TIP-MAG

Vol.2 No.2

2021

Timber Industry Presents Magazine

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THE QUEST FOR KNOWLEDGE IS NEVER AS IMPORTANT AS IT IS DURING TIMES OF UNCERTAINTY.

> *"…across the globe, Forestry is a challenging sector to be in. On a daily basis we need to deal with economic, social, biotic and abiotic challenges."*

I INTRODUCED the last issue of TIPMAG (issue two) by stating I could not have imagined the challenges the COVID pandemic had in store for our industry when writing the introduction for the first issue of TIPMAG. Equally true, is back then I could never have imagined that 6-months later we would be besieged with a third wave, neither could I have anticipated the strength, resilience, adaptability and determination of our Sector, and every individual within it, has demonstrated.

Reading through this issue I am heartened that during a pandemic that has rendered so much stationary, research and development stop for nothing. The exciting goings-on at the Forest Molecular Genetics Programme is a testament to this and I believe will be crucial in ensuring the Sector can meet the increasing demands and challenges the next decade is likely to throw at us.

The dedication of the *Leptocybe* working group should be applauded. Their work is critical in controlling a pest that has the potential to negatively impact productivity across great swaths of the forestry landscape and has established a model the Sector can upscale to a national monitoring programme.

I am also excited by research showcasing how as an industry we prioritise sustainability, whether that is lessening our environmental footprint or improving the welfare of the forestry workforce. The FSA landcover survey, facilitated by FSA's Environmental Management Committee (EMC) has enabled the qualification of unplanted land within the forestry landscape. While this in itself cannot definitively answer whether these spaces benefit biodiversity and its conservation, it is the first step in the process of evaluating this. In addition the research by Mondi raises important questions about ensuring PPE meets both the label requirements and the physiological needs of those wearing them.

Finally, in a world where sustainability is becoming increasingly important, I am pleased that as an Industry we are ahead of the curve. Years of self-regulation and certification have ensured South African forestry has been built upon three pillars of sustainability – economic, environmental and social.

I hope you will enjoy interrogating this issue and consider contributing to the next.

Dr Ronald Heath
FSA Director:
Research and Protection

EMPOWERING COMMUNITIES BY MAINSTREAMING RESPONSIBLE FOREST RESTORATION

THINK GLOBALLY, ACT LOCALLY!

Michal Brink – CEO, CMO Group

FOREST Stewardship Council® (FSC)® Certification is often touted as being out of the reach of communities and small growers, due to the onerous requirements of this standard. But over the last 18 months, it has been shown that when interpreting the FSC standard at its core it is in fact quite flexible and accommodating to small growers. The use of FSC certification as a tool to manage responsible forest restoration in South Africa has also come to the fore over the last 12 months. Thus, demonstrating itself to be an all-inclusive standard that can address responsible forest management from the smallest charcoal producer in the rural eastern Cape by clearing Alien Invasive Plants (AIPs), to the large plantation companies in South Africa and elsewhere.

"…it has been shown that when interpreting the FSC standard at its core it is in fact quite flexible and accommodating to small growers."

THE GREEN WORLD OF TODAY

We are living in times of circular economies, carbon trading and the green business being on everyone's lips. In September 2015, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development. This is intended to be a "plan of action for people, planet and prosperity" and "seeks to strengthen universal peace in larger freedom" (UN, 2015). It sets the priority to eradicate poverty in all its forms and dimensions, which is seen as an indispensable requirement for sustainable development. The same organisation has also announced 2021 to 2030 as the decade of ecosystem restoration and forest restoration is squarely aligned in this space, as well as repairing watersheds and other ecosystems, such as those encroached by AIPs. With so much happening in the green business arena, responsible buyers have developed and continue to develop clear policies to protect their "green/environmental/sustainable" reputation. Buying natural, resourced-based products comes with higher reputational risk than many factory-produced products due to the potential environmental and social impact associated with naturally sourced products.

There has thus been a global megatrend over the last years to prove responsible natural resource management by certifying the production streams of products and then tracing them to the final market. In the case of forest products, two global certification systems have emerged, namely FSC and PEFC. Forest products are being viewed with increased scepticism when not FSC certified. Many of the global retailers have also made it a policy decision to buy only FSC certified products when dealing with the developing world. The reason for this, is the credibility of the FSC standard, in particular, its acceptance by environmental and social NGOs as a credible tool, as opposed to other certification standards like PEFC. For example, buying charcoal produced in Germany from a PEFC certified company in Germany may be quite acceptable for a supermarket chain

Michal Brink

like Aldi Group, but when buying the same charcoal from any African country they will require an FSC certificate due to the shortfalls in PEFC as a certification scheme and the concurrent risk it then poses to the buyer in Europe. This is further confirmed by the market uptake of FSC chain of custody certificates as opposed to PEFC. There are three times more FSC CoC certificates in the world today compared to the rival PEFC system, indicating the clear market preference for the one vs the other.

So, any producer in the developing-world has a significantly better chance of accessing the mainstream markets – often tied to retailers in the developed world – if they carry the FSC label. The reason for obtaining certification is not only for market access, but in many cases, also to obtain a market premium on pricing. FSC Charcoal, for example obtains a premium of 15% to 25% above uncertified charcoal in global trade.

CMO, in recent years has entered the FSC small grower certification market and has identified what the past perceived constraints were to small grower FSC certification and devised solutions to overcome these. It quickly became clear that the main constraint is not tied to either of the two certification schemes, but rather to meeting the legal requirements in a particular country. Furthermore, all FSC group schemes in South Africa are paper heavy and over designed, outside the scope of the FSC standards themselves. To solve these issues, CMO software was developed over the last two years and that has now been implemented in several countries across the world – particularly with small growers. The key to the allowing small growers to become certified at scale at a national level lies in CMO's obsession with simplicity in the systems being rolled out in the field with rural communities. Over the past two years, CMO has managed to create the largest FSC certificate on the continent in Namibia by applying this approach. In South Africa, CMO has also shown the power of simplicity by rolling out FSC certification within communities with ease over the last 12 months, such as charcoal production in communal areas by the removal of AIPs , as well as, the certification of out growers under the Mondi Zimele scheme. One last piece of the puzzle that has been missing, is the availability of a trading portal for certified FSC products to unblock the supply chain. Such a portal is currently under development and will be operational by the end of 2021. This will then allow the poorest of the poor to have direct access to selling their certified product, such as FSC certified charcoal, to the largest supermarket chains in the world.

The FSC Pesticides Policy is stringent in its requirements for certificate holders, providing assurance to stakeholders that social and environmental values have been protected and conserved. The revised Policy requires an environmental and social risk assessment be applied when utilising highly hazardous pesticides, which competing schemes do not offer to international markets. The beauty of FSC certification is the additional funding that can now be raised to ensure that consistent aftercare is applied after AIP eradication programmes – something that no other scheme has on offer and that is currently being implemented in both Namibia and South Africa. After-care requires a predetermined follow-up programme to be defined and documented for a time that will ensure services protected in the ecosystem are indeed restored in the long term. In South Africa, the focus is on water, while CMO is focusing on forest restoration in Namibia, by thinning out the heavily encroached woodlands. The level of restoration is measured and reported annually to the relevant certification body. The application and verification of the FSC Ecosystems Services Procedure is also well placed to help South Africans with obtaining additional funding from interested donors and investors. CMO is already working to implement this in Breede and the Matatiele areas.

Scaling is no longer an issue, and with the future of plantation forestry expansion in Africa lying squarely in the hands of the small grower, FSC is the system of choice to access an increasingly cautious market both within South Africa and abroad. As the saying goes: "Think globally but act locally!"

FOREST CERTIFICATION: MAKING A DIFFERENCE OR GREENWASHING?

Craig Norris – employed by NCT Forest and current Chairman of SAFAS

"Forest Certification is promoted as a system to endorse sustainability in the broad sense, but certification systems often endorse compliance with a set of indicators that are not relevant to local context or /scale……real sustainability issues are often overlooked."

I ESTABLISHED a Forest Stewardship Council® (FSC®) Group Certification scheme in 1998 and have invested a lot of time and energy into trying to accommodate all scales of forestry operations under an umbrella Group Scheme. I have also been involved with many of the FSC initiatives to accommodate family forestry type operations. 22 years on, I do not think that we are any closer to achieving this objective under the FSC system. If anything, the system has become more complex and onerous…. just read the new FSC pesticide policy!

Why is it that the large Forestry companies in South Africa are all certified and most of the small and medium scale operations continue to struggle to get certified or even maintain certification? One would imagine that large scale would be one of the primary risks associated with industrial monoculture plantations and that large-scale operations would be scrutinized more closely than small…the reverse is what happens.

In my opinion it has nothing to do with large operations being more sustainable than small but simply that larger operations have the systems and economies of scale to deal with the complexity and cost of certification systems. Perhaps the current certification systems are not designed to identify the real economic, social, and environmental risks according to scale and local context?

Lets look at some local examples to support this arguement.

