

This is a final draft. Please send any comments to Melissa Jenkins (mmjenkins@fs.fed.us, (208) 624-1154) by November 1, 2005.

DRAFT

Greater Yellowstone Area

Decision Guidelines for Whitebark Pine Restoration

**Compiled by Melissa M. Jenkins
Caribou-Targhee National Forest Silviculturist
March 2005**

Table of Contents

General Discussion.....page 1

Part I: Broad and Mid Scale Assessments.....page 4

Part II: Stand Level Assessments.....page 9

Part III: Prioritization Matrices.....page 13

Part IV: Justification and Reasoning for Consideration Items....page 16

References.....page 32

Whitebark Pine General Discussion

Whitebark pine (*Pinus albicaulis*) is a keystone species of upper subalpine ecosystems. If a keystone species is lost from a community, biodiversity can be greatly reduced.

Whitebark pine serves several important ecological functions such as protecting watersheds, promoting post-fire forest regeneration, and providing a food source for wildlife. In the Greater Yellowstone Area (GYA), whitebark pine seeds are a critical food source for the threatened grizzly bear, along with many other mammals and bird species. Bears usually get the whitebark pine seeds by digging up cones hoarded by squirrels in middens. When whitebark seeds are available, bears will eat them almost exclusively and human/bear conflicts are reduced (Renkin 1992, Mattson, 2001). Whitebark can also serve as a “nurse” tree, facilitating the survival and growth of other conifers on burned or harsh sites (Tomback et al. 2001).

Whitebark pine is declining throughout its range due to a combination of white pine blister rust, mountain pine beetle and succession to more shade tolerant conifers (Keane, 1994, Tomback 2001). In the book *Whitebark Pine Communities, Ecology and Restoration* (Tomback, Arno and Keane editors, 2001), whitebark pine experts emphasize the need to start active restoration immediately. “What we do *not* have, however, is the luxury of taking plenty of time to implement these techniques; implementation must begin now” (Keane 2001). “Without management intervention, the future for whitebark pine during the next several hundred years is one of continuing decline, functional extinction, and local extirpation” (Kendall 2001).

While immediate restoration treatments are likely appropriate in some portions of the Greater Yellowstone Area (GYA), there must to be a note of caution regarding the emphasis on restoration treatments. Managers in the GYA must consider that 27.5% of the whitebark in Yellowstone NP burned in 1988 (Podruzny 1999, Mattson 2001). Also, many of the whitebark stands within the GYA, especially within Yellowstone National Park, are a persistent mix of whitebark pine and lodgepole pine. Research on whitebark pine restoration has been focused in forest communities where whitebark is succeeding to subalpine fir and spruce; less is known about its interactions and successional progression with lodgepole pine. Because both pines are shade-intolerant, the loss of whitebark to succession in these stands occurs at a slower rate than in stands where whitebark competes with fir and spruce (Keane, 2001).

Managers must also consider what is best for whitebark pine in the long-term may not be what is best for species that depend on them, such as the grizzly bear, especially in the short-term. “Insofar as we understand them, the means for conserving whitebark and grizzly bears may seem somewhat uncomparable.” (Mattson 2001). While bears require large areas free from human activities, restoration treatments bring humans into the whitebark zone. Grizzly bears may suffer from the short-term effects of anything that removes cone-producing whitebark pine or reduces the population of squirrels or the size of middens. On the other hand, whitebark may need extensive management for it to

remain abundant in the long-term (Mattson 2001). These decision guidelines are an attempt to put an emphasis on restoration treatments while minimizing negative short-term effects to grizzly bears.

The guidelines in this document are not designed to give specific thresholds that determine when active restoration activities should occur, but are meant to guide land managers as to which attributes to consider when evaluating the condition of their whitebark pine communities and provide a relative need for active restoration. Managers should use this information along with specific management direction established for their National Park or National Forest to determine when, where and if active restoration should occur. Active restoration treatments include: prescribed burning, mechanical silvicultural treatments, a combination of fire and mechanical treatments, and planting (Keane and Arno, 1996, 2001). Restoration treatments other than planting are designed to eliminate or reduce competing species and increase the regeneration opportunities for natural-selection to produce white pine blister rust (*Cronartium ribicola*) resistant seedlings. Planting can increase rust resistance by using seedlings from suitable seed sources with the highest known levels of resistance.

The collection of seed for genetic restoration efforts is not included in the guidelines. There is general acceptance that land managers in the GYA should proceed with the genetic white pine blister rust resistance breeding program for whitebark pine. Identifying and collecting seed from phenotypically rust resistant individuals for the genetic breeding program is a high priority, and participation by all National Forests and National Parks in the GYA is strongly encouraged.

Managers should promote public education concerning the ecology and decline of whitebark pine in the GYA. The Whitebark Pine Ecosystem Foundation www.whitebarkfound.org would likely be willing partners in any public education efforts.

Global warming has the potential to impact whitebark pine significantly (Romme and Turner 1991; Bartlein et al. 1997). Because of its long life span and the 75+ year time period needed to begin producing cones, whitebark pine does not rapidly adjust to change. Increasing temperatures would “push” the lower elevational limit of whitebark pine up in elevation. Less hardy conifer species would be able to establish in higher elevation whitebark stands that are currently climax. Mountain pine beetle populations are thought to be killing more whitebark pine during the current epidemic than they have historically because of warmer temperatures in the whitebark pine zone (Logan and Powell, 2001, 2003). A warmer climate may also accelerate the spread of blister rust (Koteen 1999). Though the effects from global warming could be severe, they are complex and difficult to predict. Currently there is not a consideration item in the guidelines addressing global warming. Restoration treatments that reduce competition from other tree species would benefit whitebark pine exposed to warmer average temperatures in the future.

Monitoring is a critical step that often does not receive adequate emphasis. Managers must monitor the effects of restoration treatments with quantifiable attributes tied directly

to treatment objectives. Monitoring will answer questions regarding whether or not the objectives of the treatment were met and provide information that will help refine future treatment methods.

The justification and reasoning behind each management consideration item in the guidelines, along with a more detailed discussion, may be found on pages 16-30.

This document is a work in progress. Research on white pine blister rust resistance, grizzly bear use of whitebark pine, mountain pine beetle protection methods, whitebark pine planting guidelines, effects of global warming and successional processes is ongoing. These guidelines should be revised as needed when new information becomes available and as additional consideration items are identified.

GYA Decision Guidelines for Whitebark Pine Restoration

Part I Broad and Mid Scale Assessments

Broad scale applies to large areas such as a National Forest, National Park, Bear Management Unit or Primary Watershed. Once an assessment is completed at a broad scale, a mid scale assessment will likely be needed to further refine the assessment of whitebark pine restoration needs. The same consideration items (1 thru 8) should be used for both broad and mid scale assessments. Generally, mid scale assessments would be done on areas within the broad scale assessment no smaller than about 5000 acres, or a hydrologic unit code (HUC) Level 6 (USGS, 1987).

An example of prioritizing broad or mid scale assessment areas for restoration using consideration items 1-8 is provided in a weighted matrix on page 14.

1. Broad/Mid Scale: Historical acres whitebark vs. current acres whitebark (reasoning on pg 16).

A. Small decrease or an increase in acres with whitebark pine from historical levels= Less need for active restoration

B. Large decrease (>20%) in acres with whitebark pine from historical levels= Greater need for active restoration with emphasis on preventing loss of key remaining areas.

2. Broad/Mid Scale: Size class distribution (reasoning on pgs 16-17).

A. Whitebark is well distributed in all size classes= Low priority for active restoration

B. High percentage of whitebark in large size classes= Greater need for active restoration

3. Broad/Mid Scale: Average acres burned historically vs. acres known to have burned or been harvested since fire exclusion began (reasoning on pg 17-18).

Acres of the whitebark type known to have burned or that were harvested with regeneration treatments since approximately 1900 :

A. Greater than what historically would have burned= Less need for mechanical or fire treatment. Consider the need for planting (see pgs 20-21).

B. Fewer than what historically would have burned = Greater need for active restoration treatments.

4. Broad/Mid Scale: Landscape distribution of whitebark pine (reasoning on pg 18).

Stands with a whitebark pine component are:

A. Well distributed across the landscape= Does not create the need to prioritize treatment in a particular area.

B. Not well distributed across the landscape= Areas with high loss of cone producing trees (greater than 70% are no longer producing cones) that are more than 10 km from another whitebark pine seed source should be prioritized to create regeneration opportunities.

