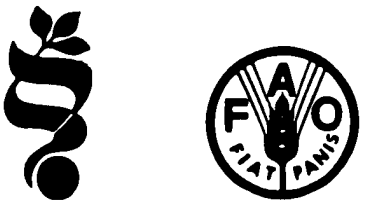
Genetic Resources of Tree Species in arid and semi-arid areas



Food and Agriculture Organization of the United Nations

FAO/IBPGR

GENETIC RESOURCES OF TREE SPECIES IN ARID AND SEMI-ARID AREAS

A survey for the improvement of rural living
in Latin America, Africa, India and Southwest Asia

Based on the work of

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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SUMMARY

There is a strong case for mounting the second phase of the FAO/IBGR project on genetic resources for the improvement of rural living in arid and semi-arid areas of Latin America, Africa, India and South-west Asia. The project would be welcomed in the eight countries visited (Chile, India, Israel, Mexico, Peru, Senegal, Sudan and P.D.R. Yemen). Thirteen competent institutes interested in participating have been identified and consulted and their facilities for, and specific interests in, the project reviewed.

Priority would be given initially in exploration and collection operations to Acacia nilotica, A. senegal, A. tortilis and Prosopis spp.. Collection areas have been identified in the countries visited. Clarification of the taxonomic status of some of these species and their variants should receive early attention.

Evaluation of three Australian species, Eucalyptus microtheca, E. canaldulensis and Acacia aneura, would begin within the first year of the project, as soon as seed is distributed and of the above Acacia and Prosopis species a year later. Test sites have been identified although most require to be located in detail.

Environmental information for seed collection and testing sites, in some cases detailed but in others generalized, is presented in a series of annexes as background material for planning and the use of participants in other countries.

In situ and ex situ conservation measures have been initiated in a few countries, particularly India, but all are at a very early stage of development and a more systematic programme of in situ conservation is desirable.

Recommendations are made for the establishment of a second phase of the project under the guidance of a full-time Coordinator based in Rome.

The phase of the project now proposed should be regarded as an operational pilot project. Provided that it is successful, it should prepare the way for an expanded, long-term programme in genetic resources of tree species for improvement of rural living, covering a wider range of developing countries and a more comprehensive list of species. For the long-term programme, close coordination would be required at the regional level through the provision of a full-time Coordinator in each of the three developing regions of Africa, Asia and Latin America.

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I. INTRODUCTION

1.1 REASONS FOR THE PROJECT

Trees can be of great value for agricultural communities through the provision of fuelwood for cooking and heating, poles for building, wood for household use, food for men, fodder for animals, shade or shelter from wind, and stabilization of soils.

In the past the potential symbiosis of agriculture and forestry in rural communities has often been neglected by agriculturists and foresters alike. Although taungya in Asia (also known as "shamba" in East Africa) has long been used as a management tool, through the temporary combining of agricultural and forest crops, only recently has the importance of a more systematic relationship between tree crops and agriculture been emphasised by international action, e.g. the FAO/SIDA programme on Forestry for Local Community Development and the increased activities in the field of agroforestry by the International Development Research Centre, IDRC.

The International Board for Plant Genetic Resources (IBPGR), at its third session, recognised that, in principle, it should support limited projects in forest genetic resources, including "exploration and conservation of the genetic resources of a few species important for agriculture in connection with either fuel requirements or the stabilization of marginal environments".

At its fifth session the Board confirmed its intention to include in its 1979/80 budget provision for the first phase of a programme in forest genetic resources and agreed that the programme should:

(i) Concentrate on provision of genetic material of tree species which will be of value for planting by rural communities.

(ii) Concentrate on the arid and semi-arid areas, where problems are most acute.

(iii) Give top priority to species for production of fuelwood, which is the crux of the situation in most rural communities.

At the same time the Board recognised that some fuelwood species will provide additional products or services, e.g., food, fodder, shelter and soil protection. A list of species proposed by the FAO Forestry Department is given in Annex I complete with the relevant geographical distributions. Only four genera are represented, namely, Acacia, Azadirachta, Eucalyptus and Prosopis.

For the species in Annex I, the same series of operations is required as for agricultural or industrial forest crops, viz., exploration, collection, evaluation, conservation and utilization. In the case of Eucalyptus camaldulensis, collection throughout the range was done some years ago. Evaluation results are already available from a number of countries (Lacase 1970, 1977) and some ex situ conservation/selection stands are being established, with the assistance of UNEP and FAO. For the other Australian species, Eucalyptus microtheca and Acacia aneura, collection is already included in the current operations of the Division of Forest Research, CSIRO, Canberra, with financial support from FAO. For other species action in exploration and collection must be stimulated and coordinated.

The FAO Panel of Experts on Forest Gene Resources has coordinated global action in forest genetic resources over the last decade. In allocating its scarce resources it has deliberately given priority to supporting institutes working with fast-growing species for industrial plantations in the moister areas of the tropics, e.g., tropical pines, teak, Gmelina. Its contacts with institutes working in the arid areas has therefore been limited.

For these reasons the Board considered it essential that the first phase in a programme for the conservation of gene resources of tree species for the improvement of rural living in tropical arid and semi-arid areas should consist of a survey of needs and possibilities in Latin America, Africa and south-west Asia, an estimate of the scale of operations required and the identification of institutes which could cooperate with the Board in carrying them out. The Board expected that Phase 1, to be carried out in 1979, would lead to proposals for a Phase 2, the action programme starting in 1980. The method of survey missions to provide a sound basis for subsequent action programmes had been used successfully for agricultural crops by both the Board and TAC. 1/

1.2 OBJECTIVE OF THE PROJECT (PHASE 1)

To survey needs and possibilities for a cooperative programme in the conservation of gene resources of tree species for the improvement of rural living in arid and semi-arid areas of Latin America, Africa, India and south-west Asia and to make proposals for an early action programme, with estimates of financial support that would be required and of the results to be expected.

1.3 TERMS OF REFERENCE FOR THE CONSULTANTS

The Project Description developed to give effect to the proposals outlined above (unpublished document FAO/FORM FO 2/331 of 14 November 1978) provided for the appointment of consultants to work simultaneously in the three prescribed geographical zones. The terms of reference for the consultants were as follows:

"The consultants will visit selected countries/organisations within the natural distribution ranges of Acacia and Prosopis in Latin America, Africa and south-west Asia in order to:

(i) Draw up a list of priorities for an action programme by species, country and operation;

(ii) Recommend locations for future seed collections of Acacia and Prosopis species with information on seeding season and periodicity, collection methods, access, etc.

(iii) Obtain information on the possibilities of long-term conservation of indigenous stands in situ, and on interest in establishing ex situ conservation and selection stands of Acacia, Prosopis and arid zone Eucalyptus species;

(iv) Obtain information on possibilities of bulk supplies of genetic material of potentially important provenances, and on local research started or planned for individual selection and breeding within provenances of Acacia and Prosopis species;

(v) Obtain information on local experience in seed collection and handling (including protection against pests and diseases) and on facilities for seed storage;

(vi) Ascertain interest by countries/institutes to participate in international provenance trials of Acacia and Prosopis species and arid zone eucalypts (E. microtheca and E. camaldulensis);

(vii) Identify institutes willing and competent to carry out the above operations;

1/ Technical Advisory Committee to IBPGR

(viii) Ascertain the kind and amount of outside assistance needed by institutes willing to cooperate;

(ix) Identify additional species to be included in the programme;

(x) The consultants will prepare a report summarising the information collected under (i) - (ix) above for the following countries: Chile, India, Israel, Mexico, Peru, Senegal, Sudan and the People's Democratic Republic of Yemen (PDR Yemen)."

1.4 FORM OF THE REPORT

In preparing the report it was considered desirable to record, for convenience of reference to those concerned with this international cooperative project, much of the detailed pertinent information that was acquired during the missions. Thus, there is a chapter and annex for each country visited as well as a chapter for overall conclusions and recommendations allowing easy access to information on one or more specific countries or regions.

In addition to the genera originally listed and approved for inclusion in the project by IBPGR others, which were considered of high priority or of great potential value by the countries visited, are included in the annexes. However, due to limited funds it is not likely that these can be included in the presently proposed second phase of the project.

Although detailed information on the type and amount of assistance required by the potential cooperators was collected by the consultants, specific recommendations on finance is pending approval by IBPGR of the proposed second phase of the project.

II. SENEGAL

2.1 PARTICIPATION

Two institutes in Senegal wish to participate in the Project, they are:

a) The National Centre of Forest Research (CNRF) which forms part of the Senegalese Agricultural Research Institute which in turn is under the aegis of the General Scientific Research Delegation.

b) The Department of Water and Forests, part of the State Secretariat for Water and Forests which itself is controlled by the Ministry of Rural Development.

The Department of Water and Forests is not responsible for any forest research work as such but it has been able since 1974, with finance from IDRC (International Development Research Centre), to carry out some preliminary investigations focused exclusively on local shrub species and long established exotic species of arid zones.

Although these two institutions belong to two different Ministries they are both national institutions and there is close collaboration and intensive planning at the research programme level. The CNRF acts as technical adviser to the Department of Water and Forests' M'Bidi station and has already participated in the design and preparation of research procedures.

Judging by the nature of the research programmes the services of the two institutions are complementary with the CNRF specializing mainly on exotic species and the Department of Water and Forests working on local species, gum arabic in particular, and shrub varieties of the arid zones of the Sahel and other regions.

Concerning research personnel the staffing situation at CNRF seems to be relatively better and greater experience is available for carrying out establishment trials. However, both institutions and more particularly the M'Bidi station, are urgently in need of further instruction in experimental design and analysis of field trials. The Department of Water and Forests would welcome and give their support to any offers of assistance to train its staff at M'Bidi in experimental design and statistical analyses.

2.2 SPECIES

Three additional research sub-programmes are required to support Senegal's current forest policy. These are:

(i) Silvicultural and genetic improvement of Eucalyptus spp.

(ii) Reinforcement of the CNRF seed service

(iii) Propagation and improvement of local species in the Sahel zones.

2.2.1 Genetic Improvement of Eucalypts

Most of the research work for the genetic improvement of Eucalypts carried out so far has been confined to two species, viz., E. camaldulensis and E. microtheca.

E. camaldulensis: this species was introduced at the beginning of the century in the Cape Verde peninsula where it has become acclimatised. Its origin is not known. Early studies showed that this species has frequently been crossed with E. rudis and E. tereticornis which explains why the progenies are very heterogeneous. Since 1968 seed from 26 sources in the Australian tropical hinterland supplied by CSIRO (Commonwealth Scientific and Industrial Research Organization, formerly the Forestry and Timber Bureau, Canberra) have been tested and a new collection of 31 provenances collected in 1973 by CTFT (Centre Technique

Forestier Tropical) in the Kimberley district, the Northern Territory and northern Queensland were established in 1974 and 1975. Elimination tests have shown that provenances from northern Australia are superior to the "local varieties" and to the Moroccan and Tunisian seed sources. Among them, No. 8292/FTB and No. 8411/FTB seem particularly resistant to drought and interesting from the point of view of growth.

E. microtheca: this species was tried for the first time in Senegal at Bambey and Déni Youssouf (on Dek soil). It proved to be the species most resistant to drought on heavy, compact soils during the period 1970-73. Among about twenty provenances tested a Pakistani provenance "Dera Ismael Khan" gave trees of good shape and rapid development.

The CNRF is particularly interested in the collection of provenances of E. microtheca and would be pleased to receive samples of different provenances.

2.3 EXPLORATION AND COLLECTION

With very limited means at their disposal for exploration, collection and storage of seed, neither the CNRF nor the Department of Water and Forests will be able to meet the need for seed for the expanding afforestation programme. Currently, the CNRF uses the cold room of the Livestock Service intended for the storage of vaccines and it is already overloaded. This is an important problem because the season of seeding of a number of tree species is too late to raise nursery plants of the right size in time for the next planting season, which means that the seeds have to be stored for up to a year.

Considering the size of the afforestation programmes in the country, there is a case for establishing a unit specialized in seed collection, handling and storage. In the first stage the CNRF should be equipped with the means for collection, extraction, storage and testing of seed. A vehicle would be required for exploration and collection. A full-time forester with a team of 5 workmen should be recruited and trained to staff the Seed Unit. In the second stage it could be made autonomous and, with supporting legislation, could function as an independent body serving both the CNRF and the Department of Water and Forests.

2.4 EVALUATION

The following local species of Acacia are of particular interest in a programme of improvement:

A.nilotica var. adansonii

A. senegal — A. raddiana

A. tortilis — A. albida

To this list three Australian Acacia may be added:

A. holosericea — A. timida

A. aneura

The first introductions of these at M'Bidi have proved interesting.

In addition to the Acacias the following Prosopis species should be included for purposes of comparison:

P. juliflora — P. alba

P. chilensis — P. nigra

P. africana

Excluding A. senegal, for which a provenance test is already underway at M'Bidi, all the other species need to be studied in first stage species elimination/comparison trials at four different sites. These are:

(i) M'Bidi (Ferlo area), rainfall 100 to 300 mm/annum.

(ii) Bandia (Thies), rainfall usually about 650 mm/annum but only 450 mm in recent years.

(iii) Keur-Mactou (Sine-Saloum), average annual rainfall for the period 1931 to 1960 was 788 mm but has dropped to about 550 mm over the last 10 years.

(iv) Linguère: average annual rainfall for the period 1931 to 1960 was 525 mm but has dropped to 350 mm over the last 10 years.

On the basis of 49 tree plots, 3 replications per species per site and a spacing of 4 x 4 m, this would require nearly 3 hectares of field trials at each site giving a total of some 12 hectares for the four stations. For certain indigenous species it may be possible and desirable to include more than one provenance in the trial. This would, however, increase the size of the trials.

Some additional genera of interest to the country and of potential interest to other arid/semi-arid regions are listed in Annex 2.

2.5 CONSERVATION

Impoverishment of the genetic resources of the indigenous Acacia species has taken place in the more densely populated parts of Senegal, but small local patches of vegetation are preserved for religious reasons, e.g. around cemeteries, and lack of access has preserved trees in other areas. Ex situ conservation of the arboretum type has been done in the Parc Forestier de Hann. A more systematic programme of in situ conservation is desirable but is dependent on more detailed knowledge of the distribution, variation and degree of impoverishment of the main species.

2.6 UTILIZATION

The Department of Water and Forests, within the framework of its responsibilities for the conservation, protection and improvement of forest lands, set up a gum tree (Acacia spp.) research station in the Ferlo area in 1974. This station, which is financed by IDRC, is evaluating some 18 provenances of gum trees and studying the best techniques for the introduction of various provenances of Australian acacias. Apart from the work on eucalypts referred to in Section 2.2.1, no other genetic improvement of any of the other species mentioned in this report is practised. However, the need is recognised for the introduction of better provenances of exotics, particularly of E. microtheca, than those currently available in the country, and to identify superior populations of native species.

2.7 SEED STORAGE AND HANDLING

The problems of storage and handling have been referred to in Section 2.3.

III. SUDAN

3.1 PARTICIPATION

The Head, Forest Research Institute (FRI), Soba, near Khartoum, confirmed that Sudan as represented by his Institute, wishes to participate in the Project. In this and in the proposed programme and priorities described here he was supported by the Director of Forests Administration.

FRI is one of several institutes, each with its own advisory Research Technical Committee, that carry out the programme and report to the Director-General of the Agricultural Research Corporation, which is responsible in turn to the Minister of Agriculture and Natural Resources. The FRI has an authorised establishment of 16 professional officers, one of whom is the Research Officer for Arid Zone Forestry. It maintains close working links with various departments of the University of Khartoum, particularly the Forestry Department, which is represented on the advisory committee. FRI is indeed the logical establishment to represent Sudan in the Project.

3.2 SPECIES

Sudan proposes to make and evaluate one provenance collection of each of the three native sub-species of A. tortilis and would make similar collections of A. nilotica to satisfy requirements of other participants.

Seed of A. senegal is not available for export from the Sudan. Participants interested in this species would therefore obtain their requirements from neighbouring African countries, Arabia, India and other parts of SW Asia.

FRI selected about 100 putatively high gum Arabic producing phenotypes of A. senegal in the El Obeid area and planted stock raised from open pollinated seed in unreplicated family plots at Goz Ashgar some 10 years ago. Yields of individual trees are being monitored and poor producers are being culled.

As indicated in Annex 3.1, Sudan wishes to evaluate the available collections of E. camaldulensis and E. microtheca, both of which are already grown under irrigation in arid and semi-arid areas of the country. E. microtheca is the most important species in the irrigated green belt plantations south of Khartoum, the others being E. camaldulensis and E. tereticornis. These plantations are grown to control dust storms and to provide fuel and pulp wood. E. microtheca is also an important irrigated woodlot species in the Gezira (Ahmed, 1977). The plantations of this species are believed to have been derived from a single tree of eastern Australian provenance introduced to the School of Agriculture, Khartoum, in 1926. One of their main characteristics is the poor stem form of all trees.

The Sudan is also interested in evaluating provenances of the six Prosopis species included in the FAO list. They would do this under the International Development Research Centre (IDRC) project "Potential of Prosopis spp. as a forage and tree crop in the Sahel" which was the subject of a notice in the IDRC quarterly newsletter on forestry research in Africa, No. 2/1978. On reading this notice the Director, Forest Resources Division, Forestry Department, FAO, asked the Director of IDRC for further information about the project since he was concerned that there should be no duplication of effort by the IBPGR Project.

IDRC stated that they were associated with a project in Peru for pasture improvement by planting various provenances and species of Prosopis. One activity resulting from this was to be exploration of the genus throughout S. America and the making of a series of seed collections. This idea had been dropped when it was found that such activity was to be undertaken under the auspices of IBPGR. (Personal communications between L. Huguet, FAO, and L.G. Lessard, IDRC, dated 10 November 1978 and 26 February 1979 respectively).

Under the IDRC financed project FRI is required to secure the seed through direct approaches to source countries. Collections received under the IBPGR project would accordingly be welcome and would be paid for if necessary. Sixteen collections have already been secured; 7 from SW Asian and Middle East sources and the remainder from the USA. The seed has been sown and sufficient plants of 7 of them have been raised for an experiment.

It is desirable that, subject to mutually acceptable arrangements being made between FAO (on behalf of itself and IBPGR) and IDRC regarding evaluation procedures, acknowledgements and costs, seed of whatever Prosopis collections are made under this project be made available to Sudan to enable them to carry out their part of the IDRC study.

3.3 EXPLORATION AND COLLECTION

Information on distribution and other features and proposals for the collection of provenances of A. tortilis and, if required, A. nilotica are given in Annex 3.2. Climate and soil data are reviewed in Annex 3.4.

No difficulty is anticipated in collecting the quantities of seed required. FRI is prepared to support the collections with herbarium specimens and seed collection reports. It is prepared to distribute the seed collected to other countries.

3.4 EVALUATION

The provenances and species which it is proposed to evaluate, and test sites, are listed in Annex 3.3. Generalised site information is given in Annex 3.4.

Local collections of the same species will be used as comparison species for the eucalypts.

Nursery facilities are available at Soba, Wad Medani, Kennana and El Obeid. For technical reasons the stock for the Kennana test site will probably be grown at Wad Medani. FRI is quite flexible regarding date of arrival of seed.

Site preparation comprises stumping out any natural vegetation and constructing the irrigation configuration of alternate ridges and furrows for 4 x 4 m spacing with mechanical equipment. Planting is done on one side of the ridge (not on it or in the furrow). Weeding is done manually and test areas are fenced and provided with Acacia mellifera hedges. Fire lines are provided where necessary and guards are mounted to protect plantations from browsing or theft.

The eucalypts would be irrigated regularly. Normally A. tortilis would not be irrigated but this could result in loss of a trial since the roots would be confined to the upper 80 cm and the water table is much deeper. The evaluation plots would therefore be irrigated during the first two years, once a month to begin with and less frequently thereafter.

The Head, FRI, and members of the professional staff are conversant with techniques for designing, establishing, assessing and analysing the results of replicated and randomised trials. Responsibility for the eucalypt and A. tortilis trials would be assigned to a professional officer, the Prosopis trials to another. The conduct of the eucalypt trials would be undertaken by a graduate forestry student at Khartoum University who would use the data for his M.Sc. thesis. A team of research assistants would assist in all cases with assessments.

The IDRC project plan for evaluation of Prosopis provenances provides for 49-tree plots with four replications at each of the four sites, i.e. one more replicate per site than is proposed for the IBPGR project.

The Head, FRI, stated that there would be no difficulty in making results and later, seed available to other countries. This is taken to apply equally to any Prosopis grown from seed provided under IBPGR supported arrangements. It was explicitly stated, however, that "a commitment to publish was not implied, although there would be no aversion to this if it were appropriate and if the resources to support such effort were available".

FAO consultants or staff would be welcome to visit and collaborate in the trials and their assessments.

3.5 CONSERVATION

Acacia tortilis is under extreme pressure from grazing in some areas. Although local (regional) ordinances exist under which species or specific areas can be protected, these have not so far been applied to this species as they have, in some instances, to Cordia abyssinica and Balanites aegyptiaca.

Although there is no specific gene conservation programme for A. tortilis the species is included incidentally in several enclosures and reserves, e.g. game reserves and the Khartoum Green Belt. Several of these, however, have been destroyed by, or are under pressure from, urban expansion or mechanised agricultural schemes.

Small areas of natural A. nilotica forest have been preserved as natural seed sources by the Forests Administration near plantations of the same species along the Blue Nile.

Instances occur of conservation of indigenous species as a result of recognition of their value to local economies. The value of A. senegal, producing Gum Arabic, is one. The fact that farmers do not cut A. albida in western Sudan or along the Nile because of the value of its pods as fodder, is another.

Deliberate gene conservation of the species covered by this project is desirable in view of grazing and other pressures on the natural environment. However, its formal practice lies for the most part in the future.

3.6 UTILIZATION

With the above exception of the programme near El Obeid to phenotypically select superior gum producing trees of A. senegal and to protect stands of A. nilotica along the Blue Nile as seed sources, no selection or genetic improvement of the species covered under this project is practised and there are presently no plans to develop such programmes. However, the need is recognised to introduce better-adapted provenances of exotics (e.g. E. microtheca) than those currently available in the country, and to identify superior populations of native species.

3.7 SEED STORAGE AND HANDLING

Larvae of Burchid and related insects can be troublesome in Acacia seed. However, if maturing seed is collected early and dusted with Gammexane or Gamma BHC before storage in sealed plastic bags enclosed in metal containers, viability is maintained for at least five years even if stored at room temperature. The seed should be treated with sulphuric acid before sowing.

FRI is authorized to treat seed for export and to issue phytosanitary certificates.

The Plant Protection Division, Ministry of Agriculture and Natural Resources, administers the Plants Diseases Ordinance of 1911 and the Plants Import Order and Regulations of 1942 which regulate all import of seed.

IV. INDIA

4.1 PARTICIPATION

Three institutes were visited as potential participants in the project:

(i) Forest Research Institute, Dehra Dun (FRI);
President, J.C. Varma; Director of Forest Research, R.C. Ghosh.
(Reports through the Inspector General of Forests, B.P. Srivastava, to the Secretary for Agriculture, Dr M.S. Swaminathan).

(ii) Central Arid Zone Research Institute, Jodhpur (CAZRI);
Director, Dr H.S. Mann; Head, Division of Plant Studies, Dr C.P. Pareek; Junior Silviculturist, K.D. Muthana.

(iii) Central Soil Conservation Research and Training Institute, Dehra Dun (CSCRTI);
Director, Dr. K.G. Tejwani; Head, Division of Plant Science, Dr. R.K. Gupta

Both CAZRI and CSCRTI are component establishments of the semi-autonomous Indian Council of Agricultural Research (ICAR). They report through Dr. O.P. Gautam, Director-General, Department of Agricultural Research and Education, to the Secretary for Agriculture.

Each of the Institutes expressed interest in participating in the Project. A fourth institute, the International Centre for Research on Agricultural Crops for the Semi-arid Tropics near Hyderabad, had been suggested by FAO officials in Rome as possibly having an interest. However, enquiries in New Delhi and perusal of recent reports on the programme of the Centre indicated that this was unlikely. Accordingly the matter was not pursued further.

FRI's interest in the Project arises from a number of its current programme responsibilities and activities. As a result of recent decisions by the Secretary for Agriculture the Institute is preparing plans and estimates for the development of a National Bureau of Forest Gene Resources. This will incorporate and extend activities under FRI's functions of exploration, collection or other acquisition, evaluation, conservation and utilization of germ plasm. The existing programme in this area is conducted in collaboration with the State forest departments. It includes continuing development of the long established Indian Preservation Plots system (Kaul, 1975) which will be integrated, where appropriate, with the national MAB Biosphere Reserves initiative in which FRI is participating; compilation of distribution maps for Indian tree species; extension of the National Germ Plasm Bank for ex situ conservation of which the work with teak at the Indo-DANIDA centre in Hyderabad forms a part, and evaluation of germ plasm of tree species potentially suitable for a variety of purposes, e.g. Acacia nilotica and Leucaena leucocephala.

To carry out its functions FRI works partly through its regional centres at Burnihat, Coimbatore, Jabalpur and Hyderabad and in collaboration with the Sylviculturists in the State Forest Departments. It is planned to open another centre at Ahmedabad to concentrate work relevant to the arid and semi-arid zones.

The FRI staff includes personnel familiar with provenance testing and related work as well as specialists in forest genetics and tree physiology. It can provide data processing and analysis service. The Institute is responsible for provision of phytosanitary certificates and is authorized to import research quantities of plant material direct. At Dehra Dun and some regional centres it maintains seed cold storage and testing facilities.

Silviculture as related to agriculture and plant genetics are components of the programme of the Division of Plant Studies of CAZRI. The Institute staff includes specialists in several disciplines relevant to this Project, e.g. soil science, biochemistry, plant physiology. There are difficulties in recruiting suitably qualified forestry personnel and the four geneticists devote most of their attention to crops other than forest tree crops. The Institute has done a good job of maintaining the tree species and provenance trials at Jodhpur station and demonstration plantings in the district. Although new work has been limited in recent years the Institute wishes to extend and strengthen this part of its programme.

CAZRI collaborates with the Director, Desert Afforestation and Pasture Improvement Branch of the Rajasthan Forestry Department and has contacts with the Forest Departments of Haryana and Gujerat. It operates several field stations representing different degrees of desertification and a range of soil types in Rajasthan and would use facilities at three of them (Pali, Bikaner, Jaisalmer) as well as those at Jodhpur as centres for collection and evaluation of materials under this project. Biometrics service is provided from the Indian Agricultural Research Institute in Delhi and seed import and export are effected through the National Bureau of Plant Genetic Resources of the same Institute, which is concerned primarily with agricultural crop seeds. There are no cold storage facilities for seed at CAZRI.

CAZRI is well situated and equipped to participate in the Project and would provide great strength in the Rajasthan area.

Dr. Gautam nominated CAZRI as the ICAR establishment he would wish to participate in the IBPGR Project.

CSCRTI at Dehra Dun coordinates the research, demonstration and training programmes of a group of eight stations (Chandigar, Agra, Vasad, Kota, Hyderabad, Ootacamund and Bellary, as well as Dehra Dun) concerned to promote integrated land use systems as a means of bringing the 15 % of India's land area known as the "wasted lands" into production. Three additional centres are planned. Technology transfer is effected through a series of Operational Research Projects of which four are in operation (three in the Himalayas; one at Bellary in South India) and four more (all in the Himalayan region) are planned.

The staff of CSCRTI comprises specialists in a wide range of disciplines in plant science, hydrology and related fields. The Plant Science Division is concerned with grasslands, horticulture and forestry. Although difficulty is experienced in recruiting forestry specialists its staff includes a forester. The Institute does not participate in exploration or collection of genetic materials. However, it is interested in evaluation of introduced collections through its arboretum studies programme in which row plots usually unreplicated are used to screen out materials suitable for the degraded lands.

The programme of CSCRTI is strongly oriented towards the Himalayan and immediately adjacent regions and to degraded lands and shifting cultivation areas in the dry central areas of India. The possibility of its participation in the evaluation phase of the Programme either immediately or in later stages, should be explored by the coordinating agency for the Project in India.

The State forest departments proposed as participants in the project are those of Gujerat, Rajasthan, Punjab, Haryana, Maharashtra and possibly Andhra Pradesh and Karnataka.

