Development of a Backpack-Mounted Pollen Vacuum

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Abstract

Supplemental pollination is regularly used in seed orchards to minimize gain dilution due to pollen sources outside the orchard. This practice requires large amounts of pollen. Standard pollen-collection methods can be labor intensive. This article describes parts needed and assembly steps for constructing a backpack-mounted vacuum system that is cord free and maintains suction efficiency without the need for filtration bags. This pollen-collection system has been used successfully at the Washington Department of Natural Resources Meridian Seed Orchard. The vacuum system also has potential for collecting native plant seed.

Introduction

Most Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) seedlings planted in western Oregon and Washington are grown using orchard seed from tree-improvement programs. The genetic gain level of orchard seed continues to increase as breeding and testing programs provide higher gain parents for inclusion in seed orchards (Jayawickrama 2005, St. Clair et al. 2004). As gain increases, the problem of gain dilution due to pollen contamination from sources outside orchard boundaries becomes more significant. One way to minimize gain dilution due to pollen contamination is to apply supplemental pollination, using pollen collected from high-gain parents. This type of pollen management is facilitated by the adoption of high-density orchard systems, similar to those used in fruit horticulture (Kolpak et al. 2015). These orchard systems keep crowns within reach from the ground, allowing for better access to pollen catkins and cone flowers and more rapid movement among trees. To take advantage of this improved orchard structure, however, better tools are needed.

Supplemental pollination programs require efficient collection of large amounts of pollen. The standard method of collecting Douglas-fir pollen for breeding work or supplemental pollination has been to collect branchlets of pollen catkins just before pollen shed, dry them under controlled conditions to enhance shedding, then sift the pollen through a sieve to remove needles, catkins, and other debris from the pollen (Webber and Painter 1996). With this method, however, both the collection and processing stages are labor intensive. Vacuuming the pollen from the trees is a more efficient process that eliminates the collection and processing of branchlets. The primary disadvantage of using a vacuum is that conditions must be favorable for pollen shedding, which usually occurs on dry afternoons. When weather is unfavorable, collecting branchlets will probably continue to serve an important role.

Pollen Vacuum Systems

Several vacuum systems were developed for orchard pollen collection in the 1990s by researchers at the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station (Copes et al. 1991, Silen 2000). Although these and similar systems work, they are cumbersome to move around the orchard, particularly when visiting many small trees. Some orchardists have used electric backpack canister vacuums, such as those used by cleaning staff in large commercial buildings. While the units themselves are fairly light and mobile, workers are still tethered to an electrical cord plugged into a generator that must be moved through the orchard. Also, this style of vacuum typically uses a filtration bag to capture material. The bags tend to plug up fairly quickly, reducing suction and requiring frequent replacement. Some gas-powered leaf blowers come with adapters to allow them to be used as vacuums. Using this type of leaf blower would allow for freedom from electric cords but would still have the same issue with plugging the filtration bag.

Meridian Pollen Vacuum System

We combined a gas-powered leaf blower with a small cyclone separator to create a backpack-mounted vacuum system that is free from electric cords and maintains suction efficiency without the need for changing filtration bags. The key features

are a fitting that captures the inflow to the blower so that it can be routed through a vacuum hose and a small cyclone separator that allows the pollen to fall out of the air stream before the air enters the blower and is expelled (figures 1 and 2). We tested the vacuum as described in this article and confirmed that essentially all pollen entering the vacuum is being captured by the separator, even at full throttle.

Vacuum Assembly

See table 1 for a list of parts needed. We provide brands and models of the components that we used simply because we tested the units using these components and verified that they work properly. Other brands and models may also work well, but we did not test other options. We did find that the cooling system of some blowers is not compatible with the airflow constriction inherent in this setup, which can result in engine overheating and failure.

