



Tree Protection News

Newsletter of the Tree Protection Co-operative Programme (TPCP) and DST-NRF
Centre of Excellence in Tree Health Biotechnology (CTHB)



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FROM THE DIRECTOR'S DESK

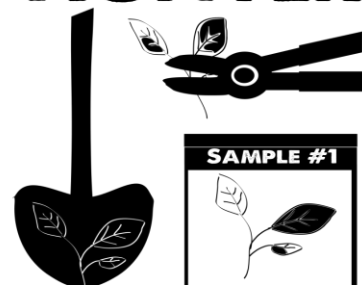
"Can one clone a tree endlessly?" This was a question that I asked at the last annual meeting of the Tree Protection Co-operative Programme (TPCP) in May this year. The question arose from our efforts to understand the unexpected and serious 'collapse' of a *Eucalyptus grandis* x *E. urophylla* clone in Zululand. Despite intensive efforts in this direction, we have not been able to detect the presence of any biological agent associated with this disease. Numerous tree health authorities from many different countries have seen these dying trees and any number of explanations have been presented. The fact that green and otherwise healthy trees become infested with wood-boring insects and fungi might be considered a "red herring". They certainly contribute to the death of the trees but their biology tells us that they are responding to cues relating to stress. Casper Crous, research fellow in the TPCP team, has come up with a very plausible explanation for this stress relating to the ability of the clone to respond to drought. This was shared with TPCP members at our annual meeting and I have subsequently heard of similar clone collapse in various other parts of the world. There is much more to say about this problem. But the lesson to be learned is that we know very little about the biology of the trees on which we are basing a major industry. We are already finding that tree health issues are becoming increasingly important. The clone collapse 'syndrome' emphasizes that this field is much more complex than we might have expected.

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Compiled by Jolanda Roux with contributions from the TPCP and CTHB research team
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BECOME A PATHOGEN HUNTER



This story of another, this time complex tree disease problem, is only one of many that I could share in illustrating the activities of the TPCP during 2015. The year has rushed by seemingly faster than ever. Just this morning, I was asked when I begin to plan for the next meeting of the programme. The short answer is that this starts well before the prior meeting occurs. But it does seem like just yesterday that I was working with the remarkable research team to draw together a well-balanced and representative programme for the meeting. For a team the size of the TPCP, this is always a challenge. We could clearly have presentations for a week long and not possibly cover the breadth of the many projects that we deal with. Those that are shorter term and 'problem solving' and those with a longer term view and on which we have come to depend to be able to serve the forestry industry in the future. We also seek to have a balance between insects and pathogens and the key tree species on which we work. What I can assure readers of Tree Protection News is that next year's meeting will be another great event. If this is not already in your diary - plan to be in Pretoria on Tuesday 16th and Wednesday 17th May. If you would like to take up the opportunity to take a deeper look into our work, stay for a few days more and we will share more time with you!!

I will not yield to the temptation to try and cover in this editorial, details regarding the many ongoing activities of the TPCP. But I must share with you the fact that we are 'once again' involved in a major new building project. This emerges from funding from the Sector Innovation Fund (SIF) and Sappi that is enabling us to substantially increase our tree pest biological control facilities. Building has begun and new staff members have been appointed that should enable the TPCP to deal more effectively with the numerous new insect pests that have become serious threats to the sustainability of our industry.

Every year I hope that this will be a year where we do not record a new pest or pathogen in our plantations. Although they are not always serious problems, I don't think that a single year has past in the last decade (perhaps longer) when



Wilhelm de Beer and contractors at the cleared site for the expanded biological control facilities at FABI

we have not found some new fungus pathogen or insect pest on a species of pine, eucalypt or wattle. This illustrates the scale of the problem that we are dealing with. But it also begs the question "when will we reach a threshold" of not having to continuously deal with new problems. There is no clear answer here but the reality is that there are literally hundreds – perhaps thousands of pests that potentially threaten our industry. We must make every effort to keep those not present in our country out. That alone is an enormous (some say impossible!) challenge given the 'global village' in which we live. But perhaps the most complex issue to deal with is the fact that some of the worst threats are those from native pests. And they are already with us, simply in wait of the 'genetic window'- a particular clone or genotype on which they are able to develop.

