# TREE PLANTING GUIDELINES FOR UGANDA

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The Sawlog Production Grant Scheme has been a partnership between the Government of Uganda and the European Union from 2004 to mid - 2009.

# DEDICATION AND ACKNOWLEDGEMENTS

This publication is dedicated to the many private sector tree growers throughout Uganda who have made such an impressive start in establishing the timber resource the country badly needs. It is hoped that your efforts will inspire many more people to invest in this profitable and satisfying business and in doing so greatly stimulate rural development in the region. Collaboration with Pat Hardcastle (Chapter 6) and the Uganda Gatsby Trust (Chapter 21) is also acknowledged.

# PHOTO CREDITS

All the photos in this book are by SPGS staff unless otherwise stated. The SPGS has a large library of photographs of all aspects of plantation development in Uganda (and beyond), which are freely available (for non-commercial use only) provided the SPGS is acknowledged as their source.

# COMMON CONVERSIONS

Metrically-challenged readers might find the following conversions useful since we have used metric measurements throughout this publication.

| | | |
|---|---|---|
| 1 mm | = | 0.039 inch. |
| 1 in | = | 25.4 mm. |
| 1 m | = | 3.281 ft. |
| 1 ft. | = | 0.3048 m. |
| 1 ha | = | 2.471 acres. |
| 1 acre | = | 0.4047 ha. |
| 1 ha | = | 10,000 square m. |

# DISCLAIMER



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# ABBREVIATIONS

| | |
|---|---|
| APO | Annual Plan of Operations |
| CFR | Central Forest Reserve |
| DFS | District Forestry Services |
| EG | *Eucalyptus grandis* |
| EIA | Environment Impact Assessment |
| EU | European Union |
| FABI | Forestry & Agricultural Biotechnology Institute (Pretoria University, RSA) |
| FGHY | Fast Growing High Yielding |
| FMP | Forest Management Plan |
| FRMCP | Forest Resources Management & Conservation Programme |
| FSC | Forest Stewardship Council |
| FSSD | Forest Sector Support Division (formerly Forest Inspection Division – FID). |
| GoU | Government of Uganda |
| ha | Hectare |
| $m^3$ | Cubic metres |
| MAI | Mean Annual Increment |
| MDs | Man-Days |
| MUK FoF | Makerere University Faculty of Forestry & Nature Conservation |
| MW&E | Ministry of Water & Environment |
| NAO | National Authorising Officer (under GoU's Ministry of Finance) |
| NFA | National Forestry Authority |
| NFC | Nyabyeya Forestry College or New Forests Co. Ltd. |
| P&D | Pests and Diseases |
| PCH | *Pinus caribaea* var. *Hondurensis* |
| PPE | Personal Protective Equipment |
| PSP | Permanent Sample Plot |
| R&D | Research and Development |
| REDD | Reduced Emissions from Deforestation and Forest Degradation |
| RSA | Republic of South Africa |
| SPGS | Sawlog Production Grant Scheme |
| TA | Technical Assistance |
| UFD | Uganda Forestry Department |
| UGT | Uganda Gatsby Trust |
| UIA | Uganda Investment Authority |
| UTGA | Uganda Timber Growers Association |

# INTRODUCTION

We tell the students attending the SPGS's introductory training course, that we teach them not just how to plant trees (as anybody can do that) but how to grow 'High Yielding, Fast Growing' forest plantations. Growing trees as a business in Uganda, whether for timber or other wood products, can be a profitable and deeply satisfying business venture but only if it is carefully planned and well managed. This publication will hopefully help people to do just that.

Many readers undoubtedly will be relieved to hear that in writing this book, no prior knowledge of forestry was assumed since most of the commercial-scale planters in the recent past in Uganda have been new to the business. The book covers all the stages 'from seed to sawlog'. It focuses on the establishment and management of the main commercial tree species currently being grown in Uganda and is based on the a unique blend of the senior authors' experience of forestry in Southern and East Africa combined with detailed practical knowledge by the SPGS team over the past five or so years, working with tree growers both large and small throughout Uganda.

This SPGS Tree Planting Guidelines had its origin around 2004, when the fledgling Sawlog Production Grant Scheme (SPGS) quickly realized that many potential tree growers in Uganda had little knowledge of how to establish and manage tree crops to maximize (and sustain) timber yields from plantations. With very little new planting in Uganda since the early 1970's, even the country's professional foresters have had little exposure to commercial forest plantations.

In contrast to the local situation, commercial plantation forestry has developed enormously in many tropical and sub-tropical countries over the last 30-40 years. Countries with little natural forest like South Africa and Swaziland, have developed major plantations to meet regional requirements and later built a major export business based on wood products. Even countries with large natural forests like Brazil, established huge plantations that now support major export industries. In all these cases, many new techniques have been introduced and refined to achieve very high (but sustainable) growth rates – for example: clonal forestry, detailed site characterization for optimum site species matching, fertilization and breeding trees for pest and disease resistance.

Many of the individual Chapters in this book were published as separate SPGS Plantation Guidelines from 2005-08. They proved to be very popular with those already planting (and those thinking of planting) on a commercial scale in Uganda. The format adopted for these earlier publications has been retained for this compilation – especially the use of simple, non-technical language and a liberal sprinkling of many colour photographs throughout to illustrate key points.

In keeping with the objective of aiming at the general reader, it was decided at a late stage to change the title from *A Silvicultural Manual for Uganda* to the *SPGS Tree Planting Guidelines for Uganda*, as we realized many potential readers might be put off by a term familiar to foresters but not the general public - namely, silviculture. Silviculture is simply the science – and some would say the art – of growing trees.

Whilst the book focuses on growing trees mainly for timber production (sawlogs), many of the principles are the same for growing a range of other products from planted trees.

The response of private growers during the SPGS's first phase (2004-08) shows that despite a late start, given the right assistance and direction, Uganda could relatively quickly become a major regional timber producer. Prevailing conditions make the country eminently suitable for developing a major commercial forest industry and there is certainly no shortage of potential investors (large and small, local and foreign) in the sector.

We hope that this publication not only benefits current and potential tree growers in the region but that it will also go some way to help people take forestry more seriously as an industry in Uganda. A well-planned commercial forestry industry will provide many thousands of rural jobs; it will provide substantial revenue (in terms of taxes and savings on imports) and it will eventually take considerable pressure off the country's remaining natural forests.

The focus of this publication on commercial tree growing in no way belittles the importance of small scale and community tree planting. The SPGS has produced a separate simplified guideline specifically for the smaller grower and this is available free from SPGS and from **www.sawlog.ug.**

We at the SPGS pride ourselves on good communication to direct us forward: we thereby encourage readers to give us feedback on this 1st edition of the ***SPGS Tree Planting Guidelines*** so that it can be improved on in the future. Commercial forestry is a dynamic field, with new advances happening all the time. Further hard copies are available from the SPGS (see inner front cover for contact details): it is also available as a free download (in pdf format) from **www.sawlog.ug**

## GENERAL PUBLICATIONS

The following are general publications that are recommended: more specific references are included at the end of each Chapter.

**Evans** J & J Turnbull, 2004. *Plantation Forestry in the Tropics* (3rd Edn.). Oxford University Press; pbk; 467pp. www.oup.com *NB. Copies are usually available from SPGS at cost price (ca.UGX150,000).*

**Higman** S *et al*, 2005. *The Sustainable Forestry Handbook: A Practical Guide for Tropical Forest Managers on Implementing New Standards*. Earthscan, UK; hbk; 332pp. www.earthscan.co.uk

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# CHAPTER 1:
# TREE PLANTATIONS AND THE SPGS

*Ugandan planters admiring a superb, mature pine plantation in South Africa (Global Forest Products - now York Timbers, Sabie, RSA 2007).*

## 1.1 WHY FOREST PLANTATIONS?

As a country develops and its population expands, the per capita consumption of wood and wood-based products rises steadily. The natural forests and woodlands that once seemed never-ending are suddenly almost finished. In the past, the response was often for the Government to then plant the trees to provide the timber, the poles and the fuelwood - though this has not proved very successful in a number of countries due to poor planning and management. The next cry often heard is *"We must force people to plant trees!"* and this approach invariably fails too, even though lots of seedlings may be produced in the process. In Uganda, we may have found the solution: create the right investment environment and then provide support to private sector entrepreneurs willing to develop commercial tree plantations.

Planted forests now account for around 140M ha, or around 4% of global forest area. Importantly, however, these plantations provide over one third of the industrial wood produced in the world and their extent and productivity are increasing (FAO, 2006). Forest plantations are generally very cost-effective ways of producing wood and they are often much more efficient and profitable than natural forests in terms of production of utilisable materials. The sustainable yield of exploitable trees in natural forests in Uganda is only around $2m^3/ha/yr$, compared with well established and managed plantations, where the average annual yield can easily be 10-15 times this figure. Poorly planned plantation developments, however, can sometimes have negative impacts, especially in terms of environmental (and sometimes social) issues.

*Kamusiime Association Committee Members (with Paul Jacovelli) in Bushenyi, Nov. 2008.*

*Mpanga CFR, Mpigi - Fast growing plantations are needed to 'compensate' for such natural forests.*

This Chapter presents an overview of plantation forestry. In particular, it highlights the value of tree plantations not just to the individual investor but to the country as a whole. Tree plantations can be established for numerous reasons - e.g. timber or pole production, pulpwood (for paper or packaging), bioenergy (industrial or domestic fuelwood) and watershed protection. Whilst this book focuses on timber and pole production, most of the concepts are the same whatever the final product: the only differences might be the species choice, the initial spacing, the thinning regime and the time of final harvest.

Commercial forestry is a frequently misunderstood industry with regard to its potential for rural development. It will only realise this potential, however, if the development is carefully planned and the forests well managed. Commercial forestry is not just about planting trees but about developing a sustainable (and profitable) industry based on timber and other wood products. This requires knowledge not just of growing trees but of the modern wood processing industry and its raw material requirements. The history of commercial plantations in Africa is littered with expensive failures, where the tree resource was established without proper consideration of the processing facilities and the end markets.

It is important to note that to gain the maximum benefit from a commercial forestry industry requires large areas of plantation resource to support the establishment of efficient processing facilities that can process a wide range of products from the plantation resource. Thus the development of plantations must be strategically planned to ensure sufficient resources are concentrated in suitable locations rather than scattered around.

Tree plantations are akin to commercial agriculture, being largely monocultures of exotic species (mostly pines and eucalypts) which are capable of growing fast and producing high yields

of utilisable products (whether it be fuelwood, poles or sawlogs) when properly managed. Trees on farms and other agroforestry systems can play an important role but large-scale, commercial plantations are essential to provide the bulk of the country's wood requirements, which includes the raw material for wood-using industries. Well-managed tree plantations can yield over 20 times the utilisable timber compared with an equivalent area of natural forest. Tree plantations are thus extremely important to supply a country's timber and other wood products requirement.

The key benefits commercial forestry development brings are as follows (NB. these are discussed in more detail later in this Chapter):

- **Economic development** (attracting investment; import savings; export earnings).
- **Employment** (establishing large plantations needs large labour inputs: many more jobs are created later when the trees are processed).
- **Conservation** benefits through 'compensatory' plantations that take the pressure off remaining natural forests by producing wood (and other products) in a much more cost-effective way.

**Economic development & Employment:** A well-planned, commercial plantation sector becomes a major source of rural employment as well as eventually becoming a major revenue-stream for government, particularly as the trees are the raw material for many added-value businesses like industrial utilisation (sawmills and wood-chipping plants) and furniture making. Plantation forests can save on costly imports (and thus foreign exchange) as well as providing major export earnings.

*Excellent 5-yr Pinus caribaea (improved Australian seed) at Besepo (U) Ltd.'s Mubende plantation (Dec. 2008).*

*Katugo CFR, Nakasongola: poor seed + poor management = a poor investment.*

Intensively managed plantations provide many thousands of rural jobs – both directly and indirectly in various support industries. The forestry industry is thus a great way of stemming the flow of migration to cities: it also trains people how to grow trees in cost-effective (i.e. commercial) way and creates many opportunities for entrepreneurs to start up e.g. offering contracting and other support services to investors. Establishing just a minimum of 75,000 hectares of timber plantations in Uganda would create at least 20,000 jobs and many more in added value processing once the plantations are mature.

A good example is Swaziland, which is a small country in Southern Africa. Despite not being blessed with Uganda's fertile soils and good rainfall, Swaziland has developed a resource of 160,000 hectares of pine and eucalypt plantations (all by the private sector): the Swazi forest industry now directly employs 8,000 people and many more indirectly and contributes 15% to the country's GDP. The main attraction for private investors into Swaziland from 1949 onwards was the offer of large areas of land without encumbrances and the desire of the government to support commercial private investment.

Commercial forestry – especially in the tropics and sub-tropics – also offers excellent investment opportunities for a country, especially a country like Uganda, where growth rates are high and commercial-scale tree growing can be highly profitable. This is a good time for commercial forestry too, with numerous institutional investors currently investing heavily in forestry, which offers diversification, reduced risk, protection against inflation and is seen as a socially responsible investment[1]. Forestry also offers the prospect of attracting revenue from carbon credits: in Uganda both the private and public sectors are currently actively seeking to benefit in the near future from REDD[2] payments.

**Conservation of natural forests:** By producing such high volumes of utilisable products, intensively grown plantations can thus take considerable pressure off natural forests, which generally supply such products in much more extensive way. This 'compensatory' benefit of plantations will only work, however, with an effective mechanism in place for protecting the natural forest areas. It is important to note that plantations can never replace natural forests, which are often very complex ecosystems – tropical high forests, for example, have many hundreds of species all occupying their own niche.

[1] *Investment is nearly always tied to international Certification by an independent body (e.g. Forest Stewardship Council) that checks whether the business meets agreed standards - economically, socially and environmentally (see Chapter 23).*

[2] *REDD – Reduced Emissions from Deforestation and Degradation.*

*First thinning of 4-yr old Pinus caribaea (Australian seed) at Busoga Forest Co., Mayuge (Nov. 2007).*

## 1.2 PLANTATIONS AND THE ENVIRONMENT

There are some organizations and individuals who cannot see any positive benefits coming from tree plantations. There are claims that plantations destroy the environment, dry up rivers and that they displace small farmers. Indeed, some of these criticisms are valid, e.g. where rich natural forests have been cut down to make way for fast growing pulp plantations; where local people have been forcibly displaced for plantation development and where poor planning has led to reduced water-flow in some key watersheds.

Much of this anti-plantation hysteria, however, is unbalanced and chooses to ignore the undoubted benefits to be gained from carefully planned and well managed tree plantations – on a national, regional or individual level (as noted earlier in this Chapter).

It should be stressed that tree plantations are generally much less degrading to the soil than many agricultural crops. The adoption of sound silvicultural practices (as emphasized throughout this book) will also reduce the impact of plantations: for example, careful planning to avoid clearing natural forests or planting riverine areas; minimizing erosion through avoiding hot burns and contour planting; the use of fertilizers to maintain soil fertility. As emphasized in Chapter 4 of this book, plantation planning now includes social and environmental dimensions. Large plantation developments now also consider the many other benefits trees can provide, which can contribute greatly to national development goals.

**Some highly relevant comments:**

**On plantations:**
*"Plantations and natural forests are complementary rather than alternative land uses. Given the variety of purposes they can fulfill, there is a need for both large and small-scale plantations"(Sawyer, 1993).*

**On sustainability:**
*"Measurements of yield in successive rotations of trees suggest that there is, so far, no significant or widespread evidence that plantation forestry is unsustainable. Where yield decline has been reported, poor silvicultural*

*practices and operations appear to be largely responsible. Plantation forestry appears to be entirely sustainable under conditions of good husbandry, but not where wasteful and damaging practices are permitted" (Evans, 1999).*

**On measures to minimize negative impacts:**

*"Overall there is no reason why there should be severe negative impacts from plantations. Providing adequate guidelines and standards are framed and implemented it is possible to minimize negative impacts and to ensure that issues of equity in respect of costs and benefits are achieved.What is required is to explore the full range of options silviculturally and in terms of ownership patterns, etc. and to ensure that plantation developments take place within a transparent and participatory framework of rational land use decision making"(Hardcastle, 1999).*

Prior to the SPGS starting, Pomeroy (1999) looked specifically at the potential environmental impact of commercial plantations and made a number of recommendations to mitigate any potential damage.

## 1.3 PUBLIC OR PRIVATE SECTOR?

Traditionally, commercial forestry was the business of the State, who had access to large areas of land suitable for growing trees and was prepared to invest for the long time periods associated with growing timber. In Africa, the State (often with support from development banks and/or international donors) established large plantations in many countries – e.g. Malawi, Tanzania and Kenya. Many of these large plantation developments, however, have suffered from poor site selection, using poor genetic material, have been poorly maintained or have been placed too far from markets (Cossalter & Pye-Smith, 2003).

In other countries (e.g. South Africa, Swaziland and Zimbabwe), the private sector developed the plantations and these have generally been better managed and profitable. In the last 20 years or so, there has been a shift (particularly in the Southern Hemisphere) towards privatizing state forests, which is well documented by Garforth & Mayers (2005). The trend in most countries is now clearly towards increasing private sector involvement in commercial plantations.

Chamshama & Nwonwu (2004) list the factors contributing to the success and failure of planted forests in sub-Saharan Africa as follows:

**Success factors:**

- Overall environment for private investment.
- Political stability.
- Research outputs & technological improvements ('best practices').
- Fast growth of exotic species and use of improved germplasm.
- Land availability and tenure.
- Pricing policies.
- Non-restrictive legislation.
- Linkages with downstream processing.
- Use of supported out-grower schemes.

*SPGS's Thaddeus Busingye advising a small grower supported by the SPGS in Luwero (2007).*

**Failure factors:**

- Public sector domination.
- Land tenure system and property rights.
- Political instability and conflicts.
- Limited local utilization capacity and demand.
- Scarcity of water.

The forest sector reforms in Uganda resulted in a policy that states (p.17):

*"The private sector will play the major role in developing and managing commercial forest plantations. This may be either through large scale industrial plantations on government or private land or through small scale plantations on farms. The role of government will be to support and regulate this development. The government will create a positive investment climate to encourage private investment in commercial forest plantations" (GoU, 2001).*

From 2003-2008, the private sector in Uganda has taken the baton and run with it, largely due to the support of the SPGS. The National Forestry Authority (NFA) has planted *ca.*6,000 ha in this period, with the private sector planting over 15,000 ha. Whilst the NFA's future planting targets are not known, what is clear is that the private sector is prepared to invest in commercial forestry in Uganda, provided the investment environment is right (Chapter 2 gives more details).

## 1.4 PLANTATION SUBSIDIES & THE EVOLUTION OF THE SPGS

Subsidies of one sort or another have been the key drivers in attracting private sector investment into forest plantations in many countries. These subsidies can be direct (e.g. grants or loans) or indirect (e.g. tax exemptions or government provision of goods or services). There is an ongoing debate about the cost-effectiveness of incentives - see Bull *et al* (2006) and Bodegom *et al* (2008). It is clear that when carefully planned and administered, however, that packages of direct and/or indirect incentives can be very effective in attracting private investors into establishing commercial forest plantations.

The experience in Uganda under the SPGS since 2003 also bears this out (Kazoora, 2007). The SPGS started out as a part of a bigger EU-funded programme, the Forest Resources Management and Conservation Programme (FRMCP), which ran from 2002-06 and was primarily concerned with conservation of the most important remaining natural high forests and woodland CFRs. The plantations were considered as being 'compensatory' for the timber and other products 'locked' away in the protected CFRs. The interest from private growers (both large and small scale) in Uganda, however, has moved this concept on so that timber plantations are now being seen as a serious investment in their own right.

Two factors have been important to attracting private investors into the commercial forest sector in Uganda – namely, the SPGS incentive package (described in the following section) and the availability of long-term tree planting permits in specific CFRs around the country. Some CFR planting permits had been issued to private 'investors' under the old Uganda Forest Dept. (pre-2004) but with little or no support (or pressure to perform), very few serious plantations were established. Under the newly formed National Forest Authority (NFA), however, many permits were issued from 2004 onwards.

## 1.5 THE SPGS

The SPGS is a joint European Union and Government of Uganda project that started in 2004[3] . In just four years, over 10,000 hectares (ha) have been established by private growers (both large and small scale) and the demand has been created to multiply this many times over. It is estimated that as much as 5,000 ha of additional planting could have been carried out by private growers outside of the direct SPGS

[3] *The Norwegian Government and the EU are planning to co-fund Phase II of the SPGS from 2009-2013.*

support. The project has not just stimulated the planting of timber crops throughout the country but has kick-started the development of many areas which are essential to support the emerging sector – especially commercial forestry research, training, sourcing improved seed and improved nurseries. In doing this many thousands of rural jobs are being created, both directly in plantation establishment and maintenance and indirectly in a range of support services.

The SPGS gives planting grants and technical support to private sector growers establishing from 25 to 500 ha over two years throughout the main tree growing areas in the country. During Phase I (2004-08), the SPGS offered UGX 600,000 per hectare to contracted clients. Crucially, no money is paid up front and the grants are only dispersed after site visits by project staff to check against agreed standards. Potential growers can either plant on their own (private) land or on CFR land (the latter with a tree planting permit from the NFA). Only private sector individuals, formal private associations or companies can apply for the grant support.

For further details of the SPGS (including how to apply), see SPGS (2009) or visit the project's web site - **www.sawlog.ug** The background to the formation of the SPGS can be found in Jacovelli & Carvalho (1999) and Kazoora & Tyler (2001); whilst an analysis of the project's achievements are described in greater details in Jacovelli (2009) and Kazoora (2007).

At the time of going to press, the details of the next phase of the SPGS (2009-2013) were not finalized. Readers are directed to the project's regular Newsletters and web-site for the latest information.


*Kamusiime Assn.'s Brenda Mwebaze receiving the 1st SPGS payment from EU's Christer Hermansson (2005)*

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Fig. 1: How the SPGS is achieving its results and getting trees established through private investors.

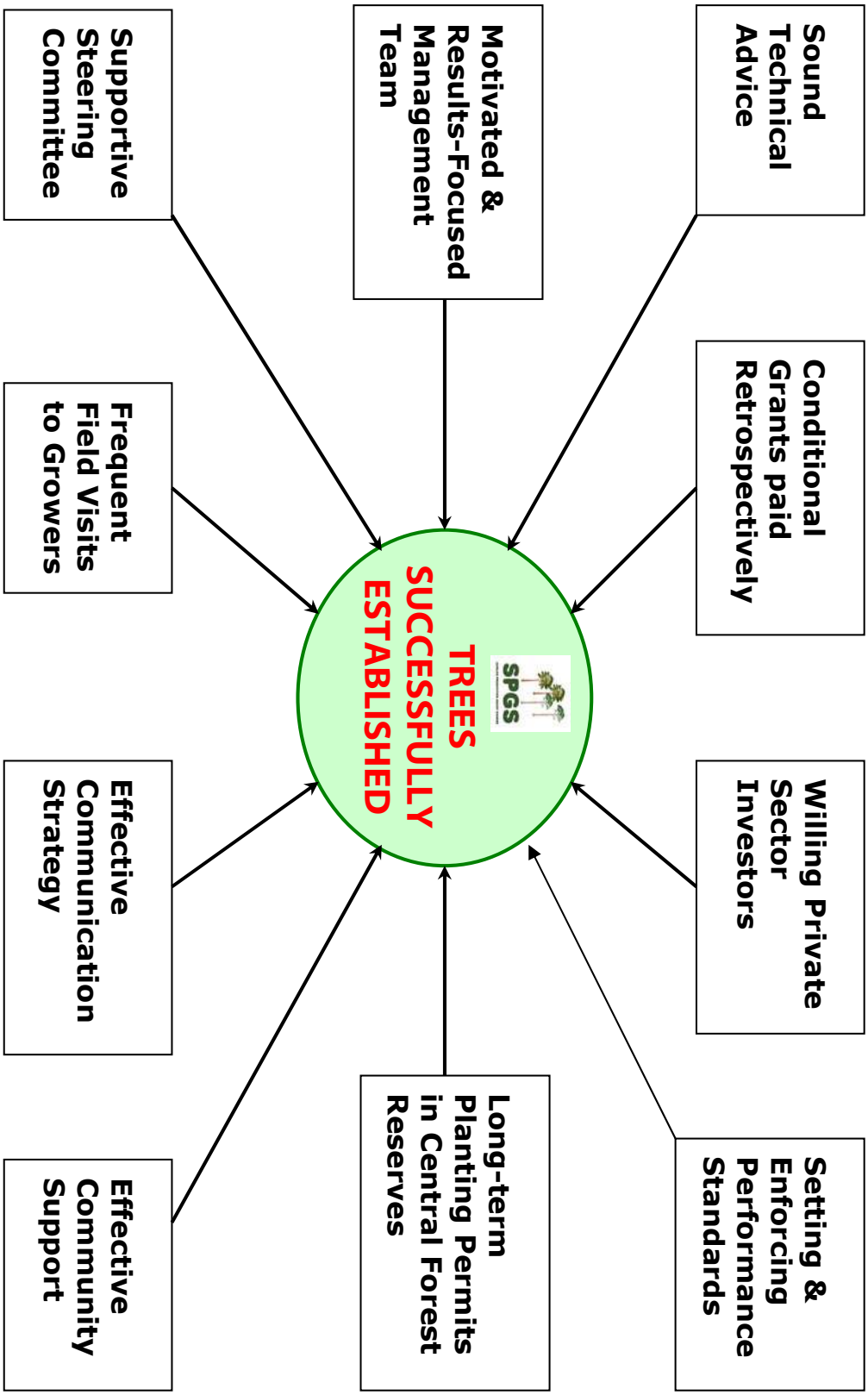



Fig. 1. Why The SPGS is Working

# CHAPTER 2
# WHY INVEST IN TREE PLANTATIONS IN UGANDA?

*Improved seed and good weeding are evident in this 3-yr Pinus caribaea at Nakasongola (Robert Nabamyumya, Feb, 2007).*

## 2.1 UGANDA

Uganda is mostly a fertile, beautiful country and gives most visitors the impression of being adequately forested. But closer inspection reveals that all is not as it seems, with deforestation and land degradation being serious environmental issues. 80% of the current 30M population live in rural areas and greatly depend (>90%) on fuelwood for their energy needs. With the population growing at around 3.4%, the population will double in just 20 years. Deforestation and encroachment even into the Protected Areas (Central Forest Reserves and National Parks) are increasingly becoming problematic too. The country's remaining natural forests and woodlands (now forming less than 20% of total land area) are disappearing at the rate of about one percent per year.

*3-yr Eucalyptus grandis (improved RSA seed) at James Finlay's Mwenge tea estate, Kyenjojo - growing at over 60m$^3$ per ha per year (1998).*

The per capita forest cover has declined from 0.3ha in 1990 to just 0.1ha in 2004.

With demand already exceeding supply, there is a fuelwood and a timber crisis rapidly looming in Uganda. What is very worrying is that Uganda also has a very poor timber plantation resource, with less than 1,000 ha of mature plantations remaining countrywide and no more than 25,000ha of timber plantations in total. The scenario looming should seriously concern all Ugandans: a dire shortage of fuelwood; loss of an extremely rich biodiversity; expensive timber imports and many environmental concerns related to forest loss (including soil erosion and changes in the local climate).

Amidst all the gloom there are, however, some shafts of sunlight. One is that Uganda is clearly a good place to grow trees commercially and very high growth rates are achievable if sound silvicultural practices are adopted. Another attraction for private investors is the looming supply:demand imbalance, which has lead to around 20,000 ha of timber plantations being established since just 2003. As will become clear in the following sections, however, a lot more needs to be done.

## 2.2 THE STATUS OF PLANTATIONS IN UGANDA

For the reasons outlined earlier in this report, most countries have established a plantation resource to meet their industrial wood requirements but Uganda has lagged behind in this regard. In the late 1960's and early '70s, around 12,000 hectares of timber plantations were established in strategic Central Forest Reserves (CFRs) around the country, e.g. Katugo (Nakasongola), Lendu (West Nile), Rwoho (Mbarara), Mafuga (Kabale) and the hill Reserves of Kyenjojo. As these plantations matured from the late '80's, they were systematically harvested to meet some of the nations' timber demand. They are still being harvested but less than 1,000 hectares of mature plantations[1] remain today.

[1] *The majority of these plantations were tropical pines, which mature at around 20 years.*

*Deforestation of private forests is a major concern in Uganda. Owners put little value on such forests.*

Unfortunately, however, the UFD failed to replant these old plantation areas as they were cut. Through a combination of poor policies and weak management, the plantations were not replanted as they were harvested. Allowing people the use of the land for growing food crops in between the trees – the so-called 'taungya' system - was a miserable failure too; other attempts to force sawmillers to replant (or contribute to a UFD replant fund) also failed. For many years private tree growers received poor technical support from the UFD, for example, only very poor quality seed was available and many silvicultural and management techniques commonly employed in many other countries, were not introduced. It was only through the support of the European Union's FRMCP programme from 2002 and the start of the SPGS in 2004, that the country's plantation problem began to be addressed. Much still remains to be done though.

As mentioned earlier in Chapter 1, enshrined in 2003 National Forestry & Tree Planting Act and 2001 Forest Policy is the increased role of the private sector. Indeed, some private 'investors' had been given large land leases in CFRs in the 1980's and 1990's – e.g. Busoga Forestry Co. and Deutche Forst Consult in Bukaleba CFR (Mayuge), Global Woods Ltd. in Kikonda CFR (Hoima) and Nileply Ltd (CFRs around Jinja). There was, however, limited investment in commercial plantations, with little pressure being put on permit holders to plant. Only with the advent of the EU-funded SPGS in 2003, did these larger companies – and many small-medium growers too – start seriously investing in commercial plantations (Busoga, Global & Nileply have planted over 2,500 ha between them since 2003).

Amongst the new investors is the New Forests Company Ltd., who started operations in 2005/6 and have already planted over 4,000 ha in CFRs in Mubende and Kiboga and private land in Bugiri. Over 100 private Ugandans have also started seriously investing in commercial forestry since 2003 – e.g. Ponsiano Besepo and Richard Bakojja (both Mubende), Babeyaka Vanancio (Kabale) and Kamussiime Association (Bushenyi) – all of whom have established over 100 ha each in the last few years, mostly on CFR land but increasingly on private land too.

The private sector has shown their commitment by forming the Uganda Timber Growers Association (UTGA) in 2007, which shows early signs of being a serious trade organisation, already representing a substantial number of the private plantation investors. This is good sign and should be encouraged to give the private investors a common voice.

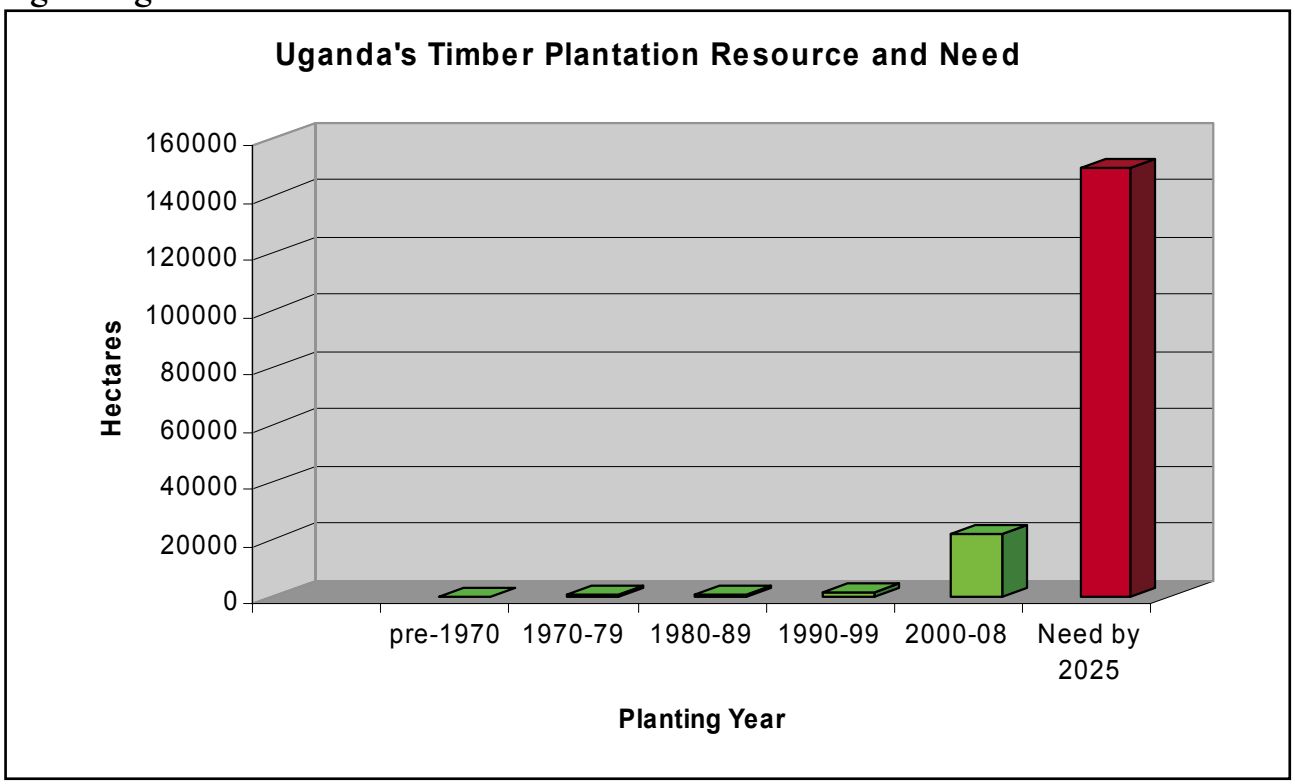
## 2.3 UGANDA'S PLANTATION NEEDS

**Plantation Area:** A study carried out in 2005 concluded that Uganda needs a minimum of 75,000 hectares of high yielding, tree plantations just to meet its projected internal demand by 2025: this equates roughly to 3,500 ha of new planting per year (Unique, 2005). This figure is calculated from available estimates of current timber consumption (270,000$m^3$/year and growing at 2.5% per yr.); GDP growth of 5%; predicted plantation yields of 350$m^3$/ha at 20 years (mean for pine). At present, Uganda has probably no more than 25,000 ha of dedicated timber plantations – 70% of which is under 4 years old. Within a short period (no more than 3-4 years), the mature crop will be finished and (as Fig. 2 shows clearly) there is then a very worrying 'hole' of at least 10 years where there is no mature crop available[2] .

*A very poor pine crop at Katugo CFR. planted 2001. Most planting pre-2003 in Uganda made the same mistakes - wrong species, poor seed and poor weeding.*

[2]*These mature crops cannot be stretched more than a few years because they are in a very poor state of health, not having being well maintained or protected over the years.*

**Fig. 2. Uganda's Industrial Plantations**




Since pines take some 20 years to mature, only faster growing eucalypts can produce timber in this time period and hence they should have an important role in Uganda's plantation strategy.

The figure of 75,000 ha is to meet internal demand only, thus if Uganda is looking to export timber or wood products, the need would be greater. This is why the NFA set a target in 2005 of a minimum of 150,000 ha, aiming for 50,000 ha itself, the balance from the private sector[3] . This target would require 7,000ha per year to be planted – more than double what is currently being achieved (even with the incentive of the SPGS). At least 70% of the timber plantations established in the past decade in Uganda, have been by the private sector and it is expected to continue this trend.

**Land for plantations:** In the previous century, the government gazetted many CFRs for their suitability for plantation development: many of these were never planted and some have been heavily encroached for years now. In addition to these specific plantation Reserves, many more CFRs that used to have rich natural forests have since been highly degraded by deforestation and clearance for agriculture. Thus there are large areas of CFR land suitable (>100,000 ha) for commercial tree planting, though not all in accessible and/or contiguous areas[4]. There are also significant areas of private land where commercial forestry could be developed. Whether the land is private or public, it is strongly recommended to only use degraded forest land or land that never had trees on previously (e.g. some grassland areas) for plantation development. The SPGS, for example, does not sanction the clearance of intact forest for plantations.

The location of plantations in relation to the market is important since timber is a bulky and heavy product. The most profitable commercial forestry enterprises have their resource (i.e. the tree plantations) located strategically close to the primary processing facility. The NFA in their 2005 Plantation Strategy (unpublished) continued the theme from the UFD, who in the 1960's and '70's concentrated their plantations in a few areas where large CFRs suitable for good tree growth were located.

[3] *NFA, 2006. Timber Plantation Investment Programme: A Briefing Note.*
[4] *Further information should be available from the NFA who allocate tree planting permits in CFRs.*

*Richard Bakojja's pine (PCH) planting in Mubende is close to a main road and also many other commercial planters in the vicinity (2004).*

**Plantation development costs:** the SPGS estimated in 2003 that the average cost of establishing commercial plantations in Uganda is UShs1.2M per hectare. A more recent study commissioned by UTGA estimated that the direct costs of establishment had increased to around UGX1.5M in 2008 (UTGA, 2008). This takes into account the employment of intensive silvicultural techniques such as using improved (usually imported) seed, thorough land clearance and chemical weed control. Although some growers establish their plantations significantly cheaper than this, many will not achieve the maximum growth potential of the trees on their land. The 75,000 ha estimate is based on fast growing, well established plantations (see Chapter 3 for further details).

**Financing Uganda's plantation development:** the NFA invested heavily in commercial plantations in its first three years (largely with EU support) but financial constraints have since caused the organisation to reduce its planting programme (1,750ha in 2006/07; a total of *ca.* 6,000ha 2004-08). The NFA publicly states that its target is to establish 50,000ha of plantation itself, though this will depend on the organization attracting external funding. The private sector has shown their willingness to invest in the business when the policy (e.g. availability of CFRs) and the support environment are right (especially the SPGS grants and technical advice).

Phase II of the SPGS is expected to start by mid-2009 and run for some four years. At the time of going to press, the detailed *modus operandi* of the project had not been finalized, though it is likely that at least an additional 20,000 ha of timber plantations could be supported.

## 2.4 INVESTING IN TIMBER PLANTATIONS IN UGANDA

**Plus side:** Uganda has a distinct advantage over other countries with available land, excellent growing conditions for trees and a fast-growing demand (locally and regionally) that offers an attractive investment environment to the investor.

**Land:** Despite the rapid growing population, there is still plentiful land for significant commercial forestry development in Uganda, both in CFRs and on private land. It is important to note that for a commercial forestry venture to be viable, it needs land that can support good tree growth: this means land with adequate moisture and soil depth. Tree planting in marginal areas is not profitable. Many CFRs were set aside for plantation development early in the last century but were mostly not used. These Reserves (and many others since) have been heavily degraded but are still suitable to support commercial forestry. Private growers since 2003 have also proved that many are willing to utilise their own land for tree growing. Encroachment on both CFR and private land, however, is a major obstacle to expansion within the sector.

**Climate:** Uganda has a tropical climate modified by altitude. Rainfall is greater in the mountains and in the Lake Victoria region and averages from 800-2000mm per annum. Many parts of the country receive a bimodal rainfall pattern with two rainy seasons each year (see Chapter 3). Dry seasons vary across the country although temperatures vary little throughout the year ranging from around $17^0$C to $27^0$C.

**Yields:** With good silviculture, commercial forestry plantations in Uganda are capable of matching some of the best growth rates found anywhere in the world (see Table 1).

*2.5 yr old PCH at Oruha CFR, Kyenjojo. One of the FRMCP's demo. plantings in 2003 (Australian seed).*

**Table 1. Comparative Plantation Growth Rates**

| Country | Area *(ha)* | Species | Yields* *($m^3$/ha/yr)* | Main Product(s) |
|---|---|---|---|---|
| | | | | |
| Australia | 135,000 | *Pinus caribaea* | 20 | Sawlogs |
| | 45,000 | *Araucaria cunn.* | 15 | Veneer logs and sawlogs |
| Brazil | >4M | *Eucalyptus spp.* | 45 | Pulpwood & Charcoal |
| Malawi | >100,000 | *Pinus patula* | 18 | Pulp & sawlogs |
| South Africa | 700,000 | *E. grandis* | 20 | Pulpwood |
| | 600,000 | *P. patula & elliottii* | 15 | Sawlogs |
| Swaziland | 120,000 | *P. patula* | 19 | Pulpwood |
| | 30,000 | *E. grandis* | 18 | Mining timber (+ pulp) |
| Tanzania | 50,000 | *P. patula* | 18 | Pulp & sawlogs |
| | 20,000 | *Acacia mearnsii* | 8-18 | Tannin (+ electricity) |
| | 10,000 | *Tectona grandis* | 14 | Sawlogs |
| **Uganda** | **16,000** | ***Pinus caribaea*** | **20-35** | **Sawlogs** |
| | **4,000** | ***E. grandis*** | **40-60** | **Fuelwood; small poles (+ sawlogs)** |

* *Yields for countries with established plantations are from various published sources; Uganda's yields are based on predictions from experience of SPGS/NFA since 2002: many are yielding less than this due to poor silvicultural practices.*
*Source: SPGS (2006): Presentation by Paul Jacovelli (SPGS's CTA) to 1st National Plantation Seminar organised by the SPGS at Sheraton Hotel, Kampala, June 2006.*

**Table 2. Examples of Returns on Investment in Timber Plantations**

| Country | Indicative Returns – Constant prices | Comments |
|---|---|---|
| New Zealand, Australia | 8 to 8.5% | Stable politically, assured markets |
| Brazil, Chile, Spain, Turkey | 10 to 12% | Often for industrial pulpwood with very short rotations: market cyclical, fair to good stability |
| UK | 3 to 5% | Fair growth rates, politically stable, aim was strategic timber supply, service values now predominate |
| Germany | 0.5 to 1% | Return on established forest compared with liquidation value, maintaining forest cover is enshrined in the constitution |
| **Uganda** | **10-14%** | **Assumes an SPGS subsidy** |

*Source: Hardcastle et al (2005). NB. RoR are highly dependent on the price received for the final product as well as the availability of a subsidy/grant for establishment, which is commonly provided (like the SPGS in Uganda).*

It should be noted though that to date, not all growers are achieving these optimum growth rates due to a combination of a lack of practical skills in the country and poor planning. Nevertheless, the potential is there to achieve excellent rates of returns on one's investment. A study in 2005 calculated that a rate of return of 10-14% could be achieved which compares very favourable with commercial forestry anywhere in the world (Table 2).

**Demand/Markets:** The lack of mature plantation resource has been discussed earlier in this Chapter and it is a very attractive environment for investors currently (or thinking of) establishing commercial tree crops in Uganda. There is a large internal demand for general purpose timber in Uganda, for which pine and eucalypts are well suited. Transmission poles are currently being imported from South Africa – which, in a country (Uganda) that can grow eucalypts so much quicker, sounds ludicrous but is all about supply and demand. There is also a ready market for timber and timber products in Rwanda and Southern Sudan. Markets are discussed later in Section 2.5.

**SPGS Support:** As explained in Chapter 1, in its first phase (2004-08) the SPGS provided UGX600,000 (***ca.***US$320) per ha to contracted clients. The project also provided substantial (and largely free) technical support to growers (or potential growers) – in the form of one to one discussions with technical staff, site visits, free publications and training courses. Whilst the details of Phase II (2009-2013) have not yet been finalized, it is likely to offer even more support to growers - both large and small.

The SPGS's practical training courses have been particularly useful, being aimed squarely at growers' Supervisors and/or Field Managers.

*One of the SPGS's practical training courses, frequently run for private planters (Oruha CFR, Kyenjojo, 2005)*

The SPGS training is subsidized (tuition and course notes are free but the clients have to contribute to accommodation and transport). Further details of the SPGS's training courses are in Chapter 3 (Section 3.8).

**UTGA:** The Uganda Timber Growers Association (UTGA) formed in 2007 and is rapidly gaining strength (and reputation) for representing the interests of private sector tree growers. UTGA's focus to date has been to lobby for better government/NFA support and importing improved seed for its members. They are planning to expand support to areas such as bulk purchasing and training in the near future.

**UIA:** The Uganda Investment Authority (UIA) has targeted forestry as one of the attractive areas of investment in Uganda. Some useful information is available on their web-site www.ugandainvest.com though it does highlight the lack of reliable (and recent) data in the sector.

**Constraints facing Investors:**
It would be amiss for us to overlook some of the constraints that might affect those investing in forestry in Uganda: the main issues are summarized below:

**Land:** commercial forestry requires large areas of suitable land in order to achieve economies of scale and reduce distances to market etc. Security of tenure is also very important - whether investors are planting on private or land leased from the NFA. Some of the CFRs now being offered by the NFA for planting by private investors are illegally encroached: some of this occurred during the years of poor control by the UFD leading up to the sector reform process but many incidences are more recent. The Uganda Timber Growers' Association (UGTA) is now lobbying hard on behalf of private investors to get better Government support to resolve these issues. UTGA and SPGS are also well represented on the Presidential Investors Round-table discussions (2006-09), which is a forum aimed at highlighting (and resolving) bottle-necks to greater investment in the sector.

**Infrastructure:** the poor state of the rural road network in Uganda is a major constraint to investors in the forestry sector. It is important to have good access to plantation areas – for establishment purposes, for fire protection as the crops develop and particularly to get the logs to market at harvest. Most Districts are doing very little to repair or upgrade their roads, putting the burden on the investor and thereby reducing the profitability of the venture. As more people invest in forestry, however, it is expected that there will be more pressure put on the authorities to show a commitment to investing in rural infrastructure in support of the investors in commercial plantations.


*Rural infrastructure in Uganda is generally poor, limiting access especially during wet periods.*

**Location:** some of the people planting trees commercially over the past few years have not really thought about markets and in particular about the high cost of getting their timber to market once it is mature. Such strategic planning will be the focus of the next phase of the SPGS, though it needs closer collaboration between private sector and the country's main landlord when it comes to land for planting – namely, the NFA.

*4-yr PCH (Australian Seed) at Nileply's Ngereka CFR planting (2007)*

**The Forestry Tax Anomaly:** Forestry is not competing on a level playing field when compared to other land uses. The long timescale between planting and harvesting (between 12-25 years or more) leads to plantation being taxed more heavily than other investments yielding a similar return. There is no income against which to offset the early expenditure and the main income when the trees are harvested is taxed as it were an annual income with no recognition of the years it has taken to accrue. This anomaly is dealt with in different ways in various countries, mainly through exemptions from, or lower rates of, land, inheritance, input purchase and income taxes. In Uganda this could be rectified by either allowing the costs of replanting to be set against the proceeds from felling of the first crop or exempting plantation forestry from income taxes, as in the UK. A reform of the VAT system should also be undertaken to promote private investment in the sector. Further details can be found in Hardcastle *et al*, 2005.

**Research & Development & Lack of Skills:** The surge of interest in commercial plantations since 2003 has highlighted the lack of commercial forestry research support in Uganda and also the serious lack of trained staff with knowledge of commercial forestry. None of the current institutions (NaFORRI, Makerere University and Nyabyeya Forestry College) are geared up to support commercial plantations, which is hardly surprising given that there was virtually no planting for over 30 years in Uganda.

Many of the intensive silvicultural techniques for commercial forestry have been developed in other countries (e.g. Southern Africa) and it is these that are being introduced into Uganda, particularly by the SPGS and some of the bigger planters.

There are encouraging signs, however, on both research and training. One is the formation of a Commercial Forestry Research and Training Steering Committee (COMFORT) in 2008. This group (Chaired by the SPGS) has already prioritized the most urgent needs of private growers and has already started to fund practical studies to assist investors in the sector. The approach is very much on demand-driven, result-orientated work and away from the institution-driven era of the past.

The other encouraging sign is that Makerere University's Faculty of Forestry is planning to launch a degree in Commercial Forestry later in 2009. The SPGS was amongst the supporters of this; the project has contributed to the curriculum and will also play a support role to try and ensure that the course meets the needs of the sector.

## 2.5 MARKETS

The main markets growers are targeting currently in Uganda are shown in Table 3:

**Processing capacity:** Uganda currently has a very low capacity for processing sawlogs. In ye-olde colonial days, there were a number of big sawmills to process the huge hardwood logs from the natural forests like Budongo and Kalinzu: these have all gone, along with virtually all the valuable, big trees too. Most of the processing of plantation sawlogs over the past 15 years or so has been with highly inefficient, mobile Lucas sawmills: even the majority of the natural forest trees are still being cut with primitive hand saws (pit-sawing). What most new growers will not realize is the inefficiency of these small methods

**Table 3. The Main Markets for Commercial Forestry Plantations in Uganda**

| PRODUCT | MAIN SPECIES | MINOR SPECIES | SPECS | NOTES |
|---|---|---|---|---|
| Sawlogs | *Pinus caribaea* | *E. grandis; Euc Clones; P. patula; Hoop pine; Musizi* | 30 cm avg DBH. | Need to encourage more Euc (shorter rotation) |
| Chip | Any | Any | Any | Nile PlyWoods; will pick up within 50 kms: *ca.*UGX15,000 /T paid |
| Transmission poles | *E. grandis* | *Euc clones?* | See separate Table 4 below. | UMEME |
| Building poles | *E. grandis* | *Euc. clones* | Straightness; various sizes | |
| Fencing poles | *E. grandis* | *Euc. clones* | Must be treated | |
| Firewood | *E. grandis* | *Any* | Any – but bigger pieces must be split. | |

**Table 4. UMEME Specifications for Transmission Poles (*ca.*2007)**

| Pole Class | Pole Length (m) | Min. top end Diam. (mm) | Max. top end Diam. (mm) | Min. Diametre 1.5m from the butt (mm) |
|---|---|---|---|---|
| Light | 9 | 150 | 175 | 200 |
| | 10 | 150 | 180 | 210 |
| | 11 | 170 | 190 | 220 |
| | 12 | 180 | 200 | 240 |
| | 13 | 200 | 220 | 250 |
| Medium | 9 | 170 | 190 | 230 |
| | 10 | 180 | 200 | 240 |
| | 11 | 190 | 210 | 250 |
| | 12 | 197 | 220 | 260 |
| | 13 | 200 | 230 | 270 |
| | 14 | 210 | 240 | 280 |
| Stout | 9 | 190 | 240 | 285 |
| | 10 | 190 | 245 | 295 |
| | 11 | 197 | 250 | 305 |
| | 12 | 200 | 250 | 320 |
| | 13 | 210 | 255 | 330 |
| | 14 | 220 | 260 | 340 |

of conversion. A Lucas saw will struggle to achieve 20% recovery from plantation-grown sawlogs, compared with a modern, medium sized sawmill which would expect closer to 45-50%, especially if they utilize off-cuts.

So the commercial forest sector is really starting from scratch in Uganda. Hence it is so important to plan strategically now so that the plantation timber resource is concentrated around certain areas where efficient processing units will be attracted into the area. It is clear from the map (Frontispiece) that there has not been very much strategic planning to date when it comes to location of some of the commercial growers. The SPGS and UTGA are working together on this and also need to engage the NFA in the process.

It has been calculated that Uganda needs a minimum of 5,000 ha of productive plantation in any one region (within a radius of around 50 kms – more if the roads are good), to justify such a processing facility (Jacovelli & Finch, 2005). The benefits to the grower would be enormous, since only well managed and efficient processing plants can afford to pay the grower a decent price for their wood, whether it be sawlogs or small material for chipping. Such mills also need the raw material for their livelihood, which in turn means that they need to ensure good relations with their suppliers.

The only large timber processor currently operating is Nile Plywoods Ltd. in Jinja (Western Uganda), who produce chip and veneer products from both plantation and natural forest species. Given the current age structure of Uganda's plantations, it is unlikely that anyone will invest in more modern utilisation equipment until a substantial volume of the resource currently being planted approaches maturity (maybe in 10 years time).

*Mature eucalypt logs being hand-sawn for timber in Western Uganda (2003).*

The current 'big four' investors in Uganda are:

- **The New Forests Company** (planting Mubende, Kiboga and Bugiri).
- **Busoga Forestry Co.** (a subsidiary of Green Resources Ltd.) planting in Bukaleba, Jinja.
- **Nile PlyWoods Ltd.** planting in Jinja and in Eastern Uganda.
- **Sustainable Use of Biomass Ltd.** (a subsidiary of Global Woods Ltd.) planting in Kikonda, Hoima.

Each of these investors have already planted significant areas and have plans for over >5,000 ha (some substantially more). They will in time invest in processing facilities (only Nileply already have), which will be an opportunity for nearby growers to benefit. Since 2004, the NFA have planted around the old plantation CFR areas of Lendu (West Nile), Katugo (Nakasongola), Rwoho & Bugambe (Mbarara) and Mwenge (Kyenjojo). There are also 'clusters' of small-medium growers (mostly supported by the SPGS since 2004) in Mubende, Luwero/Nakasongola, Hoima and Gulu (see Frontispiece map).

With support from UTGA and SPGS (and cooperation from the NFA in terms of planting permits), it is hoped that these and future private growers will benefit from modern processing units in such areas and not rely on highly inefficient conversion methods of the recent past.

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*A Lucas mobile saw-mill operating in Katugo CFR (2004). These machines are very inefficient for processing plantation logs.*

*This small pine sawmill in Southern Africa has a much higher recovery of timber compared to a mobile mill.*

*Eucalyptus grandis produces building and fencing poles even from early thinnings (Ferdsult, Lugazi, 2008).*

*Poles for sale from Mohammed Sekweyo's excellent 3-yr Eucalyptus grandis planting in Masaka (2008).*

*Treated UMEME poles (probably imported from RSA)*

*45-yr old Hoop pine (Araucaria cunninghamii) logs in Queensland, Australia. Rotations of less than 30 years would be possible in Uganda.*

*Treated pine timber is perfect for basic construction timber.*

*Eucalyptus scaffolding poles supporting Kampala's developing economy.*

# CHAPTER 3
# PLANTATION PLANNING AND BUDGETING

*To achieve uniformity, high stocking & a healthy crop requires careful planning and budgeting (3-mnth GC, SAPPI, 2004)*

## 3.1 INTRODUCTION

This is probably the most important Chapter in this book, especially because most failures in commercial tree planting in Uganda over the past few years can be directly attributed to poor planning and budgeting. Establishing what we at the SPGS call Fast Growing, High Yielding (FGHY) tree crops does not happen by chance but is the culmination of many silvicultural operations that must be carried out well and at the optimum time: Table 5 highlights the key silvicultural issues for successful plantations.

Establishing and managing a productive tree plantation requires high levels of professional knowledge, experience and judgement - but before we frighten off potential tree planters, you should also know that many private growers in Uganda under the SPGS have learnt many of the key issues remarkably quickly over the last few years.

To succeed in any commercial forestry venture, however, the potential investor needs not only a good understanding of the silvicultural operations involved in establishing and managing plantations but also requires a sound knowledge of the eventual markets one is targeting too. Knowledge of the costs (and expected revenue) involved is also crucial so that the investor can make the decision whether the returns are acceptable.

This Chapter summarizes the key factors that affect plantation productivity and profitability. **The focus throughout is on careful, forward planning and realistic budgeting: the objective is maximizing not only the sustainable yield of timber but also the returns on one's investment.** The 14-Step Plan is a useful summary developed for the SPGS's training courses (Table 6).

## 3.2 FACTORS AFFECTING PLANTATION PRODUCTIVITY

FAO (2002) cite the following key factors that affect forest plantation productivity:

- **Access:** good access to the planting site is important to be able to carry out all the required establishment activities as well as subsequent management operations such as thinning, pruning and fire protection. When the trees are mature (and even when thinning operations are yielding utilizable material), good access is required to transport the logs to the mills. It pays to plan the internal road network early on.

- **Site selection:** the main components of site quality are soil depth and drainage; soil physical and chemical composition; the competing vegetation; the amount and distribution of rainfall, and the general climate of the area.

**Table 5. How to Achieve Fast Growing, High Yielding Tree Crops.**

| OBJECTIVE | KEY ISSUES | REFER |
|---|---|---|
| UNIFORMITY | Thorough land preparation<br>Use of improved seed &<br>High quality seedling/clone<br>Good weeding | Chapter 13<br>Chapter 7<br>Chapter 8<br>Chapters 11 & 12 |
| HIGH STOCKING | Timing & quality of planting<br>Quick beating up (< 1 month) | Chapter 14<br>- |
| HEALTHY CROP | Good site-species matching<br>Timely weeding<br>Protection from animals & fires<br>No taungya<br>Monitoring for pests & diseases | Chapters 5 & 6<br>Chapters 11 & 12<br>Chapter 16<br>Chapter 15<br>Chapter 17 |

# TABLE 6. SUCCESSFUL TREE PLANTATIONS - THE SPGS 14-STEP PLAN

1. **Plan** 12 months in advance & **budget** accordingly (seek professional **advice** where necessary).
2. **Train staff** in the SPGS's techniques to reduce costs & achieve **Fast Growing, High Yielding** crops.
3. **Match species** with site and objectives.
4. Use only select, **improved seed**.
5. Plant only **high quality plants**.
6. **Time land preparation** carefully to coincide with rains and seedling development.
7. **Pre-plant weed** control where necessary: do NOT plant into a weedy site.
8. Ensure correct plant **espacement**.
9. Beat-up (replace failures) **soon** (<1 month) after planting.
10. Ensure **weed competition** is kept to a **minimum** – especially in early phase of establishment.
11. **Protect** crop from animals and fires.
12. **Monitor** growth and tree health.
13. **Thin** and **prune** on time.
14. Target best **markets** for crop and sell at optimum time.

Trees can often do well on degraded land and land marginal for agriculture. However, it must be remembered that shallow soils (e.g. hilltops) will not produce very productive tree growth.

- **Species choice:** in most cases, introduced species often outperform local species in terms of utilizable wood production though trials should be carried out to assess this. This book focuses on just a few species – dominated by tropical and sub-tropical pines and eucalypts – which will generally outperform local species (NB. An important factor is that improved genetic material is available only for these key exotic species). Only Musizi *(Maesopsis eminii)* of Uganda's indigenous species at this stage shows the potential to match the growth of selected, imported pines and eucalypts (see Chapter 5).

- **Use of improved genetic material:** huge gains in productivity have been realized through using genetic material that has been improved through rigorous selection and testing (see Chapter 7).

- **Nursery practices:** the nursery plants must have a good root configuration, a balanced root:shoot ratio and be free from pests and diseases: these are the main characteristics that determine how the seedlings survive and grow when planted out (see Chapter 8).

- **Site preparation:** good site preparation should reduce competing vegetation to acceptable limits and enables good access for planting (Chapter 13).

- **Spacing:** research has proven that tree crops have an optimum space they need to grow and this obviously increases with time as the trees enlarge. Appropriate spacing also reduces the weed control required (Chapter 13).

- **Planting:** planting is the culmination of much planning and physical work and yet is often carried out by untrained and poorly supervised workers. This crucial operation should be carried out only by well trained and supervised people (Chapter 14).

*Exemplary establishment of PCH at Busoga Forestry Co., Mayuge (Jan. 2006).*

- **Post-planting care:** the control of competing vegetation by physical (manual) or chemical (herbicides) means is vital to achieve FGHY crops

- **Thinning and Pruning:** timely thinning and pruning are important to increase the value of the remaining crop. Both operations improve access to

*Poor planning and inadequate weeding will result in a failed crop (private planter, Luwero, 2004).*

the stand too, which is important in times of fires and for the early detection of any pest and disease problems. The general health of a thinned stand is improved also through removal of any diseased trees and reduced competition between trees.

## 3.3 COMMON MISTAKES MADE BY GROWERS

We thought that it would be instructive to list the common problems planters have made over the past few years in Uganda, in the hope that others do not have to climb the same steep learning curve and make the same (sometimes very costly) mistakes.

1. **Poor Planning and Timing:** it is essential in forestry to plan well in advance – preferably one year before initial planting takes place. This gives sufficient time to draw up one's business plan, to secure adequate funds, to demarcate areas on the ground, to recruit and train staff, to establish a nursery (or order seedlings), to plant early in the rainy season, etc. Rushing to get some trees in the ground invariably is a mistake.

2. **Inadequate Funding:** forestry is not an investment that suits everybody. It is long-term (even with Uganda's fast growth rates) and requires most of the investment in the first few years. Establishing fast growing, high yielding plantations is not cheap either, contrary to what many think. Even with the SPGS grant, the investor must have sufficient funds available for the field activities - especially in the critical period immediately before and after planting.

3. **Poor Advice:** for those new to the business, we strongly urge them to seek professional advice before deciding to

invest in forestry. It should be noted, however, that the lack of commercial tree planting for many years in Uganda has meant that there has been little exposure to commercial forestry practices, even amongst professional foresters. To date there is no national register (or accreditation) of foresters with experience in commercial plantations and so it is prudent to first check the experience and track record of people offering to assist you. The SPGS should be your first point of call for advice on funding, silviculture and management of commercial plantations, whilst UTGA offer advice relating to support services to the sector. Studying this book will also go some way to improving one's understanding of the business.

4. **Wrong Species Choice:** it is unfortunately all too common to find new growers planting either the wrong species on a site (especially *Pinus patula* and Teak) or planting areas that should never be used for commercial tree planting (e.g. planting trees in wetlands or on rocky mountain tops). Remember mistakes such as the wrong species choice (or poor seed – see next point) will be around for a long time and potentially render the investment unprofitable (see Chapter 3).

5. **Poor Seed:** most people new to commercial forestry invariably do not understand the importance of only using improved tree seed and thus are tempted to buy the cheapest seed on offer. By 'improved' we mean seed produced from a special stand (i.e. plantation) where the parent trees have been scientifically tested and selected for their superior qualities – such as fast growth, straight stem form, wood quality, resistance from certain pests and diseases etc. With virtually no tree improvement research for most of the commercial species currently being planted in the region, most seed will have to be imported until there are local, improved sources available. Commercial tree growers must insist on planting only the seed origins recommended by the SPGS (see Chapter 7 and the SPGS's Newsletters for up to date information).

6. **Poor Quality Seedlings:** prospective planters can either order seedlings from an external nursery or raise them in one's own nursery. Whichever option is chosen, seedling quality (including seed source) is crucial for a successful plantation and yet many growers still plant inferior quality seedlings. Immature, damaged or diseased seedlings should be rejected at the nursery but even if they reach the planting site, they should be discarded there (see Chapter 8).

7. **Taungya:** many people believe that the most cost-effective way to establish a tree plantation is to invite local farmers to grow

*SPGS's Bric Malligan advising a grower on their weed control in a newly planted pine crop (2005).*

their food crops amongst the young trees, thereby reducing establishment costs. With strong supervision and enforcement of rules, the system can work but the experience in the region over the past 30 years or so has been disastrous as far as the tree plantations are concerned. Invariably the farmers have little interest in the trees and try by whatever means to prolong the time they can grow their food crops (see Chapter 15).

8. **Insufficient Weed Control:** the excellent growth conditions for trees in the region also benefits weed growth too. Where insufficient attention has been paid to weed control – especially in the most critical period immediately before and after planting – the plantations will not reach their full growth potential and the profitability of the investment will suffer. Where weed growth is particularly rampant, the tree plantation may fail completely (see Chapter 11).

9. **Not Involving the Local Communities:** engage with the surrounding communities at the earliest possible opportunity so they understand and support your plans. Where possible offer local people employment and consider other support, such as tree seedlings for them to plant on their own land (or NFA CFR land, if available nearby). Larger investors should consider supporting community projects e.g. schools, clinics or improved infrastructure. When it comes to protection of the plantations from fire and theft throughout the rotation period, having the support of local communities is invaluable (see Chapter 1).

10. **Poor Thinning Regime:** once one's plantation is well established (which should be 1-2 years with eucalypts; 2-3 years with pines), the next important operation is thinning to reduce the numbers of trees per hectare. By reducing competition, thinning encourages rapid diameter growth on the trees left behind. Many growers are reluctant to thin either on time or to leave the recommended tree numbers when they do thin, thinking the more trees they have, the more money they will make. This is a big mistake and leads to lots of small trees instead of growing large, valuable sawlogs as fast as possible (see Chapter 20).

*Timing of all silvicultural operations is most important culminating in planting into a well prepared site.*

11. **Staff Training:** whilst labour is generally available in rural areas, they will usually be unskilled and often not used to regular employment. Even the professional staff (e.g. Supervisors or Field Managers) will often need training in the techniques and standards recommended throughout this book. With commercial forestry being so new in Uganda, there are very few competent Contractors available either (see Section 3.8). Investment in training can thus be critical to successful plantation establishment.

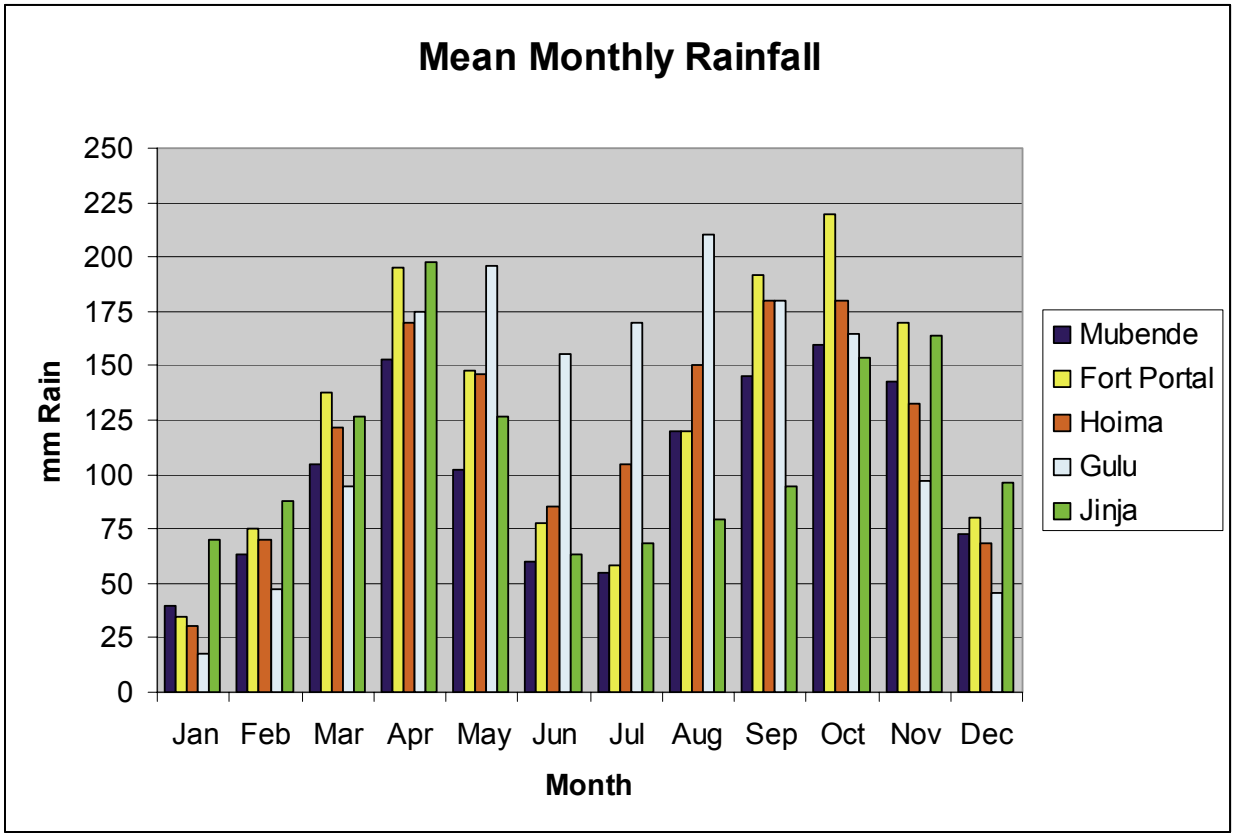
## 3.4 PLANNING AND TIMING

In commercial forestry, the timing of all operations revolves around optimizing the time for planting. The aim is to plant the trees as early in the rainy season as possible, which gives the young plants the best opportunity to acclimatize to their new environment and to start growing rapidly before the onset of the inevitable hot, dry period. To do this successfully, requires detailed knowledge and careful planning so that the conditions are just right to promote fast tree growth.

