Whitebark Pine Direct Seeding Trials in the Pacific Northwest

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Background

Whitebark pine (*Pinus albicaulis*) is a critical species in many high elevation ecosystems and is currently in serious decline due to white pine blister rust (*Cronartium ribicola*), mountain pine beetle (*Dendroctonus ponderosae*), and competition from other species (Schwandt 2006; Tomback and Achuff 2010; Tomback and others 2001). Many areas needing restoration are very remote or in areas where the planting of seedlings may not be logistically or politically feasible. Consequently, it is important to determine if direct planting of seeds is practicable and which treatments enhance germination and chances of survival.

Collecting seed and growing whitebark pine seedlings is an expensive, complex and labor-intensive process that takes several years (Burr and others 2001; Farmer 1997). There is limited information related to direct seeding, but McCaughey (1990) studied regeneration of whitebark pine seed under three shade levels, three seedbed types, two sowing types and four predator exclusion levels. He found germination increased with shade cover and planting depth and was significantly higher on exposed mineral soil than litter or burned seedbeds. Seeds sown on the surface and not protected by rodent exclosures were all eaten by rodents.

Recent advancements in seed treatments have greatly improved germination success in nurseries, but have not been tested in the field. Direct seeding field trials to test these seed treatments, as well as rodent repellants, were established on two sites in late fall of 2005 and 2006, and four additional trials were installed in the fall of 2009. Results from these and additional tests may greatly improve the cost efficiency and feasibility of whitebark pine restoration across its range.

Objectives

The objectives of our direct seeding trials were:

- to develop techniques for direct sowing of whitebark pine seeds,
- to determine the germination success of seeds and survival of seedlings,
- to compare the survival of seedlings from directly planted seeds with that of outplanted nursery-grown seedlings in the same study areas; and
- to compare germination success of 3-seed caches with individual seeding.

Methods

Test sites were selected across the West and were in typical whitebark pine habitats with easy access that had recently experienced either natural or prescribed fire. The 2005 test site was a harsh, exposed site on Vinegar Hill near Baker City, OR (figure 1). The 2006 test site was a more mesic site on Mt. Bachelor near Bend, OR (figure 2). The 2009 sites were: Fairy Lake on the Gallatin National Forest near Bozeman, MT (figure 3), Thompson Peak on the Lolo National Forest near Plains, MT (figure 4), Ulm Peak on the Idaho-Montana state line west of Thompson Falls, MT (figure 5), and Gold Pass on the Idaho-Montana state line west of St. Regis, MT (figure 6).

Approximately 1000 seeds, collected from local seed sources, were planted at each site in a randomized complete block design with five replicates of eight treatments of 20 seeds per treatment. Treatments included: a 30-day warm stratification, scarification by sanding, a combination of warm stratification plus scarification, and control. The two early trials included three seed treatments to control rodent predation (using Thiram®, Ropel®, and hot pepper). At the Mt. Bachelor site, some of the seeds were planted in small peat pots to test the effect of improved moisture availability on germination and survival. The 2009 trials also included a

Figure 1. Vinegar Hill installation (November, 2006) with logs for shade.

In: Keane, Robert E.; Tomback, Diana F.; Murray, Michael P.; and Smith, Cyndi M., eds. 2011. **The future of high-elevation, five-needle white pines in Western North America: Proceedings of the High Five Symposium.** 28-30 June 2010; Missoula, MT. Proceedings RMRS-P-63. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 376 p. Online at http://www.fs.fed.us/rm/pubs/rmrs_p063.html

Figure 2. Mt. Bachelor site, installed September, 2007.

Figure 3. Fairy Lake installation (September, 2009) using snags and standing trees for shade.

Figure 4. Thompson Peak installation (September, 2009) using logs for shade.

Figure 5. Ulm Peak installation (September, 2009) using snow fence for shade.

Figure 6. Gold Pass installation (September, 2009) using snow fence for shade.

Figure 7. Germinating seedlings from 3-seed cache next to dead planted seedling at Thompson Peak site (July, 2010).

Figure 8. Row of germinating warm-stratified seed at Gold Pass (July, 2010).

planting of three-seed caches next to two-year old seedlings (figure 7).

Survival of germinants may be an even bigger challenge than enhancing germination; so half of the treatments were protected from rodent predation by hardware cloth cages. In addition, all treatments were placed behind logs (figures 1, 4), snow fences (figures 5, 6), or standing trees and snags (figure 3) to provide shade.

Installation of these trials was accomplished by U.S. Forest Service District and Forest Health Protection personnel. Germination and survival will be documented each spring and fall for all sites for at least three years.

Results

2005 and 2006 Trials

The majority of seed germination occurred the first spring following planting for all treatments. Some germination did occur the second year, especially for the control and scarification treatments, but no seeds germinated after two years. Warm stratification significantly improved germination, especially the first year at both sites. Seed scarification improved germination somewhat but did not improve on the warm stratification, even when combined with it. The rodent repellants appeared to have no positive effect and actually reduced germination in some replicates. The peat pots tended to be more of a source of curiosity for the rodents than a deterrent as many were dug up and scattered across the hillside.

