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TIP-MAG 2024

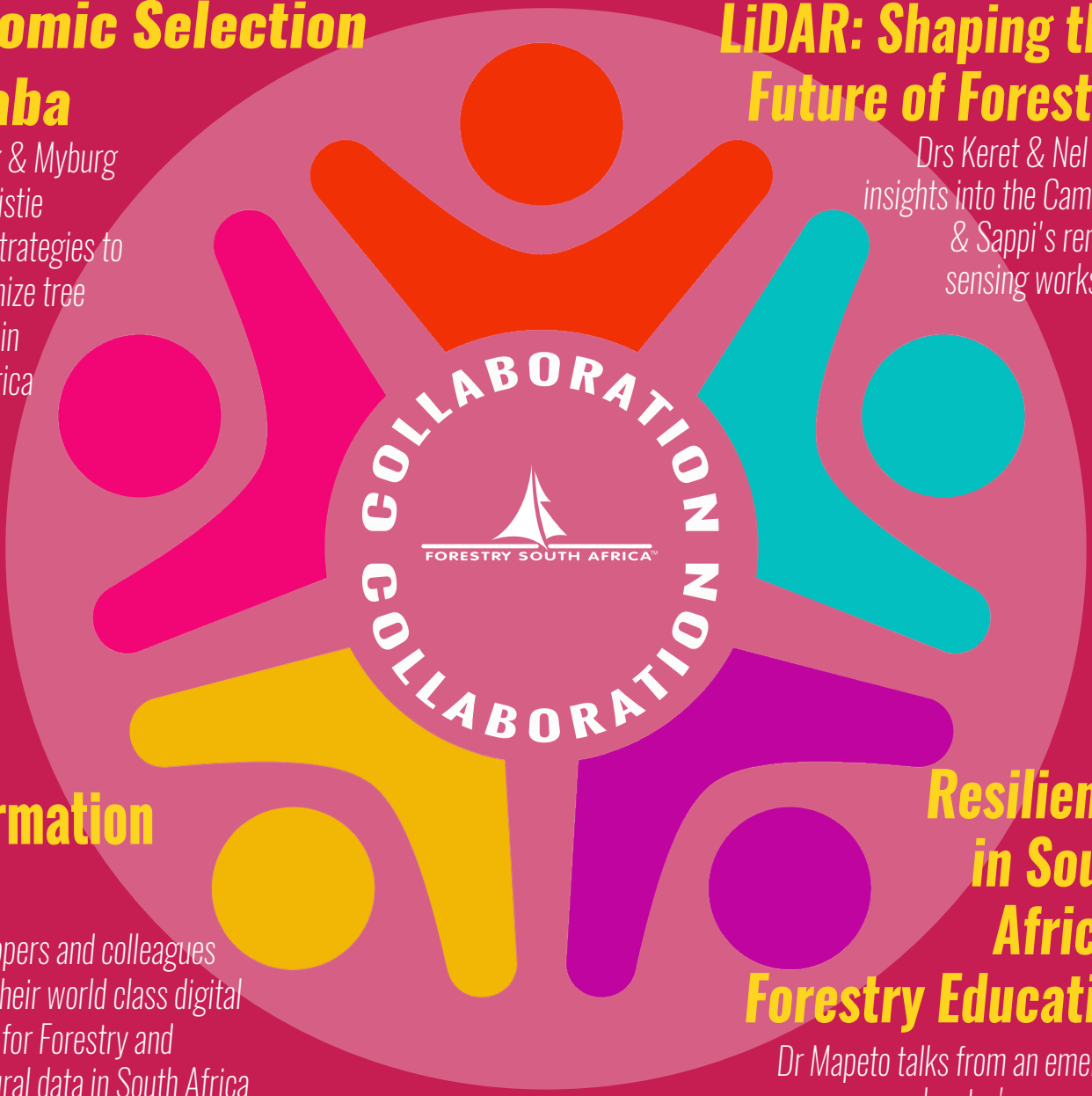
Timber Industry Presents Magazine

Genomic Selection Indaba

Profs Izik & Myburg & Dr Christie discuss strategies to revolutionize tree breeding in South Africa

Remote Sensing & Terrestrial LiDAR: Shaping the Future of Forestry

Drs Keret & Nel give insights into the Camcore & Sappi's remote sensing workshop



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FOR A long time, when asked which one word I most associated with our Sector the answer was simple – resilience. Since the early days of forestry, over a century ago, our trees, plantations, foresters, silviculture tools and techniques and forest products have shown remarkable resilience in the face of broad social, economic, political and environmental challenges. The latest being COVID-19 and the economic downturn, political instability, associated infrastructure challenges and climatic disasters which followed.

Today, however, I find it difficult to offer 'just one word', as the last few years has seen another come to the forefront – in my mind at least. That is collaborative. To be honest, I think of it as our Sector's greatest superpower, the ability to come together in times of crisis but also 'just because' and solve situations or offer opportunities as a collective. Collaboration is the reason organisations like mine, Forestry South Africa, are so effective. Be it in the form of working groups and committees or through partnerships with government, academia, research institutes, sister associations and international colleagues, collaboration is what enables growth and progress.

This issue of TIP-MAG shines the spotlight firmly on collaboration and its importance across almost every aspect of forestry. Yolandi Ernst and Megan Govender's article discusses the importance of collaboration between stakeholders in generating knowledge and creating power. Tatenda Mapeto articulately stresses the importance of collaboration between government, industry and higher educational institutes if we are to produce graduates of the future that match the challenges and needs of industry.Friket Isik, Nannette Christie and Zander Myburg illustrate the importance of international collaboration and collaborating at the Genomic Selection Indaba if we hope to revolution tree breeding in South Africa. While Bernard Slippers, Arne Schreuder, Hannes Strysom and Brett Hurley illustrate how digital platforms that facilitate collaboration will enable the Sector to capitalise on the 4th Industrial Revolution of artificial intelligence, robotics and the internet of things.

> *"Collaboration, I think of as our Sector's greatest superpower!"*

Collaboration between industry is also a hot topic, with Bianca Prozesky, Avashoni Zwane, Eric Visser and Sanushka Naidoo illustrating how collaborations between industry giants and leading lights in the forestry research space is taking us one step closer to disease resistant trees. While the CAMCOR event brought the whole industry together to join forces in shaping the future of forestry using remote sensing. Wattle rust is another area where teams are coming together in a collaborative effort to find alternatives to the traditional chemical controls which are already prohibited and will be completely unavailable next year.

When people say, 'collaboration is key', I think they undersell its importance. Collaboration is integral to all we do in the Forestry Sector and is essential for sustained, exponential success. Yes, we can move forward working in our own silos, but this is very limiting and unlikely to create the exponential growth we see when a collaborative initiative brings a raft of ideas, positions, funding opportunities and contexts to the table. It is why, for me, resilience has been joined (if not, knocked off from) its pedestal by collaboration.

Dr Ronald Heath
FSA Director:
Research and Protection

DEDICATION TO PROF MIKE WINGFIELD, FOUNDING DIRECTOR OF FABI

"His extraordinary contributions to forest biotechnology and tree health have not only advanced scientific understanding but have also had profound practical implications for forestry industries around the world."

IN THE vast and intricate tapestry of forestry and agricultural sciences, certain figures stand out as monumental pillars of knowledge, innovation, and dedication. Among these luminaries, Prof Mike Wingfield, the founding director of the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria, shines with unparalleled brilliance. His extraordinary contributions to forest biotechnology and tree health have not only advanced scientific understanding but have also had profound practical implications for forestry industries around the world.

This year, as Prof Wingfield celebrates his 70th birthday, we take this special moment to honor his lifetime of achievements and his unwavering commitment to the betterment of forestry and agricultural sciences. His illustrious career, spanning several decades, is marked by his relentless pursuit of knowledge and his dedication to addressing critical issues facing commercial forestry. His research primarily focuses on insect pests and pathogens that threaten forest health, exploring both their ecological impacts and potential biotechnological applications. Under his visionary leadership, FABI has become a globally recognized center for excellence, driving forward groundbreaking research and fostering a collaborative environment that bridges academic inquiry with industry needs.

One of Prof Wingfield's most notable achievements is the establishment of the Tree Protection Co-operative Programme (TPCP), a pioneering initiative that unites the University of Pretoria with all major forestry companies in South Africa, the industry body Forestry South Africa (FSA), and the Government Department of Environment, Forestry, and Fisheries (DEFF). Celebrating its 34th anniversary in 2023, the TPCP is instrumental in safeguarding South Africa's 1.5 million hectares of commercial plantations, embodying Prof Wingfield's ethos of collaborative problem-solving and proactive forest management.

His role extends beyond South Africa, impacting forestry practices and policies worldwide. As President of the International Union of Forest Research Organisations (IUFRO) from 2014 to 2019, and now as Immediate Past President, Prof Wingfield has influenced global forestry research agendas, promoting sustainable practices and international cooperation. His leadership within IUFRO, one of the oldest and largest scientific unions, underscores his dedication to fostering a global scientific community committed to forestry research and innovation.

