Seed Programs

I. National Programs

A. Introduction

National seed programs are necessary to support national reforestation and afforestation efforts by ensuring an adequate supply of high-quality seeds of suitable species and sources. Countries of the Association of Southeast Asian Nations are losing over 1.2 million hectares of forest lands annually to other uses. Deforestation of "officially" designated forest lands in India has not been excessive since the 1950's (about 3 percent of the lands under the Forest Department), but more than 10 times this area of wastelands, small groves, etc., has been denuded. Within the framework of national programs, State or Provincial seed programs may also be needed.

B. Objectives

1. Learn the general functions of a national forest-seed program.
2. Examine possible administrative structures of a national program.
3. Examine an existing national program as a case study.

C. Key Points

The following points are important in national seed programs:

1. The primary function of a national forest-seed program is to ensure an adequate supply of suitable tree seeds.
2. National programs can serve many other important functions.
3. National programs should serve the needs of all tree planting: industrial wood plantations, watershed protection, social forestry plantings, agroforestry, etc.

D. Tree-planting activities should be served by a national forest-seed program.

1. **Industrial wood products**
2. **Fuelwood and charcoal**
   a. Village forests
   b. Individual landowners
   c. Commercial production
3. **Watershed protection**
   a. General protection
   b. Protection in specific areas (i.e., reservoirs, mine spoils, dune stabiliation)
4. **Windbreaks or shelterbelts**
5. **Urban planting**
6. **Wildlife habitat and food plantings**
7. **Agroforestry planting**
8. **Social forestry**
9. **Conservation of genetic resources**

E. Scope of the Program

1. **Population distribution**
2. **Physiographic characteristics**
3. **Available land area and ownership**
4. **Realistic annual goals**
5. **Seed storage needs**
6. **Use of indigenous species**

F. Species Choices

1. **Indigenous species and land races** These may be best.
2. Exotics- Caution should be used wi th exotics.
3. **Seed source - Provenance** tests are needed.
4. **Natural plant succession should** be **followed.**

G. Administrative Structure -Many government agencies or ministries may be involved, such as:

1. **Forestry ministry levels**
   a. National
   b. Provincial or State
   c. Village or other local structures
2. **Comprehensive natural resource agencies**
3. **Agricultural agencies**
4. **Military departments**
5. **Division of responsibilities**
   a. Overall planning
   b. Seed acquisition and distribution There may be a central location or regional centers for the following:
      (1) Collecting and cleaning
      (2) Testing
      (3) Storage
      (4) Certification
      (5) Record keeping
      (6) Sales to other countries
      (7) Sales within country
   c. Seedling production can be based in:
      (1) National or State nurseries
      (2) Village nurseries
      (3) Private nurseries (farmers)
      (4) Commercial nurseries
   d. Plantation care - Two factors must be considered:
      (1) Protection, primarily from animals, fire, and people
      (2) Measurement of survival and early growth
   e. Research - Many problems may require research, such as:
      (1) Seed problems
      (2) Species, site, and seed source evaluations

H. Critical Steps

Several critical steps in the planning process call for good decisions:

1. **Planting goals-** what, where, and how much?
2. **Availability of seed supply**

a. Indigenous species
b. Commercial sources

3. **Collection crews**
   a. Equipment and transport
   b. Training
   c. Legal obstacles
4. **Nursery administration**
   a. Site
   b. Personnel
   c. Equipment
5. **Collection goals**
6. **Seed centers—National,** State, or regional?

