Collection

I. Genetics and Seed Source

A. Introduction

Seed quality involves both the genetic and the physiological quality of seeds. In this section, the general principles and methods for selection of seed source and improvement of seed quality through genetic selection are presented. Genetic improvement of seed quality is based on the seeds' ability to produce trees that are genetically well suited to the sites where planted and for the products desired. In later sections, physiological quality of seeds will be considered. Good seeds are those that have both high physiological quality and genetic suitability.

B. Objectives

1. Recognize the importance of seed origin (provenance) and recommend general rules for seed movement.
2. Review the advantages and disadvantages of exotic tree species and interspecific hybrids for tree improvement.
3. Define factors that must be considered when a tree improvement program is initiated.
4. Identify the conditions required for genetic improvement of tree seeds (genetic gain concept).
5. Distinguish between a minimum initial strategy of genetic improvement and a maximum long-term strategy.
6. Identify some terms and concepts of new biotechnology for genetic improvement.

C. Key Points

The following points are essential to understanding seed source and genetic improvement:

1. A successful tree improvement program should not be tried in another country or region without considering desired products and available sites.
2. Knowledge of phenotype and genotype is necessary to understand genetic improvement of trees.
3. The genetic gain equation explains the advantages of one improvement method over another.
4. Genetic gains can be obtained from selections among species, provenances within species, and/or trees within provenances.
5. The primary risk of using exotics or nonlocal provenances is planting on unsuitable sites.
6. Test plantings are the only sure method to determine genetic quality of seeds.
7. Without results of test plantings, the safest rule is to use seeds from phenotypically selected stands or trees in the local provenance for native species or land race for exotic species.
8. The seed orchard concept has two parts—the breeding program and the production program.
9. Seed orchard breeding programs involve progeny tests and selection for the next advanced generation of genetic improvement.
10. Seed orchard production programs are managed to maximize seed production through protection and cultural treatments.

D. Tree Improvement

1. **Tree improvement** is the development and application of genetically improved trees and intensive cultural practices to enhance forest productivity through artificial regeneration.
2. **Tree improvement programs** are plans of action to bring about desired objectives. The following factors should be considered when a tree improvement program is initiated:
   a. Products desired
   b. Sites to be regenerated
   c. Adaptation to the planting sites
   d. Conservation of forest gene resources

E. Strategies for Genetic Improvement

1. **Genetic gain**
   a. Genetic improvement (genetic gain) is accomplished by:
      (1) Having a population of trees with genetic differences
      (2) Selecting the genetically desirable trees
   b. The amount of genetic gain ***(R)*** to be captured from phenotypic selection of parent trees for a particular trait is:

   $$R = i\, V_p\, h^2$$

   where i = the intensity of selection
   h^2 = the heritability of the trait
   Vp = the amount of phenotypic variation.

   c. Gain can be captured from selection among species ***(R_s),*** selection among provenances within species ***(R_P)***, or selection among individual trees within provenances (R_I). The total gain *(R_T)* is the sum:

   $$R_T = R_s + R_p + R_I$$

2. **Species selection**
   a. Species-site studies are needed.
   b. Exotic tree species should be used sparingly.

c. Interspecific hybridization can be used to obtain valuable traits.

3. **Seed source**

a. Provenance refers to where the mother trees were growing and the seeds were collected. Seed source is the same as provenance. Origin is where the original progenitors were growing in natural forests and where their genetic characteristics were developed through natural selection.

b. "Local" sources should be used until provenance test results are available.

c. Purposes of provenance tests include:

(1) Mapping patterns of geographic genetic variation

(2) Delineating provenance boundaries

(3) Determining the best provenances

d. The general results of provenance testing are:

(1) Wide seed transfer is safer near the center of a species' range than near its edge.

(2) Where environmental gradients are steep, movement of material must be restricted.

(3) Provenances from harsh climates (cold or dry) grow more slowly.

