Chapter 2. Obtaining and Preparing Seeds

The process of growing any native plant begins with procuring a supply of high quality seeds or other propagules. In Chapter 1, we talked about the various types of native plant propagules, and now, we will discuss how to find and process seeds to get you ready for your first crop.

2.1 Important Seed Concepts

Before collecting or buying any native plant seeds, you should understand a few critical concepts.

2.1.1 Seed Dormancy

Although native plant seed can be categorized in many ways, its ability to germinate promptly is the most important from a grower's standpoint. This seed characteristic is known as dormancy, and for our purposes, we'll discuss non-dormant and dormant seeds. Non-dormant seeds are those that will sprout in a relatively short time—a few days, weeks, months but generally less than 1 year—without any special treatments. Examples include aspen, willow, and asters. Non-dormant seeds do not require any pre-sowing treatment other than soaking in water, and they are usually sown in the nursery soon after collection. Storage and handling of non-dormant seeds is critical because they must be kept moist. Temporary storage should be in a shaded, cool location. Large seeded, non-dormant seeds, such as acorns and nuts, must be kept fully moist by keeping them in trays under damp burlap bags or in plastic bags filled with moist sand or peat moss. Just prior to sowing, seeds are usually soaked in water for a few hours to a few days, depending on species.

Dormant seeds require some sort of pre-sowing treatment, but store easily for long periods and can tolerate drying. Most conifers and many other native species fall into this category. Pre-sowing treatments to overcome seed dormancy will be discussed later in Section 2.8, Seed Treatments. Dormant seeds retain viability for periods longer than a year and can be dried to low seed moisture levels and stored under lower temperatures.

2.1.2 Seed Source

Plants are genetically adapted to their environment, and this adaptation is known as "seed source" in nursery jargon. If you plan to collect seeds locally, grow plants, and outplant them in the same climatic region, then your plants will be adapted and seed source isn't critically important. If you purchase seeds, however, then you must consider where they were collected.

Collecting seeds from a wide genetic base fosters a more diverse gene pool at the outplanting site. This can protect a planting against unforeseen biological and environmental stresses, and it also protects against potential genetic problems in future generations. For restoration and conservation projects, maintaining genetic diversity is a key project objective.

2.2 Purchasing Native Plant Seeds

If you need a small quantity of seeds or don't have the time or resources to spend collecting your own, purchasing from a seed dealer may be more appropriate.

Seeds for many native plants are available from seed collectors or seed dealers. Seeds are generally listed by common or scientific name, and it only makes sense that local seed vendors will more likely have the species that you are looking for. Finding the proper seed source is often more difficult. It's a good idea to ask the seed dealer which seed sources of a particular species they have in stock, rather than specify which source you're looking for. Some unscrupulous dealers always seem to have whatever source you need if they want to make a sale badly enough. To find reputable seed dealers in your area, call some local native plant nurseries or your local native plant society.

2.3 Collecting Native Plant Seeds

Collecting seeds may be appropriate if you want seeds from a specific location or from specific plants. Just like people, plants of a particular species come in different shapes and sizes and, young plants usually resemble their parents. Therefore, only collect seeds from healthy and vigorous plants—ones that look like you want your plants to look. It may be easy to collect seeds from low growing plants or trees with limbs close to the ground, but this growth form may be genetic. So, with forest trees, especially those that are being grown for timber purposes, avoid trees that are forked, crooked, or have excessively large limbs.

Before starting any seed collection, learn as much as you can about the ecology of the plant species. Some seeds are large and easy to collect while others will require special procedures or equipment. Annual plants, and perennial grasses and forbs, produce some seeds every year but the seed crops of perennial woody plants, such as shrubs and trees, can vary considerably from year to year. For example, trees like aspen produce seeds in 1 year, but others like pines and oaks can take 2 years or more to produce seeds.

For an example of why it's important to know the biology and ecology of a native plant species, let's consider the oaks. Oaks can be divided into two groups: the "white" oaks, which produce acorns in one year and the "red" oaks, which take two years. In southern Oregon, two oak species grow on the same site. California black oaks (red oak group) have large acorns that are easy to collect (Figure 2.1A), but this species takes 2 years to produce seeds and only have abundant seed crops every 8 years or so. In contrast, Oregon white oaks (white oak group) produce acorns in a single year. By knowing the biology of this species, the location of a seed crop can be predicted by observing the abundance of the female flowers on second year twigs (Figure 2.1B).

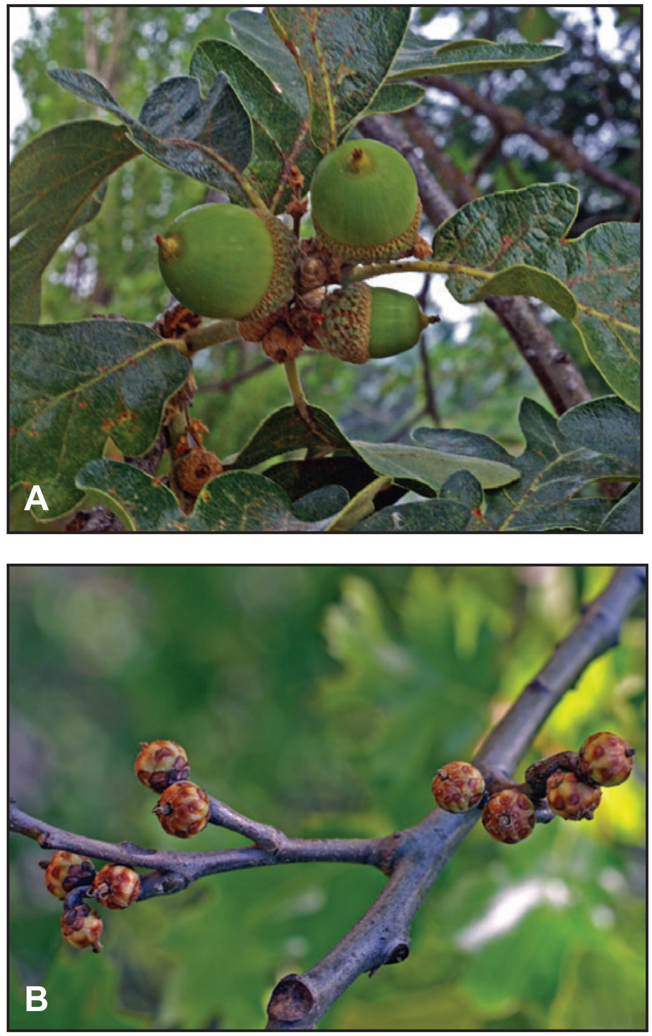

Figure 2.1*—Oak acorns vary in the time they take to mature and how long they can be stored. Acorns of California black oak (A) take 2 years to mature but can be stored for several years. Future seed crops can be predicted by observing the small female flowers on twigs (B).*

Native Plant Seed Collection Guidelines

- Always ask permission to collect seeds from private lands, and don't collect from public lands without a permit.
- Be absolutely certain of the positive identification of plant species. If in doubt, collect and press a specimen for identification.
- Collect a few seeds from as many individual plants of the species as possible. A good rule of thumb is to collect from at least 30 individuals.
- Try to collect the same amount of seeds from each plant; no one plant should be over-represented in the collection.
- If you are collecting seeds from a different location from where you will be outplanting your crop, try to select an area with similar elevation, aspect (north, south, east, west), and soil type.
- Leave enough seeds as a food source for animals and to ensure the natural reproduction of the plants.
- Avoid soil disturbance and plant damage while collecting seeds, especially in fragile habitats.
- If possible, leave an area to rest for at least two growing seasons between collections. Keep in mind that longer periods may be needed for some plant species.
- To prevent possible contamination of your seeds, avoid weed infested areas if possible.