I recall having a long debate with an auditor regarding the need for a documented budget and long-term management plan. The context was an assessment of one of the most successful private timber farmers in the country, he does not draw up a formal budget or management plan. He knows his operation well enough to understand the liquidity of his business and the need to replace equipment when required. His farming operation is expanding, he understands timber markets well and has planted a variety of tree species to cover diverse markets. He does not need a documented budget or management-plan, it will make no difference to the economic sustainability of his operation…. low risk, tick the box and move on.

One of the biggest risks to the sustainability of tree plantations in South Africa is poverty and unemployment. Large plantations adjoining poor communities are at risk unless the communities see value and benefits from the plantations. In recent times many forestry operations have been mechanized and outsourced. Labor forces have been reduced and value addition is far removed from the plantations. Procurement is often done centrally to improve economies of scale. Profits are paid out to shareholders who do not invest in local economies. Such operations are providing few benefits to local communities……high risk, lots of questions need to be asked. On the other hand, family forestry operations are part of the community. employing locally, using local shops and services, and often supplying a small local processing plant with the pulp wood component transported to a far-away pulp mill….low risk, fewer questions need to be asked.

Last year a local farmer asked me to come and have a look at the damage caused to his farm by soil wash from an adjoining certified plantation. The plantation in question was at the head of a valley and all the compartments in this catchment had been mechanically harvested (machines need to harvest big areas to be cost effective). The brush had subsequently been burnt on a hot day (difficult to wait for suitable conditions when large areas need to be planted). Also, a hot burn is convenient because it leaves a clean site for mechanical planting. A severe thunderstorm with intense rainfall then resulted is a large proportion of the topsoil being removed from these compartments and deposited on the neighboring farm, silting up a dam, breaking fences, destroying the farmers pumphouse, and dumping sediment in a perennial stream. Intensive, large scale operations are high risk and need to be assessed accordingly.

What is the solution? In my opinion it is to develop a risk- based standard, relevant to the local plantation industry and legal framework.

The good news is that this has already been done in the form of the Sustainable African Forest Assurance Scheme (SAFAS). This system is underpinned by a "Value Based Platform" which allows a company, group manager or individual to assess the risks to the sustainability of a particular operation/ management unit and provides the tools to address any shortcomings. The risks are assessed according to scale, intensity, and the environment in which the plantations occur.

We need to move away from a system where one size fits all and move towards a system where the real risks are assessed in a local context and addressed accordingly.

"What is the solution? In my opinion it is to develop a risk- based standard, relevant to the local plantation industry and legal framework."

MONITORING OF *LEPTOCYBE INVASA*

A VIEW OF LEPTOCYBE INVASA AND PREDATOR PREY INTERACTIONS

Wayne Jones – Sappi, Forestry Research

Wayne Jones

THE South African Forest industry faces many challenges to remain viable where people, environment, technologies and processes interact. One such interface is the impact of subtle climate change triggers that are contributing significantly to abiotic and biotic stressors, which have a negative impact on plantation resources. These increasing pressures that impact tree growth and yield have put the spotlight, squarely, on the need to understand the dynamics, interactions and long-term solutions for the pest and diseases that we face. To this end, forestry companies, universities, institutes and government have made significant investments over the years into applied research programmes and skills development to deal with this ongoing threat.

In all the turmoil of funding applications and uncertainty, it takes clear and agile minds to invest where appropriate. One such example is the *Eucalyptus* Pest and Pathogen Working Group (EPPWG), which seeks to develop risk mitigation strategies by establishing a national network of pest and disease monitoring, identification, research and management projects across the eucalypt growing areas of the country. It also aims to develop and maintain geospatial, pest, disease and data analytics expertise through ongoing partnerships and collaborations with members.

Critical to this process is ongoing and adequate funding at both a national government and industry level. Over the past three years the EPPWG has made significant progress in executing monitoring projects, developing infrastructure and establishing data networks for the flow and analysis of information – and this in a time of reduced funding and the COVID-19 pandemic. This has been made possible through funding from Forestry South Africa (FSA), in-kind industry contributions and the extensive work by applied and academic scientists at the Institute for Commercial Forestry Research (ICFR) and University of Pretoria in the Forestry and Agricultural Biotechnology Institute (FABI). This has allowed project leaders within the EPPWG to leverage additional funding to ensure this work continues, including skills development and infrastructure capacity.

> *“Critical to this process is ongoing and adequate funding at both a national government and industry level.”*

The South African forestry industry has seen several examples of pests and disease issues requiring urgent and ongoing attention. For example, In Pinus species, *Sirex noctilio* (wood wasp) and *Fusarium circinatum* (pitch canker fungus) have been prominent pests. Both these threats require extensive pest and disease management programmes across various forestry disciplines to keep the pest under control and or improve disease tolerance through breeding efforts. One such example in the eucalypts has been the losses due to the gall forming wasp, *Leptocybe invasa* (blue gum chalcid), which is native to Australia (**Figure 1**).

Figure 1: *Leptocybe invasa* female

Since it was first discovered in South Africa in 2007, *L. invasa* has become a significant pest on various eucalypt species and eucalypt hybrid varieties and continues to have an impact across most eucalypt growing areas, in the country. *L. invasa* causes severe damage to trees by laying eggs on newly produced, growing shoots resulting in the formation of galls. These trees have stunted growth, suffer severe deformities and in some cases, mortality (**Figures 2 and 3**). The most effective means to control *L. invasa* is the use of biological control and selecting tolerant species and hybrid varieties developed through tree breeding programmes.

Developing biological control agents and monitoring their presence at monitoring sites is key to the successful control of *Leptocybe* linages.

Figure 2: *Leptocybe invasa* gall formation on the petiole

Figure 3: *Leptocybe invasa* damage to leaf midrib

Figure 4: *Selithricodes neseri*

Figure 5: *Quadrastichus mendeli*

Figure 6: *Megastigmus pretoriensis*

Figure 7: *Megastigmus zebrinus*

A number of parasitoids have been identified and it remains critical to understand the roles and interactions between these parasitoids in the galls. Most common is *Selithricodes neseri*, newly found *Quadrastichus mendeli*, *Megastigmus pretoriensis* (indigenous) and *Megastigmus zebrinus* (**Figures 4, 5, 6 and 7**).

Monitoring success of *L. invasa* and its natural enemies depends on set methodologies to ensure consistency across sites when using various company contractors to collect data. Selected sites, including pure species and hybrid varieties, are monitored for the presence and prevalence of *L. invasa*, and the severity and type of galling damage. In addition, separate sites are used to collect galled plant material, and the emerging wasps are counted to assess the presence and prevalence of the natural enemies of *L. invasa*. This same material is used to collect *L. invasa* for molecular analysis to determine the spread of a new genetic lineage of this pest. Measurements generally occur in compartments less than 18-months-old, from late summer into winter over a five-month period to allow for across site comparisons. The occurrence of galls on the petioles, midribs and branches and little leaf syndrome are recorded.

Looking at the period from 2018 to 2020 the following has been achieved. During 2018, 125 sites were monitored for *L. invasa*, followed by 187 sites during 2019 and 126 sites during 2020. Even with limited funding five industry partners made a commitment to participate, by monitoring plots with a total of 200 sites across the country scheduled for 2021. In the same period, an additional 150 sites were assessed for the presence and prevalence of *L. invasa* natural enemies, and the spread of the new genetic lineage of *L. invasa*. Interpretation of the data is complex as it needs to consider the interactions between genotype, latitude, altitude and the presence or absence of biological agents. Within genotype more complexity exists where seed source or hybrid variety needs to be considered. In addition, the various levels of attack intensity within and across site determines the level of tolerance and potential for recovery.

During 2018 damage was observed across 24.7% of the sites followed by 55.1% during 2019 and 55.5% during 2020 (Figure 8). A general trend of sustained to higher susceptibility across all *E. grandis* genotypes, with clear evidence of increased occurrences in *E. dunnii* was evident. At a landscape level increases have been noted in Mpumalanga (North) and Zululand with a decline in Limpopo, Northern KwaZulul-Natal (KZN), KZN Midlands and Eastern Cape with southern KZN remaining static. These population fluctuations are in part natural responses to the climatic conditions experienced regionally at a given time and is probably accentuated by the generally low number of sites surveyed. Assessment of the natural enemies indicated a diverse parasitoid population in Limpopo, Mpumalanga (North) and Zululand, but a limited presence of the parasitoids in KZN Midlands, Eastern Cape and Mpumalanga (South). The distribution of the new genetic lineage of *L. invasa* was confirmed to have spread to all the main eucalypt growing areas.