4. **Improvement strategies**

a. The initial strategies for a new program are:

(1) Collect available information

(2) Select among indigenous tree species

(3) Select seed production areas within the "local" seed sources near the planting site

(4) Remove phenotypically inferior trees from seed production areas

b. The long-term strategies for maximum and continued gains are:

(1) Collect all existing information

(2) Select several species for the program

(3) Conduct provenance tests

(4) Select the phenotypically "best" trees

(5) Establish a first-generation seed orchard

(6) Test progeny

(7) Remove genetically poor trees

(8) Select the best individuals for a second-generation seed orchard

(9) Test the progeny of these second-generation selections

c. New strategies for genetic improvement are:

(1) Gene transfer

(2) Selection of cells in a cell-suspension culture

(3) Fusion of protoplasts (without cell walls)

(4) Somaclonal variation

F. The Seed Production Program

The production program may be combined with the breeding program or may be kept separate. The objective of a seed production program is to produce sufficient quantities of genetically high-quality seeds to meet seed needs.

1. **Seed Production Areas** (SPA's)

a. Existing stands can be managed for production of seeds.

b. SPA's are used on an interim basis.

c. SPA's can utilize superior provenances.

d. SPA's can provide seeds for minor species.

e. The genetic quality of seeds is improved by:

(1) Removing undesirable trees

(2) Establishing a pollen dilution zone

f. Seed production is increased by:

(1) Thinning the stand

(2) Fertilizing

(3) Establishing access roads

2. **Seed orchards—A** seed orchard is a collection of selected trees established and grown together under intensive management for production of genetically improved seeds.

a. There are two types of orchards:

(1) Seedling seed orchards

(2) Clonal seed orchards

b. The genetic quality of seeds is increased by:

(1) Reducing inbreeding

(2) Establishing a pollen dilution zone

(3) Separating provenances into different orchards

c. Seed production from orchards can be increased by:

(1) Choosing good soil and climatic conditions

(2) Spacing wide enough for full crowns

(3) Fertilizing

(4) Irrigating

(5) Subsoiling

(6) Protecting from insects

(7) Protecting flowers from late spring freezes (cold water irrigation)

(8) Ensuring supplemental mass pollination

G. Sources

For additional information, see Burley and Styles 1976, Khosla 1982, Nienstadt and

Snyder 1974, Rudolf and others 1974, Wright 1976, Zobel and Talbert 1984, Zobel and others 1987.

II. Production

A. Introduction

Most tree-planting programs are begun by collecting seeds from in-country sources, both natural stands and plantations. To plan these collections effectively, seed managers should understand the factors that affect tree seed crops and generally know what seed yields may be expected. With this basic information, opportunities may arise to stimulate seed production in key areas, such as seed orchards or managed seed stands.

B. Objectives

1. Recognize the problem of periodicity of seed production in trees.
2. Learn how environmental factors affect seed production.
3. Learn how seed production can be stimulated in trees.

C. Key Points

The following points are essential to understanding seed production:

1. Many tree species bear good crops in cycles.
2. Production is less frequent in high latitudes and high altitudes and among heavy predator populations.
3. Environmental factors influence flower production, pollination, and seed maturation.
4. Several options are available to stimulate seed production.
5. Except for seed orchards of a few species, production data are extremely variable.

D. Periodicity of Seed Crops

1. **Temperate species**
   a. Many conifers bear in cycles.
   b. Many angiosperms produce good seed crops every year.
   c. As latitude or altitude increases, the interval between good crops and the frequency of crop failure increase.
2. **Tropical species**
   a. Periodicity may depend on wet/dry cycles.
   b. Some species (e.g., *Tectona grandis)* usually flower each year. Other species (e.g., *Pinus kesiya, Cassia siamea, Cupressus lusitanica,* and *Delonix regia)* produce good crops most years.
   c. Dipterocarps in Malaysia bear irregular heavy seed crops at 1- to 6-year intervals.
   d. Some *Eucalyptus* species have large crops more regularly when grown in plantations.
3. **Genetics—Fecundity** is an inherited trait.
4. **Documentation—There** are few detailed studies and data.