Potential tree growers must carefully study the weather patterns in the region to be planted. Whilst many parts of Uganda have the bimodal rainfall pattern (i.e. two rainy seasons per year – sometimes referred to as the 'long' and 'short' rains). One of these wet seasons is generally more consistent than the other, though in some areas planting can be successfully carried out in both seasons. Local knowledge is important here. Fig. 3 shows the rainfall for a range of sites across Uganda. NB. Note that historical records in Uganda suffer from the inevitable 'blip' from the early 1970's to the late '80's when the country was in political turmoil. Although we have used data from the Atlas of Uganda (GoU, 1967), it is clear that patterns have changed in some areas as a result of local deforestation and more widespread climate change: hence local knowledge is important to target the best planting period(s).

PCH seed must be sown just 4 months prior to the planting time (3 months for *E. grandis*). With the high demand for improved seed, this means that it must be sourced well before that time (see Chapter 7). The timing of operations will also depend on a number of other factors too - such as the difficulty of land clearance and the availability of sufficient labour at the required time.

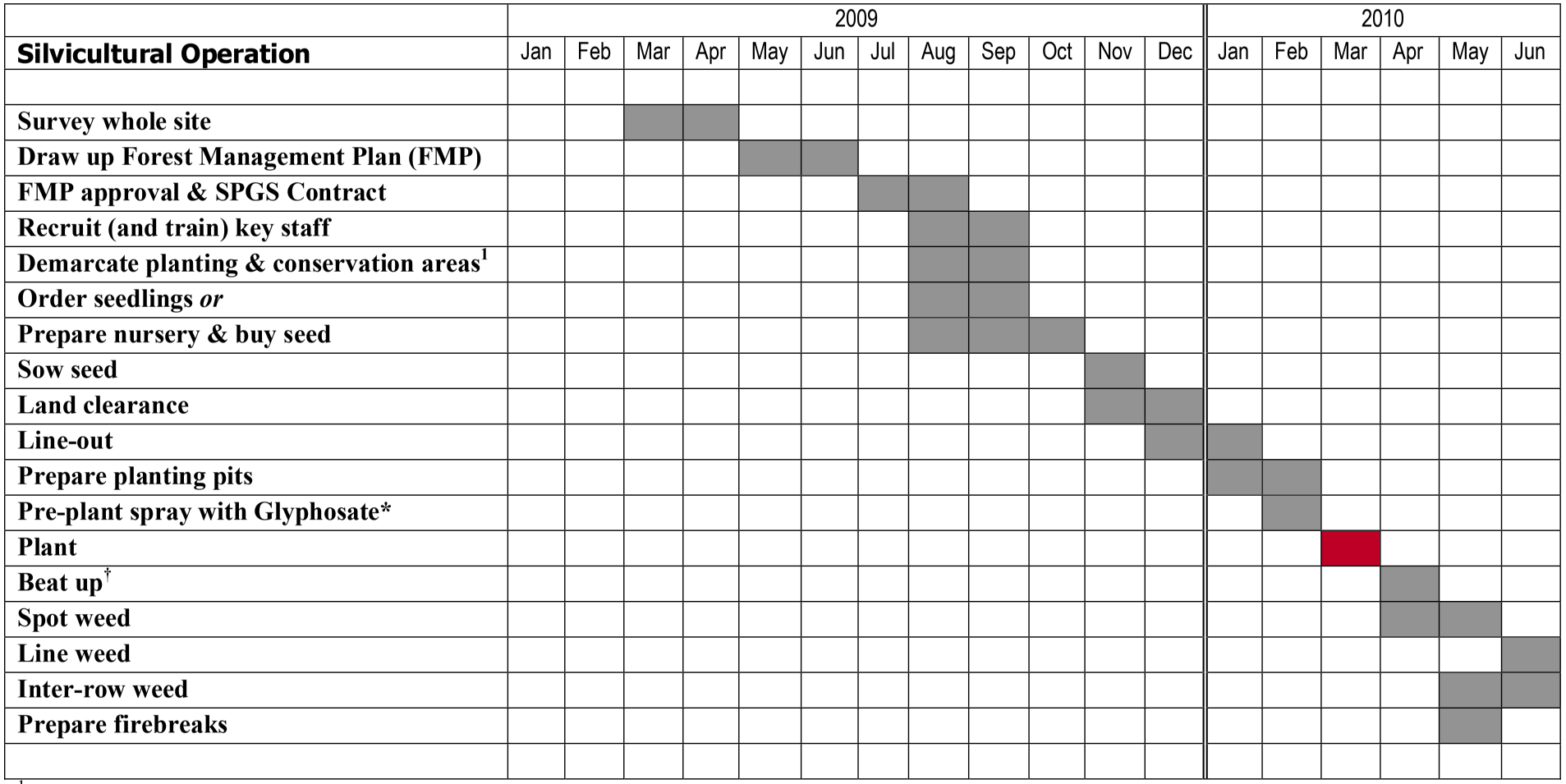
**Fig. 3. Rainfall Distribution from Selected Regions in Uganda**




Source: GoU (1967).

## Fig. 4. A Planning Timetable for Silvicultural Operations in Uganda

*NB. This example assumes pine (PCH) planting in March 2010*




[1] *Including road access to site and within the site.*

* *Where necessary.*

† *Replacement of failures.*

## 3.5 COMPARTMENTS

For ease of planning and for subsequent record keeping, dividing the area for planting into manageable blocks (compartments) helps with all subsequent establishment and management operations. Each compartment should have a road or at least a firebreak around to stop (or at least slow down) a fire. Internal boundaries should be at least 5 m wide; external boundaries must be at least 10 m wide. These roads are also important to allow access to the compartment for all preparation and establishment operations.

We recommend that the maximum size for any one compartment is 30 ha. Normally a compartment will only have one species and one age-class: some examples are given below:

- Cmpt. 1 - p.04/07 PCH – 24.8 ha: this means Comp. 1 was planted in April 2007 (p.04/07) with *Pinus caribaea* var. *hondurensis;* its area is 24.8ha.
- Cmpt. 2 – p.09/06 EG – 10.5 ha. Cmpt. 2 was planted in Sept. 2006 (p.09.06) with *Eucalyptus grandis* and is 10.5ha.

If Cmpt. 1 subsequently had a small fire in (say 2.0 ha was burnt), when this is replanted it becomes Cmpt. 1b and the remaining Cmpt. becomes 1a (with a revised area of 22.8ha). Adopting this system of compartments greatly helps with record keeping too, since all the work carried out in a compartment can be recorded in a Cmpt Register and kept in the office. The dates and costs of each separate activity within a compartment (including the exact seed origin used, general observations such as a pest outbreak etc.) then help build up a complete history of each compartment. This becomes an extremely useful tool to help staff understand the effect of various actions on the crop. Ideally compartment records should be updated at each month end.

This system greatly helps to plan (and budget for) all subsequent silvicultural and harvesting operations and forms the basis of the Annual Plan of Operations (APO). The APO lists all the work expected to be carried out in each compartment in a given year. To do this reasonably accurately requires detailed knowledge of each silvicultural operation as well as knowledge of the site(s) concerned. It also requires an understanding of labour productivity and costs, since the APO forms the basis of the budget. First though, we need to take a closer look at the costs involved in the tree planting business.

*A demo. PCH crop (planted 2003) in Nakasongola by the FRMCP. Growers must budget to carry out operations on time (2007)*

## 3.6 ESTABLISHMENT COSTS

In this section the term 'establishment' is taken to mean the period up 'canopy closure', which is when the trees' branches in adjacent rows start touching and thereby greatly reduce the light falling onto the inter-row. With eucalypts in Uganda, this should be achieved in just 12 months (though with poor weed

[1] *Equivalent to around US$650 per ha at Feb 2009 exchange rates.*
[2] *Then known as Rwenzori Highlands Tea Co. under the Commonwealth Development Corporation.*
[3] *GlobalWoods Ltd. is the parent (German) company.*

*Attending the regular SPGS field meetings is an important way of understanding the business of commercial forestry. (Colewoods, Hoima, 2007)*

control this is frequently not the case); with pines, however, it will take 2-3 years. The objective of all commercial tree growers is to achieve canopy closure as soon as possible since weeding costs are then greatly reduced.

Just prior to the SPGS starting in 2003/04, an internal study was undertaken into the costs associated with commercial tree establishment in Uganda (Table 7). This estimated that the average cost of establishment around the country was UGX 1.2M per ha[1] . The costs were based on the experience with the FRMCP (the parent programme of the SPGS) establishing its demonstration plantings around the country as well as the private sector's experience at James Finlay (U) Ltd.[2] and Sustainable Use of Biomass Ltd.[3] planting at Kikonda, Hoima. Very few other planters (including the UFD) had much experience of the more intensive silviculture and associated costs as prescribed by the SPGS.

The figure of UGX 1.2M per ha did not account for regional (or local) differences between sites. It also did not include overhead costs, e.g. preparing a FMP; road construction; purchase of tools & equipment; the cost of training; offices or other building construction etc. As Phase I of the SPGS (2004-08) progressed, many growers claimed that their costs were higher than the SPGS estimate of UGX 1.2M per ha. In particular, the rising cost of oil in 2007/08 lead to increased costs of fuel, fertilizer, herbicides etc.

It has also been observed, however, that in many cases, costs were often higher than they needed to be because of management issues such as poor planning and timing of operations; no pre-plant spraying (which can drastically reduce subsequent weeding costs); little training and poor supervision (leading to high unit costs). This is why the SPGS has placed so much emphasis on teaching investors (and their field staff) the key issues of commercial forestry and especially how careful planning and timely operations can significantly reduce the unit costs of plantation establishment.

## Table 7. Average Establishment Costs for Pine in Uganda

| Year | Operation | | | | | | Notes |
|---|---|---|---|---|---|---|---|
| | | Labour | | Stores &/or Equipment | | | |
| | | MDs/ha | UGX/ha | Item | No. | UGX/ha | |
| 0 | Site survey | 0.5 | 22,500 | | | | Inc. road & cmpt. alignment |
| 0 | Procure/raise seedlings | | | plants | 1111 | 333,300 | |
| 0 | Land clearance | 40 | 160,000 | | | | Inc. piling & burning |
| 0 | Line out | 6 | 24,000 | | | | |
| 0 | Pitting | 6 | 24,000 | | | | |
| 0 | Pre-plant spray | 2 | 8,000 | Glyphosate | 5 | 90,000 | Avg. lts per ha |
| 1 | Plant | 7 | 28,000 | | | | |
| 1 | Beating up | 2 | 8,000 | plants | 167 | 50,100 | Replacing failures |
| 1 | Fertilize | 0 | 0 | | | | Eucalypts only |
| 1 | 1st - yr row weeding | 60 | 240,000 | | | | Spot and/or line |
| 1 | 1st- yr inter-row weeding | 20 | 80,000 | | | | Slash and/or spray |
| 1-2 | Fire protection | 1 | 4,000 | | | | |
| 2 | 2nd-yr weeding | 40 | 160,000 | | | | |
| | | | **736,000** | | | **473,400** | |
| | **G/T** | | | | | | **1,209,400 / ha** |

***Assumptions***:

1. Labour MD cost - UGX4,000/day; seedlings – UGX 300 (avg. cost for PCH); Glyphosate – UGX 18,000 /lt.
2. Usually there is a 3rd cost column for machinery costs but there are so few operations mechanized in Uganda at present, this has been excluded.

**Table 8. Post-Establishment Costs in Uganda**

| Operation | Pine | | Eucalypts | | Comments |
|---|---|---|---|---|---|
| | *Year*† | *Cost* | *Year*† | *Cost* | |
| | | (UGX/ha) | | (UGX/ha) | |
| Maintenance (weeding) | 3-20 | 30,000/yr | 1-12 | 20,000/yr | Woody vegetation & invasive weeds |
| Fire Protection | 3-20 | 10,000/yr | | 10,000/yr | Highly dependent on economies of scale |
| Pruning – 1st | 3-4 | 50,000 | 2-3 | 50,000 | For access |
| Pruning – 2nd | 5-7 | 50,000 | 3-4 | 30,000 | For timber quality |
| Pruning – 3rd | 8-10 | 50,000 | 6-8 | 30,000 | For timber quality |
| Thinning – 1st | 5-6 | 50,000 | 1-2 | 50,000 | Often to waste |
| Thinning – 2nd | 7-9 | 50,000 | 4-5 | 50,000 | Small sawlogs/poles |
| Thinning – 3rd | 10-13 | 50,000 | 7-8 | 50,000 | Sawlogs |
| Road maintenance | 2-20 | 20,000/yr | 2-12 | 20,000/yr | Highly dependent on economies of scale |

† *Based on the average costs from SPGS growers' experience.*

The costs of subsequent operations have not been included in Table 7 since the SPGS has focused on establishment. This establishment period, however, accounts for the vast majority of expenditure of commercial forestry. Table 8 summarizes the additional (average) costs that will be incurred up to the time of harvest.

Fig. 5 shows the approximate cash flow for a commercial pine crop in Uganda. Until 2nd and 3rd thinnings (which should yield saleable products), cash flow is negative. It is only the final crop (here shown being sold at 22 years) that produces the windfall revenue – provided the crop has been well managed and is reasonably accessible.

## 3.7 THE IMPORTANCE OF LOCATION & ECONOMIES OF SCALE

Both the location and scale of one's tree planting are important contributors to the profitability of any plantation development. Small, isolated plantations are more costly to establish because of their relatively high overhead costs; being remote, they also often suffer from poor supervision and management and are at a high risk from fires throughout their lifespan. When it comes to selling the trees from such isolated stands, the transport costs are extremely high too – since the markets will generally be a long distance away. Hence it is strongly recommended to develop plantations only in areas in reasonable proximity to the markets.

The other important factor to consider in commercial forestry is the major economies of scale that can be made. To understand this, consider the cost of developing a single 25 ha block of pine: it will require a reasonable access road to supervise the establishment (and get the plants there in the rainy season); it will need a boundary road to protect it from fires; maybe a small office/store to keep tools and other equipment in; the Supervisor and labour have to be trained; then it has to be protected from fires (and other threats) for 20 years.

Compare this with a development of 500 ha or more. This would require almost the same as a 25 ha development (though obviously more kms of roads and fire-break are needed and more labour required) but the costs are now spread over a much greater development. Hence the unit costs are significantly lower as the size increases. Small growers can also reduce their high costs by clubbing together with other growers in the

vicinity: this should also help greatly when to comes to eventually harvesting the crops – e.g. by group marketing.

## 3.8 THE IMPORTANCE OF TRAINING

In the big picture of plantation forestry, training is most important. It is common for those new to commercial forestry to hire the cheapest labour available, invest virtually nothing in training and then wonder why the crops are poor (and so expensive to establish). Such short-term cost-savings are nearly always a false economy. It was noted in Chapter 1 that the intensive, commercial forestry being supported by the SPGS has not been practiced before in Uganda. Thus all levels of staff and labour need training in the new techniques.

The Field Managers and Supervisors, in particular, must receive practical training in what we at the SPGS term 'modern' or intensive silviculture. They need a basic understanding of the key issues - for example, why it is so important to use only improved seed or why planting into a weedy site is a great mistake.

For those hoping for an SPGS grant, they also need to be clear with regard to the SPGS's standards. Since 2004, the SPGS has organized a wide range of training courses that provide exactly the practical, focused training that those new to the business require. The main training courses run by the SPGS to date are as follows:

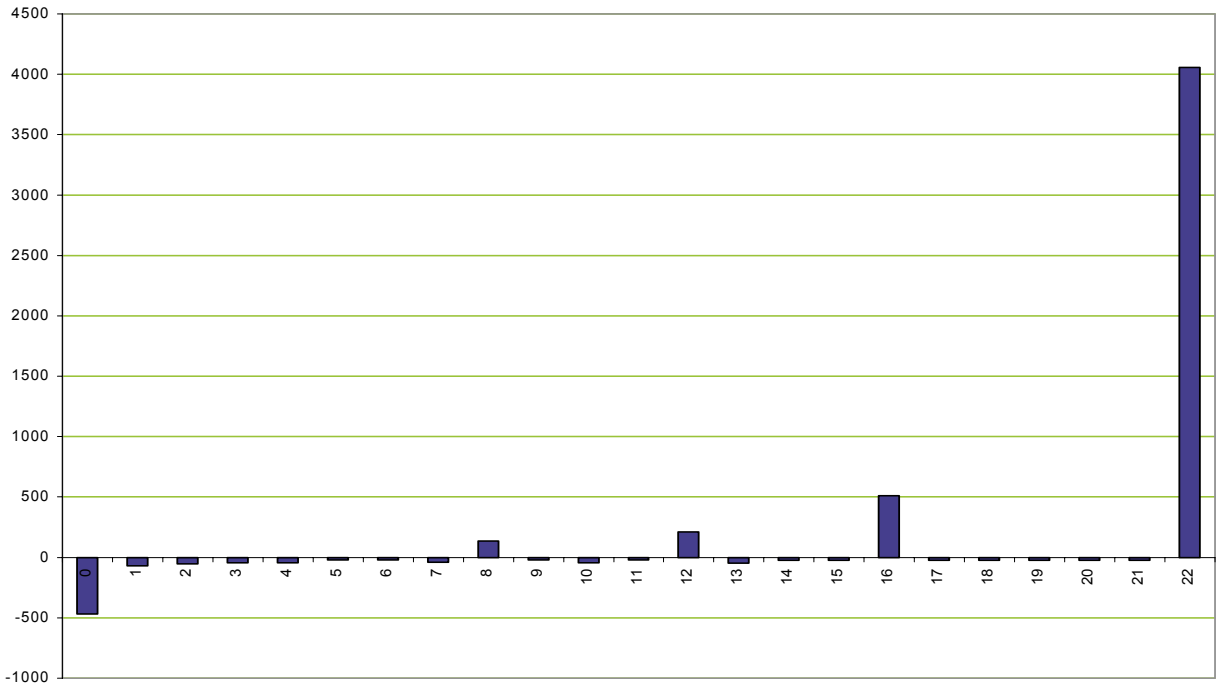
*Key staff must be properly trained in 'new way' of growing trees commercially. The SPGS run many practical courses (Jinja, 2007)*

- **Plantation Planning and Establishment**: which covers many of the planning issues described in the Chapter as well as hands-on land preparation activities, nurseries, herbicide spraying and planting. This course importantly instills in the participants what distinguishes a good plantation from the rest.
- **Plantation Maintenance:** which covers the main post-plant operations of weeding (manual and chemical), fire protection, pruning and thinning.
- **Safe Use of Glyphosate Herbicide:** this includes maintenance of equipment; calibration and health and safety issues.
- **Fire Protection:** covering the basics of fire prevention, detection and fire control.
- **Thinning & Pruning:** hands-on skills training to ensure both operations are carried out correctly.

All these courses benefit from the wide commercial experience of SPGS staff. They are targeted at growers' Field Managers and/or Supervisors. In addition to the core silvicultural skills, the courses teach people the basic standards that are embedded within the SPGS's contracts with growers. Once the Manager or Supervisor has the skills, the field labour must then be taught the necessary skills. Ample time must be allocated to carry out such training: this will eventually pay handsome dividends to growers.

Due to public demand, the SPGS is starting Forestry Contracting training in early 2009. Contracting is at a very early stage of development in Uganda and thus is not the panacea that new investors in commercial forestry think it might be. There are a growing number of forestry contractors emerging but care has to be taken when hiring a contractor such as checking on their knowledge of the operations discussed in this book and getting references from previous clients. To date there is no register of recommended contractors in Uganda, though the SPGS is in discussion with UTGA over this issue.

**Fig. 5 Net Annual Cash Flow Pine - US$ / ha - Interest Charges Excluded**




Source: Hardcastle *et al*, 2005.

*SPGS's CTA passing on his knowledge to trainees at one of the SPGS's courses (2006).*

## 3.9 LABOUR ISSUES

Anyone who is seriously investing in commercial forestry cannot ignore the most important resource – namely, their labour-force. Forestry is generally tough work: outdoors in all weather and often physically demanding. In order to control (or reduce) costs and to have a stable, contented work-force, conscious efforts must be made to improve their conditions. This involves ensuring that people are trained and provided with the appropriate tools and protective clothing in order for them to carry out their tasks effectively and safely.

Small things can make a big difference: for example, providing clean drinking water and a basic meal at the work-site. Some South African companies provide a daily meal known as 'power pap' (vitamin-enriched maize) at the work site. Other things to consider

*It will be a while before Uganda has contactors as organised as this team in Peak Timbers, Swaziland (2004).*

could be to provide transport to and from work each day and giving them basic overalls and work-boots. NB. Personal Protective Equipment (PPE) is a pre-requisite for those working in certain situations – e.g. people working with chemicals and chainsaw operators.

The most important measure is to pay the workers a reasonable wage and ensure that it is paid on time. As the workers become more experienced, it is good practice to also consider a bonus system for workers, related to clear targets being achieved (NB. these must include quality standards too).

## 3.10 STANDARDS & LABOUR PRODUCTIVITY

The SPGS has introduced (and insists on compliance with) basic silvicultural standards. This is not to frustrate growers but to ensure that their plantations are FGHY and thereby likely to be profitable. The SPGS's standards for all establishment and maintenance operations are detailed throughout this book and should be seen as minimum standards for growers to achieve. Thus whilst the SPGS insists on a minimum of 80% stocking after planting, it is common for commercial companies in other countries to insist on no less than 95%.

With commercial forestry being so new in Uganda, there is also a poor understanding of the unit costs of operations. There is a tendency to pay a fixed cost for each operation (e.g. spot weeding at UGX 40,000 per ha), regardless of the site and the level of weed growth. The term 'man-day' (i.e. the number of people it takes to carry out a task per ha) is not widely understood either. Ideally, what is needed is a work-study exercise, looking at conditions around the country as well as the standards for plantation establishment and management. The SPGS is planning to work closely with UTGA to do just that in the near future.

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# CHAPTER 4
# ENVIRONMENTAL AND SOCIAL ISSUES

*Commercial forestry and conservation of key areas can go hand in hand with careful planning and management (nr. White River, RSA, 2008).*

## 4.1 INTRODUCTION

Whilst the key objective of commercial forestry investors is to maximize the production of utilisable products, in order to sustain this production, plantations must be planned and managed in an environmentally and socially sustainable manner. This Chapter discusses techniques that will ensure that both the commercial and environmental benefits are maximized, whilst greatly reducing any likely adverse impacts on both the people and the environment. Plantations can be managed to enhance biodiversity conservation, protect soil and water resources and to minimize any possible negative impacts.

The current emphasis on biodiversity conservation and climate change arises from global concerns for the quality of our environment and how it impacts on peoples' livelihoods. Forests – both natural and man made (i.e. plantations) - can have a major impact on both the environment and on the social well-being of communities. In addition to providing much-needed rural employment, plantations can be a vital source of fuelwood and building poles for local communities. They also significantly reduce the amount of $CO_2$ and other greenhouse gases in the atmosphere through their fast growth. Plantations can also stabilise the soil and reduce the impact of heavy rain, thereby preventing soil erosion and protecting water-sheds.

*Wetlands and important biodiversity areas should be left unplanted - like this valley in Swaziland (Peak Timbers, 2004).*

With the growing global awareness of such issues, many commercial forestry operations worldwide are looking towards having an independent evaluation to ensure their operations are not just sustainable from a business point of view but also from an environmental and social standpoint too. The best known of these independent Certification bodies is the Forest Stewardship Council (FSC), which has set Standards and Criteria to cover all aspects of a business. Principle 4 of FSC stresses that forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities. Some of the larger private forestry companies in Uganda are now pursuing FSC accreditation, whilst the SPGS (working closely with UTGA) is attempting to initiate a 'Group Certification' scheme to cover small growers who meet their criteria. Chapter 23 has further details on Certication and FSC.

## 4.2 PLANTATIONS AND BIODIVERSITY

The environmental impact of a plantation depends largely on HOW and WHERE the plantation is established. It is important to start out with an overall assessment of the potential planting site by carrying out a simple Environmental Impact Assessment (EIA) – see Annex 1. This assessment will tell you what areas should be retained unplanted and what "biodiversity features" should be protected during forestry operations. If your site consists mostly of semi-natural habitats e.g. swamps, then planting is generally not a good idea – it may result in an overall decrease in biodiversity, which is an unwanted result. If, on the other hand, the site has patches of semi-natural habitat present, aim to retain these as unplanted areas in your overall forest design. These protected areas should have an appropriately sized buffer zone. All main features of conservation value - such as rivers, lakes, streams and wetlands – should be clearly mapped in the planning stage. Threatened

animal species and valuable plants species such as medicinal plants should also be protected and conserved.

As noted in Chapter 1, commercial forestry has developed a bad reputation in some countries, particularly where natural forests with a very high biodiversity value have been cleared for fast growing tree plantations. Plantations should only be established on sites where there are no (or few) trees, such as grasslands or sparsely wooded areas, or where the natural forest has been heavily degraded. With many heavily degraded Central Forest Reserves (CFRs) and privately owned ex-forest areas, there is no shortage of suitable land for plantations in Uganda. NB. The SPGS will not support growers who are clearing areas of reasonably intact natural forests. Only sites where it is considered that the natural forests are highly unlikely to regenerate will be considered suitable for plantations.

## 4.3 PLANTATIONS AND WATER USE

There are some people and organisations that blame tree plantations for excessive water use – as well as for every other environmental problem. Whilst these accusations are frequently based on hearsay rather than sound scientific evidence, the impact of plantations on the quality and quantity of water must be considered with all large scale plantation developments. With appropriate planning and management, plantations will not cause major impacts on stream flow or ground water quality or quantity. The impact on water resources can be moderated by the species, the area planted (and unplanted) and the way the plantations are subsequently managed. When establishing new plantations in areas where water availability is a critical issue, the planning should take this into account.

*Areas of high conservation value need protection and can be tourist opportunities (Sabie, RSA - York Timbers, 2007).*

Different tree species show different patterns of water use, growth and survival that vary significantly with climate and water table depth. Their capacity to grow fast and ability to grow roots through harsh soil conditions, and other physiological attributes can give rise to different outcomes in relation to site-water balance. However, the ability of trees to use ground water in any significant amount seems strongly dependent on the depth of the water table. Where the potential reduction of deep and high quality groundwater is of concern, the important considerations should include the nature of the land in which trees are planted, its overall hydrological features and the extraction of the ground water by down stream users. Matching tree species with sites is important to minimise negative hydrological impacts. NB. The specific case of eucalypts and the environment – which has attracted the most debate in Uganda and elsewhere - is discussed in more detail in Chapter 10 – *Eucalypts.*

## 4.4 PLANTATIONS AND SOIL QUALITY

Soil quality is of fundamental importance for the productivity and sustainability of forest plantations. It is therefore important that the forest industry's practices do not have negative impact, which may lead to a loss of soil of fertility in the long-term. The biggest issues relating to soil quality are soil erosion, soil compaction and soil water and nutrient loss. Erosion tends to increase during site preparation and road construction, when the soil is exposed to wind and running water. The amount of erosion depends on slope, soil type and rainfall, and the nature of the tree canopy. Soil compaction on the other hand is caused by use of heavy machinery during land preparation and harvesting. Fertilizing eucalypts is recommended not just to stimulate tree growth but also to maintain long-term soil fertility. Fertilizing is not generally recommended with pines until research results show that it is cost-effective.

*Commercial forestry is creating many jobs but the workforce must be well looked after for them to be productive and loyal.*

## 4.5 PLANTATIONS AND EMPLOYMENT

The increase in commercial tree planting in Uganda is having a major impact socially. Firstly, the labour intensive establishment operations are providing many thousands of jobs in the rural areas where they are needed most. Whilst many of these jobs are unskilled and seasonal, as the industry develops there are an increasing number of full-time jobs as well as opportunities for entrepreneurs to provide support to growers – for example, various contracting services and nurseries. Once the plantations approach maturity, there will undoubtedly be a significant multiplier effect as forest industries start adding value to the raw material from the plantations. In countries with a mature commercial forest industry (e.g. South Africa), this multiplier effect can be as much as six times when one considers the people dependent on the industry.

As the commercial forest industry develops in Uganda, it is the responsibility of employers to ensure that their workers are treated fairly and in accordance with the country's relevant labour laws. We would recommend, however, that employers go further than this: developing good relationships with ones' workforce has major benefits in terms of costs and productivity. It also pays dividends in the long-term when one has cultivated a dedicated workforce as they are much more likely to support the owner when there are problems like theft, fires or encroachment. This Chapter highlights ways to manage one's workforce so that they not only work in a safe environment but also in a cost-effective and productive one.

## 4.6 WORKER HEALTH AND SAFETY

Forest work is often characterised by difficult working conditions, heavy work and high accident rates. This often results into low productivity and low wages. Many tend to associate better work safety and stable employment to mean high cost, lower productivity and less economic efficiency. On the contrary, improvements in working conditions and productivity can go hand in hand. Sustainable management of forests is not possible without the sustainable use and development of the human resource.

**Physical hazards:** Forest operations involve a number of activities that may result in severe physical injury to workers. Injury may result from improper use of equipment. Falling trees

*A properly equiped chainsaw operator at Shiselweni Forestry Co., Swaziland.(2005)*

and loose branches are a significant cause of injury, particularly when workers are engaged in clearing and other tree entanglements.

**Hand tools & equipment:** These may include pangas, slashers, hoes, axes etc. Improper use of these tools may result into severe accidents. The following safety measure should be taken:

- Workers should be properly trained in the safe use of hand tools and equipment including work group coordination e.g. safe working distances.

*An accident waiting to happen! A chainsaw operator spotted in a Ugandan forest (2003).*

- Tools should be used for the right purposes they are made for and should be kept in good condition (and with sharp blades).

- Workers should be provided with all the necessary appropriate Personal Protective Equipment (PPE).

**Chainsaws:** Chainsaws are expensive but very important tools in commercial forestry, being very effective for operations such as land clearing, thinning and particularly for the final crop's harvest. They are also extremely dangerous tools when in the worong hands. The potential for accidents while using a chainsaw is high, with any injuries sustained usually being severe. Provided some golden rules are followed, however, they can be used safely:

Before operating a chainsaw in the field, the operator must be professionally trained in the machine's operation, maintenance and safe felling practices. They must also wear the following essential PPE:

- Safety boots with steel toe-caps and covering the ankles.
- Chainsaw operator safety hat, with a transparent face shield and ear protection.
- Full length chainsaw operator trousers that have in-built protection to snag the chain saw if the blade touches them.
- A close-fitting shirt (i.e. no torn or loose clothing that could snag on the blade).
- Chainsaw operator mitts (gloves) to protect hands and cushion the fingers from the occupationa hazard known as 'white-finger' caused by long-term exposure to high frequency vibrations.
- A 1st-aid kit should always be available at the work site too.

**Machines and vehicles:** Accidents may occur in connection with the use of machines and vehicles including tractors and trucks that transport workers. All vehicles should be kept in good working order. Maintenance of roads is also important to reduce wear and tear on vehicles.

**Lone and isolated workers:** Forest operations may necessitate that workers are isolated and out of ear-shot from a supervisor or other workers. The risk is considered too high if this isolation means that a forest worker could be over one hour away from anybody capable of providing aid and assistance.

**Noise and vibration:** Chain saws, vehicles and other mechanical forestry equipment emit noise at excessive levels. Control measures should include wearing of hearing equipment and implementation of work rotation programs to reduce cumulative exposure.

**Chemical hazards:** Accidents may be as result of skin contact, inhalation (breathing in), and ingestion (swallowing) of chemical substances. Measures should be taken to reduce adverse impacts – especially training workers and issuing (and ensuring it is worn!) appropriate PPE.

- Cotton overalls should always be worn during spraying operations to avoid contact with the skin.
- Gloves and aprons should always be worn during cleaning operations to protect the skin from corrosive effects of cleaning agents. Also when decanting the indiluted chemicals prior to application.
  NB. All protective clothing should be cleaned and maintained in good order. Gloves should be washed inside out after each usage.
- **Foot wear:** gum-boots provide sound grip from slipping, mechanical and chemical damage and should always be worn during spraying operations.
  **NB.** Overalls should not be tucked into the gum-boots.
- **Eye protection:** eyes are the most vulnerable parts of the body to chemicals or physical damage. When handling volatile chemicals safety glasses, goggles a face shield or full face respiration must be worn to protect the eyes.
- **Storage:** separate areas must be set aside for storing all chemicals and this area must be physically separate from where food stuufs (or other workers' properties) are kept. Only authorized personnel should have access to the chemical store.
- **Spray equipment:** always ensure the equipment is in good working order, with no leaks.
- **Training:** above all, ensure all those handling chemicals are trained by professionals and have at least a basic understanding of 1st aid.

**Health and Nutrition:**
Most forestry is still characterized by a difficult working environment, heavy physical efforts and high accident risk. This often results in a vicious circle of low productivity, poor wages and an unstable workforce. To secure the future of forestry, human resources as well as forest resources must be managed in a sustainable manner.

**Cost of accidents:**
The cost associated with accidents is often not fully appreciated by forest managers. One reason might be that they often do not know the true cost of accidents. Typical costs of accidents include: evacuation, treatment, loss of working time due to injuries, time lost by other employees when an accident occurs, replacement of injured employees by less skilled workers, which may result in lower productivity or lower quality of the work and damage to equipment. If all these and many other indirect costs to the employer and employee are taken into consideration, definitely the bill for negligence of safety requirements will be high.

**Living conditions:**
In general, forestry operations take place far from urban centres, and workers must travel long distances every day or remain for several days or weeks in camps near the workplace. Where camp standards are low, labour turnover is likely to be high.

**Nutrition:**
The energy content of food is important because most forest activities demand great physical exertion. Insufficient food supplies results in short working days and low productivity. In hot working environments it is equally important to ensure supply of drinking water of adequate quality. For heavy jobs, such as chainsaw work, a worker needs approximately one litre per hour. Dehydration drastically reduces working capacity and the ability to concentrate, thereby increasing the risk of accidents.

If working conditions are unattractive, turnover is inevitably high, which makes it impossible to stabilize the workforce. A high labour turnover drains skills, and reduces productivity and earnings.

## 4.7 PLANNING TO IMPROVE ENVIRONMENTAL & SOCIAL ISSUES

**Maps:** It is important to refer to maps of appropriate scale (e.g. 1:10,000) which indicate various features of the area. Maps should be consulted to identify existing infrastructure, existing plantations, contours and site classification elements such as terrain, topography, and soil. Maps assist in making decisions on:

- Areas suitable for afforestation.
- Site-specific management requirements.
- Slope restrictions to determine site preparation method.
- Demarcation of special management areas.
- Choice of harvesting system.
- Location of new infrastructure (e.g. roads, buildings etc.).

**Tree Species & Site-Species Matching:** Selection of which species to plant on a particular site is a decision that is as important to nature conservation as it is to commercial aspects of forestry planning. There is a rule-of-thumb in commercial forestry which says you should plant the "right trees in the right place". This rule also applies when you are trying to improve the ecological value of your forest. The problem is that the species which have the most to offer nature conservation may not always give the best economic return, and so species selection is a question of achieving a balance between commercial and ecological considerations. Having selected your primary commercial species, incorporating other species into your plantation (especially indigenous species) can significantly enhance its ecological importance. Chapters 5 & 6 have further information.

*Well organised and protected spray operators at one of the SPGS's training courses (2007).*

**Wetland Delineation:** Wetland means land characterised by water at a frequency and duration sufficient to support support wetland vegetation or aquatic life. Wetlands are usually characterised by soggy ground, clay soils and plants adapted to wet conditions. For their high

*An SPGS training course teaching people how to delineate the boundary of a wetland area (Luwero, 2008).*

biodiversity value, wetlands should be identified and protected. The process of establishing the actual wetland boundaries is what is referred to as wetland delineation. When delineating a wetland, the best tool to use is a soil auger, which drills down into the soil and removes a sample to inspect. If the soil is clay, sticky and/or contains bright (red or orange) mottling against a grey background, then that implies the area is a wetland. The same procedure is repeated by taking samples from spots away from the wetland until the soil type changes to well drained, non-sticky soil free of mottling. It is important to note that the actual line between upland and wetland will vary depending on number of factors but especially the terrain of the area.

**Land Preparation:** some of the major environmental concerns relating to commercial forestry are soil erosion and soil compaction and in this regard, the method of land preparation is crucial. The potential for soil loss increases greatly with increasing precipitation and on steep land. Cultivating planting sites with heavy equipment during rainy seasons is especially likely to cause serious soil erosion and soil compaction and may deleteriously impact on the long-term productivity of a plantation.

Due to both equipment constraints and erosion hazards, very steep slopes should thus not be mechanically ploughed. The burning of trash prior to planting can also have negative consequences for the soil structure and nutrient status, especially if the fire is very hot, which can happen where the conditions are very dry and there is a lot of trash. Thus careful timing of trash burning is recommended to avoid very hot fires.

**Chemical Application:** Various chemicals are used worldwide in commercial forestry to improve yields and/or to protect tree plantations. Herbicides are used to suppress weeds and fertilisers are applied to obtain good yields; nursery plants are often protected from insect and fungal pests by the timely use of selected pesticides. All these uses may involve a wide range of equipment ranging from manual or machine-operated sprayers to application by hand. The substances used may be powders, liquids or gases, many of which, through their toxic and corrosive effects may be poisonous or harmful to both humans and the environment if not properly used. Some practical measures must be adopted to eliminate or minimise the harmful effects of these chemicals need to be adopted to ensure that these chemicals are safely

*Burning of trash should only take place in cool conditions (RSA, 2007).*

used to avoid unnecessary risk to humans and the environment:

- Chemicals must be applied by trained operators wearing the necessary protective gear (see previous Section).
- Chemicals must be used according to the manufacturers' recommendations (NB. always read the product's label).
- The application of chemicals must avoid the risk of contaminating ground or surface water.
- Chemicals must be applied only at the recommended rates for the target pest.
- Chemical containers should be thoroughly rinsed and safely disposed of (puncturing and burning in pits will ensure they are not re-used).
- Chemicals should not be transported to the field in bulk to avoid dangers of accidents.
- Avoid spraying during windy conditions to avoid chemical drift from the application point. This is particularly important when spraying near special conservation areas. For further details refer to Chapter 12 – *Safe Use of Herbicides.*

**Planting:** Planting a good quality tree will help ensure a healthy plantation that optimises the site. Contour planting (the practice of planting along the contour instead of up-and-down the slope) is strongly recommended. It is also important to ensure that plant containers are removed from in-field and disposed off in a properly managed disposal site, burnt or possibly recycled as they can be a source of environmental pollution. For details refer to Chapter 14 - *Planting and Beating-Up.*

**Fertilizing:** Fertilizing is an important practice in commercial forestry (especially with eucalypts) and can ensure high and sustainable yields from sites if it is done properly and appropriately.

Inappropriate practices can be detrimental to plants and have negative environmental impacts. Note that fertilizers are only of benefit in areas with proven positive responses.

**Weeding:** Weeding can be done manually or chemically to suppress weeds. On steep slopes, weed control should not be 100% and it should be done along the contours. Where selective weeding is required to avoid non-target plants, plantations should be weeded manually. Chemical weeding can be very cost effective and it also results in the vegetation remaining (albeit dead) on site holding the soil. For more details refer to Chapter 11 –*Weed Control.*

**Fire Protection:** Fires are a perennial hazard in plantation forestry. Unplanned (and sometimes planned!) burning in plantations may result in the uncontrollable spread of fires, which destroy not only the tree crops but other valuable fauna and flora too. Firebreaks should not run up and down the hill as this encourages erosion in the rainy season. Use of roads and natural features as firebreaks limits the negative impacts of very many fire breaks. These and other fire management strategies are important to ensure that the forest resource and its ecological values are protected. For more details refer to Chapter 16 – *Forest Fire Protection.*

**Harvesting:** Timber harvesting operations are a potential major source of environmental damage, especially where heavy, wheeled machines are employed. Where operations might cause environmental damage, the appropriate measures must be taken to minimize the damage and to mitigate the impacts of any damage that has already occurred – for example:

- Have reliable maps at a suitable scale showing conservation areas, compartment boundaries, roads etc.

*A well designed and maintained forest road (Sappi, RSA).*

- Use appropriate equipment (considering the topography, soil and weather conditions).
- Plan the harvest so that very large, adjacent compartments are not harvested together (NB. having a mosaic effect of different ages is recommended).
- Trees should not be felled in special management areas.

**Road Construction and Maintenance:** Good forest roads are crucial for effective forest management. All forest maintenance (and especially thinning and harvesting) operations require the accessibility provided by a suitable road network. Potential adverse impacts of roads include:

- Sedimentation and runoff from roads may cause reduction in water quality
- Reduction in slope stability on unstable sites
- Accelerated soil erosion

Measures can be taken, however, to reduce the adverse impacts of road construction:

- Identify and avoid unstable areas
- Locate roads on ridges, where possible and away from waterways
- Plan and mark road alignment prior to road construction
- Avoid working in wet conditions
- Allow road to consolidate before use
- Maintain a proper drainage system.

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# Annex 1
# CHECKLIST OF CARRYING OUT SIMPLE EIA

| | | | Yes | No | n/a |
|---|---|---|---|---|---|
| 1 | ***Maps :* Does your map indicate the following?** | | | | |
| | | Compartment boundaries | | | |
| | | Special Management zones | | | |
| | | Terrain classifications | | | |
| | | Existing infrastructure e.g. road network | | | |
| | | Stream and crossing locations | | | |
| 2 | ***Special Management Zones/Wetland Mangt: Identification & classification of*** | | | | |
| | | Wetland areas :- delineation | | | |
| | | Rivers | | | |
| | | Lakes | | | |
| | | Streams | | | |
| | | Swamps | | | |
| 3 | ***Archaeological, Cultural and Traditional sites:*** Indicate presence of the following. | | | | |
| | | Sites of religious or spiritual significance | | | |
| | | Archaeological or historical sites | | | |
| | | Graves and burial sites | | | |
| | | National Heritage sites | | | |
| | | Any other | | | |
| 4 | ***Species of special Conservation Significance*** | | | | |
| | | Plants | | | |
| | | Animals | | | |
| | | Plans to protect these species | | | |
| 5 | ***Indigenous forests*** | | | | |
| | | Buffer zones | | | |
| 6 | ***Fire protection:*** | | | | |
| | | Fire break system | | | |
| | | Fire Mangt resources:- Equipt; communication, trained staff | | | |
| | | Fire fighting safety policies | | | |
| | | Use of natural features for breaks | | | |
| 7 | ***Access*** | Plan for roads | | | |
| 8 | ***Site species matching: Have you considered these characteristics of the area.*** | | | | |
| | | Soil | | | |
| | | Climate | | | |
| | | Water use efficiency | | | |
| 9 | ***Land preparation*** | | | | |
| | | Demarcated<br>according to compartment planning | | | |
| | | Special management zones & areas of special interest identified. | | | |
| 10 | ***Chemical applctn*** | Trained staff | | | |
| | | Proper equipment | | | |
| | | Plans to dispose chemical containers | | | |
| 11 | ***Planting*** | | | | |
| | | Use of quality, disease-free plants | | | |
| | | Fertiliser application | | | |
| | | Disposal of planting containers | | | |
| 12 | ***Weeding*** | Biological weed control | | | |
| | | Manual weed control | | | |
| | | Chemical weed control | | | |
| 13 | ***Labour force*** | Availability of clean water | | | |
| | | Provision of meals at least 2 times a day | | | |
| | | Protective clothing | | | |
| | | Housing | | | |
| | | Wages | | | |

# CHAPTER 5
# TREE SPECIES FOR COMMERCIAL TIMBER PRODUCTION

*"Plantations are a major source of industrial wood in Africa. Many projects, however, have performed poorly because of poor species choice, lack of species trials, limited site characterisation and unforeseen pests." UNEP/WMO Intergovernmental Panel on Climate Change. 2005. 15 yr old E. grandis at Nseleni Estate, Kwambonambi, RSA (2007)*

So you are interested in planting trees commercially in Uganda are you? Well the most important decision you have to make is what species to plant. This depends primarily on two main things: firstly - what products you want to produce and secondly what species will grow well on your land. This Guideline will aid this decision with details of the silviculture and management of potential species, as well as their growth rates, expected rotations and the wood's utilisation characteristics.

Before planting any particular tree species (especially on a commercial scale), it is essential to understand their site requirements and their growth characteristics. Failure to appreciate this will often result in a crop that does not perform well and may well result in the plantation development being a financial disaster.

It should be noted that the species referred to in this Guideline are only those with potential for commercial scale sawlog (i.e. timber) production. Of course, many of the species will produce other products as well (such as fuelwood and poles) but still the main aim of the NFA and private investors - especially those on the SPGS - is timber production.

## EXOTIC VS INDIGENOUS

We are often asked why most of the species recommended for commercial plantations are exotic (i.e. not native to Uganda) and why we don't plant more indigenous species. The main reason is that most of the indigenous trees grow too slowly (e.g. Mahoganies *(Khaya anthothica* and *Entandophragma spp.*) and Mvule (*Milicia excelsa*) and thus render the investment unprofitable. Many indigenous species are also very difficult to grow in a plantation situation (e.g. Mvule and *Prunus africanum*). The exception to this is Musizi (*Maesopsis eminii*), which is a fast growing indigenous tree with considerable promise for timber plantations on suitable sites in Uganda. On appropriate sites, however, we do encourage planters to plant a proportion of indigenous trees but for commercial reasons, faster growing trees - especially eucalypts and pines - will dominate plantations for timber in Uganda for the foreseeable future.

Pines and *Eucalypts* are the main species used for plantations throughout the tropics and sub-tropics because of their ability to grow well in a plantation situation. They are natural pioneer species – which means they are adapted to grow over a range of sites and in an open situation. In addition, there is a lot known about their silviculture – both in the nursery and in the field situation – and also their growth and utilisation characteristics. Breeding programmes in a number of countries also means that there is improved seed available for the most important commercial species.

## MIXED SPECIES OR MONOCULTURE?

## EVEN OR UNEVEN AGED?

The vast majority of commercial plantations worldwide are monocultures i.e. comprising one species only in a given area. Additionally, each block (usually called compartment or sub compartment) will be of the exact same age. Conservationists often criticise commercial forestry organisations for this approach but they fail to understand the economics of plantation forestry and also the complexities of managing different species and/or ages growing together. A sound plantation development, however, should develop a mosaic of different species and ages over the estate. With fast growing eucalypts on specific sites, it is also recommended to apply fertiliser to maintatin the nutrient status of the soil.

The main plantation species referred to in this guideline – especially pines and eucalypts – can produce very high yields when grown intensively in a monoculture, even-aged situation. Silvicultural prescriptions (and budget figures) can also then be easily applied to large areas. There are huge economies of scale to be made having blocks of trees the same species and age/size.

## RISKS

Growing large blocks of monocultures (and with a narrow genetic base if using improved seed) comes at a price too. Such plantations are more at risk than a natural population when it comes to fires and pests and diseases and hence, precautions have to be taken to minimise such risks – e.g. restricting compartments to maximum 30ha; having blocks of different ages and species scattered throughout the estate; developing infrastructure (especially roads); having a fire prevention and control plan.

An important – though longer term - method of reducing risk is to have in place a breeding programme that maintains a wide genetic base that could be called on should there be a catastrophic pest or disease outbreak in any of the major species in the plantation programme.

## BE SCIENTIFIC!

Going to a nursery and asking for pine or eucalypt seedlings is like going to a library and just asking for a book: you are highly unlikely to get the one you wanted! There are over 100 different species of Pine and some 600 eucalypt species - each with their own characteristics. For commercial plantations, it is essential to select not just the correct species for the site but to obtain the right seed origin or provenance from within a particular species. Thus the recommendations in this Chapter are very specific and should be carefully followed.

## SPECIES IN THIS GUIDELINE

We considered a long list of potential plantation species for inclusion in this Chapter. The species were split into two categories - primary and secondary. Only the former group of species have been included here. The primary group are those species which are currently being planted for commercial timber production in Uganda. Please bear in mind, however, the comments made earlier in the Introduction section about matching sites with species.

The secondary group is a mixed group of species that fit into one of the following categories: those only likely to be useful on a very limited area in Uganda, those severely limited by seed availability or those worthy of trial before recommending wider planting here.

## SPECIES LIST: *( * = indigenous to Uganda)*

**Primary:** *Eucalyptus grandis, Pinus caribaea var. hondurensis, Maesopsis eminii*, Pinus patula, Pinus oocarpa, Cupressus lusitanica, Araucaria cunninghamii, Tectona grandis, Terminalia suberba.*

**Secondary:** *Araucaria hunsteinii, Terminalia ivorensis, Pinus kesiya, P. tecunumanii, Eucalyptus camaldulensis, E. tereticornis, E.pellita, E. urophylla, E. paniculata, hybrid Eucalyptus clones (GU & GC), Cedrela odorata, Agathis robusta, Prunus africanum*, Podocarpus spp*., Grevillea robusta, Mahoganies* (Khaya anthotheca, Entandophragma spp.); Milicia excelsa*.*

## ABBREVIATIONS:

In the interest of space in the species' datasheets, standard abbreviations have been used:

| | | |
|---|---|---|
| asl | - | above sea level (in metres) |
| ERD | - | effective rooting depth (cm) |
| ha | - | hectares (1ha = 2.47 acres) |
| Lat. | - | Latitude |
| Long. | - | Longitude |
| MAI | - | mean annual increment ($m^3$/ha/yr). |
| MAR | - | mean annual rainfall (mm) |
| sph | - | stems per hectare |

# EUCALYPTUS GRANDIS

**Family:** *Myrtaceae*
**Common names:** Blue gum; Saligna; "*Kalitunsi*"

**Natural Occurrence:**
EG occurs naturally in Australia between Lat. $16^0$S (N. Queensland) and $33^0$S (NSW), mostly in coastal areas and up to 600m asl. EG grows to 75m in places.

**History of Growing in Plantations:**
EG is one of main sub-tropical/tropical plantation species worldwide, with well over 20M ha planted (mainly Brazil, India, Southern & Eastern Africa). Grown in Ug since 1912 but species has hybridised and very few pure EG now. Well known to Ug farmers and is a common cash crop for fuel and poles. Grown commercially as a fuelwood crop in tea estates throughout Ug.

**Characteristics & Uses:**
EG has very versatile wood properties including excellent pulp and paper qualities. In Ug it is frequently grown for fuelwood, building poles and is increasingly used as a source of timber, large poles and veneer. The sapwood is pale pink; the heartwood darkens to a richer red-brown on exposure to the light. It has an air-dry density of 600-750kgs/$m^3$. EG wood is not naturally durable and thus must be treated if in contact with the ground. Fast grown trees can have growth stresses and appropriate utilization techniques must be used to achieve good recovery rates. EG is an excellent source of nectar for bees.

**Site Requirements:**
**ERD:** at least 750 mm with no impediment to rooting (any stone-lines must be shattered before planting).

**MAR:** requires >1,000mm/yr. Alt. EG prefers cooler climates (in Ug, best growth is in western region). EG does not tolerate severe droughts; it is tolerant of waterlogging but for a short time only.

**Seed Recommendations:**
For commercial plantations, use only improved seed from seed orchards in Southern Africa. Best local stand is Fort Portal: other locally collected seed is highly likely to be contaminated (hybridised) and will not perform as well. Hybrid clones (with EG as mother) are planted more than pure EG worldwide now but are still in the research phase in Ug.

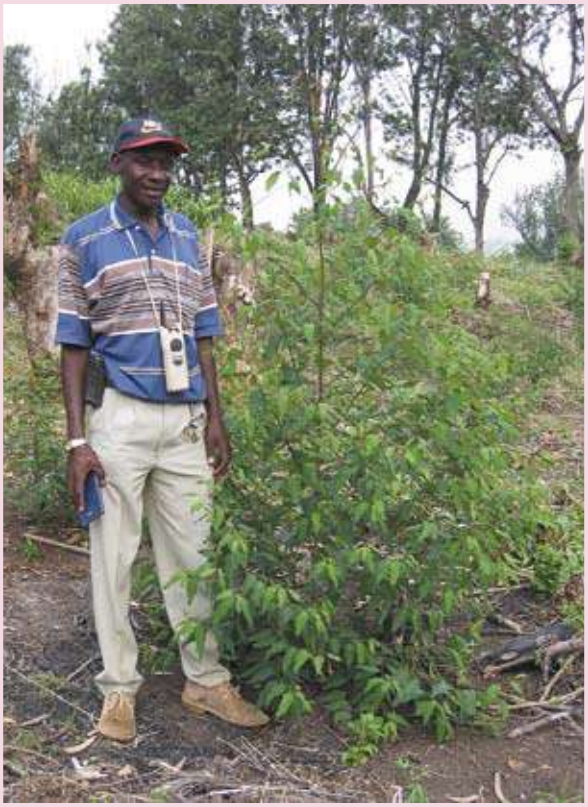
**Silviculture:**
**Seedlings:** mature in 3 months in nursery from seed. Spacing: for fuelwood and small poles: 2.5 x 2.5m to 2.0 x 2.0m (1600-2500 sph); for timber and big poles: 3.0 x 3.0m to 2.7 x 2.7m (1111-1372 sph). **Establishment:** EG is very sensitive to competition (especially grasses) early on in its life and thus sites must be kept weed free until canopy closure for maximum yields. Pre-plant spraying with Glyphosate is the most cost-effective method of weed control. EG responds well to fertiliser at planting too. **Management:** EG is a light demanding, shade intolerant species, which responds well to thinning. To produce large diameter stems for timber and poles, EG must be thinned heavily from an early age - starting no later than 2 years in Ug. Final crop densities of 250-400 sph are recommended. EG plantations do not respond to thinning or weeding once they have stagnated due to either weed competition or dense stocking. Pruning in stages will also be necessary to produce high quality sawlogs. EG readily coppices up to 10 years old: coppice regrowth must be selectively thinned on time. EG is very sensitive to fire.

**Yields:**
On suitable sites and with good silviculture EG can produce outstanding growth - MAIs > $50m^3$/ha/yr have been achieved in western Ug. Avg. MAIs expected in Uganda are 25-$45m^3$/ha/yr. With poor silviculture, EG will grow slowly and can totally fail. Rotations for sawlogs expected to be 8-15 years.

**Common Pests & Diseases:**
Good silviculture (i.e. minimum stress) will greatly reduce EG's suceptibility to the Chalcid wasp in Ug. Termites are a major problem in hot, dry areas - but these are not good EG sites anyway. Prone to range stem canker diseases, hence the use of clonal hybrids (see Chapter 17).

**Other Issues:** Complaints of excessive water use are periodically blamed on EG. Rapidly grown plantations of any intensively grown crop may reduce water catchment yields - thus care must be taken when selecting sites for large-scale EG planting. (See Chapter 10)

**Summary: On good sites EG can grow extremely quickly but it requires good land preparation and thorough weeding. EG can produce timber and large poles in only 8-15 years but only if thinned early and heavily. It is also essential to use only improved, select seed. Easy to raise from seed and coppices vigorously**



*3 month E. grandis (James Finlay's Musizi tea estate, 2003).*

## PINUS CARIBAEA var. HONDURENSIS

**Family:** *Pinaceae*
**Common names:** Caribbean pine; Pitch pine.

**Natural Occurrence:**
PCH has a wide natural distribution in the Caribean basin from lat. $12^0$-$27^0$N; long. $77^0$-$90^0$W; mostly at low elevations up to 760m asl. PCH varies much in form and growth throughout its natural range.

**History of Growing in Plantations:**
PCH is planted widely for its timber throughout the American, Asian and African tropics and sub-tropics. In Ug it was introduced in the 1960's but not from the best seed sources. Many of the best individuals have since been felled.

**Characteristics & Uses:**
PCH is a fast growing and versatile tree for tropical lowland plantations. Its needles usually occur in fascicles of 3. PCH generally forms a straight stem - up to 45m under favourable conditions. It produces a versatile wood (density 400-650kg/$m^3$) which saws, dries and machines easily. Trees >12 years can develop resin in the heartwood - heavy pruning helps reduce this. PCH can produce good quality oleoresin which can be distilled to produce terpentine and other products.

**Site Requirements:**
PCH grows on a wide range of tropical and sub-tropical sites at altitudes up to 1500m asl (usually <1000m). PCH requires an ERD of at least 600mm and shallow sites should be avoided. It is moderately drough resistant. MAR: requires >1,000mm/yr.

**Seed Recommendations:**
Natural populations of PCH exhibit great variation in growth rate, stem form and branch characteristics. PCH has been the focus of international provenance (seed origin) trials since the 1970's. Results have proven that the Australian clonal seed orchard seed (from Forest Plantations,

Queensland, Australia) has consistently perfomed better than natural collections. Improved seed from South African (Mondi) and Brazilian seed stands is also recommended for Ug.

**Silviculture:**

**Seedlings:** PCH is easy to raise from seed: mature in 4 months in nursery from seed. Mycorrhiza are needed for seedling growth: thus litter from old stands must be added to nursery potting mix. **Spacing:** 3.0 x 3.0m (1111 sph) recommended for timber stands being raised from improved seed. **Establishment:** PCH requires full sunlight to grow - thus the site must be cleared well before planting. Whilst PCH can tolerate some weed competition, it cannot tolerate overhead shade. For best growth, keep the 1m diameter planting pits clear of weeds and slash the interrow vegetation frequently until canopy closure. On very weedy sites, pre-plant spraying with Glyphosate will be cost-effective. **Management:** To produce large diameter stems quickly, PCH must be heavily thinned. The actual age of thinnings will depend on growth rates but on average in Ug, 1st thin @ 4-6yrs to *ca.*700 sph (35%); 2nd thin @ 6-9yrs to *ca.*500 sph (35%); 3rd thin @ 9-12yrs (35%) to a final crop of *ca.*300sph. High pruning in stages is recommended to produce clean logs. Because of PCH's light canopy, stands will have to be periodically cleaned to keep weed growth in check. PCH is moderately fire resistant after around 5 yrs when it develops thicker bark.

**Yields:**

PCH can produce MAIs of > 30 $m^3$/ha/yr on good sites in Ug but only with excellent silviculture. Avg. MAIs expected are 15-25$m^3$/ha/yr. Rotations for sawlogs are expected to be 18-25 years.

**Common Pests & Diseases:**

PCH is susceptible to damping off in the nursery. It is also prone to root rot fungi (e.g. *Armillaria mellea, Phytophthora cinnamomi*) in young plantations, which can cause isolated (or group) deaths.

Susceptible in some countries to fungal needle diseases (e.g. *Mycosphaerella spp.*) in young plants.

**Other Issues:**

The availability of improved seed has restricted planting of PCH in some countries (including Ug in 2005) though efforts to increase imports are underway. Foxtailing can be significant if grown on very fertile sites: rather plant hardwoods.

**Summary:**

**PCH is a fast growing tropical species that adapts to a wide range of sites. It is the prime species for timber plantations in Ug - especially for the shallower soils on lower elevation sites. Only imported, improved seed is recommended for commercial planting in Ug.**

*Richard Bakojja's (rt) 3-yr old PCH in Mubende (2007)*

# MAESOPSIS EMINII

**Family:** *Rhamnaceae*
**Common names:** Musizi.

**Natural Occurrence:**
MUS occurs between $8^0$N and $6^0$S in a band across West, Cenral and East Africa from Kenya to Liberia. MUS is found throughout the wetter parts of Ug, being a coloniser of disturbed forest.

**History of Growing in Plantations:**
MUS has been used more for enrichment planting in NHF than pure plantations in Ug. Many of these trees (from the 1960's and '70s) have since disappeared from the CFRs where they were planted, being targetted by timber thieves. Farmers in Ug do, however, frequently plant MUS as shade for crops (including coffee and cocoa) and also value its timber. The potential of MUS has long been recognised and it is now being promoted for timber plantations on suitable (fertile) sites around Ug.

**Characteristics & Uses:**
MUS is a semi-deciduous tree that produces a widely used, general purpose timber (380-480kg/$m^3$). The wood is light brown and easily saws, dries and machines, though it has inter-locked grain and thus doesn't finish well. It is used mostly for general indoor construction. MUS is not liked for exterior work (or veneers) because its yellow heartwood stains paint. Unless grown in full sun, MUS can have poor stem form as it moves towards the light (heliotropism). Many birds, rodents and primates eat (and thus disperse) the olive-like seed.

**Site Requirements:**
MUS requires moderately fertile, deep and well- drained soils. It needs MAR of >1200mm (but does tolerate some drought) and altitudes <1200m asl.

**Seed Recommendations:**
Since MUS has not been acknowledged as a major commercial plantation species, there is no genetically improved seed available. Potential growers are thus recommended to use only seed from selected 'plus trees' (i.e. mother trees with superior characteristics). The NFA's National Tree Seed Centre should have such seed available.

**Silviculture:**
**Seedlings:** plantable seedlings (ca. 20cm tall) should be ready 3-4 months after sowing. Germination can be erratic. **Spacing:** For dedicated timber plantations, MUS should be grown at a spacing of 4 x 4m (625sph) or 3 x 3m (1111sph): the latter spacing will give better weed control and quicker canopy closure. For agroforestry situations (and where timber production is also an objective) a wider spacing can be employed e.g. 6 x 6m (277sph). **Establishment:** MUS is a light demanding species and sensitive to competition. It must be well weeded and not over-shaded by weeds. Low agricultural crops (beans e.g.) can be grown between the tree rows provided the trees are not interfered with. **Management:** MUS stands must be thinned early to ensure the crowns have unrestricted access to light.

*Pat Hardcastle besides a large Musizi Tree (ca. 20yrs) in JFU's estate in Mukono (2003)*

Typical thinning regime for a 3x3m spaced crop would be: remove 50% *ca.* yr 4; then a further 50% at yr 8; 50% yr. 12. Although naturally self-pruning in the NHF situation, MUS can develop large branches when grown in more open situations and thus pruning to produce clean lower stems is thus recommended. MUS is reported to coppice freely after being cut and is highly susceptible to fire.

**Yields:**
MUS has not been grown intensively in pure stands in Ug but yields are expected to be around 15-25$m^3$/ha/yr. Rotations for sawlogs are expected to be 15-25 years but will depend largely on site conditions and management regime (especially espacement).

**Common Pests & Diseases:**
MUS trees are susceptible to browsing damage by wild antelopes after planting out. They can also develop stem cankers (*Fusarium spp.*) when stressed.

**Other Issues:**
MUS is considered an 'invasive alien' in the East Usumbaras in Tanzania due to its aggressive colonising abilities. In Ug MUS offers a high potential for timber production in degraded forest land but more research is needed to determine the species' best management practices.

**Summary:**
**MUS is a fast growing indigenous tree of considerable promise for timber production in Ug. It is a natural colonising species and is widely used for enrichment planting and as shade for agicultural crops in Ug. Its stem moves towards the light and thus plantations must be thinned on time.**

## PINUS OOCARPA

**Family:** *Pinaceae*
**Common names:** Ocote pine, Nicaraguan pitch pine

**Natural Occurrence:**
POO grows naturally in Mexico, Guatemala, Belize, Hunduras, El Salvador & Nicaragua - between Lats. 28$^0$N and 13$^0$ N. POO is occurs naturally between 200-2500m asl, although its best growth is found on well drained slopes at around 1500m asl. POO occupies sites with a more severe dry season than PCH.

**History of Growing in Plantations**
POO has been widely introduced to tropical and sub-tropical sountries in Africa, Asia and S. America. It was introduced to Ug in the 1960's though it appears that these might not have been from the best natural seed sources.

**Characteristics & Uses:**
POO is similar in growth characteristics and habit to PCH, with a light, conical crown. The leaves (needles) of POO are usually in fascicles of 5 (occasionally 3 or 4) and 20-25cm long. POO produces a high quality sawtimber, less prone to splitting and warping than most other pines. Wood density 450-600 kg/m3 and is used for light construction purposes.

**Site Requirements:**
POO grows in a wide range of soils. Best growth, however, will be on well drained, deep soils at approximately 1500m a.s.l. and MAR >1000 mm. POO can tolerate long, dry seasons once established and will also tolerate temporary waterlogging. PCH performs better on shallow soils.

**Seed Recommendations:**
In international trials, provenances from Nicaragua and Mountain Pine Ridge (MPR), Belize performed better. Most of best local trees have disappeared and thus locally collected seed does not exhibit the excellent stem form and growth of imported PCH seed orchard

seed. Until other seed sources are identified, use POO select seed only on steep, shallow sites where PCH will not perform as well.

**Silviculture:**
Very similar to PCH.

**Seedlings:** POO is easily grown from seed: direct sowing into pots is recommended (ca. 50,000 plants/kg). Mycorrhiza must be added to potting mix. Seedlings should be of plantable size (*ca.* 20cm tall) within 4 months in Ug.

**Spacing:** 2.7 x 2.7m is recommended (1371 sph) since the available seed is not improved.

**Establishment:** As for PCH.

**Management:** Heavy, early thinnings will be important for producing large sawlogs as quickly as possible. High pruning in stages will also be required to produce clean logs. POO at 2-4 years has the ability to respond at ground level after a fire has destroyed the main stem. POO becomes more fire resistant with age.

**Yields:** POO is expected to yield 15-20$m^3$/ha/yr - generally less than the PCH from improved seed. Specific seed origins can, however, yield very well.

