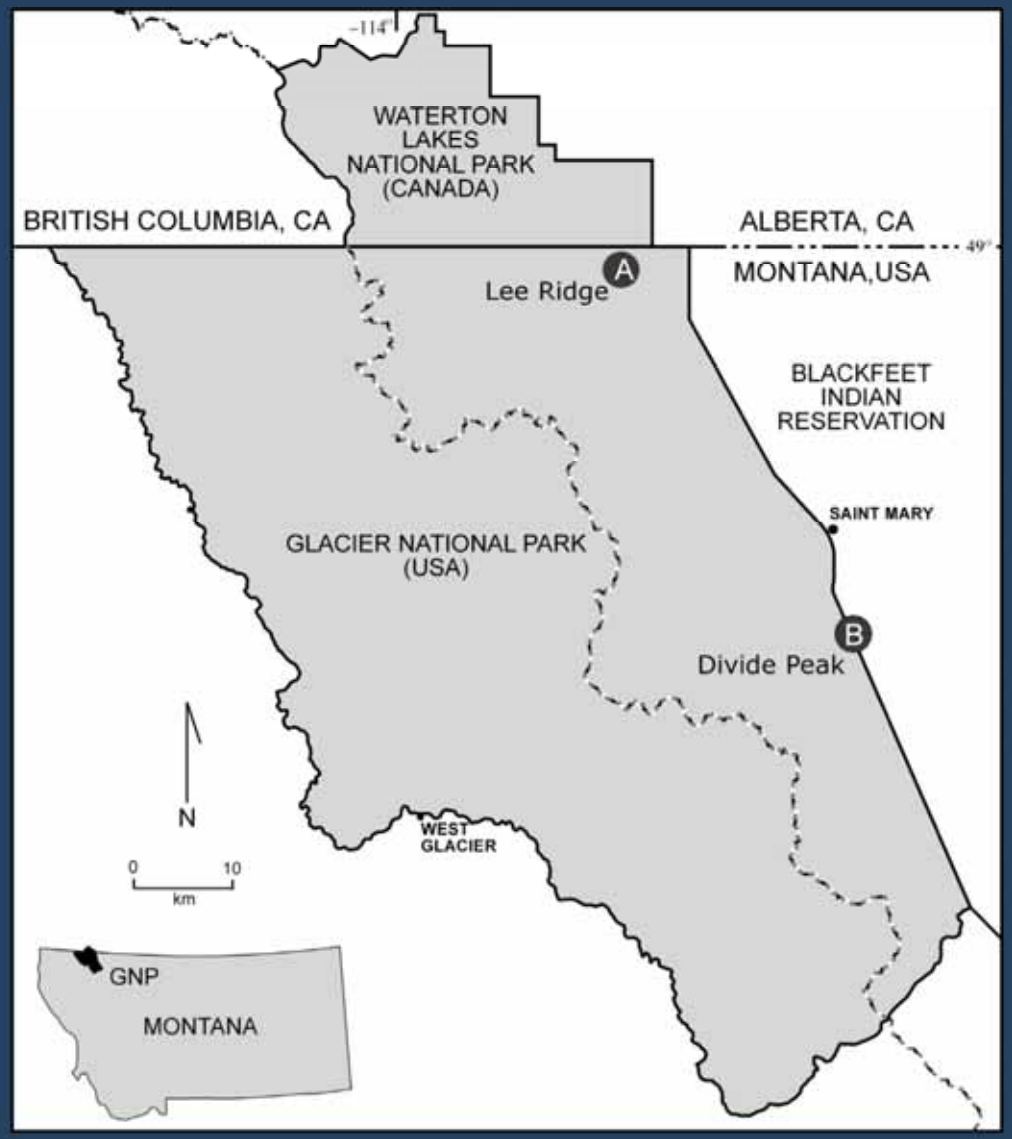
(Resler 2004; Resler and Tomback 2008)

Plays an important role in shaping vegetation spatial pattern at alpine treeline.

- Establishment in 'safe sites' by nutcrackers (microsites).
- Serves as facilitator for leeward tree establishment.
- Unusually robust seedlings.

Whitebark pine establishing in lee of *Salix*.