FRI, through its Forest Research Branch, is for several reasons the obvious and perhaps only feasible agency to assume the coordinating role for the project in India. This is suggested by its current functions and new mandate in relation to forest gene resources in the country; its long and close association with IBPGR and the FAO Panel of Experts on

Forest Gene Resources; its relationships with the State Silviculturists in this and related work; its pipeline, through them, to the operational programmes and problems of the State forest departments; its historical relationships with CAZRI, and its familiarity with and facilities for the kind of work that will be entailed. FRI has been criticised for its ineffectiveness in carrying out this sort of role in the past. Whatever the true position or causes for this may be, the coordinating function cannot succeed without clear definition of mandate, provision of adequate resources (including time) and effective communication between the coordinator and other participants, leading to thorough planning and vigorous project implementation.

The Director, CSCRTI indicated willingness for his organization to participate in the Project with FRI as coordinating agency. However, the Director of CAZRI and his Director-General stated their preference to participate independently, with direct contact with FAO. For obvious reasons however this is not warranted: coordination by one agency within India of that country's overall participation is obviously necessary and there is no reason why all participants should not receive proper recognition for their contributions. Dr. Swaminathan, Secretary of Agriculture, with whom the matter of coordination was discussed, reserved his position and stated that the Indian Government would decide in due time what coordination arrangements should apply.

4.2 SPECIES

The species of immediate interest in India are shown, with uses, silvical features and priority ratings, in Annex 4.1.

4.3 EXPLORATION AND COLLECTION

The first three indigenous species shown in Annex 4.2 are proposed for collection in year 1 of the Project (Phase 2) in the States of Gujerat, Rajasthan, Punjab and Haryana and possibly also in Maharashtra and Andhra Pradesh. Subject to demand, provenance collections of the other three species could also be made. Prosopis juliflora, which was introduced into India a century ago and which is now widespread, could be added to the list if desired. This species shows considerable variation of form in India.

Details of distribution, climate and soil patterns, silvicultural features, geneecological variation, seeding season, seed weights, scale of current planting and proposed collection areas for three species are given in Annex 4.2

Specific collection areas will be identified during detailed local project planning. It may be noted that CAZRI have identified the environs of four of their field stations in Rajasthan as collection areas.

With the three exceptions of Azadirachta indica, the seed of which quickly loses viability, Acacia nilotica varieties where they become more scattered near the western extremities of their natural range in the arid zone and A. nilotica var. jaquemontii in areas where it is repeatedly coppiced to provide basket making materials, no difficulty is anticipated in securing the quantities of seed required for 30 sets of provenance trials and subsequent ex situ gene conservation stands. No difficulty is anticipated in gathering the seed from a minimum of 25 mother trees per provenance, spaced at least 50 m apart In some cases this spacing may be considerably extended. The six species listed do not display any notable degree of periodicity in seed production and they all produce seed copiously.

Since viability of Azadirachta indica seed falls off after about a week and there is no known storage procedure to extend this period special arrangements will be required to ensure that seed reaches the nurseries of recipient countries rapidly and in good condition. The arrangements should be made between the countries concerned by direct communication. However FAO could probably assist by bringing the importance of speedy handling and dispatch to the attention of key personnel concerned. In the absence of an improved storage method for A. indica seed there would be no point in collecting material of this species for conservation planting before it is actually required. (FRI is considering the initiation of research aimed at developing a methodology for storage of A. indica seed).

Both CAZRI and FRI are prepared to support seed collections with herbarium material and to furnish seed collection reports. They are also willing and able to distribute seed to other countries. FRI, which issues phytosanitary certificates, would do so direct; unless arrangements are made for them to use FRI's facilities, CAZRI would export through the National Bureau of Plant Genetic Resources in New Delhi.

4.4 EVALUATION

The species proposed for evaluation in the first phase of the Project are the 11 of first priority shown in Annex 4.1. The line between first and second priorities is very fine and the species in them may be regarded as interchangeable according to timing of seed availability.

As shown, there is interest in the three Australian species proposed in Annex 1, seeds of which are now available for immediate distribution. If a choice were necessary E. camaldulensis would be the preferred eucalypt.

The exotic species listed in Annex 4.1. extend the initial FAO list considerably and indicate the degree of interest in developing good gene pools in the subject area to which the Project relates.

Subject to review when seed is available and detailed local planning is done, test sites are proposed as shown in Annex 4.3. Site descriptions for the locations in Rajasthan and more general information for the remainder, are given in Annex 4.4.

Collections from the best local stands of E. camaldulensis, or E. tereticornis where the former is unavailable, will be used as comparison species for the trials of eucalypt provenances; a local Prosopis juliflora collection will be used as the standard for all other species.

No special seed delivery arrangements from outside India will be required since cold store facilities are available at several centres.

Good nursery facilities are operated by CAZRI in Jodhpur where sturdy seedlings are produced in nine months from sowing in metal or plastic tubes. The Institute also operates nurseries at its Pali and Bikaner stations. Good nursery facilities are also operated under the control of State Silviculturists and at FRI and its regional stations. Thus the distances over which plants will have to be transported will not be unduly great and, given reasonable care of plants once they have left the nursery, they should pose no undue hasards.

Standard local site preparation methods would be applied by State forest departments and CAZRI, i.e., the land would be stumped and cleared. Pits 30 cm^3 would be hoed by State cooperators. At CAZRI pits 45 cm in diameter and of the same depth are prepared by power auger.

Clean weeding and working of the soil (with mechanized equipment at CAZRI stations), fencing or trenching to exclude stock, and fire protection measures, would be applied as normally practised by CAZRI and the State forest departments. Proper labelling, demarcation and mapping of plots would be done immediately after planting and maintained thereafter in accordance with the standard practices of the authorities concerned.

Experimental design, according to the nursery stock available, and guidance in the conduct of the trials in the field, would be given as necessary by FRI. Several members of the staff at CAZRI have statistical design and analysis skills and experience. Assessment data would be collected by state silviculturists and their specialist staffs who would undertake processing according to the facilities available. Final processing and collation of these results would be done by FRI who would collaborate with State specialists in the preparation of reports for publication. Subject to whatever arrangements for collaboration with FRI might be made by the local coordinator, these operations would be undertaken for CAZRI by that Institute's Silviculturist and other trained staff. As noted CAZRI is able, when necessary, to call on the Indian Agricultural Research Institute in Delhi for biometric support and services.

It was emphasised by experienced investigators in India that evaluation criteria should include parameters that express the values sought in the materials being tested, or which would permit their derivation, e.g. wood volume; thermal value; quantity of foliage, twigs, fruits.

There would be no difficulty about making the results of trials and eventually, seed, available to other countries. Obviously, collation of results by FRI, with due credit to participants, would facilitate this process.

It would clearly be advantageous for the import and export of seed into and out of India for the evaluation and conservation phases of the Project to be coordinated by and channelled through FRI who, as already noted, are authorised to issue phytosanitary certificates. This would also simplify for India the whole matter of seed storage, i.e. it could be concentrated in whatever degree is desirable, at FRI.

4.5 CONSERVATION

4.5.1 In situ conservation

The need for in situ conservation of gene resources has been recognised for many years and has found expression in the system of Preservation Plots under which, by 1975, 163 representative examples of natural forest types and 25 of plantations, mainly of indigenous species, were selected and designated accordingly. Natural forest plots range from a few ha to 4 000 ha; those in plantations are small (Kaul, 1975).

A few Preservation Plots in Gujerat include Albizia lebbek. A species recorded as Acacia catechu occurs in one plot in this State and several in Maharashtra. None of the other species listed in Annex 4.1 were included in the old system.

The Preservation Plots system is to be absorbed into the National Bureau of Forest Gene Resources project which is to cater for both in situ and ex situ conservation. Responsibility for development of this project has been assigned to FRI. Like the Preservation Plot programme in recent years, the project is to be conducted in collaboration with the State forest departments and will embrace two relevant activities that are already in progress. The first of these is the exploration phase represented by the FRI-State Forest Departments species distribution mapping programme. The second is the Biosphere Reserves programme which was reported on at the Fourth Session of the FAO Panel of Experts on Forest Gene Resources (FAO, 1977).

FRI's regional centres, including one to be established this year at Ahmedabad to cover the semi-arid and arid region, are to be involved in the project in addition to the State forest departments.

Individual species or groups of species will be selected for attention and assigned priorities according to the following criteria:

(i) the risk that genetically diverse materials of the species and their relatives might be lost in the future, particularly the near future, as a result of changes and developments in agriculture and land use, including the introduction of new varieties;

(ii) the economic and social importance of the materials to be collected, measured in terms of their present usefulness and importance;

(iii) the recognized requirements of plant breeders and research workers for genetically diverse materials and the expected significance in economic and social development of the improved types and varieties of the crops they will be able to produce with these materials.

These criteria tie in with the guidelines for selection of reserves under the Indian Department of Science and Technology and FRI MAB programmes.

The six indigenous species listed in Annex 4.2 of which it is proposed that seed should be collected by India during the first phase of this Project, are among the first priority group of species that the States have been asked to work on regarding distribution and for selection of Biosphere Reserves. This work is in progress and a few potential Reserves have been identified.

4.5.2 Conservation in seed stores

Seed storage is regarded in India not as gene conservation but purely as one stage in the process of establishing conservation and other stands.

4.5.3 Ex situ conservation of artificial stands

This activity is conceptualised as the ex situ conservation phase of the National Germ Plasm Bank discussed under Section 4.5.1 above. This part of the project is to comprise several areas of responsibility:

(i) The Indo-Danish Seed Centre, Hyderabad (Madan Gopal, Director): teak and eucalypts.

(ii) The Coordinator, Pines, at FRI (G.C. Pande): pine species.

(iii) The Coordinator, High Level Conifers, at Simla (R.V. Singh): the species which his title indicates;

(iv) Director of Forest Research, FRI (R.C. Ghosh) and staff: poplars.

It is not yet known who will be responsible for Acacia, Prosopis and other species important for social forestry in the arid and semi-arid zones although the new regional centre at Ahmedabad would likely be involved. Under this phase of the programme work is most advanced with teak for which materials are being surveyed, selected and assembled for the establishment, initially, of three Banks (stands). Some preliminary work has also been done with eucalypts.

Gene conservation in the formal sense used here does not form part of the programme of CAZRI. It is relevant to note however that artificial stands of Acacia tortilis, A. senegal, Prosopis juliflora and Azadirachta indica, the sources of some of which are known, are established on lands controlled by this Institute in Rajasthan.

4.6 UTILIZATION

Whilst the matter was not discussed in detail, the Director of Forest Research indicated that FRI would be prepared to arrange, through State forest departments or other appropriate agencies, for the bulk supply of seed of important provenances to other countries. With the exceptions noted, the indigenous species discussed in Section 4.3 produce seed fairly copiously each year; collection and processing should not present insuperable problems.

Except for some preliminary work with E. camaldulensis and E. tereticornis at FRI, neither that Institute nor the State forest departments have become involved yet in any individual selection and breeding within provenances of species suitable for the semi-arid and arid zone. FRI has distributed seed of three provenances of Acacia nilotica for planting by the Forest Departments of Tamil Nadu, Gujerat and Uttar Pradesh. Through its forest genetics group the Institute plans to start a programme of individual selection in A. nilotica, Azadirachta indica and Albizia lebbek in two or three years' time.

CAZRI started this year to collect open pollinated seed from selected phenotypes of Prosopis cineraria in different parts of its range in India with a view to establishing progeny tests from which to select superior types for breeding.

4.7 SEED STORAGE AND HANDLING

Refrigerated seed storage facilities of a capacity adequate for the needs of this Project are available at FRI, Dehra Dun, and at its regional centres at Burnihat, Coimbatore, Jabalpur and Hyderabad.

Seed insects can be troublesome but are readily controlled by dusting with Gammexane, BHC powder or sulphur.

As noted, retention of viability of seed of Azadirachta indica for more than about a week is a problem to which no solution has yet been found. FRI are considering devoting resources to this problem in the near future with the object of developing a means of storing the seed for a reasonable period without serious loss of germinability.

FRI at Dehra Dun is authorised to import and export research quantities of seed direct and is empowered to issue phytosanitary certificates. Larger quantities of seed are channelled through the National Bureau of Plant Genetic Resources. Seed viability is only rarely impaired by over-zealous treatment against insects or disease organisms.

Before imported seed is released, two certificates must be furnished:

(i) the usual phytosanitary certificate

(ii) a second, stating that the "seeds have been collected from trees free of pathogens and insect pests".

The object of the second certificate is to obviate the import of seed from trees susceptible to attack by pests or diseases.

No current plant quarantine regulations are known which might affect import or export of seed.

V. ISRAEL

5.1 PARTICIPATION

The Forestry Division , Agricultural Research Organization, Ilanot, of which Dr R Karschon is Director, is the single Israeli institute that would collaborate directly with FAO as a participant in the FAO/IBPGR Project. In accordance with established practice it would work with the Forest Department, Land Development Authority, whose headquarters are at Kiryat Hayim, Haifa, for inputs such as seed collection, site preparation, planting and post-planting maintenance. The Forestry Division wishes to participate in the Project in the manner described in this report. In this it has the full support of the Forest Department.

The group at Ilanot comprises a number of competent specialists who have established an international reputation for effective forestry research. They represent specialisations and have facilities that equip them fully for the type of activity envisaged under this Project. Their working relationships with the operational Forest Department add great strength and flexibility to their capabilities. The two organizations are linked functionally by research development and liaison staff. In Israel forestry and agriculture are closely integrated in programmes of mutual concern.

5.2 SPECIES

For some years the Institute has conducted a strong programme of studies of provenance variation in Eucalyptus camaldulensis Dehn. It has 70-80 provenances of this species under trial. It is not therefore concerned to acquire the E. camaldulensis provenances offered under this Project. The Division is interested, however, in evaluating the E. microtheca F.v.M. and Acacia aneura F. Muell. materials offered, plus any provenances of the Prosopis species on the FAO list (Annex 1) that become available.

A considerable amount of research was done on Israeli Acacia species in the 1950's and 1960's. This resulted from the fact that an early Prime Minister of the country, noting that the Russians were seeding large areas with indigenous Acacia species, required that a programme addressed to using native Israel Acacia species be mounted in relation to conditions in the Wadi Araba area. (See Annex 5.1 and map at Annex 5.5). This thrust, though it produced good scientific results, came to nothing operationally because of the very different moisture conditions in the Israel environments compared with those that apply in the Russian deserts, where rainfall conditions are better and seeding is done into the snow. With the exception of A. aneura, Israeli foresters are therefore not interested in acquiring seed lots of Acacia spp. for evaluation. However, they are prepared to collect seed of A. tortilis Hayne, A. raddiana Savi and A. albida Del. for distribution among cooperating countries. The taxonomy and distribution of these species are discussed in Annexes 5.2 and 5.3.

Karschon (1966) mentioned Prosopis farcata (listed by Burkart, 1976, as P. farcta) as one of the species comprising oasis vegetation in Wadi Araba. This species was not discussed during the Mission's visit to Israel but should be investigated as to its worthiness of collection and evaluation at some stage under this IBPGR Project.

5.3 EXPLORATION AND COLLECTION

The distribution and ecology of Acacia species in Israel are well documented, vide Annex 5.3. Genetic variation within or among the populations has not been studied; there is no call at present for such studies to be undertaken by Israel.

Proposals for the collection of seed of A. albida (from four localities) and A. raddiana and A. tortilis (one locality each) are presented in Annex 5.3.

Subject to confirmation when detailed plans for the Project as a whole are made, 2 kg each of A. albida and A. raddiana and 1.5 kg of A. tortilis should be collected for evaluation in participating countries. The quantities required for storage for the conservation phase will be about 9 kg for the first two species and 6 kg for the third.

There are no access problems. No difficulty is anticipated either in the collection of the required quantities of A. raddiana and A. tortilis seed from at least 25 trees spaced at least 50 m apart or to ensure that trees are represented in each collection by approximately equal quantities of seed. For A. albida, however, the situation will be different because the stands, which are clonal (Cutler, 1969; Halevy, 1971; Karshon, 1976) are relatively small and seed is not produced in large amounts. The quantity from each of the four collection areas might therefore fall short of what is required. Also, the number of seed trees per site is liable to be less than 25, particularly if reasonable steps are taken not to ensure that a clone is not represented more than once as a seed tree. Depending on the outcome of the collection effort, therefore, either the collections would be evaluated individually even though they be small in both quantity of seed and number of mother trees, or they might all be combined into a single Israeli provenance.

The consultant was advised that liberal allowance should be made for damage to seed by Bruchid larvae since 40 % of seed is likely to be damaged by the time it is collected. The quantities mentioned above allow for 50 % losses due to a variety of causes. It might be wise to increase them by a further 50 %.

The collections will be made on behalf of the Institute by the Forest Department, which has a specialised Seed Section. In most cases the collection will be made by foresters visiting source areas for a day. In some instances, however, collection might be done by a seed company. This is staffed by trained reliable personnel and would be closely supervised by the Department. In that case and because of the manner in which budgeting and accounting are done, payment would be required at about $ 20 per kg for A. raddiana and A. tortilis and $ 25 per kg for A. albida. Delivery to FAO in Rome would be by post at no extra charge. If air freight is preferred freight charges would be extra. An allowance of approx. $ 500 should be made for these items in the budget for the Project.

The Institute is prepared to furnish herbarium material and a collection report for each batch of seed. A form adapted from that used in the Thai-Danish Pine Project would be appropriate.

The Institute is prepared to distribute the seed collected in Israel and assumes this would be done through FAO.

5.4 EVALUATION

As noted in Section 5.2 the Institute is interested in evaluating the E. microtheca and A. aneura provenances from Australia and any provenances of Prosopis species that may become available.

If the number of provenances is small, e.g., three, they would be tested at two or three sites. If the number is large, a single site would be used.

Test sites for E. microtheca are yet to be determined. The A. aneura and Prosopis species trials would be sited in 200-300 mm rainfall, semi-arid areas north and west of Beersheba where the soils are loess or sand, or mixtures of the two. Irrigation would not be provided.

The comparison species for E. microtheca would be E. camaldulensis, either a selected local provenance or one from Australia. A. cyanophylla (now A. saligna) would be used as the standard for A. aneura.

Good nursery facilities are available at Ilanot where it is expected that all plants would be raised (in tins or plastic bags) and distributed to planting sites.

Standard site preparation and plantation maintenance procedures on loess soils are to plough or rip the area, to plant at 3 x 3 or 4 x 4 m depending on the site, and to disc the area once or twice a year, particularly in the first year. In drier areas or where ploughing is inapplicable, sites are prepared by throwing up soil so that runoff is funnelled into planting areas, thus being concentrated where it is needed. Site preparation, planting, maintenance and protection are done by the Forest Department with design and related inputs by the Institute, who make the assessments.

The results of the evaluations would be published in the normal way Requests for information before this would be met either directly or through FAO.

The competence of the Institute in provenance research notwithstanding, it should be furnished with a copy of the manual on species and provenance research compiled by Burley and Wood (1976).

5.5 CONSERVATION

The Acacia species of the desert and semi-desert areas of Israel are not in danger of extinction: they occur in relatively large numbers and are not subject to browsing or charcoal burning. Parts of the areas in which they occur are in nature reserves. It is the view of the Israeli foresters that formal conservation measures are not required.

However, some A. albida stands may be in danger of extinction, because the species is regarded as being of little value to the country and no priority is given to conserving the stands for national purposes.

The Forestry Division at Ilanot would be interested in acquiring further quantities of seed of promising provenances of exotic species as a step in the development of useful cultivars for local use. It would be prepared to supply the same but notes that seed from provenances of exotics, produced in Israel, is likely not to be genetically pure.

5.6 UTILIZATION

Whilst Israel is prepared to supply seed of native Acacia species it has no direct use for these species itself. However, it is interested in developing well adapted eucalypt cultivars for provision of timber and, to a lesser extent, shelter and soil protection. Prosopis species and A. aneura are of interest in relation to the latter values and also to some extent for fodder. Successfully adapted provenances would be used in simple individual tree selection programmes.

5.7 SEED STORAGE AND HANDLING

Cold seed storage facilities are not used. It has been found at Ilanot that seed in sealed containers retains high germinability for at least 7-8 years in the existing store where it is isolated from high temperatures.

In common with other countries in the Middle East and Africa, Israel has found that the seeds of native Acacia species are subject to attack by larvae of several species of Bruchidae. This matter is the subject of several important published reports on the identity and biology of the insects concerned, e.g. Southgate 1975a; 1975b; 1978. Karschon (1975b) followed up his observation (1961) that up to 40 % of the seed may be damaged by the time it is collected, by studying germination in relation to this problem. He found that soaking the seed in water which has been brought to the boil acts mainly on seeds with destroyed or damaged embryos, while immersion in sulphuric acid brings about germination of all viable seeds. He demonstrated that satisfactory germination can be secured from sowing unripe seed. He stressed the need for fumigation prior to storage as a means of arresting deterioration due to Bruchid damage. A commercial insecticide powder known as "Phostoxin" is successfully used at Ilanot.

It has been reconfirmed at Ilanot that seed of Australian Acacia species is not subject to Bruchid attack: the chemical nature of their seeds renders them immune (Karschon, personal communication). Thus, the A. aneura seed would not be affected.

Seed must be exported from Israel through the Plant Protection Service in Tel Aviv who fumigate it and provide phytosanitary certificates. Imported seed is subject to inspection by the same Service and a phytosanitary certificate is required.

VI. PEOPLE's DEMOCRATIC REPUBLIC OF YEMEN (PDR Yemen)

6.1 PARTICIPATION

The single institute interested in and capable of participating in the Project is the Agricultural Research Centre, a unit of the Ministry of Agriculture, located at El-Kod, some 60 km east along the coast from Aden. One of the ten disciplinary components of the Centre is the Forestry Section, the staff of which includes two professional foresters: A.S. Balaidi, Head and M. Bazara. There is no other Forestry Agency in the country.

The El-Kod Centre is supported through UNDP Project PD4/75/019: Improvement of Crop Production which is financed by UNDP ($ 3 940 000 annually) and UNCDF ($ 825 000).

At present Dr. E. Costin, the acting FAO Country Representative, is Project Manager and the Director of the Centre, Abdul Wahit, is Co-Manager. Dr. Costin is also Forestry Expert in the project, with A.S. Balaidi as Forestry Counterpart.

Since 1972 the Forestry Section has effectively undertaken species and provenance trials (Costin et. al., 1976a) and shelterbelt development and demonstration plantings (Costin et. al., 1976b) at El-Kod and other locations in the region. The Section is now heavily involved in capitalizing on the success of these by conducting training and extension programmes under which individual farmers, using plants raised in the Section's nurseries (one is located at El-Kod, another at Lodar) plant trees to provide fuel, fodder and shelter.

In view of these initiatives the capacity of the Section to undertake further Research and Development work is limited. It is enthusiastic to do so, however, and the local benefits likely to accrue from participation in this Project make it desirable that they do so, within the limits of available resources. In fact, when news of this Project was received, the Section was on the point of initiating its own study of variation in PDR Yemen Acacia tortilis.

It would obviously be to the Section's advantage to stagger work under the Project, e.g. by early supply of seed of exotic species to be evaluated in PDR Yemen, where this is available, so that the load of new work is spread in time.

6.2 SPECIES

The species in which PDR Yemen is interested are shown in Annex 6.1. The three shown as indigenous (Acacia tortilis, A. senegal and Prosopis cineraria) occur also in other SW Asian and/or African countries.

Several other species on the FAO list, particularly exotic Acacia spp. and Prosopis spp. are of interest but must await attention at some future time.

6.3 EXPLORATION AND COLLECTION

The Forestry Section proposes to collect four provenances of A. tortilis (one an exotic) and one each of A. nilotica (an acclimatized exotic), A. senegal and P. cineraria.

Details of distribution and other features of these species and of the collection areas are given in Annex 6.2 and generalised site information in Annex 6.4.

Pressure of browsing by goats and heavy infestation of ripening seed by insects are liable to cause difficulties in seed collection. To offset the latter, the Section will endeavour to collect fruits as soon as the seed is mature enough to be brought in.

Seed storage facilities are not available. Some assistance might be provided in this respect under this Project. If it is not, or if storage facilities cannot be arranged elsewhere, collection should be confined to the quantities required for provenance evaluation only.

Although collection areas are accessible by road, those in the mountains are somewhat remote and the seed trees scattered. The operation will require a degree of supervision which it is not easy to provide but which will be arranged for nonetheless.

The Forestry Section is prepared to distribute seed to other countries but noted that there are no facilities in PDR Yemen for fumigation of seed or for the issue of phytosanitary certificates. Either, countries importing seed from PDR Yemen will have to do so without certification and to treat it on receipt, or arrangements will have to be made to send the seed to another country for treatment and subsequent distribution.

The Forestry Section is prepared to support its seed collections with collection reports and herbarium specimens. However, it pointed out that it will be difficult, particularly with the staff available, to dry specimens frequently enough to obviate their disintegration.

The Section proposes to make its Prosopis cineraria collection at the Research Centre, El-Kod. Although this will obviously be less laborious than collecting from natural stands, the latter is preferable and must be urged for three reasons. Firstly, there is no assurance that the genetic diversity of the El-Kod material is as great as would be provided under the "25 mother trees at least 50 m apart" specification set for the project. Secondly, there would be no assurance that the El-Kod material has not been contaminated by pollen of another Prosopis sp. growing in the area, i.e. the 51-species arboretum. The third reason is the need for conservation in face of the situation described in Section 6.5 below. This postulates, in fact, the desirability to make and distribute at least two PDR Yemen provenances from natural stands.

6.4 EVALUATION

The sets of provenances to be evaluated are listed in Annex 6.3. The E. camaldulensis trial will be located in a coastal deltaic site at Ciar and the others either here or at El-Kod, 13 km away. Conditions at the two sites are similar: rainfall about 50 mm per annum; average annual temperature 25° C (mean minimum 18° C, mean maximum 36° C); low dew point; about 10 hours of sunshine daily. Soil a deep alluvial sandy loam; well drained; low salinity; poor, powdery structure; low organic matter; pH about 7.5.

The comparison species for E. camaldulensis will be a local collection of the same species. Local P. cineraria will be used for the remainder.

Good nursery facilities are available at El-Kod. Standard planting practice is to stump, clear, level and disc the land, to construct irrigation channels, demarcate and prepare planting spots at 3 x 3 m or 4 x 4 m. Plants are irrigated monthly during the first year while tap roots reach down to the water table, whereafter irrigation is withdrawn. Maintenance is by hoeing weeds and cultivation, fencing to exclude stock and for demarcation and patrolling to guard plantings and control fire. These operations are liable to be frustrated to some extent by labour shortages.

The lack of seed storage facilities was discussed in the previous Section. It is desirable to arrange for seed to arrive early in September so that it can be sown at once, without having to be stored.

The local professional foresters have been accustomed to working with the FAO Forestry expert on design, analysis and other phases of provenance evaluation. In his absence they may benefit by some assistance in design and analysis from whoever coordinates the project.

The Head of the Section stated that there would be no difficulties in making the results of the experiments available.

6.5 CONSERVATION

The local P. cineraria is in danger of extinction as a result of pressure of use This is one reason for current efforts to collect seed and distribute plants to farmers in the country through the forest nurseries. There are no MAB or similar in situ conservation measures. Consideration should be given to the establishment immediately, say in India, of an ex situ conservation stand of each of, say, two provenances from within PDR Yemen so that the species could be re-introduced later if necessary.

A. tortilis displays ability for effective natural regeneration, which accounts for its frequent predominance over other species. A. nilotica is increasing in the extent of its range and frequency and A. senegal does not appear to be under threat.

6.6 UTILIZATION

The Project has been mooted none too soon to meet needs in PDR Yemen where the requirement for fuel/fodder/shelter species is increasing; some species are already subject to heavy use and the opportunities for utilization of good gene resources are increasing with the programme for distribution of tree materials to farmers from the forest nurseries. With a growing programme of this type, it is inconceivable that the manpower and other resources of the Forestry Section will remain static or that the need to develop superior cultivars of important species will be neglected.

6.7 SEED STORAGE AND HANDLING

The absence of seed storage facilities has been referred to in Sections 6.3 and 6.4. Considering the climate of Yemen and the prevalence of seed insects, this factor is a hindrance to progress in building up a good forestry programme, including development of genetic resources. Consideration should be given to providing a suitable oil-operated refrigerator to meet the needs of the Section.

Other bottlenecks are the lack of seed fumigation facilities and a phytosanitary certification programme. These matters might be recommended to be taken up in conjunction with agriculture under some other aid programme.

VII. CHILE

7.1 PARTICIPATION

There are two competent and well-organized institutes wishing to officially participate in the Project: (1) the National Institute for Agricultural and Animal Husbandry Research (INIA) and (2) the Forestry Institute (INFOR) which can be considered as the research body of the National Forestry Corporation (CONAF).

Both INIA and INFOR are Chilean State agencies which guarantees the seriousness and continuity required for the objectives pursued. They are staffed with a group of competent professionals and can rely upon continuous advice from universities and international experts by virtue of existing agreements.