I. Other Considerations

1. **Continuity of operations**
2. **Training**
3. **Multiple functions**
   a. Some foresters also grow and distribute fruit trees.
   b. In some countries, only one seed laboratory is available to test both agricultural and tree seeds.
4. **International organizations** that can help in planning:
   a. ISTA — ISTA Secretariat
      Reckenholz, P. 0. Box 412
      CH-8046 Zurich
      Switzerland
   b. IUFRO — IUFRO Secretariat
      Schonbrunn
      A-1131 Vienna
      Austria
   c. FAO — Forest Resources Development Branch
      Forest Resources Division
      Forestry Dept., FAO
      Via delle Terme di Caracalla
      I-00100 Rome
      Italy
   d. ICRAF — International Council for Research in Agroforestry
      P.O. Box 30677
      Nairobi
      Kenya

J. Case Study

K. Summary

The functions of a national seed center are:

1. Further develop taxonomy and aids to species identification.
2. Collect and disseminate data on the ecology of individual species, thus enhancing understanding of the performance of species.
3. Promote measures, as necessary, to conserve the genetic resources of important species.
4. Develop optimum seed collection strategies based on knowledge of breeding systems.
5. Maintain existing seed collections and ensure their future development as programs evolve to utilize promising species and provenances.
6. Assist collectors from other countries within the framework of national policy; some countries restrict collections by foreign nationals.
7. Provide information on the physical and physiological characteristics of seeds, and any diseases that might be borne by seeds.
8. Encourage quarantine practices that minimize the chances of domestic insects becoming established in other countries.
9. Disseminate information by providing appropriate training, symposia, and publications.
10. Disseminate seed samples for research or species trials to other institutions or countries on a cost or exchange basis.

L. Sources

For additional information see Gregg 1983, Hellum (in press), Robbins and Shrestha (in press), Rudolf 1974.

II. Seed Centers

A. Introduction

National forest-seed programs require some sort of national tree-seed center, institute, or laboratory. Dedicated facilities and some centralized authority are suggested for tree-seed centers. Their level of technology may vary with the country's needs, but these centers should serve as the focal point of seed activities.

B. Objectives

1. Learn the general functions of national tree-seed centers and how they support national seed programs.
2. Examine several options for center design.

C. Key Points

The following points are essential to seed center development:

1. The primary function of a seed center is to support the national forest-seed program.
2. Seed centers provide seed services, research on seed problems, training of seed workers, and extension activities for seed users.
3. Many countries will require regional or subcenters for efficient operation.

D. Functions

1. **Services**
   a. Coordinates seed collection
   b. Conditions seed collections
      (1) All operations at a main center

(2) Drying and extracting at regional centers

c. Storage of seeds
(1) Operational storage
(2) Long-term storage of surplus stocks
(3) Very long-term storage

d. Testing
(1) National seed program collections
(2) Other in-country users
(3) Third-party testing

e. Certification

2. **Seed research**
a. Applied research
b. Basic research

3. **Training and extension**
a. Train seed collectors, analysts, and others
b. Extension programs for nursery workers and farmers

E. National or Regional Centers

1. **National centers** can be more responsive to political realities.
2. **Regional centers** can expand the scope of operations.
3. **Compromise — National** centers are best for storage, testing, and research; regional centers are good for collecting and cleaning.

F. Location Concerns

1. **Proximity to seeds**
2. **Transportation**
3. **Isolation**
4. **Technical help**
5. **Disaster potential**

G. Center Design

1. **Activity zones** include the following areas:
a. Loading dock
b. Drying area
c. Extraction equipment
d. Cleaning equipment
e. Conditioning equipment
f. Seed storage
g. Testing laboratory
h. Offices for records and supervision
i. Supply storeroom.

2. **Building design — Suggested** floor plans and designs are available from ISTA.

3. **Equipment**
a. Commercial sources are best, but much can be made locally.
b. Spare part sources are crucial.
c. Maintenance must be available.
d. Electrical supply must be dependable.

4. **Staffing—Supervisors** should have defined areas of work:
a. Director of the center
b. Collection supervisor
c. Extraction and cleaning supervisor
d. Testing supervisor
e. Inventory and shipping supervisor

5. **Training—All** staff members should be trained in their specialties by university staff, special short courses, or on-the-job training at an established center. If personnel change jobs, the new people must be trained immediately. The skills of long-time staff should be updated as new methods are developed.

