

*ANNUAL REPORT AND
RECORD OF RESEARCH*

JULY 1988 TO JUNE 1989

KENYA FORESTRY RESEARCH INSTITUTE

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FOREWORD

Kenya Forestry Research Institute (KEFRI) was established in July 1986 as a national statutory Scientific Research Institute under the Science and Technology Act, Chapter 250. This is the Third Annual Report and Record of Research since the Institute was established. The report highlights the activities of the Institute from July 1988 to June 1989.

The year 1988/89 was quite a successful one for the young Institute, The Board of Management Concluded the task on rationalization of Research, Development and Management Policies. Significant progress was achieved towards the implementation of research programmes, staff growth, training and dissemination of research findings.

National forestry research priorities were established and a strategic plan to guide KEFRI in the next decade is being prepared. It is my hope that, once completed, the plan will enable the Institute to attract sustained funding.

Collaboration with organizations both within and outside Kenya was strengthened and this has begun to yield useful results. The Institute received assistance from various donors and I wish to extend my appreciation to all of them. At the same time I "would like to call upon other agencies to assist this young Institute to branch into priority areas established during the year. I am confident that with continued support, KEFRI will make effective contribution in economic, social and environmental needs of Kenya.

Prof. Thomas R. Odhiambo
Chairman, Board of Management
Kenya Forestry Research Institute (KEFRI)

PREFACE

KEFRI's mandate is to undertake research, development and application in all aspects of forestry. In fulfilling this function, the Institutes's R & D programmes focus on developing technologies and solving problems that continue to constrain sustainable forestry development and management.

In my last report, I had indicated that plans for a priority setting workshop on national forestry research had been finalized. I am pleased to report that the Workshop was held during the year and it was attended by KEFRI's Board of Management and Scientists, Forestry Managers from Forest Department and Wood-based Industries, Scientists from allied fields and some NGOs. The objectives of the Workshop were to define a sharper focus on R & D programmes. Priorities Identified at the Workshop were:

- (i) Research in silviculture and Forest Environment embracing:
Agroforestry, dryland silviculture, plantation silviculture, forest ecology, tree improvement and tree seed technology.
- (ii) Research in forest/tree protection and support programme.
- (iii) Research in forest/tree products, harvesting and marketing.
- (iv) Mobilization of resources for research including human resources development, institutional linkages, co-operate research, information dissemination and finance.

The Workshop recommendations provided the basis for preparation of KEFRI's Strategic Plan that set out future orientation of the Institute. Preparation of the plan was being finalized by the end of the year. It is my hope that the plan will attract donor funding and that the Institute will soon move into new priority areas identified in the Workshop.

Following the completion of major physical development, the Institute occupied the new headquarters comprising of Administrative Offices, Laboratories, Library, Workshop and Training/Resource Centre. The new facilities have provided a sound base for KEFRI.

There is, however, a need to construct more offices to accommodate Accounts Department. The construction of staff houses at Muguga and Kitui made slow progress.

Construction of an office and laboratory was completed at the newly established Turkana Forestry Research Centre. Within the new facilities, this Centre will be useful for undertaking arid lands forestry research in Kenya. A new Research Centre was opened at Marigat, Baringo District during the year. This centre will address itself to forestry and related land use problems in the drier parts of Baringo and the neighbouring districts.

During the year, 18 new senior members of staff were appointed. The arrival of the new members particularly in Administration and Accounts Department improved the services needed in these areas. Training remained an important area for improving the research capability of KEFRI Scientists. During the year, 5 more Assistant Research Officers went for post graduate training in various overseas Universities.

In my last year report, I had expressed concern on the inadequacy of financial resources for implementation of core research programmes. The situation remained the same during this year. However, KEFRI Scientists did commendable work inspite of the limited funds available.

The plantation silviculture and tree improvement sub-programmes continued on species trials and improved the productivity. Evaluation of long term experiments and analysis of a backlog of data collected over the years started. New experiments in dry areas were established in Turkana, Baringo, Bura and EMI area. Screening of multipurpose Agro-forestry trees and shrubs was started at Muguga and Maseno. CARE-KEFRI trials in Siaya district were assessed and analysed. Existing permanent sample plots in indigenous forests were maintained and a study on ecology and botany of Arabuko-sokoke forest initiated. Considerable progress was made in tree seed production and methods of improving germination in dry areas. In forest products research was initiated on non-wood tree products such as gum resin, tall oil, gum arabic etc. Research continued on wood properties of Kenyan grown timber species and on charcoal production from improved earth kiln.

Mycorrhizal and Frankia research continued and rhizobia studies were initiated for enhancing tree establishment in dry areas. Socio-economic studies as related to forest/tree development and management were undertaken in several areas.

New collaborative research work was developed with the University of Helsinki and the National Museums of Kenya. Collaborative research with various organisations indicated in the last report continued. These included ICRAF, KAKI, ACIAR, MIDP, IDRC, JICA, FINNIDA, NORAD, ODA, EEC AND GTZ. The Institute worked very closely with Forest Department which is the main client.

In an *effort* to improve publication of research findings, an Editorial Committee was established during the year. The Committee has taken its work seriously and better quality publications will be expected in the coming year. The activities of the Institute continued to be disseminated through KEFRI Newsletter, local and international journals, annual reports, monographs, proceedings of various conferences and refresher courses organised for *KEFRI* clients. The standing monthly colloquium continued to provide good forum for interaction among KEFRI Scientists and for exchange of ideas and experiences with visiting scientists.

In conclusion, I wish to sincerely thank all KEFRI staff members for their contribution and enthusiastic support during the year.

J.A. Odera
Director, KEFRI

MEMBERS OF THE KEFRI BOARD OF MANAGEMENT

- | | | |
|----|--------------------------|----------|
| 1. | Prof. Thomas R. Qdhiambo | Chairman |
| 2. | Prof. Fred Owino | Member |
| 3. | Prof. George Eshiwani | Member |
| 4. | Prof. David Ngugi | Member |
| 5. | Dr. Fransis M. Muthuri | Member |
| 6. | Mr. Boaz.R.K Shuma | Member |
| 7. | Mr. Paul K arap Konuche | Member |



Forest Ecology

B.N. Kigomo, BSc MSc, D. Phil
J.M. Were, BSc
J.A. Awimbo (Ms), Bsc
D.K. Muchiri, Dip. For.
B. Owuor, Dip. For.
W. Kipkemoi
F. N. Gachathi
S. Wakaba
F.. Muindi (Ms)
R. Oywer (Ms)
A.N. Mutiso (Mrs)

Senior Research Officer
Assistant Research Officer
Assistant Research Officer
Forester
Forester
Lab. Technologist III (up to March 1989)
Lab. Technician I
Lab. Technician III
Lab. Technician III
Lab. Technician III
Copy Typist

Forest Economics and Policy Studies

P.O. Ongugo, BSc, MSc
J.K. Cheboiwo, BSc
H. K. Kariuki
RX Mutwol
J. Nyala (Ms)
E. Waiganjo (Ms)

Research Officer (arrived November 1988)
Assistant Research Officer
Lab. Technician III
Lab. Technician III
Lab. Technician III
Copy Typist

Forest Entomology and Zoology

M. Gichora (Ms), Bsc
A.L. Owuor, BSc
M.K. Karanja, C&G Lab. Tech.
F.C. Mbathi
J.K. Mbathi
D. Hongo
J.N. Nyamo
J.N. Kabute
H.M. Kuria
E.N. Maruku (Ms)

Assistant Research Officer
Assistant Research Officer
Senior Lab. Technologist
Technologist I
Technologist III (up to December 1988)
Lab. Technologist
Lab. Technician I
Lab. Technician I
Lab. Technician III
Copy Typist

Forest Genetics and Tree Improvement

S.Y.S. Kaumi, BSc
P.O. Oballa, BSc, MSc
F.J. Obiri, BSc
G.M. Muluvi, BSc
J.F. Kamiri, C.& G.
M.D. Kibuku
P.O. Wanjawa
S. Thogo
J.M. Wambugu
V.W. Chege (Ms)

Principal Research Officer (up to August 1988)
Research Officer
Assistant Research Officer
Assistant Research Officer
Lab. Tech. Lab. Technologist
Lab. Technologist III
Lab. Technician I
Lab. Technician I
Forest Nursery Supervisor
Copy Typist

Forest Pathology and Mycology

E.J.M. Mwanza, B.Ed. (Science) M. For. Science
L.M. Mwangi, BSc, MSc
J. Karinga (Ms), BSc
F.M. Munga, Dip. For.
S.K. Waithaka
A. Mukwana
V.J. Mburu
A. Mulongo

Research Officer
Research Officer
Assistant Research Officer
Forester
Lab. Technician I
Lab. Technician I
Lab. Technician I
Lab. Technician I

T.M. Owiyoo
B.O. Ng'ong'a
L.A. Gibera
F. Wesonga
J. Akinyi
L.W. Njuguna

Lab. Technician III
Lab. Technician III
Lab. Technician III
Lab. Technician III
Lab. Technician III
Lab. Technician III

Forest Products Research

B. Chikamai, BSc, MSc
T. Kabii, BSc
J. Githiomi, BSc
D.M. Mikile
A.D. Musekah
J. Kituva
B. Sabaya (Ms)

Research Officer
Assistant Research Officer
Assistant Research Officer
Lab Technologist III
Lab Technologist III
Lab Technologist III
Copy Typist II

Forest Soils

C.K. Serem Dip. Ed. BSc
A.C Yobterik (Ms), BSc
D.M. Kamau, Bsc
G.K. Mbutia
J.K. Lelon
G.N. Ngigi
J. Arek
J. Adundo
M. Kimondo (Ms)
M. Gathara (Ms)

Assistant Research Officer
Assistant Research Officer
Assistant Research Officer
Lab Technologist II
Lab Technologist III
Lab Technician III
Lab Technologist
Lab Technologist
Lab Technician
Lab Technician

Plantation Silviculture

J.M. Kimondo, BSc, MSc
T.O. Omenda, BSc
Kamau Mburu, BSc
J.G. Kariuki BSc
M.Gathura, Dip. For.
C.M. Muchoki, Dip. For.
Njeru, Dip. For.
D.I. Mwangi, Cert. For.
B.K. Wachira
S.O. Ochieng
R.I. Gibera (Ms)

Research Officer
Assistant Research Officer
Assistant Research Officer
Assistant Research Officer
Forester
Forester
Forester
Forester Assistant
Lab. *Technician* III
Lab. *Technician* III
Shorthand Typist

Social Forestry Training

A.Kaudia (Mrs), Bsc
M.N. Muchiri, Bsc, Msc
K. Watanabe
Y. Watanabe
C.K. Kirinya, BSc, MSc
E.K. Kireger, BSc
D.M. Mutta (Ms), BSc
T. Niino
Y. Yanagihara
H. Hatori
H. Yamashita

Training Manager
Research Officer
Chief Adviser (JICA) SFTP
Japanese Expert, SFTP
Research Officer, Project Manager
Assistant Research Officer
Assistant Research Officer
Japanese Expert, SFTP
Japanese Expert, SFTP
Japanese Expert, SFTP
Japanese Expert, SFTP

S. Takabatake
M. Arai
O. Edazawa
L.O. Sabaya
M.O. Mukolwe, Dip. For.,Bsc.
J.C. Njuguna, Dip. For.
GX Kimani, Dip. For.
C.N. Ong'weya, Dip. For.
D.O. Otieno
J.S. Mutange
S.A. Othuon
S. Athanas
C. Sikuku (Mrs)
J.N. Nyamai (Ms)

Japanese Expert, SFTP
Japanese Expert, SFTP
Japanese Expert, SFTP
Senior Lab. Technologist
Forester
Forester
Forester
Forester
Lab. Technician III
Lab. Technician III
Lab. Technician III
Lab. Technician III
Typist
Typist

Social Forestry Catering

T. Owade
Lydia Ngure

Chef
Housekeeper

Tree Seed Technology

W.O. Oloo, BSc, MSc
G. Rode (German)
C. Schaefer (German)
J.W. Wanyondu (Ms), BSc
W.M. Muceke, Dip. For
A. Bora, (Ms) Dip. For.
J. Munyao Dip. For
D.K Musya, Dip. For.
Z.W. Siva, Dip. For.
D.KM. Kinuthia, Dip. For.
J.K. Kiamba
A. Nganga (Ms)
J. Gichana
J. Obango
L. Wambui (Ms)
R. Njambi (Ms)

