Joint KEFRI-FD National Conference

Forest Department/MENR

on

"The State of Forest Research and Management in Kenya"

Proceedings

3-5 June 1996
Muguga

Assisted by

The State of Forest Research and Management in Kenya

Proceedings of Joint KEFRI-FD National Conference held from 03-05 June 1996 Muguga, Kenya

Edited by:
Balozi Kirongo Bekuta
Rolf Schulzke

Published by:
Promotion of Sustainable Forest Management - KEFRI/FD/GTZ
German-Kenyan Technical Co-operation

Published and distributed by:
Promotion of Sustainable Forest Management-KEFRI/FD/GTZ
Kenya Forest Research Institute
P.O. Box 20412 Nairobi, Kenya
German Technical Co-operation (GTZ)
P.O. Box 41607 Nairobi, Kenya

Printed by:
Executive Printing Works Ltd.

February 1997
Nairobi, Kenya

ISBN 9966-9897-4-9

Table of Contents

Page No.

Page No.

FOREWORD

A joint Kenya Forestry Department (FD) and Kenya Forestry Research Institute (KEFRI) conference was held from the 3rd to the 5th of June, at Muguga, Kenya.

Concern for the wise use of the already dwindling forest resources in Kenya (approx. 2.7% of total land area) necessitated the convening of a national conference to consolidate all the available information on the management of the few remaining natural forests, dryland biodiversity and exotic plantations.

The conference brought together a total of 178 participants comprising of forest researchers, managers and representatives from the donor community, NGOs and private forestry organizations.

In discussing the "State of Forest Research and Management in Kenya", the participants heard views and suggestions on all important fields of Research and Management, Biodiversity Conservation, Education and Extension needs which were addressed in 10 sessions.

A brief session was held to commemorate KEFRI's 10th Birthday!

In publishing these proceedings, we assume that the contents of the papers have not been reported elsewhere before; and if they have, then the responsibility is solely with the Author(s). We hold no responsibility on the reporting, contents or any part thereof.

Some papers were left out either because they didn't meet the deadline or presented only preliminary results due to the state of research.

Balozi Kirongo Bekuta
Plantation Silviculture
KEFRI

Rolf Schulzke
Research Management Expert
GTZ-PSFM Project

ADDRESSES

Address by:
JÖRG ALBRECHT
DEUTSCHE GESELLSCHAFT FÜR TECHNISCHE ZUSAMMENARBEIT (GTZ) GMBH

Honourable Minister for Environment & Natural Resources, the Director of Forestry, the Director of KEFRI, Representatives, Ladies and Gentlemen,

Let me convene - first of all - the greetings of the Ambassador of the Federal Republic of Germany, Mr. Michael Gerdts. He wishes this conference success, fruitful discussions and stimulation for KEFRI's and Forest Department's future work. Moreover, he wishes KEFRI on the occasion of its 10th anniversary many more years of successful research.

The work of KEFRI and the FD is work within the environment. A sound environment is inseparably connected with the welfare of all Kenyans.

FORESTS play a major role as they generate clean, fresh water and air, protect soils from erosion and maintain thus the soil fertility. Agriculture without a forested environment cannot be productive over a longer period of time. Wildlife need forests as their habitat. Thus, the two major income generators of Kenya's economy depend on intact forests. Moreover, numerous forest products - apart from timber - are important in the lives of Kenyans and especially the rural communities.

REGULAR FORESTRY, Ladies and Gentlemen, is only possible under four major conditions:

- the availability of well trained personnel
- the availability of applied silvicultural and management methods in balance with people's needs and nature
- the availability of adapted quality forest reproductive material
- a sound organizational structure of the forestry organizations.

The GERMAN COMMITMENT in the forestry sector of Kenya goes back to 1985, when the Kenya Forestry College and Kenya Forestry Seed Centre projects were started. In 1994, a third project which aims at the development of sustainable forest management methods for all forest types and supporting the MoU between Forest Department and KEFRI was started.

Moreover, later this year, a fourth project will start: the support to the collaborative MoU between Forest Department and the Kenya Wildlife Service (KWS).

The Kenya/German Technical Co-operation in the forestry sector is thus developing into a comprehensive approach and support to the sector. It must be mentioned that these projects are KENYAN projects. They are not isolated nor separated from the normal working procedure. They are integrated parts of existing institutions and collaborations. Let me, at this opportunity thank all the institutions, organizations and individuals who have collaborated in the past 10 years for their support and acceptance of the German contributions and innovations.

It is my hope that the collaboration will continue for another couple of years, including and involving other related institutions. This conference shall contribute to the collaboration of all parties involved in forest management. At the same time, it will be a cut in KEFRI's research approach. A new way of collaboration has been initiated under the Promotion of Sustainable Forest Management Project in the last two years. This has become necessary as the requirements on forests, forestry and consequently forest research of today are different from those of some years ago.

The key words are: multiple-use forestry, sustainability, and participatory forest management.

When this conference was planned, it was meant to be a rounding up of past research trials which were mainly aiming at timber production of exotic tree species. Moreover, in the past 7 years or so, KEFRI's research staff has increased manifold. Young university absolvents joined the Institute and have had only little opportunity to demonstrate their capabilities and to gain experience in writing research papers, presenting research results and standing in open discussions.

The very much improved relationship between Forest Department and KEFRI will be demonstrated by a number of joint papers, making this conference a real meeting between field managers and researchers. GTZ is pleased to contribute to the taking place of this conference. It is my hope, that the attendance will be throughout as good as at this moment and that there will be hot inspired discussions and a number of new stimulations for the future collaboration between all concerned parties.

May this conference be a challenge and fun at the same time for all participants!

Address by:

HONOURABLE JOHN K. SAMBU, M.P.,

MINISTER FOR ENVIRONMENT AND NATURAL RESOURCES, ON THE OCCASION OF THE OFFICIAL OPENING OF THE FIRST KEFRI-FD CONFERENCE AT KEFRI HEADQUARTERS IN MUGUGA ON 3RD JUNE 1996 AT 10:00 A.M.

Greetings!

The Director KEFRI, FAO Representative, Members of KEFRI Board of Management, The Director Forest Department, The Director KETRI, EU Representative, GTZ Representative, Conference Participants, Distinguished Guests, Ladies and Gentlemen,

It gives me great pleasure to address you during the First Joint Conference on Forestry Research and Management organized by Kenya Forestry Research Institute and the Forestry Department. I wish to take this opportunity to welcome all of you to this very important conference and to wish you success in your deliberations in the coming three days.

Background

Ladies and gentlemen, this conference comes nearly two years after the signing of a Memorandum of Understanding between KEFRI and the Forest Department on the 6th of December 1994. The memorandum (MoU) was intended to foster close working relations between forestry research and forest management.

Prior to 1980, Mr. Chairman, the instruments of forestry research were vested with the Chief Conservator of Forests, who is now called the Director of Forest Department in the Ministry of Environment and Natural Resources. When KEFRI was established in 1986 and transferred alongside other Government research institutes to the Ministry of Research, Technical Training and Technology, this welcome development gave rise to a few other problems which the 1994 MoU seeks to address.

Before the MoU was signed, it had become increasingly noticeable that there was inadequate consultation between the Forest Department and KEFRI. Research needs and priorities were being set without due regards to the Forest Department which is charged with the responsibility of managing our forests. There was resource wasting and each body looked inward and not outward to see what could be shared. It became increasingly more difficult to mount effective research and development programmes and to exchange beneficial information.

The MoU, ladies and gentlemen, intends to address the problems I have already mentioned and to set up a mechanism to deal with any eventuality. Presently, two joint committees at Policy Level and Technical Level have been set up. There is the Forest Department/KEFRI Research and Management Policy Liaison Committee (PLC), and the Technical Forest Department/KEFRI Research and Technical Liaison Committee (TLC).

Policy Liaison Committee (PLC)

According to the MoU, the PLC shall give guidelines on:

Forestry Management

Research Priorities, Strategies and Orientation

Research Application and Information Dissemination
Research Monitoring and Evaluation
Manpower development, and
Management of Shared Resources, among others.

Technical Liaison Committee (TLC)
On the other hand, the TLC will consult and;

Make forestry research and management policy recommendations to the PLC for consideration,
Review and identify research and management problems, and provide guidance to researchers, field management staff and other interested parties,
Evaluate research needs and proposals and set priorities, strategies, direction and scope, taking into account targeted problems, beneficiaries and users, resource constraints and time frame;
Give guidance on effective dissemination and application of research output, for the benefit of targeted users,
Review and evaluate implementation of research and management decisions and the application of research information and its impact in management, and
Formulate collaborative strategies for training, manpower development and sharing of expertise and information, among many other benefits.

The MoU document gives itself a framework for reviewing and amending itself every three years. I congratulate both the Forest Department and KEFRI for coming up with such a document and for recognizing that the prosperity of this nation is based on careful, exploitation of our resources with consultation among the diversity of stake holders in the forest and agricultural industries.

Conference
I am sure, Mr. Chairman, that this conference is part of the recommendation of the MoU as a result of serious consultations between the various committees and sub-committees of the two organisations. Looking at the title of the conference as "The State of Forest Research and Practices in Kenya", I have no doubt in my mind that we are following the right objectives.

I have been informed that the major themes of the conference are:

* Recent research findings and management issues
* Focus on future forest development in Kenya, and
* Commemoration of the 10th KEFRI Anniversary

Ladies and gentlemen, I hope you will find time to go beyond the major themes of the conference and look at issues like environmental degradation, climate change, and threatened food situation in our country.

Forest
For the last few years, forest cover has decreased tremendously due to pressure exerted by a rapidly growing human population. This consequently means that forests can no longer supply adequate timber, poles, woodfuel, medicine and many other products that are traditionally associated with forests.

As most of you already know, gazetted forests comprise only 2.9% of the country's total land area, rendering the forest resource insufficient to supply the needs of the rapidly increasing population. Only 20% of Kenya is classified as high and medium potential land. Most of the gazetted forest land is also found here. 80% of the population is concentrated in this small area creating pressure on the agricultural land and consequently leading to illegal cultivation, overgrazing and poaching of trees in the meager forest reserves.

Woodlots

Mr. Chairman, it is not my desire to cast a black shadow on the conference but to bring into perspective the existing problems and issues that we must focus on to develop our country. It is clear in this country that 80% of the country's population consists of subsistent farmers. In the olden days, when forest resources were plentiful, our farmers used to play the dual role of conserving forests while providing livelihood for their families. With the increasing adoption of a cash economy in most parts of the country, exploitation of forest resources has exceeded conservation efforts, hence the need for extension activities.

The general trend, now, is that the gazetted forest land has continued to decrease, but there has been some compensation. I stand to be corrected with my assertion that the trend is that individual farmers in Kenya, put together, could be holding more forest cover than the Government in its gazetted lands. If this is true, and I hope it is, our farmers must be congratulated, and our forest management strategies should change in recognition of the people's efforts.

Ladies and gentlemen, the trend in farm forestry or community based forestry is to allocate poor pieces of land to forestry. We cannot blame our famers for this as it appears to be a rational decision. The better pieces of land must be reserved for growth and development of food crops. Let us go with the decision of our people and look for ways and means of improving their technologies in farm forestry, agroforestry, social forestry and community forestry.

I can imagine the disappointment that is read on the faces of young forestry graduates when they visit farms and find trees cut down in favour of food crops. I also know the disappointment of our young extension officers when they distribute seedlings at the beginning of the rainy season only to find that half of them have either been left to die in a corner or were planted and abandoned for livestock to feed on. I feel the same concern but I also realize that, at the time that is happening, the livestock is of more value to the farmer. In the long-term however, the trees that take several years to mature are equally valuable. Let us not therefore despair too quickly.

Research

Mr. Chairman, the scholarly demand of research sometimes appears to be out of tune with the practical reality of foresters in the field. For the farmer, the period research takes is too long and of no benefit, because he needs quick results. The farmer wants a solution in three months because his daughter will be going to school in two months. He wants a quick solution because the leak in his mother's house is worsening everyday. This makes it important for research to be double pronged and multidisciplinary. Short term solutions must be investigated alongside basic research, and alternative remedies must also be found from related research areas. Field officers must also be able to diagnose problems on the ground effectively and communicate situations and problems in clear and concrete terms to avoid waste of time and enable researchers to formulate relevant research proposals and methodologies.

Challenge
The two Institutes should work together in harnessing further collaboration with other actors in forestry sector development not forgetting NGOs and grassroots groups. I am particularly interested in seeing a leadership in widening and sharing of research management information with our neighbours, thus capitalizing on the opportunities that have been opened through the signing of the East Africa regional co-operation. This would greatly benefit all of us particularly in the procurement of diversified and quality seed, coping with outbreak of diseases, timber trade, effective management of important ecosystems like Mts. Elgon and Kilimanjaro lying on the borders.

Congratulations
May I at this juncture congratulate Kenya Forestry Research Institute who are celebrating their 10th Anniversary this month. I think that this conference is a double blessing to KEFRI which has now come of age.

Thanks
Ladies and gentlemen, I would like to extend a word of appreciation to a number of organizations which have been directly associated with the development of forestry in this country. No doubt quite a number of other donor agents have continued to support forest development in Kenya and the government appreciates this assistance.

Opening
I am sure that you will conduct mature discussions and come up with solutions and resolutions that will benefit our people and assist us in our effort in increasing forest production and conserving the environment. It is also my hope that the spirit of the MoU will pervade all your deliberations to enable you identify your strengths and weaknesses so as to come up with more innovation strategies for increased food production and forestry expansion in this country.

Finally, ladies and gentlemen, it is my honour and privilege to declare this conference officially open.

Thank you.

Address by:

MR. WAMATU NJOROGE

PERMANENT SECRETARY, MINISTRY OF RESEARCH, TECHNICAL TRAINING AND TECHNOLOGY, ON THE OCCASION OF THE OFFICIAL CLOSING OF KEFRI-FD CONFERENCE AT KEFRI HEADQUARTERS IN MUGUGA ON 5TH JUNE 1996 AT 4:00 P.M.

Greetings

The Director KEFRI; Members of KEFRI Board of Management; The Director of Forest Department; GTZ Representative; Conference participants; Distinguished guests; Ladies and Gentlemen,

It gives me great pleasure to address you during the official closing of the First Joint Conference of KEFRI and the Forest Department. I would have wished to be with you from the beginning of the conference, to participate in the formulation of conference resolutions, but I found myself officially engaged elsewhere.

Objectives

Ladies and gentlemen, I am informed that the theme of the conference was on the "State of Forest Research and Management in Kenya", and that the main objective was to bring together forest research scientists and practicing foresters.

Mr. Chairman, KEFRI and the Forest Department are very important partners in the development and management of our forests and conservation of our biodiversity. It is important that the two institutions work together just like the left hand works with the right hand. This is because, the innovations and technologies developed in KEFRI will not be meaningful unless they are understood and suitably packaged for public consumption by the Forest Department. It also makes more economic sense for problems experienced by our farmers to be translated and communicated through the Forest Department to KEFRI for further investigations.

Resolutions

Mr. Chairman, I am informed that in your deliberations you have recommended the closing up of gaps in degraded forests resulting from selective tree harvesting practices. I am pleased to note that part of your recommendation is to spare "mother" trees to be used in regeneration exercises and to suppress rapid colonization by weeds in large canopy gaps left behind after harvesting. This will definitely result in better production by unit area and enhance environmental conservation.

I am also informed that you have made recommendations on multipurpose management of our indigenous forests. This is a policy factor and we shall need appropriate time frame to develop strategies to accommodate the change without disrupting the ongoing programmes on plantation development for timber and fuel wood production.

Mr. Chairman, the Government takes views expressed at this forum very seriously and will study the resolutions and come up with an appropriate plan of action. As you are aware, Kenya is committed to the improvement of the lives of its citizens. To this end, the Government welcomes the call for an increase in availability of quality forest seed and improvement in nursery techniques and silvicultural practices.

Ladies and gentlemen, the devastating effects of the cypress aphid are still fresh in our minds. We therefore welcome the recommendation on the increased use of indigenous forest species as a measure in pest and disease management. Also important is the use of biological control of pests and diseases. It must be emphasized that our local people are familiar and feel more comfortable working with the species they know.

The conference itself, ladies and gentlemen, is a good example of a forum for technology transfer. This should be followed with a speedy processing of the proceedings, so that those who have not attended the conference can also benefit from the fruits of the conference. But the most important task is the actual translation of the resolutions, and technologies into the user friendly language of our farmers.

Thanks

Finally, ladies and gentlemen, let me extend my appreciation to all of you for making this conference a success by gracing it with your presence, and active participation. I would like to extend my gratitude to KEFRI, Forestry Department and GTZ for organizing the conference. I am equally grateful for the assistance which we received from the Federal Republic of Germany, the European Union and the World Bank.

May I also thank KEFRI in particular for extending this modern facility to the conference.

Closing

Ladies and gentlemen, it is now my pleasant duty to declare the KEFRI-Forestry Department Conference officially closed.

Thank you.

EXECUTIVE SUMMARY
(Issues and Recommendations)

EXECUTIVE SUMMARY

Conference Issues and Recommendations

The following were highlighted in presentations, panel discussion and final plenary sessions:-

Forest Planning/Management

Issue 1

Since early 1980s, FD had not maintained an effective Forest Management Planning Unit. Although FD re-established Planning Division, headed by a Deputy Director, in October 1995, no concrete steps have been taken by FD to re-activate this vital functional unit and its integration with other units in formulation and supervision of implementation of forest management plans from the headquarters to the forest station levels. Even the planning team which was put together by the Forestry Masterplan project in 1994 is rapidly being scattered at FD headquarters through inconsistent staff re-assignments.

Recommendation 1

FD should take immediate steps to institutionalize forest management planning at all levels using the highest professional skills and ethics. The Planning Division of FD should be accorded the profile and resources to reflect solid long-term commitment to sustainable management of the country's forest resources. Managers of forest resources should be given a free hand to execute set management plans without undue interference from some stakeholders, particularly politicians.

Issue 2

Currently, foresters in the field are not managing forests under their jurisdiction in conformity with existing Technical Orders(TOs), their technical know-how, and professional ethics. This undesirable situation is due to professional laxity on the part of foresters and insufficient in-service training and supervision on the part of FD management.

Recommendation 2

FD should ensure that all foresters under its employment are well versed on management TOs and that they uphold the same in their day-to-day work.

Publicity and Public Awareness

Issue 3

Currently, the public profile, respect and image of foresters as qualified practitioners and advisors on forestry development is very low due to institutional inertia(bureaucracy, incongruent guidelines and directives), professional laxity, poor public relations, low publicity, undue influence from outside FD. FD staff are plagued by frequent leadership changes (there have been 6 heads of FD appointed in the last 10 years) and public retribution.

Recommendation 3

FD top management should cultivate enhanced stature and authority as to effectively intervene in, and influence decisions at the top national political and policy levels.

Recommendation 4

FD and KEFRI should make special efforts to repackage their technical information and messages (including press releases) for better communication with the public. This calls for high profile public relations offices at both FD and KEFRI.

Plantation Research

Issue 4

While the bulk of past forestry research focused on establishment and management of plantations of exotic species(mainly pines, cypress, and eucalypts), recently emerging trends call for drastic review of priorities for plantation research. For example, the recent outbreak of cypress aphid (*Cinara cupressi*) and, to a lesser extent, the known pests and diseases of other exotic species all point to the urgent need to pay much greater attention to the genetic variability bases of species grown in plantations. The recent discontinuation of the taungya method of plantation establishment calls for revitalization of research on less labour intensive methods of site preparation, plantation weeding and other plantation-based silvicultural practices.

Recommendation 5

KEFRI and FD should determine new opportunities, priorities and strategies for future research which more comprehensively address the issues of genetic variability bases of plantations, cost-efficient and less labour intensive methods of plantations establishment, tending and management.

Indigenous Forests Research

Issue 5

It is recognized that KEFRI and researchers in other institutions have paid relatively little attention to research which can lead both to better understanding of the ecological functioning of indigenous forests and to prescriptions for their more sustainable management.

Recommendation 6

KEFRI and FD should assign higher priority to indigenous forest research and management and, establish a strong programme in this area with emphasis on management of mixed and pure stands of economically important indigenous species like camphor, elgon olive, mvule, etc.

Issue 6

Partly due to the present weak knowledge base on the functioning and management of indigenous forests, and partly due to the low priority which FD currently accords effective manage this resource, technical guidelines for management of various types of indigenous forests and indigenous species in natural communities and in monocultures have not been developed for use by field foresters. For example, currently FD has only one Technical Order on management of indigenous forests.

Recommendation 7

KEFRI and FD should jointly launch and actively support an initiative to draft technical guidelines for field foresters. Such guidelines should be developed through consultation with experienced researchers and field foresters in commissioned working groups. The guidelines so developed should be based on sound research results. It is specifically recommended that the "Promotion of Sustainable Forest Management" project takes this as one of its mandates in the next phase which begins in July 1996.

Social Forestry, Agroforestry, and Forestry Extension

Issue 7

The current programmes of KEFRI and FD on social forestry, agroforestry and forestry extension are not integrated and, together, do not constitute a holistic and sustainable approach to forestry development implemented by and to the benefit of farmers and communities. Together, the current programmes have significant overlaps and inadequacies both at the technical(e.g. extension packages) and at the policy levels. Furthermore, the Forestry Masterplan, in its present version, does not sufficiently address this issue under its relevant section on "Farm Forestry".

Recommendation 8

The present Forestry Masterplan be revised to ensure integration of programmes and a holistic approach to social forestry development in the country.

Recommendation 9
FD should greatly expand its "Forest Extension Services" to include the promotion and implementation of social forestry programme country-wide. This will entail more specialized staff and more comprehensive social forestry extension packages with broadened focus on social forestry, agroforestry, and farm woodlot management.

Recommendation 10
KEFRI should integrate and consolidate its relevant programmes on agroforestry, social forestry, and dryland forestry research. The proposed "Farm Forestry" programme of KEFRI should be renamed "Social Forestry" in conformity with the desired holistic approach.

Forestry Education, Training, and Research
Issue 8
The extent to which forest resources of the country can be managed and expanded depends largely on availability of motivated and well-trained foresters. Furthermore, field foresters must continuously benefit from dynamic research and training institutions in upgrading their skills and knowledge for new job challenges. Thus, forestry education, training and research institutions are vital production units in capacity building for sustainable forest management. By any standards, Kenya's forestry education, training and research institutions are weak in performance and are not sufficiently targeted on identified national development challenges for the forestry sector. The critical limitation in all these institutions remains lack of funding - particularly for field exercises and research operations. Furthermore, according to the present funding arrangements in the country, these same institutions are accorded low priorities (way out of proportion with total contribution from and investment in the forestry sector). Unless the present funding arrangements are changed, these institutions remain the weak links in sustainable forest management chain.

Recommendation 11
All investments in forestry development in the country should have components for capacity building earmarked for forestry research, training and education institutions. The recipient institutions must, in turn, re-structure their operations for expected delivery and accountability to supporting institutions and projects.

Recommendation 12
Forestry education curriculum at Moi University should be reviewed - particularly in the emerging development challenges in ecosystem stability and biodiversity conservation, integrated land-use planning, social forestry, etc. This exercise should be undertaken in full consultation with potential benefactors and experts locally and externally.

Recommendation 13
The recent initiatives by FD to achieve semi-autonomous status for the Londiani Forestry Training College should be fully implemented. In this regard, teaching staff should be directly recruited by the college Board of Directors.

Environmental and Biodiversity Conservation
Issue 9
In the past, foresters focused on management and conservation of forests and plantations within gazetted forest land constituting a tiny proportion of the country's land area. Even within the limited area of gazetted forest land, foresters are not in command of knowledge and regulation of biodiversity wealth and environmental conservation roles. However, by far the greater concern is with biodiversity and tree resources in the vast arid and semi-arid lands (ASALS) which are being exploited without regulation and with major impact on environment and biodiversity conservation. For example, currently foresters (even

when posted in the vast non-gazetted forest land areas) do not take management and conservation of the vast woody vegetation of ASALS as falling into their responsibility. Indeed, the various relevant Acts are silent on this issue and need appropriate revisions.

Recommendation 14
The new forestry bill currently under preparation for presentation to parliament should adequately address environmental and biodiversity conservation outside gazetted forest land and should provide FD and foresters with legal instruments for control and regulation of exploitation of tree resources on individual farms and communal lands.

Issue 10
Existing biodiversity in forests and woodlands is little known. Some valuable products therein could be more optimally exploited while some components may be threatened with extinction. Available information and data remain scattered in various institutions, projects, and individuals. Moreover, the wealth of indigenous knowledge in various communities is not being systematically documented and utilized for their sustainable management.

Recommendation 15
A national focal point for biodiversity documentation and information(referral databank) should be actively supported through collaboration among key players. Documentation of indigenous knowledge base should be accorded high priority at the referral databank. The National Museums of Kenya should assume this national role.

Issue 11
Kenya is signatory to several international conventions and agreements related to environmental and biodiversity conservation. In addition, Kenya has responded actively to related international initiatives such as the formulation of forestry masterplans and national environmental action plans. However, it has been the general experience that adherence to these conventions and agreements are not monitored on a permanent basis. Of particular current interest is the *Convention on Biodiversity* and the *Forest Principles* of *Agenda 21* - all of UNCED or Rio conference of 1992. In particular, there is on-going international follow-up action to *Agenda 21* which is leading to global consensus on principles, criteria, and indicators for sustainable forest management. This is an important process which will culminate in forest certification as basis for global trade in forest products.

Recommendation 16
FD should review forest management guidelines in the background of emerging international consensus on principles, criteria, and indicators of sustainable forest management.

Forest Health

Issue 12
Many forest diseases and pests directly reduce the quantity and quality of seeds, seedlings, planted trees, forests and their products. This, consequently directly or indirectly reduce the future supply of tree products. It is therefore necessary to undertake research towards early detection and control of tree pests and diseases.

Recommendation 17
KEFRI should undertake research on diseases and pests in tree seed, nursery seedlings, forest plantations and farm woodlots, and natural forests. A comprehensive database of forest pests and diseases together with rational methods for their control should be developed for improved forest management.

Issue 13

Current arrangements for regular monitoring, early detection, and rapid response to outbreaks of diseases, pests, fires and game damage lack coordination, dynamism and focus. Reports from field foresters are irregular, vague and often remain scattered in the offices of FD and KEFRI. The Forest Health Centre was recently established within FD in reaction to cypress aphid outbreak. However, the long-term functions of this new centre with respect to all diseases, pests, fires, and game damage have not been specified.

Recommendation 18

As part of the pending re-structuring of FD a unit should be established with staff and necessary facilities for regular monitoring, early detection and coordination of rapid response on unexpected threats to forest health. The present Forest Health Centre at Karura should be reorganized and revitalized to play this role with the provision that all the attendant research revert to KEFRI.

Issue 14

Accidental fires cause huge losses in plantations and natural forests(currently estimated at some 3,000 hectares per annum). Although field guidelines are clear on fire prevention and suppression, forest stations lack resources for the required measures. The forest fires control unit at FD headquarters has not been active for some years and currently lack equipment and other resources for coordinated action on fire danger assessment, prevention and suppression.

Recommendation 19

FD should take immediate action to re-activate a forest fires control unit. Standing arrangements for collaboration with the Kenya Army and KWS should be strengthened.

Tree Farming and Private Forestry

Issue 15

Many farmers grow trees in farm woodlots, boundaries, and as components of agroforestry systems in response to concerted campaigns by government and non-governmental organizations. Others rely on tree products such as carving wood, valuable oils and gums etc., for business. However, prices of the many tree products are not market-driven and often discourage private entrepreneurship. The *Marketing Section* of FD currently mainly focuses on review of stumpage values of FD plantation timber. Generally prices of forest products in FD forests are lower in comparison with private forests. This presents unfair competition as royalties are usually below the prevailing market value.

Recommendation 20

FD should regularly revise pricing for all tree products in gazetted forests according to prevailing market trends so as to encourage investment in social and private forestry and should take necessary steps to reduce unfair competition.

Donor Support

Issue 16

Currently, there exists an impasse between FD and several potential donors on conditionalities around the implementation of the revised forest policy and reorganization of FD to support the policy changes. It is expected that the recommended changes will go a long way in ensuring more sustainable forest production and conservation in public and private land.

Recommendation 21

FD should push more aggressively for support by relevant government bodies towards final endorsement and approval of the revised forest policy.

Issue 17

Funds from GOK in support of forestry research have sharply declined in recent years. Thus, it has become necessary for KEFRI to seek funds from other sources to supplement the declining GOK support. So far, only a handful of donors have helped KEFRI in specific project areas. However, the greatest impact from donor support can be realized when KEFRI makes a consolidated appeal to a consortium of both local and external potential donors for support of the entire research programme of the institute.

Recommendation 22

KEFRI should develop its medium term strategic plans and budget. It is recommended that KEFRI solicit support and participation of influential donors in this exercise. Beyond that, KEFRI and FD should consider going on joint appeals for funding for priority areas of research-driven forest management where information gaps are clearly identified.

New directions at FD

Issue 18

FD reported that the revised forest policy had received Cabinet endorsement but was yet to be debated in parliament. This important document not only underpins the Forestry Masterplan but contains strategies for resolving major current forestry-related land-use conflicts. The protracted delay in its formal approval and implementation has stalled, for over two years, important development initiatives at FD.

Recommendation 23

Ministry of Environment and Natural Resources(MENR) should, as a matter of great urgency, push for the draft policy to be debated in parliament and to be approved. This should be closely followed-up with the bill for the new Forest Act.

Issue 19

The Director of Forestry asserted at the conference that although the new forest policy has not gone the round of formal approval, foresters can direct developments according to the new policy. While this spirit is commendable, there are two important pre-requisites for effective implementation of the new policy by FD. Firstly, the functional structure of FD must be changed and re-aligned according to requirements for effective implementation of the new policy. Secondly, the Director of Forestry must issue, clear guidelines on how foresters must readjust their operations in line with the new policy. It should be added that FD need not wait for formal approval of the new policy before it starts on the above pre-requisite tasks.

Recommendation 24

FD presents to MENR and to GOK concrete proposals for a substantially re-structured FD as needed to implement the new policy. Concurrently, FD top management articulates guidelines and instructions to foresters for the implementation of the new policy.

New directions at KEFRI

Issue 20

KEFRI Director reported at the conference that KEFRI had embarked on a major exercise of re-structuring and consolidation of its programme. While it was not clarified how this exercise relates KEFRI strategic plan process, it is a timely and commendable move by KEFRI.

Recommendation 25

KEFRI should move on with the planned re-structuring and consolidation of its research programmes with advice of both internal and external reviewers.

LIST OF PARTICIPANTS

Adongo, E. A.
Provincial Forest Officer
Forestry Department
P.O. Box 1048, KISUMU

Agiso, R. O.
Chief Research Technologist
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Ahenda, J.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Akinga, W. N.
Deputy Project Manager
KFDP-Forest Department
P.O. Box 30513, NAIROBI

Albrecht, J.
Programme Co-ordinator
GTZ-PSFM Project
P.O. Box 41607, NAIROBI

Aluoch, G. O.
Regional Forester
OSIENALA (Friends of Lake Victoria)
P.O. Box 4580, KISUMU

Ambune, E. K.
Assistant Director
Forest Department
P.O. Box 30513, NAIROBI

Aoko, Gerald
Information Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Apudo, M. G.
Forester
Forest Department
P.O. Box 30513, NAIROBI

Barasa, P.
Information Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Baraza, J. W.
Senior Training & Extension Officer
Forest Department
P.O. Box 30513, NAIROBI

Brooks, T.
Ornithologist
National Museums of Kenya
P.O. Box 40658, NAIROBI

Chagala, E.
Principal Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Changkwony, M. K.
Officer-in-Charge Baringo
Kenya Forestry Research Institute
P.O. Box 57, MARIGAT

Cheboiwo, J. K.
Centre Director
Kenya Forestry Research Institute
P.O. Box 892, KITUI

Chege, F.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Chesaro, J. C.
District Forest Officer- Kericho
Forest Department
P.O. Box 1, LONDIANI

Chikamai, B.
Principal Research Officer
Kenya Forestry Research Institute
P.O. Box 30241, NAIROBI

Choge, S. K.
Research Officer II
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Day, R.
Deputy Scientist-in-Charge
IIBC
P.O. Box 76520. NAIROBI

Diro, P.
Forest Manager
Pan African Paper Mills Ltd
P.O. Box 680, ELDORET

Giathi, G.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Gichora, M.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Gikonyo, R. G.
Deputy Director
Forest Department
P.O. Box 30513, NAIROBI

Gisemba, J. N.
Administration Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Githiomi J. K.
Research Officer
Kenya Forestry Research Institute
P.O. Box 30241, NAIROBI

Gitonga, J. M.
District Forest Officer
Forest Department
P.O. Box 106, KITUI

Goot, W. van der
European Commission
P.O. Box 45119, NAIROBI

Gor, J. O.
Senior Forestry Advisor
GTZ-KGFT Londiani
P.O. Box 8, LONDIANI

Ikiugu, C. K. P.
District Forest Officer-Nakuru
Forest Department
P.O. Box 25, ELBURGON

Kabugi, H. M.
Provincial Forest Officer-Coast
Forest Department
P.O. Box 80078, MOMBASA

Kagombe, J. K.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kaguamba, R.
Dryland Biodiversity Programme
P.O. Box 40568, NAIROBI

Kahuki, C. D.
Forestry Officer
Forest Department
P.O. Box 30513, NAIROBI

Kahunyo S.W.
District Forest Officer
Forest Department
P.O. Box 1197, THIKA

Kamanga, J. M.
District Forest Officer
Forest Department
P.O. Box 110, MERU

Kamau, D.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kamondo, B. M.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kariuki, E.
Senior Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Kariuki, J. G.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kariuki, M.
Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Kariuki, P. M.
District Forest Officer
Forest Department
P.O . Box 46, HOMABAY

Kaudia, A. A.
Information Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Keogh, R.
Training Co-ordinator
KFDP-Forest Dept. Hq.
P.O. Box 30241, NAIROBI

Kigomo, B. N.
Deputy Director
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kihara, J. N.
Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Kimani, M. W.
Lecturer
University of Nairobi, Dept. of Land Dev.
P.O. Box 30197, NAIROBI

Kimini, C. N. T.
Forester
Forest Department
P.O. Box 28, NYERI

Kimiti, J.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kimondo, J. M.
Senior Research Officer
Kenya Forestry Research Institute
P.O. Box 74, KIKUYU

Kinuthia, M.
News Reporter
Kenya Broadcasting Corporation
P.O. Box 30456, NAIROBI

Kinyanjui, G. M.
Deputy Co-ordinator; Research & Liaison
Forest Department
P.O. Box 30513, NAIROBI

Kinyua, J. K.
District Forest Officer
Forest Department
P.O. Box 546, MURANG'A

Kioko, J. M.
District Forest Officer-Embu
Forest Department
P.O. Box 2, EMBU

Kiriinya, C. K.
Silviculturist
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Kirongo, B. B.
Officer-in-Charge Nyeri Station
Kenya Forestry Research Institute
P.O. Box 12096, NYERI

Kitti, J. M.
District Forest Officer
Forest Department
P.O. Box 2, MACHAKOS

Koech, C. K.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Konuche, P. K. A.
Ag. Director
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Korir, E. K.
Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Langat, D. K.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Legilisho-Kiyiapi, J.
Lecturer
Moi University, Dept. of Forestry
P.O. Box 1125, ELDORET

Lelon, J. K.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Lonzi, T. M.
Provincial Forest Officer-Eastern
Forest Department
P.O. Box 2, EMBU

Mwai, M. M.
District Forest Officer -Vihiga
Forest Department
P.O. Box 781, MARAGOLI

Mwangi, J.
Manager, Forest Health Centre
Forest Department
P.O. Box 30241, NAIROBI

Mwangi, L.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Mwanza, E. J. M.
Senior Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Mwatika, N. M.
DistrictForestOfficer-Transmara
Forest Department
P.O. Box 114, KILGORIS

Mwendandu, R. J.
Training Manager
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Ndambiri, J. K.
Senior Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Ndegwa, N. M.
Research Officer
Kenya Forestry Research Institute
P.O. Box 30241, NAIROBI

Ndung'u, M.
Director
Kenya Trypanosomiasis Research Institute
P.O. Box 362, KIKUYU

Ngibuini, H. M.
Managing Director
Timsales Ltd
P.O. Box 18080, NAIROBI

Nieuwenhuis J.
Technical Advisor Training/Extension
COMIFOR
P.O. Box 53147, NAIROBI

Njagi, T. K.
Assistant Director of Forest
Forest Department
P.O. Box 30513, NAIROBI

Njehia, S. N.
District Forest Officer-Makueni
Forest Department
P.O. Box 395, MAKUENI

Njenga, M. G.
Research Officer
Kenya Forestry Research Institute
P.O. Box 201, MALINDI

Njigoya, J. M.
Forestry
Forest Department
P.O. Box 1233, KAKAMEGA

Njuguna, J.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Njuguna, L. M.
DisrictForestOfficer
Forest Department
P.O. Box 28, NYERI

Njuguna, P.
Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Norton, H. L.
Representative
FAO/UN
P.O. Box 30470, NAIROBI

Nyamai, D.
Principal Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Nyamai, J. M. S.
Deputy Chief Executive
Permanent Presidential Commission on
Soil Conservation and Afforestation
P.O. Box 30510, NAIROBI

Oballa, P.
Senior Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Ochieng ', G.
Deputy Director
Forest Department
P.O. Box 39282, NAIROBI

Odee, D.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Oduol, P. A.
Database Co-ordinator
National Museums of Kenya
P.O. Box 40658, NAIROBI

Ogombe, F. O.
Forest Officer
Forest Department
P.O. Box 22, KERUGOYA

Ojwang', J. A.
District Forest Officer
Forest Department
P.O. Box 376, SIAYA

Okeyo, M. M.
Forester-Kitale
Kenya Forestry Research Institute
P.O. Box 99, KITALE

Omollo, E. O.
Senior Forest Officer
Forest Department
P.O. Box 30513, NAIROBI

Omenda, T.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Omondi, W.
Senior Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Onchieku, J. M.
Research Officer
Kenya Forestry Research Institute
P.O. Box 30241, NAIROBI

Ongugo, P. O.
Senior Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Ong'weya, C. N.
Forester
Kenya Forestry Research Institute
P.O. Box 5, TURBO

Orinda, B. O.
Forest Officer
Forest Department
P.O. Box 74, KIKUYU

Orondo, S. B. O.
Research Officer
Kenya Forestry Research Institute
P.O. Box 382, LONDIANI

Owino, F.
Consultant
FORIN
P.O. Box 13762, NAIROBI

Owuor, B.
Assistant Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Schulzke, R.
Research Management Expert
PSFM KEFRI/GTZ
P.O. Box 41607, NAIROBI

Shihuma, J.
District Forest Officer
Forest Department
P.O. Box 775, KISII

Sigu, G. O.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Simons, T.
Programme Co-ordinator
International Centre for Research in Agroforestry
P.O. Box 30677, NAIROBI

Tessema Yemi
JPO, Forest Conservation
IUCN
P.O. Box 68200, NAIROBI

Thathi, F.
Press
Kenwide Media Ltd
P.O. Box 70460, NAIROBI

Uvoo, A. D.
Assistant Director
Forest Department
P.O. Box 30513, NAIROBI

Wainaina, R. G.
Planning Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Wairagu, M.M.
Forestry Advisor
Nyayo Tea Zones DC
P.O. Box 48552, NAIROBI

Wairungu, S.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Waiyaki, E.
Research Scientist
National Museums of Kenya
P.O. Box 40658, NAIROBI

Wakhungu, H. K.
Biometrician
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Wamichwe, K. M.
Senior Forest Officer
Forest Department
P.O. Box 39282, NAIROBI

Wandago, B. O.
District Forest Officer
Forest Department
P.O. Box 210, CHUKA

Wanyiri , J. M.
Forestry Officer
Kenya Forestry Research Institute
P.O. Box 30513, NAIROBI

Wanyondu, J.
Research Officer
Kenya Forestry Research Institute
P.O. Box 20412, NAIROBI

Were, J. M.
Associate Research Officer
International Centre for Research in Agroforestry
P.O. Box 30677, NAIROBI

White, S. P.
Plantation Management Specialist
KFDP
P.O. Box 30513, NAIROBI

Yakhama, J. I.
District Forest Officer
Forest Department
P.O. Box 289, OL KALOU

Yobterik, A.
Research Officer
Kenya Forestry Research Institute
P.O. Box 25199, KISUMU

Yssel, W. van
Project Co-ordinator
FD/COMIFOR
P.O. Box 53147, NAIROBI

PAPERS

SESSION 1:
FOREST POLICY AND LEGISLATION

THE REVISED FOREST POLICY AND LEGISLATION: THE VISION AND FOCUS ON FUTURE FOREST DEVELOPMENT IN KENYA

J. K. MACHARIA
Forest Department Headquarters

1. INTRODUCTION:

The last authoritative statement of a forest policy for Kenya was made more than 28 years ago in Sessional Paper No. 1 of 1968. At that time there was need to modify and restate the forest policy inherited from the colonial time, to fit the circumstances of the new Republic. Since the last policy was adopted, however, significant changes have taken place in the country and the world. Kenya's population has more than doubled, from 10 million to 25 million, while its indigenous forests and forest plantations have continued over the years to decline (1.3 million hectares only). The population is expected to double again in the next 25 years, which will further raise the pressure on forest resources through a growing demand for subsistence and manufactured products. The need to conserve soil, water, and biodiversity will become even greater than it is now.

Nationally, forestry development is no longer seen as a sectoral issue, and is understood to be a component in integrated efforts which aim at raising the living standards of the people, creating employment, and increasing industrial output to provide goods for the domestic market and for export. Internationally, Kenya has accepted the conventions on climate change and biodiversity, as well as the Agenda 21, which all relate to forestry development. Kenya has also accepted the "statement of principles for a global consensus on the management and conservation and sustainable development of forests" of the 1992 UNCED meeting held in Rio de Janeiro.

In response to the changing situation and needs, we have just completed a Forestry Sector Master Plan that will guide the forest sector for the next 25 years, as well as outline its commitments as part of the global society. Such a Plan can no longer be based on an outdated forest policy. Thus, the Forestry Master Plan has embarked on a careful analysis of the present policy to support its drafting and improvement, which was undertaken with the involvement of representatives from related government sectors, non-governmental organizations, private sector, other stakeholders, and individual experts. The FD has also conducted extensive inter-agency consultations on the draft policy. It can be concluded therefore that the proposed policy incorporates the present forest-related values of the people of Kenya, and that it can be taken as a firm expression of the national will.

1.1 Features of the New Policy and Expected Benefits to Kenya

The proposed *Kenya Forest Policy* gives particular emphasis to: 1) the need for protecting the forest, and conserving its biodiversity and other resources; 2) the continuing importance of wood as the predominant rural and urban energy source, and the renewable nature of woodfuels; 3) the enhancement of social forestry and farm forestry to reduce the pressure on indigenous forests, including the adoption of multipurpose management of resources that are not strictly protected as national parks or reserves; 4) broadening of the institutional framework for forest management, followed by clear definition of the responsibilities of the various partners in forestry development, and the building of their capacity through education, training, and research; 5) the rationalization of forest industry to maximize its contribution to the national economy; and 6) respecting the international commitments of Kenya, and understanding the role of woody vegetation in the hydrological and atmospheric balance and carbon storage.

Kenya stands to benefit from such a Forest Policy in terms of:

- Meeting sustainably and competitively the needs of the present and future generations for forest-based products and for conservation services and amenities.

- The protection of the indigenous forests; the development of woodlands, bushlands and plantations; and the conservation of biodiversity, soil and water resources.

- The contribution of the forestry sector to national and rural economic development, including the enhancement of people's participation and sharing of the benefits accruing from forestry development.

- Continued support by the international community to Kenya's efforts to sustainably develop and conserve its forest resources, including the facility established as a result of UNCED to provide financial support to internationally significant forest conservation activities and for economic sectors which decrease the pressure on forest resources.

2. POLICY OBJECTIVES

The policy objectives are (to):

- Increase the forest and tree cover of the country in order to ensure an increased supply of forest products and services to meet the basic needs of present and future generations and to enhance the role of forestry in social-economic development.
- Conserve the remaining natural habitats and the wildlife therein, rehabilitate them and conserve their biodiversity.

- Contribute to sustainable agriculture by conserving soil and water resources through tree planting and appropriate forest management.

- Support the government policy of alleviating poverty and promoting rural development, through income based on forest and tree resources, by providing equity and participation by local populations.

- Fulfil the agreed national obligations under international environmental and other forest-related conventions and principles.

- Manage the forest resources assigned for productive use efficiently for maximum sustainable benefits, taking into account all direct and indirect economic and environmental impacts: also review the ways in which forests and trees are valued, in order to facilitate management decisions.

- Recognize and maximize the benefits of a viable and efficient forest industry for the national economy and development.

3. POLICY STATEMENTS

3.1 Policy on Land Management for Production and Conservation Forestry

- **Farm Forestry:** Forests and trees on farms and private lands will be managed according to the priorities set by the national development objectives or duly authorized managers. The State will provide financial support to the management of areas kept for soil and water conservation purposes as necessary and will vigorously promote all forms of farm forestry.

- **Forest Plantations on Public Land:** Forest plantations on public land should aim primarily to increase the supply of forest-based products and services. Their management should be self-supporting, profit-oriented and, in the long run, revenue earning, so that they can contribute to and support essential non-profit forest activities, such as forest conservation.

- **Indigenous Forests, Woodlands and Bushlands:** All gazetted indigenous forests, woodlands, bushlands, and mangroves should remain reserved. They will be managed by state-approved agencies which will allocate them primarily for:

  - regulated multi-purpose forestry, using zoning concepts which do not endanger the conservation functions of the forests;

  - preservation of biodiversity, and providing products and services mainly locally on a subsistence basis, by community participation where appropriate.

- **County Council Lands:** On all county council lands, with the exception of national reserves and other special land categories, forests and other types of woody vegetation will be professionally managed to satisfy the local forest-based needs, taking into account sound management and conservation principles.

- **General Management Principles:** The rationale of forest management depends on local conditions set by the climate, soil, and the tree species, and on the actual forest-related needs of the people, which incorporate both social and cultural aspects. In all circumstances, the forest resources will be managed in a sustainable manner with due regard to environmental conservation. Reliable information on forest resources and their utilization should be ensured.

  Where the conservation targets are met and the demands of the local population for forest products satisfied, indigenous forests and plantations will be intensively managed and, if necessary, expanded for increased wood production and trade.

  The priority protection areas are the indigenous forests of substantial religious, cultural and traditional medicinal values and the habitats which encompass representative samples of Kenya's flora and fauna, forest areas with vital catchment functions, and threatened mangrove ecosystems. To ensure sustainability in land use, conservation and management of fragile arid and semi-arid lands should be promoted to include preservation of fragile ecosystems.

3.2 Policy on Forest Products and Industries

- **Self-Reliance:** The country will aim for competitive self-sufficiency in most wood-based forest products. Forest industries should guarantee high quality of these products so as to satisfy the domestic demand and to contribute to export trade.

- **Priority Forest Products:** The forestry sector's primary contribution to the basic needs of the people of Kenya is to ensure a sustained production of fuelwood and charcoal. Other priority forest products are construction wood and various paper products. Numerous non-wood forest products, such as forage, medicinal plants, fruits, and extracts are also high-priority products.

  It is of special concern for the Government to ensure a sustainable supply of these products and, especially in the case of woodfuels, to promote and support new and improved systems of production and utilization and, by encouraging energy saving and other measures, to contribute to a better adjustment of the demand with the supply.

- **Rural Emphasis:** Forest industries located in rural areas, particularly small-scale industries, should be developed in line with the general Government policies concerning industrial development, since they contribute to the rural economy. They should be promoted by incentives with due regard to encouraging efficiency of raw material use and to minimizing any harmful environmental effects.

- **Wood Processing and Trade Forest Products:** Integrated use of forest raw materials will be promoted so as to reduce their wastage. Exports of processed forest products will not be restricted but exports of roundwood will remain under licensing. Imports of wood-based products will be generally liberalized, but tariffs for domestically available products may be considered.

4. POLICY ON SUPPORTIVE INSTITUTIONS

4.1 Improving the Efficiency of Forest Production

The Forest Department will concentrate on policy matters, forest regulation, and monitoring of the performance of the various executing bodies in the forestry sector. The management of the Forest Estate, both for production and conservation, will increasingly be entrusted to private or public enterprises, tree farmers and communities.

The medium-term aim is to use the best available means to create an efficient forestry enterprise which is also responsible, directly or, through management agreements with other suitable enterprises, community organizations or individuals indirectly, for the management of industrial plantations and indigenous forests on public land. As a first step, the best economic agent capable of the required investment performance and public accountability, which guarantees gradual lessening of the financial burden on the government budget should be established as soon as possible.

While creating a self-supporting management structure which covers the industrial plantations and indigenous forests on public land, the Government will permanently maintain the highest forestry authority, especially on forest policy development and inter-agency coordination (including fiscal and environmental policy), forest protection and law enforcement, tax collection, licensing of harvesting and other forest management operations, forestry extension, and the maintenance of forestry databases.

4.2 Institutional Development

The forest policy framework will be updated regularly in connection with the national planning system; also legislation will be enacted to implement the policy effectively. The missions of the relevant agencies of the Government will be revised accordingly. This policy will be strengthened through education, training and research initiatives which will be revised from time to time.

For effective monitoring of the implementation of the adopted forest policy, forestry legislation, and strategic forestry plans, the Forest Department will set up an efficient policy and long-term planning unit, whose tasks will also cover forestry database development and inter-agency coordination.

As decided by the Ministry of Environment and Natural Resources, a consultative group consisting of experts in their personal capacity may be convened to advise the Director of Forestry on forestry issues which need inter-agency cooperation.

4.3 Funding of Non-Profit Forestry Activities

The mandate of the forest management organization responsible for commercial plantation forestry will include revenue generation for the funding of such non-profit priority activities as conservation for biodiversity and watershed management as well as forestry research and education, from funds which are generated by profit making operations. National forestry institutions will cooperate efficiently with international facilities established for covering the incremental cost of achieving benefits associated with forest conservation and sustainable development, and for supporting economic sectors which would stimulate economic and social substitution activities.

4.4 Non-Governmental Organization and Professional Associations

The State will actively encourage and support non-governmental organizations undertaking forest-related development activities especially at the local level, and will involve these organizations, as well as professional forestry associations, in the further development of national forest policy and strategy.

5. POLICY ON OTHER CONCERNS RELATED TO FORESTRY DEVELOPMENT

5.1 Co-ordination with Related Policies

The State will harmonize all land-use policies to ensure consistency and to make sure that they are developed using the best available information. It will prevent changes in land-use that promote deforestation, constrain farm forestry or endanger the protection of forests with unique cultural or biodiversity conservation values, Excisions in gazetted forests will be discontinued except in cases of public utility, for which suitable inter-sectoral and local-consultation procedures will be established.

Appropriate measures for environmental impact assessment should be taken where actions are likely to have significant adverse impacts on important forest resources and where such actions are subject to a decision of a competent national authority.

5.2 Traditional Rights and Livelihood

When not in conflict with the principles of sound and sustainable resource utilization and management or national development priorities, the traditional ways of life of the people living within and adjacent to designated forest areas, and the forest-related cultural values and religious practices of these people will be respected.

5.3 Gender Issues

Special attention will be given to the support of women in promoting forest management, training of professional and technical forestry personnel, forest conservation through participation, and funding of farm forestry. Linkages between established women groups and forestry extension should be vigorously promoted.

5.4 Forestry Research

Scientific research in forestry will be promoted as the basis for sustainable development and management of forest resources. Financial support will be increased, particularly for problem-oriented research and development of improved forest and tree management systems according to the priorities set in the forestry research and development programme; this programme will be reviewed and updated regularly. Closer contacts will be established between research and practical forestry.

5.5 Education and Training

Forestry education and training as well as training within other related sectors will be promoted so as to create a professional and technical staff capable of fulfilling all necessary tasks of forestry development, utilizing, when appropriate, the existing facilities for regional and international cooperation with regard to Forestry development.

The mandate of forestry extension will be expanded to cover fully not only the needs of farmers involved in farm tree growing but also those of the communities sharing an interest in indigenous forest management, as well as those of the individuals and enterprises in the private sector involved in medium or large-scale industrial wood production.

Building-up of awareness of forest conservation, management and utilization issues will be supported and intensified among the general public and the teaching of forestry in primary and secondary schools promoted.

5.6 Multiple Effects of Reforestation and Afforestation

Tree planting and land rehabilitation by natural regeneration will be promoted not only for the sake of wood production, but also because of the positive environmental impact of these measures, such as protection of soil and water resources and sequestration of atmospheric carbon dioxide. The environmental effects of tree planting should be assessed in relation to all benefits and risks associated with the tree species in question.

Urban forestry, amenity tree planting and the management of indigenous vegetation should also be promoted to enhance the beauty of man-made environments, to improve their value for human habitation and settlement, and to conserve and manage their valuable biological diversity.

5.7 Ecotourism in Indigenous Forests

Ecotourism is an increasingly important forestry activity which should be promoted for maximum benefit to the local people and the raising of revenue for forest conservation, but at the same time ensuring minimum environmental damage.

6. THE VISION AND FOCUS ON FUTURE FOREST DEVELOPMENT IN KENYA

In future forestry development will be based on five development programmes whose formulation will be aimed at meeting the concerns of the forestry sector comprehensively. It has been found useful to try and deal separately with the area of interest of each development partner and hence each programme is geared towards meeting specific forest needs/roles.

These development programmes will deal directly with forests and other woody vegetation, their utilization and products, and the environmental functions. Four of the primary programmes will be concerned with conservation, development, management and utilization of each of the four broadly defined forest types and tree resources, the fifth one will deal with industrial aspects of wood and non-wood forest products utilization.

The programmes are namely 1) conservation and management of indigenous forests; 2) dryland forestry; 3) farm forestry; 4) forest plantations; and 5) forest industries.

In addition to the primary development programmes, five institutional development programmes aimed at strengthening the capability of the forest sector to carry out the primary programmes are proposed.

7. CONCLUSION

The new forest policy has been turned into a Sessional Paper which is awaiting deliberation by parliament. The new Forestry Bill is in its 3rd draft state and will be deliberated on by parliament as soon as the new policy receives its endorsement.

Implementation of the Kenya Forestry Master Plan has already started partially but will be the basis of any future Forestry Sector development in Kenya.

BIBLIOGRAPHY

Kenya Forestry Master Plan. MENR 1994.
Forestry Policy Sessional Paper No.1 of 1968. Government Printer
Kenya National Environment Action Plan. MENR June 1994.

SESSION 2:
FOREST PRODUCTIVE MATERIALS/NURSERY MANAGEMENT

PROCUREMENT AND MANAGEMENT OF FOREST REPRODUCTIVE MATERIALS IN KENYA: THE CURRENT STATE

WILLIAM OMONDI
Kenya Forestry Research Institute

SUMMARY
Besides the immense task of providing seeds to satisfy the forest department's planting programs and lately to an increasing number of organisations and individuals, Kenya Forestry Seed Centre (KFSC) has taken a leading role in providing basic knowledge on seed-handling methods to enhance their use in planting. In addition, seed procurement through the informal sector plays a major role in the promotion of tree planting and may soon become a major source of planting material in keeping with the current legislative requirements. In order to guarantee sustainable development of the forestry sector, strong linkages between seed and seedling producers, Research Institutions and the Forest Department must be established and strengthened to streamline policy as regards seed procurement.

The establishment of the Tree Seed and Seedling Producers (TSSP) as a vehicle for improving seeds and seedlings' distribution at farm level and promoting the use of improved germplasm ranks highly on the recently amended Government policy. This paper discusses critical issues on the tree seed industry in view of the past and present policies.

1. INTRODUCTION

The increased demand for tree and forestry products has necessitated the government to step up afforestation and reforestation campaigns both in the gazetted forests and in farmlands. Over 200 million seedlings of various species are required annually to maintain such an ambitious program.

To satisfy the demand of that magnitude, over 10 tons of forestry seeds is needed. This calls for efficient and effective seed procurement and distribution systems with an ultimate aim of achieving a sustainable production of high quality tree products to meet both farmer and industrial demands. KFSC has been the principal supplier of forestry seed in Kenya. However, in the last few years, the scenario has slightly changed with the emergence of other non-governmental organizations, private establishments and local vendors all involved in the local seed industry. Being young, the industry is characterized by several shortcomings; prime among them is the quality of the seeds being procured and distributed. Due to lack of quality standards, the bulk of seeds in the market have inferior physiological and genetic quality. Besides, the majority of the actors have minimal knowledge on seed handling technology. Like quality standards, the prices of the seeds are not set. Although this may be favoured by advocates of free market, whose primary goal is profit driven, the overall effect can be disastrous if no regulatory measures are put in place.

Failures of tree planting programs can be an expensive burden for forestry and the country's economy. Central to the causes of most failures are the choice of tree species, seed origin and unpredictable environmental changes. Until recently, the choice of seed has been lowly prioritized when it comes to plantation establishment or other planting programs. Due to lack of information coupled with ignorance as regards the source of seed, long-lasting, expensive mistakes with grave consequences can be committed. In the past and unfortunately even presently, some establishments measure success by the number of seedlings raised in nurseries and the total area planted notwithstanding the survival rate, the productivity and the stability of such plantations.

The extension service of the Forest Department with its facilitation approach, finds it easier to pass on the task of seed procurement to the KFSC. Recent trends in seeds supply systems in Kenya demand a review of this policy to encourage own seed collection by organised groups.

2. SEED SOURCES

Prior to 1986, the bulk of seed used in plantation development were from general collections i.e. collections from trees growing naturally within a region. In the absence of improved seed sources of many indigenous species it was necessary to provide germplasm to meet planting demands while parallel efforts are initiated to identify and improve alternative sources. It must also be emphasized that collections from naturally growing populations will continue for some time. At present the following seed sources (Table 1) produce seeds of superior quality. Most of the established seed sources are of agroforestry species as detailed in Appendix 1.

Table 1: The number and area of selected seed stands by 1995

Category	No. of species	Size
Selected single trees	13 indigenous	minimum 30 trees/spp
Selected seed stands	18	985 Ha
Established seed stands	14	60 Ha
Seed orchards	2	23.5 Ha

The present shortfall in supply of some species can be attributed to inadequate seed sources. This can be solved through collaboration between FESD, KFSC, NGO's, ICRAF, FD and TSSP on establishment of appropriate seed production units of the highly demanded tree species. This would ensure that seed sources meet the standards as stipulated in the Seed Act of Kenya, Tree Seed Regulation (1993), and allow participatory approaches in this venture. A lot of germplasm is also found on farms. Farmers especially TSSPs should be involved in the identification and conservation of good seed sources.

3. SEED COLLECTION AND SUPPLY

3.1 The KFSC Perspective

In 1976, about 2000 kg of seed was collected by the KFSC of which 900 kg were dispatched to meet planting demands mostly by the Forest Department. In 1992, 10,000 kg was collected and 6000 kg issued out, a 5 fold increase in seed collection and 7 fold in supply. By the end of 1995, 220 different species with different provenances had already been handled. The Seed Centre currently handles not only this wide range of species but strives to harness as much provenances in each species as possible. This is founded on the object of capturing the broadest genetic pool of a species. It is estimated that between 1990 and 1995 KFSC supplied to the Forest Department enough seeds to establish about 925,588 Ha. In practice however, only a fraction of this plantation area might have been achieved; this being attributed to:

- Poor handling of seeds after dispatch from the KFSC stores resulting into significant loss of viability
- Low germination rates in the nursery due to non-application of appropriate pre-treatment methods
- Poor nursery practices leading to high seedling mortality
- Reduced seedling survival in the field as a result of unfavourable environmental conditions and/or poor silvicultural practices

Table 2: The distribution of seed stands of some popular MPTS established by KFSC

Source: KFSC records

Species	Site\District	P. year	Area (ha)
Acacia mangium	Gede\Kilifi	1988	2.5
Albizia falcataria	Gede\Bukura	1988	1.0
*Calliandra calothyrsus**	Kakamega Forest	1991	0.5
*Cassia siamea**	Jilore\Kilifi	1989	1.5
*Cassia siamea**	Gede\Kilifi	1989	1.0
Grevillea robusta	Njukiini\Kirinyaga	1992	4.0
Grevillea robusta	Kitale\Trans-Nzoia	1992	4.0
*Gliricidia sepium**	Kakamega Forest	1987	2.0
Grevillea robusta	Kakamega Forest	1990	2.0
Grevillea robusta	Ragati\Nyeri	1988	6.0
Leucaena diversif. K156	Gede\Kilifi	1989	0.5
Leucaena hybrid Kx3	Gede\Kilifi	1989	1.0
Leucaena leucoceph. K636	Kibwezi\Machakos	1989	0.5
*Mimosa scabrella**	Kitale\Trans-Nzoia	1990	1.5
Parkinsonia aculeata	Kibwezi\Makueni	1989	0.4
Prosopis chilensis	Kibwezi\Makueni	1987	0.9

*** Stands whose seed productivity has been hampered by fire, site and other natural catastrophes.**

Table 3: Seed supplied by KFSC for plantation development; 1990-1995

Species	supplied (kg)	seedlings*	Ha
Pinus	604	43 billion	35,988
Eucalyptus	948	948 billion	790,000
Cupressus	1,083	116 billion	97,287
Vitex	1,970	1.6 billion	1,313
TOTAL	**4,725**	**1,108.6 billion**	**925,588**

* Potential number of seedlings which could be raised

The adoption of a more technical approach to collection and distribution means that seed lots are maintained and characterized on zonal basis based on climatic and vegetation information. This allows full exploitation of the species' performance by planting them in areas where they are most adapted thus minimizing the risks of failures both in the short and the long run. Careful and adequate documentation is therefore an important aspect in seed procurement. Any seed-lot whose origin and physiological qualities is not known is **worthless**.

Training has been adopted as a strategy for transferring technology to relevant groups. This will in the long term increase seed collection and availability country-wide and reduce total dependence on KFSC for seed supply. The courses attract steady enrolment from outside the country than within. Some TSSPs like KWAP also conduct training and produce simple manuals that go along way in sensitising people on important issues in tree seed handling.

KFSC proposes to gradually decrease its involvement in active procurement of agroforestry species by collecting less but will remain duty bound to collect seeds from improved sources for plantation development. The need to develop closer planning and effect cost sharing with the Forest Department ranks highly in KEFRI'S future policy. The present infrastructure and technical potential at the KFSC guarantees any Government Department of availability of quality germplasm once co-ordinated procurement procedures are established. In the meantime it is only fair that the TSSP's are encouraged to collect species which are within the farmlands (e.g *Dovyalis caffra*), leaving KFSC in this respect to act as a Quality Control agent and as a facilitator for technical knowledge and marketing.

KFSC will in addition, regularly inspect seed dealers and seed sources with a view of identifying technical gaps and assisting where necessary.

3.2 Collectors and Suppliers Other than KFSC

A recent survey carried out by KFSC (Ahenda and Omondi 1994), showed that a lot of agroforestry seeds in circulation by the NGOs don't emanate from KFSC. The actual quantities of these seeds could not be ascertained. However, the survey showed that besides procurement from KFSC, many NGOs and farmer groups are continually resorting to alternative sources of seeds. This follows the increased demand for planting non-industrial trees on land outside gazetted forests. Increased promotion of tree planting by rural based projects to counter effects of woodfuel shortages, on farm tree product requirements and environmental degradation are notable. The demand for industrial species is easily quantifiable taking into consideration the land area for commercial plantations and the small number of species involved. However, it is indeed a tedious task to establish the seed demand for non-timber species given the number of species involved.

- **Forest Department**

Whereas it is undebatable that seed is the most important input in any planting activity, policy changes within the Forest Department have not addressed the issue of seeds appropriately. The Department continues to rely on KFSC for most of its seed requirements. On the other hand KFSC, with its tight budgetary allocation and faced with the accelerating cost of seed production, can not meet the Department's demands especially for its extension (FSED) programs. Despite these constraints, the Forest Department still enjoys the benefits of a wanting policy of free issues from the KFSC.

To alleviate the crisis in the availability of seedlings, FESD up to the early eighties established huge nurseries to stock seedlings for distribution to farmers. But by the late eighties (Nyaga 1988), had realised the practical constraints of this procedure. The current policy of facilitation aims at alleviating seedling shortages although it remains implicit on seed procurement.

It is recommended that the department takes seriously the issue of seed and seedling production for its plantation development and extension activities by adopting the following policies:

- Appointing a senior officer at Assistant Director level, to co-ordinate seed and seedling procurement taking into consideration the department's annual planting programmes.

- The seed issue be addressed at the District level by officers who shall also oversee all seedling production activities. This arrangement shall provide the DFO's ample time to concentrate on administration and management issues. Furthermore the officers charged with these responsibilities will have the opportunity to develop interest in the field of seed science and technology. The recent appointment of a seed officer at the research liaison office is a positive step towards achieving this goal.

- **The Role of Forest Based Industries**

Most forest based industries in Kenya have the main objective of utilising plantation products with little or no interest in the regeneration of trees and forests. The industries hence depend almost entirely on state forests for their raw materials. Forestry Master plan development programme suggests the leasing of public land to industrial concerns to grow their own trees. They would thus be required to take up operations like seed and seedling production for their nurseries. Although Pan African Paper Mills have partially been involved in this endeavour, their continued reliance on KFSC for their seed requirements needs to be reviewed. The rational long term option is to invest in production by either contracting KFSC or other credible institutes own seed and seedling production programmes as stated above.

In the latter option, the seeds shall have to be subjected to a certification scheme by an independent body; preferably KFSC. In addition the institutions shall have to put into place the necessary mechanism to implement the programme, i.e. train or recruit qualified personnel and purchase and install appropriate equipment for seed production.

- **The Role of the Farmer**

According to a recent world-bank study, most farmers in sub-saharan Africa use substandard seeds in their food crop production activities. The situation for tree seeds can not be any better. This scenario is detrimental in that it inhibits government initiative in providing access to good quality planting material.

Farmers provide local NGO's with about 70 % of seed requirement, (Schnier 1991). Seed exchange between farmers is prolific in some areas although difficult to quantify. The majority of farmers are less concerned with seed quality issues especially the genetic aspects, given the small sizes of their seed sources. A survey conducted by Kamondo (1993) on farmers in Western Kenya revealed that only a small number of them procured seed of acceptable quality. Looking at this further a field, where large quantities of such seeds are bought by tree planting projects, one can easily visualize the risks in terms of survival rates and sustainability of such programmes.

- **The Concept of Local Seed and Seedling Producers**

The current distribution system is not efficient as only a few farmers are able to obtain seedlings through the Forest Department. The National workshop on Tree Seed Distribution and Marketing (1996) suggested among other things the establishment of Tree Seed and Seedling dealers in view of the fact that only a limited group of farmers seemed to be interested and capable of collecting seed, and raise seedlings from local nurseries. The majority of farmers for practical reasons prefer to acquire seedlings from nurseries. That is why it is more practical to have seed collection and seedling production left only to a few well motivated players in a given community who should be helped to influence markets outside the local communities through linkages, as suggested by Kamondo *et al.* (1996).

This arrangement should promote the development of a realistic distribution system and work towards alleviating seed and seedling shortages at national level. Such entrepreneurs would initially rely on KFSC for technical information and assistance but would gradually, upon training of personnel take up the onus of timely supplying of the appropriate species. They should be registered as seed dealers as allowed in the Seed Act and controlled (in an educative way) to safe guard the interests of the user, the environment and themselves.

The success of the TSSP will depend on tree seed being given the value it deserves. This means that all seeds and seedlings should be issued at a cost. The prices should be set according to the cost of production, seed quality, and the species demand (Kamondo *et al.* 1996). Previous policy deliberations had recognized this as the only way of establishing an organized seed industry. All that remains is its implementation.

- **NGOs and other Government Departments**

The biomass division of the Ministry of Energy was perhaps among the first Government Departments to recognise the importance of alleviate woodfuel shortages in rural areas by facilitating seed and seedling distribution. Their policy is to procure and distribute seeds and seedlings to farmers for woodlot establishment in selected regions. This is in line with the subsidiary operation of manufacturing energy saving wood stoves. Their policy of seed purchase from farmers proved unsustainable with the emergence of wealthier projects which offered better prices. The Ministry is however credited for introducing and promoting suitable species and for establishing seed production units in regions of their operation.

Kenya wood-fuel and agroforestry project (KWAP) is perhaps one of the pioneer NGOs in the country to have operated a tree seed packaging and distribution system. This is probably the most organized NGO in terms of objectives and implementation strategy. However, the seed procurement policy still calls for serious streamlining, given that most of the seeds are procured from private vendors and other NGOs countrywide. The question of seed quality and its repercussion remains elusive and not prioritized within the project. The project recently facilitated the organization of two National workshops (1994 and 1996) where major policies were formulated.

- **Donor-Funded Afforestation Projects**

Many tree planting projects have been initiated since the eighties to alleviate shortages in tree products and facilitate efforts in combatting soil conservation and hence supplement Government efforts in promoting tree planting activities.

The liberalized seed procurement system in which these projects find themselves in has caused serious shortfalls in seedling production in many established state nurseries. Opportunist seed vendors move seed from one project to another in quest of higher prices; leading to artificial shortages of seeds of species in high demand at farm level e.g. *Grevillea robusta* and *Caliandra callothyrsus*. In most cases seeds remain unused for long periods while on transit resulting in significant physiological deterioration. Besides quality and pricing problems, the harmonization of the tree seed market is further made difficult by the unpredictable and often erratic nature of demand which is largely controlled by projects with big budgetary provisions on seed procurement. Consequently such projects provide easy sinks for large quantities of seeds at handsome prices forcing farmers and private opportunists to supply them with large quantities of seeds of unknown origin and physiological status. In their urgency to distribute seeds, some relief agencies might not always make the right decisions regarding their operation programs. In most cases they require quick results in terms of the amount of money spent and quantity of seeds distributed within the region of operation. The success of these activities are in most cases, presented in impressive "paper reports" without considering their impact on the targeted local people. Such projects would provide better services if properly co-ordinated through a well established National forum e.g. Forestry Seed Committee.

4. SEED TECHNOLOGY RESEARCH

Previous research efforts in seed technology had been restricted to determination of appropriate handling and presowing treatments. These were based mainly on establishing protocols to facilitate improvements in collection, handling and germination capacities of seed lots. Emphasis on seed collection and supply and negligible budgetary allocations to fund extensive research limited the programs to establishment of improved seed sources of several agroforestry species. Recent collaborative efforts between KFSC, ICRAF, DANIDA and IPGRI should hasten the implementation of the restructured research programme.

The Research program at KFSC is organized around ten core areas:

- Phenology, reproductive biology, and seed production

- Genetic structure of seed sources
- Seed handling and dormancy
- Seed storage
- Recalcitrant seed handling
- Local and indigenous knowledge in seed handling
- Seed quality testing

4.1 The Role and Impact of Research

The adoption of science and technology have been stressed in many areas as the sure way of improving a country's economic status. This is easily assessed in areas such as food production and industrialization. Forestry is by no means an exception and seed technology lies central to its advancement. The ultimate goal of seed technology research is to understand and offer solutions to the variables which limit any aspect of seed performance so as to avoid losses which occur through the production system. Gains of up to 30 % in volume have been reported in *Pinus* species established from seeds from improved sources.

Initial research efforts in Kenya emphasized the practical aspects of seed handling; from collection to sowing. In this area, a lot of knowledge has been generated. Seed handling protocols have been worked out for the majority of the important tree species e.g. *Vitex keniensis, Cordia abyssinica, Melicia excelsa, Podorcarpus latifolia* to mention a few. This has enabled KFSC to compile the Tree Seed Handbook for Kenya.

In a bid to reduce the indiscriminate movements of germplasm across various ecological regions, KFSC instituted a more technical seed utilization process through zone based collection and distribution. The centre has also carried out surveys to establish farmers' practices in tree seed handling in an attempt to seek fruitful synergy between the two sources of knowledge.

Collaborative programs established by the International Seed Testing Association (ISTA), Tree and shrub committee, mandated KFSC to determine germination protocols for some tropical species not covered within ISTA rules. Initial efforts have been the determination of the number of seeds to be used in the germination test of large seeded species; notably *Balanites aegyptiaca, Croton megalocarpus* and *Afzelia quanzensis*.

