INTERNATIONAL YEAR OF PLANT HEALTH 2020

Tree health in South Africa: Retrospect and prospect

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DATES:
Received: 07 Mar. 2020
Revised: 25 June 2020
Accepted: 29 June 2020
Published: 26 Nov. 2020

HOW TO CITE:
Wingfield MJ, Hurley B, Wingfield B, Slippers B. Tree health in South Africa: Retrospect and prospect. S Afr J Sci. 2020;116(11/12), Art. #8038, 8 pages. https://doi.org/10.17159/sajs.2020/8038

ARTICLE INCLUDES:
☒ Peer review
☐ Supplementary material

DATA AVAILABILITY:
☐ Open data set
☐ All data included
☐ On request from author(s)
☐ Not available
☒ Not applicable

EDITORS:
Teresa Coutinho
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KEYWORDS:
forest pathology, forest entomology, tree diseases, forest pests

FUNDING:
None

South Africa is a country with very limited natural forest cover. Consequently, the timber and fibre needs of the country cannot be provided for from indigenous forest. It is largely for this reason that South Africa initially developed a highly productive plantation forest industry, which today makes a substantial contribution to the local economy. These plantations are based on non-native species of *Eucalyptus*, *Pinus* and Australian *Acacia*. In the early years of establishment, South African plantations were relatively free of pest and pathogen problems. But, over time, an increasing number of insects, fungi and bacteria have emerged as serious threats to the sustainability of the forestry industry. Numerous native pests and pathogens, especially insects, have adapted to these introduced tree species to cause damage or disease. The problem is compounded by the accidental introduction of non-native pests and pathogens, and this has been at a rapidly increasing rate over the past three decades. Some of these introduced pests and pathogens also threaten the fitness and even the survival of many indigenous South African tree species. Fortunately, South Africa has developed an impressive knowledge base and range of integrated management options to deal with these problems. This development was first driven by government programmes, and in more recent years by public–private partnerships between industry, universities and government. It is clear from the pattern of emergence of pests and pathogens in recent years that South Africa will deal with an increasing number of these problems and a continuously changing tree health environment. This requires robust investment in both quarantine and mitigation mechanisms to protect the country's biodiversity as well as to ensure the sustainability of its wood and fibre industries.

Significance:

- This review about tree health in South Africa was in part inspired by the 2020 International Year of Plant Health. Plant health, and particularly tree health, is an important topic in regard to the sustainability of our forestry industry and conservation of our native forests. South Africa has been a leader in the field and this review highlights some of the achievements that researchers in the country, both past and present, have attained.

Introduction

South Africa is an arid country and consequently has very limited resources of natural forest in the western part of the country. This is the primary reason why South Africa was one of the first countries in the world to establish commercial plantation forestry based on non-native tree species. These plantations were able to accommodate local demand for wood products, especially for construction and fuelwood. In the process, this allowed small tracts of natural forest and woody ecosystems to be spared from destruction.[1]

The first commercial plantations established in South Africa were those of *Pinus pinaster* (around 1825), soon overtaken by *P. radiata* and much later by *P. patula*. Likewise, *Eucalyptus* was an early addition to the exotic tree resource with the first planting of *Eucalyptus globlus* in 1887. Subsequently, commercial forestry has grown considerably in South Africa based mainly on *Pinus* and *Eucalyptus*, but also including Australian *Acacia* species, mainly *Acacia mearnsii*. According to Forestry South Africa, as of February 2020, the current landholding representing commercial plantation forestry in South Africa is approximately 1.2 million hectares.

Many factors affect the health of trees. These factors include damage by insect and nematode pests and pathogens such as bacteria, fungi and viruses. Climatic factors such as rainfall, temperature and wind, as well as edaphic factors including soil structure and quality, are all important contributors to the overall health and vigour of trees. For the purpose of this review, we deal exclusively with pests and pathogens – thus broadly the fields of forest entomology and forest pathology as they relate to the health of forest trees in South Africa.