Prof Wingfield's research has delved into numerous significant pathogens and pests, including the notorious *Chrysoporthe austroafricana, Diplodia sapinea*, and various species of *Ceratocystis, Fusarium*, *Mycosphaerella,* and *Ophiostoma*. His work on the *Sirex* wood wasp, *Eucalyptus* gall wasp, and other critical pests has been crucial in developing biological control strategies, mitigating their impact on forest health. His extensive publication record, with over 1,000 papers in highly recognized journals and a substantial number of PhD students under his mentorship, reflects his profound influence on the field and his commitment to nurturing the next generation of scientists.

The accolades and honors bestowed upon Prof Wingfield are numerous and well-deserved. His inclusion in the Clarivate list of most highly cited scientists, the Kwame Nkrumah Science Award from the African Union, and honorary doctorates from prestigious institutions like the University of British Columbia, North Carolina State University, and the University of the Free State, among others, testify to his outstanding contributions and global recognition.

Beyond his scientific achievements, Prof Wingfield's role as an advisor to the University of Pretoria Executive highlights his commitment to institutional development and academic excellence. His guidance has been instrumental in shaping policies and initiatives that uphold the university's reputation as a leading research institution.

In celebrating Prof Mike Wingfield's 70th birthday, we honor a visionary whose work has left an indelible mark on forestry science and beyond. His legacy is one of passion, dedication, and an unwavering commitment to advancing our understanding and protection of the world's forests. As he continues to inspire and lead, we are reminded of the profound impact that one individual's dedication to science and collaboration can have on global forestry and agricultural biotechnology.

Prof Wingfield, on behalf of Forestry South Africa and TIP-Mag, we extend our deepest gratitude and admiration for your remarkable contributions and enduring legacy. Your work continues to be a beacon of excellence and inspiration for all in the field. Happy 70th birthday, and may your contributions to science and forestry continue to flourish for many years to come.

> *"His legacy is one of passion, dedication, and an unwavering commitment to advancing our understanding and protection of the world's forests."*

GENOMIC SELECTION INDABA: STRATEGIES TO REVOLUTIONIZE TREE BREEDING IN SOUTH AFRICA

Professor Fikret Isik[1], Dr Nanette Christie[2], Professor Alexander A Myburg[2]

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Professor Fikret Isik

Dr Nanette Christie

Professor Alexander A Myburg

GENOMIC selection (GS) is a molecular breeding technique used in plant and animal breeding. Its application is expected to fundamentally change tree breeding over the next decade. This method uses a large number of DNA markers to predict the genetic merit of trees at the seedling stage for traits of interest.

A GS Indaba was organized to bring together key stakeholders in the South African tree breeding community. The aim was to explore the use of genomic applications and plan for future precision tree breeding in South Africa. The event took place on 26-27 October 2023 at Mbulwa Estate in Sabie, Mpumalanga. The Indaba was the culmination of the 'Quantitative Genetics and Molecular Breeding' course led by Fulbright Visiting Professor Fikret Isik, in collaboration with Prof Zander Myburg and Dr Nanette Christie from the University of Pretoria's Forest Molecular Genetics (FMG) Programme.

Before the Indaba, preparatory events were held, including an online course and two workshops. The first workshop in Pietermaritzburg earlier in 2023 focused on genetic data analysis, while the second, combined with the GS Indaba, explored hands-on genomic selection practices followed by strategic discussions on

> *"Genomic selection (GS) is a molecular breeding technique... ...Its application is expected to fundamentally change tree breeding over the next decade..."*

the application of GS in South African breeding populations. Prof Isik's interactions with forestry companies in 2023 provided crucial insights into the state of conventional and molecular breeding efforts in the country.

Considering recent advancements such as DNA marker array development, large-scale genome sequencing projects for eucalypt trees and sequencing of a reference genome for tropical pines, the GS Indaba offered a timely assessment of South Africa's readiness for molecular breeding approaches. A number of challenges relating to the history and design of local tree improvement programmes were identified.

> *"The South African tree breeding community is tightly knit and cohesive. Its members demonstrate a willingness to share resources, collaborate on large-scale projects, and exchange material."*

CHALLENGES:

- South African forest tree improvement programmes have a long history especially for species such as *Eucalyptus grandis*. However, local tree breeding populations have not been designed for the implementation of GS. Implementing GS technology require well-structured, closed breeding populations with at least two generations for which accurate phenotypic and genotypic data is available. Current breeding efforts, especially for interspecific hybrids, often rely on crossing first-generation parents or even wild unimproved parents, followed by large-scale testing of clonal progeny from a handful of crosses. From these trials, a small number of superior genotypes are selected for commercial deployment. This means that most local tree improvement programmes are essentially 'testing and selection' efforts. The feedback from the testing and selection phase to the breeding phase (which parents to cross for the next generation) is mostly lacking or neglected.
- Genome-wide genotyping of forest tree species is still costly at approximately $25 per tree or seedling. Even though the current eucalypt and pine genotyping arrays have proven to be robust, cheaper DNA sequence-based technologies will be available in the near future. The FMG Programme led the development of a 50,000 SNP marker array (Pitro50K, Thermo Fisher Scientific) for tropical pine species. Similarly, a multi-species Eucalypt SNP array developed by EMBRAPA in Brazil has been used in eucalypt breeding programmes. Next, the FMG Programme will be working in collaboration with Prof Isik on a low-cost ($10-$12 per tree) AgriSeq SNP genotyping platform (Thermo Fisher Scientific) for pines, while for eucalypts, whole-genome resequencing will soon become a cost-efficient alternative.
- The power of GS lies in being able to predict the genetic merit of trees when the candidates are still seedlings, thereby circumventing the lengthy and expensive field testing needed to assess the traits of those trees. The challenge for tree breeders is then to stimulate flowering in the juvenile plants and cross the GS selections in order to reduce the breeding cycle time. For cold-tolerant *Eucalyptus* species in SA, reproductive (late and uneven flowering) and propagation hurdles are critical limitations to developing GS approaches. Further research is needed to shorten the reproductive cycle and by stimulating early flowering of cold-hardy *Eucalyptus* species and pines.
- The lack of skilled staff, databases, computational infrastructure and detailed GS plans are barriers to implementing GS in most organizations. A long-term GS plan is needed for successful implementation of GS. The plan should include a timeline, milestones, resources, and clear deliverables. Senior management support is crucial to ensure successful implementation and sustained progress in a breeding strategy that may span decades.
- Highly skilled workforce turnover is a prevalent challenge, particularly as South Africa contends with the allure of opportunities abroad, leading to the departure of some of its finest talent.
- Pedigree errors, loss of seedling identity and pollen source errors are particularly prevalent in tree breeding programmes and nurseries. Misidentification of pollen, seed, and seedlings can have severe and negative long-term implications in forest tree breeding.

OPPORTUNITIES

- Collaboration is key! The South African tree breeding community is tightly knit and cohesive. Its members demonstrate a willingness to share resources, collaborate on large-scale projects, and exchange material. Organizations are already collaborating under the Camcore (https://camcore.cnr.ncsu.edu/)

umbrella to test species and provenances.

- Despite the departure of some of its finest talent, South Africa boasts a cadre of proficient forest geneticists and tree breeders, demonstrating resilience in retaining a pool of well-trained professionals. These experts are well-positioned to spearhead advancements in molecular breeding, showcasing the nation's commitment to fostering expertise in cutting-edge fields.
- The South African tree breeding community is fortunate to have the full support and direct engagement of the FMG Programme at UP. This Programme, and the Precision Tree Breeding Platform hosted by it, has provided tremendous value and services to tree breeding programmes in SA, including high-throughput DNA isolation services, development of DNA markers, genotyping panels, and research projects addressing the challenges facing tree breeding and managed forests.
- The DNA isolation service and the development of microsatellite markers for DNA fingerprinting and parentage analysis by the FMG is a great resource and opportunity for the SA tree breeding community. Arguably, the highest impact in SA breeding programmes has been the implementation of DNA fingerprinting to correct the misidentification of genotypes or species during all phases of breeding, propagation and deployment.

CONCLUSIONS AND RECOMMENDATIONS

Based on the presentations, discussions during the GS Indaba, interactions of Prof Isik with tree breeding professionals, and site visits, the organizing committee reached the following conclusions and recommendations.

1. **GS is not a silver bullet. It is an important tool in a tree breeders' toolbox.** Implementing GS in operational breeding programs is still expensive. It requires managing complex logistics and therefore a focus on species or hybrid combinations in which the benefits of GS can be realized.

   We recommend a collaborative approach under the Camcore umbrella with FMG support to start pilot projects focused on important species or hybrid combinations. This way, costs are shared, reducing the initial investment for each company. It will also help to create large and well-defined training populations to be used by the participants. This approach ensures a careful and effective introduction of GS, building a common foundation for success among different groups. If some well-resourced companies are interested in building their own GS programmes, we strongly recommend beginning with a pilot project to gain experience before expanding to multiple breeding populations.