Assembly Steps

[Conversions: 1 in = 2.54 cm; 1 ft = 30.48 cm]

1. **Assemble power unit.**

   a. Cut power unit shelf (9 by 13 in) from sheet of ¼-in plywood. On each 9-in side, cut a notch 3 in long and ½ in deep, centered between the corners.

   b. Attach blower to plywood shelf as follows:

      i. Blower should be positioned so that blower base under air outlet is 1.5 in from 9-in side of shelf, and black handle is flush with 12-in side of shelf; mark this position on the shelf with a pencil.

      ii. Make 2 straps, 2 holes long, from steel hanger strap; bend between the holes to form an "L" bracket. Place each L against the feet on the inlet side of the blower base along the 12-in side of the shelf, and mark the position of the strap hole on the plywood.

Table 1. Parts required for assembly of Meridian Pollen Vacuum System.

Power unit	Separation unit	Power unit to separation unit connection	Suction hose and funnel
1—pack frame (Alaskan Outfitter frame from Cabela's)	1—small cyclone separator (Dust Deputy from Oneida Air Systems; part #AXD001004)	1—4-by-2 in rubber coupling for ABS pipe	4 ft—1 ¼ in flexible vacuum hose (bought from local vacuum store)
1—gas-powered leaf blower (Echo ES-250)	1—clear plastic jar with 5-in diameter lid [it is somewhat difficult to find this size; we found one holding peanut butter-filled pretzels]	1—2 in PVC 90° elbow	1—2 ¼-by-1 ¼ in reducer (bought from local vacuum store)
1—2 -by-2 ft piece of ¼ in plywood (cut down to 9 by 13 in)	1—3 ft long by ¾ in wide by 1/8 in thick aluminum bar	1 ft—2 in Class 200 PVC pipe	1—right-angle hose adapter (from Oneida Air Systems, part #AHA000004)
1—3 ft long by ¾ in wide by 1/8 in thick aluminum bar	1—8-by-9 in piece of ¼ in plywood (cut from sheet listed under power unit list)	1—2 ½ in diameter by 5 ft long Dust Deputy flex hose with cuffs (from Oneida Air Systems, part #AXD250066)	2—hose clamps large enough to fit over 1 ¼ in hose
4—vibration dampeners; ¼ in male coarse thread by ¼ in female coarse thread (McMaster-Carr part #9378K31)	4—1 ½ in L-brackets (can also make these from aluminum bar)	1—right-angle hose adapter (from Oneida Air Systems, part #AHA000004)	1—large funnel, with outlet sized to fit snugly into 1 ¼ in hose
1 roll—3/4 in-by-10 ft galvanized steel hanger strap	12—¼ in bolts, 20 thread, ¾ in long	4—½ in sheet metal screws	1— 9-by-1 in PVC pipe
6—¼ in bolts, ¾ in long, coarse thread	4—¼ in bolts, 20 thread, 1 ½ in long	1 roll—duct tape	2—1 ½ in long, 20 thread, ¼ in bolts
4—¼ in bolts, 1 in long, coarse thread	4—¼ in flat washers		2— ¼ in lock washers
4—¼ in bolts, ½ in long, coarse thread	16—¼ in lock washers		2—¼ in nuts
16—¼ in flat washers			
18—¼ in lock washers			
10—¼ in nuts			
2—#8, ½ in long sheet metal screws			

ABS = acrylonitrile-butadiene-styrene; PVC = polyvinyl chloride. Conversions: 1 in = 2.54 cm; 1 ft = 30.48 cm.

