CONIFER SEED — FROM CONE TO SEED BED

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CONE COLLECTION

The first process in the propagation of conifers by seed is the collection of the cone containing the seed. Cones are collected mainly during the months of September and October. Collection may be from standing or felled trees, from the ground, or from squirrel caches.

Cones should be checked for seed maturity and seed quality before full scale picking. Various tests for determining maturity can be made: cone flotation, color of cone or seed, character of seed endosperm and embryo. Seed quality can be checked by cutting the cone and examining for blank or damaged seed.

The Pacific Southwest Forest & Range Experiment Station has delineated fourteen seed collection zones in California. All the area with a zone is considered to have the same climatic and edaphic conditions. Therefore, planting stock propagated from seed collected any place in the zone may be planted at any place within the zone and be considered as being planted into the same environment as that in which the seed was produced.

When the cones are collected they are kept separate by species, differences in elevation, and area. A "Report of Cone Collection" is filled out by the person supervising the collection for each distinct lot of cones. Information entered is: species; location — i.e. county, township, range, section, and elevation; dates of collection; number of sacks of cones collected; number sacks rough-cleaned seed processed; condition of crop — Good, Fair, or Poor; special remarks; and identification of collector. Each "Report of Cone Collection" is prenumbered, and for the moment, the lot of cones defined by the information on the report is assigned this number. Every sack of cones in the lot is tagged inside and out with this number for identification and then sent to the Division of Forestry nursery at Davis, California, for processing. The "Reports of Collection," when completed, are also sent to Davis.

Information given on the "Report of Collection" is transferred to another card called the Production Record. This card is then used to keep a case history on the seed processed from the cones, as it is used. When the collection information is placed on the Production Record the lot of cones is assigned a Code Number. The Code Number is made up from the initials of the scientific name of the species, the collection zone source, the elevation, and the year of collection. For instance, sugar pine seed collected in Zone III at 4000 feet elevation, in 1962, would be assigned the Code Number PL III 4 2. PL is the initials for *Pinus lambertiana,* Roman numeral III is the zone, the number 4 is for 4000 feet elevation, and the number 2 is for the year 1962. Separate lots of cones similar in species, collection zone, elevation, and year of collection all have the same Code

Number and are, therefore, combined into one lot. The number(s) of the lot(s) making up one Code Number is listed on the Production Record card.

EXTRACTION AND CLEANING

As the cones are received at the extraction plant they are placed under one of two different drying treatments. Cones of most species are spread in the sun on cement slabs or heavy paper. The heating and drying, due to the action of the sun, causes the cones to open in a period of one to two weeks. The broken cones of the true firs are hand-processed over a screen to remove the seed from the cone scales and other large matter. A portable shaker made of expanded metal is used to remove the seed of other species from the cone.

Cones of a few species do not respond readily to air drying. Various types of kilns may be used to open the cones. A small extraction drum, 4′ x 10′, which will hold 30 to 40 bushels of cones, is used by the Division of Forestry. Warm air at a temperate of 110-140°F. is blown into the closed drum. Periodically the drum is turned to shake the seeds from the opened cones. Eight to twenty-four hours of heat are required to open most cones. A forced air kiln, with a daily capacity of 800 bushels of cones, is being planned for construction in the near future. The extracted seed is passed over a scalper which removes the bulk of the debris. After the scalping operation pine seeds are de-winged, using a small cylinder lined inside with corrugated rubber and having a rubber-tipped paddle wheel which rubs the seed against the lining. A two-screen cleaner with a rough air separation is used to remove the remainder of the debris. The seed may be upgraded by means of a pneumatic separator which blows off the poor quality, light seed.

During the entire processing of the seed, the various lots are kept separate according to the Code Number. Certain information is transferred to the Production Record card after the seed is cleaned. This information is: the pounds of clean seed obtained, and the number of pounds of clean seed per sack of cones collected.

CONE STORAGE

Seed of a number of species of conifers require storage at quite low temperatures. Species which should be stored at, or near, 0° F. are white fir, red fir, sugar pine, Douglas-fir, Sierra redwood, and Coast redwood Species such as ponderosa and Jeffrey pine can be stored at higher temperatures, up to 35° F., if the moisture content of the seed is below about 10%. However to insure increased periods of storage with high viability, all conifer seeds should be held at or near 0° F. and below a moisture content of 10% of oven-dry weight.

