KENYA FORESTRY RESEARCH INSTITUTE

A GUIDE TO PROPAGATION, MANAGEMENT, MARKETING AND UTILIZATION OF EUCALYPTS IN KENYA

EDITED

BY

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PREFACE

Eucalyptus is one of the most important plantation and farm forestry species in Kenya today. The high preference for Eucalypts is due to their fast growth, good stem form, coppicing ability, reasonably durable wood, tolerance to water logging, multi-purpose uses (firewood, poles and posts, timber), ready markets for their products and easy workability characteristics. Eucalypts were first introduced to Kenya as plantation species in the early 20th century, to provide fuelwood for railway line to Nairobi and Kampala. Later on, these were used for power transmission poles and telecommunication. Presently most of the Eucalypts are on the farmlands established in small woodlots for fuelwood, pole, timber, windbreaks and for soil conservation. Despite the fact that there is long history (over 50 years) of 'successful' propagation, management and utilization of eucalypts by stakeholders, most of them have grown Eucalypts on trial and error. Many times they have used literature and experience that does not fit well with our local conditions. In view of this, KEFRI in its mandate to develop forestry resources and disseminate research results has undertaken to develop this guide. The main objective is to provide scientifically tested and proven information to the general public on propagation, management, marketing and utilization of Eucalyptus in Kenya.

KEFRI hopes that this guide will go along way in assisting all stakeholders make informed decisions on issues related to the farming, marketing, and utilization of Eucalypts.

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CHAPTER ONE

Robert O.Nyambati (Research Officer, KEFRI-Maseno

INTRODUCTION

Eucalyptus species are the most important tree species on farmlands in the highlands of western Kenya. The high preference for these species is due to their fast growth, good stem form, coppicing ability, reasonably durable wood, tolerance to water logging, multi-purpose uses (firewood, poles and posts, timber), ready markets for their products and easy workability characteristics. Eucalypts were first introduced to Kenya as plantation species in the early 20th century, to provide fuelwood for railway line to Nairobi and Kampala. Later on, these were used for power transmission poles and telecommunication. Presently most of the *Eucalyptus* on the farmlands are established in small woodlots for fuelwood, pole, timber, windbreaks and for soil conservation. In Kenya, the principal planting areas are in the highlands between 1800–2500m in altitude and with rainfall of 750-1800mm. Most of the *Eucalyptus* on the farmlands are established in small woodlots with further planting being restricted due to lack or limited land mainly because of high population pressure in the highlands of western Kenya.

The main production areas are; Kakamega, Vihiga, Nandi, Kisii, Nyamira, Gucha, Uasin Gishu, Kericho and Bomet districts. The commonly grown Eucalypts are *Eucalyptus saligna* and *Eucalyptus grandis* or a hybrid of the two.

This guide has been written with the aim providing scientifically tested and proven information to the general public propagation, management, marketing and utilization of Eucalyptus in Kenya. Documentation of this information is seen as the first step towards harmonising farmer developed and scientific tested techniques with the aim of improving the quality and quantity of tree products from farmlands. This would be an important step towards improving future propagation and management strategies of on farm grown eucalypts.

GENERAL INTRODUCTION TO GENUS EUCALYPTUS

Eucalyptus belongs to the family of flowering plants called **Myrtaceae** (Friis, 1995). The term Eucalyptus has been derived from two Greek words **"eu"** meaning **"well"** and **"Kaluptos"** meaning **"covered"**, a botanical reference to the trees, flowers and fruits (FAO, 1988). It is a genus of more than 500 (Turn bull, 1995) to 600 species (FAO, 1988), mostly in Australia but extending to the Malaysian region and the Philippines. Some of the giant trees have a top height of 90m, but in open scrub areas, which have a low annual rainfall, dwarf forms of Eucalyptus are quite common.

In their homeland, Eucalyptus dominate most of the natural forests, growing in diverse climates and soil types ranging in altitude from sea level to 1850m (Pohjonen, 1989). They play an important part in the closed forests of Southern Australia and typically they are trees up to 200 years forming a transition stage between older, fire damage natural forest and the closed rain forest. When planted outside their natural habitat, many species of Eucalyptus have shown a high degree of tolerance to extremes of latitude and longitude. This is in contrast to many plants, which cannot flourish when introduced to different latitudes and longitudes. Outside their natural habitat, eucalyptus were probably first grown in Portugal 400 years ago, but the first major plantings were started in Brazil

in 1904, where today the country has over 1 million ha (FAO, 1988; Turnbull, 1999). With over 100 countries in the world growing eucalypts in plantations, it is said that no other trees have been so widely propagated.

As stated above, Eucalyptus has become the most planted genus of trees in the world. From about 1 million ha in 1960, planting has approximately doubled each decade until the end of 1980s when the plantations covered about 7 million ha, with variable annual planting but estimated at about 175,000 to 200,000 ha. It has been expected that the area covered by Eucalyptus would increase to about 10 million ha by the year, 2000 (Davidson, 1989). In East Africa, over 100 species have been recorded from cultivation.
A large number of Eucalyptus have been planted throughout the tropical zone but most overseas planting is of 10 species, namely; *E. camaldulensis, E. globulus, E. grandis, E. maculata, E. paniculata, E. robusta, E. salgina, E. europylla, and E. viminalis.* They have mainly been planted for fuelwood, posts, poles, sawn timber, plywood, production of eucalyptus oil ornamental, as a source of nectar in honey production (Friis, 1995)
Different authors (Poore and Fries, 1985; FAO, 1988; Davidson, 1989;Pohjonen 1989; Amanuel Mehari, 1996; Turnbull, 1999) have indicated the major reasons that contributed to the wide spread cultivation of Eucalyptus in various parts of the earth. These include availability and easy propagation of seeds, relative ease of plantation establishment, tolerance to wide environmental conditions, fast growth, efficient conversion of solar energy, wood of high specific gravity and calorific value, high coppicing ability, exceptional hardiness and other fine qualities of their timber, good economic returns, unpalatability or tolerance of most species to browsing and grazing relative tolerance to diseases and pests etc.

Utilization

By 1974, there were about 4 million ha of Eucalyptus plantations producing an average of 60 million m^3 of wood per year. The wood produced is mainly smallwood, of great importance to the countries growing it and representing a massive financial investment for them. The yield from plantations is divided roughly into; fuelwood or pulpwood, 28%; poles and roundwood products of high quality, 10%; sawnwood, 5%. Most of the yield from short-rotation Eucalyptus forest is fuelwood, the product of lowest market value per unit of volume inspite of the fact that it may be the commodity of greatest social value to communities growing the plantations.

EUCALYPTUS IN KENYA

Robert O. Nyambati (Research Officer, KEFRI-Maseno

INTRODUCTION

Kenya has an extensive experience with Eucalyptus. In earlier years, plantations were established to provide firewood for the railway line to Nairobi and Kampala. Between 1903-6, some 19 species were tried out of which *E. saligna* and *E. globulus* were selected as the best yielding trees. The treatment of fuelwood plantations was to coppice them every 10 years until the stools began to deteriorate at about age 30. With the decline in the use of fuelwood for the railway in 1948, the plantations were proposed to produce power poles and telecommunication poles. There were also attempts to use them for sawnwood, but conversion difficulties made this venture impracticable. Eucalyptus are now used in the rural areas for fuelwood, pole, timber, windbreaks and soil conservation. The principal planting areas are in the highlands between 1800 – 2500m in altitude and with rainfall of 750-1800mm. Within this region is the well known Muguga Forest Reserve where 83 species and varieties of Eucalyptus have been planted since 1951.

Eucalyptus saligna has produced the highest volume. It is recommended that it be planted in spacings of about 2.74 x 2.74m. The Kenyan strain produces nearly $24m^3$/ha/yr of fuelwood overbark. The Kenya strain of *Eucalyptus saligna* is believed either to be hybridised with *Eucalyptus grandis*. Later tests have shown that *Eucalyptus grandis* from Queensland produced 15% more fuelwood than *Eucalyptus saligna* from Kenya. Experiments in Kenya have shown that neither the height of stumps nor the use of axe or saw felling have any effect on the survival of the coppicing of the stumps or on the size of the subsequent crop. Nevertheless it is admitted that low cuts with a saw produced slightly better coppicing and prevented the development of over-bulky stumps in succeeding rotations.

Most of the *Eucalyptus* on the farmlands are established in small woodlots with further planting being restricted due to lack or limited land mainly because of high population pressure in the highlands of western Kenya. Most of these are currently in Western Kenya region.

Table 1: Elevations at which various Eucalypts may be planted

Elevation of 0-1200m	Elevation of over 1200-2200m	Elevation of over 2200m
	E. alba	
E. deglupta	*E. bicostata*	*E. decaisneana*
E. maculata	*E. botryoides*	*E. delegatensis*
E. tereticornis	*E. citriodora*	*E. fastgata*
	E. cloeziana	*E. grandis*
	E. globulus	*E. maidenii*
	E. microcorys	*E. saligna*
	E. nitens	*E. urophylla*
	E. paniculata	
	E. pilularis	
	E. robusta	
	E. urophylla	

GENERAL ECOLOGY AND CHARACTERISTICS EUCALYPTUS GRANDIS

Robert O.Nyambati (Research Officer, KEFRI-Maseno

Habitat and wood

E.grandis is a large evergreen tree 45 to 55m high, with a tall, white and straight trunk which is 1m sometimes 2m in base diameter and self pruned for upto two-thirds of its total height. The trunk has a greyish flaky rough bark for upto 4m, and a smooth, powdery, white, greyish white or bluish – grey above. The crown is spreading and sparse when the tree grows in open, but small and compressed in closed plantations. The dark green, discolourless leaves are alternate, diolate, lanceolate, upto 16 cm long. It lacks lignotubers.

The altitude varies from near the sea level to 1000m. In the natural area, the climate is warm humid with a mean annual rainfall of 1000 – 3000 mm. *Eucalyptus grandis* prefers moist well drained, deep loamy soils of alluvial or volcanic origin.

The wood is pink to light reddish brown, moderately hard but light weight (when fresh, *E. grandis* floats on water), the basic density in African plantations is between 510 to 560 kg/m^3, the wood is course textured and straight grained, of moderate strength and durability. During seasoning, it is subject to warping, splitting and other defects. It is regarded as excellent firewood and has also served as locomotive fuel for trains.

Special features

Eucalyptus grandis occurs in pure or almost pure stands in its natural habitat. It is a fuelwood species for highland areas and in the humid tropics. Its optimal growing sites are somewhat warmer than those of *Eucalyptus saligna*. Field identification between *Eucalyptus grandis* and *Eucalyptus saligna* is somewhat difficult. Provided the choice of species has been limited to these two, the existence of lignotuber is the first sign of identification. If lignotuber exits, then the species is *Eucalyptus saligna*. However at times the lignotuber of *Eucalyptus saligna* is not clear, therefore non-existence of lignotuber does not necessarily determine the species as *Eucalyptus E. grandis*. The second means of identification is to study the seed capsules, especially the valves, *Eucalyptus E. grandis* has more valves (Predominantly 3-4) and their tips are sharp and straight or spreading, *Eucalyptus E. grandis* coppices vigorously when young, but trees over the age of 10 have been noticed to be less vigorous. The renewal of young stands by coppicing after clear felling is enough for practical silviculture. The expected number of vigorous coppice crops is from 2-5. When optimal site conditions are selected there is probably no Eucalyptus, probably no other species either, that will produce more wood volume than *Eucalyptus* grandis.

By 2 years of age, early flowering may be observed in solitary *Eucalyptus grandis* trees; however, proper seed crops cannot be expected before the age of four years, commonly, there is a good seed crop each year, a fully mature, vigorous tree can produce 2 kg of seed annually, similar to *Eucalyptus saligna* plantations of *Eucalyptus grandis* are easy to establish. The weeding requirements for maximum timber growth are similarly high.

Hazards from Diseases & Pests

Most exotic plantations of both *E. grandis* are free from any serious pests or diseases. The canker (*Cryptonechria cubensis*) is reported to attack *E. grandis*.