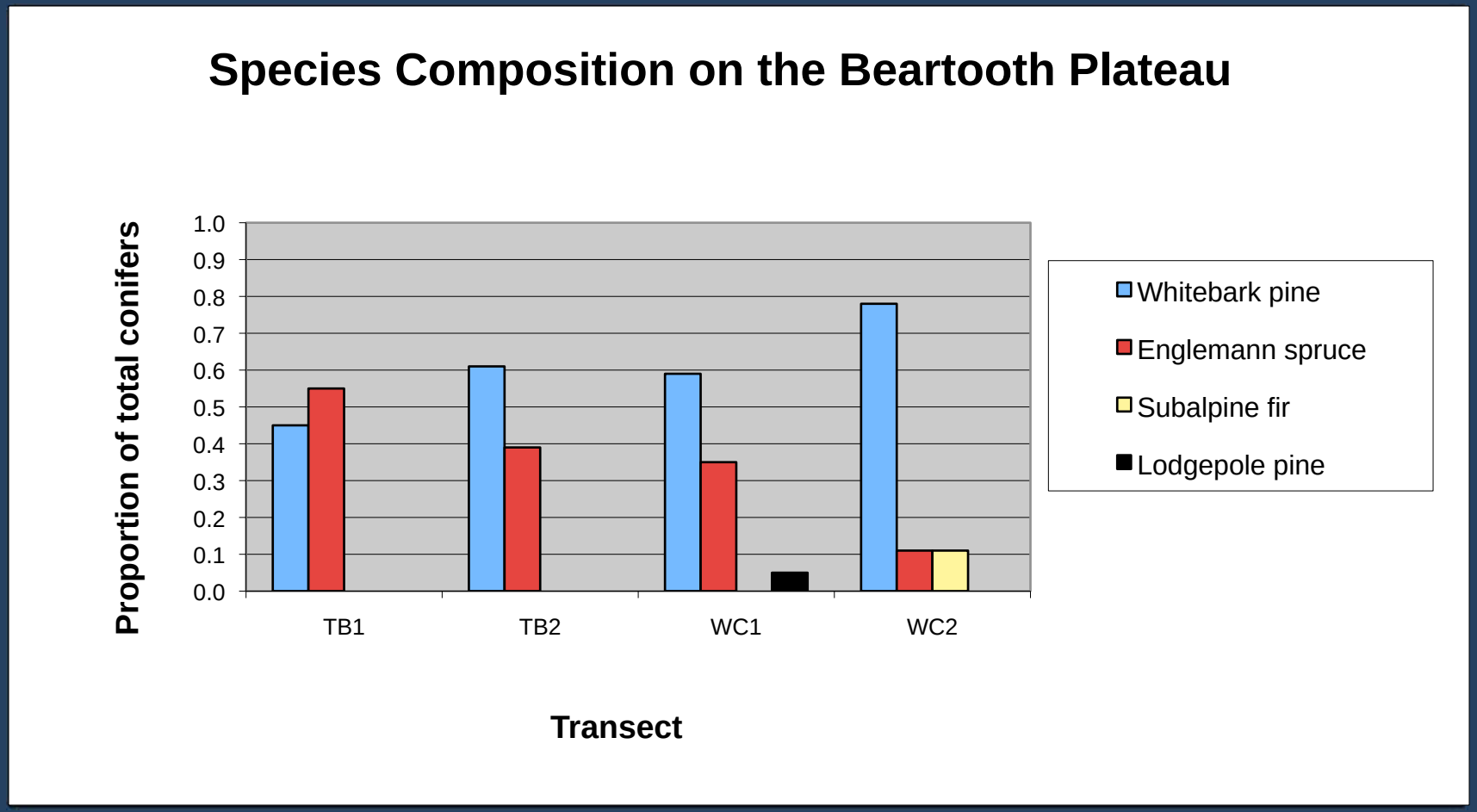
Montana Rocky Mountain Front



- 255 / 266 tree islands included whitebark pine.
- Whitebark pine was found in the lee of shelter significantly more frequently than any other species.
- Whitebark pine was initiator for 49% of all tree islands with multiple trees.
- Represented 67% of solitary trees.