2. **A successful GS program requires well-managed, multiple-generation breeding populations with strong genetic linkage between generations.** South African tree breeding programmes should allocate resources to improve well-suited landraces to local conditions rather than invest limited resources in experimenting with many new species and provenances. Breeding populations should be large enough to make genetic gain in the long term. Modern mating designs based on computer algorithms should be used to optimize multiple breeding objectives, such as increasing genetic gain and managing genetic diversity.

3. **South African breeders should transition to modern experimental designs (e.g. incomplete block designs)** to improve the quality of data collected from genetic field trials. Genetic tests need to collect high-quality data to predict the genetic merit of trees for selection. In South Africa, large randomized complete blocks with row plots are still the standard used in progeny testing. However, such large blocks at the test sites show high variation in elevation, soil fertility, and soil moisture, and are therefore highly inefficient for genetic tests.

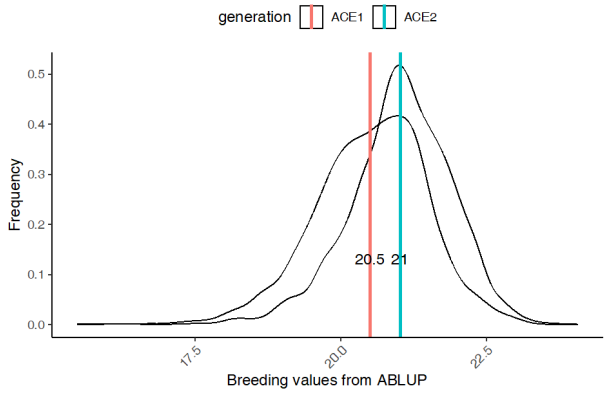
4. **Keep the genetic tests simple with one objective: separating noise from the**

"A successful GS program requires well-managed, multiple-generation breeding populations with strong genetic linkage between generations."

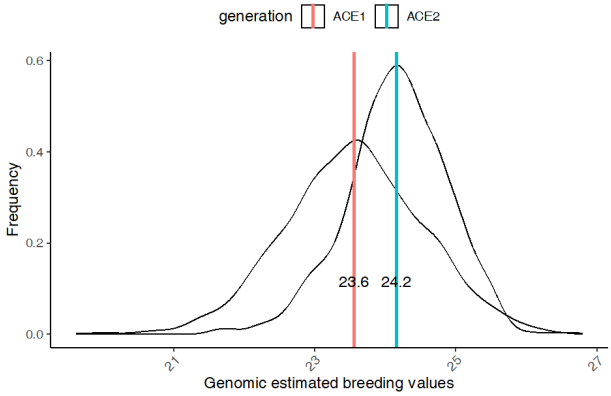
genetic signal to select the winners. Genetic field tests should not be designed to accomplish multiple objectives, such as evaluating the effects of silvicultural practices (e.g., thinning, weeding, and fertilization), while also performing growth-yield modelling. Such practices reduce the efficiency of the progeny tests and complicate data analysis. Separate field tests for silviculture and growth-yield should be planned.

GS is an important new tool for recurrent selection strategies. We call it Recurrent Genomic Selection (RGS). If the infrastructure is in place, it could revolutionize forest tree breeding. Below, we provide an example from *Pinus taeda* breeding in the USA (Figure 1) that was presented at the GS Indaba.

In summary, the GS Indaba was pivotal for South Africa's tree-breeding landscape, fostering critical reflection, strategic planning, and hands-on engagement to unleash the transformative power of genomics. Prof Isik's (North Carolina State University, USA) leadership was instrumental in guiding the industry toward alignment with emerging trends and best practices, ensuring ongoing success in molecular breeding endeavors.



Classical selection results: The distribution of breeding values for tree height of the first (ACE1, pink density plot) and second generation (ACE2, blue density plot) populations of *Pinus taeda*. Classical selection based on the height data of the first generation moved the population mean for height in the second generation (from 20.5 m to 21.0 m). Selection works!



Genomic selection results: The same two genetically linked populations were genotyped with the same SNP markers to validate the GS approach. A GS model was developed based on the data of the first generation (ACE1, pink distribution). The height of the second generation (ACE2, green density plot) was predicted using DNA markers. Genomic selection moved the mean height of the population in the right direction (23.6 m to 24.2 m), even better than classical selection. Genomic selection works!

Figure 1: Comparison of classical and genomic selection approaches in *Pinus taeda* using a two-generation population (courtesy of the Cooperative Tree Improvement Program at North Carolina State University).

"The GS Indaba was pivotal for the SA tree-breeding landscape, fostering critical reflection, strategic planning and hands-on engagement to unleash the transformative power of genomics."

RESILIENCE IN SOUTH AFRICAN FORESTRY EDUCATION: AN EMERGING EDUCATOR'S PERSPECTIVE

Dr Tatenda Mapeto

Dr Tatenda Mapeto

Nelson Mandela University, Department of Forestry and Wood Technology, Faculty of Science

THE South African Forestry Industry has a long, 112-year history of formal forester education. For most of this, the forestry education system in the country has been resilient and technically superior with regards to traditional and core forestry competencies. It has, however, become undeniable that the forester of today, and the future, needs a much broader skill set from that required in the previous century, as alluded to by Mgaga and Scholes (2019).

This change in the required skill set for today's forester has been driven by multiple factors including global environmental change, rapid advances in technology and social consciousness. In many countries this has led to significant changes in governance and management approaches that are not only focused on biological ecosystems. Developing professionals that are optimally functional in today's era and into the future implies that forestry education must include knowledge and skills development pathways that address issues such as cultural and social values, traditional knowledge and rights of forest communities, contributions of trees and forests to local people and the evolving forest business economy (Rekola *et al.* 2022). While forest education institutions build capacity for these adaptations, the immediate consequence is that the Forestry Sector / industry already experiences the poor and or moderate preparedness of the graduates entering the workforce. This industry usefulness gap bounds along political, social, and economic aspects with a recent addition to this list being a professional who can navigate big data and data analytics-driven management systems. As can be expected, non-technical competencies such as leadership ability, negotiation and mediation and an understanding of economic and business realities have become crucial.

Changes in employment trends and the need for further training and education within the Forest Sector to maintain a strong cadre of skilled foresters is a unifying theme. There is a need to revamp and rebrand the forestry profession to attract the most talented and interested students to study and eventually manage forests. It is necessary to ensure that the curriculum delivered to future professionals is not outdated and too narrowly focused but is flexible to continuously integrate key emerging topics. Notably so, a curriculum encompasses three aspects, that is, the knowledge content that is presented, the way it is presented, and the way the student's understanding of the knowledge is assessed. The implication here is that the stakeholders of an education such as industry, society and government are by default involved in crafting what knowledge should be presented, however, a substantial portion of the curriculum delivery story lies with educators who must be adequately capacitated and supported to continuously connect with the other education stakeholders to ensure optimal curriculum delivery.

The South African forestry education context recognises the

> *"It has, however, become undeniable that the forester of today, and the future, needs a much broader skill set from that required in the previous century"*

capacity development of educators and higher education institutions as a key priority. This will enable collaborative and purpose-built educational experiences that develop graduates that are better suited to quickly adapt and become successful forestry professionals. If there is a point in the life cycle of a forestry professional where industry, academia, government, and society must engage in pre-competitive collaboration, it is in the development of future professionals.There is much to be gained from communally developing forestry professionals. As we say, "It takes a village" or "You are because I am". This does not necessarily mean that individual merit, achievements, or contributions are unrecognised or discouraged, it emphasises collective ownership and cooperation.

Some of these priorities are starting to crystallise with projects such as Forest21, a joint project for strengthening capacity in South African higher education in forestry. The collaborative project was implemented between five higher education institutions (HEIs) in South Africa that have forestry qualifications. Applying climate smart forestry as a theme and problem-based learning (PBL) as the teaching methodology, one of the biggest wins of the project is that it has created a platform for forestry higher education institutions to collaborate. With the support of the Forestry Industry, given that the PBL teaching methodology requires that students are steeped in real world contexts, the project has also brought emphasis to educators on the need to connect their students to their future worlds of work. It contributes to developing non-technical competencies that are often lacking in our recent graduates.

When I joined the Forest21 project team in 2021, a key question we grappled with was the value of steeping our students, especially our undergraduate students, in real industry problems and whether this risks us being a nuisance to the industry? Our take-off point was that students will not have the capacity nor the experience to solve problems. What I have learnt is that, while it is largely true that students cannot solve real world problems, it is not that which matters, but rather their education and development that must be integrated with the world in which they are expected to make a difference as soon as they graduate. This greatly reduces the psychological and operational management distance that they must cover when they start working.It also makes for innovative graduates, a characteristic that is expected from young professionals but is often another unmet expectation.A salient point to the success of students during this time was the intentional willingness to mentor and support that we received from industry partners. Forest21 is winding down its activities in 2024, official successes and stories from what was achieved will continue to be documented, some of which can already be accessed from the Forest21 website.