Hazards from fire and drought

Since *E. grandis* does not develop lignotubers, it is sensitive to fire. It is moderately sensitive to frost. If the weather is cool, seedlings of *E. grandis* can withstand drought, but there is a high mortality rate under hot conditions, areas with a mean annual rainfall of at least 800mm are preferred.

Uses

The prick to light heartwood of *Eucalyptus grandis* is moderately strong and moderately durable. *E. grandis* has been used for utility poles although, since it is lightweight and less durable it is not suitable for transmission lines. It can be used for construction purposes, joinery, for the production of boxes, veneer and mine props, poles and posts, plywood as well as fuelwood and for the production of charcoal. The species has great potential for pulp milling, and it is one of the main species used for that purpose in the large pulp industry in Brazil *E. grandis* is also an ornamental and shade tree as well as a good honey plant.

CHAPTER TWO

SEED COLLECTION AND HANDLING

James Odhiambo Maua and Michael Meso (Kenya Forestry Seed Centre)

INTRODUCTION

Eucalyptus trees grow to a height of between 45 and 70m with straight and clear bole. The bark varies from blue–grayish to pinkish, smooth and shed in patches leaving small depressions on the surface. Leaves are grayish blue, long and slightly curved, drooping. Flowers are white to cream. Mature fruits are brownish woody capsules with broad descending disk.

Eucalyptus seed are tiny and provide quite a challenge to handle. The seeds contain no endosperm and the initial growth of the seedling depends first on the reserves stored in the embryo and then photosynthesis by cotyledons. The seeds are enclosed in a case or ovary (angiosperm) and are contained in capsules that split on many sides.

Eucalyptus seed exhibit orthodox seed behaviour and are tolerant to desiccation. They undergo maturation drying and are dispersed when their moisture content is low i.e. between 10 – 12 %.

There are about 13 species of *Ecalyptus* that grow around the country. These include:

1. *Eucalyptus grandis,*
2. *Eucalyptus globules*
3. *Eucalyptus paniculata*
4. *Eucalyptus maculata*
5. *Eucalyptus regnans*
6. *Eucalyptus saligna*
7. *Eucalyptus camaldulensis*
8. *Eucalyptus teriticornis*
9. *Eucalyptus ficifolia*
10. *Eucalyptus urophylla*
11. *Eucalyptus sideroxylon*
12. *Eucalyptus robusta*
13. *Eucalyptus nitens*

Flowering and seeding

The time of flowering and other phases of development of *Eucalyptus spp* vary between individual trees, stands of different ages, between sites with different aspects and elevation and between species. Some species flower for a couple of months while others flower throughout the year in different parts of their ecological range.

Seed collection and handling

Due to increased use of Eucalyptus products i.e. pulpwood, fuel wood, poles posts and timber, requirements for tree seeds for planting is enormous. Collection of eucalyptus seed provides a lot of challenges due to their small sizes. This calls for proper pre and post collection handling. Tree height and pole surface make climbing fort seed collection even more difficult.

Seed collection is most cheaply done following felling in production forests. Seed collection from standing trees of superior phenotype is common these days. Possible methods include climbing and cutting the branchlets with pruners or flexible saws from the ground.
Seed collection and handling comprises of a series of activities that can be grouped into four: (i) activities prior to seed collection, (ii) actual collection, (iii) seed processing activities and (iv) seed storage activities.

Planning and seed collection

Planning before seed collection is a requirement for any seed collection mission. The following are considered

(a) Permit/passes

Seed sources in private land or in land that belongs to other departments (e.g. Game park) may require prior informed consent.

(b) Quantity to collect

The amount of seed to collect will depend on its demand and the amount of seed in stock.

(c) Manpower

The labour force depends on the quantity of seed to be collected and the productivity of each individual.

(d) Equipment needed for collection

Equipments used for collecting eucalyptus are:

1. Climbing gear
2. Ladder
3. Hooks and looping shears
4. Helmet, climbing spurs, descending and safety ropes
5. Canvas sheets
6. First aid kit
7. Cotton bags
8. Sisal sacks for transporting collected fruits

Seed collection methods

There are two widely used methods for collecting eucalyptus seeds. These are crown collection and ground collection.

Crown collection

Mature unopened fruits are collected from the crown by spreading a canvas or net under the tree then climbing and hand picking or cutting fruit stalk using looping shears secateur or use a hook to shake the branches.

Ground collection

This method involves felling of trees especially in industrial plantation. But this requires good timing to avoid collecting immature seeds or over–mature ones. The method is not recommended especially when the seeds are mature and almost ready to be released.

Documentation during collection

During seed collection it is important that information related to seed source be documented. Important information include:

(e) Seed source
(f) Species
(g) Locality and size of seed source
(h) Ownership and person to contact
(i) Category of seed source
(j) History (origin, provenance, age, management)
(k) Ecological data of the site and phenology
(l) Results of flower survey

Collection of the above information allows for keeping of identity of the seed lot and also for monitoring the performance of future stands.

Seed extraction and cleaning

Eucalyptus seeds are embedded in cones and capsules, getting seeds require extraction. In general, seed extraction is important for reducing bulkiness of seed, pests and diseases. It also increases seed quality aspects such as purity and weight, which make seed storage and testing easier. Fruits of eucalyptus are extracted by various methods i.e. tumbling, shaking vigorously and of drying under shade.

For most Eucalypts, seed extraction is done by putting the branches containing the panicles on a manila sack for 1-2 days in the open. The panicles open and seeds fall off. The seeds of *Eucalyptus grandis* take 1-2 days (Woodvine, 1975) to dry. Longer drying periods lead to lose of viability. The panicles mixed with seed are then shaken over a screen in order to release and capture the seeds. It is usually difficult to separate the seed from the chaff, so the seeds are stored with some chaff.

Seed drying

The main aim of drying seed is to reduce seed moisture content to levels that will reduce rapid seed deterioration. This is a precondition for storage of any orthodox seed. Due to the small size of seeds, eucalyptus seeds are dried under shade. The seeds are light and risk being blown away if dried in the open and or hostile environment. Seeds are spread in thin layer to allow for proper drying. It is important to consider the following when drying seeds

1. Seeds should not be exposed to high temperatures
2. Dry seeds in well ventilated shelves or use a drying room
3. When in bags make sure the bags are opened to allow air circulation

4. Avoid damp conditions to reduce fungal infection

Seed storage

The seeds of most eucalyptus are not difficult to store. Mature and properly dried seeds can be stored at room temperature provided the place is air dry. Most can be held for several years if they are air–dried and then stored in dark and sealed containers at 1 – 4^{O}C. Recommended seed moisture content in storage is between 4–8%. At this moisture level, seeds can be stored at sub zero temperatures for many years with no significant loss of viability. An acceptable germinative capacity can be maintained for a year or two in unsealed containers at room temperatures (FAO 1979).

Before storage, carry out tests to determine viability, consequently carry out routine germination and moisture content tests during storage period.

E. Grandis seeds is normally stored and sold with (chaff) mixture of unfertilized ovules, after extraction. Extraction is done by drying the fruit in an open sunlight until the capsule opens letting out the seed and chaff.

Purchasers of commercial seeds should understand that what is sold is not clean seed alone. But should ask the seller or supplier to give him / her germination energy and germination percent expected. It is estimated 1kg of *E. Grandis* seed + chaff contains 630,000 viable seeds (Turnbull, 1977). The seed can be bought from Kenya Forestry seed Centre-Muguga.

Seed germination

Seed germination is the emergence and development of seed embryo of those essential structures that are indicative of the seed's capacity to produce normal plant under favourable environment. Eucalyptus seeds take between 5 to 20 days to germinate. Germination temperature is varied between 15 ^{O}C and 35 ^{O}C but optimum temperature for most eucalyptus is 25 ^{O}C. Eucalyptus do not require large amount of water to germinate.

When carrying out germination tests it is not possible to separate pure seeds from chaff. Seeds are considered germinated after producing a normal seedling. The seeds are weighed in four replicates of 1, 5 or 10 grammes and germination capacity expressed as *"germinated seedling per x grammes".*

Pre–sowing treatment

For most eucalyptus, dormancy is not a problem. After dispersal, the micro–climatic conditions are more or less favourable for germination of the seeds and initial survival of the seedling. The seeds do not require pretreatment to germinate. If at all there is dormancy (slow germination) in any of the eucalyptus, then possibly will have been influenced by the provenance, the seed year or length and conditions of storage.

Seed weight

Average seed weight for Eucalyptus is between 35,000 and 2,200,000 pure seeds per kilogram depending on the species. Examples of a thousand seed weights (TSW) for some Eucalypt species are *E. maculata (1.5g), E. saligna (33g)* and *E. tereticornis (0.25g).* However, it is difficult to achieve a purity of even 50%. The number of seeds per kg depends on the planting area and the climatic condition of the ripening year.

Dormancy

Most *Eucalyptus* seeds will germinate satisfactorily at the optimum temperature, provided that the seeds are viable and mature (Turnbull, 1977). The seeds are broadcasted on special seedbed containing sand or mixture with soil and the seed germinate between 7 – 28 days (KEFRI, 1990).

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CHAPTER THREE

ESTABLISHMENT AND MANAGEMENT OF EUCALYPTUS PLANTATIONS

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INTRODUCTION

In recent years there has been a lot of interest in growing tree in Kenya mainly by farmers. Most of them are interested in growing tree species which are fast growing and have readily market which can fetch cash for the farmers in shortest time possible. *Eucalyptus grandis* (flooded gum) being among the fast growing trees about with mean height of (3m) per year and tolerating a variety of sites is being sought very much by farmers. Many farmers start selling as from age 2 years as fitos and later as poles and posts. The silvicultural of *Eucalyptus grandis* is not well known by Kenyan farmers therefore this paper can serve as a guide to the farmers who are interested in growing *Eucalyptus grandis*,

Background

Eucalyptus Grandis plantations intended for income generating requires good seedling stock of a suitable species, adequate site preparation, and sound planting methods, effective weed control and satisfactory nutritional status in the soil. The planted trees should be able to gain rapid control of the site and should be as uniform as possible throughout the areas of similar site quality. The aim should be for uniform heights and diameters during the seedling stage of the crop. This will enable it to be harvested and marketed with greatest efficiency by the processor and this should permit the best return to the owner.

Most *E. grandis* plantations will be coppiced and harvested again at intervals of from four to ten years. Coppicing may be repeated three or four times. Uniformity in the seedling stage of crops intended for coppicing is particularly important because irregularity in the seedlings stage tends to be progressively exaggerated in the first and subsequent coppice. *E. Grandis* grows in wide range of altitudes from sea level – 200m with annual mean temperatures $5^{o}C$ – $32^{o}C$ and mean annual rainfall of 700 mm – 1200 mm. It grows very well in flooded soils as well as well drained soils.

NURSERY MANAGEMENT

A Eucalyptus nursery should be situated on a slight slope with unimpeded water and air drainage. It should have an adequate supply of water and it will use a considerable volume of soil each year to fill containers. It must have a regularly laid out beds, which can be shaded from the sun when the young plants are becoming established. The beds (or bays) for holding containers stock should be made of a convenient width and leveled. (Kiriinya, 2000). A width of 1 – 1.2 m and a maximum length of 10 m can be used for beds. The seedlings can either be raised in Swaziland beds or in containers mainly polythene tubes. The container seeds have higher survival in the field than bare rooted.

The volume of soil in the container is an important practical point. More soil gives added safety to the plants but is heavy to transport to and in the field. The recommended amount

of soil in normal nurseries is 300 cm^3 per plant or $0.3m^3$ of soil for 1000 plants (Metro 1955). Sometimes exceptionally large seedlings are required for planting in grassy area. These must be grown for 8 – 9 months in the nursery and large polythene pots. 1.5 cm in diameter x 25 cm deep is required. But normal conditions polythene tubes of 10 cm lay flat x 15 cm height are used.

Soil mixtures

Soil mixtures used for *Eucalypts* nursery containers depend very much on what is available locally. In general a light permeable non – calcareous soil or mixture which has adequate water holding capacity, whilst still allowing good drainage is generally recognized as the most suitable medium to grow Eucalyptus. Addition of organic or inorganic fertilizers is common but not universal.

