

Whitebark Pine (*Pinus albicaulis*) Direct Seeding Trials in the Northern Rocky Mountains: The Role of Planting Site and Cache Pilferage by Rodents

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Direct seeding is an emerging technique that could significantly reduce the labor and costs associated with whitebark pine (*Pinus albicaulis*) restoration, and may be compatible with wilderness values. Because other restoration methods—including outplanting of seedlings—are largely incompatible with maintaining wilderness as “untrammeled and natural,” the adoption of direct seeding may open an additional 48 percent of whitebark pine habitat to restoration efforts in the future.

We conducted a large direct seeding experiment on White Calf Mountain, Glacier National Park, Montana (USA) and Tibbs Butte, Shoshone National Forest, Wyoming (USA) to determine: (1) germination and first-year survival rates of simulated caches and how rates vary between subalpine forest and the treeline ecotone, (2) which planting site characteristics are important for germination and survival, and (3) rates of cache pilferage by small rodents (Order Rodentia). In 2012, we created simulated Clark’s nutcracker (*Nucifraga columbiana*) caches near three different microsite types (trees, rocks, or no object) at randomly selected locations using randomly generated cache sizes (numbers of seeds per cache, range = 1 to 7). Caches were revisited in 2013 and 2014 to assess germination, seedling survival, and seed loss. In 2013, 31.9 percent of 717 relocated caches germinated (25.6 percent on White Calf Mountain, 38.0 percent on Tibbs Butte). Odds of germination were 1.78 (95-percent confidence interval [C.I.] = 1.29–2.44) times higher on Tibbs Butte than on White Calf Mountain. On Tibbs Butte, odds of

germination were 1.71 (95-percent C.I. = 1.05–2.78) times higher at treeline than in the subalpine zone, and odds were increased for caches created near rocks or no object when compared to caches created near trees. About 54 percent of the caches created on both White Calf Mountain and Tibbs Butte were pilfered. At both study areas in the treeline zone, 62.1 percent of caches were pilfered; in the subalpine zone, 46.1 percent were pilfered. The estimated odds of pilferage at treeline were 3.94 (95 percent C.I. = 1.42–2.57) times the odds of pilferage at the subalpine sites. In 2014, 21.3 percent and 4.6 percent of the remaining caches germinated on Tibbs Butte and White Calf Mountain, respectively, for a total of 59.3 percent and 30.2 percent of caches created in 2012 germinating after 2 years.

Survival rates of seedlings germinated in 2013 were 66.9 and 35.6 percent on Tibbs Butte and White Calf Mountain, respectively. On Tibbs Butte, germination seems to be favored near rocks and in the open, and further investigation is needed to determine whether these findings are consistent throughout the range of whitebark pine. Because germination/survival rates exceeding 10 percent are considered successful for direct seeding efforts, observed germination rates suggest that large-scale direct seeding efforts should be considered for restoration. However, determining the regional drivers of successful germination and survival (climate, soils, seed source, and others) is necessary to ensure a full understanding of the processes required for germination and establishment to achieve the greatest success of direct seeding efforts.

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