At the Division of Forestry nursery near Davis, seed is stored in 5-gallons cans, which hold approximately 25 pounds of seed. It is planned to place polyethylene bags inside the cans to further reduce possible accumulation of moisture. The cans are marked with the Code Number assigned to the seed.

SEED TESTING

The first phase of seed testing should be the running of purity tests. Seed purity is the percentage by weight of clean seeds, true to species, in a sample containing seeds and other materials. However, because the California Division of Forestry processes seed only for its own use, and because the seed cleaning process gives seed of good purity, by ocular estimates the purity percent is recorded as 100 percent. If a particularly dirty lot of seed is obtained after the compete cleaning process, a purity test is run and the purity percent recorded.

The second phase of testing is computing the number of seed per pound. For determining this figure, a vacuum seed counter can be a valuable aid. A plate with a certain number of holes, such as 50 or 100, is connected to a vacuum line. The vacuum holds one seed at each hole, giving a known number of seed. For Division of Forestry purposes, samples of 100 seed are measured out with the counter and weighed on an analytical balance. Using ratio's, the number of seed per pound is then computed. Larger samples should probably be taken for smaller seed and for seed earmarked for sale.

Germination tests can be conducted by a number of techniques. Some of these are: tetrazolium, which is a dye which stains the embryo according to the apparent maturity of the seed; hydrogen peroxide, which promotes a rapid root radical growth; and direct germination.

The California Division of Forestry uses all three of the above methods, but the first two, tetrazolium and hydrogen peroxide, are used only when a quick approximation of the germination percent is desired. Tetrazolium and hydrogen peroxide tests generally do not give as reliable results as direct germination tests.

Direct germination tests are run in a small germinator using plastic dishes containing a perlite medium. At the present time the Division has one germinator in which 30 tests of three 50-seed samples can be run at one time. Another germinator of similar type is on order, and a third being requested in a future budget. With three germinators 90 tests of 150 lot samples or 45 tests of 300 lot samples can be made. When the third germinator is obtained 300 lot samples will be used to increase the reliability of the tests.

The germinators are maintained at a constant temperature of about 72° F. Although the larger seed laboratories run tests in germinators with alternating light and dark, and alternating temperatures, the Division of Forestry does not have this type of equipment. Tests are run for a period of about six weeks. Germination is checked weekly for the first four weeks with a final check at the end of the sixth week.

The Production Record card is used to record the results of the germination tests. As always in the processing of the seed, it is kept separated into different lots according to the Code Number.

A new method of obtaining germination figures has just recently been given some study. This is through the use of X-rays. In several European countries this method has been in use for several years,

but in the United States we are still only in the experimental stage.

A sample of seed is X-rayed and a X-ray plate developed. Very good plates clearly showing the endosperm, the seed coat, and the embryo, including the cotyledons, can be obtained. When checked by a trained viewer it is quite possible that seeds having the capacity to germinate can be distinguished from seed not havng this capacity. If this method is workable, much time in obtaining germination figures can be saved.

STRATIFICATION

Seeds of many conifer species possess or acquire an internal dormancy which may delay germination or prevent it completely. Internal dormancy can be broken by exposing the seeds to abundant moisture and oxygen at temperatures of between 32° and 41° F. The above method of breaking dormancy is called cold stratification.

Stratification, as done by the California Division of Forestry, is carried out in the following manner; the seeds are mixed uniformly with an equal volume of vermiculite, moistened with a solution of 1¼ oz. of Captan 50W per gallon of water, placed in vegetable crates lined with burlap, and then stored in a walk-in refrigerator controlled to about 35° F.

A process is being considered in which small lots of seed can be soaked in water, placed in plastic bags, and then held in the refrigerator for the proper period of time. The advantage of this method is that *no separation of seed and verimiculite is required after stratification* and before sowing.