As such, forestry education like any other industry focused education field is always challenged with remaining relevant for the societies and industries it serves. South African forestry education has maintained resilience, from substantial government involvement until the 1980s, to strong industry and government support to this day. As we face employability and innovation challenges within the sector, it is important to note that challenges are just developmental stimulants. Projects like Forest21 have stimulated the forestry education sector after the recent zoonotic pandemic plunge and we must maintain momentum. Communities of practice thatinclude, but are not limited to, fora for academia, industry, society and government, the continued coordination of forestry education outcomes and quality by industry bodies like SAIF and FSAand the facilitation of platforms that promote dialogues regarding curricula design, academic program identities and pedagogical techniques remain crucial going forward. Above all, may we all find the heart to continue to develop our future professionals for the next century and beyond.

Educators that attended one the Forest21 curriculum development workshops hosted at Fort Cox College of Agriculture and Forestry and facilitated by Nelson Mandela University. Attendees comprised of educators from the five HEI institutions that offer forestry qualifications in South Africa as well as from the three partner institutions from Finland and Norway.

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COLLABORATION AND KNOWLEDGE CO-PRODUCTION FOR A SUSTAINABLE FORESTRY FUTURE

Dr Yolandi Ernst and
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Dr Yolandi Ernst

Miss Megan Govender

> *"South Africa's Forestry Sector has turned a corner to embrace collaborative research and development strategies that strive to transform wicked challenges into opportunities for sustainable business pathways."*

SOUTH AFRICA's Forestry Sector has turned a corner to embrace collaborative research and development strategies that strive to transform wicked challenges into opportunities for sustainable business pathways. This is evident from the massive efforts from organizations in the Forestry Sector to establish platforms for co-production of knowledge that gives all stakeholders a voice and an opportunity to take part in an integrated network of knowledge sharing. It speaks to the progressive nature of the forestry community's eagerness to grow as a Sector while continuing its contribution to the economy, environment and society.

Currently, the Forestry Sector is experiencing numerous difficulties related to environmental, economic, and social aspects. Increasingly warmer and drier climate in South Africa is bound to affect tree growth, increase the risks associated with pests and diseases, and intensify disturbance events, such as fire and droughts. From an economic perspective, the burden of climate change will escalate the economic pressures of market volatility and compliance to regulatory requirements related to sustainability, environmental conservation and social responsibilities. Given these multifaceted challenges, the process of collaboration and knowledge co-production stands out as a beacon of hope for the plantation Forestry Sector in South Africa. By bringing together diverse stakeholders, including government agencies, industry players, local communities, and environmental experts, this approach not only nurtures a culture of shared learning but also paves the way for innovative solutions to complex challenges.

BUT WHAT DOES COLLABORATION EVEN MEAN?

Very simply, collaboration is a process in which individuals or groups work together to achieve a common goal or outcome. Herein we have two definitive actions – to work together,

> *"In a knowledge co-production process, participation of stakeholders at all levels of the research process – from formulating the questions, information gathering, data production and continuous feedback – represents an iterative framework for results that are implementable, readily accessible and maximises impact."*

and to produce an output of value. Collaboration brings together multiple stakeholders with individual expertise, resources, and perspectives to work towards a common goal. Through this process, knowledge co-production should lead to more relevant and actionable outcomes that can better address real-world problems.

EXPLAINING KNOWLEDGE CO-PRODUCTION

The essence of collaboration is embedded in the process of active participation and subsequent value of the output (e.g. product or solution). The more traditional linear knowledge creation path typically involves academics that formulate questions from their own perspectives and transfer the information to

stakeholders. This approach often proves inefficient as it could create unreliable results or information that is irrelevant and less useful. In a knowledge co-production process, participation of stakeholders at all levels of the research process – from formulating the questions, information gathering, data production and continuous feedback – represents an iterative framework for results that are implementable, readily accessible and maximises impact. Through leveraging the expertise of different people and different stakeholders in all stages of a project, the knowledge that is produced addresses the critical aspects and factors that are needed for effective solutions.

HOW DO WE ESTABLISH COLLABORATIONS FOR KNOWLEDGE CO-PRODUCTION?

Establishing collaborations involves building relationships and partnerships with individuals, organizations, or groups who share common goals or interests. The forestry community in South Africa provides several avenues for any stakeholder to become part of the network. The key is to take advantage of these opportunities through reaching out – show up for that conference, workshop or seminar… and actively participate. Get to know the other stakeholders and start making connections through simple conversations. Often times, these conversations lead to the identification of common concerns or problems. Following up is of course important; we often make the connections through shared ideas, but the enthusiasm wears off after events as we return to the reality of our daily tasks – make time for that email or phone call. Collaboration is the building of a relationship and continued communication is fundamental.

WHAT ARE THE CHARACTERISTICS OF SUCCESSFUL COLLABORATIONS?

The framework for developing knowledge co-production involves stages to generate knowledge focused on addressing shared problems. Successful collaboration involves connecting, evaluating, including, placing in context, participating, implementing, and gaining knowledge. By engaging as collaborators in the creation of knowledge and beginning to think about the problems we are tackling, we foster trust and form long-lasting connections with peers. During this interaction, collaborators should evaluate common concerns, recognize the key players influencing the matters, and establish the assets available to assist in the process. It is important to broaden the network and combine different perspectives, interests, and identify limitations. Levels of involvement will vary for different stakeholders, but in the end, each collaborator should share the responsibility of working towards a common goal of which the outcome should be mutually beneficial.

NEXT-LEVEL COLLABORATION IN THE FORESTRY SECTOR IS POSSIBLE

The scale of the current challenges faced by the Forestry Industry demands innovative and creative action and solutions that can only be achieved through working together. As we look to the future, the path is clear – we need to pursue unity through collaboration and knowledge co-production to tackle complex problems. By dismantling barriers between various stakeholders and actively participating, we can fully utilise the capacities and knowledge of all stakeholders to address environmental, economic, and social dilemmas and build resilience within the Forestry Sector. Moving forward, let us commit to our shared responsibility to embrace sustainable pathways for plantation forestry in South Africa.

“By dismantling barriers between various stakeholders and actively participating, we can fully utilise the capacities and knowledge of all stakeholders to address environmental, economic, and social dilemmas and build resilience within the Forestry Sector.”

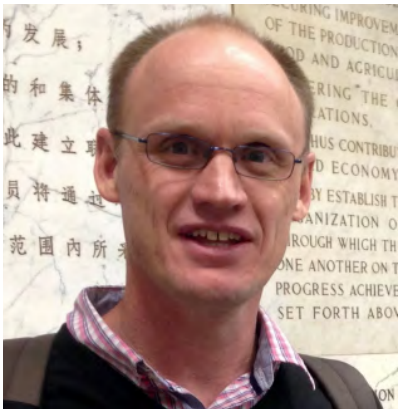
INFORMATION HUB: A WORLD CLASS DIGITAL PLATFORM FOR FORESTRY AND AGRICULTURAL DATA IN SOUTH AFRICA

Professor Bernard Slippers, Mr Arne Schreuder, Mr Hannes Strydom and Dr Brett Hurley
FABI, University of Pretoria

"South Africa's Agro-forestry Sector is facing serious challenges in accelerating technology development and adoption."

THE WORLD is well into the 4th industrial revolution of artificial intelligence, robotics and internet of things (IoT), and South Africa's Agro-forestry Sector is facing serious challenges in accelerating technological development and adoption. Technological development associated with the 4th industrial revolution relies heavily on the availability of big data. Unfortunately, much of the data that Forestry and Agriculture would require to optimally unlock the potential of these technologies is not available digitally or sits in fragmented repositories.

With initial support from Forestry South Africa (FSA), and subsequently from the University of Pretoria and the Department of Science and Innovation (TIA program), a robust cloud-based data management system and associated app have been established to address this gap, referred to as the Information Hub. The Information Hub (IH) data-platform is an initiative of Innovation



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Mr Arne Schreuder

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Africa @UP and the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria.

The Information Hub is developing a centralised point for researchers and practitioners in Agriculture and Forestry for the management, sharing, and connection of information sources. The Information Hub aims to optimise the power of the intersectional technologies, big data analytics, national and corporate development, and competitiveness in South Africa. The data-platform allows users to perform data analysis and develop innovative and locally relevant digital tools to support national industry and government needs for growth and development. The data platform can facilitate the establishment of research networks, communities of practice (CoPs), and private sector and local government partnerships.

The Tree Protection Co-operative Programme (TPCP) has made significant strides in digitizing its operations, encompassing the diagnostic clinic, culture collection, and fieldwork. This integrated platform serves as a central repository, facilitating the seamless integration of historical data, partner contributions, and newly collected information. The Information Hub acts as the core node for the National Forest Pest and Pathogen Surveillance project, enabling comprehensive data analysis and decision support functionalities. Collaborations with the Institute for Commercial Forestry Research (ICFR) and CropWatch Africa enhance GIS-based system support, information management, and in-field surveillance capabilities, further bolstering the effectiveness and efficiency of the overall surveillance framework.

