TECHNICAL NOTE

Whitebark Pine Planting Guidelines

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ABSTRACT

This article incorporates new information into previous whitebark pine guidelines for planting prescriptions. Earlier 2006 guidelines were developed based on review of general literature, research studies, field observations, and standard US Forest Service survival surveys of high-elevation whitebark pine plantations. A recent study of biotic and abiotic factors affecting survival in whitebark pine plantations was conducted to determine survival rates over time and over a wide range of geographic locations. In these revised guidelines, we recommend reducing or avoiding overstory and understory competition, avoiding swales or frost pockets, providing shade and wind protection, protecting seedlings from heavy snow loads and soil movement, providing adequate growing space, avoiding sites with lodgepole or mixing with other tree species, and avoiding planting next to snags.

Keywords: P*inus albicaulis*, reforestation, tree-planting, seedlings, plantations

Whitebark pine (*Pinus albicaulis*) is a keystone species in high-elevation ecosystems of the west. It has a wide geographic distribution (Tomback 2007) that includes the high mountains of western North America including the British Columbia Coastal Ranges, Cascade and Sierra Nevada ranges, and the northern Rocky Mountains from Idaho and Montana and East to Wyoming (Schmidt 1994). It occurs at elevations ranging from 5,000 to 11,000 ft, growing along ridge tops. It is important for watershed protection, esthetics, recreation, wildlife habitat, and is an important food source for birds, small mammals, and threatened grizzly bears (*Ursus arctos horribilis*) (Craighead et al. 1982). Clark's nutcrackers (*Nucifraga columbiana*) depend on it as a food source and are the primary seed disseminators.

Unfortunately, many fragile subalpine ecosystems are losing whitebark pine as a functional community component. Throughout its range, whitebark pine has dramatically declined due to the combined effects of an introduced disease, insects, and successional replacement. White pine blister rust (*Cronartium ribicola*), an introduced disease, has caused rapid mortality over the last 30–60 years. Keane and Arno (1993) reported that 42% of whitebark pine in western Montana had died in the previous 20 years with 89% of remaining trees being infected with blister rust. The ability of whitebark pine to reproduce naturally is strongly affected by blister rust infection; the rust kills branches in the upper cone-bearing crown, effectively ending seed production (McCaughey and Tomback 2001). Whitebark pine may have the highest susceptibility to blister rust of any of the 5-needle pines in North America. Fortunately, individual trees express notable resistance (Hoff et al. 1994, Kendall and Keane 2001). Whitebark pine appears to have resistance to blister rust allowing management strategies to incorporate resistance genes into planting programs (Hoff et al. 2001).

Montana is currently experiencing an active mountain pine beetle (*Dendroctonus ponderosae*) epidemic. According to Ken Gibson (Forest Service entomologist, Missoula, MT, personal communication, 2007), the impact to whitebark pine is the worst that has been seen since the 1930s. Mountain pine beetle prefer large, older trees, which are the major cone producers. In some areas the few remaining whitebark that show the potential for blister rust resistance are being attacked and killed by mountain pine beetles, thus accelerating the loss of key mature cone-bearing trees.

Wildfire suppression has allowed plant succession to proceed toward late successional communities, enabling species such as subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) to encroach into some high-elevation stands that were historically dominated by whitebark pine. These new cover types have higher fuel loading and increase the risk of stand-replacing wildfire. In addition, interspecies competition diminishes cone production and reduces natural regeneration.

Without prompt action, whitebark pine may soon be lost as an important vegetative component in many of our high-elevation ecosystems. In cases where natural selection of blister rust resistant trees are slow or where whitebark pine are lost to mountain pine beetle or where succession is occurring, planting whitebark pine is one management strategy for retaining or restoring the presence of whitebark pine.