Standley Glacier
Gibbon Pass
Alberta
Saskatchewan
British Columbia
Lee Ridge
Divide Peak
Montana
Wyoming Creek
Tibbs Butte
Idaho
Wyoming
Image by NASA, 11/07
0 35 70 140 210 280
Kilometers

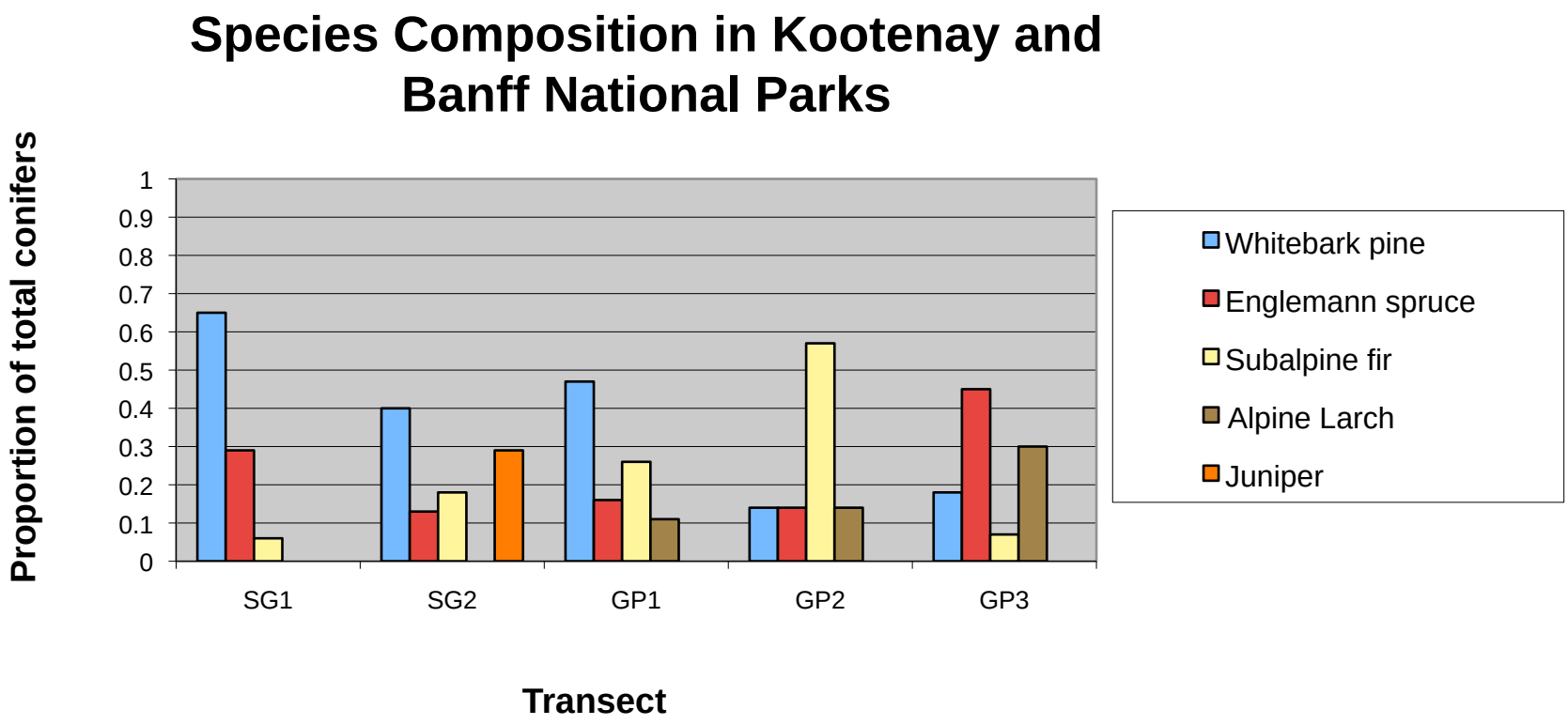
Beartooth Plateau



Whitebark pine represents

- **45/61% of all conifers sampled at Tibbs Butte**
- **59/78% of all conifers sampled at Wyoming Creek.**

Kootenay NP and Banff NP



Whitebark pine represents

- 40/65% of all conifers observed at Stanley Glacier
- 14/47% of all conifers sampled at Gibbon Pass.

