



Whitebark Pine Seed Scarifier

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Whitebark pine trees perform roles in the high-elevation northern Rocky Mountains ecosystem. The whitebark pine produces large seeds that are high in fats and proteins. These seeds are an important food source for many animal species. Red squirrels and Clark's nutcrackers (figure 1) harvest most of the seeds. Squirrels cache cones in tree cavities or at the base of trees. The nutcracker uses its long beak to break open the cones and pull out the seeds. The nutcracker then caches 10 or 15 seeds at a time just below the soil surface in open, windswept areas. These areas will be accessible when the nutcracker looks for food during the winter. Beginning in mid-August, grizzly and black bears raid cones cached by the squirrels. They continue to feed on whitebark pine seeds whenever possible.

The Clark's nutcracker and the whitebark pine depend on each other for survival. Whitebark pine cones do not open by themselves. Nutcrackers not only break open the cones and pull out the seeds, they also plant seeds every time they bury a cache. The open, windswept areas are ideal sites for the whitebark pine to germinate and grow. Because a nutcracker may only eat half the seeds it caches, many seeds germinate.

Besides serving as a food source, whitebark pine trees play another pivotal role in the northern Rocky Mountains ecosystem where they occur. Because whitebark pines can grow in areas that are too dry, windy, and cold for almost all other trees, the species dominates many harsh subalpine and alpine sites. Whitebark pines tend to grow on windy ridges where they may act as snow fences where drifts accumulate. These drifts melt later than areas with thinner snowpack, extending and increasing runoff.

Populations of whitebark pine trees have been steadily declining over the past century. Several factors have contributed to the decline, including white pine blister rust, insect infestations, and fire suppression. Due to



Figure 1—The Clark's nutcracker uses its long beak to open whitebark pine cones and pull out the seeds. —Photo by Alan G. Nelson

the importance of whitebark pine seed as a food source for the grizzly bear and the tree's overall importance in the northern Rocky Mountains watershed, whitebark pine seedlings are being grown in nurseries and planted in increasing quantities.



Growing Whitebark Pine Seedlings

Growing whitebark pine seedlings is expensive and labor-intensive (*Whitebark Pine Communities*, Tomback, Diana F.; Arno, Stephen F.; Keane, Robert E., chapter 16). Successful cone collection requires several steps. Foresters must determine which trees have resistance to white pine blister rust (estimates suggest 5 percent). The cones may be protected by placing wire mesh baskets over the branches on the selected trees. Workers either climb the trees or are lifted into the tree's branches by a cherry picker machine with a long boom (figure 2). Just before snowfall, the cones are harvested and sent to the nursery.

At the nursery, the seeds of whitebark pines require more individual attention than other native pine seeds. The seeds are soaked for 48 hours in running water. Then the seeds go through warm stratification for 30 days at 72 degrees Fahrenheit. The seeds are rinsed weekly. Next, the seeds are placed in a dark refrigerator at 34 degrees Fahrenheit for a 60-day cold stratification. When the seeds come out of cold stratification, germination can be increased significantly if a 1-millimeter-deep nick is cut in the seed coat. This cut or nick can improve germination percentages from less than 5 percent to 60 percent or more. Nicking is an extremely labor-intensive operation that involves holding a seed and cutting the seed coat with a scalpel (figure 3). After the seeds have been nicked, they are placed on moist paper in covered boxes and germinated in a controlled environment. Seeds that germinate are individually transplanted into containers once the root is about as long as the seed.

Automating the Scarification Process

Cutting the 1-millimeter nick in the seed coat by hand is time consuming. Each seed must be held so it can be cut with a sharp utensil, such as a scalpel. Seeds can easily be cut too shallow or too deep and workers might cut themselves. Skilled workers can cut about 400 seeds an hour.

The Missoula Technology and Development Center (MTDC) was asked to develop a tool to automate the nicking process, reducing the overall cost of growing the



Figure 2—Members of a Helena National Forest crew place wire mesh baskets over whitebark pine cones that will be collected later for seed.



