ICFR ZULULAND INTEREST GROUP
FIELD DAY

Date: Thursday 15th November 2007  
Venue: Sappi Training Centre, Kwambonambi  
Time: 08h30 for 09h00

PROGRAMME

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Presenter(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08h30</td>
<td>Meet for tea and coffee at the Sappi Training Centre. Kwambonambi</td>
<td></td>
</tr>
<tr>
<td>09h00</td>
<td>Welcome and introduction to the field day</td>
<td>Geoff Galloway Sappi</td>
</tr>
<tr>
<td>09h05</td>
<td>Fertilising eucalypts at establishment: A critical review with specific emphasis on Zululand?</td>
<td>Colin Smith/Illaria Germishuizen</td>
</tr>
<tr>
<td>09h45</td>
<td>Wood and fibre production potential of promising new eucalypt species in northern, coastal Zululand</td>
<td>Robin Gardner ICFR</td>
</tr>
<tr>
<td>10h15</td>
<td>Site management and Productivity of Tropical Forest Plantations: A review of the CIFOR networks’ achievements in the last decade and its relevance for Zululand.</td>
<td>Colin Smith/ ICFR</td>
</tr>
<tr>
<td>10h45</td>
<td>DEPART FOR FIELD VISITS TO ST LUCIA PLANTATION, SIYAQHUBEKA PLANTATION NEAR MTUBATUBA (Cooldrinks in field)</td>
<td></td>
</tr>
<tr>
<td>11h45</td>
<td>Visit to long-term site productivity trial at Dukuduku: Key principles for future research in forest nutrition in Zululand.</td>
<td>Colin Smith ICFR</td>
</tr>
<tr>
<td>12h15</td>
<td>Monitoring nutrient cycling processes in forest plantations</td>
<td>Steven Dovey ICFR</td>
</tr>
<tr>
<td>12h45</td>
<td>LUNCH kindly supplied by SIYAQHUBEKA</td>
<td></td>
</tr>
</tbody>
</table>
Site management and Productivity of Tropical Forest Plantations:  
A review of the CIFOR networks’ achievements in the last decade  

Colin W Smith  
(colin.smith@icfr.ukzn.ac.za)  
Institute for Commercial Forestry Research, PO Box 100281, Scottsville 3209

Summary

The extent to which intensive management practices in fast-growing highly productive eucalypt, pine and Acacia plantations affect soil properties and fertility was investigated by an international network of partners on Site management and productivity in tropical and sub-tropical plantation forests supported by the Centre for International Forestry Research (CIFOR). The aim of the work was to evaluate the impacts of management operations over successive rotations on soils and productivity of plantation species grown in the tropics and sub-tropics. In each country, several residue management techniques were tested and their effects on long-term soil and site productivity evaluated. These included inter alia residue removal, burning and broadcasting (after whole-tree or stemwood only harvesting). Productivity and soil changes were closely monitored and evaluated and compared with processes in an adjacent standing crop.

At four sites, plantation productivity was significantly affected by the residue management treatments. These sites were usually characterised by low soil organic carbon and total nitrogen (N) levels (< than 20.0 g kg\(^{-1}\) and 2.0 g kg\(^{-1}\) respectively) and a coarse texture (<25% clay content). Where residues were completely removed, growth declines also occurred due to phosphorus (P), N, calcium (Ca) and potassium (K) losses. Sites where growth differences between residue treatments were not apparent possessed relatively large quantities of soil nutrients, particularly N, relative to those contained in the residues even when large residue quantities were retained. At some sites low quantities of residues from the previous crop also contributed to the lack of a growth response to residue retention. Retaining the residues was usually accompanied by increases in exchangeable cations and N mineralisation.