2.3.1 Collecting Seeds and Fruits

Native plants produce a wide variety of seeds and fruits that often need to be cleaned and processed before sowing. The process for each species is very different so we won't attempt to cover all species here, but we will give some general examples.

2.3.1.1 Conifer Cones—Conifer fruits are woody cones that contain many hard-coated, winged seeds (Figure 2.2).

Most conifers do not produce abundant cone crops every year, and the frequency depends on the species (Table 2.1).

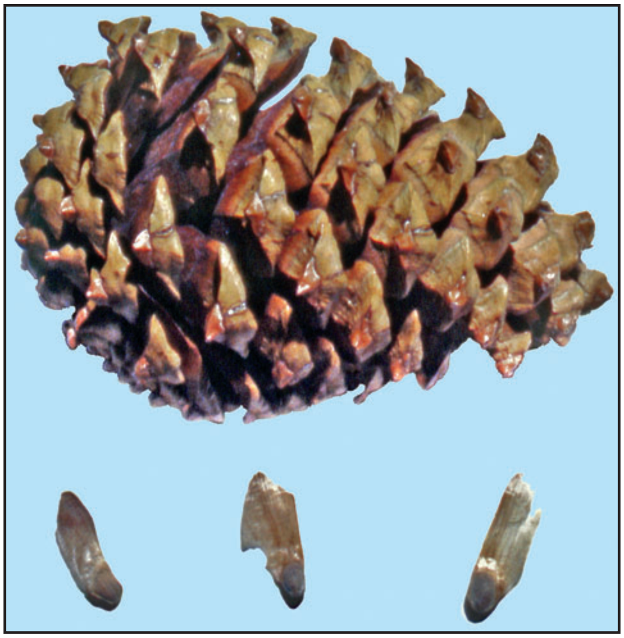

Figure 2.2—*Conifer cones are actually woody fruits that contain winged seeds.*

Generally, cones at lower elevations are ready first, ripening gradually at higher elevations. Start checking potential trees in early summer at low elevations or mid summer for higher elevations.

Because seeds develop gradually in cones, it is difficult for a beginner to determine when it's time to harvest them. In nature, most cones dry out until the seed scales open and the winged seeds blow away in the wind. So, the challenge is to harvest cones when seeds are mature, but before the cones dry too much and release the seeds. Pine cones change color from green or purple to yellowish-green to tan as the cone dries and the seeds mature. This change occurs gradually and is not a perfect guide to seed maturity, and often seeds are mature before the cone changes color.

To really tell if conifer seeds are mature, you'll need to cut the cone in half and check. Cones can be cut with a machete or hatchet. Cut cones lengthwise to expose seeds of Douglas-fir, pine, hemlock, spruce, and larch (Figure 2.3). Cones of true firs (noble, grand, balsam, and others) are cut a little different; slice the cones lengthwise about ½ inch to one side of the cone's core

Table 2.1—Four common conifers of the western U.S. and the years between good cone crops.

Common name	Scientific name	Cone cycle (years)
Grand fir	*Abies grandis*	2 to 3
Colorado (blue) spruce	*Picea pungens*	1 to 3
Ponderosa pine	*Pinus ponderosa*	2 to 5
Rocky Mt. Douglas-fir	*Pseudotsuga menziessii* var. *glauca*	2 to 11

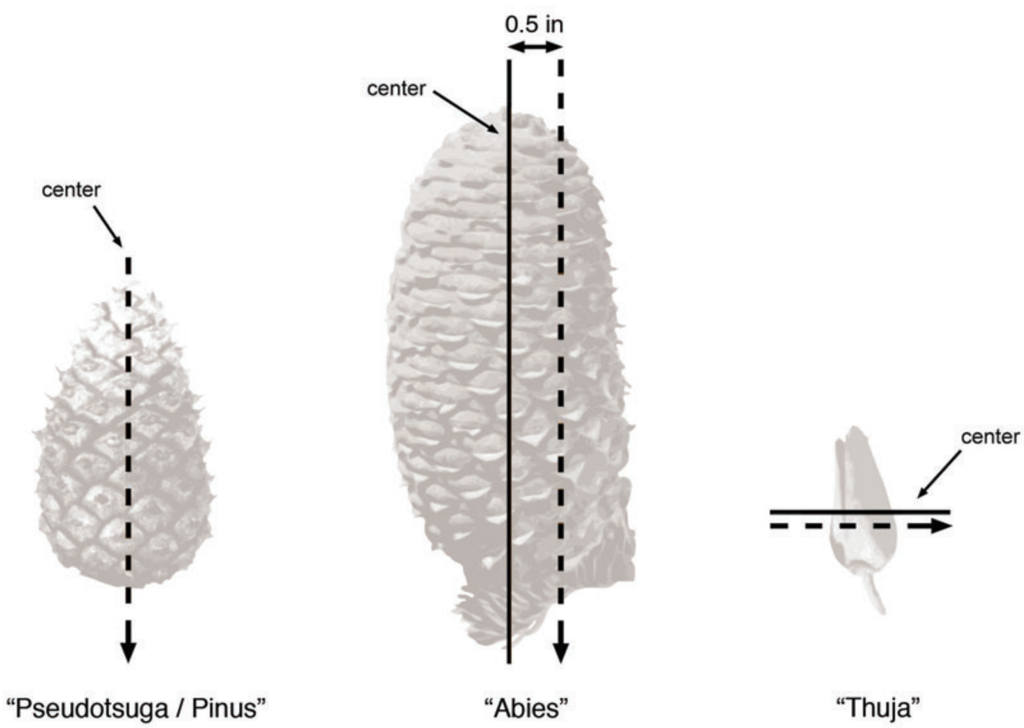

Figure 2.3—*Conifer cones can be checked for filled seeds by cutting them in half. For Douglas-fir, pine, hemlock, and spruce, cut the cones exactly through the middle (left). For true firs, cut cones lengthwise about ½ inch to one side of the cone's core (middle). For western redcedar and northern white-cedar, cut the cones widthwise just below the center of the cone (right).*

to ensure cutting through seeds. For western red-cedar, incense-cedar, and arborvitae, cut the cone widthwise just below the center of the cone.

Inspect the cut seeds on the cone faces with a hand lens to evaluate seed maturity (Figure 2.4A). Mature seeds have embryos that fill 90% or more of the embryo cavity (Figure 2.4B), and the material around the embryo is whitish and firm with a texture like coconut (Figure 2.4C). Cones can be harvested earlier, when embryos fill 75 to 90% of the cavity, but then you will have to after-ripen the cones for 2 to 6 weeks (see Section 2.7.2.1, Internal Dormancy).

Based on the number of filled seeds per cone, you can determine how many cones you will need to collect. Cones can be collected with pole pruners or by climbing the trees, but climbing should generally be left to experts. Squirrels begin cutting cones and caching them around the bases of trees at about the time that seeds mature, so the easiest harvesting is to steal a few cones from a cache but make sure you leave some for the squirrel. Place cones in burlap or nylon screen sacks, and don't contaminate your cones with needles, branches, and dirt that could introduce damaging molds. Cones have a high moisture content so fill sacks only half full to allow for air circulation and cone expansion during drying. Never toss or drop a bag of cones. Label each sack immediately with species, elevation, collection location, date, and any other pertinent information. Store sacks on open racks in dry, well-ventilated shelters, such as open-sided sheds or well-ventilated barn lofts. You may also hang sacks from rafters. Either way, sacks should be separated to permit good air circulation. Stored this way, cones will dry gradually with a minimum of overheating and mold damage. Check cones often and inspect them for mold. If mold is present, rearrange sacks to improve air circulation. If you picked cones with mature seeds, cones should dry satisfactorily in a few days, depending on the weather. If you picked green cones, it may take a few weeks or months for seeds to finally mature.