It has been observed that Eucalyptus germinate better in charcoal-burning sites. Charcoal production sites are thought to have better physical soil conditions; better aeration, moisture movement, less weed competition, temperature moderation and less cover to the tiny Eucalyptus seeds. Soils from such sites are sterilized and have fewer pathogens.

Raising of seedlings

The most common and effective ways to raise *Eucalyptus* seedlings is to germinate the small seed in tray or seedbed made of sand and prick out the young seedlings at the stage when they are showing the second pair of leaves and plant them into containers or polythene tubes. The seedlings stay into the containers until they are ready for transplanting in the field. They should be transplanted when they are 25 – 45 cm tall. During this time in the nursery the seedlings should be root pruned regularly to cut the taproots, which might penetrate to the soil in the nursery. Another alternative way is to lift them regularly so as to disturb and discourage the development of taproots outside the containers.

Sowing density of 3,000 – 10,000 seeds per square metre is recommended (average spacing 1 – 2 cm). With this density 25 – 50 % should produce sound seedlings. For *E. Grandis* with viable seeds per kilogram of winnowed seeds $5g/m^2$ is recommended. Because of its small seed size it should be mixed with 2 – 3 times its volume of fine dry sand for broadcasting. The watering is done twice a day depending on the prevailing temperatures. The seed should start to germinate within four days to 28 days and should be ready for pricking out in four weeks.

Pricking out

Pricking out should be carefully done when the seedlings have two to four pairs (Kiriinya 2000) of leaves and should only be handled by their leaves by holding the upper leaf pair together. The roots of the seedlings should not be exposed to direct sunlight and to achieve this; the uprooted seedlings should be immerged into a tin containing water before transplanting in the pots or tubes. After pricking out the containers should be kept under shade for a few days and then stored in the beds until required for field planting 3 – 6 months later.

Size and quality of plants

The period spent in the nursery and the average size of plant at planting vary greatly but the recommended time is 3 – 6 months in the nursery or between 25 – 45 cm in height. If planting has to be delayed because of unfavourable conditions or if sowing has been done too early oversize plants can be clipped or trimmed so that they can be planted in the following season.

Bare root stock

Production of bare root seedlings is a common practice in many areas. This is mainly because of the expense reduction in nursery management (purchase of tubes, pot filling, root pruning) and transportation to planting sites.

Seed beds should be well prepared using fertile soil preferably mixed with sand in a ratio of 50:50 to facilitate movement of water. It may also be an open bed constructed with off cuts or banana stems. It has also been observed that charcoal burning sites are in common use today. Charcoal production sites are thought to have better physical soil conditions such as; better aeration, moisture movement, temperature moderation, less weed competition, and less cover to the tiny Eucalyptus seeds. This is opposed to the cooler and heavier soils from the river-banks that may encourage damping off.

The seeds should be broadcast on seedbeds or branches containing capsules should be spread on the seedbeds from which the seed drop and germinate. Given the small size of Eucalyptus seed, it is particularly important that the seed is mixed with soil or sand before broadcasting. This method helps to broadcast the seed uniformly on the seed bed. Uneven distribution leads to overcrowding. Overcrowding leads to damping off, poor quality stock (sickly, weak, retarded seedlings with a poor root system). Dense sowing leads to competition for both moisture and nutrients. The young seedlings should be kept under shade for 2-3 weeks should be after sowing. Seedlings should be protected from chicken and livestock by fencing. Watering should be done twice daily or when necessary. The period spent in the nursery and the average size of plant at planting vary greatly but the recommended time is 3 –4 months in the nursery or between 25 – 45 cm in height

It is estimated that it is much cheaper to raise bare root-stock than container-raised stock. Different country reports indicate that it is one-third the cost of container-raised stock, an important saving. However, even if the climate is favourable enough to permit bare root planting stock to be contemplated, container-raised stock might offer other management alternatives. It might prove possible to plant container-raised stock at almost any season of the year and remove the pressure of eucalyptus planting at the time of other important operations. Work might have a more favourable spread in the nursery organization. Naturally, these advantages must be balanced against the higher cost of container-raised stock.

FIELD ESTABLISHMENT

Choice of site

On farmlands, Eucalyptus is mainly planted around farm boundaries, along riverbanks and valleys, on unproductive agricultural lands, homesteads, and as woodlots in some part of the farm. The reasons given for the choice of site are quite varied. Eucalyptus is planted along farm hedges to act as a windbreak and to mark farm boundaries. Planting in valleys is attributed more to the fact that such sites are not appropriate for other agricultural activities such as crop production. Planting in unproductive agricultural land is attributed to the fact that Eucalyptus is able to thrive in poor sites, where other tree species and agricultural crops do not perform well.

Ground preparation

If old agricultural land has been cultivated for a considerable period it is likely that there will be a compacted layer just below plough depth. It is necessary to prepare planting pits of about 10 cm diameter and 30 cm deep and its preferable but not essential that these be prepared before the actual planting season.

Ground preparation is an integral part of woodlot establishment with the aim of securing both high survival and rapid early growth. This is achieved by (i) control of competing vegetation; (ii) removal of physical obstructions to tree growth (iii) cultivation to improve soil structure, primarily to aid rooting but also nutrient availability; (iv) moderation of natural drainage to improve drainage on wet sites or retain moisture on dry areas.

Sites where Eucalyptus is to be planted are properly hand hoed to reduce competition for moisture and nutrients and also to improve root penetration. Complete ploughing using oxen plough to a depth of at least 10cm should be done on most sites. Ploughing should be done when the soil is moist. On stony or steep sites, where complete cultivation is impracticable, it is advisable that planting pits be prepared. The pits should be dug to a depth of about 10-20cm. On very wet/swampy places it is recommended that some drainage system should be established by ploughing farrows.

Initial spacing

A wide range of initial spacing is used depending on the product required. Producers must decide on a spacing, which suits their object of management and the fertility of the site. It should be borne in mind that the more stems per hectare the greater is the total volume yields in the early stages and the greater the cost of planting stock and planting. In general poor sites should have wider spacing and good sites a closer spacing. Below is a guideline drawn according to the products.

Table 2: Initial spacing of Eucalyptus for various uses

Initial spacing	Trees/ha	Object of management
2 x 2	2500	Pulpwood, light posts
2 x 2.5	2000	Pulpwood, light posts
2.5 x 2.5	1600	Pulpwood, light posts
3 x 2	1670	Light posts, heavy posts
3 x 2.5	1330	Light posts, heavy posts
3 x 3	1110	Saw logs, light and heavy posts

Planting procedure

In order to promote uniform growth and facilitate easy tending and harvesting, lines of trees should be regular and straight and the spaces between the trees even. In general planting should be done as early as practicable in the wet season so that the plants can take full advantage of residual warmth in the soil. There should be adequate moisture build up (i.e. when a ball of soil is squeezed the water oozes out between the fingers).

Planting is done by inserting the seedlings into their appropriate positions and firming the soil against the roots. For potted seedlings, it is important, that the pots are removed before planting to avoid rooting failure. Planting is done in such a way that the root collar is at the same level with the surface of the field soil.

In case of high mortality caused by adverse weather early in the planting season, beating up or refilling should be done as early as possible in the same season when there may be little loss of growth. Refilling in the year following the original planting is not usually very successful, unless substantial number of plants have died >65%. In such a case, complete replanting is recommended.

Fertilization

Young *E. Grandis* are known to respond quickly and generously to fertilization, people can make use of fertilizers both in the young plantations. Where fertilizers are used in the field it is common practice to apply them a few weeks to three months after planting in a circle or in two small patches on either side and 15 – 30 cm from the plant. On some soils response to fertilizers may be insignificant or not worthy the cost. Depending on the soil, the best application is of 200 Kg/ha of NPK fertilizer twice during growing season (FAO 1979).

Weed control

Eucalypts are very sensitive competition from all types of weeds in early years. *E. Grandis* thrive when it is free growing and its most sensitive to competition especially by grass (imperata) during the first year. Good site preparation has been noted to be effective in weed control. The sites should be completely weeded in the first year. Farmers are therefore encouraged to engage in ground weed control to remove grasses, herbs and shrubs that directly compete with the newly planted trees for light, nutrients and moisture. Weeds are also known to smoother and eventually kill the trees by their cumulative weight, shading and growth habit–twining and twisting.

Weeding can be done manually or use hoes to remove weeds and pangas to remove twines. Weeding is done from the time of planting. There after farmers should weed as frequently as is possible until the canopy closes. Early weeding operations include uprooting and grubbing out vines and creepers. Frequent removal of vines, lianes and climbers that are usually profuse and fast is done regularly. It is important to note that the first year of growth is very important as it determines the vigour of the plantation.

Weed control using any of the following methods is recommended:

(i) Shamba system
(ii) Complete ploughing, carried out and completed during the dry season;
(iii) Strip ploughing done during the dry season
(iv) Pitting on stony or sloppy sites. Pitting will be centred in well cultivated, holes and not cleared patches of at least one metre diameter; and

(v) On grassland sites, pitting will be carried out if it is not possible to prepare the planting site by methods (i) to (iv) above.

Thinning

Thinning should be done to woodlots/plantations at one time or another. It is important that specific thinning schedules should be followed. Thinning is usually done to (i) open up for younger trees, (ii) reduce the number of trees in a stand so that the remaining ones have more space for crown and root development and to encourage stem diameter/increment, (iii) to remove dead, drying, diseased and any other trees which may be a source of infection for or cause damage to the remaining healthy ones (iv) to remove trees of poor form-crooked, forked, basal sweep, roughly branched etc (v) to favour the most vigorous trees with good form which are likely to make up the final crop, (v) to provide an immediate financial return from the sale of thinnings (vi) to produce material for construction at home and sometimes firewood. Thinning is usually selective and a number of cases very subjective–depending on the person doing the thinning. Pangas are the main implements used in thinning. Some of the problems likely to be experienced during thinning are; bushiness, snakes, wasps, and chameleons. Damage to other trees, agricultural crops within the same farm or neighbouring farms and other properties e.g houses.

It is recommended that thinning should not be carried out on crops for pulpwood, poles, and woodfuel and for production of fiber – board material. Crops grown for plywood and timber should be thinned as follows:

Table 3: Thinning schedules for crops grown for timber

Treatment	**Top height (m) or Age (years)**	**Stems per hectare after treatment**
Plant	0	1320
Thin	12.0m but not less than 3 years	850
Thin	3 years after first thinning was prescribed	600
Thin	6 years after first thinning was prescribed	400
Thin	9 years after first thinning was prescribed	250
Thin	15 years after first thinning was prescribed	160
Clearfell	20-30 years	0

a) In thinning, the best trees with good form must be left. All thinning must be carried out as prescribed. The first thinning may be sold as withies or fuel wood but later thinning may be sold as poles.
b) Crops which are currently out of step with the above thinning schedule will be treated in consultation with the Silviculturist from KEFRI.

Unwanted coppices after thinning will be removed manually. Coppicing may be prevented by brushing the stump with used motor engine oil during the thinning operations.

Prunning

Eucalyptus species are self-pruning if they are properly spaced (see spacing). No pruning should be done because it is not cost effective and does not alter the timber quality of Eucalyptus.

Felling

The rotation of *E. Grandis* depends on the object of management. It can be as small as 2 years for *fitos*, 7 years for posts, 8–10 years for poles and > 30 years for sawn timber. But most plantations for coppicing are felled between ages 7–10 years. The felling operation is very important in relation to the survival of the plantation through successive coppicing of the stumps, which can be repeated for three or four more rotations. But for a vigorous growing stock, coppicing should be limited to three rotations. The period of felling, type of equipment used and the techniques used are all important.

The felling period should not be dry period. If a very dry season occurs felling should be done at the beginning of the rainy season to ensure enough moisture in the ground. Felling tools should be a bow saw or two – man crosscut saw or chain saw if available, pangas and axes spoil the stump and loosen it hence affects the sprouting capacity. As long as there is adequate supply of soil moisture during the cool season this will be the right time for felling because the stump will produce the greatest number of coppice shoots.

After felling lop and top should be removed from stumps so that the young coppice can develop without interference. The felling should be done at 12 cm height from the ground level for effective coppicing.