Figure 3—A scalpel is used to nick (scarify) whitebark pine seeds by hand.

whitebark pine seedlings. The center developed a prototype instrument that uses a high-speed, rotary cutting tool (Dremel tool) to nick the seed (figure 4). Seeds are fed by hand from a table into a V-shaped chute where a plunger pushes the seed at a controlled speed toward the rotating cutting head. Because the seeds have different sizes and shapes, the height of the chute must be adjusted relative to the cutting tool so a precise 1-millimeter cut is made (figure 5). The chute's height is adjusted by using a fiber-optic laser and photo sensor mounted across from,

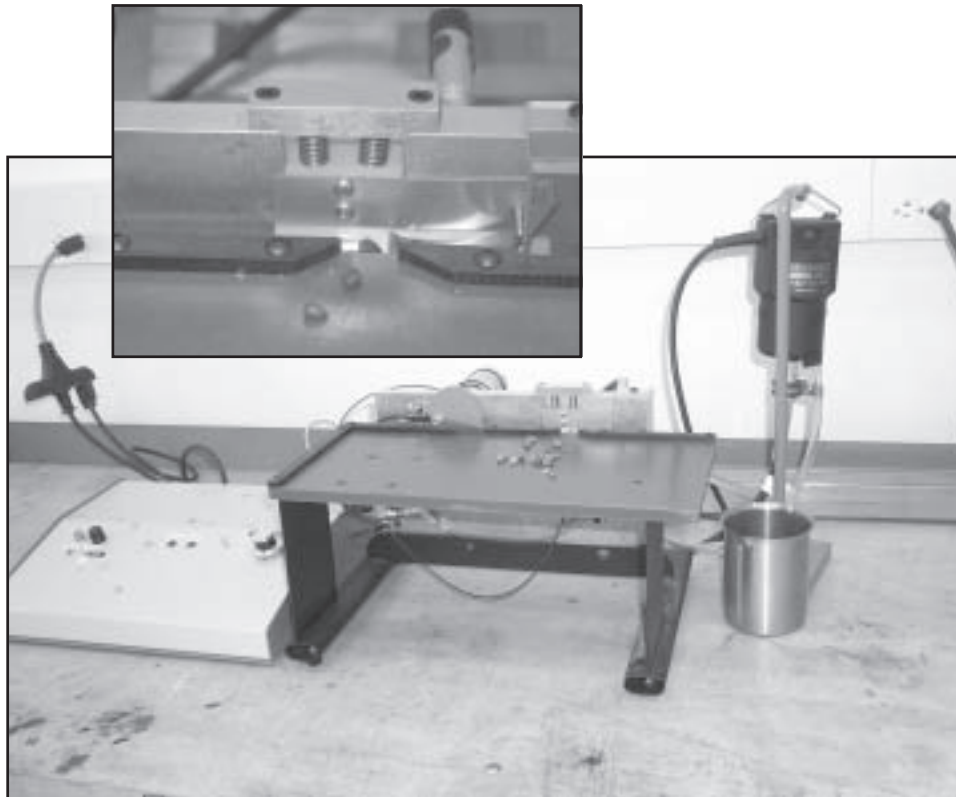


Figure 4—The MTDC prototype whitebark pine seed scarifier and the cutter head (inset).



Figure 5—Closeup of seeds nicked by the prototype machine.

and perpendicular to, the seed. As the plunger pushes the seed toward the cutting tool, the chute is adjusted vertically until the sensor detects the laser beam. The laser and the cutting surface of the rotary tool are aligned for a precise 1-millimeter deep cut. The plunger continues to push the seed over the rotary cutting head, which shaves the bottom of the seed precisely at a depth of 1 millimeter. The depth of cut can also be adjusted, if necessary.

The speed adjustment dial for the plunger and the on/off switch are located on the control panel. The high-speed rotary tool is mounted on a stand behind the instrument. A flexible shaft connects the tool to the cutting attachment that nicks the seed.

A seed scarifier costs about \$1,000 to fabricate.