Seeds of conifer species require different periods of stratification. The following chart lists these periods:

STRATIFICATION PERIODS OF CONIFER SEEDS

SPECIES	TIME
Aleppo pine, *Pinus halepensis*	None
Canary Island pine, *Pinus canariensis*	None
Coast redwood, *Sequoia sempervirens*	None
Coulter pine, *Pinus coulteri*	None
Monterey pine, *Pinus radiata*	None
Arizona cypress, *Cupressus arizonica*	4 weeks
Lowland white fir, *Abies grandis*	4 weeks
Ponderosa pine, *Pinus ponderosa*	4 weeks
Beach pine, *Pinus contorta*	6 weeks
Bishop pine, *Pinus muricata*	6 weeks
Douglas-fir, *Pseudotsuga menziesii*	6 weeks
Jeffrey pine, *Pinus jeffreyi*	6 weeks
Red fir, *Abies magnifica*	6 weeks
Scots pine, *Pinus sylvestris*	6 weeks
White fir, *Abies concolor*	6 weeks
Incense cedar, *Libocedrus decurrens*	8 weeks
Sierra redwood, *Sequoia gigantea*	9 weeks
Sugar pine, *Pinus lambertiana*	12 weeks

SOWING

A number of operations are performed to the nursery seedbed areas prior to sowing.

The first operation is the ground preparation with various pieces of equipment. If a cover crop has been grown on the area, the crop is first plowed under and then the ground disked. On fallow areas, the plowing operation is generally omitted.

Every two years, in the fall or early spring, after the ground has first been worked, liquid fertilizer is injected into the soil. The fertilizer used is 8-25-0 and is applied at the rate of about 800 pounds per acre, unless sawdust has been added; then it is applied at the rate of 4000 pounds. It is injected into the soil at the five to seven inch depth.

Periodically the nursery seedbed areas are fumigated for the control of root pathogens and weeds. Approximately two weeks prior to the desired sowing date, which is in April or May in the Division of Forestry nurseries, a mixture of methyl bromide (58%) and chloropicrin (42%) is injected at the rate of 300 pounds per acre. Immediately after injection, the ground is covered with polyethylene tarping. The tarping is left on the beds for a period of about 24 hours. After the tarping is removed, the soil is tilled to a shallow depth. allowed to air out for about 10 days, and then leveled.

To attain a density of a certain number of seedlings per square foot, it is necessary to determine the number of seeds to sow per square foot. This figure is computed by the following formula: number of seeds per square foot=

$$\frac{\text{planned density / square foot}}{\text{germination \% x purity \% x survival factor\%}}$$

The "survival factor %" is the percentage of germinated seed expected to grow to trees. A density of 30 seedlings per square foot is desired for one year stock, and a density of 40 per square foot for two year stock.

The computations for the number of seeds per square foot are worked out on a Sowing Schedule form by the nurseryman in charge of each nursery. Other information to be shown on this form for each lot of seed to be sown includes: seed/lb., seedlings/lb., lbs. sown, planned production, seed drill settings, bed number, and bed space, both calculated and actually sown. Data from the Sowing Schedule is then transferred to the separate Production Records kept for each different lot of seed. Each year, as a particular lot of seed is sown again, the data is added to the Production Record. Therefore a complete record of a particular lot of seed can be kept on one source from collection to complete use.

After the calculated bed space required for each lot of seed is determined on the sowing schedule, a seed bed layout is completed. On the layout, the nurseryman maps out the planned location and space of the lots of seed to be sown.

At the time of sowing, the seed is separated from the vermiculite stratification medium. Because seed of all the pines and of Arizona

cypress is disturbed by a number of bird species, it is necessary to treat the seed prior to sowing with a bird repellent. Various repellents, such as anthraquinones and thiram materials, are used. Arasan 75, a thiram powder, is used by the Division of Forestry.

Seed to be treated with a bird repellent is handled in the following manner: A sticker of one part Dow Latex 512R, or Rhoplex AC-33, to nine parts of water is mixed thoroughly and placed in a small cement mixer; seed is added and the seed coat thoroughly covered with sticker; then Arasan 75 powder is added at the rate of 10% by weight of the seed to be treated; the mixer is turned until all seed coat surfaces are covered with the powder; the seed is finally spread out to dry.