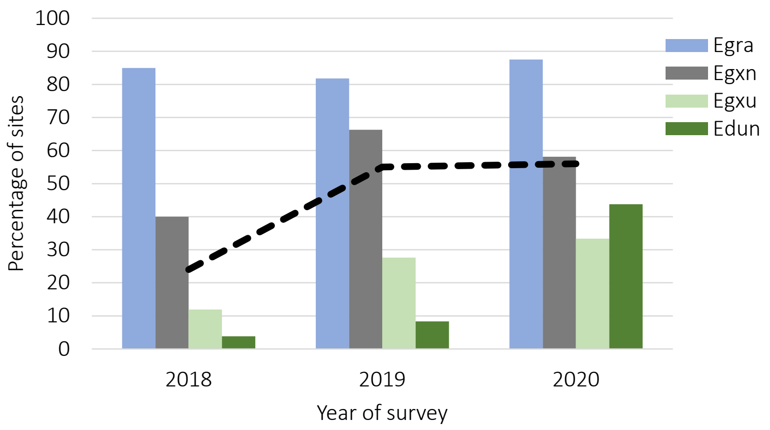

Figure 8: Temporal changes in the occurrence of damage caused by *Leptocybe invasa* in stands planted to *Eucalyptus grandis* (Egra), *E. grandis x E. nitens* (Egxn), *E. grandis* x *E. urophylla* (Egxu) and *E. dunnii* (Edun).

> *"The economic impacts of L. invasa are significant, effectively reducing the planted area of certain pillar species such as E. grandis, which has key attributes critical to the manufacturing supply chain such as pulp, sawtimber and poles."*

The economic impacts of *L. invasa* are significant, effectively reducing the planted area of certain pillar species such as *E. grandis*, which has key attributes critical to the manufacturing supply chain such as pulp, sawtimber and poles. This required significant investments in various programmes to find alternatives, create new hybrid varieties and align propagation nursery systems. Annual monitoring has shown to be a viable strategy to understand, analyse and formulate plans when dealing with pest and disease threats of this nature. Data on the distribution of a pest and its natural enemies informs if, when and what management intervention is required.

Critical to the process, remains active participation by all members to fund the collective effort at both national government and industry level. In addition to monitoring *L. invasa*, these sites also provide insights into new and ongoing threats such as Gonipterus sp. n. 2, Glycaspis brimblecombei, Thaumastocoris peregrinus, the shell lerp psyllid Spondyliaspis cf. plicatuloides, the leaf spot disease caused by Teratosphaeria destructans and others. Monitoring sites can also serve as biological control release and collection points. Integration of data resources from site, climate, genotype, time, pest and disease into predictive management tools should remain an ongoing goal to measure, control and predict any outbreaks and future threats.

ACKNOWLEDGEMENTS

Brett Hurley and Samantha Bush are acknowledged for photo contributions.

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THE VALUE OF DNA MARKERS IN SOUTH AFRICAN FORESTRY

Melissa Reynolds, Marja Mostert-O'Niell, Zelda du Toit-Boshoff, Nanette Christie and Zander Myburg – Forest Molecular Genetics Programme, University of Pretoria

> *"Since its inception, the Platform has produced DNA fingerprints for over 60 000 trees and provided research services for tree improvement to members of the South African forestry industry."*

THE FOREST MOLECULAR GENETICS (FMG) Programme's Precision Tree Breeding Platform is a technology service platform hosted at the University of Pretoria, which has offered a dynamic research service in the form of the DNA Marker Platform in South Africa since 2008. Since its inception, the Platform has produced DNA fingerprints for over 60 000 trees and provided research services for tree improvement to members of the South African forestry industry. Early work included identity verification and parentage analysis using microsatellite markers for pine and eucalypt species. Within the first five years, the Platform expanded to include applications such as estimation of species composition and hybrid verification in selected species.

Routine DNA marker applications such as these add tremendous value to tree breeding by allowing researchers to perform quality control at various steps in the breeding cycle.


Melissa Reynolds


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A set of DNA markers can be used to generate a DNA fingerprint which represents the unique combination of genetic variation at various sites in the genome of an individual. Since each unique tree genotype has its own unique DNA fingerprint, and clones share the same DNA fingerprint, DNA markers can be applied to maintain clonal identity throughout the propagation process. A reference DNA fingerprint from the original tree is established and used for comparison throughout the various propagation steps in the nursery, to ensure the deployment of the correct clones to their optimal site in the field. Failure to maintain the correct clonal identity throughout this process may result in the incorrect clones being deployed in sites where they are not well suited with subsequent poor performance or even death. While costs are incurred in using DNA marker technologies throughout the propagation process, the loss to a company may be even greater in the event of incorrect clones being deployed in poorly matched sites. This is of particular importance in areas with high disease pressure to ensure that only resistant or tolerant clones are planted.

DNA markers can also be applied to manage pests and diseases in existing trials and assist researchers in understanding the interaction between pests or diseases and their tree hosts. In instances where multiple different clones are planted in an area hit by a specific disease, DNA fingerprinting can be used to identify which clones show susceptibility and compare these with existing records. This is of particular value when clones previously thought to be resistant to a disease begin to show susceptibility to the threat. Furthermore, DNA markers can also be used to manage clones in areas subjected to abiotic stresses such as frost. However, in many cases the current strategy for producing material with resistance to biotic and abiotic stresses is through hybrid breeding using controlled pollination.

Like humans, a tree seedling inherits approximately 50% of its DNA from each parent. DNA markers can be used to confirm seed and pollen parents of a seedling in the case of controlled pollinations or in the case of incorrect pedigree records, reassign the correct parents. Many breeders also rely on open pollination when breeding pure species, and in this case if all potential parent trees have been fingerprinting, DNA markers can be applied to reconstruct the pedigrees by identifying the most likely seed and pollen parents from the set of potential parents. Parentage analysis can also be applied to verify hybrid status of seedlings if both parents of known species are identified.

"The DNA Marker Platform, as part of FMG's Precision Breeding Platform, seeks to make all these technologies accessible to small and larger breeders in South Africa…"

In cases where the potential parents of a tree or seedling are unknown, hybrid verification through a parentage analysis is not possible. An alternative strategy is available to confirm the species composition of the seedling. This requires suitable DNA markers that are able to discriminate between species and a comprehensive species reference set representing the genetic diversity within each species. The species reference set is of extreme importance as it provides a reference with which to compare the tree of unknown species. Through funding from the Forestry Sector Innovation Fund, the Forest Molecular Genetics Programme initiated several student projects in 2015 in collaboration with breeders in the South African forestry industry. The aim was to identify and sample first generation trees in conservation blocks and gene banks in South Africa to establish references sets for species of importance locally. The outcome of this research was the development of suitable species references sets for identifying pure species and hybrids for selected species. Currently, this research project is ongoing with specific focus on establishing references sets for additional species, and expanding existing reference sets to represent as many provenances as possible in the natural species range.

Accurately performing verification of pure species and hybrids requires suitable DNA markers. The DNA Marker Platform makes use of two types of DNA markers for different applications. Microsatellite markers are more labour intensive to use, but relatively few markers are required to perform routine analyses such as those described above. Turnaround time is relatively short and there is flexibility in the number of samples to be processed. However, microsatellite markers have limitations, and there are some instances where Single Nucleotide Polymorphisms, or SNP markers are more appropriate. SNP markers are more suited to automation and are highly abundant throughout the genome. However, they are often available commercially in formats suited to large population numbers and frequently are available through overseas service providers limiting accessibility to small local breeders.

Following the publication of the genome sequence for *Eucalyptus grandis* in 2014 by a group of international researchers led by Prof. Zander Myburg (Myburg *et al.* 2014), the first *Eucalyptus* SNP genotyping array was developed (Silva-Junior *et al.* 2015). This array, consisting of 60 000 SNP markers for *Eucalyptus*, was made available to members of the South African forestry companies, through the DNA Marker Platform, and was used for molecular breeding applications such as genomic selection, a method used to predict the future performance of seedlings based on modelling. The 60K SNP chip also provided excellent resolution to discriminate between pure species and hybrids of different *Eucalyptus* species, however, no similar DNA marker resource was available for *Corymbia* species. Furthermore, hybrid verification in pine species was also challenging due to the limited DNA marker resources available.

In 2020, two new SNP genotyping arrays were developed in collaboration with international consortiums. The first was a SNP array for *Eucalyptus* consisting of 72 000 markers, 10 000 of which are specific to *Corymbia*. The availability of DNA markers for *Corymbia* species will add tremendous value to tree breeding in South Africa, since this genus is gaining popularity in breeding programmes and limited DNA marker resources were previously available. The second array, released in 2020, was developed in collaboration with the International Pine SNP chip consortium for tropical pine species of interest in South Africa. This array consists of 50 000 markers, providing at least 10 000 usable markers for each of the commercially grown tropical pine species and their F1 hybrids (Jackson & Christie, unpublished). Tropical pine breeding in South Africa has not yet benefited from molecular breeding strategies currently applied in *Eucalyptus*, due to the lack of genomic resources. Furthermore, current DNA marker technologies are limited in their ability to accurately estimate species composition in hybrids of interest in South Africa. This new SNP resource will contribute significantly to the accuracy of hybrid breeding, particularly to differentiate between high and low elevation *P. tecunumanii*. These SNP resources are also ideal for various research applications such as identifying regions of the genome containing genes underlying traits of interest, and understanding the effects of selection on the genome of South African breeding material.

The value of DNA marker technologies has been demonstrated in many crop species throughout the world, and locally in the South African forestry industry through collaboration with FMG and the DNA Marker Platform. The DNA Marker Platform, as part of FMG's Precision Breeding Platform, seeks to make all these technologies accessible to small and larger breeders in South Africa, and to assist breeders in project planning, recommend appropriate sampling strategies, and provide support in analysis of data generated using DNA markers. Furthermore, the Platform and students in FMG are working to develop additional DNA marker resources for genera of interest to forestry and agriculture in South Africa, such as *Acacia* and *Macadamia* in 2021.