**Common Pests & Diseases:**
POO in Ug has been free of major pests and diseases to date. It is susceptible to damping off in the nursery and is reported from elsewhere to be very susceptible to brown needle disease *(Mycosphaerella spp.)* in the nursery too.

**Other Issues:**
The growth rate of POO is generally less than PCH, making it the less desirable of the two species. It has been found that POO hybridises naturally with PCH and this fact - combined with the better quality of POO's wood - means that it could be important for future breeding programmes in Ug. Some of the best POO natural provenances are now classified as *P. tecunumanii* (*P. tec.*). The SPGS is investigating the possibility of importing POO (and *P. tec.*) seed for trials in Ug: in the meantime PCH plantations from improved seed are likely to produce significantly better returns for commercial growers.

**Summary:**
***P. oocarpa* (POO) yields a high quality sawtimber but is slower growing than PCH. POO is well suited to higher sites and shallower soils but the current lack of genetically improved seed restricts its widespread use in Ug for commercial plantations.The SPGS does not permit use of local POO seed.**

*P. oocarpa from local seed in Bushenyi. (2003)*

# PINUS PATULA

**Family:** *Pinaceae*
**Common names:** Mexican pine; weeping pine.

**Natural Occurrence:**
PP occurs naturally in eastern Mexico, where it is a medium-sized tree (occasionally over 30m tall). It is a very variable species with regard to size, stem form and branch characteristics: forking is common.

**History of Growing in Plantations:**
PP has been widely planted in commercial plantations in southern and East Africa and South America. It is a favoured species for pulp (being less resinous than many other pines) and for sawtimber. In South Africa and Zimbabwe, PP has been the focus of intensive tree breeding programmes to improve stem form, volume and branch size.

**Characteristics & Uses:**
PP is easily identified from the drooping (weeping) habit of its foliage. Its needles are borne in fascicles of 4 (sometimes 3 or 5), 15-30 cm long and very thin. The bark of PP is reddish-brown and papery: becoming thick and scaly on older trees. PP's timber has a density of 350-400 kg/m$^3$. Its wood is soft, light, moderately strong and contains very little resin. The wood is very susceptible to blue stain and thus sawnwood must be treated quickly.

**Site Requirements:**
PP is best adopted to high altitudes with cool climates, which restricts its commercial planting in Ug to the SW of Uganda. PP prefers acidic soils with good moisture supply. PP is frequently planted off-site in Ug (especially at low altitudes) - where it will almost inevitably fail and become prone to various pests and diseases.

**Seed Recommendations:**
Cloned seed orchard PP seed from southern Africa is strongly recommended. Gains of up to 35% in timber yields have been achieved after two generations of selection and breeding. PP is a precocious seeding species - 5 yr old trees can produce viable seeds.

**Silviculture:**
**Seedlings:** PP is easily raised from seed (ca. 100,000 per kg): similar to the other pines,

*A private planter (SPGS Client) proudly posing next to his 2 year old P. patula in Kabale (South Western Uganda). PP grows very well on cooler sites at high altitude in Uganda.*

direct sowing in pots is preferred. Spacing: For sawntimber (and when using clonal seed orchard seed) a spacing of 3.0 x 3.0m is recommended. (1111 sph); otherwise 2.7 x 2.7m (1371 sph).

**Establishment & Management:**
Techniques are very similar to PCH. High pruning is particularly important when growing PP for sawtimber due to its habit of producing large whorls of branches. PP is particularly sensitive to fires as it gets older and develops thinner bark. Yields: On suitable sites, PP can grow extremely fast (over 30m$^3$/ha/yr). In Ug, it is expected to yield 20-30 m$^3$/ha/yr on the right sites and with good silviculture.

**Common Pests & Diseases:**
As an exotic, PP has proved susceptible to many pests and diseases - the major ones being *Sphaeropsis sapinea* (especially after hail damage), woolly pine aphid and more recently the Sirex woodwasp. PP is a very sensitive species: planting it off-site is highly likely to lead to health problems.

**Other Issues:**
In favourable areas, PP can become an aggressive colonising species. In Southern Africa, PP is a serious weed, invading grasslands and other vegetation types.The SPGS is already investigating the possibility of importing improved PP seed from breeding programmes in southern Africa.

**Summary: PP is the most important pine species in East & Southern Africa. On the cooler, higher sites in SW Ug, PP is the best choice for sawtimber. It can grow very fast and will produce a good quality wood if thinned and pruned on time. Improved (clonal) seed from Southern Africa is available and strongly recommended.**

## TECTONA GRANDIS

**Family**: *Lamiaceae*
**Common names:** Teak; Indian Oak

**Natural Occurrence:**
Teak is native to the South Asian and SE Asian region - between Lats. 9$^0$N to 26$^0$N. Much of its natural range is characterised by high MAR and a 3-5 month dry season.

**History of Growing in Plantations:**
Teak has been widely planted in plantations both within and beyond its natural range. It is a major plantation species in Africa, C. & S. America and in the Pacific, with over 2.2M ha planted by 1995. It has not been planted widely in Uganda but significant plantations have been established in S. Sudan and Tanzania and in many tropical W. African countries. Its high quality timber has stimulated major private investment in plantations but yield forecasts are often over-optimistic.

**Characteristics & Usess**
Teak is a large deciduous tree that grows up to 45m tall and a dbh up to 2.5m. It is sometimes fluted and forked stems are common. Its huge leathery leaves are simple and opposite. Teak yields are of the world's most beautiful timbers. Its wood is naturally durable, highly valued and used for a wide range of applications. Excellent international markets exist for plantation grown Teak but most buyers require independent Certification (e.g. from FSC - the Forest Stewardship Council).

**Site Requirements:**
The optimum site conditions for Teak are: MAR>1500mm; a 3-month dry season with monthly rain <50mm; alt.<1200m asl.; MAT 22-270 C. It is only suitable for commercial planting in northern Uganda.

**Seed Recommendations:**
Teak exhibits very large provenance differences so great care must be taken to ensure suitable provenances are used for commercial planting.

The use of improved genetic seed is essential for successful plantations.

**Silviculture:**

**Seedlings:** Teak is established by raising seedlings but more frequently by stump planting. There are 2-3000 seeds/kg and seed germination is often poor. Stumps are prepared by letting seedlings grow in rows in nursery beds to ca.10 months and then cutting stems back to 5cm above ground and the roots to a length of 20cm. **Establishment:** Teak is a hightly light demanding, pioneer species. Spacing for plantations ranges from around 2x2m (2500 sph) to 2.7 x 2.7m (1372 sph). Young plants grow quickly and even young trees cast a very dense shade. For the first few years, however, good weed control is important - especially grasses. **Management:** Heavy, early thinnnings must be carried out or the stand stagnates. A 1st thinning of 50% is often carried out at around 5 years with further thinnings every *ca.* 5 years to a final crop of *ca.*200 sph. Rotations expected to be 25-35 years: such long rotations appear necessary to realise the high value of the heartwood. Teak coppices readily from cut stumps. **Yields:** Widely varied growth rates are reported for Teak plantations, with MAI's of 2- 24 $m^3$/ha/yr quoted. With good silviculture (especially well selected seed, intense early weeding and heavy thinnings), MAIs of 8-12 $m^3$/ha/yr could be achieved in Uganda; with rotations around 30 years.

**Common Pests & Diseases:**

In India, the main pests of teak are white grubs in nurseries, with various stem borers and defoliating insects affecting plantations.

**Other Issues:**

No improved Teak seed is currently available in Ug and thus care should be taken to ensure appropriate planting material is used before embarking on a major long-term investment in Teak plantations. Work is needed to identify good sources. planting in Ug.

**Summary:**

**Teak is widely cultivated in the Tropics in plantations for its high value wood. Many plantations have failed, however, due to poor site selection and use of poor planting stock. Only very low altitiude sites in Northern Uganda might be suitable for teak but trials are needed.**

*One of the best remaining Teak stands in Southern Sudan - ca.35-yrs old.*

# ARAUCARIA CUNNINGHAMII

**Family:** *Araucariaceae*
**Common names:** Hoop pine

**Natural Occurrence:**
HOOP has a wide natural altitudinal and latitudinal range in Papua New Guinea and Australia: from sea level to >2400m asl; and from Lats $1^0$ - $30^0$S.

**History of Growing in Plantations:**
For many years, native HOOP stands supplied large quantities of defect-free logs to the Australian plywood industry. Large scale plantations (*ca.* 50,000 ha) of HOOP have since been established in Australia. In 1971, trial blocks were established in Ug (Kifu CFR) covering 3.65 ha. Although never thinned, this trial shows the huge potential of HOOP on the right site.

**Characteristics & Uses:**
HOOP grows into a very large tree (>60m and >1.8m dbh have been recorded). The mature tree is naturally straight, free from branches and with very little taper. The wood has a density of around 530 kg/$m^3$ (similar to PCH): it is not durable but is easy to work and preserve. It is used for a wide range of purposes including light construction, furniture, transmission poles (if treated). It is especially suitable for veneers and plywood because of its ability to grow large, cylindrical and clean trunks.

**Site Requirements:**
HOOP requires deep, moist soils - usually old THF sites.

**Seed Recommendations:**
HOOP seed loses its viability quickly but can be cold stored for up to 6 years (-$7^0$C). Heavy seed years only occur every 3-4 years. Only 2nd year cones are collected and before they break up on the tree. Until importations are made, seed for Ug plantations is from the thinned trial in Kifu CFR (seed from NFA).

*Impressive growth of Araucaria cunninghamii near Masaka, western Uganda. This tree is only 2 years old but on a good site (Mohammed Sekweya, 2005)*

**Silviculture:**
**Seedlings:** HOOP seedlings develop a strong tap root and thus the seedlings must be root pruned. There are *ca.* 4400 seeds/kg. Seedlings should be ready for planting 9 months from sowing. **SPH**: A spacing of 3.0 x 3.0m (1111 sph) or 4.0 x 3.0 (833 sph) is recommended. **Establishment:** HOOP seedlings are slow growing at first and then must be well weeded until canopy closure (3-4 years, depending on spacing). HOOP seedlings respond to good weeding. Although tolerant of shade, HOOP grows better in full sun. **Management:** In Australia a final crop of 400 sph are selected and pruned to 2.4m and 5.4m respectively. Two thinning operations are carried out - the first to 600 sph, the 2nd to 400 sph. HOOP is extremely fire sensitive. **Yields:** In Queensland, Australia, 40-50 yr rotations and average MAI of 15m$^3$/ha/yr are reported. MAIs up to 45 m$^3$/ha/yr are reported from Papua New Guinea. Based on the performance of HOOP in Kifu CFR, it is expected to achieve MAI's of 20-30 m$^3$/ha/yr. on appropriate sites in Ug and with good management, rotations of 20-30 years should be possible. If there were a premium for larger veneer logs, then rotations could be increased accordingly.

**Common Pests & Diseases:**
In plantations in Papua New Guinea and Australia, various rots fungi) - especially Phellinus noxius - causes problems. Ugandan plantations have been free from any serious pests and diseases to date.

**Other Issues:**
*Araucaria hunsteinii* (HUN) is preferred for plantations in Papua New Guinea due to higher growth rates than HOOP, though HUN's recalcitrant seed has restricted its commercial use in plantations.

**Summary:**
**HOOP can produce a high quality product on fertile sites in Uganda. Establishment costs are high, however, due to slow early growth. Seed looses its viability quickly and is in short supply in Uganda.**

## CUPRESSUS LUSITANICA

**Family:** *Cupressaceae*
**Common names:** Cypress; Mexican Cypress; Portugese Cedar; Cedar of Goa.

**Natural Occurence:**
Cypress has a wide geographic and altitudinal range and has been introduced all over the world. It is thought to have originated in Mexico, Guatemala and Honduras, between 15$^0$ - 28$^0$N and 89$^0$ - 108$^0$W.

**History of Growing in Plantations:**
Cypress has been planted widely both as a commercial timber plantation species and as an ornamental. In Kenya it is a major plantation species, with over 85,000ha planted. It has also been extensively planted in Ethiopia and in Mediterranean countries. It has been widely planted for hedges and windbreaks due to its low sensitivity to pruning.

**Characteristics & Uses:**
Cypress grows up to 25-30m, with a broadly pyramidal crown. It has a straight stem and a thick, reddish-brown bark that develops longitudinal fissures. It is reasonably fast growing but not as fast as Pinus patula, which is suited to similar climates. Cypress wood is highly valued due to its natural durability and its aesthetic qualities. It air dries quickly with little warping; it is easily worked and used for cabinet making, sculptures and also for a range of exterior purposes.

**Site Requirements:**
In its native habitat, Cypress prefers mountainous slopes at medium altitude (1200-3000m asl); it can tolerate a low MAR of 600 mm, provided the rain is well distributed. Cypress is found growing over much of Ug as an ornamental; for commercial planting here, however, it is best suited to the cooler, higher areas in the south-west and west.

**Seed Recommendations:**
Cypress is highly variable species, differing significantly in traits such as growth rate, stem

*Cupressus lusitanica growing in Bushenyi, western Uganda - aged 3 years.*

form, branching characteristics and resistance to diseases. No improved seed is available in Ug. at present.

**Silviculture:**

**Seedlings:** Cypress is easily raised from seed. Seed is collected from cones on the tree (flowering only starts *ca.* 15 yrs) when they turn brown. Seed must be stratified for 21 days at 2-3$^0$C and then soaked in water for 2-3 days prior to sowing. Germination rates can be low. Seedlings should be ready for planting out in 4-5 months in Ug.

**SPH:** With only unimproved seed available in Ug at present, a plant espacement of 2.7 x 2.7m (1372 sph) is recommended. Establishment: Cypress is shade intolerant – like pines and eucalypts – and thus must be well weeded in its establishment phase. It is slow growing in the early years.

**Management:** A heavy thinning regime is recommended for commercial Cypress plantations in Uganda – similar to *P. caribaea*. Pruning is important for quality timber production since the trees tend to be very branchy. Pruning in stages up to a third of total height is thus recommended. Cypress is relatively susceptible to fires.

**Yields:** In East Africa, MAIs of 7-17 m$^3$/ha/yr are reported and rotations of 25-35 years. With good management and on suitable sites, Ug should be able achieve MAIs of >15 m$^3$/ha/yr with a rotation of around 25 years.

**Common Pests & Diseases:**

The Cypress aphid, *Cinara cupressi,* has become a major pest of Cypress in E & S Africa. The aphids feed in colonies, sucking sap from twigs and branches. Heavy feeding can kill the trees. First discovered in Malawi in 1986, it has since spread to other African countries including Kenya and Uganda. Aphid populations are more prominent during dry seasons.

**Other Issues:**

With the threat of the Cypress aphid still around, it would be very risky to embark on widescale Cypress planting in Uganda. Other species can outperform Cypress on its favoured sites (especially *P. patula*) although Cypress's wood is superior.

**Summary: Cypress has been widely planted in higher elevations in East Africa and is prized for its excellent timber. It is fairly slow growing, however, and the Cypress aphid threat raises serious questions over its suitability as a major plantation species in Ug.**

# TERMINALIA SUPERBA

**Family:** *Combretaceae*
**Common names:** Limba, Fraké.

**Natural Occurence:**
Limba occurs naturally in moist, seasonally deciduous forests throughout West and Central Africa, between Lats. $10^0$N and $6^0$S.

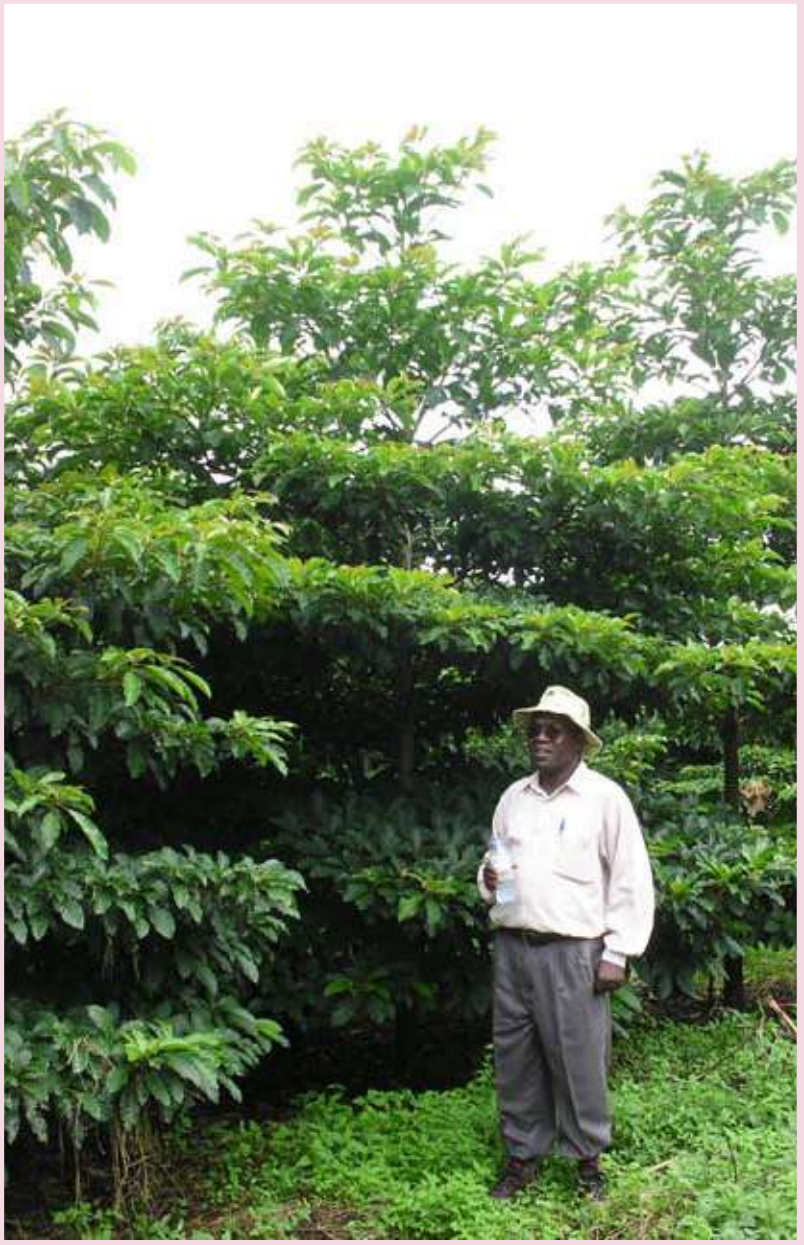
**History of Growing in Plantations:**
Limba is one of the few species of which large plantations have been established in tropical Africa – notably Cote D'Ivoire and DRC. Limba was eventually dropped as a commercial timber species in the 1980's from a major Cote D'Ivoire's plantation programme due to its poor timber qualities. It has not been widely planted in Ug, although there is a mature trial block in Mukono that shows its promise.

**Characteristics & Uses:**
Limba is a large tree (up to 30m or more), with a long straight bole. It is a moderately fast growing tree and well suited to plantation development in the humid, lowland tropics. Limba wood is relatively soft and light, with a density of 520-550 kg/$m^3$. In some parts of West Africa, Limba is regarded as a highly commercial timber but the wood can often be stained which reduces its value for certain end uses.

**Site Requirements:**
Limba prefers well drained, fertile soils. It will not tolerate extended dry seasons. It requires areas with high rainfall - MAR >1300mm; alt. < 1000m asl; MAT $24^0$-$27^0$C

**Seed Recommendations:**
Considerable variation is known to exist between natural provenances of Limba thus care should be taken before any large scale planting is undertaken in Uganda to ensure a superior seed origin is used. A limited quantity of Limba seed is available from the NTSC, collected from trial plots near Mukono, though its origin is unknown.

**Silviculture:**
**Seedlings:** The no. of seeds is *ca.* 6,000/kg (with wings), 10,000 without. Germination is usually low (50%) and can take 15-50 days. Seeds should only be collected from fruits still on the tree or recently fallen. Limba is usually planted (like Teak) as a stump, prepared from 12-15 months old plants.



*A privately owned 20 month old Limba plantation growing in Mukono District, East Ug., showing impressive early performance.*

**SPH:** A plant espacement of 3 x 3m (1111sph) up to 5 x 5m (400sph) are recommended in the literature, although the wider spacing is generally used in a taungya situation, whereby crops are cultivated in between the tree rows. Only where supervision is rigorous (and the right crops used) will the wider spacings work properly.

**Establishment:** Limba is a light demanding species and thus must be weeded well especially in the first year or two, until its canopy has closed. In Mukono, Limba has closed canopy within 18 months after intensive early weeding (planted at 3 x 3m). It grows slowly in the few months after planting but then can grow at a rate of over 2 m per year. Limba has been planted in West Africa in both pure stands and in mixed plantings with e.g. *T. ivorensis* and *Khaya grandifolia*.

**Management:** Due to its fast growth and need for light, heavy thinning regimes are recommended. Limba exhibits some self pruning abilities but to obtain large, clean logs, a number of pruning operations will probably have be undertaken.

**Yields:** In Cote D'Ivoire, Limba is grown on a 20-25 year rotation; MAIs of *ca.* 15 $m^3$/ha/yr are expected to produce a final crop dbh of 45-50cm and a total timber volume of 330 $m^3$/ha (including thinnings). Similar yields are expected in Uganda.

**Common Pests & Diseases:**
A range of pests have attacked Limba trees in plantation in West Africa. The main culprits have been stem borers and defoliating insects.

**Summary: Limba has outstanding tree form and is fast growing. Its role as a plantation species in Uganda will, however, be restricted by its exacting site requirements and its timber, which is only of average quality.**

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# CHAPTER 6
# MATCHING TREE SPECIES TO SITE

*Pinus caribaea var hondurensis (PCH) has proved a well adapted species to many parts of Uganda (5-yr old PCH, Besepo(U) Ltd, Mubende, 2008)*

## 6.1 INTRODUCTION

One of the most important decisions to be made by the potential investor in commercial tree planting is what species to plant on their land. The choice depends on a number of issues – including the availability of improved seed and the likely markets for the products. However, the most important question to consider first is - "what species will grow well on my particular site?"

Far too often growers in Uganda have decided on what they want to grow before considering the silivicultural requirements of the particular species and this can have disastrous consequences. For example, planting *E. grandis* in very hot areas of the country will cause it to be highly stressed and vulnerable to pests and diseases (and this is exacerbated by poor weeding). Also planting *P. patula* on low lying areas over most of Uganda, will result in a failed investment. Yes, the trees will often grow well for the first few years but then they will become stressed and start dying back. Why? Because *P. patula* needs a cool climate only found in the highlands of the West and South-West of Uganda. Teak (*Tectona grandis*) is also increasingly being planted all over Uganda and is struggling on most sites. Why? Because teak requires very specific climatic/site conditions – most notably, low altitude and a long dry season – conditions more readily found in southern Sudan and Tanzania.

## 6.2 SILVICULTURAL CLASSIFICATION MAP

In order to assist growers in Uganda, we have produced a map (Page 85) which provides a broad silvicultural classification of Uganda. This map was the result of some work commissioned just prior to the SPGS being launched in late 2003, when we hired the services of Pat Hardcastle from LTS International. It proved not an easy task due especially to the enormous loss of forest research data and also the lack of reliable meteorological data after the 1960's. Against all odds, however, Pat used his experience of a similar exercise carried out in Malawi to come up with the map shown. We have also drawn sketch maps showing where the main species are roughly suited to in Uganda (Page 86). NB. All these maps are only approximate guides as to which species will grow where.

Successful commercial forestry plantations require that the tree species used are well adapted to the site. The aim of this work was to try and determine which species are best suited to what sites within Uganda. The recommendations given are based on current information and knowledge. It does not mean, of course, that species will not grow in other areas. The recommendations are to secure profitable growth. Details of the zones and the species suited to those zones are on Page 84.

## 6.3 METHODOLOGY

Tree species evolve in response to the conditions in their natural environment. The key factors are the availability of water and nutrients. Trees are also affected by temperature - some preferring cold area and others hot ones. Water availability depends primarily on total rainfall and its distribution. It also depends on the depth of soil and the texture. Clay soil holds more water than sandy soil.

In order to create the 10 zones shown on the map, information on the monthly rainfall at a range of stations was examined together with information on the loss of soil water from tree crops by transpiration. Information was also gathered on temperature. From models showing the balance between rainfall (water coming in) and transpiration (water going out) for some 25 locations in Uganda, a set of relatively similar climatic regions was defined. These are zones A to L (note there is no F or I as these letters can be easily misread).

Using historical knowledge from Uganda and countries with similar conditions, recommendations were made on what species should be planted in which zones.

Soil factors must also be considered, not just fertility but also characteristics such as texture, waterlogging, stoniness and compaction as trees vary in their ability to cope with different soil characteristics This knowledge must also be used in making the final species choice.

## 6.4 LIMITATIONS

It proved impossible to find good recent information on climate and so that used was taken from the National Atlas of Uganda (1967 - 2nd edn.). The mapping was done at a scale of 1:1 M and so it is impossible to expect it to show local details. The zonation is a guide that can be used to assist decision making.

*Table 9: Silvicultural Classification Map Legend (Opposite)*

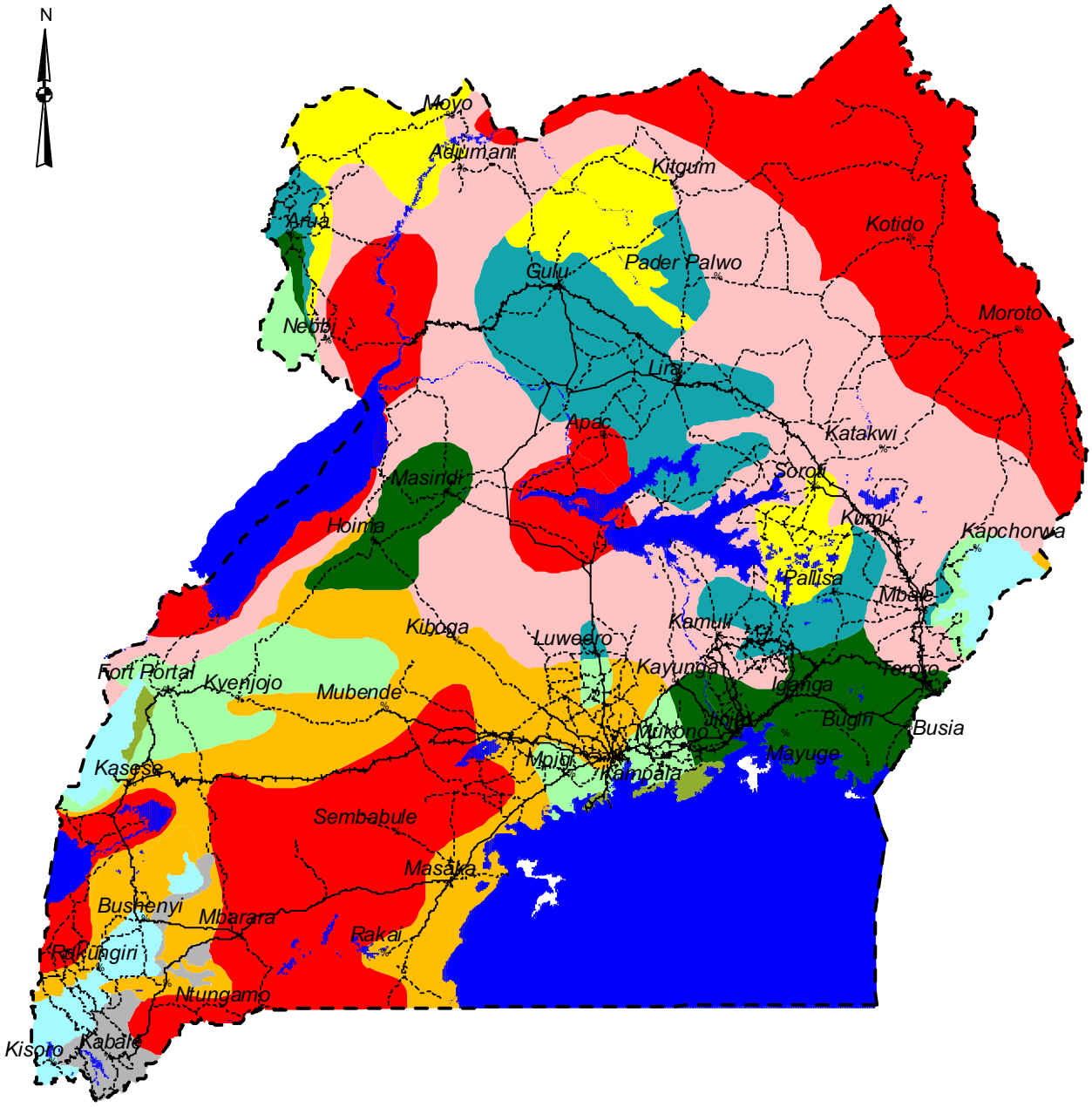
| | | Zone Name | Mean Annual Temperature | Mean Annual Rainfall | Potential for Commercial Plantations |
|---|---|---|---|---|---|
| A | | Cold, Wet | <18 °C | > 1250 mm | Good but little land available |
| B | | Cold, Dry | <18 °C | < 1250 mm | Limited, with careful site analysis |
| C | | Cool, Dry | 18 – 22 °C | 1000 – 1250 mm | Some, with careful site analysis |
| D | | Cool, Moist | 18 – 22 °C | 1250 – 1500 mm | Good |
| E | | Cool, Wet | 18 – 22 °C | > 1500 mm | Very high |
| G | | Warm, Wet | 22 – 23 °C | > 1250 mm | Very high |
| H | | Hot, Wet, | 23 – 24 °C | > 1250 mm | Yes with care, especially on weeding |
| J | | Hot, Dry | 22 – 24 °C | 1000 – 1250 mm | Yes with careful site analysis |
| K | | Very hot, Wet | >24 °C | > 1250 mm | Some but largely untested |
| L | | Very Hot/Very Dry | >22 °C | <1000 mm | None |

## Recommended Species (see also maps Page 10)

| Zones → Species ↓ | A | B | C | D | E | G | H | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|
| *Araucaria cunninghamii / hunsteinii* | | | | | ● | ● | | | | |
| *Pinus caribaea* | | | | | • | ● | ● | • | • | |
| *Pinus patula* | ● | | | | | | | | | |
| *Cupressus lusitanica* | ● | | | | ● | | | | | |
| *Eucalyptus grandis* | • | • | • | ● | ● | • | | | | |
| *Maesopsis eminii* | | | | ● | ● | ● | ● | | | |
| *Terminalia superba* | | | | | | ● | ● | | | |

***Key***: ● species generally well suited to this zone; • species worth trying on selected sites in this zone.

# FIG. 6 SILVICULTURAL ZONES OF UGANDA
## For Commercial Plantations




**Silvicultural zones**

- A - Cold, Wet - MAT < 18, Rf > 1250 mm - Fair potential, little land available
- B - Cold, Dry - MAT < 18, Rf < 1250 - Little potential
- C - Cool, Dry - MAT 18 - 22, Rf 1000 - 1250 - Some potential, careful site analysis required
- D - Cool, Moist - MAT 18 - 22, Rf 1250 - 1500 - Good potential
- E - Cool, Wet - MAT 18 - 22, Rf > 1500 - Very high potential
- G - Warm, Wet - MAT 22 - 23, Rf > 1250 - Very high potential
- H - Hot, Wet - MAT 23 - 24, Rf > 1250 - High potential with careful practices
- J - Hot, Dry - MAT 22 - 24, Rf 1000 - 1250 - Some potential with careful site analysis
- K - Very Hot, Wet = MAT > 24, Rf > 1250 - Good potential, largely untested
- L - (Very) Hot and Very Dry - MAT > 22, Rf < 1000 - No potential except on favourable microsites

- International boundary
- Town
- Tarmac
- Murram
- Railway
- Lake

40 0 40 80 120 Kilometers

Scale 1: 3,800,000

## FIG. 7: SPECIES SUITABILITY IN UGANDA

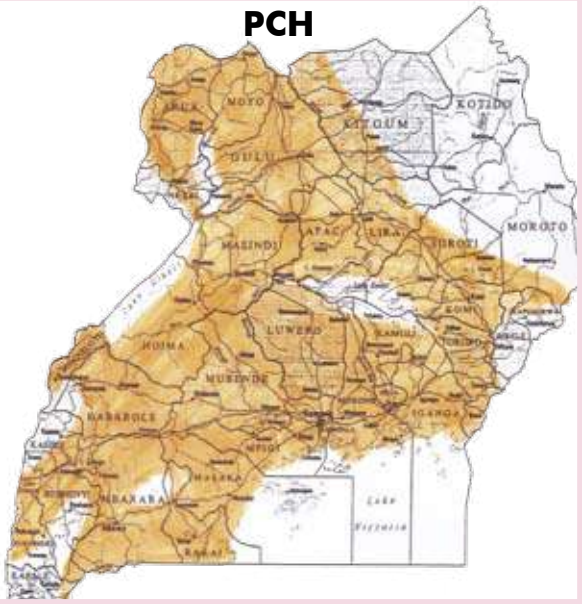
Please note that these maps give only a broad indication of which species is best suited to various parts of Uganda. If you are planning to plant a species outside the areas indicated, it might fail: carry out trial plantings first - to test species' suitability.

Map 5 (Hybrid *Eucalyptus* clones) is speculative at this stage but will be refined when the results of the 2002/03 trials are analysed. Teak was excluded because we are unsure of its suitability at all in Uganda, where the altitude is largely too high for it to grow as a commercial crop.

NB. Careful planning – including environmental assessment – must be carried out before any large scale planting programme proceeds – whatever the species.

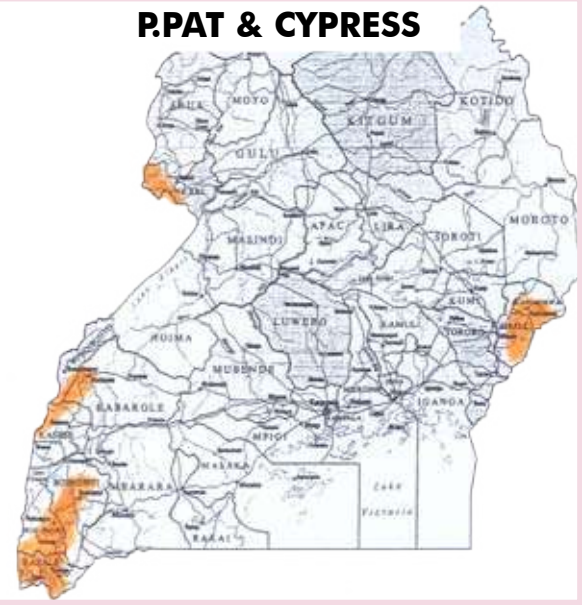
**E. GRANDIS**


**PCH**

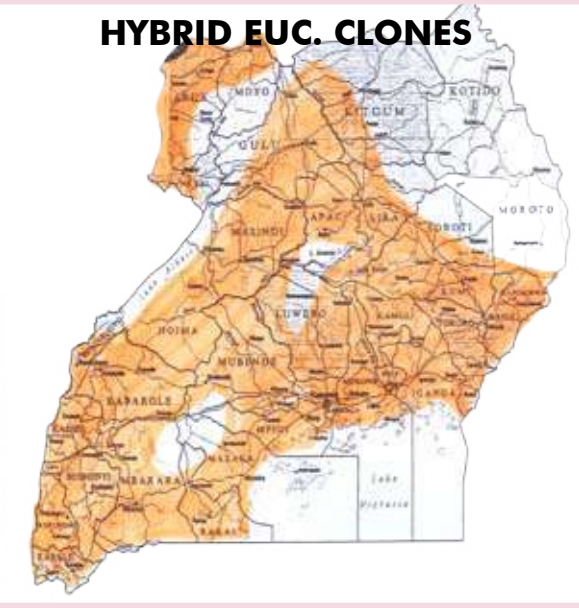



**MUSIZI & HOOP TERM**


**P.PAT & CYPRESS**




**HYBRID EUC. CLONES**



# CHAPTER 7
# TREE SEED

*One of the superb Eucalyptus grandis mother trees in Fort Portal Plantations CFR seed stand. Most good trees have been cut in Uganda.*

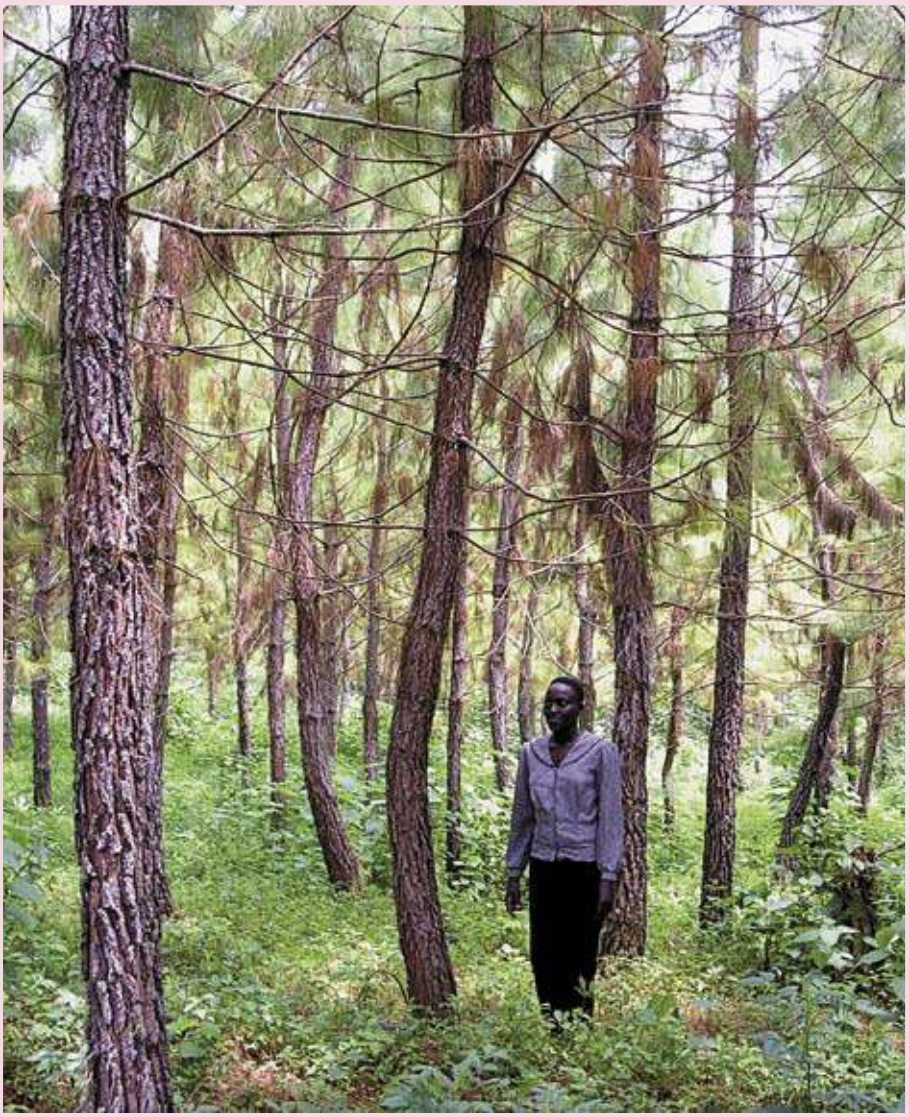
## 7.1 INTRODUCTION

One doesn't need a forestry degree to appreciate the huge difference between the plantations illustrated on these pages: the difference is largely due to the seed origins of the trees. Raising trees from seed is by far the most common method employed to produce plants for commercial tree growers in Uganda. This Chapter (along with the next one on Nurseries) summarises the key points that growers need to know about tree seed and plant quality. It is not a detailed guide for collecting seed as we believe that this should be left in the hands of professionals. What we have attempted to do, however, is to highlight the key issues that should enable the commercial tree grower to understand the impact of seed and seedling quality on plantation productivity (and therefore profitability).

The surge in interest in tree planting in Uganda over the past few years has obviously created a huge demand for seed and seedlings. With nurseries springing up at every road junction, much of the seed is undoubtedly being collected from some very poor mother trees by people who know little about genetic quality: this is also the case for some of the larger nurseries too. For those planting a few trees around one's property, seed and seedling quality is maybe not such a big issue, but for commercial scale planting, it becomes critical to the profitability of the investment. It is important to remember that when growing trees for timber, the crop is around for a long time and if poor seed or seedlings were used, the loss in yield is compounded annually.

## 7.2 SEED SOURCES AND THE MEANING OF 'QUALITY' SEED

**Seed sources:** The previous two Chapters (*Tree Species* and *Site-Species Matching*) recommended not just a particular species for a certain sits but specific seed origins (or provenances) of that species. This is due to the fact that many tree species have a wide natural distribution and the same species can differ markedly - in terms of tree form, growth and other characteristics - over different parts of its natural range. Tree breeders exploit such differences through selection and testing of superior parent trees, which is why genetically improved seed costs more than unimproved seed for any given species. Those who complain about the high price of improved seed



*The result of pine seed from poor quality, local trees (nr. Jinja, 2005)*

*Improved pine (PCH) seed from a Australian (FPQ) seed orchard.*

generally do not appreciate the crucial difference it makes to the investment. We subscribe to the motto of Forest Plantations Queensland's Seed Centre, namely:
***"Good seed doesn't cost: it pays".***

**Seed quality:** currently tree seed in Uganda is frequently being marketed as 'quality seed' without defining what that quality means. There are various levels of quality – as follows:

1. Seed from unselected, natural populations.
2. Seed from individually outstanding trees from natural stands.
3. Seed from individually outstanding trees from plantations:
4. Seed from seed production areas (or seed stands) – where the poor trees in a stand have been removed and the best trees are left to interbreed.
5. Seed orchards – specific areas managed to maximize the genetic gain as quickly as possible.

The seed quality increases going down the above list. Much of the seed used by the small nurseries comes from the equivalent of level 1 in the list: with seed being collected from the generally poor trees left in Uganda's mature plantations (the best trees having long since disappeared). These stands were initially established with seed collected from natural populations: the pines from Central America and the Caribbean, the eucalypts from Australia (and probably some from Southern African plantations too). The SPGS, however, strongly recommends that commercial growers only use seed from levels 4 or 5 only.

Sappi Forests (RSA) differentiate *E. grandis* seed based on the level of genetic improvement as shown in Table 11.

**Table 11. *Eucalyptus grandis* seed details from Sappi Forests, RSA.**

| Seed Class | Description | Price per kg EG US$ (March '09) |
|---|---|---|
| Sappi Select | Seed production areas based on domesticated or provenance seed excluding best families | 2,900 |
| Sappi Superior | 1st generation seed orchards (selected parents) | 5,890 |
| Sappi Elite | Selective family harvest of 1st generation orchards (tested parents) | 8,900 |
| Sappi Advanced | Seed produced from advanced orchards, including controlled pollinated seed that will rival current clonal planting stock. | 11,900 |

**Ugandan seed supply:** The sad history of Uganda's timber plantations was described in Chapter 1. The loss of the best genetic material has continued despite the concerns raised by Jacovelli (1998) and Kaumi & Esegu (2000). There are now no local seed sources recommended by the SPGS for any of the main coniferous species – *PCH, P. oocarpa, P. patula* and *Cupressus lusitanica*. There is only one local source of *E. grandis* recommended – namely, a small seed production stand in Fort Portal Plantation CFR, close to Fort Portal (Kabarole District, Western Uganda) . This means that commercial tree growers in Uganda will have to largely rely on imported seed for the foreseeable future.

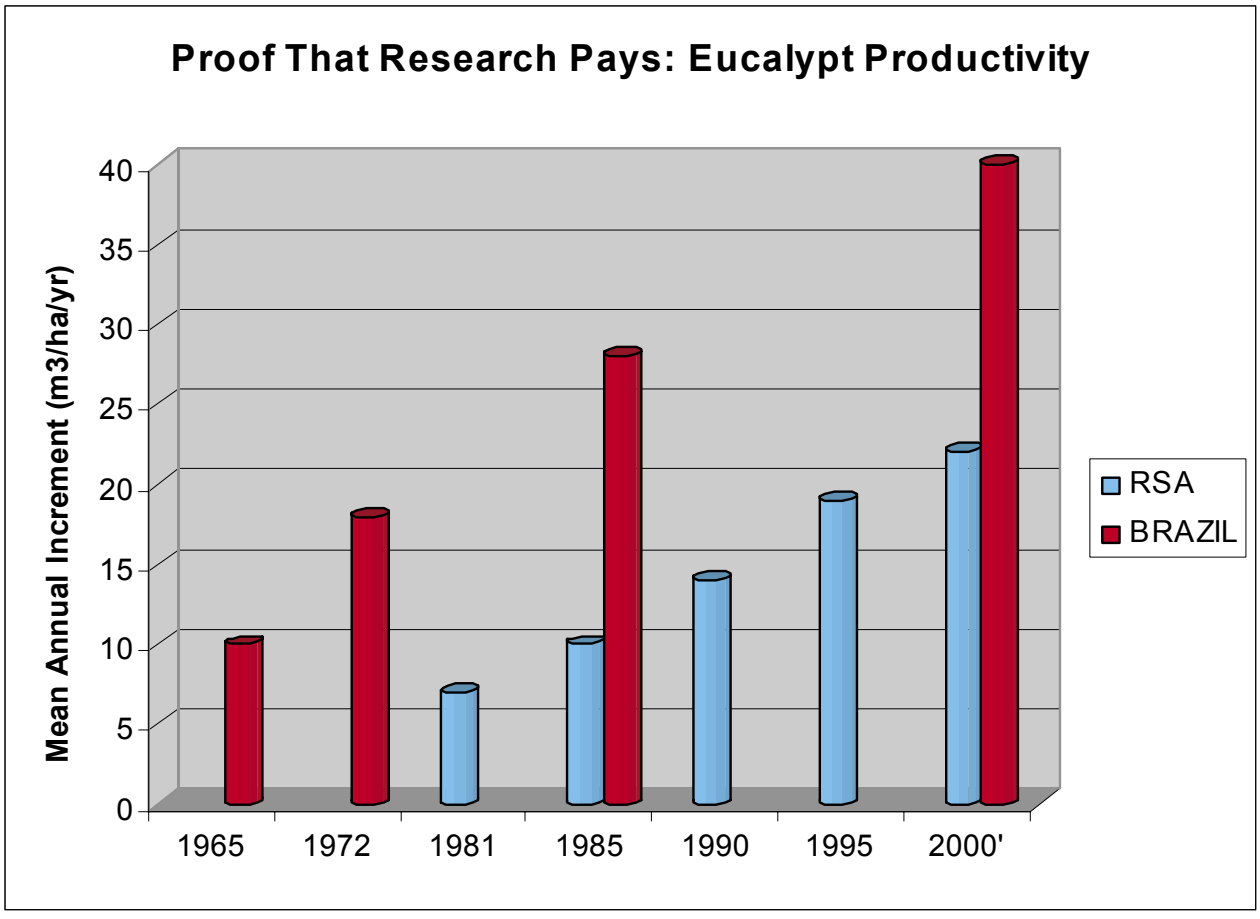
**Tree improvement programme:** Countries with large commercial forestry programmes have nearly always developed their own tree breeding or tree improvement programmes to enhance the growth and other beneficial characteristics of the main species (e.g. straight stems, light branches and resistance to specific pests and diseases). Such research programmes aim at ensuring that a country (or a company) is self sufficient in superior genetic planting material. Unfortunately Uganda does not have a tree breeding programme though there are encouraging signs that this will soon change. Fig. 8 clearly shows the importance of developing improved genetic material.

This huge increase in productivity in eucalypt productivity in both RSA and Brazil is largely due to the deployment of high quality genetic material from applied tree breeding programmes (NB. also important has been the development of mass propagation methods, improved site classification and the site-specific application of these technologies).

## 7.3 PROCURING AND IMPORTING SEED

**Calculating how much seed one needs:** To calculate how much seed one needs to purchase, there are a number of facts needed:

**Fig. 8. Gains in Eucalypt Productivity in RSA and Brazil - 1965-2000.**



- Expected no. of seeds per kilogramme for the species *(see Table 12)*.
- The area to be planted (ha).
- The number of trees per ha (known as the stocking or sph – stems per ha).

**Stocking:** the espacement between plants can vary with objectives and the means of weed control but generally when planting timber crops, it ranges from 1111 sph (3 x 3m); to 1333 sph (3 x 2m). Chapter 5 has the specific recommendations for each species. The number of plants needed per ha, however, is more than the sph figure. This is because allowances must be made for beating up (replacing failures in the field) and for transportation losses: we recommend aiming to raise at least 20% extra seedlings to cover this.

To finally calculate how much seed is needed, input the figures into the equation:

*No. kgs required = (sph x 1.2) x ha to be planted ÷ expected seedlings per kg.*

**Pines:** the parent programme of the SPGS[1] started importing improved seed in 2002. PCH from Forest Plantations Queensland's[2] advanced generation breeding programme proved an instant success when planted out in some demonstration blocks around Uganda in 2002/03 – e.g. Oruha CFR (Kyenjojo); Kasana-Kasambya CFR (Mubende) and Kasagala CFR (Nakasongola). This seed has consistently produced vigourous and healthy plants and clearly has an excellent pedigree. Under the leadership of Dr. Garth Nikles, Australia has been carrying out intensive breeding with PCH for some 50 years, though more recently it has focused on the *P. elliottii* x PCH hybrid (Nikles, 1996).

FPQ have clonal seed orchard (CSO) PCH seed as well as seed from thinned plantations derived from the best clones from the CSO. The original source of the PCH seed was Mountain Pine Ridge, Belize, which proved to be the best source in many international provenance trials. By 2004, the demand for this seed was already more than FPQ could supply and the supply-demand gap has widened year by year.

**Table 12. Seed Details for Uganda's Main Commercial Tree Species**

| SPECIES | EXPECTED SEEDLINGS PER KG* | COST GUIDE Feb 2009 UGX† | NOTES |
|---|---|---|---|
| *Araucaria cunninghamii* | 1,500 | - | *ex FPQ, Australia* |
| *Cupressus lusitanica* | 250,000 | - | |
| *Eucalyptus grandis* | 150,000 | *150,000* | *Uncleaned, local seed* |
| *E. grandis (clean seed)* | >2,000,000 | *6-12,000,000* | *Cleaned for automatic sowing* |
| *Maesopsis eminii* | 500 | *50,000* | *Unselect, local seed only available* |
| *Pinus caribaea var. hondurensis* | 35,000 | *2,340,000* | *ex FPQ, Australia* |
| *PCH* | 20,000 | *1,040,000* | *Some batches ex-Fiji and/or Brazil* |
| *Pinus oocarpa* | 25,000 | *850,000* | *Brazil* |
| *Pinus patula* | 90,000 | *500,000* | *Unselect, local seed only available* |
| *Tectona grandis* | 1,500 | - | *S. Sudan sources of unknown quality* |
| *Terminalia superba* | 4,000 | *50,000* | |
| | | | |

* *NB1. These figures can vary from different seedlots: ensure the seed supplier provides the figures (from germination tests) for each seed batch before buying.*

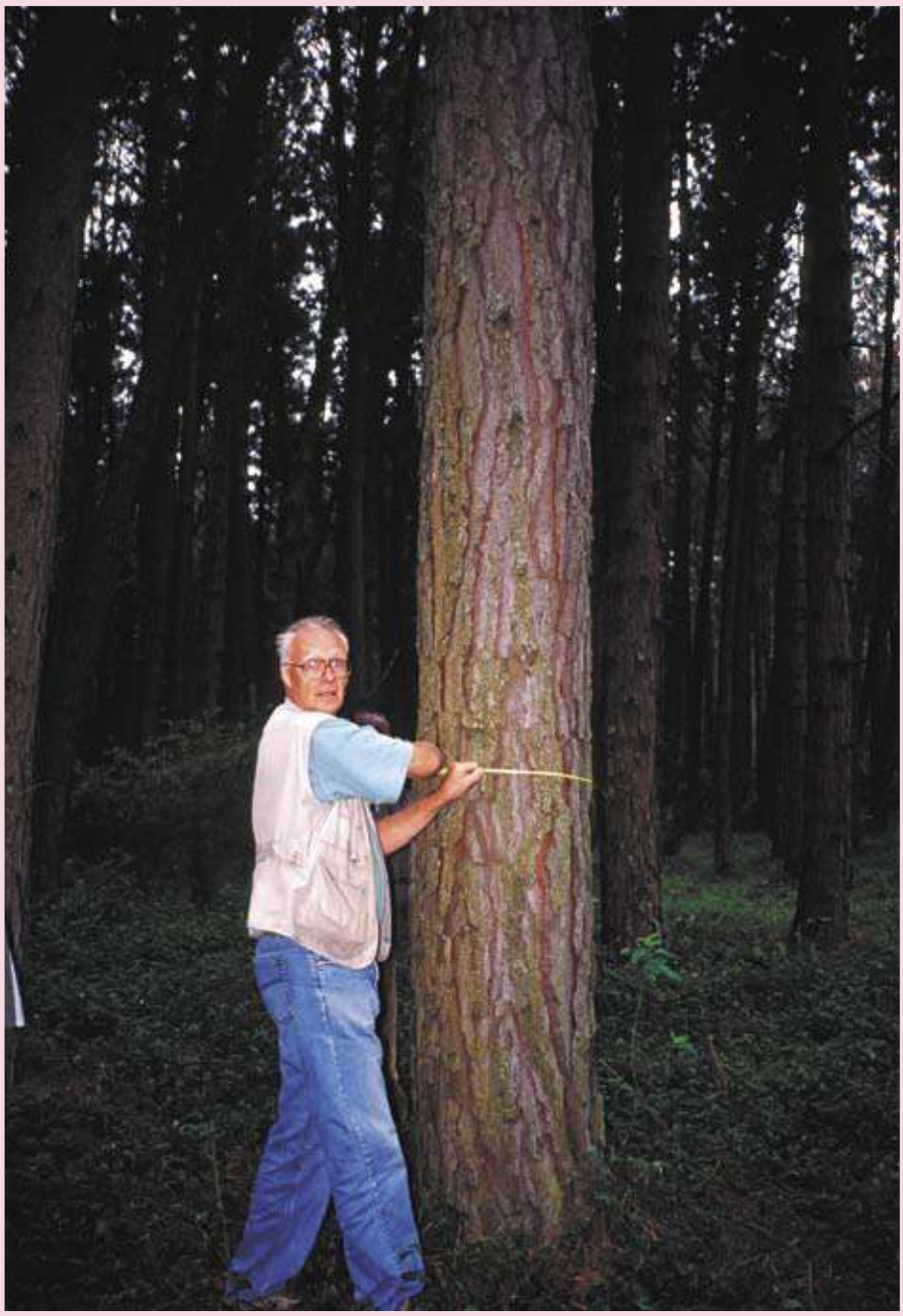
† *NB2. Refer to most recent SPGS Newsletter for latest information – www.sawlog.ug*

[1] *FRMCP – the EU-funded Forest Resource Management and Conservation Programme (2002-08).*

[2] *Then known as Dept. of Primary Industries Forestry.*

The problem has been exacerbated in recent years by a number of poor seed years from FPQ's seed orchards, due to cyclone damage, predation by native birds and prolonged wet weather during the peak collection period (FPQ, pers. comm.). Thus alternative sources had to be sought.

In 2005, a Brazilian comapany – Schuckar Seeds - was recommended through CAMCORE (Central American and Mexican Coniferous Resources Cooperative) and they have supplied PCH (and to a limited extent *P. oocarpa*) seed to Uganda since then. Small amounts of PCH have also been imported from South Africa (from Mondi Business Paper) though the supply has dried up since 2005.



*Unfortunately all such superior parent trees have long since disappeared from Uganda. (Tony Finch in Katugo CFR, 2002)*

**Eucalypts:** a big private tea company operating in Western Uganda, was the first to import improved *E. grandis* seed for their fuelwood plantations. Rwenzori Highlands Tea Company[3] imported seed orchard seed from Zimbabwe (Zimbabwe Forestry Commission) and RSA (Mondi Business Paper) and where the silviculture has been good, has had spectacular growth rates (NB. good seed source alone does not guarantee a good plantation but must be combined with good silvicultural practices - as emphasized throughout this book). Since 2003, the SPGS has imported seed orchard *E. grandis* from RSA (there were concerns over the management of Zimbabwe's orchards) from all the main companies – Mondi, SAPPI, Komatiland and Hans Merensky, though it is also often in short supply. Nb. The contact details of all suppliers are included in Annex 1.

**Seed certification:** A reputable seed company should keep accurate records of all its seed. Most important is that each seedlot is accurately labeled with the following information:

[3] *Since ca. 2004 known as James Finlay (Uganda) Ltd.*

- Species.
- Exact origin of mother trees.
- Exact place of collection (lat., long., altitude, MAR, MAT etc.
- No. of trees collected from.
- Collection date.
- Expected no. seedlings per kg.
- Each seed batch should also have a recent germination % result (NB. germination % will decrease the longer seed is stored).

A good example is shown in Table 13 from an RSA supplier to the SPGS.

**Seed procurement:** With virtually no seed orchards in the country (at least until a tree improvement programme starts bearing fruit), commercial tree growers will have to rely on imported seed for many years. To obtain the right quality seed, there are three options open to commercial tree growers in Uganda at present:

- Buy seed from the NFA's National Tree Seed Centre (NTSC) in Namanve, 12 kms along the Kampala-Jinja highway. For inquiries about availability call +256 414 286 049. NB. be sure to specify exactly the seed origin required (e.g. *Pinus caribaea var. hondurensis* from FPQ's Australian seed orchards) as NTSC also sell locally collected pine seed, which is not recommended for commercial planters here.

- Join the Uganda Timber Growers Association (UTGA) which imports improved seed for its members. For details, check on their website **www.utga.net** or contact them at 0772 979 824.

- Import seed directly: some of the large growers are already importing themselves from Australia, Brazil and South Africa. The procedures for importing are described in the next section.

**Seed importation:** The following points describe the procedures for importing seed into Uganda:

1. Establish contact with seed supplier (preferably those recommended by SPGS)[4].

**Table 13. Certificate of Seed Quality: An Example**

| | | | |
|---|---|---|---|
| A. | **Botanical name** | : | *Eucalyptus grandis* |
| | Seed lot number | : | **307.0501** (clonal mix) |
| | Year of harvest | : | September 2004 |
| | | | |
| B | **Site of collection** | : | J.D.M. Keet Plantation, Tzaneen. |
| | | | 2nd /3rd Generation clonal seed orchard |
| | S/O composition | : | 50 clones |
| | Altitude | : | 762 m |
| | Mean annual rainfall | : | 1000 mm |
| | Mean annual temp. (max) | : | 26.6°C |
| | Mean annual temp. (min) | : | 14.3°C |
| | Latitude (South) | : | 23° 46' |
| | Longitude (East) | : | 30° 05' |
| | | | |
| C | **Purity** | : | Sifted 600, 710 & 850 micron |
| | | | |

[4] *Since the SPGS permits only specific seed origins for its contracted Clients' planting, it is important to check whether the seed will be allowed under the project.*

2. Only proceed when provided with detailed seed origin information and seed quality (inc. expected nos. per kg and germination %).
3. Obtain pro-forma invoice for seedlot(s) - including courier costs.
4. Obtain Import Permit from GoU's Ministry of Agriculture.
5. Fax/email Import Permit to Supplier to enable them to raise Phytosanitary Certificate.
6. Transfer funds direct to the Supplier's bank account.
7. Track parcel on-line and ensure clearance by courier firm is fast.
8. Store seed not being immediately used.

## 7.4 SEED HANDLING AND STORAGE

Tree seed can generally be successfully stored for a number of years, provided the following general guidelines are followed:

- Keep out of direct sunlight at all times.
- Prior to storage, ensure seed is dry (preferably to only 5-10% moisture content to reduce the likelihood of fungal growth.
- Store at 0-4$^0$C in airtight containers or plastic bags.
- Eliminate obvious pathogens and protect seed during storage.
- Viability will remain high if kept at a constant temperature.

**Pre-sowing treatment:**

- Let the seed acclimatize for 12-24 hours before sowing.
- No pre-sowing treatment is required for FPQ's PCH or any *E. grandis* origins.
- Soaking in water can improve germination of some seed (e.g. Brazil PCH and *P. oocarpa* – for 24hrs; Musizi – 72 hours; *Terminalia superba* – until yellow residue comes out.

## 7.5 SOWING NOTES

- Keep a record of the sowing date(s), species, seed origin and batch numbers.
- Record what pre-sowing treatment (if any) was carried out.
- Record germination dates and %.
- Record on a map (and on the ground where necessary) where each seed batch was planted out.
- Be prepared to control fungal outbreaks.
- Book early for the next seed purchase.

NB. Always refer to the latest SPGS Newsletter **(www.sawlog.ug)**, which has the latest news on seed availability and prices.

*All early Ugandan plantations were established from unselected, natural stands (this is Katugo CFR, 2004).*

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## ANNEX 1.

## TREE SEED SUPPLIERS
## (NB. FOR HYBRID EUCALYPT CLONES (SEE CHAPTER 21).

| Species | Company | Email | www / Tel. | Notes |
|---|---|---|---|---|
| | | | | |
| PCH & Hoop pine | Forest Plantations Queensland | Leanne.sellens@fpq.qld.gov.au | www.fpq.qld.gov.au | Advanced generation clonal seed orchards |
| PCH & *P.oocarpa* | Schuckar Seeds, Brazil | info@schuckar.com | www.schuckar.com | Seed production stands |
| | | | | |
| EG | Sappi Forests RSA | Tasmien.horsley@sappi.com | | See Table 11 (this Chapter) |
| various | NFA, Uganda | info@nfa.org.ug | Tel. 0414 - 286049 | |
| | | | | |
| PCH | UTGA, Uganda | miken@sawlog.ug | Tel. 0772 979 824 | For UTGA Members |

# CHAPTER 8
# TREE NURSERIES

*Busoga Forest Co.'s nursery in Bukaleba CFR, Mayuge (2004).*

## 8.1 INTRODUCTION

This Chapter is intended to highlight the most important issues for tree planters to consider when either buying tree seedlings from an external nursery or raising them in one's own nursery. Importantly, the guide also illustrates what we mean by a "good quality seedling", whichever nursery it was raised in.

The level of tree nurseries in Uganda is very basic at present, with all of them using plastic sleeves (also known as poly-pots) and top-soil as the growing medium. Sowing, watering and root pruning are all being carried out manually. As commercial forestry expands here, however, some of the larger planters are starting to look at improvements, especially towards a containerized, soil-less nursery system. The main features (and pros and cons) of such improved nursery systems are dealt with at the end of this Chapter: the rest of this guideline assumes people are using the traditional nursery system.

It is important also to differentiate between what we would define as a commercial nursery compared with the many small, roadside nurseries in the region. Hundreds of tree nurseries have been (and still are being) established in Uganda, driven by the increasing interest in tree planting. These small nurseries can produce good quality seedlings provided they follow the basic rules as outlined in this Chapter but invariably such nurseries are not capable of producing large numbers of seedlings of a consistent quality and for a very specific time-frame. Rooting problems are common in the nurseries too – something that is often only discovered in the field as the trees struggle (or even die) a year or two after the seedlings were planted out.

Because it is almost impossible to control the quality of trees from so many small nurseries, the SPGS often recommends the smaller commercial growers to buy from one of the larger, established nurseries. Commercial tree planters - especially those under the SPGS - are in the business of establishing fast growing, high yielding, timber plantations. To establish such plantations requires a regular and timely supply of high quality seedlings, raised from selected seed sources: this can only be achieved by having control over one one's nursery or trusting in a reputable external nursery. This Chapter should help one decide which route to take.

The previous Chapter highlighted the importance of only using improved seed for commercial scale forestry. Buying seed or seedlings that have an unknown or dubious origin can be a huge waste of money in forestry, invariably resulting a poor, low yielding crop. Those about to invest their hard-earned cash in commercial forestry here (or anywhere for that matter) are strongly urged to read (and digest) Chapter 7 before tackling this Chapter.

## 8.2 DO YOU REALLY NEED TO START YOUR OWN NURSERY?

This is the question we often ask those new to the business of commercial forestry. The vast majority of people we meet who are planning to start commercial tree planting here in Uganda, seem to want to immediately start their own nursery. We often get them to consider whether this is really necessary. Starting off in commercial forestry is a steep learning curve – as many people are now finding out to their cost! Establishing and managing a nursery is expensive and also another part of the business that can easily go wrong – particularly if the investor has little or no experience in commercial tree growing.

Tree nurseries are expensive to establish and require skillful management and a reliable workforce. They require regular watering (usually twice daily), experienced staff and constant supervision. It is often a question of scale and experience. For investors planning to plant over 200 hectares or so per year, having their own nursery is more likely to make sense. For smaller growers, however, we often recommend them buying their seedlings from an established and reputable nearby nursery.


*Healthy Eucalyptus grandis seedlings being raised in the traditional poly-pots with top-soil (Uganda, 2003)*


*The old nursery system still in use in Uganda can produce good seedlings but its limitations are many (Uganda, 2005).*

*New Forests Company's well laid out nursery in Mubende (2007).*

**Before starting your own nursery: ask yourself the following questions:**

- Does the scale of my planting really justify me starting my own nursery?
- Is there an opportunity to sell seedlings to other growers in the vicinity and if so, what seedling numbers can I expect to sell and at what price?
- Do I have enough experience to budget and plan accurately or do I need assistance?
- Where do I locate my nursery particularly in relation to planting sites and external markets?
- Where do I find reliable sources of seed, germination medium, and good supply of all nursery equipments?
- Do I have a suitable site (especially important are water availability, accessibility and having a well drained, airy site that could be expanded if required)?
- Where will I get an experienced Supervisor/Manager required to run my nursery?
- Do I have workers that I can rely on to be there every day to water and protect the seedlings?
- Do I have a secure store to keep chemicals, seed, tools etc.?
- Do I have sufficient funds to start?
- How and when do I get my customers to place their orders?

## 8.3 BUYING SEEDLINGS

There are some tree nurseries in Uganda (both NFA and private) that have at least attained a level of management, which leads us to recommend them to private growers. They have all benefited from significant improvements, mostly with the support of the FRMCP (the parent programme of the SPGS) since 2002. However, there is at present no independent accreditation of tree nurseries in Uganda (though we hope this will come in time). This means that the SPGS does not accept responsibility for quality or other services provided by the nurseries we list in Annex 1.