5. Broad/Mid Scale: Grizzly bear use of whitebark pine (reasoning on pg 18-22).

A. In areas with potentially high bear use, emphasize restoration treatments that maintain or increase the quality of grizzly bear habitat over the short and long-term. Managers should consider both present and future potential high use areas. **See 5A.**

B. In areas where bear use is likely to be low or absent, emphasize whitebark pine treatments that optimize conditions that favor whitebark pine. **See 5B.**

5A. Areas with potentially high grizzly bear use (reasoning on pg 18-20).

- Prioritize management of whitebark pine for grizzly bears in areas (use Bear Management Units if present) where $\geq 13\%$ of the total area has cone-bearing whitebark pine.

- Emphasize management that maintains or restores a minimum of 13% of the area in cone-bearing whitebark pine where possible. Consider controlling natural fires that may burn cone-bearing trees and avoid harvesting any whitebark pine.
- On average, 2-4% of the total area potentially supporting mature whitebark pine in mixed species stands should be regenerated every 10 years. Consider past disturbances since around the year 1900 (already addressed in Consideration Item #3).
- Prioritize management of habitat for red squirrels in areas that are capable of supporting cone-bearing whitebark pine.
- Where whitebark pine is limited on the landscape due to losses from fire, bark beetle or succession, emphasize protection of areas that may be providing key habitat for bears.
- Emphasize maintaining cone-bearing whitebark pine in areas that are farthest from human disturbances. Avoid restoration treatments that create access or trails that may increase human use of whitebark areas.
- Avoid activity in areas that contain whitebark pine when bears are most likely to be using them (last week in August through mid-November). Consider allowing treatments to occur if surveys for bears show that the area is not currently being used by bears or if area cone crops are known to be light.

5B. Areas with low or absent grizzly bear use (reasoning on pg 20-22).

The decision guidelines in general cover this section. The primary differences with grizzly bear management emphasis areas in section 5A above are:

- Emphasize restoration treatments that provide opportunities for regeneration and good seedling survival for whitebark pine. Optimum conditions occur in large burned areas with minimal competition from other tree species for as long as possible. Design treatment sizes that reflect the amount of available whitebark pine seed source in surrounding stands.
- When consideration items indicate a high level of need for restoration treatments, emphasize treating an amount of area that exceeds historical levels of disturbance where it meets with other land management objectives.
- Treatment locations can be close to human disturbance. Locate treatments anywhere that costs and logistics of access are within reason.

- Access to whitebark communities could be used to provide opportunities for public education where it meets with other management considerations.
- Time the treatments to whenever there is the best chance of meeting restoration objectives.

6. Broad/Mid Scale: Successional potential and status (reasoning on pg 23).

- A. High percent of potential whitebark acres in climax stands (stands that will not succeed to more shade-tolerant conifers) = Less need for active restoration.
- B. High percent of potential whitebark acres in seral stands = Need for active restoration more likely. **Go to 6A.**

6A. Seral stands

- A. High percent of seral whitebark acres have moderate to high (> 40%) basal area representation from whitebark pine = Less need for active restoration.
- B. High percent of seral whitebark acres with high (> 60%) lodgepole pine basal area= Greater need for active restoration.
- C. High percent of seral whitebark acres with a well established spruce/fir understory (>618 trees/hectare or 250 trees/ac)= Greater need for active restoration.
- D. High percent of seral whitebark acres with high (> 60%) spruce/fir basal area= Greatest need for active restoration.

7. Broad/Mid Scale: Levels of blister rust infection and mortality (reasoning on pg 23-24).

- A. Blister rust infections low= Less need for treatment.
- B. Blister rust levels moderate to high (>50% to >80%)= Greater need for treatment. Emphasize saving mature trees with phenotypic blister rust resistance. Minimize burning that could affect resistant trees. Create Clark's nutcracker caching sites on potential whitebark sites within 0-3 km (0-2 miles) (Kendall and Keane, 2001) of cone-bearing whitebark pine. Consider planting if regeneration is generally absent within 3-5 years after one or more cone crops.

8. Broad/Mid Scale: Levels and trend of mountain pine beetle populations (reasoning on pg 25).

A. Mountain pine beetle levels low and not increasing= More favorable for implementation of restoration treatments. Burning and mechanical treatments can attract bark beetles even at endemic levels, so consider using preventive measures (See Consideration Item #14 below)

B. Mountain pine beetle levels high or increasing= Emphasize delaying restoration treatments until the epidemic is over. If treatments must occur, focus them in stands with little or no cone-bearing whitebark. Consider that populations may build in any species of pine trees stressed from the treatment activity (especially burning), and move into nearby stands, killing desirable whitebark pine.

Part II

Stand Level Assessments

These considerations can be applied to any forest stand with the potential to produce cone-producing whitebark pine within the broad or mid scale analysis area.

An example of prioritizing forest stands for restoration using consideration items 9-14 is provided in a weighted matrix on page 15.

9. Stand Level: Recent fire events (reasoning on pgs 25-26).

A. Stand has experienced a fire event, and it will not naturally establish adequate tree stocking within 20 years = High priority for planting with whitebark pine if needed to meet land management objectives. Use seedlings with the highest levels of potential blister rust resistant available. See page 21 for planting guidelines.

B. Stand has experienced a fire event, and it will not naturally establish adequate tree stocking within 10-20 years = Low priority for planting whitebark pine if high priority areas (above) exist.

C. Stand has experienced a fire event and it will establish adequate natural tree stocking within 10 years = Planting whitebark pine generally not recommended.

10. Stand Level: Distance from whitebark pine seed sources (reasoning on pg 26).

Stand has a high loss of cone producing trees (greater than 80%) and is:

A. Closer than 10 km to a whitebark seed source = Less need for creating regeneration opportunities.

B. More than 10 km to a whitebark seed source = High priority for the creation of regeneration opportunities.

11. *Stand Level: Grizzly bear use of whitebark pine*

11A. **Stands where grizzly bear use is emphasized** (reasoning on pg 26-27).

- Avoid restoration treatments in stands where there is evidence of recent/current grizzly bear use.
- Where whitebark is seral, emphasize managing for stands with high conifer tree density and species diversity during peak cone-bearing years (trees 100-300 years old). Optimum conditions are when basal area is ≥ 40 sq m/hectare (≥ 174 sq ft/acre) and whitebark basal area represents 15% to 50% of the total basal area.
- Where cone-producing whitebark pine need to be released from competition to maintain adequate whitebark presence in the stand, emphasize removing competing trees within one to one-half of dominant tree height around individual or small groups of whitebark pine.
- Emphasize restoration treatments that minimize the mortality of whitebark pine, especially cone-bearing trees. If prescribed burning is needed, emphasize burning in potential whitebark stands that currently have low whitebark basal area (0-1 sq meter/hectare or 0-5 sq ft/acre). Consider using preventive bark beetle treatments (See Consideration Item #14 below).
- If openings need to be created to attract nutcracker caching, emphasize keeping them relatively small (50 meter diameter is generally the minimum size recommended to optimize bird caching and provide enough sunlight to promote whitebark regeneration).
- Emphasize restoration and maintenance of whitebark in stands that are farthest from human disturbances. Do not create any roads or trails that may increase or encourage human access to the stand.

11B. **Stands where whitebark pine restoration is emphasized** (reasoning on pgs 27-28).

For a detailed description of restoration techniques, see Bob Keane and Steve Arno's discussion in *Restoration Concepts and Techniques*, Chapter 7 (pages 367-400), of the book *Whitebark Pine Communities, Ecology and Restoration*, (Tomback et al. 2001).

- Emphasis is on removing as many non-whitebark conifers as other management considerations will allow. This would reduce competition experienced by individual whitebark pine of all ages and could reduce the likelihood of a stand replacing fire.

- Create burned areas to attract Clark's nutcrackers. Recently burned over areas are the most attractive to Clark's nutcrackers. Openings created by mechanical treatments are effective also.
- Emphasize large openings for whitebark regeneration (minimum 50 m diameter/2 acres, but generally the larger the better unless seed sources are limited).
- If possible, coordinate regeneration treatments with a good cone crop.
- Consider that small whitebark pine that are old and appear suppressed (poor growth, gray bark, irregular shaped bole) generally will not become cone-bearing, even with removal of competition (Keane et al. 1994).
- Design regeneration treatments that minimize the potential for seeding in from other tree species (i.e. large, stand replacing and upwind from seed sources). This was also addressed in Consideration Item #9.