The results highlight the importance of maintaining the large nutrient capital in fertile soils by protecting the soil from erosion (manmade and natural), and preserving both the residues and the soil on infertile sites. Residue retention has the added advantage of reducing run-off, preserving soil water and retaining nutrient capital. Inasmuch as the harvesting system and product requirement determines the nutrient export in the various components of the crop as well as the residue composition and degree of site disturbance, harvesting is a key silvicultural tool to ensure long-term site productivity and sustainability of forest plantations.
Wood and fibre production potential of promising new eucalypt species for northern, coastal Zululand

Robin Gardner and Keith Little
(robin.gardner@icfr.ukzn.ac.za)
Institute for Commercial Forestry Research, PO Box 100281, Scottsville 3209

Introduction
The Institute for Commercial Forestry Research (ICFR) established a series of four site-species interaction trials in northern, coastal Zululand during 1996 to investigate the commercial potential of a range of alternative eucalypt species for the region. Some of the species, e.g. *Eucalyptus longirostrata*, *E. pilularis* and *Corymbia henryi*, had demonstrated good potential in an earlier 1992-established ICFR site-species trial series on the coastal plain (Gardner 2001; Gardner *et al.* 2007). During 2006, at the rotation age of 10 years, final measurement, assessment and wood sampling was carried out. The results of these investigations are reported on at this field-day.

Material and methods

Experimental design & treatments
- **Site:** Four trial sites located on the Zululand/ Maputaland coastal plain (*Table 1*).
- **Layout:** At each site, a randomised complete block design experiment consisting of three replications.
- **Treatments:** 21 seedlots/ clones per trial (*Table 2*).
- **Plots:** Total = 32 trees (8 x 4 trees); Inner measured = 12 trees (2 x 6 trees).

Measurements and assessments
- **Merchantable wood volume:**
  - Utilisable under-bark volume (butt to top end under-bark diameter of 0.05 m)
  - 10 best-performing treatments including controls across all four sites.
  - All four sites.
- **Fibre yield:**
  - Calculated using data for merchantable wood volume and screened pulp yield (SPY).
  - 8 of the 10 treatments evaluated for merchantable wood volume.
  - Two sites (Palm Ridge and Bushlands).

*Table 1.* Site conditions and establishment details for the site-species trials in northern, coastal Zululand.

<table>
<thead>
<tr>
<th>Site conditions and establishment details</th>
<th>Palm Ridge</th>
<th>Bushlands</th>
<th>Manzengwenya</th>
<th>Mkuzi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>28°17’ 42” S</td>
<td>28° 05’ 00” S</td>
<td>27°12’ 00” S</td>
<td>27°36’ 00” S</td>
</tr>
<tr>
<td>Longitude</td>
<td>32° 15’ 48” E</td>
<td>32° 17’ 00” E</td>
<td>32° 38’ 00” E</td>
<td>32° 03’ 00” E</td>
</tr>
<tr>
<td>Altitude (masl)</td>
<td>30</td>
<td>65</td>
<td>140</td>
<td>150</td>
</tr>
<tr>
<td>Mean annual temperature (°C)</td>
<td>21.9</td>
<td>21.8</td>
<td>21.8</td>
<td>22.0</td>
</tr>
<tr>
<td>Median annual precipitation (mm)</td>
<td>780</td>
<td>925</td>
<td>845</td>
<td>590</td>
</tr>
<tr>
<td>Mean annual A-pan Evaporation (mm)</td>
<td>1817</td>
<td>1853</td>
<td>2008</td>
<td>1935</td>
</tr>
<tr>
<td>Soils: Taxonomy</td>
<td>Bonheim (clay)</td>
<td>Fernwood (sand)</td>
<td>Fernwood (sand)</td>
<td>Bonheim (clay)</td>
</tr>
<tr>
<td>Depth (cm)</td>
<td>&gt; 100</td>
<td>&gt; 100</td>
<td>&gt; 100</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>SIb (G x C hybrid clone)</td>
<td>16.8</td>
<td>20.1</td>
<td>18.2</td>
<td>13.4</td>
</tr>
<tr>
<td>Tree spacing</td>
<td>2.7 m x 2.7 m</td>
<td>3.0 m x 2.4 m</td>
<td>2.5 m x 2.5 m</td>
<td>3.0 m x 2.5 m</td>
</tr>
</tbody>
</table>

1 Schulze (1997); 2 Eleven-year median for period January 1996 to December 2006; 3 Soil Classification Working Group (1991)
Table 2. Origins of the seedlots and hybrid clones represented in the trials in northern, coastal Zululand.