*NB1. Prices vary but as an indication – PCH (improved seed) range from UShs 300-500 per seedling; E. grandis UShs 100-150 each.*

*NB2. For updates on the prices of tree seed/seedlings and recommended nurseries, check out the latest SPGS Newsletter which can be obtained free from the SPGS office or download it from our website www.sawlog.ug*

Below is a check-list for those buying seedlings from an external nursery:

1. Work out the optimum time for planting and the seedling numbers of each species required (refer Chapter 3).
2. Order seedlings 6 months in advance and pay a deposit (usually 30%) in advance.
3. Specify not just the species but the exact seed origin of the plants required.
4. Clearly specify the time period when you expect the seedlings to be ready (NB. remember that you will often plant over a period of some weeks not all in one go).
5. Allow around 4 months from sowing for PCH and most tropical pines; 3 months for *Eucalyptus grandis*.
6. Specify the size required: 20cm is recommended (min. 15 cm; max. 25cm).
7. Plan to have the planting site prepared and pre-plant weeded immediately before the expected planting time (preferably early in the rainy season).
8. Regularly check with the nursery the state of development of the plants so that land preparation and pre-plant weed control etc. is coordinated [1].
9. When taking delivery of the trees, be prepared to reject seedlings that do not meet the agreed specifications.

*Seedlings like this should never come out of the nursery but should be culled.*

*A sturdy, healthy pine seedling ready to exploit the site and grow quickly when planted out.*

[1] *It is not uncommon for nurseries in Uganda to sell seedlings to speculative buyers even when they have taken orders in advance from clients and many seem reluctant to take deposits: clearly, the industry is still at an early phase in its development.*

10. Organise well in advance the means of transporting the seedlings efficiently to the planting site.

*NB. If you are selling seedlings to others, we urge you to plan well (especially purchasing seed and sowing in time) and also to communicate regularly with your customers (especially with regard to any possible delays or shortfalls in numbers for whatever reasons).*

The rest of this Chapter is directed at those already running (or preparing to start) their own tree nursery.

## 8.4 PLANNING A NURSERY

**Size:** This will largely depend on amount of seedlings you intend to produce annually. The optimum bed length should not exceed 20m and the space between beds (pathways) should be 1m. Filled pots of 4.8 cm diameter by 12cm height will have a gross density is 424 pots per square metre. Therefore the net density of seedlings in the production areas will be 275 seedlings per $m^2$. However space for working shade, water points, storage, office and paths must also be planned. Considering all these, around 1 hectare will be needed to produce 1 million seedlings annually.

*Discolouration of seedlings my be caused by many factors - e.g. over-watering or lack of nutrients.*

**Pots:** The size of polythene tubes used depends on how long the seedlings last in the nursery. Gauge 250 is strong and black is preferred to prevent algae from growing on the pots, which causes infection. Most species including pine, and eucalypts use pot sizes of 4.8cm lay-flat and 12cm tall. While Hoop pine, teak, Maesopsis and Terminalia will use 10cm lay-flat and 15cm tall. To fill the pots, some soil is put at the bottom of the pot and compacted to make a plug, which prevents the soil from dropping out through the open bottom during handling and transfers. Thereafter the pot is filled with a loose soil. A table located under shade a pot filling-shed, improves the working conditions in the nurseries.

*1 kg of polythene = 800 empty pots of 3 inch cut to 4.8 cm by 12cm.*
*1$m^3$ of soil fill 8000 pots of 3 inch cut to 4.8 by 12 cm.*
*1$m^3$ = 17 wheel-barrows of mixed soil.*

**General layout:** Take care when choosing a site for a tree nursery. The site should be on gently sloping area and away from other tall crops: this is important for good drainage as well as to encourage air circulation. Layout should be in a way that enables operations to flow logically through the nursery so as to save labour and time. Roads and paths within the nursery should be carefully planned. There should be gravel or hard surface outside the growing areas to prevent weed growth and facilitate transport of the seedlings. The nursery facilities should be kept clean. Every effort should be made to control weeds in and around the nursery as weeds may host insects and pathogens.

**Timing:** pines takes around 4 months; eucalypts around 3 months; Musizi and Terminalia - 5-7 months; Hoop pine - 10-12 months.

**Record keeping:** Keep records of all seed purchases, sowing dates, germination dates and %, seedling sales, pest and disease outbreaks.

## 8.5 POTTING MEDIUM

**Soil:** A good soil for nurseries is the correct mixture of sand, clay and organic matter. A simple test is to wet the soil and roll between the palms. Good soil should form a roll but break if the roll is bent. If there is too much clay, the water will take a long time to enter the soil.

*Training of nursery staff is essential - here learning direct sowing techniques on an SPGS course (2005).*

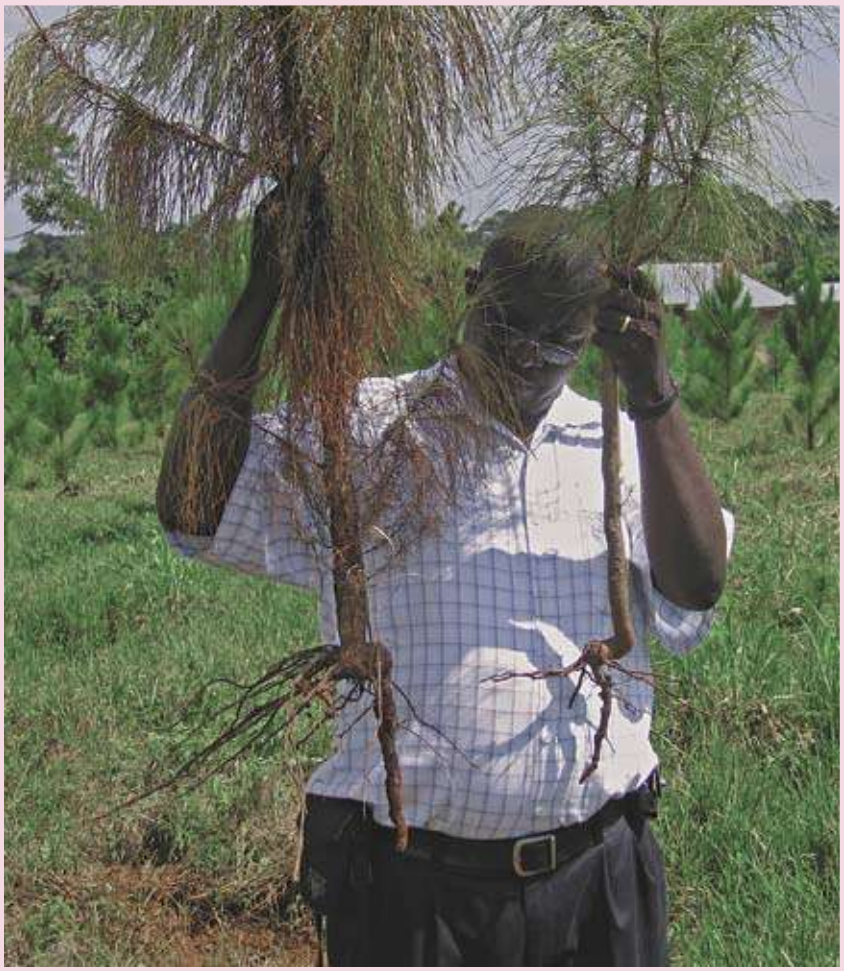
However, if a clayey soil gets waterlogged it will also take a long time to drain off. If there is too much sand in the soil it will not hold enough water for the seedlings to grow properly and it will get too hot in strong sun.
Forest topsoil should be collected during the dry season before the nutrients leach out. First clear away the vegetation and dig out the top-soil only - this can be up to 20 cm deep. Sieve the soil to remove large roots and stones before it can be mixed with the rest of the soils. Pure sand can be collected from river banks or sand mines.

A poor soil can be made better by mixing different amounts of sand, compost, clay and forest top-soil. Top-soil, sand and compost should be mixed by piling up alternatively small quantities of each in the desired proportions. Mix the soil as well as possible. This mixes the soil very well. Mix and turn the soil 3 or 4 times. All soil and sand should be kept under shelter out of the rain and the sun. The standard mixing ratio for 100% pure soils should be; 1 part of sand: 3 parts topsoil, though this will depend on the clay content of the soil.

**Mycorrhiza:** Mycorrhiza are specific types of fungi, which live in a symbiosis with certain tree species, like pines. When raising pines, mix some organic matter from a mature pine plantation with the soil (this will contain the necessary mycorrhiza fungi that pines need to grow well). The roots of the pines need the presence of mycorrhizas to be able to utilize the soil nutrients, especially nitrogen and phosphorus. The mixed substrate should be rested for at least 3 weeks before filling of pots to ensure that the mycorrhizae develop rhizomes well. The substrate should be kept moist but not wet during this curing process.

When raising pines, you need to add mycorrhiza soils in the mix as: 1 part sand; 2 parts mycorrhiza; 3 parts topsoil.

**Fertilizer:** The use of fertilizers is also recommended to encourage fast growth, strong root development and a healthy seedling. This means reduced time spent in the nursery and a seedling that is ready to grow fast as soon as it is planted out. A general NPK multi-nutrient fertilizer 17:17:17 is recommended. Apply 1.0 kg/cubic meter of substrate. Also Triple Super Phosphate (TSP) with equal amount to NPK can be used for basic fertilization in case NPK is not available. The fertilizers must be mixed thoroughly with the soil mix.



*Root deformation caused most likely by poor nursery practices.*

## 8.6 SEED SOWING

**Germination and Seed Viability:** The purpose of seed testing is to obtain data on the germination capacity and initial growing vigor of the germinants. This gives valuable information for planning nursery operations. Germination tests carried out before the large-scale production are essential to save time and to make full use of the growing time. Carefully follow any pre-germination treatments recommended from the seed supplier (e.g. allowing time for acclimatization or soaking).

**Method and timing of sowing:** Follow any recommendations from the seed supplier with regard to acclimatization and any pre-sowing treatments (see Chapter 7). Direct sowing is recommended wherever possible. For bigger seeds, direct sowing into the pot is done while tiny seeds like eucalyptus, sowing in a seed-bed is preferred and then pricked out after germination is complete.

Direct sowing allows undisturbed seedling growth and thus reduces stress for the seedling. Directly sowing the seeds in the container saves time, labour and money, because the extra step of preparing a seed-bed and transplanting is eliminated. Time of sawing depends on how long the seedlings will take to have an optimum size of a seedling (20cm tall). The seedlings should be the right at the time when the main rainfall is expected and land preparation should be complete.

Sowing should be scheduled with the aim of having seedlings of the optimum size at the time of the planting season. It is important to use high quality seeds to lower the risk of no seedlings emerging from the pots. However the tests from the laboratory should guide you how many seedlings should be sown in each pot.

## 8.7 SEEDLING MAINTENANCE

**Watering:** Remember the nursery will be full of seedlings during the dry season. Therefore it should be close to a permanent supply of water. Regular watering is vital and can be very time consuming if not available on site: where possible pump water to holding tank(s) near to the nursery and have stand-pipes in the nursery. Otherwise staff will spend most of their time lugging water around. Having strict nursery hygiene and encouraging good air circulation in the nursery are important: these measures reduce the risk of damping off.

**Pricking out and singling:** Efforts should be made to minimize the 'pricking-out' (transplanting) of seedlings as this is a common source of seedling root problems later on: for this reason, direct sowing is recommended

especially for species with larger seed, like pines. The best time for pricking out is when the small germlings have passed the cotyledon stage but before they start to produce lateral roots. When transplanting small sized germlings, the risk of damaging the roots or leaves is obvious.

This working phase needs special care and supervision because the success of growing depends largely on how carefully the pricking out is performed. Continuity of the growth of the plant must be maintained. Singling is needed if there are more than one germling in a pot.

Note that the late germinants are not recommended to be used for pricking out, since their vigor is most likely be inferior to the early germinants. Careless working or pricking out large seedlings is likely to produce crooked, so-called J-roots.

**Shade:** It is important to grow seedlings in a protected environment during their early growth. Constructing an artificial shade would protect the seedlings during hot, dry months, but would allow sunlight to penetrate during the cooler, wetter months. Shade reduces water loss in the growing substrate by limiting evaporation and water loss through the leaves by limiting transpiration. The common materials used for shade include Bamboo mats, shade cloth, tree branches and grass. All the materials used for shade must allow the required rain or sunshine to pass through when needed. Height of the shade should be 1m on higher side to 0.75m. The shade should be reduced gradually as the seedlings mature and eventually be removed completely. Removing the shade completely at once especially in sunny, hot days will burn your seedlings.

**Culling and sorting:** Nursery managers must accept that it is normal practice to throw away poor quality plants. Unfortunately, many do not. Weak seedlings can be a source of infection. It is a greater waste of hard work and money to maintain trees of poor quality in the nursery and then plant them out in the field. The poor quality seedlings left behind in the nursery are then given to the next unsuspected customer. Another bad (but unfortunately common) nursery practice is to keep plants in the nursery from one planting season to another. These are usually the left-over plants that no one wanted. By the next planting season they are overgrown and have severe root deformities. The nurseryman should make allowances for culling (i.e. rejecting poor seedlings) – at least 15% extra should be allowed. NB. Culls must be discarded: they will never make strong seedlings and thus shouldn't be sold by any professional nursery.

**Root pruning:** Since the seedling pots are sitting on the ground, root pruning has to be

*The nursery manager should regulalry inspect the trees for quality.*

done periodically once the roots appear out of the bottom of the pots. To do this, simply move the bags a few inches sideways every few weeks (routinely check seedlings to determine the need). You can also use a strong wire to prune the roots under the pots. Root pruning reduces the ability of the root system to supply water to the seedling therefore sufficient irrigation is needed after root pruning. NB. Do not plant seedlings for 3-4 days after root pruning as they will be stressed and need time to recover.

**Hardening off:** This means conditioning the seedlings to survive the shock once they are planted out and away from the protective environment of the nursery. A few weeks before planting, it is important to condition the seedlings so they are better adapted to harsher conditions in the field. In the nursery, optimum environment is offered to the seedlings to promote maximum growth rates. The most crucial time in reforestation is the time immediately after the seedlings have been planted in the field. Packing of seedlings, transportation and temporary storage in the plantation site and planting all induce stress to the seedlings. The seedlings should therefore be somewhat hardened off in the nursery in order to tolerate such stress. This is achieved by progressively reducing watering and exposing seedlings to full sunlight in the few weeks prior to transportation to the field. NB. Excessive hardening-off is not recommended as overly-stressed trees will not be able to react quickly when planted out.

## 8.8 PESTS AND DISEASES

Pest and disease control is a constant challenge in the nursery. The main culprits are outlined below:

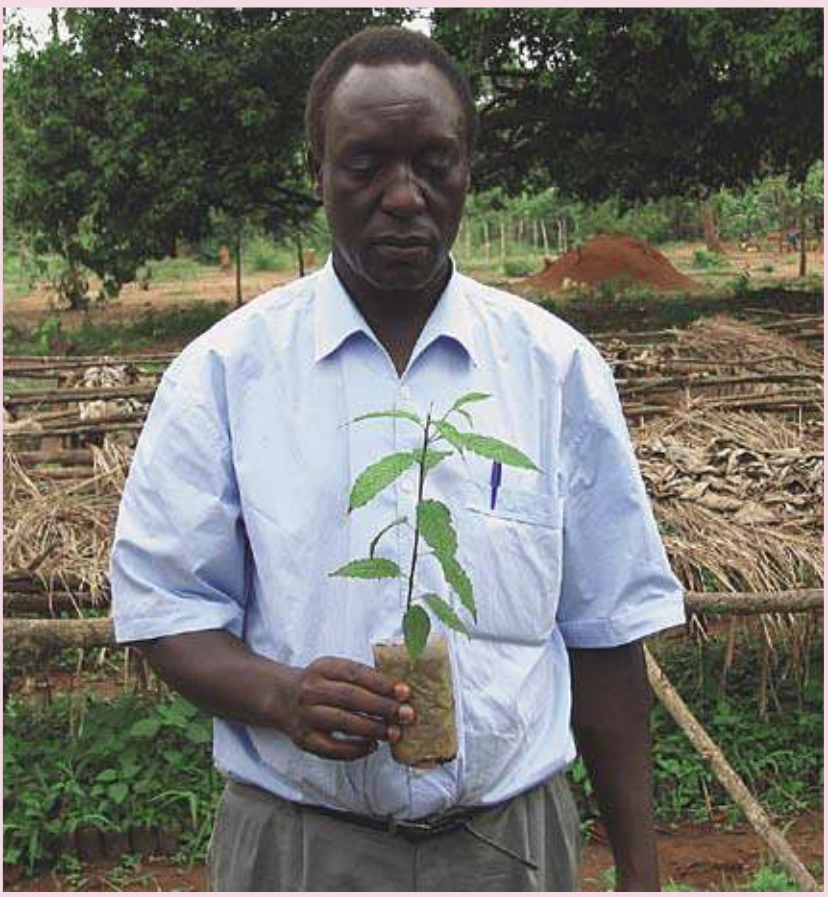
**Damping off:** Damping-off is a collective name for a number of non-specific fungal diseases that cause a serious threat to seedlings after germination. The seedlings begin to rot from the stem tissue just above the root collar resulting in the seedlings toppling over. The disease begins in patches and finally spreads to the entire bed. The humid environment created for the maximum growth of the seedlings also favours the growth of the fungi. The disease occurs in very wet conditions, often induced by over watering and excessive shading. Because of the quick spread of the disease, you have to respond to it promptly.

If the attack is at an early stage, chemicals, such as copper oxide and Benlate (Benomyl 50%) are available in Uganda and can be used. The dosage must be according to the instructions of manufacturer but care needs to be taken not to routinely use the same product since resistance may build up. Spraying should generally be done in the afternoon and no watering must be done after spraying.

*Over-grown seedlings like these should be discarded as they will struggle when planted out and will have poor roots.*

All infected stock must be removed and burnt as soon as possible. The growing medium should not be reused and all sowing equipment and the germination environment must be disinfected.

*Fusarium circinatum* (pitch canker fungus) is a major pathogen in almost all commercial tree nurseries in RSA, where the main focus has been on nursery hygiene and monitoring (with early detection and removal of infected plants). Deaths occur not only in the nursery but in the field after planting out too. In the nursery tip-dieback of the small seedlings is the most common symptom of Fusarium. Little is currently known about the disease's transmission but worryingly, it can be spread from untreated seed (ICFR, 2008).



*A good Musizi seedling ready to plant out. The shoot-root ratio should not exceed 2 to 1.*

**Pesticides:** Pesticides protect seedlings from insect pests, and fungal diseases while they are growing. They come in many forms but usually in liquids (for spraying) or powder. Several types of control procedures are available. Pest and disease control begins with the site selection and physical plant development. The most likely insects to attack a nursery stock are termites, crickets and grasshoppers. Insecticides for controlling these insects and available in Uganda (e.g. Furadan, Dusban, and Ambush) but these must be used with extreme care and according to the manufacturers recommendations.

**Safety Issues:** Chemical use has become common in many tree nurseries; unfortunately, the safe use of chemicals is not equally common. Some of them are highly toxic to humans. The degree of toxicity is usually stated on the label of the container as a LD50 value, but it is better to treat all pesticides with the respect due to any poisonous material. The workers handling the chemical must follow the product instructions strictly, dispose of excess chemical and empty containers properly, wear the right PPE and wash thoroughly when the spraying is finished

## 8.9 QUALITY CONTROL

Seedling quality is governed by two factors: the genetic make-up of the parent trees, and the physical growth of the seedling. Good nursery management can make the best use of these to greatly improve the growth and survival of seedlings. Your nursery customer deserves only the best quality seedlings. A poor quality tree will always be a poor quality tree even if planted on a well-prepared, good site. It is not worth a farmer's effort to transport plants to the field, prepare an area, plant and maintain trees unless they are of good quality. Constant inspection by the supervisor ensures that seedlings that don't meet the standards are sorted out before packaging. Practicing monthly sorting ensures that, only good seedlings reach maturity for planting.

Only the best quality trees should leave the nursery, the others should be discarded (and destroyed). A plant that is not considered good quality does not suddenly become better later on. We define a good quality seedling as follows:

- Optimum height of 20 cm (measured from the root collar).
- A balanced shoot-root ratio of not more than 2:1.
- A compact, fibrous root system, with many white roots (these are the active roots).
- Well root pruned, with no root coiling.
- Seedlings must not be stressed.

NB. Nursery workers must be trained to understand the quality of seedling required.

## 8.10 SEEDLING DISPATCH AND TRANSPORT

An often over-looked phase in raising plantations is the period between the dispatch of seedlings from the nursery to the time they are planted. The time and effort spent in raising quality plants can be completely wasted if no care taken while transporting the seedlings to the field. This phase includes lifting and transporting from the produc tion nursery to the planting site (or to a temporary 'holding' nursery). Remember the seedlings have been removed from an ideal environment in the nursery to a truck where they are exposed to extreme heat, prolonged periods without water, loss of soil, and root disorganization due to rough terrain. Always water the seedlings well before transporting.

To minimize handling, plastic trays or wooden boxes can be used: we recommend the use of stackable 'lug-boxes', which are readily available.

*Transporting plants like this will cause much damage and shock to the trees.*

**Table 14: Common Nursery Problems**

| No. | Problem/Symptom | Possible Causes & Solutions |
|---|---|---|
| | | |
| 1 | Variable quality and growth rates | Only buy recommended improved seed;<br>Cull (sort) seedlings better & discard rejects.<br>Discard late germinants. |
| 2 | Seedling numbers less than expected | Sowing seed too deep;<br>Poor storage of seed;<br>Follow any pre-germination treatment recommendations;<br>Double sow % to allow for low germination. |
| 3 | Seedlings are too large or too small when rains arrive | Plan better; sow at correct time;<br>Stagger sowing;<br>Communicate better with field / customers. |
| 4 | High seedling deaths (stems appear to rot when very young) | Routinely drench with fungicide at sowing;<br>Keep systemic fungicide(s) in reserve. |
| 5 | Compacted soil in pots | Mix more sand with soil to improve drainage; check over-watering. |
| 6 | Poor root development | Sow in pots directly to avoid pricking out.<br>Use fertilizers. |
| 7 | Root coiling in pots | Get them planted out (or sold)!<br>Root prune older seedlings frequently. |
| 8 | Chlorosis (yellowing) of foliage | Apply fertilizers (only after trials to determine dose); check over-watering. |
| 9 | Weak looking seedlings | Reduce shade; fertilise seedlings. |
| 10 | No space to expand nursery | Select site carefully before starting nursery |
| 11 | Shortage of water at critical times | Before starting the nursery, ensure water supply is adequate (10 lts water per $m^2$ nursery bed is a guide); Plan on having an emergency water supply available |
| 12 | Customer does not pick seedlings | Communicate with customer/field staff; Write agreements, Insist on an advance deposits for external orders. |

Transport the seedlings in an enclosed vehicle. If the back of a pick-up truck or an exposed trailer is your only option, be sure to cover the seedlings with a tarp. This will keep seedlings out of the direct sun and protect them from drying in the wind. When transporting seedlings, never park in direct sun. Even in the boxes seedlings can heat up to damaging temperatures in the sun. The effect of stress on seedlings during packaging and transportation to the planting sites has a significant effect on the survival and subsequent growth of the trees.

## 8.11 IMPROVED TREE NURSERIES

The traditional nursery system described so far in this Chapter is capable of producing tree seedlings of high quality. It is also a system that is understood reasonably well by many in Uganda. As more commercial growers emerge and the demand for seedlings rockets, however, some of the drawbacks of this old system are becoming apparent. In particular, the logistical problems of transporting ever increasing amounts of top-soil, sand etc. and also the heavy pots to the field become very difficult.

*Using these stackable boxes protects seedlings during transport to the field.*

This traditional nursery system also can lead to root problems, with the need to regularly root prune once seedlings have reached a certain age/size. Watering also becomes extremely labour intensive as the nursery expands. Thus it is not surprising that the more serious growers in Uganda are now looking to improve their nursery systems. The trend in all countries with large commercial forestry developments has been towards more centralized nursery production. Nurseries producing over 5M seedlings per annum are common: polystyrene or (now more commonly) plastic trays are supported on tables (or tensioned wires); irrigation is by automated sprinklers systems and the growth medium is not soil but composted pine bark or coco-peat and vermiculite mixtures. The advantages of these improved nurseries are summarized in Table 15:

## REFERENCES AND FURTHER READING

**Evans J & J Turnbull (2004; 3rd Edn).** Plantation Forestry in the Tropics (Chapter 10 – Forest Nurseries)

**ICFR, 2008.** The Institute of Commercial Forestry Research's Annual Research Review 2007. See www.icfr.ukzn.ac.za

**Kapalaga I, 2003.** The Management of Small & Medium Scale Nurseries in Uganda. Study for FRMCP (available from SPGS).

**Longman KA, 1998.** Growing Good Tropical Trees for Planting: Propagation and Planting Manual (Vol. 3). Commonwealth Science Council.

**Smith-Wright J & I. Goodlet, 1990.** USUTU Forest (Swaziland) Nursery Manual.

**Temmes M (2003).** Report on Nursery Management in Uganda. Study for FRMCP (available from SPGS).

**Table 15: Pros and Cons of Modern Nurseries**

| Advantages | Disadvantages |
|---|---|
| | |
| 1. Very high production capacity possible | 1. Capitally intensive system. |
| 2. Ability to control seedling development (through fertigation) | 2. Less forgiving than old system (low water-holding capacity). |
| 3. Lends itself to automated, direct sowing | 3. Availability of growing media in Uganda |
| 4. Produces a compact, fibrous root system that prunes itself | 4. Experienced Management required. |
| 5. Grading (sorting) of seedlings simplified | 5. Smaller window of opportunity for holding plants if rains are late or site not ready |
| 6. Plants readily transported to planting site | |

*York Timber's containerized nursery in Sabie, RSA (2004).*

# ANNEX 1
# COMMERCIAL TREE NURSERIES IN UGANDA[1]

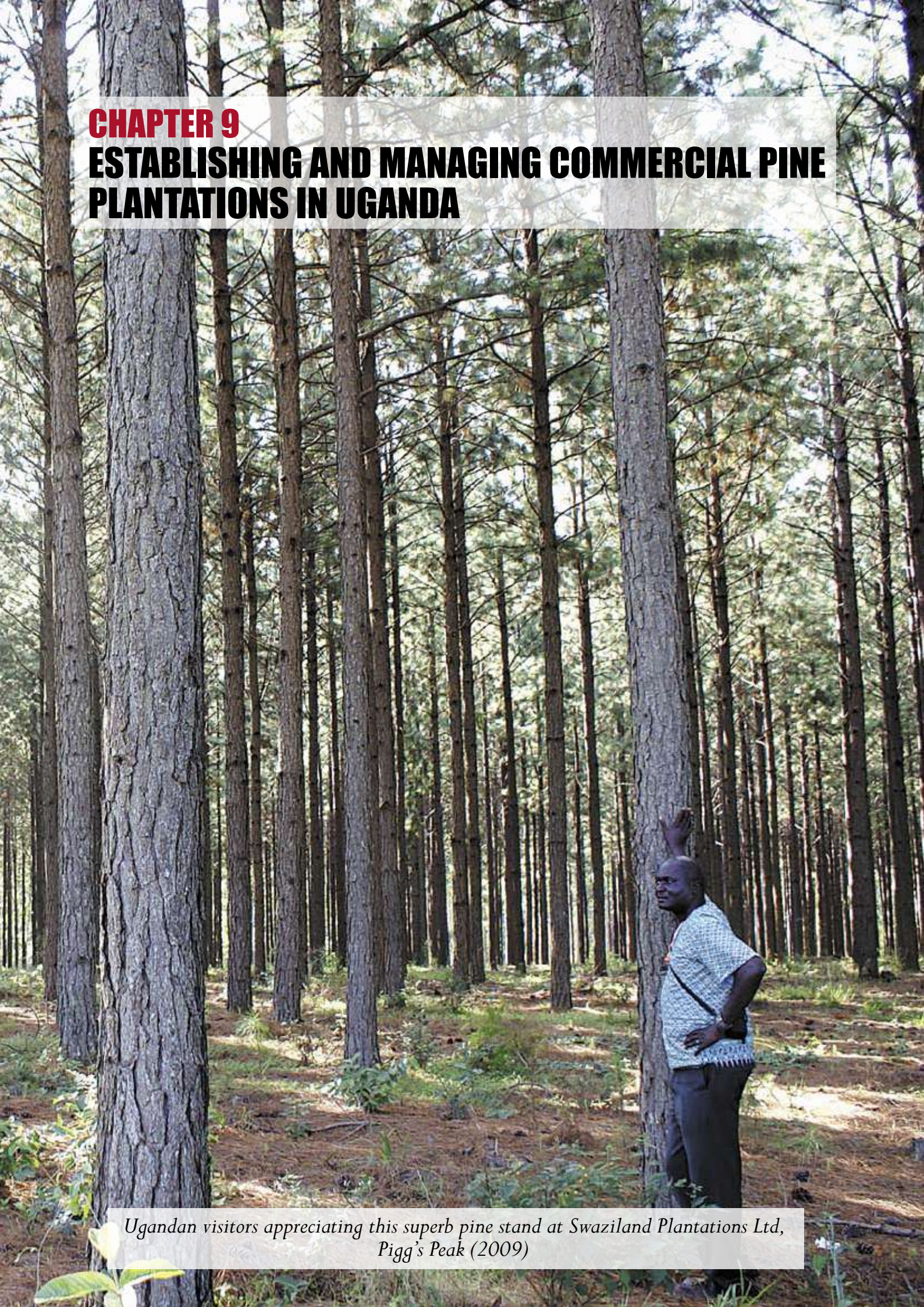
| No | Name of Nursery | District | Contact Person | Telephone |
|---|---|---|---|---|
| | **PRIVATE** | | | |
| 1. | Busoga Forest Co. | Mayuge | Plantation Manager | 0722-844197 |
| 2. | Kikonda-SUB | Kiboga | Shedrack Kajura | 0772-384024 |
| 3. | Kamusiime Assoc. | Bushenyi | Jonathan Mwebaze | 0772589659 |
| 4. | Core Woods | Hoima | Fred Babweteera | 0772-466336 |
| 5. | Norwegian A.G | Lira | Alfred Macapili | 0772-615132 |
| 6. | Fred Ahimbisibwe | Luwero | Fred Ahimbisibwe | 0772-392175 |
| 7. | UMOJA Farmers | Kakiri-Wakiso | Jocelyn Rugunda | 0712- 429922 |
| 8. | TREGD Co(U) ltd | Kampala | Paul Ochom | 0782-529133 |
| 9. | Joly | Kampala | Joly | 0774-519252 |
| 10. | Elvis Mulimba | Kampala | Elvis Mulimba | 0772-412949 |
| 11. | Vianney Besesa | Mubende | Vianney Besesa | 0772-905153 |
| | **NFA** | | | |
| 12. | Namanve NTSC | Kampala | Byenkya Simon | 0414-286049 |
| 13. | Mbarara | Mbarara | Levi Etwodu | 0772- 581494 |
| 14. | Masindi | Masindi | David Mununuzi | 0772- 466498 |
| 15. | Kityerera | Mayuge | Peter Ogway | 0772- 553991 |
| 16. | Katugo | Nakasongola | Joseph Sentongo | 0772- 468691 |
| 17. | Gulu | Gulu | Denis Oyiro | 0772- 316170 |
| 18. | Oruha | Kyenjojo | Seth Mugisha | 0772- 412484 |
| 19. | Mafuga | Kabale | Denis Mutaryeba | 0772- 544033 |
| 20. | Jinja | Jinja | Reuben Arinaitwe | 0772- 480205 |

[1] Inclusion on this list is **not** an endorsement of good management or guaranteed quality from the SPGS: customers have to judge for themselves and ask others. Reading this Chapter should also help growers to at least ask the right questions and to know what a good quality seedling looks like.

# ANNEX 2
# FOREST NURSERY (AND OTHER EQUIPMENT) SUPPLIERS

| No | Supplier/ Organization | Contact person | Product/service | Physical location | Telephone/Website |
|---|---|---|---|---|---|
| 1 | UGTA | Mike Nsereko | Improved Seed (pines and eucalypts) | C/O Plot 92 Luthuli Avenue Kampala. | 0772-979824 |
| 2 | NFA | Simon Byenkya<br><br>Israel Kikangi | Improved seed (Brazil & Australia) and local seed.<br>Mycorrhizal soils | NFA seed centre Namanve Jinja road.<br><br>Ten years and above pine trees. | 0752/0772- 653981<br><br>0772-625387 |
| 3 | UGANDA GATSBY TRUST | Simon Ogwal | Eucalyptus clonal cuttings | Kifu clonal nursery NARO/NaFORRI headquarters -Mukono | 0752-644995 |
| 4 | TWIGA CHEMICAL INDUSTRIES | Andrew Gita | Fertilizers, pesticides, herbicides, fungicides | Plot 71 7th Street industrial area - Kampala. | 0414-259811 |
| 5 | NSANJA AGRO-CHEMICAL LTD | Dick Mukisa | Fertilizers, herbicides | Plot 12 Ben Kiwanuka Street Kampala. | 0772-887474 |
| 6 | BALTON LTD | Ashish Bains | Fertilizers, pesticides, herbicides, fungicides | Plot 47/51 Mulwana road Industrial area. | 0753-330753 (www.baltoncp.com) |
| 7 | ECO-CONSERVE UGANDA LTD | Fred Odutu | Knap sacks and other tools like, spades, mattocks, hoes, slashers, pruning saws, picks. | Plot 425 Mawanda road Kamwokya-Kampala | 0772-772347 |
| 8 | TIC PASTIC CO LTD. | Apollo Masaba | Polyethylene bags. | Add: 977 Block 17, Nalukolongo Masaka Road; Plot 0301031 Kafumbe Mukasa Road, Kampala | 0712-188188 |
| 9 | PORTADOME LTD | Dick Musoke | Shed cloth. | Plot 1001 Gaba road Susie House next to American Embassy-Kampala. | 0772-409973 |
| 10 | LASHER TOOLS | Sean Cochius | Forestry hand tools | RSA-Sigma road, industries West, Germiston, Gauteng P.O.Box 254, Germiston, 1400, RSA. | www.lasher.co.za<br>Tel: +2711825-1100<br>Cell: +27118732185<br>Fax: +2711873-2185<br>Email: seanc@lasher.co.za |
| 11 | FORESTRY SUPPLIERS | Jackson | Lots of forestry equipment(internet ordering) | USA- Postal: P.O. Box 8397 MS 39284-8397 | www.forestry-suppliers.com<br>Phone: 601-354-3565<br>Fax: 601-292-0165<br>E-mail: fsi@forestry-suppliers.com |
| 12 | PROTECTO-WEAR PMB CC | | Safety clothings | RSA-4 Boshoff Street, Pietermaritzburg PO Box 152, Pietermaritzburg, 3200 | www.protectowear.co.za<br>Tel: 033-3454001<br>Fax: 033-3429257<br>Email: info@protectowear.co.za |
| 13 | MC BEANS | | Pumps and fire fighting equipment | Branches in Pietermaritzburg, Johannesburg and Cape Town | www.mcbeans.co.za |
| 14 | AQUASOIL(PTY) LTD. | | Aqua soil | P.O.Box 21410 Valhalla Pretoria 0137 South Africa. | info@soil.co.za<br>Tel: +27(0)126602233<br>Fax: +27(0)126602246 |

# CHAPTER 9
# ESTABLISHING AND MANAGING COMMERCIAL PINE PLANTATIONS IN UGANDA



*Ugandan visitors appreciating this superb pine stand at Swaziland Plantations Ltd, Pigg's Peak (2009)*

## 9.1 WHY PINE?

Pines are generally better suited than most other commercial tree species, to the grassland and degraded woodland sites that are mostly available for plantation development in Uganda. Many of these sites experience hot, dry periods and some have fairly poor soil. Pines can tolerate such conditions, provided there is sufficient rooting depth and moisture in the soil. Some pines (especially *Pinus caribaea var. hondurensis* - hereafter referred to as PCH) have proved to be very adaptable to a variety of sites and soils.

Pines are generally well suited to growing in the plantation situation. On good sites, some pine species (notably PCH) can grow very fast (e.g. mean annual increments exceeding 30m$^3$/ha/yr in Uganda). Most pines also produce a very versatile, general-purpose timber, which is now widely accepted by timber buyers and the Ugandan public.

In certain areas in Uganda – particularly the better sites with deep soil and high rainfall – growers could consider planting other species for timber (or pole) production: for example, *Eucalyptus grandis* (which will produce timber in considerably less time than pines); Musizi *(Maesopsis eminii)*, Hoop Pine *(Araucaria cunninghammii)* and Terminalia *(Terminalia superba)*. For more information refer to Chapters No. 5 (Tree Species), No. 6 (Site-Species Matching) and No. 10 (Eucalypts).

## 9.2 PINE SPECIES FOR UGANDA

The main pine species for plantations in Uganda are PCH, *Pinus oocarpa* and *Pinus patula*. *P. patula* is easily identified from the drooping habit of its foliage – hence, its common name of weeping pine. It is not so easy to tell PCH from *P. oocarpa*, however, although generally PCH bears its needles in groups (fascicles) of 3, whereas *P. oocarpa* usually has its in groups of 5 (be warned though, each species can have fascicles of 2, 4 or 5!). Young *P. oocarpa* trees often appear very bushy for a while after planting out, with branches sprouting from very low down on their stems: this characteristic, however, enables the trees to re-sprout (coppice) if the plantation gets burnt. Remember all pines described in this guideline are not established through coppicing as such.

Other species have been tried in Uganda but have not performed well – including, *P. radiata* and *P. kesiya*. Other pine species may become available for commercial planting in the future – e.g. naturally occurring hybrids between PCH and *P. oocarpa* (which have shown promising 'hybrid vigour' in Brazil) and also an artificial cross between PCH and *P. elliottii* (very successful in Queensland); *P. caribaea var. bahamensis*, and better provenances (i.e. seed sources) of *P. tecunumanii* and *P. kesiya* – but these need to be first planted on a trial basis before we can confidently recommend them for Uganda's conditions.

*PCH is well suited to Ugandan conditions (1.5 yr old PCH at Sustainable Use of Biomass, Hoima, 2006).*

## 9.3 SITE-SPECIES MATCHING

*3-yr PCH (FPQ Australia seed) demo site (Kasagala CFR, 2006)*

***P. caribaea var. hondurensis*** (PCH) is a lowland tropical pine found naturally in Central American and the Caribbean basin. In its natural environment, PCH grows best at low altitudes (from sea level to *ca.* 700m) and on fertile, well drained sites with Mean Annual Rainfall (MAR) of 2-3,000mm. PCH has been extensively planted throughout the American, Asian and African tropics and subtropics, with substantial plantations in Australia, Fiji, Brazil, Venezuela, China and Vietnam. PCH is the most productive of the three varieties of *P. caribaea* (the others being *var. bahamensis* and *var. caribaea*).

PCH requires a tropical and humid climate, with Mean Annual Rainfall (MAR) of over 1500mm for optimum growth. PCH can resist moderate droughts but shallow soils and very hot, dry sites should be avoided. It grows on wide variety of soil types but requires a well-drained soil (and at least 600mm rooting depth) for good growth. In Uganda, it grows up at altitudes up to 1500m but prefers the lower altitudes.

**PCH - *Pinus caribaea var. hondurensis* - is by far the pine suited to most sites in Uganda but only use improved seed – which for many years will have to be imported.**

***P. oocarpa*** occurs naturally in Mexico and Central America from 350 to 2500m altitude and with MAR of 1000 to 1500mm. As a consequence of its wide natural distribution, *P. oocarpa* is a very variable species, which means that great care has to be taken when introducing it to other countries – as can be seen from the poor performance of the species in some Ugandan plantings. *P. oocarpa* is generally less productive than *P. caribaea*, having slower initial growth and poorer wind-firmness, making it less desirable than PCH. Its lighter crown encourages a weedy under-storey to develop too, which increases the weeding costs and fire risk in plantations.

**Locally collected *P. oocarpa* has a poor stem form and is not currently recommended for planting in Uganda until improved seed is available.**

In Uganda, *P. oocarpa* has traditionally been recommended over *P. caribaea* for higher altitude sites (>1200m) and also sites prone to periodic flooding. Such wet sites should generally be avoided for commercial tree planting with any species: additionally the poor form of the locally collected *P. oocarpa* compared with the improved PCH leads us to recommend PCH on most other planting sites. It is hoped to obtain better provenances (i.e. seed origins) of *P. oocarpa* (and its closely related species – *P. tecunumanii*) in the near future but it will obviously be a number of years before results from any trial plantings bear fruit.

***P. patula*** is the main commercial timber (and pulp) species in Southern African plantations. In Uganda, it is frequently being planted 'off-site' (i.e. on sites where it is not adapted to). When planted on low altitude, hot sites, *P. patula* does not perform well (it may grow well for the first five years but there after, the growth rate starts declining and die back may result): it requires high altitude, with a cool and moist climate. The only region which meets the species' requirements in Uganda, are the highlands in the South-West (Kabale). Further details can be found in Chapter 6 – *Site Species Matching.*

**_P. patula_ is frequently planted off-site (at low altitudes) in Uganda. It is only suited to cooler, moist areas in the south-west of Uganda.**

## 9.4 PLANNING ISSUES

Even the tropical and sub-tropical pines cultivated in Uganda generally grow slower than most *Eucalyptus* species, particularly in their establishment phase. Pine plantations in Uganda only close their canopies after around three years, which has consequences for planning silvicultural operations – especially weeding.

*Poor planning (poor seed, weeding etc.) will result in failure (Nakasongola, 2003).*

The adoption of the best silvicultural practices, however, not only speeds up the onset of canopy closure but also ensures the highest yields possible on the site are obtained. These practices are a combination of techniques – namely:

- Use of improved seed (preferably seed orchard seed);
- good land preparation;
- timely weed control to minimise competition, especially in the first 3 years and
- thinning at the recommended times and densities.

**NB.** Pruning is also recommended but is a quality issue not directly affecting the plantation yield. The expected rotation for pines grown in Uganda ranges from 18-25 years. It is feasible for sawlogs to be produced earlier – from thinning operations at maybe 8-10 years and final crops from 15 years onwards – but only on productive sites where heavy, early thinnings have been carried out. With the imbalance in supply and demand predicted for Uganda, the actual rotation will undoubtedly be determined more by market forces than silvicultural ones.

The cost for establishing commercial pine plantations in Uganda has been estimated by the SPGS to be around Ushs1.2M[1] per hectare: this is an average cost across a range of sites in the country. The costs can vary depending on a range of factors but especially the optimum timing of operations, the techniques employed for land clearance and weed control and the experience of the workforce (both basic labour and supervisory staff). For further

[1] *US$ 600 at Mar. 2009 exchange rate of 1US$ = Ushs2000.*

information refer to Chapter 3 – *Plantation Planning, Costs and Yields.*

## 9.5 SPACING AND STOCKING

The traditional spacing for pines in many tropical and sub-tropical countries has been 9'x9', which equates approximately to 2.7m x 2.7m (or stocking of 1372 sph[2] ). Assuming you are using improved seed, good quality seedlings and have good standards of land preparation (as detailed throughout these guidelines), it is recommended to plant PCH at a spacing of 3 x 3m (1111 sph). Until improved seed is available here, however, the recommended spacing for both *P. oocarpa* and *P. patula* is 2.7 x 2.7m (1372 sph), which provides an allowance for more selection from the crop at thinning stage.

**Planting at 1111 sph compared with 1372 sph represents almost a 20% saving in plant costs and in the labour intensive preparation of pits.**

## 9.6 IT'S ALL IN THE GENES: SEED AND SEEDLING SOURCES

As emphasised throughout these Plantation Guidelines, the seed source is critical to the success of your plantation. The pictures in Chapter 7 should speak for themselves and illustrate why the SPGS only recommends using improved, imported pine seed.

Most of the original pine stands in Uganda were established from unselected seed from natural stands in Central America and many trials around the world have shown that PCH has a notoriously poor form in its unimproved state.

Virtually all the Ugandan plantations have since been felled anyway, and those that remain are not good enough to collect seed from. It is also true that in a number of the older PCH stands in Uganda, seed production has generally been poor: the reasons for this are uncertain but similar observations have been reported from South Africa, Malawi and Zimbabwe, where poor seed availability has restricted the species' commercial planting over the last 20 years or so.

The consequence of having no locally produced, improved PCH seed means that for many years, Uganda will have to continue importing seed to meet its needs. To meet this demand for PCH seed, seed is being imported from the only countries with PCH breeding programmes – namely, Australia, South Africa and (since 2005) from Brazil. This situation will only be resolved when Uganda has its own pine breeding programme bearing fruits and to date this has not even started.

*Forward planning is the key to good establishment (FRMCP's Kasana Kasambya CFR demo. site; Australian PCH, 2004).*

[2] *sph = stems per hectare.*

**Australia:** Forest Plantations Queensland (FPQ)[3] in Australia, has established over 50,000 ha of PCH plantations (and a further 44,000 ha of a hybrid between *P. elliottii* and PCH). To support this major plantation development, FPQ have been involved in intensive breeding programme with PCH and it is seed from their advanced generation, clonal seed orchards which has been imported into Uganda since 2002. The parent trees in these seed orchards have been selected for their fast growth, resistance to pests and diseases, and their superior stem form and branching characteristics (see photo). PCH has formed the basis of an extensive pine breeding programme by Forest Plantations Queensland (FPQ) in Australia, for over 50 years.

*Excellent PCH establishment by Kamusiime Assn., Bushenyi, 2006.*

The quality of this FPQ seed is clear to see from the earliest plantings carried out by the FRMCP[4] in 2002/03 in demonstration plantings around Uganda. With the major expansion into commercial forestry since 2003 (by both the private sector under the SPGS and the NFA), the demand for the FPQ PCH seed has quickly outstripped supply. Following a visit by SPGS staff in mid-2006, however, more seed has been made available to Uganda but the supply still falls way short of total demand.

**South Africa:** in South Africa, PCH was planted in lowland sites near the coast but the species has now gone out of favour due to its low-density wood, which does not compare well with alternative species for either pulp or solid wood products. South Africa also started a breeding programme with PCH and although they hardly plant the species now, they have maintained their seed orchards: although very limited in quantity, Uganda imports seed from these orchards when available.

**Brazil:** With rapidly increased demand in 2005, FPQ could not supply Uganda's needs and so efforts were made to find suppliers of other improved PCH seed sources. Following a recommendation from CAMCORE[5], a reputable supplier from Brazil's São Paolo state – Schuckar Seeds – was contacted. Schuckar have seed production stands of PCH (and other pines) and seed from these has been imported into Uganda since 2005. NB. Whilst the early performance of the Brazilian PCH seed is generally good, its germination is significantly less than the Australian seed (refer to table) so more has to be sown to get the required number of seedlings.

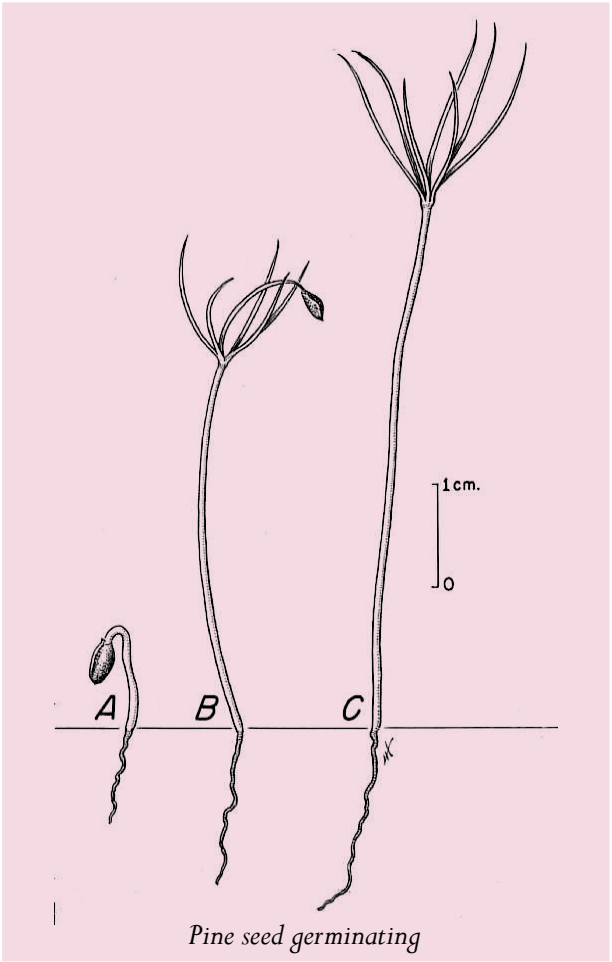
Chapters 7 and 8 (*Tree Seed and Tree Nurseries respectively*) have more details and should be read in conjunction with this Chapter: also refer to regular Seed Update page in the SPGS's quarterly Newsletter.

[3] *Prior to 2006, known as the Dept. of Primary Industries (DPI).*
[4] *The EC-funded Forest Resources Management & Conservation Programme (2002-2006) – was the parent programme of the 1st phase of the SPGS.*
[5] *CAMCORE – the Central American & Mexican Coniferous Resources Cooperative.*

## 9.7 SITE PREPARATION

The chosen method of land preparation will depend on the nature of the vegetation to be cleared and the resources (labour, machinery etc.) available to the grower. Whichever method you choose, the most important issue with land preparation is to time it so that the land is clear in time for subsequent operations – namely, lining out, pitting and pre-plant spraying operations. Clearing land too early will lead to heavy weed growth, which will again have to be controlled prior to planting. Clearing too late leads to delays in planting: planting late in the rainy season is always risky and usually ends in failure of the crop.

Choose the most appropriate and cost-effective method for land preparation. Piling and burning the trash makes the site easier to mark out for planting and also helps with subsequent weeding operations.



*Pine seed germinating*

Lining out carefully also makes it much easier to do all other subsequent work (and supervision of work).

It is also important to prepare good planting pits so that the young seedlings get the best start possible. Pits should be a minimum of 25cm in diameter, cultivated to a depth of 25cm. Where it is hard to dig the pit to this depth (like up the hill) with a hoe, a pick axe (mattock) should be used. The pits should not be prepared too long in advance of planting otherwise the soil can compact again. For further details, refer to Chapter 13 – *Land Preparation*.

## 9.8 PRE-PLANT WEEDING

*(See Section 9.11.)*

## 9.9 PLANTING AND BEATING-UP[6]

The same rule applies for all plantation species: namely, plant as early as possible in the rainy season. This gives the young trees the maximum chance of establishing themselves well before the onset of the hot, dry period that follows each rainy season in Uganda. Normal ('dry') planting can usually take place when >50mm of rain has been received – but this depends on a number of site-specific factors and the site must be checked for soil moisture down to at least 25mm depth before deciding to plant.

Depending on the region (and the season), the best times to plant are usually early in either of the two rainy seasons experienced in most of the main plantation regions in Uganda (normally March/April and Sept/Oct). The use of super-absorbants (e.g. Aqua-Soil) can also extend the planting time.

**Blanking in the next season after the initial planting is not recommended except in exceptional circumstances, as it will inevitably lead to growth variability in the plantation.**

[6] *The term beating up refers to the replacement of failures (dead or poorly growing seedlings): it is also known as infilling or blanking – depending on where you are from!*

*Exemplary PCH (1 yr) establishment at the FRMCP's Oruha CFR demo (2004).*

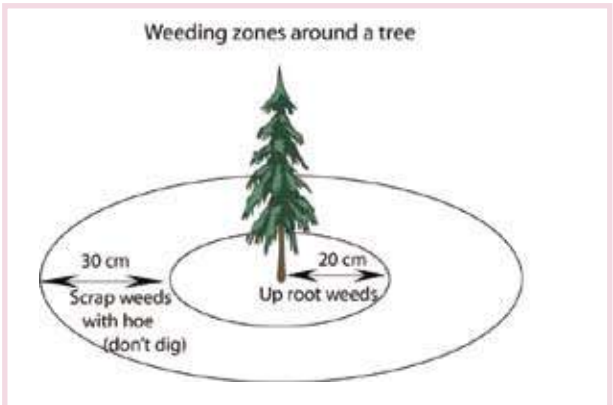
Always plan to raise (or order) up to 15% extra plants to replace the failures from the initial planting. Preferably within two weeks of the initial planting, carry out a quick survival check by counting the failures in a sample number of lines. Generally if the survival is below 90% (i.e. over 10% deaths), blanking is recommended. In the blanking operation it is important to use the same seedling stock that was used for the original planting. Late blanking and using different seed stock from the original planting are the main causes of growth variability in Ugandan plantations. For further details refer to Chapter 14 – *Planting & Beating Up.*

## 9.10 FERTILIZING

It has generally not been common practise to fertilise pine crops in many tropical or sub-tropical countries. South African research, however, has shown sustained response of pines to P (Phosphorus) applications on some sites. In Queensland, Australia, fertilisers have produced a very significant response in conjunction with site cultivation but these are very poor (infertile) sites compared to most of Uganda. Specific sites in Madagascar and Nigeria have also shown good responses to fertiliser but it is highly dependent on the site's nutrient status. There is speculation that a tip dieback in PCH seen in 2008 in parts of Uganda could be caused by Boron deficiency, though this is still being investigated. At this stage in Uganda, however, we do not recommend fertilising pines, until research proves it to be worthwhile.

## 9.11 WEEDING

There is no point wasting time and money on preparing the planting site to a high standard, planting high quality seedlings and then neglecting weeding – and yet this is exactly what many tree planters in Uganda are doing! As emphasised throughout these Guidelines, weed control starts well before planting. ***The aim is to control problem weeds before planting and then to keep any subsequent weeds to a minimum.*** Where there is a predominance of tough, perennial grasses and tall broadleaved weeds, for example, we recommend a pre-plant spray with Glyphosate, carefully timed to minimize the period between spraying and planting. For example, when weeds are sprayed today with Glyphosate, seedlings can be planted the following day without any harm to them.




Following planting, a manual spot (or ring) weed is generally recommended for all pine species, to minimise competition and ensure good growth of the trees. The aim of this operation is to create a weed-free zone of 50cm radius around each planted seedling. This operation usually is carried out with a sharp hoe. One common problem, however, is that the labourers hoe right up to the

tree stem. After a number of passes, much soil is removed from the base of the tree stem such that it becomes unstable and easily falls over. It is thus recommended to manually hand-pull any weeds inside the red zone (10cm radius around each tree) and use a hoe to scrape off (not digging deep) any weeds on the green zone.

Following the initial spot weed, a row (or line) weeding is often recommended: a 1 m strip (500 mm either side of the seedlings) is recommended. A line-weeding operation is easier to supervise – provided the tree rows have been aligned well. Further details on weeding refer to Chapter 12 – *Safe Use of Glyphosate Herbicide* and Chapter 11 –*Weeds and Their Control.*

## 9.12 TAUNGYA

Taungya is the practice of establishing a tree crop in conjunction with an agricultural crop. It has been used successfully in a number of countries but over the past 30 years or so, the practice has failed to produce commercial tree plantations in Uganda. Taungya has become an excuse for people to plant their food crops in Forest Reserves under the pretence of establishing tree crops, which somehow never materialise. Poor tree stocking, low yields and very bad stem form are the consequence of employing taungya in Uganda. Consequently, taungya is now not recommended for establishing timber crops in Uganda (NB. the practice is not permitted under the SPGS contracts). It is better to completely separate the growing of food crops and timber trees in time and space. Clearing land ahead of planting and allowing local people to grow food crops for up to a year prior to planting trees can work but the trees must be planted at the right time with no other crops there. For further details refer Chapter 15 – *Taungya.*

**Taungya has failed to produce commercial tree plantations in Uganda over the past 30 years or so!**

*Good land preparation and weeding will give this crop a great start (Busoga Forestry Co., Mayuge, 2006).*

## 9.13 PROTECTION

Although the tropical pines discussed in these Guidelines are relatively fast growing, rotations may still exceed 20 years (see Section 4) and a lot can happen to a plantation in that time. The plantation will have to be protected throughout its life from damage from animals (both wild and domestic), fires and pests and diseases that may come along. Protection need not be expensive but it must be carried out on time and regularly. Refer to Chapters 16 *(Fire Protection)* and No. 17. *(Pests and Diseases)* for more information:

## 9.14 FOXTAILING

The phenomenon known as foxtailing (see photo p.127) sometimes occurs in pine plantations in tropical countries – including Uganda.

*A 1m diameter spot must be kept weed free during the establishment phase of pines.*

Foxtailing is a striking form of apical dominance, which can lead to stems of over 10 metres with no branches. Foxtailed trees have poorly formed wood structure and are unstable thus will often break in the wind. The causes of foxtailing are only partly understood: it is known to be an inherited characteristic but it is also related to site and climatic conditions. There is increased incidence of foxtails on tropical lowland sites with consistently high temperatures, deep fertile soils and heavy, non-seasonal rainfall. Since foxtails are undesirable, they should be removed in the first thinning operation (see next section).

## 9.15 THINNING

If you want to produce the maximum yield of large sawlogs, thinning is an absolutely essential operation. Early, heavy thinnings, to remove poor quality trees and also to promote fast diameter growth are recommended. For the crop to develop to its maximum potential, the thinning operations must be carried out at the appropriate time. Late (or no) thinning results in a crop of many small stems and an unhealthy crop as competition sets in.

**Table 16: Suggested Thinning Regime for Pine Sawtimber in Uganda**

| Thin No. | Age | From (sph) | To (sph) | Main Product |
|---|---|---|---|---|
| 1 | 4-6 | 1111* | 700 | Too small stems |
| 2 | 6-9 | 700 | 500 | Low quality wood |
| 3 | 9-12 | 500 | 300 | Fair quality wood |
| Clear fell | 18-25 | 300 | | Industrial wood |

** assumes initial planting at 3x3m.*

The timing (and number) of thinning operations depends largely on the growth rate of a particular species on a site and the objectives of the grower (e.g. specific

market specifications for products). The thinning intensity is obviously linked to the initial stocking (sph). A suggested thinning regime for expected growth rates of pine on an average site in Uganda is outlined in the Table 16. It is worth noting that one of the most common mistakes made by commercial tree growers is their reluctance to thin either on time or to the intensity that will really maximise the benefit to the remaining crop.

**Early and heavy thinnings are strongly recommended - to produce large diameter trees as fast as possible.**

Each thinning operation obviously yields some trees, though from the early (first) thinning, they will be small (and some misshaped). As the tree size increases with age, so the 2nd and 3rd thinnings will produce smaller sawlogs. This should provide some useful income to the grower, prior to the main sale of high quality sawlogs at rotation age. Refer to Chapter 20 – *Thinning Plantations for Timber Production* – for further details.

## 9.16 PRUNING

Pruning of Pine trees is recommended for the following main reasons:

- To improve timber quality (to produce clear timber, to prevent the formation of dead (loose) knots and to reduce the size of live (sound) knots).
- To facilitate access into the plantation (for thinning, fires and observing pests and diseases).

Clear, knot-free timber is laid down in the years following pruning thus it is important to time the operation well to maximise its effect. It is also a costly (labour intensive) operation and if done incorrectly, can do more harm than good. Removal (by pruning) of up to 25% of the live crown will not affect increment significantly: the best rule to remember, however, is to never prune more than half (50%) the total tree height. Pruning is usually carried out in 3 or 4 successive stages (or lifts) as the trees grow in height. Like thinning, time of pruning is not necessarily determined by the age of trees but by the growth rates existing on a particular site. A simple guide however, is to organise a pruning operation whenever lower branches start showing signs of reduced growth vigour especially when their leaves start yellowing. For further details, refer to Chapter 19 – *Pruning for High Quality Timber.*

## 9.17 YIELDS

It is difficult to predict the expected growth rate of pines in Uganda. There are two main reasons for this: firstly, the older pine plantations in Uganda were not thinned and secondly, the silvicultural techniques recommended throughout this publication have not been in place here before (e.g. the use of improved seed and more intense land preparation and weed control methods).

*PCH foxtail (Katugo, 2005)*

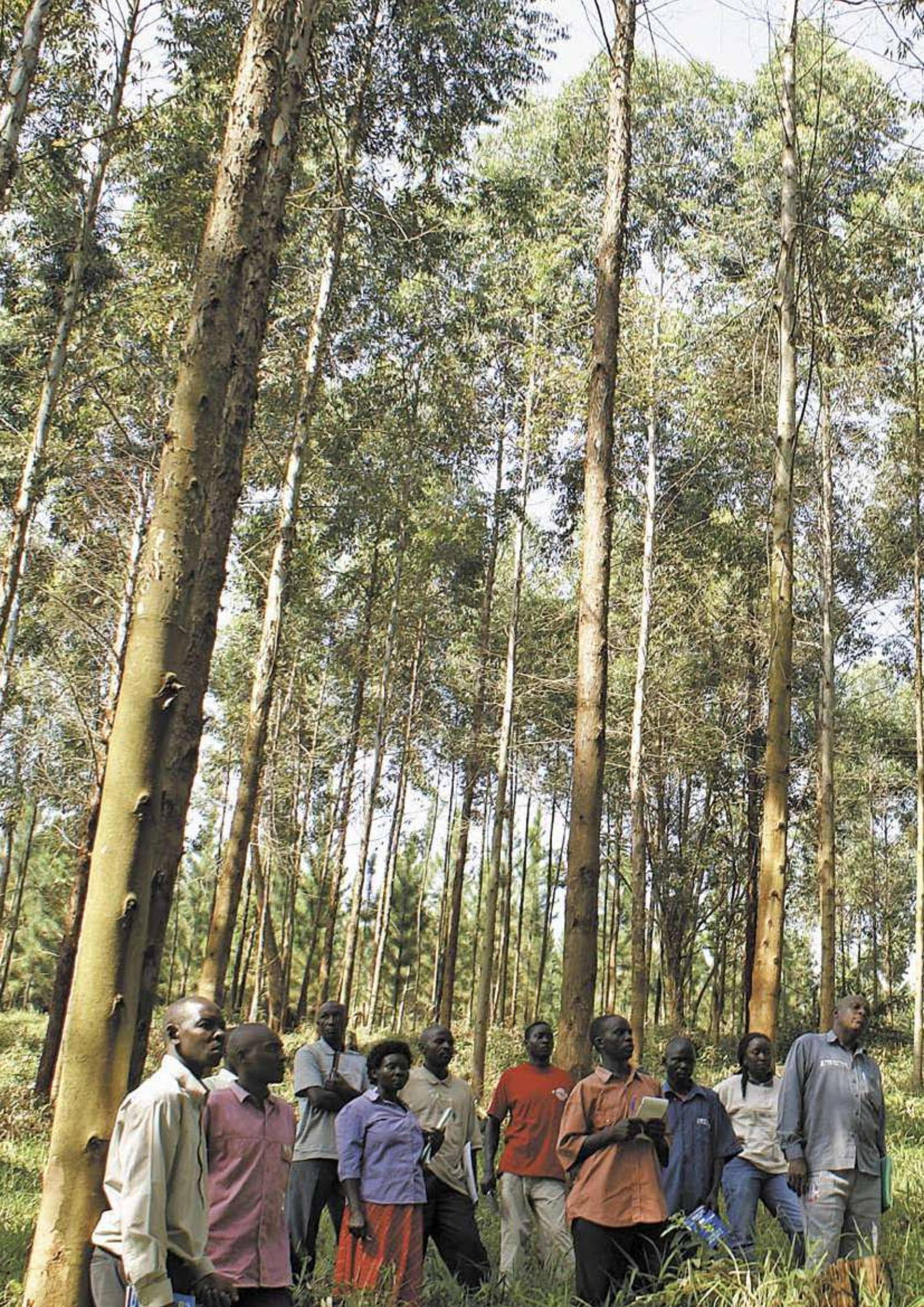
We can make predictions, however, based on experience with similar crops elsewhere.

Assuming that the pine plantations have been well established, the correct species has been planted, the crop has been well maintained (especially protected from fires) and properly thinned on time, the following yields are predicted:

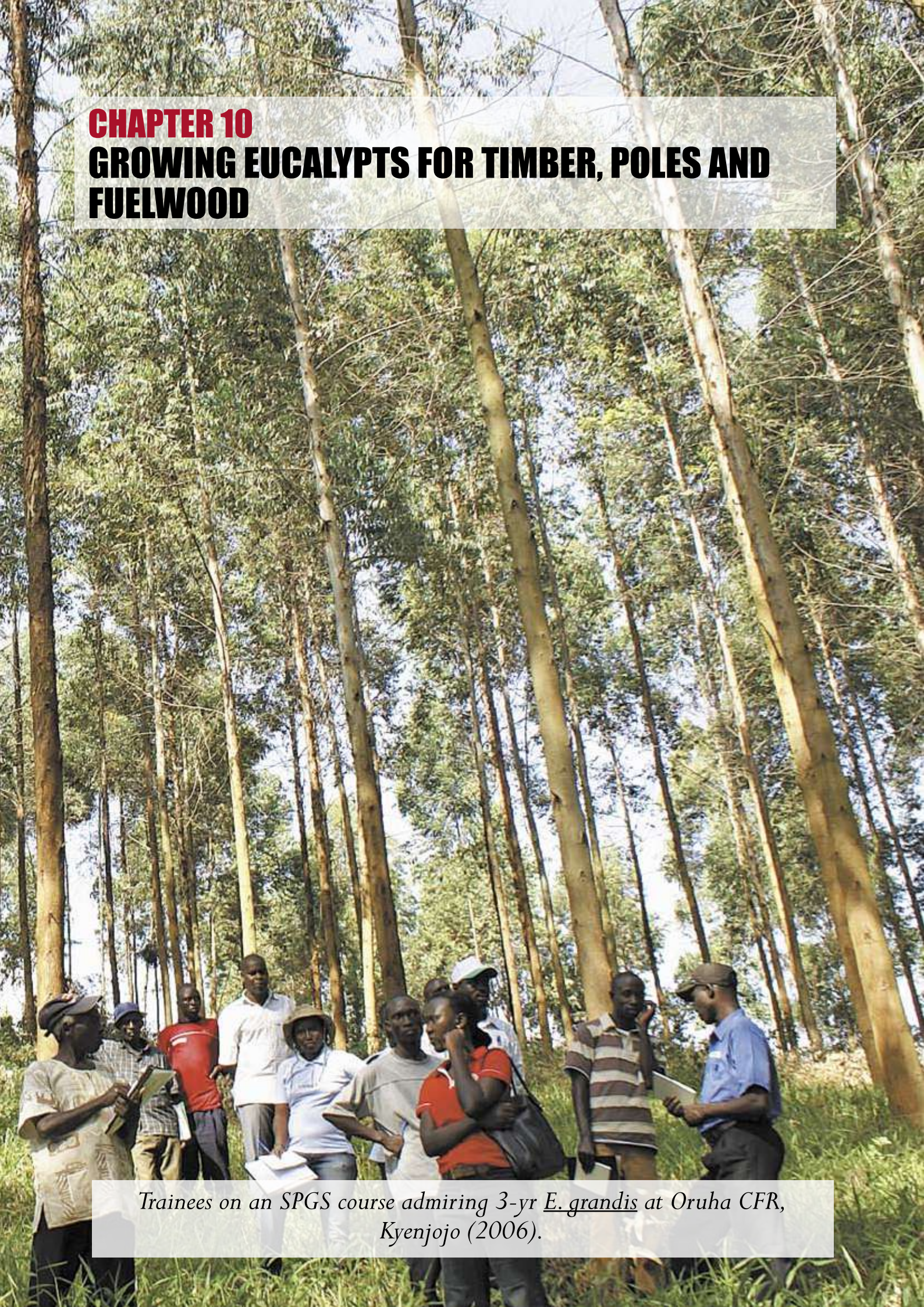
- PCH: Mean Annual Increments (MAI) of 20-35m$^3$/ha/yr.
- *P. oocarpa:* MAI 20-30m$^3$/ha/yr.
- *P. patula:* MAI 25-30m$^3$/ha/yr.