A dedicated platform has been established on the Innovation Africa @UP Information Hub to ensure the secure deposition of data collected from the National Forest Pest and Pathogen Surveillance project and facilitate the visualization of that data. A streamlined approach has been implemented to capture, clean, and integrate the data, while careful consideration has been given to the format and interpretation of the data to ensure effective communication. Stakeholders have access to their respective data and a user-friendly dashboard has been developed, providing comprehensive visualizations and summaries of infestation levels of different insect pests and pathogens at a compartment level, which can be filtered by province, plantation, host plant, time (year/month), or for a specific pest / pathogen. Although still in the early stages, efforts are underway to develop formal methods of communication that will enable real-time management responses, enhancing the effectiveness and timeliness of decision-making processes.

If you are not part of the Information Hub community yet, you can download the app from either the Apple App Store of the Google Play Store. If you are part of an organization that already use the Information Hub, contact your organization's representative to access the company specific project or data. You can also launch your own project and start to collect, organize, visualize and share your data.

You can learn more about the Information Hub here or contact us to join one of our monthly training sessions:

> *"The Information Hub aims to optimise the power of the intersectional technologies, big data analytics, national and corporate development and competitiveness in South Africa."*

TOWARDS RESISTANT TREES

BREAKTHROUGH TRIALS AIM TO IDENTIFY GENETIC MARKERS OF DISEASE RESISTANCE AGAINST STEM CANKER IN EUCALYPTUS

Mrs Bianca Prozesky, Dr Avhashoni Zwane, Dr Erik Visser and Professor Sanushka Naidoo

Eucalyptus and Pine Pathogen Interactions (EPPI), Forestry and Agricultural Biotechnology Institute (FABI), Department of Biochemistry, Genetics and Microbiology, University of Pretoria

Mrs Bianca Prozesky

Dr Avhashoni Zwane

Dr Erik Visser

Prof Sanushka Naidoo

> *"Availability of genomics and transcriptomic technologies provide opportunities to screen the genomes of trees to develop tools to help fight diseases."*

EARLY South African forestry was dominated by *Eucalyptus grandis*. However, due to the pressure of disease caused by a stem canker pathogen *Chrysoporthe austroafricana*, it became necessary to improve resistance through hybrid crosses with *Eucalyptus urophylla*. A typical canker caused by the pathogen is shown in Figure 1. Infected trees develop girdling cankers on the bark which interrupts nutrient flow and eventual die-back of foliage. While the fungus is no longer a major threat to the industry, a resurgence under climate change conditions is possible.

In 2023, the *Eucalyptus* and Pine Pathogen Interaction Programme (EPPI) team from the Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, in

Figure 1: A picture of external symptoms after infected by the stem canker pathogen, *Chrysoporthe austroafricana*

collaboration with SAPPI, undertook the largest in-field artificial inoculation and evaluation trials with *C. austroafricana*.

The trials involved *Eucalyptus grandis* x *Eucalyptus urophylla* (GU) backcrossed with *E. grandis* (G) family. The first trial was conducted on the SAPPI Kwambonambi site, and the second on the SAPPI Richmond site. In these trials, 202 GUxG genotypes were inoculated with *C. austroafricana* in multiple repeats, with total of 4040 ramets in each site. A cork borer was used to punch a hole into the stem of the trees and a fungal plug applied into the hole.

Figure 2: EPPI team members inoculating trees in the Kwambonambi, KZN trial.

Seven days after inoculation, tissue was harvested from some of the trees and stored for future gene expression studies using transcriptomics. This will provide insight into how these trees defend themselves against pathogens. Three months after inoculation, the ensuing lesions caused by the pathogen were measured. Internal lesions were exposed by cutting through the layers and in some extreme cases, the infection could be seen deep within the heartwood, as shown in Figure 3.

Figure 3: A *eucalyptus* tree showing internal canker lesion after infection by *Chrysoporthe austroafricana*

> *"This will provide insight into how these trees defend themselves against pathogens."*

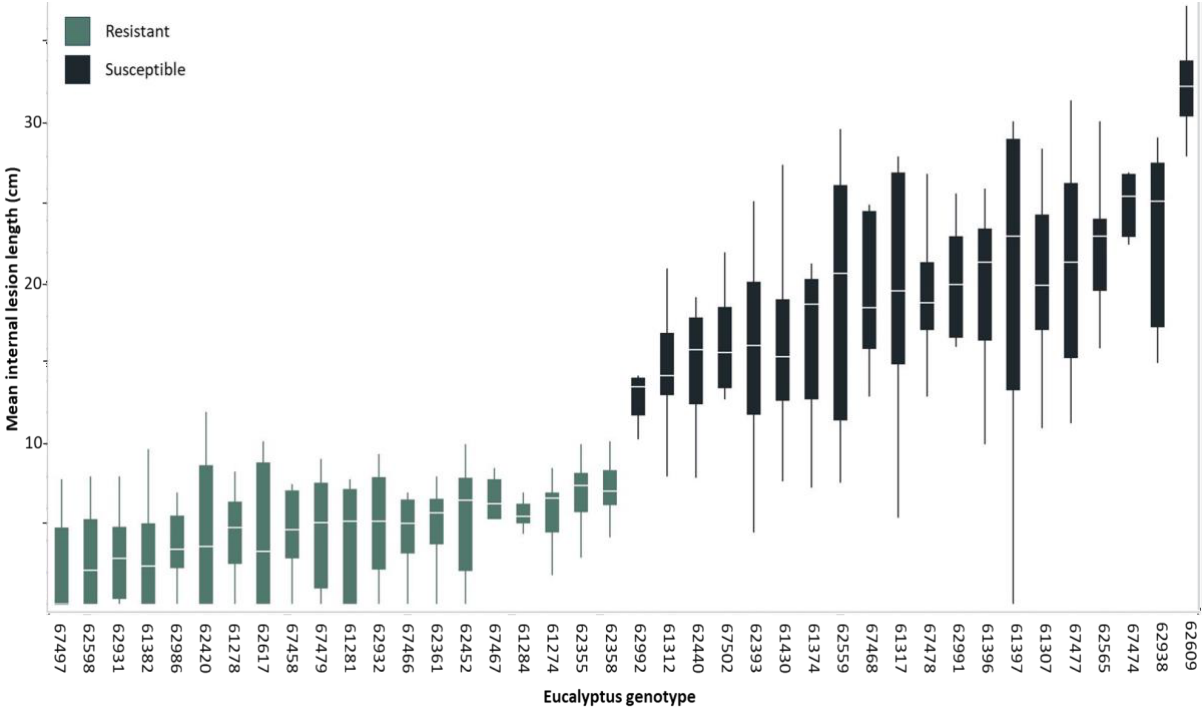

Figure 4: Average lesion lengths across ramets from Kwambonambi field trial showing clear difference of canker lesions from 20 most resistant (Green) and 20 most susceptible (Black) GU backcross genotypes.

"These genetic profiles will be used together with the phenotype data to identify the genetic regions that are associated with resistance."

Figure 4 shows the plot of the lesion lengths of some of the more resistant and susceptible trees in the trial. The same measures will be conducted on the Richmond field site to robustly determine the resistant and susceptible phenotypes based on the lesion lengths. Each individual of the family will be subjected to genotyping using the Eucalyptus 72K SNP chip, in collaboration with the Forest Molecular Genetics (FMG) programme. This will provide a genetic profile for each tree. These genetic profiles will be used together with the phenotype data to identify the genetic regions that are associated with resistance. These will be considered markers for resistance against the stem canker pathogen, and will be used for tree selection.

ACKNOWLEDGEMENTS

The team had the support of SAPPI staff, under the leadership of Dr Nicky Jones and Prof Jolanda Roux. The team is also collaborating with Mondi, who have developed a second GUxG family to confirm the findings from this trial.

Figure 1: Panoramic drone photograph of the Camcore workshop participants. Photograph taken by Sappi Resources Planning Manager and certified drone pilot Robin Hull, using a DJI Matrice M350 RTK drone, fitted with a DJI Zenmuse P1, 45 megapixel full frame camera, with a 35mm wide angle lens.

REMOTE SENSING AND TERRESTRIAL LIDAR: SHAPING THE FUTURE OF FORESTRY

Dr Rafael Keret and Dr André Nel

Sappi Southern Africa

A REMOTE sensing workshop, with a specific focus on terrestrial lidar phenotyping, was held on 15 May 2024 at the Karkloof Club outside Howick, KZN. The workshop, organised by Camcore and Sappi, included participation from local Camcore member companies Mondi, MTO, PG Bison, Sappi and York Timbers, as well as other organisations involved in relevant remote sensing projects. Camcore, an international tree breeding and gene conservation co-operative, established in 1980, based at North Carolina State University in Raleigh North Carolina USA. The Co-operative includes memberships from South America, Africa and Indonesia. Camcore's focus in the early years was on the testing and gene conservation of various indigenous Pine species occurring in Central America and Mexico. They have since broadened their focus to include Eucalypts and other hardwoods and are also actively involved in the development of enabling technologies with its members. One of the current focus areas is the use of remote sensing and new imaging technologies to assess

> *"The use of remote sensing and new imaging technologies to assess important characteristics in genetic trials."*

Dr Rafael Keret

Dr André Nel

important characteristics in genetic trials. The purpose of the workshop was to provide a review of current remote sensing projects and form a LiDAR working group among practitioners. Presentations were delivered by staff from Camcore, University of Pretoria, University of Stellenbosch, ICFR, Sappi, Mondi and York Timbers, and a hands-on coding course using RStudio was also presented during the afternoon.

