General Comments

'Companies do not work on the basis of improvisation. Almost everything is planned in advance. Planning figures as the primary function of administration, precisely because it serves as the basis for other functions. **Planning** is the administrative function that determines in advance those objectives that should be reached and what must be done to reach them. It therefore concerns a theoretical model for future action. It begins by determining objectives and detailing the plans necessary for reaching them in the best way possible. Planning is to define objectives and choose in advance the best course of action to reach them. Planning defines where the company wants to arrive, what must be done, when, how, and in what sequence' (Chiavenatto 1997).

The management of germplasm banks for *ex situ* conservation includes a sequential development of stages, that is, collection → multiplication → regeneration → documentation → characterization → evaluation → and, lastly, distribution. After 2 decades of intense concern to create germplasm banks, interest is shifting towards developing strategies to improve the composition and management of collections. The increasing global emphasis on short-term solutions has further increased the need to justify and streamline long-term conservation and, consequently, the need to ensure that decisions are optimal for the long term (Sackville Hamilton et al. 2002).

Information on the Module

This module deals with the management of plant germplasm banks according to administrative principles. It contains one lesson and a brief evaluation.

Objective

When you have completed this module, you should be able to identify the most important aspects of managing plant germplasm banks.

Next Lesson

The next lesson deals with general aspects of managing germplasm banks.

Bibliography

Throughout this module, a bibliography is provided for each section, that is, the *General Comments* and the *Lesson*. The bibliographies follow a format of two parts:

1. *Literature cited*, which includes those references cited in the text itself. Some of these citations were used to develop the original Spanish-language course on *ex situ* conservation and may therefore appear in Spanish or Portuguese. However, where practical, references to the English versions of the original Spanish-language documents are provided.
2. *Further reading*, which is a list of suggested readings in the English language, with few exceptions in Spanish. Most cover in depth the topics included in this module.

A list of *Acronyms used in the bibliographies* is also given. The idea is to save space by not having to spell out each institution's full name each time it appears in the references.

Acronyms used in the bibliographies

AECI	Agencia Española de Cooperación Internacional
AVRDC	Asian Vegetable Research and Development Center
FAO	Food and Agriculture Organization of the United Nations
IBD	Inter-American Development Bank
IBPGR	International Board for Plant Genetic Resources
IICA	Inter-American Institute for Cooperation in Agriculture
INIA	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias
IPGRI	International Plant Genetic Resources Institute
JABG	Japan Association of Botanical Gardens
JIRCAS	Japan International Research Center for Agricultural Sciences
NRC	National Research Council

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Next Lesson

In the next lesson, you will study general aspects of managing plant germplasm banks.

General Aspects of Bank Management

Objective

To identify the most important aspects of managing plant germplasm banks

Introduction

Activities for the *ex situ* conservation of PGRs are usually concentrated within **germplasm banks,** which handle collections of plant materials to maintain them alive and preserve their characteristics for appropriate use. Conservation is carried out, using collections of live plant materials in the field (botanical gardens and arboreta), seeds, or *in vitro* plants. However, the mere existence of a bank does not secure the conservation of PGRs of interest to a country, region, province, or given ecosystem. To achieve the goals of conservation, germplasm banks must be planned, structured, established, and well managed according to their objectives and to the requirements typical of *ex situ* conservation. These requirements may include significant biological, physical, human, and institutional aspects (see *Module 1, Lesson 3*).

The management of germplasm banks, as for any **business enterprise**, is administrative and, as such, must take into account the principles that deal with the four basic functions of administration: planning, organization, direction, and control. This lesson briefly refers to each of these principles and other aspects of germplasm bank management.

Administrative Principles

Management is a widespread activity and essential to every collective human effort. It consists of orienting, directing, and controlling the efforts of a group of individuals to achieve a common objective (Chiavenatto 1997). For PGRs, clearly, management should lead to the conservation of targeted species.

Planning

During planning, objectives are defined and the best course of action for reaching them selected in advance. That is, planning determines the **objectives** and details the **plans** needed to reach them in the best possible way. It therefore determines and describes the goals to be achieved, and what must be done, when, how, and in what sequence (Chiavenatto 1997).

Establishing objectives. Objectives are the future results that are hoped to be attained. They are the chosen targets that must be reached within a certain period, applying given available or possible resources. In reality, objectives exist for the entity (e.g., germplasm bank) as a whole, for each of its divisions or departments separately, and for each of its specialists (e.g., different sections established within a germplasm bank and specialists such as geneticists, biologists, and phytopathologists).

