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TIP-MAG

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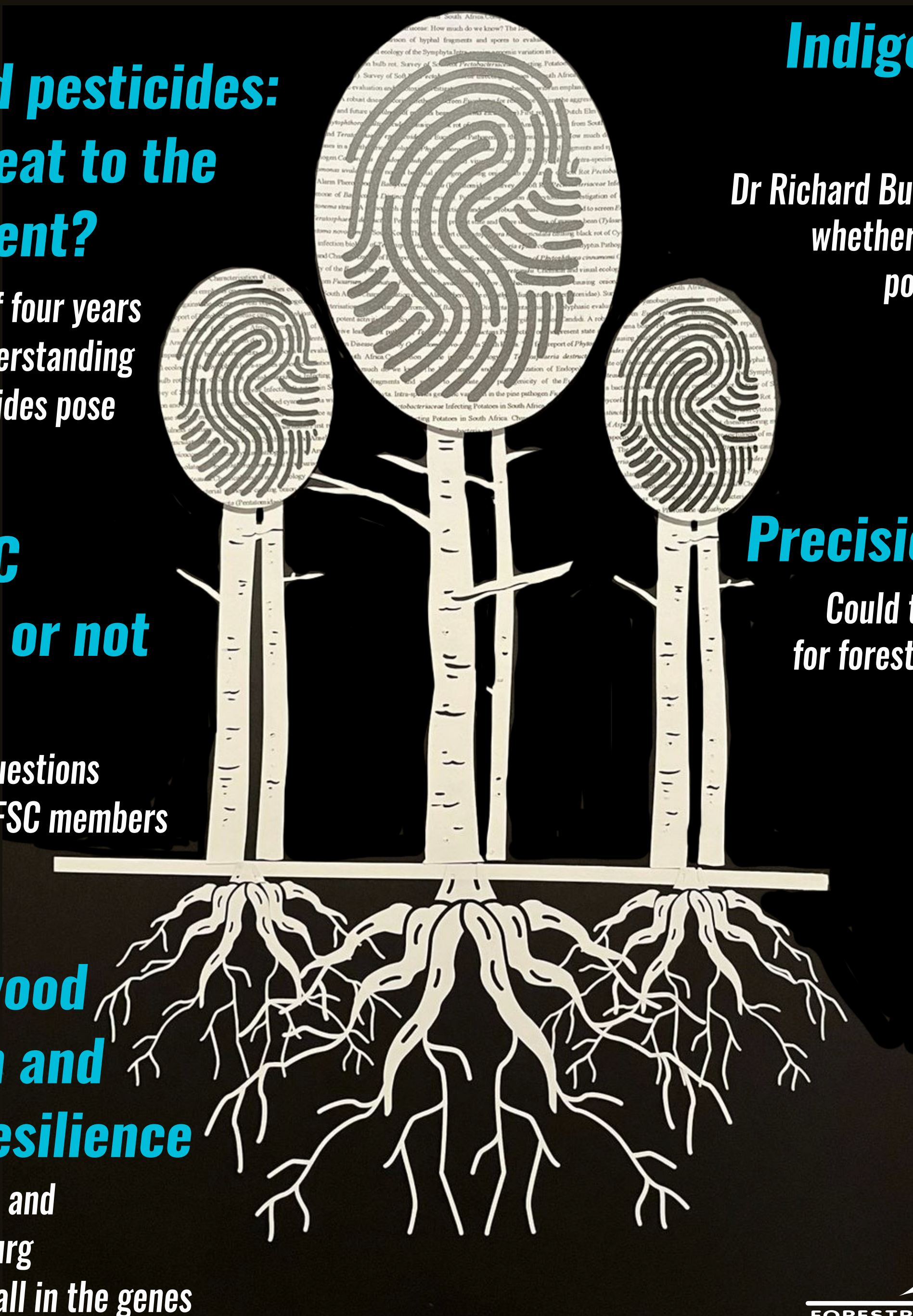
Timber Industry Presents Magazine



Regulated pesticides: still a threat to the environment?

The conclusion of four years dedicated to understanding the threat pesticides pose

Indigenous tree forestry

Dr Richard Burgdorf investigates whether this has economic potential or is simply potential fantasy

To be (FSC certified) or not to be...

Just one of the questions TIPWG is asking FSC members

Precision forestry

Could this be the solution for forestry's ever shrinking pesticide toolkit?

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FORESTRY SOUTH AFRICA™

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COVER ARTWORK: THE PIECE IS CALLED "OUR PRINT" BY SHIVAN BEZUIDENHOUT AND CLAUSETTE DEWING

As humans, we have always felt the need to leave our mark on Earth. A legacy is what will succeed us. What began as rudimentary clay prints on cave walls evolved into the digital art of the 21st century. This art is a visual representation of the impact we make as scientists. Titles published by FABIans this year are embedded between the ridges of each fingerprint. All three fingerprint trees are bound together by a strong and interwoven root system. We are the root system, the strength supporting different fields and sharing the beauty of knowledge. That is our mark as scientists. That is the legacy we choose to leave behind.

> *"As humans, we have always felt the need to leave our mark on Earth."*

FROM THE EDITOR

OPINION

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RESPONSIBLE RESEARCH

THE NEED TO CONSIDER THE CONTEXT WITHIN WHICH YOUR FINDINGS ARE PLACED AND HOW IT COULD AND SHOULD BE APPLIED

"...we should never underestimate the potential power of research to bring both benefits and constraints."

AS A SECTOR we are going through an innovation driven transformation that is very much research led. It is enabling our Industry to increase productivity and protect our growing stock to remain globally competitive, while at the same time reduce our environmental footprint and optimise our positive social impact. The research undertaken by our Sector is cutting edge, world class and makes a huge impact when applied in the field.

However, we should never underestimate the potential power of research to bring both benefits and constraints. Research when applied can dictate policy, it can transform common approaches, it can create or destroy livelihoods, it can provide environmental solutions or lead to further degradation. In short, research "*the detailed study of a new subject* (concept or idea), *in order to discover (new) information or reach a (new) understanding*[1]" is transformative but is also highly dependent upon the context in which it is slotted.

A perfect example is the first generation of energy saving lightbulbs rolled out by the UK government[2] in 2010. So impressed with their "green" credentials to reduce electricity use, the bulbs were handed out to households for free in exchange for the homeowners' original lightbulb. So successful was this initiative that millions of bulbs were produced and swapped across the UK. Only when the new energy-efficient lightbulbs came to the end of their natural lifespan (which was significantly longer than the bulbs they replaced), did the environmental consequences of this initiative start to become evident. For each energy saving light bulb contained a small amount of mercury and at the time there were very few recycling facilities that could deal with this. Furthermore, most people did not realise their potential for environmental damage and simply threw the bulbs into their landfill waste.

Examples like this is why we as researchers need to be both responsible with the conclusions we draw and far-sighted when it comes to how research findings could and should be applied or interpreted. There are so many examples of how good research has been poorly applied and as a result has resulted in the opposite impact it was intended to have. Our Sector has experienced this first hand with the proposed regulations governing genus exchange. With this in mind, I am really excited to see in this issue of TIP-MAG, five very different research articles that all place emphasis on the need to consider how their research could and should be applied and the impact of this.