Research Officer (arrived May 1989)
Research Officer (up to Dec. 1988)
Research Officer
Assistant Research Officer
Forester
Forester
Forester
Forester
Forester
Forester
Forester
Forester Assistant
Lab Technologist III
Lab Technologist III
Lab Technician III
Lab Technician III
Typist

SUPPORT PROGRAMMES

Accounts

B.T.W. Nyala
P.G. Waitimu
J. Makimii
Z. Rao (Mrs)
H. Egesa
J. Chege
S. Oduor
L. Njuguna (Mrs)
R. Gathuru (Ms)
F. Omolo (Ms)

Senior Accountant
Accountant I (arrived March 1989)
Accounts Assistant
Accounts Assistant
Accounts Assistant
Higher Clerical Officer
Higher Clerical Officer
Shorthand Typist
Copy Typist
Copy Typist

Administration and Personnel

R.W. Macharia (Ms) B.A	Senior Administrative Officer
J.M. Gisemba	Executive Officer
A.O. Otieno	Executive Assistant
S.M. Mwaldsha	Personnel Assistant
H.G. Maina	Senior Clerical Officer
J.M. Karanja	Higher Clerical Officer
M.M. Shiakamiri	Higher Clerical Officer
E. Onyango	Clerical Officer
D. Onger	Clerical Officer
D. Muthoka	Clerical Officer
E. Mungai	Clerical O
S. Wambui (Ms)	Clerical Officer
J. Mutua (Ms)	Clerical Officer
P.K Soli (Ms)	Clerical Officer
M. Njoki (Ms)	Clerical Officer
M. Waitherero	Clerical Officer
M. Cumburi	Clerical Officer
S.K Kimid	Clerical Officer
J. Mwaura (Ms)	Clerical Officer
J. Mbogo	Clerical Officer
A.O. Bosibiri	Clerical Officer
E.O. Owino	Clerical Officer
E.M. Mbugua	Clerical Officer
G.M. Kamau	Clerical Officer
M. Maina (Mrs)	Personal Secretary
L. Ndurya (Ms)	Secretary
J. Muirugi	Secretary
E. Mbatia (Ms)	Copy Typist

Information and Documentation

P. Barasa, B.A., Mass Com.	Information Officer (arrived March 1989)
G.H.O Aoko	Technologist
P.H.N. Mairu	Printing Assistant
M.N. Kasango	Printing Assistant
S.N. Kamonde	Printing Assistant (Trainee)
J.O. Otwoma	Printing Assistant (Trainee)
C. Nyogot	Scientific Illustrator
H.A. Oduor	Binder
A.K Wanguyu	Binder
E.N. Kagina (Mrs)	Library Assistant
J.K Koech	Library Assistant
N.A. Achieng (Ms)	Assistant Documentalist
A.M. Wambui (Ms)	Library Assistant (Trainee)

Maintenance

GX Kartuki	Senior Maintenance Officer
J. Gwedi	Artisan
J. Otieno	Artisan
G. Klarie	Artisan
G.W. Rongo	Artisan

A. Karani
W. Onditi
S. Oketch
G.O. Nyanguti
W.O Mate
W. Kiptui
K. Njelewa
L. Chemwalo

Artisan
Artisan
Artisan
Electrician
Electrician
Mason and Joinery
Mason and Joinery
Mason and Joinery

Planning

R.G. Wainaina (Mrs), B.A. M.A.

Planning Officer (arrived March 1989)

Supplies

G.O. Onyango
R.K. Kariuki
E.M Akali
A. Muloki
H.N. Muthoni
B. Ngugi
B.M. Osero
P. Kotacha
E. Ongalo (Ms)

Supplies Officer
Supplies Assistant
Supplies Assistant
Storeman I
Storeman II
Storeman
Storeman
Storeman
Typist

GENERAL REVIEW

MANPOWER DEVELOPMENT

Staff Position

A list of staff of the Kenya Forestry Research Institute is given in details at the beginning of this report. The directorate improved with the recruitment of the Deputy Director, Mr. Paul A. Konuche. The senior staff improved with the appointment of 10 assistant Research Officers from Moi and Nairobi Universities. Mr. Paul Ongugo joined the Forest Economics Division. The Social Forestry Training Programme got much stronger with the recruitment of the Training Manager, Mrs. Alice Kaudia and her assistant Mr. M.N. Muchiri. The Training wing also got a Chef, Mr. T. Owade and a Matron Mrs. Lydia Nguni. Mr. C. Shaefer joined the Kenya Forestry Seed Centre. The recruitment of an Information Officer, Mr. Paul Barasa, an Executive Officer, Mr. John Gisemba, an Accountant Mr. Paul Waitimu and a Planning Officer Mrs. Rispha G. Wainaina towards the end of the year under review was most welcome. During the year, Messrs Sammy Kaumi and Rhode left the service of KEFRI for Uganda and Germany respectively. Mr. Francis Mbatia, formerly with Entomology Division for 32 years retired. Miss. Esther M. Kariuki also left KEFRI services for Canada.

Recruitment of new members of staff particularly in the Administration and Accounts Section improved the services needed in these areas.

Training

The need for improved efficiency in research and development endeavour was realised through improved training of staff. More staff left for training overseas than the previous year. Messrs J.K. Cheboiwo, T. Kabii, and Miss Mercy Gichora left for MSc. in Australia. Messrs J.M. Mulatya and Harry Otieno left for their MSc in Great Britain while Mr. C.K. Serrem also left for Canada for an MSc. study course. Mr. M.O. Mukolwe left for a BSc. course in Australia.

Messrs R.J. Mwendandu and M.M. Wairagu continued with their MSc. study programmes and Miss E.M. Chagalla with her PhD., all in the University of Toronto, Canada. Mr. B. Chikamai undertook a three months course in Japan sponsored by JICA.

A number of technical and management staff enrolled or continued with their study courses at the local polytechnic and colleges.

COLLABORATION WITH OTHER ORGANISATIONS

Close collaboration with other organisations, particularly with the Kenya Forest Department and Non-governmental organizations (NGO's) was maintained. Free consultancies were provided.

The Institute Headquarters collaborated with SIDA, ODA, the Ministry of Research, Science and Technology, National Council of Science and Technology and other local groups in the mounting of the second workshop on setting National Forestry Research Priorities for Kenya. Forest genetics and Tree Improvement division worked closely with the CSIRO, OFI and Forestry Commission of Zimbabwe. Forest Ecology collaborated with the WWF, ICBP, National Museums of Kenya (NMK), IDRC, Moi University and Asian Bamboo and Rattan Research Network. The Dryland Silviculture Division continued their

research collaboration with ACIAR, NORAD FINNIDA, FAO and ODA. The Tree Seed programme benefited greatly from its collaboration with GTZ of Germany. The Agroforestry Research continued its activities in close collaboration with IITA, KARL CARE, ICRAF, AFRENA and other local organisations. Social Forestry and Forestry Economics programmes worked closely with JICA and local grassroot development groups and NGO's. The Forest Soils Research was in close liaison with CARE, several DDC's, KARI and the University of Nairobi.

TRAVEL OUTSIDE KENYA

Mr. David Odee travelled to Dakar, Senegal in November 1988 for a Workshop on Nitrogen Fixing Tree Association. Mr. P. Milimo attended a Workshop on seed biology of *Grevillea robusta* in China and visited Malaysia and Thailand after the Workshop. Mr. E.O. Ochieng visited HTA, Nigeria for a Workshop on species selection. Dr. B.N. Kigomo and Mr. J. Were travelled to India in November 1988 for an International Workshop on Bamboo. Dr. Kigomo also spent February and March in UK and also made a study tour on "Regeneration Management Practices" in Belgium and France in March and April 1989. Messrs J.M. Were and P.B. Milimo travelled on a one week bamboo germplasm collection trip to Tanzania in February 1989. Mr. B. Owuor made a similar bamboo germplasm collection trip to Rwanda in March 1989. Mr. Norman Gachathi attended a two months course on plant identification at Kew, England. Messrs E.K. Kireger, L.O. Sabaya and B.K. Kigwa travelled to Japan for short courses in Social Forestry Project activities.

MAJOR CONSTRUCTION

Construction of 6 senior staff houses at the KEFRI Headquarters, Muguga continued at a slow pace. Construction of the Kitui residential houses came to a stand-still when the contractor deserted.

Construction of an office and a laboratory at Turkana Research Centre was completed during the year. The building of a staff house at Turkana progressed well. A prefabricated office and a small conference room and a green-house were completed at the Muguga Seed Centre with the assistance of GTZ.

FINANCE AND TECHNICAL ASSISTANCE

During the financial year 1988/1989, KEFRI was allocated a total of K£2,360,640 for recurrent expenditure and K£879,190 for development expenditure by the Government. It is noted that the bulk of the development fund was funded through JICA for the construction of the Muguga and Kitui facilities. Provision for Research was greatly inadequate and activities were limited to the maintenance of the on-going research projects.

Several donor Agencies maintained their support. JICA continued to support Social Forestry in terms of personnel, equipment and training. GTZ gave support in equipment, seed collection and two members of staff. ODA continued to support the EMI project and provided staff and funds for tree establishment trials in the dry areas, while IDRC supported the procurement and propagation research on bamboo. W WF provided a small support in the conservation study of the Arabuko-Sokoke forest in the coast. Several donors continued to support concertedly the activities of the AFRENA Station at Maseno. EEC approved a committed support of Nitrogen Fixing Trees rhizobia project which started in June 1989. The Institute greatly appreciated this support that enabled projects activities to continue, and staff training to be stepped up.

KENYA FORESTRY RESEARCH INSTITUTE; BALANCE SHEET - 30th June 1989

		1988	1989
NOTE		KShs	KShs
FIXED ASSETS	2	223,967,783	226,754,317
CAPITAL WORK IN PROGRESS .	7	1,862,033	4,459,937
CURRENT ASSETS			
Debtors		248,274	600,346
Stocks		2,978,924	2,258,509
Cash at bank and on hand		9,699,783	8,546,764
CURRENT LIABILITIES			
Creditors		298,396	1,933,068
NET CURRENT ASSETS		12,926,981 .	11,405,619
		KShs 238,458,400	240,686,805
FINANCED BY:			
GOVERNMENT GRANTS FOR DEVELOPMENT			
	3	14,197,808	26,699,608
GOVERNMENT GRANTS FOR CAPITAL ASSNS			
	4	233,855,842	238,912,589
EXTERNAL GRANTS FOR RESEARCH	5	867,027	1,250,093
EXCESS OF OPERATING DEFICIT OVER RECURRENT GOVERNMENT GRANTS			
CARRIED FORWARD	6	(10,462,277)	(26,175,485)
		KShs 238,458,400	240,686,805

VISITORS TO THE INSTITUTE

The Senior Forest Officers Seminar was held at KEFRI Headquarters late 1988 and was opened by the Minister for Environment and Natural Resources, Hon. J.M. Nyagah. Also present during the function was the Permanent Secretary in the Ministry, Mr. Simeon Sleorima.

Mr. S.N. Arasa, the Permanent Secretary in the Ministry of Research, Science and Technology and Mr. C.R.J. Nyagah, the Director of Forestry, visited the Institute on the occasion of a KEFRI Board of Management Meeting on 7th February, 1989.

On two occasions, 14th February 1989 and 2nd March 1989, the Deputy Director of Forestry, Mr. J.O. Angwenyi visited KEFRI Headquarters in connection with Social Forestry Training courses.

The 1989 KEFRI commemorative tree planting ceremony at Muguga was graced and led by the District Commissioner of Kiambu, Mr. Fred Mwangi on 14th March 1989.

On 21st June 1989, a team of six Japanese working with the JICA visited KEFRI to review the activities of the Social Forestry Training and Development Project.

The President of the IUFRO, Professor Robert Buckman, accompanied by three other persons, Drs. Hans Gregersen and Allen L. Lundgren (both of USA) and Mr. Haluli G. Hilmi of FAO, Rome Italy, visited KEFRI Headquarter on 27th June 1989.

SUMMARY OF RESEARCH ACTIVITIES

Agroforestry

On-station experiments/demonstration plots at Muguga were maintained. A summary was made on an alley cropping trial of several species established at the Machakos dryland research centre. An assessment and analysis of data collected from the CARE/KEFRI agroforestry trials in Siaya District was made. A general multi-purpose tree and shrub screening trial was established at Maseno.