Yields

Eucalyptus Grandis yield higher volume than many other eucalyptus species; it has an annual mean increment of above 60 m^3 of wood and can grow from 3 – 6 m per year (for volume yield determination see Kiriinya, 2001).

ESTABLISHMENT AND MANAGEMENT OF COPPICE CROP

Coppicing

Coppice is a forest crop raised form shoots produced from the cut stumps (called stools) of the previous crop. It also describes the operation of felling and regenerating in this way and is sometime called ratooning.

In coppicing, the originally planted trees are felled and the next crop develops from vigorous shoots (coppice), which sprout from stumps. Usually one or two strong, well attached shoots are gown on for the whole rotation and eventually become almost undistinguishable from planted tree. This process is repeated several times but in practice the number of coppice crops is often restricted to three or four as each time some stumps die.

Coppice management for pole production

The first (seedling) crop is felled between the ages of 6-8 years. No actual thinning is carried out in the seedling stands but when there is need for poles or firewood at the homestead a selective selling is done. The felling of Eucalyptus is the most important operation is relation to the survival of the plantation through successful coppicing of the stumps, which are repeated several times. The period of felling, type of equipment used and techniques are all-important. The felling is planned to avoid dry periods, which lead to loosening of the bark from stumps. In coppicing, the seedling crop of trees is felled and the next crop develops from vigorous shoots (coppice), which sprout from stumps.

Sometime after felling (1-2) months, a number of shoots commence development on each stool. These vary in number from stool to stool. Many a time these are numerous. If left to grow without any form of intervention, they are likely to thin out naturally to five or six by a phenomenon described as 'mechanism of coppicing'. The number of shoots is reduced from the 6^{th} month. The thinning is done to 3-4 shoots per stem/stool and only 1-2 at 12-18 months. Volume and value yields are greatest when reduction is made at 18 months to 2-3 shoots per stool. The choice of what to leave depends on the quality/growth form/vigour straightness, healthy, firmness and pole straightness. Those close to the ground are preferred as they are less prone to wind fall. The wind-ward side coppices are left while the reward side are removed to avoid losses through wind fall. The thinned coppices may be used as firewood, house construction or sold depending on their age/diameter. The coppice shoots are thinned during the dry season. Usually one or two strong, well-attached shoots are grown for the whole rotation and eventually become almost undistinguishable from planted tree.

The process of coppicing is repeated several times however the total duration depends on how well the woodlot is managed as each time some stumps die. Dead stumps are replaced by enrichment planting.

The season of felling affects coppice regeneration. Felling in dry season delays sprouting and increases risk of stump drying out. It has been observed that the method of felling is important. A low cleanly cut stump without tearing bark from the wood is ideal. Saws rather than axes yield better coppice since the rougher surface stimulates more rapid callous development on the stool.

It is important that all brush scattered over the site is removed so as not cover the stools to avoid distortion of tender emerging coppice shoots. The height of the stool does not affect number or growth of coppice but tall stools reduce the yield of the previous stand and make he shoots less wind–firm. However, the overall size of a stool does not affect coppice growth. Small stools arise from sub-dominant trees, which is evidence of their genetic inferiority and produce poor coppice. Very large stools may inhibit sprouting because of the thick bark. However where large stools do sprout, coppice is usually vigorous since large stools arise from the most vigorous trees of the previous crop and they will always have large root stems.

Number of rotations

In each successive coppice rotation, a percentage of stumps fail to produce another coppice crop after felling. Finally there are too few stumps to produce reasonable mean annual increment and it is advisable to re–establish a seedling stand. *E. Grandis* coppice plantation mortality averages between 3 – 5 percent depending on the sites.

On reasonable sites it can be assumed that at least two satisfactory coppice crops after the original seedling can be obtained if the crops are on short rotations of up to 10 – 12 years. If the rotations are shorter, more than two coppice crops can be obtained. A common assumption used to be a total of four crops in 22 years with cuttings at 7, 12, 17 and 22 years (FAO 1979).

Table 4: Rotation ages for seedling and coppice crops

Management objective	**Rotation of seedling crops (years)**	**Rotations**	**Coppice crops**			
			Years of felling			
			1st coppice	2nd coppice	3rd coppice	4th coppice
Fuelwood	6-8	4	12-14	18-20	24-26	30-32
Pulpwood	8	3	16	24	32	-
Fibre-board	8	3	16	24	32	-
Timber	20	2	20-25	40-50	-	-
Plywood	30	-	-	-	-	-

Stump regrowth

Stump regrowth is encouraged to improve the coppicing ability of the plant/stump. It is therefore done by felling the trees as low as possible in a slanting manner to encourage drainage of water. Other management aspects include discouraging debarking at felling and by firewood collectors, weeding after felling and fencing to protect the young shoots from browsing animals.

It has been noted that cutting at higher levels encourages damage to stumps as firewood collectors usually destroy the stumps as they look for firewood. Higher cutting also leads to waste of timber and sprouts/coppices are prone to windthrow.

Stump mortality

Stump mortality is observed in each successive coppice rotation, some stumps fail to produce another coppice crop after felling. If this is continued without replacement, there finally are too few stumps to produce a reasonable mean annual increment. Satisfactory mean annual increment can be maintained by replanting close to dead stumps. Stump mortality is mainly caused by over-dense stocking on infertile sites, poor felling practices, incipient decay, burning debris nearby, unhealthy parent trees, extraction damage, increasing age, and decay of roots, debarking by firewood collectors.

It has been observed that stump diameter affects stump survival or mortality. In general, smaller stumps (3-10cm) and very large stumps (20-38cm) have a high mortality where as stumps between 10 and 20cm in diameter have a low mortality rate. General observations show that the more uniform a plantation is and the smaller the range of stump diameters, the better the survival of the stumps and the better the volume production of the coppice crop. Felling in which the stump has two slanting cuts meeting at the centre of the stump generally lead to high mortality. The V shaped cut encourages water accumulation in the heartwood leading to lot.

Treatment of Old Stumps

After the last coppice crop has been clear felled, old stumps should either be dug out and used for charcoal production or they should be killed using arboricide. Frill cuts around the stumps will be made before applying the chemical. This can be done by complete de – barking the stumps or poisoning them. The poison used commonly is 2, 4, 5 – T chemicals diluted to 5%. Where these two methods prove expensive to use, coppice shoots will be removed repeatedly during the weeding of the next seedling crop. Good establishment of the new crop will easily suppress the shoots of the old stumps and the stumps will eventually die.

CHAPTER FIVE

CLONAL FORESTRY

Muraya Minjine (Nursery manager –Tree Biotechnology Project)

CLONAL NURSERY MANGEMENT
The Case of Eucalyptus Mass Production

The objective of any clonal tree nursery is to propagate identical individuals whose superiority or advantages had earlier been identified.

The Propagation

The cloning can be done using either micro-propagation (Tissue culture) or vegetative macro-propagation (using cuttings): the later is comparatively cheaper. TBP clonal nursery has adopted the cutting method.

Eucalyptus clonal tree nursery has four salient features namely:

Clonal hedges

These are the mother bushes from which propagules are obtained. Establishment of the clonal hedges entails planting of young plantlets (ramets) at espacement that will make maximum use of a unit area of land.

The espacement adopted should put into consideration factors to avoid detrimental competition for light and nutrients and advent of disease and pest due to overcrowding. After the ramets have attained a diameter of 2-3-cm and the lower part of the stem have turned kirkish, they are felled (cutting them back) at a height of 25-30cm from the ground. The cutting back encourages sprouting of coppice, which are the actual propagule material for clonal mass propagation. For good rooting, it is very important not to stress the mother plants. Therefore a proper balancing of both irrigation and nutrient is important. It is also important to adopt a selective mode of coppice harvesting where only the mature ones are harvested leaving the young one to mature for the next harvest. This way, the ramet is not deprived of photosynthetic material (Green coppice). The tool used for felling is the lopping shears while harvesting is done using by- pass secateours. These tools must be sterilized before operations start and before working on a different clone.

Preparation of cuttings

Theses operation is more physical rather than biotic. This process entails the trimming of each coppice to produce one or more cuttings. Using a pair of scissors, a cutting of about 10cm long is made; two halved leaves are left on the cutting to facilitate photosynthesis. The reduction in size of the leaves is to reduce surface area for evapotranspitation. The cuttings are put in a bowl of water with fungicide to offer some sort of sterility. The cuttings are then placed in a medium of choice e.g. a mixture of vermiculite and perlite after applying a suitable root-inducing hormone eg IBA (Indole Butyric Acid).

Rooting of the cutting

Though a root-inducing hormone is applied on the bases of the cuttings, ambient climatic the bases of the cuttings, ambient climatic conditions to accelerate the rooting process are a must. Failure to provide the required condition normally leads to great loses. An environment with high relative humidity, warmth and well-drained medium is very important. High humidity is a factor that can be attained by misting in a semi permeable rooting house structure, which is able to cut direct sunlight and reduce the speed of strong winds. Hot sun and strong winds would normally desiccate the uprooted cuttings leading to their death. Temperatures could be raised by cutting the speed of air flowing and or use of warm water pipe systems.

A well-drained medium is recommended. Water logging leads to rotting of the bases of the cuttings. However, a balance between drainage and water retention must be worked out. This is because once the cuttings are taken out of the regulated condition rooting structure and into the hardening section, the medium should able to hold some moisture and thus nutrients for the rooted now growing cutting.

Hormones used

Different clones root well at varying hormonal concentration, though a concentration of 0.8% IBA is recommended.

Hardening

This is the process of preparing the rooted cutting to withstand field conditions. It starts within the rooting structure where misting and fertigation are reduced gradually. This is normally done in the last 7-10 days when the cuttings are still in the rooting section. The cuttings are then taken out in the open where further hardening is induced by the prevailing natural weather condition. Since the cuttings are raised in inert medium, fertigation during the hardening process in the open is necessary. Two weeks before the cutting are released for field planting, further hardening is done by reducing irrigation and denying the cuttings fertilizer all together. This rigorous hardening process eliminates the chances of poorly rooted cuttings findings their way to field. All poorly rooted cuttings will definitely die during the hardening process. This leads to high survival percentages in the field.

CHAPTER SIX

HARVESTING, SAWING AND SEASONING

J. K. Githiomi (Centre Director- KEFRI-Karura)

Harvesting

Harvesting operations in eucalyptus woodlots have much in common with those in other forest tree woodlots. However, there are some important differences. One of these is the coppice crop management, which represents today the most extended form of management in eucalyptus woodlots. Farmers apply suitable felling techniques in order to obtain full stocking from coppice after clear cutting, without incurring the extra cost of replanting. Trees are felled using chain saws, bow saws or axes depending on size, location and financial ability of the farmer or the timber dealer.

Cross-cutting

Before cross cutting, the position of the cuts is marked so as to obtain the best utilisation of the tree length for production of different items such as poles, different sawlog lengths. If only one type of product is required, the marking is at constant lengths as specified by the consumer/market requirements. In Gucha most logs are about 5m long while those in Vihiga are 2.5m long. Productivity is affected by the degree of seasoning of the wood. It was reported to be higher when logs are cross cut immediately after felling than when they have dried. The main equipments used are pangas, axes, cross-cut saws and chainsaws. Axes were reported to be very wasteful especially when the logs are dry.

Sawing techniques

Farmers noted that Eucalyptus wood does crack and warp after sawing. It was evident that many farmers do not understand the factors, which influence growth stress development as to manage plantations in a way that minimizes its effects except in the most general terms. The only options available usually in practice are to choose suitable sawing techniques.

To cope with growth stress of the magnitude found in Eucalyptus tree logs, farmers usually do balanced cutting and separation of the outer zone of the log from the central core during cutting. Balanced cutting means simultaneously making two or a larger number of sawcuts symmetrically disposed on each side of the pith, so that the central cant remains straight during sawing. The key to success with balanced cutting to minimize the effect of stress is to limit the thickness of sawn boards to a maximum of 2.5-5cm and preferably not more than 2.5cm. Market requirements may call for greater thickness but recovery of saleable wood is usually less due to distortion and end splitting. Depending on the markets, end trimming is carried out green or after seasoning. The latter is preferred since end splits which develop in sawing and seasoning can then be removed in one separation and the total loss due to splits is less than if boards must be trimmed both green and after drying.