TERRESTRIAL LIDAR

Forestry management is entering a new era of precision and efficiency with the advent of advanced technologies. One such technology is terrestrial Light Detection and Ranging (LiDAR) which is transforming how we measure and understand forests. This technology uses laser pulses to capture detailed three-dimensional point clouds, that can be reconstructed into trees and forest stands, allowing for the extraction of multiple features from a single scan. In addition to the traditional dendrometric measures of diameter at breast height (DBH) and tree height, complex metrics that were previously difficult to measure can be captured. Terrestrial LiDAR provides a platform for simultaneously capturing numerous phenotypic metrics in a single scanning campaign, including:

- Features such as leaf area index and branching angles that are crucial for understanding tree architecture, canopy structure and light interception patterns. This complex structural data can provide further insight into forest ecosystems, particularly how trees compete for sunlight and how this impacts growth, a key factor in forest dynamics.
- Direct measurements of tree volume. Tree volume estimates, derived from allometric relationships of height and DBH, can lead to inaccurate commercial volume estimates but LiDAR can improve accuracy by providing direct measurements of tree volume.
- Surface features of the stem such as branch scars, knots and bark texture, can serve as proxies to gauge trunk quality and distinguish tree species.

PROGRESS AND CHALLENGES

To demonstrate the feature extraction process participants were provided with access to LiDAR point cloud data obtained from *Pinus taeda* progeny trials. This data set was used to demonstrate how metrics such as DBH, tree height, and volume can be extracted from point cloud data using the open-source "FORTLS" and "lidR" packages in R. The packages "ggplot2" and "rgl" were used to construct 3D plots of LiDAR derived DBH and height, overlayed onto positional information per tree family (Figure 2A).

Comparison of the direct field measurements to the LiDAR derived metrics, revealed that DBH is more

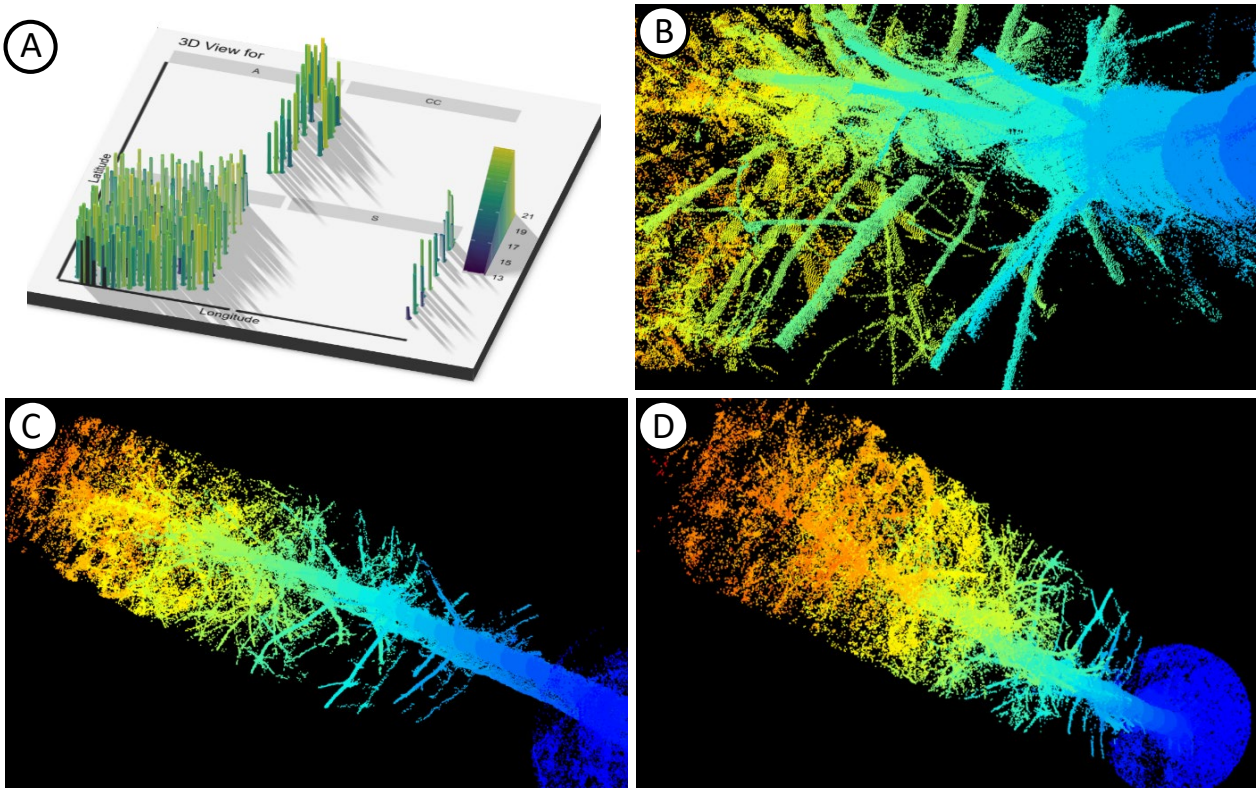

Figure 2: Demonstration of the 3D plotting feature using (A) lidar derived height and tree position within the compartment using R. Reconstructions of *Pinus taeda* using point cloud data demonstrating visualization of the (B) branching patterns, as well as the lower (C) and (D) upper perspective view along the tree profile. All figures were generated in R using open source packages.

accurately measured than height. This may arise due to occlusions caused by the tree crown that introduce noise in the foreground, leading to poor differentiation of the upper stem (Figure 2B, C, D). Removing noise from leaves and branches within and between tree canopies are areas that require further development.

Terrestrial LiDAR technology holds immense promise for revolutionizing forest inventory and tree phenotyping, however, scanning campaigns are often case specific, and yet to be optimised. As discussed during the workshop, scanning at higher resolutions or including multiple scan points is often accompanied with the caveat of increased data loading and processing times.

To address these issues, the Camcore R code was designed to extract individual trees using georeferencing information. This significantly reduced the computational power necessary to reconstruct the point clouds. This iterative technique can be applied to extract multiple trees from larger blocks of trees, depending on the specified coordinates (Figure 3).

The number of scan positions as well as acquisition speed of the LiDAR will require consideration to determine the minimal scanning time required to obtain accurate information. If a clear framework for scanning campaigns can be developed, this can be used to improve signal-to-noise ratio, reduce data quantity and computational requirements. This means the user must have clearly defined objectives, while taking into account post-processing capabilities. Ultimately terrestrial LiDAR is an evolving technology in the forestry space, and offers the opportunity to efficiently capture forest inventories, saving time and resources. The detailed data it provides supports better decision-making for thinning, optimizing space for competition, and assessing tree form. As demonstrated in the workshop, this technology provides valuable phenotypic data for genetic studies and tree selection, enhancing breeding programs. LiDAR can also assess tree flowering patterns and seed production, offering insights crucial for both conservation and commercial forestry. Evidently, the features captured by terrestrial LiDAR can inform precise end use of tree resources, while providing intricate phenotypic information for breeding and selection programs.

The Camcore team highlighted that future pipelines will focus on obtaining more complex features including tree form, total biomass, and branch angles. Participation in the workshop emphasized the importance of collaboration to achieve these goals. Shared experiences, data and knowledge transfer are crucial for advancing the use of LiDAR in forestry, making it a more reliable and accessible tool for all.