INIA has an establishment known as the Los Vilos Experimental Substation, situated in the centre of the country's arid zone and, with this as its operational centre, studies the adaptation of species in the areas known as the inland, coastal and central plain 'secanos' (dry lands), with special emphasis on plants suitable for fodder (i.a. Atriplex spp., Acacia spp., Galenia spp.). INIA is prepared to collaborate in the evaluation of species which fall within its terms of reference.

INFOR, together with the School of Forestry Sciences of the University of Chile, has actively cooperated in the project 'CONAF/UNDP/FAO/CHI/76/003 Forestry Research and Development' with special reference to research on the introduction of forestry species in the country. Both the Institute and the School have thus a direct interest in participating in the FAO/IBPGR project, as corroborated by the Chief of INFOR's Forestry Division. The School of Forestry Sciences is not specifically mentioned above as a cooperating institute, but its close connection with INFOR makes its participation self-evident.

CONAF, another official body connected with forestry activities, implements government policies based on the results of research. It is closely connected with INFOR, to the extent that the post of Executive Director of both Institutes is in the hands of the same person. CONAF is also the official government controlling agency for all forestry activities in the country.

Among institutes which work in related fields but which will not directly cooperate in the proposed project, the School of Agronomy of the University of Chile and the Production Promotion Corporation (CORFO) can be mentioned.

The ambit of action of the School of Agronomy is limited and the emphasis of its work and its priorities differs from that of the project.

CORFO, which owns the country's largest plantations of Prosopis tamarugo and P. atacamensis and which was the initiator of Prosopis research in Chile, does not include in its immediate plans the evaluation of provenance variation in Prosopis or Acacia. Its current work on plantations in the extreme north of Chile is focused mainly on the development and raising of livestock and on general experimentation relating to the livestock production potential of its plantations.

7.2 SPECIES

The species which Chile is interested in evaluating in its arid and semi-arid zones are listed in Annex 7.1; additions or deletions can be made to this list during the progress of the project. It should be pointed out that the project CONAF/UNDP/FAO/CHI has made available for evaluation a wide range of species (over 120 species have been tried) including species indigenous to the arid and semi-arid zones of Chile as well as exotic species originating in areas with similar climatic characteristics and therefore of potential value in the Chilean regions where rainfall is insufficient and poorly distributed.

Genera and species which, based on preliminary evaluation trials, are considered of interest to the arid and semi-arid zones in Chile, are listed in Appendix 7.1.

The species listed have been chosen without prejudice to species of other genera which may, at a later date, assume importance. The allocation of priorities for the various species has been made by INFOR and INIA; the priorities are in no way definitive or fixed, but are subject to results from further testing.

7.3 EXPLORATION AND COLLECTION

The distribution and ecology of many of the important indigenous species have been described by various institutes and individual researchers. They are summarised in Annex 7.3; more complete background information on soil and climate is given in Annex 7.4.

The Forestry Institute has traditionally been in charge of seed collecting expeditions for indigenous species, laying special emphasis on those species thought to be in danger of extinction. At the present time, however, the Institute does not have the necessary collection staff and, subject to availability of funds, will recruit temporary staff on a short term basis to carry out specific collections. The personal effort of its professionals as well as the impartial help of other persons concerned have, however, made it possible to satisfy immediate needs.

The Chillán Seed Centre, which is part of CONAF, is the main official body for the supply of forestry germplasm to meet national and external requests. In the case of indigenous species, the Centre does its own collection, classification and storage for subsequent distribution. Seed availability is, to a certain extent, limited, especially in the case of some species considered to be in danger of extinction, such as Caesalpinia spinosa, Gorbiera hygrometrica, Geoffroea decorticans and some species of Prosopis (P. atacamensis, P. burkartii).

Both INFOR and the Seed Centre are ready to cooperate within the limits of their means in collecting or obtaining seed to meet the needs of the proposed project.

7.4 EVALUATION

The seed sources and sites to be evaluated are listed in Annex 7.3.. Table 7.3.1 indicates the relative responsibilities in evaluation of INIA, the School of Forestry Sciences of the University of Chile and CONAF. Table 7.3.2 lists the seed sources and sites under the responsibility of INFOR; evaluation of these will be carried out jointly by the Forestry Division of INFOR and the School of Forestry Sciences of the University of Chile, under the auspices of project CONAF/UNDP/FAO/CHI starting in 1980. It should be noted that the list of species in Table 7.3.1 did not originally include Eucalyptus microtheca. However, as a range of provenances of this species has been made available through the project, it has been added to the species to be evaluated on potential eucalypt sites.

Evaluation will be made by comparing each species with the species best adapted or most commonly used at the trial site or in its vicinity. In the case of Eucalyptus, comparisons would be mainly made with E. camaldulensis and E. globulus. Introduced species would mainly be compared with the indigenous Acacia caven and A. cyanophylla as well as with Caesalpinia spinosa. Standard comparisons for fodder plants are Atriplex repanda and A. nummularia. For pines and other conifers, the reference species would be Cupressus sempervirens and/or Pinus radiata.

Native species will be evaluated comparing them with species like Quillaja saponaria, Maytenus boaria, Cryptocarya alba, Prosopis chilensis, etc.. However, as the objectives of the evaluation of these species include the determination of the most valuable or potentially valuable seed sources for conservation purposes, their relative production as compared to other species is of less importance than in the case of exotics.

The methodology of evaluation will be statistically sound, in other words, evaluation will be based on adequate experimental design, usually randomized blocks with three or four replications in square plots containing 49 trees (7 x 7) of which the inner 25 trees are measured. Trees will be planted with a standard spacing of 2 x 2 metres. Measurements and assessments to be made at regular intervals include survival, height, diameter at breast height (DBH), volume, basal area and form. Evaluation can be done on the basis of certain alternatives, which are not mutually exclusive:

(i) comparison at a specific age;

(ii) stratified evaluation, separating the species beforehand according to their expected growth rate or their end use;

(iii) comparison at a certain relative point of time, e.g. when they have completed 20% of their rotation.

At planting and during establishment precautions will be taken to avoid confounding the results with environmental factors. Thus, the sites will be fenced to keep out goats, sheep and cattle. The plants will also be protected against hares and rabbits, the only wild animals known to cause damage in plantations. Firebreaks will be cleared and maintained, weeding will be done manually to cause a minimum of damage, etc.. In the trial sites of the arid and semi-arid zones of Region IV, toward the south of the country, no irrigation will be applied in contrast to general practice in the other arid and semi-arid regions.

The seed used in the trials will be obtained directly by evaluating organizations either by collection or by barter or purchase. Species, provenance, date of collection, date of seed analysis, purity, germination percentage, viability, number of seeds per kg and any special treatments used for storage or the breaking of dormancy will be listed in the experimental records to be kept for each seedlot.

Trained personnel, under competent technical supervision, will be provided for nurseries and plantations.

Information and results from the evaluation will be made available to official or private persons requesting it.

The evaluation sites listed in Tables 7.3.1 and 7.3.2 (Annex 7) have been chosen to represent the country's arid and semi-arid zones which include three different, ecologically well-defined areas: the coastal 'secano' (dry land), the inland 'secano', and the pre-Andean range.

The methodology for establishment and evaluation of the trials is based on the FAO publication ' A Guide to Tree Species Trials in Tropical America' (1968), which has been adapted to the conditions prevailing in the country, in conformity with Report III of the Forestry Institute and the University of Chile (project CONAF/UNDP/FAO/CHI/76/003) 'Metodología para la instalación y análisis de ensayos de introducción de especies' (Methodology for the establishment and evaluation of species trials).

7.5 CONSERVATION

In the field of conservation of the forest resources in Chile's arid and semi-arid zones, two trends can be recognised. Firstly, extensive destruction of economically important species due to indiscriminate exploitation. Secondly, attempts to gradually reverse this trend by means of protection and artificial regeneration. The balance between these two opposing trends varies depending on the species. As a positive example, one could mention Prosopis tamarugo and P. atacamensis, which occur in the extreme north of the country. After becoming practically extinct due to extensive exploitation for fuelwood and charcoal for the nitrate industry, the populations of these two species have gradually been restored through extensive planting; at present the total area of artificial and natural stands of Prosopis exceeds 25 000 ha.

Plantations made on behalf of the State by CORFO consist basically of P. tamarugo. The seed used is collected from trees of good form and health and with a good seed production capacity. Apart from this, no selection has been or is being made in this species. New plantings were discontinued in 1974 but, no doubt, there is sufficient material in the already planted areas for conservation or selection at any time. Plantations of P. atacamensis have been based on a similar criterion, i.e. seed was collected from phenotypically desirable individuals. It is worth noting that P. atacamensis and P. tamarugo are the only native species of Prosopis occurring in the Tarapacá Region I of Chile (Munoz, 1971). There are special laws for the protection of these species which are scarce in their natural habitat but have great longevity.

In the arid and semi-arid zones farther south, in the Coquimbo Region IV, there are several species which have been undergoing a process of depletion as a reult of strong pressure for fuelwood, charcoal, industrial raw material and fodder. Among these species, the following could be mentioned: Quillaja saponaria, Maytenus boaria, Cryptocarya alba, Prosopis chilensis, Proustia spp., Porliera hygrometrica, Geoffroea decorticans, Atriplex repanda and, to a lesser extent, Acacia caven.

The problem has recently become acute for certain highly palatable species due to heavy grazing by animals, mainly goats, as can be evidenced in the vicinity of goat ranches, run for milk production. Grazing lands are, on economic grounds, not fenced and overgrazing is intense close to the milking sites, eventually leading to the disappearance of all vegetation, forcing migration to another location where the devastating process is repeated.

Under these circumstances, considering the greatly depleted population, consisting of maybe three or four individuals at each site, in situ conservation will be of little practical value. The species and populations are more efficiently conserved ex situ in supervised forestry reserves; also their inclusion in species introduction or evaluation trials will help to promote the spread and conservation of the populations and the genetic material they contain.

By virtue of Decree-Law 701, passed by the Ministry of Agriculture in October 1974, incentives are available for plantation establishment in Chile. These incentives amount to a contribution covering 75% of the establishment costs, provided that the work is done under the guidance of a professional forester and provided that the forestation programme has been approved and evaluated by CONAF, which fixes a nominal establishment cost according to the type of plantation, soil type, etc.. In addition, every private person or firm is, under this Law, under the obligation to replant an area equivalent to that which it exploits, under penalty of heavy fines or confiscation of the land. Thus a bonus and an obligation both work towards the conservation of native and exotic forest resources.

The above-mentioned Decree-Law 701 has recently been modified and improved by Decree-Law 2565 which maintains the incentives but simplifies the process for obtaining them, thus increasing the number of beneficiaries.

7.6 UTILIZATION

The project CONAF/UNDP/FAO/CHI/76/003, 'Forestry Research and Development' (see above), of which the first phase has recently been completed, has published three reports whose objectives are in line with those of the present FAO/IBPGR project. The titles of these reports are:

(i) 'Present Situation of Programmes of the Introduction of Forest Species in Chile';

(ii) 'Areas covered by Trials on the Introduction of Species and Location of New Experiments';

(iii) 'Methodology for the Establishment and Analysis on Species Introduction Trials'.

The aim of the reports is to assist in the selection of species and provenances which are well-adapted to prevailing conditions and which have the greatest possible potential in the area in question. Species/provenance selection will eventually be followed by programmes for the genetic improvement of the most promising species. The guidelines given in these reports, coupled with incentives available under Decree-Law 701 mentioned above, are thought to guarantee the success of Chile's plantation programme.

The various forestry and research organizations will be responsible for the distribution of the improved material. INIA, through its extension teams, is constantly disseminating new information to users as it becomes available.

7.7 SEED HANDLING AND STORAGE

As regards Prosopis tamarugo and P. atacamensis, there is no established local organization handling or storing seeds in the areas of the natural distribution of the species in Tarapacá; neither CORFO nor any other public or private organization is presently establishing large-scale plantations of these species in this area. Seed requests from abroad, which have to date been limited to small quantities, are met through collections made to meet specific requests. Once seeds have been collected and after discarding those attacked by insect larvae, they are fumigated in the presence of official inspectors from the Ministry of Agriculture, with one of several different products; sometimes they are also treated with sulphuric acid to facilitate germination. Following these measures, the seed is sent to Santiago where it undergoes a further sanitary inspection and a phytosanitary certificate is issued to accompany the seed which is generally shipped abroad as a free sample. CORFO will coordinate collection and distribution of the seed, provided small, experimental quantities are in question. In the case of larger bulk quantities, CONAF will supply the seed from its regular collections.

If seed is not treated with an appropriate insecticide after collection, it is quickly attacked by Bruchidae larvae during storage. Forest tree seeds are stored and distributed by the Chillán Seed Centre which has adequate facilities including a seed processing plant, a laboratory for analysis and a refrigerated storage room, all of which have been placed at FAO's disposal by letter from the Centre's Director to the Director of FAO's Forest Resources Division (letter No. 97 of 12 April 1979 refers).

The Division of Agricultural Protection, Agriculture and Animal Husbandry Service, Ministry of Agriculture, is the official agency which authorizes seed imports and exports and issues phytosanitary certificates for export.

VIII. MEXICO

8.1 PARTICIPATION

The Director General of the National Forestry Research Institute (INIF), confirmed his country's interest in participating in the FAO/IBPGR project and together with the Director of the Northeastern Forestry Research Centre (CIFNE) specified, for that purpose, the priorities and programme described below.

INIF is Mexico's official institute for forestry research and works under the Secretariat for Agriculture and Water Resources (SARH), through the Undersecretariat for Forestry and Fauna. The other official research bodies are the National Agricultural Research Institute (INIA) and the National Animal Research Institute (INIP).

It should be noted that the term 'forestry resource' in Mexico covers all native vegetation, whether herbaceous, bushy or arboreal.

Working in close connection with universities, institutes, professional societies, international and other organizations, INIF logically appears to be the institute to represent Mexico in the project. This argument is strengthened by the fact that the scope of its research is nationwide, with forestry research centres in all three ecological zones of the country (temperate, cold-tropical and arid), in addition to a great number of experimental areas in a range of different conditions; work is carried out by teams of professionals covering all the different disciplines needed to meet research objectives both at the regional and the national level. CIFNE alone has 35 specialized experts in addition to ancillary and support staff working for it.

8.2 SPECIES

The indigenous and exotic priority species as reported by Mexico for arid and semi-arid zones and their main uses are listed in Annex 8.1. The main indigenous species are further described in Annex 8.2.

The species can be classified as industrial, fuelwood and fodder species, and species used for soil protection and amelioration. There is also a great interest in continuing work on Eucalyptus spp., including in the programme additional species, varieties and provenances suited for arid zone afforestation with or without irrigation; this work would tie in closely with the work presently done on methods of trapping water run-off using different systems of soil preparation and planting.

High priority is given to evaluating species and provenances suited for animal husbandry, which is an important source of food and income for local populations, especially in the arid and semi-arid regions. Any effort made towards improving the animal feeding situation will eventually bring about a real improvement in the standard of living of the people in these areas.

For the reasons given above, Mexico wishes to participate in the proposed programme to help solve problems of afforestation, for the production of raw materials, energy and animal feed in arid and semi-arid areas. To this end highest importance is placed on the study and evaluation of the natural resources available, particularly of the genera Prosopis, Acacia, Atriplex, Agave, Opuntia, as well as suitable exotic species of potential value.

In principle, Mexico has no objections to exchange reproductive material with other countries.

8.3 EXPLORATION AND COLLECTION

The distribution and ecology of several of the main species indigenous to Mexico have been well described (see Annex 8.2). Generally speaking, genetic variation between species has not been exhaustively analysed; some of the species are, however, included in recently started joint research programmes with the United States of America. For example, in the case of Parthenium argentatum some US$ 5 000 000 will be devoted in 1981/85 to basic research in Mexico and USA on exploration, collection, propagation, ecotypic variation, etc.. The area of distribution and the ecology of Simmondsia chinensis has also recently been described and various provenances from Lower California are under trial. Seed availability however, is limited and there are some difficulties with sex identification in this dioecious plant.

The location of some species/provenance trials of important species is listed in Annex 8.3.

Generally speaking, there are no difficulties of access for the collection and exploration of most indigenous species; provision for seed collection has been made even in some nature reserves. The general practice is to organise expeditions led by the regional heads of Forestry Plantation Schemes to collect seed and herbarium specimens, including isolated locations where potentially valuable and often untested, genetic material may be found.

As mentioned above and as evidenced by the priority ratings in Annex 8.1, Mexico is giving first priority in its arid zone research to indigenous species of industrial utility and supplementarily to arboreal and bushy fodder species. Research on the most important industrial species is, however, already covered by the agreements and cooperative programmes with the United States mentioned above. On the other hand, practically no work has to date been done on local Prosopis and Acacia spp. although there is full awareness of their value, both for local use and for use in other countries with arid or semi-arid climates. Mexico is willing to undertake exploration and collection of these genera provided funds can be made available for collection of seed in sufficient quantities to meet the country's own requirements, as well as those of countries interested in seed of the species. Exploration and collection would be carried out simultaneously for Prosopis and Acacia in the states and localities having the greatest natural concentration of these species, that is, on the coastal plain of Tamaulipas and Nueva León and, across the mountain chain of the "Sierra Madre", mainly in the States of Coahuila, San Luis de Potosí, Zacatecas, Chihuahua, Durango and Sonora.

INIF also wishes to continue its collectionsof Atriplex species and provenances. Exploration and collection of other species of potential interest could be made during these seed collection expeditions, provided outside assistance could be made available.

In Mexico, private individuals are allowed to collect material without any special permits and without official supervision. However, all seed exports require official approval, under rules and regulations which vary from case to case.

8.4 EVALUATION

The species proposed by Mexico for immediate evaluation are those marked with priority 1 in Annex 8.1. However, these priorities are not final and may be changed according to requirements at the time the evaluation activities are started.

The areas suggested for location of the trials are in the municipalities of Ramos Arispe, Viesca, General Cepeda, Buenavista and Arteaga in the State of Coahuila; Santo Domingo in Durango; Charcas, Guadalupe and Armadillo de Los Infantes in the State of San Luis de Potosí and in Todos Santos, La Paz in the State of southern Lower California. This does not exclude other localities in other States about to be included in the arid zone programmes of Mexico.

The species to be evaluated and the number of trials to be established are in direct relation to the seed available. There is interest in evaluating, among others, Eucalyptus camaldulensis, E. microtheca and other eucalypt species from sites having characteristics similar to arid localities in Mexico, in other words, with an annual precipitation below 350 mm, temperatures varying between 15° and 25°C, and 8 to 12 dry months per year.

Comparisons would be made with certain indigenous arboreal species such as Pinus cembroides or exotic species such as P. halepensis, or naturalized species such as Cupressus sempervirens, which are of potential value for the areas in question.

In the case of Acacia spp., comparisons would be made with the native species, Acacia berlandieri and A. farnesiana and others which could be collected during the exploration and collection phases proposed above.

As regards Prosopis spp., the comparison would be made with P. glandulosa which is the predominant species of this genus in the Mexican desert.

The experimental stations and areas have trained nursery personnel and it is anticipated that germination of the seeds and raising of the seedlings in pots or polyethylene bags for subsequent planting in the permanent trial sites will not cause major difficulties.

From the point of view of experimental design, no difficulties are foreseen as INIF has staff specialized in this type of work. As a general rule, all aspects of experimental design are, moreover, discussed with national or regional coordinators before implementation.

Most trials in the arid/semi-arid areas have been laid out as factorial designs, as one of the main lines of research is that of water utilization which necessitates a range of different soil preparation and planting methods: planting in furrows made with subsoil ploughs; planting at the bottom of the furrow; with varying water trapping methods; with varying systems of water collection; direct seeding, etc.. Naturally, not all these alternatives are used in all cases. For some types of experiments, randomized blocks and lattice designs are also commonly used.

Experimental areas for the introduction and/or comparison of species are fenced to avoid damage by animals and in some cases there is weed control or pesticides are used to eliminate harmful agents.

Seed used in evaluation trials is received, stored and recorded using a registration number, identifying its provenance and other data, at the Mexican National Seed Centre, from which seed distribution is also made.

The officials in charge of the Forest Plantation programmes, as well as those responsible for the plant domestication departments, have no objections to making available the results of their evaluation trials.

8.5 CONSERVATION

In the experimental stations and areas situated in the arid and semi-arid zones of Mexico, protected areas have been established with the purpose of studying vegetation successions. These areas have a size of approximately 1 ha each, covering the various ecological zones found in the country and containing the main part of the species Mexico is interested in conserving.

For instance, in the case of Simmondsia chinensis, Euphorbia antisyphilitica and Parthenium argentatum, there are enough natural areas which, for the time being, satisfactorily reduce the danger of extinction caused by massive exploitation. Research work, both implemented and projected, presently aims at clarifying the reproductive systems of these species.

Euphorbia antisyphilitica is protected by legislation limiting its exploitation to a certain monthly level per family group. Ex situ conservation is, to some extent, being implemented through widely planting the species in trials and plantation schemes.

Other species, such as Pinus cembroides, P. nelsoni, Chilopsis linnearis, are not in imminent danger of extinction. For this reason there are no concrete plans for conservation, except for normal management of the resource. Interest in the species, their planting etc., also contributes towards ensuring their conservation ex situ.

As to Prosopis and Acacia there is no concrete in situ or ex situ conservation work, despite the fact that the species are under pressure, mainly as fodder for goats; Prosopis spp. is also extensively used for fuelwood and charcoal. However, these species do not seem to be in imminent danger of extinction, as evidenced by the natural regeneration found in their native areas.

In relation to Atriplex and other indigenous species, such as Agave, Opuntia, Porliera and others, there are no programmes for in situ conservation. However, trials, carried out by research institutes and other bodies such as universities, ensure that the resources are included in collections and gene banks, enabling subsequent reintroduction should this prove necessary.

However, it would be desirable to initiate specific conservation programmes for the species of greatest forage value, since their palatability makes them subject to strong grazing pressure which could lead to the extinction of important genotypes and provenances.

8.6 UTILIZATION

The INIF Research Centres located in the country's arid and semi-arid zones include, in their programmes, a series of research projects. Among these projects, the project on Establishment and Management of Forestry Plantations plays a prominent role. It includes sub-projects on topics such as Genetic Improvement, Forest Tree Nurseries, Conservation of Forestry Germ Plasm, Seed Handling and Storage, etc..

Through these Centres an active plan of plant selection is being developed to partly satisfy the same objectives as those of the FAO/IBPGR project, and the results of this research are, through the Centres, being made available to users. The projects are in an early stage of development and do not include all the important species; however, the need is recognised to introduce gradually better provenances and to identify superior populations of native species.

8.7 SEED HANDLING AND STORAGE

INIF has adequate seed storage and handling facilities, including cold storage facilities, at its Seed Centre in Mexico City. All forest tree seeds used by the Institute are received, stored and distributed through this Centre. Treatment against insects and fungi is also done by the Centre; chemicals with a gammexane (lindane) base against insects, and a sulphur base against fungi, are most commonly used.

Seed imported into Mexico must be accompanied by a phytosanitary certificate issued by an official agency. The Department of Plant Health of the Secretariat of Agriculture and Water Resources is the official Mexican agency authorised to issue certificates for seed exports.

It is not known whether there are specific quarantine measures which could affect the free exchange of seeds.

IX. PERU

9.1 PARTICIPATION

The Director-General of Forestry and Fauna of the Ministry of Food and Agriculture, based in Lima, confirmed Peru's desire to participate in the FAO/IBPGR project. The proposed priorities and programme were approved by him and by the Assistant Director-General, thus representing the country's official views.

The Department of Forestry and Fauna is one of Peru's chief research bodies. It works in close collaboration with other research bodies such as the Arid Zone Research Centre (CIZA) of the National Agrarian University 'La Molina'. The Department is staffed with personnel specialized in all the various disciplines connected with forestry and forest resource conservation and its Regional Stations are, in addition, spread throughout the different parts of the country. It is thus the most appropriate body to represent Peru in the proposed project.

9.2 SPECIES

Peru is particularly interested in indigenous or exotic species of the genus Prosopis and in determining the true potential of these species especially under conditions prevailing in the northern coastal zone of the country. Highest priority is given to native Prosopis species. These are presently the object of taxonomic classification in a project headed by Dr. Ramón Ferreira, Chief Professor of Botany at the Main National University of San Marcos, Lima, and holder of the National Prize for Sciences. Dr. Ferreira's work has confirmed the view that there are several different species of Prosopis which are native to Peru. These include Prosopis chilensis, P. limensis and possibly others, in addition to P. juliflora, which was earlier thought to be the main Peruvian species.

Peru is also interested in evaluating exotic species. Species of the genus Eucalyptus are of special interest, including E. camaldulensis, E. microtheca, E. grandis and others.

Indigenous and exotic priority species are listed in Annex 9.1.

9.3 EXPLORATION AND COLLECTION

At present, the collection of Prosopis seed for planting is done without a definite scheme. Often, sheep dung is collected from enclosures where animals have eaten Prosopis pods, and the seeds are sown in nurseries or, preferably, seeded directly in the field. Sometimes the fruit is macerated and, once the seed has been extracted, it is germinated in plastic bags from which it is transferred to the planting site. In other cases the pods are cut up with one seed in each section and sown directly without further processing. Sometimes these pods are collected from special "seed stands". Further accentuated by the dichogamic character of the genus Prosopis, these varying collection systems are likely to have led to considerable genetic variation in the plantations established to date.

In systematic collections for the proposed project, first-stage seed collections of Prosopis spp. would be undertaken in the natural forests growing along the Peruvian coast and in the mountain ranges (see Annex 9.2 for details).

In general, access to both natural forests and to plantations will present no problems, with the possible exception of some remote areas with broken and difficult terrain.

After collection, seed would be sent to the Seed Centre of the Ministry of Agriculture in Lima for phytosanitary analysis accompanied by a descriptive collection sheet with details on location, environment, stand characteristics and collection. Later, seed would be exchanged upon request, either directly or through FAO.

Capparis angulata which is also described in detail in Annex 9.2, with information on its distribution, climate and soil conditions, main characteristics, suggested collection areas, etc., is another plant which can be explored and collected, although information gathered at Piura indicates that the seed loses viability five or six months after collection mainly due to attacks by xylophagous insects.

9.4 EVALUATION

As pointed out in 9.2 above, Peru gives highest immediate priority to indigenous species of the genus Prosopis and to the evaluation of seed from local collections presently underway, complementing these whenever possible with additional seedlots from other countries. The local collections include a thornless form of Prosopis (possibly a variety of P. chilensis), which is receiving much attention as a potentially useful browse species and which is being reproduced vegetatively in anticipation of increasing demand. Desirable phenotypes, producing large quantities of seed, have also been selected for inclusion in the evaluation trials.

The evaluation of the Prosopis collections is not planned to be made using special experimental designs. Statistically laid-out experiments are not considered necessary by local staff at the Piura Reforestation Project, since the material will be included in plantations in the same general areas as 1 100 ha of existing Prosopis plantations, making direct comparisons of field performance possible.

However, should designs allowing statistical analyses be considered essential in the proposed project, competent assistance is available from the Department of Forestry and Fauna as well as from other institutes such as the National Universities.

Establishment should be by direct sowing without raising plants in nurseries, as results from establishment trials of Prosopis indicate that the best results are obtained by this method. In this way, the plants are given a chance to develop a deep root system which shortens the time during which watering is necessary. The use of transplants delays the development of the tap-root and the plants take much longer to get established (Salomé Valdivia, private communication). The seed should be sown in 10 x 10 m plots and, in the beginning, these are watered every 10 days. As the plants grow and their root systems develop, watering intervals are gradually lengthened. Irrigation is completely stopped when the plants reach the age of three years.

Irrigation is generally done by means of irrigation ditches or, where these do not exist, by hand-carrying water to the plants in buckets.

When sowing Prosopis, protection should be ensured against herbivorous lizards which will otherwise completely defoliate the plants as soon as they sprout.

The evaluation of Prosopis under the proposed project would be centred at Tumbes, Piura and Lambayeque plus at several additional low-lying localities. The trials would be under the direct responsibility of the Chief of Reforestation of the Piura Project, who would be assisted by additional field staff and professional advice provided by both Departmental and National Government bodies. Independently of the presently proposed project, technical and financial aid from FAO is also being requested through the Ministry of Food and Agriculture based on the pilot plantation of 1 100 ha of Prosopis in Piura. The FAO project would include species evaluation and economic feasibility studies.