Problems caused by growth stress are reduced when the length of log sawn is reduced. However handling problems are increased and market opportunities reduced with short wood, and the usual compromise is to saw logs around 5m in length. Generally, logs are sawn fresh after harvesting.

Sawing is mainly by pit sawing or chain saws. Chain saws were noted to be faster in sawing than pit sawing. They were however said to very wasteful, produce rough surfaces that are difficult to plane and that timber is very uneven along its length. This however depends on the experience of the operator. There were more chain saws in Gucha than Vihiga, an indication of the intensity of timber operation works in Gucha.

Seasoning

After sawing, timber is transported by head or vehicle and stored. All farmers interviewed did not have permanent storage facilities. In most cases timber is stored outside under the roof exposed to direct sunshine and sometimes rain. This is main cause of cracking and warping. Warping is very common immediately after sawing as the timber is exposed to direct sunshine for duration ranging from 2-10 hours while still green. Farmers noted that the degree of warping is dependent on maturity of the tree, timber length, moistness of the ground on which the tree is grown. Timber warps more if it is from young trees, timber length is more than 4m and the tree was growing on very moist environment.

In storage, pieces of timber are packed horizontally on top of one another by size. Very few farmers use horizontal bars to separate the timber as to allow for aeration. Tightly packed timbers were found to develop fungi and green algae on their surfaces.

To minimize cracking, some carpenters use small bars of timber nailed to the ends of the timber. This was particularly so with timber that was being sun dried in Luanda. Most farmers in Vihiga transport their timber to Luanda market on the same day of sawing. This may be the main cause of sun drying. Sun drying leads to severe cracking, warping and consequently poor end products.

SPECIAL PROBLEMS OF EUCALYPTUS

Principles of drying and seasoning

Freshly felled eucalyptus poles in a plantation or "green" eucalyptus sawnwood leaving the sawbench usually have as much water as wood substance in them. That is, they have close to 100% water content by weight relative to their oven–dry weight. Wood is a hygroscopic material and it loses or gains moisture until it reaches an 'equilibrium moisture content' (EMC) relative to the humidity and temperature of the air around it. The equilibrium moisture content is then maintained as long as the air humidity and temperature remain constant. The EMC of wood in the open air (air dry, wood) may vary from 12% in a fairly dry climate to 15-18% in a humid one.

Green timber, both in the round and sawn, must therefore lose moisture to the surrounding atmosphere whether or not special measures are taken to control the process of drying. As the pieces lose water, they loss weight, but in the early stages of drying there is no shrinkage or change of shape.

At fibre saturation point (25-30% moisture content) all free water and water vapour have been lost from the cell lumens, but the water intimately bound with the fibrils of the cell wall remains, once drying proceeds beyond fibre saturation point, the pieces of wood start to shrink. They shrink very little a long the longitudinal axis, more along the radial axis of the cross-section and still more in a direct tangential to the growth rings. The

amount of shrinkage can be considerable. The drying process continues, accompanied by loss of weight and shrinkage until the wood reaches EMC. The purpose of seasoning is to dry the wood as cheaply as possible and with the minimum degrade, to a moisture content which will be in equilibrium with the atmosphere in which it is to be used. The process of seasoning may be allowed to proceed slowly, as by careful air-drying, or it may be speeded up by the application of heat in a kiln.

Air seasoning

The plantation owner producing massive quantities of short and long poles will normally use simple and safe methods of air seasoning the commodities.

Gang nails, clamps or wire, or boring out the ends may be used to reduce splitting also. Properly ventilated stacks well raised off the ground, are essential drying under cover ensures less splitting than drying in the open and should be encouraged. Prophylactic spraying to prevent insect attack during drying is often required and may need to be repeated several times if attack is severe.

Short poles and posts may be air-dried in layered stacks with one layer at right angles to the next. This permits free circulation of air. In high rainfall areas, covering stacks or placing them in an open-sided drying shed speeds drying and perennials decay of sapwood.

If eucalyptus sawnwood is to be air-dried, a well designed yard should be laid out cleared from weed that hinder air flow. Foundations should be laid for the drying stacks and in the stacks the sawn pieces should be placed layer by layer, each layer being separated from the next by slats 50-100 cm apart in accurate vertical alignment, and the top of the stack protected from rain and direct sunlight. A period of 4-6 months per 25mm thickness of board may be required to air–season *Eucalyptus grandis* and *Eucalyptus saligna* (Stöhr, 1977).

Special problems

Many of the Eucalyptus present problems in seasoning. There is considerable variation among species. *Eucalyptus delgupta* is one of the easiest to season and *Eucalyptus grandis* and *Eucalyptus saligna* are also fairly easy, while *Eucalyptus globules* and *Eucalyptus fustigata* are among the more difficult species. Within a species provenance, climatic and soil conditions, growth rate, age and position within the tree are likely to affect seasoning as well as other wood properties. Old trees are usually more difficult to season than young ones. For minimum amount of defects during seasoning, a rotation length not exceeding 30 years is recommended for *Eucalyptus grandis* plantations and 25 years for *Eucalyptus saligna* which is somewhat more difficult to season (Stöhr, 1977). The thickness of sawnwood also has an important effect. Research is necessary in order to find out the seasoning methods best suited to local conditions. In general Eucalyptus sawnwood of many species needs considerable care in seasoning if it is not to suffer an excessive amount of degrade. Particular attention must be paid to the phenomenon of collapse and the means of reducing it.

Collapse and reconditioning

Many Eucalyptus and most of those grown in plantations are liable to an excessive or irregular form of shrinkage during drying known as collapse. Collapse occurs above fibre

saturation point when liquid is being removed by drying from the cells of the wood and before normal drying shrinkage occurs. Collapse affects sawnwood mainly in thickness less than 7.5–8 cm. Roundwood and thick sawnwood are rarely affected. The radial and tangential faces of sawnwood are affected differently. On the radial or quarter-sawn face, collapse shows as a "wash -board" or fluted surface which can be felt easily with the fingers. On the tangential or back-sawn face it shows as heavy open checks with distortion of the surface as well. Since the washboard effect on quarter–sawn faces can be overcome by oversize sowing and later planing, and checking is not present, this form of sawing is preferred when collapse is a problem. However, as mentioned under sawing, it is not usually a practical option with small-diameter plantation logs. Fortunately severer face checking due to collapse on back-sawn face is not usually encountered with boards 2.5cm thick and less if air-seasoned carefully. The top of the stacks should be covered to avoid direct sun and the boards should be kept out of the sun before stacking, as face checking under direct sun is very rapid.

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CHAPTER SEVEN

PESTS AND DISEASES OF EUCALYPTUS SPECIES IN KENYA

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INTRODUCTION

The origin of Eucalyptus species is in Australia. Eucalyptus is the tree genus most widely grown as exotic plantations worldwide. Eucalypts grown in plantations are fast growing, easily cultivated and suitable for industrial plantations or social forestry. Worldwide deployment of eucalypts across the tropics, subtropics and, increasingly, temperate areas has created a mosaic of exotic plantations by which pathogens and pests can move internationally. The uses of eucalypts range from commercial timber and pulp to soil stabilization medicinal fodder, ornamental, shade, windbreaks, tannin, dyes, oils, firewood, charcoal and honey production.

GENERAL PESTS OF EUCALYPTUS

There are many insect pests associated with Eucalyptus species and they are classified as insect borers, defoliators and sap-suckers. Many species of insects attack Eucalypts in both their natural range and places where they have been introduced. A number of Eucalypts – infesting economic importance and could be moved via transfer of germplasm although the risk is lower compared with virus diseases, phytoplasma, bacteria and fungi. Smaller insects, especially sap-sucking insects pose the greatest risk of being moved to new locations via germplasm. Insects may attack eucalypt seed before it is shed from the capsule (gum nut) or after it falls to the forest floor. Other insects lay their eggs in eucalypt flowers. Rooted cuttings of eucalypts present the greatest hazard of movement of insects.

CATEGORIES OF EUCALYPTUS SPECIES INSECT PESTS

SAP-SUCKERS

These insects insert their mouth parts into plant tissue for extended periods sucking the plant juice and leading to wilting and dierbark of the plant. These include members of the insect orders *Hemiptera* and *Homoptera* (e.g aphids, scales, psyllids, lacebugs).

(1) Blue gum psyllid – *Ctenarytaina eucalypti* (Maskell) (*Homoptera : Psyllidae)*

This insect pest has been accidentally introduced into a number of countries where it has caused extensive damage to eucalypt plantings. It is considered to be the most important forest insect pest in Portugal.

Biology

Eggs are laid in masses near the developing buds of host plants. Adults and nymphs feed by sucking plant juices. All life stages may be found throughout the year. Adults are strong fliers and nymphs may be dispersed by air currents. The insect can be transmitted via rooted cuttings

Host Damage

Distortion, wilting of foliage, mostly at the tips followed by leaf drop. Diebark of twigs and branches can occur during heavy infestations. There is reduction of growth in young

plants due to foliage loss. Nymphs and adults excrete honeydew which provides a medium for growth of sooty mould. Nymphs exude filaments of a white, waxy secretion or 'lerp' under which they shelter.

Distribution

Native to Australia. Accidentally introduced into New Zealand, Portugal and Spain. Its occurrence in Burundi, Tanzania, Ethiopia and Kenya has also been confirmed.

Management Option

Destroy infested germplasm

Blue gum chalcid – Leptocybe invasa (Hymenoptera : Chalcidoidea : Eulophidae subfamily Tetrastichinae)

Biology

Adults are small black wasps. They measures about 1.0 to 1.5mm long. Larvae are white, legless grubs, which are found within galls on host plants. Larvae pupate within the galls and adults emerge through a hole that they cut to the surface. Eggs laying occur soon after adult emergence. The eggs are laid in twigs, petiole, leave midribs, or a few centimeters from the tip of the growing shoot. The number of generations per year in the tropics is not known. However, the insect is more active during the dry season i.e. November to February/March. This is likely due to the adults being able to fly from one host tree to the other.

According to clark (1938), this insect pest reproduction is parthenogenetic. Each insect is capable of laying from 80-100 eggs. The egg is placed shallowly beneath the epidermis, it is ovid, white and semi-transparent, with one end produce into a blunt stalk-like protuberance. The insect is active and has considerable powers of flight which, when added to the carrying-power of winds, can easily infest very large areas within a very short time.

Host Damage

Blue gum chalcid causes formation of galls on twigs and foliage of the host trees. The galls on the foliage/leaves are on the leaf mid-rib. Galls are also found on the leaf petiole. A number of galls are observed on the twigs and on both lateral and terminal growing shoots. Repeated attacks on growing tips (shoots) leads to a gnarled (twisted) appearance (deformed leaves). It has been observed that repeated attacks can lead to loss of foliage from the terminal branches. It is important to note that twig galls can cause tissue to split and destroy the cambium. Thus heavy attacks are likely to lead to loss in growth due to reduced photosynthetic surface area. Also a further field observation is that the tree lacks terminal leader shoot.

Distribution

Surveys already carried out mapped out the areas of infestation in Western Kenya region. The districts where the infestation is clear through its host plants manifestations includes Kisumu, Vihiga, Busia, Teso, Nyando, Butere – Mumias and Bungoma.

The insect pest has been recorded in other countries like Morocco,Uganda, Iran, Israel and Italy.

The Pest Invasion

There is always need to know the possible area of a pest invasion particularly when an exotic pest recorded in a given country. The pest was first observed in Uganda in January/February 2002. The first pest infestation symptoms were observed in Busia District of Kenya in March 2003. The families living on both side of the Kenya/Uganda border exchange seedlings amongst themselves. This is the likely method of entry of the pest into Kenya.

Management Options

Immediate Management Options

a) Quarantine – No movement of affected plants materials in order to control spread of pest.
b) Issuing of pest alert leaflets by KEFRI to all foresters countrywide. Any detection or presence of the pest should be reported to KEFRI immediately.
c) Cultural control methods like cutting back the host tree seedlings in the nurseries and burning all the affected foliage material should be encouraged so that the pest does not go out of the infested area.