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SINGLE-STEP GENOMIC BLUP ANALYSIS, SAME RELIABILITY WITH BETTER ACCURACY

GENOMIC BREEDING FOR DIAMETER GROWTH AND TOLERANCE TO PESTS AND PATHOGENS IN *EUCALYPTUS GRANDIS*

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A lay-summary of research recently published.

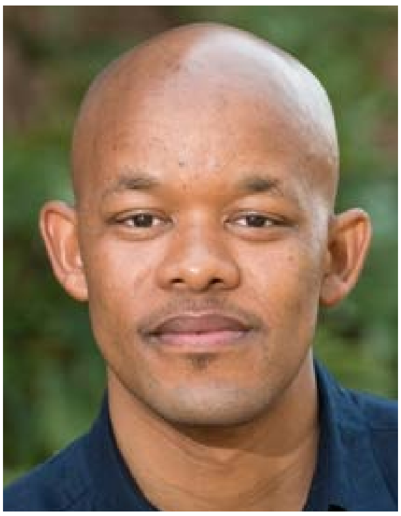
Mphahlele, M. M., F. Isik, G R. Hodge, A. A. Myburg. (2021). Genomic breeding for diameter growth and tolerance to *Leptocybe* gall wasp and *Botryosphaeria / Teratosphaeria* fungal disease complex in *Eucalyptus grandis.* Frontier Plant Science: 12:638969.
https://doi.org/10.3389/fpls.2021.638969

"Pests and pathogens pose a significant risk to Eucalyptus plantations productivity and sustainability."

VOLUME growth, wood density, pulp yield, and tolerance to pests and pathogens are essential for forest plantation productivity. Pests and pathogens pose a significant risk to *Eucalyptus* plantations productivity and sustainability. *E. grandis* is one of the most affected species by leaf pests and fungal stem pathogens in the Zululand subtropical region.

In **Figure 1** we show *Leptocybe invasa* a Queensland, Australia native insect pest, introduced in South Africa in 2007. It is damaging to *Eucalyptus* species, affecting their growth by forming galls on leaves and leaf petioles, causing stunted growth and death in severe cases. Biological control is a treatment option for *Leptocybe* infestation with parasitoids such as *Quadrastichus mendeli* and *Selitrichodes neseri*. Parasitism rates in South Africa of *S. neseri* range from 9.7% to 71.8%. Resistance-linked DNA markers explained 3-37% of the variation of resistance in *E. grandis* and 24-48% in *E. tereticornis*. Genome candidate regions on chromosome 3, 7 and 8 in *E. grandis* were identified with putative candidate genes for tolerance to *Leptocybe,* explaining 17.6% of the total phenotypic variation.

First described in South Africa in 1996, *Teratosphaeria zuluensis* is a devastating fungal stem pathogen that causes stem canker of *Eucalyptus* species shown in **Figure 2B** reduces wood quality by penetrating the cambium to form black kino filled pockets and may lead to tree death. *Botryosphaeria dothidea* is also a devastating fungal stem pathogen of *Eucalyptus* species shown in **figure 2C** affecting the stem with longitudinal cracks penetrating the bark into the wood, forming kino pockets, stem



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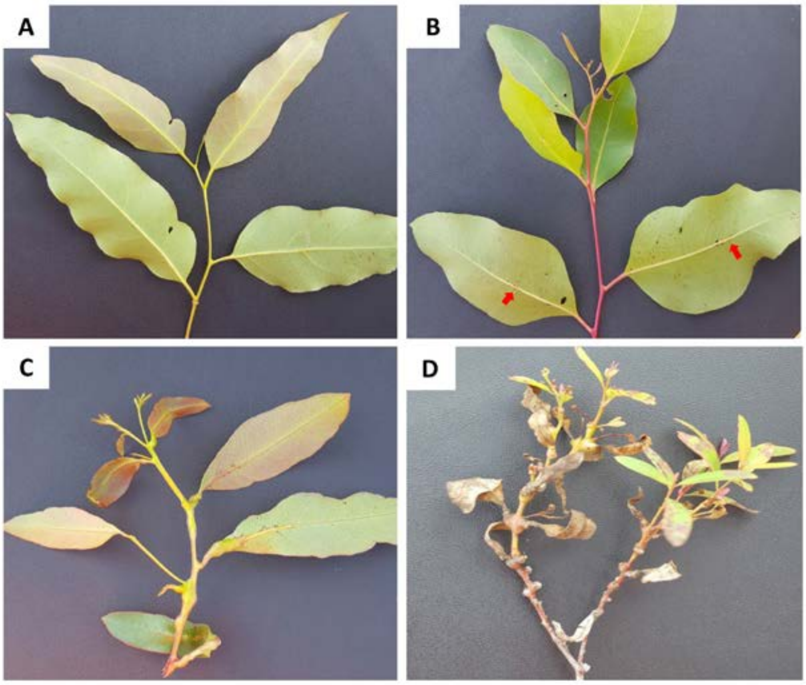

FIGURE 1: Symptoms and incidence scores of *Leptocybe invasa.* (**A**) Score 4 – No evidence of an attack on the leaf midrib or petiole, (**B**) Score 3 – Evidence of attack on the leaf midrib or petiole without galls (indicated by red arrows), (**C**) Score 2 – Evidence of attack on the leaf midrib or petiole with galls and (**D**) Score 1 – Evidence of a lethal outcome of an attack on the leaf midrib or petiole with galls.

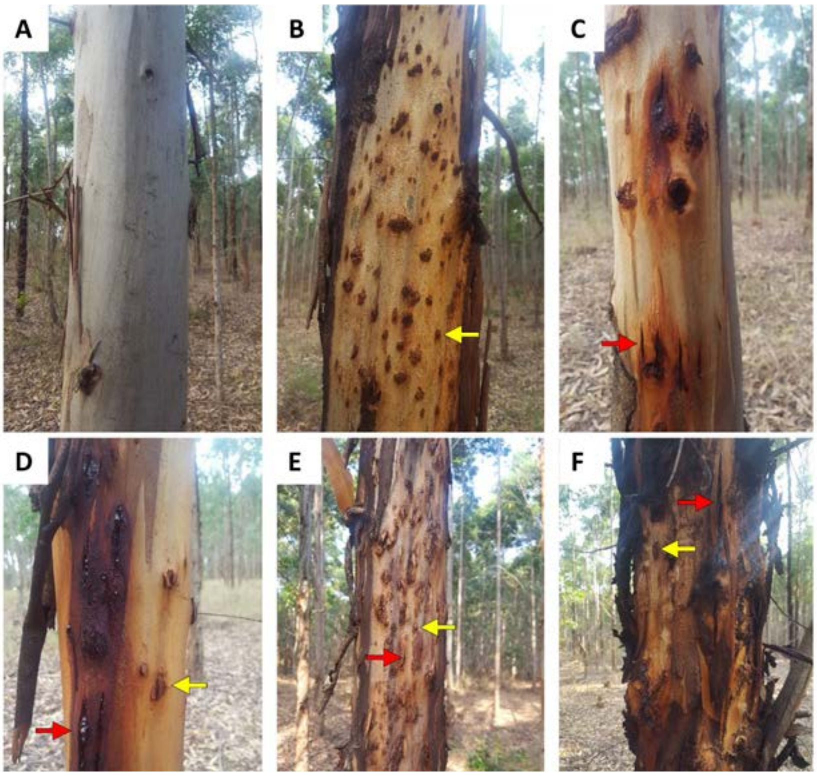

FIGURE 2: Symptoms and incidence scores for *Botryosphaeria* / *Teratosphaeria* stem disease complex. (**A**) Score 6 represents trees with no spots/cracks or redness. (**B**) Score 5 represents trees with *T. zuluense* spots with redness. (**C**) Score 4 is given for trees with *B. dothidea* cracks with redness. (**D**) Score 3 shows a tree with *T. zuluense* spots and *B. dothidea* cracks with redness. (**E**) Score 2 represents trees with heavy *T. zuluense* spots and *B. dothidea* cracks with redness. (**F**) Score 1 represents trees with heavy *T. zuluense* spots and *B. dothidea* cracks with redness and cankers.

cankers and tip dieback. It was first described in South Africa in 1994. Field assessment of the two fungal stem pathogens revealed that their symptoms can be present separately or concurrently at varying levels on trees in the form of *Botryosphaeria/Teratosphaeria* fungal stem disease complex as shown in **figures 2E and 2F**.