Drylands Silviculture

Baringo Forestry Research Station was opened during the year to support afforestation activities in the dry areas of Baringo District. At the Turkana Forestry Research Centre, two experiments on fodder production on saline soils and production of gum arabic from *Acacia senegal* were initiated. Three species trials were established at Gangara and Galegi areas and another ACIAR trial at Marimanti, Nkando and Lochiathurio through the Embu-Meru-Isiolo (EMI) Project. One ACIAR project was also assessed. A *Melia volkensii* trial plot was established in a farmer's plot at Kivala location in Kibwezi.

Plantation Silviculture

As in the previous year, the Plantation Silviculture division continued its research activities on the introduction and screening of potential plantation species to broaden the plantation species base and avoid reliance on only a few species. Major emphasis went into the analysis of backlog of data that has been collected over the years. One experiment was established at Londiani, Three experiments were assessed at Turbo and nine at Gede.

Forest Genetics and Tree Improvement

Two species and provenance trials (SPT) experiments on *Eucalyptus* species were established at Muguga and Elburgon. Five SPTs were assessed during the year. Two progeny trials of *Pinus patula* and *Eucalyptus grandis* were established at Uplands and Turbo respectively. Two progeny trials were also assessed. New conservation stands of *P. patula* and *Militia excelsa* (mvule) were established at North Kinangop and Ramogi respectively.

Short-term experiments were undertaken on the vegetative propagation of *Vitex keniensis*, *Grevillea robusta*, *C. excelsa*, *Dovyalis caffra* and *Eucalyptus*.

Work on grafting of *Cupressus lusitanica* continued at the Muguga nursery. The Muguga Forest Nursery raised some 250,390 tree seedlings plus some grafted fruits of oranges, avocado, loquarts and apples.

The division also continued with the management of the fuelwood plantations at Muguga. Six hectares were planted with eucalypts along the Veterinary paddocks in the KARI campus.

Forest Ecology

Investigations into the factors influencing the reproduction and growth of seedlings and adults phase of *Brachylaena hulliensis* (muhugu) in natural conditions were completed and summarised. Application of the study findings in the management of this tree were developed. Sample plots of indigenous species established at Chehe, Hombe and Ragati were maintained, assessed and two of them were prescribed for thinning. In the

research and development of bamboo and rattan, eight more species were procured from the regional and Asiatic region through visits to India, Tanzania, Malawi and Rwanda. Propagation and field establishment work continued at Muguga, Gede, Jilore, Kinale, Penon and Nyabeda sites.

A study on the ecology and botany of Arabuko-Sokoke Nature Reserve was initiated; 20 sample plots were demarcated and five of them sampled for species composition and diversity during the year. An ecological succession study was established in March 1988 in Kitui and reassessed in February 1989.

Tree Seed Technology

New methods of seed extraction and testing were developed, tested and recommended especially for *Prosopis* species. A total of 7,039 kg of seeds were collected from all the regional seed collection centres. Seven seed stands totalling 14 ha were established at More, Gede, Kibwezi, Londiani, Ragafi and Muguga. Studies on seed pretreatment of various species continued actively and useful breakthroughs on successful extraction of *Prosopis* species and *Dovyalis caffra* were made.

During the year, GTZ equipped the division with an x-ray for seed viability tests, and an EPSON Personal Computer. GTZ also constructed two prefabricated offices, a seminar and a computer room at Muguga Seed Centre.

Forest Entomology

A plot of *Pinus caribaea* was established as a test on its susceptibility to attack by pine wholly aphid. A study on the life-cycle of *Gonipterus scutellatus*, a weevil, was initiated at Muguga and work on termite control continued at Kitui and Kibwezi. Investigation on the role of millipedes as a nursery pest was concluded and effective control measures recommended.

Forest Pathology

Several tree species were tested for proneness to pathogenic diseases. The most common fungi affecting seeds were *Mucor*, *Aspergillus* sp., *Penicillium* sp., *Fusarium* sp and *Cladosporium* species. In the nursery seedlings studies, leaf spots were found to be common on meru oak, *Melia azadirach* and *Croton megalocarpus*; leaf necrosis on *Kigelia africana* and shot holes on *Prunus africana*. Research continued on the cypress canker and *Armillaria* root diseases. As in the previous years, work on mycorrhiza, *Frankia* in *Casuarina* and field monitoring on die-back of *Pinus patula* continued. Diagnosis of material for tree diseases continued to be done as a service to individuals and collaborating institutions.

Forest Products

Gum resin and tall oil produced from *Pinus radiata*, *P. pinaster* and *P. caribaea* in Kenya have similar chemical composition as that produced in other countries. Trees of the *Burseraceae* family common in the ASALs have great potential for the production of good quality resins for chemical and industrial use.

Research on general properties of Kenyan grown timber species, wood quality of *P. patula* and *P. radiata*, and charcoal production from improved earth kiln continued as in the previous year.

Forest Biotechnology

A study on rhizobia associated with important Nitrogen Fixing trees indicated that *Sesbania grandiflora* and *S. sesban* were specific in their rhizobia requirements while several other species were less specific. A study on low cost method of preserving less durable woods was initiated in June 1989. Investigations on the application of water storing polymer and on vegetative propagation of *Grevillea robusta* and *Dovyalis ca* were initiated

Forest Soils

Soil chemical analysis were carried out as a continuing advisory service. Soil chemical analysis under different agroforestry practices and intended afforestation sites were carried out as collaborative ventures.

Forest Economics and Policy Studies

In collaboration with other forestry programmes, the division undertook several socio-economic surveys of the Yatta B Location, Kitui; agroforestry in South Nyanza District; and agroforestry practices in Siaya District. A survey on the growing of *Acacia meamsii* by small scale farmers was analysed and summarised during the year.

Social Forestry

The division organised nine courses and seminars at Muguga Training Centre and four at the Kitui Social Forestry Training Centre. The pilot forest activities in Kitui were expanded and 60 ha of enrichment planting was undertaken. More planting was done during the year at the Embakasi Commemorative tree planting project.

Information Services

The Institute continued to share the Library facilities with KAKI at Muguga Centre. A small library was opened at the KEFRI Headquarters. JICA contributed a few textbooks. Four issues (Nos 7 - 10) of the KEFRI Newsletter, two booklets and several reports were published.

TECHNICAL REPORT

1 AGROFORESTRY RESEARCH

1.1 Introduction

A number of land use systems exist in Kenya and vary in predominance according to the agro-climatic and socio-economic conditions. There are 6 major land use systems. These include forests, shifting cultivation, mixed arable farming, plantation agriculture, grazing and agroforestry.

Mixed arable farming is the most common farm practice in Kenya. It is practised mainly under mixed subsistence/cash cropping conditions. Among the various types of arable farming, fallow system is the most common. It is characterised by small land holdings on which permanent cash crops are planted as well as food crops. The latter alternates with short fallow periods. Various constraints affect arable farming some of which are:

- (a) Lack of fertility maintenance due to overcropping;
- (b) Soil erosion due to continuous cropping;
- (c) Competition between cash crops and subsistence food crops; and
- (d) Degenerating livestock economy due to lack of fodder.

The agroforestry approach of incorporating woody perennials into existing farming systems is a positive input in view of the importance of trees in the provision of fodder, fruits, fuel and timber as well as in soil conservation.

The research in Agroforestry is undertaken mostly through collaboration with other relevant institutions (e.g. ICRAF) in order to help develop agroforestry technologies for specific land use systems through proper selection, improvement and cultivation of multipurpose woody species for use in agroforestry systems

Objectives

The three broad objectives of research undertaken are to:

- (a) utilize diagnostic methodology to identify agricultural and forestry land-use problems, analyse various constraints and make appropriate recommendations;
- (b) assemble systematic documentation of existing worldwide agroforestry systems out of which new practices and systems can emerge; and
- (c) develop and carry out training sessions in agroforestry and to provide technical support to collaborating departments/institutions, NGO's, etc. involved in agroforestry activities.

1.2 Research Activities

(a) On-station Experiments/Demonstration Plots at Muguga

- (i) An alley cropping investigation incorporating *Leucaena leucocephala* and *Calliandra calothyrsus* in a two-way spacing systematic design.

Objectives

To study the effect of inter-row and in-row spacing on the growth rate and biomass production of the two species as well as to determine the effects on crop yield and soil fertility status.

Results so far indicate that 0.5 m cutting height gives maximum crop production irrespective of the in-row spacing. The 4 m inter-row spacing gave the highest yields when compared to 3 m and 5 m inter-row spacings.

(ii) Tree/grass combination on contour band.

The combination used in the study included *Leucaena* and *Calliandra* species with napier grass. The objective of this experiment is to evaluate multi-purpose tree fodder production when inter-cropped with napier grass. The trial is at its early phase and no results are therefore available.

(iii) Multi-purpose tree/shrubs/grass selection. This comprises of promising species/provenance particularly legumes with considerable potential for fodder. The experiment is also in its early phase. The objective is to determine which trees and grass are best adapted to high altitude areas within the range of 1800 - 2000 m. above sea level.

(iv) Multi-storey boundary planting trials were also undertaken to assess the performance of different agroforestry trees when planted along farm boundaries while inter-planted with species occupying different canopy levels (tree-shrub inter-planting). The trial is too young for assessment.

(v) Another activity undertaken from Muguga Centre was the on-farm survey of various land-use systems and their potential for Agroforestry interventions for purposes of research co-ordination and strengthening of agroforestry research activities. The districts surveyed included: Kiambu, Murang'a, Nyeri, Trans-Nzoia, Uasin-Gishu, Meru and Embu. The related data will soon be analysed and documented.

(b) Dryland agroforestry Research Project - Machakos

The trials being undertaken include:

(i) On-farm alley cropping with *Gliricidia sepium*, *Cassia siamea* and *Leucaena leucocephala*.

(ii) On-farm fodder bank trials with *Leucaena leucocephala* as the principle species. The alley cropping results will be reported in the first quarter of the technical report for Phase II of the Dryland Agroforestry Research Project.

(c) CARE / KEFRI Agroforestry Research Trial Plots in Siaya District

Six Trials/demonstration plots representing different Agro-ecological zones were started in 1986. Good progress has been achieved on data collection, some of which have been analysed and documented.

The maize yields (kg/ha) and tree biomass production as affected by alley cropping with different multipurpose trees in three sites in Siaya District have already been documented.

(d) Eastern Africa AFRENA Zonal Project at Maseno

Considerable work and information have been achieved as a result of good collaboration between ICRAF and KEFRI. A total of 7 experiments and 3 observation plots have been established.

In addition to these, other experiments were also established in 1988/89. These include general multi-purpose tree and shrubs screening trials. In addition to these experiments, a number of demonstration plots have been planted.

There were no major changes in the financial status and arrangement of the projects. The project funds have continued to be administered by CARE and ICRAF in case of KEFRIICARE collaborative research and KEFRI/KARI/CRAF for the AFRENA project respectively.

1.4 Advisory and Consultancy Services

Agroforestry research programmes continued to offer advisory and consultancy services to National Institutions, NGO's and to individual farmers. A major consultancy/review was carried out at the National Museums of Kenya on collaborative work.

2 DRYLANDS SILVICULTURE

2.1 Introduction

The Drylands Silviculture Division undertakes research to guide the management of natural woody vegetation and provide solutions facing the forestry development activities in Arid and Semi-arid Lands (ASALs). The research activities include: studies on regeneration and management of natural woody vegetation; selection of tree/shrub species and provenances for various zones in ASALs; tree establishment studies comprising of, water harvesting, irrigation, etc.; studies to improve the quality of planting stock, and development of dryland tree products.

These activities are implemented through field stations located in representative ASALs ecological zones. These include Tana River (Bura - Hola), Kibwezi, Embu (EMI), Ramogi, Turkana and Marigat (Baringo).

The sub - programme also co-ordinates ASALs forestry research activities undertaken by NGOs and other agencies.

2.2 Research Activities

(a) Turkana Forestry Research Station

(i) ACIAR Species Trial

The objectives of this trial are to test the adaptability of twelve Australian tree/shrub species in Turkana and to compare their performance with those of indigenous species. The plots were assessed once. Due to prolonged drought, some of the species have died.

(ii) Fodder Trial

A total of twenty eight species with potential in fodder production were tried in five eco-climatic zones of Turkana district in the following areas: Kalokol, Kalatumu, Longonot, Karabangarok and Lorengili.