Medium term measures

- Host plant resistance tests should be carried out in order to ascertain the degree Of susceptibility of different host plants.

Long-term strategies

- Study the ecology, population dynamics of the pest with an aim of implementing classical Biological control Programme. This is the best and permanent management strategy for an exotic pest.

BORERS

These are insects that make galleries in the wood. Insects in this category are mainly weevils and beetles. Their presence is indicated by frass at the base of trees.

Apate Indistincta Murr (coleoptera, Bostrychidae)

Bostrychids are known as false powder pest beetles since they bore in dry and seasoned wood completely destroying the sapwood. They are generally polyphagous. Bostrychids are economically important borers in the twigs and branches of trees. They generally attack living, dead, or felled trees, and can cause considerable damage. In genus *Apate* adults usually attack living but probably unhealthy trees; larvae however have only been found in dead wood.

Host damage

Young trees have been found very susceptible to attack. Active boring is indicated by presence of frass at the tree base. The attack starts from the bottom of the stem and spreads towards the crown. Weak crown are prone to break when it's windy. The borers are most active during dry season and on dry trees. Resin production from frass injection holes on affected trees is a defense mechanism against further insect attack.

Distribution

The pest has been recorded in Kenya, Tanzania, Zambia (on Eucalyptus sp.) and in Malawi. In Kenya, the pest has been recorded in Districts like Kajiando, Nyandarua, Laikipia, Nakuru, Migori (Kuja river), Kiambu and Isiolo.

Invasion

Apate indistincta was first reported in Kenya in 1950.

Management Options

The borers on living trees have been chemically controlled by soaking pieces of cotton wool in Dimethoate, Ambush, or Diazinon and inserting them into frass injection holes. Borers are also killed manually by inserting sharp pieces of wire into such holes. Affected branches should be cut and burnt in order to destroy the life cycle of the pest and hence control the spread of the pest population.

Oemida gahani Dist (Coleoptera, Cerambycidae)

Biology

Eggs are laid in batches. Ovipositor occurs on the pruning scars and game damaged areas. The small larvae move inwards to the inner ("dead") part of the tree where, the galleries run up down the stem. Incubation period is about 38 days. The highest number of eggs from one female is 131. Oemida gahani can complete its life cycle in living trees. The shortest life-cycle since recorded is 14 – 15 months. From egg to adult is about 2 years.

Host damage

Oemida gahani is a tree stem borer.

Distribution

Widely distributed in all the highland forest divisions in Kenya: Nairobi, Eldoret, Londiani, Nyeri, Thomsons falls and Kisumu.

Invasion

Oemida gahani was first noticed damaging *Podocarpus gracilior* timber in Kenya in 1937. In 1950's and early sixties *O. gahani* was a serious pest in Kenya.

Management Options

1. Larvae are occasionally killed by viral diseases.
2. Plantation hygiene i.e. cleaning and burning all indigenous logs and stumps.
3. Prevention of game damage, fencing and ditching.
4. Early and frequent pruning of host species.
5. Treating of pruning scars with chemicals.
6. Separation of host plantation from natural forest.

NB

The resin of living wood is lethal to the larvae.

Macrotermes bellicosus Smeath (Isoptera Termitidae)

Termitidae are subterranean, mould building and arboreal nesting termites. 80% of all known termite species belong to termitidae family. There are 5 sub-families, the common are macrotermitinae with genus *odontotermes* spp. *Macrotermes* spp. And *Microcerotermes spp.*

Biology

Termites are social insects like bees. A community is composed of 3 castes

1. Reproductive adults (for reproduction)
2. Sterile soldiers (for protection)
3. Sterile workers (for feeding other castes)

The immature stage resemble adults in structure and have wings. Termite have no pupa stage in their development cycle. The feeds on wood cellulose.

Host damage

Damage to roots of seedlings, ring barking transplants, runs on trunks to wounds and dead branches.

Distribution

Found throughout the tropical and sub-tropical areas of the world, and in some areas extending into temperate regions.

Management Options

Biological Methods

Pathogenic fungus are used and they cause wood rot that poison termites upon feeding on them.

Chemical Control Methods

This involve use of termiticides. Two types of chemical control methods are

(a) Soil treatment
(b) Structural timber treatment

Recommended termiticides for soil against termites are: Marshal suscon, Regent 3G and Dragnet Ft.

Cultural Methods

This is use of ash, and sanitation (Removal of wood material)

Host Plant Resistance

Planting of host species that are resistant to termite attack.

DEFOLIATORS

This category of insect feed on the foliage of the plants. Defoliators are mainly moths and butterflies although a few families of beetles are defoliators.

***Gonipterus Scutellatus* Gyll (Coleoptera: Curculionidae)**

The Eucalyptus Snout-beetle, Gonipterus scutellatus Gyll., it is an Australian curculionid, was first noticed in Newlands, Cape, in November 1916, attacking eucalyptus trees. It was probably introduced into South Africa in shipments of apples from Australia some years prior to this date. By 1924 the beetles had spread throughout practically all of the eucalyptus – growing areas of the union, and was attacking no less than sixty – five species of eucalyptus in varying degrees, the three most susceptible species being *Eucalyptus viminalis, Eucalyptus globulus* and Eucalyptus maideni.

Identification of the pest

The insect belongs to the weevil family of the order: Coleoptera; Family: Curculionidae

Life – History of the Snout – Beetle

The adult females of Gonipterus lay their eggs in blackish brown egg capsules, only on the young tender foliage of Eucalyptus species. The eggs hatch into slimy, yellow larvae which devour the epidermis of the leaf and when fully grown drop to the ground, burrow into the soil and pupate.

Nature of Damage

The damage to Eucalyptus trees is caused by the feeding of both adults and larvae. The preferred feeding place of the adults is along the edge of the leaf. The greatest damage, however, is caused by the feeding of the larvae, which devour the entire epidermis of the leaf. Continual destruction of the young soft twigs and leading shoot and then later moves to debarking of twigs and branches, prevents all height growth, and in the course of a few seasons the tree takes on a stunted stag-horned appearance with clusters of dead shoots along the frame work of the branches.

Remedial measures

In 1926 an attempt was made to control the pest by artificial means. This took the form of dusting plantations with an arsenical poison from aeroplanes. These dusting experiments gave promising results from a control point of view, but proved to be economically unsound and therefore had to be abandoned.

Biological measures

The only likely avenue of attack therefore, which remained over the vast area involved was biological control. This measure entailed a search for parasites in Australia.

In 1945 the Kenya Forest Department introduced an egg – parasite – Anaphes nitens into Western Kenya from South Africa. The parasites were released in the field and the pest and its biological control agent have established a stable relationship country wide in the field.

CHAPTER EIGHT

MARKETING OF EUCALYPTUS WOOD PRODUCTS BY SMALL SCALE FARMERS IN WESTERN KENYA

Introduction

Recent studies have revealed the emergence of farm forestry from a subsistence activity into an important forestry product supply sector in Kenya. Its importance became visible with the sudden fall in round wood output after moratorium or ban was imposed on harvesting from public forests. However, the sector has been undergoing some gradual transformation for many years without being given due attention. This was because farm forestry unlike crop production components did not receive government support in its commercialization such as specific factories targeting smallholder producers, development marketing boards, and organized production support systems (inputs, planting materials, machinery). There is no compelling reason to believe that farmers could not commercialize their tree growing operations just as they do with other cash crops such as coffee and tea when given similar support packages and conducive environment. Thus farm forestry production behaviour is a product of failed institutional guidance and support than any thing else. Public plantation forests have dominated the industrial forestry sector for decades and farm forestry has not featured anywhere in the supply grid in the lucrative industrial roundwood markets. These compounding handicaps facing the farmer reduced its production behaviour to that of planting trees for marking boundaries, shade, aesthetic value, food, fodder, medicine etc. The purpose for planting trees has not been commercial in orientation and therefore most farmers did not envisage that trees would at one time or another be harvested for a range products that can be traded in the market places. This was because markets for farm forestry products were limited or missing.

However, the sudden fall in supplies from public forests has changed the landscape of farm forestry in the region. More farmers are embracing intensive tree management such as establishment, thinning and pruning heralding the commercial orientation of farm forestry activities. This chapter highlights the growing and marketing of Eucalyptus by small-scale farmers in Western Kenya.

Eucalyptus Production on smallholders Farms

Recent studies have shown that Eucalyptus growing is more dominant in western Kenya mostly in highly populated districts of Kisii, Gucha, Nyamira, Nandi, Kericho, Vihiga and Kakamega. Growing of Eucalyptus is also becoming increasingly popular among farmers in Central and North Rift districts of the Rift Valley mostly for production of polewood and sawnwood.

Existing and Potential Markets for Eucalyptus Products in Western Kenya

Eucalyptus trees grown on farms have various market opportunities of great potential in terms of demand and value in the region that include: pulpwood, transmission poles, timber, polewood for construction sector and fuelwood for domestic and industrial purposes. This classification is based on the end use of the specified products. The following are some potential markets for Eucalyptus products from smallholder farms in Western Kenya.

Transmission Polewood

There are two major users of transmission poles in Kenya namely: Kenya Power and Lighting Company (KPLC) and Telecommunications Company of Kenya (TELKOM). Farmers in the region have good potential to supply transmission poles to the two firms. Due to the fact that Eucalyptus is widely grown by farmers in the region and secondly, rotation of between 8-12 years to attain required sizes for transmission poles is favourable to farmers as compared to longer rotation tree materials such as peeler and sawlogs.

Up to 1952 when it started to treat its own poles, TELKOM used to import poles from South Africa. Forest Department became the main supplier of polewood for its treatment plant. However, during the last decade its treatment plant has been facing dwindling supplies due to declining supply from public plantations and management problems facing plantation forestry in the country. The most preferred species is *E. saligna* and *E. grandis.* Among other recommendations to potential suppliers are: a rotation of between 8-12 years depending on the site conditions, a minimum diameter of 8.75cm and length of 12 metres, uniform tapering, minimum branches and relatively straight in form.

Telkom has an annual requirement of between 33,000 and 40,000 pieces for its transmission activities. Its treatment plant at Gilgil has an annual capacity of 72,000 pieces but it is currently facing a chronic shortage of polewood for its plant. In fact by third quarter of June, 2001 no treatment was going on for lack of polewood materials.

Linkage facilitation through *Miti Mingi Mashambani* Project enabled the treatment plant to source materials from farmers that accounted for 10% in 1997 and 70% by June 2001. However, farmer's supplies were from existing plantations that have fallen fast in the supply areas.

Shortage of polewood materials has not only affected the firm's supply of transmission poles but also its export orders of 10,000 to 36,000 pieces to neighbouring countries. This market at its full operational capacity is worth over Ksh 52 million at the current price of KSh750 per piece delivered to the plant at Gilgil.

Kenya Power and Lighting Company (KPLC) is another major consumer of polewood. KPLC traditional suppliers are Forest Department and Tea estates. According to market

sources, KPLC is facing severe shortage of transmission poles due to closure of EATEC plant at Eldoret, which used to treat its polewood. Secondly there is uncertainty in supply of poles from tea estates. Currently KPLC imports most of its transmission poles from South Africa. This is however a short-term solution. Farmers have great potential to supply a significant amount of poles from existing plantations in the short term. The firm has recently embarked on recruitment of farmers to grow polewood for its requirements. KPLC annual requirements for pole in 1999 stood at over 45,000 pieces worth over KSh 167 million, the figure is net of export orders to neighbouring countries. Due to continued shortage of pole wood of desired qualities, KPLC is already considering the use of concrete pylons in its future transmission operations.

Pulpwood Industry

Pulp and paper consumption in the country stands at 130,000 metric tonnes with an annual growth of 4% (KFMP, 1994). Local production from the four mills stands at 93,000 metric tonnes. Pan African Paper Mill Limited (PPM) is the largest pulpwood consumer in the country with an annual consumption of 500,000m^3. Currently it faces shortage of over 150,000 m^3 of Eucalyptus roundwood for blending and has been forced to shift sourcing of this product to neighbouring countries. It currently buys 10% of its roundwood requirements from farms. It has started recruiting farmers to grow Eucalyptus in western Kenya. Farmers in Western Kenya are better placed to supply some Eucalyptus pulpwood to Pan Paper Ltd at current price of Ksh 450/m^3. Pulpwood market is worth over KSh 67 million annually.