The tree improvement program of ICRAF has provided a considerable contribution in the availability of improved germplasm of agroforestry tree species notably *Markhamia lutea, Grevillea robusta, Calliandra callothyrsus* and *Sesbania sesban* through their close collaboration with the National programs (KEFRI and KARI). A number of their trials have already been handed over to KEFRI as seed production units.

5. THE SEED ACT AND REGULATION

In the absence of a government policy to regulate seed production and distribution, no meaningful system shall guarantee the availability and promotion of the use of quality seed. The issue of a possible regulatory system in a completely liberalized seed industry needs special consideration. Many institutions (and individuals) whose major theme is **quantity** of available planting material have since tactfully dodged the subject of **quality** seeds and the need to protect consumers from using inferior germplasm. Although they all prioritize adequate seed availability, regardless of its quality; in order to obtain short-term results and fame, many organisations do not ponder the risks of encouraging such a system. Global examples attributed to the use of inferior germplasm are numerous and it is the height of professional negligence for those charged with the responsibility for seed procurement to advocate unscientific alternatives, especially where efforts for technological advancement are already in place.

Whereas it is true that 'quality' seeds in its broad sense can not be advocated for all seedling production activities; short term initiatives should be encouraged and developed in collaboration with the informal sector to increase awareness of seed consumers to the benefits, accrued from use of quality seed. This would consequently lead to an overall acceptance of a regulating system and an increase in the use of good seed, through the establishment and development of seed production and distribution by the informal sector.

5.1 Why Regulate Procurement and Use of Seeds?

Presently, there is no legal system of controlling the forestry seed procurement and distribution; therefore the distributors are not bound to keep any standards; leaving the consumers unprotected. This is detrimental not only to the consumer but also to the future forest tree populations. To overcome most of the problems facing the tree seed market, a legal control system is essential. The proposed Tree Seed Regulations under Seed and Plant Varieties Act (1972) is a major step in this respect.

The Regulation mandates KEFRI to set up a Seed Unit which shall ensure that the quality of seeds is maintained throughout the production and distribution channels. Similarly, it places the responsibility of protection of all seed within gazetted forests to the Forest Department.

A recent survey carried out by KEFRI Seed Centre in 1995 in various parts of Kenya provided quantitative and qualitative information on the current situation. The most striking finding of the survey was the large volumes of substandard seed in circulation. The report recommended, among other things, the registration of all dealers in order to introduce professionalism into tree seed collection and distribution and that formal training or proof of the same in seed matters be a prerequisite to registration.

Farmers with acceptable seed production units shall therefore conserve them for their economic value. Hence, the legislation shall ensure that seed of poor adaptability and quality is less likely to reach the users. Quality as referred to in the regulation comprises:

- broad genetic diversity
- appropriate provenance for the respective planting site
- good physiological characteristics

The regulation requires that all registered persons dealing with forestry reproductive materials keep complete records of all the seeds collected and distributed in order to ensure and guarantee availability of improved seed in future. To achieve these objectives, rules for establishment of seed orchards and production units are spelt out and treatment prescriptions for their collection and documentation provided.

REFERENCES

Albrecht, J. 1993 (ed): Tree seed handbook of Kenya. GTZ Forestry Seed Centre. Muguga, Kenya.

Ahenda, J. O. and Omondi, W. 1994: Survey on Marketing and Distribution of Forestry Seeds in Kenya. KFSC report.

Kamondo, B. M. 1993: Farmers Practices in Tree Seed Handling and their Future Role in Tree Seed Supply. Unpublished Thesis for MSc. Degree in Tropical Forestry. Wageningen Agricultural University 1993. pp. 77.

Kamondo, B. M. and Thirjsen, R. 1994: Proceedings of the Workshop on tree seed distribution and marketing; Elburgon, July 1994. KEFRI-KWAP, Nairobi.

Kamondo, B. M., Mbuthi, P.; Muriuki, C.; Munyasa, C.; Mwangi, M.; Wanjau, S. and Were, J. 1996: Proceedings of the Workshop on Diversified Policies for Tree Propagative Material, Eldoret, February 1996. (In press).

Nyaga, C. R. J. 1988: Policy of the Forest Department in Social Forestry. Proceedings of the Kenya National Social Forestry Seminar, Muguga-Kenya 1988.

Schnier, P. 1991 (eds): Kenya Forestry Seed Centre. Proceedings of 1st National Tree Seed Workshop 1-5 July 1991 Nairobi. pp. 227.
Seeds and Plant Varieties ACT (Cap.326). The Seeds and Plant Varieties (Tree Seeds) Regulations, 1972; 1993.

Appendix 1

The Secretary
National Tree Seed Committee
P O Box 20412
Nairobi

APPLICATION FOR REGISTRATION AS A TREE SEED DEALER

I/We hereby apply to be registered as tree seed dealer(s) in accordance with the Tree Seed Regulations and my/our particulars are as follows:-

FULL NAME OF APPLICANT(S)...

PARTICULARS OF THE APPLICANT **e.g. NGO, Govt., Donor, Private**..

POSTAL ADDRESS...

TELEPHONE and/or FAX NO..

LOCALITY...

PARTICULARS OF TREE SEED TO BE DEALT WITH*Tick where applicable

Plantations		Ornamental		Agroforestry		Others	

If others specify...

I enclose the sum of ....
in payment of this registration; payable to the Director KEFRI.

Declaration: In signing this application, I/we also declare that I/we are conversant with and shall observe the various clauses and conditions of the seed regulations.

Signed.......................................Position...................................Date..............................

APPROVED/NOT APPROVED Chairman................Secretary...............Date........Reasons for non approval..........................

Appendix 2

REPUBLIC OF KENYA

CERTIFICATE OF REGISTRATION AS A FORESTRY TREE SEED DEALER

Year of registration...

Name of dealer...

Postal address..

Telephone number..

Location of premises..

For the categories:

1. Source identified forestry tree seeds
2. Selected forestry tree seeds
3. Forestry tree seeds from untested orchards
4. Tested forestry tree seeds
5. Vegetatively reproductive materials

Registration number..

Signature ....

Secretary Chairman

NATIONAL FORESTRY SEED COMMITTEE

Designated Authority ....

CHALLENGES IN THE SUPPLY OF QUALITY SEEDS TO MEET FORESTRY SECTOR DEVELOPMENT IN KENYA

B. M. KAMONDO and J. O. AHENDA
Kenya Forestry Research Institute

SUMMARY

The supply of quality tree seeds for afforestation and tree planting activities, in general is not yet optimal in Kenya. A number of obstacles make it impossible to attain the ideal situation in spite of the available technology on tree seed matters. These range from the limited financial and logistical support accorded seed collection and distribution to the low valuation of tree seeds in monetary terms. Moreover, some research work is required for specific species with inherent biological problems.

These challenges can only be faced and solved if all involved appreciate the costs and the value of quality tree seeds and the ever changing economic environment vis-a-vis tree seed acquisition and distribution. The centralised approach to tree seed procurement and distribution has a number of problems which may hinder its success. This calls for decentralisation of the tree seeds operations, and a gradual technical empowerment of the major tree seed consumers to meet their own demands.

In the emerging free market economy, centralisation and controls cannot achieve much. However, for the protection of the seed dealers and consumers in the business, both parties have to be sensitised and given technical back-up particularly on seed quality, because with trees, the mistakes made now will be irreversible in the future.

1. INTRODUCTION

Three basic points are important in provision of germplasm for any afforestation program, *Quality, Quantity* and *Time*. All must be correct for any system that aims at providing propagative materials to users. These materials must be of high quality, sufficient and available when required.

In Kenya two broad categories of seed in use can be recognised, seeds for Agroforestry purposes and seed for Plantation development. The principle of provision of high quality tree seed in sufficient quantities and on time to meet the demands of tree planting rings true for both Agroforestry and Plantation forestry. The challenge to interpret the theme in the case of Agroforestry is however, rather complex unlike in Plantation forestry. The supply of seed to raise plantations can easily be executed by a formal institution through observance of a strict code of conduct that guarantees quality. For plantations, the quantity required, species in question and timing can be worked out almost to the exact detail. Moreover, the range of species is narrow and the actual quantities required far less compared to the Agroforestry demand. But this does not mean that supply of seed for the purpose of plantation development has been streamlined. It continues to be faced with a myriad of problems but that their solutions compared to the challenge of supplying agroforestry seed seem easier to surmount, at least on paper!

In the case of Agroforestry seed, the multiple end uses aimed at and the concomitant diverse ecological environments in which agroforestry is practised demand a wide range of species. Besides the audience to use the seed is large and spread all over the country. This requires therefore massive quantity of seed at the grass roots. A formal institutionalised and centralised supply will be over-burdened and with time will tire especially if it caters for both categories of seeds.

It should not escape notice that we are discussing challenges 10 years on after the establishment of an ostensibly 'very successful' program of tree seed supply i.e. the Kenya Forestry Seed Centre (KFSC). This paper will not discuss the 'success' or 'failure' of the program but will endeavour to present a neutral analysis in the hope that this provokes an action that will avail to users of seed enough, quality seed and on time.

2. **PRE-REQUISITE FOR QUALITY SEED**Although the title talks about challenges in the adequate supply of quality seed, it should be noted that the term supply encompasses production. This clarification is necessary because some problems in the supply of quality seed have their genesis in the shear inability to procure the seeds in the first place. Moreover, it should be recognized that quality seed transcends the mere physiological quality. It encompasses the genetical quality where the degree of genetic diversity (the wider the better) and genetic integrity in the seedlot is of great importance. And finally the quality of a seedlot is valuable only if the seed lot has some basic documentation details. It is on these scores that most seed being used for afforestation in Kenya might be found deficient. The effort to have a seedlot of sound genetic integrity and well documented looks easy on paper, but in practice, many actors find it a most taxing challenge to achieve. There is a big disparity between the written word and the practice as far as seed procurement for afforestation is concerned. Even for those who understand and believe in technology, they forget it all in the rush of having seed and result into converting seed procurement process from a technology to a mere ritual.

The following points try to highlight the specific prerequisites necessary to the provision of quality seed; prerequisites hardly observed by many of those procuring forestry seeds. (for further reading see: Albrecht (1993), Kamondo (1994), KFSC (1992), Willan 1985, Seeds and Plant Varieties ACT (Cap.326), Wolf 1992).

2.1 Ensuring Seed Quality in Tree Seed Multiplication

Certain rules must be observed if quality seed is to be collected from established seed production units. These are:

- The basic material for the establishment of the seed production unit must derive from selected seed sources or from seed orchards whose quality have been approved.
- The ecological conditions of the provenance or the area of origin of the basic material shall be known and documented.
- The site for establishment shall meet the requirements of the species in question for all ecological conditions.
- Form and conditions of the site of establishment shall be conducive for a uniform pollination of all trees. Seed orchards shall have a minimum distance of 500 m to a stand of the same species or a species which can form hybrids with the species in question.
- Seedling seed orchards shall be established with at least 1000 genotypes derived from at least 30 different mother trees. At least 100 genotypes must be guaranteed during all stages of the orchard. Seeds shall be collected from at least 30 well distributed trees and each tree shall be represented with the same amount of seeds.
- Clonal seed orchards shall be established with a minimum number of 30 clones with at least 20 ramets each. At least 90% of the clones with an equal number of ramets shall be represented during all stages of the orchard. Seed collection shall be conducted only after a regularly distributed flowering of at least 15 clones has been observed. Each clone must be represented with the same amount of seeds.

2.2 Ensuring Quality During Seed Source Identification

The provision of seeds has to reflect the different ecological conditions of the country. Seed sources must therefore be identified or if necessary established in all different ecozones. A seed zoning system, based on the similarity of ecological conditions has been developed as a suitable expedient for a preliminary provenance differentiation.

2.3 Flower and Seed Survey as a Pre-Condition for the Procurement of Quality Seed

The distribution and frequency of male and female flowers in a seed source has an important influence on the formation of the genetic variation which is afterwards to be found in a seed lot. Hence, seed collection shall only be conducted after a regularly flower distribution has been observed. Later on, the development of the fruits has to be controlled in order to determine the quality and maturity of the crop.

2.4 Ensuring Quality During Seed Collection

At least 25 trees with a distance of at least 50-100 m should be included in a collection activity. Seed shall only be collected from mature and healthy trees which fulfil the requirements on the phenotype of the respective species. To ensure an equal representation of all genotypes, the same amount of seeds per tree shall be collected. Seed collectors have to collect and keep the seed separate on a provenance basis. A clear and complete documentation and record-keeping is required.

2.5 Quality Aspects During Seed Handling

Fresh seeds are subject to deterioration. Exposure to any kind of extreme heat, cold, humidity, drought or suffocation must be avoided to maintain viability and vigour.

2.6 Seed Testing for Ensuring External and Genetic Quality

Seed testing of every seedlot should be done to ensure highest external seed quality and viability. This is a big challenge to seed collectors without an institutional backup. The tests to determine genetic integrity (the most crucial factor) are impeded technically even to seed collectors in institutions.

2.7 Ensuring Quality during Seed Distribution

The site suitability of forest reproductive material is one of the most important quality factors for practical forestry and agroforestry. In Kenya, there is an acute lack of information on species' provenances and their adaptation potential. Moreover, there is often lack of consciousness of this problem especially under high pressure to establish plantations in the shortest time possible.

3. INSTITUTIONAL CHALLENGES TO PROVISION OF QUALITY SEEDS

3.1 Research Needs

Quality seed will need research backing in all the stages presented as prerequisites in the foregoing section. The weak linkage between Tree improvement and Seed centre during the Seed Centre project days can only be termed as a wasted chance to establish bonafide high quality tree multiplication units. In future collaboration should therefore be sought to involve even other organisations like ICRAF, and NGOs in setting up seed multiplication units. There are other gaps in research and development that hamper provision of high quality seed. The handling, i.e. the separation of seeds from the fruits, the drying and storage of some important indigenous and exotic tree species frequently lack adequate information. *Antiaris toxicaria, Boscia spps., Cordeauxia edulis, Kigelia africana, Ekerbergia capensis, Prunus africana, Salvadora persica, Syzygium spps, Trichilia roka, Warbugia ugadensis* are some of the species with handling problems which require further research. The role of research in provision of tree seed should not be obscured by the more obvious hustle and bustle of seed collection and supply.

3.2 Financial Back-up

The adage that "quality seed does not cost rather it pays" should not be taken literary. In fact quality seed costs a lot in terms of investment. But it pays back even more dividends. Any attempt to operate a shoe string budget to procure seed will only result in disillusionment for everybody, the producers and users alike. There must be put in place a policy spelling out the cost of seed provided, and if the cost is less than the production cost, it should be clear how the subsidy is provided. For the National supply, KFSC should have funds allocated to enable it make meaningful forward planning, otherwise it is gross unfairness to expose KFSC to the onslaught of seed users who believe that KFSC has unlimited ability to procure seed.

Closer attention to the financial implication vis-a-vis provision of quality seed begs for answers. The national economic policies have undergone drastic change since KFSC was started. These changes have influenced the procurement and supply of quality seed. Firstly, as many institutions strive to be sustainable, KFSC has not been left out. This means that most of the customers that were receiving seeds freely previously have now got to pay for their requirements. The change of attitude among the customers to suit this new direction has been very slow, with FD resisting almost totally. Currently, seed collection and distribution operations are being covered by money generated from seed sales. This implies that if KFSC continues issuing seeds freely, then the stock will eventually run out. In an effort to economise the little financial resources generated from seed sales to meet the seed demand, a number of seed quality standards have had to be compromised. These include limited seed surveys, exclusion of distant seed sources from collection programmes and in some cases delayed seed collection. It is increasingly becoming difficult to stick to a programme of work due to sporadic financial changes.

Money is required to fuel other processes leave alone seed collection. By the time collection is being restructured, research has long ceased. And in the horizon, depreciation of facilities portend a grave crisis for provision of quality seed. Kenya Forestry Seed Centre which should remain the backbone in provision of quality seed at the national level requires allocation not only for development but for maintenance of its facilities and replacement of those that have reached the end of their economic life.

With hardly any allocation to the Seed Centre for these purposes, there is no reason to be optimistic on this matter. Allocation at the moment is inadequate and, confined to seed collection activities (see Table 1 & 2: on cost implication in seed collection in 1995).

Table 1: Direct cost of seed collection in 1995 based on least costly provenances

Month	Money required	Target Weight in Kg	Target Spps	Realised Weight in Kg	Realised species
Jan-Mar	44,000	1200	23	1160	23
Apr-Jun	109,000	1472	35	557	22
Jul-Sep	124,000	883	20	371	20
Oct-Dec	81,000	1338	20	548	20
Total	358,000	3809		2636	

60% of the total amount of money required to implement the program was available during the year under review, practically all of it from sales of seed. The major consumer of seed the FD, continues to receive seed free of charge.

Table 2: FD 'official' seed demand for 1995. Source: KFDP & FESD (Nairobi)

Species	Seedlings required	Weight in kilo needed	Cost of collection
Cupressus lusitanica	900,000	12	3,600
Dovyalis caffra	900,000	30	24,000
Juniperus procera	1,200,000	60	24,000
Grevillea robusta	900,000	30	36,000
Pinus patula	4,000,000	500	500,000

The demand forwarded from the DFOs and Foresters is ten fold that shown above.
What is the real Forest Department's seed requirement?

The other scenario created by the economic changes is the attraction of many players into the seed industry. Tree seeds are increasingly gaining monetary value. This is gradually making charitable NGOs issue seeds at a price. Unfortunately in the tree seed market, prices are currently not tied to any quality standards creating loopholes for unscrupulous businesses. A number of organizations involved in tree planting import tree seeds without following the laid down procedures to ascertain the quality of the seeds.

Liberalisation though a feasible solution in reducing procurement burden on the government (KFSC), would require a rigorous training to impact some basic knowledge on seed quality to would be para-professional practitioners. KFSC with no training budget is unable to pass the knowledge to would be seed collectors. Attempts to provide a tuition paid training have resulted in KFSC becoming an international training ground with very few Kenyan nationals benefiting.

3.3 Organisational and Human Constraints

Even with seed being collected, tested and stored at KFSC, it is sometimes difficult to grow the seed into trees due to organisational and human constraints. The continued centralised supply of seed from Muguga has been condemned as cumbersome by many analysts. Attempts to make the system effective despite its weaknesses by drawing protocols for seed indenting and supply have been constrained by human inefficiencies or lack of morale. A proposed centralised seed request and seed supply for plantation development for the forest department was still-born as field officers rejected specified channels preferring the old style of indenting which allows one to indent whatever one fancies and whenever one wants it. This creates false shortages when species like *Dovyalis caffra, Grevillea robusta, Pyracantha angustifolia, Terminalia mentalis* are demanded excessively. The human reluctance to spend more time on requesting relevant species with realistic quantities shows the trend of the profession where professionals feel bothered by professional details. This reluctance has seen the system shelved. The inability to install a system that works for seed supply to the forest department is plagued further by the high cost incurred by KFSC on behalf of a non-paying customer.

3.4 Operationalisation of the Seed Act

The Seeds and Plant Varieties (tree seeds) regulations, 1993 in the Seed Act cap. 326 was promulgated to safe guard on quality seed with the realisation that other actors beside KFSC are inevitably procuring a lot of seed. The Act recognises the establishment of a Seed Quality Control Unit (QCU) and other regulatory functionaries that would regulate seed procurement according to quality oriented rules. The regulations are yet to be gazetted. Even if gazettement is undertaken, the establishment of the QCU and its operation will require investment in terms of material and human resources. It remains to be seen how this will work given presently that funds to collect, leave alone control quality, remain inadequate. On the other hand, it is difficult to imagine all players minding seed quality in their operations without some training and guidance from such functionaries like the QCU.

4. CONCLUSION

The provision of high quality seed in Kenya for the development of the forestry sector must be supported by tangible financial and material provision both by the government and private sectors. The challenge in the long run, just like in many other sectors in Kenya will not be the lack of knowledge, but the diminishing opportunities to put into practice what is professionally sound. The professionals must be given space to put their profession into practice by being supported in their endeavours, otherwise the wealth of tree seed technology accumulated over the last 10 years will have no practical value at all.

REFERENCES

Albrecht, J. 1993 (eds): Tree seed handbook of Kenya. GTZ Forestry Seed Centre. Muguga, Kenya.

Kamondo, B. M. 1994: Seed source conservation and management for the purpose of seed production (unpublished paper).

KFSC 1992: Quality control of tree seed. (Forestry tree seed regulations). Tree Seed Information No. 8. Muguga, Kenya. 11 pp.

Willan, R. L. 1985: A guide to forest seed handling. FAO, Rome.

Seeds and Plant Varieties ACT (Cap.326). The Seeds and Plant Varieties (Tree Seeds) Regulations, 1993.

Wolf, H. 1992: The importance of Genetic Variation for Tree Improvement. In the: Proceedings of the International IUFRO symposium on Procurement and Legal Regulations for Forest Reproductive Material held in Nairobi, Kenya, 1992. GTZ-Forestry Seed Centre Muguga 1993.

PROBLEMS RELATING TO SEEDLING PRODUCTION IN FOREST NURSERIES

C. K. KIRIINYA
Kenya Forestry Research Institute

1. INTRODUCTION

The success of any afforestation or reforestation programme depends largely on the quality of the seed, the nursery techniques and the planting stock used. The general practice is to plant stock raised in nurseries. All nursery operations are directed towards the production of healthy, vigorous plants. In the past the people's need for tree seedlings was met from forest nurseries managed by the Forest Department. However, this is not sustainable at present. The unsustainability of seedlings' production is caused by the following problems:

- Unavailability of resources;
- Inefficient utilization of the available resources;
- Untimely release and insufficient allocation of resources;
- Insufficient and/or untimely release of resources (funds);
- Inadequate skills and experience;
- Poor supervision of nursery management operations;
- Laxity among officers;
- Low staff morale;
- Rigidity and short sightedness of policy makers;
- Abrupt policy changes and external interference;
- Shortage of labour;
- Poorly defined Forester/Researcher interaction

2. CONSTRAINTS

2.1 Unavailability of Resources

The financial resources from the central government are not adequate to cater for all forestry operations. The Ministry of Environment and Natural Resources does not get enough funds from the government. Therefore the little which is received, is spread thinly to cater for all the forestry operations. Items needed for seedling production e.g. transport of forest soils, potting materials, hand tools i.e. pangas, jembes, wheelbarrows etc. are not enough or are not available at all to facilitate seedling production.

2.2 Inefficient Utilization of Available Resources

Although the resources may be scarce, those available should be utilized wisely and effectively. Most resources are misallocated to other operations which might not be necessary at the time. The best solution would therefore be to avoid misallocation of resources and duplication of efforts by sharing the few available resources. For example, one tractor or lorry could be shared by two or three forest stations which are nearer to each other. Moreover transparency and accountability are crucial to ascertain best use of the resources. Appropriate tools and equipment should be provided and supervision improved.

2.3 Untimely Release and Insufficient Allocation of Resources

All the nurseries should have a work plan or a nursery calendar. The resources planned for seedling production should be received before the sowing season otherwise the seedlings may be very small during transplanting time. On the other hand if there is no forest soil at the appropriate time, raising of the seedlings at the right time becomes a nightmare. Therefore, there should be timely release of resources to match with work plans. Resources should also be allocated according to the work plans and the utilization of A.I.Es be encouraged to meet any shortfalls in allocation.

2.4 Inadequate Skills and Experience

Most of the officers who leave our training institutions are hardly involved in technical work. They spend most of their time in administrative duties, attending meetings etc. They hardly give guidance to the junior staff e.g. nursery crew or headmen. To counter this problem Technical Orders should be availed to all forest stations for reference purposes. They should also be adhered to strictly. Refresher courses for Foresters and nursery personnel should be conducted regularly. The officers should be assigned responsibilities according to their experiences and qualifications.

2.5 Supervision of Nursery Management Operations

It is a well known fact that very few senior officers have time to supervise nursery work. They leave this to junior officers e.g. Forest Assistants or nursery headmen/women. If anything goes wrong these people do not make decisions early enough for a solution to be sort. For example, seedlings dying because of pests, drought, nutrient deficiencies or diseases are common cases. The DFOs and/or Foresters should be the technical advisors so as to oversee the correct implementation of the Nursery technical order. The supervisory role should be strengthened at all levels, and the chain of command be strictly followed/observed.

2.6 Laxity Among Officers/low Staff Morale

Most junior officers/nursery personnel tend not to work as hard as they should due to low morale. The low morale is caused by, among other things, living far from the forest stations; some walk from far distances to the forest nurseries and when they reach there they are already tired. Low emoluments without any other benefits from the forests e.g. grazing/farming cause frustration to the workers even though they hardly complain officially.

2.7 Rigidity and Short Sightedness of Decision Makers

A few years ago many forest nurseries had seedlings of only a few species, e.g. Cypress, Pines and Eucalypts because they were overemphasised as fast growers. Each forest station had a given planting programme of a certain number of seedlings. Therefore, when the required number of seedlings had been attained there was no more production of other seedlings! To tackle this problem we should revise the proportions of the two main plantations species i.e. *Cupressus* and *Pinus* and promote the planting of identified suitable indigenous plantation species e.g. *Cordia*, *Olea*, *Prunus* and *Vitex*.

2.8 Abrupt Policy Changes and External Interference

Abrupt policy changes bring confusion and affect seedling production. Such policies are for example: discouraging planting of Eucalyptus by politicians because they are assumed/thought to consume more water; discouraging planting of exotics in favour of indigenous; unwarranted transfers because of malice etc. The authorities should verify allegations made against field officers before taking any action. The words of politicians should be taken cautiously. Meanwhile, professionals should be relied upon to give the correct advice.

2.9 Shortage of Labour

When the government announced entrenchment, a lot of junior officers opted to retire at an early age. This has left many nurseries with very few people e.g. nurseries which had about 15 people are now left with only five people or less. This has reduced the productive capacity of most of the nurseries.

2.10 Poor Forester/Researcher Interaction

There has not been much interaction between the researchers and the foresters in the field. The information from research which could improve seedling production has not been forthcoming to the forester in the field arguably due to unavailability of Technical Orders. The forester in the field should be interacting with the researcher as often as possible so as to gather the current technologies, through seminars, workshops and conferences and to adopt the same in the field.

SESSION 3:
SILVICULTURAL PRACTICES

SUCCESSFUL PLANTATION ESTABLISHMENT: NEED FOR EFFECTIVE AND TIMELY WEED CONTROL

BALOZI KIRONGO BEKUTA
Kenya Forestry Research Institute

SUMMARY

Plantation establishment in Kenya was traditionally by use of the shamba system where people were allowed to live in the forests and grow food crops. As they tended their crops, they also weeded for the young trees. They were re-allocated to new areas when the trees closed canopy. Following the abolition of the shamba system in the mid 1980s, plantation establishment was adversely affected. Some form of shamba system involving "non-residential cultivation" was recently re-introduced in some regions of the country. Hitherto, no definite weed control method has been successfully developed.

Research on appropriate methods of weed control in Kenyan forest plantations is still at a young stage. Complete weeding, as in the shamba system, is very expensive and may not be sustained in the long run, especially in areas with aggressive and fast growing weed species. In fact, the cost effectiveness of the shamba system lay in the unfortunate assumption by the forest industry in Kenya that weeding, as it were, was 'free labour' and was not costed.

Site fertility, previous land use, rainfall and pests can influence the weed-crop relationships and thereby exacerbate the detrimental effects on the crops. Basic studies in non-crop vegetation management, incorporating post-plant site management research, are therefore much needed. Suggestions to facilitate this are highlighted in this paper.

1. INTRODUCTION

Plantation establishment is a term used to describe the events from planting to tree canopy closure. Successful establishment is particularly concerned with ensuring the development of a healthy crop with most of the planted trees surviving to maturity. Many factors can affect the healthy growth of planted trees. Notable among these factors are seed quality, nursery regime, transport and planting quality and in particular pre- and post-plant site management (Mason 1992).

Weeding is an important and in some cases a mandatory exercise for successful plantation ventures (Evans 1982, Lowery *et al.* 1993, Marking and Gardner 1993). Walstad and Kuch (1987) and Wagner and Radosevich (1991) report weed control to result in increased growth and productivity of the desirable crop species. Crop growth is usually reduced with increasing weed abundance in a site (Richardson 1993), irrespective of the management practices (Perry *et al.* 1993).

1.1 Weeds

Weeds are any plants growing in places where they are not desired (Auld *et al.* 1987, Walstad and Kuch 1987). However, the unwanted status of a plant species is a value judgement influenced by the people, place or location and time. Moreover, weeds can be of the same species as the desired crop trees for example, e.g. wildlings in forestry. In view of these facts; Kirongo (1996) defined weeds as ***"non-crop vegetation of the same species or of a different species to the desired crops whose presence may interfere with the sound growth and productivity (final yields) of the desired crop trees through any negative interference mechanisms"***. Therefore, any species deliberately sown in the site to increase fertility for example N_2-fixers in Agro-forestry systems or to prevent soil erosion are not "weeds".

1.2 Need to control weeds

In forest monocultures the success of the desired crop is very important and management procedures normally aim to direct the available resources to these plants. Weed control should therefore form an integral part of the silvicultural and forest management regimes for successful commercial forestry.

The presence of extensive non-crop vegetation in a site can be deleterious to crop growth. High weed densities, cover and size, can compete aggressively for site resources especially nutrients (Balneaves 1981), water (Nambiar and Zed 1980, Sands and Nambiar 1984, Nambiar and Sands 1993) and light (Comeau *et al.* 1993). Non-crop vegetation can induce severe deficiencies in one or more growth-limiting resources in low quality sites. On the other hand, on high quality sites, non-crop vegetation grows luxuriantly with shrub and tree competitors establishing dominance over young planted seedlings. This can result in severe suppression and growth loss especially through poor quality and quantity of light reaching the seedlings. Non-crop vegetation can also hinder routine management activities and thereby increase tending costs. Moreover, weeds can also reduce growth rates, induce poor stem form and delay maturity and harvests (Boyall 1983).

Not all non-crop vegetation is necessarily bad. Some beneficial effects of weeds are for example:

- protecting the soil against erosion;
- forage for livestock and wildlife;
- ameliorating poor sites (Nitrogen-fixing species); and
- increasing the productivity of some systems in Agro-forestry through resource complementarity (Boyall 1983).

Moreover, inter-specific competition (competition between different species) is a dynamic process with both the crop plants and the undesirable species trying to optimize growth by maximizing use of the available resources. There is therefore, need to understand interference mechanisms between the crops and the "weeds" in order to develop successful control procedures (Radosevich and Oysteryoung 1987).

Several studies have reported the commonest form of relationship between crop yield and non-crop vegetation density to assume the shape of a hyperbolic curve (Auld *et al.* 1987, Cousens 1987, Wagner *et al.* 1989). This implies that competitive effects are significant only when the non-crop vegetation occupy a site with certain densities. Therefore, forest managers may actually leave some "weeds" in a site to grow together with the desired crops without incurring significant losses.

Kirongo (1996) showed that the response of radiata pine to weed density were different for herbaceous (grasses) and Woody (Wattle) species. Moreover, competition from herbaceous vegetation was shown to be more severe on root collar diameter than on height growth. These responses were further shown to vary depending on the season (Spring, Summer, Autumn). Furthermore, there was strong evidence that weed species did not discriminate against each other.

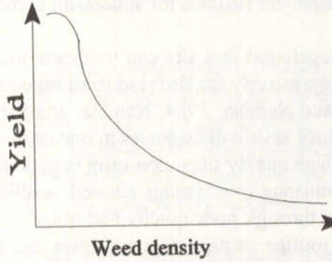


Figure 1: The relationship between desired crop yield and non-crop vegetation density (After Auld *et al.* 1987).

Crop tolerance to weeds varies with species, the control frequency, growth rates stage of development and weed morphology and physiology (Nambiar and Zed 1980). Meanwhile, site factors for example fertility, previous land use, rainfall and pests may aggravate the negative effects on the crops (Lowery *et al.* 1993).

The amount of non-crop vegetation which can be left to grow with the desired crop has to be determined for each site, crop and age (Wagner *et al.* 1989, Brand 1986). Therefore, well controlled experiments are needed if we desire to determine and differentiate between 'significant' and 'insignificant' levels of weed abundance vis-a-vis crop yield loss. The information from these studies can be used by forest managers to predict the growth trend of stands that have received different treatments as in delayed weed control and/or different weed control levels.

Figure 2 presents a case of hypothetical scenarios of stand development. Curve **B** shows normal stand development as portrayed by growth models with unknown levels of weed control. In contrast, A depicts a stand with known and insignificant weed competition. Curves **C**, **D** and E show growth trends of plantations with delayed weed control **C**, reduced and delayed **D** and total failure **E**.

2. NON-CROP VEGETATION MANAGEMENT RESEARCH NEEDS IN KENYA

Since the abolition of the shamba system of plantation establishment, the forest industry in Kenya has been trying to come up with effective and affordable weed control regimes without much success. There is increasingly more desire among forest managers for more efficient weed control methods so as to improve growth and health of planted trees, at affordable cost and in harmony with the environment.

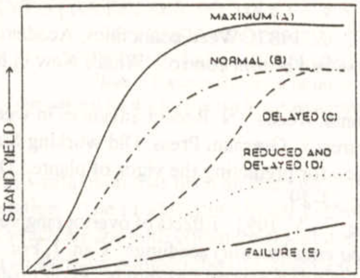


Figure 2: Hypothetical scenarios of possible stand development under different competition levels from non-crop vegetation (after Tappeiner II and Wagner 1987).

KEFRI, in conjunction with Pan African Paper Mills and Twiga Chemicals, has undertaken considerable research in Kaptagat and Turbo. However, lack of relevant know-how on appropriate experimental designs to use and/or results interpretation have slowed down research efforts. Furthermore, the use of herbicides in forested areas has not been received very well in some circles.

Hitherto, most forest managers in Kenya still use 'rules-of-thumb' and 'gut-feelings' in making decisions regarding weed control needs in young plantations. It is also a true fact that many more others still lament about the "death" of the shamba system because of its "cheapness". However, with the trends in population growth and deforestation rates in Kenya, managers and researchers should spend their time trying to find cost-effective and viable alternatives. Quantitative methods using appropriate experimental designs are therefore needed. Objective methods, especially those employing use of neighbourhood predictors of interference effects give more reliable results than subjective approaches. Kirongo (1996) used the neighbourhood approach and developed competition models, (competition indices) using least squares regression analyses (SAS 1987) to elucidate the competitive effects of weeds on young radiata pine growth in Canterbury, New Zealand.

3. CONCLUSION

Given this broad perspective, it can be seen that there is an urgent need for post-plant site management research and especially on non-crop vegetation management in Kenya. This research should endeavour to:

- come up with appropriate and effective quantitative methods of evaluating weed control needs in young plantations;
- find practical and easily measurable indices of competition for the main plantation species and regions;
- develop simple effective methods of prioritizing weed control needs to assist forest managers in decision making regarding non-crop vegetation management in Kenyan plantations; and
- evaluate the cost effectiveness of the chosen methods.

REFERENCES

Auld, B. A.; Menz, K. M.; and Tisdel, C. A. 1987: Weed economics, Academic Press.

Balneaves, J. M. 1981: Long-term gorse and broom control. What's New in forest research No. 100. NZ FRI, Rotorua.

Boyall, L. A. 1983: The control of perennial weeds. IN: Recent advances in weed research, Fletcher W. W. (Eds.). Commonwealth Agriculture Bureaux, Gresham Press, Old working Surrey. pp. 141-170.

Brand, D. G. 1986: A competition index for predicting the vigor of planted Douglas fir in South Western British Colombia. Can. J. For. Res. 19: 23-29.

Comeau, P. G.; Braumndl, T. F.; and Xie, C. -Y. 1993: Effects of overtopping vegetation on light availability and growth of Engelmann spruce (*Picea engelmannii*) seedlings. Can. J. For. Res. 23:2044-2048.

Cousens, R. 1987: Theory and reality of weed control thresholds. Plant protection quarterly 2(1):13-20.

Evans, J. 1982: Plantation forestry in the tropics, Second Edition. Clarendon Press Oxford. pp. 3-28; 203-228; 264-268.

Kirongo, B. B. 1996: Effects of non-crop vegetation on growth and productivity of young radiata pine, MSc. thesis, University of Canterbury; (Christ Church). pp. 7-11; 99- 112.

Lowery, R. F.; Lamberth, C. C.; Endo, M., and Kane, M. 1993: Vegetation management in tropical forest plantations. Can. J. For. Res. 23: 2006-2014.

Markin, J. P., and Gardner, D. E. 1993: Status of biological control in vegetation management in Forestry. Can. J. For. Res. 23: 2023-2031.

Mason, E. G. 1992: Decision support systems for establishing radiata pine plantations in the Central North Island of New Zealand, Ph.D. thesis, University of Canterbury (Christ church). pp. 10-38; 180-200.

Nambiar, E. K.; and Sands, R. 1993: Competition for water and nutrients in forests. Can. J. For. Res. 23: 1955-1968.

Nambiar, E. K.; and Zed, P. G. 1980: Influence of weeds on water potential, nutrient content and growth of young radiata pine. Australian Forest Research (10): 279-288.

Perry, M. A.; Mitchell, R. J.; Zutter, B. R.; Glover, G. R.; and Gjerstad, D. H. 1993: Competition responses of loblolly pine to gradients in loblolly pine, sweet gum, and broom sedge densities. Can. J. For. Res. 23:2049-2058.

Radosevich, S. R., and Oysteryoung, K. 1987: Principles governing plant-environment interactions: IN: Forest vegetation management for conifer production, Walstad, J.D., and Kuch, P. J. (Eds.). John Wiley and Sons pp. 105-156.

Richardson, B., 1993: Vegetation management practices in plantation forests of Australia and New Zealand. Can. J. For. Res. 23: 1989-2005.

Sands, R., and Nambiar, E. K. S. 1984. Water relations of *Pinus radiata* in competition with weeds. Can. J. For. Res. 14: 233-237.

SAS Institute Inc. 1987: SAS/STAT Guide for personal computers, version 6 Edition, Cary, N.C.

Tappeiner II, J. C., Wagner, R. G. 1987: Principles of Silvicultural prescriptions for vegetation management: IN: Forest vegetation management for conifer production, Walstad, J. D., and Kuch, P. J. (Eds.). John Wiley and Sons. pp. 399-429.

Wagner, R. G., and Radosevich, S. R. 1991: Neighbourhood predictors of interspecific competition in young D. fir plantations. Can. J. For. Res. 21: 821-828.

Wagner, R. G.; Petersen, T. D.; Ross, D. W.; and Radosevich, S. R. 1989: Competition thresholds for the survival and growth of Ponderosa pine seedlings associated with woody and herbaceous vegetation. New Forests 3(2): 151-170.

Walstad, J. D.; and Kuch, P. J. 1987: Introduction to forest vegetation management. IN: Forestvegetation management for conifer production, Walstad, J. D., and Kuch, P. J. (Eds.). John Wiley and Sons. pp. 3-14.

TREE IMPROVEMENT STRATEGIES TO MEET KENYA'S DEMAND FOR MAJOR FOREST PRODUCTS

EBBY CHAGALA[1], and TONY SIMONS[2]
[1]Kenya Forestry Research Institute
[2]International Centre for Research in Agroforestry (ICRAF)

SUMMARY

In Kenya as in many parts of the world, there has been an increase in demand for forest products mainly due to the rapid increase in population. The products in highest demand are timber, fuelwood, posts, poles, fodder and pulpwood most of which are for both commercial and domestic use. Together with the increase in demand, there has also been an alarming competition of forest land for other land uses such as agriculture and settlement, and mismanagement of available resources, resulting in a rapid decrease in forest cover. One of the strategies to meet the high demand for forest products and to reduce deforestation is to increase productivity of forests and also afforestation/reforestation. However, the success of such a strategy depends largely on the genetic quality of planting stock used, in addition to appropriate silvicultural practices. The importance of tree improvement, and thus the use of high quality planting material is now widely recognized all over the world among foresters, scientists, farmers and private companies engaged in tree planting. The main aim of a tree improvement programme is maximization of returns and improvement of quality of forest products. This objective may be achieved by utilizing the variation in nature and manipulating it to obtain the highest quality and productivity for the desirable products, and for adaptation for example to adverse climatic conditions in the Arid and Semi-Arid Lands (ASALs). Activities that are undertaken include species, provenance and progeny trials; plus tree selection; and establishment of seed orchards.

Tree Seed Improvement in Kenya was initiated in 1935 with the establishment and management of registered seed areas in selected stands of important indigenous and exotic species. An intensive tree improvement programme was initiated in 1963, entailing provenance and progeny trials, plus tree selection and establishment of clonal seed orchards for the then 3 principal soft wood species in the high potential areas: *C. lusitanica*, *P. patula* and *P. radiata*, for the production of timber and pulpwood. This programme has since expanded to cover the other major end products including those for agroforestry, and adaptation to conditions in ASALs.

For maximum gain, two strategies have been followed: i) a short term strategy to obtain immediate gains of desirable characters as rapidly and efficiently as possible; and ii) a long term strategy that aims to provide a broad genetic base essential for continued progress over many generations.

This paper summarizes the tree improvement strategy that has been developed to meet Kenya's demand for the major forest products for industrial and domestic/agroforestry use (fodder, timber, pulpwood, building and fencing posts, fuelwood and poles) in both high potential areas and the ASALs. Achievements made to date and the future plan of action are also discussed.

1.0 INTRODUCTION

In Kenya, forest products in highest demand are timber, fuelwood, building and fencing posts, poles, fodder and pulpwood. Together with the increase in demand for these products, there has also been an alarming competition of forest land for other land uses such as agriculture and settlement, and mismanagement of available resources, resulting in a rapid decrease in forest cover. Although one of the strategies to meet the high demand for the forest products, is to increase productivity of forests, success depends largely on the genetic quality of planting stock used, in addition to appropriate silvicultural and managerial techniques.

In forestry, the use of genetic principles in tree improvement was neglected for a long time. However, this is now being applied, and to date, the importance of the use of high quality planting material is widely recognized among foresters, scientists, farmers and private companies engaged in tree planting.

The ultimate objective of a tree improvement programme is maximization of returns and improvement of quality of forest products. To be able to achieve this objective, tree breeders apply genetic principles by utilizing the variation in nature and manipulating it to obtain the highest quality, productivity and adaptation (including resistance to pests and diseases and adverse climatic and edaphic conditions). Thus trees can be bred for specialized products such as timber, poles, fuelwood, pulpwood and fodder, and for better performance for example in the arid and semi-arid lands (ASALs). The cost of seed is only 2% of commercial forestry operations, yet it can have such a large effect on profitability. Therefore, investments in tree improvement are easy to justify.

Tree Seed Improvement in Kenya was initiated in 1935 when the importance of high genetic quality seeds was recognised. The programme started with the establishment of registered seed areas in selected stands of all species requiring substantial quantities of seed for plantations. These stands were protected from felling, and managed for seed production by thinning and removal of poor trees to leave only the best parent trees.

In 1949 and 1950, open-pollinated progeny trials were established using seed from the best seed parents of *Cupressus lusitanica,* which was and still is the most widely planted (exotic) species. These trials were extended to include *Pinus patula* in 1957. However, by 1960, it was apparent that a more intensive tree improvement programme was necessary. Such a programme was prescribed in 1962 and initiated in 1963, entailing plus tree selection and establishment of clonal seed orchards for the then 3 principal exotic soft wood species: *C. lusitanica, P. patula* and *P. radiata* that were in demand for timber and pulpwood production. This programme has since expanded to include other species in the high, medium and low potential areas, and caters for other major forest products as well.

To date, three tree improvement strategies have been developed: a short - and medium-term strategy to obtain immediate gains of desirable characters as rapidly and efficiently as possible; and a long-term strategy that aims to provide a broad genetic base essential for continued progress over many generations. This paper summarizes the tree improvement strategy that has been developed to meet Kenya's demand for the major forest products for commercial and domestic use such as fodder, timber, pulpwood, posts, fuelwood and poles in both the high potential areas and ASALs.

2. TREE IMPROVEMENT STRATEGIES

2.1 Genetic Principles

Variation among trees in nature may be due to genetic differences among trees, the environment in which the trees are growing (e.g. nutrient levels, soil moisture, stocking density, etc.), and the interaction between the trees' genotype and the environment. Various kinds of variation occur in nature and these include those among species, provenances, stands, sites, individual trees within a stand and within an individual tree. Studies have shown that variation among provenances and among trees within a stand are the most important.

Variation among trees caused by environmental differences are neither heritable nor predictable and are less useful in a tree improvement programme. However, they may be the cause of variability in some characters, especially those related to growth. Although tree breeders may have no control over some environmental factors such as adverse weather, strains of trees that are more tolerant to these factors may be selected in nature or developed through breeding.

Variation due to genetic differences is the most important in a tree improvement programme as it consists of the inherent quality of a tree. Most important economic characteristics in forest trees such as pest resistance, wood specific gravity and bole straightness are under strong additive genetic control. High gains can therefore be obtained from breeding for these characteristics.

To be able to make continued and maximum progress in tree improvement programmes, knowledge on the proportion of variation that is environmental or genetic and the kind of variation that exists in a species is essential. This can only be accurately acquired through genetic tests such as provenance and progeny trials using material from natural or unimproved populations. The degree of improvement will depend on the ability to accurately determine genetic and environmental differences.

2.2 Stages in a Tree Improvement Programme

There are several stages in a tree improvement programme, all or some of which may be implemented depending on the economic importance of the species to be improved. These stages may be carried out sequentially or concurrently depending on the species. Examples are:

1) Species trials on potential sites for reforestation to select the best species for a given end-product;

2) Provenance trials to determine the most suitable geographic source for seed of the successful species from (1);

3) Large-scale planting of the species using seed from the successful provenance(s) in (2);

4) Selection and classification of the phenotypically best stands derived from (2) and (3) and the management of these stands exclusively for high quality seed production. For most species, improvement to the stage of seed stand selection is sufficient;

5) Concurrently with (4) various activities are undertaken:

- selection and registration of the best 'plus' trees in terms of productivity and quality of the end product;

- propagation of these 'plus' trees (usually vegetatively but also by seed);

- inclusion of the selected trees in clonal or seedling seed orchards for mass production of genetically improved seed;

- progeny/genetic testing with the following objectives:

  * evaluating the genetic worth of 'plus' trees which allows estimation of parental breeding value. The individuals whose progenies show poor performance are removed from the seed orchard, thus improving the genetic quality of seed;

  * estimation of heritability and variance components in order to decide on the characters to be included in the breeding programme. Characters with low heritability are excluded from the breeding programme;

  * production of a base population for providing a source of material for the long-term tree improvement programme. Selections for the next generation are made from this material;

  * demonstration or estimation of gain for assessing the progress made in a tree improvement programme by comparing the relative performance of the improved and unimproved stock in the same test. If gains are low, the breeding programme is not worth the undertaking;

- control pollination using various designs such as polycross, factorial, incomplete pedigree, single-pair mating and partial dialled to obtain new combinations of genes and incorporate many genetic qualities into a few individuals;

- breeding for resistance to pests;

- genecological studies to determine the genetic relationship among trees and species; and

- conservation of the species both *in situ* and *ex-situ*.

The above programme is generally used for exotic species, while a breeding programme for indigenous species commences with the survey and mapping of the species' range, description of its variation and natural environment, and delineation of provenances. Subsequent stages are generally the same as those for exotic species.

For a successful breeding programme, both provenance and progeny tests are mandatory as variation within a species is usually high among provenances, and this variation must first be explored for maximum gain, while progeny trials form the basis for advanced generation tree improvement activities. For effective field testing, the trials are established in a uniform environment to eliminate environmental effects, well designed and replicated in environments in which the species will be grown. Replication is important in capturing genotype-environment interaction.

Furthermore, sustainable management of forests resulting from tree improvement largely depends on close collaboration between researchers and managers. The managers are important for providing land for experimental purposes and the materials from which selections are made. They are also involved in the actual selection of materials at all levels. In case of species that are planted on farms, a participatory approach to tree improvement is essential to ensure sustainable forest management, especially of indigenous species. In addition, because there is little control on the selection of individuals for planting on farms, maximum care should be taken that improved material released to farmers is of a very broad genetic base. This would ensure that continued selections on farms results in maximum gains in the long term.

2.3 The Short Term Breeding Strategy

- **Programme Description:** The short-term strategy involves the stages of species and provenance trials, large scale planting of successful provenance(s), and establishment of seed stands. This stage has two objectives. The first objective is to select the best provenance(s) from which seeds for large scale planting may be obtained. Success in a tree improvement programme is determined largely by the seed source (provenance), and the largest, cheapest and fastest gains in most tree improvement programmes are made by use of the proper species and provenance. Provenance testing is therefore mandatory, and provenances from the whole species' range should be included to be able to capture the variation within the species.

For agroforestry trees of which there are more than 2500 species, the expense of carrying out extensive collections can only be justified once a species has proven itself. The paradox is however, that a species may not be able to prove itself unless its full range of variation is available.

The second objective is to determine the provenance(s) to be sampled more intensively in order to broaden the genetic base which is important for the long-term breeding programme. This can be achieved by making new phenotypic selections in the best provenances, which consequently increases the selection at family level, and subsequently increases gain. Maximum gains for the short term strategy are therefore obtained through selection at the provenance, family and within-family levels.

Achievements: Presently for many exotic and indigenous species, stages 1, 2 and 3 have been reached. Species and provenance trials have been established with the aim of selecting the best provenance for various end products and adaptation. To date, many species/provenances have been selected, the selection criteria depending on the desirable end product(s) as follows:

- For the high potential areas, four exotic species: *C. lusitanica, P. patula, Eucalyptus grandis* and *E. saligna* are now extensively planted on a commercial scale and by small scale farmers for production of timber, poles, posts, fuelwood and pulpwood;

- Indigenous and exotic agroforestry species/provenances have been selected for improvement of soil fertility, high fodder production , fuelwood and as upper storey species in high, medium and low potential areas. These include: *Grevillea robusta, Casuarina equisetifolia, Calliandra calothyrsus, Markamia lutea, Maesopsis eminii, Sesbania sesban* and *Leucaena* spp;

- In the ASALs, indigenous and exotic species/provenances that have proved to be adapted to the dry conditions include: *E. camaldulensis, Melia volkensii, Azadirachta indica* and *Senna siamea* (Syn. *Cassia siamea*). Although the main selection criteria for these species was their survival and fast growth rates in the harsh environments, they also provide major forest products such as poles, posts, timber, fodder and fuelwood that are much needed in these areas;

- Seed stands have been established and single trees selected for many indigenous and exotic species in high, medium and low potential areas. Seeds from these sources are supplied to various end users including the forest department, private companies and farmers. Seeds from selected single trees are first bulked before distribution;

- Survey and mapping of selected species' range and delineation of provenances according to geographical location has been undertaken;

- Delineation of provenances for selected species using modern methods (isozyme technique) is already underway for *Vitex keniensis* and *Populus ilicifolia*.

- **Future Action Plan:** There exists a large data base on species and provenance trials and in most cases, the best species for the various end products have been selected. However, complete data analysis, a review of the information and proper selection of the most successful provenances has not been done. This will be undertaken as a matter of priority. After selection of the most successful provenances, large amounts of seed will be collected from the natural range and planted on a large scale to provide material for further breeding.

In the past, the tree breeding strategy for industrial purposes in the high and medium potential areas concentrated mainly on three exotic species: *C. lusitanica, P. Patula* and *P. radiata*. However, it is important to diversify species in case of catastrophes such as pests and disease attacks. Already, *C. lusitanica* and *P. radiata* which have been the most widely planted commercial species have suffered severe attacks from the cypress aphid *Cinara cupressi* and *Dothistroma* needle blight (caused by *Dothistroma pini*), respectively. This necessitates that the number of species to be planted should be diversified. In this regard, large amounts of seed of provenances of *Pinus oocarpa, P. maximinoi, P. patula* susbs. *tecunumanii* and *P. kesiya* which have shown impressive growth will be obtained from their natural range and planted widely to provide material for an intensive breeding programme. Furthermore, *P. pseudostrobus,* var. *oaxacana* has shown impressive growth rate in species trials and a range wide provenance trial will be established. Wood quality assessment to determine suitability of these species for the various products will first be made.

Earlier in the century, it was believed that indigenous species were slower growing than exotics, and some of them were also difficult to propagate both vegetatively and by seed. This contributed to the lack of large scale planting of indigenous species. However, with proper tree improvement strategies, coupled with sound silvicultural management indigenous species may be grown successfully and can be highly productive. For conservation purposes and to further diversify the species in plantations, provenance trials of indigenous species especially *Maesopsis eminii, Juniperus procera, Polyscias kikuyuensis* and *Vitex keniensis* will be initiated.

Although large scale planting of *P. radiata* has been discontinued due to its high susceptibility to *Dothistroma* needle blight, it is still the most popular species for the pulp and paper industry. Breeding for resistance to this disease involving local selections of resistant material and introductions of improved material from New Zealand and Australia is ongoing and results are encouraging. However, introduction from the native range in California and Guadalupe Island is essential. This is because earlier introductions to Kenya were from Australia and New Zealand; probably from third generation crops that had been derived from a small amount of seed from the original natural range. Manmade and natural selection for conditions in Australia and New Zealand had probably occurred by the time of introduction, and also inbreeding and loss of genes for the Kenyan conditions. Introduction from the natural range will be essential for broadening the genetic base and for the success of the programme.

The recent attack of *C. lusitanica* by the cypress aphid *Cinara cupressi* has necessitated breeding for resistance to this pest. Individuals showing apparent resistance to the aphid have been selected and progeny trials established. Establishment of additional trials is planned. Early assessment of the trial show insignificant attack by the aphid and general field observations show an overall recovery from attack by the aphid. This implies that either the trees have developed resistance mechanisms to the aphid or the aphid populations have reduced. Both possibilities are being explored, in addition to those of biological control.

Survey, mapping, and delineation of provenances using modern methods is planned for selected species.

2.4 Mid-Term Strategy

- **Programme Description:** Mid-term strategy may be divided into two phases. One phase is the production phase which includes selection and registration of 'plus' trees and their propagation and establishment in clonal/seedling seed orchards for mass production of improved seed. These orchards have to be established on sites where seed production for the particular species is high and adequately isolated from contamination from the same species or from a species that may hybridize with it. This necessitates additional information on phenology, site requirements, age of physiological maturity, and internal factors within the trees that influence flowering and seed production. For indigenous species, seed orchards should be established in the main portion of the species' geographic and ecological range, while for exotic species, orchards should be established only once flowering and fruiting have been successfully proven in the area.

The clonal orchards are rogued to eliminate poor clones and to increase genetic gain based on results from progeny tests. After roguing of the seed orchards, other alternatives to increase gain can be employed such as use of seeds from the best clones/families; using the best clones/families in each environment; use of the best progeny from full-sib crosses; and clonal multiplication of seedlings originating from the best crosses.

The second phase is the progeny test phase where seeds for the tests may be open- or control-pollinated.

- **Achievements:** Plus trees have been selected locally and regionally or imported from New Zealand and Australia, and seed orchards of *P. patula* (16.6 ha.) *C. lusitanica* (9.1 ha.) and *P. radiata* (8 ha.) established. Results from open pollinated progeny trials established have been used to rogue the seed orchards and calculate heritabilities and gains. Heritability of most of the characters is high (over 0.70), and gains of upto 30% have been realized for various characters such as volume production, stem form and resistance to diseases such as cypress canker in *C. lusitanica*.

For agroforestry species, plus trees have been selected throughout East Africa for *G. robusta, C. equisetifolia, C. calothyrsus, M. lutea* and *S. sesban* and progeny trials and seed orchards established.

- **Future Plan of Action:** Although seed orchards have been established, seed production has not met the demand, and most seeds are still collected from seed stands, selected trees or locally. This has been due to various reasons such as the small number of the orchards; some orchards were poorly designed or wrongly sited; orchards are still too young to produce seeds as for *P. radiata*; poor maintenance and management; and/or in a few cases, some orchards have been destroyed by fire. Relocation and proper design of the seed orchards, together with expansion of acreage of orchards is a priority which is already being addressed.

An intensive tree improvement programme for *E. grandis* and *E. saligna* is planned and also for agroforestry (*G. robusta, C. calothyrsus, M. lutea, Leucaena* spp. and *S. sesban*), and ASALs (*E. camaldulensis, M. volkensii, A. indica* and *S. siamea*) species.

In the meantime, seed will continue to be collected from seed stands and single trees until a time when seed orchards will supply enough seed to meet the demand. As some of the seed stands have aged, high priority will be given to selection of additional seed stands from younger plantations so as to meet the increased demand for improved seed.

2.5 Long-Term Strategy

Programme Description: The main objective for the long term strategy is to ensure sustainable long term gains. One phase of this strategy is the progeny testing phase which, in addition to providing information for roguing the seed orchards through establishment of open or control pollinated progeny tests, it also creates a base population for advanced generation selection and breeding through full pedigree control. The mating design to be used depends on the labour and financial resources available, although more complicated designs give more genetic information and greater accuracy in parameter estimation. Considering the already restricted genetic base for most species, a large number of families need to be tested.

Another phase is the conservation *in-situ* and *ex-situ* of species. This entails conserving the species in different ways such as in tree/seed banks and in natural and planted stands. Materials for this phase are in the form of 'plus' trees, single trees or provenances. Modern methods such as isozyme technique may be used in this phase to determining the genetic variation in a species. The information gained may be used in various ways such as delineating of provenances, selecting provenances/stands with unique genes for *in-situ* conservation, and selecting individuals with unique genotypes to be used in control pollination for providing new combinations of genes for future selections.

- **Achievements:** Control pollination has been done using 'plus' trees for *P. patula* and *C. lusitanica*, and progeny trials established. Results show an increase of upto 20% for various characters including height, dbh and disease resistance. Selections have also been made for specific and general combining ability. Conservation *ex-situ* has also been undertaken in arboreta, tree banks and seed banks for both indigenous and exotic species. There is also ongoing research to determine the genetic variation of various indigenous species using isozymes techniques.

- **Future Plan of Action:** Control pollination will be expanded to include all the selected trees for the major exotic species such as *P. patula, P. radiata, C. lusitanica*, so as to broaden the genetic base. Information from these trials will allow for further selections for resistance to *D. pini, M. unicornis, C. cupressi* and other characters, and will be used for establishing additional seed orchards. Studies to determine the genetic variation using modern techniques will also be undertaken for the above species and also for *E. grandis, E. saligna* and selected indigenous species.

3. CONCLUSIONS

Tree improvement is one of the most important disciplines in forest development, and together with proper silvicultural practices may contribute greatly to sustainable forest management. However, maximum gains may only be realized if a proper strategy is developed to include the short term need to obtain immediate gains as rapidly and as efficiently as possible, and the long term need to provide a broad genetic base essential for continued progress over many generations.

Tree improvement is a continuous process and various species may be at different stages of improvement at any given time. Success of such a programme depends on close collaboration between researchers and managers, and also a participatory approach involving farmers and communities adjacent to the forests for their maximum benefit and also the successful conservation of indigenous forests and the environment.

BIBLIOGRAPHY

Dyson, W. G. 1964: Tree Improvement in Kenya. Comm. For. Rev. 43 (3): 213 - 217.

F.A.O. 1993: Proceedings of a Workshop on Production of Genetically Improved Planting Materials for Afforestation Programmes. 18 - 25 June 1993, Coimbatore, India. 240p.

Faulkner, R. 1962: A Tree Improvement Programme for East Africa and Recommendations for the

Establishment, Organization and Functions of the Tree Breeding section at E.A.A.F.R.O Headquarters, Kenya. Unpublished. pp. 17.

Griffith, A. L. 1955: The Possibilities of Tree Breeding and of Tree Seed Orchards in East Africa. E.A. Agric. and For. J. 20(4): 241 - 244.

Zobel, B. and Talbert, J. 1984: Applied Forest Tree Improvement. John Wiley and Sons Publishers. pp. 505.

EFFECTS OF PRUNING HEIGHT ON GROWTH OF *CUPRESSUS LUSITANICA*

JULIET WANYONDU and SIMON WAIRUNGU
Kenya Forestry Research Institute

SUMMARY

An investigation was carried out to determine the effect of different pruning intensities on the growth of *Cupressus lusitanica* (Mill). The treatments varied from removal of branches from 33% to 75% of the total tree height. These treatments were compared to unpruned controls.

The results indicated that pruning to more than 65% of the total tree height reduced diameter growth. This, however, did not affect height growth.

1. INTRODUCTION

Pruning in Kenya is a normal tending silvicultural practice carried out in Cypress and Pine plantations which are grown for veneer production, high grade constructional timber and plywood. Most conifers grown in plantations will retain the lower branches for many years, often long after the moribund branch is blocked off by depositions of extractives near the surface of the stem. This will gradually be overgrown by the stem including both bark and wood to form a 'dead' or 'encased' knot which checks and shrinks differentially, often falling out of a board and leaving a hole.

Artificial pruning, where the live branch is cut off to leave only the live section within the stem, is the most effective way of removing the knots where the lower branches are pruned off. The branches are cut to leave only the live section within the stem, and in this case the knots are tightly held in the wood structure and do not check or shrink when the timber is dried.

The economic value of pruning depends on the following factors:

- the age of the tree and hence the height from the ground at which the treatment is applicable - the higher it is up the stem, the more costly and risky it is;
- the nature of stem changes as a result of pruning, being influenced by the knotty core left by the pruning, the diameter after occlusion when the production of clear wood commences and the height of pruning this knotty core will be smaller, the earlier the treatment is carried out, but must be balanced against the possible loss of photosynthesis due to the removal of active green crown;
- the tree species, site quality and rotation length, these factors influence the amount of clear wood produced;
- the end user/use i.e. efficiency in use of the clearwood produced.

Cupressus lusitanica Mill is one of the major plantation species grown for sawlogs in Kenya. Currently, there are approximately 73,000 hectares of established plantations of cypress (MENR, 1994) which is 45% of the total plantation area. The species used to cover about 70% of the annual planting programme (10,000 ha). However, following the outbreak of *Cinara cupressi* (cypress aphid) in 1990, cypress plantations now comprise only 30% of the annual planting programme

The species occurs naturally in Mexico, El Salvador and Honduras where it is widely distributed at between 1,200 m and 3,000 m above sea level, usually on moist slopes (Streets 1962). During its introduction in Kenya; around 1900, its silvicultural management practices were adopted from South Africa. In Kenya, Graham (1949) developed the first pruning schedule.

Pruning in *C. lusitanica* should be carried out at an early age when branches are still alive to ensure a small knotty core, tight knots and high growth rate to enhance quick occlusion of the scar. This pruning operation has been adopted as it reduces damage by *Oemida gahani*, a wood borer which attacks the tree through the pruning scar. Occlusion takes place faster in younger trees as they are still growing at a fast rate.

This paper presents the preliminary results of the effects of five different pruning regimes on growth of cypress up to 35 years.

2. MATERIALS AND METHODS

The trial was set up at Mt. Blackett, compartment 8(L) at Londiani in 1949. The site lies at Latitude $0^0$10'S, Longitude $35^0$31'E and at an altitude of 2,300 m above sea level. It has shallow soils underlain by a murram pan. The mean annual rainfall is 1,260 mm mainly occurring from March to November with peaks in April and August.

A randomised block design of four replicates was used. There were five pruning treatments; ⅓, $^5/_{12}$, ½, $^7/_{12}$ and ⅔ of the tree heights in addition to an unprunned control. Each plot compromised of 50 trees spaced at 2.5 m X 2.5 m. All the trees in the trial plots were pruned at age two and then annually from the age of four to 18 years. In comparison, there are five prunings in the pruning schedule of the Forest Department (FD 1969) as shown in Table 1.

Table 1: Pruning Schedule for *C. lusitanica* Grown for Sawn Timber

Top Height or Age	Pruning Height	No.of Trees to be pruned/ha
2 years	⅓ Height but ≤2m	All trees
4 years	$^5/_{12}$ Height but ≤4m	All trees
9.25 m	½ Height	533
11.25 m	$^7/_{12}$ Height	533
13.71 m	⅔ Height; Max-11m, Min-9m	533

Thinning was carried out by removing trees of the smallest diameters regardless of height, defect or evenness of the stand. By age 16 years, there was an uneven distribution of trees in the plot due to the thinning schedule applied and in 1969, the thinning schedule was changed to allow for evenness.

At 25 years, the unpruned plots were accidentally pruned to $^7/_{12}$ of the tree heights. These were therefore not assessed at ages 30 to 35 years. Analysis of Variance was done for height and diameter.

3. RESULTS

Tables 2 and 3 show the mean diameters and heights respectively of trees under five different pruning intensities from ages 5 to 35 years.

The trees that were pruned to a ⅓ of the total tree height showed faster growth throughout the rotation. The pruning intensities from no pruning up to $^{7}/_{12}$ of individual tree height attained maximum mean annual increment (m.a.i.) at age 5 years with the exception of the ½ height pruning intensity treatment which attained maximum m.a.i. at 10 years (Table 4). The trees pruned to ⅔ mean total height attained maximum m.a.i. in diameterof 1.56 cm at age 15 years.

Table 2: Mean Diameters (cm) at the Ages 5 to 35 years for trees pruned to different heights

	Age (Years)						
Pruning Intensity	**5**	**10**	**15**	**20**	**25**	**30**	**35**
Unpruned (control)	10.1	17.9	25.8	31.8	34.6	-	-
⅓	9.9	19.1	27.4	32.6	34.5	40.8	42.8
$^{5}/_{12}$	9.2	18.2	26.6	32.3	34.9	39.8	41.1
½	8.6	17.3	25.4	31.0	33.5	36.7	39.2
$^{7}/_{12}$	8.3	16.2	24.4	30.4	33.0	36.4	39.4
⅔	7.7	15.1	23.4	29.7	32.5	37.5	38.8
LSD (0.05)	0.4	0.7	1.3	1.7	(ns)	2.8	2.2

Table 3: Mean Heights (m) of trees at different ages pruned to different heights

	Age (Years)						
Pruning Intensity	**5**	**10**	**15**	**20**	**25**	**30**	**35**
Unpruned (control)	5.9	12.5	18.3	21.4	24.3	-	-
⅓	6.1	12.5	18.2	21.6	25.6	28.5	29.6
$^{5}/_{12}$	6.0	12.5	18.2	21.7	25.2	27.8	29.1
½	6.0	12.5	18.1	21.3	25.0	27.5	29.6
$^{7}/_{12}$	6.0	12.9	18.5	21.6	25.2	27.9	29.9
⅔	5.8	12.6	18.3	22.0	25.2	28.5	29.3
LSD (0.05)	(ns)	(ns)	(ns)	(ns)	0.8	(ns)	(ns)

At 5 years, the various pruning height treatments caused marked diameter growth differences except between the unpruned, ½ and $^{7}/_{12}$ treatments (P=0.05).

At 10 years, the diameter growth rate differed significantly among all the treatments except between the unpruned and the ½ height pruned treatments. At 15 and 20 years, the mean diameter of the unpruned trees was lower than those of the ⅓ and $^{5}/_{12}$ treatments. The severest pruning of ⅔ tree height showed slow diameter growth but was not significantly different from the $^{7}/_{12}$ treatment at age 15 years and the ½ and $^{7}/_{12}$ treatments at age 20 years (P=0.05).

Table 4: Mean Annual Increment in diameter at various ages for trees pruned to different heights

	Age (Years)						
Pruning Intensity	**5**	**10**	**15**	**20**	**25**	**30**	**35**
Unpruned (control)	2.05	1.79	1.72	1.59	1.38	-	-
⅓	1.98	1.91	1.83	1.63	1.38	1.36	1.22
$^5/_{12}$	1.84	1.82	1.77	1.62	1.40	1.33	1.17
½	1.72	1.73	1.69	1.55	1.34	1.22	1.12
$^7/_{12}$	1.66	1.62	1.63	1.52	1.32	1.21	1.13
⅔	1.54	1.51	1.56	1.49	1.30	1.25	1.11

Up to the age of 35 years, there were no marked differences in height growth among the trees at the trial plot. However, at age 25 years, height growth rate for the unpruned trees had slowed down substantially and these were significantly shorter than the ones pruned to half their heights. But the half pruned trees were not statistically different from other trees pruned to various heights.

4. DISCUSSION

Pruning to ⅓ and $^5/_{12}$ of tree height gave statistically similar growth rates with respect to height at a rotation of 35 years. However the former grew to 6.7 m knot-free bole while the latter grew to 8.5 m knot-free bole. Although the $^5/_{12}$ and ⅔ pruned trees had significantly different growth rates ($P=0.05$) at age 35 years in terms of diameter, in practical terms, mean diameter differed by 2.3 cm only. With the latter pruning, a pruned log of almost knot-free 13.7 m could be obtained.

To obtain the economic advantage of clear pruned timber, the amount of knotty wood must be kept to a small core in the centre stem (Savill and Evans 1986). This implies attaining the required pruned height at an early age between 10 and 15 years. This could, however, involve removal of living branches and consequently a reduction of the photosynthetic capacity. While this could be expected to affect overall growth, it was not the case with height because height growth is mainly determined by the site quality rather than silvicultural treatments.

This concurs with observations made by Smith (1986) that diameter growth may suffer if crown ratio is reduced to around 40 per cent or more less, but height growth usually remains unaffected unless this ratio is less than 30 per cent.

Unfortunately in the attempted pruning regimes, with the last pruning done at age 18 years when average diameters were around 30 cm, the knot-free bole realised was only approximately 10 cm. Therefore there is no need to prune at this age. On the other hand, the current pruning regime provides a more practical approach in that silvicultural operations are done only five times. Further, it has an advantage because the last pruning is done at age 12 years when mean diameter is approximately 18 cm and with a rotation of 35 years, there exists the potential of a 20 cm knot-free core.

5. CONCLUSIONS AND RECOMMENDATIONS

This study showed that height growth of all trees to various heights was not influenced by the severity of pruning up to 67 per cent of the tree height. At age 35, trees pruned to various heights attained approximately similar heights of 29 metres. Pruning ⅓ of the tree height generally resulted in slightly larger diameter trees but produced less than 7 metres of pruned logs. On the other hand, the ⅔ treatment gave almost 14 m of pruned logs with a 4 cm loss in diameter. Delaying pruning up to age 18 years resulted in a knot-free core of 10 cm as opposed to a possible 20 cm if the last pruning was done at age 12 years. With a rotation of above 30 years, the ⅔ pruning height which is currently used in cypress plantations grown for timber is the best because the price of pruned logs are high compared to unpruned logs.

Since these are preliminary results new trials should be set up to the full rotation with timber quality as one of the important problems to be investigated.

To overcome the labour shortage problem being experienced in the forest estates, it is recommended that three prunings during the rotation; at ages 3, 7 and 12 years be tried.

6. ACKNOWLEDGEMENT

The authors would like to express gratitude to Mr. James Kimondo for the inputs he made in the compilation of this paper and the personnel in the Silviculture office for maintaining the field records.

REFERENCES

Forest Department (FD) 1969: Treatment of Cypress Plantation.Kenya For.Dept. Tech.Order No. 42, Nairobi.

Graham, R. M. 1949: The Cypress Plantation Management. Order No. 6, Kenya Forest Department.

Kenya Government (MENR) 1994: Kenya Forestry Master Plan. Ministry of Environment and Natural Resources Development Programmes, Nairobi.

Savill, P.S. and Evans, J. 1986: Plantation Silviculture in Temperate Regions. Claredon Press, Oxford. pp. 246.

Smith, D. M. 1986: The Practice of Silviculture, 8th Edition. John Wiley and Sons, New York.

Streets, R. J. 1962: Exotic Forest Trees in the British Commonwealth. Claredon Press, Oxford. pp. 765.

TEN YEAR GROWTH OF *EUCALYPTUS UROPHYLLA* PROVENANCES AT GEDE KENYA

C. K. KIRIINYA and J. M. KIMONDO
Kenya Forestry Research Institute

SUMMARY

Seven provenances of *Eucalyptus urophylla* from Indonesia, and East Timor were grown/raised at Gede Forest Station along the Kenyan Coast. At age ten years the Mt. Wuko and Mt. Boleny provenances had proved to be superior than the others. The provenances from Flores showed moderate height growth although within the provenances performance was very variable. Although Mt. Wuko, Mt. Boleny, Mt. Lewotobi and Mt. Langkoeroe provenances showed high growth rate, their growth was lower compared to reports from other studies. The study concluded that the provenances from Flores do better in dry, low altitude areas.