The organization's **objectives** can be visualized as a hierarchy that ranges from **global** or organizational at the top down to **operative** or **operational**, involving simple instructions for daily routines. Thus, planning comprises as much of long-term strategies and policies for reaching the organization's global objectives as of sets of **plans** that detail daily activities for achieving immediate objectives within each division or organ of the organization. Based on its organizational objectives, the entity (germplasm bank) can set its policies, directives, goals, programmes, procedures, methods, and standards.

Policies refer to the establishment of the organization's objectives or intentions to orient administrative action. **Directives** are principles established to permit the attainment of the intended objectives. As objectives are ends, directives serve to establish adequate means for reaching them and for channelling decisions. **Goals** are short-term targets. They are often confused with immediate objectives or with departmental or section objectives.

Programmes comprise the necessary activities for meeting each goal. Attainment of goals is planned through programmes, which are specific plans. They are highly variable and may include an integrated set of minor plans. **Procedures** or routines are the modes by which the programmes must be carried out or organized. Procedures are plans that prescribe the chronological sequence of specific tasks needed to carry out determined jobs. **Methods** are plans prescribed for the performance of a specific task. Usually, the method is attributed to each person who occupies a position or carries out a task, and details exactly how that task is done. Method is more limited in scope than procedure. Procedures and methods generally use flow charts to represent the flow of tasks or operations (Figure 1).

Norms are rules that delimit and safeguard procedures. They are direct and objective orders for the course of action to be followed. They are specific guides for action, and usually define what should or should not be done.

In the case of a national germplasm bank, for example, its objectives would be:

- Long-term conservation of PGRs at the national level
- Germplasm regeneration
- Characterization and evaluation of specific germplasm
- Organization of germplasm exploration and collection at the national level
- Germplasm introduction
- National and international exchange of germplasm and information
- Training, education, and organization of technical meetings and workshops

Planning scope. In addition to the hierarchy of objectives, a planning hierarchy also exists, comprising three levels: strategic, tactical, and operational.

- *Strategic planning* is the broadest planning for the organization. It projects for the long term, with effects and consequences foreseen over several years. It covers the entity as a whole, encompassing all its resources and areas of activity. It is concerned with drafting objectives at the organizational level, being defined at the peak of the organization. It corresponds to the greater plan, to which all other plans are subordinated.