Under the harsh conditions at Vinegar Hill, 43 percent of the warm-stratified seeds germinated, and 25 percent of the seeds that were both scarified and warm-stratified, germinated. The scarify only and control treatments had 20 percent and 17 percent germination respectively (table 1). There was very little evidence of rodent predation, and seeds treated with rodent repellants had less germination than the uncaged controls. Only 20 percent of all seeds germinated, and most of the seedlings were killed by heat shortly after they emerged. After three years, only 16 percent of seedlings were still alive, which is only two percent of the total seeds planted.

Germination and survival at Mt. Bachelor was much higher but followed the same pattern as Vinegar Hill. Germination of the caged warm-stratified seeds was over 70 percent; the caged warm-stratified plus scarified seeds was 56 percent; the scarified seeds was 43 percent; and the caged control was 51 percent (table 2). Although micro-site was very important to seedling survival, shade logs had little or no effect on germination and survival. However, survival at the Mt. Bachelor site was much greater on cooler, northern aspects (25 percent) than hotter aspects (<3 percent). Survival was considerably greater for caged seeds at both sites.

Preliminary Results From 2009 Trials

Germination by the end of July, 2010, at all four sites followed the same pattern found at the Mt. Bachelor and Vinegar Hill, except that the cages did not have a noticeable

Table 1. Annual percent germination by treatment at Vinegar Hill (planted November, 2005).

Treatment (100 seeds each)	2006	2007	2008	Total % germinated
Warm stratification (caged)	38.0	5.0	0.0	**43.0**
Warm stratification & scarified (caged)	25.0	0.0	0.0	**25.0**
Scarified only (caged)	11.0	9.0	0.0	**20.0**
Control (caged)	9.0	8.0	0.0	**17.0**
Control (no cage)	5.0	4.0	0.0	**9.0**
Thiram® rodent repellant (no cage)	6.0	5.0	0.0	**11.0**
Hot pepper (no cage)	0.0	7.0	0.0	**7.0**

Table 2. Annual percent germination by treatment at Mt. Bachelor (planted October, 2006).

Treatment	No. germinated	2007	2008	2009	Total % germinated
Warm stratification (no cage)	78	39.0	0.0	0.0	**39.0**
Warm stratification (caged)	144	71.0	1.0	0.0	**72.0**
Warm stratification with peat pot (no cage)	104	48.0	4.0	0.0	**52.0**
Warm stratification & scarified (caged)	112	50.0	6.0	0.0	**56.0**
Scarified only (caged)	86	30.0	13.0	0.0	**43.0**
Control (caged)	102	25.0	26.0	0.0	**51.0**
Control (no cage)	50	22.0	3.0	0.0	**25.0**
Ropel® rodent repellant	36	18.0	0.0	0.0	**18.0**
Ropel® rodent repellant in peat pot	16	8.0	0.0	0.0	**8.0**
Hot pepper (no cage)	20	9.0	1.0	0.0	**10.0**

effect on germinant survival at this early stage in the study. Germination of the warm stratified and warm plus scarified seeds at Gold Pass and Thompson Peak varied from 46 to 64 percent while germination of the scarified only and control seeds were less than half these levels (table 3). Germination of warm and warm-scarified seeds at Ulm Peak was 50.5 and 41.5 percent, respectively, while germination of the scarified only and control seeds was only 5.5 and 3.5 percent, respectively. The Fairy Lake site had very poor germination for all treatments, but germination of the warm-stratified and warm-scarified seeds (18-22 percent) was still much better than the scarified only (6 percent) or control seed treatments (7 percent).

Although the warm-stratified treatment outperformed all the other treatments, it is still premature to recommend this treatment since additional germination can be expected for at least one more year, and this treatment may have an effect on survival that has not been evaluated as yet. With the exception of the Thompson Peak site where 85 percent of the 3-seed caches had some germination by the end of July 2010, very few of these caches had any germination the first year. However, these seed were not treated, so they may not germinate until the second year.

Future Plans

Additional monitoring will be needed to better determine if the preliminary differences continue to hold up over time. The 2009 trials will be remeasured in the fall of 2010, and in the spring and fall of 2011, to document additional germination as well as mortality. Three additional trials were installed in the fall of 2010:

- Toboggan Ridge above the Lochsa River on the Clearwater National Forest in ID
- Yellowstone Club ski area near Big Sky, MT
- Southeast side of Mt. Hood in OR.

The Idaho and Montana installations included a ectomycorrhizal treatment developed by Montana State University (Mohatt and others 2008) on some of the seed as well as some of the seedlings. Additional sites in other areas may be added in the future to determine which treatments provide the best germination and survival across the range of whitebark pine.

Table 3. Average percent germination by treatment and site.

Site\Treatment	Warm Stratification	Warm Stratification + Scarify	Scarify Only	Control	Total germination
Gold Pass	64.0	46.0	23.5	20.5	38.5
Thompson Peak	53.0	54.0	20.5	22.0	37.4
Ulm Peak	50.5	41.5	5.5	3.5	25.3
Fairy Lake	22.0	18.0	6.0	7.0	13.3
Average germination	**47.4**	**39.9**	**13.9**	**13.3**	**28.6**

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