E. Effects of Environments During Flowering

1. **Temperature**
   a. During hot summers, trees usually produce heavy floral bud formation.
   b. Late freezes can destroy flowers.
   c. The combination of hot summers and late freezes suggests that orchards should be moved to warmer climates (also to escape insects).
2. **Light** has not been studied extensively. In the Northern Temperate Zone, southern and western sides of crowns have the heaviest flower and fruit crops.
3. **Photoperiod** does not appear to have a direct effect on trees.
4. **Moisture** affects flowering through:
   a. Drought
   b. Excessive rain during pollination
5. **Mineral nutrients—** The balance of nitrogen and phosphorus can affect flowering.
6. **Biotic agents—Insects,** birds, mammals, and micro-organisms can destroy flowers. These agents are very common in the following tropical tree species:
   a. Triplochiton scleroxylon; attacked by *Apion ghanaense* (weevil)
   b. Tectona grandis; attacked by *Pagyda salvaris* larvae
   c. *Pinus merkusii;* attacked by *Dioryctria* spp. (cone worms)

F. Pollination Agents

1. **Wind pollination** occurs among all conifers and most Temperate Zone hardwoods.
   a. Wind pollination requires:
      (1) Lots of pollen
      (2) Pollen shed coinciding with receptivity
      (3) Relatively close spacing of plants
      (4) Good weather — low rainfall, low humidity, and good winds
   b. Supplemental mass pollination (SMP) has been used in United States southern pine orchards.
   c. Contamination in orchards is a concern.
2. **Animal pollination**
   a. Insects and bats pollinate temperate and tropical hardwoods.
   b. Animal pollination is usually common in tropical forests with:

(1) High species diversity and wide spacing
(2) Abundant foliage to filter out pollen
(3) High humidity and frequent rainfall
(4) Absence of strong flowering stimuli
(5) Abundant animal vectors

G. Stimulation of Flowering

Flowering can be stimulated by several management practices.

1. **Fertilizing:**
   a. Use primarily nitrogen and phosphorous, and sometimes potassium.
   b. Irrigation at the same time may also help.
   c. Hardwoods may react favorably; e.g., *Acer, Fagus,* and *Juglans,* but results have been inconsistent.
2. **Girdling and other wounding** can produce "stress crops."
   a. Girdling inhibits downward translocation of carbohydrates.
   b. Some hardwoods also react favorably.
3. **Thinning—The** benefits of thinning are apparent 3 to 4 years after treatment.
4. **Growth regulator treatment —** Gibberellins (GA) application to conifers is the most common.
   a. A water-based spray is best.
   b. A GA 4/7 mixture is most effective.
   c. Both pollen and seed cones are induced.
   d. Sprays are applied at the time of bud determination.
   e. The mode of action is still unknown.
   f. Treatments are most successful when applied with girdling, root pruning, or moisture stress.
5. **Supplemental mass pollination** (SMP) — This technique is used in pine orchards in the Southern United States.

H. Postfertilization Problems

Postfertilization problems include insect damage to cones, drought, cone drop, and high winds.

I. Sources

For additional information, see Franklin 1982; Owens and Blake 1985; Rudolf and others 1974; Whitehead 1983; Willan 1985, chap. 3; Zobel and Talbert 1984.

III. Collection Operations

A. Introduction

Successful collection of tree seeds is usually the result of quite detailed early planning. Ample time must be allowed to plan an efficient and practical collection strategy and to assemble the resources necessary for its implementation. Key elements include a good estimate of crop size, proper equipment, and a well-trained crew. Comprehensive collections for research will almost certainly require more detailed planning than routine bulk collections and may require a lead time of 1 to several years depending on the circumstances.

B. Objectives

1. Identify simple techniques for seed crop estimation.
2. Determine factors that should be considered when collections are planned.
3. Understand the importance of documentation.

C. Key Points

The following points are essential for planning collection operations:

1. The best seed sources available must be selected.
2. Good planning requires advance estimates of the seed crop and, at a later date, estimates of seed yield per fruit.
3. Planning for large collections must include choice of personnel, training, transportation, collection equipment, safety of workers, labeling of seedlots, description of sites and stands, etc.

D. Seed Source

Seed source includes the following considerations:

1. **Origin — the** natural stand location of the original mother tree.
2. **Provenance** —the place where mother trees that produced the seeds are growing. (Same as seed source.)
3. **Land race — exotics** that adapt over time to provide improved sources.
4. **Seed zone maps** should be developed for all important species.

E. Estimating Seed Crops

Seed crop estimates are always valuable to the collector, especially in years when seeds are in short supply. Good crop estimates help to stretch the available crews and equipment. Seed crops can be estimated by the following five methods:

1. **Flower counts**
2. **Immature fruit and seed counts**
3. **Fruit counts on standing trees—This** method includes total counts and crown sampling.
4. **Rating systems**
5. **Cross-section seed counts** (table 3).