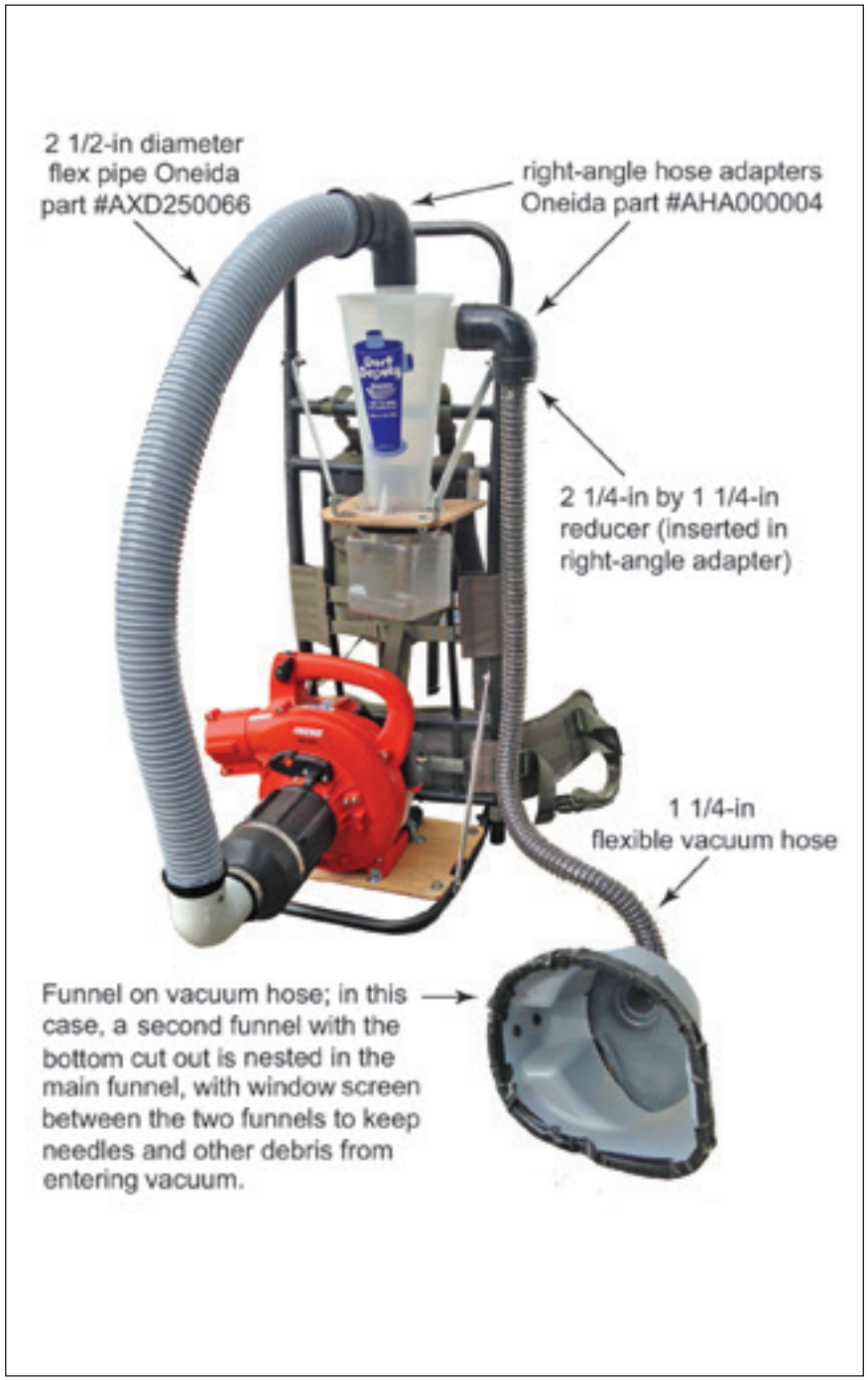

Figure 1. Rear view of Meridian Pollen Vacuum System. Conversions: 1 in = 2.54 cm; 1 ft = 30.48 cm. (Photo by Rocky Oster, 2015)

Figure 2. Side view of Meridian Pollen Vacuum System. Conversions: 1 in = 2.54 cm; 1 ft = 30.48 cm. (Photo by Rocky Oster, 2015)

iii. Cut 2 straps, 8 holes long, from steel hanger strap. Bend these straps over black handle on blower base, and mark the positions of the end holes on the plywood.

iv. Move the blower off the plywood base, and drill 5/16-in holes in the plywood at the 6 positions marked in steps ii and iii above.

v. Place the blower back on the plywood base. Attach the straps over the black handles using ¼-in by ¾-in long bolts with flat washers on both sides of the plywood and lock washers between the flat washers and nut.

vi. Attach the "L" brackets to the plywood with the same bolt/washer/nut combination in step v above; drill a 1/8-in hole through the hole in the "L" bracket into the plastic foot of the blower. Use ½-in long #8 sheet metal screws to attach "L" brackets to blower base.