Some pines, such as lodgepole, knobcone, and jack, have cones that require heating before they will open. Here's an easy way to open them. Put cones into a burlap bag and immerse the bag into very hot water (about 180 °F) for 30 seconds to one minute. Remove the bag, dump the cones onto a screen-bottomed tray, and place them in a warm location. The hot water softens the resins that keep the cones closed. As the cones dry, the scales pull open and you can extract the seeds.

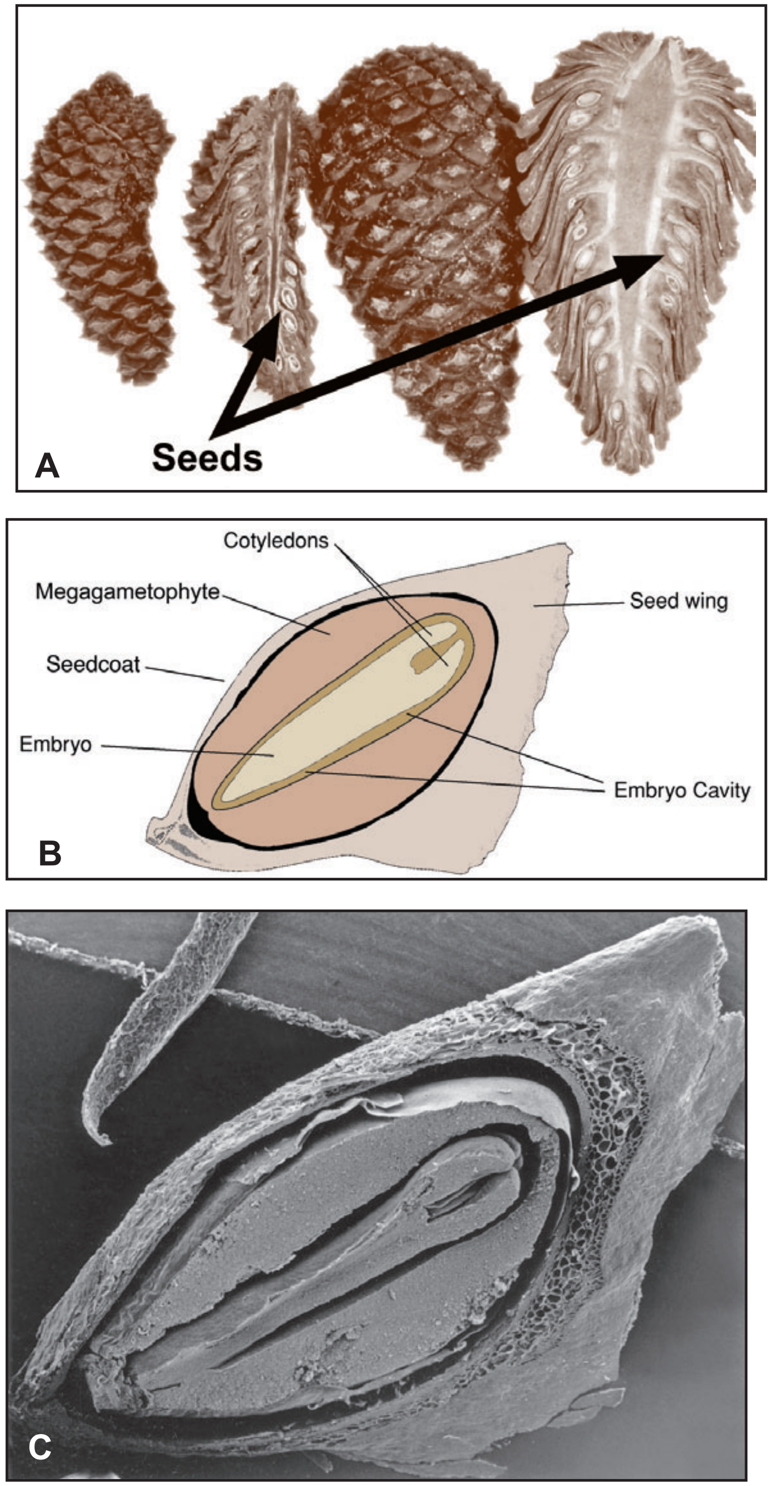

Figure 2.4*—The cut faces of conifer cones (A) can be inspected with a hand lens to evaluate seed maturity. The embryo (undeveloped seedling) in a mature conifer seed should almost fill the cavity (B). The embryo and megagometophyte (storage tissue) should be white and have a firm texture like coconut meat (C) (courtesy of L.E. Manning, Canadian Forest Service).*

2.3.1.2 Dry and Fleshy Fruits—Dry fruits are those that are woody or papery at maturity and examples are hazel nuts (Figure 2.5A) and capsules (Figure 2.5B). Some dry fruits will split open at maturity. You will need to harvest these just before the fruits begin to split open and seeds disperse. Other dry fruits have structures where both the fruit and seed are fused together and do not split open at maturity. Dry fruits can be collected like cones. Nuts and acorns can be harvested after they drop from the tree as long as they are handled and cleaned immediately after collection (described below).

Fleshy fruits are those usually comprised of three layers: the skin, the often fleshy middle, and the membranous or stony inner layer (Figure 2.6). Depending on species, fleshy fruits can contain many seeds per fruit or they can bear a tough, stony pit that encloses only one seed. Therefore, the amount of fruits you have to harvest to obtain a desired number of seeds will vary greatly from species to species. When collecting and handling fleshy fruits, it is important to keep them cool and out of direct sun. Heat buildup and subsequent fermentation can damage the seeds inside the fruits. It is also important not to let the fruits dry out, because this can make cleaning more difficult. Collect fleshy fruits in white plastic bags, and store them in a cool place or a refrigerator until they are cleaned.

Figure 2.5—The seeds of some dry fruits, such as hazel nuts, are enclosed in a thin papery shell (A). Penstemon fruits are capsules (B) that contain many small black seeds (C).

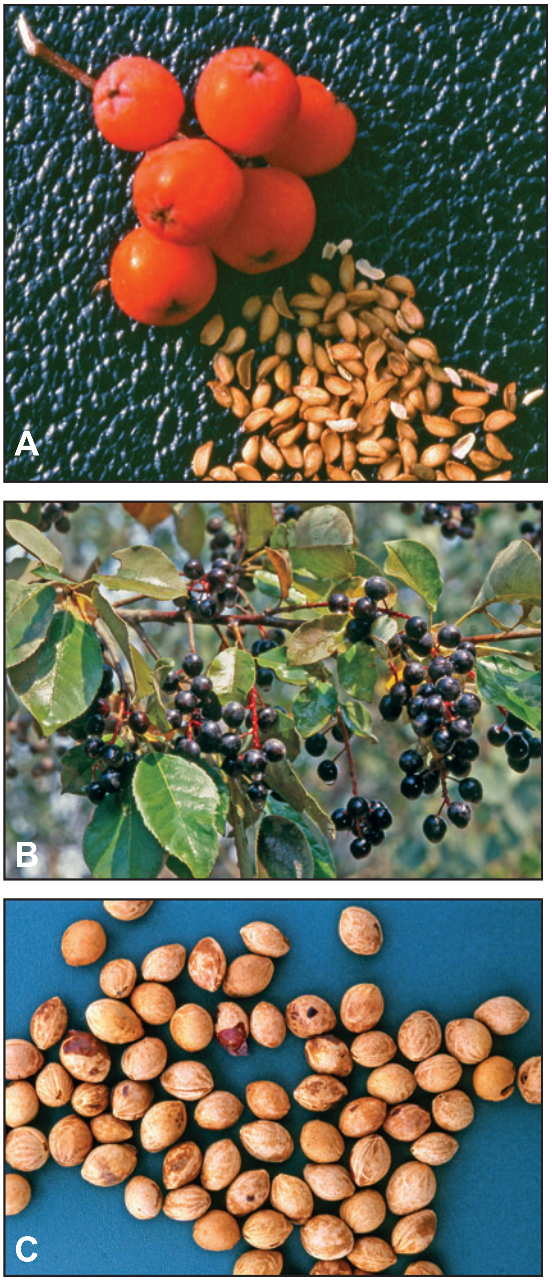

Figure 2.6—Fleshy fruits, such as mountain-ash berries, contain small tan seeds (A). Chokecherries grow in a raceme (B), and each berry contains a large hard seed (C).