Whitebark pine is rapidly declining

Fire and fire suppression

- Fire importance for whitebark varies geographically
- Fire regimes are highly variable among and within regions, e.g., the GYE
- Evidence for post-settlement fire suppression in many regions
- Natural ecological succession

Loss of whitebark pine over time

Introduced pathogen:
Cronartium ribicola (white pine blister rust)

Togwotee Pass, Wind River Range

Alternate hosts:

- Five-needle white pines (genus *Pinus*)
- Shrubs genus *Ribes*
- Herbaceous plants *Pedicularis* and *Castilleja*

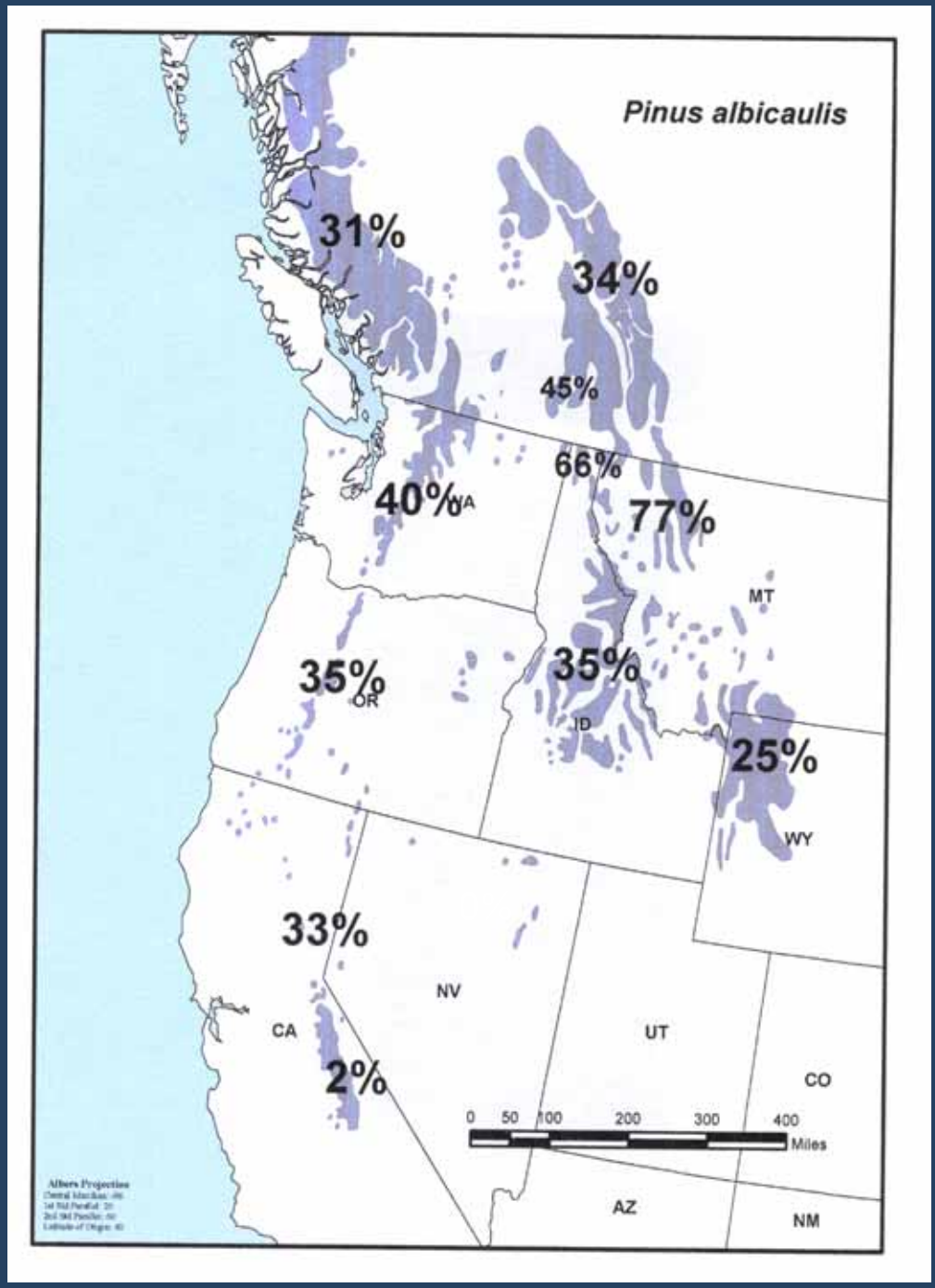
Only about 5% of trees have genetic resistance