<table>
<thead>
<tr>
<th>Species</th>
<th>Clone</th>
<th>Seedlot/clone nr.</th>
<th>Origins</th>
<th>Seed lot and clone representation in trials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Palm Ridge</td>
</tr>
<tr>
<td>A. neriifolia</td>
<td>14742</td>
<td>S of Turralin (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>A. neriifolia</td>
<td>16929</td>
<td>60km SW Goondiwindi (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>A. neriifolia</td>
<td>17147</td>
<td>15km N Crows Nest (QLD)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>C. junghuhniana</td>
<td>19490</td>
<td>Camplong (Timor, IND)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>C. citriodora</td>
<td>14852</td>
<td>Mt. Garnet (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>C. henryi</td>
<td>19468</td>
<td>Myrtle Creek SF (NSW)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>C. maculata</td>
<td>16010</td>
<td>59.4km NNW Chinchilla</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>C. maculata</td>
<td>16360</td>
<td>SW of Warwick (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. argophloia</td>
<td>15504</td>
<td>NW of Chinchilla</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. cambageana</td>
<td>13272</td>
<td>98km W Charleville (QLD)</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>E. drepanophylla</td>
<td>19376</td>
<td>Expedition Range (QLD)</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>E. longirostrata</td>
<td>15637</td>
<td>NW of Monto (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. longirostrata</td>
<td>16008</td>
<td>51.5km NNW Chinchilla</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. pilularis</td>
<td>19318</td>
<td>Mapleton SF (QLD)</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>E. watsoniana</td>
<td>17003</td>
<td>Barakula SF (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. camaldulensis</td>
<td>15049</td>
<td>Bullock Creek (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. camaldulensis</td>
<td>18482</td>
<td>Lake Buchanan (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. camaldulensis</td>
<td>18835</td>
<td>Pelford (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. tereticornis</td>
<td>13544</td>
<td>40km N Gladstone (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. tereticornis</td>
<td>13666</td>
<td>SW of Mt. Garnet (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. tereticornis</td>
<td>16927</td>
<td>50km SSE of Moura (QLD)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. tereticornis</td>
<td>17762</td>
<td>Warwick (QLD)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>E. tereticornis</td>
<td>17864</td>
<td>North Kennedy R (QLD)</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>E. grandis x camaldul</td>
<td>GC_Clon2</td>
<td>Zululand commercial</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>E. grandis x urophylla</td>
<td>GU_Clon1</td>
<td>Zululand commercial</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

1 Imported, unimproved Australian seed lot; 2 Local commercial hybrid clone

Take Home Points:

Commercial potential of alternative species

- C. henryi and E. longirostrata confirmed their excellent potential for commercial forestry application on the Zululand coastal region, as previously demonstrated in the 1992-established series.
- These two species, together with E. argophloia, have excellent potential for commercial forestry application on certain sites in the northern region of the Zululand/Maputaland coastal plain.
- E. longirostrata appears substantially more drought tolerant than C. henryi.
- E. argophloia showed the greatest drought tolerance of all species tested.
- E. longirostrata and E. argophloia demonstrated exceptional versatility regarding soil condition.
- E. longirostrata and E. argophloia may be good partners for low density, high pulp yielding species such as E. grandis and E. urophylla.

References


Fertilising eucalypts at establishment: A critical review with specific emphasis on Zululand

Colin W Smith and Ilaria Germishuizen
(colin.smith@icfr.ukzn.ac.za)
Institute for Commercial Forestry Research, PO Box 100281, Scottsville, 3209, Pietermaritzburg

Summary

A review was recently conducted to critically re-assess the state of local knowledge on the fertilisation and nutrition of eucalypts in the summer rainfall region of South Africa, with a view to summarising current understanding, and in particular, identifying gaps and opportunities in relation to key nutritional issues for forest plantation stands. The review showed that responses to fertilisation at planting occurred at some stage in the rotation in more than half (65%) of the trials that were originally established. In many of these trials the responses observed were economically impractical. In most cases the growth responses were Type 1, where fertilisation enhances the short-term availability of nutrients to the trees thus reducing the time needed to reach a given level of productivity. Frequently these early growth responses declined, sometimes within a few years of planting, whereas the benefit to the forest manager lies in harvesting the stand while growth differences are still significant. Furthermore, the small plot sizes (< 250 m²) of all past trials might have mitigated growth differences between treated and untreated plots as a consequence of litterfall and root intrusion in adjacent plots. Similarly, no attempt was made in previous studies to estimate whether or not the results could have been influenced by residual fertilisation from previous rotations. Most noticeable in past research was the lack of analysis examining the effect of fertilisation on survival, growth uniformity and time taken to canopy closure. The results of this review highlight the need to evaluate the relationships between seedling quality, planting practice, site preparation (weed control and residue management in particular) and response to fertilisation at planting.