12. Stand Level: Successional status (reasoning on pgs 28-29).

- Climax stands (not succeeding to other conifers)= Burning not recommended. Consider planting if there is >50% mortality in the overstory and insufficient regeneration to restock the stand in the understory. Emphasize using seedlings with the highest level of potential rust resistance available.
- High percent of trees in the stand are whitebark pine= Low priority for burning. Consider treatments with low risk to residual stand (i.e., mechanical treatments with possible jackpot burning of slash, and creating caching sites within 0-3 km).
- Low percent of trees in the stand are whitebark= Higher priority for burning. Consider pre-treating fuels around existing whitebark that are cone-producing or could potentially produce cones in the future. Emphasize protection around trees with phenotypic resistance.

13. Stand Level: Level of blister rust infection and mortality (reasoning on pgs 29-30).

- Stand has a low level of blister rust infections= Low priority for cone collections and planting. If planting is necessary, use seeds collected following accepted collection procedures such as those found in the Forest Service Handbook 2409.26F, Chapter 600.

- Stand has a high level of blister rust infections (most trees have at least 20-30% crown loss and trees show > 70% to 85% infection levels)= High priority for cone collections from phenotypically resistant trees. Consider designating up to three phenotypically resistant trees per stand for the genetic blister rust resistance breeding program. Do not plant seedlings from trees with blister rust symptoms such as crown loss and cankers. Consider burning in or near the stand to attract bird caching and provide conditions that promote survival of seedlings from the surviving mature rust-resistant individuals.

14. Stand Level: Levels and trend of mountain pine beetle populations

(reasoning on pg 30-31).

A. Mountain pine beetle levels in the area are low and not increasing= Minimize scorching of whitebark in prescribed burns or wounding during silvicultural treatments or cone collection; this can attract beetles even at endemic population levels. Consider using the anti-aggregation pheromone Verbenone or spraying the insecticide Carbaryl on high value trees within the stand.

B. Mountain pine beetle levels in the area are high or increasing= Do everything stated above for low levels. Emphasize delaying restoration treatments until the epidemic is over. If a treatment must occur, emphasize stands with little or no cone-bearing whitebark. Consider that populations may build in the trees stressed from the burn and then move into nearby stands; especially if the burn area has a large pine component. In mechanical or prescribed burn treatments- strongly recommend using Carbaryl on high value trees within or nearby the stand. The anti-aggregating pheromone Verbenone has been shown to be ineffective when mbp is at epidemic population levels (Progar in press). A current research project combining Verbenone with insect pheromone trapping is showing more promising results in the preliminary findings.

Part III

Prioritization Matrices

Included on the next two pages are examples of weighted prioritization matrices developed from the consideration items for both broad/mid scale level and stand level assessments. The weight given to each consideration item should be established by the group of resource managers doing the prioritization. For example, in the broad/mid scale matrix, if resource management planning has identified public education as a high priority, the weight given to public education would likely be higher than in the sample matrix below. In the stand level assessment, the weight given to current/recent grizzly bear use could be lowered if grizzly bear use is widespread or made zero if human disturbance can be mitigated by treatment timing.

The “score” is calculated by multiplying the weight given to the consideration item by the rating given to that consideration item (see matrices). A negative rating indicates that active restoration (Rx burning, mechanical treatments or planting) may have negative effect; a zero rating indicates small or neutral effect, a positive score indicates a positive effect.

While the scores are somewhat subjective, if applied consistently during the process, they are a valuable comparative tool when assessing relative need for restoration at all three assessment levels.

Broad/Mid Scale Prioritization (Example)

Consideration Item	Weight	Score		
		Area 1	Area 2	Area 3
1. Change from historical acres	10	0	10	10
2. Age class distribution	5	0	5	5
3. Acres burned last 100 yrs vs historic	10	0	10	10
4. Areas far from WbP seed source	5	5	0	0
Grizzly bear use emphasized:	----	----	----	---
5a. % of area with cone-bearing WbP	5	5	5	0
5a. Mgt needed to maintain >13%	10	0	10	0
5a. Potential for human disturbance	5	-5	0	0
Grizzly bear use not emphasized:	----	----	----	----
5b. Potential for public education	5	0	5	0
6. Successional Potential and Status	5	5	15	15
7. Level of blister rust	10	10	0	20
8. Level/trend of mountain pine beetle	10	-20	-20	-20
Score (weight x rating)=		0	30	40

The “score” is calculated by multiplying the weight for that consideration item by the appropriate rating for that item. The consideration item ratings are defined as follows:

RATINGS

- Item 1.** Small decrease or increase in acres=0, Large decrease in acres=1
- Item 2.** Well distributed age classes=0, High percentage in older age classes=1
- Item 3.** Acres burned \geq to historical=0, Acres < historical=1
- Item 4.** Acres well distributed=0, High mortality areas far from other seed sources=1
- Item 5a.** <13% of area has cone-bearing whitebark=0, \geq 13% with cone-bearing whitebark =1
- Item 5a.** Can not support >13% =0, Treatments needed to maintain >13%= 1
- Item 5a.** Increase in human use = -1, No change in human use=0
- Item 5b.** No potential for public education= 0, Potential for public education=1
- Item 6.** High % climax=0, Seral: High% whitebark=0, high %LP=1, high% SF understory=2, high% SF overstory=3
- Item 7.** Rust infections low=0, rust infections moderate=1, rust infections high=2
- Item 8.** Mpb levels high or increasing=-2, Mpb levels low and stable=0

Note: A negative score indicates that active restoration (Rx burning, mechanical treatments or planting) may have negative effect; a zero score indicates small or neutral effect, a positive score indicates a positive effect.

Stand Level Prioritization (Example)

Consideration Item	Weight	Score		
		Stand 1	Stand 2	Stand 3
9. Recent Fire Events	10	0	0	20
10. Distance from WbP seed source	10	0	0	10
Grizzly bear use emphasized:	----	----	----	----
11a. Current/recent use by bears	10	-10	-10	10
11a. Maintain optimum use conditions	10	10	10	0
11a. % whitebark pine basal area	5	-10	10	0
11a. Potential for whitebark mortality	10	-20	0	0
11a. Potential for human disturbance	5	-10	-5	10
Grizzly bear use not emphasized:	----	----	----	----
11b. Accessibility	5	0	5	10
12. Successional potential and status	10	20	10	0
13. Rust severity	10	20	20	0
14. Level/trend of montain pine beetle	10	-20	0	N/A
Score (weight x rating)=		-20	40	60

The “score” is calculated by multiplying the weight for that consideration item by the appropriate rating for that item. The consideration item ratings are defined as follows:

RATINGS

Item 9. Natural regen w/in 10 yrs=0, regen within 20 yrs=1, regen >20 yrs=2

Item 10. Distance <10km=0, Distance >10km=1

Item 11a. Recent/current grizzly bear use=-1, grizzly bear use not recent/current=1

Item 11a. Treatment not needed to maintain optimum conditions=0, Treatment needed=1

Item 11a. High whitebark basal area=-1, low whitebark pine basal area=1

Item 11a. Potential for whitebark mortality low=0, moderate=-1, high=-2

Item 11a. Potential for human disturbance low=1, moderate=-1, high=-2

Item 11b. Accessibility poor=0, accessibility fair=1, accessibility good=2

Item 12. Climax w/low mortality=0, climax w/moderate mortality=1, climax w/high mortality=2, seral w/high % wbp=0, seral w/moderate % wbp=1, seral w/low % wbp=2

Item 13. Rust infection low=0, rust infection moderate=1, rust infection high=2

Item 14. Mpb levels high or increasing stable=-2, Mpb levels low and stable=0 (*this rating does not apply if the only restoration treatment in the stand would be tree planting*).

Note: A negative score indicates that active restoration (Rx burning, mechanical treatments or planting) may have negative effect; a zero score indicates small or neutral effect, a positive score indicates a positive effect.

Part IV
Justification and Reasoning for the Decision Guidelines
Consideration Items

Consideration Item 1. *Broad/Mid Scale: Historical acres whitebark vs. current acres whitebark*

Whitebark pine is declining throughout its range due to a combination of fire suppression with subsequent succession to more shade-tolerant conifers; mountain pine beetle infestations; and the introduced pathogen white pine blister rust (Tomback et al. 2001).

Because of whitebark pine's value to many wildlife species in the GYA, it is generally preferable to keep this forest species present within the area it has occupied historically. The greater the decrease from historical acres, the greater its loss of historical ecological function and therefore the greater need for restoration treatments that promote whitebark pine. Restoration treatments can promote the re-establishment of whitebark in areas where it was historically present and is now absent, or where it has been reduced to a minor component. Restoration treatments can also increase the survivability and growth of existing whitebark by opening stands and reducing competition.