Blister rust

- Cankers kill branches, reducing canopy
- Trees are weakened
- Cone production is reduced or eliminated
- Cankers in stems kill trees

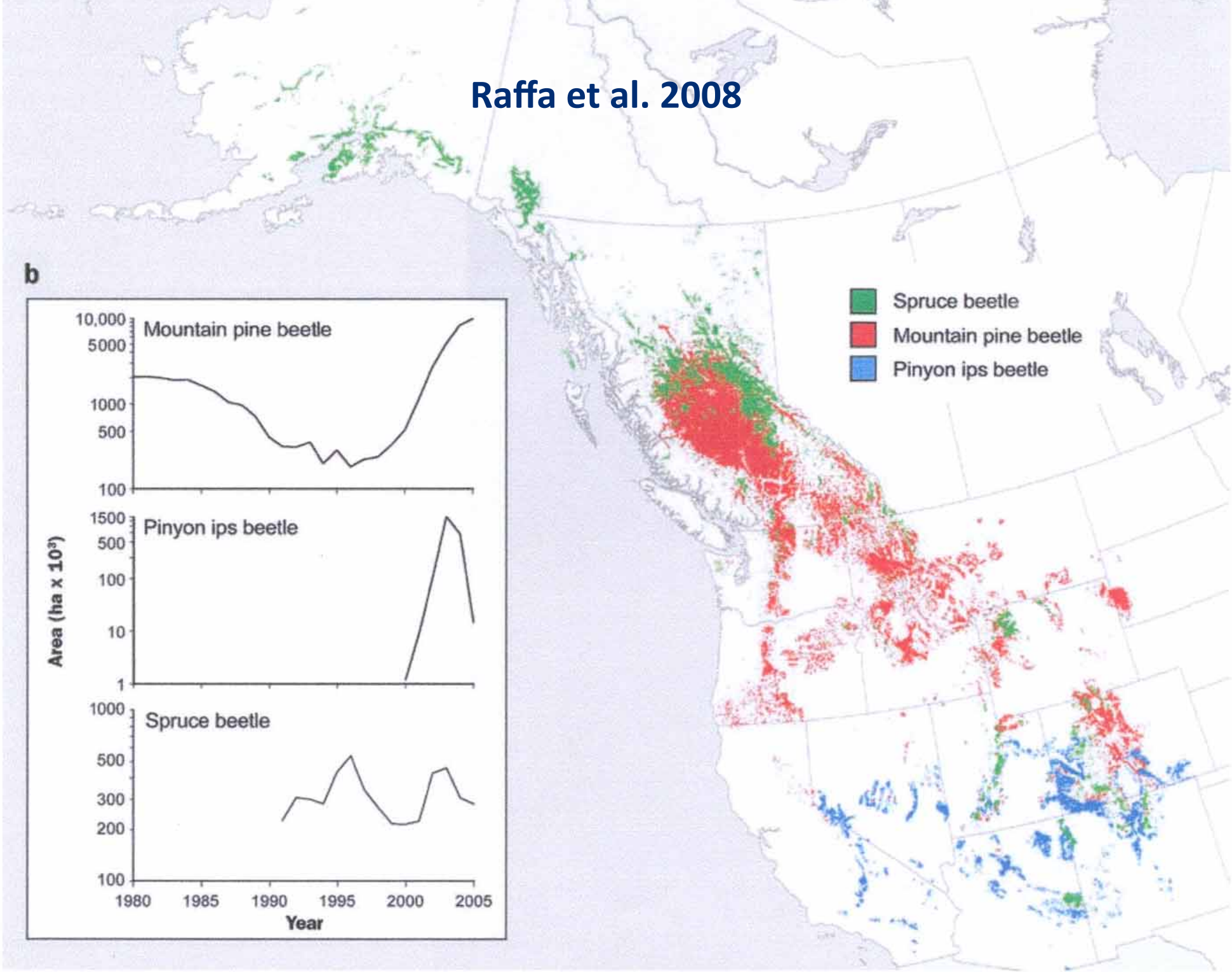
Kootenay National Park, BC

Glacier National Park, eastern slope


Pinus albicaulis
31%
34%
45%
66%
40%
WA
77%
MT
35%
OR
35%
ID
25%
WY
33%
NV
CA
UT
CO
2%
0 50 100 200 300 400
Miles
AZ
NM
Albers Projection