The objectives are to compare the performance of the selected species in these five different ecological zones and identify the best establishment method. Assessment was done during the period and the result showed complete failure of the species tried at Kalokol and Karabangarok. The performance in the other three sites was satisfactory. In these sites, use of micro-catchment improved the survival. This trial has provided useful information to the afforestation programmes in the district.

(b) Fodder Trial on Saline Soils

This trial was established during the year to assess the survival and biomass production of *Atriplex* species, to compare the performance of these species with the local ones, and, to relate the species performance in saline areas. The trial was established in June 1989. There was very little rain during the month hence the seedlings were watered during the first two weeks. This gave the seedling initial good start.

(c) Regeneration Trials

These trials were established at Napuu and Lorgum with the objectives of, assessing and demonstrating the regenerative capabilities of riverine trees including *Acacia tortilis* and *A. elatior*, as well as determining the successional status of *A. tortilis*. Initial data on the plots have been recorded. This is a long term experiment which requires regular maintenance and assessment.

(d) Gum Arabic Production Trials

Studies on gum arabic were initiated during the year to create awareness of the importance of *Acacia senegal* as an income generator, to quantify extractable gum and to monitor the regenerative capacity of this species.

(e) Embu - Meru - Isiolo Forestry Research Project

A number of established trial were maintained except the 1983 species trial at Kauri hill which was discontinued due to poor performance. Three trials were established at Gangara and Galegi areas. During March - April 1989, ACIAR trials consisting of 40, 37 and 41 species were established at Marimanti, Nkando and Lochiathuria respectively. Assessment of another ACIAR trial with *Eucalyptus camaldulensis* has shown that it is most successful and produces good quality poles.

(f) ACIAR Experiments At Gede

Maintenance and assessment of trials established during Phase One was done. However, no new trials were established at Gede during the period under review, other than a demonstration plot of *Melia volkensii*. Based on the performance and results of previous ACIAR work at the station, *E. tereticornis*, *E. camaldulensis* and *E. urophylla* are promising species.

(g) Baringo Forestry Research Station

This station was opened during the year to support afforestation activities in dry areas of Baringo district. The work plan was drawn up and includes evaluation of trials planted under FAO/Australia Fuelwood Project; introducing Australian species through ACIAR Project; and developing forestry extension methods. Trial plots established in April 1988 were maintained and assessed. New trial plots were established in April 1989. All these trials are generally doing well.

(h) Tana River Forestry Research Station

Research at Bura centre on selection and management of species that respond well to irrigation for production of fuelwood. During the year, trials established include: germination experiments on *Terminalia brownii* and agroforestry trials with *Prosopis juliflora* and *Azadirachta indica*. An irrigated *Prosopis juliflora* species and provenance were of *Prosopis chilensis*; ten of *Prosopis cineraria* and 16 of *Prosopis pallida*. Many of the existing trials were maintained. Some trials planted at Hola failed because of drought.

(i) Kibwezi Forestry Research Station

During the year, on-farm research was started and a species trial was established in a farmer's plot at Kivala location. Some of the existing trials were assessed. The results showed that *Dalbergia melanoxylon* was found to be more drought tolerant compared to some of the exotic species. However, it was found to be slow growing.

3 PLANTATION SILVICULTURE

3.1 Introduction

This sub-programme is responsible for generating information and technologies necessary for efficient development and management of industrial forest plantations. The main research activities include: introduction and screening of potential plantation species to broaden plantation species, development of techniques for improving the establishment and management of plantations; and evaluation of the existing nursery techniques.

The programme implements its activities through the field stations at Turbo, Londiani and Gede. The experiments located to the east of the Rift Valley are directly implemented by the main office at Muguga.

During the year under review, research activities in plantation silviculture concentrated on the species/provenance selection and plantation establishment techniques. The programme was also involved in the evaluation of experiments established through collaborative work between KEFRI and CARE - Kenya in Siaya and south Nyanza districts. The joint work between KEFRI and JOFCA on tree growth was assessed. One experiment was established at Londiani while three were assessed at Turbo and nine at Gede.

3.2 Research Activities

(a) Londiani Forestry Research Station

RE 392/89: A direct planting experiment with *Cupressus lusitanica* was started at Masaita 10 (F) on a clearfelled site of the same species. The objectives are to compare the survival and growth rate of trees established by using different pre-planting and tending treatment methods. Other trials at Molo, Elburgon and Londiani were maintained.

(b) Turbo Forestry Research Station

(i) RE - 310: This trial was replicated in seven sites and two replicates were assessed. The objective of the experiment is to compare the performance of various species and provenances of pines in seven different soil types. The replicate 310/5 was located on a site with shallow soils. Most of the provenances failed. The few surviving ones include those of *Pinus oocarpa* var *ochoternia* (Honduras Mort. 73) with survival rate of 68%; *P. pseudostrobus* var *oaxaca* (Mort. 59) with 68% survival and *P. oocarpa* ex *Oaxaca* (Mort 65) with 32%. The surviving provenance of these three species had about the same rate of growth which was slightly slower than that of *P. patula*, the major plantation species.

In replicate 310/6 located on escarpment soils, *P. caribaea* performed better both in d.b.h. and height followed by *P. pseudostrobus*. *P. Montezumae* had the poorest performance.

(ii) RE - 371/75: This was planted in 1975 at Turbo to compare the performances of various *Eucalyptus* species and provenances on vle soils. The species were *E. saligna* (Turbo), *E. grandis* (Muguga), *E. robusta* (Kitale), *E. robusta* (Turbo), *E. camuldulensis* (Kitale), (Pakistan), *E. tereticornis* (Central Africa Republic), and *E. tereticornis* (Kapsabet).

Results at 13 years showed that *E. grandis* from Muguga was the best in growth and survival followed by both *E. saligna* from Turbo and Kitale. The poorest performance was recorded for *E. camaldulensis* from Pakistan.

- (iii) EP 50: A provenance trial of *Liquidambar styraciflua* was established in 1986 to compare the performance of various provenance of this species. It was the first time the species was being introduced in Kenya. At two years survival of most of the provenances was good though the growth was moderate.
- (iv) ACIAR Trials: Trial plots established between 1986 to 1988 were maintained and assessed. The performance of *E. grandis* was very impressive. As a result a progeny trial/seed orchard was established in May 1989.
- (v) RE 372/75: This was planted in 1975 to compare the performance of Eucalyptus on soils with murrum pan close to the surface or within 30 cm. *P. radiator* was included as a control. The treatment were extended to *E. tereticornis* (Kapsabet), *E. tereticornis* (Central Africa Republic), *E. camaldulensis* (Pakistan), *E. camaldulensis* (Kitale), *E. grandis* (Muguga), *P. radiata* - Resistant to *Dothistroma pini*, *Pinus patula*, *E. saligna* (Turbo) and *P. radiator* (non-resistant).

At 13 years, *E. grandis* (Muguga) had the best performance of 28.9 m high, 25.8 cm d.b.h. and 61.396 survival. *E. camaldulensis* (Pakistan) though the best in survival was the poorest in height and d.b.h. at 17 cm and 14.4 cm respectively.

(c) Gede Forestry Research Station

- (i) RE 392/86: The trial was started to compare the performance of six different provenances of *Eucalyptus urophylla*. Five of the provenance came from Indonesia and one from East Timor.

At two years, the best performance was recorded in the provenances from Mt. Mandiri and Mt. Elgon in Indonesia.

- (ii) RE39/89: This experiment was planted in 1980 at Elburgon in order to introduce a broad genepool of *E. grandis* to Kenya, and to establish the natural range from where commercial seeds could be imported. 17 provenances were tested. At eight years, there was no difference among the Australian provenances. The local provenances were equally good.
- (iii) RE 40082: This trial was planted in 1982 at Gede. It had 25 species and provenances. Results at seven years indicated that the best species was *Eucalyptus deglupta* followed by two provenances of *Eucalyptus camaldulensis*, *Doberaglabra*, *Pinus caribaea*, *Acacia aneura* and *Manilkara mochisia* had failed by the sixth year.
- (iv) RE 414/84: The objectives of this trial was to test the growth and survival of species on the deep white sandy soils. The species were *Casuarina equisetifolia*, *E. camaldulensis*, *Leucaena leucocephala* and *C. mopanie*. The experiment was established in May 1948. At five years, *E. camaldulensis* was the best followed by *L. leucocephala*. *C. mopanie* was the poorest.
- (v) RE 416/81: The result at seven years showed significant differences in height but not in diameter among the eight provenances. The best provenances were those of *Eucalyptus urophylla*. The worst provenances were *E. tereticornis* (Turbo) and *E. camaldulensis* (Iondiani).
- (vi) RE 417/81: The trial was planted in 1981 at Gede. Species tried were *Gmelina arborea*, *Terminalia brownii*, *Tamarindus indica*, *Croton megalocarpus* and *Leucaena leucocephala*. At eight years, *Gmelina arborea* and *Leucaena leucocephala* were the most promising while *Croton megalocarpus* was the poorest.

- (vii) RE 419/85: This trial was planted in 1985 to compare the performance of: *Terminalia ivorensis* and *Gmelina arborea* and other hardwoods. At three years, *A. falcataria* failed. *G. arborea* was the best followed by *A. lebbeck*.
- (viii) RE383/77: This was planted in 1977 with an objective of comparing growth and survival of the following six hardwood species: *Albizia procera* (Congo Republic) *Tamarindus indica* (Gede Ruins), *Trachylobium verrucosa* (Gede Forest), *Cassia grandis* (Gede Arboretum) *Fernandoa magnifica* (Arabuko/Kakuyuni and *Azelia quanzensis* (Gede station) At eleven years, mean height varied from 5.6 m to 15.1 m. *A. procera* had the best growth but with low survival of 19%. *A. quanzensis* had the poorest growth but with good survival of 77% 4

4. FOREST GENETICS AND TREE IMPROVEMENT

4.1 Introduction

Forest Genetics and Tree Improvement Division is charged with the responsibility of conducting research to increase the yields and upgrade the wood quality of major plantation species.

During the year the following research activities were undertaken: establishment of new progeny trials, seed orchards, gene conservation stands, introduction of new germplasm and vegetative propagation. Existing experimental plots were maintained while some of them were assessed. The Division continued to be responsible for the management of the arboretum and fuelwood plantations at Muguga.

4.2 Research activities

(a) Species and Provenance Trials

- (i) A provenance trial of *Eucalyptus grandis* was established in June 1989 at Elburgon with material from Zimbabwe. The aim of the trial is to widen the genepool for future breeding work and to determine inter-provenance variation.
- (ii) E.P. 62 - Species and Provenance Trial of *Acacia koa*

This trial was assessed during the year. It was planted in 1967 to test the performance of three Hawaii provenances of *A. koa* species under Muguga conditions. At 12 years, the growth of the provenances has been slow with a mean annual growth of 0.9 cm, and 1.5 cm in height and diameter (dbh) respectively.

- (iii) E.P. 137 - International Provenance Trial of *E. tereticornis*

The trial was planted at Turbo in 1980 and has 22 provenances replicated five times on a randomised block design of 25 trees per plot at 2.5 X 2.5 m spacing. The objectives of the experiment was to introduce new germplasms for faster genetic variability.

The trial was assessed for height and diameter during the year and results indicate outstanding performance of the two Australian provenance from Schacdt's Creek and North Woolgoola (batch No. 10816 + 10775 and 10837 + 10851) At 8 years, these two provenances had a mean height of 20.0m. A local provenance of the same species had a mean height of 14.9 m. Performance of the other 19 Australian provenances was also better than the local ones.

(iv) E.P. 149 - A Trial of Central America Hardwood Species

This experiment has 14 species. It was planted in 1985 and has been replicated three times at Kibwezi, Gede and Machakos. The main objective was to test the performance of the species in order to select species for agroforestry development. The Kibwezi trial was assessed during the year. Results at 3.3 years showed promising performance of *Leucaena leucocephala*, *Gliricidia sepium* and *Senna atomenia*. The latter had not been introduced to Kenya before. The Machakos and Gede plots will be assessed in the coming year.

(v) E.P. 159 - Eucalyptus Species and Provenance Trial

The trial is meant to test the performance of provenances of *E. grandis* (5), *E. sligna* (5) and *E. urophylla* (4). The experiment was established in 1988 at Muguga. At 1.2 years, a Brazilian provenance of *E. grandis* from Embrapa (batch No. 14861 had an outstanding height of 4.0 m. The other provenance of the 3 species had also shown good performance and compared favourably with a local provenance from Londiani.