III. Labeling and Certification

A. Introduction

When forest reproductive materials (seeds, seedlings, and vegetative propagules) are not collected or grown by the user, that user should have reasonable assurance of the identity and quality of the material he is buying. Many seed-labeling laws require detailed labeling to assure the buyer of the seeds' identity, purity, viability, and freedom from pests; i.e., the physiological quality of the seedlot. Certification is more than labeling required by seed laws; it is a statement about the genetic quality and identity of the seedlot.

B. Objectives

1. Understand the purpose of certification
2. Identify the general elements of a certification program.
3. Describe the four certification categories used in the Organization for Economic Cooperation and Development (OECD) standards for international trade.

C. Key Points

The following points are essential to understanding labeling and certification of forest reproductive materials:

1. Certification is the guarantee by an officially recognized organization that forest reproductive materials of identified varieties have been grown, collected, processed, and distributed in a manner to maintain high quality and genetic identity.
2. A certification program requires a certification agency, a producer who wishes to sell certified material, records of the breeding program, certification standards, independent inspections, and certification labels.
3. The four certification categories used by OECD are:
a. source-identified (yellow tag)
b. selected (green tag)
c. untested seed orchards (pink tag)
d. tested reproduction material (blue tag)

4. Certification usually requires inspections of the production unit prior to pollination, a crop inspection before harvest, inspections during the collection-to-storage phases, and inspections at the time of packaging materials for sale.

D. Certification

1. **Definition—Certification** is the guarantee of character and quality of reproductive materials by an officially recognized organization.
2. **Purpose — Certification** is more than just labeling. Its purpose is to maintain and make available to the public high-quality seeds and propagating materials of superior crop plant varieties.
3. **International aspect** —An international scheme for certifying forest reproductive material has been developed by OECD.

E. Definition of Terms

The following definitions are for terms used in the OECD Scheme (Organization for Economic Cooperation and Development 1974):

1. **Forest reproductive material**
   a. **Seeds:** cones, fruits, and seeds intended for the production of plants
   b. **Parts of plants:** stem, leaf, and root cuttings, scions and layers intended for the reproduction of plants
   c. **Plants:** plants raised by means of seeds or parts of plants; also includes natural regeneration
2. **Clone —** a genetically uniform assemblage of individuals derived originally from a single individual by vegetative propagation, such as by cuttings, divisions, grafts, layers, or apomixis
3. **Cultivar** — an assemblage of cultivated individuals, which is distinguished by any characters (morphological, physiological, cytological, chemical, or others) significant for the purposes of agriculture, forestry, or horticulture and which, when reproduced (sexually or asexually), retains its distinguishing features
4. **Provenance** — the place in which any stand of trees is growing; the stand may be indigenous or nonindigenous. (This is the location of the seed source.)
5. **Origin—for** indigenous stands of trees, the origin is the place in which trees are growing; for nonindigenous stands, the origin is the place from which the seeds or plants were originally introduced
6. **Designated authority—** an organization or institution designated by and responsible to the government of a country participating in the OECD scheme for the purpose of implementing the rules of the scheme on its behalf

F. General Elements of a Certification Program

1. **Designated authority—** The designated authority must have legal standing.
2. **Producer—** There must be qualified producers.
3. **History of the material—These** data cover provenance, seed source, and breeding history.
4. **Supervised production—** The designated authority does this.
5. **Standards—The** material must meet minimum standards.
6. **Certification labels —** Labels are attached to all products.

G. Standards for Certification

1. **Certification classes—Forestry** programs typically use the following OECD standards:
   a. Source-identified reproductive material (yellow tag). Conditions are:
      (1) Seed source and/or provenance must be defined.
      (2) Seeds must be collected, processed, and stored under inspection.
   b. Selected reproductive material (green tag). Conditions are:
      (1) Isolated
      (2) Normal variation
      (3) Sufficient size
      (4) Sufficient age and stage of development
      (5) Phenotypic superiority
   c. Material from untested seed orchards (pink tag).
   d. Tested reproductive material (blue tag).
2. **Seed collection zones** have special features:
   a. They are delimited by administrative and geographic boundaries.
   b. Boundaries and reference numbers of seed collection zones should be established and published.
   c. Seed collection zones are necessary for "source-identified reproductive material."
3. **Other requirements of certification**
   a. The originator, developer, owner, agent, or producer must request certification and furnish:
      (1) Name of the variety
      (2) Statement of the variety's origin
      (3) Detailed description of characteristics that distinguish the variety

