In this presentation, we'll focus on the fire ecology and ecological restoration of whitebark pine. This is an interesting story of fire, bears, birds, introduced disease, as well as ecosystem change and restoration.
High mountain ecosystems
### Importance of whitebark pine

<table>
<thead>
<tr>
<th>scenery and recreation</th>
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</thead>
<tbody>
<tr>
<td>Forests collect snow and affect water quality and quantity in high mountain streams</td>
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<tr>
<td>Food for wildlife, including the Clark’s nutcracker and black and grizzly bears</td>
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</table>
This is an interesting story of...

- **Trees**
- **Birds**
- **Grizzly bears**
- **Fire**

Seeds of whitebark pine are very high in lipids and protein and so are an important food source for the animals who eat them. Both black and grizzly bears raid squirrel caches to eat the seeds. When whitebark pine seeds are available, the bears are more likely to bear cubs, to stay in the high country (farther from people). Squirrels too will eat the seeds, and so the seeds are important to the hawks that eat the squirrels.
Other characters include:

- Red squirrels
- White pine blister rust fungus
- Mountain pine bark beetles
- Currant species (*Ribes* spp.)

Photo by Peter Koot

Photo by H. Kredit, NPS

Photo by Eric Allen
This tree is found in high mountain ecosystems of the Rocky Mountains, the Cascades, and the Sierras.
Co-evolution: whitebark pine and Clark’s nutcrackers and

- Nutcrackers cache the seeds preferentially in open and burned areas
- This gives whitebark pine a distinct advantage over other conifers in regenerating large, burned areas
- Lanner: "the habits of Clark's nutcrackers account for the distribution, site preference, successional status, population age structure, and spacing of whitebark pine".
- Birds cache seeds 1-3 cm deep
- Each bird can cache as many as 22,000 seeds each year

Whitebark pine are dependent on Clark’s nutcrackers for successful regeneration. Even though the birds eat many of the seeds they cache, enough are left to establish whitebark pine seedlings.

When seeds are ripe they are rapidly harvested from cones by squirrels (these are cached under trees and logs, and bears may later raid these for food) and Clark’s nutcrackers.
Whitebark pine reproduction has evolved with the Clark’s nutcracker.
Whitebark pine decline

- Greatly reduced in extent and abundance due to combined effects of introduced disease (blister rust and West Nile virus), mountain pine beetle, fire exclusion and advancing succession

No long ago, the Great Bear Foundation petitioned the US Fish and Wildlife Service to list whitebark pine as an endangered species. They were concerned that this tree species was imperiled by human actions.

Although the petition was not approved, there continues to be concern that whitebark pine ecosystems are in peril and in need of active ecological restoration efforts.
Whitebark pine decline

- Arno and Hoff (1989) estimated that whitebark pine was once an important component on about 10-15% of the forested landscape within its range.
- Declined from 34% historically (circa 1900) to 19% currently (circa 1990) of potential whitebark pine habitat in the Interior Columbia River Basin.
- “Ghost forests” are common in central Idaho and in Montana.

These and other data are evidence that whitebark pine has declined in extent and abundance in recent decades.
Whitebark pine is functionally extinct in some areas

- ~30% of trees are dead and ~70% were infected with blister rust with an average of 25% crown kill in and around Glacier National Park
- Moderate to high whitebark pine mortality across 61% of the subalpine forest landscapes in the 600,000-ha Bob Marshall Wilderness area
- In Montana, 42% of all whitebark pine trees on permanent plots died in the 20 years between 1971 to 1992

In Montana, Kate Kendall, a bear biologist in Glacier National Park, declared whitebark pine “functionally extinct”. Data collected by Kate Kendall, Bob Keane and Steve Arno support this for much of whitebark pine range in Montana
White pine blister rust has altered landscapes

- Eurasian fungus introduced to the Pacific Northwest in 1910
- Whitebark pine is very susceptible, as are all 5-needled pines
- Reduces cone and seed production long before it kills trees
- 3 to 8% of whitebark pine trees are resistant
- Blister rust was found in 59% of the stands sampled across the Intermountain region, with increasing incidence and intensity over the last 30 years in the northern Rockies (Smith and Hoffman 1998).