2. Mount power unit on pack frame.

a. Remove bolts holding bottom shelf on pack frame; separate shelf from frame, and remove cloth platform from shelf.

b. Reattach shelf frame to pack frame using the original bolts.

c. Drill a 5/16-in hole in the outer tube on each side of the pack frame, 11.5 in above the base of the tube.

d. Drill a 5/16-in hole through each side of the shelf frame, 7 in from the pack frame.

e. Cut two 15-in pieces of aluminum bar; drill holes near the ends of the bars, 13.25 in apart.

f. Use aluminum bars to brace shelf to pack frame at points drilled in steps c and d above; use ¼-by-1.5 in long bolts, lock washers, and nuts.

g. Place power unit on lower shelf and drill 5/16-in holes through plywood and metal tube of shelf at four corners of plywood. Attach plywood to shelf using vibration dampeners between shelf and plywood (figure 2), with male end of dampeners through plywood and ¼-by-1 in long bolt through lower shelf into female end of dampeners. Use flat washers, lock washers, and nuts on male end. Use lock washers on bolts into female end. To minimize vibration, be sure that neither plywood nor blower body contacts pack frame or aluminum braces directly.

3. Assemble separation unit.

a. Cut separation unit shelf (8 by 9 in) from sheet of ¼-in plywood. Place an 8-in side against the pack frame at the cross bar behind the shoulder strap. Trace the curve of the cross bar on the plywood, and cut this curve into the plywood so the shelf can conform to the curve of the pack (figure 2).

b. Refer to the lid template from the Oneida web site; use a compass to mark a hole of correct diameter (about 3 in) on the lid of the plastic jar and on the separation unit shelf. Cut the holes in the plywood and plastic lid.

c. Look at the base of the cyclone separator. New holes need to be drilled closer to the walls of the separator so that the bolts will not interfere with the lid of the plastic jar that will be attached below. Following the same pattern as the existing holes, mark the placement of new holes that will be as close as possible to the walls of the separator while still allowing room for the heads of the bolts. New holes should be rotated so they are halfway between existing holes. After the new spots are marked, drill 5/16-in holes from below.

d. Center the cyclone separator over the hole in the plywood shelf (figure 2). The inlet of the separator should be adjacent to the curved side of the plywood and pointing toward the adjacent 9-in straight side (figure 2). Mark the newly drilled holes in the separator base on the plywood. Drill 5/16-in holes at each of those positions.

e. Center the plastic jar lid on the base of the cyclone separator, and mark the new holes from the separator on the jar lid. Drill the holes in the jar lid.

f. Use ¼-in by ¾-in long bolts with lock washers and nuts to sandwich the plywood shelf between the cyclone separator and the plastic jar lid (figure 2). Apply caulk between the layers to ensure a good seal in case of any gaps.

4. **Mount separation unit on pack frame.**

   a. Use four 1 ½-in L brackets with ¼-in bolts, lock washers and nuts to attach back of upper shelf to cross bar on pack frame (1 ½-in long bolts through pack frame, ¾-in long bolts for L brackets to plywood). New holes need to be drilled in pack frame for this step.

   b. Use ¼-by-1 ½ -in long bolts to attach aluminum bars to pack frame. Use ¼-in by ¾-in long bolts to attach aluminum bars to plywood shelf using L brackets. Use lock washers at all nuts and flat washers with lock washers on plywood surfaces. New holes must be drilled for each of these bolts.