F. Planning Considerations

The steps of planning a collection are:

1. **Define the objectives.**

Table 3. —*Sound seed yield per cone for four* Pinus *species as estimated from the number of sound seeds exposed when cones are bisected longitudinally (Derr and Mann 1971)*

Sound seeds exposed	*P. palustris* (Louisiana)	*P. taeda* (Louisiana)	*P. elliottii* (Louisiana)	*P elliottii* (Georgia-Florida)	*P echinata* (Virginia)
	Sound seeds per cone				
2	23	31	20	31	12
4	35	44	35	50	22
6	47	57	50	69	31
8	59	70	65	87	41
10	71	83	80	106	51
12	83	96	95	124	60
14	95	109	110	143	70

2. Gather background data:
- a. Search the literature.
- b. Officially contact the appropriate forest services early.
- c. Collate and summarize all information.
- d. Do field reconnaissance.
- e. Determine the number of personnel needed.

3. **Collect field data:** Information for relocation of the site in future years:
- a. Locality, including latitude and altitude
- b. Aspect, slope, climate, soils, and associated species
- c. Individual tree descriptions
- d. Herbarium specimens
- e. Other data and notes
- f. Security and labeling

4. **Plan the itinerary:**
- a. Reach the collection region well in advance of the proposed date.
- b. Organize the sequence of operations.
- c. Make the schedule flexible.

O Organize equipment permits and transportation:
- a. Specify equipment to be used.
- b. Identify applicable government regulations.
- c. Use care between the collection of the seeds and their arrival in the seed laboratories.

G. Collection Equipment—A Comprehensive List

The following items are necessary for most collection operations:

1. Administrative items
- a. Movement approvals
- b. Collection authorities
- c. Radio transmission permits
- d. Drivers' licenses
- e. Firearm permits
- f. Facilities for purchasing stores; e.g., gasoline (petrol) and oil

2. Literature
- a. Road, topographic, and soil maps to cover the collection route itinerary
- b. Literature on the genera and species to be collected

3. **Collection equipment**
- a. Notebooks, recording forms, pens, and pencils
- b. Binoculars
- c. Markers; e.g., colored plastic ribbon
- d. Camera and accessories
- e. Tree-measuring instruments; e.g., diameter tape, height-measuring instrument, and length tape
- f. Soil sampler, pH testing kit, and soil charts
- g. Compass
- h. Altimeter
- i. Hand lens
- j. Large collecting sheets; e.g., 4 by 4 m, heavy plastic or canvas
- k. Small collecting sheets
- l. Seed bags of various sizes
- m. Large grain bags for dispatching seeds
- n. Cutting equipment
- o. Safety gear
- p. Weatherproof tags
- q. Tags for botanical specimens
- r. Plant presses
- s. Papers to dry specimens
- t. Plastic bags
- u. Specimen bottles with preservative fluid
- v. Containers for soil samples
- w. String

H. Sources

For additional information, see Barner and Olesen 1984; Bramlett and others 1977; Doran and others 1983; Ontario Ministry of Natural Resources 1983; Willan 1985, chaps. 3, 4, 5 + appendices 1, 5, 6.

IV. Mat urity

A. Introduction

Choosing good stands and trees for seed collection means nothing if fruit or seed maturity cannot be easily identified on the trees by unskilled workers. If seeds are disseminated immediately at maturity, workers must know how much in advance of maturity seeds can be collected without collecting seeds that will not germinate. If predators inflict large losses on mature seed crops, a similar problem exists. Good maturity indices are often the key to successful collection.

B. Objectives

1. Learn the common indices of maturity employed in tree seed collections.
2. Understand how these techniques can be adapted for new species.

C. Ke 7 Points

Th ? following points are essential to recognizing seed maturity:

1. Seed moisture content is very important, but direct measurement in the field is impractical; indirect estimates may be substituted.
2. Color changes are the most common indices.
3. Chemical indices are possible but impractical.
4. Artificial maturation of immature seeds is an option for some species.