(4) Evidence of performance
(5) Statement on the suggested area of adaptation

b. Inspections may include:
(1) Initial field inspections
(2) Mature crop inspections
(3) Inspections during collection, conditioning, and storage
(4) Inspection at the time of packaging for sale

c. Fees are paid by producer to support the system.

H. Other Documentation

1. **Labels-Some** countries or other political entities require labels for commercial sales with identity (species), purity, germination, etc., on the labels. No certification is implied.
2. **Phytosanitary certificate -** Phytosanitary certification is required by most countries to stop the spread of insects and pathogens. It certifies that the seeds have been inspected and/or treated.

I. Sources

For additional information, see Bonner 1981a, Organization for Economic Cooperation and Development 1974, Rudolf 1974.

IV. Germplasm Conservation

A. Introduction

Loss of forests around the world is widely deplored for many reasons. One consequence of deforestation is the loss of valuable germplasm that could be used in artificial regeneration and future breeding programs. The Food and Agriculture Organization (FAO) lists more than 300 tree species or provenances as endangered. Fortunately, there are steps that can be taken to conserve this germplasm.

B. Objectives

1. Recognize the consequences of excessive loss of germplasm of forest trees.
2. Learn the strategies available to conserve germplasm.

C. Key Points

The following points are essential to understanding germplasm conservation:

1. The ideal practice would be extensive in situ preservation.
2. Ex situ conservation is widely practiced already, but "passport data" on planted material need to be maintained.
3. Seed storage can play a critical role in germplasm conservation.
4. National programs of conservation should be carefully planned and established.

D. Importance of the Problem

1. **Deforestation**
2. **Insect and disease losses**
3. **Global climate changes**
4. **Endangered species**

E. Available Technologies for Conservation

The following strategies are options for germplasm conservation:

1. **In situ conservation**
2. **Ex situ conservation**
3. **Conventional seed storage**
4. **Cryogenic storage**
5. **Storage of pollen**
6. **Micropropagation tissues**

F. Current Efforts

The following organizations engage in some germplasm conservation (table 17):

1. Food and Agriculture Organization (FAO)
2. International Board for Plant Genetic Resources (IBPGR)
3. Central America and Mexico Coniferous Resource Cooperative (CAMCORE)
4. Oxford Forestry Institute (OFI)
5. Danish International Development Agency (DANIDA)
6. Centre Technique Forestier Tropical (CTFT)
7. Commonwealth Scientific and Industrial Research Organization (CSIRO)
8. Many other countries have national seed storage facilities

G. Recommendations for Action

1. **Increased efforts in in situ conservation**
2. **International efforts for more ex situ conservation plantings**
3. **More research on conventional seed storage**
4. **Increased research with recalcitrant seeds**
5. **Establish more seed banks**

V. Applied Research

A. Introduction

Many seed problems can be solved locally without sophisticated research equipment that is costly to acquire and operate. Some investigations furnish answers without statistical treatment; others need statistical work to demonstrate their reliability. Simple designs are usually satisfactory in seed work, including completely randomized treatments and factorials. The main requirements are curiosity and dedication.