Earlier this year we discovered the 'destructans leaf blight' pathogen, *Teratosphaeria destructans*, in South Africa. I have many times made the point that this is one of the worst pathogens of *Eucalyptus* that I have ever encountered. What it will do in South Africa in the longer term is hard to tell. But there is little doubt that it will have negative impact in some areas and on some clones. The appearance of this disease raises the question "could we have prevented its introduction". This is impossible to say. How it came to South Africa is hard to tell – but this was most likely with *Eucalyptus* seed imports. And this could have been recently or a long time back.

Dealing with tree pest problems requires long term thinking and an ongoing commitment. I have said more times than many wish to hear that "there are no silver bullets". An issue so beautifully illustrated in The Scaffold's 70's ballad "Lilly the Pink" -if you do not know it -visit my Facebook page and enjoy the experience!. What we must do is to implement every possible mechanism to exclude from our borders new exotic pests. But it is equally important to continue to invest in those pests already in our country, and not forgetting those that are 'lurking" in the background but yet to cause problems. Then also growing our base of knowledge and building increasingly robust management tools to reduce losses due to the already established pests in South Africa.

There are many reasons to be optimistic about the future of commercial forestry in South

Africa. This is sometimes hard to recognize when many pests are damaging our trees and currently against the background of a serious drought. But we are fortunate to have a dynamic industry, supported by teams such as the TCP and where problems can be anticipated or at least dealt with effectively. In this regard, the TCP team relies very heavily on our stakeholders, our members and our research partners to achieve our goal of "KEEPING TREES HEALTHY". We are thus grateful to this amazing community of friends and colleagues for great support this last year. We wish you all a very happy festive season and a healthy and happy NEW YEAR.

Regards, Mike Wingfield



FABI PARTICIPATES IN THE SOUTH AFRICAN EMERGENCY PLANT PEST RESPONSE PLAN

Dr. Brett Hurley of FABI participated in the South African Emergency Plant Pest Response Plan (SAEPPRP) workshop that took place in Pretoria in August 2015. This workshop was organized by the Department of Agriculture, Forestry and Fisheries (DAFF), Directorate of Plant Health (<http://www.daff.gov.za/daffweb3/Branches/Agricultural-Production-Health-Food-Safety/Plant-Health>), with funding support from the United States Department of Agriculture (USDA).

The SAEPPRP provides an outline on the effective detection, identification, rapid response and mitigation of new plant pest arrivals in South Africa. One of the main objectives of the plan is to establish effective communication between different role players and in this regard participation in the workshop included representation from local and national government, academia and research organizations and industry. The aims of the workshop included clarifying the role of the different role players and providing inputs on possible amendments required to the SAEPPRP.

The development of an effective national strategy to respond to the increasing rate of plant pest introductions is crucial. Just in the forestry sector alone there have been five new insect pests of eucalypt trees detected in South Africa in the last ten years. The introduction of non-native insect pests and diseases poses a serious threat to the sustainability of forestry and agriculture in South Africa.



DESTRUCTANS LEAF BLIGHT OF EUCALYPTS NOW IN SOUTH AFRICA

In July 2015, Members of the TPCP reported the presence of the serious *Eucalyptus* leaf and shoot blight pathogen, *Teratosphaeria destructans*, in the Zululand area of South Africa. The pathogen was detected on *Eucalyptus grandis* x *E. urophylla* (GU) hybrid clones. Destructans leaf blight was first described from Indonesia in 1996. It subsequently spread throughout South East Asia where it causes severe damage to *E. grandis*, *E. camaldulensis* and hybrids of these species. Surveys conducted by the TPCP and Forestry companies have shown it to be present from Maputaland in the north to Mtunzini in the south of Zululand. Most recently the pathogen was also confirmed from GU hybrids in the Natal Midlands near Pietermaritzburg.