In the field of evaluation, there is also interest in continuing trials with various species of Eucalyptus, particularly for the establishment of windbreaks and live screens for the protection of crops. Among the eucalypts of interest for replicated species/

provenance trials, E. camaldulensis, E. microtheca, E. rostrata and E. gomphocephala can be mentioned. These species/provenances would be compared with the presently most promising species in the respective locations, as well as with provenances of various species of the genera Tamarix and Casuarina.

Comparisons of Eucalyptus and other species would be performed according to current norms, that is, in complete randomized blocks with four replications, planted at 4 x 4 m, with irrigation on some sites during the first stage but with no other special treatment.

The Bureau of Forestry and Fauna has no objections to making available the results of its evaluation nor to demonstrating in the field, without reservation to FAO or technical personnel from other countries, the progress of its work.

Annex 9.3 indicates sites, species and provenances proposed for future trials.

9.5 CONSERVATION

The utilization of forest resources for fuelwood, charcoal, timber or poles, wood for parquet flooring and, above all intensive grazing, mainly by goats, is creating problems in the conservation of these resources as well as upsetting the natural ecosystem, chiefly in the vulnerable northern coastal area of Peru.

Faced with this situation, the Government has imposed prohibitions on felling and charcoal-making in the Departments of Tumbes, Piura and Lambayeque through a series of Supreme Resolutions dictated between 1968 and 1974, thus preventing further depletion of stands of Prosopis and Capparis spp. In addition, by Supreme Resolution No. 398-73AG of 24 April 1973 the San Ignacio Nacional Forest in the Departments of Cajamarca and Piura was set aside for conservation purposes. The area of this reserve is approximately 180 000 ha, and it includes most of the species found in the arid zone of Peru.

Action to conserve specific varieties of useful or potentially useful species has been mentioned above, in the case of the thornless form of Prosopis spp. Implementation of reforestation programmes such as the Reforestation Project of the Department of Piura has, in addition, recently greatly increased the total area of some species, especially that of Prosopis spp..

In summary, the measures already taken to prohibit destructive utilization of forest resources in northern Peru as well as the planting programmes underway lead to believe that action for the conservation of these resources will present no insurmountable problems in the future.. Additional outside assistance will also be sought for improved programmes of conservation and selection of potentially useful native species.

9.6 UTILIZATION

In Prosopis spp. the main aim of selection is to obtain trees capable of producing increasing quantities of pods and seed from the age of three onwards. The trees should preferably be thornless to lend themselves to browsing. The State Government is planning to afforest large areas which will later be handed over for the use of local farmers. The total area of these plantations has not yet been determined. This project forms part of a long-term Government programme for the recovery of desert land using Prosopis spp., a highly versatile plant native to the desert, regenerating rapidly especially if a certain amount of irrigation is used in connection with establishment. Once it starts producing seed, irrigation can be suspended and the water can be diverted to new plantations established with the aim of multiplying this scarce resource.

Although no intensive genetic improvement work is presently being done on any of the arid zone species in Peru, there is full awareness of its importance. A programme for the genetic improvement of Prosopis and associated species would, in addition to its value per se, help accelerate the planting programme.

In addition to the use of Prosopis spp. as a browsing species, attempts are being made by the Department of Forestry to increase its use as a shelterbelt species and in plantings made for the protection of watersheds, together with other species such as Eucalyptus, Casuarina and Tamarix spp.

9.7 SEED HANDLING AND STORAGE

Up to the present there is hardly any experience in the handling and storage of Prosopis seed in Peru. Whatever seed is required is collected and immediately used locally or despatched to the places which have requested it. There is information, however, to indicate that, if stored without precautions, the seed is attacked by some Bruchidae species, but that the problem is considerably lessened if the seed is protected with an insecticide such as gammexane.

Some other potentially important species such as Capparis spp. also present problems in seed storage; seed of Capparis loses its viability within five to six months after collection.

At the central level, in Lima, a National Forest Tree Seed Bank is about to start operations. It will be fully equipped to store, treat and analyze all types of seed.

The Plant Health Division of the Ministry of Food and Agriculture is the official institute to authorize seed imports as well as to grant authorization and phytosanitary certificates for export.

X. SUMMARY FINDINGS AND RECOMMENDATIONS

10.1 THE CASE FOR THE PROJECT

The notable expansion of industrial plantation forestry since World War II, particularly in the tropical and sub-tropical zones, was based at first on the limited range of exotic species which had succeeded in early introduction trials, often of a somewhat ad hoc nature. In most cases they applied to the favourable upland areas that were then available for forestry development rather than to the somewhat harsher areas in which so much of the later development is taking place. Generalizations from scanty test results, leading to the use of species on sites to which they were not fully adapted, sometimes led to disappointments. Efforts to find species or provenances better suited to local conditions followed. More comprehensive information on variation within species has resulted from recent cooperative internationally supported programmes, such as that for Central American pines coordinated by the Commonwealth Forestry Institute (CFI), in the 1970's.

The situation in the field of social (village or agricultural) forestry almost exactly parallels that of industrial forestry, as it was 25 years ago: there is extreme interest in, and concern to support, tree planting of a kind which obviously bring benefits to hard pressed people living in harsh, unstable environments such as those in the arid and semi-arid areas. Obvious benefits have arisen from the use of a few local species that have responded to management, and from a few instances of remarkable success of introduced species, e.g. Prosopis chilensis/juliflora in several countries and Acacia tortilis (known in Israel as A. raddiana Savi) which, introduced from Israel to the Central Arid Zone Research Institute (CAZRI) at Jodhpur, India, in 1958, is now transforming extensive areas of semi-desert in Rajasthan with its provision of shade and shelter, fuel and fodder.

Social forestry programmes having a variety of objectives are being started in many developing countries with the support of bilateral or international aid programmes. With a few notable exceptions the genetic material on which they are based is not necessarily the best that could be provided, and not representative of any comprehensive programme of evaluation.

There is now an opportunity to start a coordinated, cooperative, international programme with the aim of filling the need for species and provenances for a variety of specific conditions and uses. These include the harsh conditions of the arid and semi-arid zones and the values required by the people who live there. A genetic resources development programme of the type proposed in this report should be started forthwith, before social forestry programmes are frustrated by the lack of suitable genetic materials, and before too much is planted that is less than the best available.

As noted elsewhere in this report, each institute visited was either involved on its own with the beginnings of such a programme or was contemplating starting one. Thus, this FAO/IBPGR Project is timely and will be welcomed in these eight countries and probably many others.

In addition to governments and the national institutes visited, the FAO/IBPGR Project was also fully endorsed by the International Development Research Centre (IDRC), presently promoting trials of Prosopis spp. in the Sahel; during discussions it was agreed that it is essential to continue to coordinate the activities of IDRC and FAO/IBPGR in order to avoid any overlap.

There are urgent social and economic reasons for support of this FAO/IBPGR programme. It is realistic to start with a modest list of potentially important and highly relevant species; to enlist international cooperation; to keep the early effort in each country well within the bounds of available capability. The general FAO/IBPGR strategy to be followed, involving the phases of exploration, collection, evaluation, conservation and utilization, is logical and scientifically sound. It seems certain, however, that the Project will require much greater financial support in the future than the levels proposed to the IPBGR, based on the limited number of countries and species considered in the present report. It will also require close and intensive regional as well as overall coordination, and the provision of a coordinator is essential for the success of the project.

10.2 PARTICIPATION

In the countries to which this report refers, programmes aimed at evaluating and comparing local populations of species of value to agricultural or social forestry, had either been initiated or were under consideration when visited by the consultants. It is accordingly deduced that the Project is both relevant and timely. All the agencies and institutes visited, as well as the senior administrators to whom they were responsible, indicated interest in participating in the second phase of the Project, the initiation of which they would welcome.

The following thirteen institutes are willing to cooperate in the second phase of the Project subject to approval by their respective governments.

(a) India

(i) Forest Research Institute (FRI), Dehra Dun.

(ii) Central Arid Zone Research Institute (CAZRI) Jodhpur.

(iii) Central Soil Conservation Research and Training Institute (CSCRTI), Dehra Dun.

(b) Israel

(i) The Forestry Division, Agricultural Research Organisation, Ilanot.

(c) Senegal

(i) The National Centre of Forest Research (CNRF).

(ii) The Department of Water and Forests.

(d) Sudan

(i) The Forest Research Institute (FRI), Soba.

(e) P.D.R. Yemen

(i) The Forestry Section, Agricultural Research Centre (ARC), El-Kod.

(f) Chile

(i) The National Institute for Agricultural and Animal Husbandry Research (INIA), Los Vilos.

(ii) The Forestry Institute (INFOR).

(g) Mexico

(i) The National Forestry Research Institute (INIF).

(ii) The North-east Forestry Research Centre (CIFNE).

(h) Peru

(i) The Department of Forestry and Fauna, Lima.

Each of the institutes visited in India, Israel, Sudan, Chile, Mexico and Peru has the competent staff and facilities required to participate effectively in the project. However, the FRI at Soba in Sudan has programme commitments that limit its capability for new work. Some additional staff would be required there to implement the Eucalyptus evaluation studies, but the opportunity exists to have some of the project work done by a graduate student of Khartoum University. Provision of additional funds would enable India, Chile, Peru, Mexico and Sudan to increase their contribution to the project significantly. The representative institutes in Senegal and P.D.R. Yemen are enthusiastic about participating in the project but would require inputs of technical expertise, as well as finance, to ensure their successful cooperation.

10.3 SPECIES

All species in the FAO list (Annex 1) are of potential interest to each country. Having regard to country capabilities to initiate new work, the species of most general interest have been selected for attention during Phase 2 of the project. These are:

(a) evaluation of one or more of the three Australian species, viz, Eucalyptus camaldulensis, E. microtheca and Acacia aneura;

(b) exploration and collection of indigenous Acacia and Prosopis species; and

(c) in addition to the foregoing, the exploration and collection of representatives of some additional general in the three Latin-American countries, leading to the establishment of trials of a range of indigenous and exotic provenances through the exchange of seeds between countries. Second and third priority species, as well as others not listed, should receive attention in later phases of the project.

It will be a matter of disappointment to some countries that A. senegal seed will not be available from Sudan (see Section 3.2).

Suggestions and information concerning additional species are recorded in Chapters 2 to 9 and associated Annexes. These should aid the compilation of species lists for future phases of this project.

10.4 TAXONOMY

Confusion exists in the nomenclature of Prosopis and some of the very variable tropical Acacias. Examples include the P. juliflora/P. chilensis complex in India; the probability that the sub-specific and varietal epithets in use for forms of some Acacia spp., e.g. A. nilotica, are not all valid; the fact that the A. tortilis introduced into India from Israel is referred to as A. tortilis in the former country and A. raddiana Savi in the latter. Early clarification will be important to ensure unambiguous results from the species and provenance trials. The recent publication of Burkart's monograph (1976) on Prosopis provides a good basis for resolution of the difficulty in this genus. Brenan's work on tropical Acacia species provides a good basis for clarifying their nomenclature.

In its project documentation FAO has drawn attention to the opportunity to clarify nomenclature that is presented by the exploration and seed collection phases of this project. It is most desirable that herbarium material be collected at the time of seed collection, for identification by specialists. This should be done in spite of the difficulty of preparing good herbarium material of some species in hot, dry climates.

Meantime, to avoid further confusion, the nomenclature used in this report is that which is current in the countries visited.

10.5 EXPLORATION AND COLLECTION

The numbers of separate collections proposed to be made of each species in the Priority 1 category for use in Phase 2 of the Project are given in the Annexes for each country. These are summarized as follows.

	Number of collections			
Country	Acacia spp.	Prosopis spp.	Other spp.	Totals
India	22	4	-	26
Israel	6	-	-	6
Senegal	5	-	-	5
Sudan	9	-	-	9
P.D.R. Yemen	6	2	-	8
Chile	3	15	2	20
Mexico	-	-	18	18
Peru	-	9	2	11
Totals	51	30	22	103

Generally, no difficulties due to lack of access or periodicity of seeding were foreseen. However, seed availability might be reduced locally for various reasons, e.g., browsing by goats of Acacia tortilis in P.D.R. Yemen and the Sudan and repeated coppicing for basket making materials of A. nilotica var. jacquemontii in India.

Most countries indicated that some financial assistance would be required to strengthen their existing facilities for seed collection and storage.

The institutes are all prepared to compile and submit a seed collection report for each provenance collected.

10.6 EVALUATION

Identification of the proposed provenance trial sites and generalised environmental information for them are given in the country Chapters 2 to 9 and supporting Annexes. These are summarized as follows:

Number of test sites and (provenances)

Country	Acacia spp.	Prosopis spp.	Eucalyptus spp.	Other spp.
India	8 (40+)*	7 (8+)	6 (6)	6 (+)*
Israel	3 (3)	3 (3)	3 (3)	-
Senegal	4 (8)	4 (5)	4 (+)	-
Sudan	1 (8)	4 (+)	6 (6)	-
P.D.R Yemen	1 (21+)	1 (6)	1 (3)	-
Chile	18 (8)	15 (1)	10 (7)	24 (28)
Mexico	3 (1+)	2 (+)	7 (2)	8 (8)
Peru	NIL	5 (1+)	5 (1+)	3 (3)
Total	38	41	42	41

* The plus sign (+) indicates acceptance of any provenances which may become available.

It is expected that seed of the three Australian species will be available for distribution in 1980/81. Seed for the remainder would be collected and distributed from 1981 on.

The recommended design of the evaluation trials would be square 36- or 49- tree plots that would permit assessment of 16- or 25- tree plots with one-row surrounds, arranged in randomised complete blocks and replicated four or three times respectively. The comparison species to be included in trials and for which seed would be collected locally are specified in the country chapters.

Good nursery facilities, at least reasonably close to proposed test sites, are available in most cases. Effective techniques for raising container stock are well established in each country and no difficulties are foreseen.

Site preparation procedures to be applied in each country would include stumping out indigenous trees and shrubs and a good degree of working the soil. Irrigation will be applied, at least during the first one or two years, in P.D.R. Yemen, the Sudan and Peru; in the former it is standard routine procedure, while in the latter two countries it would be used during the establishment phase for Acacia and Prosopis species to obviate loss of the trials due to drought. Spacing is usually 3 x 3 m but can be extended to 4 x 4 m to accommodate arrangements for irrigation.

All countries have the necessary expertise to establish the field trials and weeding, fencing and maintenance of fire lines are standard procedures. In P.D.R. Yemen and Sudan guards are employed full time to watch over young plantations and to ensure that routine maintenance and irrigation is carried out.

In most countries no difficulties are anticipated in the assessment and statistical analyses of the trials as all except Senegal and P.D.R. Yemen have the necessary facilities. Some assistance will be required in these two countries and the Sudan would welcome the collaboration of an outside specialist for the Eucalyptus trials, since the staff trained in this work are largely committed to existing research programmes.

Specific prescriptions regarding assessment criteria will be required to ensure comparability of results between participants and the relevance of criteria to the values sought from the species under trial, e.g. as fuel, fodder, etc. Each country would agree to make the results of evaluations freely available to other participants. It is recommended that participants be sent the C.F.I. "Manual on Species and Provenance Research with Particular Reference to the Tropics" (Burley and Wood, 1976).

10.7 CONSERVATION

All countries visited were conscious of the danger of extinction of species and the need for in situ and ex situ conservation. In Chile, Mexico and Peru certain species are protected by legislation but more is required, e.g., in Mexico there is no practical in situ or ex situ conservation work on Prosopis or Acacia despite their intensive utilization for fodder, mainly by goats.

In India the conceptual framework for a gene conservation programme is impressive. Although there is much to be done to get the whole effort rolling, some solid foundations have been laid. This is just as well because native forest tree gene resources are coming increasingly under pressure from agriculture, including grazing and browsing, and urbanisation.

In Israel no plans exist for formal conservation of native Acacia species but small stands would be established of promising provenances of exotics.

Pressure of use is threatening native Prosopis cineraria in P.D.R. Yemen and might also endanger Acacia tortilis in some areas. In the Sudan certain species (A. senegal, A. albida) are conserved in situ as a result of traditional recognition of their values in the rural economy. However, this does not apply to other species that are becoming endangered, e.g., A. tortilis, particularly near urban areas.

In Senegal small local patches of vegetation are preserved for religious reasons and lack of access has preserved trees in other areas.

Generally, a more systematic programme of in situ conservation is desirable in most of the countries visited but is dependent on more detailed knowledge of the distribution, variation and degree of impoverishment of the main species.

Obviously, it is in the best interest of each country to apply deliberate efforts to conserve native gene pools more widely. This FAO/IBPGR Project could well catalyse and support such a development.

10.8 UTILISATION

Modest beginnings were noted in India to develop gene pools of superior genotypes for arid and semi-arid zone forestry and plans were under discussion at FRI to extend this effort.

No developments of the type described above are underway in P.D.R. Yemen while ad hoc work has been done in the Sudan with A. senegal and A. nilotica, and in Senegal with Australian acacias and eucalypts.

In Chile and Mexico projects have been established and work initiated on improvement of local species. Peru is very conscious of the need for this work but cannot do so until finance is made available.

With the exception of A. senegal in the Sudan, each country is willing, subject to resources being available to do the job, to arrange collection and to export bulk quantities of seed of identified populations that might be in demand. They would also be prepared to make available seed from provenance trials or conservation stands established as part of this Project.

10.9 SEED STORAGE AND HANDLING

Seed of all Acacia and Prosopis species is subject to damage by Bruchid larvae and related insects which lay their eggs on the pods. Severe damage will result if untreated seed is stored at room temperature for extended periods. Experience has shown that damage can be minimized by early collection, immediate dusting with insecticides and adequate cold storage.

Some of the countries have good facilities and are well equipped to handle, store and test seed, others are not. In these latter cases financial assistance should be given for the purchase of refrigerated seed storage facilities

A review of the literature on seed insects, with derived guidelines for seed handling, would assist all concerned in this matter.

Each institute visited is prepared to distribute the seed which it agrees to collect. However, there may be difficulties in some cases over the question of fumigation and issue of phytosanitary certificates. For example, in P.D.R. Yemen there is no facility either to fumigate or issue certificates, and seed from that country is unlikely to be acceptable elswhere in an untreated condition. Alternative solutions are to have treatment done in another country, or for importing countries to accept untreated seed without phytosanitary certification and inspect and treat it on arrival.

The need for special arrangements to handle seed of Azadirachta indica (the viability of which is short lived) is discussed in Chapter 4.

10.10 COORDINATION, PLANNING AND COMMUNICATION

Relatively intensive coordination will be required at the regional level to ensure that progress of work under the Project is in phase with plans, that seed exchanges proceed smoothly, that the implications of unavoidable or necessary deviations are fully provided for and, later, that assessments are carried out in each country in a standard manner.

The successful implementation of the recommendations made in the preceding sections of this Chapter can only be achieved by means of a coordinated project including the eight participating countries - to be regionalized if and when warranted. This will require the appointment of a full-time FAO/IBPGR coordinator, based initially in Rome with adequate supporting staff, and funds for travel, for a period of 2½ years (6 months preparatory work plus two years of operations).

The functions of the coordinator would be as follows:

(i) Prepare plan of operations of the project, based on the recommendations of the present report.

(ii) Incorporate in the plan (a) arrangements made for botanical determinations; (b) design, assessment and analyses of evaluation trials; (c) investigation of seed production and seed pest problems.

(iii) Distribute the plan to participating countries with a request that they prepare detailed operational plans for their own particular use.

(iv) Visit the countries for detailed review and confirmation of plans with country coordinator and other officials; confirm procedures to be adopted for species identification.

(v) Develop detailed, agreed common evaluation procedures.

(vi) Coordinate exchanges of seed.

(vii) Make visits to selected countries at various phases, e.g. nursery, site preparation, planting, tending.

(viii) Discuss with participants needs for later phases of the project and develop plans accordingly. Investigate possibilities of stimulating similar operations in additional countries.

(ix) On a continuing basis, provide participants with information and advice pertinent to the project.

(x) Formulate methods of testing the genetic materials in operational use and also for measuring the benefits (values) they produce.

(xi) Administer the funds of the project and monitor the use to which they are put.

(xii) Administer the training aspects of the project (exchange of visits, ad hoc "on the job" training).

(xiii) Prepare periodic reports on the progress of the project.

10.11 PROJECT FOLLOW-UP

The project now proposed should be regarded as a short-term pilot project. Provided that it can demonstrate that real progress is being made in the improved use and conservation of the genetic resources of a limited number of species in a few selected countries, it should prepare the way for a larger long-term programme in genetic resources of tree species for improvement of rural living. An important part of the duties of the project coordinator will be to stimulate interest in additional countries, to draw up a more comprehensive list of species and areas to be covered in the long-term follow-up project, and to prepare a plan of operations for the latter.

If the scale of activities develops as it should, it will be essential to provide closer and more intensive coordination at the regional level during the long-term project. A regional coordinator for each of the main regions Latin America, Africa and Asia, stationed at a reasonably central point in each region, is likely to be the most efficient means of achieving this.

ANNEX 1

NATURAL DISTRIBUTION OF SPECIES TO BE INCLUDED

Species	Distribution
Acacia albida Del.	Senegal, Gambia, Portuguese Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Dahomey, Nigeria and Cameroon, extending north throughout the drier parts of North Africa into Egypt, Israel, Lebanon and Cyprus, and from East Africa (Tanzania, Kenya, Uganda), to Zambia, Transvaal and Natal.
Acacia nilotica (L.)Willd.ex Del.	(including 3 varieties) extends from tropical and sub-tropical West Africa (Senegal, Gambia, Ivory Coast, Ghana, Togo, Dahomey, Nigeria, Cameroon) East Africa (Tanzania, Kenya, Uganda), and North Africa (the Sahel, Egypt) through eastern Sudan and Arabia as far eastwards as India.
Acacia senegal (L.) Willd.	(including 2 varieties), characteristic of the drier parts of Somalia, Ethiopia, the Sudan and Chad through to Mauritania, extending west to Senegal, Gambia, Ivory Coast, Ghana, Togo, Dahomey, Nigeria and Cameroon, east to Tanzania, Kenya and Uganda.
Prosopis cineraria (L.) Druce (syn. P. spicigera L.)	India, Pakistan, Iran, Arabian peninsula.
Prospis alba Gris.	(including one variety), extends from the plains of subtropical Argentina to Uruguay, Paraguay, southern Bolivia and Peru.
Prosopis chilensis (Molina) Stuntz	(including 2 varieties), from Peru and Bolivia to Central Chile and north-western Argentina.
Prosopis juliflora (Swartz) DC	(including 2 varieties), from the coastal regions of Venezuela, Colombia and Panama, through Central America to Mexico, as well as in the Antillean Islands (perhaps introduced).
Prosopis nigra(Gris.)Hieronymus	(including 2 varieties), occurs in southern Bolivia, the Gran Chaco of Argentina, Paraguay and western Uruguay.
Prosopis tamarugo F. Philippi	arid mesetas in the northern provinces of Chile
Eucalyptus camaldulensis Dehnh.	a large part of inland Australia, with great climatic and genetic variation.
Eucalyptus microtheca F.Muell.	a large part of central and northern Australia with a separated occurrence on the west coast.
Acacia aneura F. Muell.	inland arid Australia.
Azadirachta indica Juss.	Burma, India (Siwalik Hills; Carnatic region; parts of the Deccan, south of the river Godavari).

NOTE:- A limited number of additional species within the same distribution areas as the above could be considered for the presently proposed phase of the Project, e.g. Acacia tortilis.

ANNEX 2 - SENEGAL

2.1 FORESTRY IN SENEGAL

1. Forest Policy

Following the recent severe drought of 1969/72 in the Sahel, the afforestation policy of Senegal has evolved into three principal elements the trends of which were already emerging:

(i) On better forest sites, priority to be accorded to quick-growing exotic species for the production of firewood and industrial roundwood.

(ii) Regeneration of the soil and rehabilitation of the degraded areas in the groundnut basin in Central Senegal, mainly through planting Acacia albida around those silted-up farmlands where water is available.

(iii) Development of village plantations outside the main forest area.

The current status of progress in each of these spheres is as follows.

2. Quick-growing Exotic Species

In the Sudano-Guinean zone where rainfall is abundant (900 to 1 500 mm/annum) and where the rainy season is fairly long, afforestation with teak, Gmelina, Cassia and Eucalyptus has been carried out. E. camaldulensis is by far the most widely used species but the results obtained so far are not encouraging due to the following factors:

(i) overestimation of production possibilities (this is not peculiar to Senegal);

(ii) insufficient knowledge of the ecology of Eucalyptus and the sites where adequate production could be assured;

(iii) inadequate tending;

(iv) risk of degeneration and premature ageing of the rootstock.

The techniques used for plantation establishment are straightforward. Production nurseries are at the disposal of CNRF and the M'Bidi research station where the necessary quantities of seedlings can be raised. The experimental plantation sites are generally situated between 2 and 3 km from the nurseries. The prescribed method currently in use for site preparation is clearing of tree stumps followed by sub-soiling and ploughing in two directions at right angles.

Weeding and maintenance work is done on the sites as soon as the seedlings have started to grow again. Generally, this is manual work performed by a number of workers which varies according to the size of the site. Protection is ensured by a barbed-wire fence with solid wooden posts made by the workers.

All Senegalese foresters and their assistants have full mastery of all the techniques of plantation establishment, but a major problem is the lack of funds leading to inadequate tending during the period of establishment. This problem is associated with plantations under State supervision. Plantations carried out under bilateral aid or other agencies with a flexible budget do not experience this problem. The survival rate in plantations generally exceeds 95%.

3. Regeneration of the Soil and Rehabilitation of Degraded Areas

This is by far the most important problem in view of the size of the areas to be rehabilitated and the absence of technical advice on plantation establishment. This rehabilitation relates to the whole forest grazing area, the groundnut Basin and the Grande Côte (Niayes) area stretching from Dakar to Saint-Louis and covering about 40 000 ha.

The rehabilitation of these mostly arid zones implies the choice and use of multi-purpose species (soil enrichment, fodder, firewood and food gathering products, gum arabic, edible fruit, etc.). The species concerned are first and foremost local acacias: A. senegal, A. albida, A. nilotica (incl. A. nilotica var. adansonii), A. raddiana; various Prosopis species: P. juliflora, P. cineraria, P. africana, P. nigra; and other species associated with agriculture such as: Solerocarya birrea, Pterocarpus erinaceus, Anogeissus leiocarpus and Tamarindus indica; plus Borassus aethiopum, Grevia bicolor, Combretum aculeatum and Crataeva adansonii.

The impacts of research concern the whole range of activities from the selection of the stands, propagation and the determination of nursery production techniques, to the distribution of the selected seed.

The National Centre for Forest Research is not yet equipped for setting up such a research programme. The first attempts carried out to date have involved essentially elimination tests using both local and Australian acacias (A. holosericea, A. timida and A. aneura).

4. Development of Village Plantations

Since the drought the Department of Water and Forests and other authorities responsible for rural development have encouraged farmers to plant trees on their concessions, often within the framework of Arbor Day celebrations. Government policy has as its aim the integration of village afforestation in the rural development programme. The village planting has ceased to be a symbolic and relatively ineffective operation and is becoming a better defined operation, involving several elements such as large-scale production of seedlings of local and exotic species. This demand is at present oriented towards local species (A. senegal, A. albida) and certain exotic genera, Eucalyptus and Azadirachta in particular. Above all the impact on research activities is the production of seeds: harvesting-processing and distribution.

Seed requirements are going to increase considerably in order to meet present demand. Development companies such as SODEVA are distributing seeds to the farmers.

In the face of these needs, it is realized that the CNRF should not lose sight of the supply control problems; the proper handling of these will certainly represent an enormous progress from the point of view of an improvement in resources, perhaps of the same scale as that which might be obtained in the following stage, that is to say the production of highly selected seeds.

2.2 CLIMATE AND SOIL INFORMATION FOR THE SAHELIAN ZONE IN SENEGAL

1. Climate

Most of the land area of Senegal is a flat plain - a western segment of the broad savannah that extends across the continent at the southern edge of the Sahara. It lies between 12° and 17° north latitude. The climate is characterized by high temperatures with annual rainfall almost entirely limited to a summer wet season which lasts six months in the south and decreases to three months in the north.

The country can be divided into three parallel ecological zones or bands running in an east-west direction across the country. In the north, there are the fibrous grasses and thorn scrub of the Sahelian zone shading into grasslands in the central band marked by shrubs and scattered trees and mixed sub-tropical forests in the extreme south. The contrasts between these three ecological zones are primarily functions of climate and availability of surface and sub-surface water supplies. To the west, bordering the Atlantic Ocean and running in a north-south direction, is the coastal belt of dunes and swampy areas extending inland as much as 25 kilometres.