Zululand

Similarly, the effectiveness of fertilising on growth of Eucalyptus in Zululand is not clear-cut. The soils appear to be very infertile, yet symptoms of major nutrient deficiencies are few and responses to fertilisation have been mixed. A review of past work revealed that 31 fertiliser trials have been implemented in Zululand since 1952 testing responses to fertilisation of Eucalyptus on sandy soils mainly at planting. Of those, just fewer than 50% responded to fertiliser at some stage of the rotation and only in 20% were significant growth improvements still evident at rotation-end. Where improvements to growth were recorded, responses to nitrogen (N) were mainly responsible. Because of this nutrient recommendations for Zululand have been formulated with a view to providing N and to a lesser extent phosphorus (P) and sulphur (S) and micronutrients depending on soil type.

Trials exploring interactions between site preparation and fertilisation have been mixed. In one trial, harvesting operations that resulted in broadcast residues and travelling over the residues showed no response to N fertilisation compared to those where the residues were windrowed. In another trial no significant interactions were recorded between site preparation (including burning) and fertilisation. Results from a more recent series of trials comparing fertilisation with burning and not burning have been inconclusive due to the large number of unstructured treatments tested.

Preliminary research into the effect of fertilisation on wood properties has been conducted in five trials. Although these results provided useful information they cannot be regarded as a basis for recommendations yet since; i) only wood density and screened pulp yield measurements were carried out in all trials; ii) it is not clear whether the effects of fertilisation were due to the direct effects of nutrients on wood properties or their effect on growth rate and iii) the original trials were not structured with wood quality tests in mind.

Due to the empirical nature of the research to date a clear scientific framework has yet to emerge for predicting responses to fertilisation of Eucalyptus in Zululand. Stand nutrient requirements are likely to be related to site preparation (in particular residue management), site productivity and harvesting practices (nutrient capital left on site). Also, stand nutrient demand is likely to change throughout the rotation. While it is suggested that the current recommendations should remain for the time being, the mixed results to fertilisation mentioned above suggest there is an urgent need to address the problem from a systems perspective. Research in three broad areas is suggested:
1. Systems research (CIFOR-LTSP approach): Conduct research to evaluate the nutrient demand of *Eucalyptus* in Zululand and relate to processes affecting supply.
   - Measure the effects of site management on nutrient availability and fertiliser requirement.
   - Study soil and residue nutrient storage and release dynamics and how they change with time.
   - Measure extraneous sources of nutrients such as atmospheric deposition and ground water.
   - Measure residual effects of fertiliser on growth.

2. Evaluate the effects of late-rotation fertilisation (pre-canopy closure and towards the end of the rotation) on growth of *Eucalyptus* in Zululand as part of a country-wide project.

3. On several key site types, using large plot sizes and monitoring until rotation-end, evaluate principals of response by key nutrient inclusion/exclusion experiments, i.e. test responses based on presence or absence of key nutrients e.g. N, P, Ca, micronutrients etc. Most fertiliser mixtures contain other nutrients that may affect responses e.g. Ca in LAN and P fertilisers.
Visit to long-term site productivity trial at Dukuduku: Key principles for future research in forest nutrition in Zululand.

Colin W Smith
(colin.smith@icfr.ukzn.ac.za)
Institute for Commercial Forestry Research, PO Box 100281 Scottsville, 3209 Pietermaritzburg

Summary
Our inability to accurately predict the likely response to fertilisation during a stand’s development or the consequences of early silvicultural management on nutrient supply, is in part due to a lack of data on soil and residue nutrient storage and release dynamics and how they change in time. This trial aims to study these processes in a Eucalyptus stand for a range of management treatments (broadcast, windrowed, residues removed, residues disturbed, burning and fertilised). The processes studied will include nutrient mineralisation rates, accretion (uptake) and tree growth. It is anticipated that the results will give us key insights into the effect of management practices on nutrient supply and demand on relatively infertile sites which are characterised by rapid residue and litter breakdown. This approach will allow more robust fertilisation strategies to be developed, together with a better understanding of factors affecting long-term site productivity. This will in turn provide forest management with a more powerful dataset for understanding the consequences of silvicultural and harvesting decisions.
Monitoring nutrient cycling processes in forest plantations