Genotyping all individuals in large open-pollinated tree breeding trials would be prohibitively expensive. Therefore, single-step genomic BLUP analysis is an attractive alternative that blends the known pedigree of the entire breeding population in a trial with the genomic relationship matrix of a subset of genotyped individuals. Single-step GBLUP analysis extends the benefits of BLUP analysis by applying genomic breeding to non-genotyped individuals. A multivariate analysis approach with ssGBLUP was used to estimate genetic parameters, genetic by environmental (G×E) interactions, the additive genetic correlations and genetic gain of diameter growth and *Leptocybe* and *Botryosphaeria/Teratosphaeria* tolerance. This study measured these three traits in three multi-generation (2nd, 3rd and 4th generation families) breeding trials of 95 open-pollinated families in Zululand (Kwambonambi, Nyalazi and Mtunzini) of *E. grandis*. Using the *Eucalyptus* EUChip60K SNP chip, a subset of 964 trees from 93 open-pollinated families were genotyped with 14,347 informative SNP markers. The across-site heritability were 0.36 (*Leptocybe*), 0.25 (diameter growth), and 0.23 (*Botryosphaeria/Teratosphaeria*). The overall Type-B correlations were 0.71 (*Leptocybe*), 0.80 (diameter growth), and 0.81 (*Botryosphaeria/Teratosphaeria*), suggesting low G×E. Diameter growth and *Leptocybe* tolerance showed a strong positive genetic correlation (0.78), while *Botryosphaeria/Teratosphaeria* tolerance had a weak negative genetic correlation with diameter growth (-0.38). The expected genetic gains for diameter growth and *Leptocybe* and *Botryosphaeria/Teratosphaeria* tolerance were 12.4%, 10%, and negative 3.4%, respectively.

Herein selection refers to selecting phenotyped individuals based on their breeding values, whereas evaluation refers to selecting individuals based on visual screening without breeding values. Recurrent selection of *E. grandis* from landrace populations in the 1970s to the current 4th generation in 2012 consistently involved direct diameter growth selection evidenced by the improvement in **Figure 3A**. In the early 1990s, when *Botryosphaeria/Teratosphaeria* appeared, tolerant trees were evaluated and not necessarily selected from top diameter growth families. Introduced in South Africa in 2007, the selection or evaluation of *Leptocybe* tolerance could not be performed in the subsequent generations because of timing and inaccessible canopies. Evaluation for *Botryosphaeria/Teratosphaeria* tolerance in the 2nd generation resulted in the increased tolerance in the 3rd generation and stagnated from the 3rd to the 4th generation and shown in **Figure 3B**. We show that the indirect improvement of *Leptocybe* tolerance from the 3rd to the 4th generation in **Figure 3C** is owed to the strong positive additive genetic correlation with diameter growth. When considering diameter growth, *Leptocybe,* and *Botryosphaeria/Teratosphaeria* tolerance in the Kwambonambi site, it is evident that their mean performances correspond with their additive genetic correlation, higher diameter growth and tolerance to *Leptocybe* and lower tolerance to *Botryosphaeria/Teratosphaeria* (**Figure 3D, 3E and 3F**). This study showed that the

> *"Genotyping all individuals in large open-pollinated tree breeding trials would be prohibitively expensive."*

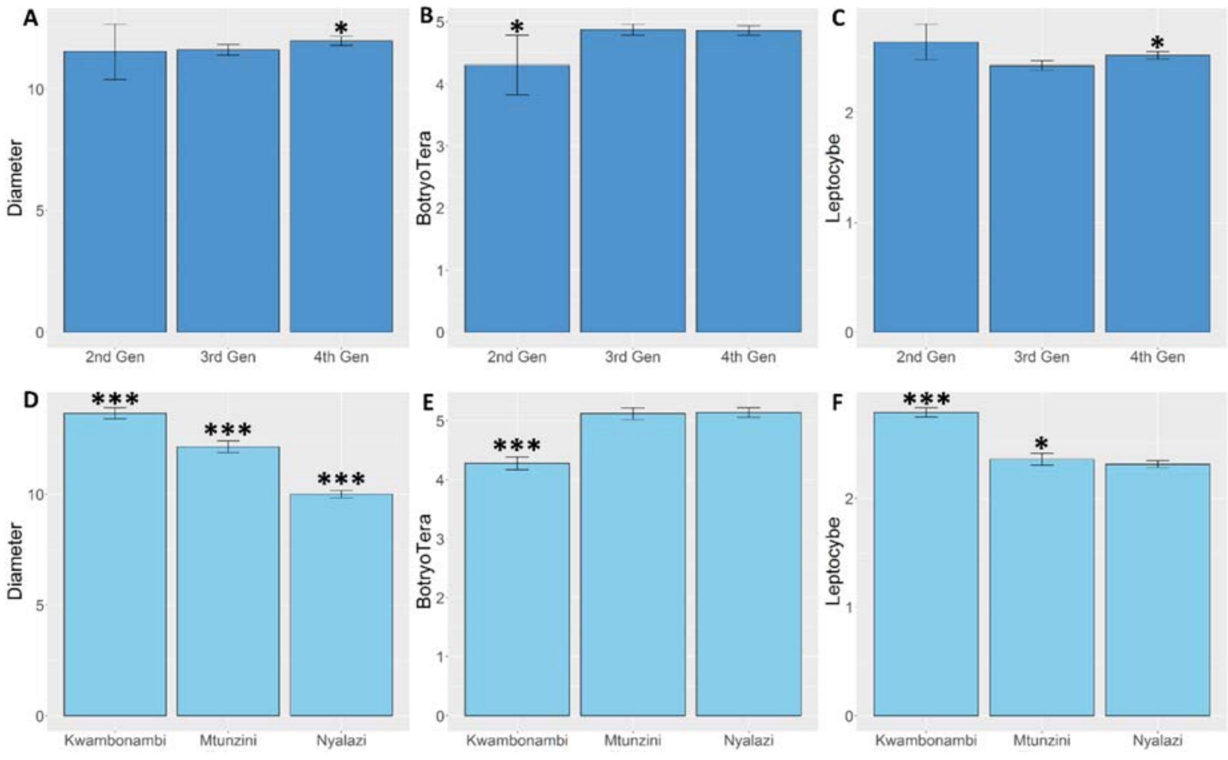

FIGURE 3: Marginal trait means with error bars indicating the 95% confidence interval. (**A**) Mean diameter growth (cm) for families in the three sites. (**B**) The mean *Leptocybe* tolerance score for families in the three sites. (**C**) The mean *Botryosphaeria/Teratosphaeria* tolerance score for families in the three sites. (**D**) Mean diameter growth (cm) for families in the three generations. (**E**) The mean *Leptocybe* tolerance score for families in the three generations. (**F**) The mean *Botryosphaeria/Teratosphaeria* tolerance score for families in the three generations. Student *t*-test was performed to ass the significant difference between the means, *p*-value < 0.05 (*), *p*-value < 0.01 (**) and *p*-value < 0.001 (***).

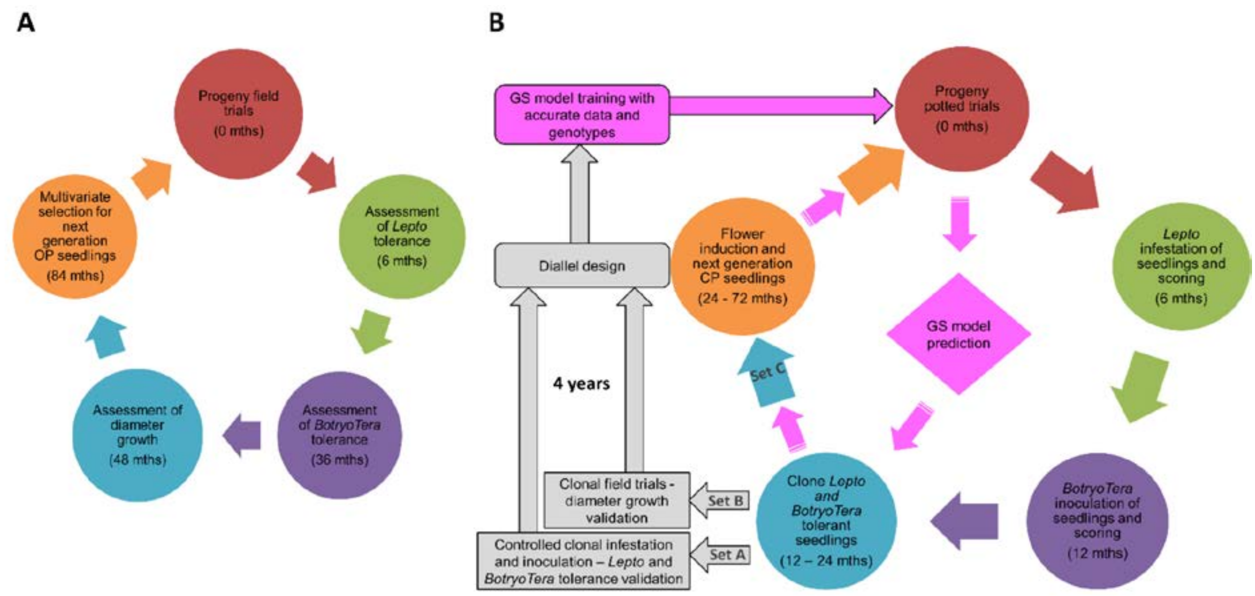

FIGURE 4: Proposed breeding strategies to improve diameter growth under pest and pathogen pressures. (**A**) Traditional field-based multivariate selection strategy whereby diameter growth is the target trait, benefiting *Leptocybe* tolerance because of their strong additive genetic correlation. *in full* (*Botryosphaeria/Teratosphaeria*) tolerance selections are made within top-ranked diameter growth families to produce open-pollinated (OP) families for the next generation. (**B**) Proposed non-field based serial selection strategy in which *Leptocybe* tolerance and *Botryosphaeria/Teratosphaeria* tolerance are scored after successive (6 months and 12 months) controlled infestation and inoculations, respectively. Candidate seedlings from within these tolerant families are cloned and used for flower induction (Set C) and generation of control pollinated (CP) families for the next generation. Another set of candidate clones are used to validate the *Leptocybe* and *Botryosphaeria/Teratosphaeria* tolerance (Set A). The thirds set is then planted in field clonal trials for diameter growth validation (Set B). Accurate phenotypes from the clonal material and genome-wide genotyping of the clones create an opportunity to train a multivariate GS model, which can reduce (*pink arrows*) the need for expensive pest and pathogen phenotyping in the next generation.