Dr Ronald Heath
FSA Director:
Research and Protection

[1] Cambridge Dictionary
[2] The Ecologist

TO BE (FSC CERTIFIED) OR NOT TO BE... THAT IS THE QUESTION!

THE NEED TO BETTER UNDERSTAND THE PRACTICAL IMPLICATIONS OF IMPLEMENTING THE FSC PESTICIDE POLICY

Dr Katherine Louise Johnson and Jacqui Meyer

Forestry South Africa, Timber Industry Pesticide Working Group

"There is a lot of merit to understanding the changes to pest management practices that certification brings"

IN JANUARY 2022, the findings of a very interesting study by Lemes *et al* was published in the Journal of Forest Economics. The study was part of a larger research project to assess the possible impacts created by Forest Stewardship Council® (FSC®) certification on pest management practices from the perspectives of certified forest plantation owners. Conducted in the Southern Hemisphere countries of South Africa, Australia and Brazil, the key findings were presented in an Interest Piece published in Issue Five of TIP-MAG (page 12-14).

Sadly, for the authors and those interested in their research, the results of Lemes *et al* study came out 8 years after the research was collected in 2014. In the time between data collection and publication, FSC revised their Pesticide Policy, releasing a new version on 1 May 2019 that became fully enacted on 1 August 2019, nullifying any practical application of Lemes *et al.* findings.

While this may have dashed Lemes *et al's* hope that the results of their study would help producers and decision makers decide whether or not to maintain certification and discuss with FSC possible revisions/ evolution of their policy, the study still provides interesting insights regarding how those on the ground, having to implement FSC certification requirements, perceive it.

There is a lot of merit to understanding the changes to pest management practices that certification brings; the level of satisfaction those implementing these changes have for both certification in general, and the revised FSC Pesticide Policy; and the challenges or difficulties they face when it comes to complying with FSC requirements whilst managing pests. All of these points are equally, if not more, relevant now under the revised FSC Pesticide Policy as they were when Lemes *et al* conducted their study in 2014. Particularly, if it does provide a platform upon which discussions between those setting FSC Policies and those implementing them on the ground can be formed.

Lemes *et al* study could also provide a base line measure from which an evaluation of how the change in the FSC Pesticide Policy has impacted the South African forestry industry. Has it brought about additional changes to pest management, or reduced the burden? Are foresters/ farmers more or less satisfied with FSC certification, both in general terms and when specifically related to pest management? And, what pest management challenges have arisen as a result of remaining FSC compliant?

Dr Katherine Louise Johnson

Jacqui Meyer

To this end, TIPWG has been assigned the task of replicating Lemes *et al* study to evaluate the changes and cost implications of FSC certification on pest management, as perceived by certified forest managers, and how the changes brought about by the recently revised FSC Pesticide Policy might have altered this.

APPROACH

Lemes *et al* granted TIPWG access to their initial questionnaire, which has provided a guide when developing the revised survey. Initially, the hope was to replicate the survey where possible to enable direct comparisons and understand attitude shifts of respondents. However, the dramatic changes to the pesticide policy rendered many of the original questions obsolete and opened new avenues of inquiry. As such, when it comes to the impact FSC's revised Pesticide Policy has on the management of pests, emphasis has been placed on understanding the changes and challenges rather than being able to draw direct comparisons with Lemes *et al* study. However, in regard to satisfaction with the FSC certification in general, question similarity has been prioritised to ensure comparisons can be made.

The survey is currently being piloted with a select cohort of respondents, who will provide feedback as to the relevance, validity, arrangement, clarity of questions, length of the survey and whether it meets expectations. Once the responses have been collected, analysed and the survey reviewed accordingly it will be distributed to all FSC certification holders, as per Lemes *et al.* By utilising contacts in FSA's Environmental Management Committee, we hope to improve upon Lemes *et al*'s 50% response rate.

> *"FSC Pesticide Policy ascertains that to make informed pest management decisions we must understand the implications the same applies to the policy itself"*

SURVEY OBJECTIVES

UNDERSTANDING CHANGES TO PEST MANAGEMENT RESULTING FROM IMPLEMENTING THE REVISED FSC PESTICIDE POLICY

A comparison of the previous and current Pesticide Policy clearly identifies that the revision has brought about many changes – as would be expected when moving from a hazard to a risk-based approach. Understanding the changes brought about and the impact they are having, both in terms of their implementation into company policies and procedures and then their enacting at ground level, will help identify how practical it is to maintain a desired level of pest management while fulfilling FSC's revised Pesticide Policy criteria.

UNDERSTANDING THE PEST MANAGEMENT CHALLENGES THAT RESULT FROM IMPLEMENTING THE REVISED FSC PESTICIDE POLICY

The implementation of the revised FSC Pesticide Policy will result in both direct and indirect challenges that pest management practitioners will need to navigate. These challenges are likely to span the social, environmental and economic sphere of forestry. By better understanding what the challenges are, why they have arisen and what they relate to, solutions can be sought and the benefits of FSC certification evaluated.

SATISFACTION WITH THE REVISED FSC PESTICIDE POLICY AND CERTIFICATION IN GENERAL

The South African Forestry Sector needs to remain competitive in a global market. Thus, anything that is implemented on the ground needs to be cost effective and viewed as beneficial, be it a new silvicultural practice or obtaining or maintaining certification. Understanding how satisfied those implementing the revised FSC Pesticide Policy are with the associated cost-benefits of FSC certification will be of interest to both the Sector and FSC.

TIMELINE

By the end of July, the piloting stage will have concluded and any changes made. The survey will then be distributed, with regular reminders sent out and respondents given two months in which to complete it. Analysis of the results will be undertaken during the last quarter of 2023, with the findings published in the January 2024 Issue of TIP-Mag.

TAKE HOME MESSAGE

The revised FSC Pesticide Policy ascertains that to make informed pest management decisions we must understand the implications (the hazards, exposure and therefore risk) of all pest management actions before actively choosing the path of least harm.

This study takes the same approach when evaluating FSC certification, surveying those implementing FSC certification requirements to gauge the perceived hazards (changes and challenges) of complying with FSC's revised Pesticide Policy to gain a better understanding of the perceived risks (costs and benefits). The Sector can then use this information to help inform its decision on certification, and perhaps FSC can use it to gain a better understanding of the practical implications facing South African foresters wanting to remain FSC certified.

A PRECISION FORESTRY APPROACH TO EXPANDING THE FORESTRY PESTICIDE TOOLKIT

INCREASED RESTRICTIONS ON THE USE OF CHEMICAL PESTICIDES FOR THE CONTROL OF FORESTRY PESTS HAS SPURRED ON THE NEED TO FIND ALTERNATIVE APPROACHES AND PRODUCTS.

Dr Bernice Bancole, Dr Benice Sivparsad and Dr Ilaria Germishuizen
Institute for Commercial Forestry Research (ICFR)


Dr Bernice Bancole


Dr Benice Sivparsad


Dr Ilaria Germishuizen

"Limited pesticide toolkit for the control of pathogens in forests plantations means there is an urgent need for alternative approaches that are environmentally acceptable and guarantee social security."