(vi) E.P. 160 - Pine Species and Provenance Trial

This experiment was established in 1987 at Muguga with the objective of comparing the growth, survival and form of *Pinus patula*, Sub-species *tecunumanii* and *P. oocarpa* provenances. The trial has 12 provenances of *P. patula* Sub. *tecunumanii* from South America. The trial has been assessed and preliminary results show that out of the 16 provenances tested, 3 provenances of *P. patula* sub-species *tecunumanii* were so far the best.

(vii) E.P. 162 - Provenance Trial of *Pinus caribaea*

This trial was planted in 1988 at Gede to compare the performance of four provenances of *P. caribaea* var. *hondurensis*. Assessment at 1.2 years indicated that initial growth rate for all the provenances was slow.

(b) Progeny Trials

(i) E.P. 165 - *Pinus patula* Progeny Trial

This is an open-pollinated progeny trial planted in May 1989 at Uplands. It consists of 40 clones selected from the Muguga tree bank planted in a randomised block design with 16 tree plots replicated in 4 blocks. The objective of the experiment is to compare rates and final volume of different clones.

(ii) E.P. 166 - *Cupressus lusitanica* Progeny Trial

This is also an open-pollinated trial and is established at Uplands. It consists of 24 clones planted in a randomised block design of 16 tree plots. The objective of the experiment is to compare the growth of the clones and determine level of inheritance in stem form, diameter, canker and height characteristics of different clones.

(iii) E.P. 164 - *Eucalyptus grandis* Progeny Trial and Seed Orchard

This is a seed orchard within a progeny trial. It was planted in 1989 at Turbo. It has 216 seedlots planted at 3 X 3 m spacings in a randomised block design of single tree plots. Each single tree is replicated 20 times on site. The trial was replicated at Makuyu.

(iv) E.P.161-Heritable Variation and Genetic Gain Estimate in Half-Sib Progenies of Selected *E.saligna*

The objective of this experiment is to compare the growth vigour and form of progenies of three selected trees of *E. saligna* at Muguga Seedlings from these trees were planted in randomised blocks. Each of the plots has 9 trees with square spacing of 2.5 m.

Results of the trial at 1.5 years showed no significant difference between the progenies in height, branch angle and branches crowding.

(c) Seed Orchards Establishment

A new clonal orchard was established at Londiani in June 1989. The orchard comprises of 28 clones with 784 ramjets at square spacing of 5 m. However, not all the ramjets succeeded at the grafting time. This implies that the planting will be completed in 1990.

(d) Genetic Conservation

(i) *Pinus Patula* Conservation Stand

A genetic conservation stand of *Pinus patula* sub-species *tecununanii* was planted at North Kinangop in April 1989. The stand had provenances from Yucul, Rafael and Camelain from Central America and is expected to offer improved seeds. This sub-species of *P. patula* has already shown superiority over the local *P. patula* species.

(ii) E.P. 157 - Conservation Stand of *Militia excelsa* (Mvule)

This experiment, planted at Ramogi in June 1989 had its seed collected from plus trees from Kwale Forest Station.

The objectives were to; test the resistance of this species to mvule gall fly; determine the effect of spacing and species mixture on the pests; and to establish a gene conservation stand.

(e) Short Term Experiments

In view of the long duration of field experiments, tree improvement programme undertakes short-term experiments covering various aspects of breeding methods and nursery techniques essential in raising good quality seedlings. Some of such experiments include vegetative propagation hybridisation of *P. patula* and *P. radiata*

(i) Vegetative Propagation

The importance of vegetative propagation in the breeding programme remains paramount. This is in view of the fact that vegetative propagation offers maximum genetic gain necessary for increased wood production and tree improvement. Experiments have been carried out on macro-propagation of *Vitex keniensis*, *Grevillea robusta*, *Militia excelsa*, *Dovyalis caffra* and the eucalypts. This involves treatments of cuttings from these species with rooting media, rooting duration and hormonal application. The seedling survival is influenced by the size and age of the cuttings.

Cuttings of *Vitex keniensis* have shown the best rooting rate on sand - vermiculite mixture when raised in the mist propagator. The rooting percentages using various media are shown in Table 4.3.

Table 4.3 Rooting Percentages

	Sand	% Of Rooted Vermiculite	Cuttings Sand Vermiculite	Sand Loam	Averages (%)
Mist propagation	75	80	86	60	75
Glass house	67	60	53	47	57

Further work on this experiment will include hormone treatment and optimum condition suitable for successful rooting in different clones.

(ii) Hybridization Of *P. patula* and *P. radiator*

An attempt was made to hybridise *P. patula* with pollen from *P. radiata*. Pollen was collected from six clones of *P. radiata* two of which were plus trees and four tree resistant to-needle blight. Pollen was enclosed using pollination bags on 25 flowers of 3 clones *of *P. patula*. After two months, 5 flowers seemed to have been fertilized but only one finally survived. This work was interfered with by the fuelwood collectors. It will therefore need to be repeated next season under stricter surveillance and will also include a reciprocal cross breed using *P. patula* pollen.

(iii) Grafting

Grafting remains an important tool in successful propagation of selected parent material. Notable failures have been recorded in *Cupressus lusitanica* and this has been attributed to fungal attack by *Monochaetia unicornis*.

Experiments have shown that graft failure may be reduced by dipping the basal scions end in Benlate solution (0.5 gm in 1 litre water) and there after raising them in a mist propagator unit. Optimum humidity and high temperatures appear to facilitate active meristematic activity at the scion joint. Further experiments on this line will be carried out to investigate aspects of different ages of stocks and scions on graft survival.

(f) Muguga Arboretum

Muguga arboretum has 250 different species planted on 289 plots. During the 1988/89 season, the arboretum was maintained as usual. 78 plots were assessed for height and diameters. Twelve plots were prepared for planting of indigenous species.

(g) Seedling Production

A total of 205, 390 seedlings were raised at Muguga Forest Nursery. Most of the seedlings were sold, others issued free, and some used for setting up new trials. Fruit seedlings raised through grafts in the nursery included oranges, avocados, loquarts and apples.

(h) Fuelwood Plantations

Extension work which involved planting of eucalyptus for fuelwood along veterinary paddocks was started and approximately six hectares were planted. This activity will continue on annual basis until shelter belts along the paddocks and hill tops are covered.

The supply of fuelwood was carried out strictly to the working schedule and compartments 2E, 3M and 4G were clear felled. Singling was completed in compartments 21, 2S and 2Q plus shelter belts within the residential areas.

5 FOREST ECOLOGY AND MANAGEMENT OF NATURAL FORESTS

5.1 Introduction

The research and development work under this Division is focused on the development of technologies for improving the scientific and cultural knowledge of the natural forests so as to provide a better understanding of their development and management. The Division also aims at developing techniques and opportunities for improved management of indigenous tree species in plantations. The programme is also concerned with the forest research geared towards developing knowledge that is applicable to appropriate management and protection of water-sheds in the various eco-zones. The role of natural vegetation in the development of herbal medicine and other cultural utilities have been recognised. The programme has therefore been involved in the identification of plant species, production of check list of plants, local names and uses and documentation of products and to some extent their exploitation methods.

The programme specifically therefore has the mandate to undertake;

- studies on forest ecology, management of natural forests and the biology of indigenous species;
- research on the management of woody vegetation in the different eco-zones in Kenya;
- development of indigenous and minor exotic species under variable environmental conditions for specific end uses;
- investigations on effects of forest management practices on soil and water conservation; and
- studies on vegetation and soil productivity dynamics under continuous forest cropping and natural logging systems.

5.2 Research Activities

(a) Sustainable Management of Indigenous Forests

There exists lack of basic ecological and management information needed for effective management of indigenous natural forests. To address this problem, several studies have been undertaken during the year.

(i) Studies on the Re-generation of "Muhugu" (*Brachylaena hulliensis*)

Investigation into the factors affecting the reproduction, especially germination, survival and growth of seedlings and adults of "Muhugu" have been monitored for the last two and half years mainly in the central highland semi-deciduous natural forests. Salient features of the study results indicate that:

- Muhugu occurs in the Central and Coastal areas of Kenya.

The tree is deciduous and seedlings, saplings and even adults are distributed in patches within a stand, a reflection of the distribution of female trees in the forest. This factor may influence the regeneration of the species and its cutting should be properly prescribed.

Flowering and seed production in "Muhugu" is influenced by the amount of seasonal rainfall and may fail altogether under inadequate rainfall during a particular year.

Up to 80 per cent of seed is subject to pre-dispersal predation by insects and as low as only 2 per cent of the dispersed seed may be expected to be viable. Due to attack by soil organisms, dispersed viable seeds survive upto a maximum of 155 weeks.

- Litter reduced germination rates, and survival of germinated seedlings especially when moisture is limiting.

Exposure of shaded seedlings to full light resulted in damage from scorching and reduced growth. Under natural conditions, seedlings should remain in shade. This will ensure better survival, and healthy seedlings of good form capable of penetrating through narrow openings of the overhead canopy. Seedlings in nursery should be gradually exposed to higher levels of light in order to produce healthy and establishable seedlings.

- Growth rates of "Muhugu" in natural conditions are slow, ranging from 0.13 to 0.44 cm. diameter per year. Low growth rates are attributed to competition and allocation of much energy to reproduction.
- As a shade bearer particularly in the early part of its life and as reflected by the species regeneration dynamics, management under a selection system for "Muhugu" is most recommendable. Cuttings should maintain an optimum ratio of the male and female trees so that regeneration is perpetuated.

(ii) Ecological Surveillance of Sample Plots

As a guide into the understanding of the ecology and silviculture of indigenous forest types as tools for sustainable management and supply of wood, the programme maintains 29 permanent sample plots of different indigenous tree species. Of these, 14 plots of Meru oak (*Vitex keniensis*) around Mt. Kenya region were visited. Sample trees were re-painted and their dbh and heights assessed. The plots were also cleaned during the year. Prescription of two plots for thinning was done.

(b) Propagation and Establishment of Bamboo and Rattan Species

(i) Procurement of Germplasm

During the year, more bamboo and rattan germplasms were procured from different sources and form as listed below. These were acquired through three collection trips to India (November 1988), Tanzania (February 1989) and Rwanda (March 1989), and some were imported.

Provenances Source	Species	Form
Indonesia	<i>Dendrocalamus brandisii</i>	seed
	<i>Bambusa arundinacea</i>	seed
	<i>Dendrocalamus strictus</i>	seed
India	<i>Dendrocalamus strictus</i>	seed
	<i>Dendrocalamus membranacea</i>	seed
	<i>B. tulda</i>	seed
	<i>Bambusa arundinacea</i>	seed
Phillipines	<i>Dendrocalamus membranacea</i>	seed
Rwanda	<i>B. giganteus</i>	offsets
	<i>B. striata</i>	offsets & cuttings

Provenances Source	Species	Form
Tanzania	<i>B. nutans</i> ,	rhizomes offsets offsets offsets offsets offsets offsets
	<i>B. thomicornis</i>	
	<i>B. vulgaris</i>	
	<i>Gigantocloa aspera</i>	
	<i>Phyllostachys henonis</i>	
	<i>Shibataea ruscifolia</i>	
	<i>Teinostachys lenonis</i>	
	<i>Neohouzeana dullooa</i>	

The project also procured limited supply of the following rattan seed.

Species	Provenance Source
<i>Calamus caesius</i>	Malaysia (2)
<i>C. trachycoleus</i>	Malaysia (2)
<i>C. manan</i>	Bangladesh
<i>C. huegelianus</i>	India
<i>C. thwaitesii</i>	India
<i>Daemonorops kurzianus</i>	India

(ii) Seed Germination Tests of Bamboo

Imported bamboo seeds were sown between February and April 1988 and by December 1988, percentage germination at Muguga ranged from 60-84% except for *D. brandisii* which gave 16%.

(iii) Propagation of Seedlings in the Nursery

All exotic bamboo germplasm performed and developed well in the nursery though after six months some species started showing poor growth at Muguga. Preparations are underway to transfer most of these to warmer conditions at Maseno, Ramogi and Gede or Jilore. Seedling survival remained however, high (90-98%) except for *Thyrsostachys siamensis* which experienced heavy loss at the Muguga nursery.

(iv) Species Trials in the Field

Field trials were established at Jilore, Gede, Muguga, Kinale, Penon, Nyabeda and Ramogi. Experience in the field to-date indicate that *Arundinaria alpina* is a suitable species for Muguga, Kinale. *Oxytenanthera abyssinica* showed poor establishment and performance in Muguga, Kinale and Penon.