D. Successful Collection

The following points are essential to successful collection:

1. **Biological ideal—to** collect at the peak of physiological maturity
2. **Practical collection—In** most collection operations, one may:
   a. Collect seeds from the ground
   b. Collect fruits or seeds from logging operations
   c. Collect mature fruits from standing trees
   d. Collect fruits from standing trees well in advance of maturity and ripen the seeds artificially

E. Collection after Dissemination

Some seeds can be collected after dissemination. These seeds are primarily large, single-seeded fruits; e.g., species of *Quercus* and *Car*ya. However, the first seeds to fall are usually bad. Workers must quickly collect the seeds before animals eat them.

F. Other Collection Strategies

Other collection strategies require determination of maturity.

G. Maturity Indices

Maturity indices include physical and chemical characteristics.

1. **Physical characteristics** include:
   a. Color change
   b. Moisture content
      (1) There are three trends during ripening:
         (a) In dry, orthodox seeds and fruits, moisture decreases slowly as seeds mature.
         (b) In pulpy, orthodox fruits, moisture decreases at first, then increases.
         (c) In recalcitrant seeds, moisture increases early, then slightly decreases.
      (2) Moisture content is related to protein synthesis.
      (3) Moisture content can be measured directly by oven methods; that is, cut cones, large fruits, or seeds; weigh; dry for 17 hours at 103 °C; and then weigh again.
      (4) Specific gravity is usually discussed separately, but it really is just an estimate of moisture content (table 4; figs. 7 and 8). Specific gravity has been measured in:
         (a) Conifers (commonly used for *Pinus)*
         (b) Quercus (inconsistent results)
         (c) Other angiosperms (little success)
   c. Other physical indices include:
      (1) Acorn cup release in *Quercus*
      (2) Flex of *P. strobus* cones
      (3) White, brittle embryo in *Fraxinus* and other genera
      (4) Embryo size (minimum percentage of embryo cavity)

Table 4.—*Cone specific gravity values that indicate seed maturity in some conifers*

Species	Specific gravity	Reference
Abies grandis	0.90	Pfister 1967
Cunninghamia lanceolata	0.95	Jian and Peipei 1988
Pinus elliottii	0.95	Barnett 1976
P. merkusii	1.00	Daryono and others 1979
P palustris	0.90	Barnett 1976
P. strobus	0.90	Bonner 1986a
P taeda	0.90	Barnett 1976
P virginiana	1.00	Fenton and Sucoff 1965