MANAGING forest plantations to maintain them in healthy, productive condition is a major challenge to foresters and an integral component of sustainable forest management. Globally, the use of pesticides is one of the available management tools where pests and diseases are either excluded or controlled. In recent times, improved understanding, and knowledge, increased social and environmental concerns, together with the change of approach to pesticide usage by international forestry certification schemes such as the Forest Stewardship Council ® (FSC®) has restricted the use of registered chemical products. This has unfortunately resulted in the availability of fewer effective products, raising concerns over increasing the risk of developing pest resilience to these products. Thus, there is urgent need for alternative products and approaches that can be incorporated in an Integrated Pest Management (IPM) programme.

According to the Food and Agricultural Organisation of the United Nations (FAO), a pest is defined as: any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products [FAO, 1990; revised FAO, 1995; IPPC, 1997]. This includes insect pests and diseases.

Steps toward the use of efficient alternative control measures in forests plantation

Following the recent restrictions and revised FSC pesticides policy, attention must be given to practices that are cost-effective, efficient, and favoured less or zero risk for both human health and environment.

A collaborative project between the ICFR and TIPWG, and funded by FSA (Forestry South Africa), is being implemented to address this. Initially, the project will investigate the prevalent pests affecting forestry nursery and plantations, collating information regarding the chemical products used in forestry sector (nurseries and plantations), their availability and efficacy.

With this information we will have a greater understanding of the chemicals and biological control products the sector is reliant upon, which are likely to be lost to the sector and therefore the elevated pests threat the sector will face going forward. Additionally, with the help of chemical and biocontrol companies, a list of alternative options will be obtained for the investigation of their efficacy against the major pathogens of the forest. Furthermore, together, we will develop protocols which will be tested on both nursery and plantation for new potential effective products registration. This information will inform the sector on the areas where research funding and capacity is required in order to find new effective biological control products and chemical that are environmentally acceptable with zero effect on human health will need be developed, tested, and ultimately registered for the use in forestry plantations.

The project will be coordinated by Dr Bernice Bancole and will involve the:

1. Needs analysis of pest threats, their damage, current control products available, including those not currently specified for forestry
2. Production of standardizing protocols for testing alternative products – in the field and nursery setting
3. Conducting field- and nursery-based testing of alternative products for the control of prioritized pests.
4. Establishing trials to enable the registration of suitable and effective products for both nursery and plantation.

"...we need to look for alternative approaches and products to ensure the industry remains productive and competitive."

By producing a standardised methodological approach for testing alternative products that is specific to the forestry sector, it will help ensure subsequent pest control related research can be compared to previous studies. This will aid the industry during FSC audits where they are asked to compare available control methods during the ESRA process. Ultimately, this project will lead to the advancement of knowledge and the testing and hopeful adoption of alternative pest control products [and approaches]. The project will also develop specialised skills and capacity in applied forest protection, which are scarce and much needed in precision forestry/agriculture and transferrable to other sectors of the South African economy.

TAKE HOME INFORMATION:

Increased restrictions on the use and availability of chemical pesticides for the control of pests in a forestry context means we need to look for alternative approaches and products to ensure the industry remains productive and competitive.

TREE GROWTH, DEVELOPMENT AND CLIMATE RESILIENCE – IT'S ALL IN THE GENES

NEW DNA MARKERS USED IN GENE-BASED MOLECULAR BREEDING TECHNOLOGY FOR GROWTH, WOOD FORMATION AND CLIMATE RESILIENCE IN *EUCALYPTUS* TREES

Ms Julia Candotti and Prof Zander Myburg
Forest Molecular Genetics (FMG) Programme, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria

SMALL differences in DNA sequence, also referred to as single nucleotide polymorphisms (SNPs), are the most common type of genetic variation found in plant and animal genomes. As a result, SNP markers have become the most widely used DNA marker technology in molecular breeding. SNP markers each typically have two variants or alleles, i.e. they are bi-allelic. As there are only two alleles, it is relatively simple to identify these variants and to automate their analysis throughout plant and animal genomes, a key requirement for routine molecular breeding operations. To deploy this technology for the South African forestry industry, we (Jackson *et al.* 2022) recently developed a 50,000 SNP marker array for tropical pine trees, which, together with a similar 72,000 SNP marker array for *Eucalyptus* trees, has become the basis for genome-assisted breeding in local tree improvement programmes.

While genome-wide SNP marker analysis has been a game-changer in plant and animal breeding over the past decade, there is a new opportunity to unlock the full genetic diversity of highly outbred organisms such as forest trees. These organisms accumulate large amounts of genetic diversity over time, resulting in multiple versions or "haplotypes" of each gene or genomic region. When breeders perform phenotypic selection, they indirectly select particular haplotypes at thousands of genes and genomic loci, increasing the frequency of desirable haplotypes in each breeding cycle. Advances in high-throughput DNA sequencing technologies now make it possible to directly detect and track haplotype variation throughout the genome. This promises to increase the accuracy of genome-assisted breeding and empower novel breeding approaches based on the ability to directly select for desirable haplotype variation in parents and progeny.

> *"...there is a new opportunity to unlock the full genetic diversity of highly outbred organisms such as forest trees."*


Ms Julia Candotti


Prof Zander Myburg

Eucalyptus tree species and its hybrids, a feedstock for pulp, paper and biorefinery products in South Africa, exhibit very high levels of genetic diversity. However, the full extent of haplotype diversity in their genomes is still unknown and a cost-effective technology to track such diversity in breeding populations is lacking. In our recent paper, Candotti *et al.* (2023, *The Plant Journal*), we describe the development and testing of a new genome-wide, haplotype genotyping technology for *Eucalyptus* molecular breeding. Haplotype markers can be generated for any locus by combining multiple adjacent SNPs in DNA sequence data from that locus (**Figure 1**). The result is a multi-allelic DNA marker type that directly tracks the underlying genomic variation in forest trees in a way not possible with individual bi-allelic SNP markers.

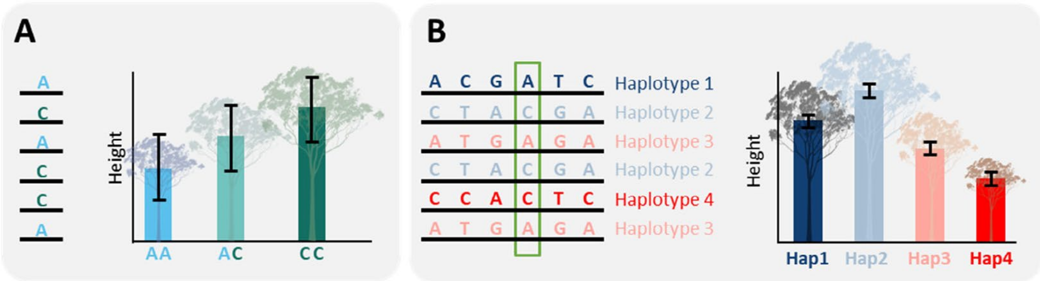

Figure 1: Accuracy of SNP and haplotype marker analysis in genetic dissection and molecular breeding. A. Hypothetical SNP marker associated with tree height. The C allele is associated with taller trees (faster growth). B. Haplotype markers present at the same locus. The green block highlights the SNP marker present in panel A. The haplotype markers are created by combining adjacent SNPs revealing the full extent of genetic variation present in the tree population. Haplotype 2 is associated with the tallest trees, while Haplotype 4 is present in the shortest trees. Going with the SNP results alone (A), the C marker allele would be selected for molecular breeding, however, the haplotype marker results (B) show that the C marker allele is also part of Haplotype 4, which would lead to the inadvertent selection of the subset of trees carrying Haplotype 4. As illustrated here, haplotype markers contain more information for genetic dissection and promise to increase the accuracy of molecular breeding. Eucalyptus trees from https://rooweb.com.au/