The sub-arid or Sahelian zone occupies much of the northern part of the country lying between a line drawn east from Dakar, corresponding with the 600 mm isohyet, and the Senegal river to the north on the border with Mauritania. It is important to note that this 600 mm isohyet is the mean for the period 1931-60. In 1972 this isohyet had slipped south by 2° latitude incorporating an extra 245 000 km2, approximately in 1972 as compared with the zone as defined by the long term rainfall mean.

The Sahelian zone is characterized by having an annual rainfall of 200 to 600 mm. The zone is often divided into two parts, with a mean annual rainfall of 200 to 350 or 400 mm and from 350 or 400 to 600 mm respectively. A rainfall of 350 or 400 mm indicates the limit, more or less of dry farming. There is a long dry season (eight to nine months) and the general appearance is of steppe land with trees or shrubs. It is a zone whose main occupation is pastoral with its agriculture mainly devoted to cereal crops. Both these forms of production are particularly subject to climatic hazards.

The Sahel-Sudan Climate is the characteristic type of the Sahelian zone in Senegal but towards the west it is modified by the influence of the Atlantic Ocean. This variant is known as the Sahel-Senegal Climate. Both are described below.

The climate classification most commonly used in French-speaking Africa is the one established by Aubréville and discussed by him in particular in the texts of Climates, Forêts et Désertification de l'Afrique Tropical (Aubréville, 1949) and Flore Forestière Soudano-Guinéenne (Aubréville, 1950). These climates are described only schematically in Tree Planting Practices in African Savannas (FAO, 1974).

The principal climatic factor is rainfall and, in particular, the duration of the dry season and of the true rainy season. This factor is represented by an "index of rainy seasons" or rainfall index which covers three sets of figures:

a) the first gives the number of very rainy months ($\geq$100 mm);

b) the third gives the number of ecologically dry months ($<$ 30 mm);

c) the second, usually the smallest, is that for the intermediary months, neither dry nor wet.

This rainfall index supplements the information on rainfall, i.e. the average annual rainfall expressed in mm.

The next most important factor after rainfall is the saturation deficit and its fluctuation over the year. Unfortunately only very few weather stations record atmospheric hygrometric measurements.

Finally, average temperatures, whether annual or monthly, are of only secondary significance in making climatic divisions within the geographic area in question.

Sahel-Sudan Climate

This is a characteristic type of climate in Africa. It occurs in a long strip roughly paralleling the equator from Senegal to the mountains of Ethiopia. It is definitely continental and does not reach the seas. On the west, the Sahel-Sudan gives way to maritime climates that may be considered as variants (e.g. the Sahel climate of Senegal).

The area stretches 3 to 4°, its limits being slightly inclined on the parallels with its northern limit in Senegal at 16° N latitude and at the Nile, 12° or 13° N latitude.

Temperature

Average annual temperature: 26° to 31.5°
Average maximum monthly temperature: 30.5° to 36.5°
Average minimum monthly temperature: 24° to 28.2°

Minima: in January and August
Absolute maximum: in April/May
Relative maximum: in October

Rainfall

Rainfall index: 400 to 1 200 mm, almost always less than 1 000 mm
Rainy season: short to very short with 2 to 4 very rainy months; maximum in August
Dry season: severe with 6 to 8 dry months, more rarely 5
Rainy season index:

2 - 2 - 8	3 - 2 - 7	3 - 3 - 6
3 - 1 - 8	4 - 1 - 7	4 - 2 - 6
2 - 3 - 7	2 - 4 - 6	4 - 3 - 5

The prevailing wind is from the north-east, the dry, dusty harmathan from the Central Sahara with its severe desiccating effect.

Sahel-Sudan Climate

This is a transition climate between the marine trade winds climate of the coast of Senegal and the Sahel-Sudan continental climate. It should not be confused with the Sahel-Senegal coastal climate which prevails only on the north/south narrow coastal strip of Senegal.

Temperature

The termperature regime is similar to the Sahel-Sudan.

Average annual temperature: 26.5° to 28.3°
Average maximum monthly temperature: 29° to 32°
Average minimum monthly temperature: 23° to 23.8°

Rainfall

Rainfall index: 500 to 900 mm
Rainy season: short, running June to October with three very rainy months
Rainy season index: 3 - 2 - 7

2. Soils

Most of Senegal is an ancient sedimentary basin, a gently undulating plain with its former ridges long since levelled by the processes of erosion and its valleys and depressions filled with alluvium and windblown sand. With few exceptions elevation is below 100 m and the rivers are sluggish and marsh-lined.

Exclusive of the weakly developed soils on young alluvium along the banks of the Senegal river, there are two major soil types in the northern and central part of the country. These are the brown-red isohumic soils of the arid tropics lying in a belt from west to east along the southern flank of the Sahara and a parallel belt of ferrugenous (fersialitic) soils lying immediately adjacent to the south occupying the northern central part of the country. These two bands of soil more or less coincide with the two ecological zones of the north and central parts of the country.

Isohumic soils - These soils have developed under semi-arid conditions in a steppe-like environment with sparse vegetation. They are characterized by having a high level of iron sesquioxides due to high soil temperatures prevailing during the short rainy season, thereby allowing only a thin layer of organic matter to accumulate. Two main soil types have been recognized in Senegal in the northern areas where annual rainfall is less than 500 mm. These are the brown-red and the brown soils, the former occupying by far the larger area.

The brown-red soils can reach 2 metres in depth with a humic upper layer of 20 to 25 cm, of colour grey-brown to brown and a characteristic red lower profile of at least 1 metre. The structure is weakly or poorly developed, tending to nutty with 80 to 85% iron content. The organic matter content is less than 0.5% and the C/N ratio does not exceed 8. Only weak leaching occurs, the pH is neutral or weakly acid. These soils formed on sands are very poor with less than 5% clay and poor water holding capacity. They are fragile and easily transported by wind. The Acacia - Zaddiana association is the type vegetation of the red-brown soils.

The brown soils have a depth of less than 1 metre with a good surface structure foliated in the first few centimetres but lumpy at depth. Organic matter content is less than 1% and well distributed throughout all horizons. The C/N ratio is less than 10. Iron comprises 70 to 75%, the colour always masked by the organic material. The pH is neutral to basic. These soils usually develop on calcium rich material or in depressions. Their texture is heavier than the red-brown soils and their mineral reserves are greater. Drainage is somewhat restricted. These soils are generally cultivated for millet and sorghum and the typical tree species are Acacia seyal, A. nilotica var. adansonii and Balanites aegyptiaca, but often these have been eliminated by the farmers. Frequently, agricultural exploitation has led to rapid soil degradation and subsequent invasion by Guiera senegalensis.

The other main group of soils are the ferruginous soils, the particular type lying south of the aforementioned red-brown soils being the tropical non-leached variety. They are typified by their vivid red colour, almost horizontal lines of accumulated materials and occasionally staining and concretions. They are known in Senegal as "diors" and are found between the 500 and 700 mm isohyets. The type found on the siliceous sands have a clay content of 2 to 6%. The top layer of 20 to 30 cm is sandy and of a grey-beige or grey colour, loose in texture, less than 0.5% of organic material. Below this layer the soil is heavier with more clay, red in colour and at depths beyond 1 metre the sand has a rosy tint. Grey humic, white and red types of "diors" are recognized. These soils are of low fertility with low levels of phosphorous. They are strongly acid with pH of 2 to 2.5 and their water holding capacity

is less than 6% at the surface and about 10% at depth. They are susceptible to wind erosion during the long dry season and to erosion by water during the summer. They have been used exclusively for growing peanuts and often Acacia albida is the sole tree species there with occasionally Tamarindus indica or Parkia biglobosa grown by the farmers for their fruits. Because of poor husbandry, many areas are becoming sterile and invaded by Guiera senegalensis. It will be possible to grow Acacia albida in these areas for the purpose of soil amelioration.

Reference:

FAO (1977) Savanna afforestation in Africa. FAO/DANIDA. FAO Forestry Paper No. 11, Rome.

Giffard, P.L. (1974) L'arbre dans le paysage Senegalais. Centre Technique Forestier Tropical, Dakar.

2.3 MAJOR VEGETATION TYPES OF THE SAHELIAN ZONE IN SENEGAL

The general impression of the Sahelian zone is of steppe with shrubs or trees, i.e. with a herbaceous layer which is short, not very dense, and mainly composed of annuals, dominated by more or less tall shrubs, of the genera Combretum and Acacia. In fact, the vegetation cover varies according to the climate and the soil type.

As regards the shrubs, Pterocarpus lucens and Combretum micranthum are dominant on skeletal and concretionary soils. These are associated with Acacia senegal, although this species also occurs along with A. seyal, A. raddiana and A. nilotica on alluvial areas. The sandy formations (frequently the ancient and recent ergs) are characterized by Combretum glutinosum and Guiera senegalensis. Balanites aegyptiaca is a shrub which occurs throughout the zone. Commiphora africana is especially abundant on sandy soils and Ziziphus mauritiana on finer textured soils. Bombax costatum and Adansonia digitata are trees with bigger leaves, which appear where the rainfall is more favourable, as do also Sclerocarya birrea, Sterculia setigera and Piliostigma sp., although the last three extend northwards under fairly dry conditions. Lannea microcarpa and Anogeissus leiocarpus are characteristic of more forest-like microclimates, whereas Tamarindus indica, Khaya senegalensis, Grewia spp. and Dalbergia melanoxylon are usually found along or near to the water courses, either seasonal or permanent. On the levees of the Niger delta there are stands of Hyphaene thebaica (doum palm) and Borassus aethiopum. Acacia albida often seems to be associated with human occupation and fallowing.

On the dry soils the grasses are predominantly annuals except for Andropogon gayanus which is associated with more favourable climates or edaphic conditions, and which in fact belongs to the Sudanese zone. Species of the genus Aristida are well represented and are important constituents of the Sahelian pasture. Schoenefeldia gracilis, Cenchrus biflorus ("cram-cram"), Ctenium elegans, Eragrostis tremula, Dactyloctenium aegyptium and Diheteropogon hagerupii are also abundant. Two leguminous annuals which provide some transient pasture during the rainy season are Alysicarpus ovalifolius and Zornia glochidiata. The wetter soils are occupied by Paspalum orbiculare, Acroceras amplectens, Cynodondactylon spp., Panicum laetum and Brachiaria cuspidata.

The soils which are inundated for moderate lengths of time are taken over by Vetiveria nigritana, those which are inundated for longer periods by the tall stems of Echinochloa pyramidalis and E. stagnina ("bourgou"), along with the wild rice, Oryza longistaminata, and Vossia cuspidata.

The annual grasses are also used to supplement the diet of the Sahelian peoples in time of famine. The seed of Panicum laetum, Echinochloa spp. and Cenchrus biflorus are so used, in the form of couscous.

People also eat the flowers, fruits, leaves or terminal buds of some Sahelian trees - Adansonia digitata, Boscia senegalensis, Balanites aegyptiaca, Ziziphus mauritiana, Hyphaene thebaica, etc. Acacia senegal is an important commercial source of gum.

The shrubs also have a part to play in the pastoral economy because of the browse they furnish to the livestock. They add to the forage and supply supplementary proteins and minerals. This is true especially of the dry season, when the herbaceous cover is short in phosphorous and nitrogen. The browse often consists of pods, or of leaves which have fallen on the ground or are eaten straight off the tree. Among the shrubs which are most important in this connection, we may note:

- For the leaves: Pterocarpus lucens, Combretum ghazalense, Boscia senegalensis, Khaya senegalensis, Balanites aegyptiaca, Commiphora africana, Guiera senegalensis and Acacia nilotica.
- For both pods and leaves: Acacia seyal, A. albida, A. raddiana, A. senegal and Piliostigma spp.

Reference:

FAO (1974) — A survey of the problem of the Sahelian Zone with a view to drawing up a long term strategy and a programme for protection, restoration and development. FAO/SWE/TF 117, Rome.

ANNEX 3 - SUDAN

3.1 PRIORITY SPECIES: SUDAN

Species	Characteristics and uses									Priority
	Fuel	Fodder		Shade, Shelter	Timber, poles	Coppices	Soil improver	Tolerant of saline soils	Drought tolerant	
		Pods	Foliage							
Indigenous										
Acacia tortilis Hayne	X	X	X			X	X		X	1
Exotic										
Eucalyptus camaldulensis Dehn.	X			X	X	X			X	1
E. microtheca F. Muell.	X			X	X	X			X	1
Prosopis cineraria (L.) Druce	X	X	X			X	X		X	1
P. alba Gris	X	X		X			X			1
P. chilensis (Molina) Stunts	X	X		X		X	X		X	1
P. juliflora (Swarts) DC.	X	X		X		X	X		X	1
P. nigra (Gris.) Hieronymus	X	X		X			X			1
P. tamarugo F. Philippi	X	X	X	X	X	X	X	X	X	1

N.B. This list excludes A. nilotica of which Sudan would collect seed of three subspecies to meet needs of the project in other cooperating countries.

3.2 PROVENANCE COLLECTIONS TO BE MADE IN SUDAN

(i) *Acacia tortilis* Hayne

Distribution, climate and soil: Subsp. *raddiana* (Savi) Brenan occurs in semi-desert areas in northern, central and eastern Sudan on the banks of wadis and sites receiving large amounts of run-off water. Areas of occurrence include Kordofan sands (rainfall 200 - 400mm), on detritus slopes round the bases of hills in 500 - 600mm rainfall areas, and on eroded clays fringing the Atbara and Blue Nile rivers (450 mm rainfall) (Sahni, 1968). Subsp. *spirocarpa* (Hochst.ex A. Rich) Brenan is almost as widespread although it occurs on drier sites; subsp. *tortilis* Brenan is the typical desert or semi-desert form growing on sandy, loamy soils, near rivers and valleys in the north and centre but more particularly in the east of the country. The species is dominant among those of the *Acacia tortilis* - *Maerua* desert scrub sub-division of Harrison and Jackson's Semi-desert vegetation type (Harrison and Jackson, 1958; El Amin, 1973). For further (generalised) information on climate and soil see Annex 3.4.
Genecological variation: Of the three subspecies, *raddiana* is typically a single-stemmed tree 7 - 21 m high with rough bark, irregular crown and glabrous twigs and fruits; *spirocarpa*, 4 - 7 m high, is a multi-stemmed tree or large shrub with smooth grey bark, umbrella-shaped crown and tomentose branchlets and fruits, while *tortilis*, 1 - 4 m high, is similar to the latter but is of smaller stature.
Seeding season: subsp. *raddiana*: March
subspp. *spirocarpa* and *tortilis*: April to June or July.
Current planting: Only in arboreta.
Proposed collection areas: Subspp. *raddiana* and *spirocarpa*: west of Nile near Kartoum
Subsp. *tortilis*: Sinkat
Typical examples of the three forms occur in these areas.

N.B. It would sharpen comparisons between the three subspecies if a collection of subsp. *tortilis* were included from the area west of Khartoum where the other two will be collected.

(ii) *Acacia nilotica* (L). Willd. ex Del.

Distribution: Over much of their range the subspp. *nilotica* Brenan and *tomentosa* (Benth.) Brenan are associated together in permanent water courses along the Nile. The former is more prevalent along the White Nile and the latter in the Blue Nile area, the best forests of it occurring along the river south of Sennar. Subsp. *tomentosa* occurs along the Nile as far north as Aswan Dam and formerly extended into Egypt. Both these subspecies occur in areas that are inundated for three, four or more months a year.
Subsp. *astringens* Roberty (syn. subsp. *adansonii* Brenan) occurs along seasonal water courses in western parts of Central Sudan, in Darfur Province and Kordofan, e.g. in the vicinities of El Obeid and Er Rahad (Sahni 1968; El Amin, 1973).
Climate and soil: See Annex 3.4.

Genecological variation: Apart from the foregoing differences in distribution which suggest variation in important ecological characteristics, the three subspecies vary botanically. Subspp. nilotica and tomentosa both have necklace-like pods, the margins of which are narrowly constricted between seeds. The pods of the former are glabrous, those of the latter tomentose. In subsp. astringens the margins of the pods are crenate, not constricted (El Amin, 1973).
Three forests of subsp. tomentosa along the Blue Nile south of Sennar have been selected on the basis of good growth and high log and fuel volume production as seed sources for plantations.
Seeding season: March-June.
Seed weight: 8000 seeds per kg. for subsp. tomentosa.
Important uses: Subsp. tomentosa logs are the basis of a flourishing milling industry. This subspecies and nilotica provide important quantities of fuel for brick-making and domestic use, hard and durable wood for railway ties, structural wood, flooring, tool handles, furniture, doors and windows. In the round the wood is used for transmission poles, fence posts and pit props. The pods and bark are used for tanning. Subsp. astringens also provides good tanning material.
Current planting: Subsp. tomentosa is widely planted.
Proposed collection areas: Subspp. nilotica: Wad Nimr and another area to be identified
tomentosa: Singa* and another area to be identified
astringens: Er Rahad and another area to be identified.
For ecological features of these places, see Annex 3.4

In addition to the above species, suggestions have been made from India to include in the programme two Sudanese species, Terminalia brownei and Prosopis africana (the natural range of a third species mentioned, Conocarpus lancifolius, does not extend from Somalia into Sudan.) Although these two species are not considered arid or semi-arid species in their native habitats, Sudan is willing to cooperate in collecting seed of them, if considered desirable.

*i.e. one of the seed source stands mentioned under Genecological variation above.

3.3 EVALUATION IN SUDAN: SOURCES AND TEST SITES

Species	Sources	Test Locations		
		Wad Medani	Kennana Agr. Res.Station, Abu Naama, nr.Wad en Nail	Green Belt, Soba
E. camaldulensis	3 Australian	X	X	X
E. microtheca	3 Australian	X	X	X
A. tortilis	3 Local			X
	4 Yemen			
	1 India (ex Israel)			
Prosopis species	all available	As arranged under IIRC project: (i) On west bank of White Nile opposite El Getaine (ii) El Obeid (iii) El Beshiri (iv) El Wus		

In addition to the above priority species, Dr. Bayoumi, Director of Forests Administration, suggested that Gmelina arborea might be considered for attention under later phases of the Project; as evidenced by work he had seen in Nigeria, certain provenances of it were suited to special sites, in dry areas, e.g. river banks. It may be noted here that the collections of this species made in India in 1976 for international provenance studies (Lauridsen, 1977) were not exhaustive in covering the species range. The insufficient coverage was mainly due to the extremely poor and irregular seed crop generally found in the drier parts of the species' range. Renewed attempts will, however, be made to complement the earlier collections.

Other species suggested for evaluation by senior officers of the Forest Administration were gum-producing Sterculia spp. and Dalbergia sissoo.

3.4 SOIL AND CLIMATE INFORMATION FOR SUDAN

Map 1 (Annex 3.5) shows isohyets and generalised vegetation types that correspond to those of Harrison and Jackson (1958). Map 2 (Annex 3.6) shows generalised soil types which, with the alternative names added between brackets, correspond with those of Harrison and Jackson (Ibid).

Rainfall amounts vary from year to year and the averages indicated on Map 1 should not be regarded as exact.

The following summary classifications of soils and vegetation are based on Harrison and Jackson's account (Ibid).

(a) SOILS

(i) Desert and semi-desert soils: In northern Sudan. Rainfall less than 200 mm. Produced under desert erosion conditions. They include skeletal soils of desert mountains, gravel pavements, hard non-cracking clay flats and windblown sands.

(ii) Stabilised dune sand: Large areas in west and central Sudan. Dunes stabilised by vegetation when relatively moist conditions prevailed. Their stability is destroyed by over-grazing. High sand fraction; low in mineral nutrients. High permeability and relatively high availability of water during the dry season.

(iii) Dark cracking clays (including the flood plains region):
These "cotton" soils occur in flat, uniform plains. Clay content 60% or more; alkaline with pH about 9. Gypsum and calcium carbonate crystals and concretions occur. They shrink and crack on drying. During the rains the cracks fill with water and the soils quickly become impermeable so that run-off and flooding occur. Available water is soon used up in the dry season and the soils become physiologically very dry so that they carry more xerophytic plants than sandy soils under the same rainfall. A dense growth of grasses occurs during the rains. The vegetation is an edaphic rather than climatic type.

(iv) Red loam and ironstone soils: Occur where rainfall exceeds 800 mm, i.e., outside the zones to which this project relates.

(v) Non-cracking clays: Scattered in many localities. Total area small. Surface hard, impermeable. Vegetation sparse.

(vi) Various hill soils. A miscellaneous group.

(b) VEGETATION

(i) Semi-desert
Sub-divisions include: *Acacia tortilis* - *Maerua* desert scrub
A. mellifera - *Commiphora* desert scrub
A. glaucophylla - *A. etbaica* scrub
Semi-desert grassland on sand

(ii) Woodland Savanna

A. Low rainfall
On clay: subdivisions include* *A. mellifera* thornland
* *A. seyal* - *Balanites* savanna
On sand: sub-divisions include *A. senegal* savanna

B. High rainfall: Savanna woodland and woodland recently derived from rain forest. These types and the Flood Region and Montane types are not relevant to this Project.
* Sometimes alternating with grassland.

The places mentioned in the text and Annexes of the Sudan section of this report are all shown on Map 1. They relate to the foregoing summary ecological descriptions as follows.

(1) Soba, El Getaine and Sinkat

Rainfall 75 - 300 mm (160 at Soba), variable, unreliable; July-August. Desert soils occur on hard surfaced off- and on-flow sites and are often covered by wind-blown sand. They are alkaline and, near Khartoum, often saline.
A. tortilis - Maerua desert scrub. A. tortilis is scattered but tends to be concentrated along drainage lines.

(2) Wad Nimr

Rainfall 75-300 mm. Semi-desert. On borders of A. tortilis - Maerua desert scrub and A. mellifera - Commiphora desert scrub.

(3) El Wuz

Rainfall 75-300 mm. Semi-desert grassland on sand. Few trees occur but A. tortilis subsp. raddiana, A. mellifera and Commiphora spp. occur along drainage lines and hollows.

(4) El Obeid, El Beshiri and Er Rahad

Rainfall 280-450 mm. Stabilized sand dunes. Low rainfall woodland savanna on sand. A. senegal savanna. Occasional wild fires.

(5) Wad en Nail

Rainfall 300-600 mm. Dark cracking clay. Low rainfall woodland savanna on clay; A. seyal - Balanites savanna alternating with grass areas which support occasional wild fires. A. mellifera an important tree/scrub species.

(6) Singa

Rainfall 300-600 mm. Cracking clay. Low rainfall woodland savanna on clay.
A. mellifera thornland.

(7) Wad Medani

Rainfall 75-300 mm. Soil is dark cracking clay. Natural vegetation is semi-desert grassland on clay. Almost treeless; A. mellifera and A. nubica are the only tree species present.

3.5 ITINERARY AND LIST OF PERSONS CONSULTED IN SUDAN

1. ITINERARY

1979

July 4: Late pm. arrived Khartoum from Aden.

5: Meeting with Dr. A.A. Bayoumi, Director, Forests Administration, and Ahmed El Houri Ahmed, Head, Forest Research Institute. Visit to FRI and short tour of station.

6: Muslim holiday.

7: Tour of Khartoum Greenbelt irrigated plantations.
Consultations at FRI with A. El Houri Ahmed, Head.

8: Meeting with Dr. Bayoumi and senior officers of Forests Administration.
Further consultations with A. El Houri Ahmed, Head, FRI.

9: To Rome by air.

2. PERSONS CONSULTED

A.A.K. Soghaier, Country Representative, FAO, Khartoum.

Mr. D. Fortes, Programme Officer, FAO, Khartoum.

Ahmed el Houri Ahmed, Head, FRI, Soba.

H.A. Musuad, Research Officer, Arid Zone, FRI, Soba.

Senior Officers of Sudan Forests Administration:-

Dr. Abdel Aziz Bayoumi, Director of Forests, Khartoum

Karnal Hassan Badi, Deputy Director of Forests

Mohammed Hanaji Obeid, Conservator of Forests, Blue Nile and Chief, Agricultural Forestry Sector

Mohamed el Amin Mukhtar, Chief Utilization Officer

Haq Mekki Awouda, Chief, Gum Arabic Sector

Ali Ahmed Saleem, Chief, Shelterbelt Sector

Ibrahim Said, Conservator of Forests, Greenbelt, Khartoum

Haydar Mustafa, Ranger i/c Western Section, Greenbelt, Khartoum.

ANNEX 3.6

LITERATURE CONSULTED AND CITED

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ANNEX 4 - INDIA

4.1 PRIORITY OF SPECIES: INDIA

Species	Uses								Characteristics				
	Fuel	Fodder		Shade, Shelter	Timber, poles	Tannin	Gum	Oil seed	Coppice	Soil improver	Saline soils	Drought tolerant	Priority
		Pods	Foliage										
Indigenous													
Acacia nilotica (L.) Willd. ex Del. ssp. indica Brenan	X	X	X		X	X	X			X		X	1
A. senegal (L.) Willd.	X	X	X				X						1
Prosopis cineraria (L.) Druce	X	X	X						X	X		X	1
Albizia lebbek	X			X	X				X	X		X	2
Pongamia pinnata Pierre	X			X					X				2
Azadirachta indica Juss.	X		X	X	X			X			X	X	2
Exotic													
(a) immediately available:													
Eucalyptus camaldulensis Dehnh.	X			X	X				X			X	1
E. microtheca F. Muell.	X			X	X				X				1
Acacia aneura F. Muell.	X		X						X	X		X	1
(b) Seed to be collected and distributed													
1/ Acacia tortilis	X	X	X				X		X	X		X	1
2/ A. senegal (L.) Willd.	X	X	X			X	X			X		X	1
A. albida Del.	X	X	X	X	X					X			1
2/ A. nilotica (L.) Willd. ex Del.	X	X	X		X	X	X			X		X	1
Prosopis juliflora (Swartz) DC	X	X		X			X		X	X		X	2
P. tamarugo F. Phillipi	X	X	X	X					X	X	X	X	1

1/ A naturalised exotic in India, introduced from Israel in 1958

2/ Species which extend into India and also shown in indigenous list.

ANNEX 4.1 (cont.)

Species	Uses								Characteristics				
	Fuel	Fodder		Shade, Shelter	Timber, Poles	Tannin	Gum	Oil seed	Coppice	Soil improver	Saline soils	Drought tolerant	Priority
		Pods	Foliage										
Prosopis alba Gris)													2
P. chilensis (Molina) Stunts)		n	o	t	k	h	o	w	n				1
P. nigra (Gris) Hieronymus)													2
2/P. cineraria (L.) Druce	X	X	X						X	X		X	1
Leucaena leucocephala	X		X		X		X		X	X			1
Gleditsia triacanthos	X		X						X	X			3
Bursera penicillata	X			X									3
Conocarpus lancifolius	X		X	X									3
Terminalia brownei Fresen													3
Eucalyptus terminalis	X			X	X				X				2
E. tessellaris	X			X	X				X				2
E. melanophloia	X			X	X				X				2

The three new eucalypts in the list, E. terminalis, E. tesselaris and E. melanphloia, have shown promise in screening trials in dry areas and provenance trials would be desirable.

Three Prosopis species, P. juliflora, P. alba and P. nigra, are accorded second order priority. This is in order to keep the number of species in the first priority group (to be initially handled) within bounds, particularly since two of them comprise several forms. Otherwise it would be desirable to handle all the Prosopis species at the same time.

Species suggested for consideration in the future are:

(i) Indigenous: Hardwickia binata
Kingiodendron pinnatum
Dendrocalamus strictus

(ii) Exotic : *Parthenium argentatum* (C. America)
Geoffroea decorticans (Chile)
Simmondsia chinensis (C. America)
Pittosporum phylliraeoides (Australia)
Colophospermum mopane (Zimbabwe)
Acacia ligulata (Australia)
A. victoriae (Australia)
A. nubica (Tropical Africa)
A. seyal (Tropical Africa)
Prosopis africana (Tropical Africa)
Casuarina spp. from arid areas in Australia

Of the species listed for consideration in the future, *Colophospermum mopane* should be specially noted. A plot of this species of Zimbabwe provenance was seen to be thriving at Jodhpur where it produces seed and regenerates readily. The foliage and twigs are considered in the southern countries of Africa to be forage of high nutritional value, the leaves being much sought after by stock and wildlife even after they have been shed in the autumn.

Dry country *Casuarina* species are of some interest. However, they have fare disappointingly in trials in several arid and semi-arid areas, e.g. in Rajasthan. The question has been raised, wether the possible scarcity of necessary root symbionts may at least partly explain the poor results obtained. This possibility should be examined if further trials of these species are contemplated.