Sowing is accomplished by means of a shop-made seed drill. The basic parts of the drill are two Oliver belt-type fertilizer spreaders, and eight Planet-Junior seeding units. Seed is sown in rows, although occasionally some seeds have been broadcast, sown by removing the Planet Jr. units. The rows are spaced six inches apart with eight rows to a seed bed. Each bed is therefore about forty-two inches wide.

Watering of the seedbeds is done by a Skinner oscillating system. The water lines are spaced 52 feet apart and are from 300 to 500 feet long. Each line is rotated by an oscillator driven by water pressure and can be adjusted for various widths of coverage. The lines operate on 40 to 60 pounds pressure and apply water at the rate of about 45 gallons per minute for a 500 foot line.

During and immediately after germination, watering is done primarily to reduce ground temperatures. Soil temperatures are checked at intervals throughout the day. When temperatures reach about 95° F. water is applied until the ground surface is moistened thoroughly, usually 30 to 45 minutes. Watering is done throughout the day in this manner. No water is applied after about 3:30 P.M. to permit the ground surface to dry out before night fall. As the plants increase in size, the watering is continued over a longer period of time at less frequent intervals. After about four months, water is applied for periods of three to four hours several times a week.

In certain areas, additional shading may be necessary for species such as Douglas-fir, the true firs, and sugar pine. Lath frames or saran netting are used.

Every two years, after the seedlings are about 12 weeks old, they are given a top dressing of 32-0-0 liquid fertilizer applied through the sprinkler system. Enough fertilizer is applied to bring the available nitrogen level to 200 pounds per acre, if no sawdust was added earlier, and to 1000 pounds per acre if sawdust was added. This 200 or 1000 pounds includes the amount added by the 8-25-0 injected prior to sowing.

Most species are raised for 1-0 seedlings; however white fir, red fir, Scots pine, Sierra redwood, Douglas-fir, and sugar pine should be 2-0 stock when released for field planting.

One of the most thorough books covering the propagation of conifers from seed is the Woody Plant Seed Manual,[1] prepared by the

[1]U.S D A Misc. Pub.: No. 654.

United States Forest Service. However in many areas it is outdated. The California Division of Forestry each year prepares a list of commercial seed dealers of plants native to California. This list is available from either the office of the State Forester, State Office Building No. 1, Sacramento, or the Davis Forest Nursery, California Division of Forestry, Route 1, Box 1410, Davis, California.

MODERATOR BATCHELLER: Thank you, Mr. Eden. We will now hear from our last speaker this evening, Mr. Dara Emery, who will discuss seed propagation of some of the native California plants. Mr. Emery.

SEED CULTURE OF CALIFORNIA NATIVE PLANTS

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This is a discussion of problems likely to be encountered in the seed propagation of California species of *Ceanothus, Fremontia,* and *Rhus.* Seed dormancy of one or more types is common to all these species. When the hot water treatment is used to break the seed coat dormancy, the seeds are added to about four times their volume of water at a temperature of 180° to 190° F., left to cool for 12 to 24 hours, and then sown before drying. Depending on the quality of the local tap water with its additives such as chlorine, iodine or fluorine, significantly better results may be obtained with the hot water treatment by using bottled drinking water, distilled water or rain water, and their use is recommended. The concentrated sulfuric acid treatment may also be used on hard seed. In this treatment it is important that the seeds be thoroughly and repeatedly washed in running water immediately following the prescribed soaking period in order to remove all the excess acid which may still be present in the charred part of the seed coats. For the type of internal dormancy that is sometimes present in seed of these species, the seeds should be put in a tightly sealed polyethylene bag with a small amount of moist peatmoss, placed in a refrigerator at a temperature of 35° to 41° F. for the prescribed period and then sown.

Ceanothus and *Fremontia* seedlings are particularly susceptible to damping-off, and it is extremely important that all soil mixes be sterilized and clean or sanitary cultural practices, such as those presented in the University of California Extension Service's Manual #23 on the U.C. System, be followed. No special soil mixes are required for these species but a very well-drained mix is desirable. The sequence in containers is from seed flat to liners to gallon cans. In some cases the seed flat is omitted and the seed is sown directly into liners.

Ceanothus Species, California Wild Lilac.

The seeds of most California species of *Ceanothus* are long-lived. Seeds ranging in age from seven to sixteen years have given good