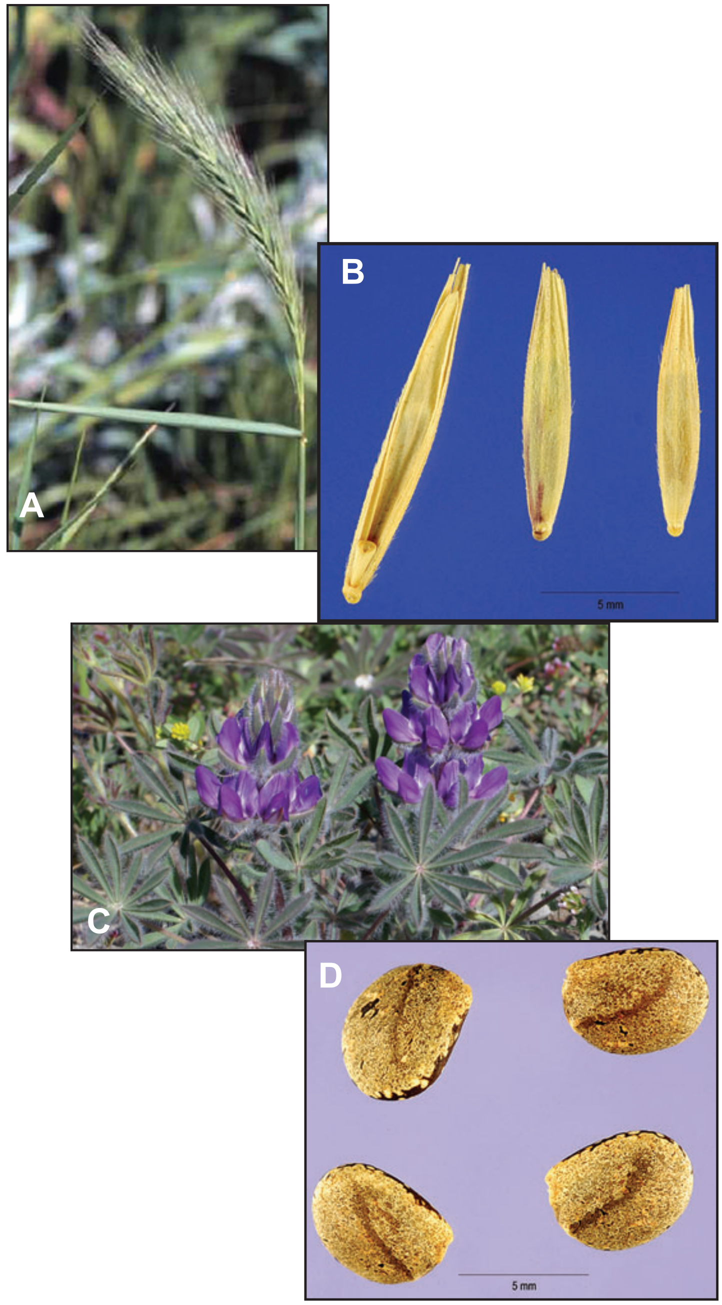

Figure 2.7—Native grasses produce seedheads that are a papery sheath (A) containing many seeds (B). Forb seedheads develop directly from flowers (C), and seeds (D) are contained within papery or woody structures.

2.3.1.3 Grasses and Forbs—Seeds of native grasses and forbs (herbaceous plants) are not contained in dry or fleshy fruits, and they can be collected directly from the plants. Grass seed heads form at the top of the plants (Figure 2.7A) and the seeds are contained in a papery sheath (Figure 2.7B). Forb seed heads form directly from the flowers (Figure 2.7C); seed heads are therefore variable in size and shape and the seeds can be hand-collected (Figure 2.7D). Photos and illustrations can be found on the USDA Natural Resources Conservation Service PLANTS database (http://www.plants.usda.gov).

2.4 Handling Seeds and Fruits After Collection

After harvest, begin drying cones, fruits, and seed heads as soon as possible. Freshly collected fruits, whether they are dry or fleshy, have high moisture content and will mold if stored inappropriately even for a few days. Drying reduces the moisture content of the seeds, helps open dry fruits, and prepares seeds for further cleaning. Good air circulation, low humidity, and temperatures maintained at 64 to 80 °F are ideal conditions for post-harvest drying. A ventilated storage shed works well for this purpose. Temperature control is very important; keep temperatures cool. Poor air circulation can also cause severe seed damage. Spread cones, dry fruits, and seed heads over a mesh screen with fine holes that allows air movement to promote even drying and eliminates moisture build up, but prevents seeds from falling through the screen. For dry fruits and cones that split open at maturity, cover the collection with a fine mesh cloth to prevent the loss of seeds after fruits begin to split open. Small quantities of dry fruits can be dried in paper bags or large envelopes as long as the bags are not packed too tightly with collected material.

2.5 Seed Cleaning and Extraction

Seed cleaning is necessary so that seeds can be sown or stored properly. In some cases, seeds will fail to germinate if they are not removed from their fruits. The seed cleaning area should be well ventilated because some fruits can cause allergic reactions and fine dust can irritate eyes and lungs. It is important to wear gloves and dust masks during cleaning, and wash your hands afterwards.

Seeds can be cleaned from fruits in many, easy ways. Some are described below. It is important to remember that dormant seeds need to be spread evenly and dried completely before storage, while non-dormant seeds need to be kept moist and in a high humidity environment until they are sown.

2.5.1 Cleaning Non-Dormant Seeds

Large seeded, non-dormant seeds are typically cleaned from other debris by floating them in water immediately after collection. This keeps seeds hydrated and facilitates the removal of non-viable seeds, trash, and other debris that will float. If nuts and acorns are collected under very dry conditions, good seeds may also float. Therefore, soak large seeds in water overnight to allow enough time for good seeds to hydrate and sink.

Other non-dormant seeds, such as willow or azaleas, are sown without further preparation or cleaning. With these species, the cottony material that surrounds the tiny seeds can aid in holding seeds in contact with the soil when they are planted.

2.5.2 Cleaning Dry Fruits, Capsules, and Seed Heads

The first step in cleaning seeds is to remove them from the cones, capsules, or seed heads. You can extract small quantities of seeds and clean them reasonably well at home with simple, low-cost equipment. As cones and capsules dry, they open and seeds fall out. Properly dried fruits will partially open inside the sacks and some seeds will fall out. To remove all the seeds, however, they may need further drying. They will dry best if placed in window screen-bottomed trays (Figure 2.8), which are placed in warm locations with good air circulation. Adding wooden spacers at each corner allows the boxes to be stacked, and fans will accelerate drying. If you have small batches of fruits, place them in a paper sack instead, but leave the top open. When most seeds fall out with a little gentle tapping, the cones or fruits have opened sufficiently. When true fir cones dry sufficiently, they disintegrate into scales and seeds.