1. INTRODUCTION

Eucalyptus urophylla (S.T. Blake Timor Mountain gum) occurs only in Timor (Indonesia) and the neighbouring Islands and is endemic outside Australia (FAO 1979). It occurs naturally on several Indonesian Islands and possibly in Papua New Guinea. It tolerates lower latitudes than other Eucalyptus found in Australia where the North most point is $10^0 41'$S (Boland *et al.* 1987). Its altitudinal range is 0 - 3000 m with mean maximum temperatures of 29^0C and mean minimum of 8 - 12^0C. The mean annual rainfall should be 1000 - 1500 mm and the latitudinal range; 8^0 - 10^0S. Due to this wide range of altitudinal distribution in Timor and its occurence on several other Islands, the Timor Mountain gum is a species which exhibits considerable variations (Pyror 1975).

According to Gunn and McDonald (1991), *Eucalyptus urophylla* is among the priority species identified by the FAO Panel of experts on Forest Gene Resource for research on taxonomy, germplasm, provenance trials and breeding. Reviewing the acceptance of this species worldwide, Martin (1977) mentioned that this species was widely grown in Congo and trees from the best provenance Lomblen, sometimes grew up to eight meters in the first year. He also explains that Timor provenances with rough bark are adapted to humid tropical climate with annual rainfall of 2500 mm and an altitude of up to 2900 m whereas the provenances from the northern Islands (Flores and others), with smooth bark, are adapted to drier areas with 750 - 1200 mm of rainfall and low altitude; 300 - 1100 m.

Based on the potential of the species, a provenance trial of *E. urophylla* was established at Gede along the Kenyan Coast. The objective was to identify good provenances or individuals of this species for afforestation programs along the Coast. This paper presents the provenances status and highlights the growth differences among them.

2. MATERIALS AND METHODS

The experiment was established at Gede in Kenya (latitude 3^0 12'S, longitude $40^0 02'$ E and 15 m altitude). The soils are alkaline loamy white sands and the topography is flat. The planting site was formerly under high natural forest which was cultivated for four years before the experiment was planted. The mean annual temperature is 28^0C and the mean annual rainfall is 940 mm.
The provenances represented are given in (Table - 1). The seeds were sown in beds using the normal nursery practices. They germinated within five days. The seedlings were pricked out after two weeks and transplanted into transparent polythene tubes of size 10 cm lay flat diameter by 13 cm long. Survival counts were carried out before transplanting to the field after 7 months (Table - 2).

A randomised complete block design of four replications were used. A guard row of *Casuarina equisetifolia* was planted. Each Plot had 20 trees spaced at 2.0 m x 2.0 m. Weeding was done two times a year for the first two years; later slashing was done once annually.

Table 1: Seed origin of Eucalyptus urophylla provenances tried at Gede (Kenya)

Provenance	Seedlot(No.)	Lat.(0^0.1')	Long.(.1) ($^{0'}$)	Alt.(m)
Mr. Wuko Flores Indonesia	12897	8^0.32'	122.35	830
Mr. Lewotobi (Indonesia)	12896	8^0.32'	122.48	475
Mt. Langkoeroe (Indonesia)	11876	--	--	--
Mt. Boleng (Indonesia)	12898	8^0. 21'	123.15	890
Bessi Laou (East Timor)	12362	8^0.37	125.38	1100
Mt. Egon (Indonesia)	12899	8^0.40'	122.27	500
Mt. Mandiri (Indonesia)	12895	8^0.15'	122.58	415

Measurements were taken at years 1, 2, 3, 4, 8 and 10. Survival, total height and diameter (dbh) were recorded. Analysis of variance was carried out on variables measured at age 10 years. Whole tree over bark volume (o.b) was computed using the following volume equation (Easley and Lambeth 1989):

$V = 0.000031D^2H$, where: V = Tree Volume (o.b.)
D = diameter (dbh) (cm)
H = Height in (m)

Volume per hectare was calculated by multiplying the sum of per tree volume in each plot by the plot area fraction represented in hectares.

Stem form grading was done subjectively, thus;

1 - good - no bend at all
2 - satisfactory - one slight bend
3 - Poor - More than one bend

Arc sine transformation for survival was done before analysis (Freese 1983).

3. RESULTS AND DISCUSSIONS

Table 2 shows summarized results of germination and survival percentages in the nursery at age 5 months. The germination for all the provenances was excellent; above ninety percent, while survival in the nursery before transplanting was between 55 - 97% for Mt. Mandiri (12895) and Mt. Egon (12899) respectively. It is noted that the high mortality was caused by erratic water supply and high evaporation rate in the nursery.

3.1 Height growth

Table 3 shows the results of measurements taken at age ten years. Total height ranged from 20.5 m for Mt. Mandiri (12895) to 25.3 m for Mt. Wuko (12897) provenances. The best provenance being Mt. Wuko. The differences in height with the poorest provenance was about 5 m. The difference among the provenances was significant at the 5% probability level. There was insignificant difference amongst the Mt. Boleng (12898), Mt. Lewotobi (12896) and Mt. Langkoeroe (11876) provenances. Also there was no significant difference between Mt. Egon (12899) and Bessilaou (12362) provenances, (Table 4). The mean annual increment for the best provenance was 2.5 m which is not very high compared to the growth of other Eucalyptus along the coast e.g. *Eucalyptus camaldulensis.* But it should be noted that at the early age, from first year to fourth year the height growth was very fast, about 5 m per year which is superior to many other *Eucalypts*. The height growth of *Eucalyptus urophylla* is not as large as it has been reported elsewhere e.g. in Congo (Martin 1977). But it is above the average of many *Eucalyptus* species. Mt. Wuko provenance had a total height of 9.6 m during the second year. This is high compared to height growth in other parts of the world. In Congo (Pointe - Noire) the dominant height of *E. urophylla* was 7.8 m after 2½ years and Congo (Londima) 9.9 m after 2 years (FAO 1979). At Papua New Guinea and Solomon Islands, the growth was far less below that ranked at Gede Kenya.

Table 2: Germination and Survival Percent in the nursery at 5 months

Provenance	Seedlot No.	Germination (%)	Survival (%)
Mt. Wuko	12897	98	61
Mt. Lewotobi	12896	96	60
Langkoeroe	11876	90	73
Mt. Boleng	12898	96	71
Bessilaou	12362	94	59
Mt. Egon	12899	95	97
Mt. Mandiri	12895	92	55

3.2 Diameter

The summary of mean diameter is shown in table 3. The biggest diameter was recorded for Mt. Wuko provenance which attained 17.2 cm followed by Mt. Langkoeroe with 17.1 cm. The lowest diameter was recorded for Mt. Lewotobi provenance which attained 14.9 cm. There was significant difference in diameter at 0.01 probability level among the provenances but there was no statistical difference among the provenances marked with the same letter (Table 4).

The diameter growth among the provenances followed the height growth pattern. The best provenance remained Mt. Wuko followed by Mt. Langkoeroe, both from Indonesia.

3.3 Volume

The highest over bark volume was computed for Mt. Wuko provenance; 550 m^3 ha^{-1}. The lowest volume was 375 m^3 ha^{-1}. The difference between the highest and the lowest was 175 m^3 ha^{-1} which is significant for all practical purposes. The volume of Mt. Wuko Provenance compared to the one of *Eucalyptus camaldulensis* which was grown at the same site is comparatively higher (Table 3).

3.4 Survival

The overall survival was above 60%. The highest survival was 89% and the lowest was 60%. The survival in the field was not very much affected by the provenance origin but mainly by climatic and environmental factors, such as drought and competition by weeds due to insufficient tending.

Table 3: Mean height, diameter (dbh), bole volume and survival percent of seven provenances of Eucalyptus urophylla at age ten years

Provenance	Seedlot No.	Height (m)	DBH (cm)	Vol. (m^3)	(M^3) ha^{-1}	Survival %
Mt. Wuko	12897	25.0	17.2	0.22	550	76
Mt. Boleng	12898	24.7	15.3	0.17	425	88
Mt. Lewotobi	12896	24.3	14.9	0.16	400	85
Mt. Langkoeroe	11876	24.2	17.1	0.21	525	73
Mt. Egon	12899	22.3	15.3	0.15	375	89
Bessilaou	12362	22.1	15.6	0.16	400	60
Mt. Mandiri	12895	20.5	16.6	0.17	425	87

3.5 Stem Form

Table 4 shows the subjective stem grades from 1 - 2, with 1 being the best. The overall stem form was excellent. Very few trees from all the seven provenances had any big bends. All the provenances could be grown for supplying straight poles. The Mt. Wuko provenance from Flores did better probably because Gede is a lowland along the Coast and is dry with rainfall between 800 - 1200 mm. Bessilaou provenance from Timor did poorly may be because it is adapted to a humid climate and at high altitudes up to 2900 m.

Table 4: Ranking of *Eucalyptus urophylla* provenances at age 10 according to height, diameter (dbh) and stem form

Provenance	Height (m)	Diameter (cm)	Stem form (grade
Mt. Wuko	20.0a	17.2a	1
Mt. Boleng	24.7a	15.3b	1
Mt. Lewotobi	24.3a	14.7c	1
Mt. Langkoeroe	24.2a	17.1a	2
Mt. Egon	22.3b	15.3b	1
Bessilaou	22.1b	15.6b	2
Mt. Mandiri	20.5c	16.6a	2

n - 446

There is no significant differences among the values with similar letters (Duncan's Multiple Range Test).

4. CONCLUSION

Martin (1977) found out that provenances from Northern Islands (Flores and others) were adapted to drier areas with 750 to 1200 mm of rainfall and low altitude between 300 and 1100 metres. This study has confirmed Martin's findings because at Gede (Kenya), where rainfall is between 750 and 1200 mm and the altitude is approximately 15 metres, the Mt. Wuko provenance from Flores have outgrown other provenances from higher altitudes.

5. RECOMMENDATIONS

Screening research should be carried out on Mt. Wuko provenance at different sites along the Kenyan coast so as to establish a landrace of this provenance for wider utilization of the species. Since other provenances did not fail completely, they should be tried at different sites at higher altitudes where they may establish successfully. *Eucalyptus urophylla* has come out as a species to be considered for afforestation along the Kenyan coast for production of poles, posts and also fuelwood.

REFERENCES

Boland, D. J.; Brooker, M. I. H.; Chipendale, G. M.; Hall, H.; Hyland, B. P. M.; Johnston, R. D.; Kleinig, D. A.; and Turner, J. D. 1987: Forest Trees of Australia Nelson CSIRO.

Easley, D. F. and Lambeth, C. C. 1989: Five year results of forty five Eucalyptus species growing in the Andean region of Colombia. Investigacio'n Forestal Research Report No.123. Endo, M. 1992. First year Growth of *Eucalyptus urophylla* provenances compared with *E. grandis* and other Eucalyptus ssp. in Colombia. Investigacio'n Forestal Research Report No. 140. Smurfit Carto'n de Colombia.

FAO, 1979: Eucalyptus for Planting. FAO Forest Papers No. II.

Freese, F. 1983: Elementary Forest Sampling. USDA Southern Forest Experiment Station, Forest Service. Agriculture Handbook No. 232.

Gunn, B. V. and McDonald, M. W. 1991: Forest Genetic Resources Information No.19 FAO pp. 34-37.

Martin, B. 1977: Eucalyptus as exotics recent progress. Proceedings Joint IUFRO Workshop S2. 02 - 08 & S2. 03 - 01. Brisbane 1977. pp. 995-1011.

Pryor, L. D. 1975: Eucalypts. In the methodology of conservation of forest genetic resources. FAO/UNEP report on a Pilot Study. FAO. Rome.

LESSONS LEARNT FROM A MEXICAN PINES/PROVENANCES TRIAL AT LONDIANI, KENYA

GITEHI GIATHI and EBBY M. CHAGALA
Kenya Forestry Research Institute

SUMMARY

A species/provenances trial of 11 Mexican pines and one Asian pine and a local land race of *P. patula* as a control was established in 1962 at Londiani. The objective of the trial was to compare the performances of these pines and to assess their potentials as alternative plantation species. The trial design was single unreplicated arboretum type plots. Their sizes varied from 9 x 9 to 5 x 5 trees per plot both between and within species. The characters assessed were dominant height, diameter at breast height (dbh) and stemform. Stemform was visually assessed as per stand without assigning individual trees any kind of score. Survival rate was also determined at the close of the experiment at age 25 years. Height and dbh were assessed at ages 2.4, 3.3, 4.7, 7, 17 and 25 years. No statistical analysis on the data collected was possible since the trial design could not allow. Also the limited number of characters assessed and the difficulties of determining the effect of different plot sizes on the growth of individual trees complicated the handling and interpretation of this data.

The survival rate for most species at 25 years was encouraging. *P. pseudostrobus* var. *oaxacana* had no mortality while *P. michoacana* provenance Moleria, *P. pseudostrobus* and *P. douglasiana* had survival of 92%, 86% and 83% respectively. The control (local land race of *P. patula*) had the least survival being 19%. *P. montezumae* (San Rafael Provenance), *P. caribaea* (Coastal plains provenance) and *P. kesiya* (stock 1660) all had a survival of less than 50%.

The members of pseudostrobus pine complex and *P. strobus var chiapensis* all showed superior height and dbh growth compared to the *P. patula* (control). Their stemforms were fair to exceptionally good. On the other hand *P. caribaea, P. oocarpa, P. douglasiana, P. montezumae* and *P. kesiya* were of poor form.

A range wide provenance trial is recommended on the *P. pseudostrobus, P. pseudostrobus var. oaxacana, P. strobus var. chiapensis and P. maximinoi* all of which did well. The materials to be used should be well documented and the number of characters to be assessed increased. Investigations on wood quality should also involve end users such as saw millers and pulp and paper industry among others.

1. INTRODUCTION

The cultivation of exotic tree species in Kenya started in late nineteenth and early twentieth century. The fast growing exotic softwood species were introduced in the compensatory plantation programme to replace the slow growing indigenous forests. Although by 1922 all pines were described as a failure species trials continued with seeds from mainly South Africa. Pines were eventually successfully grown in East Africa in 1927 following the introduction of mycorrhiza bearing soils from South Africa. By the 1950's a number of small plantations had been established in Kenya and Tanzania with *Pinus patula* and *Pinus radiata* as the main species. The performance of the two species was good in most of the areas, but there was still need to further search for other pines of equally good vigour and superior desirable characters in order to diversify species for plantation development.

Furthermore study of adaptation and performance within selected species in terms of provenances was necessary as provenance variation within a species is usually high. To address these issues, a series of species/provenance trials of Mexican pines was initiated. This paper summarizes the results of one of these trials whose objective was to compare the performances of twelve pine species and their provenances at

Londiani Kenya. The species included were: *P. ayacahuite, P. caribaea, P. douglasiana, P. kesiya, P. michoacana, P. montezumae, P. oocarpa, P. patula, P. pseudostrobus, P. pseudostrobus* var *oaxacana, P. maximinoi,* and *P. strobus* var *chiapensis.*

2. MATERIALS AND METHODS

2.1 Species/Provenances

The trial was established in 1962 at Londiani, masaita compartment and it consisted of a total of 20 species/provenances, details of which are given in Table 1.

2.2 Experimental Site

Londiani is situated on latitude 0° 10' S, longitude 36° 30′E and altitude 2300 m above sea level. The mean annual rainfall is 1270 mm distributed unimodally with peaks in April and August, and mean annual temperature of 15°C. Three dry months occur from December to February. Soils are dark brown to very dark brown clay underlying greyish brown horizon, poorly to imperfectly drained. The soils crack deeply during dry season and are water logged during rainy season.

2.3 Experimental Design

The experimental unit comprised of plots of either 9 x 9, 9 x 8, 8 x 8 or 5 x 5 trees per plot depending on the available planting materials. There was no replication. Plot sizes as per species/provenance is shown in Table 2. The espacement was 8' x 8'. For the 9 x 9, 9 x 8 and 8 x 8 tree plots, only the inner square of 6 x 6 trees were measured , while all the trees were measured for the 5 x 5 tree plots.

2.4 Maintenance and Assessment

The experiment was established and managed under 'shamba system' (taungya) until the closure of the crown. The parameters assessed were dominant height measured to the nearest 0.1 m and diameter at breast height (dbh) measured to the nearest 0.1 cm at ages 2.4, 3.3, 4.7, 7, 17 and 25 years. Stemform was visually assessed as per plot with four categories: very poor, poor, good and good to exceptional. Individual tree scores were not assigned. Survival rate was also assessed at age 25 years. *Pinus patula* Schiede which is the most common plantation species in Londiani and the adjacent areas was used as the control.

3. RESULTS

The experimental layout of the trial presented a major problem in that the data collected could not be statistically analyzed and therefore no significant tests on performances between and within species could be possible. The experiment comprised of single unreplicated plots, therefore analysis of variance (ANOVA) was not possible/meaningful, and as such residual variation could not be estimated. Also the plots of various species/provenances were different in size. This further complicated data analysis as they were not comparable.

The stemform was assessed visually per plot and the categories employed were also not clearly defined. Individual trees were not assigned any score. It was therefore not possible to compare families or individual trees within provenances.

A summary of survival at age 25 years (Table 3) shows that there were differences in survival among the species and also between the provenances. *P. pseudostrobus* var *oaxacana* recorded no mortality *P. michoacana* (Moleria provenance) had a survival of 92%, while *P. douglasiana* and *P. pseudostrobus* showed a survival rate of 83% and 86% respectively. In general the survival was encouraging for most species with the exception of *P. patula* (Narasha, local land race), which recorded the lowest survival of

Table 1: DETAILS ON THE ORIGIN OF SPECIES AND PROVENANCE AND THEIR USES

Species	Common Name	Provenance/Land race	Geographical Location	Latitudinal N/S	Longitudinal E or W	Major Uses
Pinus ayacahite	Mexican White Pine	San Rafel/59,	Mexico,Guatemala,	14° - 37° N	88° - 113° W	Furniture
Pinus caribaea	Caribbean Piten Pine	Mt. Pine Ridge BH/60	Bahamas Islands, Western Cuba, Honduras, Nicaragua	12° - 27° N	77° - 90° W	Saw and Pulp wood Oleo - resin
Pinus caribaea		Coastal Plain BH/60				
Pinus douglasiana	Douglas Pine	Atenquique Jalisco/54 Mexico	Mexico	18° - 27° N	100° -108°W	General construction
Pinus kesiya	Khasi pine	Bagnia Ex Rhodesia (Stock 1681)	India, Burma, China Thailand, Laos, Vietnam	90° - 122° N	11° - 290°E	Bridge construction
Pinus kesiya		Bagnia Ex Rhodesia Stock 1660		90°-122° N	11°E	Bridge construction, flooring, Joinery and furniture ,Poles"
Pinus kesiya		Phillippines/60				
Pinus kesiya		Ex-North Rhodesia 0397/60				
Pinus	Michoacana Pine	Uruopan/60, Mexico	Mexico	16° - 24° N	93° - 105° W	Joinery and Construction work
Pinus michoacana	Michoacana pines	Morelia				
Pinus montezumae	Montezuma Pine, Rough Branched Mexican Pine	San Rafael/60	Guatemala Mexico	14°- 26° N	90° - 105° W	Light constructional work
Pinus montezumae		Morelia/60				
Pinus Oocarpa	Ocote Pine	Morelia, Mexico Michoacaal/59	Honduras, Guatemala, Nicaragua, El Salvador, Mexico	12° - 28° N	85° - 109° W	Rail sleepert
Pinus		Valley de Bravo/60				Pulp
Pinus	Mexican Weeping	Vera cruz/60	Mexico	18		Pulp , Saw timber for light construction.
Pinus	Mexican Weeping pine	Narash (Londiani) Kenya				
Pinus pseudostrobus	False Weymouth Pine	Sierra Juaros,	Mexico, Guatemala, El Salvador, Nicaragua "	13° - 27° N"	86° - 108° W	Saw wood Match making Joinery Resin production
Pinus	False Weymouth Pine	Liano de LosFlorca/60,				
Pinus	Thin Leaf Pine	Morelia	Mexico	14° - 24° W	87° - 107° W	Match making
Pinus strobus var chiapesis	Eastern White Pine	Soliatelivencan Chiapas/60, Mexico	Mexico	35° - 51° N	52° - 96° W	Flooring Joinery

Table 2: Plot Size used for each species/provenance

Species	Provenance\Land race	Plot size (No. trees)
P. ayacahuite	San Rafael/59, Mexico	9 x 9
P. caribaea *P. caribaea*	Mt. Pine Ridge BH/60 Coastal Plains BH/60	9 x 9 9 x 9
P. douglasiana	Atenquique, Mexico	8 x 8
P. kesiya	Bagnia Ex-Rhodesia (stock 1681)	8 x 8
P. kesiya	Bagnia Ex-Rhodesia (stock 1660)	5 x 5
P. kesiya	Phillippines/60	5 x 5
P. kesiya *P. michoacana* *p. michoacana*	Ex-North Rhodesia 0397/60 Uroapan/60, Mexico Moleria, Michoacana, Mexico	5 x 5 9 x 9 9 x 9
P. montezumae *P. montezumae*	San Rafael/60, Mexico Moleria/60, Mexico	8 x 8 5 x 5
P. oocarpa *P. oocarpa*	Moleria, Michoacana/59 Mexico Valley de Bravo/60, Mexico	5 x 5 5 x 5
P. patula *P. patula*	Vera cruz/60 Narasha (Londiani), Kenya	9 x 9 9 x 9
P. pseudostrobus *P. pseudostrobus var oaxacana*	Sierra Juaros ,Ooxaca, Mexico Liano de Los Flora/60, Tuxrapex, Mexico	9 x 9 5 x 5
P. maximinoi	Moleria, Michoacana, Mexico	5 x 5
P. strobus var chiapensis	Soliatelivencan, Chiapas/60, mexico	5 x 5

19% followed by *P. caribaea* (coastal plain provenance) with 36% and *P. montezumae* (San Rafael provenance) with 42%. *P. kesiya* (stock 1660) also recorded a fairly low survival of 44%.

The variation in survival between provenance was evident in *P. caribaea*, *P. michoacana*, *P. montezumae* and *P. kesiya*. The Coastal Plains provenance of *P. caribaea* had a survival of 36%, while Mt. Pine Ridge provenance registered a survival of 72%. On the other hand, *P. keisya* (Ex-North Rhodesia provenance) had a survival of 68% compared to Bagnia Ex-Rhodesia provenance which recorded a survival of only 44%. The Vera Cruz provenance of *P. patula* had a survival of 56% compared to the local land race (Narasha) which had a survival rate of only 19%.

Table 4 shows a summary of mean dominant heights and general stemform at age 25 years. *P. pseudostrobus* var *oaxacana* registered the highest mean dominant height of 33 m followed by *P. maximinoi* with 31 m and then *P. kesiya* (stock 1660) with 30 m. *P. ayacahuite*, *P. caribaea* (Mt Pine Ridge provenance) and *P. caribaea* (Coastal Plains provenance) recorded the least dominant heights of 16 m , 18 m and 19 m respectively. The mean dominant height of the *P. patula* (Narasha) was 26 m.

Variation in height growth between the provenances was not very distinct in most species with the exception of *P. kesiya*, where the Bagnia Ex-Rhodesia provenance had a height of 24 m and ranking eleventh overall, while the Phillippines provenance registered a height of 31 m and ranked the third.

Table 5 gives dbh for all species/provenances over several years. The first dbh measurement which was taken at age 4 5 years showed that *P. ayacahuite*, *P. oocarpa*, *P. michoacana* (Moleria provenance) and

P. montezumae (San Rafael provenance) were all too small for this first measurement. *P. Pseudostrobus var oaxacana* had a dbh of 9.2 cm which was the highest and both *P. kesiya* (stock 1660) and *P. douglasiana* ranked second with dbh of 8.9 cm. *P. patula* (Narasha, local land race) had an initial dbh of 7.7 cm. *P. pseudostrobus var oaxacana* maintained the highest dbh up to the last year of assessment (25 years) with dbh of 37 cm. At this age *P. maximinoi* had the second highest dbh of 35 cm and both *P. oocarpa* (Valley de Bravo provenance) and *P. kesiya* (stock 1660) had dbh of 32 cm. *P. montezumae* (Moleria provenance) ranked least in dbh growth recording only 22 cm and *P. ayacahuite* ranked second last with a dbh of 22.4 cm. *P. patula* (Vera Cruz provenance) had a dbh of 23 cm while the local land race of *P. patula* (Narasha) had dbh of 29 cm. *P. michoacana* and *P. montezumae* also showed variation in dbh growth.

Table 3: The mean survival rate (%) of all the species/provenances at age 25 years

Species	Provenance\Land race	Survival (%)
P. ayacahuite	San Rafael/59, Mexico	67 (10)
P. caribaea	Mt. Pine Ridge BH/60	72 (6)
P. caribaea	Coastal Plains BH/60	36 (19)
P. douglasiana	Atenquique, Mexico	83(4)
P. kesiya	Bagnia Ex-Rhodesia (stock 1681)	58 (13)
P. kesiya	Bagnia Ex-Rhodesia (stock 1660)	44(17)
P. kesiya	Phillippines/60	68 (8)
P. kesiya	Ex-North Rhodesia 0397/60	68 (8)
P. michoacana	Uroapan/60, Mexico	67 (10)
p. michoacana	Moleria, Michoacana, Mexico	92 (2)
P. montezumae	San Rafael/60, Mexico	42 (18)
P. montezumae	Moleria/60, Mexico	72 (6)
P. oocarpa	Moleria, Michoacana/59, Mexico	52 (16)
P. oocarpa	Valley de Bravo/60, Mexico	60 (12)
P. patula	Vera cruz/60, Mexico	56 (14)
P. patula	Narasha (Londiani), Kenya	19 (20)
P. Pseudostrobus	Sierra Juaros ,Ooxaca, Mexico	86 (3)
P. pseudostrobus var oaxacana	Liano de Los Flora/60, Tuxrapex, Mexico	100 (1)
P. maximinoi	Moleria, Michoacana, Mexico	76 (4)
P. strobus var chiapensis	Soliatelivencan, Chiapas/60, Mexico	56 (14)

*Numbers in the brackets designate ranking

4. DISCUSSION

P. pseudostrobus var oaxacana ranked first for all characters. Similarly, both the *P. maximinoi* and *P. strobus var oaxacana* performed well and ranked high in these characters. The height and dbh growth of these pines was superior to that of *P. patula* (Narasha). In general it appears that the species with the highest height growth tended to have high diameter growth and vice-versa. This suggests a co-relation between height and dbh growth. The only exception to this general rule was *P. patula* (Vera Cruz provenance) which ranked sixth in height but eighteenth in dbh growth.

The observed variation in height and dbh growth between provenance could be partly attributed to differential adaptations to the local conditions and partly to microsite variation. It should be however noted that the differences in dbh growth between the local land race of *P. patula* and the Vera Cruz

Table 4: Mean dominant heights (m) mean annual increment (m.a.i.) and general stemform for all species/provenances

Species	Provenance	Age (years)						m.a.i.	Form (general)
		2.4	3.3	4.7	7	17	25		
Pinus ayacahuite	San Rafael/59. Mexico	1.5	1.8	2.5	5.4	12	16	0.64 (20)	poor
P. caribaea	Mt. Pine Ridge BH/60	2.1	3	3.6	7.5	13	18	0.72 (19)	poor
P. caribaea	Coastal plains BH/60	1.6	2.4	3.9	6.3	13	19	0.76 (18)	poor
P. douglasiana	Atenquique. Mexico	2.6	3.9	5.7	10	21	24	0.96(11)	poor
P. kesiya	Bagnia Ex Rhodesia (stock 1681)	2.3	3.3	5	9.4	17	24	0.96 (11)	poor
P. kesiya	Bagnia Ex Rhodesia stock1660)	2.8	3.9	5.7	9	18	30	1.24 (3)	poor
P. kesiya	Phillippines/60	2.4	3.6	5.3	8.7	17	31	1.24(3)	poor
P. kesiya	Ex-N. Rhodesia 0397/60	2.6	3.9	5.4	11	21	28	1.12(6)	poor
P. michoacana	Uroapan/60. Mexico	1.3	2.1	3.5	7.5	19	23	0.92 (16)	good
P. michoacana	Moleria.Michoacan/59 Mexico	1.4	1.8	2.6	6.6	19	24	0.96 (11)	good
P. montezumae	San Rafael/60: Mexico	0.8	1.8	2.7	6.6	18	24	0.96 (11)	poor
P. montezumae	Moleria/60. Mexico	1.1	2.4	4.2	7.8	18	22	0.88(17)	poor
P. oocarpa	Moleria. Michoacan/59. Mexico	1.7	2.4	3.3	6.3	14	24	0.96(11)	very poor
P. oocarpa	Valley de Bravo/60 .Mexico	1.3	2.1	3.6	6.3	17	27	1.08(9)	very poor
P. patula	Vera Cruz/60 .Mexico	3.1	4.8	7.5	12	26	28	1.12(6)	good to v.good
P. patula	Narasha. Londiani. Kenya	2.5	4.2	6.6	11	20.8	26	1.04 (10)	good to v.good
P. pseudostrobus	SierraJuaros. Oaxaca/60 Mexico	2.2	3.3	6.2	11	27	28	1.12(6)	good to v.good
P. pseudostrobus var oaxacana	Lianode Los Flora/60 Tuxrapex Mexico	2.4	3.9	5.6	10	26	33	1.32	good to v.good
P. maximinoi	Moleria. Michoacan/59 Mexico	2.2.	3.9	5.8	9.6	21	31	1.31(2)	good to v.good
P. strobus var chiapensis	Soliatelivencan.Chiapas/60. Mexico	2.2	3	4.7	8.1	20	30	1.24 (3)	good to v.good

*Numbers in the brackets designate ranking

Table 5: Mean diameters (cm) for all the species/provenances

Species	Provenance	Age (Years)						m.a.i. (m/yr)
		2.4	3.3	4.7	7	17	25	
Pinus ayacahuite	San Rafael/59,Mexico	-	-	-	7.6	17.6	22.4	0.9 (19)
P. caribaea	Mt. Pine Ridge BH/60	-	-	6.4	10.9	20.1	25	1.0 (16)
P. caribaea	Coastal plains BH/60	-	-	5.6	8.9	18.5	27.0	1.08(13)
P. douglasiana	Atenquique, Mexico	-	-	8.9	15.5	23.9	28.0	1.12(11)
P. kesiya	Bagnia Ex Rhodesia (stock 1681)	-	-	7.1	13	22.4	26	1.04(15)
P. kesiya	Bagnia Ex Rhodesia (stock 1660)	-	-	8.9	15.7	26.4	32.0	1.26(3)
P. kesiya	Phillippines/60	-	-	8.6	15.5	24.6	30.0	1.2 (5)
P. kesiya	Ex-N. RHODESIA 0397/60	-	-	8.6	17	24.9	30.0	1.20(5)
P. michoacana	Uroapan/60, Mexico	-	-	6.3	12.7	19.4	24.0	.96 (17)
P. michoacana	Moleria, Michoacan/59 Mexico	-	-	-	15.2	24.9	30.0	1.20(5)
P. montezumae	San Rafael/60; Mexico	-	-	-	14	23.2	29	1.16(9)
P. montezumae	Moleria/60, Mexico	-	-	5.9	11.4	18.8	22	.88 (20)
P. oocarpa	Moleria, Michoacan/59, Mexico	-	-	-	15	23.3	28.0	1.12(11)
P. oocarpa	Valley de Bravo/60, Mexico	-	-	-	14.5	25.9	32.0	1.26(3)
P. patula	Vera Cruz/60, Mexico	-	--	8.4	13.5	20.5	23	.92 (18)
P. patula	Narasha, Londiani, Kenya	-	-	7.7	16.5	25.1	29.0	1.16(9)
P. pseudostrobus	SierraJuaros,Oaxaca/60 Mexico	-	-	8.2	16.5	22.1	26	1.04(14)
P. pseudostrobus var oaxacana	Lianode Los Flora/60 Tuxrapex, Mexico	-	-	9.4	19.9	31.5	37	1.48(1)
P. maximinoi	Moleria, Michoacan/59 Mexico	-	-	7.8	16.5	30.5	35	1.42(2)
P. strobus var *chiapensis*	Soliatelivencan,Chiapas/60 Mexico	-	-	4.7	11.7	22.9	30	1.2 (5)

*Numbers in the brackets designate ranking.

provenance could be due to their different survival. The local land race had only 19% survival , while the Vera Cruz had a survival rate of 56%. The former, therefore, due to availability of a large open growing space could have utilized it to put more diameter growth at the expense of height.

Generally, observations on stem form showed that *P. oocarpa, P. douglasiana, P. montezumae, P. caribaea* and *P. kesiya* had poor form and were of less commercial value for sawlogs. However, the members of the *pseudostrobus* pine complex: *P. pseudostrobus var oaxacana, P. pseudostrobus, P. maximinoi* and *P. strobus* var *chiapensis* had good to exceptionally good form. This was comparable to or better than that of *P. patula*. Also the superior growth vigour of these pines to that of *P. patula* indicate that they have potentials which should be explored through further trials.

5. CONCLUSION AND RECOMMENDATIONS

The performance of *P. pseudostrobus, P. pseudostrobus* var *oaxacana* , *P. maximinoi* , *P. michoacana and P. strobus* var *chiapensis* was good and very encouraging. It is therefore recommended that range wide provenance trials be established for each of these species in this locality and in other potential pine growing areas of the country.

For a more reliable data, the number of quantitative and qualitative characters should be increased and an appropriate scoring system for different qualitative characters be devised and applied. Characters of importance to be considered include: branch sizes, branch angles, stemform, wood quality and resistance to pests.

Such investigations should involve end users such as the saw millers and pulp and paper industry as these species are assumed to be suitable for timber and pulpwood. The seeds to be used in these trials should be well documented and a statistically valid experimental design employed.

BIBLIOGRAPHY

Chapman, E. W. 1966: Minor Exotic Tree In Kenya. Technical Note No 103, Forest Department, Republic of Kenya, Nairobi.

Critchfield, W. B. and Little, Jr. E. L. 1966: Geographical Distribution of Pines of World. USDA, Forest Service, Misc. Publication; pp. 991.

Greaves, A. 1982: *Pinus oocarpa*. Forestry Abstracts, Review Article, vol.43.No.9:505-532.

Kietzka, J. E. 1988: *Pinus maximinoi*: A Promising Species In South Africa. *South African Forestry Journal* 45:33-38.

Loock, E. E. M.1977: The Pine of Mexico and British Honduras. *Bulletin* No.35. Department of Forestry, Pretoria, South Africa pp. 262.

Martinez, M. 1948: Los Pinis Mexicanos. ed 2. pp. 361. Ediciones Botans, Mexico.

Mirov, N. T. 1967: *The Genus Pines*. The Ronald Press. New York pp. 602.

no, F. and Dyson, W. G. 1971: East African Agricultural and Forestry Research Organization (E.A.A.F.R.O.). Technical Note No.27. *The Growth of Pines at Muguga Arboretum.*

Poynton, R. J. 1977: *Tree Planting in Southern Africa: vol.1. The pines*. Report To The Southern Africa Regional Commission For The Conservation And Utilization Of Soil (SARCCUS). Department of Forestry, Republic Of South Africa. pp. 576.

Stead, J. W. 1983: A Study Of Variation And Taxonomy of *Pinus pseudostrobus* Complex. Common W. For. Rev. 62(1):25-35.

Street, R. J. 1962: Exotic Forest Trees In The British Commonwealth. Oxford: The Clarendon Press.

Styles, B. T. 1976: Studies On Variation In Central American Pines 1 The Identity Of *Pinus oocarpa* var ochotenerai Martinez. Silvae Genetica. 25(3-4):109-118.

Vidakovic, M. 1991: Conifers: Morphology and Variation Graficki Zavod Arvatske, Croatia, pp. 754.

SILVICULTURAL CHALLENGES IN THE DEVELOPMENT OF PRODUCTIVE FORESTRY IN KENYA

P. K. A. KONUCHE
Kenya Forestry Research Institute

SUMMARY

While Kenya has a low forest resource base, the demand for forest products and services is rapidly increasing. This calls for improvement in the management of forest plantations and natural forests to increase productivity of the limited forest area, intensification of farm forestry and better management of woody vegetation in the drylands. To achieve this silvicultural research is required to develop suitable and reliable silvicultural systems. The silvicultural issues which need to be addressed are discussed in relation to farm forestry, management of indigenous forests, development of industrial plantations and management of the drylands woodlands. Issues of particular attention are: the development of trees preferred by the farmers and improvement of farmer developed technologies; improvement of selective cutting systems, development of silvicultural systems for multipurpose forest management and characterization of indigenous species as regards their light requirements; diversification of plantation species, increased planting of indigenous species, and reducing the costs of silvicultural operations; and, development of silvipastoral systems and browse species for drylands.

1. INTRODUCTION

With an estimated three percent of the total land area under forest cover, Kenya has a low forest resource base. Because of the rapidly growing human population, the limited forest land is under great pressure for conversion into land for agriculture and settlement. The demand for forest products, especially woodfuel is also increasing. Land productivity is also declining in farmlands. In the drylands, deforestation is leading to rapid environmental degradation. Low rate of replanting in harvested industrial forest plantations is a major problem. For a long time we have relied on a few exotic species in our plantation programmes, but this is becoming unsustainable.

In order to meet the basic needs of the present and future generations while enhancing the role of forestry in socio-economic development and environmental conservation, it is necessary to improve the productivity of our forests. Improvement in forest productivity, however, should not be seen as advocating intensive silviculture only, but rather adopting suitable and reliable silvicultural systems. The challenges facing silvicultural research are, therefore, to develop new technologies or improve the current management systems in order to increase and sustain the productivity of natural forests, industrial plantations and trees in farmlands. Technologies for improving the productivity of woodlands in drylands which cover approximately 80% of the country are also required.

1.1 Natural Forests Management

The forest policy in Kenya has always emphasized the management of our forests primarily for protective function, especially the protection of soil and water resources (Government of Kenya 1968). Wood production has therefore been regarded as a secondary function. The new Forestry Policy has expanded these functions to include the conservation of biodiversity and production of non-timber forest products to meet the basic needs of the local communities (MENR 1994). Production of timber products is, however, still important to support the economic development of the country.

The selective cutting system practised in Kenya's forests for many years, resulted in depletion of valuable tree species (Kigomo 1989, Konuche 1994, MENR 1994, KIFCON 1994), and has left forests characterized by:

- large canopy gaps of varying sizes;
- few mother trees of mainly inferior genetic quality;

- poor natural regeneration of depleted species; and
- abundance of colonizing pioneer species.

Among the slightly over sixty species considered as commercial, those which have been over-exploited are cedar (*Juniperus procera*), camphor (*Ocotea usambarensis*), elgon teak (*Olea capensis*), meru oak (*Vitex keniensis*), podo (mainly *Podocarpus falcatus*), mvule (*Milicia excelsa*) etc. On the other hand *Neoboutonia macrocalyx, Macaranga capensis, Dombeya goetzenii*, etc. are among the many pioneer species which have proliferated in wetter forests in the highlands. These species are not marketable at the moment and efforts must be made to make use of them.

Silvicultural research areas needed to improve the productivity of our natural forests are:

- **Improvement of Selective Cutting System**
  The present poorly regulated selective felling needs to be improved towards a true selection system. In the true selection system, single stems or small groups of trees are removed as they reach maturity on a more or less continual or polycyclic basis (Schmidt 1991). The ecologists and silviculturists need to work very closely with the practising foresters to establish pilot areas covering different forest types to test the suitability of this silvicultural system under our conditions.

- **Development of Silvicultural Systems for Multipurpose Forestry**
  As indicated earlier, the current forest management objectives in our natural forests include conservation of biodiversity and production of non-timber forest products. Foresters, therefore, need to move away from classical silviculture of developing techniques of stand treatments for timber production. They need to develop integrated systems to guide the caring of forests for multiple use, especially the conservation of biodiversity and production of non-timber forest products. They need to pay attention to the diversity and structure of our forests. Surveys will have to be carried out to obtain information on the status of a number of over-exploited species and recommend suitable conservation strategies. For example, a species like camphor is difficult to regenerate in Mt. Kenya forests because of heavy browsing by elephants. But can it be conserved or planted in Kakamega and Nandi forests where there are no elephants? The genetic variation of some of the depleted species will need to be understood.

- **Rehabilitation of Degraded Natural Forests**
  Degraded forests are those which have been heavily disturbed through either selective cutting or clear cutting but without replanting. Such areas have been colonized by pioneer species which seem to hamper the regeneration of the desired species. In order to improve the stocking in these forests, it is necessary to understand the ecological requirements of the exploited species. Recent studies by Kigomo (1989) and Konuche (1994) indicate that some of our indigenous species require some degree of shading to survive and grow at seedling phase. Other studies by Sharew (1994) also show that species like cedar regenerate well in burnt sites where mineral soil is exposed. Ecological characterization/classification of our indigenous species on their light requirements is therefore an important challenge to our ecologists. This will provide information on the possible reasons why natural regeneration is poor.

  In the past, efforts have been made to restock some of the areas through enrichment planting, but with little success. This is possibly because the species used for enrichment planting are light demanders. The role of the colonizing species in natural succession in Kenya is little understood and they are often condemned as impeding the natural regeneration of commercial species. Perhaps they play a vital role as nurse trees. If they do, do we need to intervene or accelerate the recovery process? If so when and using which species? Answers to these questions are urgently needed.

Finally, with the increasing demand for land for livestock production, foresters will be called up on to allow local communities to graze their animals in forest areas. Studies are therefore needed to determine the effects of grazing on forest regeneration. Can we develop silvipastoral systems in our natural forests?

1.2 Farm Forestry Development

The dwindling supply of wood from traditional forest plantations provides opportunities for development of farm forestry. MENR (1994) has already reported increasing forest cover in farmlands in high potential areas. Farm forestry, therefore, has the potential to supplement wood production from traditional sources for both domestic and industrial uses. However, this is only possible if the farmers are guided on proper management of farm forests.

Trees on farms are grown for diverse objectives such as windbreaks, shelter belts, shade for some cash crops and animals, hedges and boundary trees, amenity purposes and production of fire wood and poles for construction. In some cases, some farmers grow trees as cash crops. As availability of wood becomes scarce from forest reserves, more and more farmers will adopt commercial tree farming. Farmers are therefore likely to prefer trees with the following characteristics:

- fast growth for short rotation;
- easy to propagate and establish, e.g. able to coppice;
- trees that require little care, e.g. not browsed by animals;
- multipurpose use;
- agroforestry trees; and
- trees that yield products of high demand or cash value.

Farm forestry silvicultural research should therefore pay attention to development of trees with these characteristics. It will be important to diversify species for farm forestry. Development of çheap and effective production technologies for intensive short rotation and agroforestry systems are needed.

We are beginning to acknowledge that our farmers are innovative in tree management. Researchers should therefore be ready to learn and improve what the farmers have developed. For example, the treatment of *Grevillea robusta* seed around Mt. Kenya is farmer developed technology. How can we improve on this and many others? The adoption of developed or improved technologies by farmers need to be addressed. Traditionally, research findings have been disseminated through technical notes and technical orders. These are obviously inappropriate to farmers. Moreover most of our farmers cannot read or write.

1.3 Industrial Plantations

Industrial plantations have played an important role in economic development of our country through supply of timber, pulpwood, plywood poles, etc. The problems facing sustained development of industrial plantations are: rising costs of silvicultural operations; low rate of replanting harvested areas; and the heavy reliance on a few exotic species, *Cupressus lusitanica* and *Pinus patula*. These species are also planted as monocultures and are not suitable for the conservation of the environment and biodiversity, particularly when poorly treated.

Silvicultural research should, therefore, address the issues of developing cost-effective tending techniques needed to successfully replant clearfelled areas. Since the costs of silvicultural operations have become astronomical, we need to review them. For example, do we really need to do high pruning? Should we continue to plant at the current spacing regimes and reduce the stockings by half about six to seven years later?

Secondly, since the use of exotic species in our plantation programmes is becoming unsustainable, we need to start the planting of indigenous species. A large number of our indigenous pioneer species such as *Macaranga capensis, Polycias species, Croton macrostachys, Cordia africana, Dombeya goetzenii*, etc. are probably suitable for plantation programmes. However, we know very little about their silvicultural requirements. For example, it has been observed that *V. keniensis* can grow as fast as *C. lusitanica* if it is well tended and moderately shaded (Konuche 1994). Unlike exotic species, most of our indigenous species seem to grow well in mixtures. It is therefore necessary to investigate on their compatibility, appropriate design for mixed species planting and management regimes. Some species, e.g., cedar show a wide range of distribution from about 1100 m to 3000 m above sea level and we know nothing about its variation and that of many others. Provenance trials of many of our indigenous species are therefore needed. The use of indigenous species in plantation programmes is likely to reduce the occurrence of pests and diseases. It will also result in biodiversity-oriented silviculture.

1.4 Drylands Forestry

The woody vegetation in our drylands, covering about 80% of the country, has the capacity to provide many goods and services such as: wood for fuel and construction; fodder for livestock especially during the dry seasons; materials for handicrafts; honey, fruit, nuts; gums, resins, dyes and other products for pharmaceutical use; and rare plants and animals for tourist industry. For many years the pastoral communities in these areas have managed the forests/woodlands on sustainable basis. However, these forests are now disappearing rapidly because of the need for agricultural land, settlements and increasing demand for fuelwood. Concerted efforts are, therefore, required to manage these forests on sustainable basis. Research is needed to support the various objectives of forest management. It is important to focus on adaptive research, testing the effectiveness of technologies already known. Silvicultural research must address technical aspects related to improving the productivity of woodlands for livestock production. It is important to focus on learning and improving the traditional silvipastoral systems. Particular attention should be paid to: the grazing and burning regimes and their effects on regeneration and growth; identification of silvicultural requirements of indigenous browse species for planting in settled areas; and survey of rare or over-exploited trees and shrubs and developing propagation techniques and conservation or planting strategies. It should, however, be emphasized that because of the harsh environment, large-scale reforestation in the drylands is impracticable. Silvicultural technologies should, therefore be simple, effective, adaptable to the local conditions, and be easily adoptable by the local communities.

REFERENCES

Government of Kenya 1968: Forest Policy for Kenya. Sessional paper No. 1. Government Printer, Nairobi.

KIFCON 1994: Kenya indigenous forest conservation programme. Phase I Report, Nairobi.

Kigomo, B. N. 1989: Studies on the regeneration and growth characteristics of *Brachylaena huillensis* in semi-deciduous forests of Kenya. Ph.D. Thesis, University of Oxford.

Konuche, P. K. A. 1994: The influence of light environment on indigenous tree seedlings in Kenya. Ph.D. Thesis, University of Edinburgh.

MENR 1994: Kenya Forestry Master Plan: Development programmes. 422 pp.

Schmidt, R.C. 1991: Tropical rainforest management. IN: Rain Forest Regeneration.

Sharew, H. 1994: Regeneration of *Juniperus procera* and *Afrocarpus gracilior* in the Afromontane forests of Ethiopia. Ph.D. Thesis, University of Edinburgh.

SEARCHING FOR ALTERNATIVE METHODS OF ESTABLISHING *CUPRESSUS LUSITANICA* (MILLS.) IN CLEARFELLED PLANTATIONS TO REPLACE 'SHAMBA SYSTEM' IN KENYA

SYMONDS B.O. ORONDO
Kenya Forestry Research Institute

SUMMARY

A direct planting experiment was established in 1989 on a clear felled plantation at Masaita in Londiani forest . The experiment compared methods of establishing *Cupressus lusitanica* Mills, with 'shamba system'. The results after three years indicated that the 'shamba system' was significantly better than the other methods investigated. However, slashing which was the second best option to the 'Shamba System' should be investigated further, as the aim of the experiment was to find an alternative to the shamba practice.

1. INTRODUCTION

During the 1970s, the government changed the policy on establishment of forest plantations, where the free issue of forest land to forest workers was abolished. This was replaced with land rental system which allowed people to cultivate forest land on paid licences. The new system became unpopular gradually, as the tenant farmers showed more interest in their food crops at the expense of forest trees. The forest department therefore found it necessary to investigate alternative methods to replace the 'shamba system'.

In another direct planting at Molo, Konuche and Kimondo (1990) observed that *C. lusitanica* could be successfully established in freshly clearfelled plantations without 'shamba system'. However, operational costs were not considered. Therefore it was found necessary to carry out another similar experiment incorporating operational costs, as a basis for evaluation.

RE:392/89 was established in May 1989 at Londiani. The trial aimed to compare survival, growth and operational costs of different site preparations, post-planting and tending methods. The results obtained after five years are discussed in this paper.

2. MATERIALS AND METHODS

2.1 Site Conditions

The experiment was established on a clearfelled plantation of *C. lusitanica* at Masaita block in Londiani. The experimental site was situated on a gently sloping ground at an altitude of 2326 m above sea level. The soils are imperfectly drained, moderately deep with dark brown compact clay, underlying a layer of humic friable loam. The area receives an annual rainfall of 1300 mm and the mean maximum and minimum temperatures are 26^0C and 6^0C respectively.

At the time of establishing the experiment the site was overgrown with grass and other perennial weeds. A heavy regeneration of cypress had also began to grow, and a thick layer of debris from felled trees was lying on the ground. No burning or cultivation was done prior to establishing the experiment.

2.2 Experimental Design and Layout

The experimental design was a randomised block design; 3 x 5 x 4 factorial split plot with three site preparation methods (main treatments) and five weeding or tending methods (sub-treatments), all replicated four times. Each sub-plot of 0.0375 ha had three rows of 20 planting spots at a spacing of 2.5 m x 2.5 m. The whole experimental area was 2.25 ha.

3. TREATMENTS

- **Site Preparation Methods - Main Treatments**

A1. No operation (except manual removal of *C. lusitanica* regenerates within half metre radius of the planting spot) - control.

A2. Cutting of vegetation and removal of slash along planting lines.

A3. Cutting of vegetation and burning of slash within the entire plot.

- **Weeding Methods - Sub-Treatments**

B1. No weeding (except removal of *C.lusitanica* regenerates within half metre radius of the planted seedlings, where necessary) - control.

B2. Spot hoeing 0.5 metre radius round each planted seedling. The operation was done twice in the first year and once during following years.

B3. A combination of spot hoeing, 0.5 metre radius, round each tree and slashing along the planted lines or rows (implementation as in B2 above).

B4. Total cultivation of whole plot similar to the 'Shamba System' (implementation as in B2).

B5. Slashing in the entire plot (implementation as in B2).

3.1 Planting and Tending

A total of 3600 tubed *C.lusitanica* seedlings from Turbo Nursery were used in the experiment. Planting was done a year after the site was clear felled. The site was grown with grass and other weeds. Beating-up was done 6 months after planting. All trees were pruned to ½ height at the age of 2 years.

3.2 Assessment and Data Analysis

Assessment of survival (%), height (m) and diameter (cm) were carried out on 18 trees in the middle row of each plot at age 2 and 5½ months, then 1.6, 2.6 and 5 years after planting. The operational costs (human-hours) for each treatment were recorded each time of operation.

Analysis of variance at 0.05 probability level was performed on the parameters assessed. The differences between treatment means were tested for significance using the least significant difference (LSD) test at p = 0.05.

4. RESULTS AND DISCUSSIONS

During the last assessment, the plots with B4 treatment had less weeds and *C.lusitanica* regeneration than the other plots. Plots with B2, B3 and B5 treatments were bushy and had a heavy regeneration of *C.lusitanica* but B1 (control treatment) was the worst. Cypress regeneration were observed to have overgrown the planted trees in height and diameter. However, no data was collected to support this observation statistically.

Results of survival, height and diameter growth at 5 years are given in table 1. The initial costs of establishment and tending are also given in tables 2 and 3.

4.1 Survival

Site preparation treatments did not affect survival significantly throughout the 5 year period, but variation between blocks was highly significant (P = 0.001) during the last assessment. However, the survival was higher where the vegetation had been cut and burnt (A3) than in A1 and A2.

The high survival observed in treatment A3 is supported by studies by Ochieng (1969) in a direct planting experiment, who also observed no significant differences between no treatment, cutting all vegetation and cutting and burning all vegetation. The low survival in A1 and A2 could have been due to weed competition as observed during the last assessment. In a site preparation experiment with eleven treatments for *Eucalyptus grandis* in South Africa, Schonau *et al.* (1981) reported complete cultivation to give superior tree growth.

Pudden (1953), Dyson (1963) and Ochieng (1969) demonstrated that young cypress trees were very sensitive to grass and herbaceous weed competition. Plumb (1958) also stressed the importance of planting *C.lusitanica* on well prepared sites free of weeds. Similarly, Konuche and Kimondo (1990) concluded that direct planting of *C.lusitanica* could be done successfully if trees were planted soon after clearfell; before the weeds had invaded the site.

Weeding influenced survival significantly ($p = 0.05$). But the interaction between site preparation and weeding was not significant (Table 1). Clean weeding (B4) had the lowest survival among the weeding treatments. These observations are contrary to what other studies have reported; for example in a similar weeding trial of *Eucalyptus tereticornis* at the coast, it was observed that total or clean weeding had significantly higher survival than in either spot hoeing, slashing or no weeding treatments.

The low survival in the clean weeded plots could also have been caused by bush bucks. Signs of nipped tops of the young seedlings in these plots were observed during the early stages of establishment. Pudden (1953) also reported cases of browsing by bush bucks in Molo area.

4.2 Height and Diameter Growth

Site preparation treatments affected both height and diameter at breast height (dbh) significantly at age five years ($p = 0.05$). Diameter at ground level (dgl) was not affected significantly. Cutting vegetation along planting lines (A2) had significantly better height and diameter growth than cutting vegetation and burning (A3). However, the difference between A2 and A1 was not significant, although A2 was still better than A1 in both cases (Table 1). Cutting and burning did not result in significant increase in height and diameter growth compared to the control.

These results differ with observations by Ochieng (1969), who reported cutting and burning to increase growth significantly. The low increment in height and diameter growth was probably due to the browsing by the bush bucks, which seemed to have retarded tree growth especially in the cleaner plots, during the initial stages.

Elsewhere, studies on the effect of burning slash on planting site for Teak in India also indicated no significant effect on height growth (Chacko *et al.* 1989). This may be due to reduced organic matter and soil nutrients , especially nitrogen which becomes volatile.

The response on height and diameter growth to weeding and the interaction between site preparation and weeding treatments was highly significant ($p = 0.01$). Among the weeding treatments, only total or clean weeding (B4) had significantly better height and diameter growth than the rest. The increase in height and diameter growth for all the weeded treatments combined was 32% and 84% respectively, better than control treatment. Konuche and Kimondo (1990), reported weeding to have increased height growth by about 18 % above no weeding plots/treatments.

4.3 Cost Analysis

Cutting of vegetation and burning slash in the entire plot (site preparation treatment A3) was the most costly during the initial site preparation stage, while the control was the cheapest. However, treatment A1 was the most costly during pitting and planting operations, while A3 was the cheapest (Table 2). The total overall costs for site preparation and tending for the 5 years showed that the control treatment was more expensive, but slashing the site (cutting) and burning was the cheapest.

Table 1: Survival, Diameter and Height growth of *Cupressus lusitanica* in three site preparation and weeding treatments in Masaita at age 5 years

Site preparation treatments	Weeding treatments	Sub-treatments mean (weeding)				Main treatments mean (Site preparation)			
Main treatments	**Sub-Treatments**	**Surv. %**	**DGL (cm)**	**DBH (cm)**	**Ht (m)**	**Surv. %**	**DGL (cm)**	**DBH (cm)**	**Ht. (m)**
A1 - No operation -control	B1	71	1.69	0.45	1.74				
	B2	82	1.87	0.69	2.25				
	B3	83	2.64	1.17	2.54	76	3.11	1.52	2.69
	B4	68	5.41	3.24	3.79				
	B5	78	3.92	2.06	3.15				
A2 - Cutting Vegetation along planting lines	B1	79	2.83	1.39	2.76				
	B2	82	2.94	1.69	3.02				
	B3	76	3.49	1.90	3.11	76	3.42	1.89	2.99
	B4	69	4.99	3.14	3.53				
	B5	76	2.86	1.34	2.54				
A3 - Cutting and Burning vegetation In whole plot	B1	88	2.79	0.97	2.17				
	B2	85	3.16	1.01	2.21				
	B3	90	3.27	1.20	2.26	83	3.46	1.35	2.35
	B4	74	5.63	3.07	3.46				
	B5	79	2.45	0.51	1.83				
Sub-treatments mean (weeding treatments)	B1	79	2.44	0.93	2.22				
	B2	83	2.65	1.13	2.49				
	B3	83	3.14	1.42	2.64	79	3.33	1.59	2.68
	B4	70	5.34	3.15	3.59				
	B5	78	3.08	1.30	2.44				
LSD (p = 0.05)		18.7	1.15	0.86	0.70	NS	N.S.	0.53	0.53

B1 - No weeding (Control) along planting line
B2 - Spot hoeing (1 m diameter)
B3 - Spot hoeing plus slashing
B4 - Total cultivation whole plot (shamba system)
B5 - Slashing in entire plot

Many Authors have emphasized the importance of clean weeding i.e. "Shamba System" or "Taungya" as a successful method of establishing forest plantations in the tropics. Takeda *et al.* (1992), Smythies (1938) and Tilander (1985) noted that Taungya had proved very successful in various afforestation programmes in south East Asia where it has been practised since the 1860s. Besides increasing the growth vigour of the young trees, Plumb (1958) and Alieu (1983) observed that the system has been accepted as the most economical method in establishing forest plantations. Bene *et al.* (1976) also reported the system to be more profitable in terms of tree survival, food crop production, financial income to the farmers or tenants and preserving fertility of soil.

Table 2: Initial cost of establishing *C. lusitanica* using three site preparation methods at Londiani

Operation	Cost in human hours/ha				
	A1	A2	A3	Total	Mean
Demarcation of plots	9.3	9.3	9.3	27.9	9.3
Slashing and burning debris	0	29.9	149.6	179.5	59.8
Pitting planting holes	113.1	70.2	60.7	244.0	81.3
Planting and beating up	54.8	31.4	7.8	94.0	31.3
Total	117.2	140.7	227.4	545.4	181.7
Proportion by treatments (%)	32.5	25.8	41.7	100	

A1 = No operation control ;A2 = Cutting vegetation along planting lines only; A3 = Cutting and burning slash in whole plot

Total or clean weeding (B4) was about 5 times more costly than the control treatment (B1) and more than twice the cost of slashing entire plot (B5), which was the second most costly operation (Table 3). Site preparation/weeding combination A1/B4 was the most expensive, but had highest growth increment (MAI) of 0.69 m (ht), 0.65 cm (dbh) and 0.95 cm (dgl), with a percentage survival of 68 %. Similarly the combination A2/B2 was the cheapest but it was among the poorest.

Table 3: Total tending operational costs (Man hours) for five weeding methods in three site preparation methods for establishment of *C. lusitanica* in Londiani after 5 years

Site preparation (Main treatments)	Weeding Methods (Sub-treatments)	Human Hours/Ha.					Total	
	weed	1st weed	2nd weed	3rd weed	4th pruning	1st methods	Weeding methods	Site prep. methods
A1 - No operation (Control)	B1	0	78.9	72.7	5.3	2.0	158.9	
	B2	56.5	101.7	120.7	10.7	2.0	291.6	
	B3	79.0	126.0	150.0	16.0	2.7	373.7	2014.3
	B4	98.0	319.0	360.7	66.7	3.3	847.5	
	B5	73.6	107.6	141.3	18.0	2.0	342.6	
A2 - Cutting vegetation in plantation lines	B1	0	55.9	74.0	8.7	2.7	141.3	
	B2	41.5	108.3	112.1	14.0	2.7	278.6	
	B3	69.6	122.9	143.3	15.3	2.0	353.1	1981.7
	B4	88.7	358.3	299.3	75.3	2.0	823.6	
	B5	72.4	136.7	164.7	9.3	2.0	385.1	
A3 - Cutting and burning Slash in entire plot	B1	0	60.7	90.7	3.3	2.0	156.7	
	B2	29.9	111.7	127.3	9.3	2.7	280.9	
	B3	63.8	142.4	148.7	17.3	2.7	374.9	1969.5
	B4	87.2	294.3	296.7	64.7	3.3	746.2	
	B5	59.1	155.7	183.3	10.7	2.0	410.8	
Weeding treatment mean	B1	0	65.2	79.1	5.8	2.2	152.3	
	B2	42.6	107.2	120.0	11.3	2.5	283.6	
	B3	70.8	130.4	147.3	16.2	2.5	367.2	1988.5
	B4	91.3	323.9	318.9	68.9	2.9	805.9	
	B5	68.4	133.4	163.1	12.7	2.0	379.6	

B_1 - No weeding except annual removal of cypress regenerates; B_2 - Spot hoeing 1 m diameter;
B_3 - Spot hoeing + slashing along planted line; B_4 - Total cultivation in whole plot; B_5 - Slashing in whole plot

The results of the experiment show clearly that site preparation and early tending are very important for successful establishment. Honore (1958) observed that the differences in cost of establishment of a well tended plantation and that of a badly tended one can be very considerable at 5 % compound interest over 30 years or more. It is further observed that poor tending may add several years to the rotation required to bring the crop to maturity.

5. CONCLUSIONS AND RECOMMENDATIONS

The results of this experiment support previous observations that satisfactory establishment of *C.lusitanica* can be achieved by direct planting in clearfelled plantations without necessarily preparing the site, provided this is done immediately following clear felling. Where planting is delayed for one or more years after clearfell as it is the case presently, slashing or cutting of vegetation can be done but burning of debris may not be necessary. Clean weeding at least twice during the first year and once during the 2nd and 3rd years is very essential for better survival and enhanced growth.

As the aim of the experiment was to come up with alternatives to the shamba system, then the next best tending method (slashing) should be investigated further.

REFERENCES

Alieu, D. K., 1983: Agroforestry practices in Sierra Leone A paper presented in Lilongwe Workshop on Multipurpose tree, 7 pp. En.XA SL. Sierra Leone Africa.

Bene, J. G.; Beall, H. W.; Corte, A. 1976: The Tropical Forest Over exploited and Under Used Research Priorities in Tropical Africa. Project report to the President of IDRC. pp 69. En.XA. Africa South of Sahara.

Chacko, K. C.; Sankar, S.; Pandalai, R. C.; Nandakumar, U. N. 1989: Studies on the effect of slash burning on planting site for teak. Project Silvi 05/1981 (October 1981 - September 1985). KEFRI - Research - Report No. 61. IV + 21 pp, 13 ref Peechi, India; KEFAL Forest Research Institute.

Dyson, W. G. 1963: Notes on the Silviculture of Cypress grown for timber in Kenya. Forest Department Technical Note No.84.

Honore, E. J. 1958: Shamba Hygiene. Kenya Forest Department Technical Note No.61.

Takeda, S.; Bruijnzeel, L. A.; Pothital, M.; Preeyarysorn, O.; Simon, H.; Wiessum, K. F.; Karki, J. B. S; Bhatta, B.; Singh, - K. P.; Pandey, O. N.; Hou Y. Q. 1992: Taungya: Forest plantations with agriculture in South East Asia. IN: Sustainable Rural Development Series No.1. Jordan, C. F.; Gajaseni, J.; Watanabe, H., (Eds.). Willingford, UK; CAB International. XIV 153 pp.

Konuche, P. K. A. and Kimondo, J. M. 1990: Prospects of replacing clear felled forest plantations without "Shamba system". Technical Note No.8. 16 pp. 5 Ref. Kenya Forestry Research Institute.

Ochieng, E. A. 1969: Results of direct planting experiment (*C. lusitanica*): Kenya Forest Department Technical Note No.123.

Plumb, C. C. 1958: Resident labourers, Shamba Management, Plantation Management and Practical Hints. Kenya Forest Department Technical Note No.55. Kenya.

Pudden, H. H. C. 1953: The advantage of the "Shamba System" and the disadvantages of grass infested plantations. Kenya Forest Department Technical Note No.11.

Schonau, A. P. G; Themeta, R. V-von; Boden, D. I. 1991: The importance of complete site preparation and fertilizing in the establishment of Eucalyptus grandis. In proceedings of the Forest Seed, Nursery and Establishment, Worleng Group, 3rd Meeting. South African Forestry Research Institute, Seasveld Forestry Research Station, George, South Africa. pp 1-18.

Smythies, E. A. 1938: The Taungya plantations of Bhinga, Bahraich Division, UP United Provinces Forest Department Bulletin No.13 pp 9. India.

Tilander ,Y. 1985: A study of the North Bengal Agrosilviculture project. Report from a minor research task. Working paper, International-Rural Development Centre, Swedish-University of Agricultural Science. No.34, 91 pp. 4 app., ADE.

OPPORTUNITIES AND CONSTRAINTS IN THE DEVELOPMENT OF FARM FORESTRY

NYAMAI D.O[1].; MUITA, D.W.[2]; and MENGICH, E.K[1].
[1]Kenya Forestry Research Institute
[2]Forestry Department

SUMMARY

The present degradation process of our forests imposes upon all those who have a conscience the duty to take a stand. The minimal cover so far left is grossly inadequate to maintain proper sustainable ecological balances or even to protect the threatened vital water catchments. The current shift in emphasis towards the development and promotion of "Farm Forestry and Agroforestry for the people" has become an important development challenge which presents a ray of hope in the forestry and agricultural sectors in much of the developing world.

This paper examines the historical account and development trends and opportunities of Farm Forestry and its application in agroforestry, environmental conservation and rural development. Central to the development and application of Farm Forestry and utilization of tree/forest resources is the formulation of appropriate policy and legal framework in harmony with existing land-use patterns thus avoiding potential sectoral conflicts.

The study also explores strategies for the adoption of a more positive attitude towards people and forests. The role of participatory by-laws and/or norms as well as incentive packages in the management and conservation of natural resources are analysed. The study also noted that new priorities to be adopted for Farm Forestry and Agroforestry resources must be based on specific and local conditions of each ecological zone and should mainly be developed on three important themes as follows:(i) trees in agroforestry development targeting maintenance of the agricultural resource base; (ii) trees in the economy in general but specifically in the provision of such products as woodfuel, fodder, timber, paper and pulp, medicine, food among others; and (iii) trees in environmental conservation through protection of soil, water catchments, waterways, and in the rehabilitation of degraded and denuded areas including the enhancement of biodiversity, cottage industries and the avoidance of the greenhouse effect. Finally, the study paid particular attention to the major constraints against the optimum use of Farm Forestry and Agroforestry resources. These have been identified to include low scientific potential and poorly adapted training, information crisis, absence of appropriate technologies, lack of participatory approaches involving local populations in the planning, implementation and utilization of Farm Forestry and agroforestry programmes.

1. INTRODUCTION

Man directly draws materials from forests and wood formation that are commonly called forest and/or tree products. These products include construction timber for industry and craft work, wood for fuel (directly or in the form of charcoal), and wood for the production of pulp. Forests and woodlands also contribute to environmental conservation, and provide man and his cattle with alimentary and pharmaceutical products derived from the various parts of plants.

Throughout the history of man, the balance between man and the forest has undergone major variations:

- a first balance was achieved before the discovery of agriculture. Indigenous people, hunters and gatherers did not clear the land. The forest therefore remained intact.

- second type of balance was achieved even after the introduction of formal agriculture, and continued until the entry of the Europeans. Cultivation, not developed to the present extent, followed the classic techniques of cultivating the land and letting it lie fallow. The destruction of forests was then approximately compensated for by natural regeneration during the fallow period.

- the present time has seen extensive land clearing. With, on the one hand, the penetration of the Europeans into Kenya and, on the other, an increase in local population and their entry into the global economy. This evolution has reached a point today which dangerously threatens the balance between man and the forest and, even worse, the very existence of the forests themselves. In many cases, the forest resources have been subjected to simple clearing operations with no control effort or reforestation method suitable to establish a sustained yield. This attitude together with the vagaries of the climate and an increase in local population was translated into a reduction of the forest cover, and an acceleration of the phenomena of desertification, certain consequences of which have manifested themselves with tragic results in many countries such as the Sahel.

In an attempt to address these problems, significant changes in forestry development thinking and activity have taken place during the last decade with shift in emphasis towards forestry for the people. In attestation of this change, for example, many regional and global fora have commonly adopted "forest for the people" as the main theme for research and development in forestry.

The study of farm forestry initiatives within the developmental strategy is an enormous but necessary and urgent task. In fact, FAO (1978) has properly emphasized, the importance of Community/Social forestry resources for local people. The economic development of these resources shall not be able to contribute significantly to social and economic development of our countries unless we establish a solid framework of researchers and forest managers who shall be able to combine their scientific, technological and administrative knowledge for the common good.

This paper shall endeavour to:

- discuss the implications of policy and legal framework of farm forestry in relation to land-use;
- evaluate the main constraints in the development of farm forestry resources and evaluation of these resources;
- evaluate the strategies for the promotion and adoption of more positive attitude towards people and forests, including the role of incentives; and finally,
- formulate farm forestry priorities based on three themes as follows: (i) trees in agroforestry development for maintenance and sustainability of agricultural resource base, (ii) provision of products such as woodfuel, timber, fodder, medicine, pulp and paper, food among other things, (iii) trees in environmental conservation.

2. EVALUATION OF FARM FORESTRY INITIATIVES IN KENYA

Within the framework of this presentation placed in the context of the developmental forestry strategy, the term "on-farm forestry" shall be considered in a wide sense, encompassing *agroforestry, social forestry, communal forestry, rehabilitation forestry*, and *woodlands*.

Many foresters, in the past, used the term "farm forestry resources" in a restrictive sense, while virtually exclusively devoting themselves to the production of timber. They ignored or neglected, on the other hand, the other potentials of social forestry which are, however, quite considerable. In Senegal, for example, 16.8 per cent of the total income produced by forests, comes from forest fruit and leaves for alimentary or medical use hence conferring the "concept of farm forestry or Agroforestry". Moreover, Youdeowei (1981), observed that the entire use of vegetal resources in the arid or semi-arid regions of Africa is considerable; 29.6 per cent of the vegetal species are used for feeding cattle, 20.4 per cent for human consumption, 14.5 per cent in medicine, and 10.7 per cent in construction. Tables 1 and 2 give a more detailed presentation of the statistics on 64 ligneous species for fuelwood energy in savanna regions, a topic which has drawn increasing attention over the last few years.

The scope and general characteristics of farm forestry are quite variable depending on the socio-economic and bio-physical factors. For instance, Owino (1988) and Wiersum (1984) reviewed different social forestry models as a component of farm forestry in which it was indicated that social forestry can be developed around five themes as follows:

- The "super-management model" where the national forestry service provides the capital, know-how and organization for social forestry projects at the village level;

- The "support service model" where the national forestry service provides professional knowledge but relies on farmers to provide land, labour, capital, organization and indigenous knowledge in the implementation of social forestry programmes;

- The "partnership model" where the national forestry service enters into a contract with the community to jointly implement social forestry projects;

- Community forestry project with assistance of intermediary (donor assisted projects like those of many NGOs) based on the partnership model; and

- Incentive programme for social forestry based on the "support service model" but incorporating a special fund or bank.

Similarly, Agroforestry systems and technologies are equally diverse often involving many disciplines and participants e.g. the farmers, communal organizations (organized groups), foresters, agriculturalists, social scientists and various institutions with different mandates. However, the success of the programme will depend on how well the specific objectives and activities are conceived and articulated. All the above models have been relied on by various governmental and non-governmental organizations to varying degrees of success.

In Kenya, Farm Forestry is now recognized as a component of integrated national efforts aimed at raising living standards, creating employment and increasing industrial output to provide goods both for the domestic market and for export. The objectives of promoting tree planting at farm level as provided in the Revised Forestry Policy Draft (1996) are to:

- increase the forest and tree cover, in order to ensure the sustainable availability of tree products and services as well as enhance the role of farm forestry in Socio-economic development;

- contribute to sustainable agriculture by conserving soil and water resources;

- support the government policy of alleviating poverty and promoting rural development by increasing the income based on tree resources, providing employment and promoting equity and participation by local communities in farm forestry development; and

- recognize and maximize the benefits of a viable and efficient farm forestry/agroforestry tree-based industry to the national economy and development.

The Forestry Extension Services Branch (FESB) of the Forestry Department is the government's key line agency for promoting national rural tree planting and conservation on private land, notably small-holder farmlands, community land and rangelands amidst other agencies which have major influences on the planning and implementation of rural forestry activities, resource allocation and policy formulation.