Mountain pine beetle in whitebark pine

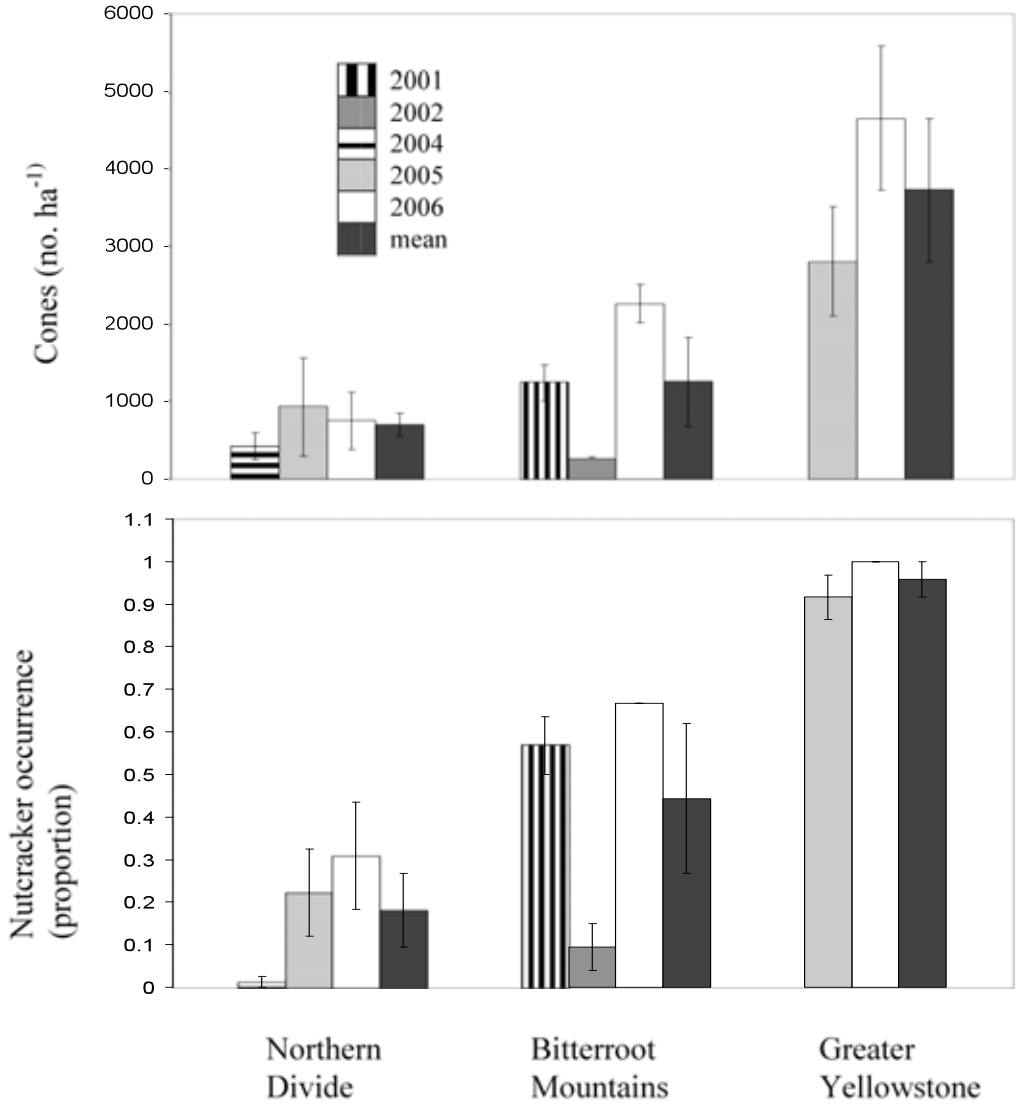
Raffa et al. 2008