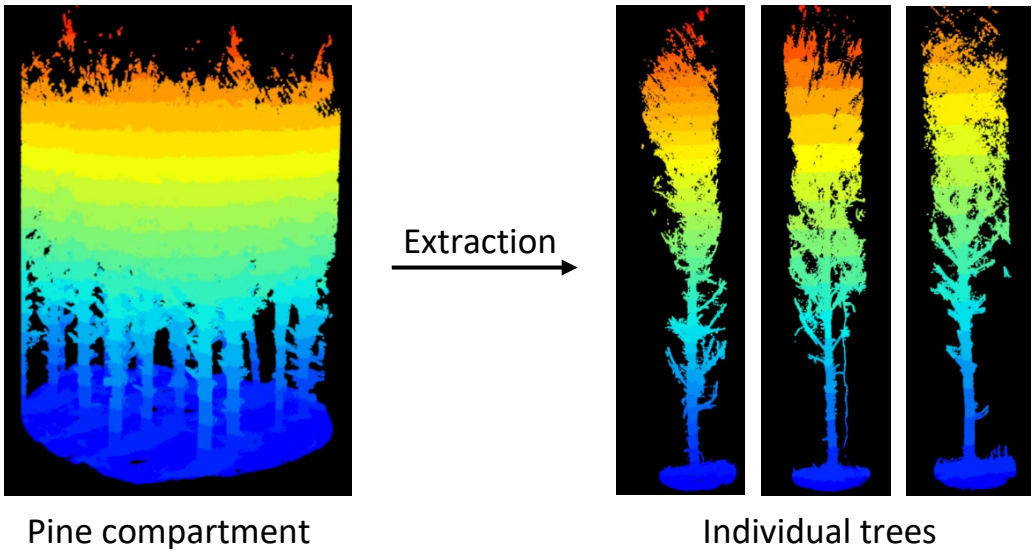

Figure 3: Extraction of individual *Pinus taeda* trees from the compartment using measured GPS coordinates.

> *"Ultimately terrestrial LiDAR is an evolving technology in the forestry space, and offers the opportunity to efficiently capture forest inventories, saving time and resources."*

BIOLOGICAL CONTROL OF WATTLE RUST USING TWO MYCOPARASITIC FUNGI

Dr Benice Sivparsad[1], Ms Nonkululeko Poswa[2], Dr Bernice Bancole[1,2] and Professor Mark Laing[2]

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Dr Benice Sivparsad

Ms Nonku Poswa

Dr Bernice Bancole

Professor Mark Laing

WATTLE rust, caused by *Uromycladium acaciae* (Cooke) P. Syd. & Syd, is the most economically important disease currently affecting black wattle plantations in South Africa. Since its initial outbreak in the KwaZulu-Natal Midlands in 2013, the disease has spread rapidly throughout the main growing areas and is now considered to be a major threat to the long-term economic sustainability of the South African black wattle industry. The disease causes matting of leaves, pinnule and rachis malformation, and stunting of cuttings and young trees. A severe infection of this disease will result in reduced growth, and even mortality of young wattle trees. Azoxystrobin or triazole-based fungicides and the deployment of resistant or tolerant lines of *A. mearnsii* have been the two control measures used to manage wattle rust. However, a change of approach to pesticide usage by international forestry certification schemes such as the Forest Stewardship Council (FSC) has limited the number of applications of fungicides that can be made per season. In addition, registered rust fungicides with the active ingredients of cyproconazole and propiconazole have been prohibited for use by the Registrar (Act 36 of 1947) due to their toxicity according to the criteria Carcinogenicity, Mutagenicity and Reproductive (CMR) Toxicity and will be phased out from June 2024. Therefore, there is an urgent need to develop alternative control measures for wattle rust that will comply with Forest Stewardship Council (FSC) regulations and also meet the criteria of CMR toxicity.

A collaborative project between the Institute for Commercial Forestry Research (ICFR), University of KwaZulu Natal (UKZN), and A-PHP (Andermatt Plant Health Products) was implemented to assess the biological control efficacy of selected mycoparasitic strains of *Sphaerellopsis filum (*Biv.*)* B.Sutton and *Lecanicillium* sp. for the control of wattle rust. The project was funded by the National Research Foundation (NRF, RTF grant) and formed the basis of the MSc study of Ms Nonkululeko Poswa.

The research was undertaken as a series of potted trial experiments housed at the ICFR nursery. Samples of formulated *S. filum* were obtained from A-PHP and sporulating cultures of *Lecanicillium* sp. were obtained from UKZN (PhD student - Peace Mwelasi, Department of Plant Pathology, Pietermaritzburg). In Pot Trial 1, both fungi were tested on rust-infected seedlings of 3 wattle varieties (PSO14, SP644, FW54). Results showed that the 3 wattle varieties were not significantly different in their resistance to rust (untreated control), nor in their response to treatments with the fungicide, or *S. filum* and *Lecanicillium* sp. Treatment with *S. filum* produced a statistically significant reduction in wattle rust. Treatment with *Lecanicillium* sp. did reduce

wattle rust progression but the reduction was not significant when compared to the untreated rust control (Figure 1). In addition, characteristic white mycelial growth on rust pustules showed that successful colonization of rust pustules occurred with both *S. filum* and *Lecanicillium sp.* (Figure 2). Colonised leaves were viewed under an environmental scanning electron microscope (ESEM) to examine the interaction between the biological control agents and wattle rust. Under the ESEM, *S. filum* and *Lecanicillium* sp. demonstrated mycoparasitic activity on spores of wattle rust. Hyphae of *S. filum* and *Lecanicillium* sp. were seen attaching to and puncturing rust teliospores, causing the teliospores to rupture and deflate (Figure 3). Overall, results showed that both *S. filum* and *Lecanicillium* sp. were able to colonize, mycoparasitize and reduce wattle rust disease on all tested wattle varieties. Based on these favourable results, a second trial was initiated to evaluate the dosage and application frequency of both fungi for optimal control of wattle rust.

In Pot Trial 2, conidial suspensions of *Lecanicillium* sp. and *S. filum* were prepared at dosages of 1/2x, 1x and 2x; and sprayed at three frequencies: once- off, bi- weekly (every two weeks), and monthly. Results showed that all treatments reduced wattle rust relative to the untreated control treatment. Notably, the bi-weekly treatment with a, 2X dosage of *Lecanicillium* sp. resulted in the least amount of rust disease, which was not significantly different to that of the fungicide treated control (Figure 4).

In Pot Trial 3 fertilization with potassium silicate (silicon, Si) was combined with the best biocontrol treatment to determine whether Si could enhance disease control. In this trial, conidial suspensions of *Lecanicillium* sp. were applied at a 2x dosage at bi-weekly intervals (best performing treatment in Pot Trial 2) with 4 different dosages of silicon (0, 100, 200 and 400ppm). Results showed that all treatments reduced wattle rust relative to the untreated control treatment. Treatment with *Lecanicillium* sp. + 400ppm silicon resulted in the least amount of rust disease. However, the *Lecanicillium* sp. + 0ppm silicon treatment also produced a significant reduction in rust (Figure 5). This suggests that a combined application of *Lecanicillium* sp. and silicon does not result in a significant reduction in wattle rust disease.

> *"Biological control of wattle rust using mycoparasitic fungi is a safe, efficient and compliant alternative to fungicide."*

TAKE HOME MESSAGE

Biological control of wattle rust using mycoparasitic fungi is a safe, efficient and compliant alternative to fungicides. Results of these potted experiments show that bi-weekly spray treatments of *Lecanicillium* sp. to young seedlings can reduce wattle rust disease progression to levels that rival that of a commercial rust fungicide. Further field trials are needed to confirm these findings and to explore the feasibility of applications for optimal control. A PhD study on the field evaluation of the use of *Lecanicillium* sp. against wattle rust in wattle plantations will be initiated in 2025.

Ms Nonku Poswa applying treatments of mycoparasitic fungi to rust-infected seedlings

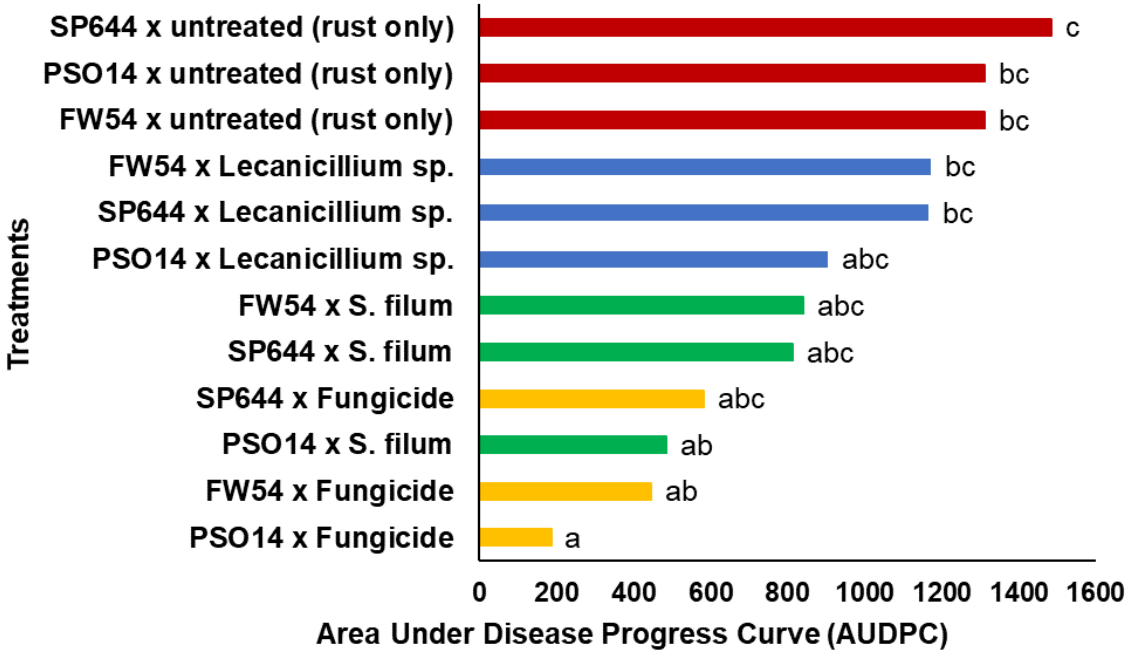

Figure 1: Effect of treatment with *Lecanicillium sp.* and *Sphaerellopsis filum* on wattle rust on three wattle varieties

"A severe infection of this disease will result in reduced growth, and even mortality of young wattle trees."