In our study, we used proprietary Flex-seq marker technology from Rapid Genomics (LGC Biosearch, Gainesville, Florida, USA) to identify haplotype diversity at 6293 genes in the *Eucalyptus* tree genome. We targeted these genes based on multiple evidence lines supporting their involvement in growth and wood properties, pest and disease resistance and abiotic stress responses. The Flex-seq technology uses pairs of long oligonucleotide probes to target specific gene regions. In this case, nearly 18000 target regions were sequenced, i.e. an average of two to three target regions at each of the 6293 genes. We identified SNPs within the target sequences and combined the SNPs at each target locus into haplotypes (**Figure 2**). The probe panel was then tested in four *Eucalyptus* species (*E. grandis, E. urophylla, E. dunnii* and *E. nitens*) to determine its transferability across species and hybrid combinations.

We detected on average 10-11 SNPs in each target region and these combined into 3 to 4 unique haplotypes per target region in each species, and 10 to 11 haplotypes per target region across all four species. This level of diversity observed within each short (200 bp) target region, suggests a very large number of

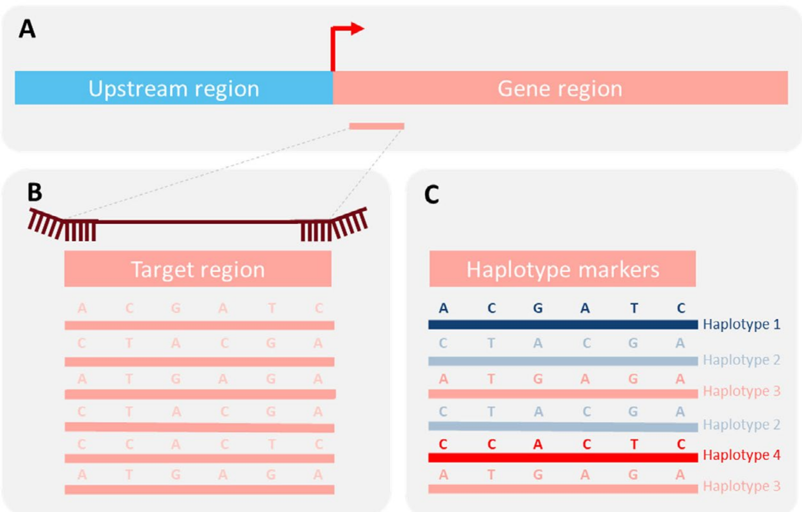

Figure 2: Overview of the development of the haplotype panel for *Eucalyptus*. A. Target genes were identified and one or more regions of interest selected per gene. B. Probe pairs (depicted by whisker structures) were designed to target the regions of interest. Each target region (approximately 200 bp) was then sequenced using a next-generation DNA sequencing platform in each of 20 targeted individuals in four *Eucalyptus* species. C. SNPs identified within the target region were combined into haplotypes to identify all of the variants present in the four species

haplotype combinations in eucalypt tree populations when extrapolated to the 3 million possible target regions in the genome. However, with only 3 to 4 haplotype alleles on average per target region in each species, it will be feasible to track haplotypes across parents and progeny at thousands of gene loci suggesting that the Flex-seq marker panel will be a useful tool for molecular breeding in *Eucalyptus* trees.

To further evaluate the information content of the haplotype markers we compared their heterozygosity, the likelihood of an individual carrying two different alleles at a marker locus, with that of individual SNP markers. The average heterozygosity of the haplotype markers was 39.4% compared to 7.7% for SNP markers, a five-fold difference. This means that a larger proportion of haplotype markers will be informative for genetic dissection and molecular breeding in *Eucalyptus* breeding populations than is the case for individual SNP markers.

Figure 3 illustrates how the haplotype panel can be used for molecular breeding. First, genetic dissection of complex traits of interest can be performed using the haplotype markers. Second, significantly associated loci and haplotypes at those loci can be identified and their effects on the trait determined. Third, desirable haplotypes can be identified in parental populations to determine which parents to cross to generate progeny with desirable multi-locus haplotype combinations for the trait of interest.

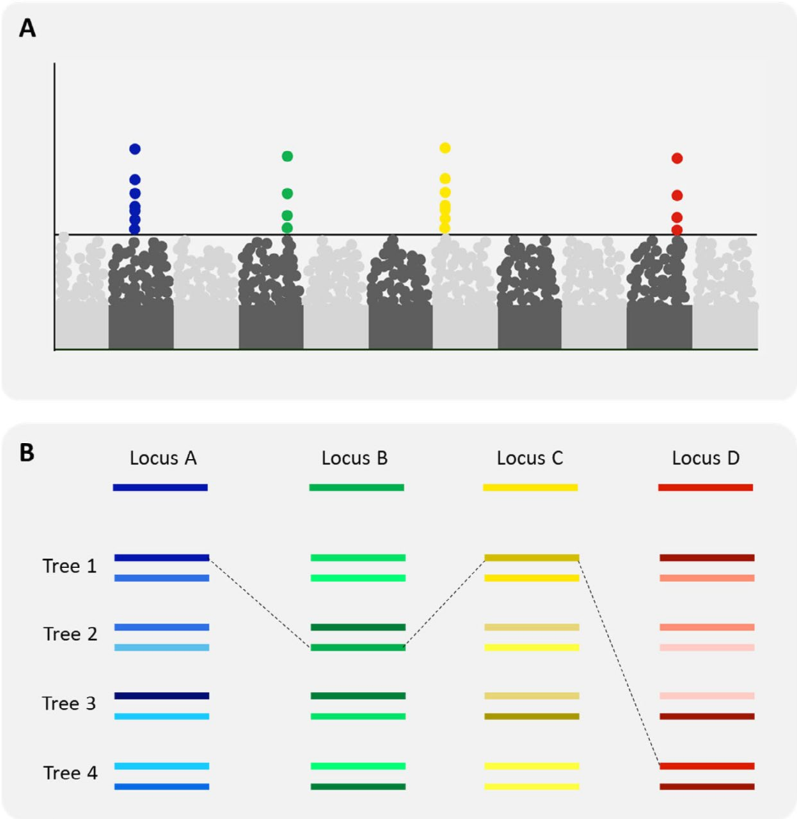

Figure 3: Use of the haplotype marker panel for genetic dissection and molecular breeding. A. Haplotype markers can be used in a genome-wide association study (GWAS) to identify loci significantly associated with the trait of interest. B. Desirable haplotypes underlying each significant locus can then be identified and desirable combinations of haplotypes across the loci determined. This can guide the selection of parents to cross to generate offspring with desired multi-locus haplotype combinations. The dotted line represents the possible assembly of the desired haplotype combination through the crossing of parental trees harbouring those haplotypes

CONCLUSION

The development of a new haplotype marker panel has provided the first insights into haplotype diversity within and between *Eucalyptus* tree species. The haplotype survey revealed a moderate number of haplotypes per target region, making the tracking of haplotypes within populations manageable. Additionally, the haplotype markers were more polymorphic than the SNP markers, making them favourable for genetic dissection and molecular breeding. The next step is to use the haplotype markers for genetic dissection in larger populations to identify target loci associated with growth and wood properties and resilience to biotic and abiotic stress. Ultimately, targeted or genome-wide DNA sequencing approaches will provide *Eucalyptus* tree breeders with a supplement to the SNP array technology able to better exploit the genetic variation underlying complex traits. Flex-seq technology can also be developed for pine trees as a cost-effective, gene-centric molecular breeding tool supporting the solid wood products industry.