Industrial Fuelwood Consumption

Fuelwood for Tea Industry

The tea industry is one of the prime agricultural activities in western Kenya that use fuelwood in the processing of tea beverage. Although most large tea estates are self-sufficient/reliant in fuelwood needs, factories under the umbrella of Kenya Tea Development Authority (KTDA) that depend on furnace oil, provide potential markets for tree growers in their catchment areas.

Annual fuelwood demand in tea processing sector depends on various factors that include total annual output, leaf moisture, boiler efficiency, and energy conservation measures in the processing systems, Angwenyi and Kamau (2003). In 2002, ready made tea output was 287 million kg at an estimated efficiency of 250 kg ready tea per solid cubic meter of fuelwood. The estimated fuelwood demand was 803600 solid cubic meters. At the current estimated price of Ksh 800 per cubic meter stack at factory gate, the total value of fuelwood used in the tea sector is estimated at KSh 918.4 million. KTDA factories accounting for 60% of the total consumption. The KTDA market potential stands at 688,800 cubic meters fuelwood with an estimated value of KSh 551 million.

Domestic, Textile and Food processing

Western Kenya is an important region in the production of industrial and non-industrial Eucalyptus products from farms. Since there are no records indicating the share of farms in both industrial and domestic markets, however, given its vast forest resource base it is reasonable to assume that its role and participation in these markets is significant.

Ngibuini (2003) reports that out of the estimated 18.4 million m^3 of total accessible fuelwood available in the country, 64% or 11.5 million m^3 are from farmlands mostly in

the form of fuelwood. The current demand for industrial logs in the country stands at about 1.5 million tones per year and serious shortages are being experienced in the pulp and paper, saw milling, plywood and particle-board industries. The vast markets for Eucalyptus products produced from farms in Western Kenya include sawlogs, fuelwood for processing bricks, tobacco, sugar, milk, and textiles. Fuelwood is also used in fish smoking, bread making and cooking food in restaurants, kiosks and institutions. Table 5 below show some estimated national market demand for various forestry products that Western Kenya is a significant player. Farm forests in Western Kenya have high potential to enter or have commanding control in some of these markets if well developed.

Table 6: Potential markets for Farm Forestry Products in various consuming sectors

Sector	**Tones per year.**	**Farmers participation**
Firewood	30,000,000	High
Tobacco curing	78000	High
Bricks curing	56000	High
Fish smoking	18000	High
Bakeries	94000	High
Restaurants /kiosks	5,500,000	High
Private /Public institutions	250,000	High
Total estimate	**36,651,000**	

Source**:** Ngibuini (2003)

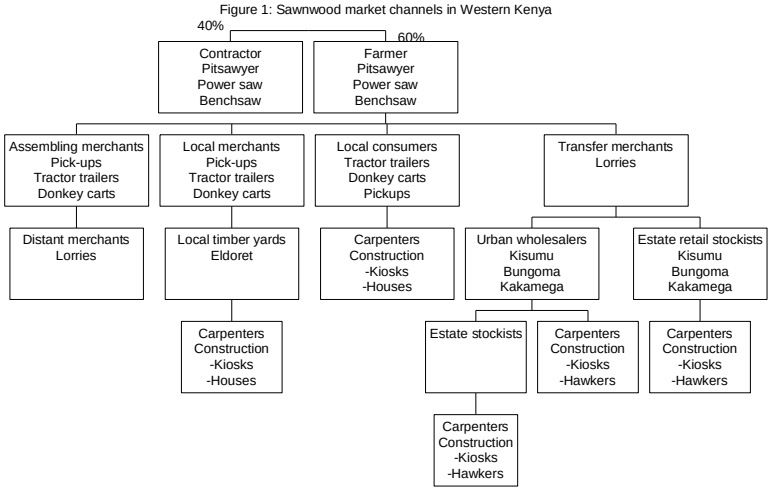
Production and Marketing of Sawnwood

Eucalyptus sawlogs are processed mostly by; bench saws, power saw and pitsaw operators at farm level. Studies by Muthike (2002) have shown that these mobile methods don't differ significantly in their recovery rates. However, recent high demand for sawnwood has encouraged contractors to enter the sawlog markets. Recent estimates indicate that up to 60% of the processing of trees on farms is done by the farmer and 40% by contractors using mobile saw operators. Merchants using pick-ups and lorries transport these products to regional markets. Distant transfer merchants transport sawnwood from sawmills and assembling points to regional markets mostly Kisumu, Bungoma, Kakamega and even distant markets such as Mombasa.

The market chain for sawnwood may involve up to four stages: Farmer/contractor - assembling merchants-transfer merchants–wholesalers-retailers–consumers. The length of the chain depends on the distance the products moves and as well the horizontal integration of the transfer and wholesaling merchants within the chain. A Small proportion of processed sawnwood is sold directly to small buyers in the rural areas

mostly carpenters and business and farm structure developers. In the regional markets transfer merchants sell to timber yard wholesalers and retailers. Most sawnwood transfer merchants deliver on order to specific timber wholesalers. The urban retailers can do sawnwood from transfer merchants or local wholesalers. Figure 1 shows typical market channel for sawnwood from Uasin Gishu District.

Figure 1: Sawnwood market channels in Western Kenya

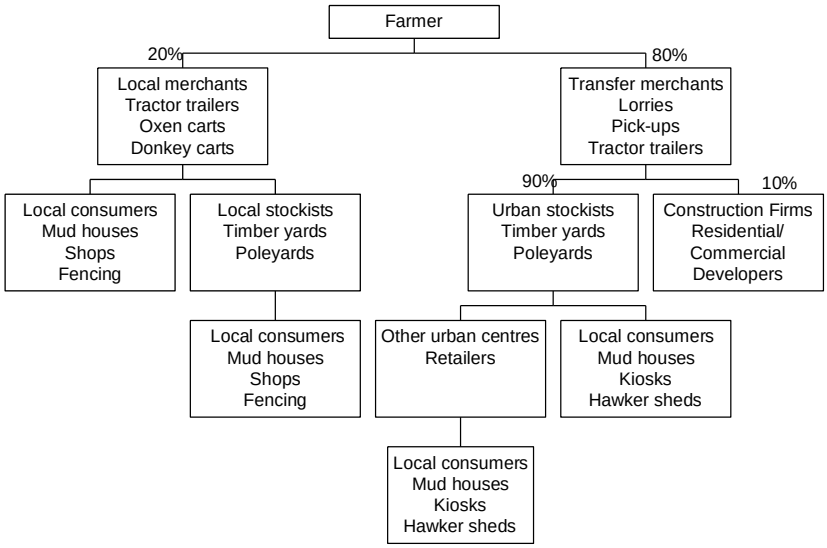


The number of wholesalers and retailers in the regional markets differ in number and size depending on the population and the geographical spread of the consumers in the town. Large towns like Kisumu consume larger volumes of sawnwood and thus have more selling outlets than smaller towns like Mbale. For the last few years, Eucalyptus sawnwood has gained popularity as a utility hardwood for production of design furniture, coffins and even construction beams. This is due to its relative abundance, its high density and red colour, which give good finish. The market exists in sawlog and sawnwood sector

Production and Marketing of Construction Polewood

Eucalyptus has a lot of uses in the construction sector that ranges from the construction of mud houses, hawking stalls to construction of high rise commercial and residential buildings. The production and marketing patterns differ from one area to another. In the North Rift, a combination of low and inconsistent demand and the dominance of dispersed routes and sometimes-direct purchases by consumers from farms has hampered development of trade in polewood between the hinterland and urban areas. The polewood trade routes are not easy to trace because of bilateral price discovery, frequent exchanges and frequency of small quantities each time a transaction takes place. However, Kisumu lacks vibrant polewood production in the surrounding farms and depend on Vihiga District for its supplies. The trade between Kisumu and Vihiga District is an important activity that involves two to five lorry loads of polewood and smallwood deliveries to Kondele and Nyalenda markets daily. The merchants buy and transport polewood from farms using lorries and once in the yard are sold to consumers mostly mud house builders, hawking shed owners, residential and business developers and retailers in estates.

Figure 2: Polewood Market channels from Vihiga District in Western Kenya

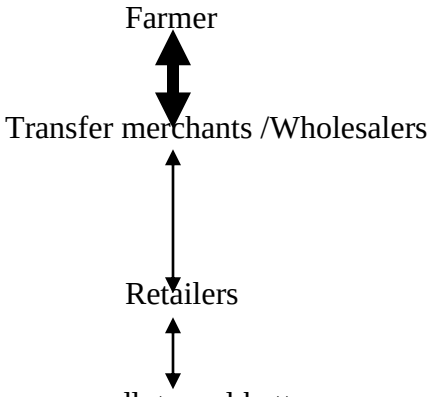


It is estimated that 80% of the output from Vihiga is transported to Kisumu and the rest is consumed within District. Kondele and Nyalenda markets take 90% of the imports while developers and other consumers elsewhere in Kisumu and the surroundings share the rest. Kondele and Nyalenda markets acts as the main distributors to retailers and consumers in Kisumu and outlying regions.

Price Formation in Polewood Trade

In the polewood producing areas of Vihiga District thousands of farmers have small woodlots of varying sizes and management regimes for polewood production. Kisumu merchants have commission scout agents in the production areas who collect information on the availability of polewood on their behalf. Sometimes large woodlot owners may travel to Kisumu to seek buyers. The merchants are well conversant with quality and sizes that customers prefer and that becomes handy in the selection of woodlots and bargaining with woodlot owners (Figure 2). Merchants are well informed on market conditions as compared to farmers and thus have advantage in the bargaining process. The merchants number less than 10 and thus have wider latitude in selection on who to buy from than the farmers.

Figure 3: Schematic presentation of Polewood market structure in the study area. The thickness of the arrows indicates price formation strengths of the players in production-consumption chain.



Those farmers who have larger woodlots and better-managed stands thus yielding high quality have better leverage in the bargain process. This is because merchants would want to acquire high quality and large quantity of polewood from one purchase thus reducing scouting and assembly costs. However, farmers with smaller woodlots and poor quality polewood are likely to be penalized by polewood merchants. In 2001 farmers were selling standing woodlots to merchants from Kisumu, an hectare of well stocked high quality polewood can fetch up to Ksh 30,000. Once sold, the buyer will clear fell and load using hired labour at a cost of Ksh 400 per 7-ton lorry and transport to Kisumu at Ksh 4500. Both the woodlot owners and merchants prefer complete clearfelling for it allows uniform regeneration and merchant's access to all sizes of polewood. The number of poles per seven tonne lorry load varries depending on the sizes of polewood from 350 for king size poles, 750 for mix up to 1000 for medium sizes. Once in the yard the polewood is classified by size and quality into varying categories for different uses thus attracting different prices. Merchants act as wholesalers to both retailers and final consumers within Kisumu and surrounding areas.
Taking Vihiga and Kisumu market as a typical production and consumption centres for polewood in the region for the study period 2001/2002, farm gate prices for king size polewood oscillated between Ksh 30 to 40 depending on the construction activities in Kisumu and neighbouring districts (Table 3). Transports cost and delivery prices ranged between Ksh 4 to 6 and Ksh 40 to 50 respectively. The retail prices as well oscillated from 50 to 60 shillings. The polewood prices are mostly influenced by the demand conditions at Kondele Market. High demand conditions make merchants to increase consumer prices that are transmitted through the market chain to the farm gate and vice versa.

Table 7: Mean Prices of king size polewood from Vihiga District Kondole Market, Kisumu in 2001/2002.