The most appropriate method for estimating the historical range of whitebark will vary depending on site specific conditions and the information available for your area. One tool for establishing historical range of variation of whitebark pine that has been suggested by Robert Keane is the LANDFIRE model (Keane, personal communication, 2005).

Consideration Item 2. *Broad/Mid Scale: Size class distribution*

The major consequence of fire exclusion is widespread senescence and mortality of whitebark pine among successional community types. In much of its range (e.g. Sierra Nevada, Cascades and the Great Basin), whitebark pine exists primarily in climax stands. Seral whitebark stands occur mostly in the northern Rockies of the U.S. and in some intermountain regions. In these areas, instead of the historic mosaic of whitebark communities at different seral stages, the landscape is becoming homogeneous with late seral forests of subalpine fir and spruce (Tomback et al. 2001). Fire exclusion has limited the opportunities for whitebark pine to regenerate and establish young age classes where it is seral.

Mature whitebark pine are more susceptible than young whitebark to insects and disease, in particular the mountain pine beetle (mpb). Young whitebark pine are less susceptible to mpb because the beetles prefer attacking larger trees. Maintaining a diversity of age

(size) classes would ensure that some stands that are less susceptible to bark beetles are always present.

Whitebark pine produce the best cone crops when trees are from about 100 to 300 years in age. A diversity of stand ages would ensure that stands growing out of the prime cone production period are being replaced by stands growing into the prime cone production period.

Resistance of whitebark pine to white pine blister rust in natural populations is very low with estimates that generally range from <1 to 5 percent (McDonald and Hoff, 2001). New whitebark stands established with seeds from the healthy trees in stands heavily infected and damaged by blister rust would have the highest probability of having some trees resistant to blister rust. If opportunities for regeneration are not provided until most of the whitebark is dead or no longer producing cones, the surviving (rust resistant) trees will be at such low numbers that virtually all of their seeds will be eaten (McKinney and Tomback in prep.). Insufficient seeds will be present to adequately regenerate stands of whitebark pine. See Consideration Items 9 and 13 for discussion on prioritizing stands with high infection levels for the collection of cones and planting.

Consideration Item 3. *Broad/Mid Scale: Average acres burned historically vs. acres known to have burned since fire exclusion began.*

A major reduction in high-elevation fires since about 1929 has led to successional replacement of whitebark pine on more productive sites in the part of its range where it would otherwise be abundant (Tomback et al., 2001). In regions where whitebark pine communities are successional, fires occurred historically every 50-400 years (Arno 1980; Romme 1982; Barrett 1994).

Active restoration treatments should be emphasized in areas where the current fire return interval is lower than the historical frequency. A good tool for estimating historical burn frequencies is the LANDFIRE model (Keane, personal communication, 2005).

Whitebark pine will continue to decline as long as fire exclusion limits the availability of sites suitable for nutcracker caches while blister rust kills trees faster than they can regenerate. Burning creates suitable caching conditions for Clark's nutcrackers and optimal growing conditions for whitebark regeneration. Burning close to areas with moderate levels of blister rust infections/mortality would favor natural selection of rust resistant individuals because the surviving cone-bearing trees would likely contain rust resistant genes (Hoff et al. 2001, Kendall et al. 2001).

If information on historic fire return intervals is lacking, consider that regenerating 2.5% of the total whitebark pine type every 10 years would result in regeneration of all stands in 400 years. At 400 years, the high end of the fire return interval, peak cone production from individual trees is over. That would mean at a minimum, 25% of the seral whitebark pine type should have burned since 1900 to be within the maximum historic

fire return interval range as defined by Arno and others (Arno 1980; Romme 1982; Barrett 1994). Consider past disturbances that have occurred since approximately 1900 in the average because trees created by disturbances prior to 1900 are entering the prime cone production age (100-300 years). Research by Randy Walsh, Colorado State University and National Park Service, is refining information on fire disturbances that played a role in the whitebark pine type in the GYA. Information from his research, including the role of mixed severity fire, will be incorporated into the guidelines when it becomes available.

Consideration Item 4. *Broad/Mid Scale*: Landscape distribution of whitebark pine.

Local extinctions can occur if stands of whitebark pine decline and seed sources are not close enough to provide adequate regeneration (10 km is the maximum distance to expect nutcrackers to reestablish a whitebark stand (Keane 2001). Landscape assessments need to identify areas where local extinctions are possible and prioritize these areas for regeneration treatments.

Consideration Item 5. *Broad/Mid Scale*: Grizzly bear use of whitebark pine.

5A. Areas with potentially high grizzly bear use.

Why Whitebark Pine Seeds Are So Important To Grizzly Bears

Grizzly bears consume substantial amount of pine seeds in only a small part of their historic North American range. Heaviest use occurs in the Greater Yellowstone Area and the east front of the Montana Rocky Mountains, in regions that experience a continental climate (Mattson, Kendall, Reinhart, 2001). Craighead and others (1982) estimated that pine seeds were the most important source of energy for grizzly bears in their study area located east of the Continental Divide in the Rocky Mountains of Montana (Mattson, Reinhart, 1994).

Whitebark pine seeds have several features that make them valuable bear food. They are large, which makes the seed easier and more energetically rewarding for grizzly bears to handle and consume. Whitebark seeds are a rich source of dietary fat (average 30-50% fat content). The seeds are important for female grizzly bears; reproductive success of females is contingent on the accumulation of body fat. On average, females eat twice as many pine seeds as do males. Female grizzly bears that frequently used whitebark pine seeds exhibit substantially higher reproductive rates (larger litters, more likely to reproduce, and reproduce at a significantly earlier age) than females who consumed few pine seeds (Reinhart et al. 2001). Whitebark pine seeds also have a great affect on the survivorship of subadult males and adult females.

During years of abundant whitebark pine cone crops, bears forage almost exclusively on pine seeds, using habitats in the high elevation whitebark pine zone (Podruzny et al. 1999). When bears stay in the more remote high elevation areas where whitebark is present, they are farther away from human facilities and potential human/bear conflicts. Human/bear conflicts are the leading cause of bear mortality. During years when bears eat few pine seeds, conflicts with humans and associated bear mortality, increase dramatically (Mattson et al. 1992). Human activity and access in the whitebark pine zone should be limited since they increase the chance of bear mortality.

The Squirrel Connection

Yellowstone grizzly bears obtain virtually all of the pine seeds they eat by excavating cone caches made by red squirrels (Mattson, 1997, Prodrzny 1999). Squirrel densities appear to limit bear use of pine seeds more than the abundance of whitebark pine. The density of middens excavated by bears was highest in forest types dominated by a mix of whitebark and lodgepole pine (Mattson and Reinhart 1997).

In Bear Management Units (BMUs) with >13% of the area supporting mature whitebark pine, the relation between availability of squirrel middens and use of middens is strong (Mattson 2000).

The abundance of red squirrels and their middens is the primary influence on the extent of whitebark seed use by grizzlies. Thus management of whitebark pine habitats for grizzly bear use primarily involves management to favor red squirrels (Mattson and Reinhart 1996). Optimum squirrel habitat within the whitebark pine zone consists of habitats with high overstory-basal area and high species diversity on moderate slopes (Podruzny, Reinhart, Mattson, 1999). Optimum stand characteristics that favor red squirrels and the use of their middens by grizzly bears are when basal area is ≥ 40 sq m/hectare (≥ 174 sq ft/acre) and whitebark basal area represents 15% to 50% of the total basal area (Mattson 2000).

Most middens excavated by bears coincide with years of large cone crops (Podruzny et al. 1999). Grizzly bear use of squirrel middens can start as early as late July; heavy use typically does not occur until last week of August, first week of September and persists until bears den in late October/early November. If a substantial number of cones remain in squirrel middens, bear use resumes typically by early June of the following year and lasts until cones are depleted. When bears feed on pine seeds, they feed on virtually nothing else (Mattson et al. 2001).

Fire Effects

The fires of 1988 burned an estimated 27.5% of the whitebark pine in Yellowstone National Park (Podruzny et al. 1999). Four percent of Yellowstone whitebark types were known to have burned prior to 1988 and 4% burned in years 1994/96/2001 combined for a total of about 34% (Reinhart personal communication in 2001 GYCC Whitebark Pine Committee meeting notes).

In terms of the grizzly bear, long-term productivity of the whitebark pine zone in interior ecosystems would be best assured by disturbance regimes that replaced approximately 3

percent of mature acreage per decade (Mattson and Reinhart 1994). Considering this recommendation and the fact that 34% of the whitebark pine type that has burned in Yellowstone, this would mean that the recommended amount of disturbance has been reached in the Park and little or no burning is needed at this time if analyzing the Park as a whole. Smaller analysis areas (i.e. BMUs) within the Park may have differing results.