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ARE PESTICIDES AND THEIR REGULATED USE STILL A THREAT TO THE ENVIRONMENT?

THE CONCLUSION OF FOUR YEARS DEDICATED TO UNDERSTANDING THE PERCEIVED THREAT PESTICIDES POSE

Noxolo Ndlovu

Junior Research Scientist, NCT Forestry

GLOBALLY, there is a common consensus that pesticides are bad. This awakening started in earnest with Rachel Carson's Silent Spring, which opened many people's eyes to the devastating impact the indiscriminate overuse of pesticides had on the natural environment. Thankfully, the world of pesticide regulation has moved on a long way since the first edition of Silent Spring was published in 1962, with the use of pesticides subject to international and country specific legislation, as well as certification requirements in the case of the Forestry Sector. Protecting trees against the negative impact of pests (including weeds) and pathogens is necessary for the economic viability and sustainability of the forestry industry. To this end, pesticides are used to achieve the goal of tree protection.

For decades, pesticide use within southern hemisphere forest plantations have been approved (or

INTRODUCING NOXOLO NDLOVU

Noxolo is on track to submit her Ph.D thesis in October 2023. In the interim, she has also secured a position at NCT Forestry as an entry level researcher and looks forward to broadening her horizons through involvement in various areas of forestry research.

Noxolo fell in love with biology when she was in high school and was fortunate to be granted an opportunity to pursue forestry through a Mondi bursary. Noxolo described herself as a curious individual and so furthering her studies and pursuing research was a logical step for her. Ultimately, she sees herself as a research scientist or forestry practitioner collaborating with various stakeholders across the whole forestry value chain to address and solve industry-related challenges, as such, secure the sustainability of the SA forestry industry. She envisions herself as a leader who leads with integrity, excellence, and inspires others to reach their full potential.

When asked about future trends and sector challenges impacting the focus of her research, Noxolo says that she believes that as an industry we not) based on conclusions drawn from laboratory pesticide fate studies and/or northern hemisphere-based pesticide fate field studies. These studies were often conducted under/within environmental conditions and application regimes that are vastly different to those relevant to southern hemisphere forest plantation conditions and therefore do not accurately reflect the pesticide behavior (and risks associated with its use). In the past decade, however, countries like New Zealand have made great progress in this area. Several pesticide environmental fate studies have been implemented (e.g. Baillie *et al.* 2015, Garrett *et al.* 2015) and have found that pesticide-use in New Zealand forest plantations when done in accordance to industry-specific use patterns poses minimal risk to the environment. Within SA forest plantations, however, the impacts associated with the use of pesticides to non-target soil and water organisms remain largely unknown.

To close this knowledge gap, Forestry South Africa's (FSA) Timber Industry Pesticide Working Group (TIPWG) commissioned and funded a Ph.D student, Noxolo Ndlovu, from Nelson Mandela University to investigate the environmental behaviour of pesticides and risks posed by their use within South African forest plantations. Her research addresses the long-standing unknown of how pesticides behave under South African forest plantation environmental conditions, and therefore the associated risks to non-target organisms. The study looked at factors such as mortality and adverse impacts on growth, reproduction and/or behaviour of

will never completely get away from using pesticides – although it likely to be on a reduced scale. To ensure environmental protection, especially for new pesticides, Noxolo believes there will always be a need for conducting SA forestry-relevant pesticide fate studies and she looks forward to being involved in the future pesticide environmental fate studies.

When asked what other research areas excited her, Noxolo immediately singles out tree improvement, "I love how tree improvement research secures the future of forestry by developing trees that can adapt to the changing environment while meeting market requirements".

"...the impacts associated with the use of pesticides to non-target soil and water organisms remain largely unknown."

earthworms, soil microorganisms, fish, macroinvertebrates, and aquatic plants. In the context of Noxolo's research, pesticide behavior refers to:

- pesticide concentrations in soil and water following their application,
- pesticide persistence (or degradation time) in soil and water,
- and the risks of leaching.

This is important since the severity of effects to non-target organisms (**the risk**) is a product of the concentrations to which the organism is exposed (**the hazard**) and the duration of exposure i.e pesticides persistence (**the exposure**).

RISK = Hazard x Exposure

Under the supervision of Prof Keith Little and two pesticide environmental fate experts from New Zealand, Dr Brenda Baillie and Dr Carol Rolando, her study sought answers to the following three questions:

1. At what concentrations do the pesticides occur in soil and water after their application?
2. How long do the pesticides remain in water and soil after application (persistence)?
3. How do the concentrations and persistence implicate the health of non-target soil and water organisms, like earthworms and fish?

The study was implemented on a site considered representative of typical SA forestry sites, as it was implemented within the most common climatic zone that occurs across the SA forest industry – the warm temperate (WT), which accounts for 57% of the SA forestry area. The study was also implemented on one of the 11 most common geologies that occur across SA forest plantations and was planted to a species that is most commonly planted in WT areas (*Eucalyptus*). Pesticides were applied as per standard SA forestry operational practice.

KEY FINDINGS

The results are mostly positive and encouraging:

1. Glyphosate – by far the most applied pesticide within the SA forestry industry – degraded quickly in soil and water, and concentrations were consistently lower than those known to pose a risk to non-target soil and aquatic organisms. This is good news because it shows that the way in which the SA forestry industry applies and uses pesticides poses a low risk to the environment.
2. When used in accordance to label specifications, pesticides can be successfully used as part of Integrated Pest Management approach.
3. Moreover, results of this work can be used to refute decisions (if any) by certification bodies and/or local legislation to prohibit the use of specific pesticides based on the perceived risk they pose to non-target species.

It should be noted that this study followed the pesticide application procedure based on label and regulatory requirements and therefore requires those using it to justify their pesticide use to follow the same strict adherence to product label recommendations, regulatory requirements and standard operating procedures outlined on the Timber Industry Pesticide Working Group website (https://www.tipwg.co.za/).

Although the results are positive, it is acknowledged that they are drawn from a single study, implemented on one site. To substantiate the claims made in this study, similar research should be rolled out across different SA forestry sites, to draw more concrete conclusions and recommendations.