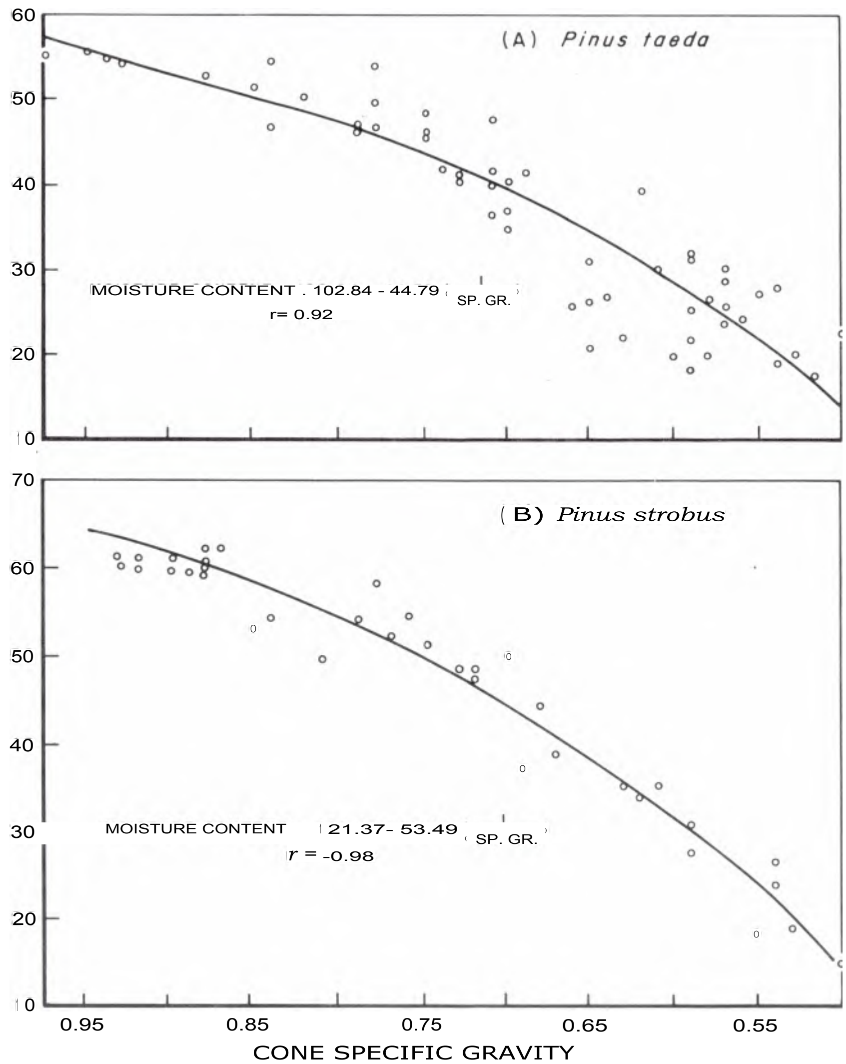

Figure 7. — *The relationship of moisture content to specific gravity for cones of* Pinus taeda *and* P. strobus *(Bonner 1991b).*

2. **Chemical characteristics**
   Chemical indices are biologically sound but not practical. They include:
   a. Accumulation of storage foods (fats and sugars)
   b. Elemental analyses of calcium, magnesium, and phosphorus for angiosperms of Southern United States
   c. Growth substances
      (1) Indoleacetic acid (IAA)
      (2) Gibberellins

H. Artificial Maturation
   Immature seeds can be artificially matured by picking the immature seeds, then ripening them under special storage conditions. However, seed yields and quality usually suffer. Artificial maturation includes the following considerations:
   1. Single-seed or multiple-seed fruits
   2. Avoiding dormancy through early collection
   3. Useful for collecting on remote or expensive sites

I. Delayed Collections
   For trees with serotinous *(Pinus* and *Picea)* or species with delayed fruit abscission *(Platanus* spp.), there is no rush to collect the fruits.

J. Sources
   For additional information, see Bonner 1972a, 1976; Nautiyal and Purohit 1985; Rediske 1961; Willan 1985, p. 33-38.

V. Postharvest Care

A. Introduction
   The time between collection and extraction is often overlooked as a crucial segment of seed acquisition. Fruits and seeds, often high in

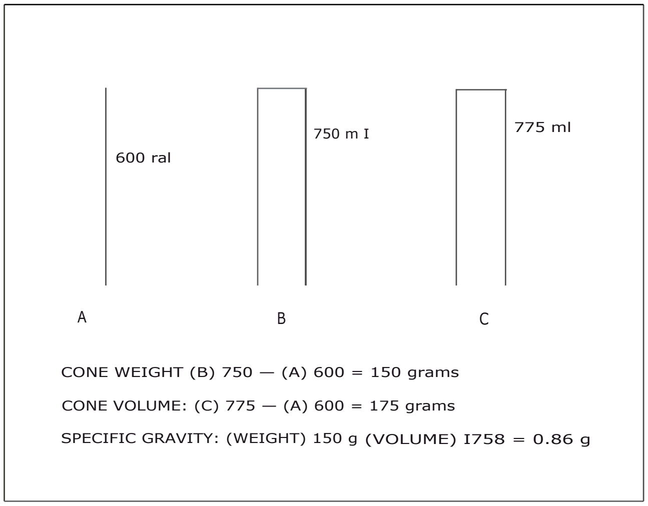

Figure 8.—A *simple technique for determining specific gravity of pine cones in the field using a graduated cylinder. (A) Fill the cylinder with water to the 600 mL mark. (B) Float the cone in the water and record the water level. (C) Using a pin or needle, submerge the cone enough to completely cover the cone with water, but no more. Record the new water level (adapted from Barnett 1979).*

moisture content, must be stored and/or transported for extraction and cleaning. Special care must be taken during this period to avoid loss of seed quality, especially in tropical and subtropical areas where transportation systems do not allow immediate delivery to extraction centers.

B. Objectives
  1. Recognize the crucial times when seed quality may be lost.
  2. Plan storage and transportation systems to minimize the danger to seed quality.