recurrent selection strategy successfully improved diameter growth and indirectly improved *Leptocybe* tolerance, with limited to no impact on *Botryosphaeria/Teratosphaeria* tolerance. Based on the results, we further discuss and propose the utility of genomic selection in *E. grandis* to simultaneous improve diameter growth and tolerance to *Leptocybe* and *Botryosphaeria/Teratosphaeria*.

When assessing pest and pathogens in field trials, several challenges may appear; seasonality and severity of pest and pathogens occurrences, different plant parts that are affected, leading to inaccurate and incomplete expression of tolerance or susceptibility. Such challenges reveal inadequacies of established selection strategies, thereby requiring revision, evidenced by the stagnation of *Botryosphaeria/Teratosphaeria* tolerance from the 3rd to the 4th generation due to its negative additive genetic correlation to diameter growth. If successful phenotyping of pest and pathogens and diameter growth in field trials is achieved, we illustrate in **Figure 4A** a multivariate selection approach can be used to select diameter growth (indirectly for *L. invasa* tolerance) and then only consider selecting *Botryosphaeria/Teratosphaeria* tolerant individuals in high ranked families. Circumventing field trials and their challenges the phenotyping of pest and pathogen, in **Figure 4B** we propose a serial selection strategy to train and develop a multivariate genome selection model with controlled pollination in potted trials. This approach would require integrating nursery and field phenotypes to develop a more accurate multivariate genome selection model and accelerate improving diameter growth and *Leptocybe* and *Botryosphaeria/Teratosphaeria* tolerance in *E. grandis*.

INVESTIGATING THE EFFECTIVENESS OF COTTON OVERALLS DURING PESTICIDE SPRAYING OPERATIONS

Nonkululeko Ntinga – Mondi South Africa – Operations Research Specialist

"Wearing the prescribed PPE under such conditions can expose the spraying applicator to heat stress due to the lack of permeability of items such as the waterproof PVC smock."

IN PESTICIDE spraying operations, Personal Protective Equipment (PPE) is primarily used to reduce the risk of dermal pesticide exposure to the body. According to the Occupational Health and Safety Act 85 of 1993, the employer's responsibility is to ensure that adequate control measures are in place to mitigate workplace safety and ergonomics risks. Although risk mitigation steps can reduce identified risk exposures, it should be noted that new risks can be introduced through specific control measures.

The following PPE items are currently prescribed by product label and worn by pesticide applicators: 100% cotton long sleeve overalls, waterproof PVC smocks, gloves, socks, and gumboots. Pesticide spraying operations

	1	2
Operation	Chemical Hoe	Pre Plant Spray
Pesticide	Roundup WeatherMax	Round Up WeatherMax
Active ingredient	Glyphosate (glycine)	Glyphosate (glycine)
Equipment	Knapsack	Tractor and Lances
Operation illustration		

Table 1: Description of field investigation

are generally carried out during the spring/summer season when the body discomfort index average is high due to high temperatures. Wearing the prescribed PPE under such conditions can expose the spraying applicator to heat stress due to the lack of permeability of items such as the waterproof PVC smock. Cotton overalls are made of more breathable material and create cooler and comfortable conditions for the pesticide applicator. Based on the toxicity level of most pesticides applied infield during foliar spraying operations, the hypothesis is that 100 % cotton overall provides sufficient protection against pesticide skin contact.

A field study was conducted to examine the effectiveness of 100 % cotton overalls during pesticide spraying operations by determining if any pesticide breakthrough occurs during the operation. In the context of pesticide exposure, pesticide breakthrough refers to the action when the applied pesticide touches outside of PPE and breaks through the surface to reach the pesticide applicator's skin.

Figure 1: 100 % cotton overall (**A**) and 100 % cotton long-sleeved white T-shirt, white long johns (**B**).

"...no pesticide breakthrough was observed on the inner garments, proving that the 100 % cotton overalls were effective in protecting the pesticide applicators against dermal pesticide exposure."

Two field investigations on two different sites were conducted on spraying operations in Nyalazi KwaZulu Natal. Both operations used a team of six pesticide applicators. During the first field investigation, the team was tasked with carrying out a manual pesticide hoe spraying operation using knapsacks. In the second field investigation, the team was tasked to undertake semi-mechanised pre-plant spraying operation using a tractor-trailer combination and lances. (**Table 1**).

All pesticide applicators were issued with new 100 % cotton overalls to be worn during the pesticide application. To determine actual body exposure by the pesticide, the applicators wore an inner layer underneath the 100 % cotton overall, consisting of a 100 % cotton long-sleeved white T-shirt, white long johns, and white socks (**Figure 1**). A blue non-reactive dye was added to the pesticide mixtures in both operations to identify the exposure areas on the white undergarments visually.

The field investigation was carried out for one day shift in each operation, with the pesticide applicators only wearing cotton overalls, inner layer garments, socks, and gumboots. At the end of the shift, the white garments were assessed for any blue dye stains. For both spraying operations, no pesticide breakthrough was observed on the inner garments, proving that the 100 % cotton overalls were effective in protecting the pesticide applicators against dermal pesticide exposure.

It should be noted that the condition of the knapsack used during the operation has a significant influence on the results observed during this field investigation. For example, leaking knapsacks caused by improper or no maintenance may result in pesticide breakthrough. Therefore, it is the responsibility of the pesticide applicator and supervisor to ensure that knapsacks are maintained with no leakages during the operation.

Although this field investigation showed that 100 % cotton overalls provided sufficient protection against pesticide breakthrough to the pesticide applicator. It is suggested that further field investigation be conducted over more extended periods and under different weed densities to understand better the influence of these variables on the results found.

GREEN DESERT?

THEY CAN'T SEE THE PATCHWORK LANDSCAPE FOR THE TREES!

Katherine L Johnson and Ronald Heath – Forestry South Africa (FSA), Pretoria, South Africa

Katherine L Johnson

Ronald Heath

SUMMARY

THE PLANTATION forestry landscape is often labelled as a "green desert" by those opposed to forestry plantations, yet various studies in South Africa and around the world show that forestry plantations, could well be far from barren. This perception of plantation forestry landscapes most probably stems from the idea it is a wall to wall monoculture stand or crop of non-native tree species. This too is potentially misguided, with the plantation forestry landscapes including networks of natural areas between the forestry stands, including grasslands, woodlands, indigenous forests, fynbos and wetlands, amongst others. When well-designed and managed, these ecological networks provide the habitat requirements and ecological processes to support biodiversity that is representative of nearby protected areas.

A first step to assessing the conservation potential of the ecological networks on these forestry landscapes involves mapping and quantifying the different types of land cover. For this reason, Forestry South Africa initiated a study to survey almost 70% of the forestry landholdings in South Africa, with companies providing information on various types of landcover on their landholdings. The analysis confirmed that the plantation forestry landscapes in South Africa includes a range of ecosystem types in the natural areas, amongst a matrix of planted compartments, infrastructure and roads.

> *"When well-designed and managed, these ecological networks provide the habitat requirements and ecological processes to support biodiversity that is representative of nearby protected areas."*

INTRODUCTION

Plantation forestry landholdings are often characterised by the public, journalists and frequently conservation biologists, as "biological deserts" or "green deserts" (Acosta, 2011; Horak *et al.*, 2019; Qiu, 2014). More specifically, these plantation forestry landscapes are perceived to be a monoculture of non-indigenous trees, providing little in the way of habitats or ecological services to the indigenous flora or fauna.

The plantation forestry stands are crops of non-native species, where indigenous flora/habitats/ecosystems have been actively removed to plant and grow tree crops, and fauna are occasionally present, but in very low diversity. This is comparable to the establishment of any agricultural land use. Therefore, when viewing these tree crop fields from a species and habitat diversity perspective, they are deemed to be "barren".

However, when taking into account the matrix or networks of natural areas (unplanted and open areas) between the commercial forestry crop areas on the plantation forestry landholdings, there is a range of biodiversity features, ecological processes and ecosystem services that continue to persist on the plantation forestry landholdings.