Testing

During the spring of 2002, the U.S. Department of Agriculture, Forest Service, Coeur d'Alene Tree Nursery completed testing of the prototype whitebark pine seed scarifier. The tests had several objectives. One objective was to determine whether seeds nicked by the prototype scarifier germinated at a percentage equal to or greater than those nicked by hand. Another objective was to determine whether the location of the nick affected the germination percentage. Seeds nicked by hand are always cut on the seed's seam where the seed coat will open into two equal halves. The machine is not as consistent, but usually nicks seeds on the seam. The nursery also wanted to know whether germination percentages changed when the seed was sown in the growing boxes with the nick up or nick down on the moist paper.

For these tests, about 800 seeds were nicked with the prototype machine and 800 were nicked by hand. Each batch of 800 seeds was divided in half, with 400 seeds sown nick up and 400 sown nick down. All the seeds were sown in germination boxes (figure 6) and placed in an environmental chamber at about 70 degrees Fahrenheit with long days (the light on for long periods).

Testing Results

Results of the testing are shown in figures 7 and 8. The germination rate of machine-nicked seeds was 35 percent compared to 33 percent for the hand-nicked seeds. The germination rate for the seeds scarified by the machine and sown nick up was 39 percent compared to 31 percent for those sown with the nick facing down. These rates compare to 27 percent for hand-nicked seeds sown facing up and 39 percent for those sown facing down.

The time to scarify the seeds was estimated. While the fastest worker can nick 400 seeds per hour, the machine can nick about 1,500 seeds per hour.

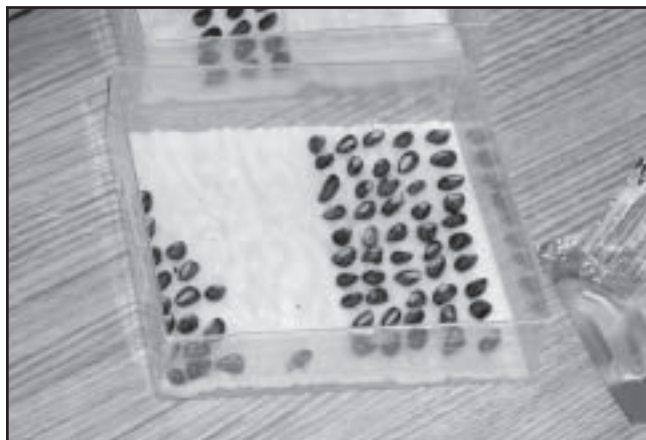


Figure 6—Nicked seeds are placed in germination boxes at the nursery.

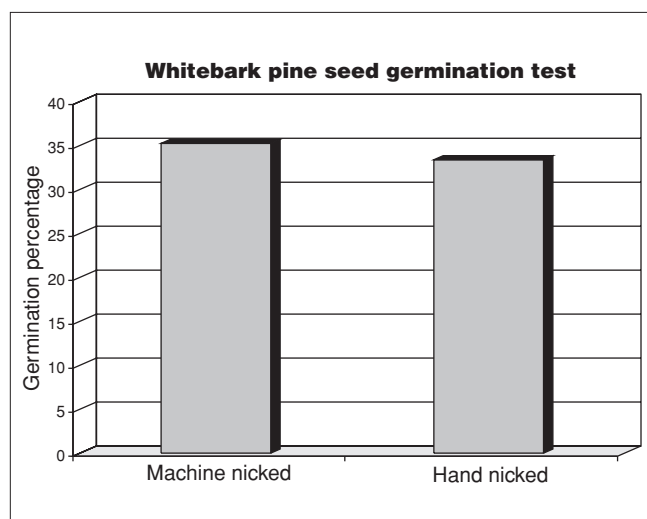


Figure 7—Overall germination percentages of whitebark pine seeds nicked by hand and those nicked by machine.