Gigantocloa aspera (rhizome and offsets) established and performed well at Jilore. At one year, top height is 6.1 m and 5.7 m. The three month old rhizomes and offset materials collected from Tanzania seem to have started off well at Muguga.

In all field trials, establishment and survival are mainly influenced by moisture availability through the year. Watering was done to facilitate establishment where possible.

(c) The Status of the Arabuko-Sokoke Nature Reserve

This project commenced in September 1988 and by June 1989, four site trips had been made. Field activities during the year involved:

- establishment of 20 sample plots of the different sub-communities of the nature reserve;
- data collection in five plots on species composition, tree population structure and ecological factors particularly soil distribution, physical and chemical characteristics; and
- identification of species at the National Museums of Kenya Herbarium and preparation of a preliminary checklist of the species composition in the nature reserve.

(d) Tree/Vegetation Dynamics and Succession in Semi-arid Vegetation

This is a collaborative project with JICA in the Pilot Forest Project in Kitui. A permanent sample plot was established in February 1989 in Yatta B2 Location. Initial woody vegetation species was assessed and a continuous surveillance of the plots under different exposure/disturbance treatments will be closely monitored.

6 TREE SEED TECHNOLOGY

6.1 Introduction

The Tree Seed Technology programme undertakes activities relating to the development of high quality seeds, proper timing for seed collection, sound methods of seed handling, storage and germination. The objective of the programme is to improve seed equality for the entire national planting programmes through the decentralised seed collection activities in different agro-ecological zones. The Kenya Forestry Seed Centre (KFSC) at Muguga is the focus of the programme from where all the regional activities are planned for implementation. Along with conducting and disseminating research findings related to the above activities, other activities of the Tree Seed Division include:

- establishment and management of seed stands and orchards to improve seed production for various species;
- single seed tree selection;
- phenological survey of all seeding tree species in Kenya and tree seed quality control.

6.2 Research Activities

(a) Establishment of Seed Stands

In an attempt to ensure continued supply of high quality tree seeds for future afforestation programmes, the KFSC established various seed stands as shown in the Table 6.1.

Table 6.1

Species	Place/District	Area (Ha)
<i>Cassia siamea</i>	Jilore/KILIFI	1.5
<i>Cassia siamea</i>	Gede/KILIFI	2.5
<i>Dalbergia melanoxylon</i>	Kibwezi/MACHAKOS	2.0
<i>Eucalyptus grandis</i>	Londiani/KERICHO	2.0
<i>Grevillea robusta</i>	Ragati/NYERI	3.0
<i>Warburgia ugandensis</i>	Muguga/KIAMBU	1.0
TOTAL		14.0

(b) Single Tree Seed Selection

Many single trees were selected and marked as seed sources of different provenances. This was done particularly for indigenous tree species which can only be found in mixed natural forests. Seeds from some of these selected trees will in future be used to establish seed stands.

Phenological studies were carried out and compiled for most of the species. The results of these studies will help in organising future seed collection activities.

(c) Seed Pretreatment

Seed dormancy has contributed to reduced seedling production in many nurseries. Seeds of many indigenous tree species exhibit not only extensive dormancy periods but also hard seed coats; factors which affect tree planting programmes. To ensure a steady supply of germinable seeds, several pretreatment methods to break seed dormancy of various species were carried out during the year.

Table 6.2 shows a list of successful pretreatment methods and resulting seed germination percentages (GC%)

Table 6.2

Species	Pretreatment Method	G.C.
<i>Acacia albida</i>	Nipping	99
<i>A. nubica</i>	Hot wire scarification	90
<i>A. zanzibarica</i>	Nipping	92
<i>A. nilotica</i>	Hot wire scarification	88
<i>A. stultimani</i>	Hot wire scarification	94
<i>A. gerrardii</i>	Hot water, 24 hrs till cool	67
<i>A. mellifera</i>	Nipping	96
<i>A. tortilis</i>	Nipping	85
<i>A. brevispica</i>	Nipping	59
<i>A. xanthophloea</i>	Hot water, 24 hrs till cool	78
<i>A. mearnsii</i>	Hot water, 24 hrs till cool	72
<i>A. seyal</i>	Hot water, 24 hrs till cool	60
<i>A. fraxinifolius</i>	Nipping	82
<i>A. reficiens</i>	Nipping	73
<i>Parkinsonia aculeata</i>	Nipping	80
<i>Chorisis ventricosa</i>	Hot water, 24 hrs till cool	79
<i>Delonix regia</i>	Conc. H ₂ SO ₄ for 50 mins	70
<i>Antiaris toxicaria</i>	Sown fresh	67
<i>Zizyphys macronata</i>	Nipping	99
<i>Trachylobium verrucosum</i>	Nipping	74
<i>Sesbania sesban</i>	Cold/tepid water overnight	83
<i>Cassia siamea</i>	Conc. H ₂ SO ₄ for 45 mins	94
<i>Albizia procera</i>	Hot water, 24 hrs till cool	59
<i>Tamarindus indica</i>	Hot water, 24 hrs till cool	88
<i>Cordia sinensis</i>	Conc. H ₂ SO ₄ for 30 mins	57
<i>Afzelia quanzensis</i>	Hot water, 24 hrs till cool	90
<i>Balanites aegyptica</i>	Cold water, for 24 hrs	50
<i>Brachychiton acerifolium</i>	Cold/tepid water for 24 hrs	83
<i>Schinus molle</i>	Sinkers-cold water, 24 hrs	53
<i>Vitex keniensis</i>	Depulped, cold water, 24 hrs	56
<i>A. malanoxylon</i>	Boiling water - 30 sec. then tepid water over-night	62
<i>Militia excelsa</i>	Sinkers	80
<i>Polyscias kikuyuensis</i>	Depulped - sinkers	60
<i>Erythrina abyssinica</i>	Nipping	82
<i>Sesbania macrantha</i>	Hot water, 24 hrs till cool	60
<i>Tecoma stans</i>	Sinkers - soaked in tepid water till cool	72

(d) Effects of various Treatments on Germination of *Sesbania sesban* and *S. grandiflora* Seeds

The aim of the experiment was to raise the overall germination percentage and to hasten the rate at which germination occurs in the two species. Results are indicated in Table 6.3, 6.4 and 6.5 (see page) (insert latter)

63 General Activities

(a) Seed Extraction and Testing

New methods of seed extraction were introduced, tested and recommended. Routine extraction methods were followed for *Pinus patula cones*, *Eucalyptus* spp and those seeds which do not require physical extraction. A new method of extraction for *Prosopis* spp was introduced.

The same drying techniques were used in all the seed collection Centres. This involves spreading the seeds in concrete beds and covering them with polythene sheets. The method proved to be the most economical and practical. In future other methods will be adopted if the price of polythene sheets remain high.

(b) Seed Collection and Supply

During the period under review, a total of 7,039 kg of seeds was collected from all the regional collection centres. This shows a decline from the previous year; the reason being that more emphasis was put to species of high demand rather than seed quantities.

Terminalia mentalis, *Grevillea robusta*, *Vitex keniensis* and *Leucaena leucocephala* were the seeds with the highest demand in the year. Out of the total amount of seed collected, 5,531 kg was dispatched to various programmes during the year. Out of this total, about 3,677 kg (6696) were supplied to the Forest Department while the rest were sold to local NGOs, commercial companies for export. Only small quantities were used for research purposes in KEFRI. The sale of seed earned KEFRI about KShs.100,000 in revenue.

A number of areas remained important sources of seeds of certain species e.g.. Cheche and Ragati for *Vitex keniensis* while Kinale, Nyandarua and Londiani were sources of *Pinus patina*. Due to lack of seed stands and orchards for many species especially of indigenous type, selected mother trees were the most important sources of seeds. It is the aim of the KFSC that seed may only be collected from known and acceptable sources.

(c) Pre-treatments Tests

Table 6.3 Germination of *Sesbania sesban* from different Provenances in the laboratory

Pretreatment	Kisii	Nzoia %	Kitui %	Kakamega %
Hot water	66	58	54	61
Cold water	2	25	62	71
H ₂ S04	77	82	81	78
Hot wire	84	69	54	57
Control	5	38	42	12

Table 6.4 Germination percentage of *Sesbania sesban* from different Provenances in the glasshouse

Pretreatment	Kisii	Nzoia	Kitui	Kakamega
	96	96 %		96
H				
Hot water	66	48	58	61
Cold water	49	38	63	26
H ₂ SO ₄	81	71	79	71
Hot wire	82	80	38	41
Control	13	38	67	29

Table 6.5 Germination Percentages of *Sesbania grandiflora* from Kitui in the glasshouse (G/H) and laboratory (Lab) Different pretreatment

Pretreatment	Laboratory	Glass House
Hot water	39	78
Cold water	38	66
H ₂ SO ₄	66	76
Hot wire	90	89
Control	58	42

6.5 Shows various pretreatment tests

(d) Extraction of Prosopis Species Seeds

Prosopis species are resistant to drought, well adapted to heat and poor soils. 44 species of prosopis particularly *Prosopis juliflora*, *P. chilensis*, *P. alba*, *P. pallida* and *P. tamarungo* are common in Kenya. Due to their capability to fix nitrogen in the soil and to produce good fodder (*P. chilensis*), firewood and charcoal (*P. juliflora*), their seed demand is currently very high.

Extraction of *P. juliflora* seeds is time consuming since it is difficult to separate the seed from the pods. A suitable extraction method is therefore recommended. A method was developed by Bura Forestry Research Project (KEFRI/FINNIDA). Where a mature and dry pod is cut in 2-3 cm pieces. These pieces are then soaked in water to soften the husk for a day. The piece may be ground with a hand operated meat grinder. The ground material is put on wooden trays and spread out for sun drying and then put in a mortar and seed separated from the other material by using a sieve. The recommended pretreatment for the seeds is nipping the seed coat. After sowing the seeds in the nursery, frequent root pruning is necessary.

(e) Extraction of *Dovyalis caffra* (Kei apple) Seed

The seed demand for *Dovyalis caffra* (Kei apple) is very high. Seed extraction is time consuming and the seed technology the programme has been unable to meet the existing seed demand. It is therefore useful to develop a more effective and applicable extraction method. Due to the content of acid substances in the Kei apple fruit, use of plastic hand gloves is recommended during all steps of extraction.

To soften the skin of the mature fruits, they are soaked in water for about a week until they are fermented. The fruits are then turned over daily. When the fruit skin is softened, the fruit is squeezed to separate the

seed from the pulp. All the squeezed material is put on a coffee wire mesh tray which is scrapped until only the seeds are left. The seeds are spread out on a canvas or wooden tray undershade for drying. The water from the squeezed and fermented seeds can be used as a herbicide to combat weeds. Sowing out the seed immediately gives the best germination results. The seeds of *Dovyalis caffra* lose viability within three months.

(f) Buildings and Equipment

A prefabricated building was constructed at Muguga consisting of two offices, one conference room and a computer room. An equipment store and one seed drying bed were constructed at Kitale Sub-centre.

In Londiani and Nyeri, several drying beds **were renovated** to ease congestion. All the construction activities were funded by the GTZ project.

Some seed handling and testing equipment were procured through GTZ. The most notable however was the X-ray machine for seed viability and an EPSON personal computer for documentation and data analysis.

Results indicated that all other treatments except cold water, increased the germination capacity of the *Sesbania* seeds for all the provenances. However, both sulphuric acid and hot wire scarification were the most effective pretreatments. These findings indicated that germination of the two *Sesbania* species seeds are hindered by inability to imbibe water due to the hard seed coat. Consequently, any damage to the seed coat as with scarification or acid treatment will facilitate penetration of water into the seed.

In normal nursery practices, it is not possible to adopt some pretreatment methods, e.g. hot wire scarifications. However, other easier methods like the hot water treatment is recommended before such seeds are sown.

7 FOREST ENTOMOLOGY

7.1 Introduction

The main objectives of carrying out research in forest entomology is to control pest of the important tree species. Control of such pests ensures good wood quality. In an attempt to control tree pests it is important to note the interrelationship between tree and food crops in pest management. Research in this section therefore addresses these issues.

7.2 Research Activities

(a) Pine Wholly aphid

Attempts were made to identify the predators of the aphid purposely to evaluate their effectiveness as bio-control agents. For this purpose, a small experimental plot of *Pinus caribaea* was established during the year.