5. **Connect power unit to separation unit (see figure 2).**

   a. Cut blower vacuum tube so that tube extends 2 in beyond ridges at base.

   b. Remove cover on inlet side of blower and screw shortened vacuum tube into blower.

   c. Attach rubber coupling to vacuum tube.

   d. Glue 2.5-in long piece of 2-in PVC pipe into the PVC elbow.

   e. Insert PVC pipe extending from elbow into rubber coupling and tighten.

   f. Place the Oneida right-angle hose adapter on the top of the cyclone.

   g. Shorten the Oneida flex hose to 40 in, and use it to connect the elbow adapter at the top of the cyclone unit to the PVC elbow pointing up from the power unit (figure 1). The fitting on the bottom end of the flex hose needs to be wrapped with several layers of duct tape to fit snugly into the PVC elbow. To keep the connections between the vacuum tube and the blower, as well as the hose and the PVC elbow, from vibrating loose, drill and insert ½-in long #8 sheet metal screws.

6. **Connect suction hose and funnel (see figure 1).**

   a. Attach Oneida right-angle hose adapter to inlet side of cyclone.

   b. Fit 2 ¼-in by 1 ¼-in reducer into elbow.

   c. Slide 1 ¼-in vacuum hose over reducer and attach with hose clamp.

Figure 3. Using the Meridian Pollen Vacuum System, one person can collect more than 0.5 qt (500 cc) of pollen per hour under good shedding conditions. (Photo by Rocky Oster, 2015)

   d. Insert funnel into other end of vacuum hose and attach with hose clamp.

   e. Bolt 8-in long segment of 1-in PVC pipe to back of funnel to serve as a handle. Use 1 ½-in nuts, lock washers, and bolts for this.

   f. For pollen-collection use, consider installing window screen material over top of funnel to screen out needles, catkins, and other debris.

Operating the Meridian Pollen Vacuum

We have successfully used the vacuum described in this article to collect a large volume of pollen in a short time when shedding conditions are good (figure 3). Good shedding conditions typically occur on warm, dry afternoons when humidity is low. If pollen sheds easily when branches

are lightly tapped, vacuuming conditions are good. It is important to focus on individual trees that are shedding heavily, because large tree-to-tree variation exists on any given day due to phenological differences. We found that, under good shedding conditions and focusing on the most productive trees, one person can collect more than 0.5 qt (500 cc) of pollen per hour.

Although our reason for developing this backpack vacuum was to collect pollen, we believe it may also have utility for efficient collection of some kinds of native plant seed. The system would need to be tested on each species, however, to confirm that the cyclone separator is effectively collecting the desired seed.

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REFERENCES

Copes, D.L.; Vance, N.C.; Randall, W.K.; Jasumback, A.; Hallman, R. 1991. Vacuum collection of Douglas-fir pollen for supplemental mass pollinations. Res. Note PNW-RN-503. Corvallis, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 8 p.

Jayawickrama, K.J.S. 2005. Genetic improvement: boosting plantation productivity in the Pacific Northwest. Western Forester. May/June 50(3): 10–11.

Kolpak, S.E.; Smith, J.; Albrecht, M.J.; DeBell, J.; Lipow, S.; Cherry, M.L.; Howe, G.T. 2015. High-density miniaturized seed orchards of Douglas-fir. New Forests. 46(1): 121–140.

Silen, R.R. 2000. Low budget pollen collector. Tree Planters' Notes. 49(3): 49–50.

St. Clair, J.B.; Mandel, N.L.; Jayawickrama, K.J.S. 2004. Early realized genetic gains for coastal Douglas-fir in the northern Oregon Cascades. Western Journal of Applied Forestry. 19(3): 195–201.

Webber, J.E.; Painter, R.A. 1996. Douglas-fir pollen management manual. 2nd ed. Working Paper 02/1996. Victoria, BC: British Columbia Ministry of Forests, Research Branch. 91 p.