At this stage management options for the disease is limited. Early data suggests that there are differences in clone susceptibility.

To help us gather information on the spread and host range of *T. destructans* we appeal to foresters to look out for the disease. Please contact Izette Greyling (izette.greyling@fabi.up.ac.za, 083 269 1983) or Jolanda Roux (jolanda.roux@fabi.up.ac.za) if you spot the disease in your plantations.



Symptoms of *Teratosphaeria destructans* infection on eucalypt leaves. Spots on leaves often start as chlorotic (yellow/light green) blotches, sometimes turning red. These blotches are not contained by veins. Black spore masses may be visible on the underside of affected leaves.



FIRST RELEASE OF *GLYCASPIS* BIOLOGICAL CONTROL AGENT IN RSA

August 2015 marked the first releases of the parasitoid wasp *Psyllaephagus bliteus* in eucalypt plantations in South Africa. This wasp parasitizes the nymphs of the red gum lerp psyllid, *Glycaspis brimblecombei*, and has been released as a biological control agent in many countries where this insect has become a pest.

Glycaspis brimblecombei is native to Australia but has become a serious pest of eucalypt trees in regions where it has been accidentally introduced. This includes South Africa, where *G. brimblecombei* was first detected in 2012 and subsequently spread to the main eucalypt growing areas in the country where high infestations developed on susceptible eucalypt genotypes.

Populations of *P. bliteus* were found in Gauteng earlier this year and thus the insect did not need to be imported into the quarantine facility of FABI for host specificity testing. The wasp can be collected from established populations in Gauteng and distributed to affected eucalypt plantations across the country. The initial releases of *P. bliteus* were in the Tzaneen and Zululand areas, with subsequent releases in the KZN Midlands. Releases will continue until the wasp has been spread to all areas infested with *G. brimblecombei*.



Glycaspis brimblecombei lerp and exposed nymphs on a eucalypt leaf



Glycaspis brimblecombei damage to a eucalypt leaf



Sonia du Buisson (HM) and Samantha Bush (TPCP) releasing *Psyllaephagus bliteus* in the Tzaneen area



Psyllaephagus bliteus (in tube) and its target pest, *Glycaspis brimblecombei*

STUDYING PLANT PATHOGENS THROUGH CITIZEN SCIENCE AT FABI

Citizen science has over the past few years become an important component in the detecting and monitoring of plant pests and pathogens. PhD student Joey Hulbert is undertaking the first official citizen science project at FABI, combining educational outreach with hypothesis driven research. The project is designed to engage the public in a research project about *Phytophthora* species in the fynbos biome of the Western Cape Province.

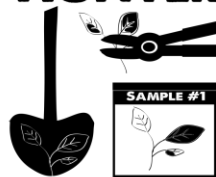
Joey has already undertaken two public engagement activities as part of the Cape Citizen Science project. The first of these was at an Arbor Week Expo in Stellenbosch. Most recently, together with staff of the Kirstenbosch National Botanical Garden(NBG), they invited a group of homeschool students to participate in survey activities in Kirstenbosch.

Project and managers at the Kirstenbosch NBG had reported the presence of this pathogen in their *Protea* garden. During the activity, each citizen scientist collected samples of dying plants while learning about microorganisms as causal agents of disease. Joey enjoys the public engagement component of Cape Citizen Science, but he is excited to see their contributions grow into valuable data as he isolates *Phytophthora* from the samples they collected.