Keane and Arno (2001) describe a seven-step process that is important in whitebark pine restoration efforts; managers need to add planting to this critical reforestation process. The practice of planting whitebark pine is relatively new compared to traditional conifers such as Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), ponderosa pine (*Pinus ponderosa*), and western larch (*Larix occidentalis*). There is limited research on planting techniques for whitebark pine, but knowledge about physiological and ecological characteristics of this species is increasing. Initial planting guidelines for whitebark pine were developed by Scott and McCaughey (2006). This article incorporates new information and experience to expand and further define those planting guidelines.

Growing Whitebark Pine Seedlings

The first step in a planting program for whitebark pine is collection of viable seed from potentially rust-resistant trees within the local seed zone (Mahalovich and Dickerson 2004, Bower and Aitken 2008, Burns et al. 2008). Cones should be protected with wire cages to eliminate loss from seed predators, and cone collection techniques should be followed to ensure quality seed is collected

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Figure 1. Whitebark pine plug seedling showing a well-developed root system. Photo courtesy of the Targhee National Forest, photo library.

(Mahalovich and Dickerson 2004, Davies and Murray in press, Murray 2007).

Whitebark pine has large seeds with a hard permeable seed coat (Farmer 1997, Krugman and Jenkinson 2008). Once collected, seeds need sufficient time in a conditioning environment to mature. McCaughey (1994b) recommends periodic inspection of cones to determine maturity and final collections when embryo-to-total-seed-length ratios are above 0.65 and endosperm-to-total-seed-length ratios reach 0.75 or more.

The Forest Service nursery at Coeur d'Alene has developed a protocol for germinating and growing whitebark pine seedlings (Pitel and Wang 1990, Burr et al. 2001, Gasvoda et al. 2002). Steps in this protocol include removing seed from cones, testing seed quality, storing seeds, preparing seeds for germination, producing seedlings, preparing seedlings for planting, and delivering seedlings. Seedlings are produced in relatively large containers (10 $in.^2$ volume).

With the potential of global warming in upper elevation zones, geneticists in the United States may modify seed transfer guidelines in the future when adequate survival information is available. In Canada, Bower and Aitken (2008) suggest moving seed from milder to colder climates to a maximum of 3.4°F in mean annual temperature in Canada and 1.8°F in the US Rocky Mountains.

Planting Guidelines

Based on ecological and physiological information, planting trials, research, and experience in the Northern Rocky Mountains, we recommend that the following nine guidelines be included in planting prescriptions for whitebark pine.

1. Plant large, hardy seedlings with well-developed root systems (Figure 1). Seedling vigor is important for both survival and growth of planted seedlings.

Table 1. Percent survival of whitebark pine planted in 1987 measured over eleven years across four physiographic conditions on Palmer Mountain, Gallatin National Forest, Montana.

	Physiographic Condition			
Year	Swale	15% Slope	Ridge	9% Bench
1987	100	100	100	100
1988	80	96	100	95
1989	58	86	100	86
1992	2	21	57	52
1993	2	20	47	44
1998	2	20	47	39