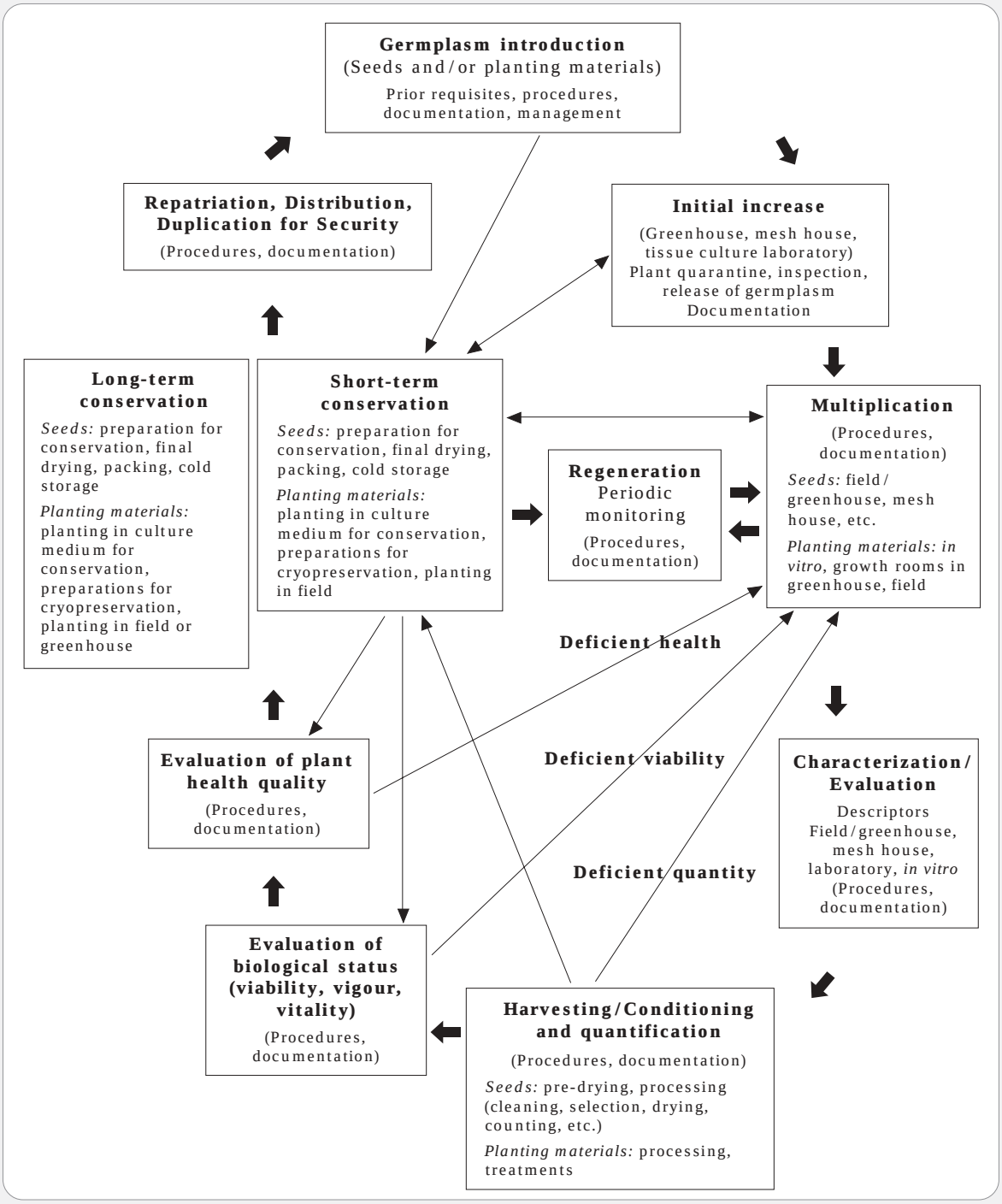

Figure 1. Proposed flow chart for the *ex situ* management of germplasm, in which different stages of the process are visualized and certain tasks and operations are mentioned. Thick arrows indicate normal flow of operations; thin arrows indicate conditioning. (From *Flow Chart for Germplasm Management at GRU, CIAT*, redrawn by B Pineda.)

- *Tactical planning* is done at the departmental level. It projects for the medium term, usually the annual fiscal period. It covers each department, encompassing its specific resources, and is concerned with reaching the department's objectives. It is defined within each department of the entity.
- *Operational planning* is that carried out for each task or activity. It projects for the short term, for what is immediate. It covers each task or activity separately and is concerned with meeting specific targets. It is defined for each task or activity. Operational planning usually constitutes goals, programmes, procedures, methods, and norms.

Types of plans. Plans are the product of planning and constitute the intermediate event between planning and implementation. They have common purposes: prediction, programming, and coordination of a logical sequence of events, which, if they are successfully applied, must lead to the attainment of the objectives orienting them. They are usually strategic, tactical, or operational in character, and tend to be of several types:

- Procedures, related to methods
- Budgets, related to money
- Programmes or programming, related to time
- Norms or regulations, related to conduct

Organization

Organization, as a function and integrated part of administration, is the act of organizing, structuring, and integrating resources and pertinent organs of its administration; and of establishing relationships among them and the functions of each. It depends on planning, direction, and control to form the administrative process. So that objectives can be attained, plans executed, and people performing efficiently, activities must be suitably grouped, in a **logical manner**. Authority should be distributed so that it prevents conflicts and confusion. Organization consists of:

- Determining specific activities needed to attain planned objectives (specialization)
- Grouping activities into a logical structure (departmentalization)
- Allotting activities to specific positions and people (occupations and tasks)

Direction

Direction constitutes the third administrative function, following planning and organization. Once planning is defined and organization established, things must happen. This is the role of direction: to activate the entity, giving it the dynamics to function. Direction is related to action, such as implementation, and has much to do with people. It is directly related to actions taken with the entity's human resources.

People need to apply themselves to their positions and functions, to be trained, to be guided and motivated to obtain the results expected from them. The function of direction is related directly to the way by which the objective or objectives must be reached, by means of the activity of the people comprising the entity. Thus, direction is the administrative function that refers to the interpersonal relationships between administrators at all levels of the entity and their respective subordinates.

So that planning and organization are effective, they need to be made dynamic and to be complemented by the orientation given to people, through adequate communication, skilful leadership, and motivation. To direct subordinates, the administrator—at whatever level of the entity—must communicate, lead, and motivate. As no entity exists without people, direction constitutes one of the most complex administrative functions in that it implies orientation, assistance with execution, communication, motivation; in short, with all the processes that administrators use to influence their subordinates so that they behave according to expectations and thus achieve the entity's objectives.