Joey Hulbert at the Arbor Week Expo in Stellenbosch

**BECOME A
PATHOGEN
HUNTER**



**HOW TO BE A
CITIZEN
SCIENTIST**



Joey (left) teaching school children about plant diseases

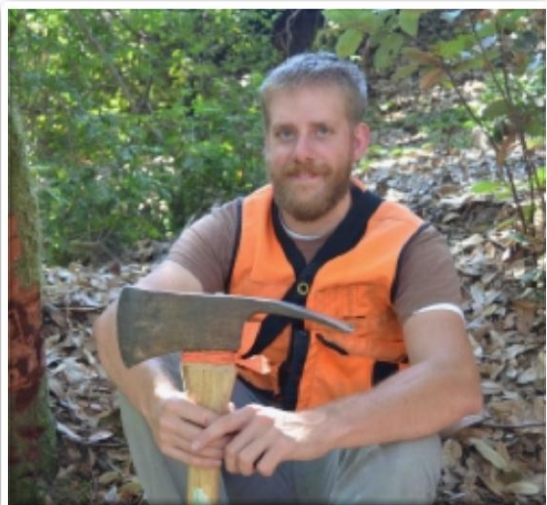


WELCOME TO THE CTHB AND TPCP RESEARCH TEAMS

Dr. Stuart Fraser joined the TPCP research team as a post-doctoral research fellow in September. He will be working on the *Acacia mearnsii* rust pathogen, *Uromycladium acaciae* during his time in South Africa.

Before coming to South Africa Stuart read ecology at the University of Sheffield and undertook research towards an MSc in Conservation and Forest Protection at the Imperial College in London. For his MSc work he studied local adaptation in the germination requirements of *Eucalyptus obliqua* and its importance on the susceptibility of the species to climate change. This entailed time at the University of Melbourne in Australia.

Stuart completed his PhD studies in early 2015 and obtained his degree from the University of Aberdeen in Scotland. For his PhD he worked on the variation in host susceptibility to *Dothistroma* needle blight within *Pinus* species commonly used in British forestry.



Joey Hulbert is a PhD student from the USA. He is working on *Phytophthora* species in the fynbos of the Western Cape Province and leading FABI's first Citizen Science project. Joey obtained his MSc from Oregon State University where he also worked on *Phytophthora* species. He holds a B.Sc. degree in Forestry and Natural Resources from Washington State University and an M.Sc. in Wood Science and Plant Pathology.

FABI COLLABORATES WITH RESEARCHERS OF NATURAL RESOURCES CANADA



Marc holding an Asian long horned beetle during his visit to Canada



Dr. Allison setting up an experiment to test the effect of competitors on *Sirex* development

The entomology team of the TPCP and CTHB research teams has established strong research collaboration with forest health scientists in the United States of America and Canada over the past few years. Recently, Marc Bouwer had the opportunity to visit the Great Lakes Forestry Research Centre situated in Sault Ste Marie, Ontario, Canada, to establish an international collaborative research project in the field of chemical ecology with Dr. Jeremy Allison.

During the visit Marc had the opportunity to work with state of the art sampling facilities and an electro-antennography system coupled to a gas chromatograph. These instruments allow one to measure electrophysiological responses of insects to volatile chemicals that can be sampled from the insects themselves or their host plant material. Pest insects that were investigated included the Cabbage Looper moth (*Trichoplusia ni*), Emerald Ash Borer (*Agrilus planipennis*) beetle and Spotted Pine Sawyer (*Monochamus mutator*) beetle. Marc also had the opportunity to visit their quarantine facilities where the Asian Long Horn Beetle (*Anoplophora glabripennis*) is kept.

Marc gained experience in trapping Cerambycid beetles with aggregation pheromones. This work has led to the development of a collaborative field trial that will be conducted at the ARC Roodeplaat near Pretoria in South Africa. This trial aims to test North American Cerambycid pheromones such as Monochamol (the pheromone of the White Spotted Pine Sawyer beetle, *Monochamus scutellatus*) for activity on South African Cerambycid beetles. These experiments will shed some light on the unknown South African Cerambycid pheromones and their structural similarity to pheromones of beetles from other continents.