Thus, at 20 years old, PCH might be expected to produce 400-700m$^3$ per ha (total volume including what is removed in thinning operations) - but remember - these high growth rates will only be achieved by following closely the recommendations made in this Guideline, particularly with regard to seed source, seedling quality, site selection, good land preparation, weeding before and after planting and then thinning to the correct stocking on time.

*Contractors at Komatiland Forests (RSA) doing a 5m prune of P. patula (2009)*



# CHAPTER 10
# GROWING EUCALYPTS FOR TIMBER, POLES AND FUELWOOD



*Trainees on an SPGS course admiring 3-yr E. grandis at Oruha CFR, Kyenjojo (2006).*

## 10.1 EUCALYPTS IN CULTIVATION

Eucalypts are planted on a massive scale worldwide for fuelwood, poles, timber and other wood products. They are grown both by small farmers for profit and subsistence and by large conglomerates for industrial wood supply. An estimated 15 million hectares of eucalypts had been planted worldwide by 1995. The genus has many favourable characteristics including high growth rates, wide adaptability to soils and climate, seed availability and ease of managing due to the coppicing ability of many species. Importantly for Uganda (with its looming timber crisis), eucalpyts can often produce utilisable wood products faster than any other species.

*E. grandis grown for transmission poles and sawlogs - Merensky Ltd. (RSA, 2009)*

Eucalypts have also attracted some controversy in some countries, where they have been accused of environmental degradation - sometimes caused by other factors (especially widespread deforestation and poor agricultural practices) but sometimes due to the poor selection of the planting sites. This aspect is dealt with in some detail later in this Chapter.

The main focus of this Chapter is on one particular species – *E. grandis,* which is by far the most widely planted species (for poles (small and large), fuelwood and timber) in the main commercial tree growing regions of Uganda. It covers the key silvicultural issues that growers need to focus on to achieve high growth rates and yields with *E. grandis* but should be read in conjunction with other relevant Chapters in these Guidelines too – especially No.5 – *Tree Species*; No.6 – *Site-Species Matching* and No.22 – *Eucalyptus Coppice Management*. Hybrid eucalypt clones are dealt with separately in Chapter 21.

## 10.2 EUCALYPTS IN UGANDA

Uganda has a long history of cultivating eucalypts, dating back to 1912, when they were introduced to supply fuelwood for railways and administrative centres as well as to drain swamps swamps (in an attempt to reduce the breeding grounds of malarial mosquitoes!). Eucalypts are now an integral part of the rural Ugandan landscape, providing many thousands of small farmers with a regular supply of fuelwood and building poles. Increasingly, more commercial growers are now seriously starting to cultivate eucalypts for larger transmission poles and for timber.

Exceptionally high growth rates are achievable – particularly with *E. grandis* – in certain parts of Uganda. Although eucalypts have been grown for a long time in Uganda, very few growers have applied the high silvicultural standards required to achieve such high yields. The key standards – which will be stressed throughout this Chapter – are using improved seed, careful site selection and intensive, early weeding. Planting *E. grandis* on unsuitable sites combined with poor weeding, leads to stress, poor growth and quite often a failed plantation.

*Good management can produce such results (10 mth old GU, Ferdsult, Lugazi, 2009)*

Eucalypts – especially *E. grandis* – can, if properly managed, yield sawlogs in 8-12 years in Uganda, compared with a minimum of around 20 years with *Pinus caribaea*. *E. grandis* can also produce electricity transmission poles in the same time as for sawlogs. When you add into the equation the fact that to grow both sawlogs and transmission poles, you need to thin the plantations periodically to give the best trees more space to grow bigger, then your bank manager is much happier, since your thinnings should yield fuelwood and small poles long before the windfall of the final harvest.

But before everybody rushes out to replace their Pine and Musizi plantations with *E. grandis*, there are some important factors to bear in mind - namely:

- *E. grandis* will only grow well in cooler areas of Uganda (e.g. western areas) and on deep, fertile, well-watered sites; plating off-site (especially on hotter, drier areas) will lead to stress and often disease.
- Growing *E. grandis* is more difficult than Pines – they require excellent land preparation and weeding to achieve high yields.
- Whilst *E. grandis* grows very fast on the right sites, its timber is usually tense since it builds up a lot of internal stress as it grows. This means that timber recovery will be low unless specific techniques are adopted when converting the trees to timber.
- Other *Eucalyptus* species (and hybrid *E. grandis* clones) will in time be tested and available in Uganda. These will give growers more options but further research is needed before planting commercially on a large scale.

## 10.3 PLANNING

Before planting eucalypts (or any species for that matter) commercially, it pays to plan carefully from the start. Whilst this was emphasized in Chapter 3, it is even more important for eucalypt growers because of their more exacting site requirements (compared to most pines) and the rapid speed of their growth. *E. grandis* requires a minimum of 750 mm effective rooting depth, an MAR of at least 1,000 mm and does not tolerate competition from weeds.

The other options to consider when growing eucalpyts - such as the level of mechanisation and the weeding method(s) employed – will depend on the scale of one's plantation development. Larger operations often mechanise the land clearance and us echemical weed control before and imeediatley after planting until canopy closure.

## 10.4 GROWING *E. GRANDIS* FOR FUELWOOD

The method of establishing *E. grandis* is virtually the same whether one is growing it on a short rotation for fuelwood or on a much longer rotation for timber and large poles. What differs is the initial spacing (often closer for fuelwood crops) and the management of the coppice regrowth, which cannot be done when the crops are grown for timber (refer Chapter 22 – *Managing Eucalyptus Coppice)*. As a fuelwood species, *E. grandis* is not the best (it has a low to medium density wood) but what it loses in calorific value it can often more than compensate for in terms of high yields. Whilst wood density generally increases with age, there are issues such as the size of the material to consider too.

Since 1994, James Finlay (U) Ltd.[1] have been establishing high quality *E. grandis* fuelwood plantations in their tea estates in Western Uganda, using improved seed from RSA, Zimbabwe and JFU's own plantations in Eastern Kenya. Growth rates exceeding 60m$^3$/ha/yr have been recorded from their plantations, but only where their silviculture was spot-on. Rotation for fuelwood and poles depend on the size of product required: building poles are generally produced from two years onwards, whilst a pure fuelwood operation in Uganda might have a rotation of 3-6 years.

## 10.5 WHY GROW EUCALYPTS FOR TIMBER AND POLES?

The simple answer is because on the right sites they can produce timber quicker than anything else! Exceptionally high growth rates are achievable – particularly with *E. grandis* - in certain parts of Uganda. With the best practices, eucalypts can yield real rates of return of over 15% in Uganda. This is good news for the grower who can realise returns on an investment sooner than any other tree species. Eucalypts also offer the only realistic way to bridge the looming shortfall in timber supply in Uganda and yet very

*Eucalypts are an important crop for many Ugandans (Bushenyi, 2001)*

[1] *Until ca. 2003, known as Rwenzori Highlands Tea Co. Ltd., under the UK's Commonwealth Development Corporation.*

*The NFA's Fort Portal seed stand shows excellent growth of E. grandis (2003).*

few people are growing them for timber here at present. There are a number of reasons why this is so, namely:

- Growing eucalypts well is not easy and requires careful silvicultural practices – especially the use of improved seed, intensive land preparation and thorough weeding (pre and post plant).

- The main species - *E. grandis* - will only grow well on suitable sites with good rainfall and deep, fertile soils.

- Many *E. grandis* hybrids have been developed to extend the range of the pure species onto warmer and drier sites (refer Chapter 21).

- Eucalypts have developed a reputation in some places for excessive water use: this is partly through poor site selection but partly also through a poor understanding of the issues involved (see section 10.14).

- Wood recovery from fast grown eucalypts can be low if the logs and timber are not handled properly (see section 10.12).

When planting eucalypts for timber, in addition to choosing suitable sites, the grower must decide on the species, seed origin, optimum spacing (which determines the plantation density or stocking) and also plan for suitable thinning and pruning regimes. Timely thinning and pruning operations are essential for the production of quality eucalypt timber *(see* Chapter No. 19 – *Pruning* and No. 20 – *Thinning).*

## 10.6 SPECIES SELECTION

There are a number of suitable eucalypt species to grow for large-sized poles and also for timber. Where there are deep, fertile soils and MAR >1250mm, however, *E. grandis* will usually perform the best. Provided improved seed has been used and the crop has been properly managed, *E. grandis* will produce large, straight stems and could be providing you with a good income from 2-3 years (building poles), large poles by 8 years and timber from around 12 years onwards.

Two species that grow well in hotter, drier areas – *E. camaldulensis* and *E. tereticornis* - will not produce good sawtimber: they are more suited to fuelwood production. The SPGS is planning a series of species trials from 2009 onwards, which will include some other species that have potential for timber production on specific sites – including *E. cloeziana*, *E. pellita, E. urophylla* and *Corymbia citriodora var. variagata* (previously *E. citriodora)*. Various hybrid *Eucalyptus* clones (ex-Mondi, RSA) have also been tested around Uganda since 2002/03 and are now being produced commercially by Uganda Gatsby Trust (see Chapter 21 – *Hybrid Eucalyptus Clones*). We cannot wholeheartedly recommend these yet for large scale commercial planting for sawlogs,

however, until their timber quality has been tested. See the SPGS's regular Newsletters for updates[2].

## 10.7 SEED

Two factors have combined to reduce the genetic quality of eucalypts being planted in Uganda – namely, the lack of improved seed available from those countries planting the species on a commercial scale and also the widespread hybridisation (inter-breeding) between species in Uganda, which has resulted in virtually no pure seed available within the country.

As emphasised in Chapter 7, use only SPGS recommended seed origins for Eucalyptus spp.

*E. camaldulensis generally has poor form (Tanzania, 2007).*

In the recent past for *E. grandis*, this has mostly been improved, seed orchard seed from private South African companies. The only local seed source recommended is the NFA's Fort Portal Plantation seed production stand: nearly all other local *E. grandis* seed sources have hybridised and are not pure. The South African *E. grandis* seed is usually clean (i.e. had the chaff removed) and should produce over two million plants per kilogramme. Most other *E. grandis* seed will be uncleaned, with expected seedling yields closer to 100-150,000 per kg (NB. Always check the germination rate with each batch of seed from the seed supplier).

## 10.8 STOCKING

When growing eucalypts for timber or large poles, the plant stocking (spacing) should not be as dense as for fuelwood and small poles. Recommended spacing for timber is 3.0m x 3.0m (1111 stems per hectare) or 2.7m x 2.7m (1372 sph). Closer spacing (i.e. a higher stocking) will lead to earlier canopy closure but costs more in terms of higher planting and seedling costs. The closer spacings can be used where there is a good market for small poles but with all these spacings, the thinning regime discussed later must be followed if one wants to maximize the production of good quality, big trees.

For fuelwood and small building poles, a higher stocking compared to timber crops is justified, especially as the rotation is only a few years. Common *E. grandis* stockings fuelwood range from 1337 to 2500 sph, depending on the nature of the site and the size of poles required (NB. higher stockings will generally produce a lot of smaller poles; if larger poles are required, reduce the stocking). The following plant espacements are common for fuelwood crops: 2.7 x 2.7m (1337 sph); 2.5 x 2.5m (1600 sph); 3.0 x 2.0m (2,000 sph) or 2.0 x 2.0m (2500 sph).

[2] *SPGS Newsletters are available from the SPGS's office: they can also be down-loaded from www.sawlog.ug*

## 10.9 PLANTATION ESTABLISHMENT

**Land preparation:** The same golden rules for establishment of all *Eucalyptus* crops apply - namely: thorough land preparation; pre-plant weed control; planting only good quality seedlings; planting early in the rains; blanking (infilling) no later than 3 weeks after the initial planting and most importantly, regular weeding in the first few months after planting.

**Fertilizing:** *E. grandis,* like many *Eucalyptus* species, often responds dramatically to fertiliser application too. Fertilising also promotes fast early growth, which helps the crop to capture the site more quickly (reduced weeding costs). 30 gms Single Superphosphate (SSP) per tree at the time of planting is generally recommended (NB. soil tests and fertiliser trials should really be carried out if planting large areas). Commercial growers in RSA commonly apply shortly after planting ca.100-150 gms per tree of NPK 3:2:1 (25%) or equivalent of a different formulation. Although trials need to be conducted under Ugandan conditions, there is no doubt that eucalypts respond dramatically to fertilizer application provided the weeds are well controlled (otherwise the weeds gratefully use the nutrients).

**Weeding:** Poor weeding is by far the major cause of poor growth in eucalypt plantations throughout Uganda. Unlike pines, eucalypts do not tolerate competition and they are particularly sensitive to grasses. Weed little and often is the golden rule and do not wait until there is a major weed problem in the plantation because by then, the damage will have been done. Eucalypts do not suddenly respond after being released from severe weed competition: they have an in-built memory: thus if a plantation has started off badly, it will always be poor plantation. Provided the weeds are well controlled before planting, focus on keeping the 1m diameter planting pits weed-free and ensuring the weeds in the inter-row do not compete with the planting line. Weeding frequently (when the weeds are small) keeps the costs down and also maximizes the benefit to the trees (refer Chapter 11- *Weed Control*).

**Glyphosate:** For commercial scale (>25 ha) planting of eucalypts for timber (or where labour is in short supply), the use of Glyphosate herbicide can be very cost-effective if correctly applied. Glyphosate is a non-selective herbicide, which means that it can only be used safely before planting the trees. If Glyphosate is used after planting, the trees must be protected from the spray. NB. Before using Glyphosate, read Chapter 12 – *Safe Use of Glyphosate.*

*Poor weed pre- and post-plant results in a failed plantation (Jinja, 2004).*

## 10.10 PLANTATION MAINTENANCE

**Thinning:** Timely thinning is the secret to maximizing the yield of big trees. Shield (2007) states:

***"More eucalypt plantations are ruined for timber production by late thinning than by any other cause".***

One can only grow large, straight trees by regularly thinning out the crop, leaving the best trees to grow to a bigger size. The thinnings will, however, produce an interim crop of firewood and poles, which could be an important source of early income for the grower (if close to markets). The first thin can be selective or can remove one whole line; later thinnings should be more selective, leaving behind the best trees but ensuring that the remaining trees are fairly evenly spaced. NB. refer to Chapter 20 – *Thinning*. Table 17 gives the recommendations for thinning *E. grandis* for sawlog production. Note that the ages are a guide only as crops develop differently over various sites and with different planting espacements.

*A well thinned E.grandis plantation for transmission poles and sawlogs (RSA, 2007).*

**Table 17. Recommended Thinning Regime for Eucalyptus Sawlogs in Uganda**

| Age | Thin | | Notes |
|---|---|---|---|
| | from | to | |
| 1.0-2.5 | 1111 | 700 | Should be done at canopy closure to minimize competition |
| 5-6 | 700 | 500 | Ages are guide only – depends on crop growth |
| 7-8 | 500 | 300 | Assumes clear-fell *ca.*12 yrs |

**Pruning:** Plantation-grown *E. grandis* exhibits good self-pruning properties but branch shedding only takes place 2-3 years after they die, which leaves knots in the timber. For fuelwood crops knots are not that important but for timber they are, since the presence of knots will reduce the value of the final product. Thus when growing *E. grandis* for timber, growers are recommended to prune all branches up to 7m (or even beyond if required) to produce clean boards or poles. As usual the pruning should be carried out in a series of stages or 'lifts', which ensures that the knots are restricted to the core-section of the tree. The timing of pruning very much depends on the growth of the crop but

should always be done before the lower branches die (refer to Chapter 19 – *Pruning for High Quality Timber* – for further details).

**Pests and diseases:** Growers of eucalypts must be aware of a number of actual (and potential) threats to their crops. These include a small, gall-forming insect (*Lepocybe invasa* - known as the Blue Gum Chalcid) which causes stem deformation and dieback; fungal stem cankers (especially *Botryosphaeria*); various leaf spot fungi and bacterial blight. All these (and more!) are dealt in more detail in Chapter 17 - *Common Pests and Diseases in Ugandan Plantations.* It is important to note that with nearly all pests and diseases, the incidence is much greater in trees that are under stress and thus our recommendation is always to ensure one's plantation has the optimum silvicultural treatment and is fast growing and healthy.

## 10.11 HARVESTING AND REPLANTING

**Rotation:** The final crop rotation depends largely on growth rates, the thinning regime and the size (and wood quality) the markets want. On good sites in Uganda, poles and timber trees could be produced as early as 8-10 years: the wood would not be high quality but would be structurally fine for roof trusses, general construction and low-cost furniture. For better quality timber, rotations are likely to be from 12-15 years.

**Harvesting:** *E. grandis* trees often contain very high growth stresses. Logs will often split on felling, leading to poor timber recovery. Older trees tend to develop 'brittle heart', which also results in poor quality boards. It is advisable to cut logs in the longest length that can be handled by extraction equipment, transport and then saw them as soon as possible.

**Replanting:** With eucalypt crops grown for timber or large poles, replanting will be essential when the final crop is harvested. This is because many of the stools will have been cut at various stages and regrowth will have been suppressed due to the shade from the remaining trees.

## 10.12 UTILISATION OF EUCALYPT TIMBER

Observations and experience converting *E. grandis* in Uganda and elsewhere has shown that the following are important:

**Age of the trees:** As the trees get older, the tension in the wood increases. It is preferable to harvest trees younger than 15 years. Seasoning defects are higher in older, denser timber thus it is advisable to use fast grown, young plantation logs.

**Silvicultural regimes:** A number of studies have proved that when it comes to timber quality, it is important to maintain uniform growth throughout the stand's life. If the trees are allowed to grow freely (i.e. with little competition), it ensures a high production of sizeable stems per hectare but importantly, it also produces superior, more uniform wood. Thus many growers of *E. grandis* for sawtimber place emphasis on wide initial espacement and heavy early thinnings.

*A Lucas saw cutting a large eucalypt log (Montigny, Swaziland, 2009)*

**Timing of tree felling:** Fell the trees in the rainy season rather than in hot, dry weather to reduce cracking. Also process the logs as fast as possible after felling to minimize end cracking.

**Method of sawing:** Lucas saws were designed for cutting large, individual logs to save on the transport costs of taking them to a more efficient mill: using them for smaller, plantation logs is very wasteful due to high wastage and the heavy load on the machine cutting timber with significant stress. Pitsawying, though labour intensive, produces good results, especially if logs are converted soon after felling. Note, however, that this method is hardly the one we should plan for in the future, where undoubtedly more attention will be focused on working conditions and health and safety. The best results, however, are from bandsaws or frame saws – of which there are very few in Uganda at present.

*E. grandis* sawlogs awaiting transport to the mill (Merensky, RSA, 2009)

**Timber Handling and Drying:** Handling of freshly cut *Eucalyptus* planks is also very important. It is believed that a certain level of drying has to be undergone until the timber 'calms down'. The drying, however, must be carried out in a controlled way. The following quotes are extracted from Plumptre (1965).

*"There is no doubt in the writer's mind that Eucalyptus grandis as grown in plantations in Uganda can be used as a commercial timber. It is decorative and once seasoned properly, has good working properties".*

*"The main problem in dealing with the timber is in the seasoning: seasoning defect is high particularly in the older, denser wood. It is, therefore, an advantage to use young fast grown plantation timber provided the log is over 12" diameter".*

*"Once seasoned correctly, the wood shows little signs of movement, even with considerable moisture changes, ad it appears surprisingly stable".*

Immediately after sawing, the planks should be stacked in uniform stacks and covered from direct sunlight and rain. The planks must be stacked with closely spaced 'stickers' (small pieces of wood to separate each layer of timber) and the whole stack weighted down. *E. grandis* will air dry down at MC (Moisture Content) to around 20% quickly (depends on the prevailing climatic conditions) after which it can be kilned down to ca.14% MC and ready for use in most applications.

## 10.13 MARKETS

**The large pole market in Uganda:** UMEME Ltd. (formerly Uganda Electricity Board) in Kampala has strict specifications for the supply of transmission poles. They must be straight; at least 8 yrs old; free from spiral grain, decayed knots and splits. The detailed specifications for UMEME poles can be found in Chapter 3 (p. 24) of these Guidelines. NILELPY, in Jinja, also are major buyers of good eucalypt logs (but also buy standing) for peeling for veneer. Their minimum diameter (DBH – measured at 1.3m height) is 300mm and in lengths of 9' to 27'.

**The eucalypt timber market in Uganda:** As other species become rarer, and people see the products being made locally from eucalypt wood, there is a growing demand for the timber in Uganda. Recovery of timber is very low at

present as more attention needs to be paid to proper drying of the wood and also product design.

**Thinking about the end-products:** Cutting with a view to specific end-use products is also advisable e.g. the carpentry, 4 x 2" and 6 x 2" pieces will give high recovery: bigger sizes tend to develop deep cracks and smaller ones tend to bend and crack. The length of the planks also depend on the end-use of the timber and yet Ugandan timber dealers (and sawmillers) remain obsessed with a 14' length. Look around the room as you read this and think how many wooden items are in multiples of 14'. Not many – right?

## 10.14 ENVIRONMENTAL ASPECTS OF GROWING EUCALYPTS

*"Do they really use up so much water?"* and *"Do eucalypts degrade the land"?* are common questions fired at the SPGS team. Since the SPGS often recommends planting eucalypts where growers have suitable sites, we believe that we have an obligation to ensure people understand the issues better so they can make informed decisions, not ones based on rumour and ignorance. Hence the inclusion of this section on what is known in some countries as 'the great *Eucalyptus* debate". We do not need to reinvent the wheel and start decades of research to prove the point either: the environmental aspects of planting eucalypts have been scientifically studied in many countries. Below we present a summary (in simple language) of the key issues.

**Excessive water consumption:** It is often claimed that eucalypts have a high water demand which leads to a reduction in downstream flow. Indeed, it is hardly surprising that they have such a reputation since they have been introduced into some countries (including Uganda) to drain swamps for malarial control. Eucalypt plantations are also used in Australia to deliberately lower water tables in areas with high salinity.

In this regard, eucalypts are no different to any plants: they require water (and nutrients) to grow. Eucalypts are very efficient in terms of biomass produced (requiring only one half to one third of the water used by many agricultural crops). The faster trees grow, however, the more biomass they accumulate and clearly, the more water reserves will be drawn on, no matter what species.

Where water is plentiful, this presents no problems; where it is scarce, however, eucalypts will compete for available water and this could lead to conflict. Careful planning should help alleviate any conflicts - particularly by identifying areas where eucalypt plantations will not compete for water with other users.

*Eucalypts growing along the River Nile near Jinja (2007).*

**Nutrient depletion:** In common with any crop, eucalypts require nutrients to grow. Eucalypts are in fact very efficient users of available resources (related to the often harsh environment where they evolved in Australia) but clearly their nutrient demand will be high in order to sustain their very high yields when cultivated intensively. Consequently it is normal practice to apply fertilizers when planting eucalypts on a commercial scale. This practice is no different from any other intensive farming system.

**Site degradation:** Eucalypts are sometimes blamed for increasing soil erosion. Again here there is no evidence to single out eucalypts for special criticism. More important than the species planted is the erodibility of the soil, and the management of the crop. On sites that might be at risk of erosion (e.g. steep slopes and sandy soils) there are management techniques that can be adopted to minimize the damage.

**Biodiversity loss:** There are claims that eucalypt plantations - along with other exotic tree species - cause massive loss of biodiversity. This depends on what vegetation was there beforehand: clearly a monoculture does not have anything like the biodiversity of a natural rain forest but this is an unfair comparison since such plantations should not be established in such areas by clearing intact natural forests. In Uganda, plantation development is focused on degraded forest land and grassland: in this case a eucalypt plantation may well reduce further biodiversity loss.

**Climate:** Research has shown that there is nothing to distinguish eucalypts from plantations of any other tree or from different types of native forests in their effect on rainfall or on other regional climate patterns.

**Comment:** Clearly there are double standards being applied here: commercial forestry is often criticised for practices that are standard in

*Eucalypts provides firewood and take pressure off natural forests.*
*James Finlay's Ankole Tea Estate adjacent to Kalinzu CFR (2004)*

agriculture, whether it be planting monocultures of high yielding varieties or fertiliser application. Thus many of the criticisms leveled against eucalypts could equally apply to many plantation crops.

In many places where there is the most noise against planting eucalypts, the main contributors to the local environmental problems - namely, massive deforestation and poor farming practices (compounded by global warming) - are conveniently overlooked. In some degraded areas, eucalypts are the only trees that survive and thus attract the blame for all the regions' environmental woes.

For those keen to point the finger of blame for droughts, global warming and poverty, eucalypts should be seen as part of the solution rather than the cause of such problems.

**Conclusions:** Ever increasing demands are being placed on the world's forest for both wood and non-wood products. To compensate for this, tree plantations have rapidly expanded and will continue to do so, especially in regions where growth rates can be high. Eucalypts are important plantation species in many tropical and sub-tropical countries for their ability to produce high volumes of utilisable products in a short time. In Uganda, eucalypts are valued by both small farmers and larger commercial growers and yet they have attracted criticism from some quarters mostly for their alleged impact on water, climate and soils.

Considerable scientific research has been carried out on the subject in India, South Africa and Australia - all countries where eucalypts are important to the economy and the livelihoods of many. The results show that eucalypts are not as harmful as they have often been portrayed but that the high water consumption associated with high biomass yields, needs to be considered, in an integrated way, with other economic, socio-economic and environmental factors. The challenge for planners and forester managers is to design sustainable systems for growing eucalpyts, which minimizes some of the adverse hydrological impacts whilst maximizing the economic and socio-economic benefits.

## 10.15 PRACTICAL RECOMMENDATIONS

- Better planning and more careful selection of sites where eucalypts can be grown with little impact on the environment;
- restrict large scale planting where rainfall is marginal for intensively grown eucalypts (generally <1200mm per year, though this depends on location);
- identify areas where water for the local community is more important than trees in the catchment;
- consult with local people during the planning;
- break up large blocks of trees with indigenous vegetation if possible;
- delineating scientifically the wetland zone and no planting in it.
- routinely fertilize eucalypt crops to maintain the soil nutrient levels.

In Uganda there is clearly a need for people to better understand the issues to enable an informed debate - at both the national and local level - to take place. We need to move away from polemics to a more rational debate of the diverse roles played by trees in the Ugandan economy and the importance of tree plantations to meet the country's ever increasing biomass demand. The requirement of a eucalypt plantation for water and soil nutrients has to be balanced against other possible claims on those resources. Careful planning - especially involving local stakeholders - should alleviate many of the concerns.

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# CHAPTER 11
# COMMON WEEDS AND THEIR CONTROL

*Study this Chapter and save yourself a lot of bother (and lots of Shillings too).*

## 11.1 IMPORTANCE OF WEED CONTROL

The inclusion of this Chapter on weed control before those on land preparation and planting is deliberate so as to encourage the reader to think (and plan) for weed control well before planting. All too often those new to commercial forestry rush to plant their trees without having a clear weed control strategy in place. Planting into an already weedy site is a great mistake and severely restricts one's options for weeding in the crops' early years too.

There is no question that weed growth is the main problem confronting commercial tree growers in Uganda, leading to very costly control in the early years of plantation establishment. The country's generally highly favourable conditions for tree growth, also leads to rampant weed growth and unless the weeds are controlled effectively, the plantation investment will suffer seriously (and may even fail completely). As with many silvicultural practices, however, careful planning can greatly reduce the impact of weeds on tree growth as well as minimize the cost of weed control.

It is important to see weed control not in isolation but as one aspect of plantation establishment: and here we stress the importance of good planning and timing again. The better the site preparation and the earlier the trees are planted in the rainy season, for example, the fewer weeding operations will be necessary. Good silviculture is a balance of all the available techniques such as good land preparation, careful site-species matching, good quality seedlings, timeous planting, quick beating up and subsequent weed control.

It has been clearly proven in many tropical and sub-tropical countries that intensive weed control is highly beneficial to hardwood species – and especially *Eucalyptus spp*. Eucalypts are particularly sensitive to grass and weed competition and for optimum growth, it is always advisable to keep eucalypt plantations weed-free until canopy closure (*ca.* 12 months in Uganda, provided weeding is done well - Schonau, 1988).

Although pines are generally more tolerant of weed competition, trials have also clearly demonstrated significant growth improvements where weeds have been removed from young pine plantations. Most studies have shown, however, that it is not cost-effective to keep pine plantations totally weed free, unlike eucalypts.

This Chapter describes the main weeds encountered in Uganda and recommends the best approach to controlling them.

*Allowing weed competition like this will result in a failed plantation (Bushenyi, 2004).*

It should be stressed that only rarely is the approach recommended to completely eradicate a species (e.g. the case of the highly invasive *Lantana camara*) but it is usually a case of controlling the weeds to an acceptable level so that our tree crop can establish and develop well. Chemicals are only recommended where considered appropriate and where they are, health and safety considerations are stressed.

*Ensure plantation staff know what the main weed problems are likely to be.*

## 11.2 WHAT IS A WEED?

A weed is an unwanted plant or a plant that grows in an undesired place, in our case the tree plantations. Weeds have the ability to grow fast and dominate an area very quickly: they thus compete against our desired (planted) crop. This competition deprives the planted trees of the nutrients, water, sunlight and space needed to grow quickly and with a good form. Weedy plantations are stressed, of poor form, stunted and are susceptible to pest and disease attack. By weeding we remove this competition and other negative impacts of weeds thus helping to provide the optimum growing environment for our tree crop. Weeds are more competent than the trees when it comes to growth and ability to tap soil nutrients because of their characteristics listed below:

- Efficient methods of seed dispersal.
- Ability to establish easily.
- Rapid and efficient reproduction.
- Rapid growth and aggressiveness as competitors.
- Well developed (and some times deep) root system.
- Adaptability, i.e. are able to grow in a wide range of habitats.
- Hardiness, i.e. able to withstand adverse growing conditions.
- Difficult to eradicate.

Because of weeds' efficient seed dispersal it is important to keep the entire area under control. Weedy areas provide a seed bank that keeps infesting areas being managed. In addition to the competition for resources, weeds also provide shelter for rodents and a food source for cattle and wild antelopes: these animals will often then cause damage to the trees. Weeds also increase the fuel load within a plantation and thus significantly increase the fire risk during the dry seasons.

**Only with good weeding will you achieve the growth potential of the tree crop and make the returns expected on the plantation investment.**

## 11.3 THE IMPACT OF WEEDS ON TREE GROWTH

Weeds, just like any other crops, require water, soil nutrients and other resources for growth. They therefore compete with the trees for these necessities of life. Weeds have the following negative impacts on tree growth:

- They take up the nutrients that would have been used by the trees to enhance growth, thereby retarding tree growth.

- Weeds once taller than the trees, shade them from sunlight: they thus impair tree photosynthesis and upward growth.
- With severe weed competition, trees will struggle for the sun, often leading to mal-formed or spindly (i.e. weak) tree stems.
- They lower plantation hygiene and lead to plantation stress rendering the plantation susceptible to pest and disease attack - e.g *Leptocybe invasa* (Chalcid wasp) attack in stressed eucalypts.
- Weeds provide fuel for forest fires; hence they constitute a fire hazard.
- They hamper movement within the plantation when carrying out various forestry operations – whether for routine inspections, thinning or fire fighting.
- Weeds may attract grazing animals into the plantation, which in turn may damage the trees.
- Weeds around the trees attract rodents and termites, which may then feed on the trees.

*Ensure that the spray-team is well trained essential (NFA, Katugo, 2005).*

## 11.4 WEED IDENTIFICATION

Before one can decide how best to control any particular weed, it is essential to clearly understand what weed problem one is dealing with (or expecting). This entails having a basic knowledge of the main weeds, how they grow and finally, knowing how to cost-effectively control the target species. Rather than using a purely scientific classification system, we have developed a more practical way of classifying the main weeds that tree growers will encounter in Uganda. Under this SPGS weed classification system, weeds are classified into six broad categories as outlined below:

1. **Fast growing, annual broad-leaved weeds:**
A wide range of annual broad-leaved weeds can emerge from the soil seed bank and compete with trees. These weeds normally reproduce by means of seeds, and in most cases complete their life cycle in one year (after seeding). Although they grow very fast, these weeds are generally fairly easy to deal with by removing them early enough before they compete with the trees and before they set seed. The most common example is Black-jack (*Bidens pilosa*), which can be found in all tropical foresters' socks.

2. **Annual grass weeds**
Annual grasses germinate from seed and reproduce in one year. Though easy to control they need to be dealt with before they pose a serious threat to the trees. Sweet buffalo grass (*Panicum schinzii*) is one example of a common annual grass.

3. **Perennial, shrubby broad-leaved weeds:**
These weeds generally reproduce through seed, but also through various vegetative structures. They include coppice regrowth,

invasive species and climbers. They can impair movement within the plantation to carry out the various operations of pruning, thinning and harvesting. Their management can therefore be aimed at one or more phases of the life cycle such as prevention of seed setting or exhaustion of underground roots. The best known examples are Lantana (*Lantana camara*), bramble (*Rubus cuneifolius*) and bugweed (*Solanum mauritianum*).

4. **Perennial grass weeds:**
These weeds are among the most troublesome for tree growers. They easily spread and are particularly resilient to control. They have a range of mechanisms for propagation; seeds, rhizomes, stolons. They also constitute a serious fire threat on the plantation during the dry season. Management programmes should focus on prevention of spread, cultivation and desiccation of roots. The main problem species are elephant grass, couch grass, spear grass and sugar cane.

5. **Woody weeds:**
These include indigenous tree regrowth (e.g. *Combretum spp.*), *Eucalyptus spp*. coppice and alien invader species such as Paper Mulberry (*Broussonetia papyrifera*) and Black Wattle (*Acacia mearnsii*).

6. **Sedges:**
These are biologically different from grasses and are very difficult to kill because of their underground rhizomes. Yellow nutsedge (*Cyperus esculentus*) is common in wetter areas in Uganda.

The main weed species mentioned in this section are described later in this Chapter after a more general discussion of weed control.

## 11.5 TIMING OF WEED CONTROL

It cannot be over-stressed that weeds will have a negative impact on tree growth and the profitability of the plantation business. Adequate weed control is crucial to achieve Fast Growing, High Yielding plantations. Weeds need to be controlled until the trees themselves are able to suppress them: thus the objective is always to minimize the time until what is termed 'canopy closure' – namely, when the trees' branches touch between the rows and start to cast shade. The timing of various weed control measures will depend on the nature and intensity of the weed problem. It is common to divide the control measures into pre- and post-planting and these are described in the following sections.

**Adequate site clearing:** During land preparation, vegetation that would have competed with the trees is removed or controlled. This helps to achieve high survival and rapid early growth of the planted trees. The indigenous trees and shrubs should be cleared to as close to ground level as possible for easier control of coppice regrowth. Chapter 13 gives details on the land preparation techniques.

**Pre-plant spraying with Glyphosate:** Pre-plant spraying with Glyphosate is often an extremely cost-effective way to control target weed species, especially the tough, perennial grasses. It only works well, however, when the planning and timing is right: this involves careful timing of land clearance, lining out and pitting operations to coincide with the optimum time for planting. The success of the operation, however, is closely related to the size (i.e. stage of development) of the target weeds and the level of training and supervision of the spray team. The subsequent weeds are the annual broad-leaved weeds that are easier to control even by slashing or lower concentrations of Glyphosate. **NB.** Chapter 12 should be studied before even thinking of spraying.

**Early post-plant weed control (either manual or chemical):** From the time of planting, the plantation should be kept weed free. The weeds should be killed when they are still young otherwise they become difficult to deal with once they have established.

**Periodic follow-up weed control:** It should be noted that most weeds grow faster than the newly planted trees. Adequate pre-plant spraying and early post-plant weeding are not enough to wipe them out. A follow up weeding programme should be developed to ensure that weeds are kept as low a possible until the trees are established. For *Eucalyptus spp,* an intensive weeding programme should be developed to ensure 100% weed control. This ensures maximum growth of the tees and promotes plantation health.

## 11.6 FREQUENCY OF WEED CONTROL

Because weeds are resilient and prolific seeders, they are difficult to eradicate. With proper planning and timely weeding, however, the weed intensity will reduce and it will be easier to remove the weeds. The interval between successive weedings will also increase. Weeding both manually and with herbicides only remove weeds that have germinated: seeds will continue to germinate. Therefore follow up inspections and weeding will always be required.

So once you have weeded an area, don't walk away and forget it: inspect it regularly. The timing of the next (follow-up) weeding is vital: leave it too late and the weeds will seed and you will be back at the beginning. Time it right and you will eradicate the weeds when they are vulnerable and before they have a chance to seed. This will result in a lower weed infestation next time and possibly a longer gap between weeding.

*Good spot weeding - the minimum required (Arthur Busingye, - Bushenyi, 2006).*

*Highly organised contractor spraying team carrying out a pre-plant glyphosate spray. (Peak Timbers, Swaziland, 2009)*

**The timing of the follow-up weeding operation is a vital part of a cost-effective weeding strategy: time it so that you can eradicate the weeds when they are small.**

Always remember that weeding needs to be done before the weeds seed. A clue to when a weed is going to seed is when it flowers. If your weeds are flowering you need to get in and weed quickly.

## 11.7 METHODS OF WEED CONTROL

When deciding on which method of weed control to employ, it is important to know the weed profile of the plantation. Knowing the types of the problem weeds on the plantation or proposed plantation site will help in choosing the most appropriate methods of dealing with the weeds. There are three main categories of weeding: chemical, mechanical and manual. The main features of each method are outlined below.

**Chemical weeding:** This involves the killing of weeds using chemicals called herbicides. The major herbicide used in forestry world-wide is Glyphosate (Glyphosate is the active ingredient). Glyphosate kills any green plant material so it is safer to use it in the pre-plant situation (i.e before the trees are planted), at least until one is satisfied with the level of training of the spray-team. When using Glyphosate in the post-plant situation, it is essential to prevent it from coming into contact with the planted trees. The herbicide is sprayed over the weeds while caution is taken to prevent any from touching the trees. The trees should thus be protected using buckets, cones or shields.

Before any spraying is done, the spraying team should be trained in the basics. They should also be provided with protective working gear to prevent body contact with the chemical. Good storage of the chemical and proper disposal of used chemical containers are also important.

Provided the spraying operation has been carried out properly, the weeds remain where they were but do not compete with the trees because they are dead (or dying). If the area was very weedy it may increase the fire danger in the short term but then so would a manual operation.

**Mechanical weeding.** This is where mechanical means are used to eradicate weeds: disking, ploughing, rotovating or slashing behind a tractor are examples. Using a hand-held brush-cutter to slash down weeds is another. Mechanical weeding can be very cost effective, especially as large areas can be covered quickly. The main drawback, however, is having suitable conditions that enable the tractor access throughout the plantation: tree stumps and slope often make it impossible to carry out safely. Even where conditions are suitable, great care must be taken not to damage the tree roots - which with older seedlings will be exploiting the inter-row area where the tractor will be passing. Where mechanical weeding is planned, it is recommended to increase the inter-row plant spacing to safely accommodate the tractor.

**Manual weeding.** Manual weeding is the most common method for small-cale plantings. It involves reliance on man- power, which uses simple tools such as hoes, slashers and pangas to remove any competing vegetation. For the best results, mere cutting is not always adequate and some cultivation by hoeing is always needed to kill weeds especially grasses and invasive broad-leaved weeds. Manual weeding can be carried out in a number of ways:

**Hoeing must never take place within a zone 20cm around the young tree: weeds in this zone need to be hand-pulled to minimize the disturbance and damage to the young trees' roots.**

**Slashing:** This is normally a full cover operation whereby the entire area is slashed or a spot operation where the weeds are only high in certain areas (e.g. the inter-row). There are no major skills required here but two points to note are:

- The slashing needs to be done as low as possible. People will tend to slash higher as it is easier. The vegetation is thinner and younger therefore softer. Supervision must ensure that the slashing is done as close to the ground as possible. This will reduce the slashing frequency.

- Care must be taken to not slash the tops of the trees off (known as 'Sheffield Blight'). One way of reducing this danger is by first doing a spot weed around the tree, thereby exposing the tree and creating a gap between the weeds being slashed and the trees. Another useful method is by placing a stick between the tree and the weeds to

*Ensuring a 1m diameter pit is kept clear - the basic SPGS standard.*

be slashed: this could be a walking stick that the labourer moves with, keeping it between the slasher and the tree so that it protects the tree from any misplaced slashing.

**Hoeing: Hoeing can be three different kinds:**

- **Spot hoeing.** The area immediately around the tree is hoed and the rest is left, slashed or sprayed with herbicide. It is recommended to weed a circular area of a minimum 1 metre diameter (i.e. 0.5m radius) around each tree.

- **Line hoeing.** The tree line is hoed and the inter-row (the row between the trees) is left, slashed or sprayed with herbicide. Line hoeing on a slope must be done along the contour to prevent erosion and if it is going to be sprayed with herbicide, spraying with herbicide on a slope is always done on the contour. A 1 metre strip is normally recommended for line weeding (i.e. 0.5m each side of the tree line).

- **Full cover hoeing.** The entire area is hoed. This method must not be done on erodable, steep slopes as there is no vegetation to prevent erosion.

**NB.** Hoeing must never take place within 20cm of the tree. The tree has many sensitive surface roots that will get damaged thus retard the growth if this area is hoed. Weeds in this zone need to be hand pulled.

A weed control programme may make use of any combination of the above weeding methods: each situation has its unique set of circumstances with regards to the weeds on the site and the situation regarding labour availability and skills' level.

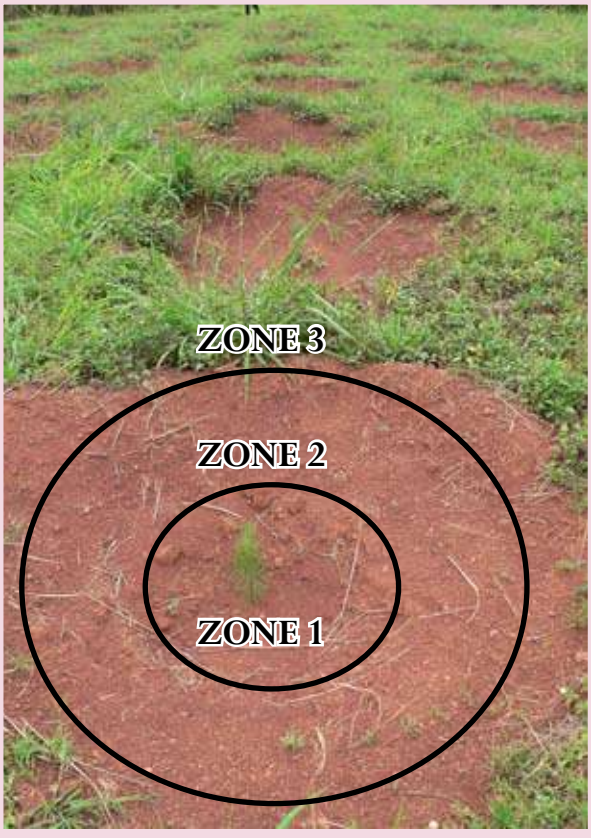
## 11.8 WEEDING ZONES

There are three main areas that need to be weeded:

**Zone 1-** This is the area within 20cm of the seedling. There are many of the seedlings' surface roots in this area. Weed infestation in this area therefore will compete hugely on the seedling. Also because of these surface roots only hand pulling of weeds should be done. A hoe scraping off weeds will cut and destroy the seedlings surface roots. In this zone the competition is high so no weeds should be allowed.

**Zone 2-** This is the area from 20cm to 1m from the seedling. This is another important area that needs to be kept clear of weeds. Here the weeds compete for nutrients as well as space and sunlight. Hoeing can be done in this zone. In this zone weeds should be kept to a minimum. Any weeds must only be young and small (having limited root development).

**Zone 3-** This is also called the inter-row. Small young weeds will not compete directly with the seedling. However as they get taller and their root systems develop, they will compete. Also mature weeds will seed and infest the other two zones. On slopes it is advised not to scrape this area, either use herbicide or slash to prevent soil



*Weeding Zones*

erosion. In this zone weeds should be kept below half a metre in height.

## 11.9 HOW TO ACHIEVE COST-EFFECTIVE WEEDING

1. Many of Uganda's existing and potential plantation sites have a climate and vegetation that encourages massive weed growth once the land is cleared and planted. Therefore, step one of a good weeding strategy will often be a good pre plant herbicide application, which will help all subsequent weeding and give the trees the best start possible (provided the pre plant spray is carried out close to the time of planting).

2. Remember that the gap between the first and second weeding may be short but the time will increase as you do successive weeding operations, as long as you don't let the weeds seed. If they seed you go back to step one.

3. A good herbicide operation will give you a longer period between weeding compared with manual weeding. This is because it kills the weed not just chopping them in half or moving them around.

**Table 18: Summary Comparison of Different Weeding Materials**

| | Chemical | Mechanical | Manual |
|---|---|---|---|
| **PROS:** | Very cost effective if carried out well and at the right time. | Cost effective if land is well prepared from the planning phase. | Relatively unskilled labour can carry out job. |
| | A well trained team can cover large areas each day. | Large areas can be completed quickly. | Cheap (and widely available) tools. |
| | Kills very persistent weeds (especially perennial grasses). | | Can be carried out in all weather and on all types of terrain. |
| | The weeds are suppressed for a longer time | | |
| | | | |
| **CONS:** | Weather dependent – not applicable in rainy and windy days | Weather dependent – some areas may not be accessible when wet. | Does not necessarily kill the weeds. |
| | Can cause serious damage to the tree crop if spray drifts during operation. | Requires accurate planting lines; fairly flat terrain and no obstacles to tractor. | Very time consuming (i.e. expensive) when weed growth is heavy. |
| | Can be expensive if not properly managed (herbicide will disappear!). | Equipment is expensive: requires a tractor in good working order. | Careless workers can damage tree roots (with hoes) or slice the tops of trees (slashers / pangas) |
| | Safety issue with workers | With careless operator can cause serious root damage to trees. | Physically difficult with certain tough or well established weed species. |
| | Must use well-trained team. | | Cultivation creates ideal seedbed conditions for weeds. |
| | Requires transport of water to field | | High labour requirement |

*RSA companies have a zero tolerance of weeds in eucalypt plantations (Mondi, RSA, 2007).*

4. During the wet season it is important to turn over weeds when hoed out, (roots in the air), if not they can just continue to grow in a new place.

5. Get as much of the root out as possible. Weeds store nutrients in the roots, by removing those nutrients it makes it more difficult for the remaining roots to sprout.

6. Slashing is quick and cheap but all it does is make the weeds shorter. Other than in grassy inter-rows, slashing should only be used as a preparation for a herbicide operation. Better still spray before they get too tall.

7. Refer to Section 11.8 on weeding zones. Weeds should not be tolerated within Zone 1. Weeds should be kept to the minimum in Zone 2 and never older mature weeds and weeds are allowed in Zone 3 but should be kept below half a metre in height.

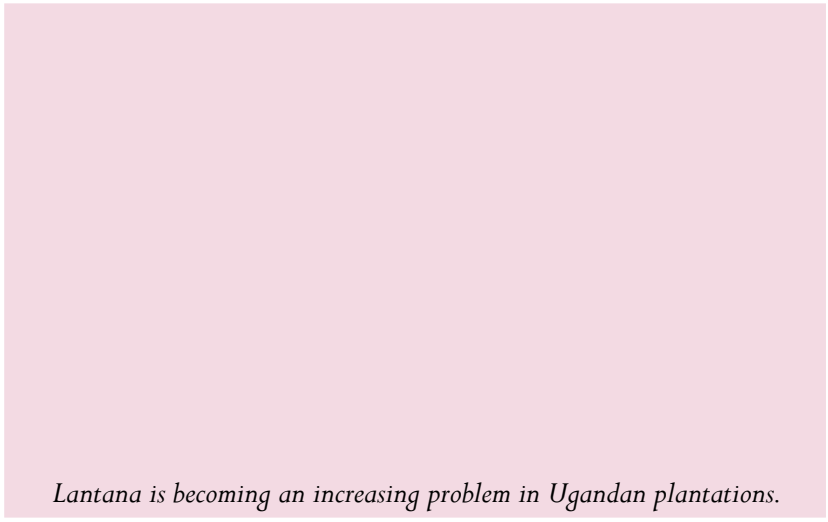
Remember the better the weeding, the quicker the trees will grow; the quicker the trees grow, the sooner it reaches canopy closure and the sooner it reaches canopy closure, the sooner you can stop weeding. It is as simple as that!

## 11.10 THE MAJOR PLANTATION WEEDS IN UGANDA

This section focuses on the main problem species commonly found in tree plantations in Uganda. The first three are all 'invasive' exotic species that have escaped cultivation and have become 'naturalised' in their new environment, whilst the next four species are all perennial grasses that are difficult to control.

***Lantana camara* (common name: lantana or tick-berry).**

Lantana is a heavily branched, perennial shrub that grows in compact clumps and forms dense thickets. It is native to Tropical America and has attractive flowers (in a variety of colours from cream and yellow, to orange-red and even purple), which is why the plant was introduced into many gardens in the first place. Lantana invades forest plantation margins, savanna woodlands, water courses, roadsides and degraded land. Its stem is usually covered with short, stiff hairs and



*Lantana is becoming an increasing problem in Ugandan plantations.*

recurved prickles. Its leaves are dark green, paler below, rough and hairy. It has glossy rounded fruits that are fleshy and purplish / black when ripe. These fruits are poisonous to children and livestock.

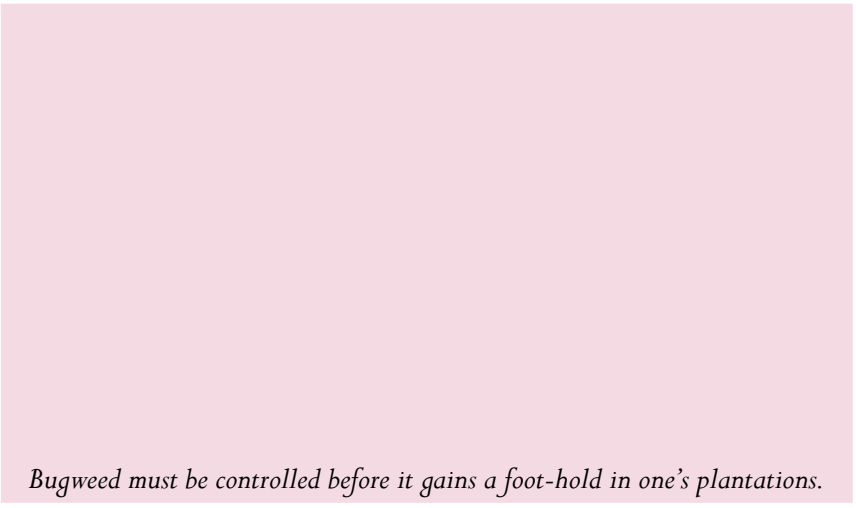
Lantana reproduces mainly by seed, which is spread by birds and some times by water. It flowers throughout the year and the tiny flowers are grouped in clusters approximately 2.5cm in diameter. It has a pungent smell when crushed. Lantana forms dense, impenetrable thickets, which not only suffocates the desired trees but also prevents access for management, fire fighting and harvesting. It can adapt to a variety of habitats and is now rapidly spreading through out much of Uganda.

**Control:** Lantana eradication is laborious and expensive and so any plants should be removed immediately upon detection. Once it has become a dense thicket, it becomes difficult (and more expensive) to remove. When small individual lantana plants are found, they can be best removed by manually pulling them out completely. This is more easily done when the soil is moist. In thickets of more established lantana, a combination of work is required namely:

- Cut off and remove the branches (and carefully burn them if possible).
- Allow the stumps to re-shoot and when no more than knee height (less than half a metre), apply a full cover spray with Glyphosate (a 3% solution).
- Repeat this operation until the stump no longer shoots.
- The above steps will be required to be done more than once, so monitor the site and spray on time. Spraying late or not following up at all will result in the re-establishment of the Lantana.

***Solanum mauritanum* (Bugweed, tobacco bush).**

Bugweed is a branched shrub or small tree that grows up to 5m high. It grows on forest edges, on road-sides, on wasteland, in urban spaces and along water courses. Its stems are mostly covered in whitish, felt-like hairs. Its leaves are large, dull-green and velvety above: the have a strong smell when crushed. The berries are first green then yellow in compact clusters. Bugweed causes serious problems in plantations as it can very quickly reach a height that will shade out the trees. Its fruits are attractive to birds, which eat the berries and transport the seeds for long distances to forest and scrub patches where they roost. In young forest plantations, feeding birds can perch on the young pine trees and break the growing tips.



*Bugweed must be controlled before it gains a foot-hold in one's plantations.*

**Control:** eradication of Bugweed can be done in several ways:

- By cutting it down and painting the stems with herbicides. Large numbers of seeds accumulate in the soil so follow-up control by hand or with herbicides is essential.
- By hand pulling them out when they are still small, this is very effective.
- Herbicide application (using Glyphosate at around 1.5% solution or 2 litres per hectare) can also be done if the foliage can be reached.

**NB.** When mechanically cleared, the clouds of fine hairs that are dislodged contain toxins that may cause respiratory problems in workers clearing these plants. In the control of bugweed, it should be noted that the smaller the bugweed, the better the results will be, as mature bugweed has an extensive root system.

### *Broussonetia papyrifera* (Paper Mulberry).

This deciduous tree occurs naturally in Japan and Taiwan but has become a major weed in many arts of the world. Like many invader species, it has spread from gardens where it was planted as an ornamental shrub. It grows to a height of about 15m. Its twigs are hairy reddish brown; the bark is tan and smooth; the wood is soft and brittle, opposite or whorled along the stem. The leaf margin is sharply toothed; the leaf base is heart-shaped to round with pointed tips, and the upper leaf surface has a rough feeling. It exudes a milky sap when cut. The fruits are reddish purple to orange, 1.5-2.0 cm in diameter.

In Uganda, paper mulberry has taken over some areas of Mabira CFR, where the natural forest trees had been cleared for agriculture in the past. It spreads by seed and through vegetative expansion, by producing new shoots from the roots. Paper mulberry is highly invasive and can spread very quickly so prompt action should be taken once it is found on one's plantation. The practice of harvesting small branches and leaves of paper mulberry to be used as animal fodder as

*Paper mulberry - a very agressive, woody weed.*

a means of control only assists in its spread and is thus not recommended. The control of Paper Mulberry is most effectively done by either chemical or manual means:

**Chemical means:** Basal bark, cut stem, hack-and-squirt, or injection methods of herbicide application are recommended because these methods, if used properly, focus the application onto the target species, minimize the overall amount of herbicide applied and reduce environmental impacts.

Basal bark application of the broadleaf systemic herbicide Garlon® 4 can also be used with a 50% mix in water for cut stump applications. Herbicide can also be applied using a hatchet to make angled cuts into the trunk, into which concentrated herbicide is squirted from a hand-held bottle. For this method, use a 10% mixture of Garlon® 4 in horticultural oil, or a 15% rate for larger trees. NB. Until Garlon® 4 or its equivalent is available in Uganda, however, a high concentration of Glyphosate (6 lt/ha or a 3% mixture can be tried).

**Manual means:** Pull seedlings by hand when the ground is moist ensuring that as much of the root is extracted as possible to reduce vegetative propagation. Seedlings need to be piled and burnt to prevent re-growth and spread. Multiple slashing operations will be required for larger trees, ensuring that all slashed material is collected and burnt to prevent spread.

*Elephant grass strongly competes with the young trees and must be controlled before planting.*

***Panicum maximum* (Guinea grass).**

This is a widespread vigorously growing indigenous grass, a principal weed in agriculture and a source of great concern in forestry. It is a perennial tufted grass with a short, creeping rhizome. It is robust with stems, which can reach a height of up (and in extreme cases beyond) 2 m. As the stems bend and nodes touch the ground, roots and new plants are formed. The leaf sheaths are found at the bases of the stems and are covered in fine hairs. It remains green until it ages, paving way for young shoots to grow.

*P. maximum* prefers fertile soil and is well adapted to a wide variety of conditions. It grows especially well in shaded, damp areas under trees and shrubs and is often seen along rivers. It has a high leaf and seed production and is very palatable to game and livestock. It is widely cultivated as pasture and is especially used to make good quality hay. If it receives adequate water, it grows rapidly and occurs in abundance. In Uganda it is used to make brooms. The harvesting process however leads to many seeds being dropped, which may germinate leading to more infestation. It is important to control this grass early, as plants that are not controlled at an early stage develop large perennial clumps. These clumps are tolerant to even the strongest herbicides and must usually be removed by hand (uprooting). Care must be taken to remove all germinating individuals as these may establish very soon and out compete the trees.

***Pennisetum purpureum* (elephant grass, napier grass, Uganda grass).**

This is a tall, robust, perennial, tufted grass that grows forming bamboo-like clumps or thick stems up to 4.5 metres high. It grows on moist soils in areas with over 1,000 mm of rainfall annually and widely distributed along the banks of watercourses. It grows best on deep, fertile soils. Its leaves are light green, blades up to 120mm long and 30mm wide, the margins thickened and spiny. It is usually cultivated for ornamental purposes and fodder. It invades forest margins, river-banks, valley floors in sub-Tropical regions. Its origin is Tropical Africa. It is a difficult grass to eradicate once it has established and requires an integrated approach involving both manual and chemical means. A high concentration of herbicide is required though. It is also important, easier and cheaper to eradicate elephant grass when it is still young (upon spotting).

***Cynodon dactylon* (couch grass).**

Commonly known as Olumbugu (Luganda), this weed is thought to have originated in Tropical Africa or Asia. It is now a widespread and troublesome weed reported to be the most widespread grass weed in the world. It creeps along the ground and roots wherever a node touches the ground, forming a dense mat.

*Couch grass forms a dense carpet.*

It is fast growing, tough and drought resistant. When damaged, it recovers quickly. It is also highly aggressive, crowding out most other grasses and invading other habitats, and has become an invasive species in some areas. It reproduces by means of an extensive system of stolons and underground rhizomes. It also disperses on animal hooves. It does not grow very tall, with a flowering stem rarely reaching 40cm. The seed heads are produced in a cluster of 3-7 spikes together at the top of the stem, each spike 3-6 cm long. It has a deep root system; in drought situations with penetrable soil, the root system can grow to over 2m deep, though most of the root mass is less than 60cm under the surface.

Because of its extensive underground system, this weed is extremely difficult to eradicate. Repeated ploughing and harrowing will give a fair degree of control by breaking up the runners and exposing them. This reduces the root reserves and increases the efficiency of herbicides when they are applied on the regrowth.

### *Imperata cylindrica* (spear grass, cogon grass).

This is a noxious grass weed in many regions of the world and one of the most troublesome grass weeds in some tropical countries. It estimated that the total coverage of *I. cylindrica* throughout the tropics is 2,000,000km² (natural grasslands included). This weed has a wide distribution, adaptation to a wide range of climatic conditions and soils. It has a high competitive ability. *I cylindrica* is a perennial grass growing up to 4m in height. The leaves are about 20cm long and 2cm wide, have a prominent white midrib, and end in a sharp point. Leaf margins are finely toothed and are embedded with silica crystals. The upper surface of the leaf blade is hairy near the base; the undersurface is usually hairless.

It occurs in moist places, tending to take over once it has established. It spreads by a system of underground rhizomes, which makes it difficult to

*Spear grass is very tough to control and must be pre-plant sprayed.*

eradicate. It invades agricultural areas, coastland, natural forests, planted forests, range/grasslands, riparian zones, scrub/shrub lands, urban areas and wetlands. Normally, it does not occur in closed forests but appears once the forests are opened up for agriculture or lumbering. In fact, *I. cylindrica* is very successful in areas that are frequently burnt, overgrazed or intensively cultivated; it rapidly colonizes disturbed sites.

It is resistant to many control methods including burning. Dry and vast *I. cylindrica* wastelands are highly prone to frequent and intense fires, which destroy native vegetation and hamper the succession of native plants by killing shoots. Natural regeneration of tree vegetation is usually retarded or impossible due to the weed's high competitive ability. Following fires, *I. cylindrica* regenerates very rapidly from its underground rhizome system and may dominate on sites previously disturbed by slash and burn agriculture for up to 7 years. Hand pulling is an option but is extremely labor intensive. Slashing will not help much either.

Burning alone is not an option, as it only stimulates additional weed growth. An integrated approach is best, utilizing burning to remove thatch layer, follow with mowing or dicing, and late season applications of a broad-spectrum herbicide such

*Excellent weed control in 3-mnth old E. grandis (James Finlay's Mwenge Tea Estate, 2003).*

as Glyphosate. Follow-up herbicide treatments at 4-6 month intervals are needed to clean up newly emerging weed.

## 11.11 SUMMARY

- Weeds are public enemy no. 1 in plantation forestry as they compete with the trees for nutrients, light and water. It is therefore important to keep plantations as free from weeds as possible.
- The best way of controlling weeds in plantation forestry is by starting to control them before planting (i.e. pre-plant weed control).
- Never let the weeds in a plantation get above shin height or else they will be difficult to control.
- Long-term maintenance requires that one's target weeds be killed before they produce seed.
- Various methods of weed control can be used for example chemical, manual, mechanical means and browsing. An integrated approach is usually the most effective especially on large, old established infestations of weeds.
- Herbicides should be applied when the weeds are still actively growing. Timing is important to maximize cost-effectiveness.
- Prevention is by far better than cure; fight the weeds before they become well established and hard to fight.
- Chemical weeding is often most cost-effective method of weed control in commercial forestry but this is only true when carried out properly, with adequately trained and carefully supervised staff.

## REFERENCES AND FURTHER READING

**Bromilow C, 2001.** Problem Plants of South Africa: a Guide to the identification and control of more than 300 invasive plants and other weeds. Briza Publications, RSA; pbk; 258pp.

**Schönau A.P.G., 1988.** Requirements for Intensive Silviculture. Paper presented at IUFRO Symposium on Forest Research: Future Needs in South Africa. 21pp. *Available from SPGS.*

# CHAPTER 12
# SAFE USE OF GLYPHOSATE HERBICIDE

*A contract team pre-plant spraying Glyphosate (Peak Timbers, Swaziland, 2009). Good training of the spray team is essential for success*

## 12.1 WHY USE HERBICIDE?

Herbicides provide us with a means to control weeds –

- ***Quickly:*** it is much quicker to spray a hectare than to manually hoe it.
- ***For a longer period:*** with using a herbicide the weeds are suppressed for a longer period. The dead material also suppresses seed germination. A manual operation opens up the area for seeds to grow and often a hoed weed just re-roots and carries on growing.
- ***Making weeding easier in the future:*** The herbicide when used correctly kills the hardier species of weeds and subsequent weeds are normally softer annuals and grasses that are easier to control.
- ***With less labour:*** With a small, well-trained spraying team, a larger area can be controlled. This allows for the labour to be used more efficiently and releases them for other forestry operations.

For these reasons the herbicide weed control operation can be very cost effective ***but only*** where the spraying operation is planned carefully and carried out by well-trained (and supervised) personnel. Thorough weeding before and in the early establishment phase of tree plantations is the surest way to achieve every commercial growers' objective – namely - fast growing, high yielding plantations.

**Chemical weeding using Glyphosate can be very cost-effective and save labour but only where the spraying operation is planned carefully and carried out by well trained (and supervised) personnel.**

## 12.2 GLYPHOSATE

**Glyphosate:** The most commonly used herbicide in forestry operations worldwide is Glyphosate. Glyphosate is the active ingredient (a.i.); the herbicide, however, is sold under many different trade names – e.g. Roundup, Mamba, Pin Up, Glyphogan, Kalach. Glyphosate costs around Ushs 18,000 per litre - depending on one's negotiating powers (often related to the quantities being purchased). You must however check that the Glyphosate you buy contains the minimum of 360 g/l of the active ingredient - Glyphosate or Phosphonic acid as isopropylamine salt.

**How safe is Glyphosate to people?** All chemicals are graded according to a lethal dosage (LD) scale. This scale is determined by experimenting to see how much of the chemical is required to kill half (50%) of the experimental population. The scale is referred to as the LD50 scale. The oral LD50 of Glyphosate is 5000mg per kilogram of body weight. This means for every kg a person weighs they would have to drink 5 litres of chemical to have a 50% chance of dying. The classification is therefore "practically non toxic".

**How safe is Glyphosate to the environment?** Glyphosate is quickly and completely biodegradable when it comes into contact with soil microorganisms. Because it completely biodegrades it does not build up over time - no matter how many times you spray onto a specific area. As with all chemicals, they should only be used as instructed on their labels.

**How Does Glyphosate Work?** Glyphosate is a systemic herbicide, which means that it is absorbed through the leaves of a plant and moves down into the plants' roots. Here it stops the plant from making the amino acids required for the growth of the plant causing it to die. This does take some time, however, so don't expect to see dead weeds the next day! Yellowing will normally be seen within a week or two. Glyphosate will kill all green plants and thus it is also classed as a non-selective herbicide.

**Important Points to Remember:**

- Because Glyphosate biodegrades when in contact with soil, it will start biodegrading if mixed with dirty water or if sprayed onto dusty leaves. Even in clean water it will biodegrade with time so it is important to use what is mixed the same day and not keep the mix overnight. This is why we mix into the knapsack as described later on and also why pre-mixing the spray solution in large drums is not good practice.

