STATUS REPORT OF THE MEXICO CITY METROPOLITAN AREA REFORESTATION PROJECT[1]

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INTRODUCTION

Mexico City undeniably ranks as one of the world's largest cities, with a population of at least 19 million (1990 est.). The rapid urbanization coupled with a unique topography of mountains surrounding the metropolitan area has resulted in frequent stagnated polluted air masses over the city. The ring of mountains (two of which exceed 5,000 m) reduces the flow of winds that would otherwise disperse the atmospheric pollution. At an altitude of approximately 2,240 m, the atmosphere of Mexico City contains 23 percent less oxygen than at sea level. This intensifies the pollution problem due to the incomplete combustion of fossil fuels from motor vehicles and industrial activity. Over the last 20 to 30 years, Mexico City has experienced a significant and rapid increase in both population growth and motor vehicle usage.

The impetus for this project began in Mexico with the concern for the air pollution problem. International support to tackle this problem was solicited. The Japanese and Mexican governments finalized a course of action during the early 1990's. During 1996, Sumitomo Corporation, a Japanese corporation, was awarded the bid for the Mexico City Metropolitan Area Reforestation Project. International Forest Company (IFCO), headquartered in Alabama, is part of the team Sumitomo put together to participate in this project. The purpose of this project is to recuperate and restore eroded and deforested areas, as well as establish new green areas, with the purpose of controlling the suspension of dust particles that affect the population of Mexico City, and in general, improve the air quality.

This multifaceted project contracted with the government of Mexico City, and is specifically under the direction of the Comisión de Recursos Naturales (CORENA). This project includes the following facets:

1. establishment of a Forest Operations Center which will include a technical training center, a center for prevention and control of forest fires and a laboratory;
2. repair of existing and construction of new look-out towers for forest protection;
3. repair and construction of forest roads;
4. expansion of a radio communication system
5. and establishment of a tree seed processing center, laboratory, and containerized nursery complex.

The project area is south of Mexico City and north of Cuernavaca, covering more than 132,000 ha. The project area falls within 3 governmental jurisdictions: Federal District, State of Mexico, and State of Morelos. These jurisdictions jointly agreed that this project area was in urgent need of tree cover. The eastern edge of the project area is bordered by two well-known volcanoes, Iztaccíhuatl (Sleeping Lady) and Popocatépetl (Popo). These volcanoes exceed 5,200 meters in elevation. The topography of the project area as a whole is very mountainous. The average annual rainfall is above 1000 mm per year, with most of the rain coming in the months of June through September. At the nursery site, which is located on the northern edge of the project area, the average annual rainfall is about 725 mm per year.

Sumitomo Corporation subcontracted the responsibility to provide the technology necessary for the administration, operation and maintenance of the Seed Processing Facility and Container Nursery Complex to International Forest Company, it's subsidiary, International Forest Seed Company de México, in conjunction with Especies Forestales SA de CV. The production area of the nursery is designed for an annual production of 30 million trees. During IFCO's contract period, nine million seedlings will be grown and shipped during the first year of operation, 1997-1998. During the second year of operation, 1998-1999, 13.5 million seedlings will be grown and shipped. IFCO's contractual responsibility for the seedlings ends at the nursery gate. At the end of the project 5000 kg of seed must be left in storage for future use. A theoretical and practical training program must be implemented to train the professional and technical personnel of CORENA to enable them to take over operation of the nursery complex at end of the contract period. Seedling trials are established on a regular basis, in an effort to increase knowledge about the species being grown in the nursery.

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[1]Starkey, T.; Germishuizen, P.; de los Reyes, I.E. 1999. Status report of the Mexico City metropolitan area reforestation project. In: Landis, T.D.; Barnett, J.P., tech. coords. National proceedings: forest and conservation nursery associations—1998. Gen. Tech. Rep. SRS-25. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 91-95.

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Especies Forestales, is a subcontractor to IFCO and also their Mexican partner. Their responsibility is the daily operation of the seed plant and nursery, providing and managing the necessary labor and the purchase of all materials.