(b) *Gonipterus scutellatus* (Eucalyptus snout weevil)

Studies on the life-cycle and biology of this insect are currently being undertaken at the Muguga arboretum. These studies commenced within the year under review and therefore reports are expected in future.

(c) Termite control

Termite control is important both at the nursery stage and at the initial stages of tree establishment. They sometimes determine whether a tree grows or not especially in the ASALs. Research in this area was geared towards the determination of a suitable chemical control to replace Aldrin. Trials were set up at Kitui station in 1988, and are still being monitored. Another trial site has since been set up at Kibwezi where the termite menace is more pronounced.

(d) Millipedes

Millipedes are common nursery pests. They cut the young seedlings especially during germination. The main aim of the research work on millipedes was to identify a control measure to ensure high percentage seedling germination and growth. This eventually would reduce the cost of tree establishment

8 FOREST PATHOLOGY

8.1 Introduction

The pathology programme is involved with the diagnosis of causes and control of diseases affecting trees at all levels i.e. from the seed to the mature trees. The programme has generated and documented key information on major tree diseases. The purpose of controlling tree diseases is to ensure maximisation of various tree products as well as tree survival.

8.2 Research Activities

(a) Diseases of Tree Seeds

Several tree seed orchard species e.g. *Antiaris sp.*, *Aningeria adolfi - friedemiani*, *Delonix elata*, *Sesbania sesban*, *Dischrostachys cinera*, *Eucalyptus globulus*, *Juniperus procera*, *Pinus patula*, *Dodonea viscosa*, *Acacia mellifera*, *A. Polyacantha*, *Dobera glabra* and *Salvadora persica* were studied.

Rhizopus stolonifera, *Mucor*, *Aspergillus sp.*, *Penicillium sp.*, *Fusarium sp.*, *Cladosporium sp.* and some unknown fungi were found to be associated with almost all the above tree seed species. Three fungicides were used to control the fungi, i.e. Captan, BeNate and Fernasan D. These fungicides did not enhance germination but inhibited microbial growth. However, the effectiveness of the fungicides will be evaluated in later experiments. However, Captan in low concentration (0.001) was found to be effective in controlling surface fungi. This was followed by BeNate and Fernasan D also in low concentrations.

(b) Diseases of Nursery Seedlings

A number of diseases e.g. leaf spots on *Vitex keniensis*, *Melia azadirach*, *Croton megalocarpus*; leaf necrosis on *Kigelia africana*, and short holes on *Prunus africana* were recognised in nursery seedlings. These foliage diseases mostly affect indigenous tree species. Applications of 1 percent BeNate fungicide was enough to control the leaf spots. more research work is however underway to identify more fungal pathogens attacking the indigenous tree species.

(c) Diseases of plantation trees

(i) Cypress canker

Sibling progenies of *Cyprinus lusitanica* from East Africa 'plus tree' resistant to *Monochaetia uncomis* were maintained at Muguga.

(ii) Armillaria root disease

Studies have shown that three distinct groups based on their appearance exist in Kenya. These groups also differ in their chemical characteristics as evidenced by the analysis of their isozyme patterns and mating behaviour. They are however, different from those found in North America and Europe.

Further studies will attempt to establish whether other species and strains exist and to determine their pathogenicity to the indigenous and exotic plantation trees in the country. Later a quantification of the damage caused by the disease will be undertaken.

8.3 Other research activities

(a) Mycorrhiza research

Trial plots of *Pinus caribaea* set at Kwale, Msambweni, Muguga and Kibwezi were monitored during the year. **The objective was to determine how the species responded to the inoculation with mycorrhiza fungi.**

In similar trials established at Jilore and Gede, at the coast, using *Afzelia quazensis*, an indigenous tree species, mycorrhizal associations were identified.

Isolation of pure cultures of mycorrhiza fungi started during the year. This was done through tissue cultivation of sporocaps obtained from *P. caribaea* seedlings inoculated with spores of locally collected mycorrhiza fungi. *Rhizopogon migrecens*, *Hebeloma crustuiforme*, *Scleroderma bovista* and *Pisolithus tinctorius* were successfully isolated in Hagem media for the first time. Isolation from mycorrhizal roots of *P. caribaea* were not successful even after several attempts.

(b) Nitrogen Fixation in Casuarina

The response of *Casuarina cristata*, *C. cunninghamiana*, *C. equisetifolia*, *C. glauca*, *C. obesa* and *Allocasuarina decaisneana* to inoculation with crushed nodule inoculum of *Frankia* collected from *C. equisetifolia* was studied under glasshouse conditions. In unsterile field soil, inoculation was found to increase overall growth, nodulation, dry weight of shoot and root, and nutrient status of all the above species except *A. decaisneana*.

The interim results also indicated that inoculation of the five species with the endophyte is beneficial in sandy soils in spite of the presence of natural *Frankia*. The endophyte showed host specificity with the genera *Casuarina* and *Allocasuarina*.

8.4 Advisory Services

Advisory service was offered to other KEFRI programmes, forestry institutions and to farmers. **Leaf spots on *Celtis africanum* ex mbagathi and *Prunus africanum* ex kiambu rural nursery** caused by *Phoma* sp. Leaf spots were found to be common according to reports and appropriate advice was given for their control.

8.5 Pathological activities West of the Rift Valley

Turbo and Londiani Pathology section continued with surveillance of disease problems. Some dieback of *P. patula* plantation was reported. Though *Diplodia pinea* were found, it appeared to have been secondary infected due to possible stress through waterlogging. In Sabatia a seven year old plantation of *C lusitanica* was found to be attacked. This disease had spread from old *Grevillea robusta* stumps of a previous plantation.

8.6 Types of Diseases Reported

Several disease problems were reported and diagnosed. Among the diseases reported included:

- (a) Leaf spots on *Celtis africanum* ex Mbagathi, *Prunus africanum* ex Klarnbu rural caused by *Phoma* sp.
- (b) Armillaria root rot on *Cuppressus lusitanica* ex Sabatia *Podocarpus gracilior* ex state Lodge Nyeri caused by *Armillaria*.
- (c) Stem rot of *Melia volkensii* cuttings from ASALs Forestry Research Programme caused by *Fasarium*.
- (d) Mildews on *Celtis africanum* seedlings ex Upper Matasia Ngong caused by *Erysiphe* sp.
- (e) Short holes on *Prunus africanum* ex social forestry Project nursery caused by *Phoma pruni*.
- (f) Leaf yellowing on *Podocarpus gracilior* ex State Lodge Nyeri caused by *Corynelia uberata*
- (g) Dieback on *Pinus patula* ex Turbo Forest associated with *Diplodia pinea*.
- (h) Damping off of *Pinus radiata* seedlings ex Muguga nursery caused by *Pythium* sp.

9 FOREST PRODUCTS

9.1 Introduction

Forest products programme generated useful information in relation to maximum utilization of wood products. Research activities in this area is based on the observation that there is widespread inefficient use of wood, neglect of non - wood products, poorly defined wood marketing structure and technology transfer to target groups. The activities were designed with the objective of addressing these issues. Efforts have been made towards identification of more forest/tree products and their possible sources. Research in the development and promotion of lesser known wood products in panel, furniture, carvings and related sector is also being emphasised.

9.2 Research Activities

(a) Gum Resin and Tall Oil Production

The objective of this research activity were to evaluate the quality of gum resins and tall oil produced from *Pinus radiata*, *P. pinaster* and *P. caribaea*. In addition to these, the effects of tapping on wood quality and chemical analysis of the resins and oils were undertaken.

Results from these studies have shown that the quality and quantity of gum resin and tall oil produced are good. Their chemical composition conform to those from other countries where similar work has been done.

(b) Analysis of gum from *Acacia senegal*

The objectives were to evaluate the quality of Kenyan produced gums and to compare the results with the known standards. It was found that the quality of Kenyan produced gums, though lower in quality than those from Sudan, could be improved through better management.

(c) Chemistry of resins from Burseraceae family

Trees from this family are abundant in the ASALs. Their development to produce resins which are currently in very high demand in the world may enhance the development of the ASALs. The objective is therefore to develop strategies for the exploitation of this potential with the emphasis on:

- (i) The production of general comparative monographs describing physical and chemical characteristics of the resins, and
- (ii) To carry out detailed analysis of chemical composition of the resins for use in perfumery and pharmaceutical industries. This study has so far indicated that trees of the above family have a great potential for the production of good quality resins for chemical and industrial use.

(d) To identify general properties of Kenyan grown timber and other commercial tree species.

As a result of the above research work, adequate information on most of the Kenyan grown timber, including indigenous tree species has been collected and is available as reference material.

(e) Assessment of wood quality of *Pinus patula* and *pinus radiata* and its impact on industrial use

Due to their susceptibility to blue stain, timber from the above tree species is not suitable for industrial use. Most people prefer timber from Cypress trees. The study has established that with good treatment and handling, timber from *P. patula* and *P. radiata* is comparable to that of Cypress.

(f) Establishment of clear wood strength value for Kenyan commercial Cypress and Pine

Strength values are important in wood constructions. This study was started with the objective of making available to users, strength values of the above timber species most commonly used in Construction. Strength values have been accumulated and more work is still going on to improve them.

(g) Charcoal from improved earth kiln

The efficiency of charcoal production has been very low as most of the producers use poorly constructed and managed earth kilns. The objectives of carrying out this study was to improve charcoal production in terms of quality and quantity. Result of this study have shown that by improving traditional earth kiln, charcoal production can be increased by about 2596 in terms of quality and quantity thus controlling wood wastage common in the traditional charcoal burning methods.

(h) Charcoal recovery and quality

Three methods of charcoal production were compared for evaluation purposes. Considering all factors, the improved earth kiln was found to be the. most efficient charcoal burning method compared to drum and sectional metal kilns.

10 FOREST BIOTECHNOLOGY

10.1 Introduction

The purpose of Biotechnology research is to support forest development and management. Research focused on both fundamental and applied aspects relevant to forestry and tree development. Priority areas include; microbiological research of biological association, particularly nitrogen fixing trees and rhizobia symbiosis studies, tissue culture technology for the development of mass vegetative propagation.

10.2 Research Activities

(a) Rhizobium Biotechnology

Following a preliminary survey of Rhizobia associated with important Nitrogen Fixing Tree (NFTs) which began at the inception of the division, our culture collection has accumulated 70 productive Rhizobium isolates with another 40 culture isolated from a broad spectrum of NFTs from different areas in the country.

The rhizobial germplasm provides a broad genetic variability from which adaptive strains to various environmental conditions can be selected for high nitrogen symbiotic association with selected tree species. Filter mudbased Rhizobium inoculum are being produced for utilization by farmers, foresters and researchers on request.

A cross - inoculation study has been undertaken using the following nitrogen fixing tree species: *Acacia albida*, *Acacia mearnsii*, *Calliandra calothyrsus*, *Leucaena leucocephala*, *Prosopis juliflora*, *Sesbania sesban* and *Sesbania grandiflora*. It was found that Rhizobium strains isolated from the NFTs were variably effective and that on the basis of beneficial symbiosis, *S. grandiflora* and *S. sesban* were specific in their rhizobial requirement while the other species were less specific.

(b) Wood Preservation

A low cost method of preserving less durable woods has been under investigation. Emphasis has been put on the preservation of Eucalyptus species for poles and posts. The method uses a preservative. A trough made from 200 litre oil drum holds the preservative and uses fuelwood to accelerate impregnation. In addition, various timber species have been subjected to different chemical treatment and concentrations to determine their efficacy and durability under different environmental conditions. Evaluation of various methods of application (pressure and non-pressure) and timber pre-treatment preparations (seasoning removal of the bark, incising, pre-cutting/boring etc) is under investigation.

(c) Tissue Culture Technology

Tissue culture technology is being explored for tree species where seed production is not possible or viability of the seed is low or the seed deteriorates very fast. Current basic work involves the use of plant parts rather than depending on the process of sexual fertilization (seed).

(d) Water Storing Polymer

This is an on-going study set up to assess the effects of different levels of polyacrylamide P4 Polymer on water loss from sandy soils and on establishment and the survival of transplanted young seedlings of *A. albida*.