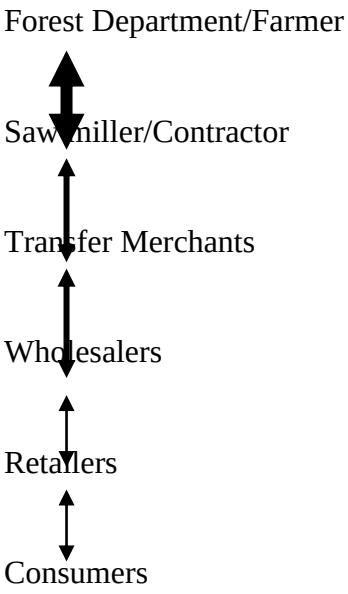
Place	8cm diametre polewood piece (king size) from Vihiga in Ksh
Ex Vihiga Division in Vihiga District	30-40
Unit transport costs per piece	4-6
Delivery prices at Kisumu	40-50
Retail prices at Kisumu	50-60

Source: own data collected in market survey 2001-2002.

Price Formation in Sawnwood Trade

Eucalyptus sawnwood has become an important hardwood popular in carpentry works and most of it is produced from farms as compared to softwood. Sawnwood for Kisumu town the largest regional market originate from Nandi, Kisii and Western province. In the immediate past, saw milling enterprises in the North and Central Rift districts were the dominant suppliers of softwood sawnwood in the region and thus had the power to influence regional prices. Farm produced Eucalyptus sawnwood thus was a price taker in a market dominated by softwood sawnwood produced by sawmills. Due low volume output and dispersed production pattern, most transfer merchants ignored farm forestry produced Eucalyptus sawnwood in favour of more abundant supplies from softwood saw milling enterprises. However, sawlog scarcity had become the dominant factor in recent times due to frequent moratoriums and sometimes outright banning on harvesting from public forests. The outcome was immediate and their impacts were quickly felt through out the region and have changed production patterns in the region in favour Eucalyptus produced on farms (Figure 4).

Figure 4: Schematic presentation of sawnwood market structure in the study area. The thicknesses of the arrows indicate price formation strengths of the players in production-consumption chain.



The recent changes have seen the emergence of farm forestry as the dominant player in the sawlog business in Western Kenya region. The market control power has shifted from saw millers to sawnwood contractors. Prices for sawlogs from farms have increased by more than 4 times and sawnwood by more than double from Ksh 8,000 per tonne to over Ksh 15,000 per ton. The sawnwood contractors have increased but are less than 50 in the production areas that have expanded to mostly Nandi district. Price setting power has shifted to between the sawnwood contractors and transfer merchants and farmers with large stumpage that can attract larger clients at the production areas.

Table 7 shows that despite relatively medium number of sawwood outlets in Kisumu, few large wholesalers control a large proportion of the total stock in specified market places. Despite their control over large stock, retail prices are similar across the yards. Kisumu exhibits relative specialization in Eucalyptus sawnwood retailing. Kondele stocks mostly softwoods for construction whereas Kibuye stocks a high proportion of hardwood and less softwood. Further, in Kibuye some merchants specialize in specific timber sizes such as 6x1 to 12x1 sizes whereas others stock smaller sizes 2 x 2, 3 x 2 and 4 x 2. This is because Kibuye is the hub of furniture making in Kisumu and there is a large number of users of hardwood of various sizes of sawnwood. This makes it viable to specilaize at the retail end.

Table 8: Sawnwood stocking by sampled timber yards in Kisumu in 2001/2002.

Location	No.of Outlets	Est.stock Tones	Remarks
Kondele	16	120	One wholesaler control over 60% of the total stock
Kibuye	12	42	Two wholesalers control over 50% of the total stock
Nyalenda	7	25	Two wholesalers controlled about 70% of the total stock

The findings attest to the fact that sawnwood wholesalers still dominate at the distribution end of the marketing channel especially under condition of scarce supplies. The longer the distances that sawnwood have to be obtained increases the likelihood of its concentration in fewer merchants. This is currently taking shape in Kisumu. The concentration is because transfer merchants who ferry large consignments will favour merchants who have the ability to place and pay for lorry load orders of sawnwood thus reducing their marketing cost margins mostly related to time and risk. However, in smaller regional markets such as Bungoma and Kakamega substitution of widely traded cypress sawnwood by relatively abundant locally farm produced Eucalyptus sawnwood is visible. Though no statistics on the current break down on species being stocked in these outlets, it is visible that stocking of Eucalyptus sawnwood is more pronounced among small merchants and retailers. The recent changes have significantly enhanced the role and influence of farm forestry produced sawnwood in overall sawnwood trade in the region.

During the survey period between 2001 and 2002 on average gate prices, transport costs, delivery prices and retail prices rose in the regional market. Similarly, taking Uasin Gishu and Kisumu as a typical production area and regional market respectively. Sawnwood prices rose on average from Ksh 8 to 11 per 30 cm running length or an equivalent of Ksh 8,000 to 11,000 per tone at the sawmill gate in Uasin Gishu. The transport cost to Kisumu the major sawnwood market in the region as well rose from Ksh 1.00 to 1.20 per 30 cm. Similarly, the delivery prices rose from Ksh 9 to 11 and the retail prices at major Kisumu outlets rose from Ksh 12 to 15 in for the popular 4x2 and 3x2 sizes (Table 8).

Table 9: Mean Prices for sawnwood from Uasin Gishu at Kisumu market in 2001/2002 (4x2 and 3x2).

Place	Prices in Ksh per tonne (4x2 and 3x2)
Ex saw mill in Uasin Gishu	8,000-11,000
Unit transport costs	1,000-1,200
Delivery prices at Kisumu	10,000 to 12,000
Retail prices at Kisumu	12,000-15,000

Gross Marketing Margins in Polewood Trade in Western Kenya

Polewood production for Kisumu markets is concentrated in Vihiga District that has dominated this market for decades. The merchants at Kondele Market in Kisumu report that consumers prefer Vihiga polewood because of its high quality. The qualities mentioned include low moisture content and thus less likely to split on nailing or drying. Table 8 shows that a part from the producer, two marketing agents involved in polewood market chain: transporters and merchants. Gross marketing margins (GMM) share of consumer price for the producer and the two marketing agents indicate that the farmer fetches 46%, transporters 20% and merchants 35%.

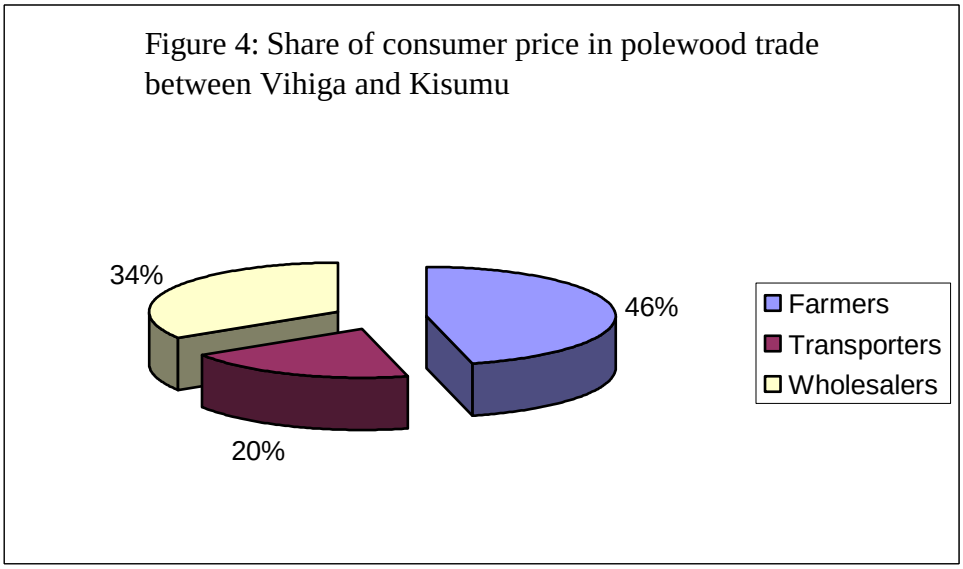
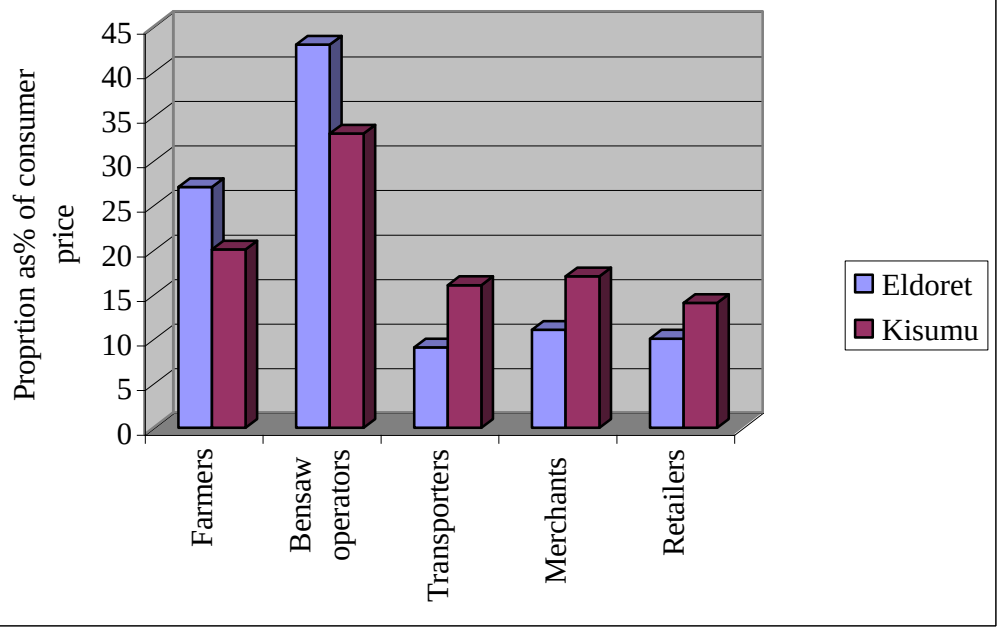


Figure 3: Gross Marketing Margins in sawnwood Trade in Western Kenya

The operation mechanism presented is that for sawnwood produced on the farm by hired bench saw operators. Benchsaw processing is a labour intensive activity involving up to 7-10 skilled persons responsible for log sizing, loading, sawnwood sizing, measurement and stacking of processed sawnwood. Sawnwood production referred to

was from farms was within 60 kilometres radius from Eldoret town mostly in Ainabkoi Division. Figure 3 shows that benchsaw produced sawnwood processing takes up the largest share of consumers price (43%) followed by farmer's share (27%) whereas marketing agents downstream receive less shares in Eldoret town. Similarly, the share of each agent decreases with increased distance from production areas. The shares in Kisumu markets follows a similar pattern with the farmer receiving (20%) showing that increased marketing costs reduce the farmer's relative share of the consumer price as well.

Figure 4: Share of consumer price of benchsaw produced sawnwood in Eldoret and Kisumu



Source: own data collected in market survey 2001-2002.

Comparative Analysis of GMM for Polewood and Sawnwood

Table 7 reveals that actual farmer's share of consumer price decreases with increased processing services that is required to transform the product into forms desired by the consumers. This is evident from the contrasts between sawnwood and polewood trade in the regional markets. The highest farmers relative consumer price share is achieved from the least processed products than otherwise. For Kisumu consumer price, farmer's share in farm forestry product trade decreased from polewood (45%) to (16%) in sawnwood. The farmer's share in sawnwood trade can increase from 26% to 68% if the farmer takes up processing services. However, it is worth to note that vertical integration has cost and risk implications to the farmer and that may explain why most of them don't undertake such services. Processing entrepreneurs employ better production tools and skills and are more conversant with product specifications and market pricing mechanisms. The farmers may not have the investments to purchase machinery needed for processing sawnwood and may not easily access services of

skilled manpower.

It is therefore feasible to argue that at infancy stages, marketing of farm Eucalyptus products from trees grown on farms poses several challenges. Most of the marketing agents are part timers and their dependence on marketing of these products for income generation is irregular. The scenario is made worse by frequent government interventions in production and movement of farm forestry products. These interventions distort market performance as it increases costs of marketing through travels seeking permits from various government offices and police inspections along roads to regional outlets. The merchants pass on the costs of transport, bribes, processing costs and poor quality product to the farmers and consumers. These unfavourable factors impose penalties on farmers and consumers as the more informed merchants try as much as possible to maintain their margins. This scenario has the effect of worsening the farmer's take home share and squeezes consumer's quantity purchases.

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