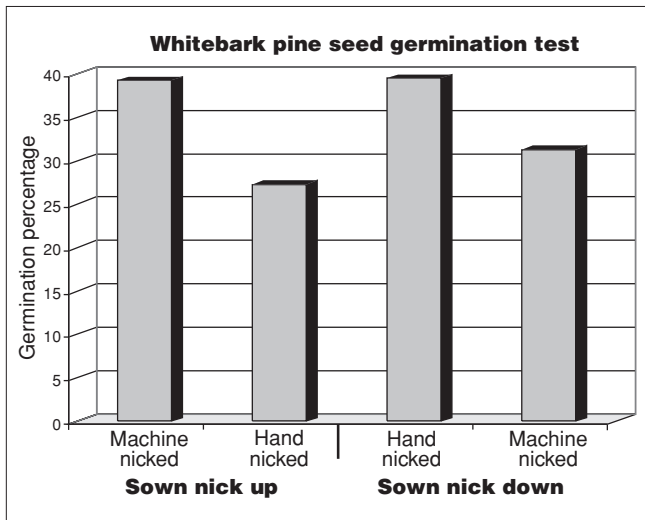


Figure 8—Germination percentages of seeds nicked by hand and those nicked by machine when placed in germination boxes with the nick up or with the nick down.

Conclusions

MTDC has developed a prototype whitebark pine seed scarifier that can nick seeds as effectively as those nicked by hand and more than three times as quickly. This machine should help reduce the costs of growing whitebark pine seedlings, saving districts reforestation costs and allowing more whitebark pine to be planted. The machine is safer than nicking seeds by hand, eliminating the possibility of hand lacerations. Seeds nicked by machine should be sown with the nick-side up, even though seeds nicked by hand should be sown with the nick down. Fabrication drawings will be available from MTDC. The machine costs about \$1,000 to fabricate.

About the Authors

Dave Gasvoda (retired) has a B.S. degree in electrical engineering from Montana State University. He joined MTDC in 1969 and worked on a wide variety of projects before retiring in 2001. Electronic devices he designed have saved Forest Service nursery workers hours of backbreaking labor.

Andy Trent is a project engineer at MTDC. He received his bachelor's degree in mechanical engineering from Montana State University in 1989. Before coming to MTDC in 1996, he worked as a civilian engineer for the Department of the Navy. Andy works on projects in the nurseries and reforestation, forest health protection, and watershed, soil, and air programs.

Chuck Harding is a mechanical engineering technician in MTDC's equipment fabrication shop. He came to the center from the U.S. Air Force Reserve where he worked as a metals technology technician. He has been with the center since 2000.

Karen E. Burr is a horticulturist at the USDA Forest Service Coeur d'Alene Tree Nursery overseeing seed and seedling quality activities. She was formerly a research plant physiologist at the Forest Service Rocky Mountain Research Station in Flagstaff, AZ. She received her Ph.D. in horticulture from Colorado State University.

Library Card

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Describes a prototype whitebark pine seed scarifier developed by the Missoula Technology and Development Center that allows workers to nick (scarify) seeds three times as fast as if they were doing so by hand, with reduced risk of injury. Populations of whitebark pine have declined over the past century because of white pine blister rust, insect infestations, and fire suppression. Whitebark pine seeds are a favored food of the grizzly bear, a threatened species protected by the Endangered Species Act in the 48 contiguous States. Whitebark pine trees, which may be the only trees growing in some sub-alpine and alpine areas of the northern Rocky Mountains,

also catch snow during the winter. The drifts melt more slowly than thinner snowpack in bare areas, extending runoff. The scarifier should help reduce the costs of growing whitebark pine seedlings, possibly allowing more whitebark pines to be planted. Seeds collected from whitebark pine trees resistant to blister rust are germinated in nurseries. The germination rate increases from about 5 percent to 60 percent or more if each seed has a 1-mm-deep nick. Workers can nick about 400 seeds an hour by hand, compared to 1,500 seeds an hour when using the prototype scarifier. The scarifier costs about \$1,000 to fabricate. Fabrication drawings will be available from the Missoula Technology and Development Center.

Keywords: Clark's nutcracker, drawings, equipment, germination, grizzly bears, nurseries, reforestation

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