C. Key Points

The following points are essential to post-harvest care:
  1. High moisture contents and high temperatures are dangerous for orthodox species.
  2. High moisture levels must be maintained in recalcitrant seeds, but excessive heat is a problem with these seeds.
  3. Fruit storage can be advantageous for some species because of the afterripening processes that occur in the seeds.

D. Storage Before Extraction
  1. **Operation schedules** — Time does not permit seeds from all trees or families to be collected at peak maturity; therefore, some must be picked and stored.
  2. **Predrying—** Drying during storage can remove enough moisture to lower drying costs.
  3. **Completion of maturation**
     a. 5 or 6 months in cool, moist conditions complete maturation for *Abies.*
     b. Similar benefits are possible for highest seed quality for some pines of the Southern United States.
     c. Premature collection is suitable for some multiseed hardwoods; e.g., *Liquidambar, Liriodendron,* and *Platanus.*

E. Southern Pines
  1. **Storage** is usually related to operation schedules.
  2. **Outdoor storage** is better than indoor storage.
  3. **Containers**
     a. All containers must provide air circulation among the cones.
     b. Burlap bags (about one-third hectoliter, loose weave) or wooden crates are best.
     c. Plastic bags or sacks should not be used.
     d. Paper sacks are satisfactory for small lots.
  4. **Time**
     a. Storage can improve germination rate.
     b. Maximum length of storage depends on the species.
  5. **Other factors**
     a. Original maturity of cones is important; more mature cones cannot be stored as long as less mature cones.
     b. Local weather is important; warm, rainy conditions increase the risk of cone molds.
  6. **Immaturity/Dormancy** can be changed during cone storage.
  7. **Heat and molds**
     a. Green cones can generate heat.
     b. External molds are common in some containers, but these molds may not cause damage.
     c. Good aeration is essential; it prevents mold growth on cones during drying.

F. Serotinous Cones
  1. Storage is not a major problem for *Pinus glauca, P. contorta,* or *P patula.*
  2. Some pine seeds need to remain in the cones to reach maturity.

G. Other Conifers
  1. True firs *(Abies)* miist complete ripening in the cones.
  2. Seeds of most *Picea* species should be extracted as early after collection as possible.
  3. *Pseudotsuga* cones can be stored for 3 to 4 months in dry, well-ventilated conditions.
  4. The recommendations for tropical pines are:

a. Cover with good ventilation, with temperatures between 20 and 35 °C.
b. Protect from rodents and fungi.
c. In Honduras, *Pinus caribaea* is precured until all of the cone changes from green to brown.
d. In New Zealand, immature cones of *P. radiata* are stored for 10 weeks at 20 to 24 °C.
e. In Indonesia, green and green/brown cones of *P. merkusii* are stored for 2 to 4 weeks.

H. Hardwoods

1. Immature fruits of some species will respond to artificial ripening, but seed yields and quality suffer.
2. Seeds of some species should be stored for as short a period as possible. Orthodox species include:
   a. *Eucalyptus* — *Store* in tightly-woven cloth bags.
   b. Legumes — Storage is easily managed.
   c. Drupes—Short storage will help to complete ripening.

I. Summary

Most species fit into one of three groups:

1. **Harvest dry, keep dry—Start** drying immediately, and keep dry after extraction (e.g., *Pinus, Liquidambar, Liriodendron, Acacia,* and *Eucalyptus).*
   a. Use a slow drying rate.
   b. Provide good aeration.
   c. Use suitable containers, including:
      (1) Burlap bags
      (2) Racks
      (3) Wooden crates
      (4) Canvas or plastic sheets
2. **Harvest moist, then dry—Keep** moist when collecting and during extraction, but dry seeds for storage (e.g., *Nyssa* and *Prunus).*
   a. Spread to avoid heat.
   b. Use trays or bags.
   c. Avoid outer coat toughness.
   d. Extract, wash, and dry for storage.
3. **Moist forever—This** method is used for recalcitrant seeds because drying decreases quality (e.g., *Quercus, Aesculus, Shorea,* and *Hopea).*
   a. Never dry.
   b. Keep moisture 30 percent.
   c. Refrigerate to a safe temperature:
      (1) 1 to 3 °C for temperate species
      (2) 15 to 20 °C for tropical species
   d. Use polyethylene-lined containers or bags.

J. Sources

For additional information, see Bonner 1987a; Willan 1985, p. 78-86.