3. MAIN CONSTRAINTS IN THE DEVELOPMENT AND OPTIMUM USE OF FARM AND AGROFORESTRY RESOURCES

3.1 Low scientific potential and poorly adapted training

It has been mentioned very pertinently that the low number of suitable personnel be they foresters, agroforesters, agriculturalists, ecologists, or social scientists able to consider the various alternatives available for the development of farm forestry and agroforestry resources is, at the present time, alarming. Whilst this number fails to increase in all the disciplines, it will be impossible to master the economic problems posed. The question is whether the present research and extension capacities existing in Kenya are capable of facing the complex biological and socio-economic/cultural problems requiring local solutions. Do our research and extension/development institutions have the scientific manpower necessary to effectively confront the basic problems with which we are faced?

Besides the quantitative lack of indigenous researchers and extension experts, the fact must also be emphasized that their training is often poorly adapted to the real problems with which they are faced. The traditional preoccupation concerning silviculture for instance, which is to preserve the forest while controlling it at the same time for the production of timber for industry, is often in conflict with the requirements of rural populations who live and depend on the forests. Forestry legislation which in some cases has not changed since the time it was printed in the colonial era, is often perceived by local peoples as being too clearly repressive. Classical training has therefore been able to be described as ending up in the training of foresters better equipped to deal with trees than with people.

3.2 Information crisis

The rapid increase in knowledge, the increasing cost for updating libraries, even the more modest ones, and other documentation systems have led to what has been called an "information crisis", namely, that in quite a few major disciplines, knowledge has been accumulated but the information remains inaccessible for a considerable number of potential users who sometimes are totally unaware of the existence of this information. This information crisis has a very direct effect on many of our institutions. In the field of arid and semi-arid lands, for example, a great volume of knowledge already exists and the present problem should rather be the application of this knowledge whose very existence is yet to be known.

Any people oriented forestry activity should have as its broad objective: to improve the welfare and living conditions of the target community and the trees being planted are only a means to this end just as other undertakings e.g. agriculture, health and livestock improvement. This makes people the prime target of the project and the most important resource towards successful implementation.

To register their cooperation in this endeavour and to ensure continuity and sustainability, the community has to be aware and appreciate the problem being addressed through tree planting. They should contribute ideas on how to approach the problem before engaging their energy. Creation of awareness and mobilization should be inbuilt and planned as an activity. The methodologies adopted will depend on the target group, existing infrastructure and available resources. It is actually one activity in community or farm forestry that requires minimal input cost(s) with substantial returns.

There is need for re-training and/or an education programme covering the relevant officers in the field who will implement the tree planting activities. Also the various leaders who will give the necessary support have to be involved so that their commitment could be relied upon. Farmers who are the main beneficiaries need to be educated on "basic" aspects of tree planting, as they are the determinants in the success of the programme.

The training should be structured according to the needs of each group. Therefore it may be necessary to carry out training needs assessment for each individual group. Such an assessment will assist the trainers in articulating the particular need for the group.

Each group can only be available for a given duration to undertake this training. Training duration for various groups are suggested as follows:

- For the field staff from the Ministries of Agriculture, Forestry Extension and Non-governmental Organisations (NGOs), a two week duration is necessary. The training should emphasize tree growing, agroforestry, social forestry and seed technology.
- Staff from other government ministries would require about one week. The emphasis in their training should be in coordination work.
- The leaders, by virtue of being busy should have a three day training session during which their support role especially in public awareness creation and mobilization of the people should be highlighted.

Also, there is urgent need to develop different types of support materials used in furthering a given technology to the beneficiaries who might be the extension staff in the field or the individual farmers involved in tree planting. The content of each of the materials usually depends on the intended recipient of the information. The support materials mostly include:

- **Posters:** These are useful in creating public awareness. They should be tailored to carry simple straight forward information.
- **Leaflets:** Useful in passing simple technical information on how certain things are done.
- **Extension manuals:** Useful to lower cadre staff. They guide them on the basic facts of tree growing in monocultures or mixed/intercropping systems with crops, tending and general management.
- **Training manual:** Useful for trainers who will train the new officers in the field.
- **Booklets:** Provide easy to read materials on practical farm forestry techniques including agroforestry.
- **Films and videos:** Mainly in creation of public awareness.
- **TV and Radio:** Though at times they do not get to the actual people for whom they are intended, they assist in public awareness creation.

3.3 Absence of appropriate technology

There is often suitable scientific knowledge in many cases but it is not applied because of technological constraints. As emphasized by Okali (1981), the expanded use of fire as a land clearing tool is not due to lack of scientific knowledge of the harmful consequences of this practice. There are simply no other suitable solutions which are cheaper and more convenient.

Similarly, forestry exploitation techniques used in temperate forests are not well adapted to the specific conditions of tropical forests where the scarce number of individuals per species of trees has led to the destruction of wide areas of forest land to obtain a few species of commercial value. It has been estimated, for example, that to obtain 6 to 10 m^3 of cylindrical logs may lead to the destruction of up to 300 m^3 per hectare (Okali 1981). In brief, the tree that can be used is well hidden in the forest.

3.4 Local populations are not sufficiently involved

It has often been the case that local populations have not been surveyed. An effort in this direction however would have made it possible to learn from the experience accumulated by these people over the centuries in the management of their ecosystem. These studies could also be of assistance in defining forestry operations with respect to the way of life and goals of the population which is the basic condition to ensure their motivation and support for intervention projects.

Experience has shown that a lot of projects and programmes have failed to take off after formal completion because the target groups had not internalised them. Extension is not normally emphasised during the project formulation, appraisal and implementation stages. Consequently people's participation should be encouraged in order to ensure sustainability of development efforts and programmes. Participation is the voluntary involvement of the people in the development of their own lives and environment. Unfortunately on most occasions the people's problems are defined, solutions identified and implementation strategies designed by others. Since the people are not consulted, they often stand aside as observers and do not identify themselves with the project or programme. The situation could be averted if a little time is spent working out a strategy to involve the beneficiaries.

Within a given community, there exists a body of knowledge, experience and when the people are involved, they will not only feel valued but will contribute their resources willingly. If their involvement is well sought, the people will also support the programme, see it as theirs, be committed to it and even internalize the project. However, for this to succeed technical information must be provided to the people. For example, even with many trees on the farm, the market for excess product is lacking. These are some of the areas information could be organized and passed to the farmer. All leaders should go out to the people and convince them through public meetings and various other types of meetings that tree planting is beneficial to them in particular and the environment in general.

Participation by beneficiaries is thus a prerequisite for sustainability of the tree planting programmes in any community. If people participate in identifying their problems and working out solutions to those problems, they feel acknowledged and usually will support the activities. Thus the main agenda calls for equipping these personnel in the field with enough material support to facilitate the farmers in achieving their set goals.

3.5 Application of suitable Incentives

To achieve the goals and objectives of farm forestry, the government must guarantee programme sustainability through various deliberate strategies. Recognition that aggressive programmes may drain the government treasury and organisation, calls for a deliberate move to recognize and attract more private participation in seed collection and raising of seedlings by schools, individuals and other private companies. This can be guaranteed through organised participatory schemes mentioned hereunder:

- Woodfuel conservation subsidy scheme based on reducing the effective price of paraffin to encourage its use as an alternative to charcoal and solid wood.
- Commercialization of seed and seedlings to attract more players in farm forestry development activities.
- Introduction of interest-free loans to small scale farmers wishing to establish farm forestry and agroforestry enterprises such as woodlots and shelterbelts in the farms.
- Provision of certificate of participation for all entrants in environmental conservation and farm forestry competitions and awards.

- Encourage and organize visits and tour programmes for individuals, organisations and schools participating in farm forestry programmes.
- Provision of tools and equipment to the individual groups and NGOs involved in collection of seeds and raising seedlings.
- Provision of in-country's, overseas and upgrading training courses for serving officers who are promoting and developing the national farm forestry strategies.

Other incentives to promote conservation of our forest resources include encouragement of use of other sources of energy such as solar energy, gas, electricity, wind, biogas, etc. all of which should be reflected in a change in the type of houses being constructed in urban as well as rural areas.

3.6 Other problems

- A major constraint has been the problem of co-operation between different countries and between different fields of activity within the same country. It is certain that each country, taken individually, is incapable of gathering, in the short term, a "critical mass" of researchers, technicians, infrastructure and financial resources to successfully conclude its projects for the use of its forestry resources. Moreover, within the same country, research results are not always sufficiently evaluated because of lack of real collaboration between the research field and the production sector, in this case the extension and farmers.
- Limited financial resources are obviously a major constraint, but it appears that it is rather poor management of funds than a real lack of funds that constitutes the true problem. Many projects conceived without taking proper consideration of the national realities are burdened with recurrent expenses which exceed national financial capacities (particularly in the case of artificial plantations to be maintained).

4. PRIORITY STRATEGIES FOR THE DEVELOPMENT OF FARM FORESTRY RESOURCES

The priority strategies to be adopted for mitigating the problems naturally result from the nature of the constraints listed further above. However, these priority areas are not in any way different from those designed for forestry sector in general. It is worth mentioning here, however, that the Lagos plan of Action for the economic development of Africa 1980-2000 has established the following priority guidelines for the Forestry Resources Sector in general:

- establishment of an inventory of farm forestry resources;
- introduction of new species and provenances for increased productivity using cross-breeding and fertilization techniques;
- promotion of indigenous research on local species in certain ecological zones;
- refinement of techniques for better use of manpower resources and the appropriate choice of equipment for clearing operations, planting etc;
- refinement of storage and preservation techniques of forest products;
- refinement of suitable techniques for the use and management of forests, utilizing the most suitable silvicultural systems;

- training manpower and disseminating information on the management and exploitation of forests and agroforestry technologies.

The most important thing is to redefine the priorities for farm forestry management and to ensure a properly adapted training system for the researchers, technicians and extension experts who would be responsible for its application. In most forestry programmes, research and extension work now under way essentially concerns the silviculture of artificial plantations, composed of varieties of rapidly growing species (mostly exotics). While still accepting the need for such an effort, given the present situation in many countries (accelerated destruction of the natural forest, increasing shortage of wood, low productivity of natural formations, lack of knowledge on very complicated systems as in agroforestry and natural tropical forest ecosystems and on their management), it seems more and more obvious that a parallel effort must be made in the direction of the management of both man-made and natural forests. The present generation of researchers and extensionists must be trained to regard trees in the farmlands as a source of a great variety of goods and services and not only as a source of wood.

Very old practices, though poorly understood, associate the cultivation of food crops with the cultivation of trees. It is worth assigning an important place to the developmental perspectives of these agro-forestry practices, for although it is more and more realized that agro-forestry systems must be based on incontrovertible facts, research work is scarce. The problems specific to agriculture or forestry seem to be more a subject of research on their own rather than the problems encountered when these production systems are combined. The International Centre for Research in Agroforestry (ICRAF) together with National Research systems will play a major role in this respect.

The impact of energy requirements on forestry resources demand that a major effort be made to lighten the burden on natural formations, while encouraging improved wood burning methods, and seeking alternative sources of energy such as natural gas, solar energy, wind power, etc. It is a well-known fact that, in most of our countries, 70 to 90 per cent of the entire consumption of domestic energy is wood-based for which the urban populations in many countries spend up to 30 per cent of their income. The time devoted by rural populations to the collection of wood, and the high proportion of their income that urban populations devote to fuel, make it necessary to consider the passive use of other energy sources as an important condition for the development of forestry resources in general.

4.1 Promotion of Commercialization of Farm Forestry Products

Most people associate tree planting with long gestation period while others view a tree as taking a lot of space in their shambas and therefore better left to the forest plantations. Another view is that tree planting is a complex scientific undertaking and only foresters can handle it. These attitudes discourage rather than encourage farm forestry activities. However, a number of farmers have been planting trees for decades without any extensionists. Agroforestry on the other hand has brought out multi-purpose tree and shrub species (MPTs) that not only grow to maturity within short rotations, but also coppice for decades to produce poles, fodder, fuelwood, forage and green manure to enrich the soil for higher food production. These MPTs can also be intercropped with food crops without causing any harm.

The above observations show there exists a market/demand for the various minor forest products which directly implies the demand for seed and seedlings must exist. Thus individual farmers should not only be seen participating in seed handling and raising of seedlings, but must also be encouraged to take the two as commercial enterprises. It is absolutely essential that the bulk of this task be spread among various communities, organizations and institutions. Furthermore the fact that farmers have been producing seedlings of agricultural crops such as cabbage, tomatoes, etc, indicates they can produce tree seedlings as long as there is demand.

The Government Departments could contribute positively by reviewing their seedling prices to stop acting as sources of cheap seedlings. The pricing also should be harmonised between all producers to encourage afforestation. Commercialization of seed and seedling production has thus a potential that must not only be exploited but consciously and systematically developed as it complements government efforts in making seedlings available to farmers and other land users for farm forestry activities.

4.2 Identification of appropriate priority farm forestry activities and their adaptation by farmers

The new priorities to be adopted for the development of farm forestry activities, must be specific to the local conditions of each ecological zone. Nyamai (1996) reviewed research and development activities conducted in forestry and agroforestry in Kenya to date. Out of about 1000 abstracts 50 per cent or more, indicated the following future priority areas related to farm forestry and agroforestry research and extension:

- **Themes specific to the humid and sub-humid zones**
  - farm forestry development (woodlots, boundary planting, management of woodlands/formations and water courses, etc)
  - agroforestry systems development and improvement
  - improved management of farm forestry resources
  - improved silvicultural techniques of valuable species including indigenous spp.
  - production of improved seed
  - prevention of soil erosion
  - bio-diversity conservation
  - protection and restoration of the soil
  - promotion of multiple use concept of forestry resources e.g. eco-tourism, Wildlife conservation, inland fisheries, Mushroom production etc.
  - rehabilitation forestry (role of forests in the stabilization of the environment)
  - socio-cultural attributes (e.g. ritual trees, sacred forests and woods etc).

- **Subjects specific to the arid zone**
  - reforestation possibilities
  - possibilities of a sustained production of firewood, multi-purpose wood and construction timber (maintenance of productivity)
  - termites/insects and fire control
  - irrigated forestry plantations
  - management of natural formations
  - desertification control.

These studies should be undertaken in a certain order. It is advisable to determine the fields where new information is absolutely essential and those where the information already gathered is sufficient and has only to be mobilized in the service of development. In summary, it is necessary to find a solution to the information crisis so that the information available can be made accessible to those who seek it. This knowledge must not remain sequestered within the enclosed walls, but it must be translated into a practical development message for the foresters, agriculturalists and farmers working in the field. In this respect, the following questions must guide the conduct of the researchers vis-a-vis the extensionists:

- How much weight is given to local problems in the definition of research and extension priorities?

- What information and contact networks are provided to ensure that the data acquired from research and extension are used to the benefit of the developmental process and, simultaneously, to enquire into the real concerns of local populations?

5. CONCLUSION AND FUTURE DIRECTION

- Farm forestry research and extension, while obtaining inspiration from the techniques applied in the temperate countries, must focus on the specific aspects of agro-ecosystems and the types of relations which local populations have established with their forests for countless years. Thus, it would be able to find original approaches and to determine its own particular path.

- Trees occupy a significant land area in sub-humid and humid areas including Savanna regions. Land use inventories have suggested that planted and managed trees usually cover between 5 and 10 percent of agricultural land. On average, over 20 percent of the total smallholder agricultural land area has been used for growing trees, or has otherwise been left under natural woody cover. Even when other forms of land use could generate substantially higher levels of household income, the planting and management of trees has remained an important form of land use. This is in part an outcome of problems with agricultural labour supplies. Though other land uses may be more lucrative, labour for smallholder agriculture has become constrained and farmers are not able to cultivate other crops because of the much higher levels of labour use that would be required.

- Central to the question of why trees are a common form of land use is attributed to the fact that agricultural labour has become constrained in the first place, in the fact of burgeoning urban sector unemployment and a phenomenal population growth rate. The answer is partly related to long-term policies which have favoured the development of a migrant labour economy - policies that date to the earliest days of Colonial settlement and that sought to mobilize labour for work on European farms.

- At the same time, the consolidation and registration process of land capitalized on traditional tree planting practices by requiring that consolidated holdings be demarcated with planted trees. This was a long-term outcome of accepted customary land tenure practices that involved the planting of specific trees along the boundaries of sub-clan lands as well as the planting of subdivisions within these holdings.

- Land tenure reform introduced important changes affecting tree tenure. In customary law, whoever planted a tree (provided they had some sort of cultivation right) was its owner. With land reform, trees became the property of the registered land owner. The effects of land reform on tree tenure were mostly profoundly felt by the landless, who may have had right of use to trees growing on sub-clan lands, but who lost these rights as land was registered in the names of private land owners.

It is unlikely that guarantees of private tree ownership by themselves, a result of land tenure reform, actually encouraged people to grow more trees. Ownership of planted trees had long been guaranteed by customary law. Planted trees always belonged to whoever planted them but only as long as they held some sort of cultivation rights. Land tenure reform increased the security of these rights. It is this security that had a greater impact on farmers' interest in tree planting and in making other improvements to the land.

In Kenya for instance, limited controls on tree cultivation and management are supposed to be enforced through the Chief's Authority Act and the Agricultural Act. There is, however, no consistency in the extent to which these controls are enforced. In some areas, chiefs may require a farmer to obtain a license before trees can be harvested, and this has acted as a disincentive to plant trees because there is no assurance that they can be harvested for the benefit of the person who planted them. As a result, trees are sometimes harvested or managed individually or in small blocks, rather than in even-aged stands.

- Over the last 15 years or so, there have been numerous publicly-supported or aid-financed efforts to encourage farmers in Kenya. These efforts have seldom taken into account the extent of existing farmers' tree growing activities. Plans for future efforts have the same disregard for the obvious and widespread local knowledge and awareness about tree growing. The challenge for planners and development agencies alike is threefold.

  Firstly, it is critically important that efforts to introduce tree planting innovations are put into a context which more accurately reflects local farmer ability and knowledge. Conventional approaches to rural forestry extension have been expensive and ineffective, particularly in the light of what farmers have been able to accomplish in the absence of these types of inputs.

  Finally, the long-term security of rights to trees and their products has been affected by externally imposed controls on planting and harvesting. An assurance that benefits and income from the farm production of tree products will accrue to the farmer and not to the Government or the local councils, will be essential before there can be any hope that farm trees will meet the many demands that will be placed on them in future.

REFERENCES

F.A.O. 1978: Forestry for local community Development. F.A.O. Forestry Paper No. 7. F.A.O. Rome.

Nyamai, D.O. 1996: Review of forestry and agroforestry research conducted in Kenya to date. Centre for Arid Zone Studies (CAZS), University of North Wales, Bangor, U.K. Joint publications with KARI/KARD (In Press).

Okali, D. U. U. 1981: Resources foresters. IN: Comptes Rendus du symposium sur l` Etat de la Biologie en Afrique, Accra, Ghana, 12-17 April, 1981. E.S. Ayensu et J.Marton-lefevre, (eds.), Washington D.C., 1981.

Owino, F. 1988: Development of social forestry in Kenya and application of agroforestry techniques. Paper presented at the Kenya National Social Forestry Seminar, held in Muguga, 31st August, 1988.

MENR 1996: Revised Forest Policy Draft. Nairobi.

Wiersum, F.K. 1984: Developing strategies for social forestry: A conceptual approach. Working Paper. Environment and Policy Institute. East-West Centre, Honolulu, Hawaii.,Youdeowei, A. 1981: Op. Citation.

Table 1: USE OF VEGETAL RESOURCES IN THE ARID & SEMI-ARID AFRICAN REGIONS (From Youndeowei, 1981)

USE	NO. VEGETAL. SPS USED	% OF THE TOTAL
Food for	40	20.4
Fuel		5.1
1. fuel	10	1.5
2. oil	3	
Medicines	28	14.5
Animal	58	29.5
Construction		
1. Dune	11	5.6
2. Building	21	10.7
Dyes	1	0.5
Sunscreening	2	1.02
Pr. rubber	2	1.02
Fiber	12	6.1
Pr. wax	1	0.5
Pr. tannin	7	3.6

Table 2: MAIN SPECIES OF FUEL WOOD IN TROPICAL AFRICA

Table 2 (from Moss, 1980)

A. The Thirty-two most frequent species

Taxonomic classification	in forest	in savanna
Albizia falcataria	18	0
Albizia zygia	18	0
Albizia gummifera	18	0
Albizia coriaria	18	0
Albizia lebbeck	15	1
Acacia spp.	15	1
Fantumia elastica	15	1
Celtis zenkeri	12	0
Bridelia micrantha	12	0
Bridelia atroviridis	12	0
Lecaniodiscus capanoides	8	0
Trichilia heudelotii	8	0
Spodias mombin	8	0
Ficus exasperata	7	1
Butryospermum paradoxum	0	6
Hymenocardia acida	2	3
Hymenocardia heudelothi	2	3
Trichilia prieuriana	2	3
Phyllanthus discoideus	3	0
Ficus capensis	2	1
Anogeissus latifolia	1	2
Terminalia ivorensiws	0	3
Terminalia guinnensis	0	3
Distemonanthus benthamianus	0	2
Parkia clappertoniana	0	2
Acacia polyacantha	0	
Subsp. campylacantha	0	2
Afrormosia laxiflora	2	0
Prosopis africana	0	2
Antiaris africana	2	0
Irvingia gabonensis	2	0
Pentadesma butyracea	2	0
Nesogordonia papaverifera	2	0

PRELIMINARY GROWTH AND YIELD OF VITEX KENIENSIS GROWN IN PLANTATIONS IN KENYA

MBAE N. MUCHIRI
Kenya Forestry Research Institute

SUMMARY

In an effort to develop alternative site indices, volume function models, stand volumes and financial yield tables for *Vitex keniensis* plantations in four forest stations in Mt. Kenya region; namely Ragati, Chehe, Chuka and Meru, data from 19 Permanent Sample Plots (PSPs) distributed in 12 plantations and 75 temporary sample plots distributed in 16 plantations were analysed. Tree mean diameter at breast height (dbh), mean dominant height , total bole and merchantable volume to 15 cm top diameter were used to develop site indices and two equations for rapid assessment of volume and sale of stumpage.

Stand volume tables were developed from mean dbh, mean dominant height, number of trees per hectare and the volume equation currently used by the Forest Department for estimation of stumpage volume. Stand financial yield tables were finally developed from the stand volume tables and the Forest Department revised royalties for 1995/96.

1. INTRODUCTION

Forest plantations currently supply over 90% of Kenya's industrial wood (Anon 1983). They are therefore of great importance in enhancing industrial and social economic development of the country. Of the country's 48 604 million ha of land under forests, forest plantations cover only 164 000 ha (Kenya Forestry Master Plan 1994). The total area of cypress is 73 900 ha, pines 59 600 ha, Eucalyptus 15 800 ha and indigenous hardwood species 15 800 ha. Of the indigenous hardwood plantation species, *Vitex keniensis* comprises 1000 ha.

Previous forestry establishment, management, growth and yield studies dealt with these plantations though with little emphasis on indigenous hardwood species. However, a change of policy by the Forestry Department in the mid 1980s increased the plantation area of indigenous species. Commensurate growth and yield studies of the major indigenous hardwood plantation species are therefore urgently needed with a view of collecting and generating data required for drawing up reliable management regimes for these plantations.

This paper presents growth and yield tables for *V. keniensis* grown in plantations.

2. MATERIALS AND METHODS

2.1 Plantations

Annual breast height diameter (dbh) and dominant heights were measured in four forest stations in Mt. Kenya; namely Ragati, Meru, Chuka and Chehe. Nineteen Permanent Sample Plots (PSPs) in seven plantations in Ragati were measured between 1964 and 1989. Further, 75 temporary plots in 15 plantations in Meru in 1992; four in Chuka and seven in Chehe in 1994 were also assessed. Details of these plantations are presented in Annex 1.

The soil type in these plantations is humic *nitosols* (Jaetzold and Schulzke 1983) which can be described as "well drained, extremely deep, dusty red to dark reddish, brown, friable clay, with acid humic top soil". The average annual rainfall - Chuka 1500 mm, Meru 1151 mm, Ragati 1406 m and Chehe 1610 mm. Respective altitudes are: Chuka 1550 m; Meru 1800 m; Ragati; 2012 m; and Chehe 2100 m above sea level. All stations are characterized by moderately high temperatures during the day with chill nights and mornings.

2.2 Sample Plots

Permanent Sample Plots were subjectively located in the plantations and each had an area of 0.04 ha. Temporary sample plots were also circular with an area of 0.04 ha. They were randomly located on the plantation maps and demarcated on the ground using compass and linear tape. Plot centres were conspicuously marked with posts of durable wood. In every plantation five sample plots were established and assessed.

2.3 Standing trees' diameter and height measurements

Diameters of all the trees in a plot were measured using a diameter tape at 1.3 m above the ground. Loose bark and any other material found on the point of measurement were removed prior to the assessment. In addition, if any abnormalities such as bark swelling or knots coincided with the point of measurement, assessment was done either below or above the point.

Total tree height and bole height of the dominant trees (based on a ratio of 100 largest diameter defect free trees per ha) were measured with a Suunto clinometer.

2.4 Felled trees' diameter and heights

A total of 174 dominant trees of good form were selected from the temporary sample plots (at least two trees per plot), and assessed for dbh and height when standing. They were then felled, branches removed and over bark diameter at intervals of one metre to a 15 cm top diameter and the length of tree tip (height from 15 cm top diameter to the tip of the stem) measured.

3. RESULTS

3.1 Site Index

Dominant height and age data from the PSPs and temporary sample plots were used to fit a linear regression of the model:

$$S = H_d - b_i\,(\text{Log}A - \text{Log}\,A_1),$$

Where:

S = Site index in metres
H_d = dominant height, m.
A = age of the plantation (years)
A_1 = Index age
Log = logarithm to base 10
b_i = regression constant.

Setting the index age at 50 years, the following site index equation was derived.

$$S = H_d - 21.4151\,(\log_{10}A - \log_{10}A_1) \text{ ---------- equation } \mathbf{(1)}$$

Where:

S = Site index
A = Stand age, years
H_d = Dominant height, m

3.2 Single Tree Volume Equation

Volume of each felled tree was calculated using the modified Newton's formula (Wenger 1984):

$$V = [(g_0 + g_n + 2(g_1 + g_2 + g_3 \text{ --- } + g_{n-1})\,L/6 + g_n\ .h/3]$$

Where:

V = total tree volume, m^3
h = tree tip length, m
g_n = basal area at the beginning of the tip such that
0,1,2, ---n = intervals at which diameters were taken
L = length of the sections at which diameters were taken.

- **Total over bark volume and diameter relationship:** Among the set of multiple regression equations tested in terms of goodness of fit, (F-ratio and standard error), the best model was equation (2):

$$V = 0.0004D^2 - 0.0004D^2; \quad (R^2 = 98.0, F = 2125.7200, SE = 0.027)$$
LSD = 0.05 --- equation **(2)**

Where:

V = total over bark volume, m^3

D = dbh, cm.

- **Total over bark volume, diameter and height relationship:** The best fit of the models tested was equations (3) and (4) below:

$$V_1 = 0.000012.705\ D^2 H_1; \quad (R^2 = 98.6, F = 2786.789, SE = 0.029)$$
LSD = 0.05 -- equation **(3)**

$$V_2 = 0.00017478D^2 H_2; \quad (R^2 = 98.1, F = 4543.290, SE = 0.027)$$
LSD = 0.05 -- equation **(4)**

Where:

V_1 = total over bark volume, m3

V_2 = total over bark bole volume to 15 cm top diameter, m3

D = DBH, cm

H_1 = total height, m

H_2 = stem height to 15 cm top diameter.

- **DBH and Dominant height relationship:** The best fit of the regression models derived was equation (5):

$$H = 0.0019D^2 + 0.4666453D + 6.671348;$$
$(R^2 = 0.61, SE = 2.83)$ LSD = 0.05 -- equation **(5)**.

- **Volume form factor:** From the felled trees over bark volume to 15 cm top diameter data, a volume form factor based on dbh was calculated to be 0.064.

3.3 Plantations Stand Volume and Financial Yield Tables

Based on the predicted basal area and dominant height recommended by the technical order for treatment of *vitex* crops (Forest Department Technical Order No.47), and the Forest Department's revised royalties for 1995/96 stand volume and financial tables (Table 1) were derived using the and volume equation used by Forest Department (FDGO No. 245) given below:

$$V = 0.02591 - 0.00004038D^2 - 0.001464\ H + 0.00003787D^2H \text{ ---- equation(6)}$$

Where:

V = total volume over bark, m^3

D = diameter at breast height, cm

H = total height, m.

*Stand volumes and financial yield tables (Table 1) are in the appendix.

4. DISCUSSION

- The site index model that has been developed can easily be applied to predict the growth pattern of dominant height of *Vitex* plantations in Kenya. It could also be applied in other areas where *Vitex* is grown because (Assman 1970, Evans 1982, Karani 1982, Hamilton 1981) the average dominant height is not significantly affected by different levels of thinning intensity.

- The high F-ratio and R^2 values show a highly significant allometric relationship between volume, dbh and dominant height.

Regarding the two models for predicting volume, it is difficult to tell which is more accurate because there are no hard and fast rules to decide whether the separate or combined estimate is better in any specific situation (Cochran 1977; p. 203). It is however evident that model 2 is more appropriate for rapid assessment and model 3 where greater accuracy is required e.g. for sale of stumpage and repeated inventories. In instances where logs' sale is by ground scale model 4 is recommended because it could be applied accurately. This model could be more appropriate when selling thinnings because errors encountered when measuring height in dense plantations are eliminated.

4.1 DBH/Dominant Height Relationship

Model 5 can be used to show that height increases rapidly with diameter at early ages and decreases progressively and then levels off. At this point the change in height growth with diameter is negligible though diameter growth continues until such a time when the biological rotation is achieved.

4.2 Stand Volumes and Financial Yield Tables

The stand volume tables and financial yield presented in Table 1 show that an hectare of a *Vitex* plantation of average site class with a density of 200 trees would attain a mean dbh of 48.9 cm, mean dominant height of 28.2 m and a total standing cumulative volume of 998.7 m^3. The corresponding values at ages 30 and 50 are 300 trees, 30.8 cm dbh, 21.5 m height, 218.6 m^3 standing volume, 631.8 m^3 cumulative volume; for age 30 and 200 trees, 43.0 cm dbh, 26.3 m height, 350.9 m^3 standing volume, and 861.3 m^3 cumulative volume for age 50 years. These data compare quite well with those derived by Kigomo (1981) from data of a sample plot of a *Vitex* plantation in Ragati.

In comparison, a *Cupressus lusitanica* plantation of average site class and a stocking of 266 at age 30 would attain a mean dbh of 45.3 cm, mean dominant height of 29.5 m, total standing volume 496 m^3 and cumulative volume of 742 m^3.

Financial analysis (annex 2) shows that the gross discounted value (at 2%) of an hectare of *Vitex* plantation of average site class at 30 years is Kshs. 271 408.60 and that of a similar regime of cypress plantation is Kshs. 238 976.80. Corresponding figures over a period of 60 (two rotations of 30 years for cypress and one rotation of vitex of 60 years) years are Kshs. 760 153.90 and Kshs. 416 302.60. It is therefore more profitable to invest in an hectare of *Vitex* plantation than an hectare of cypress plantation assuming that the cost of establishing these plantations are equal and the end products are complementary. This assumption is however not true. Consequently, it is recommended that detailed investigations and wood quality studies be undertaken.

5. ACKNOWLEDGEMENTS

The author would like to sincerely acknowledge those who assisted in field data collection and partial analysis and particularly the following: Mike Khale of GTZ, M. A. Gitonga, L. N. Ndegwa and M. Nyaga of Moi University and the Inventory Branch of Forestry Department, Kenya.

REFERENCES

Assman, E. 1970: The principles of forest yield study. Pergumon Press.

Anon, (?) 1983: Republic of Kenya. 5th Development Plan.

Cochran, W. G. 1977: Sampling Techniques. John Wiley & Sons. New York.

Evans, J. 1982: Plantation forestry in the tropics. Claredon Press. Oxford.

Forest Department, Technical Order No.47. Treatment of vitex crops.

Forest Department, General Order No.245. Forest Department annual revision of royalties for 1995/96.

Hamilton, G. J. 1981: Effect of higher intensity thinning on yield. Forestry 54-1.

Jaetzold, R. And Schulzke, H. 1983: Farm management handbook and Agro-ecological map of Kenya. Ministry of Agriculture. Vol. I-IV.

Karani, P. K. 1982: Interim results of thinning research (*Cupressus lusitanica*) in Uganda. The Commonwealth Forestry Review, Vol.57(4), No. 174.

Kenya Forestry Master Plan, 1994: Development Programmes Ministry of Environment & Natural Resources. Nairobi 1994.

Kigomo, B. N. 1981: Observations on the growth *Vitex keniensis* Turill (Meru Oak) in plantation. East African Agricultural Journal 47 (2): 32-37.

Wenger, F. K. 1984: Forestry handbooks. 2nd Edition John Wiley and Sons.

Annex 1: PLANTATIONS STUDIED

Forest Station	Compartment	Age	Area (ha)
Chuka	1L	12	20.8
"	1G	14	7.0
"	1B	16	10.0
"	1A	18	17.4
"	2C	22	17.8
"	2E	25	12.1
"	3E	28	12.0
"	1C	31	13.0
Ragati	1(0)	16	4.1
"	7I	22	10.9
"	2C	25	15.0
"	7F	30	17.0
"	1G	33	6.0
"	7D	46	9.7
"	2C	62	6.0
Meru	1I	44	2.0
"	1L	24	19.0
"	2E	27	23.0
"	2F	29	30.4
"	3A	32	6.0
"	3C	30	8.6
"	3E	34	9.0
"	3F	33	22.7
"	4J	17	13.8
"	4M	24	20.0
"	6A	15	14.5
"	6G	21	18.6
"	6I	20	14.5
"	7F	13	16.8
"	7J	10	19.3

Annex 2. COMPARISON OF REVENUE OF AN HECTARE OF VITEX PLANTATION TO AN HECTARE OF CYPRESS PLANTATION

Age yrs	Mean DBH in	Mean DOM Ht. cm	No per ha	Basal area sq.m/ha	Mean vol/tree cub.m	Volume per ha cub.m	Price/ cub.m Ksh	Revenue/ha Ksh	Thinning revenue Ksh	Total revenue Ksh	Discounted revenue Ksh	Discounted revenue Ksh
7	14.7	10.2	1347	15.1								
8	15.7	11.4	888	17.3	0.063	29	137		1827	1827	1687.25	
12	22.7	15.7	533	21.6	0.177	63	253		5166	6993	4584.3	51587
18	32.5	21.4	355	29.7	0.460	82	361		5904	12897	4935.7	
22	41.5	24.6	266	36.6	0.809	72	430		35712	48609	28691	
30	45.3	29.5	266	42.9	1.865	496	541	268336		316945	199078.5	
Total first rotation											238976.8	271408.6
Second rotation												
7	14.7	10.2	1347	15.1								
8	15.7	11.4	838	17.3	0.063	29	137		1827	318772	1251.85	
12	22.7	15.7	533	21.6	0.177	63	253		5166	323938	3401.3	
18	32.5	21.4	355	29.7	0.460	82	361		5904	329842	3662.25	
22	41.5	24.6	266	36.6	0.809	72	430		35712	365554	21291.5	
30	45.3	29.5	266	42.9	1.865	496	541	268336		633890	147719	
Total first and second rotation											416302.6	760153.9

Table 1. STAND VOLUMES AND FINANCIAL YIELD TABLES FOR VITEX KENIENSIS PLANTATIONS OF AVERAGE SITE CLASS

Age yrs	Mean DBH m	Mean DOM Ht cm	No per ha	Basal area sq.m/ha	Mean vol/tree cub.m	Volume per ha cub.m	Cumulative volume/ha cub. m	Price/ cub.m Ksh	Revenue/ha Ksh	Thinning revenue Ksh
7	16.8	7.8	2000	44.3	0.086	173	173	361	62427	
8	17.4	9.2	2000	47.5	0.106	211	211	361	76314	
9	18	10.3	2000	50.9	0.124	248	248	361	89620	
10	18.6	11.3	2000	54.3	0.143	287	287	361	103567	
11	19.2	12.2	2000	57.9	0.163	327	327	361	118033	51557
12	19.8	13	1000	30.8	0.184	184	327	361	66443	
13	20.5	13.7	1000	33.0	0.207	207	350	361	74697	
14	21.1	14.4	1000	34.9	0.230	230	373	361	82899	
15	21.7	15	1000	37.0	0.252	252	395	361	91125	
16	22.3	15.6	1000	39.0	0.277	277	420	361	99916	
17	22.9	16.2	1000	41.2	0.303	303	446	361	109289	
18	23.8	16.7	1000	44.5	0.337	337	480	361	121593	57038
19	24.1	17.3	500	22.8	0.358	179	480	723	129290	
20	24.7	17.7	500	23.9	0.384	192	493	723	138926	
21	25.3	18.2	500	25.1	0.415	207	508	723	149874	
22	26	18.6	500	26.5	0.448	224	525	723	161788	
23	26.6	19	500	27.8	0.479	239	540	723	173026	
24	27.2	19.4	500	29.0	0.511	256	556	723	184791	
25	27.8	19.8	500	30.3	0.545	273	574	723	197094	
26	28.4	20.2	500	31.7	0.581	290	591	723	209947	
27	29	20.5	500	33.0	0.615	307	608	723	222263	
28	29.6	20.8	300	20.6	0.650	195	608	723	141034	81193
29	30.2	21.2	300	21.5	0.690	207	620	723	149720	
30	30.8	21.5	300	22.3	0.729	219	632	723	158015	
31	31.4	21.8	300	23.2	0.768	230	644	723	166613	
32	32.1	22.1	300	24.3	0.814	244	657	723	176627	
33	33.3	22.4	300	26.1	0.889	267	680	723	192824	
34	33.6	22.7	300	26.6	0.918	275	688	723	199027	
35	33.9	22.9	300	27.1	0.943	283	696	723	204450	
36	34.5	23.2	300	28.0	0.990	297	710	723	214648	
37	35.1	23.4	300	29.0	1.034	310	723	723	224201	
38	35.6	23.7	300	29.8	1.078	323	736	723	233713	
39	36.3	23.9	200	20.7	1.130	226	736	723	163448	70276
40	36.9	24.2	200	21.4	1.183	237	747	723	171113	
41	37.6	24.4	200	22.2	1.239	248	758	723	179225	
42	38.2	24.6	200	22.9	1.290	258	768	723	186592	
43	38.8	24.8	200	23.6	1.343	269	779	723	194152	
44	39.4	25.1	200	24.4	1.402	280	791	723	202737	
45	40	25.3	200	25.1	1.457	291	802	1050	306020	
46	40.6	25.5	200	25.9	1.514	303	813	1050	317901	
47	41.2	25.8	200	26.6	1.578	316	826	1050	331395	
48	41.8	25.9	200	27.4	1.631	326	837	1050	342550	
49	42.5	26	200	28.4	1.693	339	849	1050	355610	
50	43	26.3	200	29.0	1.754	351	861	1050	368406	
51	43.6	26.4	200	29.8	1.811	362	873	1050	380314	
52	44.1	26.6	200	30.5	1.868	374	884	1050	392180	
53	44.7	26.8	200	31.4	1.934	387	897	1050	406116	
54	45.2	27	200	32.1	1.993	399	909	1050	418503	
55	45.9	27.1	200	33.1	2.063	413	923	1050	433300	
56	46.5	27.3	200	33.9	2.134	427	937	1050	448156	
57	47.1	27.5	200	34.8	2.206	441	952	1050	463339	
58	47.7	27.8	200	35.7	2.289	458	968	1050	480633	
59	48.3	28.1	200	36.5	2.373	475	985	1663	789296	
60	48.9	28.2	200	37.5	2.442	488	999	1663	812117	

THE EFFECT OF PLANTATION FOREST PRACTICES ON WOOD QUALITY

J. K. GITHIOMI
Kenya Forestry Research Institute

SUMMARY

The paper reviews the effect of plantation forest management practices on wood quality. Forest practices modify growth in a variety of ways. Espacement, either at planting or thinning, weeding, pruning and fertilizer application affects wood quality. The primary objective of forest management is to enhance rate of growth which in turn influences the wood properties that may affect wood technical performance and hence commercial acceptance. Wood quality properties include, knottiness, density, grain angle, compression wood, which are used by technologists to judge quality. Studies have shown that some silvicultural activities lead to reduced wood quality. However, the reduction in wood quality in relation to increased volume production is insignificant.

1. INTRODUCTION

The term wood quality frequently refers to cumulative effect of wood properties on some specified products (Zobel and Van Buijtenen 1989). Defining wood quality goals is a difficult process due to complexity that arises from the large number of wood quality characteristics that might be considered such as wood density, fibre length, extractives content, fibre angle and cellulose content (Kellogg 1982). In addition, stem characteristics such as sapwood and heartwood content, kino vein number and frequency, decay and discolouration and knot size and frequency, will affect end product quality. However, different end products will have different optimum wood and stem quality characteristics. Therefore, there is no absolute index of wood quality. The properties thus depend very much on the user. This means that wood quality may be best defined when the final product is known. However, the most widely used index of wood quality is basic density or specific gravity.

The Silvicultural forest practices are aimed at improving the economics of production by increasing yields, and improving wood quality. The forest managers influence the type of wood through two types of operations: i) those which modify the site; and ii) those which act directly on the crop. The former are actions which aim to improve quality, e.g. cultivation, drainage, irrigation and fertilizer application. These act on the crop as a whole. The latter are practices such as spacing, thinning and pruning which influence the growth of trees or groups of trees. Both these practices have a common factor in that they influence the character of wood produced. Changes in the crown lead to change in pattern of growth in the stem. It is these changes in size, number, distribution, frequency of divisions, the cells, which have an effect on the gross wood properties.

This paper reviews information on how the wood properties which determine quality are influenced by the range of forest management options. The forest management practices considered here are spacing, thinning, pruning, coppicing and resin tapping.

2. DIFFERENT SILVICULTURAL TREATMENTS AND THEIR EFFECT ON WOOD PROPERTIES

2.1 Effect of Spacing

The effect of initial spacing on knot size is provided by various studies, e.g. Braastad (1970), Grah (1961). An examination of 15 year old *Pinus radiata* in Australia by Cromer (1961), showed a linear relationship between average branch size and initial spacing, with knot size increasing at wider spacing. The knot sizes tend to be greater near the ground but there is no evidence for an increase in number of knots. Some studies have shown a decrease in specific gravity with increased spacing between the trees (Zobel and Buijtenen 1989, Klem 1952). However, general findings have been that normal spacing variation (i.e. stand density commonly used by silviculturists) has little effect on wood properties such as specific gravity or tracheid length.

2.2 Effect of Thinning

Thinning results in remaining trees suddenly being in an environment quite different from the one in which they had been growing. When thinning is done correctly, it results in improved growth and tree quality (Zobel and Buijtenen 1989). Thinning removes poor trees leaving high quality trees thus improving wood quality for sawn timber or plywood.

In some species of hardwoods, the results of thinning are not positive in relation to wood quality. Opening up a stand (allowing more light) can cause stem epicormic sprouting which results in numerous knots. Sometimes thinning causes the formation of poorer quality trees, although this is rare depending on age when thinned, thinning density and the tree species, (Zobel and Buijtenen (1989). Thinning may cause development of larger branches with bigger knots but this can be avoided if it is done at the proper age and in a proper way.

Trees growing on steep hill sides or which are exposed to prevailing winds are associated with uneven crown development. Thinning should be avoided in such cases, as it may lead to one-sided growth of the crown which could result in localised compression wood and irregular stem formation. There has been contradictory information on the effect of thinning on basic density (Paul 1958). Some studies have reported increase in basic density with thinning (Lowery and Schmidt 1967, Reid 1963). While others have shown no significant differences after thinning (Myers 1960).

2.3 Effect of Pruning

Pruning is done to promote a higher proportion of clear wood by reducing limbs and knot size which give logs suitable for sawnwood and plywood. In some species eg. *Pinus radiata*, pruning causes early cessation of juvenile wood formation and this induces a change in the characteristics of wood. Polge (1969) reported increase of latewood from 14-26%, density from 0.48-0.58 and tracheid length from 3-4 mm after pruning *P. radiata*.

Pruning is done to remove dead branches or green branches from the lower part of the crown. The lowermost branches are removed to increase the length of clear bole without adversely effecting stem form or growth though the remaining branches in the crown may increase in diameter (Larson 1969).

If pruning is not done properly, it would result in loss of potential benefits e.g. if the saws used to remove the limbs, cut deeply into the bark, or if the machetes used chop into the wood. This could delay the production of good clear wood and may lead to the formation of large occluded area and defective core. The wooded area produces wood that has deformed tracheids, curly grain or other defects. One of the most common defects of pruning are resin pockets. Meanwhile, incorrect pruning may also facilitate entry of rot-producing organism into the wood.

2.4 Effects of Coppicing

For some hardwood species, the standard forest management practice is to harvest the stand and let the tree sprout, (coppice). The amount of reaction wood is often greater in coppices and the distribution of limbs is more irregular e.g. in *Eucalyptus* species. This is especially true when two or three stems are left per stump. Such stumps lean away from one another and tend to have most of the limbs only on one side. The leaning stems have much more tension wood than straight, single stem and there is defect related to the heavier limbs on one side of the tree.

2.5 Effect of Resin Tapping

In some pine species, tapping the trees for resin is a standard silvicultural procedure. Wood in the stem following tapping becomes resin-soaked and it is difficult to use for certain products e.g. pulp production (Zobel and Buijtenen 1984).

REFERENCES

Braastd, H. 1970: A spacing experiment with Picea abies. (?) 28: pp. 295-329.

Cromer, D. A. N. 1961: New approaches in Forest Mensuration as a basis for management *Pinus radiata*. Common wealth For. Timber Bulletin. pp. 99.

Grah, R. F. 1961: Relationship between tree spacing, knot size, and log quality in young Douglas - fir stands. J. For. 59: 270-272.

Kellog, R. M. 1982: Coming to grips with wood quality. Forest chronicles. pp. 254-

Klem, (?) 1952: Effect of planting space on the quality of spruce wood and sulphite pulp. (?) 8: 257-93.

Larson, P. R. 1969: Wood formation and the concept of wood quality. Yale Sch. For. Bull.74.

Lowery, (?) and Schmidt, (?) 1967: Effect of thinning on the specific gravity of western larch crop trees. USDA For. Serv. Res. Note.

Myers, C. A. 1960: Estimating oven-dry weight of pulpwood in standing ponderosa pines. J. For. 58: 889-891.

Paul, B. H. 1958: Specific gravity changes in Southern pine after release. South Lumber Mgmt. 197 (2465): 122-124.

Polge, (?) 1969: Density of planting and pruning of live branches or why, when and how to prune. RFF. 21 special silviculture 31: 451-462.

Reid, J. S. 1963: Wood quality in rapidly growing conifers planted in New Zealand. IUFRO sect. 41: 1-38.

Zobel, B. J. and Van Buijtenen, J. P. 1989: Wood variation, its causes and control. Springer-verlag, London.

PERFORMANCE OF EUCALYPTUS SPECIES AND PROVENANCE TRIALS AT GEDE - KENYA

GORDON O. SIGU & DAVID K. LANGAT
Kenya Forestry Research Institute

SUMMARY

Two trials RE.380 and RE.415 were established at Gede in 1977 and 1979 respectively to select appropriate Eucalypts species and provenances for the coastal lowlands. The first trial consisted of nine provenances of *Eucalyptus camaldulensis*, two of *E. tereticornis* and one of *E. microtheca*. The second trial had seven provenances of *E. camaldulensis*, two provenances of *E. tereticornis*, one provenance each of *E. hybrid* and *E. alba*. The results of the two experiments indicated that the growth of different species and provenances were varied and significant at 0.05 probability level. *E. camaldulensis* S(S-10687) from Nive River Australia, *E. camaldulensis* (S-10550) from Kimberley Australia and *E. tereticornis* (2640) from Bukedi Uganda all showed superior growth. *E. microtheca* (S-12594) from East Katherine Australia and *E. hybrid* (001) from Ghana performed poorly in all the assessments.

1. INTRODUCTION

Eucalyptus have had an important place in plantation forestry in Kenya since the beginning of formal forestry management in the 1920's. Although they have been planted on a smaller scale compared to other exotics like cypress and pines, they have proved to be a popular species for farm forestry (Dyson 1974). About 130 species of eucalypts have been introduced into Kenya from Australia out of which only a few have been established in plantations (NAS 1980). Eucalyptus species are known to provide a wide range of wood products and have a fairly good performance in most ecological zones. Owing to population pressure and the need for more wood products, there has been a greater shift to marginal lands for reforestation. To meet the pressing demand and to ease over-reliance on *Casuarina spp.*, an effort was made to identify the most promising and fast growing species of eucalypts for coastal lowlands. Earlier, species trials in Kenya indicated that *Eucalyptus camaldulensis* and *E. tereticornis* were promising candidates for marginal lands, though not suitable for arid lands receiving annual rainfall of less than 450 mm (Berger and Lysholm 1978). A crucial aspect of successful cultivation of *E. camaldulensis* is the selection of the right provenance (Turbull and Brown 1984). In order to select appropriate provenances for the coastal lowlands two experiments; RE. 380 and RE. 415 were set-up in 1977 and 1979 respectively. The objectives of the trials were to compare growth and survival performance between species and provenances at Gede.

2. MATERIALS AND METHODS

2.1 Experimental sites

The experiments were established at Gede forest station which lies at latitude 3^0 18' S, and longitude 40^0 8'E. The altitude is 10-15 m above sea level, with a mean annual rainfall of 940 mm. The mean annual temperature is 28^{0}c. The soils are alkaline loamy white sands (latosols) derived from tertiary sediments.

2.2 Experimental design

Experiment RE. 380 was planted out in April 1977 in a completely randomised block design with 3 replicates. Plots had 64 plants each at 2.5 m x 2.5 m espacement. Nine provenances of *E. camaldulensis*, two of *E. teriticornis* and one of *E. microtheca* were established.

Experiment RE. 415 was planted out in April 1979 in simple randomised block design of four replicates. Seven provenances of *E. camaldulensis*, two of *E. tereticornis*, one of *E. hybrid*, and *E. alba* were used. There were 29 trees per plot at 2.5 m x 2.5 m espacement.

2.3 Seed sources, nursery management and field tending

Seeds for the experiments were from various sources as described in Table 1. Seedlings were raised in nursery beds, pricked out after one month into polythene tubes and were in good condition when planted out 5 months later. The planting sites were prepared by slashing the vegetation, burning and pitting. Total weeding was done immediately after planting. Regular weeding and slashing was done for the first 3 years. Subsequent tending was carried out by vegetation slashing and climber cutting.

2.4 Assessment and data analysis

Height, diameter at breast height (dbh) and survival were assessed. Both height and diameter were measured for the inner trees in a plot with the outer ones acting as guard rows. For RE. 380, 36 trees were assessed for dbh and 4 trees with largest dbh for height. For RE. 415, 20 trees had their dbh measured and for height 5 trees with largest dbh were measured. Survival percent was based on the total number of trees alive in each plot. Analysis of variance was done on height, dbh and survival using computer software *SPSS for MS Windows version 5.0*. The analysis of variance for survival was carried out after arc-sine transformation. Turkey test was performed on dbh and height for age 9 (RE.380) and ages 5, 7, 11.5 years for RE.415.

Table 1: Origin of eucalyptus species and provenances seedlots

Speciess		Provenance locality	Seed lot No.
1.	*Eucalyptus camaldulesnis*	Ramogi-Kenya ex-Zanzibar	412-006
2.	" "	North Cloncurry-Australia	S-10688
3.	" "	Burkley River-Australia	S-10690
4.	" "	Kimberley - Australia	S-10550
5.	" "	Murchisson River - Australia	S-10182
6.	" "	Aver Rock - Turnoff, Australia	S-10494
7.	" "	North Cloncurry - Australia	S-10689
8.	" "	Nive River - Australia	S-10687
9.	" "	Lushoto - Tanzania	1307
10.	*E. tereticornis*	Bukedi - Uganda	2640
11.	" "	Barakula Queensland - Australia	S-10817
12.	*E. microtheca*	East Katherine - Australia	S-10594
13.	*E. tereticornis*	St. Laura - Australia	S-11953
14.	E. hybrid	Ghana	001
15.	*E. alba*	EAAFRO Arboretum	400-601

3. RESULTS AND DISCUSSIONS

The results of the two trials indicated that the performance of the species and provenances were varied and significant at 0.05 probability level. There were no significant differences among blocks for both sites. The results for RE. 380 and RE.415 are as indicated in Tables 2 and 3.

3.1 Survival

In both trials the survival performance of most of the species and provenances was generally good. There was variable survival for *E. camadulensis* which was reflected strongly in the various provenances with *E. camaldulensis* 1307 from Lushoto, Tanzania showing poor survival. In RE. 380, North Cloncurry, Australia, provenances of *E. camaldulensis*(S-10688) had the best survival at 98% at 7 and 9 years while in RE. 415, the best overall survival was shown by the Kimberley - Australia provenance. At age 7 years, *E.microtheca* had better survival percent than *E.tereticornis* (2640) Bukedi-Uganda, *E.alba* and *E. hybrid*.

Table 2: **Mean diameter height and survival at 5, 7 and 9 years**

Species	Provenance	Age (years) 5			7			9		
		DBH (cm)	Ht. (m)	Sur.(%)	DBH (cm)	Ht. (m)	Sur.(%)	DBH (cm)	Ht. (m)	Sur.(%)
E. camaldulensis	Ramogi ex-Zanzibar (412-006)	10.4	9.9	97	11.2	17.0	94	12.3	20.6	94
"	North Cloncurry Australia (S-10688)	9.2	10.9	99	10.6	14.0	98	11.3	16.0	98
"	Burkley River Australia (S-10690)	9.8	11.2	97	10.8	15.9	95	11.8	18.2	95
"	Kimberley Australia (S-10550)	9.3	12.1	96	11.5	18.0	95	11.9	18.7	95
"	Murchisson River Australia (S-10182)	8.9	10.4	92	10.3	14.7	83	10.0	18.7	88
"	Aver rock Turnoff Australia (S-10404)	8.7	10.2	92	10.7	14.4	66	11.3	16.1	66
"	North Cloncurry Australia (S-10689)	10.4	10.3	97	11.0	18.6	93	11.9	19.6	93
"	Nive River Australia (S-10687)	11.3	11.5	93	12.1	17.5	84	13.7	20.7	79
E. tereticornis	Barakula-Queensland Australia (S-10817)	9.2	11.6	85	12.4	17.6	69	12.2	19.3	69
"	Bukedi-Uganda	10.9	10.8	84	14.5	19.7	66	13.1	20.7	64
E. microtheca	East Katherine Australia (10594)	3.4	4.8	91	4.0	6.7	87	4.0	7.2	87
E. camaldulensis	Lushoto-Tanzania (1307)	9.4	9.6	34	14.3	12.9	28	11.3	16.01	17

Table 3: Mean diameter height and survival at ages 4, 5, 6, 7 and 11.5 years

Species	Provenances	Age (years) 4			5			6			7			11.5		
		dbh cm	ht m	sur %	dbh cm	ht m	sur %	dbh cm	ht m	sur %	dbh cm	ht m	sur %	dbh cm	ht m	sur %
E. tereticornis	Bukedi-Uganda (2640)	9	11.4	79	12.6	13.6	79	14.4	17.4	77	15.9	20.7	75	20.5	23.4	68
"	St. Laura Australia (S-11953)	7.4	10.0	97	9.3	11.2	97	9.8	12.1	97	10.5	15.35	97	12.1	17.1	87
E. camaldulensis	Aver-rock Turn off-Australia (S-1049)	6.9	9.6	97	8.3	10.7	96	9.1	11.8	89	9.6	13.3	75	12.5	13.9	51
"	Kimberley-Australia (S-10550)	8.2	12.8	100	11.8	13.5	100	12.8	16.4	99	13.8	16.9	99	15.7	19.6	96
"	Burkley river Australia (S-10690)	8.2	9.6	99	10.3	11.3	99	11.2	12.4	99	11.9	14.6	99	13.5	16.9	95
"	N.cloncurry Australia (S-10688)	6.6	9.5	96	9.7	11.1	96	10.7	12.3	96	11.3	16.7	96	13.3	16.5	94
E. hybrid	Ghana (001)	5.8	8.6	77	8.4	10.5	77	9.3	12.4	77	9.9	16.9	77	12.9	19.4	55
E. camaldulensis	Murchisson river Australia (S-10182)	7.2	8.9	77	9.1	11.1	77	10.2	16.3	77	11.2	14.8	73	13.7	17.3	59
E. alba	EAFRO Alboratum (400-602)	7.4	8.6	61	10.9	12.5	61	12.9	13.8	60	14.9	17.7	52	19.1	19.3	39
E. camaldulensis	N. Cloncurry Australia (S10689)	8.7	9.7	97	8.1	12.2	97	11.7	14.5	97	12.4	16.9	97	13.7	19.7	92
"	Ramogi-Kenya ex Zanzibar (412-006)	6.9	9.0	71	10.2	11.4	71	11.5	12.6	71	12.9	19.4	60	16.2.	22.6	60

Table 4: Turkey test of Mean dbh at 9 years

Species Provenances	1	2	3	4	5	6	7	8	9	10	11	12
1	--	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
2	--	--	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
3	--	--	--	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
4	--	--	--	--	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
5	--	--	--	--	--	N.S.	N.S.	*	N.S.	N.S.	N.S.	*
6	--	--	--	--	--	--	N.S.	*	N.S.	N.S.	N.S.	*
7	--	--	--	--	--	--	--	N.S.	N.S.	N.S.	N.S.	*
8	--	--	--	--	--	--	--	--	N.S.	N.S.	N.S.	*
9	--	--	--	--	--	--	--	--	N.S.	N.S.	--	*
10	--	--	--	--	--	--	--	--	N.S.	N.S.	--	*
11	--	--	--	--	--	--	--	--	N.S.	--	--	*
12	--	--	--	--	--	--	--	--	*	--	--	--

Table 5: Turkey test of Mean height at 9 years

Species & Provenances	1	2	3	4	5	6	7	8	9	10	11	12
1	--	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	*
2	--	--	*	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
3	--	--	--	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
4	--	--	--	--	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.	*
5	--	--	--	--	--	*	N.S.	N.S.	*	N.S.	N.S.	*
6	--	--	--	--	--	--	*	*	N.S.	*	*	*
7	--	--	--	--	--	--	--	N.S.	*	N.S.	N.S.	*
8	--	--	--	--	--	--	--	--	*	N.S.	N.S.	*
9	--	--	--	--	--	--	--	--	*	N.S.	--	*
10	--	--	--	--	--	--	--	--	N.S.	--	--	*
11	--	--	--	--	--	--	--	--	*	--	--	*

3.2 Diameter and height growth

At ages 5 and 7 years there were significant differences between species and provenances in both experiments in terms of dbh and height growth. In RE 380, *E. microtheca* differed significantly from the other two species i.e. *E. camaldulensis* and *E. tereticornis*. The diameter growth for *E. camaldulensis* was uniform except for the Australian provenances, Murchisson River and Aver Rock Turnoff which differed significantly (0.05 probability level) with Nive-River provenance at 9 years. There were no significant differences between *E. camaldulensis* and *E. tereticornis* except for Murchisson river provenance and Bukedi-Uganda provenance. *E. camaldulensis*, Nive-River provenances (S-10687) had the best performance in diameter growth at 9 years followed by *E. tereticornis*, Bukedi - Uganda provenance, *E. Camaldulensis*, Ramogi ex Zanzibar and *E. camaldulensis*, Kimberley, Australia. The best height growth at nine years was shown by *E. camaldulensis*, Nive-provenance, followed by *E. tereticornis*, Bukedi provenance, *E. camaldulensis*, Ramogi ex-Zanzibar and the Kimberley, Australian provenance. *E. microtheca*, East Katherine, Australia, performed poorly for all the ages.

In experiment RE. 415, *E. tereticornis*, Bukedi, Uganda had superior diameter and height growth followed by *E. camaldulensis* Kimberley, Australia, *E. alba*, *E. camaldulensis*, Burkley river and Ramogi ex-Zanzibar provenances. Generally, *Eucalyptus alba* (400-601) had good dbh and height growth but poor survival.

There was varied performance for *E. camaldulensis* generally for both experiments in terms of dbh and height growth. *E.camaldulensis*, Kimberly, Australia provenance had a mean annual growth increment of 1.7 m in height and 1.3 cm dbh. With the right provenance on a favourable site, *E.camaldulensis* grows very fast. Mean annual growth increments of 2 m in height and 2cm in diameter can be maintained for the first 10 years (NAS 1980). The differences in performance confirms the fact that the performance of eucalyptus species is influenced by provenance (Turbull and Brown 1984).

4. CONCLUSION

From the results of the two trials, the best provenances of *Eucalyptus camaldulensis* for planting at Gede are Nive-River Australia, Kimberley-Australia and Ramogi ex-Zanzibar provenances. The Bukedi-Uganda provenance, *E. tereticornis* is also relatively suitable.

REFERENCES

Berger, T.J. and Lysholm, G. 1978: Species and provenance trials with hardwood. Establishment methods. *Pinus caribea* and *Eucalyptus tereticornis*. Gede and Jilore, Kenya EAC/NORAD Afforestation Project, Technical Order No.2 21 pp.

Dyson, W.G. 1974: Experiments on growing Eucalyptus woodfuel in the semi-dedrous forest zone in Kenya. E.Afr. Agric. J. 39:349-355.

National Academy of Sciences (NAS) 1980: Firewood crops, Shrub and Tree Species for Energy Production. Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation. Board of Science and Technology for International Department, Commission on International rotations. Washington D.C.

Turbull, J.W. and Brown, A.G. 1984: Choice of species and seed sources in Eucalypts for wood production. Hillis, W.E and Brown, A.G. (eds.). CSIRO Australia academic press.

GROWTH PERFORMANCE OF *EUCALYPTUS GRANDIS* AT ELBURGON AND TURBO

OBALLA, P.O. and GIATHI, G.
Kenya Forestry Research Institute

1.0 INTRODUCTION

Eucalyptus species is one of the most important tree species grown in Kenya. It is widely planted, occupying approximately 17,000 hectares of Government forests and about 9,000 ha. of private plantation forests. More than half of the total area occupied by eucalypts is estimated to be under two species: *Eucalyptus grandis* Hill ex Maiden and *E. saligna* SM. The species are mainly favoured for production of both poles and posts for building, cable transmissions, fencing, pulp and fuelwood. The species are fast growing; a height of 25 m in 9 years has been reported (Gottneid and Thogo 1975). Sustainability of the species through coppice management is another important factor that has been appreciated by growers (Howland and Freeman 1970, Dyson 1974, Kaumi 1983). In a fuelwood experiment at Muguga, Dyson (1974) reported a yield of 227 m^3ha^{-1} for a six year first coppice rotation compared to 178 m^3ha^{-1} at the same age on first felling of a seedling raised plantation.

However, the product supply from these species have been rapidly rising to an extent that a large deficit exists today. This is further aggravated by the limited land available for forestry. This, therefore leaves the genetic improvement of the species as the most viable option of increasing the productivity.

Genetic improvement work on one of the species, *E. grandis* was initiated in late 1970s to raise the productivity. However lack of dependable base population for the work was a major setback. Doubts have been expressed as to the genetic purity of the existing crop of *E. grandis* and *E. saligna* growing in Kenya since their chances of hybridization is thought to be very high (Howland and Freeman 1970). Authenticated materials for the improvement programme had to be procured from natural range and other places to set the base population.

This paper summarises results of two experiments set with three main objectives: i) to systematically widen the genetic base of *E. grandis* in the country; ii) to find the best adopted natural range from where commercial seeds could be imported; and iii) to test the performance of the commercial seeds amongst themselves and against the local collection.

2. MATERIALS AND METHODS

2.1 Provenance Trial Site

The experiment was planted at Elburgon in Nakuru District. The site is situated at latitude 0° 21' South and longitude 35° 52' and an altitude of 2378 m above sea level. Annual rainfall is 1300 mm distributed bimodally with peaks in April and August and the mean temperature is 17° C. Six months dry period occur often from October to March, but neither frost or hails are experienced. Soils are sandy loams, low in humus content, which may have been derived from transported materials or basement parent materials. They are also deep, at least 3 m to the underlying rock. Initially the site carried an old crop of *E. saligna* which had been clearfelled one year before the experiment was established. The site was used for cultivating annual agricultural food crops.

Seventeen seedlots representing an equal number of provenances were procured from Australia through the International Union of Forestry Research Organization (IUFRO). Two Kenyan landraces of *E. grandis* and one of *E. saligna* were included in this trial. The provenance details are as shown in Table 1.

Table 1: Provenance details of *E.grandis/E. saligna* planted at Elburgon

Species	Seed lot No.	Locality/Provenance	Lat °(S)		Long. (E)		Altitude (m)
E. grandis	12380	East of Mareeba Qld	17	03	148	36	740
"	12426	S.F.R. 700, Gillie Qld	17	13	45	42	730
"	12383	Herberton area Qld	17	20	145	24	1000
"	12381	Wondecla area "	17	25	145	28	1010
"	12409	Ravenshoe area "	17	42	145	28	940
"	12382	Tully Falls area "	17	49	145	13	800
"	12462	West of Paluma "	19	00	146	00	900
"	10693	Northeast of Gympie "	26	27	152	42	76
"	10694	Southeast of Gympie "	26	18	152	46	76
"	10625	Kenilworth "	26	18	152	33	530
"	10696	Bellthorpe "	26	52	152	33	460
"	11243	South of Tyalgum NSW	28	27	153	12	100
"	11244	South of Murwillumbah "	28	33	153	23	300
"	11681	North of Woolgoolga "	29	32	153	12	30
"	7810	North of Bulahdelah "	32	20	151	13	120
"	7823	North of Coffs Harbour "	30	10	153	08	18
"	12894	Seed Orchard, S. Africa	-	-	-	-	-
"	M.A 74	Muguga Arboretum Plot 74	1	13	36	38	2040
"	ME	Muguga Estate Cpt 2G	1	13	36	38	2040
E. saligna	S.L (saligna)	Lugari stand, Kenya	0	08°N	35	52	1800

Qld = Queensland - Australia (North)
NSW = Nes South Wales - Australia (Southern)

The experiment was planted in May 1980. The experimental design was a complete randomized block with five replicates. Plots of 36 trees at an espacement of 2.5 m x 2.5 m were used. Only the inner 4 x 4 trees were assessed. The trial was established and managed under shamba/taungya system for a period of approximately two years.

The characters assessed were dominant height, diameter at breast height (dbh), stem-form and branch persistence. Height was measured annually but the data presented herein is for the last assessment at age 9 years. Stem-form was subjectively assessed based on a 1 to 5 point scoring system, with 1 being the worst and 5 as the best. The branch persistence was based on a similar scoring system but the scores were 1, 3 and 5, with 5 as the best. For details of these scoring systems see Appendix 1.

2.2 Analysis

Single tree volume was calculated using the following formula:

$$\log vol = b_0 + b_1 x \log(dbh) + b_2 * \log(h).$$

Where :

$b_0 = -4.34442$
$b_1 = 1.75657$
$b_2 = 1.12342$

The volume of the trees on a plot was averaged to obtain mean plot volumes.
The mean annual increment (M.A.I) for each plot was calculated as follows:

$$M.A.I. = (vol * survival \%)/9 \text{ years.}$$

M.A.I. = (vol * survival %)/9 years.

Where:

M.A.I.:	=	mean annual increment at 9 years
Vol.:	=	mean plot volume (m^3)
Sph.:	=	number of stems per hectare.

Simple comparisons between this M.A.I and theoretical M.A.I (where survival is assumed to be 100%) was done. Analysis of variance on the data was done using SPSS statistical package.

2.3 Progeny Trial Site

A total of 20 seedlots representing progenies of 19 plus trees selected from Zimbabwe and one local provenance were planted at Turbo (Table 2). The experiment was sited in Nzoia compartment 5C (latitude 0° 25' N, longitude 34° 40' E), at an altitude of 1800 m a.s.l. Mean annual rainfall is 1300 mm and mean temperature are 18° C. Soils are shallow derived from phonolite lava, forming a fairly flat topography. The site was originally planted with *Pinus patula* which was clearfelled two years before the planting of the trial.

Table 2: Progenies included in *E. grandis* trial at Turbo

Seedlot No.	Plus tree No.	Collection site	Parentage and origin
9670	218	Comp. I16 Mtao (1)	S/N 4196 from B16 SSO
9681	230	Comp.J 13 Mtao (1)	S/N 419 from B 16 SSO
9699	248	Comp. A 65 Mtao	S/N 4196 from B16 SSO
9702	251	Compt. A 8b Mtao	S/N 4196 from B 16 SSO
9704	253	Compt A 8a Mtao	S/N 4196 from B 16 SSO
9705	255	Comp. A 8a Mtao	S/N 4196 from B 16 SSO
10935	292	P. test E5 Grassland (22)	S/N 4544 from B 16 SSO
10936	293	P. test E5 Grassland (22)	S/N 4511 from B 16 SSO
10937	294	P. test E5 Grassland (22)	S/N 4529 from B 16 SSO
10940	297	P. test E7 Grassland (22)	S/N 4671 ex S/N 2545FRC SSO
10941	298	P. test E7 Grassland (22)	S/N 4663 ex S/N 2507FRC SSO
10942	299	P. test E7 Grassland (22)	S/N 4669 ex S/N2609FRC SSO
10943	300	P. test E7 Grassland (22)	S/N 4679 ex S/N 2524FRC SSO
10944	301	P. test E7 Grassland (22)	S/N 4661 ex S/N 2608FRC SSO
10945	302	P. test E7 Grassland (22)	S/N 4670 ex S.N 2557FRC SSO
10946	303	P. test E7 Grassland (22)	S/N 4679 ex S/N 2546FRC SSO
10947	304	P. test E7 Grassland (22)	S/N 4660 ex S/N 2546FRC SSO
10948	305	P. test E7 Grassland (22)	S/N 4659 ex S/N2569FRC SSO
E. saligna Turbo		-	-

The selection sites for plus trees in Zimbabwe were at Grassland and Mtao. The two places as reported by Matheson and Mullin (1997) differ in environmental conditions as follows

- Grassland (latitude 18° 10'S, longitude 31° 29'E) is at an elevation of 1,460 m, with 885 mm annual rainfall, and has deep sandy soils derived from granite,
- Mtao (lat. 19° 20'S, long. 30° 35'E) is at an elevation of 1,460 m, with 690 mm annual rainfall, and has deep aeolian Kalahari sands

A randomised block design of five replicates with 25 trees per plot at a square spacing of 2.5 m was used. The tending of the plots was by the "shamba system". Assessments were carried out annually on counted for survival, but for height and diameter assessment, only 3 x 3 inner trees were measured. The data was analysed for variance and this paper also presents the results at 6.4 years.

3. RESULTS

Table 3 shows mean survival, height, dbh, stemform and branch persistence scores for the provenance trial. The provenances were sorted according to mean height in decending order.

The local landrace of *E. saligna* recorded the least height growth; 22.0 m at the end of nine years. Among the *E. grandis* provenances, Woolgoolga North from New South Wales (NSW) had the least height; 22.7 m and S.FR. 700 and Ravenshoe, Queensland attained heights of 22.8 m and 22.9, respectively. Tyalgum (NSW) had the highest growth height, recording an average of 25 m at the close of the experiment. However, no significant differences between the provenances for height growth were evident at the 0.05 probability level. The local *E. grandis* provenances; Muguga arboretum and Muguga plantations recorded heights of 23.8 m and 23.6 m, respectively. They ranked 12th and 15th overall in height growth vigour. The performance of South African seed orchard progeny was not impressive as expected, ranking eighth overall with a height of 24.3 m.

Provenance Tally (Qld) recorded the least dbh; 16.8 cm and Herberton (QLD) the highest; 19.9 cm. As with height no significant differences ($P<0.05$) were observed. *E. Saligna* however, recorded an impressive diameter growth and it ranked sixth overall with 18.0 cm. The South African seed orchard progeny recorded a value of 17.6 cm ranking twelveth. There was no marked differences in both height and diameter growth between the northern and the southern Australian provenances. The influence of altitude of the seed source on growth vigour was also not obvious.