The full results of this work will be shared once the work has been published in scientific journals. Readers are welcome to read the published literature review providing a background/rationale of the work at: DOI:10.2989/20702620.2022.2045879.

TAKE HOME MESSAGE

Understanding the environmental behavior and risks associated with pesticide-use under SA forestry conditions will:

1. Guide decision making at industry- and operational levels with regards to pesticide use.
2. Highlight areas where risk mitigation strategies are most necessary.
3. Ensure the SA forestry industry meets its mandate of protecting environmental values.

> *"...the way in which the SA Forestry Industry applies and uses pesticides poses a low risk to the environment."*

INDIGENOUS TREE FORESTRY: ECONOMIC POTENTIAL OR POTENTIAL FANTASY

By Dr Richard Burgdorf[1], Dr Mallika Sardeshpande[2], and Mr Glen Cooper[3]

[1]Institute for Commercial Forestry Research (ICFR), Research Associate

[2]University of KwaZulu-Natal, Post Doctoral Researcher

[3]Institute for Commercial Forestry Research (ICFR), Researcher

> *"...can conservation, commercial forestry and socio-economic interests occupy a mutually beneficial space?"*

INTRODUCTION

ALONG with providing an extensive description of the various trees grown in South Africa and their wood characteristics and properties, in their book, the "Guide to the properties and uses of Southern African wood" Dyer *et al* (2016) suggest that up to 7% or more of South Africa's 123 million hectares of land could sustain "natural forest habitat", potentially representing the pre-anthropic forest coverage in our land. According to the FSA commercial planted forestry of exotic species currently covers ~1.2 million hectares or 1% while 0.5% is covered by indigenous forest. However, depending on the definition of "forest", which presumably includes savannah woodlands and other areas covered by trees, it is also suggested that up to 14% of the land in South Africa is currently covered by forest. Forests, grasslands, and other biomes live in a balanced antagonism, mitigated by fire or other factors, and commercial forest plantations, agriculture, invasive alien vegetation, urban development, and other activities encroach upon these important biomes. However, the numbers suggest that a relatively small percentage of forests in South Africa are populated with indigenous tree species. Maybe indigenous forest trees could or should represent a bigger part in the mix of forests or forestry in South Africa? But for this to happen, conservation efforts alone may not suffice, and some form of sustainable indigenous forestry may need consideration.

In South Africa, planted forests consist almost entirely of exotic, and often invasive, tree species, although these sustain a successful commercial forestry industry bringing much needed work and income to the country. However, in many other parts of the world indigenous tree species form a major component of commercial wood production industries. In South Africa, the destructive exploitation of indigenous forest is discouraged or prohibited, depending on the where they grow, and several species are protected and cannot be harvested at all. Barry James discusses the legalities of harvesting indigenous trees, derived from the

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National Forests Act (Act no. 84 from 1998) in Dyer *et al* (2016), stating that "Removal of any wood from forests requires a license, as does the removal of wood from protected areas, whether the trees are a Protected species or not." This does not appear to apply to trees on private land, with a few exceptions, such as protected species. However, harvesting indigenous trees for firewood is one of the biggest drivers of deforestation across Southern and Eastern Africa. This is one of several practices threatening South Africa's protected indigenous forests, which as a result can be considered as informal harvesting. It raises an interesting question: can conservation, commercial forestry, and socio-economic interests occupy a mutually beneficial space? Can a space in which the social needs provided by the trees that become forests, which also provide invaluable ecological services, planted on public, private, or communal lands , be supported and possibly thrive with mutual support and commitment from conservation and commercial forestry efforts?

In addition to the well-known works of Keith Coates Palgrave, describing indigenous trees and their uses, in 1984 R.J. Poynton produced a volume titled "Characteristics and Uses of Selected Trees and Shrubs cultivated in South Africa" which lists some properties of indigenous trees, such as relative growth rates, tolerance of drought and frost, use of wood for timber, posts or firewood, and other uses such as fruit or honey production and land reclamation. Therefore, the potential of indigenous tree production for commercial use has not been entirely overlooked. Yet relatively little literature addresses this issue further. In Dyer *et al.* (2016) Barry James eloquently discusses the issues around the sustainability and commercial forestry potential of indigenous species. His discussions suggest a relative paucity of well-executed indigenous tree growth trials (or breeding efforts for that matter) and research on indigenous tree cultivation, although he does make mention of the valuable research by Professor Coert Geldenhuys and explains some of the sensible reasons for developing indigenous tree cultivation, such as native forest restoration and the control of invasive alien weeds, especially in sensitive riparian areas. However, the view that indigenous trees can be grown "commercially", in the same way as the plantation forestry industry using exotic species, is not supported. In this context, a primary challenge is to examine whether the economic activity involving indigenous tree cultivation could be related to the concept of commercial forestry in a current or modern South African context.

Consequently, in an uncharacteristic venture, and maybe with a greater social engagement component than is typical of the applied research at the ICFR, we initiated a project exploring this issue in a joint research project with the University of KwaZulu-Natal (UKZN). The project was undertaken by MSc student, Mr Kuhlekonke (Kuhle) Mathenjwa, under the supervision of Dr Richard Burgdorf (ICFR) and Dr Nokwazi Mbili (UKZN), in collaboration with the UKZN WoodRights group, represented by Dr Mallika Sardeshpande, who was an invaluable liaison between the ICFR/UKZN team, the Shongweni community and other stakeholders involved in this work.

METHODOLOGICAL APPROACH

Kuhle performed both qualitative surveys of indigenous tree production by local communities and quantitative growth experiments at various KZN localities.

He began by holding two community engagement sessions and surveys at the Buffelsdraai site north of Durban to elucidate the local knowledge, uses, and economic activity involving indigenous tree cultivation. Kuhle also surveyed a Shongweni community's indigenous tree production and use to determine candidate tree species for growth experiments. A trial community tree nursery for the most used indigenous trees (**Table 1**) was established at a site in the Shongweni community (**Figure 1**). This was followed by a greenhouse-based pot trial to examine the growth of these indigenous trees on degraded soils for land restoration purposes as an additional benefit. Both the field and pot trial experiments included a growth-promoting fungus treatment to test any benefit from a low-cost biological agent for indigenous tree cultivation.

Figure 1: The Shongweni and ICFR team during the trial establishment of indigenous trees, March 2022

Finally, he tested propagation methods for the indigenous tree species included in this work, via stem cuttings, widely practiced in clonal commercial forestry.

The outcomes of this work will cast more light on the mutual social, conservation, and forestry interests at a community level. The seeds of such thinking are already in place, evidenced by collaboration and support from the eThekwini Municipality, and WILDTRUST, which provided the seedlings for the research, as well as members of the rural Shongweni community. Community member, Mr Philani Mhlongo and his team at the Shongweni community nursery developed and maintained the trial indigenous tree nursery and Mr Glen Cooper, a scientist at the ICFR (**Figure 2**) provided project management, logistic support, and laboratory analysis.