Figure 2: Colonization of rust pustules with *Lecanicillium sp.*

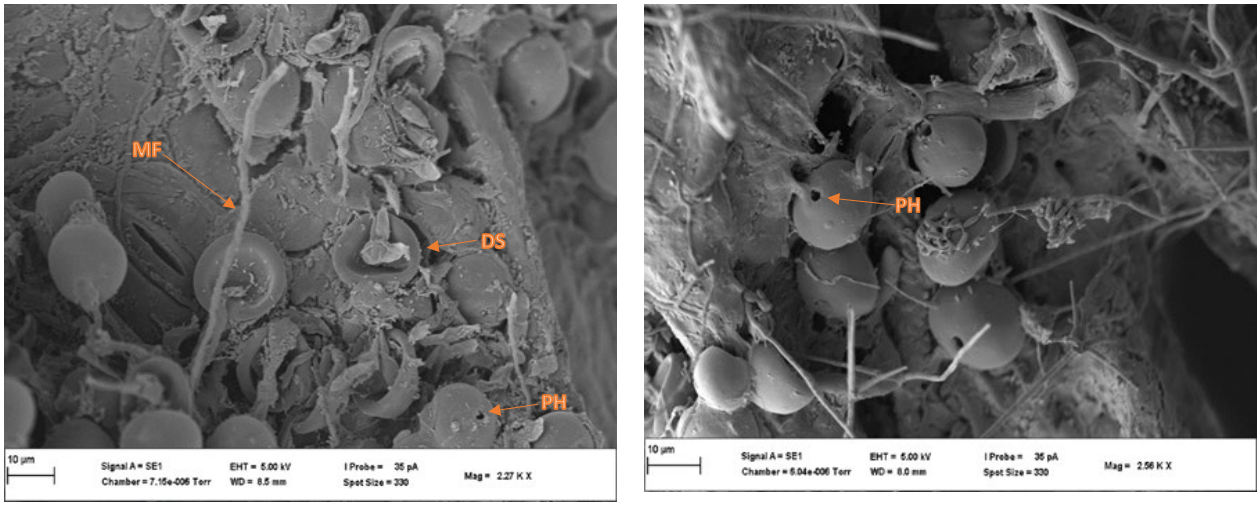

Figure 3: ESEM of mycoparasitic fungi (MF) vs wattle rust showing deflated rust spores (DS) and puncture holes (PH).
Image: Phumelela Peace Mwelasi (PhD Plant Pathology Candidate, UKZN)

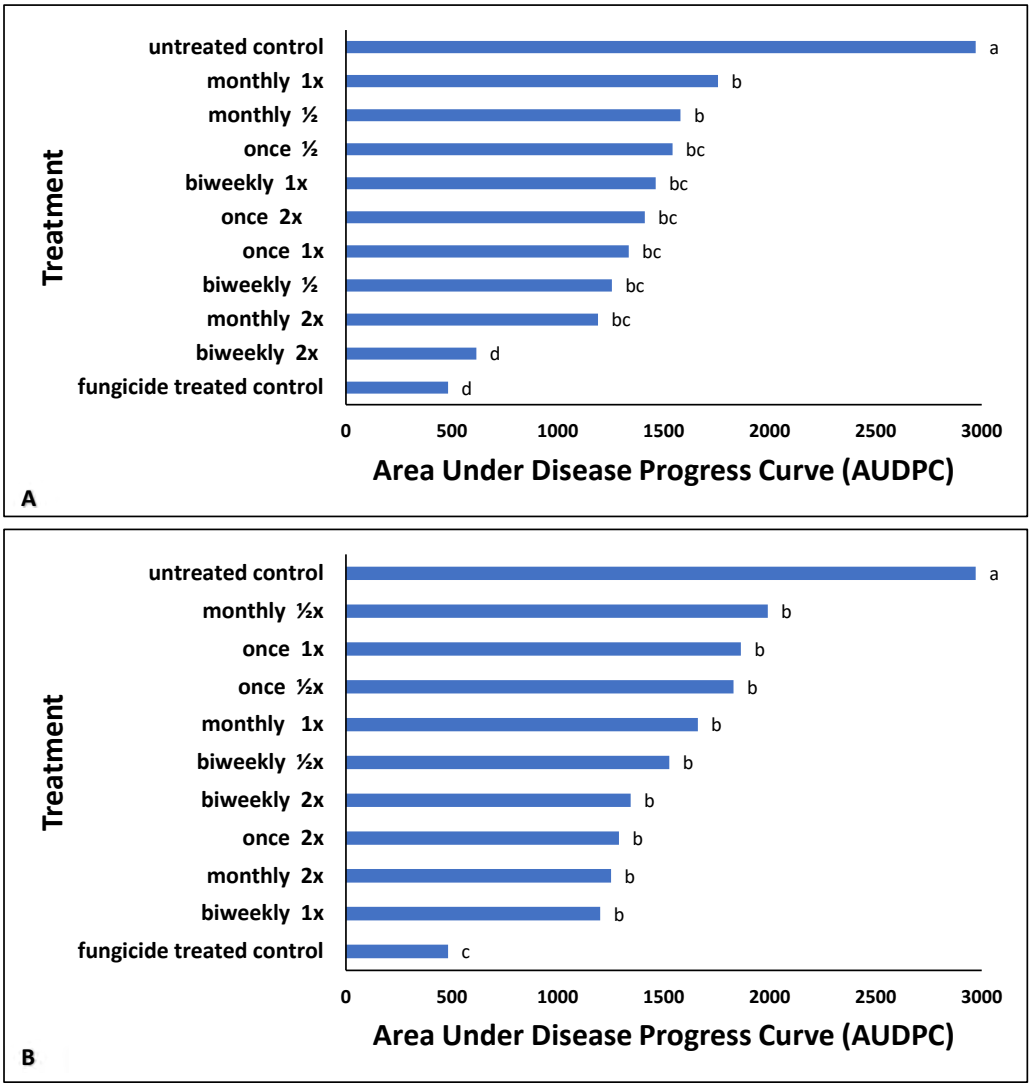

Figure 4: Effect of treatment with (A) *Lecanicillium sp.* and (B) *Sphaerellopsis filum* at different application dosages and frequencies on wattle rust

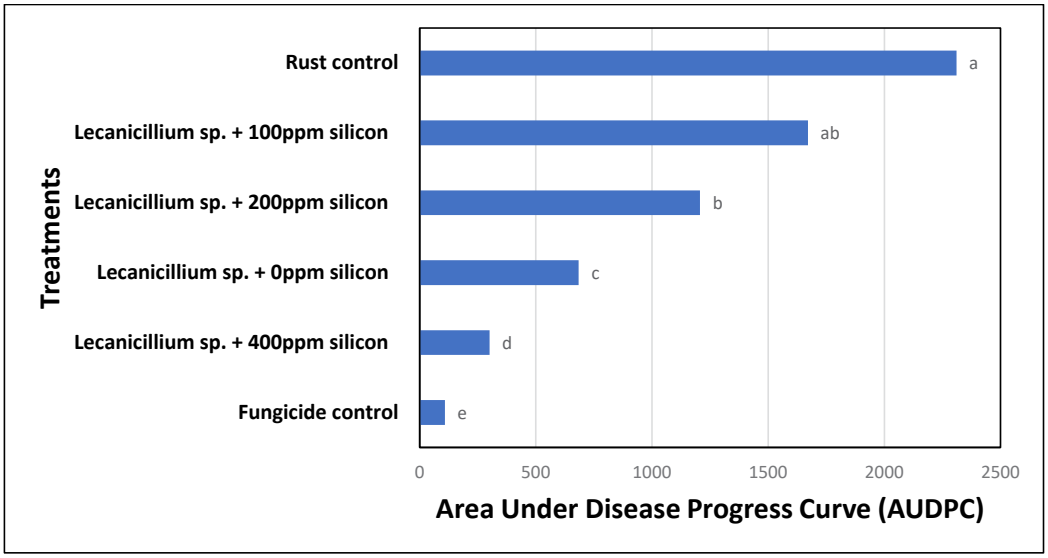

Figure 5: Effect of combined treatment of *Lecanicillium sp.* and potassium silicate (silicon) on wattle rust

> *"Further field trails are needed to confirm these findings and to explore the feasibility of applications for optimal control."*

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