In general the survival rate was well above average only the Mareba and SFR 700 having values of less than 50% (seeTable 3). This was so inspite of the plot having been adversely affected by poor shamba hygiene while young (Kaumi pers. comm.) and later on by illegal removal of mature trees. This successful establishment shows that it would be possible for more introductions of new germplasm to be made without worrying much about the environmental conditions in the source region. However, caution and care should be exercised when dealing with materials from the extremes of their natural range and with highly bred materials.

There were no significant differences stem straightness ($P<0.05$). The provenance with the highest mean score and therefore the best boles on average was Wondecla of Queensland. It had a value of 3.99. Woolgoolga (NSW) on the other hand recorded a mean value of 2.7, which was the worst bole average.

The ability of different provenances to self-prune naturally was high as shown by their high significant differences between provenances at ($P<0.05$). The Gympie North East (QLD) and Tyalgum (NSW) provenances showed the best natural prunning ability with average scores of 4.5 and 4.4 respectively. Woolgoolga and Tully Falls had a mean score of 3.6, which was the lowest implying the least ability to self prune.

The actual standing volume and the corresponding mean annual increaments are shown in table 2. The Pa!uma provenance had a standing volume of 303 m^3/ha and Gympie (North East) 298 m^3/ha. These were the highest and the second highest volumes recorded. Meanwhile, Mareeba East and SFR 700 recorded the least volumes of 179 m^3/ha. These two provenances had also the least survival figures. The maximum obtainable volumes were calculated based on the actual m.a.i. assuming that the survival showed negligible or no effect on both height and diameter growth. This would make provenances Bulahdelah North and Tully Falls record have m.a.i. of 57 m^3/ha/yr and 54 m^3/ha/yr respectively and Wodecla; 37.8 m^3/ha/yr the least. Woolgoolga would have a mean annual volume increment of 38

Wodecla; 37.8 m³/ha/yr the least. Woolgoolga would have a mean annual volume increment of 38 m³/ha/yr. Dyson 1976 reported a m.a.i of 296 m³/ha/yr with *E. grandis* harvested for fuelwood at the end of six years. Provenances from Mareeba (Qld) and S.F.R. 700, Gullie Highway (QLD) had the least survival and those originating Southeast and Northeast of Gympie (Qld) the highest.

Table 3: Mean plot values of the characters assessed at 9 years of age

Provenance		Mean Survival %	Mean H (m)	Mean Dbh (cm)	Mean Stemform Score (1-5)	Mean branch Scores
E. grandis						
South of Tyalgum	NSW	67.8	25.1	17.7	3.8	4.4
North East of Gympie	Qld	76.2	24.7	17.1	3.6	4.5
Bellthorpe	NSW	66.2	24.7	18.0	2.6	4.0
West of Paluma	Qld	70.0	24.6	18.0	3.6	3.8
North Bulandelah	NSW	55.2	24.6	19.7	3.4	4.0
South of Murwilumbah	"	73.8	24.4	17.6	3.2	4.0
North of Coffs Harbour	"	65.4	24.3	17.8	3.5	4.1
Seed Orchard	RSA	68.8	24.3	17.6	3.7	4.3
Tully Falls area	Qld	55.0	24.2	19.9	3.3	3.6
East of Mareba	"	45.2	24.0	17.2	3.5	4.0
Herberton area	"	72.0	24.0	16.8	3.3	3.9
Muguga arboretum plot 74	Kenya	55.6	23.8	18.0	3.5	4.1
Southeast of Gympie	Qld	76.4	23.7	17.0	3.2	4.1
Kenilworth	"	73.8	22.7	16.9	3.2	4.0
Muguga Estate Plantn. 2G	Kenya	71.6	23.6	17.3	3.5	4.2
Wondecla area	Qld	63.8	23.5	18.6	3.9	4.1
Ravenshoe area	"	65.4	22.9	18.3	3.3	3.7
S.F.R. 700, Gillies Highway	"	49.0	22.8	18.4	2.8	4.2
North Woolgoolga	NSW	57.6	22.7	16.9	2.7	3.6
E. saligna						
Lugari Stand *E. saligna*	Kenya	61.2	22.0	18.0	3.2	3.8
Mean		63.33	23.88	17.87	3.4	4.01
Standard Error		8.98	0.79	0.83	0.32	0.24

The accumulated volume per hectare calculated from plot means showed no significant differences ($p<0.05$). Provenances from the West of Paluma and Southeast of Gympie had the highest mean annual volume increament and therefore the accumulated volumes at the end of the 9th year. The provenances form east of Mareeba and S.F.R. 700, Gullies Highway both from Northern Australia and Woolgoolga provenance from Southern Australia had the least standing volume. Table 4 shows the highest possible volumes obtainable by different provenances based on the plot means but by introducing the element of the maximum stock rate per hectare of 1600 stems. Based on this, provenances from North of Bulahdelah would register the highest mean annual volume increment and therefore standing volume and Woolgoolga provenance, the least.

3.1 Results of the progeny trial

A summary of mean heights and percentage survival at 2.2 and 6.4 years are presented in Table 5. The progenies are ranked according to their height performance at 6.4 years. There were significant differences in mean heigh growth among the progenies at age 2.2 which had disappeared by age 6.4 years. Height growth was highest for progenies of tree numbers 303 followed by numbers 252, 292, 297, and 299 at age 2.2 years. At 6.4 years the best 5 progenies were 293, 299, 304, 301 and 302, indicating no linear correlation in early and late growth performance. The leading progeny was 34% taller than the control which was below average in height and diameter growth.

Table 4: Volumes (actual and maximum) obtainable and their corresponding M.A.I

Provenance		Actual Standing Vol. m³	M.A.I. (m³/ha/yr)	Maximum Obtainable Vol. (m³/ha)	M.A.I. (m³/ha/yr)
West of Puluma	Qld	303	33.20	433	48.1
Northeast of Gympie	"	298	33.10	391	43.4
South of Murwillumbah	"	289	31.10	392	43.6
North of Bulahdelah	NSW	285	31.70	516	57.3
South of Tyalgum	NSW	283	31.40	417	46.3
Bellothorpe	Qld	281	31.20	425	47.2
Southeast of Gympie	"	279	33.10	367	40.8
Seed orchard	RSA	275	30.50	399	44.3
Muguga Estate Compt. 2G	Kenya	274	30.40	382	42.4
Wondecla area	Qld	273	30.30	430	37.8
Tully Falls area	"	271	30.10	493	54.8
Herbarton area	"	267	29.70	371	41.2
Kenilworth	"	236	26.20	394	43.8
North of Coffs Harbour	"	232	25.80	355	39.4
Lugari *E. Saligna*	"	230	25.60	377	41.9
Ravenshoe	"	229	25.30	406	45.1
Muguga arboretum plot 74	Kenya	227	25.20	413	45.9
North Woolgoolga	NSW	197	21.90	342	38.0
S.F.R. 700, Gillies Highway	Qld	191	21.10	390	43.3
East of Mareeba	"	179	19.90	393	43.7

Table 5: Mean growth values for progenies of *E. grandis at* 2.2 and 6.4 years

Plus Trees No.	Progenies at 2.2 years		Progenies at 6.4 years		Survival (%)
	Mean Ht. (m)	Survival %	Mean Ht. (m)	Mean D. (cm)	
293	9.5	93	22.5	18.1	4.8e+43
299	9.5	93	22.4	16.9	
304	9.1	71	22.1	18.4	
301	9.0	76	21.6	17.7	
302	9.0	85	21.6	17.4	
303	9.1	93	21.5	15.7	
294	7.8	92	21.4	18.6	
292	9.5	89	21.3	17.3	
253	8.2	92	21.1	17.2	
218	8.5	94	20.8	17.0	
305	8.7	94	20.8	16.1	
297	9.5	93	20.5	17.8	
252	9.7	90	20.4	16.4	
255	7.8	85	20.1	16.6	
230	8.8	73	20.0	18.5	
248	7.8	90	20.0	16.8	
251	7.2	74	19.9	16.4	
300	8.4	82	19.2	16.4	
298	9.2	78	18.9	17.2	
Local *E. Saligna*	6.3	86	16.7	14.3	
	8.6	86	20.6	17.0	
Mean	0.8	7.8	1.5	1.0	
Standard dev.					

The mean annual increment in height for the progenies of five the leading plus trees was 4.4 m at 2.2 years and 3.4 m at 6.4 years. The leading progeny had M.A.I. of 4.5 m at 2.2 years and 3.5 at 6.4 years. This was quite high compared to 3.3 m at 3.8 years and 2.8 m at 8 years reported by Konuche (1989) for Turbo and Elburgon respectively. Gottneid and Thogo (1975) reported a M.A.I. of 2.8 m at 9 years which is the recommended felling age at Muguga for seedling raised *E. grandis*. There was however a lot of human interference in the experiment after age 3 years that the data did not reflect the actual survival of the progenies according to their adaptation.

4. CONCLUSIONS

The importation of commercial quantities of *E. grandis* seed for pilot plantations can be undertaken, with the Bulahdelah, Tully Falls, Paluma, Ravenshoe and Gympie provenances being given priority. Progenies from five leading plus trees should be imported in large quantity to form part of the base population for advanced breeding.

Though there were no significant differences in growth traits between the provenances, the same cannot be said for wood quality. The determination of wood quality should therefore be done as an integral part of this study. Phenology studies should also be carried-out on this trial which should and subsequently be converted into a seed stand.

REFERENCES

Boland, D. S.; Booker, M. I. H.; Chippendale, .G .M; Hall, N.; Hyland, B. P. M.; Johnson, R. D.; Kleinig, D. A.; Turner, T. J., 1984: Forest Trees of Australia. CSIRO (Publ.), Melbourne. pp. 687.

Dyson, W. G. 1974: Experiments on Groovy Eucalyptus Woodfuel in the Semi-decidious Forest East Africa Agriculture. J 39: 349-355.

FAO 1995: Eucalyptus for Planting. FAO Forestry and Forest Products Studies No. 11 FAO (Publ.) 1979 and Rome. pp. 677.

Gottneid, D. and Thogo, S. 1975: The growth of Eucalypts at Muguga Arboretum. E.A.A.F.R.O. For. Tech. Note No. 33.

Howland, P. and Freeman, G. H. 1970: Interim Results from a Fuelwood Yield Trial on Eucalyptus. East African Agriculture and Forest J. 35: 257-264.

Kaumi, S.Y.S. 1979: Early growth and survival of eucalypts tried on shallow soils at Turbo. Kenya For. Tech. Note. 150.

Konuche, P.A. 1989: Provenance trial of *Eucalyptus grandis* in Kenya.KEFRI Tech. Note 3.

Matheson, A.C. and Mullin, L.J. 1987: Variation among neighbouring and distant provenance of *Eucalyptus grandis* and *E. tereticornis* in Zimbabwean field trials. *Aust. For. Res.* 17:233-260.Mullin, L.J. Barnes, R. D. and Barret, R. L. 1981. Improvement of eucalyptus in Zimbabwe. *Sth. Afri. For. J.* 118: 20-25.

Oballa, O. P. 1989: Interim Results of a Progeny Trial of *E. grandis* at Turbo KEFRI Technical Note No. 5. KEFRI (Publ.) Nairobi.

Appendix 1: SCORING SYSTEM STEMFORM AND BRANCH PERSISTENCE

Stemform

Scores	Description
1.	- Stem form only fuelwood
2.	- Stem with more than average defects
3.	- Average straight stem
4.	- Stem with minor deviations
5.	- Perfectly straight stem

Branch Persistence

Scores	Description
1.	- A tree with very persistence branches
2.	- A tree of average branch persistence
5.	- A tree with long bole, branches cast naturally.

SILVICULTURAL CHALLENGES IN THE DEVELOPMENT OF PRODUCTIVE EARLY GROWTH PERFORMANCE OF *CASUARINA EQUISETIFOLIA* PROVENANCES IN GEDE KENYA

JAMES M. KIMONDO
Kenya Forestry Research Institute

SUMMARY

The growth performance of 25 provenances of *Casuarina equisetifolia* both from its natural range and from land races, two from Kenya, is compared. The diameter at ground level ranges from 3.5 cm for the Watamu provenances to 40.7 cm for four provenances from the natural range of the species; Vietnam, (19128), Papua New Guinea (18153) and two from Malaysia (18244 and 18157). Mean height growth among the provenances varied from 3.2 m, again for the Watamu provenances, to 4.2 m for the Malaysian provenances (18244). These two parameters exhibited significant differences among provenances. All the provenances had high survival rates of at least 80 percent.

The provenances growth in the field correlated, though not strongly, with that in the nursery. Just before planting, the Guinea provenance (18121) had the least height at 30 cm, while the Watamu landrace had 40 cm. However, the best height growth exhibited by the Malaysia provenances (18158, 18157 and 18240) and the Thailand provenance (18298) was observed one year after planting in the field. Preliminary results revealed the possibilities of using the growth performance in the nursery in selecting the most adaptable provenances.

1. INTRODUCTION

Casuarina equisetifolia is a nitrogen fixing tree and has been planted widely since 1900 (Doran and Hall 1981). At the Kenyan Coast, the species is one of the most suitable species for planting in both in public forests and private farms for providing building poles. Its wood is dense and makes good fuelwood and charcoal as well as timber for general construction.

Information on the growth of *C. equisetifolia* in Kenya is generally scanty. Turnbull (1981) reported that seedlings can grow to a height of 3 m in one year and trees in an average plantation may grow from 7 to 8 m tall after four years. Vivekanandan (1981) also reported a height growth of 3 to 4 m during the first year.

Despite the many years that it has been grown, there is so far no information on the appropriate provenances for the various end uses. As such, the 1990 Casuarina Workshop in Cairo, Egypt, recommended that an international collaborative effort be made to undertake a comprehensive collection of seed from the full range of both natural and derived occurrences. This was in recognition that its utilization throughout the world would be fully maximised if the genetic sources are readily known and available for provenance trials.

With the collaboration from CSIRO (Commonwealth Scientific and Industrial Research Organisation) the most probable and appropriate provenances based on climatical, ecological and edaphic preliminary evaluations were used to set up trials in various countries. In total 67 provenances were collected for distribution with the Kenya Forestry Seed Centre collecting eight of them from the main *Casuarina* growing area at the Kenyan Coast. The project objectives are to determine:

- the seed sources most appropriate for planting in the Kenya coast;
- the soundness of using local seed sources as has been hitherto the case.

Two local provenances were included as controls. This paper presents the growth performance of 25 provenances of *C. equisetifolia* during the first year.

2. MATERIALS AND METHODS

The location of the 25 provenances and the number of individual trees whose seed were collected are shown in Table 1. The planting site, Gede, is situated at latitude 3^0 12' South and longitude 40^0 35' East at an altitude of 15 m. The area is generally flat receiving 940 mm distributed in a bimodal regime; April to June and October to December. Maximum temperatures range from 24°C to 32°C. The soils are alkaline loamy white sands that are well drained.

Five grams of each of the 25 provenance seedlots were supplied by CSIRO, Division of Forestry. The seeds were sown in November 1992 in a seedbed without any pretreatment. After germination, the seedlings were pricked out into clear polythene tubes. Inoculation with isolates of frankia was not done as the nursery soil was obtained from old casuarina plantations. However, spraying with liquid fertilizer, 'Foliar Feed', was done to augment the poor nutrient status of the sandy soils used. Root pruning was carried out regularly for all seedlots to encourage development of fibrous roots. The seedlings were shaded with coconut palm leaves during the first three months to avoid excess heat and evapotranspiration. This was gradually phased out thereafter. Watering was done twice daily, in the morning and evening.

The trial plots were planted in late May 1993 in a randomised complete block design of four replicates. The provenances were randomly allocated in each replicate independently of the others. Each plot had 25 trees at 2 m x 2 m. A 2 m space was left between plots while a 4 m space was left between blocks. The trial had one guardrow surrounding each replicate. The whole experimental area was cultivated three times during the year to reduce weed competition for both nutrients and moisture.

3. ASSESSMENT AND ANALYSIS

In the nursery, 50 seedlings were randomly selected from every seedlot at the ages of 3 months, 4.5 months and 6 months (just before planting) and their heights measured. Height and diameter at 15 cm above the ground were measured for all trees in all plots at five months and one year after planting.

The assessments after one year in the field were analysed and used to determine whether differences in growth existed among the provenances. The nursery measurements were compared to the volumes assessed in the field to determine the existence of any possible relationship between the two stages of growth that can allow early determination of suitable provenances.

4. RESULTS

4.1 Height Growth

The height measurements carried out in the nursery are shown in Table 2. At 3 months, the four fastest growing provenances were: the Bako National Park, Sarawak; Tanjung Aru, and Pantai Moyog Sabah all from Malaysia and Had Chao Mai Trang (Thailand). The slowest growing provenances were: Ela Beach (Papua New Guinea), Mariana Island (Guam), Ma'morah (Egypt) and Watamu (Kenya). Mean height at 3 months ranged from 13 cm for the slow growers to 30 cm for the fast ones. At 4.5 months and six months (just before planting), the best four provenances remained the same as at three months. However, among the slow growers only the Mariana Island and the Watamu provenances had not improved. The mean height at six months ranged between 30 cm to 73 cm.

Table I: Seed Origin of 25 provenances of *Casuarina equisetifolia* planted at Gede, Kenya

Provenance Location	Country	C S I R O Seedlot No.	Lat.(o')	Long.(o')	Alt.(m)	Number of seed trees
Natural Provenances						
Wangetti Beach, Cairns QLD	Australia	15958	16 415	145 34E	30	36
Darwin, NT	"	18008	12 25S	130 50E	20	11
Wainunu Vanua Levu	Fiji	18271	16 50S	178 59E	300	10
Mariana Island	Guam	18121	13 00N	144 00E	2	-*
Pantai Moyog, Sabah	Malaysia	18157	5 55N	116 05E	2	2
Tanjung Aru, Sabah	"	18158	5 55N	116 05E	2	2
Bako National Park Sarawak	"	18244	1 44N	110 30E	30	4
Kuantan Pehang	"	18348	3 48N	103 20E	-*	11
Ela Beach	Papua N.G.	18153	9 05S	148 17E	10	5
Panay Island	Phillipines	18154	11 31N	122 30E	30	10
Ban Bang Sak Phangnga	Thailand	18296	8 46N	98 16E	5	18
Had Chao Mai, Trang	"	18298	7 33N	100 37E	2	21
Efate	Vanuatu	18312	17 45S	168 18E	30	4
Landraces						
Cotonou	Benin	18355	6 23N	2 13E	8	15
Yanjing For. Farm, Guangdong	China	18267	21 25N	111 02E	4	12
Daodong State For. Farm, Haina	"	18268	19 58N	110 59E	10	20
Montazah	Egypt	18122	31 16N	30 05E	13	10
Ma'morah	"	18125	31 13N	29 55E	-*	9
Haingara Balukhand Orissa State	India	18014	19 50N	85 53E	10	12
Rameswaram, Tamil Nadu	"	18119	9 15N	79 20E	5	13
Hambantota	Sri Lanka	18287	6 08N	81 07E	16	-*
Thach Lien, Nghe Tinh	Vietnam	18085	18 24N	105 48E	5	5
Hai Thinh, Ha Nam Ninh	"	18128	20 22N	106 21E	2	8
Kenyatta Beach	Kenya	18134	4 00S	39 00E	10	10
Watamu	"	18137	3 19S	39 17E	12	9

** Indicates information was not provided*

The mean heights at five months and one year after planting in the field are shown in Table 3. At five months, they varied from 1.06 m for Watamu landrace to 1.81 m for the Bako National Park provenance and differed significantly at 1 percent probability level ($p<0.01$). The best four provenances were again the same three from Malaysia; Bako National Park, Tanjung Aru and Pantai Moyog while the fourth was Cotonou landrace from Benin. The heights at 1 year ranged from 3.16 m for Watamu to 4.15m for the Bako National Park Sawarak provenance. The heights differed significantly at 1 percent probability level. The Papua New Guinea (18153) and Thailand (18298) provenances were at this time among the best growers together with the Benin (18355) provenance.

4.2 Diameter at Ground Level

Table 3 also shows the results of measurements taken in the field at five months and one year. At five months, diameter ranged between 1.0 cm and 1.6 cm. The differences among the provenances were significant at 0.01 probability level. At one year, the dbh range was from 3.5 cm to 4.7 cm. Note that the diameter growth among provenances followed closely the height growth pattern. The best provenance remained the Bako National Park from Malaysia, while the poorest is the local landrace from Watamu.

Table 2: Number of Seedlings Pricked out, provenance viability of and Height growth of *C. equisetifolia* in the Nursery at Gede

Provenance Origin	Seedlings Pricked Out	Viable Seeds 5 gm	Average Height (cm) in the Nursery 3 months	5 months	6 months
Natural Provenances					
Wangetti Beach Cairns QLD Aust.	230	875	15	24	32
Darwin, NT, Australia	240	1225	19	35	47
Wainunu Vanua Levu, Fiji	160	-*	20	32	48
Mariana Island, Guam	340	2750	13	17	30
Pantai Moyog Sabah, Malaysia	330	875	30	49	70
Tanjung Aru, Sabah, Malaysia	450	1500	30	49	73
Bako Nat. Park, Sawarak, Malaysia	440	1000	30	43	70
Kuantan Pehang, Malaysia	430	1461	26	40	58
Ela Beach, Papua New Guinea	330	1725	13	22	52
Panay Island, Phillipines	440	1742	16	34	43
Ban Bang Sak Phangnga, Thailand	340	675	26	40	66
Had Chao Mai, Trang, Thailand	320	1450	29	49	70
Efate, Vanuatu	440	-*	18	32	62
Landraces					
Cotonou, Benin	320	-*	26	43	66
Daodong State For. Farm Haina Ch	440	2130	25	36	62
Montazah, Egypt	430	1378	17	23	40
Ma'morah, Egypt	430	2478	13	20	44
Haingara Balukhand Orissa , India	440	2295	23	37	46
Rameswaram, Tamil Nadu, India	330	555	24	28	50
Hambantota, Sri Lanka	440	1200	23	33	49
Thack Lien, Nghe Tinh, Vietnam	460	978	27	29	50
Hai Thinh, Ha Nam Ninh, Vietnam	440	1285	18	30	43
Kenyatta Beach, Kenya	330	1508	18	29	50
Watamu, Kenya	320	1264	14	25	40

4.3 Survival

Survival was high for all the provenances and did not differ significantly at both five months and one year. All the individual plots in the four blocks had at least 80 percent of the trees still growing. In July, 1994 and between September and October 1994, almost all trees had their foliage yellow from the bottom upwards. It was thought that this was because of prolonged drought which had been experienced in the area. This phenomenon which caused a few deaths however, disappeared with the onset of the short rains.

5. DISCUSSION

Marked variation in growth was observed among the 25 provenances of C. At the time of planting, provenances from Malaysia, Thailand, Benin, China and Vanuatu formed a distinct group showing better height growth than those that came from other places. The provenances from the natural range of the species such as Australia, Fiji, Papua New Guinea, and Phillipines together with landraces from Egypt, Sri Lanka, Vietnam and Kenya exhibited slow growth.

Table 3: Height and diameter at ground level of *Casuarina equisetifolia* provenances at 5 months and 1 year at Gede

Provenance Origin	Seedlot No.	Mean Ht.(m) at 5 months	1 year	Diam. (cm) at 5 months	1 year
Natural Provenances					
Wangetti Beach Cairns QLD Aust.	15958	1.4	3.5	1.3	3.9
Darwin, NT, Australia	18008	1.2	3.5	1.1	3.6
Wainunu Vanua Levu, Fiji	18271	1.3	3.5	1.3	4.1
Mariana Island, Guam	18121	1.4	3.2	1.3	3.9
Pantai Moyog Sabah, Malaysia	18157	1.7	3.9	1.6	4.7
Tanjung Aru, Sabah, Malaysia	18158	1.7	3.8	1.5	4.5
Bako Nat. Park, Sawarak, Malaysia	18244	1.8	4.2	1.6	4.7
Kuantan Pehang, Malaysia	18348	1.4	3.7	1.2	4.5
Ela Beach, Papua New Guinea	18153	1.5	4.0	1.5	4.7
Panay Island, Phillipines	18154	1.4	3.5	1.4	4.4
Ban Bang Sak Phangnga, Thailand	18296	1.3	3.5	1.1	4.0
Had Chao Mai, Trang, Thailand	18298	1.5	3.9	1.3	4.6
Efate, Vanuatu	18312	1.5	3.7	1.6	4.5
Landraces					
Cotonou, Benin	18355	1.6	3.9	1.6	4.6
Yanjing For.Farm Guangdong Ch.	18267	1.5	3.6	1.4	4.1
Daodong State For. Farm Haina Ch	18268	1.4	3.7	1.4	4.3
Montazah, Egypt	18122	1.4	3.5	1.3	4.0
Ma'morah, Egypt	18125	1.4	3.3	1.3	3.7
Haingara Balukhand Orissa , India	18014	1.4	3.5	1.4	4.5
Rameswaram, Tamil Nadu, India	18119	1.4	3.6	1.5	4.3
Hambantota, Sri Lanka	18287	1.3	3.6	1.3	4.4
Thack Lien, Nghe Tinh, Vietnam	18085	1.5	3.7	1.5	4.5
Hai Thinh, Ha Nam Ninh, Vietnam	18128	1.5	3.8	1.5	4.7
Kenyatta Beach, Kenya	18134	1.3	3.7	1.2	4.1
Watamu, Kenya	18137	1.1	3.2	1.0	3.5

The above grouping was not very clear, five months after planting with some provenances previously recorded as slow growers showing improved performance (e.g.18128, 15958 and 18121). Others performed poorly in the field. These were for example 18008 and 18137. The growth at one year followed closely the pattern at five months both in terms of height and diameter.

The results of this trial indicate that the best three provenance in the nursery were still superior in the field, five months after planting. However, the trend gets less clearer at age 1 year. This is especially so with respect to diameter at ground level. Moreover no selection can be done at this early age to meet any specific management objectives and more time should be allowed for further observations. Further caution should be exercised while interpreting these results by virtue of the number of (seed) mother-trees used to represent a provenance should best be 20. Less than this number mean underpresentation of the provenance in terms of genetic variability in a population. Usually the result is a high growth performance where only a few superior trees are selected (Zobel and Talbert 1984). Burley and Wood (1976), on the other hand suggested that whenever possible it is preferable to collect seed from not less than 25 to 30 trees to capture as much as possible the potentially valuable genetic variation within the population. With the exception of the Benin (18355) and the Thailand (18298) provenances, whose seed were collected from 15 and 21 trees respectively, the other two provenances with high growth rate had seeds collected from four trees only. Two of the remaining Malaysian provenances with high growth rate (18157 and 18158) had seed collected from two seed trees each!

It is difficult therefore to relate the trial measurements to any of the site charecteristics such as latitude, longitude or altitude confidently. The Malaysian provenance (18244) among those from outside Kenya

It is difficult therefore to relate the trial measurements to any of the site charecteristics such as latitude, longitude or altitude confidently. The Malaysian provenance (18244) among those from outside Kenya is closest to the equator as is the case with the trial site. Also its altitude of 30 metres is close to that of Gede. Provenances originating from areas too far north or south, that is more than 10° latitude on both sides of the equator generally showed low growth. This observation to some extent agrees with the recommendation made by Zobel and Talbert (1984) that seed from high latitude sources should not be moved to low latitudes and vice versa.

The low growth rate observed with the Watamu landrace, which is near the trial site may suggest that the growing Casuarina crop that dominates the area is of inferior quality. The Kenyatta beach landrace is comprised of superior locally selected material which may explain its slightly better growth performance (Mwangi pers comm.). As a fast growing and relatively short rotation (4-5 years) species, the one year performance reported in this paper represents the very early stage of its rotation. With the change in ranking between five months and one year among provenances, early selection for growth is not practical.

At this preliminary stage it can be stated that most of the provenances and landraces have moderate to high growth rate. This therefore implies that future plantations could be more productive if the better foreign provenances are used as seed sources. However more time is needed to determine the good provenances for production of various desired end products.

6. RECOMMENDATIONS

Further research is required to evaluate the appropriate silvicultural management especially the initial spacing as most provenances have their canopies closing at 1 year. The trial should be maintained and assessed annually to allow comparison of juvenile and mature growth of the species.

Acknowledgement

The author is grateful to CSIRO and KEFRI for providing the seeds and financial support to undertake field assessments. The contribution of Mr. Balozi Kirongo Bekuta, Mr. Gathura wa Mwangi and the Gede Forestry Research Station field staff members in trial establishment and maintenance is greatly appreciated.

REFERENCES

Burley, J. and Wood, P. J. (Compilers) 1976: A manual on species and provenances research with particular reference to the tropics. Tropical Forestry Papers No. 10 CFI University of Oxford.

Doran, J. C. and Hall, N. 1981: Notes on Fifteen Australian Casuarina species. 19-52. IN: Midgely, S. J.;Turnbull, J. W. and Johnstone, R. D. (Eds.) Casuarina ecology management and utilization. Proceeding of an International Workshop, August 1981. Canberra Australia.

Turnbull, J. W. 1981: The use of *Casuarina equisetifolia* for protection of forest in China. 55-57. IN Midgley, S. J.; Turnbull, J. W. and Johnstone, R. D. (Eds.) Casuarina ecology management and utilization. proceeding of an International Workshop, August 1981. Canberra Australia.

Vivekanandan, K. 1981: The status of Casuarina in Sri Lanka 99-101. IN: Midgely, S. J.; Turnbull, J. W and Johnstone, R. D. (Eds.) Casuarina ecology management and utilization. Proceeding of an International Workshop, August 1981. Canberra Australia.

Zobel, B. and Talbert, J. 1984: Applied Forest Tree Improvement. North Carolina State University. John Wiley & Sons. New York.

SESSION 4:
ENVIRONMENTAL AND BIODIVERSITY CONSERVATION

RESEARCH PROGRAMME ON SUSTAINABLE USE OF DRYLAND BIODIVERSITY (RPSUD)

RICHARD KAGUAMBA
Co-ordinator RPSUD

SUMMARY

An insight of research goals and objectives into the dry land ecosystems of Eastern Africa is given in relevance to the Regional Research Programme on Sustainable use of Dryland Biodiversity (RPSUD). The need for regional cooperation in understanding the many problems linked to land degradation and, also the numerous opportunities that may be offered through sustainable exploitation of dryland biological resources is explained. The paper highlights the importance of local community involvement in searching as well as sharing of knowledge of these complex ecosystems and mentions the urgent need for professional enhancement of institutions and individuals in support of dryland biodiversity management.

1. INTRODUCTION

In the East African region, more than 60% of all lands fall under the drylands category, which entails both arid and semi-arid lands. Such lands are commonly regarded as of low productivity, while their ecosystems are called fragile. Indeed, the region has over the past decades witnessed several droughts which in some cases caused large amounts of human suffering and led to massive international humanitarian aid. The droughts, which are characteristic of the prevailing climate, appear to have become ever more devastating because of population pressure on one side and desertification on the other.

Research into drylands has, traditionally, been more or less confined to studies into the possibility to maintain and improve agricultural and livestock production levels combined with reduction or reversal of land degradation. Only recently has more attention been paid to the ecosystems at large and the potential for sustainable development based on a wider range of exploitation opportunities. Several earlier assumptions, like those about the negative effects of overgrazing, may not be tenable. Dryland ecosystems tend to be extremely resilient, overstocking (with wildlife as well as livestock) may actually be the advantage of the systems as a whole; the ecosystems may offer many opportunities for sustainable, non-traditional, exploitation; and many abandoned indigenous modes of human exploitation might be revived to sustainably contribute to the quality of life of the populations concerned.

Most important, however, is the finding that the biodiversity of drylands- which provides the basis for any type of exploitation - is far more varied than previously assumed. Most international research in the field of biodiversity has been focused on rain forests and humid zones. However, the dryland systems appear (in response to the vagaries of the climate) to be far more dynamic. This means that efforts to conserve the biodiversity of these systems and to use them sustainably have an importance that goes beyond the short-term objective of the prevention of land degradation, food security and improvement of human livelihood. The present integrity of the biodiversity of drylands is of great importance to the long-term biodiversity on the planet as a whole.

The dryland ecosystems of the Eastern African region form, more or less, a continuum from the Ethiopian highlands to Southern Tanzania. The wide variety, both of and within species, is very great. This is also true for the variety of indigenous modes of exploitation and human responses to the restrictions imposed on human exploitation by both the ecosystems and the climate that governs them. At the same time problems like land degradation and vulnerability of human populations to drought are, although in some parts of the region more serious than in others, basically the same. This warrants regional cooperation with regard to particularly research and training into biodiversity and its sustainable utilization.

2. EASTERN AFRICAN DRYLAND ECOSYSTEMS, BIODIVERSITY AND SUSTAINABLE DEVELOPMENT

The drylands of the Eastern African region may, from the Ethiopian Highlands to Southern Tanzania, be put under the common dominator of savannahs and Savannah woodlands.

The term "savannah" covers a wide variety of rather vague definitions, but the (non-degraded) landscape is possibly best described as a formation where the herbaceous stratum is continuous and important, interrupted to a greater or lesser extent by fire-tolerant trees and shrubs. Savannahs cover 65% of the land mass of the African continent and about 60% of the Eastern African region.

In spatial terms there is no typical savannah ecosystem but rather a gradient of related ecosystems which at the wet and the dry ends of the climatic spectrum evolve into respectively closed forests or steppes. In the major part of Eastern Africa there are commonly two dry and two wet seasons, of which one is always shorter than the other. This seasonal aspect of the rainfall determines both the diversity of the vegetation structure and the phenology of the plant cover. Moreover, the occurrence of droughts and fires is thought to be necessary for the vegetation to retain its resilience. The savannah vegetation is variable, involving two principal elements:

- The height of the (mainly perennial) herbaceous layer, which may vary from several decimeters in low-lying savannahs to several meters in others.
- The structure of the shrubs and the tree canopies which, may range from total absence of trees (on some edaphic savannahs) to the presence of stands of tall trees (e.g. the *Acacia droponolobium* wood lots in Laikipia lowlands).

2.1 The Eastern African savannahs (*Moist, dry and cold savannahs*).

The Eastern African Savannahs and savannah woodlands can be divided into three major type: a) moist savannahs; b) dry savannahs; and c) cold savannahs. The differences are caused by rainfall patterns as well as altitudes. Each type has its own indigenous mode of human exploitation, which may vary from subsistence agriculture to pastoralism and hunting or gathering. Each system also has its own type of animal populations. Human exploitation has, over the centuries, more or less shaped these landscapes. The main tool has been fire which has been used as a management tool during several millennia. Patterns of human settlement as well as subsistence agriculture have also been of importance.

- **Moist savannahs:** This type of Savannah is characterized by relatively high rainfall and short dry seasons. These conditions support tall perennial herbs. The woody stratum can be very diverse but is often reduced in wetter areas, mainly because of the effect of "hot" fires. In such fires the flames go higher and may affect tall trees because of the height of the undergrowth. Because of the relatively high humidity, however, growth is rapid. The moist savannah has traditionally been used mainly for subsistence agriculture and dry-season grazing by pastoralists, while hunter-gatherers have also been around. It is presently the most endangered type of savannah because of its potential for cash crop production. Wildlife populations may be quite high.

- **Dry savannahs:** These savannahs have lower rainfall and longer dry seasons. For this reason, the perennial herbs attain much lower biomass levels. Growth of vegetation after fire is limited and often delayed. The variety of species in the herbaceous layer is higher than in moist forests. This, combined with the absence of tse-tse flies, makes such savannahs suitable for large ungulates. In general, the variety of species of wildlife is considered greater than in moist savannahs, although the populations may be lower. The dry savannahs are traditionally the areas used mainly by pastoralists, as well as by some hunter-gatherers.

- **Cold savannahs:** In the highlands, at high altitudes, pockets may be found of the so-called cold savannahs. Although they may be characterised by different rainfall-regimes, the major factor that decides on vegetation growth and re-growth is the temperature. The cold slows down the plant growth but compensates partly for the dryness by reducing the transpiration rate of the vegetation. Depending on the rainfall regime, these lands have traditionally been used for subsistence agriculture or dry season grazing.

2.2 Wetlands

In the dryland savannah systems, wetlands may occur in depressions where rainwater collects or a seasonal river ends. In terms of biodiversity the value of wetlands surpasses that of other parts of drylands, particularly because of their value to migrating animals. Wetlands commonly serve also as grazing reserves in pastoralist land management systems. In terms of biodiversity wetlands are, again, areas where species may have developed in isolation over long periods of time. Research into the biodiversity of wetlands may not have to be confined solely to natural wetlands. Man-made surface dams and pans may contain a wide variety of life forms too.

2.3 Biodiversity

The biodiversity of savannah ecosystems does not result only from the amount of rainfall, the presence of vegetation, its reaction to fires and its nutritional value. The high variety of species in the Eastern African region is to be explained also by two factors:

- **Landscape and long term climatic cycles**: In Eastern Africa the savannah systems are not continuous, but intersected by mountainous systems which may contain remnants of tropical rain forests, as well as cloud forests. This variety of ecosystems over a relatively small area has contributed to the evolution of a wide variety of particularly bird species of which the habitats do not have to be confined to one ecosystem only. Within the Eastern African savannah systems there is remarkably high variety, within species of large mammals. This is mainly because of the long-term fluctuations of global climate. The climatic changes at regular intervals may effectively reduce the population area and separate savannah living populations. When the savannahs regain their former territory, the various species may, during their separation have developed distinct races.

  Among the examples are ostriches, giraffes and rhino. The Phenomenon also explains the marked difference in, for example acacia-species between Ethiopia and Tanzania.

- **Distribution of rainfall**: In dry savannahs in particular, rainfall is so erratic that a given area may suffer what technically should be called a drought while only a few kilometers away rainfall is normal. This phenomenon, combined with low population densities, is seen as another factor that contributes to variation. Small, isolated populations of particularly plant species may, over prolonged periods, be subjected to different weather regimes and develop different genetic strains.

  The overall consequences are, as mentioned, a great variety in both plant and animal species. Genetic research done at the National Museums of Kenya has indicated that in at least some cases of higher mammals revision of the morphology-based taxonomy might be in order. The value of research into varieties and subspecies will increase considerably when done on a regional scale, so that populations may be compared.

2.4 Systems Dynamics

As more insight is gained in the functioning of dryland ecosystems it is becoming ever more obvious that in the long term the oscillation of the climate between "good" and "bad" years is the major factor that decides on the dynamics of the systems concerned.

While it is generally assumed that in most ecosystems the optimum situation is reached when the species are in balance with each other, dryland ecosystems are increasingly understood to be in need of conflict to retain their main characteristics. Usually, a number of good years is followed by a number of bad years and the systems use the good years to "boom", in preparation for the bad years when they "bust". During the build-up of the boom population growth is, in plant as well as in animal species, remarkably high. Overstocking is increasingly seen as an important aspect of the system. Due to the large numbers of animals the growth of herbs and trees is kept in check. When the boom ends, lack of food greatly reduces the numbers of direct vegetation users, so that a hardy core population of both vegetation-and animal species may survive the following bust.

These theories, which have not yet been extensively researched in the field, are of extreme importance for any decision about sustainable exploitation. Inventories and surveys may, for example, be of less value when not supplemented with information on the phase of the climatic cycle at which the research was done. In the Eastern African region, rainfall patterns may differ to such an extent that one area may go through a bust while the other may be booming. Thus, regional cooperation would allow for comparison of data. This would be of great importance to any management decision and policy.

3. PROBLEMS AND SOLUTIONS

The increased attention paid to drylands and dryland ecosystems resulted mainly from the international concern about desertification and land degradation in drylands. This problem is commonly seen to be caused by factors like overpopulation and over-exploitation, in the contest of an inhospitable climate and generally low levels of soil fertility. RPSUD, as a regional programme responds to two International Conventions:

- International Convention on Desertification- which addresses impact of desertification on biological diversity and sustainable utilisation of these resources in drylands; and
- International Convention on Biological Diversity.

Both of these conventions call for interagency and inter-governmental co-operation, increased information exchange and dialogue as well as increased support for education & training results of which would improve capacity of recipient countries to prevent loss of biodiversity.

4. INCREASED POPULATION

Under the pressure of population growth, the pastoralists of Eastern Africa may have been confronted with land degradation long before the problem became obvious in agricultural systems. This, then, may not as much as have been a matter of having to deal with the fact that their land appeared to be degraded, but of a growing awareness that other, not yet used, land, was better. The fact that, after a given period of land use, the grass "at the other side of the hill" may have been greener may have contributed to the past Southward migration of East Africa's main pastoralist communities. What these pastoralists left in their wake was, however, not really degraded land.

Thus, the problem of land degradation in dry savannahs became serious only after population growth coincided with the advent of land use for cash cropping plus other commercial purposes. Another cause is the transition of the communities concerned into the modern cash economy. As the need for cash increases, the numbers of small livestock increase too.

Of interest are the different ways in which degradation manifests itself in different types of savannahs. In the moist savannahs, loss of natural vegetation and wildlife occur, but deforestation, soil erosion and loss of soil fertility are the main problems. In dry savannahs with pastoralist exploitation systems, soil erosion may occur and may sometimes be rather dramatic, but generally remains localised.

Bush encroachment, however, also reduces the opportunities for tall trees to grow and while charcoal burning is a major income generating activity in dry savannahs, the tall trees tend to disappear fast and the problem of bush encroachment increases.

5. RESOURCES MANAGEMENT

With the emergence of land degradation as a major problem that affects the productivity of most drylands, land management has become an important issue. The approach of most management techniques appears, however, to be production-oriented. Little attention is paid to ecosystem integrity or ecosystem rehabilitation. Actually the expression "land management" is not often ever used: The term "range management" is more popular. This in itself indicates already a bias towards livestock production. Among the causes of this rather one-sided view is that in both agricultural and pastoralist societies only the most market-oriented mode of resource exploitation has been promoted by modern developers, while others were either neglected or forgotten.

Under low population pressure these resources did not easily run the risk to be depleted. When the need arose they were managed. Some were exclusively for women, others could not be taken during given seasons and there have been documented cases of trees that were private property, on communal land. This type of resource exploitation has disappeared almost completely. As a result, food security has become too dependent on the availability of cash, while diets have changed, in many cases for the worse. Land management practices that take only agricultural or livestock production into account cannot also but go at the cost of these other resources and thus contribute to the impoverishment of these ecosystems.

In general, with solely agriculture and/or livestock the exploitation base is too narrow for the prevailing ecosystems to cope up with. The carrying capacity of any ecosystem is limited considerably when human exploitation is concentrated on only a few of the available natural resources. The problems are then, aggravated when through factors like population growth and the need for cash, the pressure increases considerably.

6. RESEARCH FOR CONSERVATION, RESOURCE MANAGEMENT AND SUSTAINABLE DEVELOPMENT

As awareness increases about the need for sustainable development, it becomes more obvious that efforts to control desertification, to rehabilitate degraded lands and to promote sustainable development should be seen as components for overall resources management policies. Such management should entail the identification of new, sustainable income earning opportunities as well as reinforcement of food security through natural resources' usage. Rehabilitation efforts may be geared to either create such opportunities, make them more widely available, or promote their sustainability.

In the first place, however, research is needed in the true nature of land degradation. Also, research is needed in the management of conservation areas. The traditional approach to in-situ conservation of particularly animal species has been to close the protected area from the local population. Since human exploitation has been among the main factors that created the landscapes concerned, this type of conservation leads to rapid deterioration of the conserved areas. There are, in Eastern Africa, several examples of conservation areas which have become so impoverished that there is more wildlife outside the conservation areas than within. This contributes to the conflict between human populations and wildlife outside parks, particularly when agricultural activities intensify.

7. GENERAL RESEARCH NEEDS

In general, research aimed at improved management of biodiversity in drylands should include issues like indigenous use and potential modern utilization. Our programme aims at covering some of these important aspects:

- taxonomic research;
- presence of species at various levels of land degradation;
- human perception of the present ecosystems;
- traditional land use at local level;
- potential use at local, national or global level;
- sustainability of resource(s) utilization; and
- resources management.

8. COMMUNITY INVOLVEMENT IN RESEARCH

Involvement for local communities in research is important for, among else, the following reasons:
a) local communities possess knowledge about their own environment and the ways it may be used;
b) research aimed at sustainable development should be followed by effective monitoring on the ground. If it would always be done by scientists, then this would create a long -term dependency. For this reason, research methodologies that allow local populations to do the work themselves have to be developed.

Important, in this respect, is sharing of results. All too often local communities are not adequately informed about the findings of the research. Sharing of results before this research can be published may even lead to further refinement.

9. RPSUD: TOWARDS REGIONAL COOPERATION IN EASTERN AFRICA

When several countries in a region share as one of their main characteristics an almost uninterrupted savannah landscape, they also share many of the problems linked to land degradation as well as many of the opportunities that may be offered through sustainable exploitation.

In such a case cooperation with regard to biodiversity research for sustainable development would, obviously, prevent duplication. In the Eastern African region, however, there are more specific reasons for cooperation among institutions involved in biodiversity research and sustainability.

In this region, and particularly in the drylands thereof, the majority of the population is directly dependent on the natural resources their environment may have to offer. Due to a combination of factors that include population growth, ill-designed development and drought, their opportunities to a decent livelihood are diminishing rapidly. This means that they are ever more forced to literally erode their natural resources. Their land carrying capacity is diminished considerably, partly because of loss of biodiversity. The problem of **sustainable use** of drylands is the same all over the region. Cooperation in this area will promote dissemination of information on local solutions to management problems, which may be applicable outside each others' traditional setting.

Although in the countries of the region the landscapes are of the same type, they are subject to somewhat different climatic regimes. This means that droughts (and thus busts in ecosystems as well as booms) may occur at different points in time. With regard to land degradation assessment, research into indicator species and research into the potential for sustainable resource exploitation will mean that much time can be saved. By conducting such research at the same time in, for example, the Northern and will mean that Southern parts of the region, bust and boom conditions may be covered simultaneously.

Of importance is also the long term climatic cycles that characterises the regions. The variation caused by these cycles is noticeable with regard to trees. This, combined with the tendency of many (plant and small mammal) species to adapt to strictly local conditions puts the Eastern African drylands in the category of the most diversified drylands in the world. Much of this variety is not yet understood, or even studied. At the same time, however, differences may be so subtle that only cooperation between researchers from different areas within the region can reveal them.

With regard to the identification of protocols for the collection, storage and dissemination of biodiversity data, there is already a high amount of cooperation in Eastern Africa. This is not the case, however, in the field of sustainable development and, particularly, the research needed for this approach as well as the training thereof. It is felt that in this field too, protocols and common approaches are needed. In the region, the various institutes of higher learning that provide training in biodiversity-related fields commonly do lack the means to adequately assist their students in the identification and implementation of research projects as part of their training. Moreover, there is no training opportunity at MSc. level for subjects like biodiversity and sustainable development. Cooperation between institutions from the region is now enhancing the possibility to establish such a specialised training at one of the institutions, with the opportunity to do research in, for example, the National Museums of Kenya or comparable institutions of the other participating countries, under the supervision of scientists from the region.

10. RPSUD BACKGROUND

The Research Programme on Sustainable Use of Dryland Biodiversity is a three year project, funded by the Swedish Agency for Research Co-operation with Developing Countries (SAREC) and was launched in late 1995. It is intended to increase the capacity of Eastern African institutions and organisations to assess and sustainably utilize dryland biological resources. The programme is currently being implemented in the Eastern African region by a consortium comprising the National Museums of Kenya, the Universities of Addis Ababa and Dar es Salaam and the Biodiversity Institute of Addis Ababa, Ethiopia.

We seek to enhance the research abilities of both institutions and professionals by assisting in the development of the necessary skills to support dryland biodiversity management. The long term goal of RPSUD is to support sustainable development in the drylands of the countries of the region through the promotion of research into biological diversity. To achieve this goal the programme has a primary objective to strengthen the capacities of individuals, institutions, organisations and local communities in identifying, and acting on the need for sustainable management of biological resources in support of human development.

RPSUD has four specific objectives:

- Support research in the field of sustainable resource management and utilisation.
- Support for training, initially up to MSc. level.
- Collection, evaluation and dissemination of results, lessons learned and other relevant information.
- Regional co-operation between the participating institutions in terms of capacity building.

10.1 Programme Components

- **Capacity Building and Training (CBT):** This is intended to enhance the effectiveness of the consortium institutions to make more constructive linkages between sustainable utilization of dryland biological resources and development. Both professionals and their institutions will benefit from this programme.

  The main objectives of CBT are:
  - Provide assistance for curriculum development towards regional training programmes;
  - Strengthen capacity to prioritise, plan and implement projects for sustainable management of biological resources in drylands;
  - Improve the collection, management, analysis and dissemination of information on the status of biodiversity in drylands;
  - Assist to formulate proposals for research, institutional strengthening and other specific activities in the field of dryland biodiversity.

- **Research Grants Programme:** This programme is managed by RPSUD with the assistance of a special independent *Research Review Committee*. It is based on a competitive research grants award for member country researchers in universities and other development institutions. Training and capacity building exercises are important elements in this component. The supporting institutions and professionals must be involved in sustainability activities with a focus on drylands and in one or more of the following areas in order to qualify for an award:

  - Utilisation and Management of dryland biodiversity.
  - Dryland habitat monitoring and assessment.
  - Cultural and societal influence on biodiversity conservation.

RPSUD prepares annual announcements requesting proposals. The announcement contains brief information on research topics, level of funding, criteria for grant selection and other administrative guidelines.

- **Information and Outreach:** RPSUD seeks co-operation and exchange of information with other organisations involved in international work regarding dryland biodiversity, agencies, private foundations, academic institutions, zoos, botanical gardens and museums. The programme has a bi-annual newsletter and supports the wider publication of findings in research implemented under, or supported by, the RPSUD in either existing or special publications.

Further information about RPSUD can be obtained from: Dr. Richard Kaguamba, Research Programme on Sustainable use of Dryland Biodiversity, National Museums of Kenya, P.O. Box 40658, Fax: 741424 and 751319, Nairobi.

SESSION 5:
FOREST PROTECTION

THE STATUS OF FOREST INSECT RESEARCH IN KENYA

MERCY GICHORA
Kenya Forestry Research Institute

SUMMARY

Kenyan forests harbour insects which are problematic at times and no form or stage of forestry development has as yet been found immune to pest attacks. This should not, however, blind us to the fact that there are other insects present that are economically and ecologically beneficial. We should thus endeavor to conserve forest insects biodiversity knowing very well that other insects that are neutral in status can join either category from time to time. This makes it necessary for us to be acquainted with the insects that are present in our forests at all times.

While it is true that there are serious insect pest problems currently facing Kenyan forests, with the current emphasis on Integrated Pest Management, there is hope of safely overcoming them. In particular, insects for which effective short or medium term solutions have not been found can benefit from tree breeding programmes that address the long-term goals of pest management. Efforts should also be made to diversify tree species and to adopt techniques and practices in forest plantation management that aim at averting pest disasters. The future of effective forest insect research in Kenya lies in closely collaborating with end-users.

1. INTRODUCTION: Types of Insects Present in the Forest

There are basically three categories of insects present in a forest. In the first category are pests which are insects which compete with man for the forest resource. They may be defoliators which eat the leaves of trees and slow down the photosynthetic process, thus reducing the growth rate and vigour of the trees. In the second category are borers which eat the bark and woody tissues of trees, weakening them and leaving trees to break and fall during the windy or fruiting season. They could also be borers that attack wood in the post harvest phase, and are all capable of reducing the strength and value of tree products to a considerable degree. Pests can also be sapsuckers, insects which drain away the living sap which plants rely on for their sustenance. Sapsuckers include aphids and scale insects. Their feeding activity stunts growth and if present in large enough numbers, such insects may lead to wilting and die-back of the affected trees. The excess sugary sap which sapsuckers exude in the process of feeding is often colonized by sooty molds, giving the plants an unsightly black look and ruining their aesthetic value.

In the third category are beneficial insects. These serve important economic purposes such as honey production. Others are available for commercialization purposes as are some rare beetles, butterflies and moths. Silk moths, for example, produce excellent fibre. These insects give rise to non-timber wood products and increase the worth of our forests. Moreover, insects can also play important ecological roles - as pollinators, predators and parasites where they help to regulate the balance of nature. Such insects provide avenues for sustainable forest production by ensuring an abundant seed supply of some tree species. The rest regulate insect pest populations affecting other trees. These are silent roles that are often overlooked but which make it essential for the insect biodiversity in our forests to be conserved in totality.

In the fourth group are insects which may be considered neutral in their status in relation to the forests. This may change for the better or worse in the future. As such, all forest insect populations need to be monitored regularly to reveal their current status and relationship of one to the other. Such undertakings, often referred to as insect surveys, should be carefully planned and regularly conducted.

2. HISTORY OF FOREST ENTOMOLOGY RESEARCH IN IN KENYA

In 1950 the Entomology Division was first established in the East Africa Agriculture and Forestry Research Organization (E.A.A.F.R.O.). The mandate of the Division was to undertake research on insect pests affecting forests in at least two East African countries- Kenya, Uganda or Tanzania. This policy remained in force even after the political independence of these countries, with the East African Community (EAC) continuing to handle regional activities after independence. At one stage, the mandate of research was expanded to cover animal problems as well, during which time the name was changed to Entomology and Zoology Division. In 1977, the EAC collapsed and Kenyan pest problems became the main focus of the Division.

The forest research conservancy that was housed within the Forest Department in the Ministry of Environment and Natural Resources merged with the former E.A.A.F.R.O., now under KARI, in 1982/83. Shortly afterwards, in 1986, KEFRI came into being. Entomology research became a Subprogramme of the Forest Protection Programme. Currently, the emphasis is on insect research with the understanding that animal problems are adequately handled by the Memorandum of Understanding between Forest Department and Kenya Wildlife Service.

3. PEST INCIDENCES IN FORESTRY

All stages and forms of tree propagation in forestry are susceptible to pest attack. Thus pest related losses occur in tree seed production as well as in storage. Seedlings in the nursery are prone to pest attack so are young saplings during the tree establishment phase (first five years). Standing trees in isolation and in stands are just as susceptible to pests as are the harvested trees and timber in use. Likewise, neither the indigenous forests nor the exotic plantations are immune to pests. Concerning the practices of agroforestry and social forestry, there are pest problems just as in more traditional forestry circumstances.

4. APPROACHES TO FOREST PEST MANAGEMENT

In the past, Kenya is fortunate to have always approached forest pest management using environmentally safe methods, discontinuing the use of unsafe products as quickly as possible and adopting newer and safer technologies without delay. There is a wide choice of methods to select from but chemical and biological control have always been the key components of pest control. There has been collaboration at the regional level as previously discussed.

Currently, the emphasis is on Integrated Pest and Disease Management (IPDM). Chemical control is regarded as a short-term and emergency control measure which can only be justifiable in high-value crops such as tree orchards or nurseries, with all other safety factors being considered. Biological control is a viable medium term approach to pest management coupled with the adoption of cultural methods wherever possible. In the long-term, breeding for pest resistance is seen to provide a lasting solution to pest problems in the country. More collaboration is required between the KEFRI research programmes.

Adequate planning to avert pest disasters remains a big challenge for the FD and KEFRI pest research. However, with the planning division at FD now in place, research could be adopted in the planning stages for all forestry ventures and different approaches taken to the monoculture plantation management policy now in force. In particular, it will be worthwhile to diversify tree species and to try mixed cropping where appropriate in order to reduce the impact that pests can have on forest plantations. Species and site-matching should receive more attention in future as this is among the preventive measures that can be taken in good time to avert possible pest disasters.

In future, closer ties should be sought with the end users of forest pest management research in their various capacities. The recent efforts to revive the Forestry Department Technical Orders will, for one, play an important role in strengthening KEFRI and FD links on insect matters among others. Efforts will also be made to table research proposals with an involvement of end users at every stage of development and implementation. The revival of the East African Community is viewed as a potential positive step for pest research given that the three countries face similar problems for which a regional approach may be the best way forward.

5. CONCLUSION

The attention that pest research has received in forestry has been satisfactory in the past, with many pests so far having been safely brought under control. This has relied heavily on biological control but the approach is now widening to accommodate all measures and to deliberately combine them to lead to environmentally and financially sound pest management practices. It is possible to improve on this situation by paying more attention to long-term planning of our plantation programmes and reviewing plantation management with the aim of averting future disasters. Research/end-user linkages as well as consultative collaboration will require strengthening because they are vital for the success and sustainability of forestry pest management in Kenya and the East African region.

THE ROLE OF ANIMAL DAMAGE TO FOREST MANAGEMENT IN KENYA

S. K. MURIITHI
Forest Department

1. INTRODUCTION

During the eighth British Commonwealth Forestry Conference held in Nairobi it was recommended that conservation of wildlife be accepted as one of the objectives of Management of our Forest estate. This was further strengthened in 1992 when Kenya Wildlife Service and Forest Department signed a Memorandum of Understanding (MoU) for integrated joint management of forests which are rich in biodiversity.

Wildlife has both beneficial and detrimental effects on some objectives of forest management. Some beneficial effects are recreational, commercial, conservation of biodiversity and aesthetics, etc. Some of the detrimental effects include, destruction of natural vegetation where the carrying capacity in an area is exceeded or where large population of animals congregate such as watering points and around saltlicks. This has been observed in the salient in Aberdares, particularly and hotels, and in the Shimba Hills in the narrow Mwarugaji corridor. They also adversely affect and impede natural regeneration as hypothesised in the case of camphor in Mt. Kenya (Waweru 1996).

Most damage to exotic plantations is caused by elephants, buffaloes, antelopes and sykes monkeys. The damage includes uprooting, bark stripping, breakage, trampling and bud nipping. These affect tree growth, form and timber quality. Bark stripping opens avenues through which further attack by pathogens e.g. *Oemida* etc. occurs. Damage is more pronounced in cypress than in pine. The latter may heal after the exudation of resin thus forming a barrier to further attacks by pathogens. Muriithi and Njuguna (1995), in a survey on forest plantation game damage identified the factors influencing the extent of game damage as:

- Proximity to the indigenous forest
- Species
- Age class
- Proximity to saltlicks and watering points
- Degree of steepness (terrain)
- Proximity to National Parks and Game Reserves
- Practice of non-resident cultivation
- Agent of destruction

1.1 Proximity to Indigenous Forest

The survey noted that all the sub-compartments which were adjacent to the indigenous forests were more damaged than those neighbouring farms. This observation should be expected since the wildlife are more secure in their natural habitat especially during the daytime when there is human activity in the plantations.

1.2 The Species

The most damaged species (in order of severity) especially bark stripping was *Pinus patula*, *Cupressus lusitanica*, *Eucalyptus spp.*, *Grevillea robusta* and *Pinus radiata*. The survey found that indigenous plantations were not affected by game damage. This includes *Vitex keniensis* (Meru Oak) and *Juniperus procera* (cedar).

1.3 Age Class

The most important damage was bark stripping. The most affected were the older *Pinus patula* stands as compared to the younger ones (this refers to the severity of damage to the trees). The same phenomenon was lacking in other species.

1.4 Proximity to Saltlicks and Watering Points

The availability of saltlicks and watering points results in high wildlife concentrations in the same area. All the plantations near these facilities had more damage than those that were found further away. It should be noted that Hombe forest station had the highest level of damage severity due to the availability of two saltlicks (one near the station and an artificial one at Mountain Lodge).

1.5 Degree of Steepness

The survey noted that in areas where the destructive agent was big game i.e. elephants and buffaloes, steep terrain was a deterrent. Most of the damage happened in areas with fairly flat terrain where animal movement is easy. However the same cannot be said to be true in areas where the agent of destruction was small game e.g. antelopes, rats and the sykes monkeys.

1.6 Proximity to National Parks and Game Reserves

The survey team noted that around Mt. Kenya, the sub-compartments neighbouring the parks were prone to destruction. This was especially noted around Naro Moru (near Mt. Kenya National Park) and Irangi forest station. The same trend was also noted on the eastern side of the Aberdares notably around Zaina, Kiandongoro, Kabage and Zuti. This was not so for the western side of the Aberdares due to the steep cliff extending from the National park to the plantations. This includes Geta and North Kinangop forest stations.

1.7 Practice of Non-Resident Cultivation

The survey recorded a higher degree of trampling on young plantations in areas where the shamba system was not being practised. These areas include Kimakia and Gatare forest stations in Thika and Murang'a Districts respectively, Irangi forest station in Embu District and Chehe forest station in Nyeri District.

It was also noted that in areas where the shamba system was being practised the farmers were protecting their crops thereby protecting the young plantations in the process. No recent game damage was noted in the plantations near the farms which were inside the forest area. However, in areas where the shamba system was not being managed properly the cultivators ring bark cypress trees near their shambas. The barks were used to construct temporary sheds for shelter and command posts while protecting their crops from big game at night. These areas include Nanyuki, Gathiuru and Keriita forest stations.

1.8 Agent of Destruction

While the elephants preferred *Pinus patula* in all areas covered by the survey, monkeys preferred debarking *Cupressus lusitanica*. This was especially serious around North Kinangop forest station (Nyandarua District), Kinale, Kerita and Uplands forest stations in Kiambu District.

2. RECOMMENDATIONS

2.1 General Recommendations

The game damage which adversely affect tree growth and the quality of timber is caused by elephants, buffaloes and sykes monkeys. The damage caused by elephants and buffaloes is concentrated in Mt. Kenya and the eastern Aberdares forests, while the damage caused by sykes monkeys is concentrated in the western Abardares with the highest concentration being around Kiambu and Nyandarua Districts.

The following recommendations are based on the field study and previous experiences on past methods used to protect plantations from game damage.

2.2 Maintenance of the Old Game Moats

The whole length of the old game moats in Mt. Kenya and the Aberdares should be maintained. Due to shortage of labour, this is only possible if funds are set aside to pay casuals. After maintenance of the whole length, further maintenance will be limited to several points which are frequently destroyed by elephants. The game moats are effective as was evidenced in the study when the team encountered a maintained moat around Kangaita forest station. This moat was maintained through the collective efforts of the farmers who had taken advantage of the non-residential cultivation. The moat prevented damage to the crops.

There are about 80 km of game moats between Kangaita and Ontulili which should be maintained.

2.3 Construction of New Game Moats

This should be done in areas where there are no moats especially where there are large areas of unprotected plantations. These areas include Mucheene in Meru and some parts of Zaina in Nyeri. The small pockets of plantations which are surrounded by indigenous forests should be abandoned and alternative plantations established in other viable areas. Areas where plantations are not viable include Irangi forest station in Embu District and part of Castle forest station near Upper Kamweti area in Kirinyaga District.

2.4 Choice of Species

Since some species are more susceptible to game damage than others. It is therefore recommended that plantations of high value indigenous species be established areas which are in the elephants migratory routes for example Meru Forest Station. The most successful indigenous species in both Mt. Kenya and the Aberdares include *Vitex keniensis* and *Juniperus procera*.

2.5 Introduction of Other Barriers

The erection of an electric fence is a deterrent to big game. However, this involves high capital cost. It is currently done by KWS through funding by the EU for Mt. Kenya and the Rhino Ark, in the Aberdares. The Forest Department and KWS have already formulated a policy on alignment of electric fence. The fence will be aligned between the indigenous forest and the plantation in order to protect both plantations and farmlands from wildlife menace. The work on the fence from Kabage-Kiandongoro and Zaina which will cover a distance of 40 km is expected to commence soon. Negotiations to fund 50 km of electric fence from Ragati to Naru Moru are at an advanced stage after submission of the Environmental Impact Assessment (EIA) to the E.U.

2.6 Culling of Animals

Close liaison between FD/KWS should be sought to cull animals in areas where the animals have exceeded the carrying capacity. Culling should be extended to the sykes monkeys since it is impossible to erect barriers which can keep the monkeys away from the plantations except when an electric fence is used. Forest station areas with high populations of sykes monkeys include Kinale, Keriita, Uplands and North Kinangop.

2.7 Scaring of Animals

The Forest Department and KWS under the FD/KWS MoU should look for ways and means of forming a game control unit which should scare and/or drive away animals from the plantations.

2.8 Non-Resident Cultivation

It was noted that the shamba system was found to protect the plantations during the early stages of plantation establishment. The human activities keep away big game while cultivation enhances plantation hygiene thereby protecting the young plantations from destruction by rats, antelopes etc. The electric fence will protect the crops and hence encourage farmers to take up cultivation.

2.9 Rationalization on Plantation Establishment

Future reforestation programs should ensure that pockets of plantations within indigenous forests, game watering points, saltlicks and migratory routes are avoided. As far as is practically possible plantation establishment should start from reserve boundaries so that future plantations form a buffer between settlement and protection forests. Plantations should be reasonably contiguous thus forming economically manageable blocks or zones.

BIBLIOGRAPHY

Melly Reuling 1992: KWS Forest Elephant Survey KWS.

Thomson, M. 1993: Economic Analysis of Plantation Damage Caused by Wildlife along the South-Western side of Mt. Kenya KIFCON.

Warmald, T. J. 1965: Technical Note No.99 of August 1965 Forest Department.

Manegene, S. M. (and others) 1996: Environmental Impact Assessment for the Proposed Fencing on the South West Zone of Mt. Kenya Forest Reserve.

Muriithi, (?), Njuguna (?) 1995: Report on Game Damage Survey , Mt. Kenya/Aberdares. Supplementary Report 3b KFDP, Forestry Department.

Waweru, P. 1996: The impact of Game on forest Ecology, with special reference to Elephant impact on Regeneration and Establishment of East African Camphor Wood (*Ocotea usambarensis*) in Mt. Kenya forest. An MSc. Research Proposal.

Otto Schieiner, 1995: Integrated Management and Conservation of Natural Forest Ecosystem, Project Appraisal Vol 1 Main Report.

THE MANAGEMENT AND ROLE OF FIRE IN FORESTRY MANAGEMENT AND [1]DEVELOPMENT IN KENYA

UVOO A.D.
Forest Department

1. OBJECTIVES

The objective of fire control and management in this country (Kenya) is to eradicate, in as far as possible, the annual damage suffered in the forests due to the effects of uncontrolled forest fires. Table 1 shows the total area burnt per year between 1991 and 1995. The policy is such that Forest Districts shall be as self-sufficient as possible in all operational matters, education, training and other precautionary measures aimed at Fire Prevention to actual suppression.

2. FIRE CONTROL AND MANAGEMENT

The broad strategy followed to control rate of burn is outlined below and includes Fire Prevention (risk and hazard reductions), fire pre-suppression (man-power, transport, equipment, detection, communication, water supplies, roads, bridges and firelines) and fire suppression. Emphasis has always been on fire prevention in as far as resources have allowed, with the development of back-up fire fighting capacity to deal with fire outbreaks caused by arsonists, honey hunters, escapes of shamba development, smokers, etc. The strategies followed are:

2.1 Fire Weather

To monitor seasonal weather patterns and provide an early warning to the Director of Forestry, and hence the whole of the Department, so that Department's resources may be used to the best advantage.

2.2 Hazard and risk reductions

To study fire causes and to indicate sources of fire incidences and possible points of attack. This gives some indication of the risks to be reduced or eliminated.

2.3 Mechanical and green Firebreaks

Besides the natural forest firebreaks, mechanical and vegetative or rather green firebreaks have been mechanically constructed or established by planting tree species whose litter is relatively non-flammable.

2.4 Equipment

The most suitable types of equipment for use in forest fire management operations and control are employed.

2.5 Planning

Effective territorial planning to prevent forest fires are enforced. Here it should be mentioned that although the undesirable effects of uncontrolled fires are recognized on forest land in general, the first priority is given to the protection of tree plantations which represent a considerable financial investment in Kenya, both in the value of establishment costs and in the wood value as a natural resource.

2.6 Public Education

The public is educated on the dangers of forest fires and the harm they cause in order to make everyone fire conscious and the necessity of fire control. The main target here is the rural public living near or in the forests.

---

[1] This paper was designed for oral presentation. It has been left in its original form.

2.7 Training

The aim is to train:

- Officers to think in terms of cost and other related values on every operation involving fire protection;
- Fire fighting crew in handling equipment, fire fighting techniques and organization of fire fighting gangs; and
- Patrollers to be in continuous communication with the office from wherever they will be.

2.8 KWS and other Services

To involve KWS so as to improve fire detection and suppression.

2.9 Research

Research was discontinued due to lack of facilities.

3. ROLE OF FIRE IN FORESTRY MANAGEMENT AND DEVELOPMENT

Repeated burning of forests results in deterioration of slash (litter). Slash on forest soils may:

- help prevent soil erosion;
- add humus to the soil and this is useful in poor sites, burning leads to loss of volatile minerals e.g. nitrogen;
- influence soil/water relationships;
- help light rains to soak better;
- help to hold heavy rains for longer periods and as a result more water is made available to the soil;
- help to prevent excessive evaporation and may thus be beneficial in hot climates;
- help to protect seeds/seedlings against birds and animals;
- help to prevent the growth of grass;
- help to protect young regeneration against sun and wind.

However, excessive slash may have disadvantages for example:

- prevent seed from gaining access to the mineral soil,
- hamper the growth of seedlings through physical interference or through some inhibiting influence;
- keep the soil too cold,
- harbour some insects which can reach epidemic proportions in forests; and
- inconvenience the exploitation of forests or silvicultural work.

- fire is sometimes used as a means of land preparation method during planting.
- some seeds require fire to break dormancy and germinate.
- fire is used to carry out early burning to reduce slash and fire hazard in fire risk areas.
- as a bad servant, fire destroys vegetation (biodiversity as a whole).

Table 1: Area burnt between 1991-1995

Year	Plantation	Natural Forest (Ha)	Bush/Bamboo and Grass (Ha)	Suppression cost (Kshs)	Estimated damage loss (Kshs)
1991	1 846.0	266.0	6 608.0	443 573.00	9 552 768.00
1992	6 170.0	5 494.0	13 302.0	5 959 306.00	89 127 411.00
1993	1 731.0	515.0	1 718.00	500 819.00	11 901 422.00
1994	3 048.0	548.0	1 102.0	1 369 537.00	27 230 262.00
1995	689.0	69.0	1 913.0	318 770.00	3 784 651.00

THE ROLE OF FOREST HEALTH MANAGEMENT CENTRE IN KENYA

JOE MWANGI
Forest Health Management Centre

SUMMARY

A new Centre for Forest Health Management, situated in the Forest Headquarters was started in 1994. This Centre developed from the Cypress Aphid Control project which had been established in the Forest Headquarters in 1990. Several forest health problems were discovered while implementing the Aphid control activities. The new centre was initiated to address these problems which are mainly related to protection of forests. The key activities handled by the Centre comprise monitoring, detection, suppression and loss assessment. This paper presents a summary of the operational and research achievements that have been made so far.

Operational activities have been implemented by Forest Health Management Centre whereas research activities have been implemented by the Kenya Forestry Research Institute, the International Institute of Biological Control and Moi University. The difference between *Operations and Research* has been shown clearly.

1. INTRODUCTION

You will put a smile on the face of an Aids patient if you administer a treatment that increases his/her life by one more day. If **Pearl Omega** by Professor Obel will do this, then the patient will take it with utmost hope, even with the knowledge that further tests are pending. Usually, such a prescription is not administered by the developer but by practitioners such as nurses and technologists.

Similarly, KEFRI, Moi University, IIBC, ICIPE etc. are prescription developers, Forest Department the practitioner and forestry resources is the patient. It is obvious therefore that the developer and the practioner must work together.

Poor post planting survival was identified as a major problem constraining establishment of forests (Forest officers conference 1994).

Enforcement of known technologies, standing technical orders, policy and legislative bye laws are urgently needed today (Ngibuini *et al.* pers com. 1996).

Poor silviculture leads to unhealthy plantations. Weak forests become more amenable to pest infestations. For example, it is well known that forest trees in stress will turn to stored carbohydrates. The mechanism which triggers the process is easily recognised by biodeteriogens, hence the inception of an infestation. Moreover, unhealthy plantations lead to production of poor quality wood. Such wood has low strength values and a corresponding low added value. For example, the amount of wood preservative is directly related to the wood anatomical properties.

Additionally, unhealthy indigenous forests will fail to provide the appropriate and expected benefits. There is need to continually monitor the condition of these forests, enumerate changes that are occurring and take appropriate action where this is needed. For example, is regeneration of *Ocotea usambarensis* occurring? If yes, is the regeneration healthy or is most of it suffering game damage?