4.2 PROVENANCE COLLECTIONS TO BE MADE IN INDIA

(i) *Acacia nilotica* (L.) Willd. ex Del. Subsp. *indica* Brenan

Distribution, climate and soil: Indigenous in E. Gujerat and Rajasthan, W. Punjab, Haryana and the Deccan. Naturalized in nearly all parts of India. Tolerant of a wide range of soil variation: saline, black cotton, clay and sandy soils. Occurs particularly in riverain alluvium subject to flooding and black cotton soils. Except for var. *jaquemontii* on sand dunes, it does not occur in arid areas. Minimum temperatures in the areas where it occurs vary from -1° - 15°C. **For further environmental information see Annex 4.4.**

Genecological variation: Three distinct forms of the Indian subspecies are recognized, i.e. (i) var. *cupressiformis* with a narrow, erect crown, (ii) var. *vediana* with rounded crown and (iii) var. *jaquemontii*. Ecotypic variation has been studied by Kondas at Tamil Nadu Agricultural University but no results have yet been published. Seed of different origins was distributed in 1978 by FRI to Gujerat and Tamil Nadu for testing. Occurence of *jaquemontii* on sand dunes suggests adaptation of this variety to such sites.

Silvical features: Coppices well in moist areas though not as well as Sudan strains. FRI has succeeded in speeding up early growth of seedlings to get them out of the bushy stage by applying IAA and IBA. The tree is leafless during the rains and flushes when they are over. Seed requires treatment with sulphuric acid for good, even germination. Growth rate in semi-arid areas is fair only.

Seeding season: April-June. Abundant. Repeated coppicing of var. *jaquemontii* may render seed collection difficult locally.

Seed weight: 7 000-11 000 per kg.

Important uses: Important source of gum. High tannin content is of economic importance. Fodder in dry season when other species leafless; however, fodder value is low c.f. *A. tortilis* which is now usually preferred. Var. *jaquemontii* is repeatedly coppiced in desert areas of Rajasthan to produce material for basket making. Thick-barked var. *vediana* is fit only for firewood. The others have strong, tough timber with durable heartwood. A good fuel and hedge species.

Current planting: Fairly widely planted, usually in single rows. Shows promise in semi-arid but not in arid areas.

Proposed collection areas: Subject to distribution of varieties, seed of each will be collected in Gujerat, E. Rajasthan (Pali), NW Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka. It is believed that var. *jaquemontii* might not be available outside the first two of these States. Two collections of this variety should be made in each of them. See Annex 4.4 for generalised environmental information.

(ii) Acacia senegal (L.) Willd.

Distribution, climate and soil: Semi-arid areas of N.W. India: Gujerat, Rajasthan, Punjab, Haryana. In desert areas usually on shallow soil overlying rock or kanka (pebble) pan. For environmental information see Annex 4.4.

Genecological variation: None recorded for India.

Silvical features: Usually a small, poorly formed tree.

Seeding season: February-March; some in August-October.

Seed weight: 7 000 per kg

Important uses: Fuelwood, fodder, gum.

Current planting: There are small, very slow growing plantations in Rajasthan and neighbouring States.

Proposed collection areas: Punjab, Haryana, Gujerat and at Jodhpur and Jaisalmer in Rajasthan.

(iii) Prosopis cineraria (L) Druce (syn. P. spicigera L.)

Distribution, climate and soil: A semi-arid zone species with distribution extending to saline soils of Kutch, Rajasthan and Gujerat; rarer in Punjab, Haryana. Not clear to the author whether it occurs naturally in black cotton soils in the Deccan. See Annex 4.4 for general environmental information.

Genecological variation: None recorded.

Silvical features: Will grow (slowly) where there is a calcareous kanka pan. Repeated pollarding renders seed collection difficult locally.

Seeding season: June - August

Seed weight: 25 000 per kg

Important uses: Heavily pollarded for fodder, fuelwood, timber.

Current planting: In mixed village and farm plantings in Gujerat and Rajasthan.

Proposed collection areas: Jodhpur area in Rajasthan; Kutch in Gujerat; Punjab, Haryana.

(iv) Azadirachta indica Juss.

Distribution, climate and soil: Indigenous in the dry forests of the Deccan and Burma. Now widespread in India where it grows well in frost-free areas. Scattered to fairly common in semi-arid and arid areas. For climate and soil conditions see Annex 4.4

Genecological variation: The species succeeds in dry as well as moist areas. This may indicate genetic variation but it has not yet been adequately tested.

Silvical features: Frost tender. One of the few species that will grow over a calcareous kanka pan. Seed loses viability rapidly after a week. No effective storage technology available.

Seeding season: June - August.

Seed weight: 3 300 per kg.

Important uses: Fair as a fuelwood. Oil from fruits. Oilcake. A useful soil improver.

Current planting: Scattered small plantations. Mainly in strip plantings along forest roads, e.g. Bhuj area of Gujerat.

Proposed collection areas: Wet eastern, moist centre and moist and dry zones in S. India. Pali and Jodhpur in semi-arid and arid areas respectively in Rajasthan.

(v) Albizia lebbek

Distribution: Widely distributed in India, e.g. from Andaman Islands to arid areas of Rajasthan.

Climate and soil: Does well on a wide variety of soils. See Annex 4.4 for general environmental information.

Genecological variation: Implied by distribution but not tested.

Silvical features: Does well in the most unfavourable areas, e.g. high pH soils of Rann of Kutch. Will grow over a calcareous kanka pan.

Seeding season: January - March.

Seed weight: 8 000 - 13 000 per kg.

Important uses: Fuel, timber, fodder.

Current planting: Extensively used, mainly in mixed plantings, all over India.

Proposed collection areas: As for Azadirachta indica but including saline area in Gujerat.

(vi) Pongamia pinnata Pierre

Distribution: Virtually throughout India up to 1 200 m, on sites ranging from stream sides to dry, inhospitable areas.

Climate and soil: See Annex 4.4 for general information.

Genecological variation: Implied by distribution but not tested.

Seeding season: March - May.

Seed weight: 800 - 1 500 per kg.

Important uses: Fuel, fodder, oil from fruit, cordage, medicinal, timber.

Current planting: Widely used as an avenue or shade tree. One of the most dependable species in the drier areas.

Proposed collection sites: As for Azadirachta indica.

(vii) Acacia tortilis

One collection will be made, preferably in Rajasthan, to represent the provenance introduced in 1958 from Israel.

4.3 EVALUATION IN INDIA: SOURCES AND TEST SITES

Species	Sources	Test Sites								Total Sites
		Rajasthan				Gujerat (Kutch)	Haryana (Saraswati)	Punjab (m. Hudhiana)	Maharashtra	
		Pali	Jodhpur	Bikaner	Jaisalmer					
Eucalyptus camaldulensis	3 Australian	X	X			X	X	X	X	6
E. microtheca	3 Australian	X	X			X	X	X	X	6
Acacia aneura	3 Australian	X	X	X		X	X	X		6
A. tortilis (3 sub-species)	1 local (exotic), 4 Yemen, 3 Sudan, any other available		X	X		X	X	X		5
A. senegal	5 India, Yemen, all available African		X	X	X	X	X	X		6
A. albida	any available	X		X		X	X	X	X	6
A. nilotica (all forms)	16 Indian, 6 Sudan, 1 Yemen plus all others available	X	X			X	X	X		5
Prosopis chilensis	All available incl. Sudan "cultivar"	X	X			X	X	X	X	6
P. tamarugo	All available	X	X	X		X	X	X	X	7
P. cineraria	4 India, 2 Yemen		X	X		X	X	X	X	6
Leucaena leucocephala	Any dry zone (Provenances or cultivars)	X	X			X	X	X	X	6

Note: Should additional seed of the above species become available it could be tested in Andhra Pradesh and Karnataka.

4.4 SOIL AND CLIMATE INFORMATION FOR INDIA - CHECK LIST

(The undernoted data is given on the pages following this check list)

1. India: Relief Types (From Jasbir Singh, 1974)
2. India: Soils - generalised classification (Ibid)
3. Soils of Haryana (From Alexander, 1972)
4. Soils of Karnataka (Ibid)
5. Soils of Punjab (Ibid)
6. Soils of Andra Pradesh (Ibid)
7. Soils of Rajasthan (Ibid)
8. Soils of Gujerat (Ibid)
9. India: Average monthly rainfall (for selected stations) (From Jasbir Singh, 1974)
10. India: Average moisture balance patterns (Ibid)
11. Average annual rainfall (From Anon, 1978)
12. - 15. Average annual rainfall, by quarters (Ibid)
16. - 19. Mean daily maximum temperature; Jan, Apr, Jul, Oct (Ibid)
20. - 23. Mean daily minimum temperature: Jan, Apr, Jul, Oct (Ibid)
24. Annual highest maximum temperature (Ibid)
25. Annual lowest minimum temperature (Ibid)
26. Proposed trial and collection sites in Rajasthan: average rainfall
27. Proposed trial and collection sites in Rajasthan: temperature data.
28. Soils of proposed trial and collection sites in Rajasthan.

Note: Maps 11 - 15 based on data for 1901-50
Maps 16 - 23 based on data for 1931-60

4.5 ITINERARY AND LIST OF PERSONS CONSULTED IN INDIA

I. ITINERARY

1979

June 6: New Delhi: Assignment began
Consultations with: R.D.H. Rowe, World Bank Office
Dr B.N. Ganguli, Principal Economist, Office of I.C., Forestry
Travelled to Dehra Dun by tourist taxi

7,8 : Consultations at F.R.I. with J.C. Varma, President; R. C. Ghosh, Director of Forest Research; K.C. Sahni, Director of Forest Biology; G.C. Pande, Pine Specialist; O.N. Kaul, Ecologist; Dr H.P. Bhatnagar, Physiologist.

9: Consultations at Soil Conservation Research Institute with Dr K.G. Tejwani, Director; Gurmel Singh and R.K. Gupta, Division Heads. Returned to New Delhi in evening by taxi.

11: Consultations with Dr B.N. Ganguli; Dr D.G. Gautam, Director-General, Department of Agricultural Research and Education.

12: Arrived Jodhpur by air 9 a.m.

12,13: Consultations at Central Arid Zone Research Institute with Dr H.S. Mann, Director; Dr O.P. Pareek, Head, Division of Plant Studies, K.D. Muthana, Head of Silviculture.

13: Returned to Delhi by air in evening.

14: Consultation with M.K. Dalvi, Additional I.C., Forestry

15: Consultations with S.B. Palit, I.C. Forestry; R.N. Kaul, Joint Commissioner, Soil Conservation (Forestry)

17: To Dehra Dun in pm by FAO car

18: Consultation at FRI with R.C. Ghosh, Director, Forest Research; Return to New Delhi in evening.

19: Consultation with Dr B.N. Ganguli.

20: Consultation with B.P. Srivastava, I.C. Forestry

22,23: Consultations with Y.P. Bali, Joint Commissioner (Soil Conservation)

25: Visit to All India Soils and Land Use Survey and discussions with Dr R.L. Karali, Senior Soil Survey Officer and other scientific staff.

26: Consultation with Dr. Ramanathan, Indian Meteorology Dept.

28: am Meeting with Dr M.S. Swaminathan, Secretary, Dept. of Agriculture and Irrigation; pm departure by air for Bombay.

II. PERSONS CONSULTED

R.D.H. Rowe, World Bank Office, New Delhi

Dr B.N. Ganguli, Principal Economist, Office of F.C. Forestry, New Delhi

J.C. Varma, President, Forest Research Institute (FRI), Dehra Dun

R.C. Ghosh, Director, Forest Research, FRI

K.C. Sahni, Director, Forest Biology, FRI

G.C. Pande, Pine Specialist, FRI

O.N. Kaul, Ecologist, FRI

Dr H.S. Mann, Director, Central Arid Zone Research Institute (CAZRI), Jodhpur

Dr O.P. Pareek, Head, Division of Plant Studies, CAZRI

K.D. Muthana, Junior Silviculturist, CAZRI

B.P. Srivastava, I.G. Forests, New Delhi

M.K. Dalvi, Additional I.G. Forests

S.B. Palit, Deputy I.G. Forests (General)

R.N. Kaul, Joint Commissioner, Soil Conservation (Forestry)

J.S. Bali, Joint Commissioner, Soil Conservation (Soil Conservation and Land Development)

Dr R.L. Karali, Senior Soil Survey Officer, India Soil and Land Use Survey

D.K. Yadav, Soil Survey Officer, India Soil and Land Use Survey

S.K. Suiha, Assistant Soil Survey Officer, India Soil and Land Use Survey

B.K. Pattack, Assistant Soil Survey Officer, India Soil and Land Use Survey

Dr O.P. Joshi, Soil Chemist, Soil Survey Officer, India Soil and Land Use Survey

Dr Ramanathan, Divisional Officer, India Met. Service

Dr O.P. Gautham, Director General, Dept of Agricultural Research and Education

Dr K.G. Tejwani, Director, Central Conservation Res. Inst., Dehra Dun

Gurmel Singh, Chief Scientist Dryland Agriculture, Central Conservation Research Institute, Dehra Dun

Dr R.K. Gupta, Head, Division of Plant Science, Central Conservation Research Institute, Dehra Dun

Dr A.S. Alwan, FAO Country Representative, New Delhi

N.H.B. Hughes, Programme Officer, FAO, New Delhi

H. Roder, Assistant Programme Officer, FAO, New Delhi

ANNEX 4.6

LITERATURE CONSULTED AND CITED

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ANNEX 5 - ISRAEL

5.1 CLIMATE OF ISRAEL

Three broad climatic zones are recognised as depicted on Map 1 (Annex 5.5). The Mediterranean region in the north is characterised by a long dry summer and a mild winter with average rainfalls exceeding 400 mm and approaching 800 mm. The hill country in the north and centre of this zone is temperate, with some snow in the winter.

The Saharo-Arabian region in the south which extends up the Wadi Araba and part way up the Jordan Valley, is characterised by desert and semi-desert conditions; it is hot and dry, the winters being warm with cold nights. Rainfall is less than 150 mm per annum.

These two zones are separated by the Irano-Tiranian or steppe region which is characterised by extreme ranges of diurnal and annual temperature and mean precipitation of 200-400 mm. Summers are hot and dry, winters cold and harsh. Sub-tropical conditions prevail in the Jordan Valley (Anon.c.1978; Reves and Kisikowitch, in press).

The following exemplary data are from various sources:

Place	Climatic Zone	Elevation (m)	Rainfall (mm) mean annual	Temperature °C	
				mean max. hottest month	mean min. coldest month
Mt. Carmel (Haifa)	Mediterranean		c. 700		
Ilanot	Mediterranean		640		
Netanya	Mediterranean		517	30	9
Tel Aviv	Mediterranean	0	540	30	11
Jerusalem	Mediterranean		486		
Menahamia	Irano-Tiranian		c. 380		
Beersheba	Irano-Tiranian	270	200	34	6
Ein Hatseva	Saharo-Arabian	137	70	38	8
Jericho	Saharo-Arabian	-260	143	39	10
Sodom	Saharo-Arabian	-380	51	41	10
Eilat	Saharo-Arabian	5	30	40	10

Map No. 2 (Annex 5.6) depicts the rainfall and vegetation zones of Israel.

5.2 THE TAXONOMY OF ACACIA RADDIANA SAVI AND A. TORTILIS HAYNE

Karschon (1961) described A. raddiana Savi, at one time known as A. tortilis Hayne, as a tree of moderate size attaining a height of 8 - 10 m, usually with a short trunk from which several large branches diverge to form a round, irregular, umbrella-shaped crown. The bark is rough, greyish with red tints. Leaflets and young twigs are glabrous, pods more or less spirally curved.

The same authority described A. tortilis Hayne, at one time known as A. spirocarpa Hochst ex A. Rich., as a multi-stemmed shrub or tree attaining a height of 4 - 6 m, with a flat topped crown. The bark is smooth, reddish; the leaflets and young twigs pubescent; pods spirally twisted, constricted between the seeds.

He noted that Brenan, 1957 (quoted in Karschon 1961), proposed to consider both trees as subspecies of one species, i.e. A. raddiana Savi would become A. tortilis (Forsk) Hayne subsp. raddiana (Savi) Brenan, while A. tortilis Hayne would become subsp. tortilis.

Karschon's 1961 nomenclature is used in Israel. Specialists there believe, on the basis of published seed weights (see Karschon, 1975 b) that the "A. tortilis" introduced from Israel into India is A. raddiana Savi.

5.3 PROVENANCE COLLECTIONS TO BE MADE IN ISRAEL

(i) Acacia albida Del.

Distribution: Information about the distribution of this species in Israel was summarised by Halevy (1971) whose map is reproduced as Map 3 (Annex 5.7). Since that time Aloni (1972) has described a newly discovered occurrence near the west coast between Haifa and Tel Aviv. Several of the earlier records of occurrences of the species are beyond physical confirmation since the stands (trees) have now disappeared. Karschon (1975a) noted that if reported occurrences at Jericho were correct, this would then be the only area in the Middle East where the range of A. albida and A. raddiana overlap.

Unlike the other Acacia species in Israel, A. albida occurs as a series of disjunct relics in non-desert areas as well as in some where near-tropical conditions persist. High groundwater levels characterise many but not all of these sites; hydric conditions are adverse in some of them, e.g., basalt areas. A. albida occurs in three locations in Lebanon, the most northern one being 30 km north of Beirut. According to Brenan, 1959 (quoted by Halevy, 1971), the tree was said to occur in Cyprus but Wickens (1969) stated that it was introduced there.

Variation: No information.

Silvical features: The tree in Israel is clonal and reproduces from root suckers (Halevy, 1971; Karschon 1976). Halevy (1971) recorded that the phenology of A. albida in Israel is similar to that displayed in tropical Africa, i.e. it remains adapted to ecological conditions in the tropics. Thus it flowers throughout the year and is partially deciduous at the end of the summer (which may have been induced by anaerobic conditions due to flooding in its African habitats). Wickens (1969) noted that the tree sheds its leaves at the beginning of the rains in areas of Mediterranean climate. The shift from reproduction by seed to reproduction by suckers may have enabled the tree to survive well beyond the tropical conditions of Africa.

Seeding: Seed production in the clonal stands is limited and it may not be possible to collect the quantity desired or from as many as 25 trees sufficiently widely spaced to ensure that no two of them belong to the same clone. There are no access problems. The seed collection season is April-June.

Seed weights: No information.

Current planting: Nil.

Collecting sites: Shimron (Nahalal) on the road from Nazareth to Haifa; Menahamia; Emek Haela (Valley of the Pistacea*); Ashdod.

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* Where David's son Absolom was killed in battle when, as he rode a horse, he hit his head on a branch of a Pistacea atlantica tree.

(ii) Acacia raddiana Savi

Distribution: According to Karschon (1961) the species is relatively frequent in the Dead Sea area and in both the Saharo-Arabian and Irano-Turanian regions of the Negev. Single trees occur at the higher elevations in these areas and in the western Negev. The northern limit of the tree is in the loess soil district of Beersheba and at Jericho. The latter, it appears, is the only area in the Middle East where its distribution overlaps with that of A. albida (Karschon 1975a). Its altitudinal range is from 390 m below to 700 m above sea level.

The species has a relatively wide temperature tolerance, being (like A. tortilis) controlled in its distribution by temperature rather than precipitation. Its northern limit corresponds more or less to the 300 mm isohyet.

Karschon (1961) gives accounts of detailed sites, microclimates and plant communities in which the species occurs.

Variation: Nothing specifically known of genetic variation. See note on taxonomy at Annex 5.2 and next paragraph. Trees are found that are intermediate in certain characters between this species and A. tortilis.

Silvical features: Coppices vigorously and tolerates lopping of large branches. Evades rather than tolerates drought. Has an extensive and deep root system which enables the tree to thrive in dry desert wadis where sufficient accessible soil moisture at depth is available throughout the year. Tolerates low temperatures and occasional frosts. Although there is variation between individuals the tree is characteristically almost evergreen, winter dormancy only occurring at higher elevations in the northern Negev. Capable of very high transpiration rates (Karschon, 1961).

Seeding and seed characteristics: Flowers freely and produces copious seed. Seeds collectable June-July (Karschon, 1975b). Seeds are 3-7 (6) mm long by 3.5 - 4.5 (4) mm wide. There are 19 000 in a kg. Dispersal is probably mainly by flood water through runnels and wadis and by animals eating the pods. As much as 40 % is already partly or completely destroyed by Bruchid larvae when collected (see Section 5.7 in country report).(Karschon, 1961). No access problems.

Current planting: Not more than about 0.5 ha (negligible).

Collecting site: Wadi Araba, possibly near Ein Hatseva. Site conditions are described in general in Annex 5.1 and in detail in Karschon, 1966.

(iii) A. tortilis Hayne

Distribution: According to Karschon (1961) the species is much less widespread in Israel than A. raddiana Savi. Limited to Saharo-Arabian zone (see Annex 5.1 and 5.5.) Main distribution is in Wadi Araba and its tributaries, the most northern occurrence being at En Gedi, half way up the west coast of the Dead Sea. It occurs at lower elevations in the Central Negev but neither in the western nor northern Negev. Its altitudinal range extends from 390 m below to 500 m above sea level.

A. tortilis has much less tolerance of low winter temperatures than A. raddiana and is almost confined to the hottest areas of the region, e.g., Wadi Araba and the Dead Sea shores where temperatures never fall to 0°C. It also appears to avoid areas of higher relative humidity. Mean annual rainfall is below 200 mm and very irregular.

It occurs on a wide range of soils provided they are well drained and non-saline. Karschon (1961; 1966) gives detailed accounts of microclimates, soils and plant communities in which the species is found.

Variation: No specific information about genetic variation. See Annex 5.2 on taxonomy. Intermediate types between this species and A. raddiana occur.

Silvical features: Coppices vigorously and tolerates lopping of large limbs. The extensive and deep root system enables it to thrive in desert conditions where sufficient moisture is available at depth throughout the year. Does not readily tolerate low temperatures; cannot withstand frost. Almost evergreen. Has very high transpiration rates. More drought and salt tolerant than A. raddiana. Seed dispersal by runoff water and by animals. (Karschon, 1961).

Seeding and seed characteristics: Flowers freely and produces seed copiously. Ready for collection in June - July. Seeds are 3 - 5 (4.2) mm long by 2 - 3 (2.4) mm wide. 50 000 per kg with as many as 40 % affected by Bruchid larvae by the time they are collected. See Section 5.7 in country report for discussion of seed germination.

Current planting: negligible.

Collection site: Wadi Araba, possibly near Ein Hatseva. Site conditions for the area are described in detail in Karschon (1966) and in general in Annex 5.1.

5.4 ITINERARY AND PERSONS CONSULTED IN ISRAEL

I. ITINERARY

1979

July 15: Arrived Tel Aviv

16: Consultations at Forestry Division, Agricultural Research Organisation, Ilanot.

Late afternoon: to Haifa by car with senior Forest Department officials, via Mishmar Ha'Emek Forest and other places of interest.

17: Discussions at Forest Dept. headquarters, Kiryat Hayim; tour of forest and land development and management areas en route to Tiberias and south of Sea of Galilee. Inspection of A. albida stand at Chimron (Nahalal).

18: Tour of coastal zone, particularly near Caesaria. Further consultations and tour of Eucalyptus camaldulensis research areas and arboretum at Forestry Division, Ilanot.

19: Departure from Tel Aviv.

II. PERSONS CONSULTED

Dr Gabriel Schiller, Ecologist, Forestry Division, Agricultural Research Organization, Ilanot

Dr R. Karschon, Director, - do -

Dr C. Grunwald, Geneticist, - do -

Dr Y Zohar, Silviculturist, - do -

Dr A Weinstein, Botanist, - do -

Mr Moshe Kolar, Deputy Director, Forest Department, Land Development Authority, Kiryat Hayim

Dr Y Revav, Seed specialist, - do -

Dr J Kaplan, Coordinator, Forest Research and Extension, Land Development Authority, Kiryat Hayim

ANNEX 5.5

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ANNEX 6 - PDR YEMEN

6.1 PRIORITY OF SPECIES: PDR YEMEN

Species	Uses							Silvicultural characteristics				Priority
	Fuel	Fodder		Shade, shelter	Timber, poles	Gum	Tannin	Coppices	Soil improver	Drought tolerant	Saline soils	
		Pods	Foliage									
Indigenous												
Acacia tortilis Hayne	X	X	X			X		X	X	X		1
A. senegal (L.) Willd.	X	X	X			X						2
Prosopis cineraria (L.) Druce	X	X	X					X	X	X		1
Exotic/provenances												
Eucalyptus camaldulensis Dehn.	X			X	X			X				1
**Acacia tortilis* (Forsk) Hayne	X	X	X			X		X	X	X		1
A. nilotica (L.) Willd, ex Del.	X	X	X		X	X	X		X	X		1
**A. senegal* (L.) Willd.	X	X	X			X						2
**Prosopis cineraria* (L.) Druce	X	X	X					X	X	X		1

* Species which are also native to PDR Yemen and shown in indigenous list

6.2 PROVENANCE COLLECTIONS TO BE MADE IN PDR YEMEN

(i) Acacia tortilis Hayne

Distribution: From sea level to 1 300 m throughout the country. Mostly along water courses and on shallow soils that are periodically flooded. Varies from pure stands giving more than 50 % coverage of the ground to scattered trees, sometimes mixed with Ziziphus spina-christi, Balanites aegyptiaca and thicket species such as Salvadora persica. In minor water courses or away from drainage depressions A. tortilis becomes stunted and is often mixed with other drought resistant species, such as A. nellifera and A. senegal.

Climate and Soil: See Annex 6.4.

Genecological variation: Three different forms are recognisable:

(a) in coastal areas the tree branches at ground level to form many stems, is stunted, wide and flat-crowned and does not grow into a proper tree;

(b) further inland, up to about 600 m altitude, the tree has a clear bole and narrow crown and reaches 7 - 8 m;

(c) in the inner desert at 900 - 1 000 m, the tree has smooth reddish-brown bark (in contrast to the greyish bark of the other two forms) and an umbrella-shaped crown. It is not known whether the reddish bark of this form is due to the action of wind blown sand. The second variety, e.g., at Lodar, has more prominent, stouter spines than the inner desert form.

The two small plantations at El-Kod (see Current Planting below) were established with seed from India, the original source. These stands display marked tree-to-tree variation in several features, e.g., habit varies from the low form with forking at ground level to tree-like; spines vary from thin to stout; bark varies from reddish to grey, fissured to smooth.

Seeding season: Flowering occurs in April - May and seed is collectable in June - July.

Important uses: Acacia tortilis represents a valuable resource of fodder (leaves, flowers, pods) during the dry season. Highly prized for fuel and charcoal.

Current planting: There are two small plantations totalling some 0.75 ha at El-Kod, established with seed from India (original source Israel).

The species is used on a small scale in the new programme of planting by farmers which is being fostered by the Forestry Section at El-Kod.

Proposed collection areas:

(a) Costal area, between Shuqra and Ahwar.

(b) Lodar area in the principal inland agricultural zone.

(c) Behan in the inner desert.

(d) El-Kod Agricultural Research Centre: the exotic provenance introduced from India (original source Israel).

(ii) Acacia senegal (L.) Willd.

Distribution: Widely distributed at middle altitudes of 200 - 900 m, often being mixed with A. tortilis. Occurs on sandy, sandy loam and shallow rocky soils along drainage lines.

Climate and soil: See Annex 6.4.

Genecological variation: Not apparent.

Seeding season: October - November.

Important uses: Fuel and forage. A potentially important source of gum.

Current planting: Nil.

Collection area: Nisab at 800 - 900 m on the high plateau. Sandy loams of the semi-desert. Rainfall 150 mm/annum. Frost occurs occasionally.

(iii) Prosopis cineraria (L.)

Distribution: Occurs mainly in coastal areas east of El-Kod where annual rainfall averages less than 100 mm and the water table is at 6 - 7 m. In wadi deltas where the water table is not too deep, e.g., Wadi Maifa, Bir Ali, Balhaf. Often in areas of saline-alkaline soils.

Climate and soil: See generalised information in Annex 6.4.

Genecological variation: Not apparent.

Seeding season: Flowers March - April and seed is collectable June - July.

Important uses: Shade and shelter, fuel and fodder: the foliage is very palatable to stock.

Current planting: Although planting has so far been limited, the species has been introduced recently into the Hadramaut. At El-Kod it makes fine shelterbelts.

Collection area: Agricultural Research Centre at El-Kod from shelterbelt trees grown from seed introduced from Wadi Maifa and Balhaf. It is most desirable to collect seed from a natural stand as well.

(iv) Acacia nilotica (L.) Willd. ex Del.