Figure 2: The Shongweni and ICFR team after indigenous tree species trial establishment. From left to right: Glen Cooper, Kuhle Mathenjwa, Dr. Mallika Sardeshpande, Banele Phelakwe, Philane Phelakwe, Sihle Matabane, Philane Mhlongo, and Thalente Mkhize

QUALITATIVE SURVEY

Kuhle's survey on the use and importance of indigenous tree species to local communities at Inanda (**Figure 3**) and a focus group discussion and interviews with "Treepreneurs" (volunteers from local communities who propagate and sell plants to the municipality's restoration program) provided the list of candidate species for this project (**Table 1**).

Five species were selected, *i.e.*, *Ficus sur*, *Harpephyllum caffrum*, *Canthium inerme*, *Trichilia emetica*, and *Sclerocarya birrea* (see **Table 1** for common names). While they do not represent the best sources of timber or firewood, they have the added benefit of potentially adding to food security. This was a compromise to balance the socio-economic interests of growing and using trees with conservation efforts that discourage their destructive harvesting, while promoting indigenous tree cultivation research.

Figure 3: Community survey at Inanda, Durban

Table 1: List of common indigenous tree species around rural communities and their relative frequency of use in a year. The species selected for the growth experiments are highlighted in bold

COMMON NAME	ISIZULU NAME	SCIENTIFIC NAME	FREQUENCY/ANNUM
Marula	**umGanu**	*Sclerocarya birrea*	**0.25**
Flat Crown	umHlandlothi		0.25
Fever Tree	umHlosinga		0.18
River Bushwillow	umDubu/umBondwe		0.22
Natal Mahogany	**umKhuhlu**	*Trichilia emetica*	**0.22**
Sugar bush	isiQalaba		0.15
Broom Cluster fig	**umKhiwane**	*Ficus sur*	**0.25**
African Medlar	umTulwa		0.23
Wild Plum	**umGwenya**	*Harpephyllum caffrum*	**0.23**
Red Stinkwood	iNyazangoma		0.23
Water-berry	umDoni		0.24
Umzimbeet	umSimbithwa		0.23
Forest silver-oak	iPhahla		0.19
White Stinkwood	uSinga lwesalukazi		0.23
Sweet Thorn	umuNga		0.14
Buffalo Thorn	umPafa/umLahlankosi		0.18
Turkey-berry	**umVuthwamini**	*Canthium inerme*	**0.24**

The survey revealed that fruit, and medicine from bark and leaves were the most utilized indigenous tree products, whereas timber and firewood were least utilized, possibly due to the availability of alternative sources of timber and energy, or from successful conservation efforts. It would be interesting to see if this is the same in other regions locally or nationally. This highlighted the interest and need for tree production for medicinal properties. However, it was shown that the Treepreneurs and those individuals involved with the eThekwini Reforestation Project had the greatest knowledge on these uses. So, although rural communities do actively utilize indigenous trees more educational resources are needed to guide them to benefit from a wider range on indigenous tree species available to them.

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NURSERY GROWTH TRIAL

There were no significant differences in sapling survival with or without fungal growth promoter treatment at the community nursery field trial (**Table 2**). *H. caffrum* exhibited the highest overall survival rate, even after experiencing livestock grazing.

Table 2: The survival rate of five indigenous tree species after being treated with a growth-promoting fungus in the field (n = 24 trees , i.e., 12 trees per treatment)

Species	Untreated		Survival rate (%)	Treated		Survival rate (%)
	Grazed	survived		Grazed	survived	
H. caffrum	12	12	100	10	12	100
T. emetica	10	12	100	12	10	83.33
S. birrea	12	10	83.3	12	11	91.7
F. sur	12	10	83.3	12	11	91.7
C. inerme	12	11	91.67	12	12	100

Growth data recorded at one year post planting showed that the fungal treatment generally had no significant effect, when the species were analysed together. However, in the case of Root Collar Diameter (RCD) for *H. caffrum*, the treatment potentially inhibited growth, which is interesting and could be investigated further. Therefore, further research on alternative indigenous tree biological growth promoting organisms may be required which could benefit conservation, land restoration, as well as commercial forestry of exotic species. However, *F. sur* appears to be the fastest growing tree in the field based on these results (**Figure 4**).

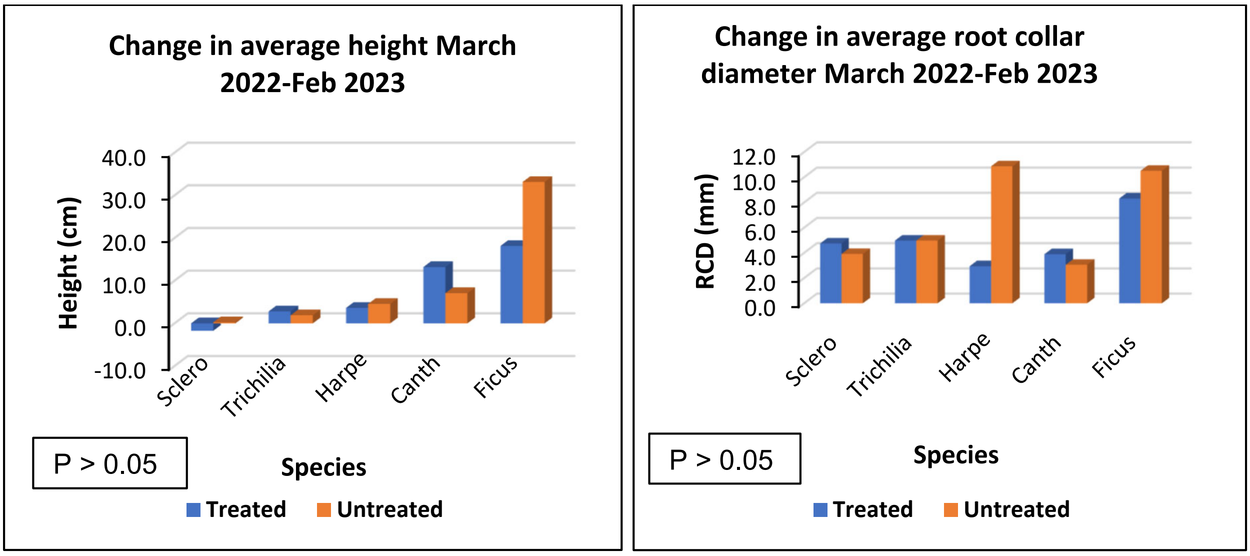

Figure 4: Change in the growth of indigenous tree species in average height and root collar diameter over 11 months in the field

GREENHOUSE TRIALS

The greenhouse pot trials using degraded soils (*i.e.,* anthropogenic soils sourced from the Buffelsdraai dump site), with and without fungal treatment, also showed *F. sur* had the highest growth for indigenous trees with no statistically significant effect by fungal treatment ($P > 0.05$). However, as expected, the measured parameters (particularly height, which is an important factor for commercial forestry) were considerably lower for indigenous trees than for the *Eucalyptus grandis* control (which had no fungal treatment). This is testament to the reason why exotic species were initially selected and continue to be used for commercial forestry in South Africa.