Steven Dovey
(steven.dovey@icfr.ukzn.ac.za)
Institute for Commercial Forestry Research, PO Box 100281 Scottsville, 3209 Pietermaritzburg

Introduction

As a forestry industry we are reliant on sustainable timber production to ensure that present and future market demands are met. To do this we need to increase or at least maintain current productivity, with decreasing management and resource inputs. Forest managers and owners together with researchers depend on reliable research data when choosing between various site management operations. This partnership has formed through managers being aware of possible negative impacts that new silvicultural operations may have on future productivity.

To assess management impacts on productivity we need to know:

- What resources are required, in what quantity and at what times to meet growth demands for best productivity;
- We need to understand site supply potential and tree demand over time with the impacts of management;
- We need to relate resource supply, demand and management interactions to tree growth and future productivity;
- Then, through reviewing all the operations and processes, find opportunities for improvement.

Nutrient resources and tree growth

We know that leaves grow trees, resources grow leaves and that management practices manipulate resources. Site dependant resources include energy in the form of photosynthetically active radiation (PAR), carbon, hydrogen and oxygen (air and water), and plant nutrients (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and a number of micronutrients).

A plantation forest derives nutrients from the earth (soil), the air, decomposing plant material, possibly groundwater and fertiliser.

Biogeochemical nutrient cycling

Nutrients move between and within the soil - plant - atmosphere continuum. Nutrients and the cycling processes are manipulated through, and as a consequence of, plantation management and tree growth. These manipulations can temporally or permanently affect the availability or accessibility of nutrient required for plant uptake.

Plant uptake is responsible for the largest quantity of nutrients extracted from the various site sources. These nutrients are stored and locked up in the trees and litter (and roots). Considerable quantities of nutrients are lost during harvesting. Further losses also occur as a result of residue management, nutrients leaching out of the soil, de-nitrification and volatilisation processes, soil erosion and fire.

The important thing to remember is that what we do now has an impact on current and future productivity!

The Dukuduku biogeochemical nutrient cycling study

This project will attempt to quantify changes in nitrogen fluxes on a sensitive site after felling, through the inter-rotation period, planting (and beyond). The aim is to determine the extent to which the nutrient flux processes can be influenced by management practices. Ultimately the intention is for the complexity of the nutrient cycling and management interactions to be placed into a simple system of soil, plant and litter indicators for our site classification system. This will be used to inform managers of the consequences of various management choices on current and future productivity.
Dukuduku
This is considered a high risk site because it has potential for rapid nitrogen (N) loss and small soil and litter N reserves as a consequence of:
• low clay and soil organic matter;
• high rainfall and high temperatures;
• rapid growth and litter decomposition;
This site has the added benefit of security and excellent technical support.

Experimental approach
The study will attempt to exert a nutrient pressure on the system during stage of greatest loss, the inter-rotation period, then again by using residue burning as a tool. A number of key nutrient cycling processes will be monitored throughout.

Some research outcomes will be:
• Nutrient flux monitoring and modelling data
• Water volume flow and ecosystem solute chemistry data
• Data describing nutrients in each system component
• Data describing biomass, litter fall, decomposition and N-mineralisation processes
• Data describing changes in soil and litter chemistry

Possible implications of this research
The data will be used to:
• Assess the impact of management operations on nutrient supply and demand;
• Develop nutrient cycling models to describe the system, and potentially to extrapolate to other sites by gathering additional basic data for those sites;
• In the long-term, develop nutrient input-output budgets to evaluate the effects of management operations on long-term site productivity;
• Develop models of supply and demand to assist in understanding key periods of nutrient demand and hence fertilisation strategies;
• Establish when and how to manipulate nutrient availability (fertiliser/residue management etc);
• Allow the determination of sensitive site types to nutrient depletion and recommend corrective management strategies;
• Generate indicators or warning signals of excessive nutrient loss and possible productivity decline;
• Understand the timing of nutrient requirements for optimal productivity; and
• Decide when to manipulate nutrient availability (fertiliser/management).