Several studies (Parrotta *et al.*, 1997a; Humphrey *et al.*, 2000; Sax, 2002; Brockerhoff *et al.* 2003; Barbaro *et al.* 2005; Carnus *et al.*, 2006; Brockerhoff *et al.*, 2008; Graves, 2015) suggest the plantation forestry landscape is not as void of biodiversity as can be perceived. Even some uncommon and threatened species are being recorded within plantation forestry landscapes as more targeted surveys are being undertaken (Kleinpaste, 1990; Barbaro *et al.* 2008; Raman 2006; Berndt *et al.* 2008 and Horik *et al*, 2019). This is certainly true of South Africa's plantation forestry landscape, where, for example, a survey conducted by BirdLife SA identified several endangered and threatened species residing within it (Whitcross, 2018). These studies suggest the plantation forestry landholdings in South Africa could well offer some opportunities for biodiversity conservation efforts, but to do so, this will depend on how the natural areas or ecological networks are designed and managed, amongst other factors.

The importance of looking at the plantation forestry landscape as a whole rather than just at the timber stands only is highlighted in a study by Horak *et al*, (2019). Here, they looked at eight different floral and fauna groups with disparate dispersal abilities, taxonomic affiliation and ecological requirements across the indigenous forest and plantation forestry landscapes. Their findings suggest that we could expect to see similar patterns of biodiversity on plantation forestry landholdings as natural areas outside the plantation forestry landholdings. This maybe is due to availability/retention of habitats and ecological processes within the matrix or networks of natural areas.

To gain a better understanding of the patchwork nature of the forestry landscape in South Africa, a study was initiated to quantify the different landcover types within this landscape. The objectives of this study were two-fold:

- To formally quantify the ratio of planted vs unplanted land within the forestry landholdings
- To break down "unplanted land" into its various components (infrastructure/roads, natural ecosystems).

METHODOLOGY

Forestry South Africa represents approximately 93% of the South African Forestry Industry, including 13 forestry companies, around 1 300 medium-scale private forestry businesses and approximately 20 000 small-scale growers (FSA, 2021).

A survey of FSA's corporate members and co-operatives (who represent most of the medium-scale and small-scale growers) was conducted between September 2020 and March 2021. Of the 25 forestry companies that were asked, 18 contributed. Those who responded, own or manage a combined 832 274 hectares of planted compartments, which based on the latest South African Forestry figures (Godsmark and Oberholzer, 2018) represents 69,9% of the total planted area in South Africa.

The survey included ten questions, (Appendix one) eight of which included notes defining the terms used and ensuring participants were clear on what was required. It should however be noted that companies may differ in their landholding mapping techniques and the age of datasets may vary.

> *"...illustrating that amongst the planted compartments and forestry infrastructure there are expanses of grasslands, fynbos, indigenous forest and water bodies."*

RESULTS AND DISCUSSION

In total, survey respondents own or manage 1 294 655 hectares of land (Table one). Of this, 832 274 hectares (64%) is planted, and 442 330 hectares (34%) remain unplanted, whilst the other 2% is allocated to "other" (non-forestry crops and for some companies to infrastructure and roads). These results show that the plantation forestry landscape is a patchwork matrix of both planted and unplanted areas. As such, it has the potential to act as a multifunctional production landscape.

UNPLANTED FORESTRY LANDSCAPE

While 34% of forestry-owned and managed land is unplanted, not all of this remains in its natural or semi-natural form. Of the 442 330 hectares of unplanted forestry land, 305 884 hectares or 69% was allocated as grassland, fynbos, indigenous forest or water bodies (Figure one). A further 12% (53 502 hectares) was allocated to roads and infrastructure with the remaining 19% falling outside the scope of the survey's questions and thus labelled as other (Table two).

Grasslands were the most predominant habitat type, followed by indigenous forests, water bodies and then fynbos. This hierarchy is expected, given the geographic location of plantation forestry landholdings in relation to the dominant biomes in South Africa.

The analysis shows the potential value of plantation forestry landholdings, as multifunctional production landscapes contributing to conservation targets due to the remnants of ecosystems present on the unplanted portions of our landholdings.

GRASSLANDS

Although 29%, 339 237 km^2, of South Africa's land surface is covered by the grassland biome, only 2.8% of this is formally protected while 30% has been irreversibly transformed (SANBI, 2014). Much of what remains, is fragmented and approximately 80% is privately owned.

While the 171 197 hectares of grassland found within the forestry landscape only amounts to just under 1% of South Africa's remaining grasslands, less than 3% of South Africa's grasslands are currently formally protected. If properly designed and managed, the ecological network of grasslands found within plantation forestry landholdings could contribute to grassland biodiversity goals.

INDIGENOUS FORESTS

The South African Government website states that South Africa has approximately 481,500 hectares of indigenous forests (Skowno *et al*, 2019). The forestry landscape is home to 11.7% of South Africa's indigenous forests, and by law the forestry sector is required to manage these forests.

CONCLUSION

The plantation forestry landholdings in South Africa are potentially contributing to biodiversity conservation and ecosystem services goals, the actual contribution of which needs to be confirmed in more detailed analysis and assessments. This is due to the matrix of natural areas amongst the commercial timber stands and infrastructure areas, which provide a range of habitats and ecosystem services, (Baral *et al*, (2016).

While this land cover survey illustrates the presence of these spaces within the forestry landscape, a more detailed study would be needed to ascertain the conservation significance of these natural areas.

What this study can allude to, is that with over 80% of the forestry landscape in South Africa Forest Stewardship Council® (FSC®) certified, most of these natural areas is under some form of proactive management as an integral part of forestry management plans.

The ongoing loss and fragmentation of natural ecosystems by intensive land-use activities and growing settlements remain one of the main causes of biodiversity loss. This makes the management of ecological networks within the plantation forestry that contain fragments of these natural ecosystems landholdings more critical than ever. These ecological networks, when well designed and managed (Samways & Pryke, 2016) may also aid in linking with natural spaces outside the plantation forestry landholdings, helping to improve connectivity in the broader fragmented nature of South Africa's these rural landscapes.

TAKE HOME MESSAGE

This survey achieved its objectives by quantifying the different types of land cover found within the plantation forestry landholdings, illustrating that amongst the planted compartments and forestry infrastructure there are expanses of grasslands, fynbos, indigenous forest and water bodies. In doing so, it should help dispel the misconception that the plantation forestry landholdings are a wall to wall planted compartments of monoculture, non-indigenous trees, devoid of biodiversity.

Future studies will be required to fully understand the conservation significance of these natural areas. Multifunctional production landscapes when ecological networks are well designed and managed show the potential to contribute to the conservation of biodiversity and ecosystem services (e.g. provision-, regulating-, habitat- and cultural-ecosystem services). These findings lend themselves to the growing body of evidence supporting the arguments made by Anja Gassner, Global Landscapes Forum Science Advisor and Senior Scientist World Agroforestry ICRAF, and her colleagues in a recent article in The Conversation (Gassner *et al*, 2021) stating the need to include the potential to manage multifunctional landscapes for biodiversity in updates to the UN Convention on Biodiversity. However, to do this properly, we would need to look at how we classify the natural areas found within the plantation forestry landscape. Conservation targets, like those used by SANBI, are done at a vegetation type level and not the broader biome level used in this survey. To assess the actual contribution of these forestry landholdings to various conservation goals, further analysis and understanding at a more detailed vegetation type would be required.

ACKNOWLEDGMENT

The authors would like to thank Brent Corcoran, for his role in shaping this article. His advice was greatly appreciated.

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TABLES AND FIGURES

Table one: Survey responses to questions two to five, providing a total hectarage of those surveyed, the total hectarage planted to trees and other crops, as well as, the total hectarage left unplanted.

Company	Total land area (ha) owned or managed	Total area (ha) under timber	Total area (ha) under other crops	Total area (ha) unplanted
A	25 402.34	14 387.71	0	11 014.63
B	92 848.00	67 665.00	0	25 183.00
C	2 176.70	1 078,30	339.90	698.50
D	253 680.00	172 186.00	1052.00	70 476.00
E	5 996.00	2 171.00	0	3 822.00
F	62 270.10	37 143.00	74.10	25 053.00
G	32 128.00	20 606.00	81.40	11 440.40
H	29 825.30	21 147.30	0	8 678.10
I	19 639.00	10 588.00	0	9 051.00
J	76 392.00	33 706.00	0	42 686.00
K	189 747.00	120 957.00	0	68 790.00
L	394 306.00	258 606.00	0	135 699.00
M	4 597.45	2 344.82	0	2 252.63
N	2 475.70	1898.50	89.50	487.70
O	4 208.00	3 024.00	0	1 577.00
P	9 177.03	5 929.50	745.54	2 023.33
Q	89 796.46	58 835.86	40.00	23 398.00
TOTAL	1 294 665.08	832 274.19	2 422.44	442 330.29

Table two: Survey responses to questions six to ten, providing a breakdown of the total unplanted area into the various land cover components.