***Figure 2.8**—Screen-bottomed boxes are an excellent way to allow conifer cones, dry fruits, and seedheads to dry without losing the seeds.*

The next step is to separate seeds from cones, fruits, and other debris. Separation is typically accomplished with a combination of screening and air separation. Move the dry fruits and seeds to another screen box with a mesh size large enough to permit the seeds to fall through (Figure 2.9A). Gentle shaking will let seeds and smaller impurities fall through the screen, leaving cones and larger debris on the screen. Screen mesh size will vary greatly with species. For example, a 1⁄4 - to 1⁄2-inch mesh works well for Douglas-fir, while a 3⁄8- to 5⁄8-inch mesh is necessary for larger true fir seeds. But with other small seeded plants like sedges, rushes, and some wildflowers, you will need very fine mesh screens or kitchen sieves to properly separate seeds from other debris. Extracted seeds may be mixed with pitch globules, dry leaves, wings, and other debris. Repeat the screening process with a mesh size that retains seeds but allows the smallest debris to pass through (Figure 2.9B). You're then left with seeds and seed-sized debris.

Many native plant seeds have wings or other appendages that need to be removed to make sowing easier. Wings can be manually removed by filling a burlap or cloth sack 1⁄4 full, tying or folding it shut, and gently kneading the seeds by squeezing and rubbing the sack between your hands (Figure 2.10). Friction between seeds and between seeds and burlap will detach wings. Remember to knead slowly and gently because too much friction might damage seeds. Another trick for dewinging conifer seeds is to alternately moisten the seeds and let them dry, and then repeat the rubbing process. A few species, such as alder, western redcedar, and angelica, have very tight wings that should be left on the seeds. Repeat the screening process again with a mesh size that retains seeds but allows the smallest debris to pass through.

The final step in the seed cleaning process is fanning or winnowing, which separates detached wings, hollow seeds, and seed-sized impurities from good seeds. Winnowing can be done outside on a breezy day or, for smaller batches, just cup the seeds in your hands and blow through them while gently bouncing the mixture. For larger batches, winnow in front of an electric fan, which separates seeds

Figure 2.9—*Wooden frame boxes with screened bottoms (A) can be used to separate seeds from other debris. Depending on the type of dry fruits and seed size, several boxes with different sized mesh may be needed. With gentle shaking over a series of screens, pure seeds can eventually be obtained (B).*

Figure 2.10—Many native plant seeds have wings or other appendages that must be removed before sowing. An easy way to de-wing seeds is to put them in a cloth bag and gently knead the bag and seeds.

from the lighter debris (Figure 2.11). Most heavy, sound seeds will come to rest near the base of the fan, and hollow seeds, wings, and lighter impurities will tend to blow farther away. Changing the fan speed or moving farther way will improve the separation. After each winnowing, collect a small sample of seeds and cut them in half to check for soundness. This way you can determine where the hollow seeds are and discard them. All species will probably require several successive separations to obtain a desired degree of seed purity. A good target for most species is 90% or more sound seeds.

2.5.3 Cleaning Fleshy Fruits

Fleshy fruits should be processed soon after collection to avoid fermentation, mummification, heat buildup, or microbial damage. Just before cleaning, soak fleshy fruits in water to soften the pulp. Fruits can be soaked for a few hours to a few days, depending on the species. Change the water every few hours during soaking. Flesh can be hand squeezed or mashed using a wooden block, rolling pin, or other device. Fruits can be also be cleaned by wet screening, which involves hand rubbing the fruits against screens using a steady stream of water to eliminate the pulp.

A modified food blender or kitchen food processor (Figure 2.12A) can be used for small lots of fleshy fruits. Just coat the impeller blades with rubberized plastic or tape (Figure 2.12B) so that seeds are not damaged during cleaning. The final processing step is to thoroughly wash seeds with fresh water to remove any remaining pulp, and then place them on a drying rack for several days before storage.

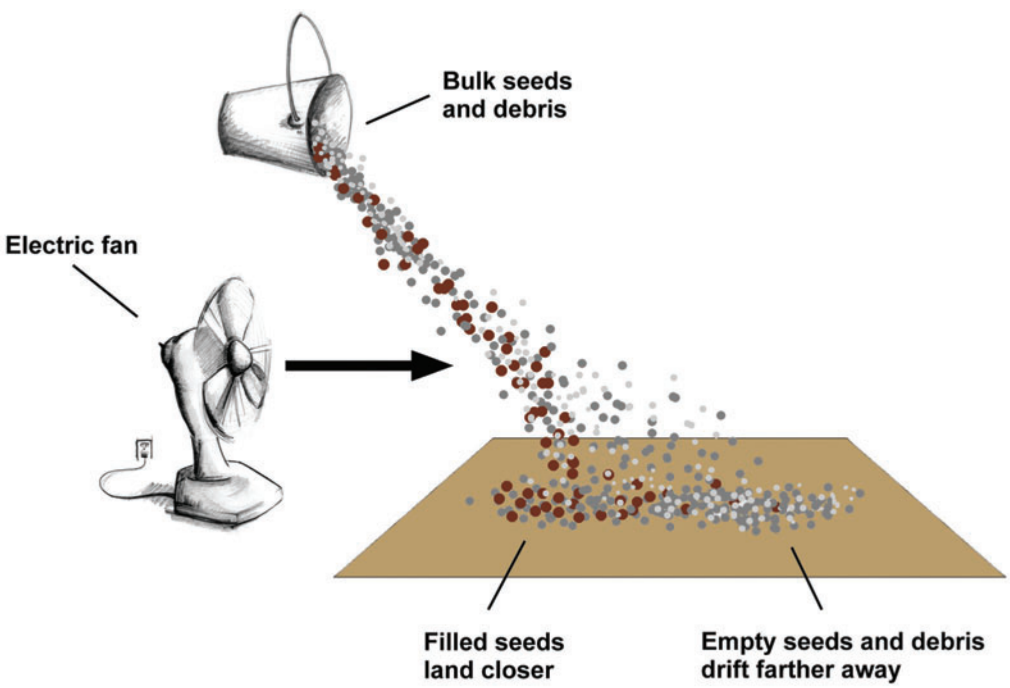

Figure 2.11—Winnowing in front of a fan separates filled seeds from empty seeds and other lighter debris.

Figure 2.12*—Small batches of berries or other fleshy fruits can be cleaned with a modified food processor (A). Coating the impeller blades with plastic or tape (B) prevents seed damage.*

Remember, how seeds and fruits are handled during collection, temporary storage, post harvest handling, and cleaning can directly affect seed quality, viability, and storage life.

2.6 Storing Seeds

Most seeds can be sown immediately after cleaning. Immediately after harvesting and cleaning, sowing seeds into bareroot beds or containers left outdoors exposes seeds to their normal cycle of climate and allows any dormancy to be overcome naturally (see Section 2.7, Seed Dormancy). In the case of spring ripening seeds, such as elm, they can be planted immediately and will germinate and grow during summer. Seeds that are sensitive to drying, such as acorns, willow, and Culver's root, perform best when sown immediately. Sowing immediately after harvest is the best option when you have as many seeds as you need, have adequate outdoor space prepared, and can protect the seeds from predation while they undergo exposure to natural conditions. Storing seeds will be necessary if you have collected more seeds than you need in a single year and expect to use those seeds in the future, if you are not ready to plant the seeds, or if the conditions simply are not favorable for planting immediately. If stored, most seeds require some treatment to alleviate dormancy (see Section 2.8, Seed Treatments; Appendix 6.1). Seeds that require scarification (see Section 2.8, Seed Treatments) need to be treated before sowing whether they are stored or not.