Distribution: This species is an exotic in PDR Yemen, having been introduced about 1948, probably from the Sudan. A drought-hardy species which appears to be better adapted to local conditions even than A. tortilis. It grows from the coast to 1 350 m. In the lowlands height growth is moderate, crowns dense, bark dark brown with much gum exudation. At higher altitudes height growth is greater and crowns more open. Little variation tree-to-tree is noticeable.

Seeding season: Seed is available almost year round but July - September is the best time for collection. A heavy seed-bearer.

Important uses: Fodder and fuel.

Current planting: It is one of the more important species distributed from forest nurseries and there are several km of plantings along roadsides, e.g, at Abyan, Lahash, Dhala, Behan, Nisab.

Collection area: Behan, 900 m. Deep sandy loam soil. 150-200 mm rainfall with flood conditions.

6.3 EVALUATION IN PDR YEMEN: SOURCES

Species	Sources
Acacia tortilis	3 representing PDR Yemen forms 1 exotic, PDR Yemen (Israel via India) 1 exotic, India (ex Israel) 3 Sudan
A. senegal	1 PDR Yemen 5 India African collections when known
Prosopis cineraria	2 PDR Yemen 4 India
A. nilotica	3 Rajasthan, India 3 Sudan 1 exotic PDR Yemen
Eucalyptus camaldulensis	3 Australia

6.4 CLIMATE AND SOIL INFORMATION FOR PDR YEMEN

The following account is based on that of Costin (1972).

(i) Climate:

During the pleistocene, SW Arabia was subjected to alternating wet and dry periods. A drying process extended outwards to the coast and PDR Yemen now has an arid or semi-arid climate.

Mean annual temperature varies betwen 20 - 40°C at the coast, 0 - 35° C in the mountains. The coastal plains are hot and humid in summer, cooler and less humid in winter. In the mountains and their foothills the climate is drier and cooler and at the highest elevations, over 1 500 m, it can be cold and even frosty.

Mean annual rainfall is less than 100 mm at the coast and in the east and north-east, 300 mm in the higher mountains and over 700 mm in the Dhala highland district. There are two rainy periods during the year: one in April - May, the other in July - September.

Winds on the coastal plains are often violent. They are variable in direction, blowing from the east or west. The very strong east wind, known as Asiab, blows in March and April. The somewhat more moderate west wind, the Kows, blows in July-August.

The climate at El-Kod and in the mountains is illustrated by the following tables and in the Physical and Agricultural map at Annex 6.6.

(ii) Soils

The majority of the soils are either alluvial or colluvial. The former occur in the deltas of wadis and the latter on the terraces and easier slopes of the mountains and hills.

The alluvial soils of the deltas are of light texture, being sands, loamy sands, sandy loams, silty sandy loams or silty clay loams. Loamy sands and sandy loams predominate. The delta soils are usually of good depth, high permeability, good aeration and are mostly non-saline. Saline soils occur along lagoons and where the water table sometimes reaches the surface.

With irrigation the alluvial soils support many agricultural crops and good growth of a variety of tree species.

Light brown colluvial soils in the foothills have arrested development because of the low rainfall. However, with periodic flooding they can support good agricultural crops. Heavier soils occur in the higher mountains but have been subject to severe erosion.

Soil and, more particularly, rainfall conditions are reflected in the Provisional Vegetation Map at Annex 6.7.

Meteorological data for El-Kod, 1965 (Anon. 1966)

Month	Temp °C Max	Temp °C Min	R.H. %	Dewpoint °C	Rainfall mm
Jan	27.5	18.1	73	18.1	0.7
Feb	28.3	17.1	73	17.7	
Mar	29.2	17.4	67	17.5	
Apr	31.4	23.1	70	22.6	1.7
May	33.8	21.4	65	21.4	
Jun	35.6	24.9	63	23.0	
Jul	35.4	25.7	68	23.9	
Aug	34.7	25.7	66	23.0	
Sept	34.9	25.3	71	24.5	
Oct	32.2	20.6	65	20.1	
Nov	30.3	21.2	70	20.2	
Dec	28.6	18.4	65	16.9	0.1

Rainfall Data for 2 Mountain Stations (Cinos, 1966)

Month	Mukeiras 2100 m	Behan 1100 m
Jan	1.0	5.1
Feb	8.6	7.6
Mar	6.9	10.2
Apr	32.7	43.2
May	13.3	2.5
Jun	2.7	5.1
Jul	46.6	53.1
Aug	94.7	2.5
Sep	30.3	-
Oct	0.6	-
Nov	-	-
Dec	0.6	-
	238.0 mm	129.3 mm

6.5 ITINERARY AND PERSONS CONSULTED IN PDR YEMEN

I. ITINERARY

1979

June 29: Arrived Aden am by air from Bombay.
pm: meeting with Dr E. Costin, FAO Forestry Expert and Acting FAO Country Representative.

30: Tour of Agricultural Research Centre, El-Kod, and forestry trials and demonstrations with professionals of Forestry Section.

July 1: Discussion with Abdul Wahit, Director, Agricultural Research Centre, El-Kod, and field trip to Lodar.

Evening: met Mohamed Baamer, Deputy Minister of Agriculture; Jasim Naser, Deputy Minister, Ministry of Planning, and Dr E. Costin.

2: Consultations with Dr E. Costin, A.S. Balaidi, Head, Forestry Section, and M. Bazara, Forester.

3: Consultations with Dr E. Costin.

4: To Khartoum by air via Jedda.

II. PERSONS CONSULTED

Dr E. Costin, FAO Forestry Expert and Acting Country Representative, FAO, Aden

A.S. Balaidi, Head, Forestry Section, Agricultural Research Centre, El-Kod

M. Bazara, Forester, Agricultural Research Centre, El-Kod

Abdul Wahit, Director, Agricultural Research Centre, El-Kod

Mohamed Baamer, Deputy Minister, Department of Agriculture

Jasim Naser, First Deputy Minister, Department of Planning

ANNEX 6.6

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7.1 PRIORITY SPECIES: CHILE

Species	Characteristics and Uses																Priority
	Fuelwood, charcoal	Fruit, fodder	Foliage	Shade	Windbreaks	Wood	Poles	Soil improvement	Soil protection	Saline tolerance	Tannin	Handicrafts	Honey	Pharmaceutics	Cosmetics	Drought resistance	Resins	
Indigenous																		
Acacia caven Mol (1)	x		x	x				x	x			x				x		1
Caesalpinia spinosa (1)	x		x	x				x			x	x				x		2
Prosopis chilensis (1) (3)	x	x	x	x			x	x	x	x		x	x			x		1
Prosopis tamarugo (3)	x	x	x	x	x		x	x	x	x		x	x			x		1
Quillaja saponaria (1)					x		x		x			x	x	x	x			1
Atriplex repanda (2)			x						x	x								1
Atriplex coquimbensis (2)			x						x	x								2
Schinus molle (1)				x	x					x				x				2
Galenia secunda (2)			x						x									1
Atriplex nummularia			x						x	x								2
Maytenus boaria Mol (1)			x	x					x	x				x				2
Cryptocarya alba (1)																		2
Porliera hygrometrica (1)	x		x									x		x		x	x	3
Lithraea caustica (Mol) Miers (1)	x					x	x											3
Geoffroea decorticans (Gillies (1)	x				x		x	x				x	x	x		x		3
Exotic																		
Acacia cyanophylla (1) (2)	x		x	x	x		x	x								x		1
Eucalyptus camaldulensis (1)	x			x	x	x	x									x		1
Eucalyptus microtheca (1)	x			x	x	x	x									x		1
Eucalyptus bicostata (1)	x			x	x	x	x									x		1
Atriplex semibaccata (1) (2)			x						x	x								2
Atriplex canescens (2)			x						x	x								2

(1) Indicated by INFOR
(2) Indicated by INIA
(3) Indicated by CORFO
(4) Indicated by CONAF

7.2 PROVENANCE COLLECTIONS TO BE MADE IN CHILE

(i) Prosopis tamarugo, Phil Mimoseae

Common name: 'Tamarugo'

Distribution, climate and soil: It occurs only in the Tarapacá region of northern Chile, with its widest natural geographic distribution range between the localities of La Guaica and La Tirana in the surroundings of Salar de Pintados (lat. 20° 15' to 20°30' South; long. 69° to 70° West), at altitudes between 1 000 and 1 200 m a.s.l.

Climate is temperate arid with practically no rainfall. Temperatures vary between absolute minimums of -5°C and -12°C (1966) and absolute maximums of 36°C and over, with daily fluctuations which may reach 40°C. Between May and September there are frequent frosts which diminish in October. Relative air humidity during the day fluctuates between 10 and 30% and several times reaches 80 or 100% for some hours of the night. There are mists 6 to 10 times between December and February (summer).

P. tamarugo prospers mainly in soils of lacustrine origin, which have changed into salinas. Filling material consists of clays and silt covered by a salt layer from 0.3 to 1.0 m thick. It also grows in soils without a saline crust, both sandy and clayey, with a water table between 2 and 40 m deep.

Genecological variation: No information. Not studied.

Main characteristics: Withstands highly saline soils and may even be irrigated with water containing more than 4% salt. Some researchers consider that P. tamarugo can absorb atmospheric moisture through its leaves and carry it down to its roots which exude it into the surrounding soil by means of a process similar to guttation (Sudzuki, 1969).

It is thought that P. tamarugo would find difficulty in adapting to certain places not as cold as those from which it originates (López, personal communication).

For germination seed must be immersed in water at 20°C for 24 hours before sowing, or for a shorter time if sulphuric acid not in excess of 10% is added to the water.

Seed collection: February, March.

Seed weight: 25 000-30 000 seeds/kg.

Important uses: Fodder tree. Its fruit and leaves are palatable for sheep, goats and cattle. The nutritional value of the fruit is comparable and even superior to that of high quality hay (Latrille, García, 1968). Good producer of fuelwood and charcoal, wood for poles and/or rustic building, honey tree.

Establishment methods: Transplanting to the field direct from beds at height of 5 to 10 cm. More than 22 000 ha have been planted in this manner in the Tamarugal Pampa.

Suggested collection areas: Salares del Obispo, Pintados and Bellavista, and the vicinity of La Tirana, all in the Tarapacá Region.

(ii) Genus Prosopis Mimoseae

Common name: 'Algarrobo'

Distribution, climate and soil: Found distributed in different localities from the extreme north to Santiago, usually existing in sandy and somewhat stoney

soils with a water table at a depth not exceeding 40 m. Prefers lime-rich soils. In the north it occurs in association with P. tamarugo, and with A. caven in Santiago and surroundings, being practically non-existent beyond 1 800 m a.s.l.
It prospers in climates ranging from the northern temperate arid to the mediterranean climate of the central zone of the country, with precipitation of up to 350 mm and average temperatures of 15°C.
Genecological variation: Several species are believed to be included in the generic name of 'algarrobo': a) P.atacamensis Phil which, in the northern region would be associated with P. tamarugo and largely resembles the Argentine P. alba Gris; b) P. siliquastrum Phil, described for San Pedro de Atacama, Antofagasta; c) P. chilensis (Mol) Stuntz with distribution between Copiapó and Santiago; and d) P. burkartii.
The morphological characteristics of the above species are very similar. There are differences in leaf size, number of pairs of opposite leaflets, fruit size, presence of thorns and size or lack thereof as well as their area of distribution.
Main characteristics: Drought resistant. Tolerant to saline soils. Seeds require treatment with sulphuric acid to accelerate germination.
Seed collection: February to April.
Seed weight: 20 000 to 35 000 seeds/kg.
Establishment methods: Transplanting from nurseries into permanent sites. There are about 2 600 ha of artificially planted Prosopis in Tarapacá.
Important uses: The fruit is mainly used as fodder and the foliage for browsing. Fuelwood and charcoal are of excellent quality with a high calorific content. The wood has been used for building and found to be very resistant. Also used for poles and honey.
Suggested collection areas: For P. atacamensis, La Tirana and Refresco. For the other species, Coquimbo, Aconcagua, Metropolitan Area.

(iii) Acacia caven Mol Mimoseae

Common name: 'Espino'.
Distribution, climate and soil: Occurs between Coquimbo and Bío Bío, i.e. from 30 to 38° lat. S approximately, in areas not much affected by the influence of the sea, situated on the eastern watershed of the coastal Cordillera, some 25 km east of the shore. Precipitation ranges between 150 and 1 000 mm in the southern part of its area of distribution. Average temperature fluctuates between 13 and 15°C with extremes of -3 and 35°C.
It adapts to a large variety of soils starting with clayey, preferably sandy texture, with pH close to neutral, but can stand saline and slightly acid soils.
Genecological variation: No information.
Main characteristics: Tree or bush depending on soil and moisture conditions. Resprouts readily and adventitious buds are easily observed in secondary roots which give rise to true shoots. It reproduces by seed which, for best results, should be pre-germinated in seed beds.
Seed collection: From December on.
Seed weight: 10 000 seeds/kg.
Important uses: Mainly fuelwood and charcoal, considered the best in the country. Wood is hard, heavy and very compact and is used in handicrafts and for tool handles. Honey tree. The fruit, called 'quirinca' has a tannin content of up to 23%.

Establishment methods: Raised in nurseries and transplanted to permanent site.
Suggested collection areas: Metropolitan Area and Region IV south.

(iv) Quillaja saponaria Mol Rosaceae

Common name: 'Quillay', 'Palo de Panamá'.
Distribution, climate and soil: Grows between Ovalle and Malleco (30°50' to 38° lat. S), both in the coastal zone and on the Andean Cordillera to altitudes exceeding 2 000 m a.s.l. Climate and soil conditions are described in Annex 7.4.
Genecological variation: No information.
Main characteristics: Evergreen foliage. Low percentage of fertile seeds (about 20%), germinating one month after seeding. Slow growing.
Seed collection: From February on.
Seed weight: 140 000 seeds/kg.
Important uses: The inner bark, known as 'trojas de quillay' has a saponin content of 12% making it useful for cosmetics, handicrafts, hand carved saddle stirrups, manufacture of liquid containers. Produces excellent honey.
Establishment methods: Transplant from nurseries to a permanent site.
Suggested collection areas: Regions IV and V in coastal zone and Metropolitan Area in the Andean pre-Cordillera.

(v) Atriplex repanda Phil Chenopodiaceae

Common name: 'Pasto salado'.
Distribution, climate and soil: There are few specimens in natural populations but its area of natural distribution is between the Huasco and Petorca Rivers, approximately between 28°15' and 32°45' lat. S at altitudes of 800 m a.s.l., i.e. in zones with 80 to 250 mm rainfall and average temperature between 14 and 16°C. Further details on climate and soil characteristics of this sector are given in Annex 7.4.
Genecological variation: No information.
Main characteristics: Highly drought-resistant forage bush. Propagates easily if protected from browsing during early stages of development.
Seed collection: From February on.
Seed weight: Estimated about 250 000 seeds/kg. Unconfirmed estimate.
Important uses: Exclusively as a forage plant to complement natural pastures. Its high palatability makes it vulnerable to elimination when completely defoliated.
Establishment methods: Seeded directly into water-catching furrows. By now some 6 000 ha of forage bushes have been planted in the region of Coquimbo, of which A. repanda covers a large proportion.
Suggested collection areas: Artificially regenerated areas between Coquimbo and Aconcagua.

7.3 EVALUATION IN CHILE: SOURCES AND TEST SITES

TABLE 7.3.1 Responsibility for Evaluation: INIA; School of Forestry Sciences, University of Chile; and CONAF

Species	Provenance	Test Sites														Localities
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Atriplex atacamensis	Chile (native)											X	X				1. Los Vilos Substation INIA 2. Corral de Julio, U. of Chile 3. Las Palmas U. of Chile 4. Tipay U. de Chile 5. Peñuelas Reserve, U. of Chile 6. Rio Blanco Reserve, U. of Chile 7. Dunas de Ritoque, U. of Chile 8. Rinconada U. of Chile
Atriplex repanda	Chile (native)	X										X	X				
Atriplex nummularia	Australia	X									X	X			X		
Atriplex canescens	USA	X										X					
Atriplex lentiformis	USA	X			X												
Atriplex halimus	Israel	X			X						X				X		
Atriplex coquimbensis	Chile (native)	X															
Atriplex semibaccata	Chile (naturalized)	X			X							X					
Galenia secunda	S. Africa	X			X												
Kochia brevifolia	Israel	X			X												
Medicago arborea	USA	X															
Acacia cyanophylla	Australia	X	X					X	X		X	X		X		X	
Acacia greggii	USA	X															
Acacia caven	Chile (native)		X		X	X		X	X								
Acacia capensis	Australia		X						X		X			X	X		
Quillaja saponaria	Chile (native)		X	X	X	X		X	X	X	X			X	X	X	
Brachychiton populneum			X														
Casuarina cunninghamiana	Australia		X														
Cupressus macrocarpa	USA		X					X									
Eucalyptus camaldulensis	Australia		X					X	X		X			X	X	X	
Eucalyptus citriodora	Australia		X						X		X	X		X		X	
Eucalyptus globulus	Australia		X					X	X						X	X	

Continued on next page

TABLE 7.3.1 (continued)

Responsibility for Evaluation: INIA; School of Forestry Sciences, University of Chile; and CONAF

Species	Provenance	Test Sites															Localities
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Eucalyptus gomphocephala	Australia		X							X			X	X	X	X	9. Peralillo CONAF
Eucalyptus fruticetorum	Australia		X							X		X	X	X	X	X	
Eucalyptus microtheca	Australia		X					X	X	X	X	X	X				10. Quilitapia CONAF
Peumus boldus	Chile		X	X		X											
Maytenus boaria	Chile		X	X	X	X		X	X								11. Higueritas CONAF
Prosopis chilensis	Chile		X	X		X		X	X		X			X	X		
Pinus halepensis	Spain		X					X									12. Fray Jorge CONAF
Pinus radiata	Chile (naturalized)						X	X									
Pinus eldarica	USA						X										13. Pachingo CONAF
Pinusxattenuradiata	USA						X										
Ceratonia siliqua										X							
Schinus molle	France																14. Las Cardas
Cryptocarya alba	Chile		X			X		X	X		X				X		
																	15. Los Vilos

7.3 EVALUATION IN CHILE: SOURCES AND TEST SITES

TABLE 7.3.2 Responsibility for Evaluation: INFOR

Species	Provenance	Localities								
		1	2	3	4	5	6	7	8	9
Acacia caven	Chile	x	x	x		x			x	
Acacia cyanophylla	Australia	x	x		x	x		x	x	
Acacia decurrens	Australia		x			x		x	x	
Acacia longifolia	Australia	x	x	x	x	x	x	x	x	
Acacia melanoxylon	Australia				x					
Acacia cyclops	Australia				x			x	x	
Caesalpinia spinosa	Chile	x				x	x	x	x	
Cupressus macrocarpa	Chile (naturalized)				x					x
Cupressus sempervirens	Spain				x				x	x
Eucalyptus maidenii	Australia			x						
Pinus attenuradiata	USA		x	x	x					
Pinus halepensis	Spain		x							
Pinus radiata	Chile (naturalized)		x	x	x					
Prosopis chilensis	Chile	x	x	x		x	x	x	x	
Quercus suber	Spain		x	x	x					
Quillaja saponaria	Chile	x	x	x		x	x	x	x	x
Schinus molle	France	x				x	x	x	x	x

Localities	Commune	Province	Region
1. Embalse La Paloma	Monte Patria	Limarí	IV
2. Cuesta La Dormida	Olmué	Valparaíso	V
3. Chacabuco	Chacabuco	Metropolitain Area	
4. San Enrique	Santo Domingo	San Antonio	V
5. Hurtado River (valley)	Río Hurtado	Limarí	IV
6. Hurtado River (hills)	Monte Patria	Limarí	IV
7. Hurtado River, north	Paihuano	Elqui	IV
8. Las Cardas	Andacollo	Elqui	IV
9. Laguna del Ica	Los Andes	Los Andes	V

7.4 SOIL AND CLIMATE INFORMATION FOR CHILE

Continental Chile with its closest islands extends over 4 000 km between 17°30' and 56° lat.S. Such a latitudinal extent makes for great varieties of climates and conditions for vegetative growth, which range from a desert climate with practically no rainfall to areas where yearly precipitation exceeds 4 000 mm.

Some authors have divided the country into 12 climatic zones from north to south: Littoral desert, Transitional desert, Transitional Mediterranean, Arid Mediterranean, Semi-arid Mediterranean, Central Mediterranean, Sub-humid Mediterranean, Humid Mediterranean, Rainy, Central Southern, West Southern and East Southern. The main characteristics of these climates as well as their location appear in Table 7.4.1, the characteristics being naturally of a general order: sometimes the values change so that the limits of the different zones are not stable and are only given by way of approximation.

Another related factor is the influence of the sea on the arid and semi-arid zones which extend some 20 km inland; localities near the sea with the same precipitation as that of the inland zone may have comparatively more moisture available to the plants due to the lower evaporation occurring there.

Climatic data are also given for various localities of the arid and semi-arid zones in order to give a more graphic description of the conditions in which the species commented on above develop. Data and localities appear in Table 7.4.2.

As regards temperature, there are two noteworthy facts: firstly, the difference of 13° C between the average temperatures at the northern and southern extremes of the country is not as large as could be expected, considering the distance of 4 000 km; secondly, the daily thermal fluctuations are large, especially in the area extending from 37°30' (average fluctuation 18°C) to the northern boundaries of the country.

Topographically Chile is a strip bounded generally by the Andes Mountains on the east and the Coastal Range along the seaboard, forming a central depression crossed by rivers descending from the Andes to flow into the ocean.

In broad terms, soil types are the following: in the extreme northern zone soils are calcareous from the surface and usually contain gypsum, with low exchange capacity and slight alkaline reaction. They are primary soils with abiogenetic weathering with a prevalence of gravel and gravel with fine earth in the mountains and fine earth of a reddish tint in the depressions.

In alluvial conditions there are weathered crusts of compact iron carrying an accumulation of sulphates. Aquatic tracts present solonchaks of sulphates and in the western part of the depression there is a bar of nitrate solonchaks.

In a second zone, between 28 and 32° lat. S, the soils are varied. There are soils with a grey-cinnamon humic horizon 5 cm thick and soils with a more reddish metamorphic horizon of 50 cm forming fragmentary soils under alluvial conditions in acid rocks, and similar soils formed in Sasalto rocks.

The following morphological structure is found in the fluvial and marine terraces of the zone: in the upper part a non-calcareous granular horizon and, underneath, a calcareous metamorphic horizon with a nutty structure, and another with calcium carbonate concretions, and still another to a depth of 2 m with gravel, stone or compact marine argillites. Soil reaction is slightly alkaline.

In the fluvial flood plains there are alluvial soils of gravel and stone and solonchaks are not rare.

On the Andean slopes they correspond to alpine mountain meadows in the more humid parts and are desert fragmentary in the drier areas.

In the zone between 32 and 37° lat. S four sectors may be distinguished: low maritime, coastal range, central valley and Andean range.

The first consists of marine terraces made up of gravel or argillites with the following morphology: a reddish grey metamorphic horizon with prismatic structure and dendrites of iron and manganese hydroxides; the metamorphic horizon is 20 to 150 cm thick, showing effervescence only in the lower part.

In aquatic alluvial conditions there has been a development of dark soils with cracked surfaces and a marked micro-relief as well as primitive sandy soils which are being developed in the coastal dunes.

In the coastal range soils are thin and are called 'non-calcic grey'. They are thought to be a special group between the cinnamon greys and the forest greys.

The lowlands of the central valley are filled with pro-alluvial and alluvial glacio-volcanic deposits. It is the country's best farming region.

Soils of dark clays are being formed under aquatic eluvial in the low part of the valley, appearing to be grumosols. The central valley is characterised by soils with horizons with silicate cementation overlain by bleached and gley horizons. Sulphated solonchaks are found in the depressions; alluvial soil of gravel and stone are developing in the river flood plains.

Soils similar to those of the coastal range are found in the Andean region.

In the zone extending from 37 to 42° lat. S the four regions described above are found.

The low maritime sector consists of recent marine deposits, where the prevalent soil group has a granular humic horizon becoming a dark cloddy horizon as the depth increases. Soil reaction is slightly acid.

In this zone the coastal range consists of granites and metamorphic rocks within which weathering strata of red clays of 10 to 15 cm have formed. Acid reaction pH from 4.3 to 5.0.

The central valley is made up of developed soils with deposited gravel of volcanic ash which are the 'trumaos' with a high organic matter content and weak acid reaction (pH 5.6 to 6.2) constituting the amorphous trumao soils. Next to them are the hydromorphs - the 'ñadis', meaning bogs or swamps - which are volcanic soils no thicker than 1.50 m lying on gravel which have a horizon that is compact, cemented and impermeable to water.

Soils similar to the trumaos are formed in gravelly glacio-volcanic deposits also containing volcanic ash. Alluvial soils are also forming in the flood plains of the rivers crossing the central valley.

In the Andean part, trumaos developed into volcanic ash predominate.

The last zone, between 42 and 56° lat. S has as its characteristics a humid sector, an arid sector and the Patagonian pampa.

The humid province has little data on soil types but it is supposed that they are forest grey; in the southern part they could be sub-arctic and in aquatic conditions peat-gley and peat-bog could form.

In Chile the arid region embraces the sectors of Chile Chico and Magallanes whose soils have a very well-defined humic horizon, dark grey and granular lying on a washed or grey horizon. There are no carbonates.

In the southeastern sector soils are podsols with alluvial humus. Bog soils are prevalent in the depressions.

In the Patagonian plains, northeast of the Andean piedmont, soils with a dark humic horizon have developed under which there are gleyed horizons. Soils may be classified as chernozems. The depressions contain solonetz, solods and peat-bog soils.