Source: Scott and McCaughey 2006

2. Reduce overstory competition. Although there are no defined basal area or trees-per-acre guidelines for overstory removal, experience suggests removing all overstory trees within a minimum 20-ft radius around the planted seedling. Whitebark does not create wide crowns when grown in competition with faster growing species such as lodgepole pine, subalpine fir, western white pine (*Pinus monticola*), and Engelmann spruce.
3. Plant in habitats that support whitebark pine. Whitebark pine is out-competed by other species on milder midelevation sites but has a slight competitive advantage on high elevation windswept ridgetops with shallow soils. In the northern Rockies, it is present on a variety of habitat types (Pfister et al. 1977) and is commonly found as a long-lived seral in the *P. albicaulis/Vaccinium scoparium*, *A. lasiocarpa–P. albicaulis/V. scoparium*, and *A. lasiocarpa/Luzula hitchcockii* habitat types (Arno and Hoff 1989).
   a. Avoid planting in burned lodgepole pine stands. Lodgepole pine typically regenerates quickly with high seedling numbers and rapidly out-competes whitebark pine.
   b. Do not plant in "mixed plantings" with other conifers. Whitebark pine seedlings grow slower and may eventually be suppressed by lodgepole pine, Douglas-fir, subalpine fir, and Engelmann spruce (Izlar 2007).
4. Reduce understory vegetation to make soil moisture and nutrients available.
   a. Avoid planting in beargrass (*Xerophyllum tenax*) because it is extremely hardy, competitive, has a tough and fibrous root system that is difficult to eliminate, and it quickly regenerates after fire. Few planted seedlings survive with beargrass within 16 in. (Izlar 2007).
   b. Sites supporting grouse whortleberry (*Vaccinium scoparium*) may need little or no site preparation. Recent work suggests a facilitative nurse plant relationship (Perkins 2004). When grouse whortleberry is not present, planting spots may be created by exposing mineral soil with a minimum radius of 12 in.
5. Avoid planting in swales and where soils are deep. Pocket gopher (*Thomomys talpoides*) activity increases in swales and where soils are deep. Gophers feed on roots of planted trees (Ferguson 1999) as well as burying them with soil. Ridge tops or exposed slopes are generally more suitable planting sites (Table 1) (McCaughey 1994a, Scott and McCaughey 2006)
6. Provide shade and physical protection. Plant on north side of stumps, rocks, large anchored logs, or other stationary objects to improve water utilization, reduce light intensity and stem heating, and provide protection from wind, heavy snow loads,

Figure 2. Whitebark pine seedling planted in the shade of a stump to protect it from intense heat, help with conservation of water, and act as a barrier to shifting snow and soil.

and snow creep (Figure 2). Logs should be stable and unable to roll over or onto seedlings. Large stable protection objects, upslope from planted seedlings, have been observed to redirect soil flow around seedlings and provide shade. When protection objects were located down-slope, soil "pooled" and partially buried seedlings, although many seedlings still survived. On steep slopes, the effect of snow movement was evident from the numerous cases of sheared-off tops on planted seedlings.

7. Avoid planting next to snags. Although snags make good initial seedling protection objects, downed trees, stumps, rocks, or broken off snags are better. Dead trees eventually fall and there are reports of planted whitebark pine pulled out of the ground or damaged by falling trees.
8. Avoid overcrowding to prevent future tree-to-tree competition. Open grown trees have the largest crowns and produce the most cones. Adjust spacing guides based on expected survival. Estimating 50% survival in the first 3–5 years, initial planting density should be 15 ft × 15 ft, producing 194 planted seedlings per acre, yielding approximately 85–100 live trees per acre.
9. Plant in moist soil. Soil should feel moist in the hand. Summer and fall plantings have been successful avoiding the need for long expensive snow plowing or delayed entry due to heavy spring snows. Modify planting windows based on climate and weather, especially droughty conditions.

Discussion

New information from research studies and monitoring observations has significantly improved the quality and effectiveness of previous planting recommendations. Planting whitebark pine is only a small part of the whitebark pine restoration strategy. Enhancing conditions for natural regeneration with prescribed fire or managed wildland fire are also actions that will make significant contributions to restoration. With proper attention to planting prescriptions and ensuring appropriate nursery culturing regimes, we can augment blister rust resistance and survival of planted trees where natural seed sources and natural regeneration are limited.

Genetics programs are testing for genetically improved seedlings patterned after western white pine and sugar pine (*Pinus lambertiana*) blister rust resistance programs, which will be a great aid in restoration. Development of natural selection stands is a management option where phenotypically resistant trees seem to be common (Hoff et al. 1994). However, where opportunity exists to plant whitebark pine, we cannot afford to wait for the development of rust resistant tree stock.

A growing number of silviculturists are being challenged to design and implement planting prescriptions for establishing whitebark pine on harsh sites where planting has previously seemed impractical. With continued research and monitoring, prescriptions that increase the number of blister rust resistant whitebark pine can be refined.

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