To properly store seeds, they must be mature and free of mechanical injury. The key to good seed storage is to control moisture content and temperature. Remember that, in general, non-dormant seeds normally remain viable only for a few days to 1 year and must be stored moist. Some nut and acorn bearing species can be stored for several months, as long as seeds have high seed moisture content (35 to 50%) and are stored under cool and moist conditions. To provide constant gas exchange, non-dormant seeds are usually stored in unsealed containers in plastic bags filled with moist peat moss in refrigerated storage.

Dormant seeds, however, can be dried, which increases the amount of time they can be stored. Once dormant seeds are clean, air-dry them in drying trays for 2 to 4 weeks to reduce their moisture content. At room temperatures, seeds can be stored for short periods of time in bottles or plastic bags in boxes. Make sure that you label the containers with species, collection date, and location (Figure 2.13).

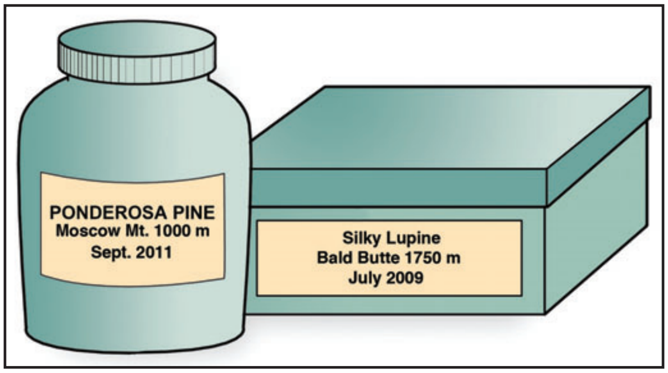

***Figure 2.13**—Controlling moisture content is the most critical aspect of seed storage, so place seeds in airtight bottles or in zip-lock-type plastic bags in a protective box. Make sure all storage containers are properly labeled.*

For larger quantities of seeds, refrigerated storage is recommended. All native plant seeds can be stored under refrigeration (34 to 41 °F) in airtight containers. If possible, use a self-defrosting refrigerator that maintains the humidity at 10 to 40%. If the door is rarely opened, the humidity in a self defrosting unit will stay at lower humidity levels. Many dormant seeds can be stored for long periods at temperatures below freezing; some trees seeds will remain viable for 10 years or more. Because high seed moisture reduces viability, store seeds in airtight containers.

2.7 Seed Dormancy

Dormancy is a fascinating physiological adaptation that ensures native plant seeds germinate at appropriate times for survival and growth. It also is a mechanism by which plants increase the time their seeds remain viable. Seed dormancy is, therefore, one of the major challenges to growing native plants because it can be highly variable, not only between different species but among seed sources of the same species. In this section, we will discuss seed dormancy types and seed treatments that are used to overcome, or "break," dormancy. Good information on ways to overcome seed dormancy for individual native plant species can be found in Appendix 6.1, or on the Native Plant Network (www.nativeplantnetwork.org).

2.7.1 Non-Dormant Seeds

Non-dormant seeds germinate immediately after maturation and dispersal from the mother plant. The time it takes for the seeds to germinate, however, is variable. Some species may germinate immediately (willow and aster) while others may take up to a month to germinate after sowing (white oaks).

2.7.2 Dormant Seeds

Dormant seeds are those that do not germinate immediately after maturation and dispersal from the mother plant even when the right environmental conditions exist. Causes of dormancy are either inside the seed (internal) or outside the seed (external) and some species have a combination of these. When seeds have more than one type of dormancy, that is, internal and external, or more than one type of internal dormancy (described below), they are said to have "double dormancy."

2.7.2.1 Internal Dormancy—Internal dormancy is caused by some property of the seed that prevents germination. With some species, certain environmental conditions (usually cold and moist) are necessary to change the seeds' metabolic processes and allow germination. With other species, the embryo within the seed is under-developed at time of seed dispersal and a period of after-ripening (set of correct environmental conditions, usually warm and moist) is needed for the embryo to fully mature before germination can occur. Some species may require a combination of warm, moist conditions followed by cold, moist conditions for an extended period of time before germination is possible.

2.7.2.2 External Dormancy—External dormancy generally describes seeds with hard seed coats that are a barrier to water. Depending on species, various environmental factors cause these seeds to become permeable during a certain time of year, or after several months or years. In nurseries, these seed coats must be modified by a technique called scarification (see Section 2.8.2, Scarification). Some species may have double dormancy so the seeds must first be scarified to allow water uptake, and then given additional warm and moist and/or cold and moist conditions to alleviate any internal dormancy.

2.8 Seed Treatments

Soaking some seeds in running tap water for a few hours up to several days is often helpful because seeds must have exposure to water and oxygen before they can go through metabolic changes needed for germination. Stored seeds are usually at low moisture content and must become fully hydrated before they are capable of germination or before temperature can be effective in breaking seed dormancy. Soaking seeds in running water also helps to remove any naturally occurring chemicals present on or within the seeds that prevent germination.

Seed cleansing is used to remove bacteria and fungi from seed coats, and it is particularly important for seeds that easily mold or take a long time to germinate. Seed cleansing is a standard procedure used at most nurseries to prevent one of the most common nursery problems: damping-off disease. Running water soaks (Figure 2.14A) can effectively cleanse seeds and all native plant seeds will tolerate this procedure. Seeds can also be cleansed with solutions of household bleach (Figure 2.14B) or hydrogen peroxide (Figure 2.14C). For example, two standard procedures are to either soak seeds in 3% hydrogen peroxide for up to 4 hours, or in a 40% bleach solution (2 parts bleach [5.25% sodium hypochlorite] in 3 parts water) for 10 minutes. After soaking in either bleach or hydrogen peroxide, be sure to thoroughly rinse seeds with running tap water. Always test treatments on a small sample first to ensure it does not damage the seeds.

2.8.1 Stratification

Many dormant seeds require a cold, moist period before they germinate; this happens naturally during winter. Stratification is a nursery term that describes the combined use of moisture and temperature to overcome seed dormancy. Historically, stratification meant layering seeds between moist substrates and exposing them to cold temperatures. Although nowadays stratification is often used to describe any temperature treatment that causes metabolic changes, we will use the historic definition.

During stratification, seeds are kept moist at temperatures of 34 to 41 °F. Some species may only require a few days or weeks of stratification while other species may require several months. Different seed sources of a given species may break dormancy at different times during stratification. You can expect to see some variation when dealing with many seed sources. As a general rule, it is best to use the maximum recommended dormancy breaking treatment (see Appendix 6.1). Another valuable advantage to stratifying seeds is that it increases germination energy (how fast the seeds germinate when placed in favorable conditions) and uniformity, which is desirable. If seeds begin to mold during stratification, remove them from stratification and rinse them thoroughly in running tap water to remove the mold. Place the seeds in a clean plastic bag and return to the refrigerator. You may need to repeat this process often, so keep a watchful eye on your seeds.

A few species have double, internal dormancy that is best removed through a combination of a warm, moist treatment followed by stratification (see Appendix 6.1). The warm, moist treatment enhances the after-ripening of seeds with under-developed embryos. Juniper, Pacific yew, hawthorns, and trilliums are examples of species that often benefit from both treatments. The requirements and procedures for warm, moist treatment are basically the same as for stratification, except temperatures are increased to around room temperature. Again, seeds should be soaked in running water for 12 to 48 hours and then placed either

Figure 2.14—One of the major reasons for poor germination of native plant seeds is seed coat contamination, so a running-water rinse (A) is recommended for all species. Large seeds can be surface sterilized with bleach (B) or hydrogen peroxide (C).

into a plastic bag or between moistened paper towels. Place the bag in a dark area. For some pine species, a 2 to 4 week period is probably sufficient, but juniper and yew seeds may require 15 to 20 weeks of warmth. (Because of the long warm treatment, bareroot growers should probably sow juniper and yew seeds in late summer or early fall [see Section 3.2.3.2, Sowing and Germination].) Once the warm period is over, seeds are transferred to a refrigerator to complete their stratification. Check often for mold because it can grow rapidly at the warmer temperatures. After stratification, re-soak seeds in running water for 12 to 24 hours. Soaking ensures the seeds have plenty of water to begin the germination process.