Company	Total area (ha) grassland	Total area (ha) fynbos	Total area (ha) indigenous forest	Total area (ha) waterbodies	Total area (ha) roads and infrastructure	Other
A	2 664.27	103.79	3 216.60	2 464.93	549.88	2 015.16
B	8 385.00	0.00	8 115.00	6 679.00	2 004.00	0.00
C	0.00	0.00	581.80	116.70		0.00
D	36 926.00	0.00	6 296.00	15 426.00	9 967.00	1 861.00
E	3 600.00	0.00	122.00	100.00	0.00	0.00
F	0.40	8 237.30	4 169.80	4 244.20	1 203.50	7 197.80
G	9 993.70	0.00	0.00	0.00	831.60	615.10
H	2 124.80	0.00	897.10	2 692.80	2 963.40	0.00
I	0.00	3 897.00	2 886.00	463.00	1 207.00	598.00
J	19 699.00	0.00	553.00	5 086.00	15 585.00	1 763.00
K	9 512.00	0.00	20 248.00	5 921.00	6 685.00	26 424.00
L	62 820.00	0.00	12 943.00	3 892.00	10 563.00	45 481.00
M	1 241.15	664.50	313.10	31.54	2.26	0.09
N	137.80	0.00	116.60	185.30	39.50	8.50
O	1 184.00	0.00	0.00	0.00	393.00	0.00
P	909.84	0.00	739.20	113.37	0.00	260.92
Q	12 000.00	0.00	1 072.44	12 098.07	1 508.52	
TOTAL	171 197.96	12 902.59	62 269.64	59 513.91	53 502.66	86 225.18

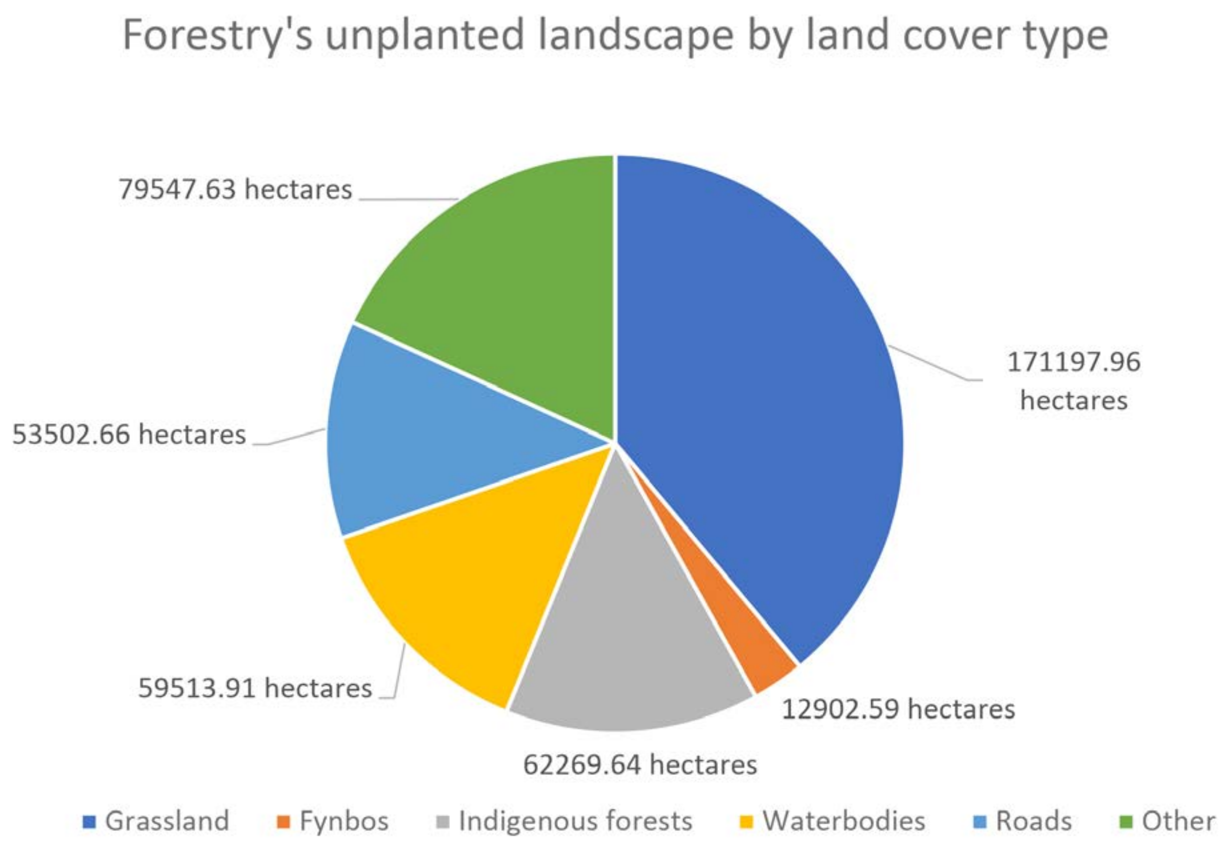

Figure one: Break down of the unplanted forestry land (hectares) by the land cover type.

APPENDIX ONE

FSA: LANDCOVER SURVEY

QUESTION ONE

Company name	

QUESTION TWO

Total area (ha)	
Notes: Total area owned, or, under the control (e.g. leased from a third party) of the FSA member.	

QUESTION THREE

Total area under timber (ha)	
Notes: Total area used for planting commercially grown tree species (pine, *Eucalyptus* & wattle), irrespective of the rotation stage (prepared for planting, planting, planted compartment, harvesting etc.).	

QUESTION FOUR

Total land area under other crops (ha)	
Notes: Total area planted with commercial crop *(sugar, avocado etc.)* **other** than forestry species (pine, *Eucalyptus*, wattle).	

QUESTION FIVE

Total land area remaining natural/ unplanted (ha)	
Notes: Any land owned, or, under the control (e.g. leased from a third party) of the FSA member, that has not been transformed in the last 10 years to any form of crop, pasture, plantation, road, or infrastructure.	

QUESTION SIX

Total area (ha) of natural/unplanted area designated as **grasslands**	
Notes: For this purpose, *(Definition)* grasslands are areas dominated by a single layer of grasses, trees are absent except in localised areas, such as rocky outcrops, geophytes (bulbs) are often abundant and frosts, fire and grazing maintain the grass dominance and prevent the establishment of natives tree species.	

QUESTION SEVEN

Total area (ha) of unplanted/natural areas designated as **fynbos**	
Notes: For this purpose, (Definition) fynbos areas are defined as an area that is covered by a growth of evergreen shrubs, especially the family Proteaceae (proteas), Ericaceae (ericas – small heather like trees and shrubs) and restioids (shrubby grasses (Cape reeds), small narrow rolled leaves (or leaves absent) and tough wiry stems.	

QUESTION EIGHT

Total area (ha) of unplanted/natural areas designated as **indigenous forests**	
Notes: For this purpose, *(Definition)* indigenous forest areas are defined as those restricted to frost-free areas with a mean annual rainfall of more than 525mm in the winter rainfall region and more than 725mm of rainfall in the summer rainfall area. Indigenous forests occur in patches (except in the southern Cape), a continuous canopy of mostly evergreen trees and beneath it a multi-layer of shrubs and tall tree seedlings, very little ground cover due to dense shade and fringed with a distinctive plant community (ecotonal communities) able to tolerate fire	

QUESTION NINE

Total area (ha) of unplanted/natural areas designated as a natural **water bodies or wetlands**	

Notes: For this purpose, wetlands can be defined as an area include one or more of the following identifiable attributes:
Suggest: Definition: wetlands can be recognised as an area that includes one or more of the following:

1. HYDROMORPHIC SOIL

Prolonged soil saturation: hydromorphic soils display unique characteristics resulting from **prolonged and repeated saturation** resulting in changes in the chemical characteristics of the soil (e.g. iron, which is insoluble under aerobic conditions, becomes soluble when the soil becomes anaerobic and can be leached out of the soil profile). Once most of the iron has been dissolved out of the soil as a result of **prolonged anaerobic conditions**, the soil matrix is left a greyish, greenish or bluish colour - **a gleyed soil.**

Fluctuating water table: wetlands that are seasonally or temporally saturated result in an alternation between aerobic and anaerobic conditions in the soil. The change from anaerobic to aerobic spoil *(soil)* conditions causes dissolved iron to return to an insoluble state and can be deposited in the form of patches or mottles in the soil. The recurrence of this cycle of wetting and drying over many decades concentrates these coloured insoluble iron compounds in the form of mottles. Soil that is gleyed and has mottles indicates a zone that is seasonally or temporally saturated.

2. HYDROPHYTIC (WATER-LOVING) PLANTS

Certain plants have adapted morphologically, physiologically and reproductively to grow, compete, reproduce and persist in anaerobic soil conditions; for example the presence of air spaces in the roots and stems that allow the diffusion of oxygen from exposed parts of the plant into the roots, adventitious roots (specialized roots that develop from a non-root tissue part of a plant such as its stem or branch as a result of hostile conditions – anaerobic soils), shallow root systems and seed dispersal mechanisms by water.

3. HIGH WATER TABLE

A high-water table that results in saturation at or near the surface leading to anaerobic soil conditions developing in the top 50cm of the soil

QUESTION TEN

Total area (ha) of roads/infrastructure	

Notes:

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