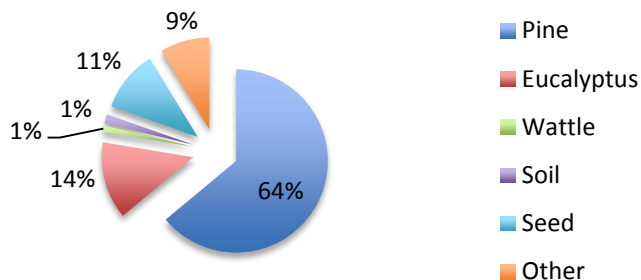
DIAGNOSTIC CLINIC AND EXTENSION ACTIVITIES

The Tree Diagnostic clinic of the TPCP and CTHB programmes, together with regular field extension activities, form an integral part of the monitoring and surveillance activities of the programmes. The clinic received a total number of 974 samples between January and November 2015. The majority of these of *Pinus* species, and especially for testing for the pitch canker fungus, *Fusarium circinatum*.

For the period January to December the research teams undertook a total of 51 field trips for research and extension. During these trips *Teratosphaeria destructans* was discovered for the first time in South Africa and pitch canker of mature *Pinus patula* observed in the Limpopo Province. The distribution of the Myrtle rust pathogen, *Puccinia psidii*, was also extended to include the Louis Trichard and Thohoyandou areas of Limpopo. Members of the TPCP and CTHB team also contribute to multiple industry field days and training activities.

We encourage all foresters, farmers, conservation agencies and other members who require assistance with the diagnosis of tree health problems to contact us. Your eyes are critical for the detection of potential new pests and pathogens in the country.

Sample sources January - November 2015



TPCP/CTHB researchers evaluating the impact of *Puccinia psidii* on *Eugenia natalitia* seedlings in the Limpopo Province.



The shell lerp psyllid, *Spondylaspis plicatuloides* ("skulpie") on a eucalypt leaf

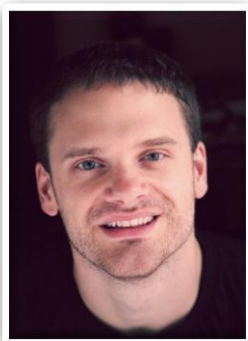


Darryl Herron (Diagnostic clinic manager) investigating the cause of eucalypt death

CONGRATULATIONS

FABI applauds the graduates who made the Institute proud at the Spring Graduation Ceremony of the Faculty of Natural and Agricultural Sciences on September 3. We congratulate them all and wish them well in their future endeavours.

PhD



Dr. Stephen Taerum – Origin and diversity of the invasive red turpentine beetle and its fungal symbionts.



Dr. Tania Weller-Stuart – Genomic and functional characterization in *Pantoea ananatis*.



Dr. Mingliang Yin – Taxonomic revision of four major species complexes in the Ophiostomatales (Fungi, Acomycota), with specific reference to associates of conifer-infesting bark beetles in China.

MSc

Francois Boshoff – Diversity and evolution of rhizobia associated with native and non-native *Acacia* species in South Africa.



Drs. Mingliang Yin and Stephen Taerum with their primary supervisor, Dr. Wilhelm de Beer (middle)

NATURE PUBLISHING GROUP VISITS FABI AND UP

A free online portal with a focus on Africa could open up opportunities on the continent to promote scientific research done in Africa to a wider global audience. This was revealed at a discussion hosted by FABI in August with representatives from the Nature Publishing Group (NPG), publishers of the most cited general science journal, *Nature*, and its regional online portals *Nature China*, *Nature India* and *Nature Middle East*.

Bernard Slippers of FABI facilitated the discussion, which included the head of NPG in the Middle East, Jon Giuliani, Executive Editor of NPG Middle East, Mohammed Yahia, UP Principal and Vice-Chancellor, Prof. Cheryl de la Rey, Deputy Director-General of International Cooperation and Resources at the Department of Science and Technology (DST), Daan du Toit, Deputy Director of High-End Skills at DST, Vusi Malele and the Director of the Centre for the Advancement of Scholarship at UP, Prof. Robin Crewe.

NPG is investigating the possibility of partnering with African universities and other partners to launch a free online portal, *Nature Africa*, in 2016. With already 50 million online users worldwide, the NPG is uniquely placed to communicate science in Africa to a wide global audience. Mohammed Yahia said *Nature Africa* would also contribute to breaking down the barriers between scientists and the general public by communicating science in a manner that is easily accessible, free of jargon and through the use of multimedia and social media platforms.