Much of the decline has been attributed to whitepine blister rust.

This disease was introduced to the US accidentally. Whitebark pine and other 5-needled pines are very susceptible to the disease. There is some natural resistance in the all whitebark pine populations. Some scientists have called for creating openings near where there are rust-resistant whitebark pine trees so that those trees can regenerate. Biologists hope that the at least some of the seedlings that would establish in those openings from seed from rust-resistant trees would also be rust resistant.
Fire exclusion

- Large fires historically lasted weeks or months
- Modern fires are usually extinguished at lower elevations before they spread to whitebark pine
- Subalpine fuels are usually too moist to support extensive fires until late in the summer during unusually dry years when fire managers are unwilling to risk fire spread from drier areas
- Fire fighters are more successful at suppressing fires when they are small, and so we suppress most fires that start

For the reasons listed, we think that there are fewer fires now in whitebark pine forests than occurred in the past.

In some areas, however, there were extensive fires in whitebark pine forests within the last few decades (e.g. 1988, 1994, 2002)
Landscapes burning less often

- Even under policies, such as wildland fire use for resource benefit and limited suppression, in large wilderness areas
- Historical fire frequency varied: 29 to 144 yr for mixed-severity fires, and from 80 to 500 yr for stand-replacing fires

Landscapes have burned less often than historically, even in areas where we are managing for fire as a natural process.
In Selway-Bitterroot Wilderness, the cumulative area burned, a reflection of both fire size and frequency, in the upper subalpine forests that support whitebark pine:

- 1935 to 1975, an era of aggressive fire suppression even in the wilderness, was less than 1/17th of that experienced during the early part of this century under the relatively natural (but also drier) conditions from 1880 to 1934.
- 1975 to 1996, during “prescribed natural fire management”, when some lightning-ignited fires were allowed to burn naturally, was still less than 1/10th of the cumulative area burned from 1880 to 1934.
- Trends are probably even more pronounced for the smaller wilderness areas.

For instance, in the Selway-Bitterroot Wilderness area, we know from fire atlas data that the fire rotation has changed even though there has been a very active fire management program that includes wildland fire use there.

In smaller wilderness areas, wildland fire use is not often an option, and so the reduction in fire extent is probably more pronounced.
The future outlook for whitebark pine ecosystems is bleak unless we act quickly.
Human-induced changes threaten whitebark

- Whitebark pine will be lost from Yellowstone National Park with the warm temperatures and dry summers predicted with a doubling of the carbon dioxide content of the atmosphere (Bartlein et al. 2004)
- Lightning fires are predicted to occur more frequently if carbon dioxide content of the atmosphere doubles
- Fire frequency, extent and severity of fires in subalpine forests could increase with climate change if springs continue to warm
- Bleak outlook with blister rust and advancing succession

We know that human-induced environmental changes will happen, and that many of these will have consequences for whitebark pine.

It’s possible that if large fires are more frequent in the future that they will help create opportunities for mass selection.
<table>
<thead>
<tr>
<th>Isolation of Whitebark Pine Populations</th>
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<tbody>
<tr>
<td>• Its range is currently fragmented</td>
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<tr>
<td>• Global warming may intensify the</td>
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<tr>
<td>problems associated with the</td>
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<tr>
<td>whitebark pine’s distribution</td>
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<tr>
<td>pattern.</td>
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Figure from Morgan and Murray 2000

Whitebark pine populations are often relatively isolated today. If they continue to decline in extent, they will become increasingly isolated in small patches further apart (Morgan and Murray 2000).
Restoration approaches

- Restore natural fire regimes
  - Wildland fire use (lightning)
  - Prescribed burns (planned ignitions)
  - Suppression is the most common fire management action in most wilderness areas and parks
- Cut to favor whitebark pine
  - Some is being done
  - Often legally or practically impossible
- Breed rust-resistant individuals
  - Some people are simulating bird caches
  - Potential for widespread planting is low in wilderness areas and parks

The Whitebark Pine Ecosystem Foundation has called for ecological restoration of whitebark pine.