2.8.1.1 Naked Stratification—This method is best for larger quantities of seeds (more than a handful or two). Start by putting seeds into a bag made from bridal mesh, cheesecloth, or women's nylons. A square piece of mesh, with seeds placed in the center, can be tied to form a crude bag (Figure 2.15A). Don't put more than a half pound of seeds per bag. Label it. Place the bag into a bucket and allow water to run through it for 12 to 48 hours. After soaking, allow the bag to drip dry for a minute or so and suspend it within a plastic bag (Figure 2.15B). Hang the bag in your refrigerator for the required time (Table 2.2; Appendix 6.1). Check it often for mold. If mold is present, gently rinse the seeds in running water and rehang in the refrigerator.

2.8.1.2 Sandwich Stratification—This is the best technique for small amounts of seeds, for very small seeds, and for those species that only require a few weeks of stratification. Loosely stack paper towels about ⅛-inch thick and moisten them completely. Drain off the excess water by vertically holding one end of the towel (Figure 2.16A). Then, place seeds one layer deep on half the paper towel surface. Be sure to distribute the seeds evenly across the moist paper towel so that they do not contact each other. This will help prevent the spread of mold to other seeds. Fold the paper towels over the seeds (Figure 2.16B). Put your sandwich into a clear, plastic zip-lock type bag and refrigerate for the required time (Table 2.2; Appendix 6.1). Check occasionally to ensure seeds are moist and not moldy. If they're moldy, remove the sandwich. Rinse seeds under cool, running tap water. Wash out the zip-lock type bag with warm water and soap. Spread seeds onto a new stack of moistened paper towels, put the sandwich back into the bag, and refrigerate. Keep checking for mold.

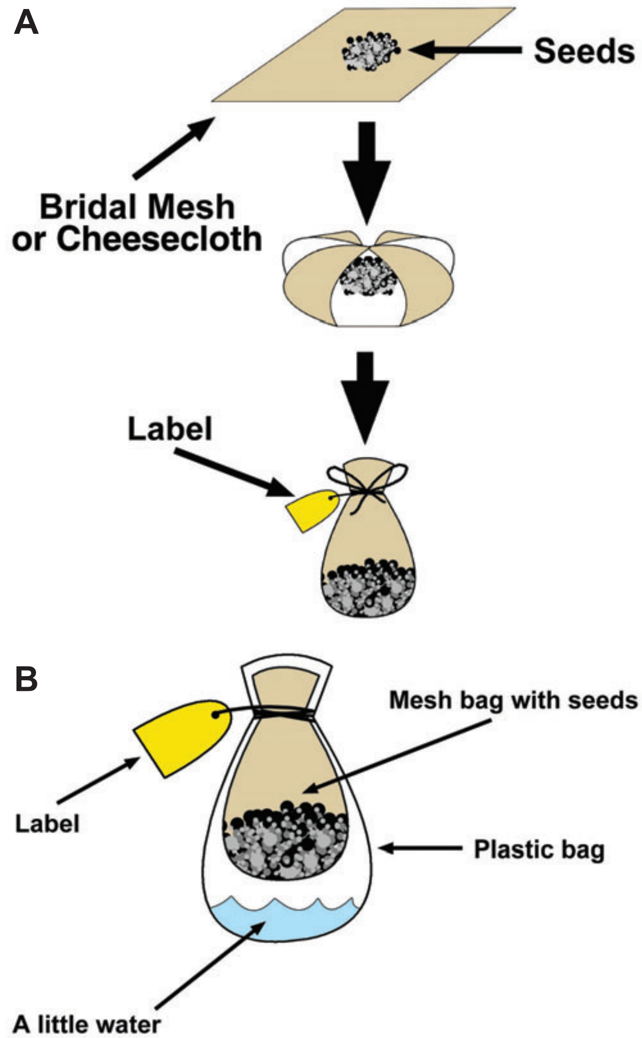

Figure 2.15*—Use bridal mesh or cheesecloth to make a bag to soak and stratify seeds (A). After soaking and draining, place the mesh bag into a larger plastic bag and add a little water to maintain 100% humidity around the seeds without immersing them (B). Don't forget to label bags properly.*

Table 2.2—Stratification durations for six common native plants. See Appendix 6.1 for more species.

Common name	Scientific name	Days of stratification
New England aster	*Aster novae-angliae*	60
Beaked sedge	*Carex utriculata*	30 to 60
Dogwood	*Cornus florida*	90
Indian blanketflower	*Gaillardia aristata*	0 to 60
Colorado (blue) spruce	*Picea pungens*	0 to 28
Antelope bitterbrush	*Purshia tridentata*	60 to 90

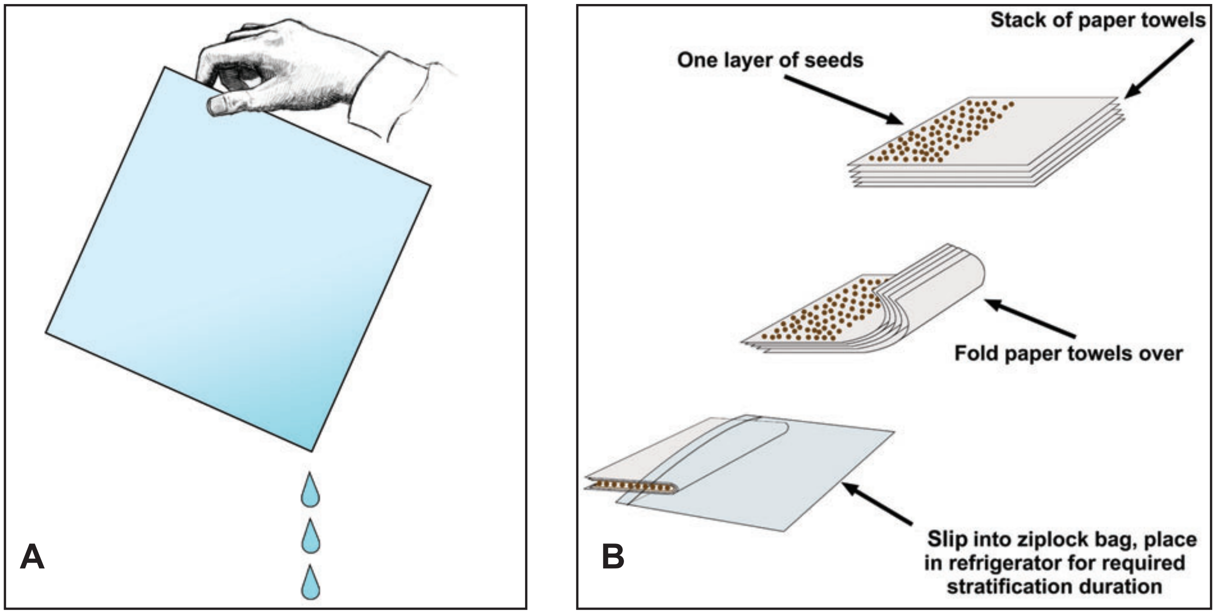

Figure 2.16*—Sandwich stratification requires paper towels that are moist but not soaking wet, so hold them by the corner until excess water drips off (A). Place one layer of seeds on the towels, fold them, place in a plastic zip-lock-type bag (B), and refrigerate.*

2.8.2 Scarification

Scarification is any method used to treat hard and impermeable seed coats so that moisture can enter the seeds, thus allowing them to germinate. In nature, hard seed coats often have a "plug" that must be softened or opened by exposure to extreme temperatures or the digestive acids in the stomachs of animals. Some species with hard seed coats that benefit from scarification include lupine, globemallow, and sumac (see Appendix 6.1). Other species that are adapted to fire or inhabit desert environments may also benefit from scarification.