FACILITIES

Cone and Seed Processing Facility

A 48 tray recirculating dry kiln was built and provided for the project by International Forest Company. In addition, the cone processing area also has a cone tumbler for separating the seed from the cones, storage hoppers, conveyor belts, a hammermill and a circulating head forklift. In the seed processing area, BCC, Sweden has provided a Rotating Drum dewinger, seed cleaning and sizing equipment and gravity separators. Seed is dried in a specially constructed room in which the air is recirculated and dried. Processed seed is stored in refrigeration units at below freezing temperatures.

Seed Laboratory Facility

The seed laboratory is connected to the seed processing facilities. All the necessary equipment to conduct standard tree seed test such as purity, moisture, seeds per kilogram, x-ray, and germination tests have been provided. Two large walk-in Convirons growth chambers are part of the laboratory facilities. One is used for stratification, the other for seed germination tests.

Water Treatment Facility

This facility located adjacent to the nursery complex provides irrigation water for the trees. Sumitomo Corp. is responsible for the operation and maintenance of this complex. Treated water is received from the government operated water/ sewage treatment plant. This water is filtered, retreated and passed through a reverse osmosis process before it is stored in one two large covered cement cisterns (each 1920 m^3) for use in the nursery. The plant has a capacity to process up to 500 m^3 per day of treated water.

Media Mixing and Filling Facilities

A 2000 m^2 open sided building adjacent to the substrate building is provided for the storage of bulk raw materials required for sowing. The substrate building which houses the media mixing equipment, filling lines and container washers has approximately 1900 m^2. A four storage hopper continuous feed, on-demand, media mixer supplied by Bouldin & Lawson, McMinnville, TN. feeds a dual line container filling unit, automatic seeder and capper supplied by BCC, Sweden.

A peat-based media is being used in this project. The exact composition of the growing media is proprietary.

The containers being used in this project were supplied by BCC. The HIKO trays being used are non side-slit 93cc capacity cavity (40 cavities per tray), 310 cc capacity cavity (15 cavities per tray) and 530 cc capacity cavity (15 cavities per tray). By contract agreement, up to 80 percent of all seedlings produced are being grown in the 93 cc containers.

Containers are placed on plastic pallets on the production pads. Each pallet holds ten containers and can efficiently be moved by two individuals. The pallets are supplied by BCC.

Nursery Production Areas

The nursery is divided into 8 uncovered production units. One production supervisor can manage each unit. Each production unit has 6 container pads for growing. These container pads are each approximately 2000 m^2. Each production unit is grouped around a work shed and packing area with 3 container pads on either side. In total, there is 96,000 m^2 of growing space available for production, excluding the greenhouse.

Each container pad is irrigated with a traveling irrigation boom that rolls on rails on the ground. The irrigation boom system was supplied by BCC. The irrigation nozzles being used are TeeJet standard flat spray tip. Each production unit has two, two-headed Smith 1:200 R8 Measuremix Injectors located in the unit's work shed.

Shade cloth supports, locally designed for the project, are compatible with the BCC plastic pallets. The shade cloth used is a white 30 percent Ludvig Svensson thermo screen. This shade cloth is designed for use during the sensitive period of germination and can also be used to provide protection at times of high frost risk.

Additional Facilities

The nursery complex also includes a set of offices with a connecting laboratory. The laboratory is equipped with microscopes, centrifuge, distilled water unit, oven, autoclave and basic laboratory supplies.

A 360 m^2 building is provided for the storage of fertilizers and chemicals.

A greenhouse, with approximately 1,400 m^2 utilizable area, was supplied through BCC. The polycarbonate-covered greenhouse is equipped with cooling pads, floor heating, automatic vented roof and automatic shade cloth covering. Three booms provide irrigation within the greenhouse.

ACTIVITIES

Cone Prospection, Collection and Species Selection Activities

Mexico has the greatest number of pine species (including varieties and forms) of any country in the world. Pines are the most economically important timber species in Mexico and Central America. The large number of species has made the field identification of some species confusing, academic and at times mystical.

Cone prospection begins in the in late spring and the summer months. The species selected for the nursery are those requested by CORENA (table 1). The guidelines for the project dictate that the species grown in the nursery should, if at all possible, be those species indigenous to the project area. Personnel from the Seed Operation visit numerous natural stands of trees and make an evaluation of the stands cone bearing potential. At each site that shows good potential, data on the site is collected and placed in a computerized database for future reference. Also, on private land, prior agreements must be obtained for collection of cones.