2. INSTITUTIONALISATION

In 1990 a Cypress Aphid Control Unit was established in the Forest Headquarters. While this unit was implementing its activities, many other pest problems were discovered. These problems could not be contained by the unit and this justified the inception of the Forest Health Management Centre (FHMC) in 1994. The Centre is under the Forest Department and occupies the former KIFCON offices.

3. VISION

The ultimate vision of the FHMC is to maintain healthy forests through application of known technologies and to promote pro-active research.

4. SPECIFIC OBJECTIVES

The specific objective of FHMC is to enhance protection of forests by application of appropriate management of biodeteriogenic pests that cause enormous losses to Kenya's forestry resource.

Pests include animals (both vertebrates and invertebrates), diseases and weeds (FAO/UNEP Panel of Experts on Integrated Pest Control in Agriculture 16th session).

5. KEY ACTIVITIES

Key activities include monitoring, detection, identification of problems and knowledge gaps, suppression and loss assessment.

6. ACHIEVEMENTS SO FAR

6.1 Operations

- **Industrial Forests (Cypress)**

Cypress aphid has been the main biodeteriogen affecting tree species in the family Cupressaceae. Three aerial surveys have been conducted. The first aerial survey (1992) showed that 56% of cypress plantations had suffered severe damage. This information was digitized and entered into a Geographic Information System. This allowed for easy comparisons of the damage with subsequent aerial survey results. The second aerial survey (1993) showed that about 10,000 ha of cypress plantations had been killed by the aphid. The third aerial survey (1994) showed an additional mortality of 2259 ha.

Following the aerial surveys a total of four confirmatory ground surveys took place.

Recommendations on salvaging of aphid infested plantations have continuously been provided. Before this provision, the aphid had been used as pretext to clearfell some very juvenile plantations.

In addition, chemical control has continued to be used on hedges and ornamentals both in private and public lands. Guidelines on safe use of chemicals have continued to be provided. Prior to the training on safe use of pesticides, four people had died due to poisoning by aphicides

Responding to demands of alternative hedge species, a demonstration nursery was started in Karura (1994) and this has over 12 different hedge tree species. Kei apple annual production, for example, is 60,000 seedlings

On biological control an augmentation programme using the local natural enemies has been started.

A pesticide training programme as mentioned earlier was developed to train field staff on safe use of pesticides. A total of 40 staff from the Forest Department, KEFRI, and the chemical manufacturing industry were trained as trainers to teach other field staff on the safe use of pesticides. A pesticide by the name of PIRIMOR was screened and the data generated used to register the pesticide (Pirimor) temporarily by the Pest Control Products Board (PCPB) for one year pending more screening of the chemical. This pesticide was used as an emergency control measure to contain the aphid damage on cypress hedges and nursery seedlings. Private individuals were given the necessary advice by the National Aphid project staff on how to apply the pesticide to control the aphid damage on their cypress hedges and ornamentals.

The project collaborators participated in ASK Agricultural Shows where information and research findings were disseminated to the general public. A project newsletter named GREEN HORIZON and a Pest Watch poster were launched. This coupled with public media news releases helped to transfer information to the public. Consultants from the United States Department of Agriculture helped to provide specialised training in key areas and institutional strengthening.

- **Agroforestry**

The most affected tree is the famous *Leucaena leucocephala*. In order to ensure early detection of infestations through creation of awareness of the pest and its damage, information leaflets were distributed to field extension officers. Information received from these officers has been summarized. A map is currently being drawn to show the countrywide damage. Four national field surveys have been conducted.

Following this is a disease of *Casuarina equisetifolia*. A recent survey showed that Casuarina decline was occurring not just in the KEFRI research plots but also elsewhere along the Coast. These results have been reported in the March 1996 issue of **Forest Health Management** newsletter, the Green Horizon.

Grevillea robusta, the most popular agroforestry tree species in Kenya was reported to be in danger from a wood boring beetle. A survey carried by the Forest Health Management Centre in collaboration with IIBC and KEFRI in parts of Nyandarua, Kericho and Nakuru districts found a beetle borer was boring into the stem of these trees causing gallaries in the stem and rendering the trees susceptible to windfall. This problem will be addressed by the Forest Health Management Centre in collaboration with IIBC and KEFRI. The Forest Health Management Centre received several requests from private individuals, government institutions and other organisations to provide technical advice on several pest and disease problems on their agroforestry and ornamental trees. The Centre provided necessary advice and sometimes material support in all the occasions that a request was made.

- **Indigenous Forests**

  Mangroves: The FHMC (then Integrated Forest Pest Management Centre) received a report in 1993 that a new pest was attacking mangrove forests along the Kenyan coast. The species being attacked was mostly *Sonneratia alba*. Spot surveys carried out along the coast revealed an infestation by a borer insect, samples of which were collected and later identified by the International Institute of Entomology in U.K as *Salagena sp.* (Cossoidea: Metabelidae). The larvae of the pest were found to feed on the bark of the mangrove trees boring into the stem creating galleries in the wood and covering the point of entry with masses of frass and silk. This problem is being addressed and the Forest Health Centre is looking for a donor to fund the activities.

  Cedar: An extensive dieback and mortality of *Juniperus procera* was recently noticed in several indigenous forests of Kenya. Surveys carried out in 1994 by the Forest Health Management Centre in collaboration with USDA Forest service consultants identified the causes of the cedar decline to be a combination of several factors that include insect borers, branch galls, dwarf mistletoe, cypress aphid, debarking, poor site factors, old age, grazing, stem/root decay, twig blight, needle blight and witches broom among others. As with the mangroves problem, measures have been initiated by the Centre to address the Cedar decline countrywide.

Rose Wood: A recent survey conducted on the Mt. Kenya forest found that Rosewood species was declining. The cause of this decline has not been diagnosed as yet.

6.2 Research Activities

Several research studies were carried out on aphid attacked cypress by Moi University and KEFRI. A study on the mechanical strength properties of wood from cypress trees attacked by the aphid showed that there was no significant difference on the mechanical strength properties between the aphid attacked and non attacked healthy cypress timber. Prior to this study Saw millers were making demands for lower royalty charges on the attacked cypress wood claiming that timber from this wood was of inferior quality compared to the one from healthy cypress trees. Another study found that the cypress aphid attack had no effect on seed quality and viability hence proving wrong the hypothesis that seeds from infested cypress trees were not viable. The cypress aphid attack was found to have no effect on the anatomical characteristics of cypress trees neither was the aphid found to have any effect on the specific gravity, lignin and moisture content properties in the infested cypress trees. In order to determine whether the aphid attack had any contribution towards stem crack in cypress aphid plantations, a study was carried out which found that the cypress aphid had a positive contribution towards stem crack in standing cypress trees.

Another study to determine how the death of the trees occurs during the aphid infestation concluded that death is caused by desaping which interferes with mobilisation of nutrients. Following the outbreak of cypress aphid, wood based industries which utilise cypress as their raw material were initially hesitant to use the infested material. A survey was therefore carried out in 1993 to establish the attitude of consumers towards utilisation of aphid killed cypress trees. The survey which was done in various wood industries both large and small scale found that the wood based industries had accepted the aphid infested wood and were utilising the infested cypress wood like any normal wood material from healthy cypress trees as long as the wood had not been degraded by other wood biodeteriogens. The study concluded that aphid killed cypress trees should be harvested as soon as is practically possible and should not be left standing for more than two years to avoid other wood biodeteriogens setting in.

Another survey done in 1993 to identify alternative species which could be used as substitutes to cypress as hedge material revealed/identified several suitable species. These hedge species are now available at the FHMC demonstration nursery.

In order to monitor the effect of the aphid attack on the growth and yield of infested cypress plantations among other research work, Permanent Sample Plots (PSPs) were established in cypress growing areas for data collection and aphid population monitoring.

On genetic control options, a survey carried out identified phenotypically 45 tolerant cypress trees to the cypress aphid out of which 11 were finally selected for further tests and collection of germplasm for establishment of clonal gene banks and seed stands. A study on the variation of cypress aphid attack on the family Cupressaceae showed that *Thuja* species and *Cupressacyparis leylandii* were the most tolerant while *Widdringtonia* and *Callitris* species were the least tolerant. Among the cypresses, *Cupressus lusitanica*, *C. benthamii* and *C. Lindleyi* were found to be susceptible while *Cupressus torulosa*, *C. funebris* and *C. arizonica* were resistant. The study concluded that resistance breeding through hybridization may offer a viable long term genetic control option to the cypress aphid.

Further investigations to determine whether there are any significant differences between the dimensional stability and seasoning characteristics of sawn wood from aphid attacked and sound cypress trees found that trees killed by the aphid had higher dimensional changes and seasoning defects compared to healthy trees. Aphid attacked trees were also found generally to have lower moisture content than healthy trees.

Effects of creosote retention and penetration in wood from aphid killed cypress trees were investigated and the results showed that there was no significant difference between the wood from aphid killed and healthy cypress in creosote retention and penetration. In another study, the incidence of fungal attack on wood from aphid killed trees and short term susceptability of such wood to fungal deterioration was studied to determine whether it is more susceptible to fungal attack than wood from sound cypress trees. The study showed that there was no evidence of the wood from aphid killed trees being more susceptible than wood from sound healthy trees. In both cases, the wood was found to be colonised by bacteria, primary moulds and sapstain. Comparative studies of decay rates of wood from sound and aphid killed cypress trees were carried out. The results showed that there was no significant difference in decay rates between the two categories of wood under both ground and aquatic conditions. A related study investigated microbiological and insect deterioration of wood from trees which had been killed by the aphid and left standing in the forest for varying periods of time. The study concluded that both bacteria and sapstain fungi colonise and attack wood of cypress trees killed by the aphid and left standing in the forest for as short as six months.

A study carried to evaluate the impact of four local natural enemies (predators) of the cypress aphid found that of the four species studied *Betasyrphus adligatus* Wied. had the highest mean daily consumption rate followed by *Cheilomenes lunata* F (larvae) then *Chrysopa sp.* (larvae) and finally *Cheilomenes lunata* F (adults).

A preference test conducted by offering known number of cabbage aphids *Brevicoryne barassicae* L and cypress aphid *Cinara cupressi* Buckton showed that *B. adligatus* and *C. lunata* larvae had special preference to the cypress aphid while the *Chrysopa sp.* and *C. lunata* (adults) showed no preference to the cypress aphid.

Pesticidal screening of various insecticides on cypress aphid namely insecticidal soap (Fatty acids) Marshal, (Carbosulfan), Bestox (Cypermethrin) was done against the cypress aphid, syrphid fly larvae and ladybird beetle in a semi field condition. All the compounds were found to be efficacious on the aphid with the soap solution having the highest performance. The Cypermethrin and Fatty acids were found to be selective on non target organisms with the Fatty acids having a higher residual control on foliage than the other test compounds. Toxicities of the test compounds were generally found to be lower if safe use precautions are adhered to.

On biological control options, searches conducted in Europe and USA for natural enemies of the *Cinara cupressi* (Buckton) identified a parasitoid by name *Pauesia juniperorum* which was imported into Kenya in August 1993 and placed under quarantine for further screening. Trial releases of the parasitoid commenced in September 1994 at Kamae and Uplands Forest Stations. Monitoring of the released parasitoid has been ongoing since the trial releases began and the numbers released todate are not adequate to make a conclusive decision about the parasitoid's establishment in the field. More studies on this are still being undertaken by IIBC and KEFRI.

A study conducted to investigate the impact of the indigenous local natural enemies on the population of cypress aphid under tropical conditions showed that local natural enemies accounted for about 15% of the aphid mortality. This study confirmed the results from an earlier investigation done at the Forest Health

Centre laboratory which showed that the local natural enemies do contribute positively in the biological control of the cypress aphid though these were found to be generalists and chance feeders.

A standard rearing method for the cypress aphid was developed by IIBC which is easy to adopt and is relatively cheap. Also developed by IIBC was a standard sampling method which can be adopted within the region. Population dynamics studies on the cypress aphid showed that the aphid populations were dependant on the season and rainfall whereby the aphid populations were observed to decrease during the wet season and build up during the dry season. Damage by the aphid was observed to correspond with high aphid populations and vise versa.

An entomopathogenic fungus was found attacking the cypress aphid around Mt Kenya in Naro Moru area. The fungus was identified as *verticillium sp.* Further studies on the role of entomopathogens in the cypress aphid control were recommended.

7. WAY AHEAD

Several activities which were initiated by the National Aphid Project were not completed due to lack of funding. There is need to finance these activities meant for developing sustainable management and control measures of the cypress aphid pest through an Integrated Pest Management strategy.

There is also need to develop loss assessment schedules for cypress aphid. Operational activities involving monitoring through ground and aerial surveys as well as plantation inspection for early harvesting where necessary should be continued. Further studies on the biological control programme, utilisation of aphid infested wood, genetic control, silvicultural tactics and pathogenic control according to the unaccomplished workplan activities need to be implemented.

Regular monitoring of the health of our forests is mandatory if protection of this vital resource is to be achieved.

REFERENCES

Ngibuini, M.; Kiriinya, K. and Konuche, P. 1996: KEFRI - FD Conference, Muguga (1996).
Forest Officers Conference 1994.

FOREST DISEASE PROBLEMS IN THE DEVELOPMENT OF FORESTRY IN KENYA

ELY J. M. MWANZA
Kenya Forestry Research Institute

SUMMARY

Tree diseases play a major role in determining the future supply of our forest/tree products. Diseases affect nursery seedlings and trees in plantations or farms. Factors that influence the quantity and quality of nursery seedlings and trees in plantations and farms also influence future supply of tree products. Several disease problems in plantations have yet to be studied sufficiently enough to devise effective cultural and biological control measures since chemical control is generally very expensive and can be a pollutant. The impact of nursery diseases and plantation diseases such as *Dothistroma needle blight, Armillaria root rot, Cypress canker, Diplodia pinea dieback,* and decays in standing timber crops are discussed in this paper. Their influence in the development of forestry in Kenya is also highlighted.

1. INTRODUCTION

It is extremely difficult to cure individual trees of disease. Instead a Forest Pathologist aims at preventing outbreaks and restricting the spread of disease using such information that may be available on host specificity of the pathogens and the effects of environmental factors on disease. The interaction between the host, pathogen and environment is quite fundamental in determining if a disease will occur.

Much can often be done to reduce forest disease losses during the planning stage of forest development. Many diseases are host specific attacking only particular species of trees. A forester wishing to grow a softwood species for non-durable timber can choose from a wide range of tree species for the required product and avoid the risk of crop loss from a specific disease.

Loss to forest production by disease can be devastating. Where extensive plantations of softwoods have been established in Kenya, disease has also taken its toll. Cypress canker spread through young *Cupressus macrocarpa* plantations in the highlands following extensive planting after the second World War. Similarly Dothistroma needle blight severely crippled *Pinus radiata* to the extent that further planting had to be suspended. Tree diseases thus have a significant impact in the development of forestry in Kenya

3. DISEASES THAT HAVE IMPACT ON FORESTRY DEVELOPMENT

3.1 Nursery Diseases

Forest nurseries play a key role by providing forest managers and other tree planters with quality planting stock. Factors that influence the quantity and quality of nursery seedlings may also influence the future supply of tree products. These factors include diseases caused by fungi, bacteria and nematodes. The major diseases in the nursery include seed moulds, damping-off, Botrytis wilt and leaf spots. These diseases which are active from the time of sowing through outplanting may kill the seedlings directly or stunt or malform them so they must be rejected. Nursery diseases may be a threat to our forests when infected seedlings are planted in forested areas where disease does not and has not existed.

The economic losses due to diseases in forest nurseries include more than just the cost of producing the dead and curled seedlings. They include the cost of a second site preparation of the plantation when plantable seedlings are not available due to disease losses at the nursery or the cost of a second planting or interplanting when seedling diseases continue to cause mortality in the plantation and/or the opportunity cost of a chance lost to establish the crop. The basic land cost must also be included when forest land is held out of production by nursery disease problems. Thus economic losses resulting from nursery diseases are not restricted to the nursery operations; impacts on the forests may be even greater.

3.2 Diplodia die-Back

In an attack of Diplodia Die-back the young leading shoots fail to grow and later become reddish brown and the needles become dry, brittle and fall away. The terminal shoot may curl over. Young infected bark is thrown into ridges and furrows and turns brown. Resin is exuded profusely from the infected parts from which it drips to form streaks and lumps. On cutting an infected shoot a darkening of the pith may be seen which in dead twigs becomes dark brown to blue-black. At the same time the wood may be stained blue-black.

The affected portions are usually confined to the first and second node but cases are on record of complete trees being killed by the disease. Most pine species have been found to be susceptible to Diplodia die-back to a variable degree. *Pinus radiata* is particularly susceptible to attack especially when conditions are favorable. These conditions include severe drought, shallow soils, excessive humidity and hail damage. The causative fungus *Diplodia pineae* is found associated with the deadwood of the infected shoot.

3.3 Cypress Canker

A canker disease of cypress caused by the fungus *Monochaetia unicornis* proved seriously damaging to cypress plantations in Kenya at the end of the Second World War. This followed considerable expansion in cypress plantations which had been undertaken at the time.

It has been established that *Cupressus macrocarpa* is relatively highly susceptible to canker compared to *C. lusitanica*. Not only was *C. macrocarpa* more readily infected by the fungus, but the cankers, once established persisted for a longer time in an active form and thus more frequently killed the tree. Though *C. macrocarpa* was once widely planted in Kenya, its planting was stopped and a great deal of established plantations were cut down to prevent their becoming centres of infection.

Trees of 2 - 4 years of age are most susceptible to canker attack, older trees are less frequently killed by the disease. At about the eighth year and after, there is a marked decline in canker damage. This is because the smaller younger tree is more readily girdled and killed by canker and also because cankers spread less rapidly in older, slower growing tissues.

The occurrence of canker in our cypress plantations is particularly notable as an example of a hazard to which our exotic softwood plantations are liable. There is still doubt as to the origin of the disease as it might have been introduced into Kenya as a minor infection of cypresses and only assumed prominence when the species was extensively planted.

Effort has been directed towards the selection of phenotypically canker resistant individuals with the hope of developing from them genetically resistant clones. This programme has progressed very well with the establishment of sufficient seed orchards in the country. Currently the country is self-sufficient in supply of *C. lusitanica* seed resistant to *Monochaetia unicornis* disease.

3.4 Dothistroma needle blight

Dothistroma needle blight infection is shown by a brown dead band on mature needles, often with a minute black spot or dark band in the centre. The browning spreads up and down the needle until the needle is totally dead. Infection starts on needles on the main stem and base of branches of young trees and proceeds in severe cases to the extremities. If defoliation is consistently severe the tree will eventually die. *Pinus radiata* may be seriously attacked by the blight from the late nursery stage until it is 8 to 9 years old.

Dothistroma needle blight emerged as a serious disease in *P. radiata* in the sixties and eventually led to abandonment of planting of the species on commercial basis in 1974. Field observations showed that *P. radiata* grown in partial shade appeared less blighted than similar plants grown in the open. Research into control measures using copper based fungicides at different doses and different times of application appreciably controlled Dothistroma needle blight of young *P. radiata*. Though control by fungicides encouraged good growth performance of the species, aerial sprays by plane were too expensive, uneconomical and a hazard to the environment. This lead to the establishment of a breeding programme in the early 1970's to develop blight resistant *P. radiata* clones.

Trials with scion material from resistant selections have been periodically assessed for blight resistance as well as growth performance. It has been established that these scions are more resistant to blight and grow faster than their control counterparts. This confirms that resistance to Dothistroma needle blight is an inherited factor and can therefore be manipulated to improve production of the species for our pulp and paper industry. Concerted efforts in selecting and breeding *P. radiata*, resistant to needle blight are currently on-going with collaborative work between KEFRI and Pan Paper Mills of Webuye.

3.5 Armillaria root Disease

Armillaria occurs naturally in forest soils as a saprophyte of tree roots, growing from dead root tissues which it has invaded to the surface of living roots by means of rhizomorphs. While the tree remains in good health this sub-surface growth of the fungus does not lead to an invasion of the living root as the fungus is only a weak parasite at this stage. However, if such a tree with an association of *Armillaria* is felled, then the resistance of its roots to invasion by the fungus is greatly reduced and the whole of the stump - or a greater part of it - may become colonized by the fungus. Once this has happened and *Armillaria* has increased in mass and vigor by feeding on the extensive "food base" at its disposal it can invade living trees and kill them.

Spread of infection often happens when an indigenous forest site is clearfelled and replanted within a few years. Infections arise in the first place from indigenous stumps invaded by *Armillaria* as each tree in the new plantation is killed by this fungus, so a food base is set up for attack on another, neighboring tree. Large stumps are important in starting infections in plantations as the disease is most severe in areas where large infected stumps are most frequent.

Data on loss from disease in surveys and studies of field plots indicate that Armillaria root Disease is most damaging to pine and cypress crops between the third and eighth year of growth. After this age the fungus tends to form harmless root associations with the crop more readily. The greatest loss from Armillaria root disease occurs when the trees are unmarketable as timber. A secondary source of loss from Armillaria is the creation of gaps in the stand permitting weeds to establish and reduce increment in the crop through competition for meager site resources.

As for the control, much can be done to avoid loss from this disease at the planning stage when care can be taken to avoid introducing susceptible species into areas of high infection risk. The removal of stumps in badly infested areas may alleviate the amount of loss in subsequent plantations from the disease, but complete control has never been achieved by this method. Another practical control measure in Kenya is the "Taungya" or "shamba" system of cultivation where a clearfelled plantation is subjected to cultivation and growth of agricultural crops before planting the required tree species.

3.6 Tree Fungal Decay

Research on decay and defect in standing indigenous and exotic timber crops has been undertaken to determine the impact of heart rot and other defects on yield from stands of Mahogany, Camphor, Meru oak, Cypress and Pine. Cubic meter volume losses due to stem decay can be up to 30% in small trees and 60% in large ones. Several fungi have been identified as being the casual organisms for these defects. Though no chemical or cultural control measures are available, current research findings suggest that adoption of alternative management options such as the reduction in the rotation age of plantations could minimize the loss of merchantable timber if the defects are detected early.

SESSION 6:
FOREST TRAINING AND EXTENSION

FORESTRY EXTENSION RESEARCH FOR FORESTRY DEVELOPMENT IN KENYA

ALICE A. KAUDIA
Kenya Forestry Research Institute

SUMMARY

The paper examines past and contemporary forestry extension approaches in Kenya. The meaning of the concept of forestry extension is broad. The paper therefore focusses the analysis on social forestry extension research issues against a background of current predominant social forestry extension approaches, methods and emerging changes.

Based on a case study of Central division of Kitui district, it is demonstrated that collegial farmer participatory approach has potential for enhancing the dissemination of social forestry innovations. This proposition is based on a finding that in general terms, farmers' main sources of social forestry information are (in descending order): a) neighbors; b) Chief's Baraza; and c) social forestry extension agents.

It is suggested that social forestry extension agencies should adopt particular extension methods and approaches on the basis of demonstrated relative effectiveness of the alternate approaches and methods. The paper therefore identifies extension research issues on the basis of which investigations can be undertaken to facilitate understanding of the relative effectiveness of alternate extension approaches and hence formulation of strategic social forestry extension policies

1. INTRODUCTION

Recognition of the importance of dissemination of forestry information to clients of forestry research is not a new concern in Kenya. According to a report by Konuche (1989), the first Kenya Forest Bulletin was published in 1931 and by 1952, the Kenya Forest Department started publishing technical notes. At the same time, the academic and scholarly community was served through the publication of technical papers in internationally referred journals including the East Africa Agriculture and Forestry Journal.

Apart from print media, other functional approaches have been encouraged including: intensification of the undertaking of collaborative research and development activities by forestry research and extension agencies, formalization of inter-agency participation in activities of institutions and organizations through the signing of memoranda of understanding, and mandating a primarily forestry research institute such as KEFRI to incorporate in-service training of forestry development officers and workers in allied fields as a means of hastening the dissemination of research derived information and knowledge to users.

Conceptually, because of defined institutional mandates different meanings have tended to be associated with the dissemination of technical information by research institutes and the undertaking of similar activities by forestry development institutions and organizations. Hence it is commonly understood that extension is a function of forestry development agencies whereas the dissemination of technical information by research institutes does not entail extension. This conceptual difference is losing meaning in contemporary times for a number of reasons. One stems from the advocating of participation of farmers in the generation and dissemination of forestry innovations and technologies, see Treasgust and Jones, (1994). For example, the promotion of development oriented on-farm agroforestry research - Atta-Krah, (1994). Participation of farmers in research implies that increasingly, researchers are passively involved in extension of social forestry innovations through interactive discussions with farmers during on-farm research initiatives.

At the same time, changes in the theoretical perception of the process of extension from the transfer of technology to facilitation as outlined by Roling (1994) recognize farmers as knowledgeable actors. The definitive distinction between forestry extension by forestry development agencies and the dissemination of forestry information by research institutes does not therefore seem to be meaningful. In this paper, the concepts of extension and dissemination of information are therefore used in a broader context and encompass any activity undertaken by an organization or institution to promote the use of new knowledge. In Kenya, the approach to the dissemination of forestry information from research agencies to clients and especially farmers does not seem to have changed in context since inception six decades ago. Development agencies have tended to perceive forestry extension as a process that involves transfer of researched and validated technologies and innovations to clients. This assumes that the clients, and especially farmers, need to be taught, advised or be instructed about the production and use of forestry resources. The perception of forestry extension as a unidimensional process requiring the generation of scientifically validated technologies and innovations which are then passed on to extension agencies for dissemination to farmers and other clients overshadows the extensively documented farmers' knowledge in forestry practice (FAO 1985) and therefore underplays the role that farmers can play in the dissemination of social forestry innovations.

But , the concept of forestry extension covers diverse and functionally distinct aspects of forestry practice. The exchange of information and knowledge between forest extension agents and forest dwellers, the delivery of forestry extension advice to private land owners as well as communal land users in nomadic and semi-nomadic pastoral areas all constitute the practice of forestry extension. For clarity reasons, this paper discusses the extension of social forestry with reference to sedentary mixed farming areas.

The concept of social forestry has been variously defined by Agarwal (1986), FAO (1993). In the Kenyan context, it includes farm forestry, agroforestry, urban forestry, and other tree growing and utilization practices undertaken by local communities either individually or communally, KEFRI (1989) Kaudia (1990). Contradicting perceptions of the concept in Kenya are apparent. For instance, according to the draft summary report on the restructuring of the research and development programs of KEFRI, the concept farm forestry is implied to encompass social forestry and agroforestry. The validity of this argument is questionable given the narrow context of the concept of farm forestry as tree growing and utilization activities undertaken in private lands.

For the purposes of discussion by this paper, a general definition of social forestry as tree growing, conservation and utilization activities undertaken by communities either individually or collectively for their direct benefits has been adopted.

2. SOCIAL FORESTRY EXTENSION IN KENYA

Intensification of the dissemination of social forestry innovations in Kenya began in the early 1970s. It is in this period that the Forest Department, for instance, started the Rural Afforestation Extension Services. The number of agencies promoting social forestry and allied land use practices increased considerably in the early 1980s. This increase was probably triggered by the deliberations at the United Nations Conference on New and Renewable Sources of Energy in Nairobi in 1981 and the general global concern about the impending wood energy crisis in Sub-Saharan Africa (Leach and Mearns 1988).

Up to the mid, 1980s, social forestry extension was predominantly premised on the **transfer of technology** model. According to this model extension agents envision farmers as potential adopters who are targeted with predefined extension messages and packages. Forestry extension therefore entailed provision of advisory services to forestry extension clients and in the case of farmers, complementary incentives such as free tree seedlings, tree nursery tools and training were often provided Kaudia (1996)
In the late 1980s, a number of social forestry extension projects started to change their extension approach

and methods. The new methods aimed at integrating the participation of farmers in the dissemination of social forestry innovations and technologies. For instance, Mung'ala (1993) reports that the Forest Department changed the forest extension approach from the predominantly **advisory service** and **incentive** package approach to **facilitation** approach. The definition of the facilitation approach as reported by Munga'la (1993) suggests that the main change has been in the location of the site for production of tree seedlings from centralized large scale tree nurseries funded by the government and donor agencies to on-farm production of seedlings by farmers with increasing reliance on farmers own resources. This meaning of facilitation approach differs from the emerging perception of facilitation as an extension approach (see Table 1). From Table 1, it can be deduced that the meaning of facilitation in the context of extension services is: *a set of information and knowledge exchange activities undertaken by various actors in the process of which new knowledge is generated and applied.*

Table 1: Transfer of technology Vs Facilitation approaches

	Extension approach	
Item	**Transfer of technology**	**Facilitation**
Criterion variable	Adoption, knowledge utilization	Ownership of problem, quality of decision-making, convergence
Model of farmer	Individual adopter client, target	Independent, strategic actor, capable of expertise (indigenous knowledge generation and knowledge exchange, local group process)
Relevant disciplines	Communication, diffusion, information processing, social psychology	Policy science, sociology, convergence models, group dynamics, networks
Relevant applied sciences	Marketing, advertising applied communication	Adult learning and education, systems methodology (Checkland, 1981, 1989 cited in Roling, 1994)
Philosophical foundations	Science is the basis of truth	Consensus is the basis of truth. Reality is socially constructed

Source: *Roling (1994)*

3. THE RATIONALE FOR FORESTRY EXTENSION RESEARCH

Documented evidence indicating research driven changes in forestry extension approaches and methods in Kenya is lacking. It is therefore plausible that changes in forestry extension approaches and methods that emerged in the mid 1980s were triggered by changes in the socio-political circumstances (for example, the adoption of austerity measures on recommendation of key donor agencies like the World Bank and the International Monetary Fund). This does not necessarily mean that the alternate approaches are effective for dissemination of social forestry innovations and technologies.

A review of literature on forestry extension in Kenya indicates that research in forestry extension for the identification of approaches and methods that can be effective for the dissemination of forestry innovations with the participation of farmers has received limited attention - if any. KEFRI is the lead forestry research institute in Kenya. Examination of the proceedings of the workshop convened in 1989 for the development of a strategic research plan by KEFRI and the resultant strategic plan highlight the need for a program responsible for dissemination of information from KEFRI to its clients.

The need for intensifying the dissemination of forestry information has been a continuing concern of forestry research and development agencies in Kenya. However, some literature (KEFRI, 1989a, 1989b) indicate that no explicit research focus has been defined towards improving forestry extension approaches and methods and the dissemination of forestry information. Knowledge of the relative effectiveness of the alternate extension approaches and methods continues to be limited, but is important for strategic pianning of forestry extension and information dissemination strategies.

The research reported in this paper is an attempt towards identifying extension-communication methods that could enhance the application of forestry knowledge by farmers in a participatory development context. It tested the hypothesis that socio-economic status of households influence extension-communication avenues used for acquiring social forestry information.

4. RESEARCH METHODOLOGY

Sample surveys were undertaken in 1994. A representative sample of 82 households were randomly selected from the Central Division of Kitui district. Using a pre-designed interview schedule with a mixture of closed and open-ended structured questions, the formal personal interview method was used to obtain responses from the selected households. Efforts were made to interview adult individuals whom the households identified as the head of the household. It was assumed that the responses obtained represented the situation of the respective households in relation to the issues under investigation.

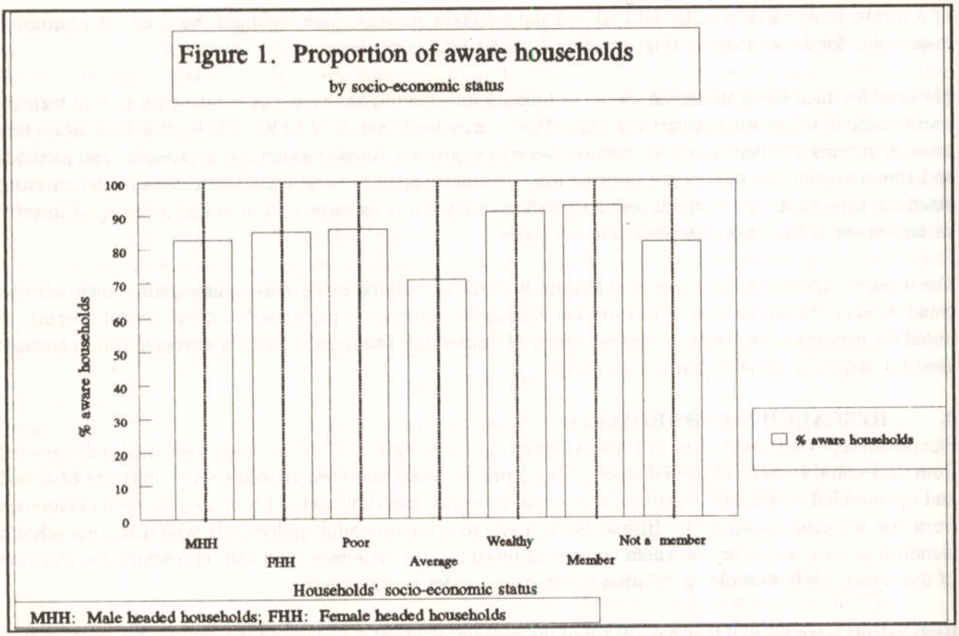
Respondents were asked if they have heard of the concept of social forestry and the sources from which they obtained information about the concept. Data on the socio-economic background of the respondent's households were also obtained. These included information on the gender of the head of the household, wealth status of the household and affiliation of the household with a women's groups that undertakes social forestry activities. The obtained data were coded and keyed into a computer for further analysis using SPSS 6.0.

Based on responses the level of awareness of the farmers about social forestry was examined. Associations between the socio-economic status of households and the reported sources of social forestry information was analyzed. The results of the analyses are discussed in the following section.

5. FARMERS LEVEL OF AWARENESS AND SOURCES OF SOCIAL FORESTRY INFORMATION

Eighty three percent of the interviewed households were aware of the concept. Minor differences were found between categories of households (Figure 1).

The high level of awareness about the concept of social forestry by the survey population in Central division of Kitui district would be expected. Kitui district has experienced continuous social forestry and related development intervention through development projects promoting various types of social forestry and environmental conservation through tree planting for about two decades Kaudia (1996). Rocheleau *et al.* (1995) also document that Ukambani has been a development target for environmental conservation and related land use interventions for a century. It was however notable that a relatively higher proportion of respondents from wealthy households and those affiliated with women's groups reported being aware of the concept. This observation supports the hypothesis that the socio-economic status of households influences the extension-communication avenues by which social forestry information is obtained.



Investigations on how the respondents became aware of the concept was used as a proxy indicator of the avenues used by households to obtain social forestry information and as a basis for drawing deductions about the relative usefulness of the alternate extension-communication avenues.

Eighty two percent of the survey population reported on their sources of awareness about social forestry. Respondents reported nine different sources of awareness about social forestry: neighbors, Chief's Barazas, social forestry extension agents, mass media, Schools, women's groups, experience and employing agency. It was found that the relative reliance on a particular source of social forestry information (based on the proportion of respondents reporting having become aware of social forestry through a source) depended on the socio-economic status of households (Table 2).

It is notable that although a high proportion of households affiliated with women's groups and those from the wealthy category said that they were aware of social forestry, the proportion of respondents citing women's groups as the source of awareness was relatively small, and that the highest proportion of responses reporting women's groups as a source of social forestry information was obtained from the wealthy category of households. This suggests a positive association between wealth status of households, affiliation with women's groups and the relative use of such groups as sources of social forestry information. Whereas women are commonly used by social forestry extension projects as a means for achieving extensive dissemination of social forestry innovations, their potential role in alienating poor households from the development process as is suggested by this research, as well as by others Brown (1990), Muuzaale and Leonard (1985) should be taken into account during the planning and designing of extension projects.

Table 2: **Sources of social forestry information by socio-economic status of households based on proportion of respondents**

	Socio-economic status of households						
	Gender of head of household		**Wealth status of household**			**Membership of women's group**	
Source of social forestry information	Female	Male	Poor	Average	Wealthy	Yes	No
Neighbour	46.00	39.00	38.00	47.00	20.00	46.00	37.00
Chief's Baraza	18.00	39.00	33.00	27.00	30.00	8.00	39.00
Social forestry extension agents	36.00	42.00	31.00	40.00	50.00	54.00	29.00
Mass media	9.00	5.80	2.40	13..00	10.00	0.00	8.00
Schools	9.00	3.80	5.00	7.00	0.00	8.00	8.00
women's group	0.00	7.60	5.00	13.00	10.00	23.00	9.00
Experience	0.00	2.00	2.30	0.00	0.00	0.00	2.00
Training	0.00	2.00	2.30	0.00	0.00	0.00	2.00
Place of work	0.00	2.00	2.30	0.00	0.00	8.00	0.00
Total respondents	11	52	42	15	10	13	52

Source: *Sample surveys, 1994.*

Overall, comparison of the proportion of respondents reporting on a source of social forestry information across categories of households indicated that neighbours, Chief's Baraza and the social forestry extension agents (in descending order) were the main sources of social forestry information. This result therefore suggests that in Central Kitui, farmer to farmer interaction is an important avenue for the extension of social forestry innovations and technologies. This observation suggests that farmer participatory extension methods could be useful for extensive social forestry extension. The result of this study agrees with other research that have investigated the effect of farmer participation in technology generation, dissemination and application. For instance, according to the research by Bremman (1990) in Thailand, a presentation by one farmer to fellow farmers about experience with *Leucaena leucocephala* hedge rows for soil conservation imparted confidence in other farmers who subsequently adopted the planting of Leaucaena hedge-rows for soil conservation.

It is however important to highlight the fact that in Kenya, sources of social forestry information such as schools, Chief's Barazas and extension agents are not mutually exclusive. Hence, it is not possible to single out any of the alternate sources as the most effective avenue for the dissemination of social forestry information. Often, it is the extension officers, who in the process of attending the periodic Chief's Baraza discuss matters relating to social forestry development. However, knowing the relative use of the various sources of social forestry information by farmers is important for the planning and designing of social forestry extension strategies.

6. THE SOCIAL FORESTRY EXTENSION RESEARCH AGENDA

It was discussed in section two that whereas the important role of information dissemination programs in forestry development in Kenya seems to have been one of the key development agenda since the 1930s, the function of such programs was mainly perceived as service for development without need for research. Consequently forestry extension research has not attracted the research attention that it deserves.

The research reported by this paper had some shortcomings. The various methods commonly used for forestry extension in Kenya, for example on-farm advisory services, group training, use of various mass media (print and audio-visuals) were not explicitly investigated. The research however enabled the identification of the various sources of social forestry information for farmers, although it did not capture the assessment of the relative usefulness of the various sources of social forestry information in terms of prioritization of the various sources by farmers. It is therefore suggested that there is need for further research to determine the relative effectiveness of the advisory service and the facilitation approaches. A comparative study of the various extension methods also needs to be undertaken to determine feasibility of the farmer to farmer method in a participatory development context.

7. CONCLUSION

Farmers are not a homogenous unit. Due to differences in socio-economic status, the relative reliance on the various sources of social forestry information differs between households. This fact is often obscured by the broad categorization of farmers into small and large scale farmers by development projects. This research has demonstrated that poorer households could be biased against in the process of delivery of social forestry extension services. It was also observed that poor households and those headed by women tended to rely on their neighbours as sources of social forestry information. This implies that divisive extension methods with a focus on poor households should incorporate farmer to farmer extension methods through; for example, the creation of village social forestry farmer networks.

REFERENCES

Agarwal, B. 1986: *Cold Hearths and Barren slopes. The Woodfuel Crisis in the Third world.* Zed Books Limited, London.

Atta-Krah, A. N. 1994: Linking researchers and farmers through developmental on-farm research. In: *Beyond Farmer First. Rural Peoples' Knowledge, Agricultural Research and Extension Practice.* Scoones, I. and Thompson, J. (eds.).

Bremann, E. 1990: Using farmers and their ideas for effective extension work. A case study from Thailand. In: *Multipurpose Tree Species Research for Small Farmers. Strategies and Methods.* (Haugen, C., Medema, L. and Latican, C. B. (eds.), The Winrock International and IDRC, Java, Indonesia.

Brown, K. 1990: Women's farming groups in semi-arid region of Kenya: A case study from Tharaka Division, Meru District. Thesis submitted to the University of Nottingham for the Degree of Doctor of Philosophy.

FAO. 1985: *Tree Growing by Rural People.* FAO, forestry paper No. 64. FAO, Rome, Italy.

FAO. 1993: *Assessing forestry project impacts: Issues and strategies.* FAO Forestry Paper No.114. FAO, Rome, Italy.

Kaudia, A. A 1990: Social forestry: The apsect approach by Kenya Forestry Research Institute. KEFRI Newsletter No. 16.

Kaudia, A. A. 1996: The Diffusion of Social Forestry in Semi-Arid Areas: A case study in Kitui District, Kenya. Unpublished thesis submitted to the University of East Anglia in partial fulfillment for the requirements for the Degree of Doctor of Philosophy. university of East Anglia, School of Development Studies, U.K.

KEFRI 1989a: Proceeding of the Workshop on Setting National Forestry Research Priorities in Kenya. KEFRI.

KEFRI 1989b: Strategic Plan 2000.

Konuche, P. K. 1989: The Role of KEFRI in Information Dissemination for forest Management and Extension services. In: Proceedings of the Workshop on Setting National Forestry Research Priorities in Kenya. 10-16 February, 1989, Nyeri, Kenya. KEFRI.

Leach, G. and Mearns, R. 1988: *Beyond the Woodfuel Crisis. People, Land and Trees in Africa.* Earthscan publications Ltd, London, UK.

Mung'ala, P. M. M. 1993: Government experience of collaboration with NGOs in rural afforestation IN: *Non-governmental organizations and the state in Africa. Rethinking roles in sustainable agricultural development.* Wellard, K. and Copestake, J. G. (eds.) Routledge, London, UK.

Muzaale, P. J. and Leonard, D. K. 1985: 'Kenya's experience with women's groups in agricultural extension: strategies for accelerating improvements in food production and nutritional awareness in Africa'. *Agricultural Administration*, 19: pp 13-28

Rocheleau, D. E., Steinberg, P. E. and Benjamin, P. A. 1995: 'Environment, development, crisis and crusade: Ukambani, Kenya, 1890-1990'. *World Development*, 23:6, pp. 1037-1051.

Roling, N. 1994: Facilitating sustainable agriculture: turning policy models upside down. In: *Beyond Farmer First. Rural Peoples' Knowledge, Agricultural Research and Extension Practice.* Scoones, I. and Thompson, J. (eds.). With a foreword by Robert Chambers. Intermediate Technology Publications.

Treasgust, S. and Jones, C. 1994: *PRA and Forestry. Abstracts.* IDS. Sussex, U.K.

THE ROLE AND LIMITATION OF THE UNIVERSITY FORESTRY TRAINING CURRICULUM IN THE DEVELOPMENT OF FORESTRY IN KENYA

JAMES LEGILISHO KIYIAPI
Moi University, Department of Forestry, Chepkoilel Campus

SUMMARY

The unprecedented global interest in conservation of world forests has in recent years led to rethinking of forest management models. The classical timber oriented management approach has been sharply criticized as being too narrow, and totally inadequate in responding to the wide range of biological, environmental, socio-economic and socio-cultural issues related to conservation and management of forests. Forestry schools, are undoubtedly, expected to play a crucial role in the evolution of these new models. This paper presents an historical overview of forestry training in Kenya, and outlines the basic structure of the curriculum. The effectiveness of the program in enhancing future forestry development in the country will largely depend on: 1) finding an appropriate balance between classical forestry thinking and proposed models; and 2) the extent to which delivery constraints are overcome, for example, building the institutional capacity to train and produce "a new breed" of graduates with sufficient technical inputs to handle the increasingly challenging field of forest resource management.

1. INTRODUCTON

The multiplicity of land use issues facing Kenya today poses a challenge to land resource managers. From both a conservation as well as management stand point, the dwindling forest land base requires rethinking of old models of management and re-orientation of institutional framework. Forestry training is a vital component of forestry development strategies. The main objective here is to provide an outline of forestry training at professional level in Kenya: historical development, the structure and philosophical basis of the curriculum; and the need for a more responsive curriculum to emerging new themes in forestry. The paper identifies key bottlenecks in the existing program and suggests possible areas of intervention, with a view to enhancing the training contribution to overall forestry development in the country.

1.1 An Historical Overview

Prior to independence, Management of Kenyan forests was under the colonial administration. The designation of certain areas as "forests" or "gazetted" forests meant that extraction of forest products from these areas was severely restricted. Management of the gazetted forests was under the colonial forest service of the United Kingdom. With independence, there was need to replace European staff of the forest service with indigenous Kenyans who had to undergo "overseas" training in Nigeria, Liberia, UK. USSR, USA and Canada.

In 1970, the University of East Africa introduced a baccalaureate program in forestry at its Makerere (Uganda) campus, into which students from Kenya, Tanzania and Uganda could enroll. Before long, however, the East African Community was dissolved, and the university of East Africa became three separate campuses and students from Tanzania and Kenya were no longer able to attend Makerere. With the help of the Norwegian government, Tanzania introduced a bachelor's degree program in forestry at Morogoro campus (present Sokoine University of Agriculture), of the University of Dar-es-Salaam to which students from Kenya were admitted. The strained relations between Kenya and Tanzania in the mid 1970s once again complicated the situation for the Kenyan students. Finally, in 1977, the establishment of a Department of Forestry in the Faculty of Agriculture (Kabete Campus) of the University of Nairobi, was approved by the Kenyan government.

The abruptness with which the forestry program was introduced during the 1977/78 academic year meant that the university of Nairobi had very little time to formulate an appropriate curriculum for the degree of Bachelor of Science in Forestry. The Dar es Salaam curriculum which was originally designed by a team of forestry experts from Norway was adopted with very minor modifications. This curriculum came under sharp criticism in professional forestry circles as being largely irrelevant in preparing professional foresters for development tasks expected of them in the tropics. Despite the deficiency, the university of Nairobi allowed the program to go through one full cycle of four years, during which extensive consultations were carried to plan and launch a revised curriculum. Notable in the curriculum review process was a consultancy report by Professor N. L. Kissick of the University of New Brunswick (Canada).

In 1984, the Department of Forestry was transferred from Kabete Campus to form the premier Department at the newly established Moi University. The Department is one in addition to four other departments (Wildlife Management, Wood Science and Technology, Fisheries and Tourism) under the Faculty of Forest Resources and Wildlife Management.

2. CURRICULUM CONTENT AND EMPHASIS

The overriding objective of forestry training in Kenya has been the realization that Kenya has a limited land base capable of supplying the needs of a rapidly increasing population. As expressed by N. L. Kissick, "*The challenge of meeting the needs of its people for the goods and services land can provide demands that the forester of the future is called upon not only to manage trees that land can produce, but also the land itself, ensuring that it is used to the fullest possible extent for the benefit of all people*." The current forestry curriculum has been developed on the premise that "knowledge imparted to students in a forestry program can be divided on the basis of whether the knowledge is professionally oriented, or related to basic sciences. Forestry knowledge related to basic sciences can be further categorized as forest biology or forest management principles".
In broad outline:

- Forest biology includes information about forest soils and sites, climate, the taxonomy, morphology and physiology of trees, forest stand structure and development, forest insects, disease, and fire as well as wildlife.

- Forest Management Principles include knowledge essential in understanding the management process, and include basic knowledge about data collection and analysis of systems, modelling, policy, law, and administrative decision making and means of implementing decisions.

- Professionally oriented knowledge or forest management practice is the application of the basic knowledge to solve forest management problems. This was the original or "traditional" thought and should still be a very important component of any forestry training curriculum. It includes knowledge about establishment, regulation, protection, and harvesting of individual forest stands.

The flow of knowledge is primarily from the basic components to the applied components, but there is also a feed-back from the applied to the basic as well as between the basic (Kissick's report).

The design and implementation of existing curriculum hinged on three underlying principles:

The Basic Resource is Land ......

Courses of study must be founded on an understanding of land - the bio-physical factors that determine its ability to provide certain goods and services; and land use - the socio-economic and political forces that determine the demand for the various goods and services land can provide. This is fundamental to the whole course of study.

The Forest is a System ......

As such, it is a complex of interrelationships which if properly understood can be modified so as to better provide for the needs of man, but if not understood can be so disturbed as to be valueless to man. This is the thrust of the forest biology and forest management principles of the curriculum.

The Forester is a Manager of this System ......

The role of a manager is to identify the options available to him/her and to select the option best suited to his/her management objectives. As a manager he/she has to work with people and must understand how attitudes develop, and the way in which attitudes may be changed. This involves working within economic constraints and have an understanding of the importance of his/her goods and services to the national needs, and political development goals of the country. Thus the practical orientation of the curriculum.

2.1 Influence on the National Forestry Development

In the absence of an objective evaluation, it is difficult (perhaps) to judge how the bachelor's level training has achieved the objectives envisaged at inception of the program. There is no doubt that the program has produced graduates who have made and continue to make considerable contribution to the development of the forestry sector. However, the Kenya Forestry Master Plan (1994) has expressed the view that the professional forestry training in Kenya (at bachelor's level) is very theoretical. To some extent, this is a valid criticism, but as I shall attempt to discuss shortly, the issue is not entirely a matter of practice vis-a-vis theory, there is a philosophical component to it.

As outlined above, the existing program should be able to produce a graduate who has a sound understanding of the forest as a system and has acquired basic knowledge of biological and management principles which are applied in forestry practice. But whether this has been achieved in practice is a different matter. What is interesting though, is the issue of perception. On one hand, there is the school of thought that asserts that there should be no room for theoreticians: what is needed are practitioners! There is no question that forestry training must endeavour to adequately expose students to field procedures and practices, but much of the practical knowledge will inevitably be acquired through years of experience in the field long after the student has graduated. At the professional level, there is also the criticism that forestry education is too technical (Richardson 1974, New Zealand Institute of Foresters 1987, Thirgood 1989). Fairfax (1984) states: "*A technician...is a person who understands everything about his job except its meaning and its place in the world.*" Neither society nor the forest resources at stake will be served if Universities are merely training technicians. There seems to be need to blend these two views. Moreover, emerging new concepts in forest conservation and management may mean forestry schools need to take a fresh new look at their curricula.

3. CHALLENGES

The extent to which existing forestry training curriculum contributes to forestry development in Kenya must be viewed from two angles:

3.1 Finding An Appropriate Balance in Paradigm Shifts

One of the criticism levelled against forestry both in developed and developing countries is that as a profession, it is pre-occupied with a singular objective- timber production at the expense of other environmental concerns. Exploitation of forest resources on a sustainable basis means striking a balance between removals and the ability of the forest to replenish itself, thus sustaining the integrity of the ecosystem. Forestry training should produce professionals who recognize the fact that forests encompass a multiplicity of uses and functions; and that by their very nature forests are complex entities. The classical timber oriented management is no longer acceptable. There are emerging issues which are of both national and global interest - concern for environmental degradation, conservation of biodiversity, social and community forestry, participatory approaches to forest resource conservation and management, research focus on Non-Timber Forest Products (NTFPs), human/resource conflict management etc. which should be addressed. The challenge therefore is to respond adequately to these issues while at the same time maintaining a "solid identity" of the profession. Where is the balance?

The program at the Department of forestry at Moi University is subject to the following key influences:

- The standards and requirements expected of all programs offered by the University;
- Changing expectations placed on the forestry and professional foresters in Kenya.

The Department recognizes the role played by the various stakeholders in forestry development and seeks to develop a responsive curriculum. To this extent, a Curriculum Review workshop is scheduled for September 30-October 5, 1996, during which views on professional forestry training would be received from a wide spectrum of stakeholders. It is anticipated that the existing program will be subjected to scrutiny and the extent of incorporation of new ideas into the curriculum debated. This will also provide a forum for examining the role of the professional vis-a-vis technical level forestry training. Periodic reviews would ensure the training is relevant and responds in a dynamic fashion to challenges facing forest resource managers.

3.2 Addressing Constraints to the Delivery Process

Delivery is as important as curriculum content. If forestry training and research at the University are to make significant contributions to forestry development in the country, then the following important elements need to be addressed and brought into sharper focus.

- Effective conservation and management of Kenya's forests requires "a new breed" of well trained forest resource managers. The challenge here is to break the "tight bondage to classical forestry thinking" and encourage a flexible, more receptive attitude to new themes in forest management. But there is a caveat: the battery of "new ideas", "fast-paced paradigm shifts", can often lead to diffused, and ill-defined forest conservation and management approaches. Rethinking the paradigms must not mean more of everything and less of science! There is no substitute to a solid understanding of the forest as a biological unit and training must stress this.

- Forest development strategies must address the problem of insufficient data on most of the country's forest resources (regeneration ecology of most indigenous species, growth data, silviculture etc.), through research in which universities should play a crucial role. There is paucity of data, on silviculture of most indigenous species- the silvicultural systems tried in tropical moist forests have been based on field observations rather than on well designed and properly executed silvicultural experiments.

  Thus, the lack of reliable data has greatly hampered forestry conservation and appropriate management practice in the country. Research information is an effective tool in the hands of a young graduate going to the field. More emphasis should be put on problem oriented-research both at undergraduate and graduate levels. A strong graduate (post-graduate) program usually corresponds with a high degree of research output and would substantially bridge the existing knowledge gaps.

- Forest research and teaching at University can be seriously undermined by lack of resources. In fact, the issue is often not so much the content of the curriculum but getting the right mix of theory and field practice. The need for adequate field exposure cannot be overemphasized. A teaching forest block allotted to the University would considerably improve the practical aspects of forestry training. But a more fundamental issue, is the total lack of funding to boost the training program at Moi University despite massive infusion of capital (in the form of loans or grants) into the forest sector in recent years. Training of competent forest resource managers is as crucial an area as any other in forestry development.

- Some of the constraints just mentioned can be addressed through institutional collaboration. This would also build in feedback mechanisms for monitoring the performance of the forestry graduates and create an interactive atmosphere between trainers and field practitioners. This would ensure that training at the University does not become too academic and theoretical and of little relevance to practical forest management. The field managers on the other hand would tap the wealth of expertise available in the University and hence improve management techniques and practices. The isolationist attitude should be discouraged. Moreover, institutional collaboration would bring about sharing of scarce human and material resources between institutions.

In the end, the greatest challenge facing any training institution (including those for training foresters) is "not merely responding to new ideas, new technologies....changing the curriculum and describing new courses, but much more importantly the whole process of delivery."

REFERENCES

Fairfax, S. K. 1984: What is and what should be taught in University forest policy courses? In: Proceedings of a workshop on forest policy and education held on January 13, 1984. R. A. Sedjo (ed.), Discussion Paper D-117. Resources for the Future, Washington, D.C. pp. 61-67.

New Zealand Institute of Foresters, 1987: Institute news: Report of the NZIF education and training committee on graduate and postgraduate training. N.Z. Forestry. 32(2): 27-30.

Richardson, S. D. 1974: Keynote address- Some major issues in professional education for forestry: An international view. In: Proceedings of the Second Congress of the International Union of Societies of Foresters held in Helsinki, Finland on August 19-24, 1974. Theme " Forestry for People." The Society of Finnish Foresters, Helsinki, Finland. pp 108-158.

Thirgood, J. V. 1988: Present realities and future possibilities for forestry education. For. Chron. 64 (5): 434-436.

Kenya Forestry Master Plan 1994.

SESSION 7:
FOREST ECONOMICS

THE ROLE AND STATE OF INTEGRATED FOREST ECONOMICS IN FOREST MANAGEMENT AND DEVELOPMENT IN KENYA

PAUL O. ONGUGO
Kenya Forestry Research Institute

SUMMARY

Plantation Forestry is largely a recent phenomenon; as most of the new plantings have occurred only since 1950. Prior to this period, trial plantings and some industrial plantations had been established in both temperate and tropical regions; but only a few countries had adopted plantation forestry as an important means of sixties/early seventies.

Plantation forestry has come to be synonymous with large scale monocultural, intensive tree growing for the production of industrial wood. The best management strategies for such apparent that the traditional model of plantation forestry is most abundant. For developing countries where most of the communities are rural based, resource constraints and subsistence needs limit successful plantation production.

Economic analyses for decision making have largely been on two fronts; those which aid in investments - including silvicultural operations, and those which deal with policy analysis - to assist policy makers and implementors in making the right decisions towards a sustained forestry and general environmental well being.

From the 1970s and the 80s the general trend in forestry development was to address the involvement of communities in forestry activities. This shift of priority from industrial to community based forestry activities saw the advent of social forestry, agroforestry and farm forestry among other strategies. Due to the realization that these approaches may not at the current rates of production sustain the forestry industries, attention has once more shifted to the dual approach of industrial and community based forestry activities. This realization has resulted into such forestry projects as the Kenya Forestry Development and the Promotion of Sustainable Forestry Management.

This paper outlines the historical development, the role and position of forestry economics ensuring the balance in the two approaches.

1. INTRODUCTION: FORESTRY IN NATIONAL DEVELOPMENT

The view of forestry in developing countries taken by forest economists and planners has been influenced by general concepts and thoughts on the economics of developing countries. Basically, has two distinct phases since (the 1950's - the earlier view based on the industrialization have prevailed approach to development of the forestry sector, and the latter approach, based on concepts of rural community forestry, and village level industry.

There has been relatively little written on the specific subject of the role of forestry in poor countries. The case for the industrialization approach to forestry in developing countries was made in its most complete form by Westoby (1962). Little development of the ideas in Westoby's approach occurred until the large shift in the general approach to development penetrated forestry circles. Thus in FAO (1980) for example, we see reference to the favourable status of forestry as an industrialization base; the high growth of demand in relation to income growth, the strong forward and backward linkages of the sector with the economy; the case of establishment of forest industries; the role of the sector as nucleus for industrial development; positive foreign exchange and employment effects.

The lessons and experiences of the industrialization approach to development have in forestry, shifted the emphasis to other types of sectoral development. Westoby (1978), in his recantation of the views advocated in his earlier work, begins by referring to the inadequacy of the GNP criterion and asserts that the approach to development of the forestry sector in poor countries advocated by him and by others had proved largely to be a failure. Food and Agricultural Organization has entered the field with a detailed policy statement on forestry in developing countries (FAO 1980).

The document identifies the problem raised by Westoby; that few deliberate efforts have so far been made directly to improve the lot of the poor in developing countries through forestry activities. Forest services, operating in outmoded technical and societal perceptions, have been unable to effectively manage and control the resources under their jurisdiction.

The general pressure of population today on forest lands, and the specific need of the poor to occupy and utilize such lands, and whatever grows on them to sustain life, means that a new approach to management of forests was needed.

FAO identified fuelwood, material for rural building and some of the non-timber forest products as being of high priority - output. Integration of forestry with Agriculture, voluntary participation of local communities in forestry and forest management and the use of appropriate technology are seen as the important elements in this approach.

The trend and history of forestry research and development in Kenya has been similar to what has been outlined above. Between the 1950's and the 1970's the focus was on industrial forestry. From late 1970's to early 1990's the shift was on community based rural afforestation. The current state where industrial forestry is implemented alongside farm forestry initiatives has come which hinted about with the development of the Forestry Master plan (1994) which limited that farm forestry alone may not be able to meet the long term demand for wood needed by the forest industries in the country. In terms of development, the focus is now on sustainable development - trees for environmental stability and the formation of the needed capital base for investment.

2. SOCIO-ECONOMICS RESEARCH IN FORESTRY DEVELOPMENT IN KENYA

Attempts have been made to analyse the status and role of research in forestry development e.g. KEFRI Priority setting seminar (1989), KEFRI Strategic Plan (1990) and Kenya Forestry Master Plan (1994).

In 1989, Socio-Economic research was directed at solving people's problems in linking research to the users of research. The priorities reflected a shift in focus from industrial forestry to social/farm forestry (Ongugo 1989).

However in its relation to plantation forestry, attention was to be given to cost of production analysis, improvement of forest industrial sector performance and the development of linkages between silvicultural and socio-economic activities of plantation management. This shift was again amplified in 1990 where under forestry socio-economics research, the main focus is on two main areas; the interactions between the increasing population pressure on land resources and resource degradation; and, interrelated social and economic issues at the household, community, regional and national levels as relating to forestry. The Kenya Forestry Master Plan (1994) has two main long term objectives in the area of forestry research: a) increasing the productivity of forests and tree resources on public and agricultural lands; and b) modification of the demand for wood and non-wood forest products by improved utilization.

The listed immediate objectives are: i) to increase the supply of forest products and services by guidance on providing wise forest management; ii) to mitigate environmental degradation, and promote the conservation of soil, water and biodiversity; iii) to improve the processing and utilization of both wood and non-wood forest products; and iv) to provide an understanding of the existing situation, prevailing problems and desirable changes and developing policy instruments and opportunities for effecting improvement in the forestry sector.

To achieve the above objectives, research and development activities have been placed under four broad areas as follows:

- **Farm forestry and dryland forestry** wherein the main research problems relating to forestry economics are diagnostic studies to assess peoples' perception of the importance and need for forestry activities; supply and demand of non-wood forest products, market research, management of common property forest resources, and community participation;

- **Conservation and Management of Indigenous Forests** The main economic research activity proposed is; quantification of environmental benefits associated with indigenous forest conservation;

- **Management of Forest Plantation:** Areas proposed for economic research are: development of cost-effective silvicultural options and provision of economic information for planning activities;

- **Forest Utilization:** Economic research activities are: estimation of the potential income which could be created by non-wood forest production activities; and, designing incentive schemes to induce farmers to undertake production of non-wood forest products.

In all the above documents, the importance of forest socio-economics in forestry development has been stressed. The implications of most of the outlined research activities have shown the need for an integrated approach to forestry socio-economics research so as to allow for the application of findings in different forestry activities. This approach can be reflected in the implementation of the promotion of sustainable forest management project where several activities are being undertaken to address different issues affecting plantation forestry development in Kenya. Some of the socio-economic research problems being implemented include thinning, pruning levels and costs, optimal rotation age, people's participation in woodlots development, approaches to local community participation in natural forest management and diagnostic studies to document local peoples' willingness to participate in different forestry research activities.

3. FOREST ECONOMICS IN PLANTATION MANAGEMENT AND DEVELOPMENT

The Forest plantation is an economic agent charged with the task of utilizing inputs and technology in an economically efficient manner to produce a set of outputs with the goal of maximizing the plantation's economic profit. The forest plantation encompasses the plantation itself and the management of the land for wood production. The focus is on the stream of management inputs, their cost and timing, and on the physical outputs, their value and timing. The most important issues in plantation management involve interrelated decision variables that are tied to profit maximization. These are; choice of location, choice of mix of inputs and level of output, and selection of management practices.

3.1 Choice of Location

The ability to control forest location allows selection of lands where forests offer the highest and best use, while lands with higher-valued alternative uses can be utilized for other purposes eg. agriculture. With plantations, commercial forests are established in regions of high biological productivity and good access to markets.

The choice of location also increases flexibility in developing a forest land configuration appropriate to efficiently providing a wood feedstock to the processing plant. If they are appropriately located, high yield plantations would require less land to continuously service a given processing plant, thereby reducing road building and local transportation costs.

3.2 Choice of Mix and Level of Output

The forest plantation is a multi-product firm capable of producing a variety of products jointly, such as pulpwood, sawlogs, peeler logs and poles. Certain inter-relationships exist between these outputs. For example, almost all sawlogs, peeler logs and poles can be used as pulpwood. However, an asymmetry exists, since all pulpwood cannot be sawed for sawlogs.

The choice of mix of outputs is of course constrained by the technical options available to the plantation managers, and within those constraints, is determined by the economics associated with the production of the various outputs, the markets and the market prices of the products. Further, the options available typically decrease as the rotation cycle increases.

3.3 Choice of Management Practices

Forest Management and technological improvements are a major source of increased productivity, and the full range of management practices and productivity increase is possible only in a plantation set up. Forest management practices contribute to both higher biological and economic productivity. Measures to enhance biological productivity include the ability to introduce genetically superior seedlings, choose species, control spacing, and limit vegetative competition etc.

Thinning is of great importance to forest plantation management. The British Forest Commission for example, recommends a thinning regime governed by three factors, (Kula 1988): a) thinning intensity; b) thinning cycle; and c) thinning type.

- **Intensity of thinning:** This is the rate at which volume is removed from a stand of trees. The higher the thinning intensity, the larger the space created for the main crop. If the remaining trees respond very well to the space created by way of high increases in diameter, then high intensity thinning, makes sense. In addition, higher thinning also yields high thinning revenue. Thinning also results in higher economic productivity by removing mortality - trees which if left unthinned may die from natural competition. The economic productivity of the forest is also enhanced by the ability to control the quality of the output. Practices that improve the quality of the output include choice of species, genetic improvement that results, for example, in straighter tree stems and increased disease resistance; and also a variety of silvicultural practices that increase stumpage quality. The latter include thinning which, while not increasing total growth, concentrates growth on fewer stems, thus producing larger high valued logs.

  The maximum intensity that can be maintained without loss of volume production is called the marginal thinning intensity.

- **Thinning Cycle which is the Interval between Successive Thinning:** Long cycles result in heavier single thinning whereas more frequent thinning entails higher single operations. The choice of thinning cycle depends on the yield class of the crop and on local management considerations.

- Thinning type refers to the type of tree that is to be removed in a thinning operation. The main objective is to retain a sufficient number of vigorous trees growing on the site. One type is known as stem thinning in which smaller stems are taken out first, leaving larger trees in a fairly even spacing. Another type is called crown thinning in which a number of the best dominant trees are selected in a stand for the final crop with some smaller trees left occupying the spaces between them. In crown thinning, the canopy becomes irregular and in some cases the stand appears to be unevenly aged.

The technical options available to the plantation manager are determined by the state of knowledge and the physical location of the plantation. A variety of technical forest management decisions must be made early in the rotation. These include the method of site preparation, choice of species seedling production, density of planting, use of fertilizers, mode and frequency of vegetation control etc.

4. STATUS OF FOREST SOCIO-ECONOMICS RESEARCH

A review of the available technical orders has shown that most of the forest research efforts had been directed mostly to silvicultural work. Very little has been done in areas of economics, socio-economics marketing and policy. This skewed coverage could have been as a result of the fact that most of the currently important tree species were introduced into the country from elsewhere.

Forestry Economics research activities have also addressed issues such as optimum rotation age/price; pruning and work studies. However, there has been a lot of changes in the understanding of the role forestry plays or has to play in national and socio-economic development of people. Social Forestry and Agroforestry have tended to be more relevant to the national needs than eg. plantation forestry management. Socio-Economics and Policy Issues have attained more importance and relevance in forestry management now than before.

Issues such as land and other resource valuation, multiple use management, assessment of peoples' needs and participation and extension of forest development outside the forestry estate has to be done concurrently with forestry development of the forest estate. The nuclear estate for industrial wood production has to be more effectively and efficiently managed so as to achieve the desired forest goods and services. At the estate (i.e. forest plantations) level, forestry economics research has to be geared towards the commercialization of log production, improvement of quality, comparison of production costs and optimization of forest land productivity. Ultimately, the aim is to make forestry more beneficial to the people of this nation and not just to grow trees for their own sake.

Since KEFRI's establishment in 1986, many socio-economics diagnostic surveys have been carried out in all the agro-ecological zones to document the status of social/farm forestry development in Kenya (KEFRI 1996). Socio-cultural studies have also been conducted with the Malakote, Masai and Luo communities in Bura, Kajiado and Siaya districts. Impact studies of the Agroforestry alley farming activities have been undertaken in Maseno, and Embu; while soil and water conservation activities have been evaluated in Siaya, Murang'a and Kilifi districts in collaboration with the Ministry of Agriculture.

Work in plantation forestry has been done in the assessment of Wattle bark and other products by small scale growers; optimal rotation for cypress and pines in Kenya and recently, studies have been initiated to assess the costs related to pruning and thinning operations of cypress and pine plantations in collaboration with other KEFRI programmes and relevant forest department branches/divisions.

5. CONCLUSIONS/RECOMMENDATIONS

5.1 The whole agenda of national development and the activities which contribute to it has changed significantly over the last forty years. Attention has shifted from the premise that forestry alone can fuel the vehicle for national development as a renewable natural resource to the realization that forestry is only an important contributor to the whole process of development. In this context, forestry research and development must contribute to the national resource base for investment in socio-economic development. This can happen both through the public and private forestry initiatives.

5.2 Forestry research in addressing biodiversity management must be based on the aspirations of the local communities while at the same time taking into consideration the national and international obligation in the conservation of flora and fauna. Cognisance of the role of forestry in soil and water conservation and its necessary contribution to agricultural development must be compromised with the need for cash generation.

5.3 Forestry research should aim to provide of adequate quality forest products necessary for socio-economic development. While it is prudent to aim at satisfying the national and regional demand for forest products, for long-term and sustainable development of the sector, forestry must compete with other sectors eg. by providing goods and services for international export opportunities. Quality and appropriate legal and policy instruments must be initiated and followed to ensure export quality.

5.4 To address the areas raised in 5.1, 5.2 and 5.3, forestry research must be fully integrated. The integration must at the same time build on the foundation already set by both research and development while at the same time address new areas of concern through the concerted efforts of both the manager, the researcher and all those who are involved in forestry research and development.

REFERENCES

FAO 1980: Towards a forest strategy for development. COFO - 80/3.1980.

KEFRI 1989: Proceedings of the workshop on Setting National Forestry Research Priorities in Kenya. Nyeri - Kenya.

KEFRI 1990: Strategic Plan 2000.

KEFRI 1996: A report on the state of Social Forestry in Kenya.

Kula, E. 1988: The Economics of Forestry: Modern Theory and Practice.

MENR 1994: Kenya Forestry Master Plan: FD - Nairobi.

Ongugo, P. O. 1989: Research Imperative in Socio-Economic issues affecting Forest Development and Management in Kenya. In proceedings of Priority setting for Forest Research In Kenya. Nyeri - Kenya.

Westoby, J. C. 1962: "Forest industries in the attack on under development in the state of Food and Agriculture, FAO, 1962.

Westoby, J. C. 1978: "Forest industries for Socio-Economic development". Guest speakers address, 8th World Forestry Congress, Jakarta 1978.

THE DEMAND-SUPPLY SCENARIOS OF FOREST PRODUCTS IN KENYA: IMPLICATIONS ON FUTURE FORESTRY DEVELOPMENT

[1]MOGAKA H. R., [2]MWAURA K. M, and [1]LUVANDA A. M.
[1]Kenya Forestry Research Institute
[2]Forest Department

SUMMARY

There is eminent pressure on Kenya's forest resources. This is attributed to increased demand for forest goods and services both at local and national levels. Some of the forest products that form an integral part of the populations' livelihood are fuelwood, timber, plywood and other boards, poles and posts among others. There are five major source-types for forest products and these include, indigenous forests; woodlands and bushlands; farmlands and settlement areas; forest department and privately owned forest plantations, with pines, cypress, black wattle trees, and eucalypts being the main species.

Currently, there is adequate supply (25 million m³) of woody materials to meet the demand (22 million m³), however, with regional variations. At the product level, there is a net deficit particularly for fuelwood of approximately 1.9 million m³, whilst there is a net surplus for timber which is about 2.1 million m³. For other products for example poles and posts, pulp and paper, and plywood and other boards, the current supply just meets the demand. Nevertheless, for most of the forest products, the demand will surpass the supply substantially by the year 2020, unless pragmatic measures are taken by all the stakeholders. For example, the expected deficits are: fuelwood = 13.7 million, poles and posts =1.0 million m³, pulp and paper = 0.3 million m³, and ply wood and other boards =0.06 million m³

Consequently, there is need for the government and other stakeholders to initiate and implement measures aimed at increasing the stock of woody materials, increase the efficiency of wood utilization and also encourage the use of other appropriate substitutes. Some of the measures that may be taken to realize the above goals include, the privatization of the forest plantations, the implementation of the new forest policy, modernization of the wood processing industry, minimizing unjustified forest encroachment for development purposes, promoting the involvement of all the stakeholders in forest planning and development, provision of necessary and sufficient incentives to forest development partners, using the forest adjacent communities for labor especially for plantation development (wide use of the non-resident shamba system) and creating more coordinated linkages between forest research institutions and forest-based industries. Finally, since forest development has socio-political, economic, and cultural dimensions, there is need to respect professionalism.

1. INTRODUCTION

Kenya's forest policy aims at managing our forests in order to meet the ever increasing local demand for the forest products as a result of the corresponding increase in population. Much of the forest produce comes from both the plantations and privately owned forests since the exploitation of indigenous forests was banned in 1982 by a presidential decree. Therefore, this paper will try to analyze the situation by looking at the Kenya Forest Master Plan (KFMP) scenario (intervention scenario) and the current scenario (no intervention). The major forest products to be analyzed in this paper will include: Fuelwood; poles and posts; Mechanical wood (sawnwood, blockboard, fiberboards, particle boards, plywood); and pulp and paper.