Seeds can be scarified several ways, but we will discuss only three of the easiest methods. How well the scarification method works depends on the species and the thickness of the seed coats. Whichever method you choose, it is very important not to damage the interiors of the seeds. Take the time to learn the anatomy of the seeds that you are working with. Trying different methods and tracking your results will help you determine the best method for that species and your seed sources.

2.8.2.1 Mechanical Scarification—The seed coats of large seeds can be filed or nicked using a knife or metal file (Figure 2.17A). Be sure to scarify on the side of the seed away from the embryo. This method is time consuming, requires precision so that the seed coat is scarified without damaging the seed, and can be dangerous if the knife is improperly held.

Rubbing small seeds with sandpaper can be effective for some species, particularly the grasses and sedges, but it is difficult to treat all seeds uniformly. One easy and effective technique is to construct a wooden box (4 inches wide, 6 inches long, and 1 inch deep), line it with 100 grit sandpaper, and then wrap a small block of wood with the same sandpaper. Place the seeds inside the box and rub them with the wood until the desired amount of abrasion is achieved.

Hobby size rock tumblers can be used to scarify hard-coated seeds and avoid the potential damage that can occur with other scarification methods. You can use a rock tumbler two ways: dry tumbling and wet tumbling. Dry tumbling involves placing seeds, coarse carborundum grit (sold by rock tumbler dealers) and pea gravel in the tumbler. The duration of treatment is usually for several hours, but it is an effective and safe way of scarifying seeds of many hard-seeded species. After tumbling, the grit can be separated from the seeds using a fine mesh screen, and the grit can be reused. In the wet tumbling treatment, water is occasionally added to the grit and pea gravel. An additional benefit of wet tumbling is that seeds are moistened and chemical inhibitors are leached out. Wet tumbling has been effective treatment for species such as redstem dogwood and golden currant.

2.8.2.2 Hot Water Scarification—Scarifying seeds with hot water works well for many species with hard seed coats because it provides a rapid, uniform treatment and results can easily be seen within a few hours (Figure 2.17B). Thickness of the seed coat may vary somewhat between sources, so it is a good idea to dissect a few seeds and examine the thickness of seed coats from each seedlot.

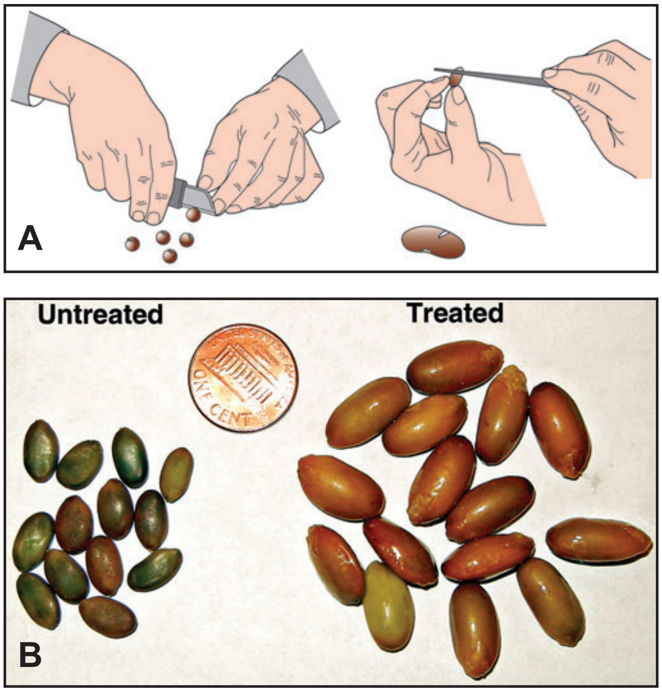

Figure 2.17—Large seeds with hard seedcoats can be mechanically scarified with a sharp knife or triangular file (A). Hot water scarification softens the hard seedcoat and greatly speeds germination (B) (courtesy of Greg Morgenson).

Doing several hot water scarification tests with a small number of seeds will help determine the length of time needed for treatment.

Seeds are added to boiling water for a few seconds and then immediately transferred to a vat of cold water so that they cool quickly to prevent embryo damage. If the seeds have been scarified they will enlarge while they are soaking in the cool water for a day or so. If the seeds have not been properly scarified, they will be the same size of the dry, non-treated seeds. In this case, you will need to re-treat the seedlot. Some species cannot tolerate excessively high temperatures, so you may only want to heat the water to 158 °F or so and monitor your results.

2.9 Premature Germination

Oh no! You're not ready to sow but you just checked your seeds and a few are beginning to sprout. You will need to plant the seeds that have sprouted (see Chapter 4), but you can slow down the germination process with the remaining seeds. Remove the non-sprouted seeds from stratification and gently spread them out to surface dry. Allow the surface of the seed coat to dry until it's dull, not glossy. Put the seeds back into a plastic bag and refrigerate. The reduced moisture content will greatly reduce the germination process.

2.10 Germination Testing

A germination test will tell you how well your filled seeds will sprout (Figure 2.18A). If you have just a few seeds and plan on growing only a few seedlings for fun, a germination test is unnecessary. A germination test will, however, help you use seeds efficiently and grow higher-quality seedlings. For species that require these treatments, germination tests usually start by scarifying and/or stratifying seeds. After stratification, rinse seeds in running water for 12 to 24 hours. If you test non-stratified seeds, rinse them at the same time, but for 24 to 48 hours. Stack paper towels about 1⁄8-inch thick and moisten them completely. Drain off the excess water by holding towels as shown in Figure 2.16. Put the paper towels into your plastic container and spread seeds over it, maintaining each group. Close the lid and place the container in a location with room temperature and out of direct sunlight. Every 5 days thereafter, count seeds with primary roots at least as long as the seedcoat, and remove them from the test (Figure 2.18B). After 30 days, you can record percent germination. Another value you may obtain is germination energy. Germination energy (also known as germination speed) tells how rapidly

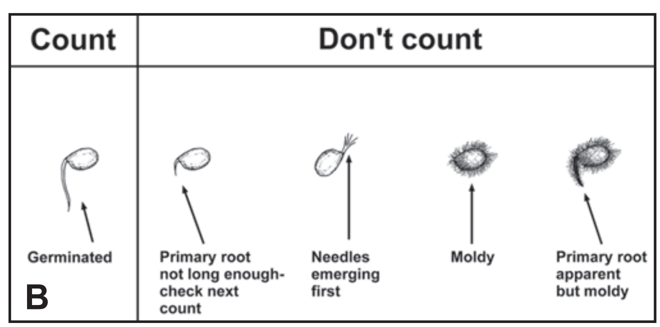

Figure 2.18—Germination tests will give you an idea of your seed quality (A), and help determine how many seeds to sow. When checking your germination test, only count seeds that have primary roots as long as the seed coat. Don't count seeds that have leaves emerging instead of roots, or are moldy (B).

seeds germinate and is usually given in days. Of the total number of seeds to germinate, check to see by what day 50% had sprouted. Ideally, most will germinate in the first 10 to 21 days or sooner. If not, your seeds may need a longer stratification period.

2.11 Additional Reading

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