Project personnel conduct cone collection for the majority of the species. Cones are collected from September until March. The cone harvest crews climb previously selected trees using spikes and ropes. Most cones are removed using pole hooks/ pruning heads. Tree climbing bicycles and sectional ladders are available if needed. Cones are collected in polypropylene bags. These bags are tagged and identified with a ten-digit number unique to the specific collection site, altitude, aspect, season and species. This identification number follows the seed and seedlings throughout the nursery period to outplanting.

For one species, *Pinus ayacahuite*, contracts for collection by local community groups, (ejidos) have been used. In several other cases, contracts with other national seed companies have been used to provide seed that is either outside the project area or not economically feasible for collection by the nursery personnel.

Cone, seed and laboratory activities—Cones and seeds are processed from early October until March. The cones are stored outside in polypropylene bags until ready for processing. The identification code is attached to each bag.

The seed lab conducts routine tests of the seed as part of the overall processing activities. International rules of testing are followed.

Seed required by the nursery for sowing is treated and stratified in the seed processing facilities.

Seedling production and development—For the first season, sowing began in August 1997. With experience, we feel that for most species an additional month of growing time is required. This extra time was needed not only to bring the seedlings to the necessary quality standards, but also to provide sufficient time to harden off the seedlings prior to shipping. Shipping season occurs during the rainy season. It is, therefore, very difficult to harden off seedlings by withholding water once the rainy season arrives.

The first growing season contributed a lot to our general knowledge of the species. Relatively little was known about the seed and seedlings of some of these species, for example *P.hartwegii* and *P.rudis.* Even less was known about the necessary growing requirements of the species, especially in a peat-based media and growing containers. The majority of the seedlings being grown in Mexican nurseries are grown in black plastic bags using a growing media predominately composed of forest soil.

The winter months gave us a set of unusual, but typical conditions for the valley of Mexico. The average minimum temperature from December through the middle of February was 1° C and the average maximum temperature was 25° C.

Table 1—Requested species for the Mexico City metropolitan area reforestation project and proportion of seedlings by species for the first growing season (1998), second growing season (1999) and the seed to be left in storage with the project in August 1999

	Seedlings 1998	Cavities to be sown for 1999 seedlings[a]	Proposed seed remaining at end of project[b]
			kg
Pinus ayacahuite	1,542,000	2,380,000	2,400
Pinus cembroides	0	300,000	1,000
Pinus greggii	0	463,094	80
Pinus hartwegii	1,230,000	1,985,198	225
Pinus leiophylla	437,000	841,720	35
Pinus michoacana	114,000	358,440	300
Pinus montezumae	1,855,000	2,386,726	250
Pinus patula	1,468,000	1,732,280	180
Pinus pseudostrobus	722,000	1,371,000	150
Pinus rudis	0	733,758	20
Pinus teocote	115,000	220,600	35
Abies religiosa	82,000	350,000	200
Cupressus lindleyii	1,193,000	1,441,204	75
Quercus spp.	200,000	300,000	0
Alnus firmifolia	225,000	451,945	20
Liquidambar styraciflua	0	33,750	0
Salix bompladiana	0	60,000	0
Total	9,183,000	15,409,715	5,000

[a]Seedling requirement for 1999 is 13.5 million.
[b] These amount of seeds represents a potential of 75-100 million seedlings singly sown. The actual number, of course, will depend upon the percentage seed germination and number of seeds sown per cavity.

The extremes during this time were -7° C to 30° C. The warm temperature were very well suited for growth, however, the cold evening temperatures were potentially damaging. We had a difficult time trying to maintain the growth of the seedling, avoiding succulent growth and stopping the plant from going dormant.

Additionally, during the spring when you expect rapid growth, the seedlings did not respond as we expected. For almost 6 weeks, extensive burning of agricultural lands and forests provided the nursery with an almost daily layer of smoke that precluded the sun from clear view for quite a number of hours each day. This had the effect of decreasing the quantity of radiant energy.

For the second season, we began sowing the first of July 1998. The goal during the second season is to have the seedlings to the quality height and root collar diameter (RCD) standards early enough to allow sufficient time to harden off the seedlings before the rainy season begins.