**Remember - Glyphosate is a non-selective herbicide: thus it will kill trees as well as weeds!**

- Because it is a systemic herbicide it needs to stay on the leaves for a while to work. Glyphosate has a rain-fastness of 4 hours, which means if it is washed off before then it may not work properly. This can also happen if the leaves of the plant are covered in dew in the morning. Additives (also called wetting agents) may be added to Glyphosate to improve its rain-fastness – examples are Frigate and Armoblen: check with your herbicide supplier and the additive's label for details. Companies in RSA are increasingly using Roundup Max, which is rain-fast in just 30 minutes (having an additive included in its formulation).

- Because Glyphosate is non-selective it will affect all plants it is sprayed onto, even the ones we don't want to kill if it lands there. We must therefore be careful to ensure that it lands only where we want it to. We can do this by making sure the conditions are correct; that no wind is blowing and by keeping the nozzle at the correct height.

## 12.3 PLANNING FOR SPRAYING

A crucial part of using herbicides is proper planning and timing. This is so that we apply the herbicide on the weeds at the right time and at the right dose. Because we aren't going to spray when it is windy or if it might rain, we need to be spraying at every opportunity we can. This means that most often we will have to switch

*Trainees on an SPGS course - good team work is essential (Kyenjojo, 2006).*

what activities we are doing once or even twice in a day. To be able to do this we need to have planned for it (refer Annex. C).

To plan properly we need to know the following:

- The **area** to be sprayed, the terrain, accessibility and possible water supplies.
- **The weed profile:** what are the target weeds? Which weed type is dominant? How tall are the weeds? Are they actively growing or seeding? (NB. refer Chapter 11).
- From the above you will determine how much **Glyphosate** is needed per ha and from the calibration you will know how much Glyphosate and water is needed for a days work.
- What **resources** are available (labour, knapsack sprayers, transport etc).

All of the above points need to be known beforehand and must fit in with your other forward planning such as clearing, lining out, pitting and planting plans. All of these activities are interlinked and changes to one affect the others.

The importance of appropriate timing for spraying cannot be overemphasized. Spraying at the wrong time can be an expensive mistake: conversely, a well-timed spraying operation can be the most cost-effective weed control method for establishing tree plantations. The spraying operation must be done timously to ensure that:

- The negative influence of competition to the planted trees is minimized.
- The young weeds get sprayed over their complete leaf area.
- The weeds are young and growing vigorously, therefore more susceptible to the Glyphosate.
- Less herbicide will be required to kill young weeds.
- The weed has not yet had a chance to flower and seed.
- The nozzle does not have to be raised thereby increasing the chance of spray drift.

*Achieving this level of weed control requires good planning and timing of Glyphosate application (Shiselweni Forestry, Swaziland, 2007).*

## 12.4 GLYPHOSATE RATES

The application rates for Glyphosate depend to a great extent on a). the target weed species and b). the size (age) of the target weed(s).

Table 19 gives the recommended rates of Glyphosate in litres of herbicide per sprayed hectare. Remember that these recommendations can and will change as circumstances change.

By maintaining records and actively managing your herbicide operations you will develop a local knowledge regarding what rates your areas and weeds require for a good herbicide operation (rates based on Mamba 360sl).

**Remember always use according to the label on the herbicide and follow the operating instructions that come with the equipment.**

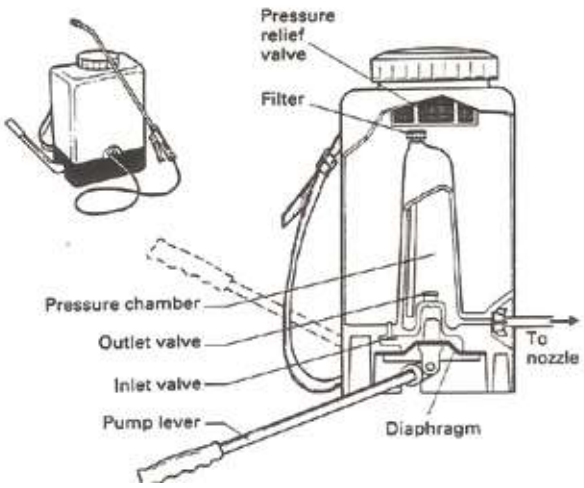
**Table 19. Recommended Dosage for Glyphosate**

| Weed type | Rate per ha. | Comments |
|---|---|---|
| Perennial broadleaves | 4–6 lt/ha | Below 60cm in height, not regrowth |
| Annual broadleaves | 2-4 lt/ha | Before weed develop a woody stem. |
| Grasses | 4-6 lt/ha | Actively growing before any leaf dieback |
| Sedges | 6-8 lt/ha | At flowering stage |

## 12.5 SPRAY EQUIPMENT

There are many ways to apply herbicides. We will however, in this guideline, concentrate on the knapsack sprayer method. This basic spraying system consists of a knapsack and a nozzle:

*Diagram of a typical knapsack spray unit.*




**The knapsack:**

- A tank with a lid and sieve. A gauge is normally molded into the side to indicate the level of mix.
- Inside the tank is the pump mechanism, mostly either a piston or diaphragm type.
- A handle to work the pump.
- A hose leading from the tank/pump to the lance.
- The lance - with a trigger, which controls the flow of mix down the tube and a tube, which carries the mix to the nozzle.

**The nozzle:**

There are many types of nozzles for different applications, for general line or blanket spraying we will use a flat fan nozzle. The width of the fan pattern depends on the specific nozzle – the one recommended for pre-plant spraying is a red flat fan, which has a 1.8m width. The nozzle must be kept clean and cared for. It must not be cleaned with any sharp or abrasive material or wire. The size of the hole is vital to its spraying pattern and volume output.

## 12.6 SAFETY & OPERATIONAL ISSUES

Any chemical should only be handled and used according to its instructions. We should also treat any chemical as dangerous even when using a relatively safe one like Glyphosate (NB. these rules also apply to the chemicals in your house such as detergents and insecticides).

*SPGS's Bric Milligan at an SPGS course - sound training before spraying is essential (Katugo, 2005).*

**For this reason we should treat Glyphosate with care and abide by the following rules:**

- Ensure rubber gloves are used by those handling the undiluted chemical.
- Ensure all those handling herbicides wear the correct personal protective equipment (PPE): one-piece, cotton overalls and gumboots are recommended (NB. the overalls' legs must not be tucked into the gumboots). Face masks (or respirators) may be required for operators using some chemicals too.
- Ensure that soap and water are always available for members of the spray team. This is used in case of accidental exposure to the herbicide and to wash hands before eating and/or smoking.
- All equipment must be in good working order: this applies to the spraying equipment as well as PPE. Leaks with knapsacks are common but they must be corrected before spraying.
- Always follow the instructions of the chemical and equipment used: the label should always have application and safety information. NB. Do not buy unmarked or unsealed containers or from unscrupulous dealers: they are highly likely to have diluted the chemical(s).
- Always consider the weather conditions: do not spray when it is windy or if rain is likely within 4 hours (unless using an additive – see Section 12.2).
- Avoid inhalation of spray mist and fumes.
- Prevent contamination of food, foodstuffs, drinking water and eating utensils.
- Do not mix, store or apply Glyphosate solutions in galvanized steel or unlined steel (except stainless steel) containers.
- Store away from any feed, seed, fertilizers and other agricultural chemicals.
- Dispose of used containers in the correct manner (normally by puncturing containers and burning in a pit – well away from any residences or water courses) - see Section 12.9.
- Always keep the nozzle at the correct height for the application: 0.5 metres is optimal.

- Only allow trained personnel to spray herbicides: the Supervisor must have attended an SPGS herbicide training course.

- Ensure the low pressure setting is selected (where applicable), for knapsack herbicide use (high pressure is used for pesticides and will increase drift).

**First Aid:** In case of skin or eye contact wash immediately with plenty of water and in the case of eyes get medical attention if necessary. Glyphosate is poisonous if swallowed.

**Always use chemicals responsibly and follow the instructions on the container's label.**

## 12.7 PEOPLE AND PRODUCTIVITY

One of the most important things you have to get right when applying herbicides is to train and motivate a team to working productively and safely. It is these people that will make the application successful or not. They therefore need to be trained properly and supervised correctly. They need to work as a team and as they get experience they will learn together as a team. This experience is invaluable and if you have a high turnover of people it gets lost and mistakes happen. Incentives to encourage this team to apply the herbicide effectively and correctly should be considered. They need to move at the same speed to ensure that the herbicide is applied evenly and at the correct dosage. That is why practicing as a team is so important as well as keeping the people that have been trained (and gained spraying experience) together. Some areas where performance can be measured are:

- **Effectiveness?** Were the weeds killed? Remember you will only be able to judge this after 2 to 3 weeks. If the work was not effective you will have to return and weed again sooner than you should. That costs you money.

- **Dosage?** Was the correct amount of herbicide applied per ha? Here you will look at effectiveness and your stock records. Too much and your money is being wasted, to little and your effectiveness is reduced.

- **Damage?** Was there any damage to my trees caused by spray drift or careless spraying? Again you will only be able to judge this after 2 to 3 weeks. Damage to your trees reduces their performance and can kill them.

- **Production?** Did the spray team do the area required? Here you would use your daily work records. You have an amount of area that needs to be sprayed in a limited time, if the work is not done in a productive manner you will not get it done in time.

*Spraying Glyphosate post-plant must be done very carefully (NFA, Kyenjojo, 2005).*

## 12.8 CALIBRATION

**Why do we calibrate?** Calibration is essential to determine how much chemical and how much total solution to spray onto the target weed to achieve the desired control. Calibration is necessary because knapsack sprayers have different characteristics and a range of nozzles and these may have different outputs. We have to know how much a specific knapsack and nozzle combination is pushing out in order to get the correct amount of chemical onto the target weeds. Walking speeds also vary according to personnel and terrain.

Another reason is that Glyphosate requires a minimum amount of water to be applied (about 250 lts per ha). If we mix with too little water (perhaps because it is flat and everyone is walking fast), it may mean that not enough solution is being applied for it to work properly. In cases like this the people will have to slow down but we can only know when we calibrate the equipment.

**Calibration method:** NB. Please refer to annexure A:

1. First work out how much mix is being sprayed out over a known area. We mark off a measured area, normally 50 or 100 meters. We also measure out the spray width that the nozzle has when held at the correct height. With these to we can work out the area (length x width).

2. We now measure the time it takes to cover this distance by timing the person. Please note that it is important that the walking conditions should be similar to those which will be encountered during the actual spraying operation. For example a person will walk slower on a steep, rocky area than on a flat, clear area. When the conditions change a re-calibration should be done.

3. We now spray out the mix for the time calculated in step 2, into a measuring container to work out how much mix gets sprayed onto the measured area.

4. Now we can put these figures into the formulae to figure out how much mix will be sprayed onto a hectare and also how many knapsacks full will it take to spray a hectare. This is needed in order to put the correct amount of Glyphosate into each knapsack every time it is refilled.

*Good results from post-plant spraying with Glyphosate (NFA, Masindi, 2006).*

**Common calibration problems** are as follows:

- Some sprayers walking too fast (thereby not putting sufficient solution on the target weeds).

- Nozzles held too low (thereby not achieving the correct spray pattern and leading to some areas being unsprayed).
- Sprayers not following the correct line(s) – causing some areas to get missed and some areas to receive double doses).
- Waving of the lances causing spots to be missed and possible drift onto the planted trees.

**Mixing:** Because the Glyphosate biodegrades over time we need to only mix what we are going to use immediately. Fill up the knapsack spray-tank to the half way mark. Add the correct amount of Glyphosate (as determined from the calibration exercise). Continue filling the tank to the full mark. Always add the herbicide and water through the sieve at the top of the knapsack and then tighten the lid. Only a person trained to do so and wearing the correct PPE should handle the Glyphosate concentrate.

## 12.9 STOCK CONTROL & DISPOSAL OF EMPTY CONTAINERS

All stock entering the store, be it new stock or unused Glyphosate returning from field, and stock issued from the store must be registered in a Herbicide Register. The number of containers received must also be indicated. Stock issued and used must be reconciled to the area and site sprayed (see Annex. B). All empty containers must be returned to the store and logged in the register. They must also be punctured to render them useless immediately.

When enough empty and punctured containers have accumulated they must be thrown into a pit. The store man must cover his mouth and nose with a particle mask or by other effective means. After checking that the smoke will not blow into any inhabited area or where there may be a fire danger, he will set light to the empty containers. Once the fire has burnt out he will cover the molten containers with a thin layer of soil. He will record how many containers were burnt and the date on which he did so.

## 12.10 PRE OR POST-PLANT SPRAY?

Glyphosate affects all green plant material, for this reason we need to be sure that we do not get any on our trees. This is why we recommend the application of Glyphosate pre-plant, where there is no chance of the trees being affected. A pre-plant spray will also provide the optimum growing environment for our seedlings: by timing it so that the spraying operation is just before we plant, we have a reasonable period of time when the weeds do not compete with our seedlings. This pre-plant spray will also influence the type and intensity of the weeds that eventually grow.

Post-plant spraying of Glyphosate is also carried out routinely by most commercial forestry companies but should only be undertaken by skilled (and well supervised) workers. Problems post-plant - especially spray drift onto the planted crop – can be very expensive and result in a patchy (or even a failed) plantation. Post-plant use of Glyphosate requires either covering the trees with some form of protection from the spray or very careful operation to ensure the chemical does not reach the planted crop.

## 12.11 PROTECTING THE PLANTED CROP

There are many different ways one can protect the trees from the herbicide but the most common are the use of upturned buckets, custom-made cones or using some form of shield.

**Buckets and Cones:** Make sure that the trees are small enough to fit inside the upturned bucket without touching the top. If the bucket is placed over a tree that is too big there is a good chance that the tip of the tree will get broken. Some of the spray team place the buckets over the trees in the area to be sprayed, ensuring that trees to the left and right of the sprayers are also covered. The sprayers can then proceed to spray

the protected area. Once the sprayers have passed some protected trees, the bucket gang can start collecting them to place over trees in front of the sprayers. The quicker the bucket gang can move the buckets to in front of the sprayers, the less time the sprayers will have to wait for trees to be covered. So the buckets roll forward covering trees in front and opening trees that have been passed. Some things to note:

- Do not stack the wet buckets as you will then be transferring Glyphosate from outside the bucket to the inside where the tree will be, which will increase the chance that the tree will get damaged.
- Do not leave the trees covered too long. It gets hot very quickly inside the buckets and if the buckets were left over the trees whilst the gang took a break, it literally cooks the trees inside.
- Do not let the sprayers run ahead of the bucket gang: the team can only move as fast as the buckets.
- The vegetation being sprayed must not spring back onto the trees as this will transfer herbicide onto them.

*Chemical coning operation using Glyphosate (RSA, 2004).*

**Shields:** Using shields is normally only possible when doing a line spraying operation. The sprayer walks down the inter-row with two people carrying a shield on either side of him. The shields prevent the herbicide from touching the trees. As long as they all walk at the same speed this is quite a quick operation, but because the protection of the trees from the spray is limited it must only be done is windless conditions and only when the trees are well above the vegetation being sprayed. Some things to note:

- The shields should be in line with the nozzle of the sprayer and not the sprayer himself.
- The shields should be kept as close to the ground as possible so as to prevent drift from going under the shields.
- The vegetation being sprayed must not spring back onto the trees as this will transfer herbicide onto them.

**Spraying with no protection:** It is possible to spray without any protection, referred to as 'open nozzle' spraying. This, however, should only be done by experienced sprayers and in windless conditions where the trees are large (spray drift sprayed onto the brown bark of older trees' stems does little damage but it will kill young trees with green bark). The spraying team also needs to be experienced enough to judge when to stop if the conditions change.

Because spraying herbicides need certain weather conditions in order to be effective and to minimize the risk to your trees, you will be forced to either not spray or reduce the hours you spray in the day. This has two major effects: firstly you

need to allow for time to complete your spraying, so don't wait till the trees are overgrown before spraying - rather spray slightly to early than to late. Secondly, you need to have alternative work available for your team in case the weather is bad and you need to be organized so that when the weather is good (remember the weather does not only go from good to bad, you will find that a day that starts out bad with regard to spraying weather can improve later on), you can start spraying quickly and not be running around trying to find equipment, people, water or even a place to spray. As with all silvicultural operations, careful planning and good timing of a chemical spraying operation is the recipe for success. Table 20 summarises the key points from the Chapter.

*Demonstrating spraying Glyphosate post-plant using shields (Corewoods, Hoima, 2007).*

**TABLE 20: KEY CHECK POINTS FOR SUCCESSFUL AND SAFE USE OF GLYPHOSATE.**

1. **Buy only good quality knapsacks, which have spare parts available in country.**
2. **Only buy from reputable dealers and only accept sealed containers with the original manufacturer's label on.**
3. **Read the herbicide's label carefully.**
4. **Ensure the correct nozzles are used for the job in hand.**
5. **Identify the target weed (s).**
6. **Time the operation so that the target weed is at the right stage of development for cost-effective treatment.**
7. **If pre-plant spraying with Glyphosate, time the operation so the spraying operation is carried out as close as possible to when the site will be planted.**
8. **Regularly calibrate equipment and spend time training a spray-team.**
9. **Spray operators must wear overalls, gumboots and other appropriate protective equipment at all times.**
10. **The knapsack sprayers must be regularly inspected for leaks and to ensure that they are in good working order.**
11. **Spraying must only be carried out under favourable weather conditions.**
12. **Spray operators must be provided with clean water and soap for washing with on site.**
13. **The herbicide containers must be properly (and securely) stored and empty ones punctured and disposed of properly to avoid re-use.**
14. **Any undesirable effects observed during or after the application of herbicide should be mitigated.**

# ANNEX A

## HERBICIDE CALIBRATION

In order to calibrate our knapsack we need to work out how much water they will apply per hectare and how many knapsacks full of water will be needed to do that. Things that affect or change this are:

1. Terrain.
2. Walking speed.
3. Pressure.
4. Nozzles.

What you will need is:

- A stopwatch or method for measuring the time in seconds.
- A measuring cylinder.
- A knapsack of the same type with the same nozzle as you will be using.
- A bucket.
- A long tape measure (preferably 50m).
- A calculator.

**Here is how we do the calibration:**

| | |
|---|---|
| **Step 1** | We need to work out what the area of the test (calibration) plot is. We do this by multiplying the length by the breadth. Plot length by the width of the spray (swath). |
| **Step 2** | Now that we know how big the plot is we can work out how many of these plots would fit into one hectare. A hectare is 10,000 $m^2$ so we divide our plot area into that. |
| **Step 3** | Now that we know how many plots will cover a hectare we must work out how much water we put onto our plot. We do that by timing how long it takes to spray the plot (in the conditions you will be spraying so that the walking speed is as close as it will be when doing you are actually spraying). Once we have the time we measure into a measuring jug the amount of water that would be sprayed in that time. (Pumping at the speed you will be when doing the actual spraying). This will give you the volume you would have applied onto the plot. You will need to convert this volume to litres if it isn't in litres already. |
| **Step 4** | Now we multiply this volume by how many plots will be in a hectare and we have how many litres of water will have been applied per ha. This will help you to make sure that you have enough water on site to spray the area. |
| **Step 5** | To work out how many knapsacks full this would be we simply divide the total volume per hectare by the size of the knapsack. This would normally be 16 or 20 litres. |
| **Step 6** | To work out the amount of Glyphosate that needs to be mixed into each knapsack when spraying in order to apply the correct dosage per hectare we divide the recommended rate by the number of knapsacks full required per ha. |

Here is an example;

1. 50m (length) X 2m (spray swath/ width) = 100m$^2$ test plot.
2. 10,000/100 = 100 test plots per ha.
3. We will pretend that it took 90 seconds to spray our test plot and that 2800ml was applied. (2.8 litres)
4. 2.8 litres X 100 test plots = 280 litres per ha.
5. In this case we have a 16 litre knapsack so 280/16 = 17.5 knapsacks per ha which we will round down to 17.
6. So if our recommended rate were 5 litres of Glyphosate per ha it would be 5/17 = 0.29 litres of Glyphosate per knapsack.

## ANNEX B

## CHEMICAL STORE REGISTER

| Date | Opening Stock | Issued | Balance | Mixture | Application Method | Destination (Comp no) | Usage Per Ha |
|---|---|---|---|---|---|---|---|
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| Balance C/O | | | | | | | |

***Annex C***

| FARM or SECTION: | | | | GLYPHOSATE REQUIREMENTS for 20……. | | | | | | SITUATION: | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | ACTUAL PERFORMANCE AND COSTS | | | |
| Block No. | Total Area Ha. | Area to be Treated Ha. | Rate ℓ/ha | Total ℓ Req. | Spraying Labour: Man-days | Water Required Daily | Date for Treatment | Problem ? | Est. Cost/ Planted Ha. | ℓ Used | Man-days | Total Cost | Cost per Planted |
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TWEEFONTE

# CHAPTER 13
# LAND PREPARATION

*Lining out, pitting and pre-plant weed control are key elements that determine whether a plantation is established successfully or not (Komatiland Forests, RSA, 2008)*

## 13.1 INTRODUCTION

Land preparation is an important part of establishment with the aim of achieving high survival and rapid early growth of the planted trees. Some form of land preparation is always necessary in order to achieve successful plantation establishment. It achieves this largely by removing (or controlling) the competing vegetation and by cultivation of the soil, which encourages fast root development of the newly planted seedlings. It is often the most costly silvicultural operation though choosing the most appropriate techniques and good timing can significantly reduce these costs.

Land preparation encompasses several separate activities, namely - clearing (often combined with burning), lining out and pitting. NB. Pre-plant spraying is also considered a land preparation activity but is dealt with in detail in Chapter 13 – *Safe Use of Glyphosate Herbicide*.

## 13.2 INITIAL CLEARING

Initial clearing is the removal of the vegetation that occurs on the site to be planted. It is important to note that the SPGS does not support the clearing of natural high forest for plantations.

*Mechanical land clearance can be very cost-effective if well planned*

The land for plantations should be grassland, land previously under plantations or heavily degraded natural forest land only. Also note that even on degraded areas where there are patches of natural vegetation occurring in valley bottoms and along rivers and streams, these should not be cleared but left for conservation purposes. Similarly, any wetland areas must not be cleared (or planted).

Land clearing can be done in a number of ways depending on the nature of the vegetation e.g:

- Manual cutting and/or slashing.
- Burning.
- Spraying with herbicide.
- Mechanical means such as mulchers or bulldozers.

Often combinations of two or more of the above are used. Whatever method is used, it is important that the area is cleared properly since the initial clearing prepares the land for all subsequent operations (e.g. lining out, pitting and pre-plant spraying). When done properly it has a positive effect of reducing the cost of following operations. Two major factors are:

1. The site must be well cleared and access uninhibited for subsequent operations. All the vegetation must be cut down to ground level and burnt or otherwise removed. By cutting the vegetation down at ground level, it means that there are no high stumps to get caught up in. Also, if the stumps coppice, the regrowth comes from close to the ground and is easier to control.

2. All or most of the vegetation must be killed. Eliminating the weeds before planting ensures that the trees we

plant have the space, nutrients and water they need to establish themselves quickly. It is also easier to use herbicides before planting. Good initial clearing helps us with all subsequent weeding operations.

**It is important that the area is cleared properly since the initial clearing prepares the land for all subsequent operations. When done properly it has the positive effect of reducing the cost of following operations.**

Often a combination of manual slashing, which target all the smaller shrubs and trees, and a power saw is employed – the saw being used to fell the bigger trees. This allows the cheaper method of slashing to be the primary source of work done while the more expensive power saw comes in later and only does what it is designed to do. Also by opening up the area first manually, the chain saw operator can work more safely. NB. Always ensure that the chainsaw operator is properly trained and has the appropriate PPE (refer Chapter 3 – *Planning*).

Some of the larger commercial planters use bulldozers to assist with the clearing. Although this can be very cost-effective, like most other forms of mechanization it can be very costly if the machine is allowed to work unproductively. To avoid this it is important to agree on the area to be cleared in a specific time period. Generally it is advisable to pay per area cleared and not for the time used. When using a bulldozer it is important that it works along the contours in areas where there is a slope - this is to avoid all the trash from being pushed into streams or natural areas as well as to help in protecting against erosion.

## 13.3 BURNING

Once the vegetation has been cleared, it can be either left on site to rot down naturally or be burnt. The former option is really only possible where there is little trash - otherwise, the material physically makes it impossible to plant and weed properly. There are two schools of thought about burning: on the one hand a well burnt, clear site makes all subsequent operations much easier. Conversely, a burn that is hot may alter some of the soil properties, making it very difficult to establish the tree crop.

We believe that were there is a lot of trash from the land clearance operations, the best option is to have a controlled, cool burn. The burn will be more successful if the cut vegetation has dried out for a period following cutting. The trash will also burn better if it has been piled together rather than scattered through out the area. Care must be taken only to burn when conditions are favourable (i.e. Fire Danger Index must not be high – refer to Chapter 16 - *Fire Protection*). Do not burn on windy days and ensure there are sufficient people (with suitable fire fighting equipment) on stand by during the burning.

*Controlled burning of trash prior to pitting & planting.*

In certain circumstances - especially where there is woody vegetation being cleared – there may be opportunities to reduce the land clearance costs by allowing people to come in and clear the area to make charcoal: this requires planning well in advance, however, so that the area is cleared in good time for subsequent operations. Remember though that any important conservation areas that were identified in the planning phase (e.g. wetlands and areas of intact forest) must not be cleared during this process.

## 13.4 THE IMPORTANCE OF GOOD TIMING

As with all silvicultural operations, the timing of land preparation is crucial for its success. Manual clearing - the most common method currently used in Uganda - can be very labour intensive, which means it can take a long time to clear a small area.

Whatever method of land clearing is employed, however, it is important to allow enough time ahead of planting so that the vegetation can be cut, piled, dried and burnt. Where pre-plant spraying with Glyphosate is planned, (this is recommended for all those planting on large scale), time must also be allowed for a flush of weeds to grow so that they can be sprayed with the herbicide just before planting,

## 13.5 ESPACEMENT

Plant espacement refers to the distance between plants, which determines the plant density (known as the stocking) on that particular site. There are an infinite number of different spacings that can be used but researchers have narrowed it down to a common range for various site types, species and end product. Table 21 shows the common spacing for the main species being grown in Uganda.

**Table 21. Common Plant Espacements for Uganda**

| Species | Spacing (m) | Stocking (sph) | Comments |
|---|---|---|---|
| Pines | 2.7 x 2.7 | 1372 | The traditional spacing of 9' x 9'. |
| | 3.0 x 2.5 | 1333 | With seed which is not highly improved |
| | 3.0 x 3.0 | 1111 | With highly improved seed for sawlogs |
| Eucalypts | 3.0 x 2.0 | 1667 | Where a good market for early thinnings exists or for a purely fuelwood regime |
| | 3.0 x 2.5 | 1333 | For sawlogs and large poles |
| | 3.0 x 3.0 | 1111 | For sawlogs where no market for thinnings |
| Musizi | 3.0 x 3.0 | 1111 | |
| | 4.0 x 3.0 | 833 | |

To work out the stocking (sph) of any chosen espacement (e.g. 3.0 x 2.7m), follow this example:

- Remember that 1 hectare is 100 x 100m.
- Divide your chosen espacement between each row into 100 (e.g. 100 ÷ 3.0 = 33.33).
- Divide your chosen espacement within each row into 100 (e.g. 100 ÷ 2.7 = 37.04).
- Multiply these 2 figures together to get the sph (33.33 x 37.04 = 1234 sph).

NB. It makes little difference to tree growth or form by not having square espacement: the trees compensate and utilize whatever space they have (and surprisingly, still grow cylindrically!).

The main features that influence plant espacement are:

- **Seed quality:** when using improved genetic material, there is less need to 'compensate' for poor trees by planting at a higher stocking.

- **The objective of planting:** closer spacing can be used when growing for fuelwood, as one will end up with high volumes but small trees.

- **The availability of markets for thinning material:** if near a good market for small poles, for example, it would make sense to plant a higher stocking of eucalypts (NB. When growing sawlogs, thinning must still be done on time and to the recommended stockings referred to in Chapter 20 – *Thinning*).

*Good land clearance makes all subsequent operations much easier (NFA, Masindi, 2005)*

- **The method of weed control to be used:** e.g. wider rows can be used where mechanical weed control is to be used.

## 13.6 LINING OUT

The espacement is determined during the lining-out operation. Good lining-out not only ensures the right stocking (sph) on the site but also determines the layout of the plantation. Planting one's trees in straight lines also makes all subsequent operations much easier - for instance, weeding, planting, thinning and eventually harvesting.

*Making charcoal during land clearance (NFA, S. Busoga CFR, 2003)*

The following points explain how to line-out successfully:

1. First, lay out a line (cable or rope) marked at intervals with one's

*Trainees lining out at an SPGS training course*

desired tree spacing: preferably this should be along the edge of the area to be planted: this is called the base line.

2. Then mark off two cross-lines at each end of the baseline at 90°. The 90° can be worked out by using a compass or the 3, 4, 5 rule (see text box). The cross-lines need also to be marked with the correct planting espacement (e.g. 3.0 m).

3. Now move the base line up between the two cross-lines, stopping at each mark and marking the pits on the ground at the marks along the line. Marking is best done by making a small hole in the soil with a sharp tool – sufficient for the people pitting to clearly see.

4. When you get to the end of the cross-lines, start over again in the area adjacent to the one you just marked.

5. The method on steep slopes is quite similar but the cross-lines need to be held level and not along the ground. The planting sites are then marked by dropping a line from the rope to the ground. If this isn't done the espacement is reduced and results into overstocking (increased sph).

## 13.7 PITTING

Pits are the holes into which you are going to plant your seedling. The recommended tool for pitting is a pick-mattock (hoes should only be used where the land is very easy to cultivate).

1. First, clear any vegetation or debris from an area of 1m diameter around the planting hole.
2. Then dig the pit itself in the centre of the cleared area. The pitting standard is 25cm deep and 25cm diameter. Loosen the soil and work around the pit digging from different sides to ensure that the pit does not go down at an angle. The soil must be loosened and large clods broken down. Rocks should also be removed.
3. All the soil should be replaced into the pit forming a slight mound.

**Timing of pitting:** The ideal time of pitting is when the ground is at least a bit moist from early

*A pick-mattock is the best tool for pitting (SPGS Training Course at Oruha CFR, Kyenjojo, 2007)*

*Introducing Mr Quality Controller - to check pitting.*

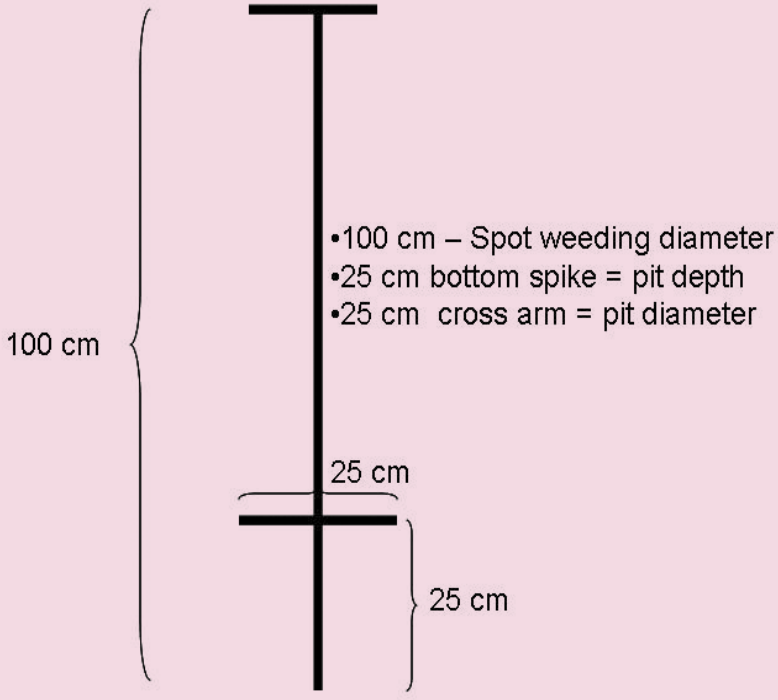
rains: it is not good practice to prepare the pits too far in advance of planting as they can become compacted in time and they can also be difficult to find after heavy rain on the site. Good pitting basically creates the best environment for the young seedling's roots to grow fast. Below are some more scientific reasons to explain the benefits of pitting:

- decreases the soil bulk density and physical strength;
- improves water infiltration rates;
- promotes higher oxygen diffusion rates;
- increases the rate of organic matter decomposition in the topsoil;
- removes weed competition from the area where the seedling will be planted.

**Please remember that the depth of the pit is critical:** if it is shallow, correct planting cannot be done and your plantation is doomed even before a tree is planted. Pit depth can be checked with a simple tool made of metal – known as "Mr Quality Controller" (see photo and Fig. 9). By poking the tool into the pit it is easy to see if it penetrates to the required 25cm depth and also whether the pit has been cleared to the minimum 25cm diameter: if not the pit needs to be re-done.

Each component of land preparation described in this Chapter must be carried out in sequence, which also means that the quality of your operation will depend on how well the previous one was carried out. For example poor land clearing makes it impossible to line-out correctly; poor lining-out leads to poor pitting and incorrect espacement. The key message is to plan carefully and allow sufficient time for each land preparation operation to be carried out prior to planting into the early rains.

## Fig 9: Planting Pit Tool




*An SPGS design for Mr. Quality Controller's dimensions*

# CHAPTER 14
# PLANTING AND BEATING - UP


*Training in good planting techniques is crucial: here, Charles Odeke (SPGS) is guiding students at an SPGS training course (2006)*

## 14.1 INTRODUCTION

Successful planting is not just about sticking the tree into the ground and hoping for the best: it is the result of careful planning and having detailed knowledge of the planting site. The key issues to get right are seedling quality, thorough land preparation, careful timing and good training of one's workforce.

## 14.2 SEEDLING QUALITY

First of all you must know what a good quality seedling looks like and thus we strongly recommend readers first digest Chapter 8 to learn more about seedling quality. Below we have summarized the characteristics a good seedling should have:

- It must come from an SPGS approved seed source (see Chapter 7).
- Healthy (i.e. no obvious signs of disease or pests and a good colour).
- The ideal size is 20 cm – measured from the root collar (15-25 cm is acceptable).
- A shoot:root ratio of no more than 2:1 is ideal.
- Good root development (i.e. well distributed around the pot and sufficiently developed to hold the soil in the pot together). NB. Do not be afraid to destructively sample some trees for their root development before taking delivery from the nursery.
- No root coiling (a sign of being kept too long in the nursery).

*A recently planted, good quality pine (PCH) seedling*

*Never plant into weedy sites or use such poor quality seedlings.*

*Excellent planting of pines into well prepared land (Peak Timbers, Swaziland, 2006)*

Thus when buying one's seedlings from a nursery (whether your own or not), you must ensure that the seedlings comply with the above standards.

In addition, you should ensure that they have been well watered and that they have not been damaged in transit. Common problems in transporting seedlings to a planting site are as follows:

- Exposed to strong winds whilst been transported on open vehicles.
- Dried out leaves, desiccated from the sun and hot air on the back of vehicles.
- The soil shaken out of the tubes leaving the fine roots exposed.
- They are often roughly handled during off-loading causing further damage.
- The pots are often piled high on their sides in the back of vehicles.

We strongly recommend that –

- There is a strict policy of culling - i.e. rejecting any inferior or damaged seedlings.
- Transport seedlings at the cooler times of the day and minimize the exposure to full sun and strong winds.
- Use appropriately sized boxes or trays to protect seedlings during transport.
- Give the seedlings time to recover from a journey if transporting long distances.
- Whilst waiting to be planted they should be shaded and well watered.
- Use appropriate means of carrying seedlings to the actual planting site.

## 14.3 LAND PREPARATION AND WEEDING

The quality of land preparation and pre-plant weeding have a major impact on planting. Provided the land has been well cleared, the weeds have been controlled and the pits prepared well, planting is much more likely to be successful. It is a common mistake to plant into a weedy site – usually due to bad planning and timing of operations leading up to planting. One should never plant into a weedy site: it will always be a costly mistake. Rather wait until the site is weeded (whether manually or chemically) and then plant. For optimum early growth, the newly planted trees must have minimum competition and a good rooting environment. For further details see Chapters 11 and 13 (*Weeds* and *Land Preparation* respectively).

## 14.4 TIMING OF PLANTING

To survive and grow well, tree seedlings must be planted at the optimum time of the year.

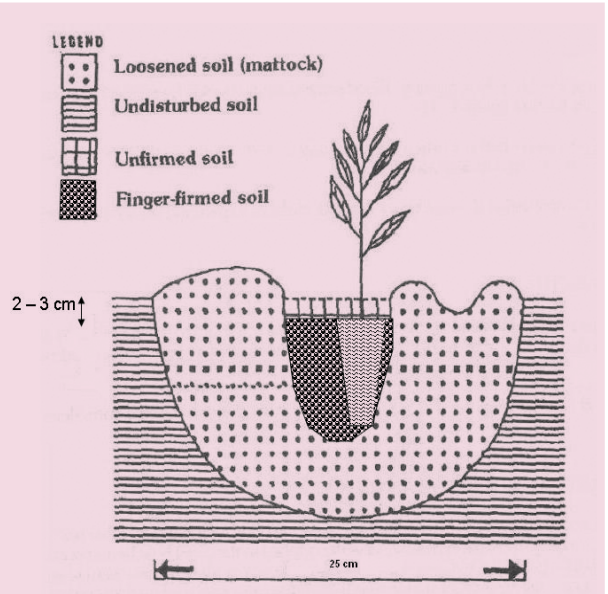



*Diagram showing correct planting technique.*

*SPGS's Alex Atuyamba teaching school-children how to plant successfully (Watoto, Mpigi, 2008)*

Generally this means planning to plant into the early rains, which gives the trees the best chance of a good start prior to the onset of the dry season. For successful planting, the site should be moist enough (to a minimum 25cm depth) and there should be a good possibility of further rains. This requires detailed knowledge of the prevailing weather conditions in the region one is planting: this can gained from meteorological records and from local experience. Many parts of Uganda have a bimodal rainfall but one of the two rainy seasons will usually be more reliable than the other, depending on the planting site's location. Thus one should plan to plant mainly early in the best rainy season (refer Chapter No. 3 – *Planning*).

## 14.5 TRAINING & SUPERVISION

Planting is a critical operation: even with the best seedlings and excellent land preparation, bad planting will still result in a poor crop. It is essential to spend time prior to the rains training ones' workers how to plant properly, since when the rains eventually arrive there is usually a mad rush to plant as fast as possible. We recommend the following techniques for successful planting:

1. Firstly, with a planting trowel dig a small hole into the centre of the planting pit. The hole must be deep enough to accommodate the whole root plug and part of the stem of the seedling.
2. Now remove the plastic sleeve from the seedling, keeping it so that you can dispose of it correctly later on.
3. Place the seedling, upright in the hole, but deep enough to cover the root plug and some of the stem (up to 2cm is fine).
4. Replace the soil into the hole around the roots, making sure that the seedling and roots remain in a vertical position.
5. Firm the soil with your fingertips, pushing down and in but not with too much force (NB. 'heeling-in' with one's boots is not recommended as it can easily damage the small roots).

Notes to remember:

- What you are doing now is going to stay with you for many years, so it is important to do it properly.
- For the same reason it is no use putting poor quality seedlings into the ground. This not only means poor in genetic terms but also small, damaged or overgrown seedlings.
- Often the consequences of poor planting are not noticed for several years, until the young tree starts to draw on greater amounts of water and nutrients to grow: it then suffers stress and will often die.

## 14.6 WATER PLANTING

It is common practice in many tropical and sub-tropical countries to add water to the newly planted seedlings. This so-called "puddle planting" gives the seedlings an excellent start and leads to very high survival rates. It is, however, an expensive operation and the logistics of getting

the water on-site to keep up with the planting, should not be under-estimated. 2-4 litres of water per seedling are used by commercial companies.

## 14.7 PLANTING USING SUPER-ABSORBANTS

Adding a 'gel' into the planting hole is another technique commonly used in many countries to give newly planted seedlings the best start. These gels are super-absorbent polymers, which - once mixed with water - slowly release it as the plant needs it. It eventually breaks down into organic parts.

There are numerous products on the market (e.g. Aqua-Soil, Stock-Osorb and Aqua-Fix) though they all can absorb 300 times it own volume, which means a kilogramme of product can absorb 300 litres of water. It also continues to reabsorb moisture after it has released some

*Water-planting eucalypt clones (Sappi, RSA, 2009)*

*Planting gel when mixed with water.*

and thus it carries on working under-ground for a long time. Some products also have nutrients in as well.

The powder is mixed into water and allowed to stand for two hours: 1 kg into 200 litres of water. At planting, half a litre of the gel solution is mixed into the soil where the tree is to be planted: the tree is planted into this 'mud' and the hole filled with soil as per the normal planting method. These super-absorbants have the following advantages:

- To extend our planting 'window' (i.e. the period where conditions are suitable for planting) – especially to enable planting to start before the anticipated rains.
- To improve the survival % after first planting, thereby eliminating the need to beat-up.
- To help the seedling get off to a fast start and colonize the area quickly, thereby suppressing weed growth and reducing establishment costs.

Although these super-absorbants are not readily available in Uganda at present, the SPGS and some private companies have imported some from RSA and Kenya over the last few years. We recommend contacting UTGA for advice. It is important to note that using such products does not mean that one can plant at any time of year

in Uganda. We still recommend planting early in the rainy season. But what these products do is enable one to keep planting in the dry spells that invariably occur in the rainy seasons.

## 14.8 BEATING-UP

Beating up - also referred to as blanking and infilling - is the operation carried out to replace any seedlings that may have died (or are struggling) immediately after planting. Whilst careful planning and good practices (as recommended throughout this book) will minimize the need for beating-up, it will often be required. Because the operation is expensive, it is recommended that beating-up should only done when the survival percentage is less than 90%.

It is common practice in Uganda to beat-up the previous season's plantings in the following season. This practice is definitely not recommended as it invariably leads to enormous variation in growth rates between the trees planted at the two different time periods. Beating-up has to be done as soon after planting as possible so that these seedlings are not over-powered by those planted earlier. With *E. grandis* this means beating-up no later than 2 weeks after initial planting; with pines, no more than 4 weeks after planting. Beating-up later than this will result in a plantation with variable seedling heights. To work out the survival percentage, follow these guidelines:

Choose a random row away from the road in the planting site. Walk along the row (usually for 50 or 100 planting sites) and count each planting site, recording how many of the seedlings planted into those sites have survived. Then calculate the survival percentage:

No. live trees ÷ total no. of planting sites counted (live + dead) x 100.

It is advisable to do this sampling over a number of lines (e.g. every 10th line) throughout the site to obtain a better reflection of the survival percentage.

*Planting in Gulu during an SPGS training course for Community Leaders (2008)*

*SPGS Staff demonstrating the stackable 'lug-boxes' for transporting tree seedlings (SPGS Clients Meeting, Hoima, 2007)*

# CHAPTER 15
# TAUNGYA

*The consequences of taungya - a failed tree plantation (nr. Masindi, 2004)*

## 15.1 INTRODUCTION

Taungya is a land management system in which food crops are cultivated along with tree seedlings. In theory, the trees are established cheaply and local people can grow some food crops at least for a year on the land, before the trees shade them out. It has origins in Southeast Asia (especially Burma and Thailand) where it was introduced by the British colonial foresters in a bid to ensure tree cover restoration following shifting cultivation. Under taungya, farmers were allowed to cultivate crops for the first few years amongst teak (*Tectona grandis*) seedlings being established on degraded forest land.

Under taungya the food crops are planted in the tree inter-row within the first few years of plantation establishment – the exact time depending on the species, the growth rates and the initial spacing. In Uganda, the practice of taungya has been practiced for many years but over the past 30 years or so (almost without exception), the results have been disastrous in terms of the establishment of tree plantations. This Chapter discusses the problems with taungya and explains why the SPGS does not promote (or support) it, except in exceptional circumstances.

## 15.2 TAUNGYA OUTSIDE UGANDA

As a form of land use, taungya aims at an integrated use of the available land resource to obtain the maximum amount of goods and services from the land. The taungya system provides for establishment of tree crops and gives peasants access to land for growing their food crops – thereby (in theory at least) reducing the need to destroy natural forests.

*Taungya has failed to produce tree plantations in Uganda over the last 30 years.*

If carried out properly (like it was done in Burma), taungya can have the following advantages:

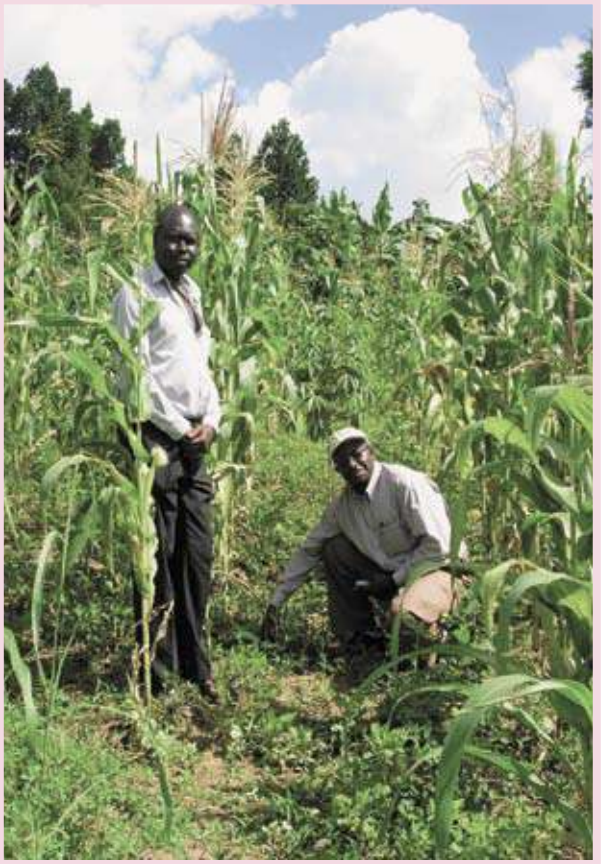
- By planting trees with food crops, weed invasion is prevented and soil cover is retained. This is because as farmers weed their crops, they weed the trees as well, and the crops planted in the tree inter row cover the soil preventing erosion.
- There is maximum use of the land as both crops and trees are grown.
- Employment is provided over a large scale – tree planters and crop growers are all employed.
- Cheaper forest establishment and protection.
- If leguminous crops are grown, the nitrogen will benefit the trees.
- It promotes food security.

## 15.3 UGANDA'S EXPERIENCE OF TAUNGYA

In Uganda, taungya does not have a long history. It has been widely used for the 'establishment' of trees in Uganda by both Government institutions and private growers, though it has more often than not been used as a smokescreen for practicing illegal agriculture in Forest Reserves. It started as a form of tree planting when the hardwood species Maesopsis eminii (Musizi) was raised in combination with cocoa to provide partial shade to cocoa in its initial years of growth and to produce timber into the bargain.

Later a small-scale taungya system was applied in the Kifu CFR to regenerate some indigenous species. Taungya plantations were also developed for planting exotic pines in the Mwenge plantation, near Fort Portal, and at a few other sites including on private land by individual farmers, all with varying degrees of success.

The crops belong either to the tree owner or the plantation workers or anyone else who gets permission to use forest land for crop production. Sometimes the plantation owners allow their workers to grow crops on forest land as an incentive. Other forest owners or managers rent out land that will eventually be planted to trees, for people to grow their food crops. This they do in a bid to reduce the establishment costs.



*SPGS's Allan Amumpe (rt) looking for the trees in a maize garden (nr. Jinja, 2004)*

Taungya is sometimes permitted in a bid to amicably wean encroachers off forest land. Investors who lease encroached forest land plant trees among the crops of encroachers but with the latter's consent. The agreement is that once the crops are harvested, no more cultivation will take place in that area.

The major crops grown among the trees are food crops - mainly maize, millet, beans, soy beans, cassava and sorghum among others.

## 15.4 THE SPGS AND TAUNGYA

The following observations can be made on the practice of taungya in Uganda:

- Farmers faced with the possibility of becoming landless once the trees are fully

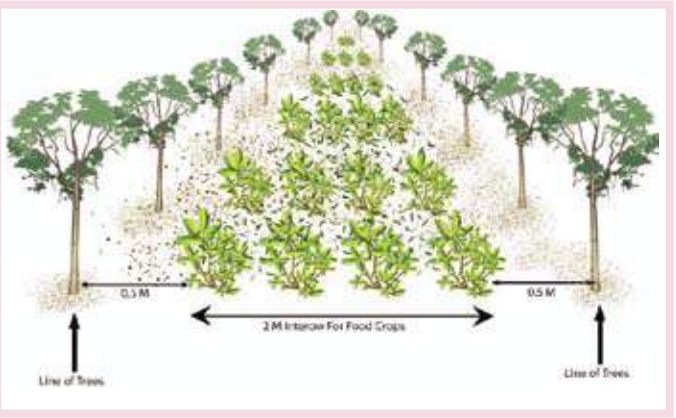
established often damage or kill the trees. In some parts of Uganda, farmers severely prune the trees' branches to prevent the trees from shading their crops and thereby extending the period they can use the land for their crops.

- In some instances, farmers physically uproot (or partially uproot to sever some roots) the trees to further extend the period they can grow their crops.

- Some instances of heaping weeds on top of saplings have been recorded. In other cases fires are initiated to kill weeds, which then damage the young trees.

- Some agricultural crops, in their own way and at a given depth, also compete for nutrients with young tree seedlings. It should be noted that agricultural crops grow faster than the trees. Millet and maize, for example, form a thick network of adventitious roots and a dense growth of parts above the ground. *Cajanus cajana* (pigeon peas) grow to form some sort of shrub attaining a height of over 1.5 metres within three to four months and tend to overtop the trees in addition to making nutrient demands on the soil.

**Fig 10: Taungya in Theory**




The above listed problems have led to poor tree plantations. For this reason, the SPGS does not currently allow taungya on any of its supported plantations. Suggestions are however welcome on how to make the practice work, especially with regard to guidelines and supervision.

## 15.5 THE MUSIZI SPECIAL CASE

Musizi (*Maesopsis eminii*) is currently the only indigenous hardwood species that is showing promise as a plantation species on a commercial scale. It is therefore one of the tree species being promoted by the SPGS. Care should however be taken to plant it on the right site (NB. refer to Chapter 5 – *Tree Species*).

*Somewhere in the millet there were pines apparently!*
*(Private Planter, Bushenyi, 2004)*

Musizi is a special case because it can be grown with a wider spacing than the rest of the other species encouraged by SPGS (4 x 4m or even more). With this kind of spacing therefore, crops can be grown in the tree inter-row (NB. with such wide spacings, initial establishment must be good or there will be very few trees to select for the

final crop). If trees like Musizi are to be grown using taungya, care should be taken to plant the crops 0.5m away from either side of the trees - to maintain the 1m diameter weed free zone (refer to Chapter 11 – *Weeds*). The trees should also be maintained and protected well, and given the same (or even more) attention as the crops.

Also to note here, is that only low, non-climbing annual crops such as ground-nuts, beans and peas should be grown. Remember tall crops like maize and sorghum will overtop the trees within a very short time. Vegetables like tomatoes and onions can also be grown. The maintenance of the trees should be coupled with monitoring the activities of the crop growers to ensure no damage is inflicted on the trees. A well managed intercropping of trees and agricultural crops should appear as below.

## 15.6 THE WAY AHEAD?

Taungya requires socially acceptable arrangements to ensure security of land tenure and an effective land allocation system. The issue of ownership of the trees and crops also needs to be considered. Most taungya problems in Uganda have been due to lack of supervision. However, through careful planning and wise manipulation, vast lands and human resources can be put in a progressive and productive combination. The planning and manipulation should be followed by careful supervision of the farmers. This supervision is difficult for vast lands under commercial forestry, since it would require many crop farmers from different backgrounds (cultures) and hence it would be very difficult to manage.

At the moment several alternatives to taungya can be suggested: land for crop growing can be set aside, separate from that to be put under commercial forestry. Alternatively, the land to be put under trees can be cultivated at least six months prior to tree planting. When tree planting commences, no other crops should be grown. This method is a cheap way of site clearing, and it has worked for a number of SPGS clients.

Before the SPGS can embrace taungya, however, research trials need to be undertaken to develop the standards for the practice. This will ensure that the existence of crops among the trees will not interfere with the required standards of stocking, weed control and tree crop quality among others.

**Important points:**

- In commercial forestry, the interest should be in the trees, not agricultural crops. Our objective is to grow fast growing, high yielding timber plantations: taungya has produced the opposite results in Uganda.
- Even with good supervision, it is very likely that taungya will only be successful over small areas. When it comes to 25 ha and above (the minimum area supported under the SPGS), supervision will be very costly.
- For as long as there is such pressure on land in Uganda, taungya will always cause problems.

*The SPGS does not support taungya as the farmers nearly always favour the food crops over the trees (Luwero, 2007)*

# CHAPTER 16
# FOREST FIRE PROTECTION

*The serious consequences of fire in plantations (Peak Timbers, Swaziland, 2007)*

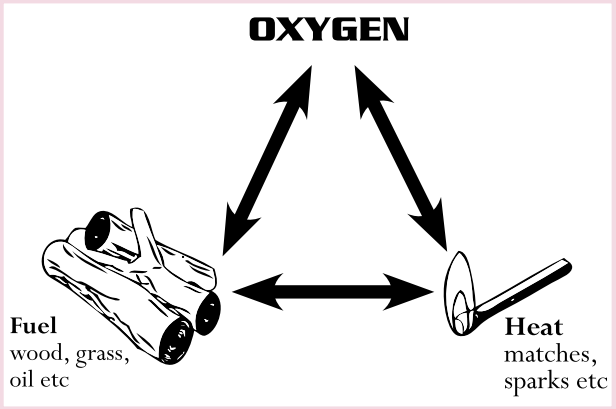
## 16.1 INTRODUCTION

**JUST ONE** forest fire can destroy the investment of many years in a few hours: hence fires must be taken very seriously as we start establishing large-scale, commercial plantations in Uganda. When it comes to fire prevention, the golden rule is: ***'Be prepared'***. With regard to fire control, the best advice is: ***'Spot fires early: hit them fast and keep them small'***. Fires are one of the greatest threats your forest faces over its lifetime. Therefore by not taking precautions such as preparing firebreaks, purchasing and maintaining equipment and training and organizing your fire fighting force, you jeopardize all your efforts. The key areas to focus on to make your forest safer are:

- Work with surrounding communities – not against them – and educate them on the dangers of forest fires.
- Identify risks well in advance and try to minimize them.
- Prepare firebreaks in advance of the driest periods.
- Purchase and maintain suitable fire fighting equipment.
- Ensure that any fires are spotted early and that there are people on standby at critical times.
- Train staff (including contractors) to ensure that they can fight fires efficiently and safely.
- Use the Fire Danger Index (FDI) system to guide levels of preparedness (described later in Section 16.6).
- Follow-up immediately after fires: ensure lessons are learned and take any disciplinary (or legal) action required.

This Chapter will expand on all these points. The advice is based on practices developed to a fine art in Southern Africa – where the plantation fire risk can be extremely high during the long, hot dry periods experienced there. Uganda's risk from fires is considerably less than Southern Africa (which has a prolonged dry season) but nevertheless, fires will increasingly become a threat to growers here and indeed, some have already lost significant areas.

**Fig 11: The Fire Triangle**




## 16.2 FIRE PREVENTION

**General:** It is much better to prevent fires starting in the first place than have to risk lives putting them out. Attention to a few issues before the fire season can greatly reduce the risk of fires and also make it easier to extinguish fires when they do start. A good place to start is to identify the risks and also to understand the main causes of forest fires.

**Identify risks:** Before the time of year approaches when fires are more likely (fire season) you need to know where your main fire risks are. These risks could be an activity that uses open fires (e.g. welding or brick making), communities (because of domestic fires and crop residue burning) and others. To identify these risks and how they affect you, you also need to be aware of the prevailing wind during the fire season. Obviously the highest risk will be on the boundary where the prevailing wind normally blows directly towards your property.

**Understanding fires:** In order to identify risks you need to know a little about the theory of fires. The simplest method is to look at the fire triangle (Fig. 11). In the fire triangle there are three main elements – oxygen, fuel and heat. For a fire to be able to burn it needs all three of these elements: remove one and the fire cannot burn. For example, when we apply water to a fire we remove the heat only and the fire is extinguished.

When we make a firebreak we remove the fuel and thus the fire stops. When we beat out the flames we remove the oxygen and the fire stops. In each case we are removing only one of the three elements but the fire is extinguished.

*Your investment of many years can be burnt in a few minutes: plan and prepare for fires.*

## 16.3 THE CAUSES OF FOREST FIRES

It is important to understand what causes forest fires so that one can not only reduce the incidence of fires but also make the plantations safer so that the impact of fires will be reduced. The more common causes of forest fires are as follows:

**Arson:** Unhappy workers or neighbours can vent their anger against you during the fires season – and it is difficult to catch people in the act of lighting the fire. Better to manage well – particularly by ensuring your workers are paid on time and any disputes with either workers or surrounding communities are resolved quickly and amicably.

**Self-inflicted:** Self-inflicted fires normally fall into two main groups – those started by the tree growers themselves that get out of hand ('own burning') and negligence with cooking and/or warming fires. The former account for a high percentage of fires and are often as a result of poorly planned 'controlled' burns during land preparation operations. Through use of the FDI it is important to have (and enforce) rules clearly stipulating when burning is permitted on your land. Never burn in windy or very dry conditions and always have adequate staff and fire fighting equipment on hand when burning trash or firebreaks. All these points are explained later in this Chapter.

Similarly, there must be clear rules regarding any fires on one's land, particularly those the workers use to cook with or warm themselves on cool days. This includes contractors, sub-contractors, your own labour as well as anyone doing any other work on the plantation such as sawmillers. Cooking and warming fires need to be contained in a designated safe area: a pit or shallow hole is ideal. They need to be supervised at all times and never left burning when leaving the site. They have to be extinguished completely and then preferably covered with soil. People found to be responsible for a cooking or warming fire that started a forest fire, need to be severely disciplined and you can only do that if you have clearly communicated the rules to them beforehand.

**Fires spreading from surrounding land:** This is very common and can start from farmers burning their crops or from an accidental fire. Foster good relations with neighboring farmers and communities. It is important that you try and educate these people as to the dangers, consequences and costs related to a forest fire: it is not only the owner of the trees that suffers but also the community at large because of loss of jobs, firewood and possibly other privileges that they have such as taking a short-cut or drawing water. Part of this education should also be making them aware of the penalties in the 2003 Forest Act for those caught setting fires, even if their intention was not criminal (up to 5 years imprisonment).

Farmers frequently burn off vegetation on their property in the dry season prior to the rains. They do this to clear the land, remove old grass and encourage new grazing. As managers of nearby tree plantations, we need to promote ourselves as knowledgeable with regard to fires so that they come to us to ask our opinion and sometimes to ask for assistance. Providing assistance should not be viewed as an avoidable cost. By helping to burn off some bush by providing labour and equipment and more importantly by controlling when that burning takes place, the risk of fires in our forests is greatly reduced. If nothing else try and get the co-operation of one's neighboursneighbors to at least warn you when they plan to burn so that counter measures can be taken. Ensuring good external firebreaks will also help to reduce the likelihood of fires spreading from surrounding land. During dangerous times, do not hesitate to extinguish fires that threaten your boundary.

*A small grower here lost most of his trees (LEMA, Luwero, 2009)*

**Honey-hunters:** People collecting honey from hives within your property often will use a smoky rag to placate the bees. Once they have gathered the honey, they often leave the rag smouldering on the ground and when a wind comes along, this can easily lead to a fire starting. Try and encourage the people you know might collect honey, to do so under the supervision of your staff.

**Others:** Cigarettes thrown from car windows have been known to start fires. Think of placing highly visible warning signs on any main roads passing through your property to make people think before discarding the cigarettes (or use their ash-trays!). Also ensure your firebreaks are well prepared along public thoroughfares. Lightning can also be a cause of forest fires though there is not too much you can do to stop this!

## 16.4 PLANNING ISSUES

There are many things we can do to make our plantations safer and these will now be discussed.

**CompartmentSize:** Itisstronglyrecommended that when you are planning your plantation development, you do not have single blocks or compartments bigger than 30ha without a road or firebreak around. Even 30ha blocks can be sub-divided with small, internal firebreaks if considered necessary.

**Roads:** roads are hugely important to gain quick access to one's plantation - not just in times of emergency (e.g. fires or if a worker is seriously injured) but also for general supervision of all silvicultural operations.

**Species Susceptibility:** Not all tree species are equally susceptible to fires. *Pinus patula* is very sensitive to fires as it has a thin bark – even a light fire may kill this species. *Pinus caribaea* on the other hand is reasonably fire resistant: this does not mean that it will always survive fires, as in times of drought or in a very hot fire it will also suffer serious fire damage. *Eucalyptus* spp. are fairly susceptible to fires but have the advantage of usually coppicing afterwards, even if the above ground parts of the trees are killed.

**Fire Season Preparedness:** Fires can (and do) occur at any time of the year but the risk is clearly greatest during extended hot and dry periods over the year. In most parts of Uganda, this usually means the periods in between the two rainy seasons – around July/August and January/February. For your particular area, weather records should be consulted (combined with local knowledge) to allow you to identify the dangerous periods of the year.

Labour availability: one needs to plan ahead so that when there is a fire, it is known (and agreed beforehand) where to mobilize help – from either one's own workers or neighbours (see Section 16.8).

## 16.5 KEY FACTORS AFFECTING FIRES

The four key factors that affect fires are rainfall, winds, terrain and the fuel load:

**Wind:** Wind help fires spread rapidly and also provides oxygen for the fire to burn: obviously the stronger the wind the faster and bigger the fire will be. By knowing where the wind blows from at any time of year helps us to plan for the fire season. Our defenses against fire need to be stronger where the wind blows into our trees.

**Rainfall:** Rainfall (or more correctly, the lack of rainfall) - increases the risk of fire. When the grass and other flammable debris are dry it burns much easier. A discarded cigarette may cause no damage in the wet season but during the dry season it may instantly start a fire that grows and threatens property and life.

**Terrain:** Terrain is the shape of the land. Other than wind, slope is the biggest cause for a fire to spread. Fire runs uphill very quickly and burns slower downhill (wind can sometimes, however, help fire move faster down slope). Fire risks at the bottom of the hill therefore pose a higher threat than those at the top of a hill. Steep terrain is also less accessible than a flat area and this makes fighting a fire much more difficult.

**Fuel-load:** Areas with a lot of inflammable material are obviously a high risk in terms of possible uncontrolled fires. Thus plantations that have not been weeded well that have tall grasses throughout are very susceptible to fires (and when fires start are very difficult to put out). Thus good weeding helps greatly to reduce fire risk. Other silvicultural operations – notably pruning and thinning – can also increase the fuel load for a period. Countries with severe fire risks (e.g. Australia and RSA) are increasingly undertaking controlled burning within established stands in order to reduce the fuel-load.

*Better weeding and firebreaks might have saved this crop (private plantation nr. Entebbe, 2003)*

## 16.6 FIRE DANGER INDEX

The Fire Danger Index (FDI) is a system whereby we measure the weather conditions in order to predict the chances of a fire occurring and the fire behaviourbehavior once it has occurred. The FDI is a numerical figure whichfigure, which places the risk in a category associated with a colour - blue, green, yellow, orange or red (see Table 12).


*Sustainable Use of Biomass (Hoima) were the first company to take fire prevention seriously in Uganda (2006)*

By knowing the FDI we can take counter measures according to the risk – such as placing temporary look-outs, getting the fire crew together, patrolling and canceling any staff movement away from the forest.

During the main fire seasons in particular, at each plantation forest station (or main office) there should be a large painted sign with an arrow indicating the colour code for the day. As you will read later on, the FDI should dictate when certain operations can be carried out in the forest safely – especially controlled burning of trash or firebreaks.

**Calculation of FDI:** The FDI is normally calculated daily at 10h00 and 14h00. To calculate the FDI you need some basic weather information. A simple weather station at the main office will suffice and doesn't need to cost the earth. The information required is:

**Table 12: The Fire Danger Index**

| Fire Alert Stages | BLUE | GREEN | YELLOW | ORANGE | RED |
|---|---|---|---|---|---|
| Fire Danger Index | 0-20 | 21-45 | 46-60 | 61-75 | 76-100 |
| Fire Behaviour | SAFE | MODERATE | DANGEROUS | VERY DANGEROUS | EXTREMELY DANGEROUS |
| Flame Length (m) | 0-1 | 1-1.2 | 1.2-1.8 | 1.8-2.4 | 2.4+ |
| Fire Control Guide | Low fire hazard. Fires unlikely to start: control and mopping up easy.<br><br>Controlled burning operations can normally be executed with a reasonable degree of safety. | Only light surface fires likely.<br><br>Although controlled burning operations can be done without creating a fire hazard, care must be taken when burning on exposed, dry slopes. Keep a watch for unexpected wind speed and direction changes. | Direct attack needed if fires start: moderate mopping up needed.<br><br>Extreme caution should be taken when controlled burning is carried out. | Spread of fires can be fast: control and mopping up difficult<br>No controlled burning of any nature should occur. Careful note should be taken of any sign of smoke – especially on the up-wind side of any plantation. Any fire that occurs should be attacked with the maximum force at hand. | Fires will be very hot and spread very fast.<br>All personnel and equipment should be removed from field. Fire teams, labour and equipment are to be placed on full stand-by. At the first sign of smoke, every possible measure should be taken in order to bring the fire under control in the shortest possible time. |

- Dry bulb temperature ($^0$C).
- Relative humidity (RH) (%).
- Wind speed (miles per hour - mph).
- No. days since last rain (no.).
- Rainfall (mm).

For those fortunate enough to have access to the internet, see the FDI calculator at: www.zfps.co.za/fdi-calculator.html, which quickly computes the FDI when you feed in the parameters listed above. For those without internet, the calculation is as follows (see Annexures A, B and C):

- The RH and dry bulb temp. are used with the alignment chart (Annex 1) to calculate the Burning Index.
- The wind speed in mph (= kph x 0.625) is added to the Burning Index to give a Basic Rating.
- The Basic Rating is multiplied by a Rainfall Correction Factor (a measure of fuel moisture - see Annex 2) to give the FDI.
- Refer the FDI chart (Table 12) for the colour coding.

