Collection & Post-collection Handling

Cone collection and post-collection handling of cones is very important in determining seedlot quality. Information specific to cone collection and handling can be found in *A Guide to Collecting Cones of British Columbia Conifers* (Eremko et al. 1989); *A Field Guide to Collecting Cones of British Columbia Conifers* (Portlock 1996), or chapter 15 in *Regenerating British Columbia's Forests* (Leadem et al. 1990). Several aspects are worth emphasizing here. The first step is locating stands that meet your demands (e.g., Amabilis fir in the Maritime seed planning zone above 800 m) followed by monitoring the crop throughout cone development. The importance of pre-collection evaluations cannot be overstated. One should have a very good idea about cone and seed maturity, potential yield and degree of pest activity before collecting cones. Sampling should become more frequent as cones and seeds are approaching full maturity (generally August to September).

Collection Methods that Minimize Seed-borne Disease and Other Problems

Seed orchard cones are generally not affected by *Caloscypha* or *Sirococcus*, but are susceptible to contamination by *Fusarium* spp. Cones collected from natural stands are subject to *Caloscypha* and *Sirococcus* infection as well as contamination by *Fusarium* spp. Often cones are observed to be covered with moulds other than these and in many cases fungi present on cones are not pathogenic in nature. These can lead to other indirect losses however such as those caused by **casehardening**. In seed orchards cone contamination by *Fusarium* spp. likely occurs via spores, prior to collection. These contaminations are beyond the control of cone collectors. However, more control is available when collecting in seed orchards compared to natural stands and three things can be done to prevent further contamination and additional spread of the fungus.

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First, if possible, collect cones during dry weather. Second, store cones in new sacks or steam or hot water-sterilize old sacks before use to prevent contamination from a previous year's collections. Finally, store filled sacks following the general recommendations for all species described in Portlock (1996) to ensure the best conditions for drying while minimizing their exposure to conditions that favour the spread of fungus. These recommendations include the following:

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- Fill cone sacks only one-third to one-half full to avoid heat buildup
- Ensure that filled sacks are tied at the top to allow for cone expansion
- Store filled cone sacks on their sides, not upright, in a dry location off the ground
- Change sacks if they become wet during cone picking
- Store filled sacks in the shade during picking
- Move sacks daily from the collection site to interim storage
- Turn sacks when and if required (dependent on cone moisture content)
- Cone and seed evaluations and inspections should continue during interim storage
- Consult references for species-specific recommendations.

Seed orchard cones are usually picked by hand and post-collection contamination is minimized. Cones from natural stands may be collected using any of several methods, including climbing, felling, collecting from helicopters and squirrel caches. Each method exposes cones to contamination and infection and steps can be taken by pickers to minimize the impact of seed-borne disease in each case. As in seed orchards, cones should always be stored in either new or heat-sterilized dry sacks (use most cost efficient) to reduce the risk of *Fusarium* contamination.

Cone collection method and efficiency will vary with species and crop intensity. Some natural stand collections are made by climbing trees when cones are mature and either placing them directly into containers or more often, by shaking branches to knock cones to the ground. Often, it is expedient to climb many trees one after another, knocking large numbers of cones to the ground, returning to collect these

later. If all the cones knocked to the ground can not be collected immediately they risk exposure to *Caloscypha*, especially if left for extended periods in cool wet weather. Cones collected in this manner should be removed from the ground as quickly as possible. Otherwise, spread tarpaulins under the trees to separate the fallen cones from the duff. A common *Sirococcus* point of entry to the seed handling system occurs when old cones which have fruiting bodies on them (**Figure 34**), are included with the new cones collected from under trees. Ensure that pickers are diligent to avoid the inclusion of old cones in collections.

Figure 34 Avoid collecting old cones with *Sirococcus* fruiting bodies (pycnidia) on them.

Coordinating cone collections with logging is an efficient method of obtaining seeds. These situations offer opportunities to harvest cones from felled trees when falling operations and cone maturity coincide. Similar precautions to those used when knocking cones from standing trees should be employed when collecting from logging slash. Cones should be collected as quickly as possible after trees have been cut to avoid heating and to minimize their contact with forest duff and any *Caloscypha* inoculum. Similarly, steps should be taken to avoid including old cones and the potential introduction of *Sirococcus* into the collection.

Aerial collections using a helicopter allow cones to be harvested from the tops of trees (**Figure 35a**). Trees with heavy cone crops can easily be selected from the helicopter and with appropriate planning and coordination this can be a cost-effective method of collecting cones providing a broader range of choice through the opening of otherwise inaccessible areas. This is especially well suited to *Abies* spp. and others in which the cones are concentrated at the top of the crown. Helicopter collection allows little opportunity to assess phenotype, although it is generally accepted that helicopter collections offer a degree of disease avoidance, similar to collections from seed orchards. However, helicopter time is expensive and without precautions, the introduction of *Caloscypha* or *Sirococcus* can negate an otherwise high quality collection.