Control

As an administrative function, control aims to ensure that the results of that which was planned, organized, and directed shall adjust, as much as possible, to the previously established objectives. The essence of control resides in verifying if the controlled activity is attaining the objectives with the desired results. Control consists, basically, of guiding every activity towards a given end. As a process, control presents phases that require explanation.

Other Aspects of Germplasm Banks

Germplasm banks are established to meet a research institution, country, or region's objective to conserve plant materials. A bank carries out different activities that range from acquiring germplasm, discovering its characteristics and potential profit, and ensuring its survival to maintaining it available for users and disseminating information that promotes its use. Banks are usually assigned to an institution or group of people (curators) with the capacity and resources to maintain germplasm under optimal conditions for the required period (IPGRI 1998; Jaramillo and Baena 2000).

Types of banks

Germplasm banks are classified according to (Jaramillo and Baena 2000; Painting et al. 1993):

- Sample type, that is, seed, field (including botanical gardens and arboreta), or *in vitro*
- Number of species conserved (mono-, oligo-, and poly-specific)
- Mandate of the institutions to which they are assigned (institutional, national, regional, or international)

Banks according to sample type conserve orthodox seeds over the short, medium, and long term under controlled conditions of humidity and temperature (Ellis and Roberts 1991; Withers 1995). Examples of seed banks are abundant, and include those of beans at CIAT (Colombia), maize and wheat at CIMMYT (Mexico), *Capsicum*, *Cucurbita*, and *Solanum* spp. at CATIE (Costa Rica), rice at IITA (Nigeria) and IRRI (Philippines), and sorghum at ICRISAT (India).

Field banks conserve species whose storage in the form of seed is problematic or unlikely. They can include botanical gardens and arboreta, which, traditionally, were established to classify and study interspecies variation (mainly medicinal species) and whose current objective is to conserve species that are rare, in danger of extinction, and/or useful for restoring ecosystems (Frankel et al. 1995; Heywood 1991; Querol 1988). Examples of field banks include those of cassava at CIAT (Colombia), forages at INTA (Argentina), potatoes and Andean roots and tubers at CIP (Peru), cassava and citruses at CENARGEN (Brazil), and yam at IITA (Nigeria). Examples of botanical gardens include the José Celestino Mutis and the Faculty of Agronomy at the University of Caldas (Colombia), the Arenal and the Lankester (Costa Rica), and the Lancetilla (Honduras).

In vitro banks are collections of germplasm maintained under laboratory conditions that reduce or suspend growth in the samples. *In vitro* banks conserve species that cannot be conserved as seed, but as different sample types such as entire plants, tissues (apices, meristems, and calluses), and DNA fragments (Frankel et al. 1995). Three examples are the cassava banks located at CIAT (Colombia), and at IITA (Nigeria), and potato in CIP (Peru).

Banks according to number of species conserved can be mono- and oligo-specific, conserving, respectively, one or a few species on a short- or medium-term basis. Examples of this category are banks for research programmes in national and international centres such as those of the soybean germplasm bank for the oleaginous crops programme at CORPOICA (Colombia), and maize for the tropical acid soils improvement programme at CIMMYT (Colombia).

Poly-specific banks are established as national centres of PGRs for given countries, and are used for research and improvement. Conservation is long term, and a broad range of species of current or potential interest is distributed. One example of this type of bank is that of INTA in Argentina, which maintains, among others, collections of *Arachis* spp., *Linum usitatissimum*, *Triticum* spp., *Zea mays*, *Sorghum* spp., *Gossypium hirsutum*, *Glycine max*, *Solanum* spp., and *Helianthus* spp. (Jaramillo and Baena 2000). IITA in Nigeria maintains species of legumes and root and tubers.

Banks according to institutional mandate are normally assigned to an institution whose mandate, nature, or geographical scope is reflected in its objectives. Such banks are therefore called institutional, national, regional, or international banks. Institutional banks conserve only germplasm used for research by the institute to which they are assigned, for example, that of the Federal University of Viçosa (Brazil) conserves germplasm only from the *Lycopersicon* and *Solanum* genera.

Regional banks are established as collaborative entities between several countries to conserve germplasm and support research of a given region. In Latin America, one example is the bank at CATIE (Costa Rica), which holds collections of several genera such as *Capsicum*, *Cucurbita*, and *Solanum*. The banks attached to international agricultural research centres were initially established to support improvement programmes, conserve germplasm of crops under their respective mandates and of other crops. Two examples are the germplasm banks of *Phaseolus* and *Manihot* spp., and tropical forages at CIAT (Colombia) and of *Zea*, *Triticum*, *Hordeum*, and *Secale* spp. at CIMMYT (Mexico).