B. Objectives

1. Learn a few principles of simple research studies.

Table 17. —*Some major international seed storage centers**

Center	Country	Approximate size of collection: Species	Approximate size of collection: Sources	Reference
		--- *Number*		
United States Forest Tree Seed Center	United States	67	197	Karrfalt (1985)‡
National Seed Storage Laboratory	United States	18	41	Bass (1985)†
Petawawa National Forestry Institute	Canada	118	2,130	Janas (1984)
DANIDA Forest Seed Centre	Denmark	46	187	Anonymous (1985)
CSIRO Tree Seed Centre	Australia	900	4,000	Turnbull and Doran (in press)
OFI Oxford, UK	United Kingdom			
Banco Latinoamericano de Semillas Forestales	Costa Rica	153	308	Anon. (1983)
Banco de Semillas COHDEFOR	Honduras	4	46	Gustavo (1985)†

*Bonner, F.T. 1986. Unpublished report. On file with: USAID Science and Technology Office, Washington, DC. [Number of pages unknown].
†Personal communication from center directors.
‡Data not available

2. Review case study examples of applied seed research.

C. Key Points

The following points are essential to applied seed research:

1. Problems can often, but not always, be solved with simple tests and experiments.
2. Standard procedures are always used when they are available; e.g., ISTA (1985) rules for germination testing.
3. Treatments are always replicated with several seed sources or in different seed years.
4. Limitations of the procedures in use must be recognized; e.g., electric seed moisture meters cannot be accurate to 0.1 percent.

D. General Considerations

1. **Replication—** The "standard" is 4 replicates of 100 seeds each (typically designated 4 x 100).
2. **Documentation—** Complete records are essential.
3. **Statistics**
   a. Studies must be designed to allow statistical analysis.
   b. Simple designs are used whenever possible.
   c. Common sense cannot be replaced with statistics.
4. **Publication — Good** results should be published.

E. Case Studies

1. **Maturity indices of fruits or seeds** — determine by:
   a. Using a minimum of five trees.
   b. Sampling for a reasonable time period.
   c. Collecting 10 to 15 fruits per tree.
   d. Taking color photographs if possible.
   e. Testing for the best parameters:
      (1) Size (length and diameter)
      (2) Weight (wet and dry; dried at 103 °C for 15 to 24 hours)
      (3) Moisture content
      (4) Germination
      (5) Chemical analyses
   f. Collecting data and plotting means on a time scale.
   g. Repeating at least twice to cover three seed crops.
2. **Extracting and cleaning methods**
   a. Possible tests include:
      (1) Sun drying vs. shade drying
      (2) Hand extraction vs. machine extraction

(3) Any mechanical action vs. hand cleaning
(4) Determining seed size effects by sizing into three groups and testing germination
(5) Dewinging vs. sowing winged seeds

b. Each treatment should be replicated 5 times; each replicate is tested with 4 samples of 50 seeds each.
c. Unusual results are always retested.
d. Suggested statistical designs are "t" tests for two treatments and complete randomization for more than two treatments.

3. **Pretreatment for germination**
a. Possible methods to test include:
(1) Hand scarification vs. mechanical scarification
(2) Hot vs. cold water soak
(3) Stratification time and temperature
(4) Chemical stimulation

b. The same general directions as described in "2.b" through "d" above apply in these tests also.

4. **Storage conditions**
a. Possible tests include:
(1) Room temperature vs. refrigerated conditions
(2) Different refrigeration temperatures
(3) Seed moisture levels
(4) Type of storage containers

b. Replicates should be large enough to allow sampling over time.
c. Frequency of testing for orthodox seeds is 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 years, and for recalcitrant seeds, frequency is 1, 2, 4, 8, 12, 18, and 24 months, then every 6 months thereafter.
d. At least four replicates should be used.

5. **Testing for recalcitrance—A** good test for recalcitrance is:
a. Bring the seedlot to full imbibition.
b. Start drying with at least two rates (slow and fast).
c. Take periodic samples for moisture content and germination.
d. Maintain the drying range from full imbibition to 10-percent moisture or until death of the seeds.
e. Designate seeds that cannot be dried below 20 percent as recalcitrant.
f. Repeat this test to confirm recalcitrance; never trust just one measurement cycle. Tests of additional seedlots are desirable.
g. Check chilling injury at 0 to 5 °C by exposing fully imbibed seeds to this temperature for 24 hours.
h. Keep statistics in perspective. Realize that they are not as important as common sense in interpretation of results.