Fire has a major influence on red squirrel midden numbers in the study area. No red squirrels or middens were found in the burned portion of the study area 7-9 years after the 1988 fires (Podruzny et al. 1999).

Midden size has a strong effect on bear use. Very small middens almost never get used while very large middens have nearly a 100% chance of use in years of large seed crops. After the 1988 YNP fires, more squirrels packed into a smaller area. The squirrels adjusted to change in habitats by using smaller territories and midden size was smaller (Podruzny et al. 1999). Grizzly bear excavations in a study area that was partially burned dropped by 64%.

Human Disturbances

Grizzly bears may suffer from the short-term effects of anything such as fire or timber harvest that removes cone-producing whitebark pine, reduces squirrel densities, or reduces the size of squirrel middens. The 1988 fires in Yellowstone burned 30% of cone producing stands in the north and 12% in the east portion of the Park.

Global warming could cause a decrease in whitebark pine, especially at the lower upper subalpine elevations. Managers should be cautious about harvesting any whitebark pine, especially at lower elevations. In addition, judicious control of natural fires may be desirable to favor the persistence of existing mature whitebark pine.

Managers should also be concerned about placement of human facilities in the whitebark pine zone. Proximity to roads and town sites reduced the probability of bear use by 66 and 92% respectively (Mattson and Reinhart, 1997).

“We encourage caution in the management of whitebark pine habitats. To prevent further loss of whitebark habitat and seed-producing trees in the grizzly bear’s range, we discourage harvesting or use of management-prescribed fires in the whitebark pine zone. Management of whitebark pine forests for grizzly bears should emphasize maintaining large secure areas of diverse habitat types supporting stable numbers of whitebark pine trees and squirrels” (Podruzny et al. 1999).

5B. Areas with low potential for bear use.

In areas with low potential for bear use that have the potential to support whitebark pine, emphasize restoration treatments that provide the optimum regeneration and seedling survival conditions for whitebark pine.

Regeneration treatments

Whitebark pine is regenerated almost exclusively from Clark's nutcracker seed caches. Therefore, regeneration treatments that optimize regeneration are those that optimize conditions that attract Clark's nutcracker caching. The optimum situation for Clark's nutcracker caching is recently burned over areas (birds may like clear pattern for remembering cache sites) greater than 50 meters diameter. These were found to be most attractive to Clark's nutcrackers (Keane and Arno 2001; Tomback et al. 2001).

Fire is the keystone disturbance that shaped most whitebark pine landscapes in the Greater Yellowstone and northern Rockies in general, so treatments should be designed to emulate fire's historic effects on the landscape (Keane and Arno 2001). While prescribed fire is the obvious tool, mechanical treatments can also be effective. Properly designed silvicultural thinning can simulate the effect of non-lethal surface fire in whitebark stands (Keane and Arno 2001). Treatment sizes need to reflect the amount of available whitebark pine seed source in surrounding stands (Keane, personal communication, 2005). Do not design treatments that create large areas for whitebark pine regeneration if there is little seed available for caching.

Seedling survival of whitebark depends on open stand conditions for as much of the rotation as possible (whitebark pine is an early seral species, and is shade-intolerant). Large burns (>1000 hectares- Keane 2001) favor whitebark pine since wind dispersed species take longer to seed in than whitebark seeds that are planted by birds flying up to 22 km to cache their seeds. Wind dispersed seed sources in locations that take advantage of prevailing winds can reduce the effectiveness of large burns (Tomback et al. 1990)

When consideration items in this document are pointing to a high level of need for restoration treatments, regeneration treatments, including planting, should exceed historic fire frequencies or the 2-3% per decade recommended under the grizzly bear emphasis management where possible to increase opportunities for regeneration of rust resistant individuals. Emphasize treatments in areas where the whitebark has been well represented in the past and is now a minor component or absent and where cone-bearing trees are within 10 km (the closer the better). See consideration items 10, 11 and 12.

Intermediate Treatments

Intermediate treatments are treatments where regeneration of the stand is not an objective. To restore whitebark pine, intermediate treatments primarily involve reducing competition from other tree species while leaving the whitebark pine. This would reduce competition for individual whitebark pines of all ages and could reduce the likelihood of a stand replacing fire by reducing fuel loadings and ladder fuels, especially if the slash is treated. Thinning that involves cutting of whitebark pine is generally not recommended due to the need to maintain as many trees for genetic diversity to provide the highest potential for rust resistance as possible.

Optimizing survival

Treatments should promote the survival of cone-bearing whitebark pine where practical, with emphasis on trees that are exhibiting phenotypic resistance to white pine blister rust.

Burn areas are the most attractive to Clark's nutcracker, but established whitebark are often killed if burning occurs. Trees are killed not only directly from fire effects, but by fire stressed trees attracting bark beetles (see Consideration Item #14). Focusing burning in stands where whitebark has the potential to be well represented, but is currently not well represented, will reduce the potential loss of existing whitebark

Large stand replacing burn areas are the most attractive to Clark's nutcracker, but mechanical treatments that remove the trees without burning can be effective (Keane and Arno 2001). Consider implementing mechanical treatments in stands where the risk of losing established whitebark due to burning does not meet with management objectives.

While whitebark pines will grow well in stands with high site productivity, they compete best on harsher sites (see Consideration Item #9 reasoning- planting guidelines).

Accessibility and Public Information

Avoid planning restoration treatments that would not be financially or logistically practical (i.e. planting whitebark or using hand crews to light a Rx burn 10 miles from a road).

The majority of the problems that whitebark pine is facing today are human caused. Blister rust is a non-native pathogen that was introduced to the U.S. around the turn of the century. Fire suppression has led to advancing succession and denser forests. This has caused a decline in whitebark pine representation and an increase in potential fire severity in parts of its range. Global warming appears to be influencing native bark beetles, making them more effective at killing mature whitebark pine than they were historically (Logan and Powell, 2001, 2003). Forest Health Protection/Monitoring aerial detection surveys show that bark beetles are currently causing significant whitebark pine mortality in the GYA.

Humans have caused much of whitebark pines decline, and it appears that humans will now have to put forth great effort to keep from losing the function of this keystone species in high elevation ecosystems. Public education is needed so that people will understand the problems and be willing to support the effort. Access to whitebark communities could be used to provide opportunities for public education where it meets with other management considerations.

Timing

Seasonal timing of treatments should occur whenever there is the best chance of meeting restoration objectives.

Consideration Item 6. *Broad/Mid Scale: Successional potential and status*

Climax whitebark stands will maintain whitebark pine as the dominant species over time. These stands usually occur at the highest elevations where other tree species cannot survive. In areas where whitebark pine is the climax species, succession to more shade tolerant tree species and related reduction of whitebark pine representation is not a concern.

If mortality in climax stands due to blister rust and bark beetles is high, managers may want to consider planting whitebark pine in order to meet appropriate forest cover objectives established during land management planning, especially if seedlings with increased levels of rust resistant are available.

In stands where whitebark is seral, successional progression causes the whitebark to be replaced by more shade-tolerant tree species (primarily subalpine fir and Engelmann spruce). The greater the representation of the shade-tolerant species, the greater the decline of more seral species such as whitebark. Succession is one of the three major factors causing the decline of whitebark pine throughout its range (Tomback et al. 2001).

Lodgepole pine usually has the competitive advantage over whitebark pine when it establishes from seed after a stand replacing event because of its fast growth, serotiny, and copious seed production. Because lodgepole pine is also a shade-intolerant seral species, it will not replace whitebark at the rate that subalpine fir or Engelmann spruce will (Murray, 1996).

Managers may want to consider treating stands with low to moderate representation of subalpine fir/spruce if this meets with other management objectives. Treating stands earlier in the successional process would reduce loss of the whitebark pine component and decrease the likelihood that the stand will support a crown fire that will kill cone-bearing whitebark.

Consideration Item 7. *Broad/Mid Scale: Blister rust infection levels and mortality levels*

In areas where blister rust levels are high, trees with low rust resistance have generally either died or their cone-bearing branches have been killed. Blister rust generally kills the small cone bearing branches long before tree mortality occurs because it can girdle the smaller diameter more quickly. In addition, branches are more likely to be exposed to the windborne spores and become infected than the bole of the tree. Establishing new stands by burning in or near areas that have moderate levels of blister rust infection would create stands with higher levels of blister rust resistance than the native population since trees with resistance to the rust are more likely to be producing cones. Thus the seeds being cached by the Clark's nutcracker would have higher levels of resistance than the natural population. If opportunities for regeneration are not provided until blister rust infection and subsequent loss of cone production is high, the remaining resistant trees

will be at such low numbers that virtually all of the seeds will be eaten by the array of birds and small mammals that use them and few will remain to germinate and create new generations of whitebark pine (Tomback et al. 2001). In this case, collection of seed and planting may be the only practical option.