From the available data, the demand for forest products at the moment is either less than the supply of the products or the demand just balances out the supply. This means despite the fact that there is enough stock to meet our demand, the situation for the future might be something totally different. It is estimated that if the current utilization and demographic factors remain unchanged then demand is going to outstrip supply by very big margins. The deficit in wood supply by the year 2020 is estimated to stand at 6.8 million m³. This situation will be looked into in more details by discussing both the current scenario and the KFMP scenario.

Therefore, it stands to reason that a number of measures need to be put into force in order to alleviate the problem of demand outstripping supply. Some of these measures stem from the management side to the utilization aspects. There is need to improve the current management system to a more sound one where professionalism, transparency and accountability should be the order of the day. The current problem where we have registered backlogs in plantation establishment need to be dealt with urgently, more efficient utilization technologies adopted and the use of any available substitutes encouraged. This may seem difficult but with determination it can be realized. The Kenya Forestry Master plan project looked into this issue in more details and it came up with the Master plan scenario which will also be looked into. From this scenario it is estimated that by the year 2020, the demand will be less or equal to supply. This is definitely encouraging news to hear.

2. AN OVERVIEW OF FOREST CONSERVATION AND MANAGEMENT IN KENYA

Forests play an important role in Kenya's economic and social development. The forest resources support a wide array of local and national activities which are subsistence and /or commercial in nature. The country's forest resources are widely spread in the country, thus, making forests an important resource on which both the local communities and other distant communities either can depend on directly or indirectly.

Forest conservation and management has an historical dimension. However, formal forest conservation and management through the designation of protected areas dates back to the early years of this century. Traditional or indigenous ways of forest conservation and management were primarily carried out by the indigenous people for various purposes, as life supporting and life giving resource. The indigenous people largely conserved their forest resources for construction materials, fuelwood, wild foods (honey, fruits, berries, meat, mushrooms), medicines, cultural and ritual sites, water (for both livestock and humans) and grazing among others. The general conservation and management practices were mainly governed by traditional, cultural or customary laws and norms. However, with the increasing population, the then colonial government had to introduce formal conservation and management systems through the designation of various sites as protected forest areas.

Some of the major aims for the introduction of formal conservation and management systems of forest resources in the country were mainly focussed at safe guarding the supply of various forest products to meet the demands of the local communities and the industrial enterprises and at the same time offer environmental security. Two major classes of forests do exist in Kenya and these are namely; the designated (commonly referred to as gazetted forests) and the privately owned forests.

Designated forest areas are parcels of land set aside by the government through an order in the Kenya gazette. Such areas are set aside for the purpose of better management and conservation of the forest resource. These forests include areas under indigenous forests, plantations, mangrove forests and even bushlands. These areas are managed by the Forest Department (FD) which from time to time performs silvicultural activities, protection against pests, diseases and fire as well as regulate their yields through the issuance of permits and license.

Privately owned pieces of land are lands under the management of other institutions including individuals, county councils, KWS, NMK etc. These parcels of land do support a large portion of forests. The exact amount of forest products being removed from the private forests cannot be quantified with a lot of certainty.

Some of the constraints being experienced by the FD include hunger for agricultural land which contributes a great deal to the decline in the size of forest land and that is why there has been increased cases of excisions. In other areas the forests have been over exploited through illegal extraction of the forest products by the ever increasing population. The department also experiences problems as a result of inadequate resources and that is why there are backlogs in the establishment of plantations in Kenya today.

2.1 Major Forest Products in Kenya

Forests in Kenya have been managed for several decades for environmental, commercial and social benefits. These forests provide fuelwood which provides about 70% of the energy consumed in the country, poles and posts, mechanical wood (sawnwood, particle boards, plywood, fiberboard, block boards), pulp and paper and a wide range of non-wood products (honey, gums, resins, medicines, tannin, fruits, fibers, wild meat, grazing). Most of these products come from designated forests though the contribution from privately owned pieces of land cannot be overlooked. In Kenya the above mentioned products are got from a number of sources which include: Indigenous forests; woodlands, bushlands, and wooded grasslands; farmlands and settlements; and lastly in the plantations (FD and private).

The indigenous forests cover a total area of about 1.2 million ha. KIFCON estimated that nearly 5,000 ha of these were being lost to agriculture as a result of frequent excisions. The report goes on to estimate that there is an average growing stock of 176 m^3/ ha, which includes stem and branch biomass. It is thought that on average about 1 % of this volume, i.e. 1.76 m^3/ha, can be harvested on a sustained yield basis, comprising on average 27 % timber, 13 % poles, and 60 % fuelwood.

Woodlands, bushlands, and wooded grasslands cover about 37.6 million ha. They are mainly spread in the arid and semi arid lands, but are also found in the high and medium potential areas. It is estimated that the average growing stock of the woodlands, bushlands, and wooded grasslands is about 15.9 m^3/ha of wood biomass, increasing at an annual rate of 0.23 m^3/ha.

Forest plantations (excluding private plantations) cover 170,000 ha, of which about 16,000 ha have been harvested but not yet replanted. The average stock on the plantations is estimated to produce an average growing stock of 347 m^3/ha of biomass. The high estimate is as a result of the over-mature stands.

Farmlands and settlements, including urban, cover about 9.5 million ha. It is assumed that most of the excised land is converted to farmlands and settlements. It is estimated that on average the farmlands and settlements contain about 7.9 m^3/ha of wood biomass, increasing at an annual rate of 0.46 m^3/ha.

2.2 Demand-Supply situation for Forest products

There are a number of assumptions underlying the demand projections of forest products in Kenya. The demand of forest products is distinguished into three main categories, i.e., the demand for forest products for commercial use at the domestic level, the demand for forest products for subsistence locally and the demand for forest products for export. There is need to determine the factors that influence the demand for each of the categories stated above, however, due to lack of adequate data, the demand for the first two categories will be discussed. Nevertheless, it is worthwhile mentioning that forest products for export make up only a small part of the production and there is possibility that this will continue being the situation for sometime in the future. According to the Kenya Forest Master Plan (MENR 1994) the demand of forest products for export has been treated as a residual, i.e., forecasts of domestic demand and supply balances were made and exports are assumed to be the excess of supply over the demand.

Trends in the consumption of forest products and hence the demand are as result of several interacting factors at various levels. However, the most important determinants fall into two categories, i.e. macro-economic demand and the micro-economic or sector and product specific demand. Some of the factors that determine the demand of forest products at the macro-level include, the demographic indicators, notably the growth of the population which currently stands at about 3.5% annually and the evolution of the population structure; the economic indicators, such as growth of Gross Domestic Product (GDP) and the development of its structure, GDP per capita, industrial production, private and public consumption, capital investments and inflation; policy factors, for example trade, fiscal and monetary; and social and cultural factors such as values, traditions, attitudes and preferences. Some of the prominent factors at the micro-level that influence the demand of forest products include, the rate of expansion of the construction sub-sector, the end use of the products and substitution trends for forest products and the level of technological advancement of the country particularly within the sectors that depend on forest products. It is worthwhile mentioning that some of these basic determinants of the demand of forest products can easily be quantified whilst others can not simply be quantified, hence the demand forecasts are largely based on qualitative assessments and assumptions.

2.3 Projected Demand-Supply Scenarios: Current (no intervention) scenario and the Intervention Scenario (KFMP scenario)

- The following assumptions have been used in calculations of the current supply scenario:
  - Indigenous forests will decline at the current average rate of 7500 ha per year;
  - Woodlands and bushlands will decline at a rate of 55,000 ha per year because of other land uses;
  - Forest plantations area will decline due to backlogs which are currently estimated at 16,000 ha.;
  - Farmlands and settlements will have an estimated 0.64 m³ per ha per year wood biomass.
- The following assumptions have been used in calculations of the Master plan supply scenario:
  - Decline of indigenous forest excisions from 5,000 ha per year to zero by year 2005;
  - Woodlands and bushlands decline will reduce by half by the year 2005. Also the wood biomass will increase due to better support and management;
  - Forest plantation decline will be arrested as averaged stands are harvested and replanted;
  - Farmlands and settlements will take up the losses in forest land, woodlands and bushlands.
- On current trend scenario on demand of wood products it is assumed that the current management and institutional constraints will continue to restrict the expansion of industrial capacity. It shows the future industry outlook in the event that the government is not committed on export promotion development strategy.
- On the Master plan scenario on demand of forest products it is assumed that there will be relaxation of institutional restriction on wood procurement and foreign trade to facilitate optimum wood allocation. Increased export orientation would facilitate larger capacity expansion of the pulp and paper industry in particular and the attainment of economy of scales.

Currently round wood (,000 m^3) demand is projected to increase to the year 2020 as a result of the increasing population. The supply of round wood is estimated to run short of demand by the year 2005 while demand and supply balances out in the year 2020 according to the KFMP scenario. This is as a result of the various measures which will be taken i.e. reduction in forest land excisions, improved technologies in the aspects of utilization, improved management regimes and encouraged use of alternatives. If the current practices are allowed to persist then we are talking of having a net deficit of 6,841,000 m^3 by the year 2020. More information is illustrated in tables 1 and 2 which compare the projected total wood demand/supply in the current and KFMP scenarios.

2.4 Fuelwood

About 71% of the energy consumed annually in Kenya comes from wood, mainly as firewood for cooking, heating and lighting; most of it being used in the rural areas, whereas charcoal is predominantly used in the urban centers. The fuelwood demand in its particular case consists of demand for wood used in charcoal production and the demand for firewood. Based on the current scenario, the demand for fuelwood is most likely to increase at an accelerating rate to the year 2020 (see table 1 & 2). According to the KFMP, estimates of per capita consumption of charcoal and firewood for 1990 (Bress' base figures), the urban per capita charcoal consumption is projected to decrease from an average of 90 kg (a range of 68 to 120 kg) per capita in 1990, (range from 64 to 68 kg) to an average of 67 kg per capita in 2020. However, the rural per capita consumption of charcoal is relatively small i.e. 8 to 36 kg or an average of 13 kg and it is projected that this will remain the same to the year 2020.

Table 1: Projected Demand/Supply of various Forest Products, Current Scenario ,000 m^3

Product/Year		1995	2000	2005	2010	2015	2020
Total Wood	Supply	25034	27738	29763	32236	35031	37989
	Demand	22384	26591	30760	35251	39924	44830
Fuelwood	Supply	18250	19812	21320	22890	24677	26424
	Demand	20107	23947	27693	31720	35880	40133
Poles	Supply	1306	1415	1465	1551	1654	1773
	Demand	1219	1435	1689	1989	2335	2736
Timber	Supply	3184	3702	3664	3952	4318	4887
	Demand	1058	1209	1378	1543	1709	1961
Pulp+Paper	Supply	261	261	261	261	261	261
	Demand	280	319	359	406	462	536
Other Boards	Supply	50	57	60	64	69	75
	Demand	50	62	79	94	110	134

The per capita fuelwood consumption is projected to decrease so that from a range of 324 to 402 kg or an average of 372 kg per capita in 1990, firewood consumption in 2020 will range from 287 to 356 kg or an average of 322 kg per capita. It is important to note that fuelwood consumption was estimated by using a gradually improving wood-charcoal conversion efficiency ranging from 7.6:1 in 1990 to 5.95:1 in 2020.

Table 2: Projected Demand/Supply of various Forest Products, KFMP Scenario ,000 m³

Product/ year	Situation	1995	2000	2005	2010	2015	2020
Roundwood	supply	25062	29431	32916	37110	41268	45738
	demand	22384	26746	31079	35697	40563	45676
Fuelwood	supply	20527	23993	27111	30392	33661	35313
	demand	20108	23947	27693	31720	35880	40133
timber	supply	1058	1365	1697	1988	2349	2806
	demand	3218	3929	4161	4884	5585	6412
poles	supply	1318	1510	1643	1834	2023	2228
	demand	1219	1435	1689	1989	2335	2736
Pulp & paper	supply	261	261	261	261	261	261
	demand	280	319	360	406	462	536
Plywood & o.b	supply	50	57	60	74	79	87
	demand	50	62	79	94	110	110

2.5 Poles and Posts

The annual demand for poles and posts is projected to grow from 1.0 to 2.7 million m^3 between 1990 and 2020, i.e. a 3.3% annual growth rate. The demand for construction poles has been estimated on the basis of an average of 0.0338 m^3 per capita used in house construction, along with an additional 189,500 m^3 per year of fence posts. The per capita wood consumption for house construction is based on KIFCON study on the use of Kenya's indigenous forests by the local households and the Kenya Power and Lighting Company Ltd.

2.6 Mechanical wood products

The analysis of mechanical wood products requirements assumed that:

- The share of construction wood in GDP will continue to increase, but not as fast as in 1988-1992 (from 8.6% to 12.6%). In the year 2000 it is forecast to be 13.0% and in 2015, 13.5%;
- Wood will slightly increase its share in construction until the year 2000, then remain stable. This is a result of the government's decontrol of the prices of competing construction materials such as cement. The recent weakening position of wood in construction has been due to increased wood prices, as a result of the decontrol, and at the same time because the prices of other materials were still controlled;
- End use segments in which wood-based panels have a higher than average share, such as furniture and prefabricated houses, will grow the fastest. Reconstituted panel products will also gain some share in certain end-uses at the expense of solid wood products, because of their price competitiveness.

The year demand for sawnwood is projected to grow from 203,000 m^3 in 1990 to 262,800 m^3 in 2020. The annual growth rate for the whole 30 year period is about 3.3%. The demand for wood-based panels will increase from 46,600 m^3 to 62,100 m^3 by 2020. Plywood will account for 70-75% of these totals.

2.7 Paper and paperboards
It is projected that the demand for paper and paperboards will grow by an average of 3.7% annually, from 129,500 tones to 388,500 tones in 2020.

- **The Way Forward**

In order to come up with an efficient management and conservation system in Kenya, a number of measures have to be put into operation. First, there is need to introduce some form of incentives to encourage small scale farmers to participate in tree planting and management. Such incentives may include provision of seedlings or seeds and even financial support depending on what the needs might be. Alternatively credit schemes could be put in place for the farmers to borrow money to be used in tree planting activities.

On farm forestry products face a problem of lack of well established marketing systems. As a result of this issue, farmers need to be assisted to identify markets for their products, work out prices for these products and if possible, increase the profitability of such enterprises. Farmers should be encouraged to manage their on-farm trees so as to produce excess products which could be exported to the just expanded PTA markets for higher profit margins. Institutions well placed in matters concerning marketing could be contracted to provide such information to the farmers.

In order to make the forestry sector more efficient and sustaining there is need to privatize some of the forestry activities. The Forestry Department has enjoyed the monopoly of managing the forestry resources. Partners such as individuals, NGOs, private companies etc. could be involved in the management of the forestry sector. Privatization of the forestry sector should be done with a lot of caution since issues concerning resource valuation, operations, regulations, harvesting, etc. need to be tackled first.

Similarly there is need tp restructure the FD administrative management thus giving the foresters who are actually on the ground more power/say over the management of the forest resources at their disposal. A ***participatory approach*** in forest management need to be adopted country wide in order to alleviate the problem in back logs in plantation establishment.

Cooperatives related with the marketing and sale of forest products need to be formed in order to assist the small scale farmers in production, distribution and marketing of on farm forest products. Such forms of cooperatives have been seen to work in other sectors like in the agricultural sector and the same should be encouraged in the forestry sector. The formation of such instructions will discourage the over exploitation of the local communities by the middle men. The Ministry of Cooperative development could be entrusted with the responsibility of offering advisory services to farmers on more profitable forest products' ventures.

There is need to develop ***new silvicultural*** systems and ***harvesting technologies*** that are most suited to our environment. These new technologies and systems should be cost effective even for small scale farmers. Technologies aimed at improving the value of our forest products need to be availed to both the managers and the farmers so that our products could fetch maximum returns. In reference to this, the products destined for export should undergo some kind of processing (semi) to increase their value on the markets. The resins and gums from the ASALs are examples of products which could be processed locally and exported at high returns.

In the recent past a lot of resources have been directed into forest ***research*** but with little/no results reaching the managers and consumers i.e. FD and farmers. Thus , there is need to adopt some of the research findings from elsewhere and applying the same to our own situation without necessarily having to go through the same process. Otherwise our limited resources for research should be directed towards biotechnology, pathology and entomology research. The signing of a memorandum of understanding between KEFRI and FD alone is not enough if we have to achieve greater success in research. We should shift from the idea of undertaking "classical' research to "adaptive" research.

4. CONCLUSIONS

Measures aimed at maintaining a balance between the demand and supply of forests products need to be put into force and some of the factors which require urgent attention may include the following among others: Improved management and conservation strategies, privatization of some of the forestry sector enterprises, increase planting stock to reduce the existing backlogs, improve research output aimed at filling the existing gaps especially in tree improvement and growth modeling, improve utilization efficiencies through the use of modern technologies and make provision for a sound package of incentives. Measures outlined by the Kenya Forestry Development Project mid term review include:

- Rationalization of future plantation establishment and management versus industry market needs. A comprehensive industrial wood products' markets study is in the 1996/97 annual work programme of KFDP.
- Plantation operations programme, which will continuously revise technical orders is recommended.
- Reduce game damage through plantation protection and future management. Approximately 35% of 25,000 ha of pines and cypress have been damaged by game. Plans to improve protection are underway.
- Continue programme to eliminate replanting and thinning backlogs. 1,000 ha require coppice reduction. This is proposed to take 3 years through June 1999. Gradual re-introduction of the non-resident cultivation (NRC) has greatly improved establishment of plantations.
- Strengthening of the roads unit to undertake road rehabilitation and maintenance. To-date a total of 33 km of plantation roads have been rehabilitated under KFDP, out of a targeted 1678 km.
- Complete first phase plantation inventory. This has already started.
- Substantial management improvement has occurred in the field including disciplined planning and reporting system of district felling plans for sawlogs. Already sawnwood working circle and district felling plans are almost complete for all districts. There is also need to update pulpwood felling plans and prepare fuelwood felling plans.
- Annual work plans and measurable indicators are already in place.
- Alternative timber marketing such as open auction of roundwood will be introduced and it is expected that this will positively influence market prices which may improve supply situation. This should also apply to Pan African Paper Mills (PPM).
- The new forest policy has been approved by the cabinet and it will soon be tabled in parliament for deliberation and subsequent approval.

BIBLIOGRAPHY

Dewis, P. A. 1996: Notes for Kenya Forestry Development Project MTR.
Foster, P. G. 1996: Kenya Forestry Development Project mid-term review.
MENR 1996: National felling plan for sawlog working circle.
MENR 1994: Kenya forestry Master Plan; Development programmes.
Wass, P. 1995: Kenya's Indigenous Forests; Status, Management and conservation.

SESSION 8:
FOREST PRODUCTS

WOOD QUALITY VARIATION AMONG THREE EUCALYPTS SPECIES AT TURBO, KENYA

M. O. MUGA and J. K. GITHIOMI
Kenya Forestry Research Institute

SUMMARY

Wood specimens were obtained from 19 year old, *E. camaldulensis*, *E. saligna* and *E. maculata* trees (12 trees for each) grown on poorly drained Vlei soils at Turbo using four establishment methods. The three response variables measured were, sapwood width, heartwood content and basic density. The results obtained showed significant differences ($P< 0.05$) in sapwood width, heartwood content and basic density among the three species. Basic density varied significantly ($P< 0.05$) with height for *E. maculata*. Significant differences in sapwood width and basic density with establishment method were only found in *E. camaldulensis*. There was no significant variation in heartwood content with establishment method for all three species. However, heartwood percent varied significantly ($P< 0.05$) with height in all the three species. All the three species could be used for pulp and paper production. It is recommended that the morphological, chemical and pulp properties of *E. camaldulensis* and *E. maculata* be assessed to determine the most suitable pulping process and paper grades.

1. INTRODUCTION

The genus eucalyptus though indigenous to Australia and the islands to the north of the continent has been planted widely in many parts of the world for the last 100 years. Eucalyptus were introduced in Kenya early this century mainly for the supply of fuelwood for firing locomotives. The early utilization for firewood, rough hewn, shelters and durable structural members has largely given way to employment in high quality building, decorative and furniture woods and veneers and a variety of paper pulps. Currently Eucalypts constitute about 10% of the industrial plantations grown in Kenya (MENR 1995). Eucalypts (mainly *E. saligna* and *E. globulus*) constitute about 10% of the pulpwood used at Pan Paper Mills. These two species are the main eucalypts species growing in many parts of the country. There are however several other species growing in small quantities in various parts of the country e.g. *E. grandis*, *E. camaldulensis*, *E. maculata*, *E. tereticornis*, *E. paniculata*, *E. robusta*, *E. citriodora* etc.

The high population growth rate of the country at 3.5% and the pressure for agricultural land has resulted in the demand for forest products putting immense pressure on the existing natural and planted forests. In order to sustain the wood supply, it is inevitable to introduce fast growing, short rotation tree crops in various parts of the country. In a bid to increase the supply of pulpwood to the Pan Paper Mills, the Forestry Research Department (now Kenya Forestry Research Institute) carried out a species establishment trial on *E. saligna*, *E. camaldulensis* and *E. maculata* in Turbo; Western Kenya, within the pulpwood regime on poorly drained Vlei soils using four different establishment methods. The experiment commenced in 1974 and the trees were to be assessed for suitability for pulp production after 10 years. However, this was not possible and sampling was done in 1993 (when the trees were 19 years old).

In choosing a species for wood production it is essential that those selected be capable of producing wood with technical properties that are suitable for the intended end products. For eucalypt pulping and paper making properties, the basic density and extractive content (heartwood content) are the main determinants. Sapwood width is also an important consideration. Wood density has an appreciable influence on many properties e.g. heat per unit volume produced during combustion, shrinkage and swelling and conversion processes including cutting, chipping, gluing, finishing, rate of drying and paper making. It is generally considered to be the single most important indicator of clear wood quality. It is the primary determinant of clear wood strength and yield of pulp per unit wood volume (Kellogg 1982). It can also be used as a measure of the amount of cell wall material present in a piece of wood and is highly correlated with cell wall thickness (Hillis 1984). Thus wood density is indicative of paper properties and has great practical value.

The strength properties that are directly associated with interfibre bonding (breaking length and burst index) decline steeply (Higgins 1970) as wood density rises from 300 to 650 Kgm³ but more gently at higher densities. Properties dependent on the interfibre bonding are higher for wood of lower density.

The amount of extractives (i.e. heartwood proportion) present in eucalypts of various species and ages is relevant in several ways to their suitability for pulping. The presence of ellagitannins and other phenolic compounds lead to increased consumption of chemicals during pulping and reduce pulp yields. The presence of extractives or thin condensation products in the black liquors resulting from the alkaline pulping of eucalypts may lead to a high viscosity and hence difficulties in burning in the chemical recovery furnaces.

The amount of sapwood may influence wood properties and utilization and it is an important criteria to forest industries involved in lumber drying, wood pulping, preservation and lumber manufacture.

One of the major industrial need is to have greater wood uniformity. Variation in wood can be related to the radial (pith to bark), axial position (base to top) and circumferential position of the sample within the tree. Considerable variations in density occur between and within eucalypt species and within trees of the same species. Variations in the heartwood content within trees of the same species have also been reported (Githiomi 1992). Variation in sapwood width has been reported too (Panshin and de Zeeuw 1980, Hillis 1972). For efficient wood utilization, the variation pattern within trees and among trees within a species and among species must be understood. This information should be known by tree breeders and growers and those who convert wood into the final products as wood variability greatly influences its quality.

The objectives of this study therefore were: 1) to determine the within tree and among species variation of basic density, heartwood content and sapwood width; 2) to asses the variation of the above properties with establishment method; and 3) to assess the suitability of the three species for pulp and paper production.

2. MATERIALS AND METHODS

2.1 Study Area

Wood samples were obtained from KEFRI's Turbo Research Station experimental plot number R E. 367 planted in 1974. The experimental plot is situated about 5 Km from Turbo Township, Kakamega District. The Turbo site (10° 38' N and 35° 4' E; 1800 m a.s.l.) slopes gently. The mean annual precipitation is about 1250 mm and mean annual temperature about 20° C. The dry season is normally between December and March. The soils are poorly drained Vlei soils with low water table.

2.2 Species established

The trial incorporated three eucalyptus species i.e. *E. saligna* (Lari/Turbo), *E. camaldulensis* (the Central African Republic) and *E. maculata* (Machakos).

2.3 Experimental Design

The experiment conformed to a complete randomised block design of four blocks each comprising of four treatment plots and with each treatment comprising of three sub plots. The four main treatments were: the control (A), complete ploughing plus harrowing (B), complete ploughing, harrowing and ridge discing (C), and single mould board plough (D). The three species, *E. saligna, E. camaldulensis* and *E. maculata* were sub-treatments. Each plot comprised of 40 trees in a 4 x 10 arrangement. Trees were spaced at 3 m x 2 m. Assessment was usually carried out on the inner two rows thus, for any given plot there was a maximum of 20 potential trees to sample from. In total there were 48 sub plots with a possible maximum of 40 trees each.

2.4 Management of the Experiment

The area was initially occupied by grass and grazed on for a long time. It was burnt twice in 1970 and 1974 to kill rats. Soil auger pits were dug at intervals of 10 m from the edge during the dry season. Although water table was reached at a depth of 2.25 m at the edge, no water was found at any depth in the vlei soil (even at 36 m). This indicated that the source of water was from the surrounding higher ground. Pits were dug beside the treatments at intervals of 120 m. Grumosolic clays were found towards the centre of the vlei soils in block 3 and 4.

The plot was ploughed with a tractor for moulding and moulding improved manually. Tractor ridging was not very successful and had to be supplemented with manual ridging. Weeding was also done to reduce competition from grass and improve aeration.

2.5 Wood Sampling and Analyses

Wood sampling was done in April 1993. Total height, merchantable height and diameter at breast height were also assessed as well. The bark characteristics of the three species were also assessed. A total of 36 trees were sampled at random, each species being represented by 12 trees (3 trees from each treatment). After felling the trees, total merchantable height was measured using a measuring tape. Discs measuring 600 mm were removed at the base height, breast height, 50% and 85% of the merchantable height. The merchantable length was considered upto 8 cm overbark top diameter. All the discs were clearly labelled and transported to KEFRI's Forest Products Laboratories at Karura for wood quality analyses.

2.6 Basic Density Determination

Two discs each 2 cm thick were obtained from each 600 mm billet and used for the determination of basic density, heartwood content and sapwood width. The disc for basic density determination was further processed according to the pattern shown in figure 1. A radial strip of about 20 mm in width extending across the north-south diameter was cut from each disc as shown in figure 1. Radial strips were also removed from the East and West sides. The strips were further cut to produce a heartwood and sapwood block for each axis. A small strip of wood about 5 mm was removed at the sapwood-heartwood boundary and discarded. The sample obtained at 85% height had only a small amount of heartwood and in some cases none. In the latter case only sapwood blocks were produced.

The weight of each sapwood and heartwood samples was taken to the nearest 0.1 g. The volume of each sample was obtained to the nearest 0.1 cm^3 using the water displacement method. The samples were then oven dried at 103°C until constant weight was achieved. Samples were considered to be at constant weight when the variation between subsequent weights was less than 0.5%.

The basic density for each specimen was calculated as follows:

$$B.D. = \frac{\text{oven dry weight of wood (g)}}{\text{volume of wood (cm}^3\text{)}}$$

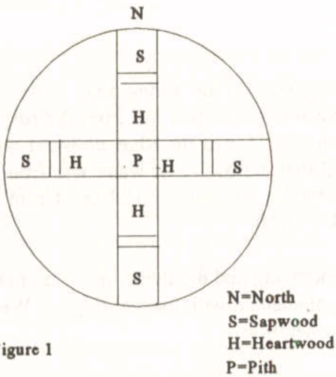


Figure 1

Figure 1: Diagram of the disc cutting pattern used to produce wood blocks for determination of physical properties.

2.7 Sapwood Width and Heartwood Content Determination

The remaining 2 cm disc was used to determine the sapwood and heartwood widths (and hence the heartwood content). Lines were drawn on the upper surface across each disc in the North-South, East-West, North West-South East and North East-South West directions as shown in Figure 2. At each sapwood-heartwood boundary, pencil dots were also marked on each line at the boundary of the sapwood and the cambium, as shown in Figure 2, to provide a reference point for the measurements. The first measurement was the distance along each line from the cambium - sapwood to the opposite cambium - sapwood boundary. This distance represented the under bark disc diameter. The second measurement was the distance along each line from the sapwood - heartwood boundary to the opposite sapwood - heartwood boundary. This distance represented the heartwood diameter. The third and the fourth measurements were of the two sapwood lines present at opposite ends of the north - south and east - west lines. Each sapwood line was defined as the distance between cambium - sapwood boundary and the sapwood - heartwood boundary. This measurement represented the width of the sapwood.

2.8 Heartwood Content

The heartwood and disc diameters obtained for the north-south, east-west, north east - south west and north west- south east axis as described above were used for analysis of heartwood content. For each disc, the four heartwood diameter measurements were averaged and this value used to compute the heartwood area. The four disc diameter measurements were also averaged and this value used to compute the disc area. The heartwood percent of each disc was calculated by dividing the heartwood area by the cross - section area of the disc and expressing the ratio as a percentage in a similar fashion to that described by Purnell (1988) and Taylor (1973). The following expression was used.

$$Hw\% = (DHw)^2/(DD)^2 * 100;$$

Where DHw is the heartwood diameter (width) and DD is the disc under bark diameter.

2.9. Statistical Analysis

The mean values for basic density,sapwood width and heartwood content were analysed using statview SE statistical programme for ANOVA, LSD and regressional analysis (in the case of heartwood content) to determine if there were any significant differences between treatments and species and within species at different bole heights.

Table 1: **Wood charateristics for *E. saligna*, *E. camaldulensis* and *E. maculata* at four different heights**

Species	Height	Sapwood width (mm)	Heartwood percent (%)	Basic density (Kg/m³)
E. saligna	Base	31.37	62.93	524
	DBH	24.38	63.46	505
	50%	39.29	42.14	511
	85%	49.83	17.77	533
	mean	**36.22**	**46.58**	**518.25**
E. camaldulensis	Base	27.75	61.05	599
	DBH	23.25	60.94	590
	50%	29.13	46.09	582
	85%	49.29	6.29	597
	mean	**32.36**	**43.59**	**592**
E. maculata	Base	47.2	34.3	675
	DBH	37.3	35.9	643
	50%	31.8	27.3	632
	85%	37.8	2.8	607
	mean	**38.53**	**25.08**	**639.25**

3. RESULTS AND DISCUSSION

3.1 Bark Characteristics

The bark for *E. saligna* and *E. camaldulensis* were thin, smooth and easy to remove while that of *E. maculata* was thick and difficult to remove. This implies that more energy would be required to debark *E. maculata* as compared to the other two species.

3.2 Basic Density

E. maculata (639 kg/m³) had the highest basic density followed by *E. camaldulensis* (592 kg/m³) and *E. saligna* (518 kg/m³) had the lowest. There was a highly significant difference ($P<.001$) in Basic density among the three species. In general the three species have intermediate densities (500 to 650 kg/m³) and therefore combine some of the advantages of high density woods (low freight rates, high pulp yield per unit volume of wood, good paper opacity) and low density woods (ease of chipping, high pulp yield per unit mass of wood, good paper strength). The mean densities for *E. saligna* and *E. camaldulensis* are within the range of densities found by Palmer *et al.* (1982) for 10 year old *E. saligna* (550 kg/m³) and 6-7 year old *E. camaldulensis* (546 kg/m³) from Kaptagat and Kitale.

There was no significant effect of height on basic density except in *E. maculata* ($P< .05$). The trends were different in each case as shown in Table 1. For *E. saligna* basic density decreased from the base to the lowest value at the breast height diameter and then increased to the highest value at 85% height. In

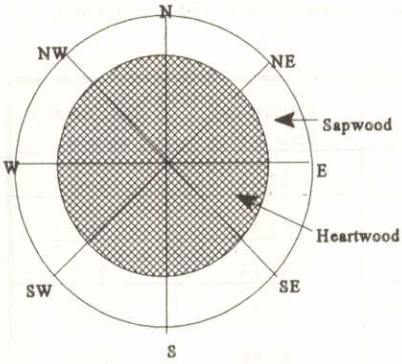


Figure 2: Illustration showing the four axial lines drawn across the disc surfaces used for linear measurement of sapwood, heartwood and disc diameter.

E. camaldulensis basic density decreased gradually from the base at the breast height and then increased, the value at the top being almost the same as that at the base. For *E. maculata* there was a significant decrease ($P< 0.05$) of density from the base to the lowest value at 85% height.

The trend in the variation of basic density with height in *E.saligna* is similar to that of 10 year old *E. saligna* from Kitale and Kaptagat (Palmer *et al.* 1982), 27 years old *E. regnans* (Dargavel 1968), *E. grandis* (Taylor 1973, Hans and Burley 1972), and *E. nitens* (Purnell 1988). For *E.camaldulensis* the trend is similar to the one reported by Palmer *et al.* (1982). *E. maculata's* trend resembles the trend in conifers. The low density of top *E. maculata* logs could be used for pulp and paper while the high density base could be used for other products, e.g. hardboards.

There was no significant effect of the establishment method on basic density except for *E. camaldulensis* ($P< 0.05$).

3.3 Heartwood Content

E. saligna had the highest mean heartwood content (46.6%)followed by *E. camaldulensis* (43.6%) while *E. maculata* (26.5%) had the lowest, which was significantly ($P< 001$) lower than that in the other two species.

The relatively high proportion of heartwood in *E. camaldulensis* and *E. saligna* could imply a large proportion of flavans of the leucodelphinidin and leucocyanidin types which discolour with alkali to a greater extent than the other extractives (Hillis 1968). These species also contain significant proportions of ellagic, methyl ellagic and gallic acids and ellagitanins (Hillis 1968, 1972) which tend to increase the consumption of chemicals during pulping and reduce pulp yield. Under some conditions complexes may form between metals (such as magnesium and calcium) and ellagic acid (Nelson 1965), causing hard deposits on or in digester screens, liquor circulation pipes, heaters, heat exchanges and spent liquor pipelines. The amount of insoluble ellagic acid-metal complexes formed during the pulping of eucalypts increases with the age of the tree from which the acid is derived. Pulpwood from young trees is therefore to be preferred.

The extractives in the heartwood as well as features such as tyloses may make the wood less permeable and therefore harder to treat with preservatives or pulping liquor (Hillis 1972). However the heartwood may be more durable because of the presence of extractives and many of the coloured heartwoods have great value in appearance.

Table 2: Wood characteristics of *E. saligna, E. camaldulensis* and *E. maculata* under four different treatments

Species	Treatment [1]	Sapwood width (mm)	Heartwood percent (%)	Basic density (Kg/m³)
E. saligna	A	35.20	39.11	528
	B	43.08	45.88	508
	C	37.17	48.48	522
	D	29.42	52.83	514
	mean	**36.22**	**46.58**	**518**
E. camaldulensis	A	42.58	40.34	611
	B	21.54	54.17	609
	C	34.87	36.69	608
	D	30.42	40.18	540
	mean	**32.35**	**42.85**	**592**
E. maculata	A	41.25	9.94	651
	B	44.96	22.00	646
	C	39.29	36.97	636
	D	28.63	32.26	626
	mean	**38.53**	**25.29**	**639.75**

[1]A - Control (undrained)
B - Complete ploughing and harrowing
C - Complete ploughing, harrowing and ridge discing

There was significant variation ($P< .05$) in heartwood content with height for *E. saligna* and *E. camaldulensis* while for *E.maculata* it was highly significant ($P< .001$). Heartwood content increased insignificantly from the base to the highest value at breast height in all the three cases (Table 1). This is consistent with what Hillis (1987) reported. He states that heartwood is reported to commence its formation at breast height. This may explain why this level has the largest amount of heartwood. The heartwood content decreased significantly from the highest value at the breast height to the lowest value at 85% height in all the three cases. This is because heartwood tends to taper from the level of first initiation towards both the crown and the butt (Hills 1987).

No significant difference was found among treatments for each species. A strong correlation was found between diameter and heartwood content (r=0.824) for *E. saligna*, (r=0.662) for *E. maculata* and (r=0.781) for *E. camaldulensis*. Tree diameter could therefore be effectively used to estimate the heartwood content of standing trees.

3.4 Sapwood Width

The overall mean sapwood width ranged from 32.5 mm for *E. camaldulensis* to 38.5 mm for *E. maculata*. These values differ from what was reported by Dargavel (1968) that sapwood for all eucalypt species is generally 25 mm or less. However the figures are within the range of values (30-40 mm) obtained by Mckimm and Ilic (1985) working with fast grown *E. nitens*. Thickness of sapwood affects the treatability, with sapwood treated for eucalypts being half that treated for confers. The sapwood is likely to check during drying especially in low density woods where shrinkage is 2-3 times that of confers (Hillis and Brown 1984). Sapwood contains starch and is hence susceptible to attack by bostrychid or lyelid borers during or after drying. All the tree species are susceptible to borer attacks (Hillis 1984) and treatment may be necessary to control lyelid borers depending on the use intended for the timber. For pulping the higher sapwood width is advantageous.

Sapwood width decreased from the base to the breast height in all three species and then increased significantly ($P< .05$) up to the highest value at the 85% height for *E. saligna* and *E. camaldulensis*. This is similar to what was reported by Panshin and de Zeeuw (1980)that sapwood is widest at the upper part of the stem and decreases in width towards the base. *E. maculata*'s sapwood width was quite uniform. This is similar to what Hillis (1972) reported that sapwood width is uniform in eucalypts.

There was significant difference ($P< .05$) in sapwood width with treatment only for *E. camaldulensis*. *E. camaldulensis* trees in the control (undrained) and ridge disced plots had sapwood width significantly higher than those in the completely ploughed and harrowed plots. This could be due to the trees in these two plots being more vigorous than those in the last plot as dominant (more vigorous) trees have been reported to have wider sapwood width (Panshin and de Zeeuw 1980). *E. maculata*'s sapwood width in single mould board ploughed plot was significantly smaller than those in the control and the completely ploughed and harrowed plots.

4. CONCLUSIONS AND RECOMMENDATIONS

- Sapwood width, heartwood content and basic density varied significantly among the three species. *E. maculata* had the highest sapwood width (38.5 mm) while *E. camaldulensis* had the least (32.5 mm). *E. saligna* had the highest heartwood content (46.6%) and *E. maculata* (26.5%) the least. *E. maculata* has the highest basic density (639 kg/m^3) and *E. saligna* (518 kg/m^3) the least.

- Heartwood content, moisture content and basic density varied significantly with height in *E. maculata*.

- The lowest basic density is at breast height for *E. saligna*, 50% height for *E. camaldulensis* and 85% height for *E. maculata*. The highest basic density is at the base for *E. maculata* and *E. saligna* and 85% height for *E. camaldulensis*. The lowest sapwood width is at the breast height for *E. camaldulensis* and *E. saligna* and at 85% height for *E. maculata*.

- The lowest heartwood content is at the 85% height and the highest at breast height for all the three species. A strong correlation exists between the diameter and heartwood content, the strongest being for *E. saligna* ($R=0.824$) followed by *E. camaldulensis* ($R=0.781$) and lastly *E. maculata* ($R=0.662$). Tree diameter could therefore be used to estimate heartwood content.

- The lowest moisture content was at 85% height for all the three species at breast height for *E. saligna* and *E. maculata* and at the base for *E. camaldulensis*.

- All the three species can be established using any of the four establishment methods.

- All the three species can be used for pulp and paper manufacture as the mean diameters are within the recommended range of 8 to 25 cm and the basic densities between 500 to 650 kg/m^3. However there is need to assess the morphological, chemical and pulp properties of *E. camaldulensis* and *E. maculata* in order to determine the most suitable pulping process and the paper grades which can to be produced.

5. ACKNOWLEDGEMENTS

Thanks are extended to the late Alexander Museka who helped in the sampling, and Laboratory analysis of samples. Thanks also go to the officer-in-charge of Turbo station, Mr. Bernard Owuor and his staff for all the support rendered. Special gratitude is extended to Ms. Nellie Ndegwa for her computer skills and input and to Ms. Veronica Kiboi for typing the document.

REFERENCES

Dargavel, J. 1968: Variation in the Basic Density of Mountain Ash. Aust. For. Res. J. 3(3): 25-30.

Githiomi, J. K. 1992: Wood Characteristics and Properties of Plantation Mountain Ash (*E. regnans*) and their variation. MSc Thesis University of Melbourne Australia.

Hans, A. S. and Burley, J. 1972: Wood Quality of *Eucalyptus grandis* (Hill) Maiden in a Fertilizer Trial at Siamambo, Zambia, E. Africa. J. 38 (2): 157-161; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

Higgins, H. G. 1970: Pulp and Paper. IN: Eucalyptus for Wood Production. W. E. Hillis and A. G. Brown (eds.). CSIRO Academic press Australia. pp. 291-315.

Hillis, W. E. 1968: Heartwood Formation and its Influence on Utilisation. Wood Science Technology 2: 260-267; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

Hillis, W. E. 1972: Properties of Eucalypt Woods of Importance to Pulp and Paper Industry. APPITA 26:113-122; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

Hills, W. E. 1984: Wood Quality and Utilization. IN: Eucalyptus for Wood Production. W. E. Hillis and A. G. Brown (eds.). CSIRO, Academic press, Australia. pp. 259-289.

Hills, W. E. and Brown, A. G. 1984: The Need for Improved Wood Production from Eucalypts. in: Eucalyptus for Wood Production. W. E. Hillis and A. G. Brown (eds.). CSIRO, Academic press, Australia. pp. 393-401.

Hillis, W. E.1987: Heartwood and Tree Exudates. Springer- Verlag, New York. pp. 268.

Kellog, R. M. 1982: Coming to Grips with Wood Quality. Forest Chronicles. pp. 254-257; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

MENR 1995: Kenya Forestry Master plan.

Mckimm, R. J. and Ilic, Y. 1985: Characteristic of Wood of Young Grown Trees of *E. nitens* with special reference to Provenance Variation III. Anatomical and Physical Characteristic. Aust. For. Res. 17: 19-28; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

Nelson, V. 1965: Heartwood Formation as a Physiological Ageing Process. IUFRO Meeting Session 41. Melbourne; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

Panshin, A. J. and De Zeeuw, C. 1980: Textbook of Wood Technology, McGraw-Hill, New York. pp 722.

Palmer, E. R.; Gibbs, J. A. and Dulta, A. P. 1982: Pulping Trials of Wood Species Growing in Plantations in Kenya. Tropical Products Institute. London. pp 57.

Purnell, R. C. 1988: Variation in Wood Properties of *Eucalyptus nitens* in a provenance Trial on the Eastern Transvaal Highveld in South Africa. S. Afr. For. J. No. 144, March; 10-22; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

Taylor, F. W. 1973: Variation in Anatomical Properties of South Africa grown *Eucalyptus grandis*. Appita 27 (30; 171-178; cited in Githiomi, J. K. 1992. MSc Thesis University of Melbourne, Australia.

THE ROLE AND STATE OF FOREST PRODUCTS RESEARCH AND DEVELOPMENT AND ITS IMPACT ON THE DEVELOPMENT OF FOREST INDUSTRIES IN KENYA

B. N. CHIKAMAI
Kenya Forestry Research Institute

1. INTRODUCTION

Forest products research is a branch of forestry concerned with improving utilization of forestry resources through Research and Development. A number of organizations in Kenya are in one way or another involved in achieving this goal. The most notable are Kenya Forestry Research Institute, Forestry Department, Kenya Bureau of Standards, Ministry of Public Works, some of the national universities (Moi University, University of Nairobi and Jomo Kenyatta University), technical institutions and wood based industries. Within Kenya Forestry Research Institute, the Forest Products Research Programme is vested with this responsibility. Its role is two-fold: i) to undertake research directed towards promotion and extension of proper utilization of wood and tree derived material; and ii) to provide advisory services to forest based and related industries and the general public on all aspects of wood technology.

The Forestry Department's main responsibility is to improve the production of timber and to promote various forest products through FITC and TPPC respectively. The Kenya Bureau of Standards is the custodian of standardization of both wood and non-wood products while the structural department of the Ministry of Public Works is involved in the use of Forest Products in construction. The major role of the three national universities (Moi University, University of Nairobi and Jomo Kenyatta University) is training human resource in the use of forestry resources. Moi University is directly involved in training scientists (wood scientists) in the science and technology of wood and derived material while the other two universities are involved in offering training on some aspects of timber engineering. A number of technical institutions offer training in masonry, carpentry and joinery as well as wood tanning that go a long way in improving the use of wood. Finally, a number of wood and non-wood based industries have their own laboratories/workshops where some aspects of research and development of their products are carried out.

2. FOREST PRODUCTS RESEARCH AND DEVELOPMENT

Whereas a number of organizations are involved in some aspects of research, the bulk of R&D is carried out at the Forest Products Research Programme (FPRP) of KEFRI which will form a greater part of the dissension that now follows.

KEFRI's strategic plan to the year 2000 has identified three priority areas of R&D for forest products research; i) ensuring most efficient use of tree/forest products in industries and domestic sector, ii) development of new forest products, and iii) ensuring more efficient extension and marketing of the products.

The programme has developed a research and development plan to address the above goals that are being implemented through its two sub-programmes; the Wood Utilization and Non-Wood Forest Products. Salient research activities include:

2.1 Efficient Use of Plantation Timber for Structural Purposes

The activity has been carried out in the programme since 1985 except that its scope got expanded in the 1990s. The current project has four components; timber grading, structural size testing, trussed rafter and development of a design code. It is funded by the governments of UK (through ODA) and the Kenya government through MRTT (for KEFRI), MENR (FD), MOPW (Structural Department) and MOC&I (KEBS). ODA has seconded an engineer to the project who serves as project coordinator. The project is thus multi-disciplinary in approach with the overall objective of enhancing the efficient use of timber for structural purposes in the construction industry.

2.2 Biomass Energy

This is an area that has received a lot of attention since the 1980s and significant developments have been realized in some areas in the country. One area is the development of community/farm forests for provision of firewood and to some extent charcoal. However, the greatest development has been in the area of biomass utilization stoves where the famous Kenya Ceramic Jiko (KCJ) has become a household name. Other stoves using both charcoal and fuelwood have since been developed and adopted to varying extent.

The area of biomass conversion is one where KEFRI and the FPRP in particular, have made valuable contribution. From research carried out since the late 1980s, the institute has developed improved earth kiln and successfully adopted with modification, technology of using drum kilns. Both these technologies have become popular among charcoal producers and are currently being extended in Kajiado and Laikipia Districts. However, it must be noted that technology transfer did not take place immediately resulting in a lag-phase in adoption. The area of briquetting using plant gums as alternative binders to corn starch was also developed and has successfully been adopted by women groups in Isiolo District through initiatives of Saltlick, a locally based NGO. Effort to improve the technology is continuing.

2.3 Furniture Making and Design

This area is the focus for current design and furniture making initiatives in the programme. Started in the late 1980s, one of the major break-through is the adoption and further innovation in the production of laminated products popularly known as fancy items. Unique success was achieved by combining art (the skills) and science (the principles) where talent from local artisans was harnessed alongside knowledge of the properties of wood and different adhesives (glues) to produce durable products with high aesthetic value. This technology has been generously shared with the department of prisons who have become the main beneficiaries as well as our partners in development.

Meanwhile, we have carried out a survey of furniture production among 8 major industries; Mortise and Tenon, Furniture Master, Interior Designs, Victoria Furniture, Tobina, Kiambu Institute of Science and Technology, Prisons Industries and various Jua Kali workshops. The aim was to identify different technologies in use for furniture production and constraints. Thus, besides learning from leaders in the furniture industry, we have identified areas which require research attention. The Forest Products Research Programme has began to examine some of these areas at its workshop. The completion of the show room at Karura is in particular going to assist in demonstrating initiatives in furniture production.

2.4 Non-Wood Forest Products (NWFPs)

The area of NWFPs is one of the most active in the programme. The NWFPs activities were also initiated in the late 1980s at two different levels. The area of herbal medicine was an initiative began at the KEFRI headquarters coordinated by a chief scientist with the initial objective of documenting different plant species used by herbalists in the country. The scope has been broadened into a group of activities referred to as plants for life. About the same time, concerns in the potential of Kenya in plant gums and resins stimulated interest at the FPRP (Karura) to initiate some investigations. This was boosted by a consultative meeting of interested parties organized by the Ford Foundation. Recommendations of the meeting formally launched the programme into research on plant gums and resins, in particular, gum Arabic, myrrh and frankincense using Isiolo District as a pilot area. The current development in commercial production of these commodities in the country is the result, in part, of the initiatives undertaken by KEFRI. Meanwhile, need also arose in the rosin industry with respect to improving field production methods. This was undertaken between 1989 and 1991 resulting in guidelines on profitable oleoresin tapping. Additional work however, is still required for radiata pine, as well as improving recovery of rosin and turpentine by the industry. The area of NWFPs was recently strengthened by the new laboratory facilities at KEFRI headquarters, thanks to support from JICA.

2.5 Some Considerations for Improving Research and Development in the Country

Despite valuable developments realized in KEFRI and the country in general, R&D in forest products is still a long way from being considered as satisfactory. A number of factors seem to be responsible. Foremost is the lack of adequate infrastructure and resources to implement research needs. For example the FPRP is not adequately equipped to tackle most of the problems facing the industry. Its laboratories are still lacking some vital equipment required to carry out the analyses. The financial resources are low and far apart. The human resource was until recently inadequate in the relevant skills (i.e. new scientists and with limited experience). This scenario applies to other institutions and even to the wood based industries.

The second factor is poor coordination. Each institution tends to operate independent of the other. For example, the linkage between FPRP of KEFRI and FITC and TPPC of FD is weak despite the complimentary roles undertaken by each. Valuable R&D information has been generated at FPRP but merely lying on shelves due to inefficient extension and marketing strategies while at the same time there are many areas which still require attention, but which are not brought to our notice. Linkage with other institutions especially, the primary wood processing industry is even worse. Though insufficient resources (equipment and human) have been cited in the past as contributing to poor linkages, the industry has a high affinity for relying on overseas laboratories albeit at an exorbitant cost. Independence in R&D undertaking among institutions and over-reliance by the industry on overseas research support are therefore the anti-thesis to efficient development of R&D in the country on the one hand and reason for under utilization of existing research facilities on the other.

Improving collaboration among relevant institutions and industries is a sure way of strengthening forest products R&D in the country. This could initially take the form of visits between/among the institutions to understand what each is doing and discuss areas requiring collaboration. In the case of FPRP (KEFRI) and FITC/TPPC (FD), joint visits to relevant wood based industries to identify needs and areas requiring interventions could be organized. The FPRP is currently working on the concept of wood use centers as a basis for generating, developing and extending various wood based technologies.

SESSION 9:
KEFRI 10TH ANNIVERSARY

A DECADE OF KEFRI'S RESEARCH PROGRESS: CHALLENGES AND ACHIEVEMENTS

P. K. A. KONUCHE and B. N. KIGOMO
Kenya Forestry Research Institute

SUMMARY

Development of forestry research in Kenya has closely followed issues of forest management needs as defined by the Government forestry policy, 5-year development plans and occasional sessional papers. From the 1930s to about 1980, most efforts in forestry development were mainly directed to the raising of exotic plantation species. Forest research was thus biased towards the development of industrial plantations and their management. From 1980, the government directed more attention to the development of indigenous forests, the farmlands forestry and forest development in the arid and semi-arid areas. Forestry research support thus shifted to these areas as emphasized by the last three 5-year Government Development Plans.

1. KEFRI ESTABLISHMENT AND RESEARCH AGENDA

Kenya Forestry Research Institute (KEFRI) was established in 1986 when these "new" challenges in the development of forestry were at their peak. The immediate tasks for the Institute were: to develop research facilities and undertake relevant training of its young scientists in line with the required areas particularly in the social forestry, agroforestry, ecology, drylands silviculture, biotechnology and other areas, including the traditional forestry disciplines.

Priorities have been identified in the need for: rehabilitation and afforestation of the arid and semi-arid areas; and social forestry including agroforestry, community forestry, socio-economics, herbal medicine. Also in the lead are concerns on the declining natural vegetation where their sustainable management, resultant environmental issues and biological diversity have been addressed. Effective avenues for the transfer of the Institute's research outputs have received considerable support, both by the Kenya Government and donor agents.

2. DEVELOPMENT OF RESEARCH FACILITIES

2.1 Capacity Building of Scientists

Through the support of Japan International Co-operation Agency (JICA) and Federal Republic of Germany (FRG), the Institute has acquired well equipped laboratories and office buildings at Muguga, and Kitui. In collaboration with the International Centre for Research in Agroforestry (ICRAF) research facilities have also been developed at Maseno.

To date, KEFRI has a total of 103 graduate scientists, 892 technologists and technicians. The young scientists have participated in numerous short-term courses; 9 have been trained to PhD level and 45 to MSc level. There are some 29 scientists at BSc. level and there are 20 who are either on MSc. or PhD training. Almost all of the latter group have served the Institute for five or more years.

Training of scientific staff has been geared to address the forestry management gaps identified as priorities in the last three 5-year Government Development Plans and more recently in the Kenya Forest Master Plan (MENR 1994).

The young scientists in KEFRI have developed remarkable leadership in these areas and have, either individually or in collaboration with other institutions and NGOs, undertaken research that has shown directions for effective natural resource management and improved land productivity.

2.2 Challenges and Achievements

Research in arid areas has developed methodologies for establishment of exotic and indigenous tree species both under rain-fed and irrigated conditions. Results of this effort has gone a long way in the rehabilitation of the disturbed natural vegetation and diversification of biological diversity. Drylands research has introduced, in particular, *Prosopis juliflora, Eucalyptus camaldulensis, E. tereticornis, E. microtheca* and *Melia volkensii* in the dry environments. Over 100 species/provenances have been screened for site/species matching and water harvesting techniques for improved tree survival and growth. A drylands forestry manual has been published.

Research in Agroforestry has concentrated on the improvement of crop and fodder production in farmlands. Efforts have also been directed to the improvement of farming environment situations and widening tree species biological base for integration into farming systems. *Leucaena diversifolia, Grevillea robusta, Calliandra calothyrsus, Gliricidia sepium, L. leucocephala* and *Sesbania sesban* have been integrated in to agroforestry farming systems. Without the use of fertilizer, crop production has been increased by 30% per unit area through improved agroforestry technologies. KEFRI has collaborated very closely with ACIAR of Australia, ICRAF, FINNIDA of Finland, JICA of Japan, DANIDA of Denmark and IDRC of Canada in agroforestry, and drylands woody vegetation research initiatives.

To enhance and diversify productivity from forest resources and to improve wood conservation, KEFRI scientists have recently gone into energy saving technology research, and non-timber forest products research. Research is going on to look at potentials and methodologies for production of gums and resins from natural and plantation forests, potentials for production and extraction of bamboo and rattan for use by local people, the role of natural vegetation as sources of herbal medicine and conservation strategies for useful local germplasm of trees and herbs. Guidelines for management and production of bamboo and extraction of gums and resins have been published. IDRC, Earth Watch and ODA have worked with KEFRI in the implementation of these research activities.

The Convention on Biological Diversity was intensively discussed and was signed at the Earth (Rio) Summit in June 1992. This created another dimension of interest in the conservation of local natural vegetation resources. KEFRI had long before recognized the need for gene conservation as bases for future resources development. Several programmes have carried out intensive research and have established a national network of seed orchards, seed stands, and clonal banks. The Institute hosts the only Forestry Seed Centre which also has a network of seven National Seed Collection Centres. This centre undertakes a useful programme in enhancing the bases for tree and forestry biodiversity while controlling the in-coming and out-going quality of forest seed germplasm. Over 1,000 ha of seed production stands have been established and a capacity for training on seed collection and handling has been adequately built up. A Tree Seed Handbook of Kenya has been published. The Federal Republic of Germany through GTZ and the Kenya Government have supported this centre concertedly.

Silvicultural research efforts were made in developing techniques of raising plantations without the "Shamba System". Efforts were also directed in eucalyptus species management, and the establishment of superior germplasm of *Casuarina equisetifolia* at the Coast. Tree improvement research also made improvement efforts on *E. grandis,* and genetic conservation of *Populus ilicifolia* (Tana River Poplar). The breeding programme of *Pinus radiata* a species earlier abandoned due to attack by *Dothistroma pinii* has been revisited. Demand by the pulp and paper industry rekindled this effort. This is a joint initiative with the Pan African Paper Mills, Webuye.

Nature Reserves were established in natural forests as gene conservation units in various representative forest vegetation types. In collaboration with World Wide Fund (WWF) and the National Museums of Kenya, KEFRI has recently undertaken investigations leading to the understanding of the usefulness of these germplasm conservation units. Recommendations have been made on the best options for management of National Nature Reserves. The last five years have occupied a number of scientists with biodiversity research. Both ecologists and socio-economists have been involved and local communities have played a key role. Main collaborators have been the ODA through KIFCON and FINNIDA through the development of the Kenya Forestry Master Plan. A collection of data bases and reviews on national biodiversity has been carried out in collaboration with the ACTS, NES and IUCN.

KEFRI has also initiated a programme that will undertake research on a multi-disciplinary base, on ecosystems management with support of the FRG through GTZ. The research programme focuses on integrated forest management and production on sustainable basis while improving the capacity in this area of forest production.

The multi-purpose tree research activities by the Agroforestry scientists and the herbal plants research activities by the Non-Timber Forest Products Division of KEFRI have gone a long way in developing technologies and avenues for conservation and utilization of biodiversity in farmlands. IDRC has been the main collaborator and supporter in these initiatives.

The Forest protection research paid adequate attention to the outbreak of diseases and pest attacks. Two bio-control agents have been identified to control **cypress aphid**. Two natural enemies of *Leucaena psyllid* and a borer of *Sonneratia alba*, a tree of the mangrove ecosystem, were also identified. Release of the natural enemies of these pests is underway. Mycorrhizal and rhizobia research were intensified with a view to finding out the impact of the organisms' association with trees on forest production in Kenya.

For the last 10 years, KEFRI has developed linkage avenues for the transfer of research output to extension officers and to other end users. Two Social Forestry Training Centres were established at Muguga (National level) and Kitui (Regional and providing training at grassroots level). KEFRI scientists, in collaboration with other ministries, conduct courses that are relevant to farm forestry practices. The main target are extension officers and local group leaders. Eight courses are conducted every/each year which include 1 for Provincial Officers, 2 for District Forest Officers and 4 for Divisional Forest Extension Officers. Other participants come from Ministries of Education, Agriculture and Livestock Development, Culture & Social Services, Physical Planning and NGOs. A course is also mounted for the District Environmental Officers. The Institute also offers courses on special requests particularly from NGOs. Teachers' courses have become popular and both Centres have conducted several of these. Surveys are undertaken on annual basis to look out for farmers who have developed innovative farm forestry practices. A Social Forestry Prize Day takes place every year in April or May. Farmers present their experiences in tree and agroforestry practices. The competition has been extended to schools. JICA in collaboration with the Kenya Government has played a crucial role in the development of Social Forestry outreach within KEFRI.

To enhance land productivity and effectiveness of the KEFRI research programmes, soils research activities were introduced and have greatly expanded over the decade. Management support of research activities also expanded through recruitment of more trained and experienced staff in the administration, human resource, supplies and finance divisions.

Considering the importance of easily understood research output, KEFRI also produces a quarterly Newsletter, **Technical Notes and Occasional Guidelines** that summarize results of its research work in a form that is easily understood. The target groups of these publications are mainly the extension officers, forest managers, NGOs and schools. KEFRI also collaborates in the development and production of the **East African Agricultural and Forestry Journal,** which is published by KARI. The Institute recently expanded the Library facilities and has an up-to-date Tree CD-ROM package.

Considering the changing needs of forestry development in Kenya, KEFRI is currently in the process of reorganizing its research programmes. The restructuring is anticipated to improve the delivery of results and address the mission of the institute more adequately.

SESSION 10:
INTERNATIONAL LINKAGES AND TECHNOLOGY

THE ROLE OF THE PRESS IN PROMOTING AWARENESS IN FORESTRY MANAGEMENT AND ENVIRONMENTAL CONSERVATION IN KENYA

PAUL BARASA
Kenya Forestry Research Institute

SUMMARY

The press has been taken to stand for the media that is responsible for gathering news and disseminating it to the public. In more recent times the word "press" has come to be interchangeably used with the word "Mass Media". Whether the word Press or Mass Media is used, the underlying meaning is that these are instruments of communication.

For scientific communities like other professionals, communication through the Press has been rare partly due to the desire to uphold standards and fear that the context may be diluted with journalese or by the press people who have been too shy to delve into scientific jargon as it takes them a long time to comprehend.

1. INTRODUCTION: Origins

The conceptualization of press as a tool for informing the public is changing rapidly. The media is gradually assuming a position of promoting and not merely recording. It is no longer the passive board where information is written for all to see. This rapid change in roles has a lot of bearing on our changing cultures and life styles.

Previously, the media was predominantly controlled by National Institutions or, more precisely, by Governments. Leading Newspapers and radio stations at the beginning of the century were in the hands of Governments. As growth in industry and trade gained momentum, business technocrats slowly started using fliers, company inscripted banners, and posters to advertise their commodities. But the most drastic changes came with the advent of the first world war. The Jewish but ostensibly the American Coca-Cola company was the first to put its mark firmly on the electronic media by saying. *"You will know civilization has reached a place if you find a bottle of coke there"*. This spurred the fighting American soldiers to put civilization into the world through "a bottle of coke". Of course, the allies won the war and "freed" the world from Nazi, Italy, and Japan. But the rest of the world suddenly realised that it was a right to be independent.

As communism and the struggle for a share of a foothold in the "freed" lands grew, communist states started setting up independent radio stations to help independence movement struggles to be heard. Kenya had its "Radio Free Kenya" transmitting from Egypt just like France, during the Nazi occupation had its "Radio Free France" transmitting from England. It was predominantly a propaganda media, but became the precursor of our present-day independent mass media.

2. MASS MEDIA POSITION IN KENYA

Walking through the streets of the major towns in Kenya, one is overwhelmed by the variety of Newspapers and Magazines on the street. Most dominant of these are the "East African Standard, the Daily Nation, Kenya Times, Drum and the Weekly Review". In the electronic media, there is the Kenya Broadcasting Corporation Radio and T.V., and the Kenya Television Network.

3. TRADITIONAL MASS MEDIA ROLE IN KENYA

If newspaper reading was not becoming too expensive for an average Kenyan, it would have been advisable to at least buy two papers daily and view news on at least two T.V. channels. Many of us are confined to either one paper or one T.V. channel depending on our preferences.

The electronic media in this country is predominantly pro-the establishment and more towards sustaining the political status-quo. Listening to and viewing KBC radio, T.V or KTN gives the impression that the material is edited by one supervising editor. The differences being the brevity of KTN material as opposed to a heavy dose of opinion on KBC.

In the print media area, the differences are in detail as opposed to policy. As a political party newspaper, the Kenya Times tends to give prominence to views favourable to the stake holders. This is good and desirable for any party organ. The Standard and the Nation are less inclined in their political bias but are heavily in support for maintaining the status quo for the sake of commerce and industry. In 1992 when Joseph Mugalla called for a National strike for workers to get a pay hike of 100%, the print media was cool although sympathetic. The electronic media was very critical. In both situations, the government and traders were hit by the Mugalla call where it hurts. The strike fizzled out leaving all of us where we were previously.

Now, how is news gathered and used? In Kenya, all mass media organizations have their reporters who gather news. They also depend on wire lines form established News agencies. For overseas news, KBC depends on the signal from Reuters, whereas KTN depends on CNN. But even dominant news agencies still borrow a lot of news footage from each other, but at a cost.

4. THE ROLE OF NEWSPAPERS

A visit to any news room of a Newspaper will reveal the presence of short wave radios, teleprinter lines, T.V. screens, and both written and typed news material. Newsrooms always have large baskets or dustbins for used or discarded newspaper material.

Every morning, there is an editorial meeting or "morning prayer session". In this session, the editorial content of the next days paper is determined. It is at this session that reporters are assigned to different News points. However, the news still has to be edited as it comes in from the field. Editors are trained to be superstitious. If they know something about a particular news story then the story is not good enough and must be put on hold for use only if no other fresh story comes. Another rule that editors go by is comprehensibility. Is it easily understood? Do I need a dictionary to read it? If it is difficult to understand then discard it. This explains why there is a big basket in the newsroom.

Since newspapers are now run as business enterprises, there is a big tendency towards commercialization. A great deal of any newspaper is devoted to commercial advertising. Forty five percent of most popular newspapers are taken up by advertising space. For example, in the Daily Nation of Wednesday March 13, 1991, thirteen pages out of 28 were devoted to advertisements. This gives revenue of roughly Kshs. 1.3 million.

1.2 The Current Approach

In that same newspaper all lead stories were political and took up three pages, International news took up three pages, sports news took three pages, and environmental news took up less than 1/48 of the newspaper and was only related to what a DC did and not to the Agricultural committee meeting which the DC was attending. Perhaps that item would not have been there at all if a lesser personality than the DC had said it. The question from such a scenario is, is it morally justified to allocate so much space to politicians at the expense of other issues? or, is the environment of such little consequence that it only gets 1/48 of the total newspaper space?

What is found in Newspapers is almost duplicated in the electronic media. Political news always take prominence, followed by sports in Kenya. You will generally find documentaries on the environment in the electronic media at off peak hours. Prime time is left for what is considered programmes of commercial interest. These are dramas, comedies, soap operas and expositions on consumer products.

5. HOW ENVIRONMENTAL NEWS SHOULD BE MANAGED

Despite very noble sentiments on the promotion of forest management and environmental conservation, the media will still shunt it out of the system. Forest issues are still not political enough. We must look for ways of politicising forestry. I have no idea how this can be achieved but I know that it can be done. If KTN can give a two minute air time to a naked uncircumcised city Urchin, they should certainly give a minute to the promotion of forest management, because without forests, we shall be all exposed naked.

Towards the end of 1992 I had a two year old boy who was just learning to speak. That was the period of great political activity in Kenya. My boy had a penchant for TV and would move very close to it. And when I would come from work the boy would greet me with a KANU salute and say "*Chogo*", instead of "*Jogoo*". He also knew that Moi was "*Mutukufu Rais*" while the "*President*" was George Bush. Continuous exposure to the same message on T.V. had given a kind of exposure to my little boy. I am sure that even grown-ups also find their thinking influenced by the media.

For example, I like eating my bread with blue band margarine and I also enjoy instant coffee. The wry side of the coin is that "blue band" is only a brand name and its only one among hundreds of other margarines in the world. My love for coffee has also been influenced by the media. I think it is more wholesome to have my own coffee beans ground at home but my family buys the instant type, with a lot of my tacit consent.

Without appearing to be propagandist, we have to get out and reach the media. We have to cut into the 15 pages of news print and command a stake in the electronic media. I am saying that we have to pay for our entry. We are already paying a cost remaining unknown by leaving the media to discover us. Let us discover them. We deserve to be on the popular media because we are good and people depend on us. Every year we should have publicity as a deliberate item of our development budget.

We need to cultivate a relation with the media. The media has to be kept in close contact. They have to be turned into allies to fight on our side. Our relation is currently characterised by "now you see me, now you don't". That has to stop. We need to maintain a relation even if we have no news to offer. Why does Coca-Cola always bombard us with "This is IT" and "Always Coca-Cola". Is it because we might forget about their existence? or is it because Coca-Cola has changed its contents? Coke has always been coke and it is known even in the remotest village. They advertise merely to foster the relation already in existence. You don't just sit back when you are the best, you must keep going. Good enough is not good enough unless it stands out for itself all the time.

6. HOW WILL THE MEDIA HELP?

I always remember what KBC said when they were first informed about the invasion of the cypress aphid. I had worked for KBC and was very enthusiastic to give them exclusive news on the exotic insect pest. I was told to pay to have the news item on air. The marketing manager gave me concessionary rate of KShs. 5000 to air the news. He was a friend of mine. We had worked together for ten years. You can imagine my disappointment. But two weeks after my encounter with KBC, things changed completely. The vice president went to examine damage caused by aphids in his constituency, and all the media now wanted to carry the news. They swarmed on me, Dr Odera, and Professor Mwangi. We became the media celebrities.

This leaves one question. At what level does information qualify to be news? It is a pity that even the best journalist in the world does not know the definition of news. There are many examples of news but quite a lot of news is thrown away by editors as non-news. This is letting down the community.

The mass media is the easiest means to reach nearly all humanity. The print media should not abdicate responsiblity in the promotion of the environment. Managing editors should start training reporters in forestry to give enlightened coverage. Space should be set aside to be filled with news on environmental matters. The print media being on paper form is an easier medium to carry to even a village situation. It can be kept stored and referred to. It can also be passed on.

The electronic media has a role too. Whereas the print media has a permanency of information, the electronic media has an immediacy. It is easier and faster to reach people with the electronic media than with the newspaper. Of course, internet is changing the whole conceptualization of news. The Standard Newspaper is, understandably, already on internet. The Nation has also entered the internet. Kenya has not officially permitted wide use of internet and only a few organizations have been granted operating licenses. But I believe it is a matter of time before the Government Liberates the International Super Highway. Uganda and Tanzania have already opened up to Internet. The U.S. government has already offered to underwrite the initial cost of internet in Kenya. Without wishing to sing praises of the American invention, I still think that internet will reduce the cost of reading a newspaper. It costs less than KShs. 6 to access a whole newspaper whereas the fiscal cost of a paper is already KShs. 20. Internet also permits one to access information in libraries without having to visit them. But I don't know if Internet can be classified as part of Mass Media. It still requires time to mature. I don't know how intellectual rights will be protected under internet.

7. CONCLUSION

Mass media will continue to have a role to play in the promotion of forest management and environmental conservation. The print media heavily depends on forests and it is in their best interest that these be exploited sustainably. Secondly, we all know too clearly the consequences of not conserving our environment: global warming and drastic changes in climates. Life as we know it today would collapse and we would cease to exist if our environment is not conserved. We would have no fresh water, no food and no trees to support our ecosystem. It is the role of the mass media to inform and promote life, it is their role to promote forest management and environmental conservation. But the biggest task lies with us whom God has entrusted with the protection of forests and the environment. We should get out there and proclaim our message again and again.

THE ROLE AND IMPACT OF DONOR SUPPORT IN THE DEVELOPMENT OF THE FORESTRY SECTOR IN KENYA

PAUL RYAN[1]
Forestry Specialist, World Bank Regional Office, Nairobi

1. INTRODUCTION

1.1 Historical Context

Going back to the early 1960s we find that a major share of investment by the Bank, and at least certain donors, was in industrial forestry, both in Africa and in other parts of the world. In fact, this period and through the 70s saw major investments in developing countries in industrial plantations, as well as in both mechanical wood industries. Interestingly enough it was also a period during which much inventory of indigenous forests was undertaken, often on a fairly large scale, even on a national basis, in some instances. It was during this period, from 1970, that the Bank commenced investment in the industrial plantations in Kenya, subsequently assisting with the establishment of some 120,000 ha through to 1988 with $47 million in loans or credits out of a total investment of some $110 million.

During the mid to late 70s, under the then Bank Forest Policy (1974), there was a major shift away from industrial forestry and into "social forestry" or "agroforestry", with the focus being rural populations and the need for these people to grow trees, but with a certain emphasis on the need to close the woodfuel "gap".

There is much that could be commented on here about the understanding of what we were doing to the efficacy of the projects that were financed but now is not the time. Suffice it to say that the switch from an industrial forestry mentality to dealing with social/farm forestry had its problems. There were many misconceptions, particularly about the rationale for interventions, and the approach was very much top-down, but there were also many lessons learnt. Many donors were also involved in similar strategies.

Over the last four or five years there has been a further shift in Bank policy and its approach to forestry projects or programs. The emphasis has been on environment and conservation. Forestry projects involving production usually are considered private sector ventures and projects are designed to support this concept. The emphasis has also swung back again to more of a sectoral or even multi-sectoral approach, rather than more sharply focused interventions. On the other hand the project approach, with often a limited time horizon, has given way to a program approach in which any one project would be part of a time slice. Among many of the bilateral donors there continues to be a more focused approach to social forestry programs, but with environment also playing a much bigger role, particularly with regard to indigenous forests.