A significant problem experienced during the first growing season was an abnormal growth of moss on the surface of the seedlings. During this season, fine vermiculite was used as a seed covering after sowing. Since most of our sowing took place during the rainy season, it was virtually impossible to control the amount of moisture in the plug. Very early in the sowing process, we noticed a film of algae on the surface of the media. By the end of the rainy season, moss had begun to form and its growth went unchecked.

One of the production experiments in the area of seedling trials was to evaluate the covering material (capping material) and moss growth. Materials such as vermiculite, fine sand, two grades of fine pebbles and tezontle (crushed and screened volcanic rock) were evaluated. As a result of this study, tezontle is being used during the second season. In addition, an algaecide is also being applied.

We also experienced difficulties with seedling density. Although the 93 cc container was ideal for most species (526 seedlings per m^2), we experienced problems with *P.leiophylla, P.pseudostrobus, P.patula, Alnus firmifolia* and *Quercus.* The growth habits of these species presented difficulty in allowing sufficient irrigation water to penetrate the foliage and reach the cavity. These species might have performed better at a lower population density using the HIKO cavity size of 150 cc (316 seedlings per m^2).

It was necessary to top prune all the non-grass stage species of conifers and the hardwoods. This was done to control the height growth, help in lignificiation and prepare the seedlings for shipment to the field. Excellent plant response was obtained when the trees were pruned with sufficient time before shipping.

Table 1 shows the distribution of seedlings by species for the first growing season and estimates of the distribution for the second season. In addition, it also presents a proposed distribution of seed in the 5000 kg of seed that will be left in storage at the end of the contract period of two years.

The shipping of the seedlings coincide with the limited rainy season. The project was originally designed to extract the seedlings from the containers and package them in a box for shipment to the field. However, CORENA requested that the seedlings be shipped to the planting sites in containers. Orders for seedlings are placed one week prior to shipment. CORENA provides the trucks that are loaded with individual containers, generally in three layers. A typical truck will hold about 18,000 seedlings in 93 cc containers and 7,000 seedlings in 310 cc containers.

Once delivered to a central area, the seedlings are either extracted and placed in planting bags or more commonly, the container are taken directly to the field by the community group which has been contracted to do the planting in that area. Planting tools consist of hoes, and round and square tipped shovels.

The authors visited a mountainous area site three weeks after planting. The seedlings were in excellent condition with new active white roots growing out of the root ball of both *P. montezumae* and *C. lindleyii.* New top growth was present in the *C. lindleyii.*

Seedling trials—In an effort to expand the available database of information for this nursery, seedling trials are conducted on a regular basis during the course of the contract period. These projects are designed to provide information that can be utilized within the nursery.

Technology transfer—CORENA considers the training program to be of prime importance. The goal of this program is to train the professional and technical nursery staff of CORENA to assume full responsibility of the nursery and seed plant at the close of the contract period in August of 1999.

The training program is a combination of both theoretical classroom training and hands-on practical training. Initially, the theoretical and practical were divided approximately equally. During the first six months of training, a total of 32 days of actual training was conducted. Recently, a switch has been made to have 20 percent of the session theoretical and 80 percent hands-on training.

The training covers all aspects of IFCO's project responsibilities. The theoretical sessions are arranged to coincide with an on going activity in the seed section or the nursery. The classroom sessions can last up to five hours. Extensive handouts are provided to the students and must be submitted in both Spanish and English.

The practical sessions are designed to provide actual on-the-job training to the students. IFCO requested that the students actually participate in all activities rather than observe and take notes.

Tests and other forms of evaluation are used to monitor the progress of the students.

SUMMARY

This project is a bold step for the Mexican government, Sumitomo Corporation, International Forest Company and Especies Forestales. To our knowledge, this is the largest nursery (potentially 30 million trees) of its type in the world where 100 percent of the trees produced are directed to an environmental effort of this type.

Certain aspects of the project, has been a learning experience for all participating parties. There are significant differences between black-plastic bag nurseries, which are very typical in Mexico, and this nursery, utilizing a different container and a peat-based media. A great deal of the published information on Mexican species has not been as useful as needed. This project will hopefully provide information, technology and models for future nurseries of this type in Mexico and Central America.

We have nearly completed the cycle of the first growing season. In general the seedling quality is very good. There are a number of items that have been and will be modified in the second growing season to insure quality improvements in all facets of production.