Nutcrackers typically cache seeds 1-3 km or less from harvest sites and sometimes cache only a few meters from seed sources (Tomback 2001). Ten kilometers is the maximum distance for sufficient seed dispersal to create a whitebark pine stand (Keane 2001). Nutcrackers are capable of carrying whitebark seeds up to 22 km, which is 100 times farther than most wind dispersed seeds of spruce and fir travel (Tomback et al. 1990).

When creating nutcracker caching sites by burning or mechanical treatment, emphasize protection of the phenotypically (potentially) rust resistant individuals. Avoid burning near resistant trees. Slash and duff can be pulled away from the trees, but often the trees are still stressed enough that they become more susceptible to mountain pine beetle (Baker and Six, 2001). See Consideration Items 8 & 14 discussions about protection from mountain pine beetle.

Planting trees of unknown resistance levels should not be done in areas of high levels of blister rust infections. Because natural rust resistance levels are so low, it is likely that the vast majority of the planted trees would not survive to cone-bearing age. Recent studies have shown that there are areas with naturally higher than average resistance (Sneizko et al. 2004). Emphasis should be put on identifying and collecting seed to produce seedlings from these areas along and on restoration efforts that promote natural regeneration with higher levels of resistance. *All Units in the GYA are strongly encouraged to get their “plus” trees identified and the seed collected from them so that the Greater Yellowstone/Grand Teton seed zone rust resistant breeding program can proceed. We currently have 65 of the 100 required collections. The eventual outcome of this effort will be a seed orchard that will produce rust resistant seedlings.*

Consideration Item 8. Broad/Mid Scale: Levels and trend of mountain pine beetle populations

In the absence of fire, both lodgepole and whitebark stands increase in age and thus suitability for mountain pine beetles (McGregor and Cole 1985).

Generally, only pines greater than 8 inches diameter breast height (DBH) are susceptible to mountain pine beetle (mpb) attack. Therefore, a diversity of age classes across the landscape insures that there will always be stands that are not susceptible.

Scorching and wounding of trees can attract mountain pine beetles, even at endemic beetle populations. Minimize scorching and wounding of 6”+ dbh whitebark during restoration treatments; trees down to 6” dbh are susceptible during mpb epidemics. Changes in microclimate that occur when adjacent trees are removed can also stress whitebark pine in the short term and make them more susceptible to mpb attack (Baker

and Six 2001). Consider protection of high value trees as discussed in Consideration Item #14 in both burning and mechanical restoration treatment areas.

If an active epidemic of mountain pine beetle is occurring, or if beetle populations are increasing, consider delaying the restoration treatments until the epidemic is over. If restoration treatments do occur, it is critical that scorching or wounding of high value whitebark pine be minimized. High value trees are primarily those that are bearing cones and/or exhibiting phenotypic blister rust resistance. Other factors that may contribute to high value are ability to bear cones in the future and resistance to mpb. Individuals of any species of pine tree stressed by the restoration treatments will attract mpb to the area, so treatments to protect high value whitebark should be strongly considered. Protection to reduce mpb mortality on high value trees includes using the anti-aggregating pheromone Verbenone (endemic populations only) or spraying the insecticide Carbaryl (see Consideration Item #14).

Consideration Item 9. *Stand Level: Recent Fire Events*

Recent fire events where there is a need to actively restore appropriate forest cover are good options for whitebark pine planting. Stands where greater than 50% of the whitebark pine cone bearing trees were killed should be considered for planting. Whitebark do not compete well with other conifers. If planting whitebark pine, choose planting sites where other conifers will reestablish slowly or where periodic treatments to remove competing conifers can be scheduled.

The likelihood and rate of natural regeneration establishment depends primarily on the abundance of seed sources, the proximity of those seed sources and the harshness of the site. A site with close abundant seed sources, particularly if the prevailing winds will carry the non whitebark conifer seed to the site, on a productive site (i.e. no harsh conditions such as steep slopes, southwest aspects, post high fire severity), will likely establish natural regeneration within 10 years.

Trees should only be planted from cone collections that selected blister rust-free parent trees. Stands Because seed transfer guidelines allow the transfer of seed from anywhere in the GYA, units with low blister rust levels should use seed collected from phenotypically resistant trees in stands with moderate or high infection levels elsewhere in the GYA. Planted seedlings should be from seed sources with the highest levels of rust resistant practical (See Consideration Item #7). It may be beneficial to plant whitebark pine on a variety of site conditions with a variety of methods in order to refine planting guidelines for your specific area that will optimize survival and growth of future plantings.

General planting guidelines developed by the Greater Yellowstone Coordinating Committee Whitebark Pine Committee in November 2001 are:

1. Plant on poorer sites if available to minimize competition from shade-tolerant conifers, forbs, grasses, and shrubs.
2. Do not intermix planting with other tree species; they can out-compete wbp.
3. Plant late June or early July; there has also been success with fall planting.
4. Use 9" container, 2-0 Supercell stock.
5. Microsites/shading helps the survival of planted whitebark seedlings. The wood or rock creating the microsite not only provides shading of the seedling, it also helps reduce competition and reduce moisture loss from the soil near the tree.
6. The lowest height growth of wbp is in the swales. Height growth improves as the slope increases with growth maximizing near the ridge.
7. Survival is best along ridges and high benches and lowest in swales. Low survival in swales is probably due to frost pockets and higher gopher populations.
8. A rocky ridge situation is the best for planting whitebark pine. Although wbp will grow better at lower elevations and in better soils, it does not compete well with other species that also grow there.

On the broad scale, planting should be done on a variety of sites, including the more productive seral sites. When practical, include the removal of non-whitebark conifer in the long-term.

Whitebark pine seedlings take 5-7 years before they start putting on much height growth after outplanting.

A doctoral dissertation done by Judy Perkins has found that grouse whortleberry (*Vaccinium scoparium*) has a positive effect and *Carex* has a negative effect on the growth and survival of planted whitebark pine seedlings (Perkins 2004). Planting spot selection should be adjusted to take advantage of this information.

Consideration Item 10. *Stand Level*: Distance from whitebark pine seed sources.

Stands that are experiencing high levels of whitebark pine mortality due to rust, beetles or succession and that are greater than 10 km (maximum distance to expect nutcrackers to reestablish a whitebark stand- Keane 2001) from a whitebark pine seed source should be a high priority for treatment. Further decline of the stand might result in a local extinction. Restoring whitebark pine in this situation may require planting since so many of the cone-bearing trees are lost.

Consideration Item 11. *Stand Level*: Grizzly bear use of whitebark pine

11A. Stands where grizzly bear use is emphasized

Grizzly bears obtain whitebark seeds from squirrel middens. In general, squirrels and their middens are more abundant in stands with high basal areas of mixed conifer species

that produce more constant supplies of squirrel food compared to pure whitebark stands that produce highly variable seed crops. Midden size and probability of occupancy decrease with increasing elevation.

Based on optimum conditions for bear use of squirrel middens, Mattson (2000) recommends an overall basal area ≥ 40 sq m/hectare (≥ 174 sq ft/acre) with whitebark basal area representing 15% to 50% of the total basal area.

In Yellowstone, grizzly bear use of whitebark pine seeds increases with increasing squirrel densities and decreases with increasing whitebark pine basal area. Maximum bear use occurs at relatively low whitebark pine densities (basal area of 3-8 sq meters/hectare or 13-35 square feet/acre).

Cone production is relatively low in stands younger than 100 years of age and reaches peak levels soon after. Moderate levels of cone production persist in stands 300-400 years old (Weaver et al., 1990). Conditions that optimize squirrel use should occur when the whitebark in the stand are at prime cone-producing age (100-300 years).

Grizzly bears suffer from anything that removes cone-producing whitebark pine, reduces squirrel densities, or reduces the size of squirrel middens (Mattson et al. 2001). Restoration efforts should emphasize techniques that minimize effects on these factors.

11B. Stands where whitebark pine restoration is emphasized

This section (11B.) discusses how areas without grizzly bear emphasis differ from those with grizzly bear emphasis. As with the majority of consideration items, regeneration treatments should be high priority in stands that are not currently dominated by whitebark pine, but historically supported, or have the potential to support, a stand dominated by whitebark pine. Treatments should promote the survival of cone-bearing whitebark pine where practical with emphasis on trees that are exhibiting phenotypic resistance to white pine blister rust.