Presently, and for the last two to three years, the Bank's approach to forestry investment has followed the new policy (1992) i.e. to enhance the environmental contribution of forested areas, promote afforestation, assist with poverty reduction and improve interventions to assist women in relation to forest product development. There is greater emphasis on forest management within a broader integrated land use approach. There are cross sectoral links that need to be not only noted but operationalized into partnerships, e.g. with agriculture and with energy.

[1]The views expressed in this paper are the personal views of the Author and not necessarily those of the World Bank.

The strategy to achieve this in Sub-Saharan Africa has involved the following principal elements:

- Ensuring that policies and legislation are appropriate, providing the correct incentives for such concepts as greater involvement of the private sector in forests development and management as well as discouraging wanton destruction of the forest resources or their inefficient use. Many of the forest policies, until at least recently, dated from the 1950s or 60s.

- Reorganizing, revitalizing forestry agencies to adapt to the updated role such agencies have to play e.g. in relation to private and community participation, while improving capabilities in fields such as resource assessment, sector planning, and environmental management.

- Involving local communities and the private sector in forest management and conservation as well as in afforestation programs supported by the correct market incentives.

- Improving knowledge of the forest resource (extent, nature, and commercial yield potential).

- Provision of the appropriate applied research, that is demanded from the field.

An underlying principle is that forests and tees have value. This value has two facets. One is the market or tangible value when one takes the trees or forest products as a commercial, or even a subsistence crop. The other is the intangible value, often linked with environmental and biodiversity roles of the forests. It is important that fair value be assigned to forests and to forest products and that the value for the latter be collected by the appropriate managers, which may be local communities, governments, or individuals.

All these policies, strategies and programs are rather meaningless without the governments concerned explicitly recognizing the economic and environmental value of the forest estate, whether it exists as woodlands, indigenous high forests or plantations. Recognition of these values means that not only forestry or environment policies and legislation reflect the need for and means of achieving proper conservation and management, but that policies and legislation of related sectors also reflect this need, while at the same time catering for the demands for other forms of land use, but on an integrated and environmental as well as economically rational basis. Kenya is moving in this direction with the new Forestry and Environmental policies, but more integration is required with other policies and practices.

2. WHAT IS HAPPENING IN KENYA NOW?

The Fourth World Bank Forestry Project (Forestry Development Project [FDP]), that was appraised in 1990 was supposed to be a first time slice for a term subsector wide forestry investment program. The primary thrust was supposed to be to assist the Government translate into action its stated commitment to natural resource management and conservation; accelerate the process of policy planning and legislation; and work towards better coordination of donor assistance. More specifically, the objectives of the project were to:

- enhance conservation and protection of indigenous forest resources as well as soil and water;
- alleviate the accelerating fuelwood deficiency;
- improve the efficiency and financial viability of timber production; and
- establish a framework for the subsector's long development.

These objectives are achieved through the following components:

- Farm Forestry Extension
- Indigenous Forest Management and conservation
- Industrial Plantations Development

- Strengthening of FD's Central Functions
- Forestry Education
- Forest Research
- Forestry Master Plan.

All this would have provided a very solid foundation for further forestry work, with the essential basis being the formulation and passing of an updated forest policy, that in turn would support prioritized investment programs drawn up in the Forestry Master Plan as part of a forestry development framework, owned and controlled by the government, but specifically by FD. Unfortunately, all has not come to pass as was proposed and Kenya is still searching for that clear forward vision for forestry, supported by wholesale government commitment to the subsector.

Project effectiveness of FDP was delayed by some 18 months until conditions for effectiveness had been met, following institutional difficulties experienced in the previous project. In the process several donors decided not to undertake previously proposed co-financing of farm forestry extension, forestry research, and education. The Overseas Development Administration (ODA) undertook a revised version of the Indigenous Forest Management and Conservation component (KIFCON), but this program stalled after the two year inception phase through inability to reach an understanding with GoK on an agreement for a subsequent phase. However, in 1995, the European Union started a project on conservation and management of indigenous forests (COMIFOR) around Mt. Kenya and on the coast, while FINNIDA is likely to start a similar program for the two other indigenous forest areas, including Kakamega Forest Reserve. FINNIDA undertook the financing of the Forestry Master Plan, which was finalized in 1995. On a separate basis, forest research has been and is currently being supported through both GTZ and Japanese Aid (JICA) funding. GTZ has also supported forestry education at KFC for several years now, with some inputs also from FDP (IDA).

At the same time there has been some excellent, but localized work done on forestry extension for farms through the FINNIDA funded "Miti Mingi Mashambani" Program in two districts in the Rift Valley, while DANIDA has funded farm forestry in Western Kenya and JICA has had a program of social forestry in several semi-arid districts. SIDA decided to undertake farm forestry extension through the Ministry of Agriculture. The World Food Program has also recently started a five year program covering support through food aid for forestry extension and industrial forestry, with the former being the priority.

3. IMPACT OF DONOR EFFORTS AND ISSUES

I, obviously, can't evaluate what the impact has been of other donor programs over the last few years, not being closely involved with these programs. But at the risk of making general observations from reports received, meetings held and field visits, I would like to offer the following comments.

The Forest Policy, together with associated legislation, is well on the way to being passed by Parliament; we hope by October, 1996, and these should form a good framework to support future forestry development and conservation. The process for formulating the policy, although somewhat delayed from the original schedule did include a number of fora for debate and comments by both other government agencies as well as the private sector and NGOs. A similar process was used to publicise the Forestry Master Plan, with comments being invited from a number of sources. However, since finalization of the Master Plan there has been virtually no action by MENR or FD to present to donors the government's priorities for forestry development in Kenya. At the same time FD has been slow in establishing a solid Planning Section in FD that should have emerged from the Master Plan process. The end result is that donors continue to decide what they think is best for investment regarding forestry in Kenya without having solid government directions as to what the government feels should be investment priorities. At the same time, the government has to realize, if they don't already, that the Master Plan should not be regarded as a one-time exercise. Planning is a dynamic process and has to continue on a constant basis. In fact there are a few things about the Master Plan that should be updated as soon as possible, being deficiencies to start with. These include information on the resources as well as on the markets for all forest products, nationally and for export. In other words more reliable data to provide rationale for prioritizing meaningful interventions is needed.

FD & MENR need to be more active in using the KFMP to set their forestry development priorities with the donors.

From my perspective, investment priorities need to focus on priority needs. These include an increasing demand for both industrial roundwood, poles and woodfuels to assist in raising rural incomes through farm forestry; and a need to protect forest-based ecosystems encompassing a fantastic array of endemic biodiversity from increasing pressure on land, for both agriculture and settlement. There are several associated support investments required. The first of these is the establishment of reliable information on the current and projected demand for both industrial wood products and wood fuels with particular reference to urban wood fuel demand. Secondly there is a need for applied research to support improved yields and more cost-efficient production of industrial roundwood poles and wood for fuel. Thirdly, there is the need to establish a broader-based and effective extension system to support farm forestry.

As I have mentioned above, work is ongoing in several of these areas from industrial plantation development and management through research and extension. However; there is much more that has to be done and on a more coordinated and focused basis.

But all these strategies and plans are just ideas and words unless the government, at the highest level, recognizes these same priorities and supports, actively, the resulting programs, both in themselves or through rational supportive policies and actions. At the moment this support could be questioned in some instances, as in the case of industrial plantations.

Over the last 25 years the Government has borrowed and invested its own funds to the tune of $110 million equivalent. By the late eighties there was reportedly 165,000 ha of plantations. For some years after, this figure was quoted to be the area of plantations, though mapping and reliable inventories had not been done for many years over much of the resource. It became obvious during the first years of Forestry IV that the actual plantation area had been considerably reduced. The backlog of effectively replanted areas was estimated to be 20,000 ha. In addition, as later surveys under Forestry IV showed, some 20,000 ha were severely damaged (30-60% of trees injured) by game in the vicinity of Aberdares and Mt. Kenya. Within the standing plantations silvicultural operations had been neglected and as much as 100,000 ha had not received the required pruning and thinning (KFMP). All this was largely symptomatic of completely inadequate government funding for industrial plantation replanting and management in the four years following the end of Forestry III. In fact total recurrent and development expenditure by government on industrial plantations dropped from about 75 million Kenya pounds in 1980/81 to about 25 million pounds in 1994/95 with expenditures on personnel accounting for 75 to 80% throughout the period. It is highly unlikely that further World Bank funds will be made available for basic planting and silvicultural treatments, particularly with a revenue earner such as the industrial plantations. The Government will have to accept responsibility for such funding after Forestry IV closes.

Another issue related to industrial plantation management in Kenya is the very poor linkage between the wood producers (currently FD) and the users (forest industry). It does not make good financial sense to grow wood for a market without determining that market's demand and preferences, but that is what is happening to a large extent, in Kenya. At the same time, the industry operates in an environment that is not conducive to long term investment and efficiency. There is tremendous uncertainty within the industry about the future supply of wood resources. Until recently, under FDP, the state of replanting left considerable backlogs particularly in areas that are more accessible to industry. There was also a lack of cut control and very little in the way of harvest plans. This situation has now been largely rectified under FDP, though some 15,000 ha (including those severely damaged by game) require replanting. Inventories being carried out will also provide a better picture of the available resource and its status. Moreover, the industry in general only receives one year licences, with no guarantee if and where licences will be issued the following year. At the same time, with stumpage prices being below the cost of production or equivalent to the value of roundwood on international markets, there is little incentive to be efficient in production with recovery rates being probably as low as 25% in many small mills. As a result as much as 200,000 to 250,000 m³ of roundwood is wasted a year, the equivalent of production from 500 ha of well managed plantations costing Kshs. 10 million to establish.

But the question of excisions in industrial plantations is also of major concern to the industry. I know from field visits of some 6,000 ha that have or are being excised in western Kenya in the last four years and with further excisions known to be occurring in Nakuru District and elsewhere that figure could be as high as 12,000 ha. The reasons for the excisions vary, but the fact that the plantations are in many cases in high productivity agricultural areas raises the question of appropriate economic land use with increasing demands for agricultural land. The return of non-resident cultivation as a method of preparing land and then tending young plantations in conjunction with agricultural crops has provably provided a more justified economic use of the land and made agricultural land available for local farmers. However, the question that the Government has to answer is "Do they want a forest industry to supply locally produced wood products for an expanding market and possibly for export?". If the answer is "yes" then a decision has to be made concerning the industrial plantation estate. Perhaps some areas may go over to agriculture completely, but there should be sufficient area with secure tenure to provide the required industrial roundwood under reasonable management. Without such security, the validity of further investments in plantations is questionable particularly when many plantations excised are immature or cut for less than full value. With current annual allowable cuts from the plantations about equivalent to current demand it's likely that unless improved management under secure land conditions is effected then Kenya will be a net importer of wood products within 20 years.

If plantation land is secure then it would be a matter of improving the management and silviculture of that estate to optimize land use and produce wood as required by the market using the most cost efficient means. Research, as is currently being supported under the GTZ Promotion of Sustainable Forest Management Project, would be needed to achieve this, as would more consideration for cost versus benefits in plantation silvicultural operations such as planting espacement, thinning and pruning. In fact, there is need to, and there are opportunities for greatly improving plantation wood yields through applied research, including enhanced and reliable genetic planting stock and improved silvicultural techniques, including nursery practices. At the same time a more efficient plantations operations management approach needs to be taken with assurances of sufficient funding. FDP is about to undertake a consultancy to see how such can be achieved with the reorganization of the Forestry Department and greater involvement of the private sector being options.

The issue of sufficient sustainable supplies of woodfuels is or should be a concern. Firstly, though, it is necessary to determine the exact state of woodfuels demand and supplies, particularly as they relate to urban centres. Miti Mingi Mashambani (FINNIDA) has done woody biomass surveys in Nakuru and Nyandarua districts. The urban consumers generally prove to be the main offenders when it comes to environmental degradation of forest resources for woodfuels though the demand here is only a quarter of that in rural areas. The increasing use of improved jikos in rural households through several projects, including the Bank's National Agricultural Extension Project has definitely made many such households more secure in woodfuel. A biomass assessment for woodfuel catchments providing these urban centres is needed, as is being done in Uganda, Malawi and Ethiopia. This should be done in conjunction with a household energy and woodfuels marketing and distribution surveys. If there is a problem then the solutions probably lie as much in improving conservation and management of the dry woodlands, the main source of charcoal for the urban areas, as in planting trees.

If planting trees by villagers for fuel or other products is warranted, lessons can be learnt from Miti Mingi Mashambani. But this sort of forestry extension, in collaboration with agricultural extension (which is already doing much on farm forestry), needs to be looked at on a national basis and a national strategy and program developed, rather than continuing only in several districts.

4. CONCLUSION

In conclusion, I think it could be fairly said that forestry development in Kenya over the last five years has not been as advanced as was hoped for in the late 80's but progress has been made in many facets from policy and planning through investments in industrial plantations, farm/social forestry, forestry extension, research and education. With the Master Plan and the new Policy and Legislation in place there is now also a platform to invest in the future. This investment still needs a more solid rationale based on reliable information on forest resources and the demand for forestry related products as well as the need for conservation of valuable biodiversity. At the same time there are several key issues that need to be addressed, particularly by senior levels of government, including security of the forestry estate and greater participation of the private sector, if future investment is to be meaningful and sustainable.

GLOBAL FOCUS ON SUSTAINABLE FOREST MANAGEMENT AND DEVELOPMENT

J. ALBRECHT
GTZ

SUMMARY

Since Rio 1992, there is a fundamental shift in global forestry, i.e. to manage the transition from single-use timber exploitation to multiple-use sustainable forest management. This reacts to the changing human requirements on forests and on the threats that forest ecosystems are facing, either caused by over exploitation of natural resources or by changing environmental conditions.

In many countries, specifically in the tropical world, the frame conditions are not yet favourable for sustainable forest management. Principles, criteria and indicators are therefore being developed by various international environment-oriented NGOs. They are considered to be an orientation for development towards sustainable forest management and at the same time to be used for the certification of forest management units and for forest products (ecolabelling).

The main features of several catalogues are presented and discussed. For the management at field level, environmental impact assessment, community participation, conservation of biodiversity and research, among others, play an important role.

Recommendations are given on how Kenya can initiate her way to certifiable levels in forest management. This seems to be of particular importance as it is assumed that the compliance of criteria for sustainable forest management will be a criterion for donor support in the sector of natural resources management as well.

1. INTRODUCTION

Sustainability has become a goal as well as a condition for many projects and activities especially in development. Not many of the term's users may be aware that the term "sustainability" and the idea behind it emerged from European forestry as early as the turn of the 16th to 17th century, thus almost 300 years ago. Methods for sustainable forest management were developed a century later, at a time, when the forests in Europe were characterised by low productivity, impoverishment of the soils and erosion of genetic diversity. This was a result of overcuts, grazing and over use of dry wood for fuel and litter for keeping livestock warm in wintertime (Muhs 1993).

In the course of time, numerous definitions of sustainability in forestry have been used:

Sustainability of:

- the conservation of the forest area
- the wood production
- the highest yield
- the stocking volume
- the site productivity
- the revenue
- increasing yields
- socio-economic services
- multiple purpose
- protection functions

The most prominent definition is probably that of G. L. Hartig (1813): "*All wise forest management must have woodlands valued and endeavour to utilise them as much as possible, but in such way that later generations will be able to derive at least as much benefit from them as the present generation claims* *for itself*'. However, all these interpretations looked at forest management from the angle of human requirements and immediate utilisation (Figure 1). The consistently increasing rate of the tropical and boreal forests' depletion gave reason to the concern of people and organisations that these definitions and the consequent forest management practices do not consider sufficiently the sustainability of ecosystems and the necessity for self-regeneration of ecosystems before or after human interference as well as the genuine rights and interests of the indigenous people and the care for species, varieties and provenances of fauna and flora.

The United Nations Conference on Environment and Development (UNCED 1992) presented in its Agenda 21 therefore a new definition: "*Sustainable forest management means care of forest areas and use of forestry products in a manner which keeps biological diversity, productivity, ability for natural regeneration, vitality and ability to fulfil now and in future important ecological, economic and social functions on local, national and global level without harming other ecosystems*". There is, thus, a fundamental shift in global forestry, i.e. **to manage the transition from single-use timber exploitation to multiple-use sustainable forest resources management** (Figure 1).

2. SUSTAINABLE FOREST MANAGEMENT

Why was it necessary to expand forest management from a production oriented concept to an ecosystem oriented multiple-use forestry? The reasons are manifold:

- the urbanisation and industrialisation and the consequent need of citizens for recreation in an unspoilt and unpolluted environment;
- the global decrease of environmental quality through exploitation and reduction of forests;
- the pollution of the environment by industrialisation and intensification of agriculture;
- the dramatic threat of a sufficient clean water supply by pollution and reduction of forests;
- man-made forests (monocultures of exotics) lack resistance to biotic and abiotic influences.

It has become clear that in order to ensure following generations the satisfaction of their rights and needs, the extraction of products from the forests (timber, fuelwood, posts, poles, water, fruits, seeds, withies, soil, stones, medicines, litter, fodder, etc.) as well as the input of waste into the environment (gases, liquids) must be controlled by appropriate management.

A comparison of the predominant past and present use with that of sustainable forest management is given in Table 1. It shows that the transfer to sustainable management has to go alongside with a change of thinking and consequently with a change of policies, laws, structures of organisations and institutions and approaches.

Sustainable forest management has thus got to be guided by environmental, social, economic and managerial aspects under the umbrella of a strong political commitment and support (Table 2). Thus, it is closely linked to the presence of certain frame conditions of which the most important are (Albrecht and Schulzke 1995):

- The availability of a legal and policy environment which is favourable to sustainable forest management;
- A positive attitude of people and governmental authorities towards sustainable forest management which comprises an information and education campaign and improved specialised training;
- An economic situation which allows the necessary budget allocation for activities in the forestry and environmental sector;

- An involvement of the forest adjacent communities and controlled population pressure on forests and forest products by applying approved (silvicultural) management methods;
- The availability of suitable research results for both, industrial plantation management on sound silvicultural and genetic basis and natural forest management on a sustainable ecosystem management.

The concern over the rapid destruction of tropical and some boreal forests raised the request for eco-labelling of tropical timber and other forest ecosystems' products. This **certification** shall prove the provenance of the product from sustainable managed forests. However, if this movement shall be successful, sustainable forest management must be measurable. For this purpose, **principles, criteria** and **indicators** must be available.

3. CERTIFICATION OF SUSTAINABLE FOREST MANAGEMENT AND FOREST PRODUCTS

In a complexity like a forest ecosystem, setting of criteria is an extremely difficult task. This is because lots of the interactions and dynamics are not yet understood properly. Moreover, criteria and indicators must be objectively verifiable and measurable. Additionally, the compliance of criteria and indicators must

Table 1: Comparison between common forest use and sustainable forest management (Kollert *et al.* 1995 modified)

COMMON FOREST USE	SUSTAINABLE FOREST MANAGEMENT
Focus on timber production and exploitation	Focus on key resources: water, soil, trees, biodiversity, community needs
Timber mining beyond sustainable level	Harvesting on sustained yield basis and under consideration of regenerative capacities of forest ecosystems
Little or no mitigation of environmental damages of timber exploitation	Investments in rehabilitation, silvicultural tending, low impact harvesting
Decline of timber yields and degradation of the forests	Sustainable timber supply, enhancing of growing stock and maintaining the regenerative capacity of the forest
High profits for licensees, comparatively low income for owner	Equitable distribution of benefits between forest owner and licensee
Neglecting of indigenous peoples' rights, exclusion of local communities from legal utilisation	Consideration of indigenous peoples' rights, involvement of communities in forest management and utilisation

be accessible and controllable by independent referees. The latter aspect is important and necessary in order to thwart discrimination and re-establish confidence and reliability in forest management.

Several renowned international NGOs have developed criteria and indicators (Table 3). The proliferation of the reference catalogues for sustainable forest management meanwhile may have created some confusion (Musa and v.d. Heyde 1995). There is thus need for harmonisation and approval under specific conditions. This is a venture currently being undertaken by CIFOR with support by the European Union from five organisations (Smart Wood [Rainforest Alliance, USA], Initiative Tropenwald [ITW, Germany], Woodmark [Responsible Forestry Standards, Soil Association, UK], The Deskundigenwerkgroep Duurzaam Bosbeheer [DBB, Netherlands] and the Lembaga Ekolabel Indonesia [LEI, Indonesia]) which are evaluated in forest management units in Germany, Indonesia, Ivory Coast and Brazil. Some important features of the condensed CIFOR-set of standards are give in Table 4 (Prabhu 1996).

It must be mentioned that the certification process is an independent one, that means, the producer/manager cannot be the certifyer of his/her own products and that in an international context, only the international certificate will count. A Kenyan Certificate, for example will only have validity in the Kenyan market and will not be recognised elsewhere.

Figure 1: Range of Forest Uses (Anjir and Klein 1996)

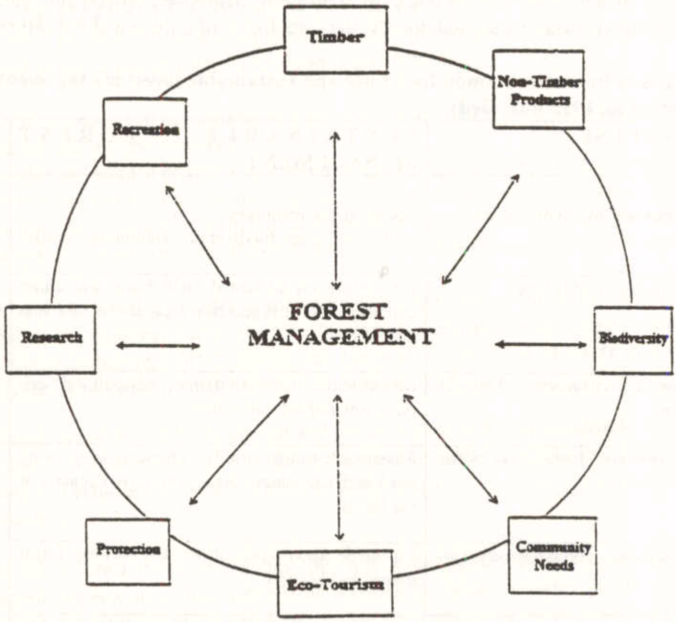


Table 2 : Principles of Sustainable Forest Management and Support by Political, Social, Environmental and Managerial Commitment

Principle	Political	Social	Environmental	Managerial
Safeguard Forest Area	- Laws - Policies - Land-Use Planning (Development, implementation and control)	- Participation of communities in protection	- Maintain /increase natural (autochtonous) biodiversity	- Develop, implement and control silvicultural methods
Security of land tenure	- Laws - Policies - Land-Use planning (Development, implementation and control)	- Participatory forest management - Recognition of indigenous rights	- Maintain /increase natural (autochtonous) biodiversity	- Extension/Education
Environmental impact	- Laws - Policies - Land-Use planning (Development, implementation and control)	- Education - Environmental Impact Assessment of land-use measures	- Maintain /increase natural (autochtonous) biodiversity	- Develop Environmental Impact Assessment procedures
Sustained Yields	- Adopt sustainable forest management principles, criteria and indicators	- Assessment needs - Education on harvest levels	- Maintain /increase natural (autochtonous) biodiversity	- Develop harvest levels on scientific basis
Sustainable Management	- Operational Forest Service - Implementation of Policy	- Participation	- Maintain /increase natural (autochtonous) biodiversity	- Operational guidelines, management plans on scientific basis

Common to all catalogues is the focus on **forest ecosystems management**, i.e. the **protection of processes**, in order to mitigate negative impacts of human interaction and to maintain the ecological functions of natural forests. The process of certification of sustainable forest management must consider two levels: decision makers at the national level and forest managers at the field level. The standards for decision makers at the national level should be generic and addressing the interfaces between the forestry and other sectors (agriculture, wildlife, tourism, water, energy, economy, local government, etc. Figure 2) and a nation's aspirations for development (Ellefson 1991). The generic standards which are clearly worked out in the *Helsinki* and *Montreal Processes* and in the ITTO Guidelines (Annexes 1,2,3) intend to (Musa and v.d. Heyde 1995):

- manage the change from exploitation to multiple-use forestry
- safeguard forest resources irrespective of forest type
- protect key forest ecosystems
- establish and maintain a cost efficient organisational structure for multiple-use sustainable forest management.

The Soil Association's "Responsible Forest Standards" (1994, Annex 4) put the precautionary principle above all generic standards: "*Where the outcome of any forestry activity is unknown, uncertain or possibly negative, activities should err on the side of caution, i.e. they should either not be undertaken or undertaken with full precautions.*" This principle is based on four standards:

- The use of management practices which sustain soil health and fertility
- Minimal dependence on non-renewable resources
- The lowest practicable level of environmental pollution
- Enhancement of landscape, wildlife and habitats

Table 3: Criteria Catalogues for Sustainable Forest Management of Major International NGOs

NGO	Standards		
	No. of Principles	No. of Criteria	No. of Indicators
ITTO		11	50
The Montreal Process		7	61
The Helsinki Process		6	105
The Forest Stewardship Council (FSC)		9	41
The Soil Association	6	20 ·	203
Initiative Tropical Forests (ITF)		64/13	278/421

Moreover: Rainforest Alliance (Smartwood), Greenpeace, DBB Netherlands, National Catalogues (for example: Indonesia, Malaysia).

Standards at the field level must reflect the management process, i.e. planning, implementation and controlling. For these standards, specific technical guidelines are to be used as a basis. The field management level (Districts, Stations and Compartments) has the strategic tasks of safe-guarding the continuity of production of forest goods and services and to ensure cost-efficient and environmentally and ecologically friendly operations under the active involvement of communities and at least, under consideration of their needs and rights (Table 5). Criteria for this level are concentrated around a cost-efficient organisation, management plans, implementation procedures and guidelines and regular controlling by project cycle management and regular field inspections.

- **Environmental Impact Assessment:** Most of the catalogues recommend an Environmental Impact Assessment (EIA) for mitigating the impacts of human activities in forest management on the environment and in particular on ecological processes. This process entails generally four steps:

  - Risk assessment;
  - Activities, options and impact prediction;
  - Measures for impact avoidance;
  - Post-activity monitoring.

- **Community Participation in Forest Management:** Indigenous people shall control forestry operations on their lands unless legally delegated (FSC 1993, SA 1994, ITTO 1992). Sites of cultural or economic significance to indigenous people shall be clearly identified and protected (FSC 1993). Socio-economic impact studies shall be included into all feasibility studies (ITTO 1992).

- **Yield Regulation:** The relationship between growing stock and growth increment is important for the determination of the harvesting level in sustainable forest management. Specifically in natural forests management, the knowledge is decisive for maintaining the biodiversity and regenerative capabilities of a forest type. In terms of climate protection, the optimal growing stock is the single most important silvicultural parameter for CO_2 fixation (Musa and v.d. Heyde 1995).

- **Timber Production:** Logging is the single most destructive element in forestry (Musa and v.d.Heyde 1995) having impacts on the entire ecosystem (biodiversity, regeneration, soil erosion and fertility, water regimes, fauna and flora). Naturally the standard catalogue of the Soil Association (Annex 4) takes care best of these aspects, having made the sustainability of soil fertility and health to be one of their four generic standards. The choice of the logging techniques, the frequencies and intensities of extraction are criteria which can minimise the damages.

- **Inspections**: In order to evaluate the compliance with standards for sustainable forest management, inspection is an important criteria in the ITW and SA catalogues (ITW 1994 in: Heuveldop 1994; SA 1994). External inspection by independent referees (third parties) aims to certify labelled forest products, i.e. their production under sustainable forest management. Internal inspection is a requirement of the forest owner to check the compliance of internal standards which have been set to meet the standards. Internal control is anyhow a requirement of good management and should be part of any forest organisation and enterprise, comprising of Environmental Impact Assessments; yield regulations; inspection, revision and approval of forest management plans and measures, etc. Planning, implementation and control ideally should follow planning and management cycles (GTZ 1991).

- **Research**: In tropical forestry and in particular natural forest management, the scarcity of scientific research results is hampering the implementation of sound management practices on sustainable basis. Too little is known about the impact of human interference on ecosystems and global effects. Several standard catalogues expressively acknowledge the important role research and development have to play (ITW, Annex 5; FSC, Annex 6; ITTO, Annex 3). The necessity for sufficient funds in tropical, mainly developing countries, for research activities is a major concern being expressed by many individuals and organisations (a.o.:Kigomo and Konuche 1996).

Figure 2: Interfaces Between Sectors Related to the Utilization of Biodiversity (GTZ 1995)

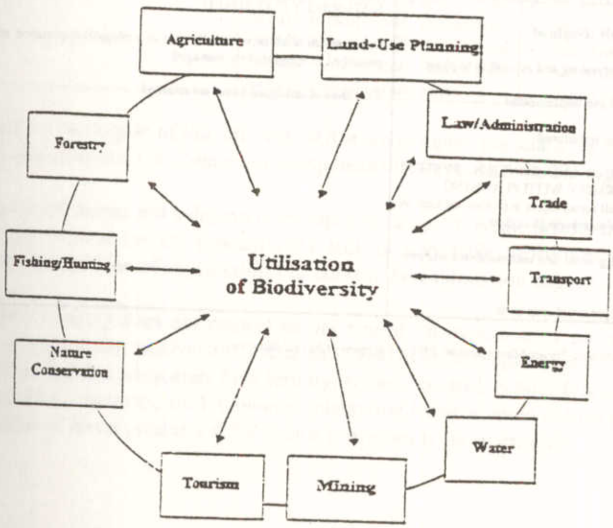


Table 4: Condensed principles, criteria and indicators of CIFOR (Prabhu 1996)

POLICY	**SOCIAL**
POLICY, PLANNING AND INSTITUTIONAL FRAMEWORK ARE CONDUCIVE TO S F M	*FOREST MGMT MAINTAINS FAIR INTERGENERATIONAL ACCESS TO RESOURCES AND ECONOMIC BENEFITS*
THERE IS SUSTAINED AND ADEQUATE FUNDING FOR THE MGMT OF FORESTS	STAKEHOLDERS/FOREST ACTORS' TENURE AND USE RIGHTS ARE SECURE
Policy and planning are based on recent and accurate information	Tenure/use rights are well defined and upheld
Effective instruments for inter-sectoral co-ordination on land use and land mgmt exist	Opportunities exist for local people/forest dependent people to get employment and training from forest companies
There is a PFE, adequately protected by law, which is the basis for SFM, including both protection and production forest	STAKEHOLDERS/LOCAL POPULATIONS PARTICIPATE IN FOREST MGMT
There is a land use plan or PFE which reflects the different forested land uses and values	Effective mechanisms exist for two way communication related to forest mgmt among stakeholders
Institutions responsible for SFM and research are adequately funded and staffed	Forest dependent people and company officials understand each other's plans and interests
	FOREST DEPENDENT PEOPLE/STAKEHOLDERS HAVE THE RIGHT TO HELP MONITOR FOREST UTILISATION
	Conflicts are minimal or settled
PRODUCTION	**ECOLOGY**
YIELD AND QUALITY OF FOREST GOODS AND SERVICES SUSTAINABLE	ECOSYSTEM INTEGRITY IS MAINTAINED
MGMT OBJECTIVES CLEARLY AND PRECISELY DESCRIBED AND DOCUMENTED	No chemical contamination to food chains and ecosystem
Objectives are clearly stated in terms of the major functions of the forest, with due respect to their spatial distribution	Ecologically sensitive areas, especially buffer zones along water courses are protected
A COMPREHENSIVE FOREST MGMT PLAN IS AVAILABLE	No inadvertent ponding or waterlogging as a result of forest mgmt
Maps of resources, mgmt, ownership and inventories available	IMPACTS TO BIODIVERSITY OF THE FOREST ECO-SYSTEM ARE MINIMISED
Silvicultural systems prescribed and appropriate to forest type and produce grown	Endangered plant and animal species are protected
Yield regulation by area and/or volume prescribed	Interventions are highly specific, selective and are confined to the barest minimum
Harvesting systems and equipment are prescribed to match forest conditions in order to reduce impact	Canopy opening is minimised
THE MGMT PLAN IS EFFECTIVELY IMPLEMENTED	Enrichment planting, if carried out, should be based on indigenous, locally adapted species
Pre-harvest inventory satisfactorily completed	THE CAPACITY OF THE FOREST TO REGENERATE NATURALLY IS ENSURED
Infrastructure laid out prior to harvesting and according to plans	Representative areas, especially sites of ecological importance, are protected or appropriately managed
Reduced impact felling specified and implemented	Corridors of unlogged forest are retained
Skidding damage to trees and soil minimised	
AN EFFECTIVE MONITORING AND CONTROL SYSTEM AUDITS MGMNT'S CONFORMITY WITH PLANNING	
Documentation and records of all forest mgmt activities are kept in a form that makes it possible for monitoring to occur	
Worked coupes are protected (e.g. from fire, encroachment and pre-mature re-entry)	
Tree marking of seed stock and potential crop trees	

Mgmt = Management; SFM = Sustainable Forest Management; PFE = Permanent Forest Reserve

4 THE IMPORTANCE OF SUSTAINABLE FOREST MANAGEMENT IN KENYA

Sustainable forest management aims at protecting the ecological **processes** which are necessary for the adaptability of ecosystems to changing environmental conditions and, at the same time, consider human requirements and needs related to forests and forest products. It is part of a network of land uses and thus inseparably linked to the conservation of biodiversity which is on its part a precondition for sustainability (Figure 2).

In spite of the enormous population pressure on the remaining forests in Kenya, in search of land and forest products (timber, fuelwood, posts, poles, fodder, fruits, medicines, grass, leaves etc.), the weak forest organisation and research institutions, the main question in Kenya must be **how to start** managing forests as a sustainable renewable resource. This seems to be a very urgent matter as the forest ecosystems in Kenya are deteriorating at a fast rate. Although Kenya is not an export country for timber and other forest products, there is reason to assume that the adoption of standards for sustainable forest management by the Forest Department and other important forest managers may be used as a qualifying factor for external aid in the near future.

The question must be raised, **why can't we do without sustainable natural forest management** as described in the standard catalogues as there are other management measures and systems to produce and protect forest and tree products, like total ban on utilisation of natural forests, intensification of plantations with exotic, fast growing tree species, tree improvement and domestication of indigenous tree species, development of agroforestry systems?

Table 5: **Strategic tasks and criteria to safeguarding sustainability (Musa and v.d. Heyde 1995, modified)**

Management level	Strategic tasks	Criteria
District Forest Office	Safe-guarding continuity of production of forest goods and services considering needs and rights of communities	• Cost-efficient organisation • Medium-term forest management plans • Implementation procedures • Controlling by project cycle management
Forest Station	Ensuring cost-efficient and environmentally and ecologically friendly operations (Environmental Impact Assessment) under the participation of communities	• cost-efficient organisation • Itemised annual plans • Implementation guidelines • Controlling by regular field inspections

The standard catalogues of the different NGOs are complex especially for the field management levels (Table 3 and Annexes 1-6). Some key components however shall be highlighted.

Bans on natural forests and indigenous tree species cannot save the forests from illegal exploitation due to the high demand for the products, the lack of affordable substitutes for local people, and the inadequate preparation of organisations to control the exploitation appropriately.

Plantation forestry does not respect nature's need for evolutionary processes nor does it consider aspects of maintaining biodiversity. Frequently, also other ecological functions of forests are neglected or cannot be fulfilled adequately (soil fertility, erosion control, habitat function for fauna, resistance to biotic and abiotic damages, etc.). However, plantation forestry could reduce pressure on natural forests for a number of forest products if the choice of species is taken carefully.

genetic variation of populations in a plantation, e.g. the degree of approximation to natural forest-like conditions will be decisive for success and minimised negative environmental effects. **Tree Improvement** activities must be seen in the same light. Although considerable gains in yield increment and resistance may be achieved, a balance must be kept with the genetic losses which most of the tree improvement and breeding measures are connected with.

Agroforestry systems as developed so far for Kenya, aim at supplying farmers with a number of goods and benefits. However, they are only to a limited extent suitable to reduce the pressure on natural forests. The simplified reason for this is that they base mainly on exotic tree species which are no real substitutes for the indigenous ones.

5 CONCLUSIONS AND RECOMMENDATIONS

There is definitely a shift in global thinking in forest management from single-use timber oriented to multiple use ecosystem oriented sustainable forest management. This movement has been initiated and stimulated by international NGOs and thus by the people. Mankind as such has become aware of the fragility of ecosystems and of the urgent need to conserve their regenerative forces and biodiversity as a basis for the stability of life. This was clearly expressed in the United Nations' Conference on Environment and Development (UNCED) in Rio 1992. Each Nation has got to contribute and do its part in reduction of waste and pollution and conservation and preservation of ecosystems and biodiversity, as we all have only one earth.

Forestry plays an important role in these tasks. Forest management must **protect the processes** within ecosystems which are necessary to maintain the capability for regeneration. By doing this, it contributes to the conservation of biodiversity which in turn is the motor for ecological processes. At the same time, methods and mechanisms must be supplied to sustainably satisfy human requirements. That's what is called **sustainable forest management**. Naturally, this goal cannot be achieved by isolated action of the forestry sector but it requires an integrated approach and intensive collaboration with other land-use sectors, policy makers and industries. Moreover, sustainable forest management has to consider people's needs and their participation, specifically of the indigenous people whose habitat and source of survival is the forest. Sustainable forest management is a rather abstract term. In order to make it measurable and thus controllable, **catalogues of standards** have been developed by several groups, including **criteria** and **indicators**. The adherence to these criteria and the compliance of their indicators is considered to be a means for **certification** of sustainable forest management and forest products. Certification, respectively non-certification will in future have considerable economic impacts on timber and forest products exporting countries (ecolabelling).

Research as a long term task has to contribute a lot in understanding the dynamics of natural forest ecosystems, especially in the tropics, and the impact of direct and indirect human activities. It is an international concern that funding of research is insufficient and that natural forests are not sufficiently included. Moreover, it is a concern that, partly due to the fact that there is little understanding in the ecological dynamics, forestry in the tropics has concentrated on exploitation of natural forests alone and on exotic monocultures.

In order to enable sustainable forest management at all, frame conditions have to be changed and new ones created. The new **Forest Policy of Kenya** is an important step forward. It has to be followed in the shortest possible time by an amended **Forest Act**. All concerned parties, including communities and NGOs should be included in the discussions on the amendment. Sustainable forest management on the basis of certifiable standards must be a major concern of the regulations. Also, the political influences in technical and land tenure matters should be mitigated by a new Forest Act.

basis of certifiable standards must be a major concern of the regulations. Also, the political influences in technical and land tenure matters should be mitigated by a new Forest Act.

The **Forest Department** (FD) of Kenya needs a new, more open and more flexible structure which allows appropriately the addressing of sustainable natural forest management under participation of the neighbouring communities, and re-investments of revenues. The staff of Forest Department must be trained for participatory and natural forest management and be actively involved in the discussions on criteria and indicators. In order to consider the views and needs of the communities and other sectors, there should be a mechanism eventually in form of advisory committees at district level. Decision making must be possible at DFO level. However, the implemention of such kind of new ideas is only possible after comprehensive mechanisms of information on forest data and of supervision and control are established (dynamic inventory cycles, environmental impact assessments, yield regulations, financial control, discipline of staff etc.). Planning, implementation and control follow cycles which are annual (forest management measures, budgets) or medium-term cycles (yield regulations on the basis of inventories, 10-12- years). The standard catalogues give clear indications on where a reform of the forest Department has to go in order to become certifiable.

The Forestry College (Londiani) and the Faculty of Forestry (Moi University) have to consider these changes in their **curricula**, putting more emphasis on ecological processes and train students in an ecologically and integrated way of thinking. Also, future forest officers and managers have to be prepared to work together with local, sometimes indigenous communities and implement joint management ventures.

The **Kenya Forestry Research Institute** (KEFRI) also needs a new structure in order to be able to quickly and flexibly respond to the requirements of sustainable forest management, especially of natural forests and the consequent needs from the field management level. An integrated approach is necessary, bringing together researchers from different disciplines, forest managers and forest users, and if possible other land-use sectors, institutions and organisations like NGOs, KWS, NMK, Tourism, Energy, Agriculture. With that, FD and KEFRI would respond to the requirement of criteria and indicators for sustainable forest management avoiding to be left behind in development and also to leave behind people and nature.

Donors are ready to support this development. Moreover, they will in future look more critically into any institutional support in case Kenya and other countries would not address appropriately the issues of sustainable forest management according to criteria and indicators including conservation of biodiversity, community participation, good forest governance among others.

REFERENCES

Albrecht, J. and Schulzke, R. 1995: Forstliche Nachhaltigkeit in tropischen/subtropischen Laendern. Allg. Forstz. 11/1995. 604-606.

Anjin, H. and Kleine, M. 1996: Standards for Sustainable Management of Dipterocarp Forests with Special Reference to Harvesting. Malaysian - German Sustainable Forest Management Project. Sandakan/Sabah, Malaysia. Unpublished. pp 8.

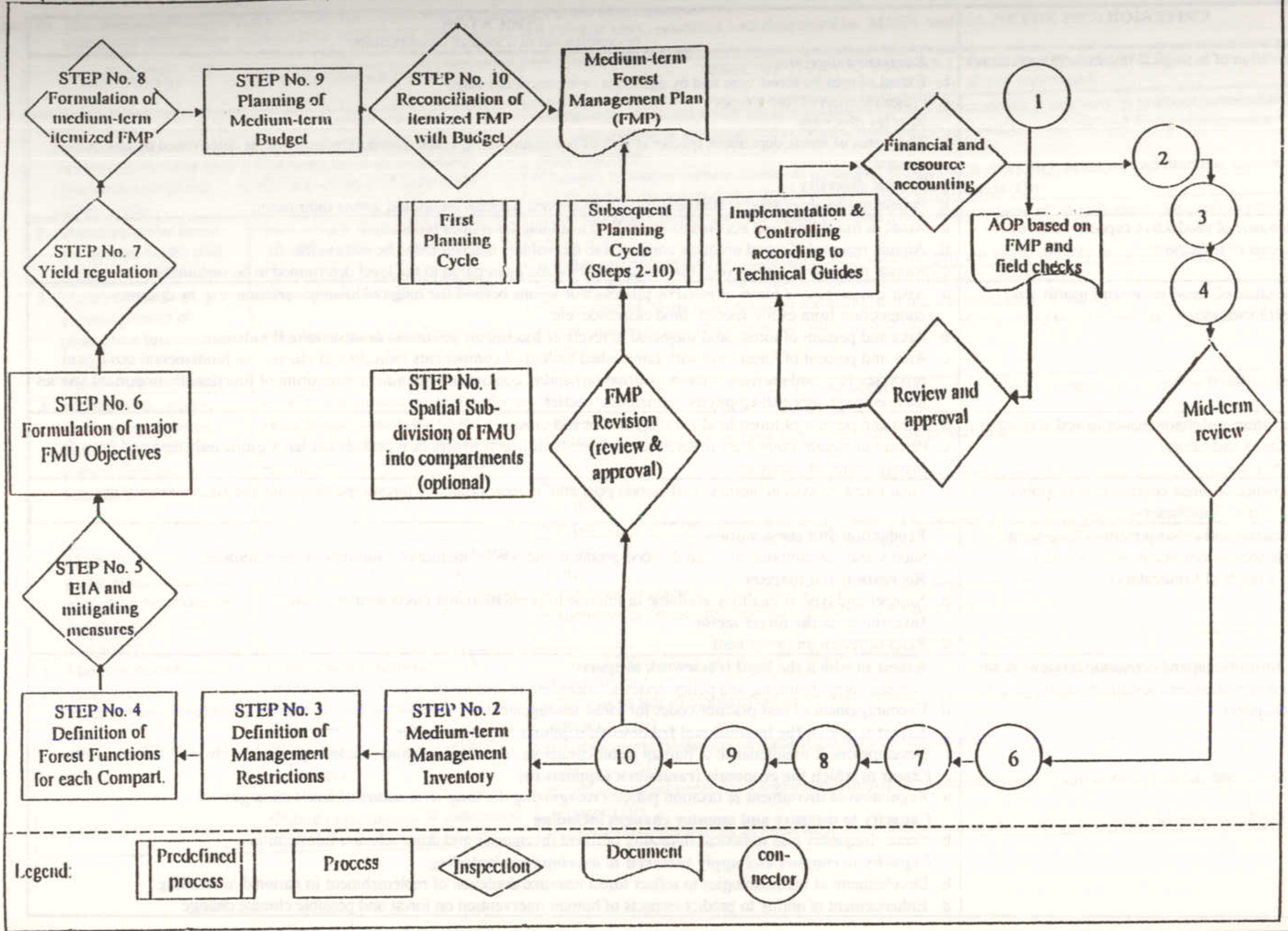
Canadian Forest Service (CFS) 1995: Criteria and Indicators for Sustainable Management of Temperate and Boreal Forests - The Montreal Process. Quebec, Canada.

Deutsche Gesellschaft Fuer Technische Zusammenarbeit (GTZ) GmbH 1991: Methods and Instruments for Project Planning and Implementation. Eschborn, Germany. pp. 20.

Deutsche Gesellschaft Fuer Technische Zusammenarbeit (GTZ) GmbH 1995: Biologische Vielfalt erhalten! Eine Analyse der Entwicklungszusammenarbeit. Dokumentation zum Fachgespraech "Umsetzung der Biodiversitaetskonventionen". Eschborn, Germany. pp. 60.

Hartig, G.L. 1813.
Heuveldop, J. (ed.) 1994: Assessment of Sustainable Tropical Forest Management. Bundesforschungsanstalt fuer Forst- und Holzwirtschaft, Hamburg, Germany.
International Tropical Timber Organization (ITTO) 1992: Criteria for the Measurement of Sustainable Tropical Forest Management. ITTO Policy Development Series No. 3. Yokohama.
Kigomo, B. and Konuche, P.K.A. 1996: Problems Facing Forestry Research Institutions in Africa. Contributionae Biologicae Arborum. In preparation.
Kollert, W.; Uebelhoer, K.; Kleine, M. 1995: Financial Analysis of Natural Forest Management on a Sustained-Yield Basis. Malaysian - German Sustainable Forest Management Project. Report No. 200. Unpublished. Sandakan/Sabah, Malaysia. pp.36.
Muhs, H.-J. 1993: Does the OECD Scheme Need Revision to Be Better Adapted to the Trade With Tropical and Subtropical Forest Reproductive Material? IN: WOLF, H. (eds.): Seed Procurement and Legal Regulations for Forest Reproductive Material in Tropical and Subtropical Countries. Proceedings of an International Symposium. Nairobi, Kenya. pp. 281 - 293.
Musa, S. and v.d.Heyde, B. 1995: Development and Application of Operational Standards for Sustainable Forest Management in Peninsular Malaysia. Malaysian- German Sustainable Forest Management Project. Project Document No. 6. Kuala Lumpur, Malaysia. pp. 49.
Prabhu, R. 1996: Testing Criteria and Indicators for Sustainable Forest Management. CIFOR/GTZ. Unpublished.
Schneider, T. 1995: Kriterien und Indikatoren fuer eine nachhaltige Bewirtschaftung der Waelder. Allg. Forstz. 4/1995. pp. 1026-1027.
Soil Association Marketing Company Ltd. 1994: Responsible Forestry Standards. Bristol, UK.
Udarbe, M.P.; Uebelhoer, K.; Klemp, C.D.; Kleine, M.; v.d. Heyde, B.; Glauner, R.; Benneckendorf, W. 1993: Preliminary Standards for Sustainable Forest Management of No. 180. Sandakan/Sabah, Malaysia. Unpublished.
United Nations Conference on Environment and Development (UNCED) 1992: Agenda 21, Vol. 1 - Resolutions Adopted by the Conference. New York.

Fig. 3: Forest Management and Inspection Cycle (example for indicator No. 4.1, Table 12.2) (source GTZ 1991 and UDARBE et al. 1993, modified)



Annex 1: The Montreal Process: Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests (source: CANADIAN FORESTRY SERVICE 1995 and SCHNEIDER 1995, modified and shortened in MUSA and v.d. HEYDE 1995)

CRITERION	INDICATOR (examples out of a total of 61 indicators)
1. Conservation of biological diversity (9 indicators)	**Ecosystem diversity** b. Extent of area by forest type and by age class or successional stage e. Fragmentation of forest types **Species diversity** b. The status of forest-dependent species at risk of not maintaining viable breeding population as determined by law or science **Genetic diversity** b. Population levels of representative species from diverse habitats monitored across their range
2. Maintenance of productive capacity of forest ecosystems (5 indicators)	a. Areas of forest land and net area of forest land available for timber production d. Annual removal of wood products compared to the volume determined to be sustainable e. Annual removal of NWFP (e.g. fur bearers, berries, etc.) compared to the level determined to be sustainable
3. Maintenance of forest ecosystem health and vitality (3 indicators)	a. Area and percent of forest affected by processes or agents beyond the range of historic variation, e.g. by disease, competition from exotic species, land clearance, etc. b Area and percent of forest land subjected to levels of specific air pollutants or ultraviolet B radiation c. Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil nutrient cycling, pollination) and/or ecological continuity (monitoring of functionally important species such as fungi, arboreal epiphytes, nematodes, beetles, etc.)
4. Conservation and maintenance of soil and water resources (8 indicators)	a. Area and percent of forest land with significant soil erosion c. Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation
5. Maintenance of forest contribution to global carbon cycles (3 indicators)	a. Total forest ecosystem biomass and carbon pool and, if appropriate, by forest type, age class and successional stage
6. Maintenance and enhancement of long-term multiple socio-economic benefits to meet society's needs (13 indicators)	**Production and consumption** c. Supply and consumption of wood & wood products and NWFP including consumption per capita **Recreation and tourism** b. Number and type of facilities available in relation to population and forest area **Investment in the forest sector** d. Rates of return on investment
7. Legal, institutional and economic framework for forest conservation and sustainable management (20 indicators)	**Extent to which the legal framework supports** b. Periodic forest-planning and policy reviews, including co-ordination with relevant sectors d. Encouragement of best practice codes for forest management **Extent to which the institutional framework supports the capacity for** c. Development & maintenance of human resources across relevant disciplines, including efficient physical infrastructure **Extent to which the economic framework supports the** a. Regulation of investment & taxation policies recognizing the long-term nature of forest management **Capacity to measure and monitor changes including** b. Scope, frequency and statistical reliability of forest inventories and other relevant information **Capacity to conduct and apply research & development including** b. Development of methodologies to reflect forest resource depletion of replenishment in national accounting d. Enhancement of ability to predict impacts of human intervention on forest and possible climate change

Annex 2: The Helsinki Process: Criteria and Indicators for Sustainable Forest Management
(source: CANADIAN FORESTRY SERVICE 1995 and SCHNEIDER 1995, modified and shortened in: MUSA and v.d. HEYDE 1995)

CRITERION	CONCEPT AREA	DESCRIPTIVE (DI) & QUANTITATIVE (QI) INDICATOR (examples out of a total of 105 indicators)
1. Maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycle	•General capacity (4 indicators) •Land use and forest area (5 ind.) •Growing stock (5 indicators) •Carbon balance (5 indicators)	•Existence/extent/capacity of legal/regulation/institutional/economic framework to promote sustainability (DI) •Existence/extent of financial and economic instruments to integrate land-use and forest management planning (DI) •Changes in timber volume classified according to vegetation types, age structure and diameter classes (QI) •Total carbon storage and changes in the storage in forest stands (QI)
2. Maintenance of forest eco-system health and vitality	•No Concept Areas distinguished (8 indicators)	•Total amount of and changes over the past five years in depositions of air pollutants, assessed in permanent plots (QI) •Changes in nutrient balance and soil acidity over the past ten years, notably pH and CEC (QI)
3. Maintenance and encouragement of productive functions of forests (wood and non-wood)	•Wood production (6 indicators) •Non-wood products (5 indicators)	•Balance between growth and removals of wood over the past ten years (QI) •Percentage of forest area managed according to a management plan or management guidelines (QI) •Total amount of and changes in the value and/or quality of non-wood forest products, e.g. game, cork, etc. (QI)
4. Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems	•General conditions (4 indicators) •Rare forest ecosystems (5 ind.) •Threatened species (5 indicators) •Biodiversity in production forests (7 indicators.)	•Existence/extent/capacity of legal/regulatory/institutional/economic framework supporting biodiversity conservation (DI) •Changes in natural and ancient forest types, strictly protected areas and forest protected by special management (QI) •Changes in number/percentage of threatened species in relation to total number of forest species using IUCN list (QI) •Proportion of annual area of natural regeneration in relation to total area regenerated (QI)
5. Maintenance and appropriate enhancement of protective functions in forest management (soil and water)	•General protection (4 indicators) •Soil erosion (5 indicators) •Water conservation (5 indicators)	•Existence/extent/capacity of legal/regulatory/institutional/economic framework supporting bio-D conservation (DI) •Proportion of forest area managed primarily for soil protection (QI) •Proportion of forest area managed primarily for water protection (QI)
6. Maintenance of other socio-economic functions and conditions	•Forest sector significance (5 indicators) •Recreational services (5 indicators.) •Provision of employment (5 indicators.) •Public awareness (4 indicators) •Public participation (4 indicators) •Cultural values (4 indicators)	•Share of forest sector at the gross national product (QI) •Provision of recreation: area of forest with access per inhabitant, % of total forest area (QI) •Changes in rate of employment in forestry, notably in rural areas: persons employed to enhance research & education (DI) •Existence/extent/capacity of legal/regulatory/institutional/economic framework to enhance research & education (DI) •Existence/extent/capacity of legal/regulatory/institutional/economic framework to provide public extension services (DI) •Existence/extent/capacity of legal/regulatory/institutional framework to recognize peoples'' CLR (DI)

Annex 3: Summary of ITTO Guidelines for Tropical Forest Management and Conservation (source ITTO shortened and modified in: MUSA and v.d. HEYDE 1995)

NATURAL FORESTS PRINCIPLES (P) AND ACTIONS (A) (examples out of a total of 41 and 36, respectively)	PLANTED FORESTS PRINCIPLES (P) AND ACTIONS (A) (examples of a total of 66 and 75, respectively)	BIO-D CONSERVATION PRINCIPLES (P) AND ACTIONS (A) (examples out of a total of 14 and 20, respectively)
POLICY AND LEGISLATION	**FOREST POLICY AND LEGISLATION**	**POLICY AND LEGISLATION**
P1/A1 Continued political commitment at the highest level and national land-use policy aiming at sustainable use of all natural resources is indispensable.	P1 First priority is to maintain and restore natural vegetation cover. Natural regeneration rather than replanting is preferred.	P2 National forest agency should have mandate and capability to ensure that forests are managed for all values include. biodiversity, with proper allocation of conservation and production areas.
P3/A6 Mechanism for regular policy revision include. research on valuation of marketed & non-marketed goods & services.	P4/5 Effective community consultation procedures are an essential component of integrated land-use planning.	A2 Provide this agency with sufficient resources to effectively achieve conservation in TPAs & production forests.
P4/5 National forest inventory irrespective of ownership include information not previously covered.	A5 Enact laws & regulations at appropriate government levels in harmony with related sectors (revision of existing framework).	P3 Inventories need to be undertaken to describe, quantify and monitor biodiversity in all targeted production forests.
P7 Zoning of PFE by forest functions: protection, conservattion, production and combination of these.	A10 Develop land allocation plans, legal instruments and investment incentives to protect any permanent forest land tenures.	A3 Develop practical biodiversity appraisal systems to guide forest land-use allocation systems at landscape and FMU-levels.
FOREST MANAGEMENT (planning, harvesting, protection, legal management, monitoring and evaluation (M&E), research and development (R&D))	**PLANTATION MANAGEMENT** (feasibility assessment, establishment, post-establishment management)	**ROLE OF PRODUCTION FORESTS IN BIO-D CONSERVATION AT THE LANDSCAPE LEVEL**
P11 Multiple-uses in timber production forests should be safeguarded by applying of EIA-standards to all operations.	A13/14 Include comprehensive EIA-procedures in all feasibility investigations. Environmental restrictions should be identified..	A6 Within constraints of the socio-economic framework, design TPAs with due attention to optimizing their size and shape.
P12 Planning at national/FMU/operational levels reduces social costs.	P19 Risk of bio-D deterioration should be reduced by species- mix.	A7 Link TPAs by corridors of natural forests to facilitate migration..
P21/A12 Harvesting system should be integral part of the silvicultural concept.	P28/29 Restrict intensive forestry to best sites. Assess soil fertility to determine amelioration scheme. Avoid soil compaction by heavy equipment	**ROLE OF PRODUCTION FORESTS IN BIO-D CONSERVATION AT THE MANAGEMENT UNIT LEVEL**
A13 AAC should be set conservatively and be reassessed when PSPs yield more reliable information.	A30 Integrate spontaneous auxiliary vegetation into silvicultural practice to improve soil cover and habitats of key stone species.	A8/9 Silviculture should retain populations of key-stone species (important in food chains or ecological functions) by protecting hollow trees and snags.
A16 Prepare working plans (harvesting sequence include. allocation of all-weather and dry-weather areas, non- harvesting areas, fire management plan, silvicultural, etc.)	A39 Prepare fire management plan taking into account local risks firebreaks, species, fuel build-up, detection, etc.).	9/A12 A mosaic of old-growth forests in close proximity to logged forests will help maintain bio-D. When determining yield allocations, harvesting should not disturb that mosaic over time.
A20/21 Forest engineering (road construction, logging) plan to specify restrictions and environmental requirements.	P37 Riparian buffer strips should be kept under special management to reduce sediment & nutrient inflow into adjacent water courses.	P10/A13 System of micro-reserves (100ha) distributed over the area acting as faunal refuges and source of recolonization.
A32/33 R&D: Study dynamics of main species to enable stand modelling and assess compatibility of logging with secondary objectives.	P48/A23 Management plans should cover at least the full initial rotation and should address areas to be excluded from planting, infrastructure network, biological pest control, local benefits, etc.	A16 In natural regeneration fellings, reduce individual gap sizes unless required for regeneration of particular tree species.
SOCIO-ECONOMIC AND FINANCIAL ASPECTS	**SOCIO-ECONOMIC AND FINANCIAL ASPECTS**	**IMPLEMENTATION, RESEARCH AND MONITORING**
P36/A34 Timber permits in tribal areas should reflect ILO/Worldbank recommendations, recognize CLRs and provide for compensation.	A18 Include socio-economic impact studies in all feasibility investigations and diversify (crop types) to meet community demands.	A20 Develop cost-effective and efficient biodiversity survey and monitoring systems and integrate with existing forest inventories.
P38/39 Forest taxes should be used as incentives to discourage resource depletion and to reflect real management cost. Share of revenue should be used to maintain forest productivity.	P24 Efficiency must be maintained by adequate in-service training and change of information between national and international institutions.	A19 Local people should be involved in the management of forests in regard of benefits and traditional knowledge in support of biodiversity conservation.
A36 Forest authority should collect all forest taxes without intervention from other government departments.	P25 NGOs should be involved in the pre-planting feasibility investigations.	

PFE = Permanent Forest Estate FMU = Forest Management Unit EIA = Environment Impact Assessment
TPA = Timber Production Area PSP = Permanent Sample Plots CLR = Cultural Land Rights

Annex 4: Soil Association: Responsible Forestry Standards (source: SA 1994, shortened and modified in: MUSA and v.d. HEYDE 1995)

PART ONE STANDARDS FOR RESPONSIBLE FORESTRY AND TIMBER PROCESSING	
1. THE PRECAUTIONARY PRINCIPLE **Where the outcome of any forestry activity is unknown, uncertain or possibly negative, activities should err on the side of caution, i.e. they should either not be undertaken or undertaken with full precautions. The principle is based on four generic standards:** **A) The use of management practices which sustain soil health and fertility** **B) Minimal dependance on non-renewable resources** **C) The lowest practicable level of environmental pollution** **D) Enhancement of landscape, wildlife and habitats.**	
2. GENERAL OPERATIONAL REQUIREMENTS	
PRINCIPLE	**INDICATOR**
1. Statutory requirements (2 indicators) 2. Operational requirements (18 indicators) 3. Labelling requirements (11 indicators)	•Producers & processors must attest to conform to all statutory requirements with regard to laws, premises, equipment and employment •Production and storage areas for certified timber must be clearly separated from those not producing according to these Standards •Certification marks must not imply broader certification than actually given by the Responsible Forestry Programme
PART TWO TIMBER PRODUCTION	
Operational Requirements	
4. Registration requirements (2 indicators) 5. Application requirements (1 indicator) 6. Record keeping requirements (10 indicators)	•Where processing or packing operations include bought-in products, the operation must be separately registered. •Complete set of documentation (FMP), activities, restocking, EIA, pollution control, AAC, FMP, M&E) must be provided •Records must be accurate, up-to-date and accessible (purchases, sales, stock levels, planting stock, chemicals & accounts).
Principles of Responsible Forestry	
7. Environmental impact (76 indicators)	•Conservation areas must be set aside and be large enough to maintain viable populations of key species. •Harvesting system must match forest condition and log dimensions. •Plantation planning must be based on site classification and take account of nutrient budget and hydrology. •Recommended: - Scale of felling should commensurate with natural dynamics of forest type and felling area - Maximum use of low-impact logging (arched winches & skyline yarders) and directional felling. - Pesticides should be part of an integrated pest management system and be applied on spots or along bands. •Prohibited : - No commercial timber extraction and road construction in watershed and wildlife conservation areas - Deliberate drainage of wet areas
8. Sustained-yield (9 indicators)	•Method of calculation of Annual Allowable Cut (AAC) must be detailed in Forest Management Plan (FMP). •AAC, rotation length, cutting cycle and coupe sizes must be set conservatively. Trees to be retained must be marked.
9. Land rights (6 indicators)	•Forestry operations in or near tribal lands must provide documentary evidence of written agreements with local communities
10. Local control, consent and benefits (22 indicators)	•Indigenous peoples control forestry operations on their land unless legally delegated to other agencies. •Employees must have right to organize and collectively negotiate terms and conditions of employment with employer. •Benefits must accrue as closely as possible to the forest. Local communities shall be fairly compensated. •Prohibited : Forestry operations should not proceed when there is local opposition or insufficient labour.
11. Economic potential (5 indicators)	•The range of the forest's products and services in the local, national and international context must be available.
12. Management and monitoring (12 indicators)	•A comprehensive written FMP based on these Standards must be available and periodically up-dated •Monitoring system to cover management performance, social and environmental effects and site productivity. •Recommended : Permanent sample plots should be established in both harvested and unharvested areas.
PART THREE TIMBER PROCESSING	
Operational requirements	
13. Registration. 14. Application and 15. Record keeping	•12 indicators (irrelevant for the purpose of this Report)
Timber Processing Standards	
16.Labour, 17.Profits, 18.Equip., 19.Storage, 20 Transpt.	•15 indicators (irrelevant for the purpose of this Report)

Annex 5: ITW Criteria for an Evaluation of Sustainable Management of Tropical Forests (source HEUVELDOP (ed) 1994 shortened and modified)

				INDICATOR (examples out of a total of 278 indicators and 421 sub-indicators)
A. NATIONAL LEVEL				
1	Main preconditions	1.1	Land-use plan	• yes - no decision (no indicators specified)
		1.2	National forest policy	• yes - no decision (no indicators specified)
		1.3	Forest law	• yes - no decision (no indicators specified)
		1.4	Forest administration	• yes - no decision (no indicators specified)
2	Other prevailing conditions	2.1	Nationality accepted values of the forest (3 sub-criteria)	• in relation to international treaties, media, ecology & socio-economics (16 ind. & 17 sub-indicators)
		2.2	Circumstances affecting forest allocation (4 sub-criteria)	• Soil/water/bio-D/climate protection, ownership, supply & demand (16 indicators & 9 sub-indicators)
3	Legal instruments for policy implementation	3.1	Laws (2 sub-criteria)	• Land-use, forestry, labour and environmental impact (4 indicators & 16 sub-indicators)
		3.2	Forest authority	• Statutory procedures at all levels to secure adequate funding and manpower (5 ind. & 5 sub-indicators)
4	Forest administration & research framework	4.1	Forest administration	• Integrated land-use planning, national forest inventories and forest zoning (7 ind. & 14 sub-indicators)
			Forestry research (4 sub-criteria)	• R&D priorities and physical/financial/human infrastructure (4 ind., 34 priorities, 13 sub-priorities)
B. REGIONAL LEVEL				
1	Functions of forestry	1.0	Functions of forestry at the regional level	• no indicators specified
2	Regional mapping of forest functions	2.1	Protection forests	• Protection of species, habitats, water, soil, wetlands and cultural sites (7 indicators)
		2.2	Production forests	• Permanent forests for single-use timber, multiple-use and eco-tourism uses (3 indicators)
		2.3	Recreation/amenity forests	• General recreation (1 indicator)
		2.4	Conversion forests	• Perennial plantations or settlement areas (1 indicator)
3	Administration (11 criteria)	•	Regional site conditions, infrastructure & incentives	• yes - no decision (no indicators specified)
		•	CLR and allocation of commercial usufruct	• Legally established land register and mechanisms for local participation (5 indicators & 4 sub-indicator)
		•	Organization and authority of forest administration	• yes - no decision (no indicators specified)
		•	FMP, management guidelines & control procedures	• yes - no decision (3 indicators)
4	Research	3.1	Regionalization of research activities	• yes - no decision (no indicators specified)
		3.2	Implementation of research results	• yes - no decision (no indicators specified)
C. LOCAL LEVEL - INSPECTION OF SUSTAINABLE FOREST MANAGEMENT				
1	General preconditions (12 criteria)	•	Management contract including period of contract	• in relation to "Checklist for Applicants and Inspectors" (28 indicators & 22 sub-indicators)
		•	Forest management planning	• in relation to forest types, area, stock tables, harvesting and site mapping (50 indicators & 98 sub-ind.)
		•	Staff qualification	• No. of staff with certificates from recognized institutions & incentive scheme (2 ind. & 6 sub-ind.)
2	Planning bases (7 criteria)	•	Planning periods	• in relation to long-, medium-, and short-term planning horizons (3 indicators & 13 sub-indicators)
		•	Biological production	• in relation to inventory, AAC-calculation, yield regulation and stand maturity (29 ind. & 19 sub-ind.)
		•	Infrastructure and timber harvest	• in relation to planning of permanent infrastructure and skidding track network (6 ind. & 38 sub-ind.)
3	Technical base (3 cr.)	•	Infrastructure, equipment and facilities	• in relation to construction/maintenance of infrastructure and equipment (16 indicators & 38 sub-ind.)
4	Control and protection measures (7 criteria)	•	Sustainability of area & volume	• in relation to yield regulation, adjustment of coupes and itemized plan (7 indicators & sub-indicators)
		•	Inspection of logging areas	• in relation to tree marking, logging, infrastructure & forest protection rules (17 indicators & 2 sub-ind.)
		•	Incentives for low-impact management & litigation	• in relation to forest owner/company, wages, fines, taxes & contract termination (9 indicators)
		•	Documentation & monitoring system and research	• in relation to experiments, species, scaling, stand history and data base (14 indicators & 19 sub-ind.)
5	For inspection (7 crit.)	•	Control of implementation (field check)	• in relation to forest protection, infrastructure, logging, stand condition & staff (39 ind. & 94 sub-ind.)

Annex 6 : Forest Stewardship Council (FSC) Principles and Criteria of Natural Forest Management (source: FSC 1993, modified and shortened in: MUSA and v.d. HEYDE 1995)

No.	PRINCIPLE	No.	CRITERION (examples out of a total of 41 criteria)
1	**Compliance with laws and FSC Principles:** Forest management operations (FMO) shall respect all applicable national laws, international treaties and comply with FSC standards.	1.1 1.3	Producers shall respect national & local requirements. In signatory countries, the provisions of all binding international agreements shall be respected.
2	**Tenure and use rights** Long-term tenure and use rights to land and forest resources shall be legally established.	2.3	Local communities with use rights shall control forest operations unless they delegate control voluntarily.
3	**Indigenous peoples' rights** Indigenous peoples' rights to own, use and manage their territories and resources shall be recognized and respected.	3.3	Sites of special cultural economic significance to indigenous peoples shall be clearly identified and protected.
4	**Community rights and relations** FMO shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.	4.3 4.4	Workers' rights should be based on ILO Conventions. FMOs shall incorporate the results of social impact assessments (mechanisms for resolving disputes).
5	**Optimizing benefits from the forest** FMOs shall encourage the efficient use of the forest's multiple products and services, in order to ensure economic viability and environmental benefits.	5.1 5.2	Forest management should account all environmental, social and operational cost and the investments necessary to maintain ecological conditions. Waste and damages should be reduced.
6	**Environmental impact** FMOs shall maintain critical ecological forest functions and minimize adverse impacts on bio-D, water, soils, non-timber resources and fragile ecosystems.	6.1 6.3	EIAs shall be completed including guidelines for environmental mitigation (criteria No. 6.4-6.9). Vital ecological functions shall be maintained/restored (e.g. natural regeneration, nutrient cycle).
7	**Management plan** FSC-consistent FMP appropriate to the scale of operations shall be written, implemented and updated, clearly stating the management objectives and the means of achieving them.	7.1 7.2	The management plan and supporting documents shall provide (9 types of information). The management plan shall be periodically revised to respond to changing framework conditions.
8	**Monitoring and assessment** Regular monitoring should be conducted that assesses the forest condition, yields, chain of custody, management operations and their impacts.	8.2 8.3	FMOs should include data collection needed to monitor growth & yield, forest composition and structure, social & environmental impacts and cost. The forest manager shall enable certifiers to trace each forest production from its origin (chain of custody).
9	**Relation between natural forests and plantations** Natural forests should not be replaced by tree plantations. Plantations should complement & reduce pressure on them.	9.1	Whenever possible, tree plantations should include trials of native species that could meet the same purpose as exotic species.

Annex 6 : Forest Stewardship Council (FSC) Principles and Criteria of Natural Forest Management (source: FSC 1993, modified and shortened in: MUSA and v.d. HEYDE 1995)

No.	PRINCIPLE	No.	CRITERION (examples out of a total of 41 criteria)
1	**Compliance with laws and FSC Principles:** Forest management operations (FMO) shall respect all applicable national laws, international treaties and comply with FSC standards.	1.1 1.3	Producers shall respect national & local requirements. In signatory countries, the provisions of all binding international agreements shall be respected.
2	**Tenure and use rights** Long-term tenure and use rights to land and forest resources shall be legally established.	2.3	Local communities with use rights shall control forest operations unless they delegate control voluntarily.
3	**Indigenous peoples' rights** Indigenous peoples' rights to own, use and manage their territories and resources shall be recognized and respected.	3.3	Sites of special cultural economic significance to indigenous peoples shall be clearly identified and protected.
4	**Community rights and relations** FMO shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.	4.3 4.4	Workers' rights should be based on ILO Conventions. FMOs shall incorporate the results of social impact assessments (mechanisms for resolving disputes).
5	**Optimizing benefits from the forest** FMOs shall encourage the efficient use of the forest's multiple products and services, in order to ensure economic viability and environmental benefits.	5.1 5.2	Forest management should account all environmental, social and operational cost and the investments necessary to maintain ecological conditions. Waste and damages should be reduced.
6	**Environmental impact** FMOs shall maintain critical ecological forest functions and minimize adverse impacts on bio-D, water, soils, non-timber resources and fragile ecosystems.	6.1 6.3	EIAs shall be completed including guidelines for environmental mitigation (criteria No. 6.4-6.9). Vital ecological functions shall be maintained/restored (e.g. natural regeneration, nutrient cycle).
7	**Management plan** FSC-consistent FMP appropriate to the scale of operations shall be written, implemented and updated, clearly stating the management objectives and the means of achieving them.	7.1 7.2	The management plan and supporting documents shall provide (9 types of information). The management plan shall be periodically revised to respond to changing framework conditions.
8	**Monitoring and assessment** Regular monitoring should be conducted that assesses the forest condition, yields, chain of custody, management operations and their impacts.	8.2 8.3	FMOs should include data collection needed to monitor growth & yield, forest composition and structure, social & environmental impacts and cost. The forest manager shall enable certifiers to trace each forest production from its origin (chain of custody).
9	**Relation between natural forests and plantations** Natural forests should not be replaced by tree plantations. Plantations should complement & reduce pressure on them.	9.1	Whenever possible, tree plantations should include trials of native species that could meet the same purpose as exotic species.