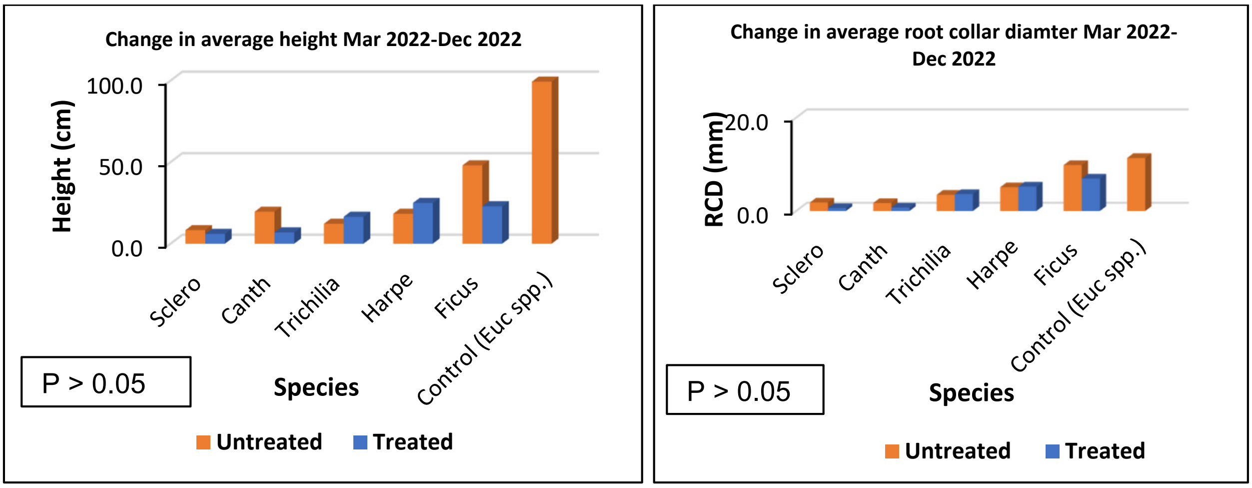

Figure 5: Change of growth in average height and root collar diameter of indigenous tree species over 9 months in the greenhouse

PROPAGATION STUDY

Under relatively ideal conditions and testing multiple cutting strategies, the survival percentage of the indigenous seedlings from cuttings planted in a rooting tunnel and monitored for 12 weeks (**Figure 6**) was very low.

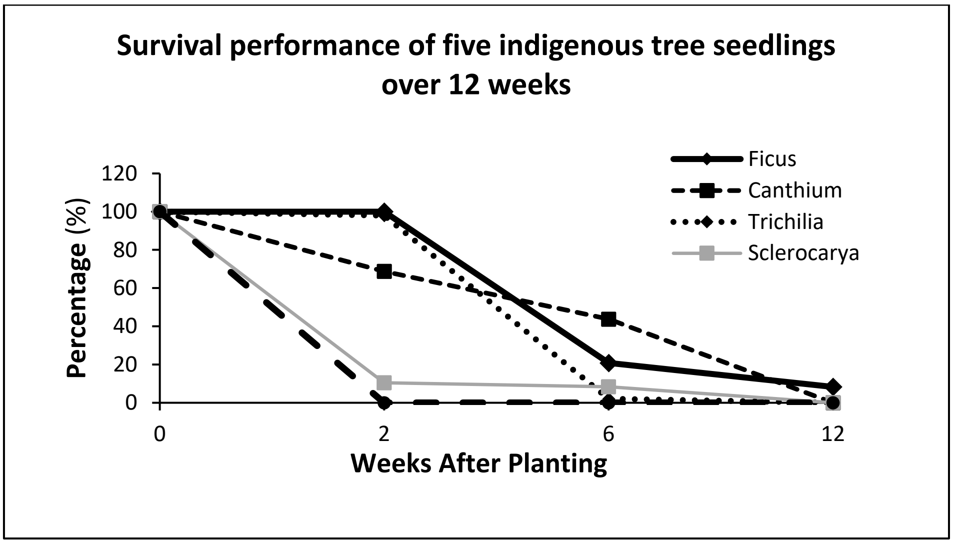

Figure 6: Survival of indigenous tree species after 12 weeks of propagation

This indicates that more research on what is known in the literature on indigenous tree cutting production, as well as empirical research, is required to develop successful protocols for cutting propagation of such species for rapid and large-scale indigenous seedling production. This supported an initial finding in this project that sourcing seedlings could be a significant barrier, both in cost and availability, to large-scale indigenous tree afforestation projects.

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CHALLENGES

Several challenges were evident in this research. Some were obvious, such as the impact of grazing by livestock which

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is a well-known problem for crop production in rural South Africa. Also, stakeholders from conservation and restoration backgrounds have justifiable reservations about the destructive use of indigenous trees which presented an inherent and understandable resistance to research on "commercial" indigenous forestry. Others became apparent later, including the complex relationship between land-use demands. Housing and food production are prioritized over tree-planting, relegating indigenous tree cultivation to a landscaping or gardening market. Further work comparing the existing versus potential local value-chain of indigenous trees is required.

SO WHAT DOES THE FUTURE HOLD?

There are many good examples globally of forestry and conservation working together to generate a social and conservation benefit. In South Africa, there is the conservation initiative by SAPPI to produce and supply *Warburgia salutaris* (Pepper-bark tree) to communities and organizations, educating them on how to sustainably harvest the medicinal properties from these trees, to reduce the threat to wild populations by bark harvesting for traditional medicine. This is a perfect example of a forestry company utilizing its tree breeding skills, technology, and capacity in the production of an indigenous tree to benefit both communities and conservation.

However, large-scale commercial production of indigenous species appears to be a long way off and may not be truly viable. Intensive indigenous tree breeding would be needed to match the growth exhibited by current commercial varieties; and even if indigenous trees were grown commercially for fruit and medicinal properties rather than timber, there would still need to be extensive research into their propagation. There is not a simple process for transferring commercially forestry protocols over to the propagation of indigenous species. Much work is still needed to define the potential of an indigenous tree cultivation industry that could be supported by commercial forestry. But we should not simply give up. The commercial forestry sector has a wealth of knowledge and much to offer conservation and local communities. Existing efforts and strategies need continued support to maintain positive relations. Eventually the nature and size of such co-operation could develop organically into what could be viewed as an indigenous tree production industry that does offer significant social, environmental, and economic benefit.

Furthermore, aside from trending ideas such as income from carbon offsets or use of other faster-growing non-endemic yet indigenous species (*e.g.*, *Trema orientale*), one practical action proposed during this work was the need for greater knowledge transfer and education. Annual Arbour Day events at local schools informing children of the importance and uses of indigenous trees in the ecosystems around them, facilitated by the commercial forestry sector, could have potential for growing awareness and common purpose in the long term. Informing future generations about the distinct roles of both indigenous and commercial species in providing ecosystem services, human benefits, and economic opportunities simultaneously encourages the ongoing conservation and possible expansion of indigenous forests, with continued support for our valuable and productive commercial forestry sector.

TAKE HOME MESSAGE

While replacing exotic tree species with indigenous species in commercial forests is likely unrealistic due to the many constraints, this study provided a 'living laboratory', thanks to community access and the inclusion of multiple stakeholder perspectives. This has enabled knowledge generation and the opportunity to seek common ground between multiple players in a complex setting. However, a great deal of work to develop fundamental knowledge and understanding is still required before more tangible interplay and value is realized for all the groups involved.

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