When considering forest tree health in South Africa, it is important to clearly distinguish between trees in natural woody ecosystems and those that are planted commercially. These are very different situations, both in terms of the impact and the management of insect pests and pathogens. Plantations, especially in the southern hemisphere, typically comprise non-native tree species often planted in high-density monocultures that are intensively managed. The choice of species, provenance or genotype is carefully controlled, and typically tailored to particular regions and sites based on numerous biotic and abiotic conditions as well as risk factors. Natural forest and woody ecosystems in South Africa are biodiverse and composed of large numbers of native trees and other plants in a complex matrix, and are typically protected from logging. In contrast, plantations are managed mainly by commercial enterprises and are of high value. Among other factors, this dichotomy leads to different approaches to managing pests and pathogens, although significant tree health challenges exist in both commercial and non-commercial woody ecosystems.

In plantations, serious damage due to pests and pathogens is usually very obvious and is considered important and worthy of intervention. In contrast, disease and pest problems in natural forests have been afforded very little attention in South Africa in the past. The value of understanding and managing health risks in natural forests has changed in recent years, due in part to the recognition of bidirectional transfer of pests and pathogens between native and non-native plantation systems, and the resulting substantial impacts on trees grown as non-natives in plantations.[2,3] Thus, the establishment of the South African Department of Science and Innovation (DSI) and

National Research Foundation (NRF) Centre of Excellence in Tree Health Biotechnology (CTHB) in 2004, which includes the health of trees and shrubs in natural woody ecosystems as well as commercial plantations, is particularly important.[4]

It is not the intention of this review to provide a detailed history of forest protection in South Africa. There are various previous reviews dealing with the history of forest pathology and forest entomology in the country, which treat this topic relatively comprehensively.[5-9] It is also not an aim to consider the finer details of the likely future concerning forest tree health in this country. That topic has also been treated in some detail in various recent reviews, particularly those relating to plantation forestry.[10,11] In contrast, we attempt to briefly capture some of the key elements of the history of forest protection in South Africa. Furthermore, we broadly consider the current situation and the likely requirements for this field in the future. Rather than focus on the specifics of numerous insect pests and diseases, for which detailed information can be found in the most recent edition of the South African Forestry Handbook, broad concepts with selected examples are provided.[12]

Pest and pathogens of native woody plants

There are extensive records of fungi and insects for South Africa[13-15], which are mainly housed in the National Collections and, in the case of insects, also in various museums. Many among these fungi and insects colonise the living tissue of trees. Yet, very little is known about most of these collections beyond some basic taxonomy. Generally, there has been little support for studies of insects or pathogens occurring in natural ecosystems. This is largely due to the fact that they are not considered to be of economic importance.

Where native trees or shrubs have exhibited signs of serious decline or damage, the causal agents are typically known or thought to be non-native. Perhaps the best example of a non-native organism with severe negative impacts on native plants is the root-feeding fungus-like heterokont, *Phytophthora cinnamomi*, which is particularly important on species of the Proteaceae in natural areas within the Cape fynbos.[16-18] Among the most susceptible native species is *Leucadendron argenteum* (the Cape silver tree), which has died in large numbers on the Cape Penisula.[19] Research on *P. cinnamomi* has shown that the pathogen was most likely introduced into South Africa.[20] The unusually large numbers of plants that have been killed, together with the rapid onset of this disease, support this view. Another contemporary and well-publicised example of an introduced pathogen that has the potential to damage native woody plants in South Africa is the root-feeding fungus, *Armillaria mellea*. This fungus was accidentally introduced into the country, most likely from Europe by early European settlers[21], and has gradually become established in the natural environment of the Cape Penisula[22,23], with devastating effects on *Protea* and *Leucodendron*.