In stands where whitebark pine restoration is emphasized:

Reduce as much competition from other tree species as practical for as long as practical. Emphasis should be on removing as many non-whitebark conifers as other management considerations allow. This would reduce competition with individual whitebark of all ages and would reduce the likelihood of a stand replacing fire. The likelihood of a fire becoming stand replacing increases as the component of shade-tolerant trees that have low fire resistance and create fuel ladders (i.e. subalpine fir) increases.

Design regeneration treatments that minimize the potential for seeding in from other tree species (i.e. large, stand replacing events, upwind from other conifer seed sources).

Create burned areas to attract Clark's nutcrackers. Openings created by mechanical treatments can also be effective, but recently burned over areas are the most attractive to

Clark's nutcrackers (Tomback 2001). Emphasize large openings for whitebark regeneration (minimum 50 meter diameter but the larger the better) unless seed sources are very limited. Large stand replacing fire events (>1000 hectares) near abundant whitebark pine seed sources can follow the successional pathway to become mature whitebark stands when wind-dispersal of fir, spruce, and lodgepole seed is limited (McCaughey et al. 1986). Whitebark pine has the competitive advantage in large burns because nutcrackers have been observed dispersing whitebark seeds over 10 kilometers (Tomback et al. 1990).

If practical, coordinate regeneration treatments with a good cone crop. When cone crops are good, each nutcracker can cache up to 100,000 seeds in a season. Because they only use a portion of these seeds to feed themselves and their families, the remaining seeds are effectively "planted" to potentially germinate and become whitebark pine seedlings.

Consider that small whitebark pine that are old and appear suppressed (stunted growth, gray bark, irregular shaped bole) generally remain suppressed and will not become cone-bearing, even with removal of competition (Keane 1994). Do not feature these trees as future cone-producing trees in silvicultural prescriptions or stand growth projections.

Consideration Item 12. *Stand Level: Successional potential and status*

In stands where whitebark pine is climax, succession to more shade-tolerant conifers is not a concern. The threats to these stands are mountain pine beetle (see Item #14), stand replacing fire (though fire of any intensity may increase mountain pine beetle), and blister rust. In climax stands with levels of mortality that do not meet land management objectives, consider planting to maintain adequate stocking and stand conditions (appropriate forest cover is defined in the NFMA 1976, Sec 4(d)(1)). Plant seedlings that have the highest level of rust resistance that is practical at the time of planting.

In stands where whitebark pine is seral, the effects of succession to more shade-tolerant conifers include the following (Keane 2001):

- Increase the risk of high severity fires. Increasing amounts of shade tolerant conifers and increasing fuel loadings due to succession, increases the likelihood of high intensity fire.
- Increase of epidemic insect and disease outbreaks.
- Decrease in plant diversity.
- Whitebark pine cone production decreases with the establishment of subalpine fir in the understory.
- Conifer encroachment into meadows causes loss of plant diversity and a reduction in fuel breaks.

Stands with a high percentage of whitebark pine representation are a lower priority for burning. This is because individual whitebark pine that are killed by fire represent loss of potential genetic contributions to rust resistance and loss of current or future cone

production. Consider treatments with low risk to residual stand (i.e. mechanical treatments with possible jackpot burning of slash). Sites that are within 0-3 km of cone producing whitebark have the optimum chance of whitebark pine regeneration establishment. Distances of more than 10 km between seed sources and caching sites are not recommended.

Stands with a low percent of whitebark pine are a higher priority for burning because of the decreased potential to kill rust resistant or potential cone-bearing whitebark pine. Consider pre-treating fuels around existing whitebark that are cone-producing or could potentially produce cones in the future. If pre-treating, pull fuels as far away from individual whitebark as practical; a minimum of 20 feet. Particular emphasis should be given to protection around trees that are exhibiting phenotypic rust resistance.

Consideration Item 13. *Stand Level: Level of blister rust infection and mortality*

Rust infected trees with more than 20-30 percent of the crown killed will never produce good cone crops again (Keane and Arno, 2001). Regeneration opportunities need to be made for areas that have moderate levels of infection so that trees with rust resistance will have the opportunity to regenerate. If restoration treatments are postponed until few cone-producing whitebark pine remain, then virtually all of the seeds produced by the resistant trees will be consumed and will not have the opportunity to become potentially rust-resistant seedlings.

Consider burning in or near moderately infected stands to create caching sites for seeds from the surviving rust-resistant individuals. Where possible, burning and silvicultural treatments should be focused on stands where the loss of the existing whitebark is not a major concern; stands with heavy rust infection or where succession has greatly reduced the representation of whitebark pine, provided other seed sources are available within a 3 kilometer distance.

Stands with high infection levels are a high priority for cone collections from phenotypically resistant trees. Trees that appear resistant in high infection level areas are more likely to be truly resistant and not just “escapes”. Consider designating up to three phenotypically resistant trees per stand for the rust resistance breeding program (see Consideration Item #7). These stands are also good candidates for planting with seedlings grown from trees with phenotypic rust resistance.

Consideration Item 14. *Stand Level: Levels and trend of mountain pine beetle populations*

All species of pine trees greater than 8” dbh are susceptible to mpb. Recent research has found that mountain pine beetle can successfully reproduce in whitebark pine smaller than 8” dbh (Logan and Powell 2001, 2003). Wounding trees, by scorching or even with

climbing spurs (sometimes used in cone collection) increases susceptibility and can attract beetles even at endemic population levels. Changing the climactic conditions around a tree by removing competing trees can create stress and make the trees more susceptible to mpb attack (Baker and Six 2001).

Strongly consider protecting “plus” trees in the rust resistance breeding program from mpb. Carbaryl is the most effective treatment, especially when beetles are at epidemic levels. Carbaryl has shown to provide greater than 90 percent protection for 2 years (Gibson and Bennett 1985). Verbonone is currently not recommended for use in protecting trees during beetle epidemics unless spraying with Carbaryl is not possible.

Even when mpb populations are at endemic levels, consider using the antiaggregating pheromone Verbenone or spraying the insecticide Carbaryl on high value trees within the stand where restoration treatments are occurring. Since mpb populations can build in stressed trees in treatment areas and spread to other areas, consider treating high value trees in adjacent stands also.

When mpb is at epidemic levels, widespread high levels of mortality are likely. Conventional wisdom was that mpb populations build in the lodgepole pine at lower elevations and sweep up into the whitebark zone. Currently in the GYA, the opposite situation appears to be occurring. Mpb is attacking whitebark pine preferentially over lodgepole where they occur side by side. Dr. Diana Six has found that mpb produce 3-10 times more offspring in whitebark pine than in lodgepole pine and that the offspring have higher fecundity rates. Mountain pine beetle also appears to be shifting from the typical two-year life cycle to a one-year life cycle in whitebark communities (Logan and Powell, 2001, 2003).

When mountain pine beetle levels in the area are high or increasing, avoid wounding or stressing trees as mentioned above in the endemic level discussion. Do everything stated above for low levels (avoid stressing whitebark trees and protect high value whitebark). Emphasize delaying restoration treatments until the epidemic is over. Stressing trees during an epidemic may have a negative net benefit on whitebark pine restoration due to increases in loss of potential cone-bearing individuals. If a restoration treatment must occur, emphasize choosing stands with little or no potential cone-bearing whitebark.

Consider that beetle populations may build in the trees stressed from the burn and then move into nearby stands; especially if the burn area has a large pine component. This is of particular concern during beetle epidemics or population upswings. In mechanical or prescribed burn treatments, using Carbaryl on high value trees within or nearby the stand during epidemic situations is strongly recommended.

Carbaryl provides 2 years of high level protection and is the best way to protect trees from mpb. Application can be difficult because the solution must be sprayed on the tree to a point of runoff (approximately 4-5 gallons of solution per tree) up to a point where the diameter of the tree is 5 inches in diameter. Verbonone comes in plastic pouches that are easily tacked on the tree. It is much easier to apply, but its level of protection is

significantly lower than Carbaryl's. Current studies are working to improve Verbonone's effectiveness. Bubble pouches containing the pheromone are put up on the tree twice during the season when mpb are flying (usually July through September). There is a study by Progar (yet unpublished) that concludes that Verbonone is not effective when beetles are at epidemic levels. Current studies are assessing the effectiveness of Verbonone when combined with other measures such as pheromone baited funnel traps. For more information on the use of carbaryl and Verbonone, contact your local State and Private Forestry, Forest Health Protection/Monitoring representative.