## 16.7 FIREBREAKS

**General:** Firebreaks are classified as external or internal. External firebreaks are belts or areas around the trees or property that are not flammable. These could be man-made such as a strip where all the vegetation has been burnt or scraped off, or natural areas such as a lake or natural forest. Note that roads are often used as firebreaks but are a risk because people use them: thus roads should not be considered as a firebreak by themselves. External firebreaks should be wide enough to stop a normal fire by themselves. The width depends on the risk but a minimum of 10m clear of vegetation is a good guideline.

Internal firebreaks are firebreaks within the property or forest. These are there to provide you with a staging point from which to fight the fire and to reduce the area burnt. Internal firebreaks are narrower than the external breaks because they are not usually designed to stop the fire themselves: you have to get there and put the fire out. The number of internal firebreaks and their width again depends on the risk but as a guideline, a minimum of 5m is recommended.

**Preparing Firebreaks:** Firebreaks should be prepared in advance of the fire season. This means planning carefully according to the climate in your location and either manually clearing or burning (in a controlled manner) the firebreaks. Manual clearing is expensive and not recommended on steep slopes as it will lead to erosion – especially as the same firebreak will generally be cleared every year. In areas where access is difficult, however, manual clearing is often the only way: hoes or rakes can be used to clear vegetation down to the soil.

*A well-managed, external firebreak (SAPPI, RSA, 2004).*

Controlled burning is usually the most cost-effective method of preparing firebreaks. It is best carried out when the surrounding vegetation is still green (and thus not highly flammable). A useful technique is to spray a 1.0m strip (called a fire-trace) with Glyphosate on either side of the proposed firebreak when the firebreak (and surrounding vegetation) is still green.

As soon as the sprayed strips have died following the spraying, the strips can then be burnt off relatively safely.

Once the middle piece of vegetation has then dried naturally, the whole firebreak can then be burnt off – the clean fire-traces on either side of the firebreak making it safer to burn. Whenever controlled burning is taking place, ensure that there are staff and equipment on site in case conditions change or the fire jumps to another area. Also remember that there should strictly be no burning when conditions are dangerous (Orange or Red FDI).

In areas where the vegetation does not dry off naturally the following technique can be used. Slash the entire break, ensuring that the slashing is as close to the ground as possible, thereby removing the maximum amount of vegetation. Let this slashed vegetation dry and then stack it in the middle of the firebreak. Burn this when it is safe to do so and before the fire season.

Roads: Roads are often used as internal breaks as long as they are kept clear of vegetation and the road verges kept clean. Strategic roads should be checked and maintained so that vehicles and labour can move quickly along them at night and not fall into a pothole or hit a boulder.

**Natural breaks:** Natural breaks are existing features that are not flammable. Examples are lakes, moist high forests and rocky areas where no vegetation grows. Natural breaks, however, are usually not suitable for driving or walking along. It is also important to mention that some natural features – such as open areas and bush lands - can be a fire risk. Some swamp vegetation becomes very inflammable when dry.

## 16.8 PERSONNEL

**People are important:** During fire season you need to be able to react to a fire and get people there quickly to fight it. The sooner you can start fighting it the smaller it will be and the easier it will be to put out, resulting in reduced damage to your forest. In order to react quickly we need to have people available to call upon. These can be people who remain on your property so they are all in one place or villagers who can be trained to respond to a siren and gather ready to be collected or dispatched. It is important to identify the people you will be using in order to train them so that they are effective when fighting fires.

In case of a larger fire you may call upon extra people who are not trained. This is fine, as you would usually use them for manual work such as opening up extra fire lines or carting water. The core fire team, however, should be at the fire face and know what they are doing.

**Fire duties:** A fire crew will always need to be managed, equipment needs to be issued and decisions made at the fire. Also at the end the final call to say that the fire is out cannot be made by the labour that just want to go home to sleep. For this reason there must always be someone trained, responsible and available to take charge at a fire (the Fire Boss).

*A well-constructed (wooden) fire-tower in Australia (FPQ, 2006)*

The Fire Boss needs to remain on station, stay sober and be within contact at all times during the fire season. This is a lot to ask one person as it is stressful work and people need time off. Hence, this responsibility is normally divided among several people, who each would be on duty for a period of time, normally a week. This person may call the others for assistance but that person remains responsible while it is their duty period. This fire duty needs to be formalized so that everyone knows whom to call upon if there is a problem.

**Volunteer labour:** Extra labour will be required to fight fires so it is important to have equipment for them and to have clear instructions on what to do and where to go. They will however want some reward for their effort. This is a very touchy point because if you pay people for fighting fires, this can quickly develop into a situation where fires are set in order to be called and paid. Obviously every situation is different: a suggestion is to have something in place where the labour or communities benefit when there are no fires.

Even your fire crews are not above this temptation so generally it is advisable to pay them whether or not there are fires. They would rather stay in bed and get some money than spend the night fighting fires to get it. A spin off is that they may even dissuade others from being careless with fire. A last thing on payment is to decide beforehand on what and how it is to be done. You do not want to sit and negotiate when the fire is burning. Give the Fire Boss authority to agree on getting extra people in so that he is not trying to get permission while the fire is burning.

## 16.9 DETECTING A FIRE

**Timing:** Spotting a fire early enables you put measures into place to extinguish that fire or if it is outside, to prevent it from entering one's plantation. The smaller the fire is when you start fighting it, the easier it is to control: once a fire gets to a certain size you cannot even fight it but have to wait until it burns itself out.

**Fire lookouts:** A fire lookout can be temporary or permanent. Temporary lookouts are measures placed for a limited time to keep a look out for fires. This could be placing someone on top of a hill when the conditions are favorable for a fire starting and spreading (e.g. in Red or Orange FDI periods). It is important though for this person to have the means to call and report a suspected fire (mobile phone or radio communication). Permanent fire lookouts (usually called fire towers) are structures built where they have a good sight over the forest. During fire season they can be permanently manned or just when conditions are bad. Again the operators in the fire towers need to have communications in order to report any potential fires.

**Mobile patrols:** Mobile patrols are fire lookouts on the move. It could be a vehicle or people patrolling a high-risk boundary or moving between vantage points covering different parts of your property. They need to be in communication as the time lost getting to a point where they can report a problem can mean the difference between a small fire causing no damage or a large one destroying all your trees.

**External people:** There are always people around, either on your property such as contractors or people passing through or off your property living and working on your boundaries. These people are very likely to spot a fire on your land much sooner than you or one of your staff does. You need to develop a system whereby people know where they can go (or call) to report a fire (or any other problem). You could develop an arrangement with a local shopkeeper or someone with a phone to act as a messenger for you. The crucial thing is for the community to know what they should do if they see a problem.

**Mobilizing people:** As mentioned earlier once a threat has been identified labour needs to be mobilized and fighting the fire started as soon as possible. There are several systems to send out the alarm from sirens to drums. The important thing is for the people to recognize that it is an alarm and not just another sound, so don't use drums if

the local choir use the same drums and play the same beat as you do! Use something unique and make sure that the people can recognize it and know what to do when they hear it.

## 16.10 FIRE FIGHTING EQUIPMENT

As soon as a fire has been spotted and people are mobilized to fight it – they will need to have quick access to appropriate equipment – and have the means to get to the fire site quickly.

**Water:** Water is an important part of that equipment as it is very effective in suppressing fire. Any serious plantation development should have some means of transporting water to fires during the fire season. It can be a tractor-drawn water-bowser, a 'bakkie-sakkie' (vehicle-mounted tank and pump) or a dedicated fire engine. Outside of the fire season, the tanks can of course be used for other purposes – especially for providing water for planting and for spraying. All these tanks must have good pumps, sufficient hoses and appropriate nozzles.

*A bakkie-sakkie - 500 lt portable tank and pump (NFA, 2005)*

*A home-made beater made from old conveyor-belting.*

Ensure that all equipment is repaired prior to the fire-season and tested regularly throughout the fire season.

**Labour:** As noted earlier, it is critical to get people to the fire as soon as possible after it starts. Having them walk to the fire is not ideal as this takes time and several will get 'lost' on the way. Ideally a vehicle should transport them quickly and safely to the fire. Once at the fire, the people need to be familiar with the equipment and with basic fire fighting methods.

**Tools:** The basic hand-tools for fighting fires are rakes, beaters and water-pumps (knapsacks).

*A customized fire-tender with water, tools and people! (RSA, 2007)*

*A rake-hoe is useful for clearing firebreaks ahead of a fire.*

- **Rake Hoes** – This is a versatile tool that can be used to scrape the ground clean as well as to rake up needles or other loose debris.

- **Beaters** – usually made from old conveyor – belt cut into strips and firmly attached to a long handle. Beaters are used to beat and suppress the fire directly: useful in grasses and low fires.

- **Knapsacks** – This is a water-filled knapsack with a double action water pump (i.e. it pumps water both with the outward and inward stroke) used to squirt water accurately and without wastage.

**Drinking water:** One must always ensure that there is drinking water available, and a system of getting it to the people fighting a fire. Fighting a fire is hot, hard work and people can dehydrate very quickly causing extra problems, as well as putting that person at the additional risk of being burnt.

## 16.11 FIRE FIGHTING

**Types of fire:** Fires are categorized by where they burn, along the ground (ground fires), just above the surface (surface fires), or in the crowns of the trees (crown fires). The closer it is to the ground the less difficult it is to fight.

**First attack plans:** As soon as you get to the fire you need to make your initial plans. Often people jump off the truck and race to the fire only to be called back and placed where you want them. Spend a few moments deciding what you plan to do and then deploy your labour. A planned and coordinated attack is far more effective than everyone doing their own thing. In fact the latter is not only ineffective but puts people's lives in danger.

**Extended attack plans:** Once you have people fighting the fire you will have more time to assess what is going on. You have to look at what the fire is doing, how fast is it moving, how furiously is it burning and what is it burning as well as where is it going. Where it is going dictates what it will do when it gets there and in most cases we can only fight ahead of a fire so we have to plan ahead. Once you have a better plan you can assess what the labour are doing, don't be afraid to change your plan, you will do so often as conditions change.

**Basic fire fighting tactics:** Fires quickly become difficult to get near and thus we have to fight most fires indirectly: this usually by quickly preparing fire-lines alongside and ahead of them (unless there are pre-prepared fire-breaks nearby that can be defended). By doing this we deprive the fire of fuel to burn and it dies back. Fire is also very dangerous and putting someone in front of a fire that is moving at any speed is irresponsible. Fire is also very unpredictable: it flares up and dies back; it changes direction and jumps so we have to know where the labour are at all times and make sure you don't get them trapped or cut off. The consequences can be fatal.

So you need to act tactically and working from the back and sides, slowly pinching the fire depriving it of fuel and slowly making it smaller and smaller before putting it out. It sounds much easier than it is and it takes years to become proficient at fighting forest fires but one never becomes a master. The number one rule though is to always make sure that everyone has somewhere to escape to and when the fire gets too strong to pull out and fall back to a safer area where you can fight the fire. The faster the fire is moving the further back you have to go. If what you are doing does not have any effect on the fire, stop and rethink your plan.

**Back-firing:** Back-firing is a technique of fighting fire with fire and can be an effective way of stopping an approaching fire-front. It is also a very dangerous technique and unless carried out by an experienced person, can create even bigger problems. Back-firing should only be done with the permission of the Fire Boss. It should only be carried out where you have adequate support (people plus water and tools) in case the back-firing itself gets out of control.

*Teamwork is important - here one worker uses a knapsack whilst his colleague rakes a trace (RSA, 2007)*

**Mopping up:** Once we have put out the flames we are left with a burnt area full of smoldering debris. This debris could quite easily start a new fire and if left unattended, almost certainly will. Mopping up therefore is to render potential threats harmless. You have to open fire-lines around the fire, being careful not to move embers into the unburnt areas. You have to extinguish all embers that may throw sparks into the unburnt area. When mopping up it is important to look at the whole fire and not only the front. This is because the wind may change direction and a different part of the fire becomes the threat. Only once all of this is done can you think of leaving the fire and sending the fire crew away. However there is a need to post guards at the site until no embers remain.

**Guarding:** The fire area needs to be guarded until no threat remains. Guards are not normally left alone but in pairs and in the case of a large fire, several pairs can be left on site. These guards need to be able to call for help in case the fire starts up again or in case of any other problems. They need to have food and water and some tools to extinguish small flare-ups. Where it is cold they need suitable clothing.

## 16.12 SAFETY, TRAINING AND RECORD KEEPING

**Safety:** Fire is extremely dangerous in itself but additional hazards are added by running around in the dark or up and down slopes carrying equipment. So strict discipline needs to be maintained. People must not run, they must not go off without permission, they must act responsibly: be alert to all the hazards and they must always know what to do if the fire turns, speeds up or flares up. After a fire everyone must be accounted for and any injuries attended to no matter how small.

**Training:** It is essential to ensure that your fire-crews (or the people that will be expected to fight any fires on your property) are adequately trained before the onset of the fire season. Before each fire season ensure your fire equipment is in good working order (and if not buy some that is!). Then spend time teaching people the techniques for fighting fires safely and effectively.

**Fire fighting records:** In order to learn from your experiences you need to know what was done. The Fire Boss needs to keep notes of everything that happened at the fire – e.g.:

- the time it was reported;
- the time people got there;
- any changes in weather or the fire;
- when extra people came;

*Back-firing should only be done as a last resort and must be closely supervised*

*Treat fires with respect: wind direction can suddenly change with catastrophic consequences (RSA, 2003).*

- when it was brought under control;
- when he started mopping up;
- when he sent people back;
- when he posted guards and left himself;
- things that broke or what went wrong;
- things that worked well and which people excelled.

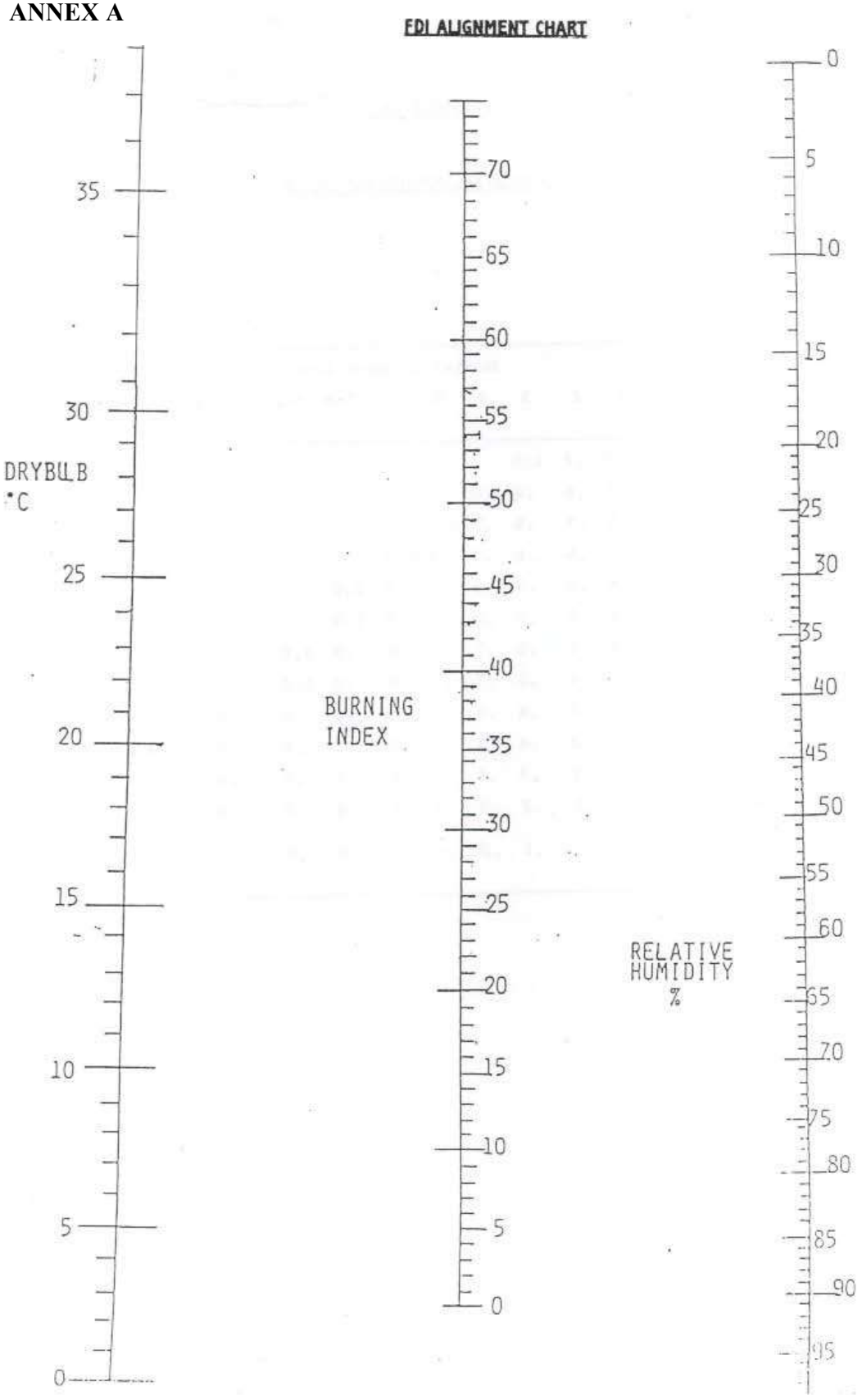
Many things happen during a fire and it is very busy. This is why the Fire Boss must make notes, to prevent him from forgetting what happened. The Fire Boss will learn from the notes he has made. Also after a fire all the equipment needs to be checked and repaired if necessary. The next fire may be just around the corner.

**Fire reports and post mortem:** A fire report needs to be completed. This forms a basis where one can see trends in the fires, time of year and places where they occur which will help you in the future. If you see that many fires occur around a certain community you can try and discover why. Another important aspect that needs to be ascertained is the cause of the fire. As soon as possible after the fire or even during mopping up this needs to be discovered. Again it will help in preventing future fires. It is also vitally important to get all the key people who were involved during the fire onto the site and review all the decisions made and talk about what could have been done.

Fire is dangerous and destructive; we therefore cannot play around with it. If someone does something negligently or does not follow instructions they need to be disciplined. This is to stop them from doing it again as well as to prevent others from doing the same. Be fair but firm.

*Good planning can greatly reduce the risk from fires (Shiselweni Forestry, Swaziland, 2007)*

**ANNEX A**


FDI ALIGNMENT CHART
DRYBULB °C
35
30
25
20
15
10
5
0
BURNING INDEX
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
RELATIVE HUMIDITY %
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95

## ANNEX B

### FDI RAINFALL CORRECTION FACTOR

| Rainfall | Number of Days Since Rain Last Fell | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1 | 2 | 3 | 4 | 5 | 6 | 7-8 | 9-10 | 11-12 | 13-15 | 16-20 | 21+ |
| 0.1 - 2.6 | .7 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 2.7 – 5.2 | .6 | .8 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 5.3 – 7.6 | .5 | .7 | .9 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 7.7 – 10.2 | .4 | .6 | .8 | .9 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 10.3 – 12.8 | .4 | .6 | .7 | .8 | .9 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 12.9 – 15.3 | .3 | .5 | .7 | .8 | .8 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 15.4 – 20.5 | .2 | .5 | .6 | .7 | .8 | .8 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 20.6 – 25.5 | .2 | .4 | .5 | .7 | .7 | .8 | .9 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 25.6 – 38.4 | .1 | .3 | .4 | .6 | .6 | .7 | .8 | .9 | 1.0 | 1.0 | 1.0 | 1.0 |
| 38.5 – 51.1 | | .2 | .4 | .5 | .5 | .6 | .7 | .8 | .9 | 1.0 | 1.0 | 1.0 |
| 51.2 – 63.8 | | .2 | .3 | .4 | .5 | .6 | .7 | .7 | .8 | .9 | 1.0 | 1.0 |
| 63.9 – 76.5 | | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .8 | .9 | 1.0 |
| 76.6 and over | | | .1 | .2 | .4 | .5 | .6 | .6 | .7 | .8 | .9 | 1.0 |

## ANNEX C

### FIRE DANGER INDEX INPUT SHEET

☐ Temperature °C

☐ Relative Humidity %

= ☐ Burning Index from Annex A

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☐ Burning Index

\+ ☐ Wind speed Mph (Kph x 0.625)

x ☐ Rainfall Correction Factor

= ☐ **Fire Danger Index**

# CHAPTER 17
# COMMON PESTS AND DISEASES OF TREE PLANTATIONS IN UGANDA

*Poor silviculture predisposes trees to attack from many pests and diseases. These eucalypts were infested with the Blue Gum ChalidWasp (Leptocybe invasa) - nr. Jinja, 2006.*

## 17.1 INTRODUCTION

Much of the success of plantation forestry in the tropics and sub-tropics over the past 40 years or so has been due to the use of fast growing, exotic species (especially pines and eucalypts) that have left their natural predators behind. It seems that the 'honeymoon' period is now over, however, with the incidence and impact of pests and diseases steadily increasing. This is largely due to the accidental introductions of pests and pathogens from areas where the trees are native to their new environments but there are also an increasing number of examples of local pests and pathogen species adapting to the introduced tree species. It is clear that in order to sustain profitability those involved in plantations in Uganda must now pay more attention to pest and disease management.

This Chapter describes the main pests and diseases currently affecting tree plantations in Uganda but importantly, it first discusses ways that tree growers can significantly reduce the threat of a serious outbreak. Some worrying pests and diseases which are already in Southern African plantations and pose a serious threat to tree plantations in Uganda, are also discussed.

The SPGS has collaborated with Forestry and Agricultural Biotechnology Institute (FABI) since 2007. In addition to the reports listed in the Reference section at the end of this Chapter, FABI have many excellent publications which provide much more detail on tree pests and diseases than there is space for here: the interested reader is directed to their web site for more information – especially the detailed, well illustrated Tree Protection Cooperative Programme's pamphlets on the main pests and diseases affecting South African forestry (TCCP, no date). SPGS collaboration with Makerere University is also yielding positive results – see especially Nyeko and Nakabonge (2008). Readers are recommended to keep up to date with the latest information on pests and diseases through the SPGS's Newsletters and web-site *www.sawlog.ug*

## 17.2 THE THREAT TO EXOTICS

Plantation forestry generally is based on a limited number of species. In Uganda, for example, PCH and *E. grandis* account for well over 90% of all new plantings since 2003. Even with PCH, most of the seed originated from FPQ's Australian seed orchards, whilst most of the *E. grandis* has come from the small number of parent trees in the NFA's Fort Portal seed stand. This means that the seed origins of Uganda's plantations are from a narrow genetic base and this is a concern when it comes to pests and diseases. If a pest species is accidentally introduced (or a native pest suddenly takes a liking to these 'exotic' species) and takes a liking to these particular species, then there is high risk that the problem will rapidly spread.

There are numerous examples from tropical and sub tropical forestry plantations where this has occurred – for example:

- The stem canker, *Cryphonectria cubensis*, is the most serious stem canker disease

*Jolanda Roux (FABI) inspecting severe BGC damage (nr. Hoima, 2007)*

of eucalypt plantations in the tropics and has caused serious losses in Brazil and RSA.

- Sirex wood wasp, *Sirex noctilio*, currently threatening RSA's pine plantations.
- Cypress aphid (*Cinara cupressi*), which caused major losses in Cupressus lusitanica plantations in Eastern and Southern Africa in the late 1980's and early 1990's.

*Poor rooting (from nursery or bad planting) causes some deaths in young tree crops.*

## 17.3 WAYS TO REDUCE RISK

In order to reduce the threat to our plantations, there are certain precautions that can be taken, the most important of which are described below:

- **Good silviculture:** careful planning combined with good silviculture can greatly reduce stress and thereby promote healthy trees. Just like in human beings, healthy trees means strong trees, which are often able to shrug off the unwanted attentions of many potential pest and disease species. The most important issues are:
  - careful site-species matching (Chapter 6);
  - diversity of species planted (Chapters 3 & 5);
  - good weeding - especially immediately pre- and post-plant (Chapter 11);
  - planting only robust, healthy plants and beating-up early (Chapter 14);
  - thinning on time and to the recommended stocking (Chapter 20).

- **Quarantine:** plant material (including seed) should not be brought into Uganda without official approval. Any seed or plant material being imported must be first cleared with the appropriate authorities: this usually means obtaining an Import Permit from the GoU's Ministry of Agriculture and a Phytosanitary Certificate from the supplier in the country of origin. The Phytosanitary Certificate will normally state that the plant material should be treated against specific pests and diseases. It is also important to bear in mind that it is not only that the imported material that might be harbouring pests and diseases but the actual plants themselves can sometimes cause a major problem. The Water Hyacinth plant and the Paper Mulberry tree (see Page 159) in Uganda are good examples of ornamental plants that have become national disasters.

- **Awareness and monitoring:** effective management of all tree health problems depends on early detection. There is thus a need to train the people who work directly with trees to recognize and interpret the symptoms of the main pest and disease problems. Routine inspections of one's plantations must be carried out and carrying out a first (access) pruning to 2.0m is strongly recommended as this greatly assists movement within the plantation (see Chapter 19).

- **Collaboration:** pests and diseases are no respecters of boundaries, whether it is a country boundary or between your own and your neighbours' trees. Thus collaboration is vital. In RSA there are collaborative initiatives for two of the most worrying pest and disease problems in pine plantations and nurseries – namely, *Sirex* and *Fusarium*. This approach should be followed in East Africa even though previous attempts to collaborate have not had much impact – or at least have not been well communicated outside of official circles (e.g. FAO's Forest Invasive Species Network for Africa). Greater involvement of the private sector in such initiatives, however, will hopefully produce more outputs in the near future.

*Pine dieback - possibly Armillaria - but not confirmed (SUB-Hoima, 2006)*

- **Selection and breeding of resistant plants:** the selection, testing and eventual multiplication of genetic material which is not susceptible to infestation or infection is a major tool to avoid losses to pests and diseases. This requires a focused research effort but experience elsewhere (e.g. breeding *Cryphonectria* canker-resistant hybrids of *E. grandis x E. urophylla* in Brazil) shows that it can pay great dividends in the long-term.

Roux and Slippers (2007) stressed the importance of research in the long term:

*"It is imperative that all parties involved in plantation forestry in Uganda realize that there are no 'quick fixes' in tree health management. Successful pest and disease management requires planning, long term vision, dedication and team work."*

*"Tree health management needs an integrated strategy …which is only achievable by basing the strategies on sound research and experience, rather than loose interpretation. Management should thus include:*

- ***Selection and breeding:*** *planting material should be continually screened for susceptibility to the major pests and pathogens.*
- ***Silviculture:*** *careful site-species matching, good planting practices, weeding etc. to create the best growing environment for the trees.*
- ***Biological control:*** *this approach can be very successful with pest problems, though it can take a long time and intensive research to develop and implement.*
- ***Chemical control:*** *generally not feasible for many pests and diseases in large plantations, though more suitable in nurseries.*
- ***Quarantine:*** *it is needed to keep pests and diseases out of a country or out of a specific area in a country.*
- ***Sanitation:*** *it is especially important in nurseries to remove or destroy all infected material.*

## 17.4 IDENTIFYING THE PROBLEM

Not all tree deaths are due to pests or diseases so it is important to first try and isolate the likely cause. Table X lists the main causes of non-organic issues that can cause tree health problems.

*Pine shoot dieback - possibly Boron deficiency (PCH, Mubende, 2008)*

The main pest and disease problems for trees growers in Uganda can be simply grouped as:

- Fungi.
- Bacteria.
- Insects.
- Larger animals.

Symptoms range from general death of a tree (or group of trees), localised damage and discolouration through to various growth deformations. The precise identification of the problem is often difficult though much can be achieved by following some straightforward procedures.

The first step is to eliminate factors that are most unlikely to be the cause of the problem. For some symptoms the cause may be easily determined (e.g. the obvious galls on eucalypts caused by the Blue Gum Chalcid, *Leptocybe invasa*). Other symptoms may have several possible causes, such as dieback or discolouration of the crown. Boa (2003) is a useful source of reference for identification of the likely causes.

Where the problem is not clear to the grower, the best advice is to 'seek professional advice', although in a country like Uganda where plantation forestry is relatively new, such diagnostic and advisory services are limited. It is recommended to take photographs and notes of any problem first and then contact the SPGS for advise. As demand for a diagnostic service increases, the situation is expected to change and the SPGS is already working with the main players in the sector to provide such a service.

General guidelines for sending plant materials and/or pest samples are as follows:

- Do not move infected material around the country, which may well spread the pest or disease problem to other areas. It is believed that the BGC spread so quickly around Uganda after being first identified in 2002, through infected nursery stock moving around the country.
- Contact the diagnostic laboratory facility first before sending any material to clarify their policy on accepting samples.
- Collect fresh material that shows early stages of symptom development or has evidence of pest infestation.
- Get the sample(s) to the investigating laboratory as soon as possible.
- Pack the samples loosely yet securely to keep the humidity low (NB. do not pack in plastic bags).
- Provide information on symptoms and any other details of the problem (NB. take photographs if possible).
- Ensure each sample is carefully labelled.

## Table 22. Tree Health Problems Caused by Abiotic Agents

| MAIN FACTOR | CATEGORIES AND EXAMPLES | NOTES | POSSIBLE CAUSE/ SYMPTOMS |
|---|---|---|---|
| Chemicals | Toxic: pesticides, herbicides<br>Pollution: deposition on plant, atmospheric, industrial waste<br>Miscellaneous: salt, oil poured into soil | The role of atmospheric pollution in tree declines may be overstated. | Leaf blight caused by herbicide drift: yellowing and/or shoot dieback, depending on dose received. |
| Mechanical agents | Machinery: used in agriculture and for construction<br>Human: malicious, accidental | Mechanical damage can provide means for pathogens (mostly fungi) to enter | Damage by grass cutting equipment: roots and/or trees with physical damage. |
| Soil conditions | Availability of Nutrients: deficiency, excess<br>Lack of mycorrhizal soil (pines).<br><br>Physical Structure: poor drainage, inhibition of root development | Trees respond in different ways to lack of particular nutrients. | Nutrient deficiencies: many symptoms but commonly - shoot dieback; discolouration and twisted needles.<br>Poor nursery practice (e.g. poor pricking out and/or root pruning) *or* poor planting: leading to distorted root structure. |
| Water | Too Much: flooding; water-logging<br>Not Enough: drought | Trees differ in their ability to withstand excess or poor availability of water | Waterlogging: yellowing & general poor growth.<br>Drought: shoot dieback. |
| Weather | Temperature: too low or too high<br>Other: lightning, hail, wind, snow | The effects of climate on tree health are often not immediate | Frost: shoot dieback.<br>Hail damage: physical damage to stems and leaves. |

## Table 23. Uganda's Main Pests & Diseases

| Common Name | Scientific Name | Species | Location |
|---|---|---|---|
| | | | |
| **PESTS** | | | |
| Blue Gum Chalcid wasp | *Leptocybe invasa* | Eucalypts | Wide |
| Termites | *Macrotermes bellicosus* & *Pseudocanthotermes* spp. | Eucalypts | Wide |
| Black pine aphid | *Cinara cronartii* | Pines | Local |
| Grasshoppers - | *Phymateus viridepes* | Pines | Local |
| Large animals | rats, monkeys, antelopes & goats. | Many | Local |
| Yellowing/browning | unknown | *Cupressus lusitanica* | Local |
| | | | |
| **DISEASES** | | | |
| Stem canker | *Botryosphaeria* canker | *E. grandis* | Wide |
| Stem canker | *Coniothryrium spp.* | *E. grandis* | Wide? |
| Pine wilt disease | unknown | Pines | Wide |
| Leaf spot | *Mycosphaerella* | Eucalypt clones | Wide |
| Bacterial blight & dieback | unknown | Eucalypts + hybrid clones | Local |

## 17.5 UGANDA'S MAIN PESTS AND DISEASES

Nyeko and Nakabonge (2008) and Roux and Slippers (2007) identified the following main pests and diseases in Ugandan plantations (Table 23).

## A). PESTS:

### 1. BLUE GUM CHALCID (BGC) – *Leptocybe invasa*.

**Description:** the BGC, which is thought to have originated in Australia, was first identified in the Middle East in 2000 and is now widespread throughout the Mediterranean and Africa. The BGC was first spotted in Uganda in 2002 and has quickly spread throughout the country. The BGC is a minute insect (<1.5mm long): it is black, with transparent wings and only female species are known.

**Symptoms:** galls form on the foliage and twigs of infected plants, where the adult females have inserted their eggs into the epidermis of young leaves, petioles and stems. The larvae then develop inside round galls and the adults emerge leaving round exit holes. Infected shoots appear deformed and heavier infestations results in severe growth malformation and even branch dieback.

*Typical symptoms of BGC on a GC clone (Mukono, 2007)*

**Extent of Damage:** the BGC effects most commonly planted eucalypts in Uganda as well as some hybrid clones too. It spreads very fast due to the small size of the wasp and its lifespan and its method of reproduction (no males required!). A higher incidence of BGC has been noted on stressed trees and also the BGC is not present in the higher, cool regions of SW Uganda.

**Control Measures:** currently no control measures are available against BGC but it is recommended to destroy material that is thought to be infected. The clear link between stressed trees and insect attack, however, means that the healthier one's crop, the less likely it is to be attacked by BGC. As is so often the case with plantations, the application of sound silvicultural practices to reduce stress, will lead a healthier crop. Common causes of stress in plantations are off-site planting, poor seedlings, bad (or late) planting and - especially with eucalypts – not weeding sufficiently.

As noted previously, it is also important to ensure that the nursery stock is not infected with BGC. It is clear that this is how the pest travelled so quickly around Uganda over the last few years. Researchers in Israel are looking into the possibility of finding a biological control agent: a predatory wasp (*Closterocerus* spp.) imported

*The exit holes where the BGC emerges to infect other trees.*

from Australia is currently under evaluation in Israel. In late 2008, the SPGS supported Dr. Philip Nyeko to travel to Israel to catch up with the latest developments with BGC control (see SPGS's regular Newsletters for the latest).

## 2. TERMITES

**Description:** termites are the most serious pests in plantation forestry in the Tropics. In the hotter and drier areas of Uganda, *Macrotermes spp.* can decimate eucalypt plants (pines are not usually affected). Trees less than two years old are generally targeted.

**Symptoms:** termites typically eat the roots, root collars and bark of trees up to two years old. Often the first symptom is the drying of the young trees from the new shoots downwards. The infected tree eventually completely dries up and dies. On closer inspection, the bark around the root collar (at or just below ground level) will be eaten and when pulled up, many of the trees' roots will often also have been eaten.

*Termite feeding has killed this eucalypt (E. grandis)*

**Extent of Damage:** damage can range from a few trees to whole blocks of trees being killed. *E. grandis* appears particularly susceptible. When the termites carry out their damage many months after planting (quite often in the following dry season), the stocking can be severely affected as it is too late to effectively beat-up. Once the canopy has closed, termites are seldom a problem.

**Control Measures:** control of the mound-building termites has traditionally been by mound destruction – notably through physical removal of the queen followed by application of insecticides. NB. Many of the insecticides currently available are highly poisonous and thus the SPGS is not generally recommending their use: growers must first check that any chemical is registered for use in Uganda, have trained their staff properly in pesticide use, provide appropriate PPE for those handling chemicals and follow the instructions on the product's label.

Nyeko and Nakabonge (2008) note the following practices that may minimise termite damage:

- Application of less persistent insecticides such as chlorpyrifos, isofenphos, carbosulfan, carbofuran, permethrin and decamethrin.
- Powder and granular formulations of some insecticides (e.g. Dusban) can be mixed with nursery soil or put into planting holes at planting.
- Using healthy and vigorous planting stock.
- Planting seedlings as early as possible in the rainy season.
- Ensuring seedlings are well watered immediately before planting out.
- Planting species or provenances that are resistant to termites.

**NB.** Dead termite mounds can be recolonised by the same or different termite species and thus it is important to regularly monitor mounds around nurseries and plantations.

## 3. BLACK PINE APHID – *Cinara cronartii.*

**Description:** the mature insect is pear-shaped, soft bodied, greyish black and just 4mm long. Populations can increase very fast as the aphid can complete a life cycle in just 16 days and only female are known.

**Symptoms:** heavily attacked trees have a black appearance from the sooty mould fungal growth which develops on the honeydew excreted by the aphids. In Uganda, the black pine aphid has only been a localised problem, though this could change as the pine plantations expand.

*Black Pine Aphid on PCH (Mubende, 2008). Photo courtesy of Prossy Bahiigwa*

**Extent of Damage:** the aphids extract large amounts of sap from the host trees. Heavily infested trees can have shoot dieback or rarely, even kill the tree. Infestations are greater when the trees are stressed, for example due to drought.

**Control Measures:** A parasitic wasp, *Pauesia cinaravora*, was introduced to RSA in 1983 and has been very effective in controlling the black pine aphid there.

### 4. GRASSHOPPERS – *Phymateus viridipes*

**Description:** these brightly coloured grasshoppers can sometimes be found feeding on the foliage of many different species.

**Symptoms:** trees can be partially defoliated through the insects' feeding.

**Extent of Damage:** the nymphs (hoppers) feed aggressively and can cause extensive defoliation. The impact on trees is not generally considered very serious as defoliated trees usually recover. Some shoot tips may be killed, however, which can affect tree form.

**Control Measures:** it is not recommended to apply chemicals to control grasshoppers.

### 5. OTHERS.

**Description:** problem species include rodents (rats, mice, moles), primates (monkeys) and larger beasts such as goats, antelopes, cattle and even elephants!

**Symptoms:** damage ranges from root damage (moles), bark stripping at ground level (rats), eaten tops (goats), bark stripping around waist height (antelopes) bark stripping high up in the tree and broken tops (monkeys), trampling (cattle).

*Bush-Buck damage to Musizi (Kifu CFR, Mukono, 2003).*

*Goats - the tree planters' greatest enemies*

**Extent of Damage:** domesticated goats and cattle cause the most serious damage though locally, all the other species can cause serious damage.

**Control Measures:** effective weed management will reduce rodent damage. The most effective control for goats and cattle is through developing good relations with surrounding communities to ensure that their animals are not left to freely graze in young plantations. Some plantation owners have encouraged local hunters to keep monkey populations down.

## B). DISEASES:

### 6. *BOTRYOSPHAERIA* STEM CANKER:

**Description:** the fungus *Botryosphaeria dothidea* is usually identified from its symptoms.

**Symptoms:** a wide range of symptoms occur – the most serious being the development of stem cankers and the death of tree tops. Stems cankers are most common on trees stressed by drought and are characterized by stem swellings, bark cracks and the exudation of black kino (which gives infected stems a dark reddish black colour).

**Extent of Damage:** widely distributed: in RSA, it is considered on of the most important pathogens of *Eucalyptus* plantations. Dieback and cankers can cause extensive losses. The stems often break at cankers and the kino pockets render the wood unsuitable for sawn timber.

**Control Measures:** no eradicative treatment is available. We recommend cutting badly infected trees out during routine thinning operations. Since the pathogen is recognised as stress related, apply optimum silvicultural techniques to minimize stress.

*Botryosphaeria stem canker fungus on E. grandis*

### 7. *CONIOTHYRIUM* STEM CANKER:

**Description:** *Coniothyrium spp*. is often referred to as 'measles disease'.

**Symptoms:** small, dark spots on young bark are the first signs, followed by larger patched of dead bark that exude large amounts of kino.

**Extent of Damage:** very serious in RSA since appearing in 1991. It affects a range of *Eucalyptus* spp. and hybrid clones.

**Control Measures:** no eradicative treatment is available.

*Coniothyrium stem canker on E. grandis (nr. Hoima, 2007)*

## 8. PINE WILT:

**Description:** the death of isolated and occasionally groups of pines was previously thought to be a combination of *Armillaria* spp. or site related stresses (e.g. drought or nutrient deficiency). Nyeko and Nakabonge (2008), however, found no typical signs of *Armillaria* and recommend further isolations and pathogenicity tests to confirm the cause of this problem.

**Symptoms:** yellowing and wilting leading to dieback and eventual death of young trees.

**Extent of Damage:** although fairly localised problem, where it occurs the impact is substantial as the trees generally die.

**Control Measures:** no eradicative treatment is available.

## 9. LEAF SPOTS:

**Description:** There are a range of leaf spot diseases caused by various fungal agents that affect many eucalypt species. The most common are *Cylindrocladium spp.* and *Mycosphaerella spp*.

**Symptoms:** leaf spots ranging from small, discrete lesions to irregular necrotic (dead) areas. Young stems can become infected and girdled, resulting in shoot blight.

**Extent of Damage:** widespread but generally not very serious.

**Control Measures:** No eradicative treatment available.

## 10. BACTERIAL WILT/BLIGHT:

**Description:** bacterial wilt (*Pantoea anantis* or *Burkholderia solanacearum?*) is widespread in tropical and subtropical regions. The bacteria occur in the soil and its mode of transmission on eucalypts is not known.

**Symptoms:** bacterial wilt can occur on trees up to 3-4 years but is most severe on plants both in the nursery and in stands up to about 18 months old.

*Pine wilt - thought to be a fungal disease (Mukono, 2008)*

*Bacterial wilt on hybrid eucalypt (GC) clone (Kifu, Mukono, 2008)*

Symptoms include leaf drop, death of stems and reduced growth rate. Infected trees usually die.

**Extent of Damage:** up to 20% losses have been reported from Brazil and China. Damage locally can be more serious: some eucalypt hybrid clones have been badly affected in Kifu nursery.

**Control Measures:** there is no known treatment. Research is needed to identify species and clones that may be more resistant to infection.

## C). OTHERS

This section describes two other groups of pests that tree growers in Uganda should be aware of: first, some insect pests that have caused major losses in Ugandan trees – namely, the Cypress Aphid and the Mvule Gall and then two worrying pests that are not yet in Uganda – the Sirex wood wasp and the Bronze Bug.

### 11. CYPRESS APHID

The Cypress aphid (*Cinara cupressi sensu lato*) first appeared in Malawi in 1986 and quickly spread to southern and eastern Africa, where it quickly devastated *Cupressus lusitanica* plantations. *C. lusitanica* was an important species for cooler, highland areas of Kenya and Uganda for both timber plantations and as an ornamental hedge. The aphid feeds in colonies, sucking sap from branches. Under heavy infestations, whole branches yellow and die back and can lead to tree death. Biological control with a parasite *Pauesia juniperorum* appears to have had some success but the planting of *C. lusitanica* is still not recommended because of the pest and the fact that alternative species will grow significantly faster on typical *C. lusitanica* sites, notably, *P. patula* and PCH.

### 12. MVULE GALL

For many years, the Mvule gall-fly (*Phytolyma lata*) has prevented many efforts to establish Mvule (*Milicia excelsa)* plantations in Uganda. The Mahogany shoot-borer (*Hypsipyla albipartalis*) has also been noted as causing serious damage to young mahogany, even in the nursery (Webster & Osmaston, 2003).

*Galls on Mvule (Milicia excelsa) in Budongo CFR (Masindi, 2004)*

## 13. SIREX WOOD WASP

Sirex (or European) wood-wasp (*Sirex noctilio*) is currently a major concern for foresters in South Africa, where it is causing widespread damage in pine plantations. The pest originally comes from New Zealand but has now spread to many parts of the world. Worryingly for us, Sirex appears to heading North through RSA, so it is probably only a matter of time before it appears in East Africa.

The female Sirex wasp is 2.5-4cm long and lays its eggs in pine trees. The eggs hatch into larvae which tunnel around the sapwood and later into the heartwood of the tree. When the larvae is ready it tunnels out into the cambial area where it emerges as an adult, leaving a very visible hole in the bark. What usually kills the tree, however, is not the wasp itself but a decay fungus it travels with – *Amylostereum areolatum*. When the female injects its eggs into the tree, it injects this fungus along with its own phytotoxic mucus: a deadly combination.

The South African forest industry has impressively mobilised resources and researchers (notably from FABI, ICFR and the major private companies) to tackle the Sirex threat. They are adopting an integrated approach, which considers biological control (using both wasp parasitoids and the nematode *Deladenus siricidicola*), as well as silviculture for forest health (especially thinning plantations to reduce stress and increase air circulation).

*Sirex wood-wasp emergence holes in P. patula (RSA, 2005)*

## 14. BRONZE BUG

The Bronze Bug (*Thaumastocoris peregrinus*) is a small (2-4mm) sap-sucking insect – recently surfaced in South Africa, where it has affected vast areas of eucalypt plantations. It is thought to have been introduced accidentally from Australia. The pest appears to cause most damage during the dry season and is also (as is so often the case with many insect pests) more serious on crops already under stress. The insect feeds on the trees' leaves, causing severe defoliation and in some cases even killing the trees. Identification is from observing the many insects and nymphs as well as noticing the bronzing of the trees' leaves. Little is known about the pest and there are no control measures at present. FABI established monitoring trials throughout RSA in 2007 to obtain data about the pest's population dynamics.

*Thaumastocoris (Bronze Bug) feeding on eucalypt leaves (RSA, 2006)*

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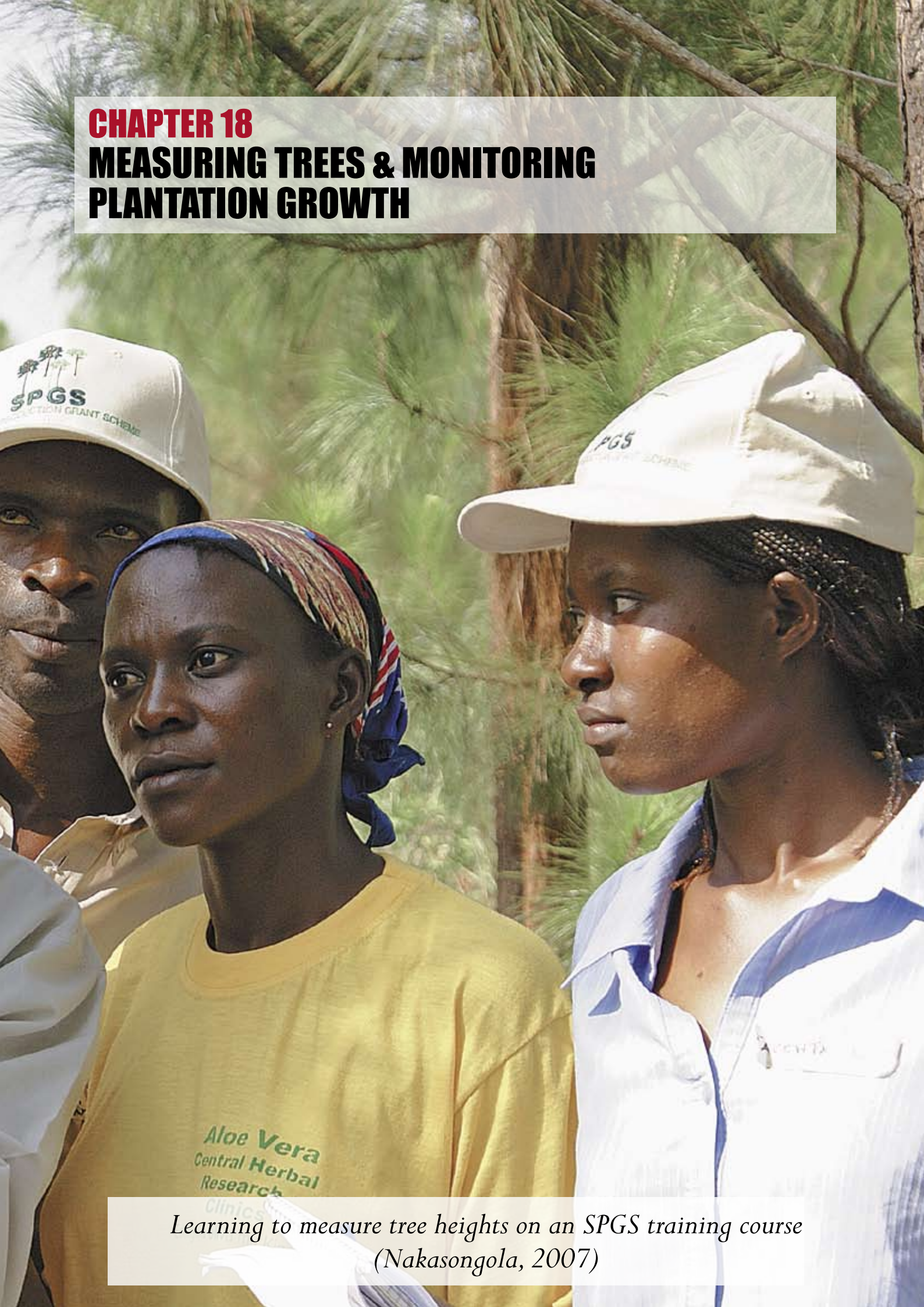
SPGS

# CHAPTER 18
# MEASURING TREES & MONITORING PLANTATION GROWTH




*Learning to measure tree heights on an SPGS training course (Nakasongola, 2007)*

## 18.1 INTRODUCTION

For any commercial tree grower, it is important to have at least a basic understanding of tree growth and current and expected stand volume. Such information is needed not only to predict future revenues (and thus to determine the viability of the tree growing venture) but also for valuation and sale purposes. This Chapter covers only the basics of the large and rather specialist field of tree and forest measurement (usually termed mensuration), inventory and yield prediction. References are given at the end for those who wish to delve deeper into the subject.

Selecting and training a good team is important with mensuration, as is the correct choice of method and instruments to obtain the required information. In a commercial plantation forestry business, many important decisions are taken on the basis of inventory results and thus it is vital that the work is closely supervised and results frequently cross-checked in the field.

## 18.2 SAMPLING

It is most important to understand that in commercial forestry, it is not feasible to measure every tree in one's plantation: this only is possible in small research plots. Thus a sample normally has to be taken, which we hope represents the whole stand. Sampling is a complex area involving detailed statistical analysis, which is beyond the scope of this publication. What is crucial, however, is to ensure that the sample of trees being measured represents a reasonable cross-section of the whole area. This is usually done by measuring trees (or plots of trees) situated systematically throughout the plantation, covering the various site factors (e.g. lower slopes, mid slopes and upper slopes) and the different species planted.

The easiest method is to take transects (lines) at regular intervals throughout the stand, with plots situated at a pre-determined distance along each transect. Each transect is normally done on a compass bearing. This takes away the bias factor, where there is often a tendency to measure only the best trees or areas in a stand and ignore the areas of poor growth or low stocking.

## 18.3 BASIC TREE MEASUREMENTS – I – TREE DIAMETER

**Tree Diameter:** Tree diameter (sometimes called girth) is a quick and easy measurement to take. Tree diameters are normally measured at breast height (dbh), which should always be 1.3m above ground level (NB. always ensure your measuring crew measure where 1.3m is on themselves as people differ in height!). The two most common instruments for measuring dbh are diameter tapes and callipers.

Diameter tapes measure directly a stems' diameter (in cm or mm) with the tape being placed around the circumference of the tree.

*Measuring stem diameter with a dbh tape (SPGS training course, Kyenjojo, 2006)*

Some diameter tapes are 'rounded down' to the nearest cm class, others (used more for research purposes) can read to the nearest mm. Dbh tapes are either plastic-coated fibreglass or steel: the former can stretch as they wear and thus should be replaced as necessary. The steel tapes are expensive and not very hard- wearing. There are some basic rules that must be followed when measuring dbh:

- The dbh tape must always be at right angles to the stem.
- Ensure that the dbh tape is not twisted.
- Remove any loose bark (or other obstacles) before dbh is measured.
- On a slope, always stand on the uphill side to measure dbh.
- The zero point on dbh tapes is the extreme edge of the steel rectangle or the point of the hook.

Callipers are also very common and offer a quick way of measuring tree dbh. They are made of steel or alloy and have one fixed and one moveable arm. The same rules for dbh tapes apply but with calipers, two measurements should be made on each tree at right angles to each other and the average recorded. The most common fault with calipers is excessive movement in the mobile arm and thus they must be regularly checked to ensure that the two arms are parallel.

*SPGS's Thaddeus Businge (left) measuring stem diameter with callipers on an SPGS Training Course (Nakasongola, 2007)*

## 18.4 BASIC TREE MEASUREMENTS – II – TREE HEIGHT

In order to calculate tree (and stand volumes) accurately, tree height must also be measured. Tree height at a given age is also an important indication of site quality for a species. There are two main measurements of individual tree height, namely total height which is the vertical distance from the base to the tip of the tree, and secondly, timber height, which is the height from the base to a specified minimum stem diameter (often around 7cm).

There are also two expressions that refer to stand height (rather than individual tree height), namely, top height (often referred to as dominant height) and mean height. Top height is defined as the average total height of the hundred trees of largest diameter per hectare. To estimate the top height of a stand, a number of top height trees are measured from sample plots throughout the stand. The number of trees depends on the variability of the crop and the size of the stand. For a fairly uniform crop over 10ha, 10 trees will suffice, whereas 16 are recommended for a more variable crop.

Mean height refers to the mean total height of a stand and is assessed by taking the heights of trees randomly selected, irrespective of diameter, throughout the stand. Tree heights are measured as follows:

**Height Rods:** For trees up 6 metres or so, height is best measured directly with a height rod. This is usually a light pole with clear markings (depending on the accuracy required) that is placed against the tree's stem and read directly by another person.

This person must stand far enough away from the tree

*Trees up to 6m are best measured with a height rod (SPGS Training Course, Kyenjojo, 2006)*

to be able to line up the top of the tree and then read from the markings on the pole. Care must be taken not to damage the tree stems when the height rod is placed alongside them. As the trees get taller than around 6m, however, height rods become too unwieldy to use and we have to then use other instruments.

**Clinometers:** The most common instrument is the hand-held clinometer (the most common brand is Suunto from Finland). The Suunto has a solid aluminium housing and a scale that rotates according to the angle of sight. Using a clinometer, a reading is taken at a known distance away from the tree - by sighting on the top of the tree and then on the base of the tree: the tree height is then calculated by adding or subtracting these two measurements (depending on whether one is above or below the tree).

When using a clinometer both eyes must be kept open (which takes some practice!). With one eye looking through the instrument at the scale, the other sights the tree alongside the clinometer housing. An optical illusion is created and the horizontal sighting line will appear to project to the side of the clinometer housing. When this line is level with the tree's top (or base), the scale can then be read.

Suunto clinometers either have a percentage (%) scale or a 15 and 20 metre scale. The 15/20 instrument can only read from 15 or 20m distance from the tree (or multiples thereof) whereas the % one can read from any distance away (which must be measured). Some clinometers also have a built in rangefinder to quickly find the exact distance from the tree: otherwise, a long tape measure is required.

**% Suunto:** using the % Suunto, follow these procedures:

1. Back away from the tree (carefully!) to a point where you can see its top clearly and make a temporary mark on the ground.
2. Measure the distance from the tree (in our worked example let us say this is 25m).
3. With the Suunto sight to the top of the tree and read the % scale (e.g. +63%).
4. Then sight onto the base of the tree (e.g. –7%, which indicates that the base of the tree is below eye level).
5. The total reading is 70% (63+7).
6. To obtain total tree height, multiply this % figure (70% = 0.7) by the distance (e.g. 0.7 x 25m = 17.5m).

**15/20 Suunto:** using a 15/20 Suunto, follow the following procedures:

1. Measure a spot 15m or 20 away from the tree to be measured, where you can see the top clearly: mark the spot on the ground.

2. Using the Suunto, sight to the top of the tree and record the reading from the

appropriate scale (the 15m scale is on the right, the 20m scale on the left as you look through it) (e.g. 17.25m).

3. Do the same sighting on the base of the tree (e.g. -1.5m, which indicates that the base of the tree is below eye level).

4. To obtain total tree height, add these figures (e.g. 17.25 + 1.5 = 18.75m).

5. The 15/20 Suunto can be used at distances of 30m and 40m but the readings on the appropriate scales must then be doubled.

The main problem with measuring tree height is often not being able to see clearly the top of the tree, especially in an unthinned, dense stand. The person using the clinometer must be prepared to frequently move around the stand in order to see the tree tops.

In stands with a lot of ground vegetation, in order to sight accurately on the base of the tree it is good practice to ask a colleague to stand against the tree and sight on where you expect his feet to be!

**The Future:** There is a range of sophisticated digital tools now available from specialist suppliers for measuring quickly and accurately tree diameters, tree height and distances. These electronic devices (clinometers, hypso-meters, relascopes and rangefinders) are, however, beyond the scope of this basic Guideline.

*Using a Suunto clinometer to measure tree heights: keeping both eyes open is a challenge !*

## 18.5 TREE VOLUME

**Basal Area:** The basal area (BA) of an individual tree is the cross-sectional area of a tree at 1.3m. BA is calculated from - BA (in m2) = ($\pi$ x dbh$^2$) ÷ 40,000 NB. Where dbh is measured in cm. and $\pi$ = 3.142.

The BA of a stand is the sum of the BAs of all the trees in the stand. The usual way of estimating stand BA, however, is to measure the dbh of trees in sample plots throughout the stand and then scale this up.

**Tree Volume:** Tree volume is a function of tree height and basal area. A rough estimate of tree volume can be obtained from the following formula: Tree vol. (in m$^3$) = Total ht. x BA x FF NB. Where FF = Form Factor (avg. FF for *P. caribaea* = 0.4; for *E. grandis* = 0.35).

For most inventory work (and especially yield prediction), more detailed estimates of volume are required: these are logarithmic equations derived from accurate measurements of many thousands of trees. They are considered, however, beyond the scope of this publication.

**Stand Volume:** The value that is of utmost interest to the forest owner (or investor) is stand volume. The maximum volume for a given species on a given site is determined not only by silviculture but also by age. To calculate stand volume, an average tree volume is calculated which is then converted into an average volume per hectare by multiplying by the mean

number of trees in each sample plot. The standing volume of the stand is estimated by multiplying the average volume per hectare by the stand's area.

## 18.6 FOREST INVENTORY

Forest Inventory is important for a number of reasons, in particular:

- To provide information for long-term planning.
- To provide data for immediate decisions on felling and thinning programmes.
- For valuation purposes.

It is important to note that a single (one-off) inventory provides only details of the current standing crop. To monitor growth rates, a recurrent or continuous inventory is required. This is discussed in the next section.

**Permanent Sample Plots (PSPs):** The most common form of continuous forest inventory is PSPs, which are located throughout the plantations and re-measured at regular intervals. PSPs have the following objectives:

- To provide information on stand growth for the efficient management of the forest.
- To estimate the potential productivity of the site.
- To quantify the effects of silvicultural treatment on growth and yield.
- To monitor changes in site productivity over successive rotations of tree crops.

Below are guidelines for establishing and assessing PSPs: a team of 4 people are usually needed, including the 'Booker' who oversees the operation.

**Location and No. of PSPS:** the PSPs should cover the range of species, age-classes and sites in the forest. For plantations in Uganda, roughly one PSP for each 15-25ha is a good guide.

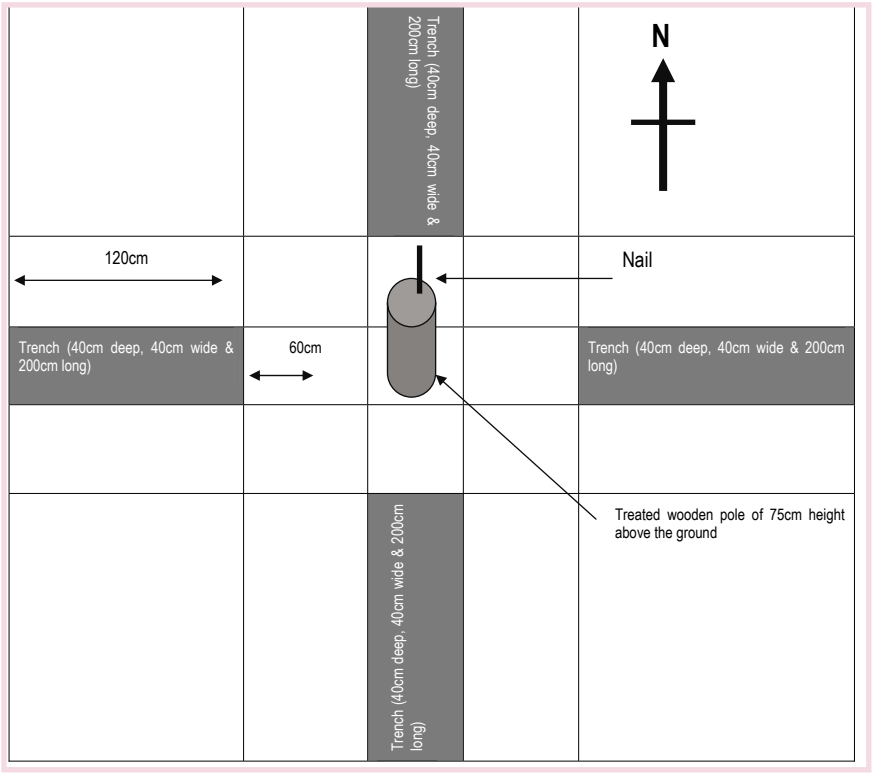
**Size of PSP Plots:** the size of plot is determined by the spacing of trees in the stand: as a guide, each plot should be big enough to include 15-25 trees. Common plot sizes are as follows:

Circular plot radius: 8.0m (= 0.02 ha).
Circular plot radius: 11.3m (= 0.04 ha).
Circular plot radius: 12.6m (= 0.05 ha).

For well established (i.e. well stocked) pine and eucalpyt plantations in Uganda, the 8.0m radius plot is usually sufficient to give enough trees.

**Mapping:** the exact location of the PSPs must be clearly marked on a large-scale map (1:10,000 or larger). The compass bearing and exact distance from a clear reference point (e.g. the road junction at a compartment boundary) to the centre of the PSP must be marked on the map. For those with digital technology, each PSP's centre can be recorded using a GPS.

**Fig13: Recommended PSP Layout**



**Centre Posts:** a treated, wooden post should be put into the centre of the plot with 4 trenches dug along N-S and E-W axes. A nail knocked into the top of the centre post is useful for measuring the plot radius with a tape measure.

**Marking Trees:** all trees within the plot boundary should be marked with permanent enamel paint at 1.3m height. All trees must be carefully checked from the centre post, to ensure that they are within the plot. The trees should be counted (and marked) in a sweep from the North in a clockwise direction. As soon as the trees in the PSP are large enough, numbers should be painted onto their stems. This can be difficult with eucalypts, for example, which shed their bark regularly. Numbered, metal tags are sometimes used instead of paint (though the disadvantage of such tags is that they have to be nailed onto the trees and are often stolen).

**Measuring Trees:** The trees are measured in order – sweeping from the North. The Booker must stand behind the centre-post and direct which order the trees are measured in. When two trees are in line, the closer one is measured first. All dbhs are measured preferably with non rounded-down dbh tapes. A sample of height trees are also measured: in an 8.0m radius plot (=1/50th hectare), the total height of the two trees of largest dbh should be measured in each plot (this gives us the Top or Dominant Height). Height should be measured to the nearest 0.25m if using a Suunto.

**Data Confirmation:** if a PSP is being re-measured, it is advisable to have the data on hand from the previous measurement. In this way, problems can be picked up immediately (e.g. if more trees than before are recorded or if a tree has appeared to have reduced in dbh). Increasingly inventory crews worldwide are using hand-held computers to eliminate such errors.

**Other Information:** Any other observations on tree conditions should be recorded at the time of measuring PSPs, for example, relating to tree health. Because of the long-term nature of PSPs, it is essential that the data is stored both on paper and digitally. PSPs should be re-measured every year. Annexes 1 and 2 can be used for data recording.

**SPGS:** In 2006 the SPGS commissioned the establishment of a number of PSPs in young stands throughout the country and these were re-measured in late-2008. The results are being analyzed.

## EQUIPMENT SUPPLIERS

**Forestry Suppliers, Inc., International**
Sales Dept., 205 West Rankin Street,
P.O. Box 8397, Jackson, Mississippi. USA.
Email int@forestry-suppliers.com
Web: www.forestry-suppliers.com

**Stanton Hope Ltd.**
11 Seax Court, Southfields, Laindon,
Essex. SS15 6LY
Tel. + 44 1268 419 141
Fax. + 44 1268 545 992
Email. sales@stantonhope.co.uk
Web: www.stantonhope.co.uk

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# ANNEX 1: PSP DATA SHEET

| PSP Plantations Form 1 | | | District | | | Measurement date | | Sheet no for this plot |
|---|---|---|---|---|---|---|---|---|
| Plot No | Forest | | Compartment | Map sheet | | UTM East | | UTM North |
| Planting year | Main species | | Site and management remarks | | | | | |

| Tree No. | Spp Code If not main | Diam cm | Quality | Coded Notes | Height m[1] | Remarks | Dist (m)[2] | Bearing Degrees [2] |
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[1] **Only 2 largest diameter trees of normal form per plot to be measured**
[2] Distance and bearing of three trees nearest the plot centre to be recorded

# ANNEX 2: NOTES FOR PSP DATA SHEET

## Silvicultural Scores

| | |
|---|---|
| 1 | Stem severely defective, decayed, bent, forked, with no usable timber currently or potentially. |
| 2 | Stem has severe defect, low forking, contains major bends, but could potentially contain a single section of sawlog. |
| 3 | Stem generally lacks straightness, several curves, sweeps, etc, one or more defects including high forks, but at least 50% of stem volume judged potentially usable for saw timber. |
| 4 | A single minor defect (small rotten branch etc.), minor curvature or sweep on one section of stem not exceeding half the stem diameter in deviation from straightness. |
| 5 | Stem defect-free and perfectly straight. |

## Coded Notes

| Coded note | Description | Action required |
|---|---|---|
| *Dead or missing trees* | | |
| NT | No tree. A tree present at an earlier measurement cannot be found at all (no stump, fallen stem or other trace). | This code must be recorded for any missing tree that cannot be found at all. |
| DT | Dead tree. Tree clearly dead, but still standing. Suppressed tree with no live foliage. | Standing dead trees must be measured for normally diameter. On PSPs it is not unusual for them to come back to life at next measurement. |
| FT | Fallen tree. Tree fallen and on the ground. The tree may still be alive. The root system has not been uplifted (see UT) | It is not necessary to measure such trees. A tree is fallen if the angle with the ground is less than 45°, other wise use LT code. Combine with DT code if tree is dead. |
| HT | Harvested tree. A cut stump has been found, indicating a harvested tree. | |
| UT | Uprooted tree (probably windthrow). The tree has fallen with the root system being exposed. | Assess as for FT – the only difference is that the roots have been uplifted, almost certainly indicating wind damage. |
| *Leaning or damaged trees, defect* | | |
| LT | Leaning tree. The tree is leaning, but at an angle of less than 45° from the vertical, has not been fully uprooted, and is still alive. | These trees should be measured for diameter. |
| FD | Fire damage. Charred bark, burnt pipe or branches, or burnt foliage from fire. | |
| RS | Rotten stem. Signs of fungi or rot on the bole, rotten pipe at base of tree. | |
| RB | Rotten branch. Dead or rotten branch, decay in the upper stem or crown. | |
| EX | Excresences. Bumps or growths on the stem, sometimes with epicormic growth. Usually a sign of fungal or insect damage. | |
| EB | Epicormic branch growth. Usually a sign of ill-health or past severe fire damage. | |
| AD | Ants or termite damage. Evident signs of ant or termite damage (hollowed bole, small trees can be pushed over). | Do not use this code if ants/termites are present but there is no direct evidence of tree damage. |
| BT | Broken top – main bole broken. | Look for signs of decay and add RS code if found (but not if unsure). |
| CD | Crown damage. Branches or tip of crown damaged for any reason (wind, tree felling etc.). | Do not use this code for dieback. |
| DB | Dieback. Leading branches are dead, but main crown still alive. | Do not use this for foliage loss due to suppression or fire damage. |
| FS | Forked stem. | Make a note of the estimated height of the fork. If the stem forks at or below 1.3 m, the tree should be counted as two trees on the plot, with the MS code. |
| FX | Foxtail. Abnormally long, branchless leader, particularly applicable to *P. caribaea* and *P. oocarpa*. | |
| *Regeneration and Silviculture* | | |
| NR | Natural regeneration. (do not apply to coppice). | Only include if stem exceeds 5 cm dbh. Make sure species recorded if not the same as the main crop. |
| CP | Coppice. | This must always be given at the first measurement for all coppice stems. |

# CHAPTER 19
# PRUNING FOR HIGH QUALITY TIMBER

*Which of these pine trees do you think is the most valuable?*

## 19.1 INTRODUCTION

Hopefully you chose the one on the left! This beautiful clean, straight stem didn't just happen on its own: it is a result of good plantation management and especially because it has been pruned at various stages throughout its life. This tree will produce clean timber for which most timber buyers will pay a premium. The tree on the left, however, for the most part has been left untouched after planting and it will produce knotty, low grade timber.