11 FOREST SOILS

11.1 Introduction

The main research mandate of the Forest Soils Division is to collaborate with the other research programmes of KEFRI in areas relating to the influence of soils on forestry development. The programme is therefore expected to develop knowledge on the effect of silvicultural and tree harvesting practices on sustainable productivity of wood, water quality and general soil nutrients with a view to developing conservation models that would forestall as well as mitigate retrogressive impact of these activities on environmental quality. This would also promote rehabilitation of degraded lands.

11.2 Research Activities

(a) Service Research/Advisory Services

Since its inception in 1985, the Forest Soils Division has mainly dwelt on service research. This involves giving service to other divisions of KEFRI (including out-stations), Non-Governmental Organisations (NGO's), and Ministry of Environment and Natural Resources (MENR). The service includes soil sampling in the field and their chemical analysis. A soil report is documented for the samples analysed.

(b) Soil Chemical Analyses

Apart from the routine soil chemical analyses done on experimental plots, the main objective is usually to evaluate the nutrient element status of the soils in relation to the growth of trees. The soil chemical analysis done in the laboratory include, pH, percent organic carbon, total Nitrogen, Bray Phosphorus, macro-elements (Calcium, Potassium, Magnesium, Sodium) and micro elements (Zinc, Copper and Manganese)

11.3 Collaborative Projects

(a) Dryland Agroforestry Research Project, Machakos

This is a continuing project based at Katumani and deals with trials on the use of leaves of *Leucaena leucocephala*, *Cassia siamea* and *Terminalia brownii* as mulches in the enhancement of soil nutrients. The objective has been to observe the effects of continued green manuring on the some piece of land. So far five seasons have already been sampled and four of them have been analysed. The tentative conclusion were included in the 1986/87 annual report. The latest samples collected in 1988 are in the process of being analysed.

(b) Siaya CARE (K) / KEFRI Agroforestry Project

This is a continuing project based at 5 sites in Siaya District. The sites are located at Abayo, Nyasanga, Bondo, Sigomre and Nyabeda. The project aims at examining the possibilities of maintaining or increasing productivity of cropping systems by establishing an alley cropping system using *Calliandra calothyrsus*, *Leucaena leucocephala*, *Markhamia lutea* and *Gliricidia sepium*. One of the objectives is to monitor the effects of the nutrient status and productivity of a site. So far, two seasons soil results have been analysed. The fourth season soil samples were collected in December 1988. A soil report for the second season is being compiled. Results of the first season and a report on biomass, growth rate and woodlots growth data have been documented.

(c) South Nyanza Afforestation Programme

A soil survey was carried out at Asego and Gembe Hills in South Nyanza in May 1988. The overall objective of the project was to improve the communities welfare through tree planting. The main approach was through reforestation of major hills in the district and encouraging individual farmers to grow more trees. 108 soil samples were collected and analysed.

11.4 Experiments Results

A summary of the results is presented in Table 11.4

Soil pH

A mean pH for Asego Hill ranged from 5.7 - 7.0 from the top to the bottom of the hill indicating that the soil acidity decreases down hill. There was no particular trend for the Gembe Hill. However mean pH range was 4.6 - 7.2

Percent Organic Carbon (% O.C.)

The % Organic Carbon for Asego Hill ranged from 3.18 - 6.69% at the bottom and at the top of the hill respectively indicating that the % Organic Carbon content increase up hill. The same trend existed for the % Organic Carbon of the Gembe Hill, although the values were lower ie. 2.17% - 2.63%.

Phosphorus (P), PPM

The **phosphorus** content for the Asego Hill soils ranged from 3.30 - 4.60ppm from the top to the bottom of the hill respectively. This indicates that the **phosphorus** level increased from the bottom of the hill base to the top. There was no particular trend for the **phosphorus** values of the Gembe Hill. However, the values ranged from 5.73 - 8.84ppm. In both hills, the P level are low as compared to the critical level of 20ppm. **Phosphorus** deficiency at the two hills may therefore be expected.

Percent Total Nitrogen (% T.N.)

The mean % Total Nitrogen for Asego Hill ranged from 0.252 - 0.63% from the hill base to the top. This implies that the % T.N. increases from the bottom of the hill to the top. There was no particular trend for % T.N. levels for the Gembe Hill. The value for the Gembe Hill ranged from 0.154 - 0.203%.

Potassium (K) PPM

The K values for Asego Hill ranged from 1.07 - 2.71ppm from the bottom of the hill to the top. This shows that the K content increased up the hill. No particular trend was identified for the Gembe Hill. K values for this hill ranged from 1.22 - 1.61ppm. In both hills, the K values showed low levels from the critical level of 0.2mg/100g soil (7.6ppm) indicating a possible K deficiency.

Sodium (Na) PPM

The values for Asego Hill ranged from 1.34 - 2.66ppm. However, no particular trend existed. For the Gembe Hill, Na values ranged from 2.29 - 3.56ppm at the bottom of the hill to the top respectively indicating that Na content increases up the hill. These levels from Na in both hills are relatively low.

C:N Ratios

In general, the C:N ratio of Asego Hill was narrower than that of the Gembe Hill ie. 11:1 and 13:1. For most stable soil systems, this ratio is 12:1, hence the value obtained for the two hills conforms fairly well.

Table 11.4 Soil tests and analysis (1988)

Year	Site	Season	pH	%Organic Carbon	%Total Nitrogen	Bray (PMM) Phosphorus	Potassium (PMM)	Sodium (PPM)
1988	Hola	-	6.0-0.81	0.27-0.81	-	-	-	-
	Kangundo	-	7.0	1.12	-	3.70	-	-
	Kitale F.S.	-	5.2	2.42	-	1.76	-	-
	Marigat	-	5.4-7.9	0.30-0.83	-	0.55	-	8.25
	Kibwezi	-	-	1.90-3.62	-	-	-	-
	Tsavo R.S.	-	4.2-5.9	0.10-0.58	0.01-0.64	0.74-14.60	1.40-3.5	-
	Uhuru Gardens	-	5.4-6.9	0.90-5.22	-	0.60-3.9	-	-
	South Nyanza	-	4.6-7.7	0.28-10.95	-	0.10-19.04	0.20-4.0	-
	Ngong Hills	-	6.2-6.4	4.84-6.02	-	0.10-0.69	-	-
	Kaptagat F.S.	-	6.4	6.68	-	-	-	-

11.5 Future Projects

According to the recommendation of the Nyeri Workshop on Setting National Forestry Research Priorities, the Soil Programme was expected to establish five core projects as follows:

- (i) Studies on soil mixture and techniques for **improved seedling production**,
- (ii) **Soil Productivity studies under agroforestry and continuous forest plantation cropping** systems,
- (iii) **Soil microbiology in forestry and other land-use systems**,
- (iv) **Soil moisture conservation techniques for seedling survival**, and
- (v) Studies on soil erosion as related to watershed.

12 FOREST - ECONOMICS AND POLICY STUDIES

12.1 Introduction

The **Forest Economics and Policy Studies Division in its research mandate** has three major objectives which are to:

- provide information on all matters relating to forest socio - economic surveys, data analysis and project evaluation;
- generate data and information on basic and, applied research in socio-economic and forestry policy, and
- provide consultancy services to individual, groups and institutions on matters concerning forest socio-economic and policy studies.

12.2 Research Activities

(a) Socio- economic surveys of a social forestry project in Kitui district

The division in collaboration with the Japan International Co-operation Agency (Social Forestry Project) carried out Socio- economic survey of the Yatta B Location. Two such surveys have so far been undertaken.

(b) Assessment of Agroforestry research needs of South Nyanza district

In conjunction with South Nyanza district Afforestation Project, a study to determine forestry research needs for the district was carried out and documented.

(c) The status of *Acacia mearnsii* cultivation by the small scale farmers

A survey and documentation of the cultivation and utilization of *Acacia mearnsii* tree species was carried out. This report is due for publication as a KEFRI Technical Note.

(e) Agroforestry practices in Siaya district

A documentation study of Agroforestry practices in Siaya district was completed and is currently being edited.

The division is in the process of compiling a detailed information report on forestry statistic to be used in Forestry and related research work.

13 SOCIAL FORESTRY DEVELOPMENT AND INFORMATION SERVICES

13.1 Introduction

The Social Forestry programme is involved in the dissemination of research findings that pertain to forestry development and especially farm forestry. The programme has the following four main components: Social Forestry Training Project; technology development and extension liaison (Pilot Forest); information and documentation; and urban amenity forestry.

The specific objectives of the programme are to: develop technical and economic packages to enhance farm forestry and community forestry; pioneer research on traditional uses of trees for domestic, industrial, medicinal and nutritional purposes; service other programmes of KEFRI in publishing, printing and disseminating research findings and refreshing the minds of those involved in forestry extension as well as farmers in social forestry activities through in-service training sessions held at Muguga and Kitui.

13.2 Activities

Details of activities

(a) Social Forestry Training

Table 13.2 (1) shows the courses and seminars held at Muguga while Table 13.3 (ii) shows courses conducted at Kitui.

Table 13.2 (1) Courses and Seminars held at Muguga National Social Forestry Training Centre

Course Title	Date	Participants
First National Forestry Seminar	31.8.88	Senior Officers of Forestry Dep., NGO's, other Govt. Dep.(102)
Social Forestry Refresher Course I	21-25.11.88	Middle level scientists, senior officers of FD, NGO's and other Government Dep./Ministries (9)
Social Forestry Refresher Course II	25.9-1.10.88	Senior & intermediate level, officer of FD at the district level, from NGO's and other Govt. dep./Ministries (22)
Social Forestry Refresher Course I/II	18-22.10.89	As in Refresher Course I&II (28)
Social Forestry Extension Officers Course	13-22.2.89 27.2-8.3.89 5-14.6.89	District Forestry Extension Officers & other Extension Officers from NGOs & other Ministries (34)

Course Title	Date	Participants
Social Forestry Prize Day	26.4.89	Outstanding NOO groups & individual farmers at the grassroots' level (80)
Forest Department Senior Staff Seminar	31.1-3.2.89	Senior Forestry Department Staff (110)
C.A.R.E. Research Assistants Course	22.1-3.2.89	CARE Field Research Asst. (7)
USAID Tree Seed	5-15.12.89	African Seed Technicians

Table 13.2 (ii) Courses held at Kitui Regional Social Forestry Centre

Courses Title	Date	Participants
Short Course for Nursery Foremen	14-17.12.88	Representatives of voluntary groups' nurseries from Kitui district (24)
Short Course for Nursery Forestry	24-27.1.89	Nursery Foremen of Forestry Departments, Kitui (29)
Short Course for Nursery Foremen	14-16.3.89	Representatives of voluntary Nursery Foremen groups' nurseries from Kitui district (14)
Nursery Foremen Course	11-17.1988	Nursery Foremen of Forest from Embu, Machakos & Meru (30)

(b) Pilot Forest Activities

The pilot forest activities in Kitui are expanding to include: the testing of various tree planting methods; testing the performance of a wide range of species; and developing techniques for raising high quality seedlings stock. A regeneration successional plot was established at Tiva. Assessment of 1987 plantations was undertaken. Through enrichment planting, about 60 ha were planted. There was poor survival of the 1987 plantings as a result of severe drought.

(c) Urban Forestry Activities

The Commemorative Tree Planting at Embakasi progressed well. Over one thousand seedlings are doing well as a result of good tending. A number of species have shown good performance on the poorly drained black cotton soils of the lower parts of Nairobi.

(d) Library Service

The Institute continued to share the Library services with KARI/Muguga. During the year, a new Library was however, opened at KEFRI Headquarters. JICA helped in the purchase of a number of reference books. Efforts were made to acquire more books by sending requests to various organizations.

(e) Information and Documentation

This division has extensively supported all the programmes through documentation, printing and publishing of research work.

PUBLICATIONS

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- Muchiri, M.N.and Waiyaki, J.N. Constraints to procurement of resources for Forestry research in Kenya.
- Mwangi, L.M. Strategies for strengthening KEFRI's out - stations.
- Mwanza, E.J. Research priorities in Forest pathology and Mycology.
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- Odera, J.A. Development of Social Forestry and the role of research.
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- Ongugo, P.O., Farmers attitude to tree planting in relation to Agriculture.
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TITLE

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- * Biological basis for intercropping in agroforestry. D. Nyamai
- * Human population growth and its consequences on forestry. J.M. Kimondo
- * Some aspects of Natural Regeneration and their application in determining sustainability and management of natural forests. B.N. Kigomo
- * Timber preservation methods for developing countries. T. Kabil
- * Kenyan Forest insect pests and their proposed pest management. M. Gichora