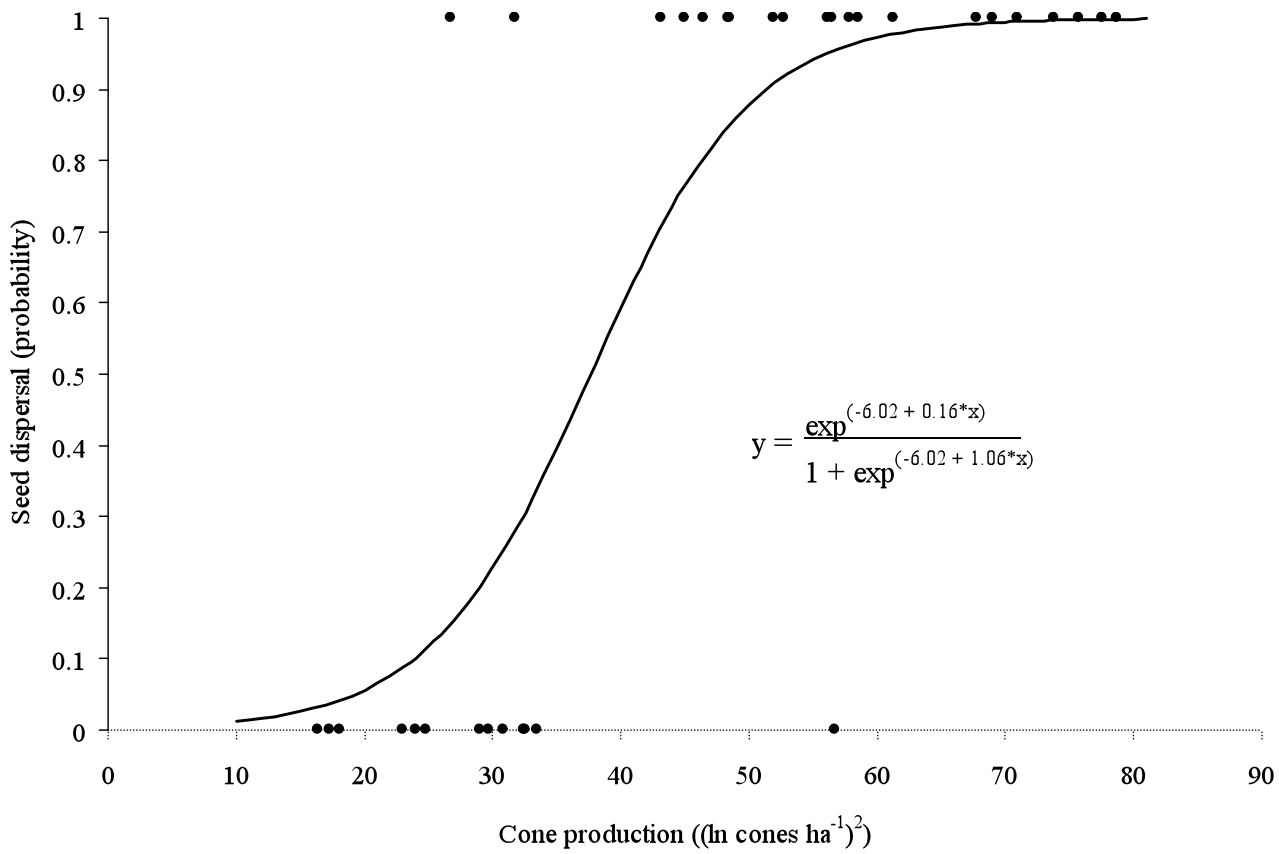
Avalanche Peak, Yellowstone National Park, 13 July 2007, EcoFlight