If you are serious about your plantation investment and - like every good business person - you want to maximise the return on your investment, then plantation management doesn't stop at planting: you must continue looking after the crop until the trees are mature. You have to protect them (from cattle, fires, pests and diseases etc.) and thin them out more than once to achieve good form and high yields. To obtain clear timber, you must also prune them and pruning is the subject of this Guideline.

## 19.2 WHY PRUNE?

Branches cause knots in timber and knots are a major cause for timber quality downgrade. Pruning is the physical removal of a tree's lower branches, usually carried out in stages or 'lifts' throughout the life of the plantation. Pruning allows the early formation of clear knot-free timber and thereby improves timber quality. Pruning is thus a technique for adding value to trees growing in plantations.

Most tree species exhibit a degree of self-pruning, especially when grown in a plantation situation, which casts heavy shade on the lower branches as the trees grow. Tree species, however, differ in their ability to self-prune: pines have much more persistent branches than most eucalypts but both require pruning if the grower wants to maximize the quality of the sawlog produced.

Pruning at the right time throughout the tree's life ensures that the knots are confined to a knotty core in the centre of the tree (as the exaggerated diagram and the plank below show). The wood around this core then has only clear, more valuable timber in it. Although hard to imagine, this is because a tree grows from the outside in - from the cambial layer of cells just inside the bark, which continually pushes new cells towards the centre as it expands outwards.

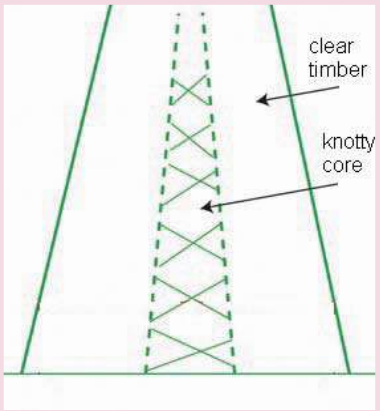
Once branches have been removed (pruned), new wood grows over the scar and the result is clear timber on the outside and a thin knotty core on the inside. Removing only live branches ensures that the knots that will be live: pruning branches when they have already died results in loose (dead) knots, which are a major degrade to timber.

Knots are undesired for several reasons:

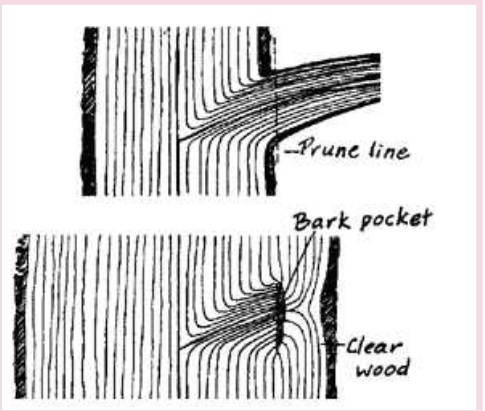
- They are visually unappealing, especially in furniture and other exposed wood surfaces.
- Knots render wood difficult to work, for example cutting, sanding and drilling.

*High pruning is standard practice when growing for timber (York Timbers, RSA, 2007)*

*Knots are generally considered as defects in timber.*




*Timely and regular pruning restricts the knots to a central core.*




*How clear stemwood is made after pruning.*

- They reduce the strength of the timber, large knots cut against the timber graining making weak points.

Timely pruning also has other benefits for a plantation:

- To make access easier for inspection, fires and other operations in the plantation (e.g. thinning; tree measurement; monitoring pests etc.).
- To remove heavy branches before they break off causing damage to the tree.
- To remove branches before they die and rot causing decay in the tree: this renders the tree susceptible to disease.
- To raise the height of the branches from the ground, therby reducing the risk of a fire from moving from the ground to the crown.
- To increase access into the compartment for silviculture, harvesting and fire fighting.

## 19.3 WHEN SHOULD I PRUNE?

This is the question every grower asks us and it is difficult to give a definitive answer since conditions vary so much in forestry. Thus pruning (like weeding and thinning) schedules vary with species, sites and growth rates. There are, however, some important guidelines that need to be followed (NB. note that the tree height and canopy density is more important than the tree age).

It is important that pruning takes place before the branches die, otherwise dead knots will form. Thus it is important to monitor one's plantation(s) to see when canopy closure (i.e. when the overlapping branches from adjacent rows start touching) is expected. This marks the onset of considerable competition and is also the trigger for thinning too (see next Chapter). Crops grown at wider espacements will generally close canopy later than those grown closer together. Table 24 gives a broad recommendation for pruning Ugandan Pine plantation species being grown primarily for timber.

*High pruning will maximize the value of the sawlogs' timber*

**Table 24. Pruning Schedule Guide**

| Prune | Pruning Ht (m) | Age Guide | | SPH | Comments |
|---|---|---|---|---|---|
| | | *Pine* | *Eucs* | | |
| 1st | 2 | 3-4 | 1-2 | 1111 | This 'access' prune is essential |
| 2nd | 4 | 5-7 | 3-4 | 700 | |
| 3rd | 7 | 8-10 | 5-6 | 500 | Some growers stop here |
| 4th | 10 | 11-13 | 7-9 | 300 | Higher pruning is costly |

*NB1. Never prune more than half tree height.*
*NB2. The ages shown are just a guide: the actual age will depend on the growth rate on each particular site.*

## 19.4 PLANNING ISSUES

Before any pruning work is carried out there is some planning to do: the main issues to be considered are:

- Estimate the size of the area to be pruned and how many trees are in that area (sph). Then you can work out the labour requirement, organize equipment and know roughly the time it should take to do the work.

- Check how tall the trees are and to what height the pruning will be done to. Pruning too high will depress the tree's ability to grow; prune too low and you will be leaving branches that can cause knots and damage the timber. The height of the pruning also influences the equipment that will be needed.

- Judge the terrain of the plantation site area: a steep area will reduce productivity compared with a flat area.

- All the pruning equipment also needs to be checked to ensure that it is in a safe working condition: the saws must always be kept sharp and clean.

- Plan to prune in conjunction with your thinning schedule - i.e. don't waste money pruning trees that are about to be thinned (NB. the exception is the 1st (access) prune, which should be 100% so that the thinning crew can move through the stand easier).

*A good quality, professional pruning saw*

*1st pruning at an SPGS Plantation Maintenance Training Course (2007)*

## 19.5 HOW TO PRUNE

When pruning light branches during the first pruning, the branch is simply cut through with a pruning saw or loppers. A sharp pruning saw is recommended rather than a pangas or hatchets, which can easily damage the tree. The cut is made just away from the stem and the remaining stub should not be big enough to hang anything on (a 'coat peg') - as shown in the picture. In all cases the equipment must be sharp to prevent tearing or ripping of the tree's bark.

The first pruning is to about two metres and can thus be easily carried out from the ground. As the pruning gets higher, the more difficult it gets and the handles have to be extended. Ladders are sometimes used for the higher pruning operations also but their use should be discouraged unless on very flat, firm ground as it can be very unsafe (see photo). Later (very high) prunings should never be done with a ladder.

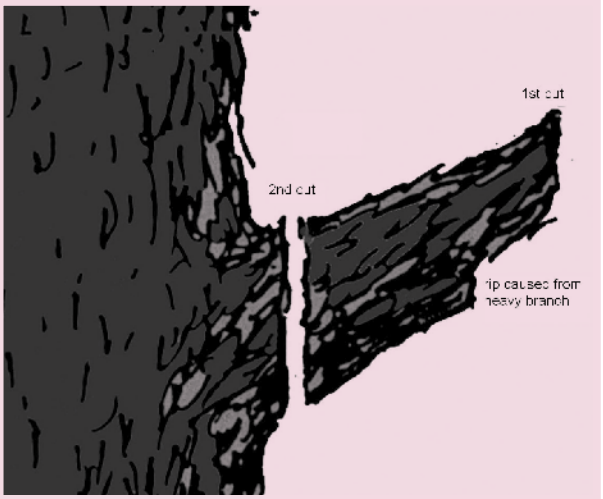
Safety is a big part of any work we do and unsafe activities such as the one illustrated here should be dealt with severely.

People will sometimes do stupid things if they think it will save time or energy. The result will be poor work done, damage to your trees and likely damage to the person. Since there is a likelihood of something falling on workers' heads as they prune, hard hats are obligatory safety equipment. Also eye protection (goggles) will be needed to protect workers' eyes from sawdust and other material dropping onto them.

When pruning bigger branches, two cuts have to be made in sequence (see Fig. 14). The first one to cut off the branch about 20cm from the stem, this removes the weight off the branch so that when the remaining piece is cut away just off the stem ,the weight does not rip the branch down causing damage to the stem and to whoever is standing underneath. Stem damage from ripping or careless sawing and cutting opens a wound for disease to enter the tree and also takes a long time to heal, leaving a scar and poor quality timber in its place.

For all the pruning operations, the cut branches alongside roads, footpaths or firebreaks need to be removed and stacked three tree lines from the risk area to prevent easy access for fires to jump into your trees.

**Fig. 14. Pruning Large Branches**




*The 2-cut procedure for cutting heavy branches.*

*Poor pruning like this will greatly reduce the sawlog's value*

The rest of the branches can be spread around the plantation to break down quickly and not create barriers which make crossing in emergencies difficult.

Remember to get good returns at the end of rotation we have to ensure that the trees are capable of producing a high quality, high value product. Although pruning can represent a significant cost to the grower, in Uganda it is highly likely to be a cost-effective operation but only if it is carried out at the right time and done well.

*Another accident waiting to happen - rather use a long pole*

*Damage to the stem like this must be avoided when pruning*

# CHAPTER 20
# THINNING TO MAXIMIZE SAWLOG PRODUCTION

*Timely thinning results in fast growth and big sawlogs (York Timbers, Sabie, RSA, 2007)*

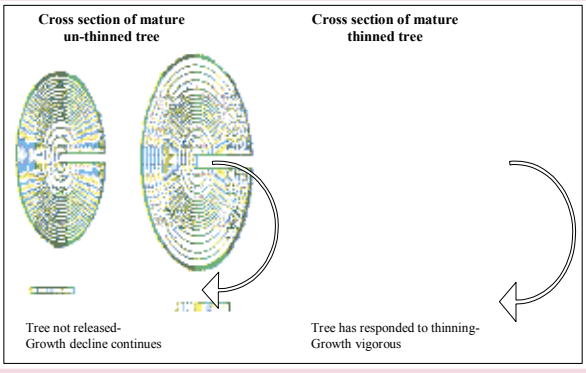
*1st thinning in 4-yr old PCH (BFC, Mayuge, 2007).*

## 20.1 WHY THIN?

Thinning is an important silvicultural operation that maximizes the production of large sawlogs in the shortest possible time. Thinning is the removal of a proportion of individual living trees from a stand before the final harvest. It is normally carried several times over the crop's life and should start soon after canopy closure, which is when competition begins. Thinning normally removes the weaker trees and gives the best trees the space to reach a utilizable size sooner.

Thinning is done so that the stand produces only large, high quality trees, which can be sold at a premium price. Where this size and quality does not matter (e.g. a fuelwood plantation) we would obviously not do the same thinning as for sawlog production. The intended market thus determines the thinning programme (or regime, as it is usually called). For the production of sawlogs and veneer logs, a number of thinnings are required over the rotation of the crop to produce final crop trees with big diameters in the shortest possible time.

**Fig. 15. The Impact of Thinning on Tree Growth**




The number of trees per hectare (called stand density or stocking) affects yield and value growth of trees, just as site quality and age do. Like other crops, trees grow poorly if there are too many or too few per hectare. Unlike most crops though, trees live long enough and grow large enough that the optimum number per hectare changes. Deliberate control of stand density by thinning improves the vigour, growth rate and quality of the remaining "final crop" trees. As a result, the forest owner benefits in three ways:

1. Growth is concentrated on fewer, faster growing trees.
2. Faster growth reduces the time required to reach harvestable size.
3. Larger trees bring premium returns at time of final harvesting.

Only high-quality trees should be permitted to grow to final harvest, eliminating volume accumulation of low-value trees. Thinning operations can provide an intermediate financial return too. Whilst the trees from the first thinning operations will often be too small to have much value, those from later (2nd and 3rd) thinnings should mostly be of utilizable size.

In any timber stand the trees compete with each other for light, soil moisture and nutrients. The more crowded the trees are, the more intense the competition. In a very crowded stand the growth rate is reduced, and eventually the weaker

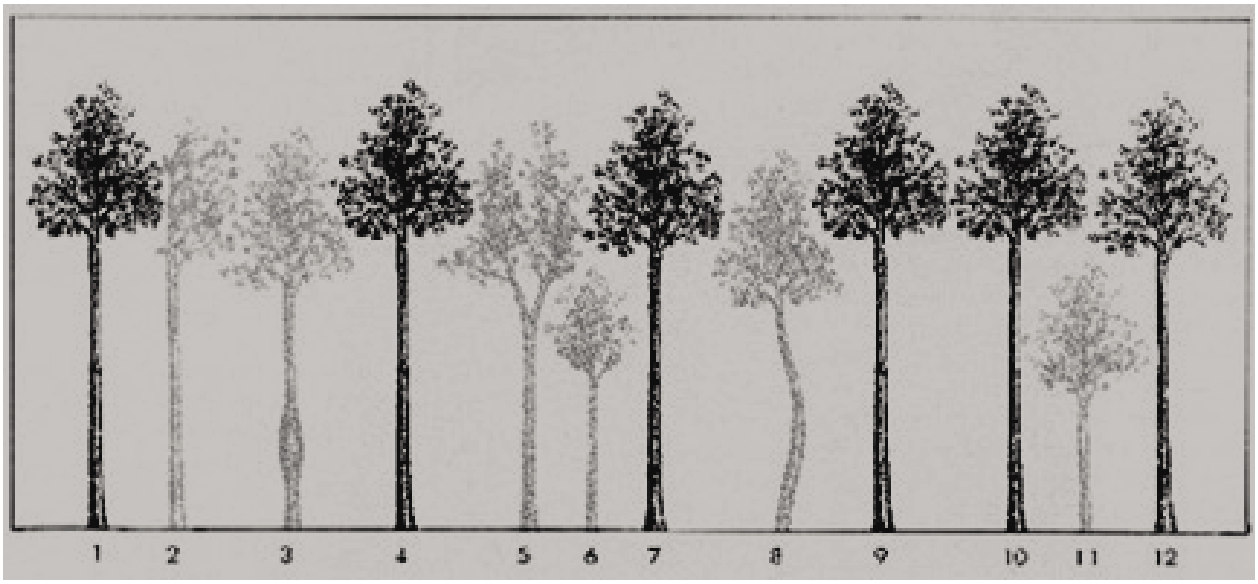
*A 3rd (and final) thinning operation in P. taeda (York Timbers, 2009)*

trees die (i.e. a natural thinning takes place). The volume of wood produced by a timber stand of a certain age on a particular site is about the same over a wide range of stand densities. This means that if the number of trees in a stand is reduced, the same volume of wood can be produced with fewer trees, while maintaining a good rate of growth.

Because the remaining trees are provided with more space for crown and root development this encourages stem diameter growth and thus the trees reach the desired size sooner. Thinning also helps to prevent stress, which may induce pests, diseases and stand instability. Thinning can also provide an intermediate financial return from sale of thinnings. The main objectives of thinnings are as follows:

- to redistribute the growth potential of the stand to the well formed, high quality trees;
- for stand hygiene (by removing dead, dying or diseased trees);
- to maintain the vigorous growth rate of the stand;
- to utilize to financial advantage all high value merchantable timber produced by the stand.

**Fig. 16. Selecting Trees for Thinning**




*The trees above removed by thinning are (2) one-sided crown, (3) bole (trunk) deformities, (5) forked stem, (6) overtopped tree, (8) crooked stem, and (11) small tree too close to larger neighbours.*

*Students learning to thin in a 3-yr E.grandis crop (SPGS Training Course, JFU, 2005)*

## 20.2 HOW TO THIN

This operation is extremely important and must be done by competent persons. The marking should be checked at frequent intervals. The following decision criteria should apply listed in priority:

- First mark obviously defective trees.
- Secondly, target trees below average size.
- Thirdly, try to maintain an even distribution of remaining trees.

Ideally thinnings should be accomplished by individual tree selection. This provides the maximum opportunity to select and favour potential crop trees. Each tree to be cut should be marked and the contractor should be penalized for cutting or damaging unmarked trees. This method will not bring the top price for the wood sold, but remember - your objective is to favour the best trees for future growth, not to produce maximum income from the thinning operation.

In plantations *row thinning* has become popular because it is quick, easy and economical. But since row thinning is non selective, it does not improve the quality of the stand. Row thinning is, however, used where the trees are all uniform: this can be achieved by using improved seed or clones and by practicing good establishment and maintenance silviculture.

A better method is a *modified row thinning* in which every fourth row is removed to provide access to the stand and intermediate rows are thinned by individual tree selection. In a subsequent thinning the middle row of the three remaining may be removed by row thinning.

Unless you have a large area to thin the first method of individual tree selection is recommended. The following points will outline how this is done. The marking for thinning operation is done using a series of plots, which will cover the entire area.

1. The plot size needs to be determined. Depending on your initial espacement the actual plot size may differ. A workable size is to take a plot of 10 by 10 trees (or stumps).

*1st thinning in 4-yr PCH (SUB, Hoima, 2007).*

2. The number of trees to remain must then be determined (see Tables in Section 20.4). This will indicate how many trees are to be left per hectare. For example, with 3 x 3m spacing, the plot size would be 27 x 27m (729m$^2$). Since 1 ha = 10,000m$^2$, this gives 13.7 plots per ha (10,000÷729) - rounded up to 14 plots per ha. Take your desired stocking after thinning and divide it by 14 to get the trees that must be left in each plot. In our example, only 50 trees should be left in each plot at first thinning.

*1st thinning is overdue in this 5.5-yr old PCH stand (NFA, Mubende, 2008)*

3. You need your marking crew, which consists of 6 people. Four to stand on each corner. One to identify the trees to be removed and one to mark those trees (normally with paint).

4. The crew starts at one point of the compartment and systematically work their way through the compartment. The corner markers stand on each corner. The identifier chooses the trees for removal using the points discussed and the marker paints a visible mark on each of those trees. They then move to the adjacent plot.

When marking which trees to thin, we recommend using a bright spray paint rather than the traditional 'blazing' with a panga. The main reason for this is that if there is an unforeseen delay between marking and thinning (as often happens), the trees are not permanently damaged and open to possible infection. Also, if mistakes are made in the marking operation, they can easily be corrected by using a different colour spray paint for the new marking operation.

## 20.3 KEY ISSUES

- Thinnings are cuttings made in immature stands to stimulate the growth of the remaining trees and improve the yield of the stand.
- Trees compete for light, moisture and nutrients, and if they become too crowded, growth slows and they may eventually die.
- Trees grow rapidly and trees grown for sawlogs are worth far more than trees grown for pulp or fuel wood
- The result of a thinning operation should be to provide more growing space for the best trees, while harvesting diseased, damaged or dying trees.

## 20.4 STOCKING

Overleaf are two tables, one for pine and one for eucalypts. These tables are rough guides as to how many trees are to be left and at what age the thinning operation should be done. The actual timing and intensity will depend largely on the species, its growth rate and the silvicultural regime employed. Thinning should take place before significant competition sets in between the trees and the operation should be done to an intensity which will keep that competition from

*Initial espacement and thining trials like this one in RSA, have found optimum stocking for main commercial species.*

reoccurring for a few years at least but also not so severe so that thick branches and extreme taper are encouraged.

**Table. 25. Thinning Regime For Pine**

| Thinning | Age | Stems left |
|---|---|---|
| 1st | 4 to 6 | 700 |
| 2nd | 6 - 9 | 500 |
| 3rd | 9 - 12 | 300 |

**Table 26. Thinning Regime For Eucalypts**

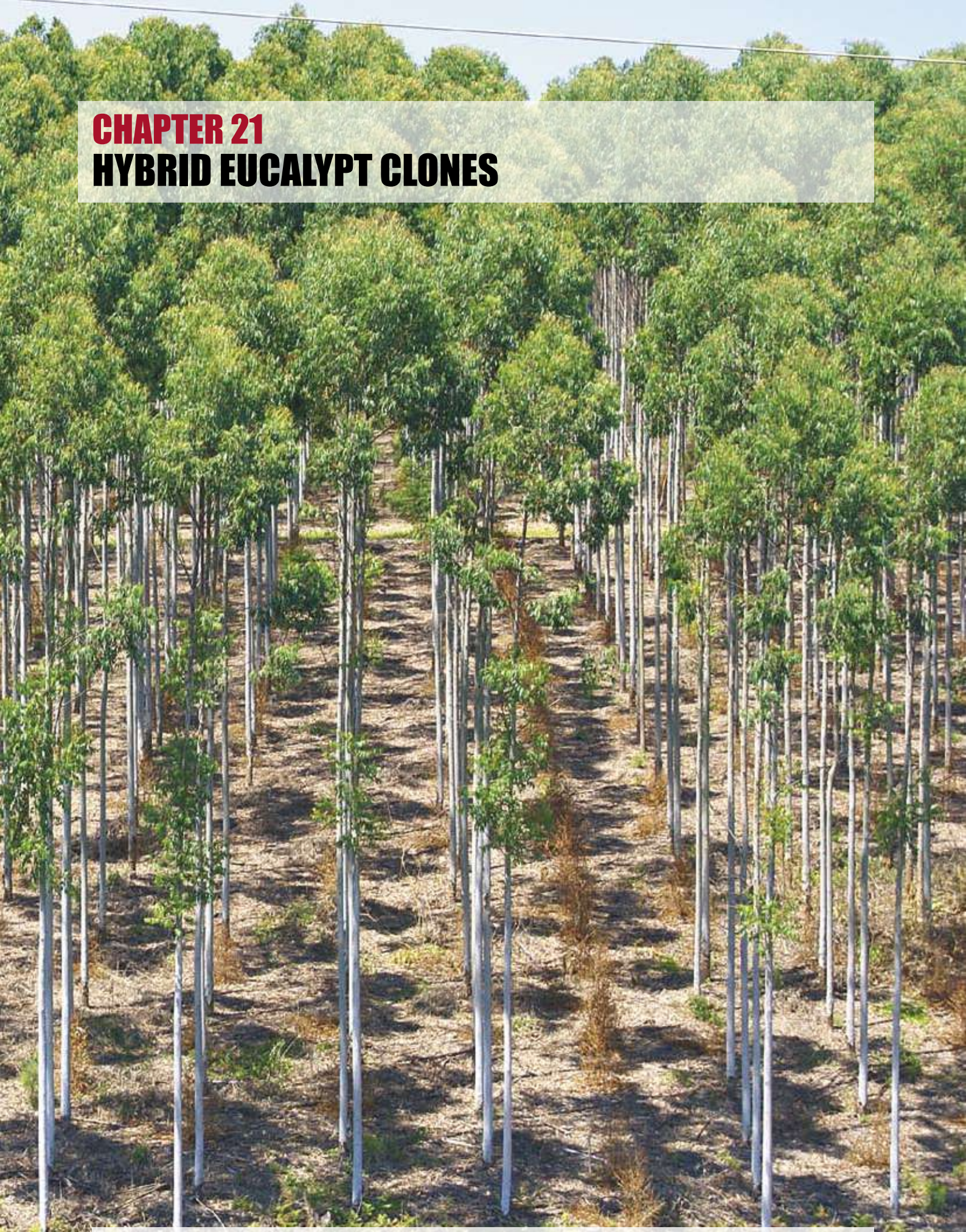
| Thinning | Age | Stems left |
|---|---|---|
| 1st | 1 to 2 | 700 |
| 2nd | 3-4 | 500 |
| 3rd | 5-7 | 300 |

## 20.5 CONCLUSION

There has been great reluctance of late to thin timber crops in Uganda because the owners (both NFA and private) do not have a ready market for the thinned trees - especially first thinnings from pines. This is a great mistake as the trees will be under severe competition and losing considerable value as a sawlog crop. Whilst nobody likes to 'thin to waste,' it is sometimes necessary for the sake of the crop remaining.

Thinning is a more expensive harvesting operation than clear cutting and, therefore, returns less money to the landowner. However, the improved utilization, intermediate cash flow and the increased value of the final crop can make thinning a profitable management decision. Do not be tempted to 'cut the best' to maximize revenues from thinnings: thinning is a silvicultural operation carried out to increase the value of the final crop. Growers must ensure that the thinning teams (for both marking and cutting) are properly trained and supervised. Never leave a sawmilling contractor to thin your stand without careful supervision as they will tend to cut the better trees.

# CHAPTER 21
# HYBRID EUCALYPT CLONES



*GC clones (Peak Timbers, Swaziland, 2007 - before the disastrous fire later in 2007.*

## 21.1 INTRODUCTION

Over the last 20 years or so, hybrid *Eucalyptus* clones have become increasingly important in commercial plantation forestry. Millions of hectares have been planted in tropical and sub-tropical countries where hybrid Eucalyptus clones form the basis of both large and small scale, commercial planting programmes. South Africa, Brazil, China, DRC, India and many South American countries are just some of the countries with major plantation industries based to a large extent on hybrid *Eucalyptus* clones.

Around 2002, a collaborative *Eucalyptus* clonal research programme was initiated in Uganda between the National Forest Research Institute (NaFORRI), the UK's Gatsby Charitable Foundation and Mondi South Africa. This research is now bearing fruit with some of these hybrid eucalypts available commercially to growers in Uganda since 2008. The SPGS - in collaboration with Uganda Gatsby Trust (UGT) – is now promoting the planting of these hybrids on a limited scale.

UGT's involvement in the testing and multiplication of these hybrid clones is to exploit their great potential to provide small farmers with a crop that can produce useful and saleable products quickly – whether it is fuelwood, poles or timber. These clones have the potential to mature faster than traditional species too, which is very significant given the backdrop of a serious wood shortage in Uganda in the very near future.

This Chapter gives a brief outline of the science behind hybrid *Eucalyptus* clones as well as some important practical information for their successful (and responsible) planting in Uganda. NB. Readers are urged to read this Chapter in conjunction with Chapter 10 – *Eucalypts,* which has important details on eucalypt silviculture (including environmental issues).

## 21.2 WHAT ARE HYBRID CLONES?

A hybrid is a cross between two distinct species. The main eucalypt species we are interested in for Uganda are *E. grandis* (G), *E. camaldulensis* (C) and *E. urophylla* (U). *E. grandis* is nearly always the mother tree in the hybrid crosses. The two hybrids we are most interested in are GxU and GxC – hereafter GU and GC. Some of the GU and GC hybrids combine the best traits of each parent and it is the best of these that we want to copy – or clone. Clones are plants produced vegetatively (i.e. asexually) from a common ancestor. The most common method is by rooting cuttings from the parent tree. All the cuttings produced from one parent are genetically identical.

## 21.3 WHAT ARE THE ADVANTAGE OF HYBRID CLONES?

In case the pictures in this Chapter don't convince you, the main reasons why hybrid clones have become so important to the forestry industry are as follows:

*NaFORRI's clonal trial at 34 months (Mayuge, 2005).*

- **Increased yield:** provided the clones are properly tested for performance and other factors, plantation yields (and thus profit) can be greatly boosted.

- **Increased uniformity:** with each individual clone being genetically identical, clonal plantations are much more uniform compared with those raised from seed. Uniformity is an important objective of commercial forestry as it decreases the unit costs of many operations and increases recovery of the final product(s).

*3 month old GC clones (BFC, Mayuge, 2008).*

- **Wider adaptability:** some hybrids are better adapted to specific site conditions – e.g. drier or wetter, colder or warmer. They can thus extend the planting range from that of each parent species.

- **Disease resistance:** some hybrids can offer better disease resistance compared to the pure species. Screening for resistance to specific pests and diseases is always incorporated into clonal testing programmes.

- **Rapid multiplication rates:** the key to successful clonal forestry is the ability to mass-produce superior clones on a large scale. Recent scientific advances have made this possible: rooted cuttings is the most common technique though some organizations are investigating tissue culture too.

## 21.4 PURE *E. GRANDIS* vs HYBRIDS

On the right sites in Uganda, *E. grandis* from improved seed is likely to produce the best timber yields. *E. grandis* generally has fast growth and an excellent stem form. There are, however, many sites not suited to *E. grandis* - being too hot and/or dry. On such marginal sites, *E. grandis* becomes susceptible to pests and diseases – especially fungal stem cankers and the BGC wasp (see Chapter 17).

*E. urophylla* is a more tropical species than *E. grandis*, being found naturally in Indonesia. This makes *E. urophylla* better suited to more tropical sites (i.e. higher rainfall and higher temperatures): it also exhibits better resistance to most pests and diseases compared to *E. grandis* on such sites. Some GU hybrid crosses thus combine the best traits from each parent producing a GU with good stem form, fast growth and improved disease resistance.

*E. camaldulensis* is naturally adapted to drier and hotter sites than pure *E. grandis*. On its own, however, *E. camaldulensis* generally has a poor stem form but when combined with *E. grandis*, certain crosses combine the best of both species. GC has been the dominant hybrid in RSA's large-scale planting for pulpwood in Kwa-Zulu Natal.

*A private farmer in Kenya proudly showing us his 18-month old hybrid eucalypts, which will soon earn him a good income (Kenya, 2004)*

## 21.5 SOUNDS TOO GOOD TO BE TRUE?

There are some reservations with using clones:

- **Site-clone matching:** It is important to note that many clones are very site specific. This means that a particular clone might perform well on one site but poorly on a different site. Limited scale planting with any one clone is thus recommended before massively expanding.

- **Timber quality:** The hybrid clones currently being produced in Uganda by UGT were initially developed by Mondi in South Africa for their superior growth and pulping characteristics. They have not been tested for their timber properties – e.g. end-splitting and density – which are more relevant to timber growers in Uganda.

- **Susceptibility to pests & diseases:** with each clone being genetically identical, there is a higher risk of widespread damage if a pest or disease takes a liking to one of the clones. This risk can be reduced by restricting the area planted to any one clone over a particular region.

- **Higher cost:** typically a clonal plant will cost 2 to 3 times that of a seedling, reflecting the higher cost of research and production. This cost, however, should be more than justified by the increased yield of the clone (provided, of course, the clone is well suited to the site and the recommended silvicultural practices for eucalypts are carried out.

- **Silviculture:** whilst clonal forestry can be an excellent way of achieving high plantation yields, without good silviculture it will be an expensive failure. As with all eucalypts, good land preparation, careful site selection and intensive weeding (pre- and post-plant) are the keys to success (NB. refer to Chapter 10– *Eucalypts* - for details).

## 21.6 CLONAL FORESTRY IN EAST AFRICA

Tree Biotechnology Projects were set up in Kenya (1997), Uganda (2002) and Tanzania (2003). They were supported by the International Service for the Acquisition of Agric-biotechnology Applications (ISAAA), Mondi BP (South Africa), and the UK's Gatsby Charitable Foundation. The aim was to introduce new fast growing tree varieties and to accelerate their production through clonal technology. The Kenyan project moved on quickly from the research phase and by 2004 was producing 1 million rooted cuttings and also had established a nationwide delivery network for the plants.

NaFORRI – in conjunction with Mondi and the Gatsby Charitable Foundation – established a series of 13 trials around Uganda in 2002 and 2003. The trials covered all the main agro-ecological zones in the country and included 12 *Eucalyptus* clones – 5 GUs, 6 GCs and one pure

*E. grandis* clone. The recommendations for these clones given in this Chapter are based on the preliminary results from NaFORRI's assessments (NaFORRI, 2007).

## 21.7 CLONE-SITE MATCHING FOR UGANDA

There are at present four GU clones available (GU7, GU8, GU21 and GU609) and six GCs (GC514, GC540, GC550, GC578, GC784 and GC796). In general, the GC hybrids performed better at the trial sites in the north and east of Uganda – on the hotter, drier sites. GUs performed better in the western and southern sites.

The recommendations made here (see Table 27 and Fig. 17) must be taken with care: more detailed analysis of NaFORRI's trial results is needed and in two of the agric-zones, the trials have not been measured (and thus we have not made any recommendations). A further note of caution is that these clones – originally selected by Mondi for their superior pulpwood yields – have not been screened for timber quality. Makerere University (in conjunction with UGT) is currently carrying out research into this aspect (SPGS, 2009).

*An outstanding 5-yr old GC in NaFORRI's Mayuge trial (2007)*

**NB.** Until we are more confident, it is recommended for any one planter not to plant more than 20% of one's total planting to the clones and not more than 10 ha of any one clone.

The plants are being raised in UGT's 3 clonal nurseries – at Kifu (adjacent to NaFORRI's new HQ in Mukono); Fort Portal (at Kyembogo DATIC) and Mbale (next to NFA along Tororo highway). The clonal beds (or 'mother garden') and the cutting process can be seen in the photos in this Chapter. The UGT nursery managers are as follows:

- Kifu: Simon tel. 0752 644 995.
- Mbale: Moses tel. 0772 595 545.
- Fort Portal: Samson tel. 0782 153 659.

## 21.8 OTHER ISSUES

**Planting Technique:** The technique recommended for planting rooted cuttings is slightly different than for seedlings. South African experience has shown that early survival and growth are better by planting the rooted cuttings somewhat deeper – to above the level of the top of the original cutting. The best guide is to plant 4 fingers from the top of the root plug (see photo). This means that the pit preparation has to be better (i.e. deeper) so that the plant is not just pushed into the pit to get the required planting depth.

**Monitoring & Evaluation:** Whilst these hybrid clones are relatively new to Uganda, growers are urged to carefully record which

*Mondi's Ray Kinsey (rt) showing the 4-finger depth for planting clones (2009)*

clone is planted where, to monitor their relative performance and to note any problems that arise with any specific clones.

**Susceptibility to Pests & Diseases:** The susceptibility of the clones to various agents is not yet known. Observations over the last few years have shown that some clones are susceptible to bacterial wilt and the BGC wasp (*Leptocybe invasa*). We also do not know their susceptibility to termites and thus more scientific research is needed before conclusions can be drawn. NB. For further details refer to Chapter 17 – *Common Pests & Diseases.*

**Importance of Further Research:** Using relatively few clones (as in Uganda) for widespread planting is a risky strategy in the long-run. Hence it will be important to increase the number of clones in production as a buffer against any problems that may arise with the older clones. The typical sequence of events in clonal forestry is as follows:

1. Identify superior individual trees and take cuttings from them.

2. Establish clonal trials with a large number of clones (>100) over a range of typical planting sites.

3. At a suitable age (3-4 years with *Eucalyptus* in Uganda – older for other species) identify the best clones (typically 10-50) from the trials.

4. Selected clones are then multiplied on a large scale – typically by rooted cuttings.

There is currently no formal tree improvement programme (TIP) for commercial forestry in Uganda. The COMFORT Steering Group (which includes SPGS, all the large private companies, UTGA and MUKFoF) – has prioritized the importance initiating an applied TIP. Key elements of this TIP will include:

- Species and provenance trials throughout the main planting regions of Uganda.

# UGT CLONAL PRODUCTION


*UGT staff taking cuttings at their Fort Portal nursery (2008)*

*The mother garden at UGT's Fort Portal nursery - with NaFORRI's clonal trial at top of hill.*

*Julian Evans & Pat Hardcastle inspecting the rooting section at UGT's Kifu Nursery (2009)*

*Yes - just 5-months old! GC clonal mother-garden at Kifu (2008)*

## Fig. 17: Agro-Ecological Zones in Uganda


Source: National Agricultural Research Organization (NARO).

## Table 27: Clonal Recommendations for Uganda (NB: Refer to Fig. 17)

| ZONE | ECO –CLIMATIC CHARACTER | RECOMMENDED CLONES |
|---|---|---|
| I | • Average rainfall of 745 mm<br>• One rainy season from April to early September.<br>• Temperature ranges 12.5 – 32.5 °C<br>• Altitude ranges from 351 – 1,524 m ASL<br>• Soils are moderate to poor<br>• Area is semi arid | ***No trial results from this zone*** |
| II | • Average rainfall of 1197 mm (min 1000 max 1300 mm)<br>• Temperature ranges from 15 - 32.5 °C<br>• Altitude ranges from 975 – 1,524 m ASL<br>• Generally flat with isolated hills | **GC 550, GC 784, GC 514, GC 578, GC 796; GU 21** |
| III | • Average rainfall range of 1340 mm – 1371mm<br>• Temperature ranges from 15 - 25 °C<br>• Altitude ranges from 351 – 1,341 m ASL<br>• Generally flat with undulating hills<br>• Good to moderate soils | **GC 540, GC 550, GC 784, GC 514; GU 21** |
| IV | • Average rainfall of 1259 mm (min 800 max 1500 mm)<br>• Temperature ranges from 17.5 – 32.5 °C<br>• Altitude ranges from 351 – 1,341 m ASL<br>• Generally flat with undulating hills<br>• Good to moderate soils | ***No trial results from this zone*** |
| V | • Average rainfall range of 1215 mm - 1328 mm<br>• Temperature ranges from 15 – 32.5 °C<br>• Altitude ranges from 914 – 1,800 m ASL<br>• Land flat and swampy<br>• Soils are poor to moderate | **GC 550, GC 540, GC 784, GC 514, GC 796, GC 578; GU 7, GU 8** |
| VI | • Average rainfall of 1,200 to 1,450 mm<br>• Temperature ranges from 15 – 30 °C<br>• Altitude ranges from 1,000 – 1,800 m ASL<br>• Hilly and flat with wetland and forested areas<br>• Soils are good to moderate | **GC 514, GC 540, GC 784, GC 550, GC 796; GU 609, GU 7, GU 8** |
| VII | • Average rainfall of 1,270 mm with high variability, from about 800 over eastern L. Albert parts to about 1400mm over the western parts.<br>• Temperature range from 15 – 30 °C<br>• Altitude ranges from 621 – 1,585 m ASL<br>• Soils are generally good to moderate | **GC 514, GC 540, GC 784, GC 550, GC 796; GU 609, GU 7, GU 8** |
| VIII | • Average rainfall range of 915 to 1021 mm<br>• Temperature ranges from 12.5 – 30°C<br>• Altitude ranges 129 – 1,524 m ASL Rolling hills with some flat areas<br>• Soils are moderate to poor | ***No trial results from this zone*** |
| IX | • Average rainfall range of 1,120 – 1,223 mm<br>• High variability, lowest about 800 mm Kasese Rift Valley, highest over slopes of Rwenzori mountains, over 1500mm<br>• Temperature ranges from 12.5 – 30°C<br>• Altitude ranges from 129 – 1,524 m ASL | **GC 540, GC 550, GC 784; GU 7, GU 8, GU 609, GU 607** |
| X | • Rainfall usually > 1400 mm<br>• Temperature ranges from 7.5 – 27.5 °C<br>• Altitude ranges from 1,299 – 3,962 m ASL<br>• Soils are mostly young volcanic and are rich in nutrients<br>• Mountainous high altitude areas | **GC 550, GC 540, GC 784; GU 7, GU 8, GU 609, GU 21** |

# CLONAL PRODUCTION IN OTHER COUNTRIES

*Placing cuttings in trays for rooting (Mondi, Kwambonambi, 2004)*

*Cuttings in the rooting section, where humidity is kept high (Mondi, RSA, 2004)*

*2-yr old mother plants for cuttings - P. patula tecunumanii (Komatiland, RSA, 2009)*

*Impressive uniformity - 10-yr old PEEx PCH hybrid clones (FPQ, Australia, 2006)*

*GC clones ready for planting (TBP, Kenya, 2004).*

- Testing of new clones from superior trees from within and beyond Uganda.
- Piloting the clonal production of pines (especially PCH and *P. oocarpa*).
- Pest and disease monitoring and also screening new material for resistance.

**Environmental Issues:** The planting of eucalypts in Uganda (as elsewhere) has attracted some criticisms from various quarters: some of these are clearly ill-informed but some are justified and thus the issue has to be addressed seriously by the sector. This important issue is dealt with in more detail in Section 10.14 – *Eucalypts & the Environment*.

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# CHAPTER 22
# MANAGING *EUCALYPTUS* COPPICE

*Healthy coppice regrowth from a Eucalyptus grandis stool*

## 22.1 INTRODUCTION

Eucalypts – like many hardwood tree species - have the ability to regrow from cut stumps or stools. In forestry, we refer to this regrowth as coppice: in agriculture it is usually known as ratooning. Coppicing is the practice of selecting certain stems and the removal of others from this re-growth. If carried out well, the operation should result in a coppice crop with the same stocking as the original crop. In theory at least, coppicing allows the grower to be able to have a second rotation (and sometimes more) without replanting. However, there are some notes of caution:

- Coppicing is only a viable option for those growing fuelwood and small poles in Uganda (NB. it is common with eucalypt crops grown for pulpwood or mining timber in RSA and other countries with such market opportunities but these do not exist in Uganda).
- Even when coppicing for pulpwood in RSA, commercial growers usually replant after just one coppice rotation as yields start declining due largely to stool mortality: better genetic material will be available too from countries with ongoing tree improvement porogrammes.
- At every harvest some stumps will die: the percentage of healthy regrowth must be monitored.
- Eucalypt plantations grown for sawlogs and/or large poles will have been repeatedly thinned during their rotation and thus there will not be enough vigorous stumps to coppice after final harvest. Such plantations will have to be replanted after every rotation.
- Plantations that have been severely stressed will not coppice well and should be replanted after harvest.

There appears to be a belief in Uganda that the more stems left to grow on the coppice stool, the better the yield will be. If one wants lots of small sticks this could be true but to obtain better yields of larger sized fuelwood and poles, these multiple shoots must be thinned out in stages, which is the topic of this Chapter.

## 22.2 WHY COPPICE?

The cut stump (especially *Eucalyptus grandis*) will normally put out many new shoots within a few weeks of being cut. If all of these shoots are left to grow, the stool develops into a bush crowded with multiple shoots. These shoots compete with each other and they struggle to obtain a secure hold on the stool. The result is bush with thin, crooked stems that are likely to be blown over in a strong wind.

Good coppicing practice selects specific stems according to their size and position on the stool and removes the rest. This allows the remaining shoots to grow well and with a good form, giving the best yield of larger fuel wood and poles. The aim of coppicing is to undertake coppice reduction in two stages so that we keep selecting the better shoots and in the end remain with a

*2 stromg coppiced stems.*

stocking (plant density) the same as the original planting.

Because not all stools coppice, some stools will be left with two shoots to compensate but most will be reduced to one. The next section describes how this process should be carried out. Note that coppicing is a skilled operation and if you let untrained people do the job you will end up with a ruined plantation and having to replant.

## 22.3 PLANNING FOR COPPICING

There are two main phases of the coppicing operation: the first of which with the harvesting of the existing (mature) crop.

**1st Phase**

The first part of coppicing is to take care when harvesting the original stand. Several points to consider when harvesting are:

1. Felling should be done with a bow or power saw. Felling with an axe invariably damages the bark where the coppice shoots from.
2. Felling should be done in blocks so that the stools all coppice at roughly the same time. Felling at random result in some stools coppicing under shade and not developing well: also when the other trees are felled they will damage the young coppice regrowth.
3. The felling cut should be done at around 10cm above the ground. It should be level and clean.
4. The stumps should not be covered with branches or other debris.
5. Care should be taken not to damage the stumps by driving over them or knocking them with poles.
6. As always, tools should be sharp and correct for the task.

**2nd Phase**

Coppice buds usually appear a short while after harvesting. They form on the cambium, which is the thin layer of tissue between the wood and the bark. Once most stools appear to have coppiced

*Poor felling will result in weak coppice stems.*

(usually after 2-3 months) it is important to carry out a survey to determine how many stumps have coppiced. The decision to replant needs to be made early on so as to be able to replant during the next planting season. There are factors that could cause a low coppicing percentage, for example, exceptionally hot and/or dry weather, species and poor harvesting practices are a few). In these cases replanting should be done. A guide is that if less than 70% of the stumps do not coppice, replanting should be seriously considered.

## 22.4 COPPICING PRACTICE

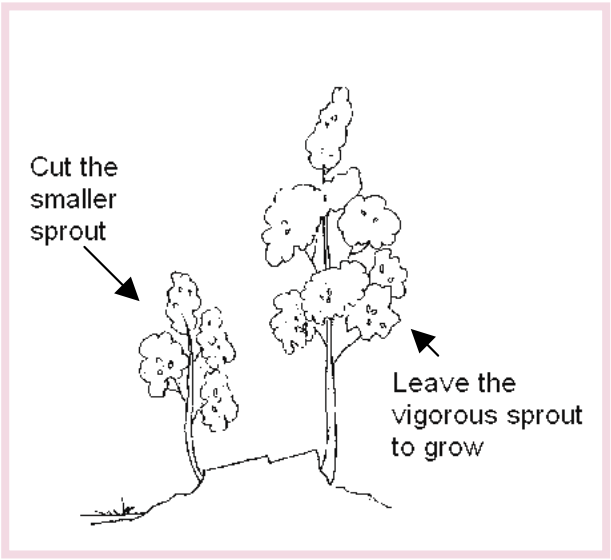
When the decision has been made to coppice the crop, the following guidelines are recommended:

1. Coppice reduction should be carried out in a 2 stage operation.

2. The 1st reduction should be carried out when the dominant shoot height is 3 to 4m.

3. 2 to 3 stems should be retained per stool at this 1st reduction.

**Fig. 18: Coppicing Eucalypts**




4. The selected stems should be dominant, reasonably straight, firmly attached (preferably from low down on the stool) and well spaced out around the stool. This reduces the likelihood of a strong wind breaking off all the stems on any one stool.

5. The unwanted stems and other regrowth from around the stool must be cut as close to the stool as possible without damaging the selected stems.

6. The 2nd reduction should be carried out when the dominant shoot height is 7 to 8m.

7. At the 2nd reduction 2 or 3 stems (only if there are 2 or 3 strong stems) should be left along the edge of a stand (along roads and fire breaks). These stools receive more light and water than those inside the plantation and can thus support more stems.

8. At the 2nd reduction 2 stems should generally be left inside the stand only on large stools adjacent to gaps or dead stumps. This is to maintain the stand at the original stems per hectare. The stems should also be similar in height so that the stand is uniform.

9. Both the 1st and 2nd reduction operations create a lot of trash, which soon constitutes are considerable fire hazard. Hence it is advised that the trash must be stacked tightly in every 5th row, with gaps 5m wide to allow access every 25m. Also no trash or trash line should come closer than 5m to the edge of the stand.

**NB1.** Remember that when selecting the coppice shoots ensure that the best shoots (equal size, spacing on stool, attachment to stool) are left. Do not be tempted to remove the ones that you will find a use for or can sell and leave poor stems for your final crop.

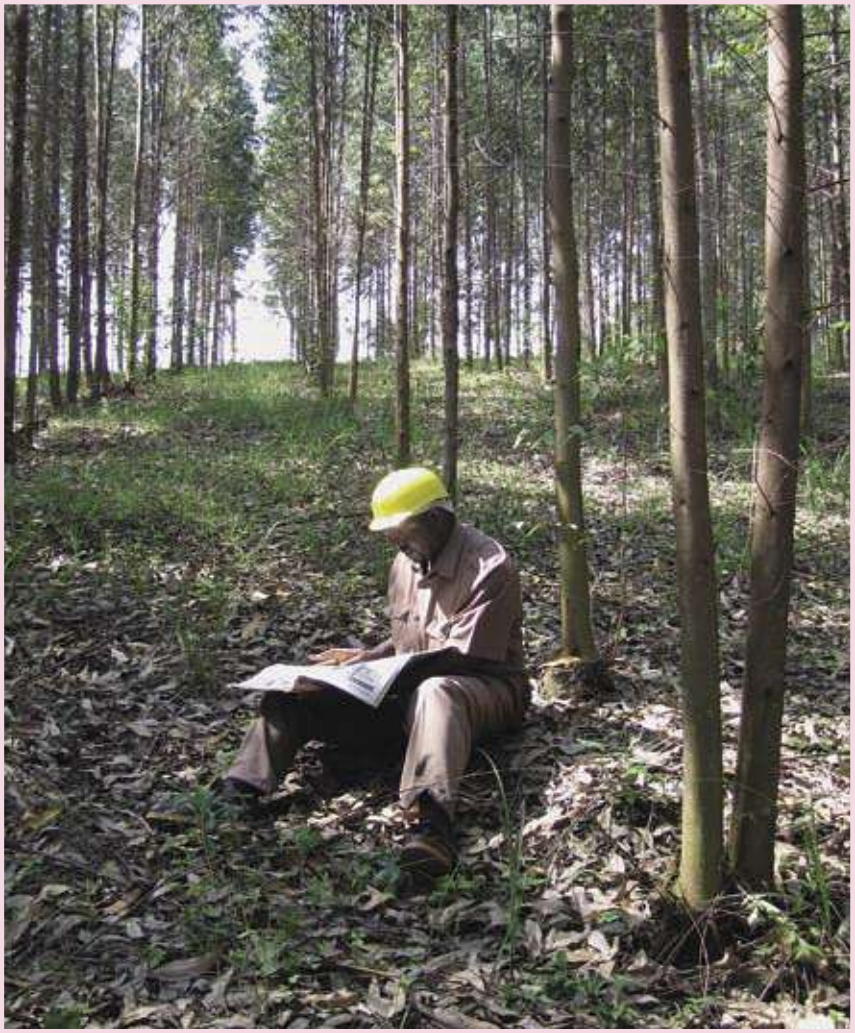
**NB2.** Coppicing should generally not be done for more than two rotations. The stump mortality after that is often high and so many shoots have to be left on each stool to compensate. This results in the size and form of the shoots being poor.

## 22.5 OLD STUMPS

Very old and large eucalypt stumps will not produce good coppice regrowth – whether for poles, fuelwood or timber. The shoots will have poor form, be weak and liable to be break off in strong winds. It is thus recommended to replant such areas using improved eucalypt seed. NB. For further details on growing eucalypts refer Chapter 10 - *Growing Eucalypts for Fuelwood, Timber and Poles.*

Killing off old eucalypt stumps is not easy. The cheapest method is usually to cut them low with a chainsaw and then to repeatedly cut the regrowth manually until it weakens. If the area has been planted round the old stumps, they will soon lose vigour as they are increasingly shaded out by the new crop. In some countries selective herbicides are used: Glyphosate (*ca.* 3% solution – check label for details) can be very effective provided the coppice regrowth is around 1m tall and the stool not too large.

*Felling damage reduces the chances of good coppice regrowth.*



*Well managed 1st Coppice crop (2-yr E.grandis at JFU's Mwenge Tea Estate, 2006)*

# CHAPTER 23
# FOREST CERTIFICATION

*A pre-Certification study being carried out for SPGS (Mubende, 2007)*

## 23.1 WHAT IS FOREST CERTIFICATION?

Forest certification is an *independent* assessment which verifies that a particular forest manages its resources in a *responsible* and *sustainable* way against agreed external standards. It provides proof that the forest management practices conform to internationally agreed standards. These standards cover not just sound business practices (e.g. planning, silviculture and administration) but social and environmental aspects too.

Certification is a voluntary procedure, which buyers may choose to specify and which growers may choose to employ. Certification started out as an NGO approach to halt the destruction of the rain forests. It has evolved since 1989 and is now part of a general worldwide trend to define and monitor standards for environmental and social improvements in natural resource use.

Certification is driven by a variety of interests. For trade and industry, it is a way of environmental marketing to sell their 'green' goods. For buyers and consumers, it provides information on the products they purchase and an increasing number are prepared to pay extra in the knowledge that the goods came from a sustainable operation. For the growers, certification is a tool for gaining market access (or advantage) by attracting price premiums for sustainably produced products.

It is a common misconception that certification is driven by governments. It is in fact driven by the private sector – particularly the growing number of consumers who want to know whether the products they are buying are produced in a sustainable manner as well as forest owners who want to get market for their products. Other interest groups spearheading forest certification include environmental NGOs, forest products industry and retailers. Governments will often be involved in agreeing a National Standard (as a major stakeholder) but the certification process is independent, which gives it credibility.

## 23.2 BACKGROUND TO CERTIFICATION

Public awareness of negative environmental impacts in regions such as the tropics has increased steadily over the years. Deforestation of tropical and temperate forests, unsustainable practices, environmental degradation, exploitation of labour, and abuse of people's rights have resulted in pressure groups to protest against such practices and to try to bring about meaningful change.

In the 80's it became evident that political solutions for stopping deforestation in the tropics were not working. In the 90's private NGO's and retailers got together to develop forest certification frameworks. The aim of these was to encourage retailers to buy only certified forest products. Consumers then began with product and retailer boycotts in the mid 1980's, but were largely still not well informed and followed popular sentiment. Issues also began to arise around the desirability and environmental impact that commercial tree plantations may have.

Soon various schemes began emerging that claimed they could certify forests and plantations as 'environmentally sustainable', or 'well managed'. Different forces drive such schemes and it is important to know the background to these before rushing in to court the first that may

*FSC-certified pine for export*
*(GFP - now York Timbers, Sabie, RSA, 2007)*

appear attractive. Some schemes are industry-driven, with obvious self interests; others have political agendas and support; while some are driven by various environmental groups.

Since the inception of forest certification, a number of commercial tree planters have embraced it mainly because of its enormous benefits which are discussed later on. To date the total forest plantation area under Forest Stewardship Council (FSC is the world's leading certification body) stands at over 100 million hectares in 79 countries across the globe. Over 3 million hectares of these are found in Africa. FSC certified forests represent the equivalent of 7% of the world's productive forests.

## 23.3 BENEFITS FOR TREE GROWERS IN UGANDA

The benefit of certification is that it is an incentive to improve forest or plantation management practices, as buyers of wood and wood products are increasingly adopting certification as an element of timber specifications. This aspect is becoming increasingly important as the gap between global supply and demand of timber products increases. Primary benefits that can be obtained from certification are:

- In many parts of the world Certification grants access into markets. Many major furniture companies in the UK and Europe have a policy to buy only certified timber.
- Certified products might receive a higher price and the producers of certified timber are able to sell the timber into a particular discerning market, as opposed to losing that market. The value of FSC labeled sales is estimated at over US$ 20 billion.
- In some many cases financiers are developing 'green' investment polices and need a mechanism to assure their investors that their money is going into forests that meet high environmental and social standards.
- There are an increasing number of instances where insurers are demanding good management and accept certification as the benchmark.
- Certification indicates to stakeholders that a particular forest is well managed.
- Demonstration of the implementation of best practices in forest stewardship.
- Since certification promotes sustainable management of forests, it ensures that the forests will serve the present as well as future generations.
- In countries like Uganda, certification may assist in accessing funds for afforestation, forest management and product development. Investors (and donors) often consider projects in developing countries as high risk. A certified operation gives them some comfort that the project risk is managed well and is sustainable.

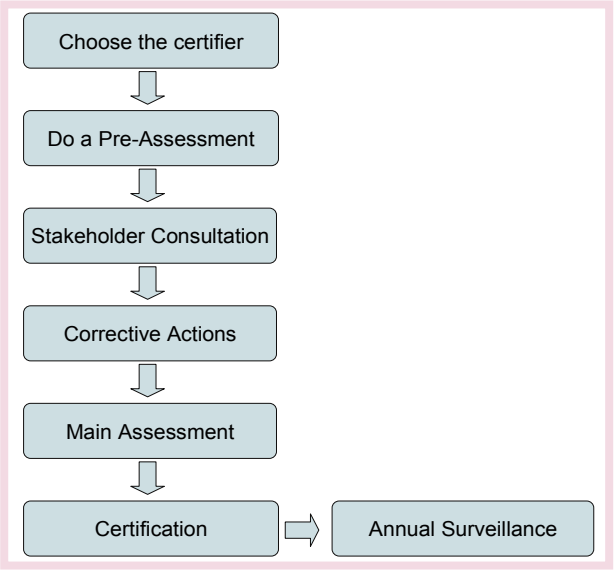
*FSC ensures safe working practices (Peak Timbers, Swaziland, 2004)*

## 23.4 THE CERTIFICATION PROCESS

The certification process involves a lot more than looking at the silvicultural standards. It involves choosing the verification scheme and the certifier (Auditor), consulting stakeholders (all

the people or bodies involved in the management of the forest, or directly or indirectly affected by or benefiting from the goods and services provided by a particular forest), identification of loopholes and rectifying them and the assessment among others. The certification process can be summarized as follows:

**Fig. 19. Schematic steps to Certification**




## 23.5 INDIVIDUAL vs GROUP CERTIFICATION

Forest owners and/or managers can choose to have either individual of group certification. This depends on the forest area in question, amount of money available to cover certification costs and technical capacity in certification among others. The two types of certification are discussed in below.

**Individual forest certification:**

- It is really only for larger growers such as forestry companies or big private concerns typically >2,000ha.
- Individual certification is relatively expensive since all certification costs are carried by the individual grower (each assessment stage has its cost in addition to the general cost of developing and implementing high standards of management).
- FSC does not allow very big growers to be part of a group scheme (*ca.* >3,000ha).
- Forest management standards (environmental, social and economic) have to be very high.
- GIS information required is quite detailed and can be expensive to gather and update (detailed plantation maps, open area maps, information systems, etc);
- Trained and experienced personnel are required to maintain certification.

**Group certification:**

- This scheme is usually applied to small to medium members up to around 2,000ha (in certain circumstances the upper limit can be more).
- It is not easy for managers of small enterprises to access to manage the process of getting certified.
- Certification is a relatively expensive exercise and a group can benefit from major economies of scale.
- At the same time, individual members of a group maintain control of their own forest and its management.
- Group certification aims to reduce administration and organization costs, and to share the costs of certification assessments amongst a group of similar growers.
- A group certification scheme has a Group Manager that handles the certification process and accesses information for the group members.
- The Group Manager is able to provide the required information, training and support to members.
- The Group Manager is responsible for auditing the compliance to the group standards of each member.
- The Group Manager and a sample of members are assessed, rather than all members.

The SPGS started in 2008 to pursue a group certification pilot scheme for 5 contracted clients, all of whom are small growers below 500ha.

## 23.6 FSC

The main forest certification bodies are FSC and PEFC (Programme for the Endorsement of Forest Certification Schemes). We have however chosen FSC as our certification scheme. FSC has probably the highest credibility from both industry and major environmental groups such as Greenpeace and WWF, and strives to get global acceptance of what constitutes a well managed forest. Its mission is to promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests. Below are some facts about FSC.

- It is a non profit organization founded in 1993 that certifies forestry operations as being environmentally responsible, socially beneficial and economically viable.
- These aspects are called the three pillars of FSC and each is considered to be of equal importance.
- The FSC has developed an international standard for forest management certification, called the Principles and Criteria (P&C). The three pillars are embodied in the P&C. Once forests are certified, products originating from them may carry the FSC label.
- FSC does not do any certification themselves, but gives a license to accredited auditing companies to use the FSC label (in Africa the largest auditing body is SGS) and assess the level of compliance.
- FSC was largely founded by funding and inputs from WWF and Greenpeace and other large NGO's.
- Since it is not driven by big business concerns, it has a good independent reputation with governments, environmental and social groups.
- It has the highest credibility of all current forest certification schemes due to the high level of stakeholder and other NGO's participation.
- The FSC standards are continually updated in order to stay relevant to current trends in sustainable forest management. The updating procedures are all-inclusive.
- The FSC label and trademark provides international recognition of responsibly managed operations. FSC also undertakes marketing campaigns that might benefit certified members.

## 23.7 CERTIFICATION COSTS

The Certification process may not be considered small but it is worth it considering the benefits accruing to it. The actual figures vary according to the auditors chosen and area considered for certification among others. In brief the costs would involve training, the pre-audit, the main assessment, annual surveillance and the FSC Certificate fee among others.

FSC does not do any certification themselves, but gives a license to accredited auditing companies to use the FSC label and assess the level of compliance. The largest auditing body is SGS Qualifor. Others are Woodmark and Soil Association among others. SGS Qualifor already did some certification work in Kibaale and Mt. Elgon National Parks under the Uganda Wildlife Authority.

## 23.8 SPGS STANDARDS

The current SPGS standards are aimed at achieving Fast Growing High Yielding (FGHY) plantations. They are mainly silvicultural standards (seed source, land preparation, planting, maintenance, protection, etc) but are currently being revised (2008/09) to incorporate more environmental and social issues, namely:

**Environmental standards:**

- No clearing natural high forests to establish plantations.
- No planting in wetlands.
- Planting the right species on the right site.
- Proper disposal of plantation wastes e.g. chemical containers, and
- Protection of riparian zones.

*Some room for improvement it appears (Uganda, 2005)*

**Social standards:**

- Encouraging good community relations and corporate social responsibility.
- Promoting good health and safety practices.
- Guiding on payment rates for the various forestry operations.

**Economic standards:**

- Proper and timely planning and budgeting.
- Planting per the management plan.
- Ensuring high stocking and good growth.
- Encouraging yield monitoring and protection.
- Timber market research.

The SPGS's standards are clearly moving towards FSC.

## 23.9 FSC PRINCIPLES AND CRITERIA

FSC has ten clearly defined Principles aimed at achieving the three pillars: socially beneficial, environmentally responsible and economically viable forestry management. These principles are:

1. Compliance with laws and FSC principles.
2. Tenure and rights responsibilities.
3. Indigenous peoples' rights.
4. Community relations and workers' rights.
5. Benefits from the forest.
6. Environmental impact.
7. Management plan.
8. Monitoring and assessment.
9. Maintenance of high conservation value forests.
10. Plantations.

These principles are broken up into further subsets, known as criteria, providing the precise conditions against which management can be assessed. There are a total of 56 criteria, each of which has a set of indicators which are in essence the actual performance measures that are assessed. The indicators define the requirements for responsible forest management at the level of the forest management unit and are the primary basis of forest evaluation. The certifier may interpret, add, or adapt some of the indicators to suit the local conditions and laws of each country, but these must still fulfill the minimum requirements of the FSC.

The principles and criteria that need special attention as far as private sector commercial forestry is concerned in Uganda are:

**Principle 4 – Community Relations and Workers' Rights.**

- **Criterion 4.1:** The communities within, or adjacent to, the forest management area, should be given opportunities for employment, training, and other services.
- **Criterion 4.2:** Forest management should meet or exceed all applicable laws and or regulation covering health and safety of employees and their families.
- **Criterion 4.4:** Management planning and operations shall incorporate the results of evaluations of social impact. Consultations shall be maintained with people and groups directly affected by management operations.

**Principle 6 – Environmental Impact:**

- **Criterion 6.1:** Assessment of environmental impacts shall be completed – appropriate to the scale and intensity of forest management operations – and shall be assessed prior to commencement of site disturbing operations.
- **Criterion 6.2:** Safeguards shall exist which protect rare, threatened and endangered species and their habitats. Conservation zones shall be established.
- **Criterion 6.5:** Written guidelines shall be prepared and implemented to: control erosion, minimize forest damage during harvesting, road construction, and all other mechanical disturbances; and protect water resources.
- **Criterion 6.6:** Management systems shall promote the development and adoption of environmentally friendly non-chemical methods of pest management. If chemicals are used, proper equipment and training shall be provided to minimize health and environmental risks.

*Sound environmental planning of plantations (Aracruz, Brazil)*

*Now we are ready for action.....*

- **Criterion 6.7:** Chemicals, containers, liquid and solid non-organic wastes including fuel and oil shall be disposed in an environmentally appropriate manner at off-site locations.

**Principle 10 – Plantations.**

- **Criterion 10.2:** The design and layout of plantations should promote the protection, restoration and conservation of natural forests, and not increase pressure on natural forests.
- **Criterion 10.4:** The selection of species for planting shall be based on their overall suitability for the site and their appropriateness to the management objectives. Exotic species, which shall only be used when their performance is greater than that of native species, shall be carefully monitored to detect unusual mortality, disease, or insect outbreaks and adverse ecological impacts.
- **Criterion 10.9:** Plantations established in areas converted from natural forests after 1994 normally shall not qualify for certification. Certification may be allowed where sufficient evidence is submitted that the owner is not responsible directly or indirectly for such conversion.

For updates on the SPGS's group certification pilot scheme, see the SPGS Newsletters – at **www.sawlog.ug** or from the project office *(see details inside front cover).*

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**Simula M & R Nussbaum, 2005.** Forest Certification Handbook (2nd Edn.). Earthscan Publications.

**Other useful web-sites:**

*www.fsc.org/*
*www.forestworld.com*
*www.certifiedwood.org*
*www.certified-forests.org*
*SGS Qualifor - www.forestry.sgs.com*
*International Labour Organization www.ilo.org/*