TABLE 7.4.1

CHILE: RAINFALL DATA

(Precipitation in mm)

Zones	Average	Median	Maximum	Minimum	Maximum / Minimum	Location °Lat.S	Provinces Embraced by Zones
1. Littoral Desert	5.3	1.8	43.8	0.0	00	17°30'-28°50'	Tarapacá to Atacama
2. Transitional Desert	45.8	37.2	214.0	0.5	428	28°50'-29°30'	Atacama (southern part)
3. Transitional Mediterranean	119.9	108.4	353.4	6.8	52	29°30'-30°02'	Coquimbo (northern part)
4. Arid Mediterranean	183.4	170.1	430.0	27.2	22.6	30°02'-31°28'	Coquimbo (southern part)
5. Semi-arid Mediterranean	375.2	345.2	893.4	88.5	13.3	31°38'-33°09'	Aconcagua-Valparaíso
6. Central Mediterranean	650.4	615.8	1345.5	167.3	9.5	33°09'-34°44'	Santiago to Colchagua
7. Sub-humid Mediterranean	895.2	864.8	1561.5	399.2	4.5	34°44'-36°36'	Colchagua to Nuble
8. Humid Mediterranean	1210.0	1181.8	1948.6	624.1	3.2	36°36'-37°59'	Concepción and Araucco
9. Rainy	1987.0	1980.1	2858.4	1263.0	2.3	37°59'-41°12'	Angol to Llanquihue
10. Central Southern	2529.4	2476.9	4125.8	1669.4	2.6	Longit.strips	Llanquihue to Magallanes
11. West Southern	2446.6	2430.0	4778.6	884.3	5.1	" "	Chiloé to Magallanes
12. East Southern	333.4	304.4	586.9	138.7	5.1	" "	Magallanes

Based on: 'Yearly Precipitation Variations in Chile' (Gastó, 1966)

Compilation of Chilean Climatic Data and Corresponding Synoptic Charts

(Almeyda y Sáez, 1958)

(Army Geographical Institute, 1969)

TABLE 7.4.2

GENERAL CLIMATIC INFORMATION FOR LOCALITIES IN ARID AND SEMI-ARID ZONES

LOCALITIES	Average precipitation (mm)					Dry period	Average temperatures (°C)				Altitude
	Total	Autumn	Winter	Spring	Summer	(Months)	Annual	Summer January	Winter July	Maximum January	(m a.s.l.)
1. Fray Jorge	64	27	31	6	-	10	15.2	19.9	10.5	28.4	140
2. Illapel	211	53	137	21	-	9	15.3	19.8	11.5	28.5	510
3. Longotoma	315	73	203	39	-	8	14.8	17.7	11.2	22.6	125
4. Ventanas	344	85	219	40	-	8	14.4	17.6	11.5	22.5	50
5. Peñuelas	649	150	439	60	-	7	14.4	17.6	11.5	22.5	220
6. Santa Marta	360	130	187	43	-	8	14.4	20.1	9.4	28.2	360
7. Colenguado	427	92	286	49	-	8	14.4	17.6	11.5	22.5	130
8. Club de Campo	380	79	234	67	-	8	14.2	20.6	8	29.4	750
9. Rinconada	354	98	214	42	-	8	14.2	20.6	8	29.4	500
10. Floresta	390	100	220	70	-	8	14.2	20.6	8	29.4	390
11. Las Palmas	647	180	390	77	-	8	13.5	20.0	7.5	27.4	70
12. Los Maitenes	617	160	385	72	-	8	13.5	20.0	7.5	27.4	110
13. San Antonio	622	190	349	83	-	7	13.5	20.0	7.5	27.4	120

7.5 ITINERARY AND LIST OF PERSONS CONSULTED IN CHILE

7.5.1 ITINERARY

December 1979

Saturday 1	- Arrival at Santiago from Lima
Sunday 2	- Free
Monday 3	- FAO Office
Tuesday 4	- Farm and Animal Research Institute
Wednesday 5	- School of Agronomics, University of Chile
Thursday 6	- Forestry Institute
Friday 7	- Production Promotion Corporation
Saturday 8	- Free
Sunday 9	- Free
Monday 10 to Saturday 22	- Drafting of report

7.5.2 PERSONS CONSULTED

Agr. Eng. Talia Gutierrez, INIA Arid Zone Programme

Eng. Daniel Claro, INIA Sheep Production and Dry Land Prairies

Eng. Raúl Meneses, Head, Los Vilos Exp. Substation

Agr. Eng. Guillermo García, Prof., School of Agronomics

Agr. Eng. Alfredo Olivares, Prof., School of Agronomics

For. Eng. José A. Prado, Chief, INFOR Forestry Division

For. Eng. Juan J. Aguirre, Forestry Division

Eng. Eduardo Silva A., CORFO

Eng. Germán Bravo, CORFO Pampa Tamarugal Coordinator

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Species	Characteristics and Uses																		Priority
	fuelwood	charcoal	fruit	foliage	shade	poles, building	pharmaceutics	human food	soil improvement	saline soils	drought resistance	wax	food industry	soil protection	rubber	handicraft	furniture making	textile industry	seed oil	
Indigenous																				
Simmondsia chinensis (Link) Schneider	x	x	x	x			x	x			x								x	1
Euphorbia antisyphilitica							x				x	x	x							1
Parthenium argentatum				x							x				x					1
Atriplex canescens				x					x*	x	x			x						1
Atriplex acanthocarpa				x					x*	x	x			x						1
Atriplex spp.				x					x*	x	x			x						2
Pinus cembroides Zuco	x				x	x		x			x			x			x			1
Pinus nelsoni Shaw	x				x	x					x			x			x			2
Prosopis juliflora	x	x	x	x					x		x			x		x	x			2
Prosopis alba	x	x	x	x	x	x			x					x		x	x			2
Prosopis torreyana	x	x	x	x	x	x			x		x			x		x	x			2
Acacia berlandieri			x	x					x		x			x						2
Chilopsis linearis	x	x		x	x	x	x				x			x		x	x			2
Agave spp.											x			x		x		x		2
Opuntia spp.				x				x			x			x						2
Larrea tridentata				x							x		x	x						2
Exotic																				
Eucalyptus camaldulensis Dehn	x	x			x	x					x						x			1
Eucalyptus spp. **	x	x			x	x					x						x			2
Pinus halepensis	x				x	x					x						x			1
Cupressus sempervirens	x	x			x	x											x			1
Atriplex numularia				x					x*	x	x			x						1
Ceratonia siliqua	x	x			x	x														2
Kochia brevifolia				x						x	x			x						1

* Considered to be a soil desaliniser.

** Eucalyptus leucoxylon, E. oleosa, E. populnea, E. gomphocephala, E. bicolor, plus other mainly Western Australian species

8.2 PROVENANCE COLLECTIONS TO BE MADE IN MEXICO

(i) Simmondsia chinensis (Link) Schneider Buxaceae

Common names: 'Jojoba', 'ha howi', 'baya de café'.
Distribution, climate and soil: Occurs naturally in the Sonora and Lower California desert. Adapts to a wide range of climate and soil conditions. Grows well in zones with low rainfall and withstands the competition of other plants. Found in neutral or basic soil (pH 6.8 to 8.9), with light sandy textures and even a certain amount of clay, even with low average depth. Minimum temperatures rarely go below 8°C and maximums rarely exceed 32°C. Not frost resistant. (La Ventana, Coah.) Precipitation ranges between 70 and 350 mm annually with rainfall concentrating in the summer although up to ten months' dry period may occur. Grows from sea level to some 800 m a.s.l.
Genecological variation: Some provenances have been selected for further study, especially from southern Lower California, but no published results on their variation are yet available despite the fact that seed used in plantations comes mainly from that area.
Main characteristics: It is rather a ligneous shrub, evergreen, with several stems or stalks reaching heights between 0.6 and 2.5 m. Leaves are opposite, thick, oblong, with a leathery consistency and pilose epidermis. Flowers occur at the foliar axils. Staminate males and pistillate females are carried on separate plants. The seeds are about 2 cm long, dark coffee in colour and contain approximately 50% oil. They require no special treatment when sown.
Seed collection: August - September. Abundant.
Seed weight: No information.
Important uses: It is a very much favoured forage plant, specially in dry seasons. Its main value lies in its oil production. The seed contains 50% of unsaturated oil which has numerous uses: lubrication (does not become rancid or decompose even after repeated heating), cosmetics as a base for creams and other products, pharmaceutical products, food products, etc. When hydrogenated it forms a solid white wax only inferior to carnauba. A substitute for rubber may be obtained from it for the manufacture of linoleum. Also used as a constituent in printing ink. The residue remaining after oil extraction has a protein content of 30 to 35% which makes it a good supplement in animal feeding.
Establishment methods: The various methods used include planting along contour lines on the upper side of a furrow; planting using various water-catching systems; establishment by direct seeding, etc. As soon as it is possible to distinguish the two sexes, transplanting or elimination of plants is undertaken to obtain a balanced number of male and female individuals.
Suggested collection areas: Because of its scattered distribution and the increased use as an industrial crop it is thought that seed should be collected in the rather isolated areas of Lower California and northern Mexico (Sonora), as well as in commerical plantations to ensure a greater variation of characteristics, thereby allowing for adaptation to varying, specific ecological environments.

Work is presently carried out using seed from collections made in the following seven localities of Lower California:

El Mesquitito	San Pedrito	Cañada Ancha
El Palmar	Cañada Honda	El Abrevadero
Gaspareño		

(ii) Euphorbia antisyphilitica Euphorbiaceae.

Common name: 'Candelilla'.
Distribution, climate and soil: Originating from and spread over the greater eastern part of the State of Coahuila, eastern Chihuahua and Durango and northern Zacatecas, it grows in areas with low rainfall between 100 and 400 mm a year, with average yearly temperatures between 15 and 22°C, with absolute maximums of over 40°C and, in some sectors, minimums of less than 10°C although only occasionally. Grows up to 1 800 m a.s.l..

Soils range from neutral to calcareous and are of varying depth; they are of alluvial origin in the low regions and of colluvial origin on the slopes. Structure is block-like with texture varying between clayey and loamy ('franca'), and even sandy in low-lying areas.
Genecological variation: The adaptation of a species to different altitudes above sea level as well as to different climatic and soil conditions, indicate potential ecotypic variation. In Coahuila and Durango there are potentially approximately 25 different ecotypes of this species, but there are no trials to verify their existence. In any case, there are remarkable morphological differences between specimens from mountainous areas and from lower areas.
Main characteristics: Shrub of varying height, up to one metre, forming stems of different thicknesses; coriaceous, seed with low germinating capacity in the field.
Seed collection: April - May.
Seed weight: No information.
Important uses: Wax is obtained by macerating stalks, which is used in the food industry to harden soft waxes (chewing gums), for water-proofing, for emulsions for giving gloss, for manufacture of carbon paper, diluents, candles, etc.. It is an important substitute for carnauba.
Establishment methods: The most widely used and successful means of establishment is by vegetative propagation, using cuttings or rhizomes. When planted as seed, the plantations yield low amounts of wax; the reasons for this is unknown.
Suggested collection areas: The same as presently, i.e. from natural populations in nature reserves in Coahuila and Chihuahua; collections are being made to select provenances (ecotypes) to be used with the view of increasing wax yield per unit area.

(iii) Parthenium argentatum: Compositaceae.

Common name: 'Guayule'.
Distribution, climate and soil: Its distribution as well as climatic and soil conditions are very similar to those of E. antisyphilitica with which it is often associated. Also found in the southeast of the State of Nueva León as well as in Coahuila, Durango, Zacatecas, San Luis de Potosí and eastern Tamaulipas.

Climatic and soil conditions are described above under E. antisyphilitica.
Genecological variation: Some provenances/ecotypes have been studied with the view of eliminating resins and improving the quality of the product (rubber), but the trials have been temporarily discontinued. They will be resumed in 1980, under a cooperative programme with organizations in Texas, USA.
Main characteristics: Shrub of up to 1.5 m height with lanceolate leaves of a steely colour. Highly resistant to drought, growing satisfactorily in soils of low fertility with a prevalence of limestone.
Seed collection: Flowers from May to October according to altitude and rainfall; therefore collection may be made from October onward.
Seed weight: No information.
Important uses: Latex for rubber manufacture.
Planting system: No information.
Suggested collection areas: Locations neighbouring Saltillo and Torreón.

(iv) Atriplex canescens Chenopodiaceae.

Common name: 'Costilla de vaca'.
Distribution: Widely distributed throughout the arid zone, particularly in Coahuila, Chihuahua, Durango, Nueva León, Zacatecas, San Luis de Potosí.
Climate and soil: Wide range of climates and soils within the arid and semi-arid zones. This forage bush tolerates soils with high saline content and high pH.
Genecological variation: There is no information and no studies on natural variation.
Main characteristics: Shrub of up to 1.40 m with high capacity for regeneration by seed. Drought resistant and particularly adapted to saline soils. Although it accumulates salt in its tissues it is quite palatable.
Seed collection: It produces abundant seeds which may be collected from September onward.
Seed weight: 300 000 to 600 000 seeds per kg.
Most important uses: As a forage bush and to protect and improve soils as a desalinizing agent.
Planting method: Direct seeding in prepared soil.
Suggested collection areas: Coahuila, Chihuahua, San Luis de Potosí, Zacatecas.

(v) Pinus cembroides Succ.

Common name: 'Piñonero' (Mexican Nut Pine).
Distribution, climate and soil: Practically distributed from the plateaux and dry slopes, from 20° lat N to the US states of Colorado and Utah, about 1 200 m a.s.l. in non-consolidated soils of various mountain ranges. Average temperature between 16 and 18°C and precipitation around 300 mm.
Genecological variation: Three sub-species have been recognized: i) var. monophylla Voss with single leaves, rarely paired, occuring in northern Lower California and southern United States; ii) var. edulis Voss, with stouter leaves, usually in fascicles of two, found on the northern Mexican border and the San Pedro Mártir mountain range of Lower California; and iii) var. parryana Voss, with four-leaved fascicles.

Main characteristics: Tree over 10 m high, with external resin ducts and smooth bark persistent for several years. Growing of plants in nurseries presents no problem and is no different from that of other pine species. However, seed production occurs only every two years.
Seed Collection: October.
Seed weight: 3 000 to 4 000 seeds per kg.
Most important uses: Utilized for fuel and building. The fruit is gathered and sold for human consumption. One kilogram of pine nuts at present sells in Mexico City for about US$ 5.00.
Establishment methods: Raised in plastic bags, planted out when the seedlings are some 15 cm tall.
Suggested collection areas: Sierra de Arteaga, Coahuila and Sierra San Pedro Mártir, Lower California; also possibly San Luis de Potosí where it is found in association with P. nelsoni.

(iv) Pinus nelsoni Shaw

Distribution, climate and soil: Occurring in the mountain ranges of north-west Mexico, usually in association with P. cembroides. Average temperature 18° C with a 300 mm yearly precipitation. Rather poor soils.
Genecological variation: No information.
Main characteristics: Low tree not exceeding 8 to 10 m, growing on the lower mountain slopes.
Seed collection: October.
Seed weight: No information.
Most important uses: Fuelwood and timber.
Establishment methods: Same as for P. cembroides.
Suggested collection areas: Northeast range of San Luis de Potosí.

(vii) Prosopis spp.

Common name: 'Mezquite'.
Distribution, climate and soil: Prosopis spp. occurs naturally throughout northern Mexico, chiefly in Coahuila, Chihuahua, Nueva León, Tamaulipas, Zacatecas and San Luis de Potosí.

It develops well in the arid and semi-arid zones with rainfall between 180 and 300 mm or over, and average temperatures about 12°C. Able to survive and grow in sites where no other species are found.
Genecological variation: The 'Mezquite' embraces a great number of species, sub-species or varieties which taxonomically are not well defined. However, the three main species are: i) P. juliflora or P. glandulosa Torrey or both; ii) P. alba; and iii) P. torreyana. The first mentioned is stunted, with a bushy habit; it regenerates aggressively, and could almost be considered a weed. P. alba is a tree of moderate height growing in relatively more humid regions (sub-terranean water closer to the surface). P. torreyana is intermediate between the two.
Main characteristics: The adaptation of the above species to arid and semi-arid zones is remarkable; they thrive both in sandy and rocky soils and are rather tolerant of high saline contents. To germinate, seeds must be treated with sulphuric acid or traverse the digestive tract of an animal.

Seed collection: August onward.
Seed weight: 30 000 to 50 000 seeds per kg.
Most important uses: Forage and fodder, timber, fuelwood, charcoal, soil improvement.
Establishment methods: Transplanting from nursery. No artificial plantings are being made at present.
Suggested collection areas: Northern Mexico.

(viii) Chilopsis linnearis Bignoniaceae.

Common name: 'Mimbre'. (Wicker)
Distribution: Northern Mexico: Nueva León, Tamaulipas, Zacatecas, Chihuahua, Coahuila, Durango, Lower California.
Climate and soil: See Annex 8.4
Genecological variation: No information.
Main characteristics: Grows along brooks or ponds in arid and semi-arid zones; up to 9 m high, diameters up to 0.3 metres.
Seed collection: August - September.
Seed weight: No information.
Most important uses: Furniture making, handicrafts, tool handles, fuelwood, poles.
Suggested collection areas: Coahuila and Chihuahua.

8.3 EVALUATION IN MEXICO: SOURCES AND TEST SITES

Species	Provenance	Test Sites *							
		1	2	3	4	5	6	7	8
Eucalyptus camaldulensis	Australia	x	x	x	x		x	x	x
Eucalyptus microtheca	Australia	x	x	x	x		x	x	x
Prosopis spp.	Wherever available	x	x						
Atriplex spp.	" "	x	x				x	x	x
Kochia spp.	" "	x	x				x	x	x
Acacia spp.	" "	x	x				x		
Pinus halepensis	" "	x		x	x	x			
P. maximartinezzii	" "			x	x	x			
Cupressus spp.	" "			x	x	x			
Simmondsia chinensis	Mexico		x				x		
Euphorbia antisyphilitica	Mexico	x	x						
Parthenium argentatum	Mexico - USA	x	x						

* TEST SITES

1. La Sauceda, Coahuila 1 520 m a.s.l.
2. La Ventana, Coahuila 1 150 m a.s.l.
3. Villa Guadalupe, San Luis Potosí 1 650 m a.s.l.
4. Sierra de Zapaliname, Coahuila 2 300 m a.s.l.
5. Sierra Arteaga, Coahuila 2 500 m a.s.l.
6. Todos los Santos, Lower California 8 m a.s.l.
7. Santo Domingo, Durango No information.
8. Armadillo de los Infantes, San Luis Potosí No information.

NB - Only the most important sites are mentioned. Additions will be made shortly.

8.4 SOIL AND CLIMATE INFORMATION FOR MEXICO

Maps 8.4.1 and 8.4.2 show the climatic and vegetation characteristics of Mexico on the basis of information from the Geographic Institute of the National University of Mexico and the Secretariat for Agriculture and Water Resources, respectively.

Three important ecological zones are recognized: i) an arid and semi-arid zone; ii) a cold temperate zone; and iii) a tropical zone.

The arid zone is defined as that in which precipitation is below 300 mm a year with dry periods of 7 to 12 months, an average temperature between 15 and 25°C, and with a vegetation consisting of xerophytic plants covering less than 70% of the ground (see map 8.4.3).

The semi-arid zone is defined as that with precipitation between 350 and 600 mm, 6 to 8 dry months, average temperatures between 18 and 25°C, and with a vegetation consisting of brush and grasslands covering more than 70% of the ground.

The cold temperate zone has precipitation between 500 and 1 000 mm, with average temperatures of about 15°C and few dry periods. Natural vegetation is arboreal or herbaceous.

The tropical zone has rainfall throughout the year, without dry periods, with high humidity and temperature. Frosts are unknown and vegetation is typically tropical.

The following climatic data, extracted from various sources, correspond to the arid and semi-arid zone:

Place	Location		Altitude	Rainfall	Temperature	Climate
	Lat.N	Long.W	m	mm Annual Average	Annual Average	According to Koepen
Palmillas	23°07'	99°32'	750	408	19°6 C	B Soh
Peñuelas	21°43'	102°17'	1.900	525	19°3 C	BS_{1} (h')
San Luis de Potosí	22°09'	100°58'	1.877	359	17°9 C	B Sok
Tados los Santos	23°00'	110°11'	6	182	22°1 C	BW(h')w(x')
La Sauceda	25°51'	101°19'	1.100	193	19°9 C	BW K

Soils are rather variable. However, in the arid and semi-arid zone predominant rocks and soils derive from the Jurassic, lower Cretaceous and higher Cretaceous periods, forming soils of the 'Chesnut' type in the north of the country, and sierozems from light grey to reddish colour, as well as lithosols in the higher regions. In soils of Jurassic origin there are localized limestones alternating with arkoses, schists and clays. In the Cretaceous soils, in addition to limestone, there are ferruginous concretions and flint nodules.

In the tropical zone in southern Mexico there are red lateritics or red earths which also are found in certain parts of Veracruz.

Yellow soils of the lateritic group are located in the Gulf of Mexico in the Veracruz area, and are associated with red earths extending toward the southeast in the central area of the Isthmus, northern Chiapas, continuing through Jalisco and becoming more irregular in the high altitudes of the Western Sierra Madre. They are considered to be transition soils between the lateritic and podzolic soils and to be derived from a wide variety of rock inclusions in calcareous material.

The 'prairie' soils are located along the western littoral, encompassing the entire State of Sinaloa and part of the States of Nayarit, Jalisco, Colima, Michoacán, Oaxaca and a small area of western Chiapas.

8.5 ITINERARY AND LIST OF PERSONS CONSULTED IN MEXICO

8.5.1 ITINERARY

November 1979

Thursday 15	- Arrival in Mexico from Rome via New York. Attended information ta[illegible] t[illegible] Republic of China Mission to INIF.
Friday 16	- Interview with Eng. William Guerra, FAO. Visit to INIF offices and interviews with some professionals.
Saturday 17	- Meeting with INIF Director General, Eng. Avelino Villa Salas.
Sunday 18	- Bus journey to Saltillo
Monday 19	- Arrival at Saltillo, interview with CIFNE Director, Eng. Lorenzo Maldonado and visit to La Sauceda Experimental Field.
Tuesday 20	- Holiday - anniversary of Mexican Revolution. Inspection of experimental work and overland journey to Torreón observing native vegetation.
Wednesday 21	- Visit to experimental area, La Ventana.
Thursday 22	- Visit to native plantations of Prosopis spp. and Atriplex at Viesca.
Friday 23	- FAO, Mexico City and meeting with INIF Director General and other researchers.
Saturday 24	- Night flight to Lima, Peru.

8.5.2 PERSONS CONSULTED

Eng. William Guerra	- FAO Programme Officer in Mexico.
Eng. Jesús Velásquez P.	- National Chief INIF Forest Management, Mexico
Eng. Luis A. González Leija	- National Chief, Dept Plant Domestication, Mexico
Eng. Avelino B. Villa Salas	- INIF Director General, Mexico
Eng. Lorenzo J. Maldonado A.	- CIFNE Director
Eng. Sergio A. Ortega	- Regional Chief, Forestry Plantations, Saltillo
Eng. Marcelino Zepién B.	- Regional Chief, Multiple Use of Non-timber Forestry Resources, Torreón

CIFNE Engineers and Technical Personnel:

Alejandro Reyes Enríquez
Homero Franco de la Cruz
Mario C. De Llano Proó

8.6 LITERATURE CONSULTED AND CITED

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ANNEX 9 - PERU

9.1 PRIORITY SPECIES: PERU

Species	Characteristics and uses											Priority
	Wood (fuelwood, charcoal)	Fruit, fodder, leaves	Shade, fencing	Windbreaks	Rubber	Parquet	Soil improvement	Drought resistance	Tannin	Saline soils	Craftmarship	
Indigenous												
Prosopis chilensis	X	X	X				X	X				1
P. limensis	X	X	X			X	X	X				1
P. juliflora	X	X	X			X	X	X				1
Capparis angulata	X	X			X			X			X	1
Tabebuia spp.	X					X		X				2
Loxopterygium spp.	X					X					X	2
Cordia rotundifolia					X							2
Caesalpinia corymbosa									X			2
Acacia macracantha		X					X	X				2
Exotic												
Eucalyptus spp.	X		X	X				X				1
*Casuarina spp.	X		X	X				X				1
Tamarix spp.	X		X	X				X				1
Simmondsia chinensis	X	X						X				1

* Also indigenous

9.2 PROVENANCE COLLECTIONS TO BE MADE IN PERU

(i) Prosopis spp. Mimoseae

Common name: 'Algarrobo'

Distribution, climate and soil: Found between 3°23' and 8° lat. S in Peru's arid coastal zone with precipitation between 100 and 600 mm and average temperature of 20 to 25°C, on flat or rolling terrain, sandy or rocky soil generally derived from Eolian or alluvial material from mountain streams, pH 7 to 8.2. Does not tolerate very heavy clays and prefers sites with high solar radiation.

Genecological variation: A study has recently been started on the existing variation and taxonomy of the species complex. It is presumed that there are at least three species: P. chilensis, P. limensis and P. juliflora with a variety of provenances/ecotypes with different characteristics, especially related to their growth habits; stunted, tall with abundant foliage, branchy, with or without thorns, fruits of different sizes and colours, etc.
Main characteristics: Drought resistant due to a very strong tap-root system. In Peruvian conditions the species seeds twice a year. The seed is hard and must be treated with sulphuric acid or pass through the digestive tract of an animal.
Seed collection: There are two seeding seasons: the main one from December to March and a short one in August.
Establishment methods: Direct seeding or transplanting from seed beds when seedlings are no taller than 30 cm.
Seed weight: 18 000 to 35 000 seeds/kg.
Important uses: Abundant fruit producer averaging 50 kg per tree. Used for animal feeding and other domestic purposes ('algarrobina' for beverages, 'galactomamosa', etc.), fuelwood, high-calorific charcoal, poles (immune to termites). Honey tree.
Suggested collection areas: Lambayeque, Piura and Arequipa.

(iii) Capparis angulata Caparidaceae

Common name: 'Sapote' (Sapota)
Distribution, climate and soil: Associates with Prosopis spp. practically throughout its area of distribution, running from northern Peru (Department of Tumbes) to the northern sector of the Department of Libertad, although intermittently. Its main occurances are concentrated in Piura and Lambayeque where soils are in general of the Calciortid group, having a clacic horizon, with a very low organic matter content (0.21-0.34%), and pH from 7.4 to 8.2, with light or moderately light texture. Capparis is drought resistant and thrives even when planted in areas where rainfall is close to nil, although rainfall in its natural habitat is between 100 and 250 mm, with average temperatures between 19 and 25°C. It has been suggested that its leaf conformation and superficial root system may enable it to capture the moisture from mists.
Genecological variation: No information.
Main characteristics: Tree which sometimes grows as a shrub when occuring on dunes. Seed of low viability and subject to attack by xylophagous insects. Highly vulnerable to termites. Difficult to grow in nurseries and very slow growing.
Seed collection: December onward.
Seed weight: No information.
Important uses: Fine grained wood widely used in craftmanship. Also used for fuelwood and the production of resins and mucilages. Its ability to adapt to sandy soils and absorb moisture from mists suggests that it might serve in fixing dunes. However, there is no experimental evidence to this effect and the difficulty of raising the species in nurseries may limit its potential.
Establishment methods: Direct seeding in Piura localities, with irrigation during first developing stages.
Suggested collection areas: Piura and Lambayeque.

9.3 EVALUATION IN PERU: SOURCES AND TEST SITES

Species	Provenance	Test Sites*					
		1	2	3	4	5	6
Prosopis spp.	Wherever available	X	X	X	X	X	
Eucalyptus spp.	" "	X	X	X		X	X
Casuarina spp.	" "	X	X	X			
Tamarix spp.	" "	X	X	X			
Capparis spp.	Indigenous	X	X	X			

* Test sites

1. Piura
2. Tumbes
3. Lambayeque
4. Chicama
5. Tacna
6. Ica

9.4 SOIL AND CLIMATE INFORMATION FOR PERU

Three natural regions can be distinguished in Peru: the eastern jungles and savannas , the central Sierras and the desert coastal zone. These regions are formed as the Andes cross Peru from SE to NW, in a curve parallel to the coast and forming two practically parallel mountain ranges which give rise to three regions with well differentiated climates: hot and dry along the coast, temperate and rainy in the Sierras, and hot and rainy in the jungle.

Coastal soils are in general silty, of alluvial origin and have been covered by wind-borne sands. They border on the Pacific Ocean in desert beaches with deposits of phosphoric rocks. In addition, near the river mouths there are underground salinas rich in potassium.

The climate of the inter-tropical coastal deserts have an average yearly temperature between 18 and 22° C, which is 5 to 7° C lower than that of other locations of the same latitude due to the effect of the cold Humboldt current. Rainfall is scarce and irregularly distributed and may be completely absent for several years; when it does occur it is usually violent and copious, although rarely exceeding 100 mm a year. Relative humidity is high with potential evapotranspiration of between 4 and 32 times the value of rainfall.

The Sierras consist of a series of plateaux cut by deep valleys, with soils generally originating from calcareous rock, mainly cretaceous. There is a transitional climate mainly in the western slopes of the cordillera where temperature decreases as a function of altitude.

The eastern zone is characterized by a temperate to sub-tropical climate. The characteristic climate of the Sierras in general offers an average temperature of about 20°C with an average maximum of 26°C and average minimum of -5°C. Rainfall is very abundant and is concentrated between December and April, decreasing from 900 mm in the north to some 300 mm in the south.

In the jungle zone or Amazonia, soils have been formed from paleozoic schists with granitic encrustations. The climate is typically equatorial with high temperatures and abundant rainfall throughout the year. Temperatures average 25°C with narrow yearly amplitudes. Yearly rainfall lies between 2 000 and 4 000 mm.

9.5 ITINERARY AND LIST OF PERSONS CONSULTED IN PERU

9.5.1 ITINERARY

November 1979

Sunday 25	- Arrival in Lima, Peru from Mexico
Monday 26	- Visit to FAO offices in Lima. Visits and various interviews at offices of the Bureau of Forestry and Fauna.
Tuesday 27	- Holiday, anniversary of the Infantry in Peru. Air journey to Piura.
Wednesday 28	- Visits and interviews at the Piura Regional Bureau. Visit to Prosopis and Capparis plantations with 'aguas negras' (stagnant water).
Thursday 29	- Visit to San Lorenzo Reforestation Programme and indigenous vegetation in Piura and Sullana. Return air trip to Lima at night.
Friday 30	- Interview with FAO Representative in Lima. Various interviews at the Bureau of Forestry and Fauna including the Director of CIZA, Agrarian National University, La Molina.

December 1979

Saturday 1	- Air journey to Santiago, Chile.

9.5.2 PERSONS CONSULTED

Eng. J. Christensen, Officer in Charge, FAO, Lima

Eng. Luis Julio Cueto León, Director-General, Forestry and Fauna, Lima

Eng. Marcos Romero Pastor Pastor, Ass't. Director-General, Forestry and Fauna, Lima

Eng. Hernán Gutiérrez Merino, Reforestation Department, Lima

Eng. José Vargas, Vice-Director, Reforestation, Lima

Eng. Salomé Valdivia Valdivia, Chief, Reforestation Project, Piura

Eng. Armando Román Rosas, Regional Director, Forestry and Fauna, Lima

Biologist Marina Ramírez Ríos, In charge of Flora and Fauna, Piura and Tumbes Region

Eng. José Yovera Suyón, In charge of Forest Plantations, Piura

Eng. Arturo Montecinos Vesallo, Professor, Piura National University

Eng. Carlos López, Ph.D., Director, Arid Zone Research Centre (CIZA), National Agrarian University, La Molina

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