The portal would not be for the publication of primary research, but would feature articles about science published from the region, news and views, blogs, podcasts and videos about science, scientists and research organizations in the region, as well as jobs openings, funding and other opportunities. As with the other Nature portals mentioned above, it also offers the opportunity to translate the information generated for it into other languages, which could significantly enhance connectivity within Africa and with the general public.



Bernard Slippers with Jon Giuliani, Mohammed Yahia and Daan du Toit in the FABI courtyard

Prof. de la Rey said such an initiative would benefit the scientific community in Africa where the rate of scientific output was still small and underreported. She said the launch of the portal would be an exciting opportunity for UP and would promote scientific research and innovation in Africa.



Prof. de la Rey addressing the audience during the visit of Nature Publishing group to the University of Pretoria

NOW WE ARE TALKING! SCIENCE IN AFRICA IS ALIVE WITH POSSIBILITIES

By *Darryl Herron*

I write this piece to you a few hours after one of the greatest science meetings in Africa. If you weren't at the CSIR in Pretoria, near a computer, reading a newspaper, finding friends on Facebook, tweeting on Twitter — between the 8th and 9th of December 2015 — you may have missed out on South Africa's and Africa's first Science Forum. As a scientist or citizen of Africa and even the world, this was something you could not afford to miss.

This forum brought together the young and old; students and professors; the public and private sectors; and gave them a platform to discuss science and how it can be used to solve societal problems, both locally and abroad, like HIV/AIDS, climate change, poverty, inequality, water security, etc. All of these issues are relevant to the global community and not just for those living in Africa. News of a forum being driven by Minister Naledi Pandor, the minister of Science and Technology in South Africa and her department, garnered huge support from the world. The halls of the ICC at the CSIR were teeming with visiting dignitaries, scientists, students, and regular citizens from South Africa, Africa and many countries off of our shores.

The massive turnout from the world at South Africa's first science forum is a promising sign. People (I use that collectively for all citizens, scientists, policy makers, government officials, industry) realize, more than ever, that science has the potential to help alleviate some of the world's problems. People are starting to realize that talented Africans have much to contribute toward the battle against climate change and sustainable energy; the fight against obesity and diabetes; and the struggle against food security and population growth — just to name a few. Africa contributes about 2.4% to the world's scientific knowledge; a number we can increase if given the chance.

That chance comes from investments, investments through partnerships with other countries, governments, scientists and their



institutes. These investments are by no means just financial; they include collaboration, skills transfer and mentorship — something that will last a lot longer than money. As a young continent, in terms of economics and science, we have the opportunity to build ourselves up, to build up a knowledge economy. We have the talent, skills and the support to take on the problems facing Africa and the world in the 21st century — and we can win. We just need the world to believe in us, and we need to believe in ourselves. It will take all of us to solve these issues and united we must stand in the face of adversity.

There was a lot of emphasis placed on the youth in Africa at the forum, especially young scientists and the role they will play in shaping the world going forward. I liked what Dr Tanya Abrahamse, CEO of the South African National Biodiversity Institute, said in the second plenary session, "The problems the world face are very complex and our current scientists are struggling to solve them. We need another type of scientist..." This came up again, when I raised it in one of the parallel sessions titled: "Preparing for careers that do not exist yet". Here, I really wanted to know what those careers would be; how the people needed to fill

NOW WE ARE TALKING! SCIENCE IN AFRICA IS ALIVE WITH POSSIBILITIES

those positions will be trained; and what those jobs will do to solve the world's problems. Unfortunately, I didn't get all the answers I wanted. However, it did get me thinking, and as I approach 30 I am reminded how time is fleeting. Is it too late for me to be the "next generation" scientist? When the CEO of the NRF, Dr Molapo Qhobela, says we need to support our young scientists, better — am I the youth? In my mind the answers to those questions are "NO!" and "YES!", respectively. Had you have asked me the same questions before this forum, I may have answered a little differently.