Organizing the germplasm

To manage germplasm, banks organize their materials as **germplasm collections** or groupings of accessions that represent a genetic variation that is targeted for conservation and/or use. Such collections may contain from tens to thousands of samples, maintained under appropriate environments and conditions. Germplasm collections are classified as base, active, core, or working.

Base collection. It groups the possible genetic variability of the species of interest, including wild relatives, intermediate forms, cultivars, landraces, and elite germplasm (Vilela-Morales and Valois 1996a, b). It is established to conserve long-term germplasm and recover missing accessions. It is not used to distribute or for exchange (NRC 1993; Plucknett et al. 1992; Towil and Roos 1989; Vilela-Morales and Valois 1996a). It may contain seed samples (orthodox only) or planting materials. If it contains seeds, these are conditioned to a moisture content of 3%-7%, packed in sealed containers, and stored in chambers at temperatures between -10° and -20°C (FAO and IPGRI 1994; Paroda and Arora 1991; Towil and Roos 1989; Vilela-Morales and Valois 1996a). If vegetative materials are conserved, they are either maintained in the field or cryopreserved.

For the variability it contains and the function it fulfils, a base collection is strategic for a country. It should be duplicated and under the charge of an institution that can answer for the germplasm's survival. It is normally the responsibility of a national programme or international agricultural research centre. Examples of base collections include those of *Arachis* spp. at CENARGEN (Brazil), *Phaseolus* and *Manihot* spp. at CIAT (Colombia), *Zea* and *Triticum* spp. at CIMMYT (Mexico), and Andean roots and tubers at CIP (Peru), and African legumes at IITA.

Active collection. It is a duplicate of the base collection, established on a short- and medium-term basis for management and distribution. It may conserve germplasm as seed, in the field, or *in vitro*. If it conserves seeds, these are stored at moisture content of 3%-7% and at temperatures between 0°C and 15°C (Engle 1992; NRC 1993). If the active collection is established *in vitro*, the material is conserved in slow growth.

Active collections may be the responsibility of a variety of institutions, both public and private, including international research centres; national, regional, provincial, and municipal programmes; universities; and nongovernmental organizations. Two examples of active collections are those of maize at CIMMYT (Mexico) and cassava at CIAT (Colombia).

Core collection. The core collection aims to represent the genetic variability of a large collection by bringing together the broadest genetic variability of a species in the smallest number of samples possible (Brown 1988). It is formed by duplicating a base collection, separating the accessions that will constitute the core collection (70%-80% of variability represented in 10%-15% of the accessions), and taking the rest to a reserve collection. The core collection is established to facilitate management and promote use of the germplasm. It permits the detection of duplicates in the base collection and helps set priorities for characterizing and evaluating the samples. It also offers easy access to the conserved materials (Frankel et al. 1995; Hodgkin et al. 1995; Pérez-Ruíz 1997).

The core collection conserves seed or planting materials under the same conditions as an active collection. As with the other two types mentioned above, a core collection is the responsibility of international centres, national programmes, or collaborative programmes for specific crops. Examples of core collections are those of potato at INTA (Argentina) and IBTA (Bolivia), cassava and potato at CENARGEN (Brazil), potato and sweet potato at CNPH (Brazil), and cassava at CIAT (Colombia).

Information systems permit the creation of a virtual core collection. If a germplasm material is well documented and the documentation system permits specific searches, the virtual core collection is obtained by seeking and marking the accessions that have the characteristics of interest (Jaramillo and Baena 2000).

Working collection or breeder's collection is established to provide germplasm to researchers, institutions, or research and/or improvement programmes. It contains accessions with characteristics of interest for crop improvement, although it is not representative of the species' genetic variability. It conserves seeds or plants over the short term. Seeds are kept at room temperature but, if the climate is hot and humid, then the rooms have air conditioning and dehumidifiers. Plants are also conserved in the field or greenhouse. Working collections are normally the responsibility of crop improvement programmes (Jaramillo and Baena 2000).

Evaluating the Lesson

After this lesson, you should be familiar with the general aspects of managing plant germplasm banks.

Before going on to the next *Module 6*, do the following exercise:

- Describe the administrative structure of your bank and, if possible, the various functions, together with the names of the people in charge of them.
- If you do not work in a bank, indicate the basic functions that a germplasm bank must have, as outlined in this lesson.

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Next Module

In the next *Module 6*, you will study principles of germplasm documentation.