Bob Keane, Steve Arno, and Diana Tomback, among others, have been tireless advocates of active management to restore whitebark pine forest ecosystems. They suggest multiple strategies, including all the ones listed here.

All of these approaches have been implemented within the range of whitebark pine. For more information, visit the web site for the Whitebark Pine Ecosystem Foundation (http://www.whitebarkfound.org/). Their mission is to support ecological restoration of whitebark pine through fundraising, information exchange, and research.
Restoration of natural processes

- Fires allow for mass selection of blister-rust resistant trees
- Using prescribed burning is effective but challenging because suitable conditions are rare
- Also use wildland fire for resource benefit
- Reintroduce native fire regimes at landscape scales

High severity fire in subalpine fir, lodgepole pine and whitebark pine, Dunraven Pass, Yellowstone National Park, Photo by S. Bunting

There is a high potential for increased wildland fire use and limited suppression. I think these will be more successfully justified based on safer, less expensive fire suppression rather than on ecological arguments, even though ecological arguments are persuasive.
## High priority for restoration: site level (Keane and Arno 2000)

- Sites that support healthy, seral whitebark pine
- Blister rust infection is low severity
- Seed source within 10 km
- Within grizzly bear habitat
- Roads or trails ease access

Bob Keane and Steve Arno identified these criteria for selecting high priority sites for ecological restoration.
**High priority for restoration: Landscape and regional scales** (Morgan and Murray 2000)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Details</th>
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<tbody>
<tr>
<td>Relatively low rate of decline</td>
<td></td>
</tr>
<tr>
<td>WBP seral and will soon be replaced</td>
<td></td>
</tr>
<tr>
<td>Area is large relative to area of proposed treatments</td>
<td></td>
</tr>
<tr>
<td>Crown fire risk is relatively low</td>
<td></td>
</tr>
<tr>
<td>Proposed treatment increases integrity</td>
<td>ecologically and spatially</td>
</tr>
<tr>
<td>Strengthens the network of sites</td>
<td>representing ecological conditions</td>
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</table>

Morgan and Murray (2000) suggested these related criteria for selecting where within the range of whitebark pine to focus restoration efforts. This set of criteria is meant to be complimentary to the site-level criteria suggested by Keane and Arno (2000)
Challenges

- Long response time in this harsh, fragile environment
- Most whitebark pine forests are in parks and wilderness areas
  - Subject to fire suppression, may not support wildland fire use
  - Active management, other than wildland fire use, is often prohibited or discouraged
  - Conflicts over clean air and water, endangered species, and managing for natural processes
- Access is often limited

The challenges for ecological restoration in whitebark pine forests are daunting.

On many sites, it will be difficult to implement any other ecological restoration activity than fire management.
Whitebark pine ecosystems are fascinating examples of the interconnection between ecosystem elements.

In these ecosystems, whitebark pine has been called a keystone species, and fire has been called a keystone process. I hope you can identify some reasons for this. A keystone species is one whose removal has many cascading influences throughout an ecosystem. Likewise if fire is a keystone process, then changing fire regimes will have many different ecosystem effects, many of them key to ecosystem function. You should be able to give examples of these.

You should also understand why people are calling for ecological restoration of whitebark pine forests and be able to identify some of the approaches that people are promoting both for prioritizing places for action and what methods to use.

And you should have a fascinating story to tell others about birds, bears, trees, fire, and human-induced changes to fire regimes, climate, and introduced diseases.

Hopefully, you have many questions. You’ll find lots of good references and additional information at the web site for the Whitebark Pine Ecosystem Foundation (http://www.whitebarkfound.org/).