Before the forum, I thought of myself as just a microbiologist; as just a PhD student; a person who studied in one area. After sitting on the edge of my seat for two days through four wonderful plenary sessions and four of the 32 interesting parallel sessions, presented by more than 50 different people that included Ministers, CEOs, Chairpersons, Directors, Writers, Professors, Doctors, Science Advisors, I no longer think that. If you think like I did, then you need to change that way of thinking. One of the many important lessons I learned from this forum was that it doesn't matter who you are, where you work, or what you study, you have a voice. You just need to speak up! I discovered chemists who manage big businesses, geneticists and psychologists who change important policies and journalists making our science accessible to the public. The possibilities and combinations are almost endless!

They all, along with the more than 1500 participants crammed into the Diamond hall at the CSIR ICC, want to see young scientists getting more involved. They want you to stand up, get funded, do great science and go on to join the leaders of tomorrow. The "next generation" scientist is one who can communicate and the language needed to have those dialogues are economics, politics and science. You and I have the unique opportunity and space to grow, to engage with scientists in other fields, policy makers, industry — all of which are working together (or wanting to) to change the world for the better. Take charge now, be the "next generation" scientist and change the world by changing yours.

SARCHI RESEARCH CHAIR FOR THE TPCP & CTHB

The University of Pretoria will host four new SARCHI chairs (South African Research Chairs Initiative; <http://www.nrf.ac.za/division/rcce/instruments/research-chairs>) amongst the 42 that was recently announced by the Department of Science and Technology (DST) and National Research Foundation (NRF). Three of these are in the Faculty of Natural and Agricultural Sciences, namely Professors Brenda Wingfield, Wanda Markotter and Namrita Lall. Brenda Wingfield will fill the SARCHi chair in Fungal genomics, which will be hosted in FABI. This position will compliment the research that is already being undertaken within the TPCP and CTHB research programmes on tree health.



FABI ANNUAL YEAR-END GALA DINNER AND AWARDS CEREMONY

The 2015 FABI year-end gala dinner and awards ceremony marked 18 years since FABI's founding. Guests included forestry industry representatives, visiting academics from around the world as well as the family and friends of FABI staff and students. Speakers at the function reflected on some of the many reasons for the successes that FABI has achieved over the past 18 years, and again in 2015. These included the communal spirit that unites FABIans as a family and how this has contributed to its achievements and success and the importance of planning in achieving success. Though planning did not always guarantee success, it was a critical aspect to achieving it.

True to FABI tradition, a highlight of the evening was the presentation of awards in several categories. These awards recognize academic excellence as well as contributions to broader scientific efforts such as public engagement. Importantly, it also provides the opportunity to thank people external to the research teams for their contributions to making FABI a success.

FABIAN of the Year: Darryl Herron

Award Recognising Contributions by a Person

External to the Institute: Managing Director of Sappi Forests, Dr Terry Stanger (in absentia)

Award for UP staff member: Prof. Anton Ströh

Best Student Publication: Darryl Herron

Best Post-Doc Publication: Drs Alistair McTaggart and Maria Vivas

Best M.Sc.: Danielle Roodt

Award for Mentorship: Tayo Adenigba, Desre Pinard, Run Lei Chang

Best Student Personal Website: Miekie Human, Osmond Mlonyeni

Award for "Getting the Message to the Public": Juanita Avontuur

Best Photograph Illustrating a FABIAN or FABIANS at work: Ludwig Eksteen

Best photograph illustrating FABI Research: Ludwig Eksteen



Darryl Herron receiving the award as Fabian of the year from Mike Wingfield



International visiting scientists, Prof. Pedro Crous (Netherlands), Prof. Treena Burgess (Australia), Prof. Louis Bernier (Canada) and Prof. Jarrko Hantula (Finland) with Prof. Brenda Wingfield (UP)



Prof. Mike Wingfield (FABI Director) with some of the 2015 B.Sc honours students who were affiliated with FABI

CONTACTING THE TPCP AND CTB RESEARCH TEAM AND DIAGNOSTIC CLINIC



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