Union Pass, Wind River Range, WY, August 2008, EcoFlight

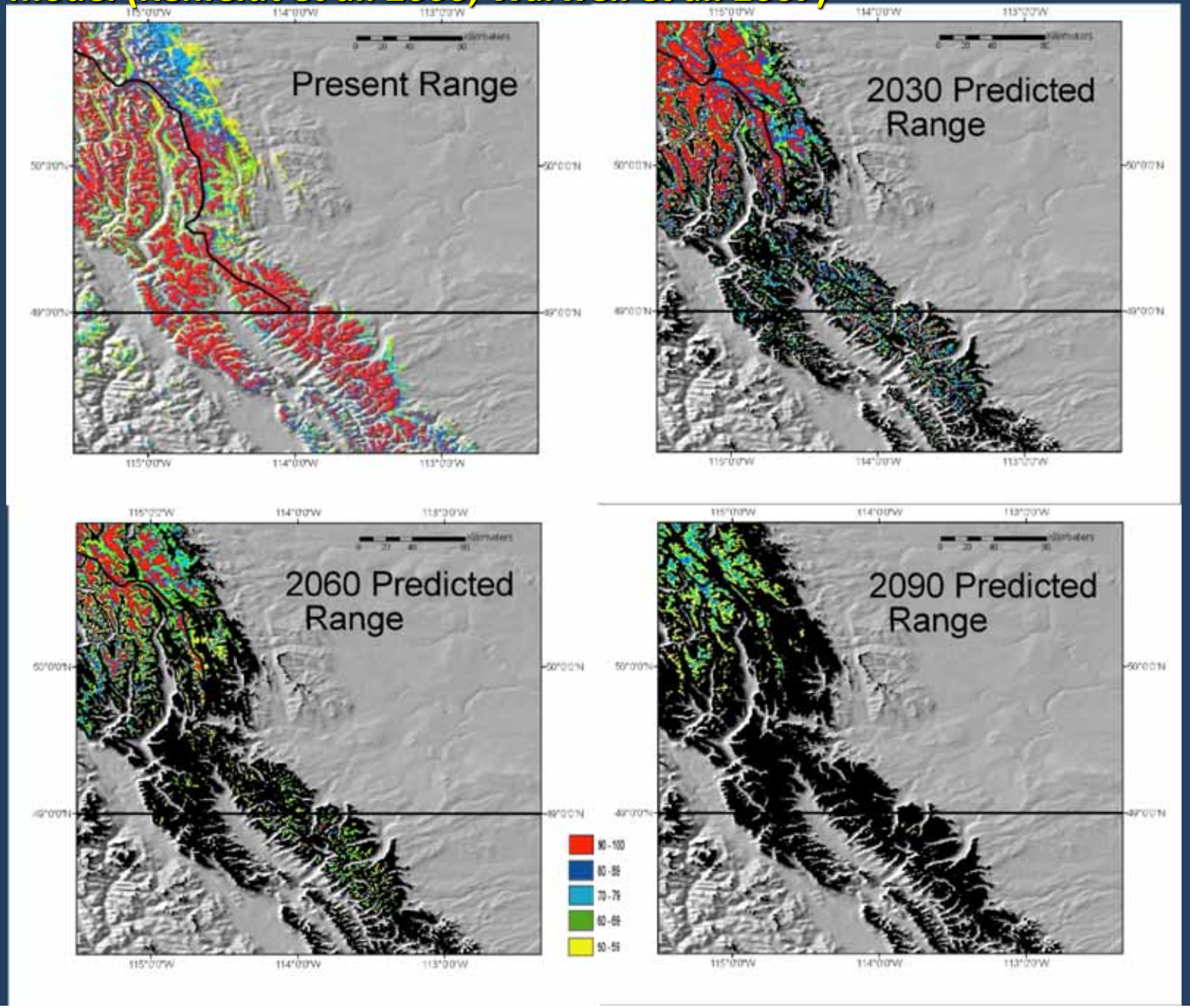
Loss of nutcracker dispersal services: McKinney et al. 2009



P of seed dispersal decreases with declining number of cones per ha and decline in live basal area (McKinney et al. 2009)



Whitebark Pine Rocky Mountain Distribution with Global Bioclimatic model (Rehfeldt et al. 2006; Warwell et al. 2007)



Some implications of functional loss of whitebark pine

- Fewer nutcrackers; less regeneration (Glacier NP).
- Lower carrying capacity for wildlife, including bears (GYE).
- Delayed subalpine forest community development after fire (older burns, Flathead NF, Bob Marshall WA).
- More homogeneous subalpine forests (spruce-fir) and more extreme fires.
- Changes in treeline communities (RM Front)
- Altered hydrology and downstream flow regimes.
- Delayed treeline vegetation response to global warming.
- Decline in regional forest community biodiversity (Crown of Continent, NW).

Many functional changes occurring now.

Outlook?

Widespread decline in whitebark pine ecosystems rangewide:

- Threshold effects?
- Genetic bottlenecks?
- Local extirpations?

Management/restoration?

- Blister rust-resistant seedlings.
- Mountain pine beetle?
- Climate change?

Whitebark pine seedlings growing in the USDA FS Coeur d'Alene Nursery, ID, next to larch seedlings

Thank you!