References

- Arno, S.F. 1980. Forest fire history in the Northern Rockies. *Journal of Forestry* 78:460-465.
- Arno, S.F. 1982. Whitebark pine cone crops—a diminishing source of wildlife food? *Western Journal of Applied Forestry* 1:92-94.
- Baker K.M., Six D.L, 2001. Effects of *Pinus albicaulis* (whitebark pine) restoration treatments on the distribution of bark beetle attacks. Masters Thesis, University of California-Berkley.
- Barrett S.W. 1994. Fire regimes on andesitic mountain terrain in northeastern Yellowstone National Park, Wyoming. *International Journal of Wildland Fire* 4:65-76.
- Bartlein P.J., Whitlock C., Shafer S.L. 1997. Future climate in the Yellowstone National Park region and its potential impact on vegetation. *Conservation Biology* 11:782-792.
- Gibson, K.E. and Bennett, D.D., 1985. Carbaryl prevents attacks on lodgepole pine by the mountain pine beetle. *Journal of Forestry* 83(2): pgs 109-112.
- GYCC Whitebark Pine Subcommittee, 2001. Notes from November 2001 meeting, taken by Melissa Jenkins- Committee Chair.
- Hoff, R.J, Ferguson D.E., McDonald G I., Keane R.E. 2001. Strategies for managing whitebark pine in the presence of white pine blister rust. Chapter 17, pgs 346-366 of the book *Whitebark Pine Communities, Ecology and Restoration*.
- Keane, R.E., Arno S.F., 1996. Whitebark pine (*Pinus albicaulis*) ecosystem restoration in western Montana. Pages 51-54 in S.F. Arno and C.C. Hardy, editors. *The use of fire in forest restoration*. Society of Ecosystem Restoration. USDA Forest Service, Intermountain Research Station, General Technical Report INT-GTR-341, Ogden, UT.
- Keane, R.E., Arno S.F., 2001. Restoration concepts and techniques. pp. 159-192, *in* *Whitebark Pine Communities, ecology and restoration*, Tomback D.F., Arno S.F., Keane R.E., 2001.
- Keane, R.E., 2001. Successional Dynamics: modeling an anthropogenic threat. pp. 367-400. *in* *Whitebark Pine Communities, ecology and restoration*, Tomback D.F., Arno S.F., Keane R.E., 2001.
- Keane, R.E., Morgan P., Menakis J.P. 1994. Landscape processes affecting the decline of whitebark pine (*Pinus albicaulis*) in the Bob Marshall Wilderness Complex, Montana USA. *Northwest Science* 68:213-229.

Kendall K.C., Keane, R.E., 2001. Whitebark pine decline; Infection, mortality, and population trends. pp. 221-242 *in* Whitebark Pine Communities, ecology and restoration, Tomback D.F., Arno S.F., Keane R.E., 2001.

Renkin, R.R. and Despain D.G., 1992. Fuel moisture, forest type and lightning-caused fires in Yellowstone national Park. *Canadian Journal of Forestry Research* 22:27-45.

Koteen L. 1999. Climate change, whitebark pine, and grizzly bears in the Greater Yellowstone Ecosystem. M.S. Thesis. School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut.

Logan J. A., and Powell J.A., 2001. Ghost forests, global warming, and the mountain pine beetle (Coleoptera: Scolytidae). *American Entomologist*, Volume 47 Number 3, Pages 160-172.

Logan J. A., and Powell J.A., 2003 Modelling Mountain Pine Beetle Phenological Response to Temperature. Mountain Pine Beetle Symposium:Challenges and Solutions. October 2003, Kelowna, British Columbia. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Information Report BC-X-399, Victoria, B.C. Pages 210-222.

Mattson, Blanchard, Knight, 1992. Yellowstone grizzly bear mortality, human habituation and whitebark pine seed crops, *Journal of Wildlife Mgt* 56(3):432-442

Mattson, D.J., Reinhart, D.P., 1994. Bear use of whitebark pine seeds in North America. Pages 212-220 in W.C. Schmidt & F.-K. Holtmeier, compilers. Proceedings – International workshop on subalpine stone pines and their environment: the status of our knowledge. U.S. For. Serv. Gen. Tech. Rep. INT-GTR-309.

Mattson D.J., Reinhart D.P., 1996. Indicators of red squirrel abundance in the whitebark pine zone, *Great Basin Naturalist*, Vol 56, No. 3, July 1996.

Mattson D.J., Reinhart D.P., 1997. Excavation of red squirrel middens by grizzly bears in the whitebark pine zone, *Journal of Applied Ecology*, 1997, 34, pgs 926-940.

Mattson D.J., 2000. Managing whitebark pine for grizzly bears: preliminary recommendations (Unpublished).

Mattson D.J., Kendall K.C., Reinhart D.P. 2001. Whitebark pine, grizzly bears, and red squirrels. pp.121-134, *in* Whitebark Pine Communities, ecology and restoration, Tomback D.F., Arno S.F., Keane R.E., 2001.

McCaughey, W.W., Schmidt, W.C., and Shearer R.C., 1986. Seed dispersal characteristics of conifers of the Inland Mountain West. Pages 50-61 in R.C. Shearer, compiler. Proceedings-Symposium of Conifer Tree Seed in the Inland Mountain West.

USDA Forest Service, Intermountain Research station, General Technical Report INT-203, Ogden UT.

McGreagor M.D., Cole D.M., 1985. Integrated management strategies for the mountain pine beetle with multiple-resource management of lodgepole pine forests. USDA Forest Service Intermountain Research Station, GTR INT-174, Ogden, UT.

Murray M.P., 1996. Landscape dynamics of an island range; Interrelationships of fire and whitebark pine (*Pinus albicaulis*). Ph.D. dissertation, College of Forestry, Wildlife and range Science, University of Idaho, Moscow.

Nijhuis, M. 2004. Global warming's unlikely harbingers, High Country News Vol. 36 No.13, July 2004.

Parsons D.J., Graber D.M., Agee J.K. and Wagtendink J.W., 1986. Natural fire management in national parks. *Environmental Mgt* 10:21-24.

Parker V.T., Pickett S.T.A., 1997. Restoration as an ecosystem process: Implications of the modern ecological paradigm. Pages 17-32 in K.M. Urbanska, N.R. Webb, and P.J. Edwards, editors. *Restoration ecology and sustainable development*. Cambridge University Press, Cambridge U.K.

Podruzny, S.R., Reinhart D.P., Mattson D.J., 1999. Fire, red squirrels, whitebark pine, and Yellowstone grizzly bears. *Ursus* 11:1999.

Reinhart D.P., Haroldson, Mattson D.J., Gunther, 2001. Effects of Exotic Species on Yellowstone's grizzly bears, *Western North American Naturalist* 61(3), 2001, pp. 277-288.

Romme W.H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. *Ecological Monographs* 52:199-221.

Romme W.H., Turner M.G., 1991. Implications of global climate change for biogeographic patterns in the greater Yellowstone ecosystem. *Conservation Biology* 5:373-386.

Sneizko, R.A., Samman S., Schlarbaum S.E., Kreibel H.B., eds. 2004. Breeding and genetic resources of five-needle pines; growth, adaptability and pest resistance; 2001 July 23-27; Medford, OR, USA. IUFRO Working Party 2.02.15. Proceedings RMRS-P-32. Fort Collins, CO: USDA, Forest Service, Rocky Mt Research Station.)

Tomback D.F. , Hoffmann L.A., Sund S.K., 1990. Coevolution of whitebark pine and nutcrackers: Implications for forest regeneration. Pages 118-129 in W.C. Schmidt and K.J. McDonald, compilers. *Proceedings- Symposium on whitebark pine ecosystems: Ecology and management of a high mountain resource*. USDA Forest Service, Intermountain Research Station, General Technical Report INT-270, Ogden, UT.

Tomback D.F., Arno S.F., Keane R.E. 2001. *Whitebark Pine Communities, Ecology and Restoration*. Island Press.

Tomback D.F., 2001. Clark's Nutcracker: Agent of Regeneration pgs 89-104 *in* *Whitebark Pine Communities, ecology and restoration*, Tomback D.F., Arno S.F., Keane R.E., 2001.

USGS. Seaber, P.R., Kapinos, P.F., Knapp, G.L., 1987. *Hydrologic Unit Maps*. Water Supply Paper. Report # 2294.

Weaver, T., Forcella, F. & Dale, D. (1990). Stand development in whitebark pine woodlands. Pages 151 155 in W.C. Schmidt & K.J. McDonald, compilers. *Proceedings – symposium on whitebark pine ecosystems: ecology and management of a high-mountain resource*. US Forest Service Gen. Tech. Rep. INT-270.