In order to optimize collection timing, monitor potential cone crops and choose helicopter cone collection areas before cones reach maturity. When collections are made, cone-bearing branches are either cut from treetops or cones are raked into a basket. With both methods, cone-bearing branches are dropped into a central area in the forest stand (**Figure 35b**). To minimize cost, cones are usually collected this way for several hours resulting in large piles of cones and branches to be sorted later. Spread tarpaulins on the ground, before the helicopter begins work, to minimize contact between cones and the forest duff. During hot weather, considerable heat can build-up within these piles. To guard against this, workers should spread the pile. In some situations, cones may not be separated from the branches and twigs for one or two days. This constitutes a risk to *Caloscypha* infection especially during wet weather. Western redcedar and western hemlock stand a risk of germinating under these conditions (**Figure 36**). During wet weather or those with heavy night dew, avoid leaving cone piles on the ground overnight. Take care also when sorting the cone/debris piles to avoid including old cones that might be infected with *Sirococcus*.

Figure 35 a) Helicopter cone collection from the top of a tree using a cone rake. b) Once cones are collected using the cone rake, they are collected in piles on the ground where they are potentially exposed to *Caloscypha*.

Figure 36 Premature germination of western redcedar in the cone.

The BC Ministry of Forests has not encouraged cone collection from squirrel caches since the late 1970s. It is briefly mentioned here to reinforce what we know with regard to the seeds or cold fungus. Cones have been traditionally collected from squirrel caches because it is relatively inexpensive and the collection period is much greater than with other methods. Observations appear to indicate that squirrels do not begin significant storage of cones until the seeds are mature. However, it must not be assumed that all cones and seeds are mature. Cached cones may require extra care and handling in interim storage. After dropping cones from trees, squirrels gather and place cones in piles or caches. These caches are usually located in cool shady areas and their biggest threat from seed-borne fungal pathogens comes from *Caloscypha*. If cones must be collected from squirrel caches, follow these recommendations to improve seed extractability and reduce the risk to seed-borne infection. Only collect cones from the top of the cache—buried, wet, or excessively dirty cones must be left behind. Clean collected cones of as much debris as possible prior to storage and give close attention to proper drying, as they are often wetter than cones collected using other methods.

Cone Handling and Seed Quality

Cone handling during and following collection can dramatically influence final seed quality as well as the incidence of seed-borne disease. Here we focus on the impacts that post-collection cone handling (interim storage) can have on seed-borne disease as well as overall seed quality. Options for impacting insect damage are limited as most feeding has already occurred. The exception is coneworm caterpillars that continue to cause damage until they pupate.

Cone and seed processing may need to proceed as quickly as possible depending on population and feeding levels. In the interim cones should be kept cool to minimize caterpillar activity and further damage.

Understanding the lifecycles of the three major conifer seed diseases reveals that each of them can become seed-borne while seeds are still in the cones. Initial contamination or infection may take place while cones are still on trees. This applies most often to contamination of cones by *Fusarium* spp., although to a lesser extent *Sirococcus* infection is technically feasible in this manner as well. *Caloscypha* infects cones when they contact the forest duff. Once cones become contaminated or infected, spread of the fungus is encouraged by moist and cool conditions. These conditions should be avoided during the period that cones are being transported or stored prior to seed extraction.

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Freshly picked cones are very moist and this moisture must be removed gradually to mimic the natural maturation process and prevent overheating and/or casehardening of the cones. Collecting immature cones or picking them during wet weather will compound moisture problems. For moist cones reduce the volume per sack to promote uniform drying.

Store cones in sacks under shelters (**Figure 37**) exposing them to freely circulating cool air to gradually remove moisture. The weave of the cone sack should not allow released seed to be lost. It is important that sacks are not stored in direct sunlight as overheating can damage cones, but they also should not be allowed to remain wet for excessively long periods as this will encourage the spread of any fungal growth. Remember that air movement is more beneficial to drying than light or heat and that shade or

Figure 37 Cones should be stored on well-ventilated racks in clean dry sacks.

indirect light with good airflow is essential. During pre-conditioning one can sometimes see a mass exodus of some insects exiting from the cone sacks as they begin the overwintering phase of their lifecycle. These insects will generally cause no further damage, but they can allow populations to build up in adjacent areas and one should consider eradication measures to avoid this.

Cone Transport

Transportation of cones from interim storage to the extractory is an important aspect of post-collection handling as seed quality can be degraded by improper transport. The keys to proper transport is to provide good circulation around the cone sacks, maintain a cool temperature and limit the time in the transport vehicle. Proper circulation can be accomplished by using pallets to separate cone sacks. For most species cone sacks should be two deep followed by another pallet. For serotinous lodgepole pine it is acceptable to stack cones sacks to a depth of four to six sacks separated by a pallet.

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The preferred transport method is in a refrigerated, closed van or trailer maintained at a temperature between 5 and 15°C. If cones are quite moist because of reduced or no interim storage (western redcedar and western hemlock) the vents must be open to allow for the removal of moist air. Non-refrigerated vehicles may be used to transport serotinuous lodgepole pine or collections that have been well conditioned. Transport time should be minimized with a suggested maximum transit time of 24 hours.