In many cases in which trees or woody plants are diseased in natural ecosystems, the origin (i.e. native versus introduced) of associated pests or pathogens is difficult to determine.[2,24] Organisms that are new to science (commonly the case) are often erroneously designated as native owing to the lack of knowledge of their true worldwide distribution. This is important because geographic origin aids in predicting the spread and severity of a novel pest or pathogen problem and informs the search for potential biological control agents. The rapidly growing availability of population-based molecular genetic tools has, however, changed this situation. A growing number of studies show that pathogens found associated with tree diseases in natural ecosystems are in many cases likely to be of exotic origin.[20,24-27]

The importance of tree health in natural forests has recently been highlighted by the accidental introduction of the polyphagous shot hole borer, *Euwallacea fornicatus*, and its fungal symbiont *Fusarium euwallaceae*.[28] The beetle is native to Asia and was first detected in South Africa in 2016, as part of a programme to survey botanical gardens for new and emerging pest risks. Originally isolated from the non-native London plane tree (*Platanus* x *acerifolia*), it has subsequently been recorded on a large number of tree species in South Africa, including native forest species. The impact of this invasive beetle and pathogen on South Africa's natural forest is currently being investigated (De Beer ZW 2020, personal communication). Its introduction strongly emphasises the importance of surveillance programmes, such as those in botanical gardens and arboreta, amenity tree plantings as well as in natural and plantation forests, and ports of entry.

Pests and pathogens of plantation trees

Native insects and fungi

Not surprisingly, the history of recording and studying pests and pathogens of plantation-grown trees dates back to the beginning of the forestry industry in South Africa.[2,29] Some of the first records of pests and pathogens in plantations were those caused by native organisms that were able to feed on the non-native trees. Noticeable examples were of the pine emperor moth (*Nudaurelia cytherea*) recorded damaging *Pinus radiata* in 1885 and Armillaria root rot[30] (now known to be caused by the native *Armillaria fuscipes*)[31] recorded on *Pinus* species in various provinces of South Africa[32].

Many other native insect pests and pathogens are now known to cause serious damage to commercially propagated species of *Pinus*, *Eucalyptus* and *Acacia* in South Africa.[3] The analysis by Crous and co-authors[3] showed that native insect pests more commonly shift to and cause damage to these non-native plantation trees than do native pathogens. Examples include the wattle bagworm, *Kotochalia junodi*, that has been severely damaging to *Acacia mearnsii* virtually since the tree was first planted in this country.[6,9] Numerous other native insects, including defoliating and wood-boring Lepidoptera and Coleoptera, white grubs and sap-sucking insects are pests of *Eucalyptus*, *Pinus* spp. and *A. mearnsii*.[12,33] Recent outbreaks of the wattle semi-looper, *Achaea lineardi*, the pine brown tail moth, *Euproctis terminalis,* and *N. cytherea* (authors' personal observation) indicate the importance of these native insect pests and the need for research to acquire knowledge on their biology, population dynamics, diversity and other aspects that will inform management actions.

The relatively large number of native insects that have been able to feed on non-native plantation trees, at least in comparison to examples of pathogens, might relate to the fact that a subset of insects are highly polyphagus. They consequently have wide host ranges and thus easily adapt to feed on non-native trees.[3] There are nevertheless a number of examples of damaging native pathogens that have adapted to damage non-native plantations. This number is also increasing because a number of contemporary studies using DNA-based techniques have shown that fungal pathogens, which might originally have been thought of as introduced into South Africa, are actually native.

A recent and fascinating example of a native pathogen originally believed to be introduced into South Africa is found in the case of the eucalyptus canker pathogen *Chrysoporthe austroafricana.* When first discovered in South Africa, this fungus was thought to be the notorious *Cryphonectria cubensis* (Figure 1). But it was later shown to be a native fungus occurring naturally on South African Myrtaceae which had undergone a host range shift to infect introduced *Eucalyptus* spp.[34-36] Likewise, the canker stain and wilt pathogen of *A. mearnsii*, *Ceratocystis albifundus,* was originally thought to be the pathogen *C. fimbriata* and was later shown to be a common natural inhabitant on the wounds of many native South African woody plants.[37] Likewise, a relatively large number of Botryosphaeriaceae canker and dieback pathogens that occur in non-native plantations are likely native to the region.[38] The origin of many pathogens remains unclear and it is expected that further sampling and growth in the number of molecular population genetic and phylogeographic studies will reveal that other pathogens on non-native plants are native.

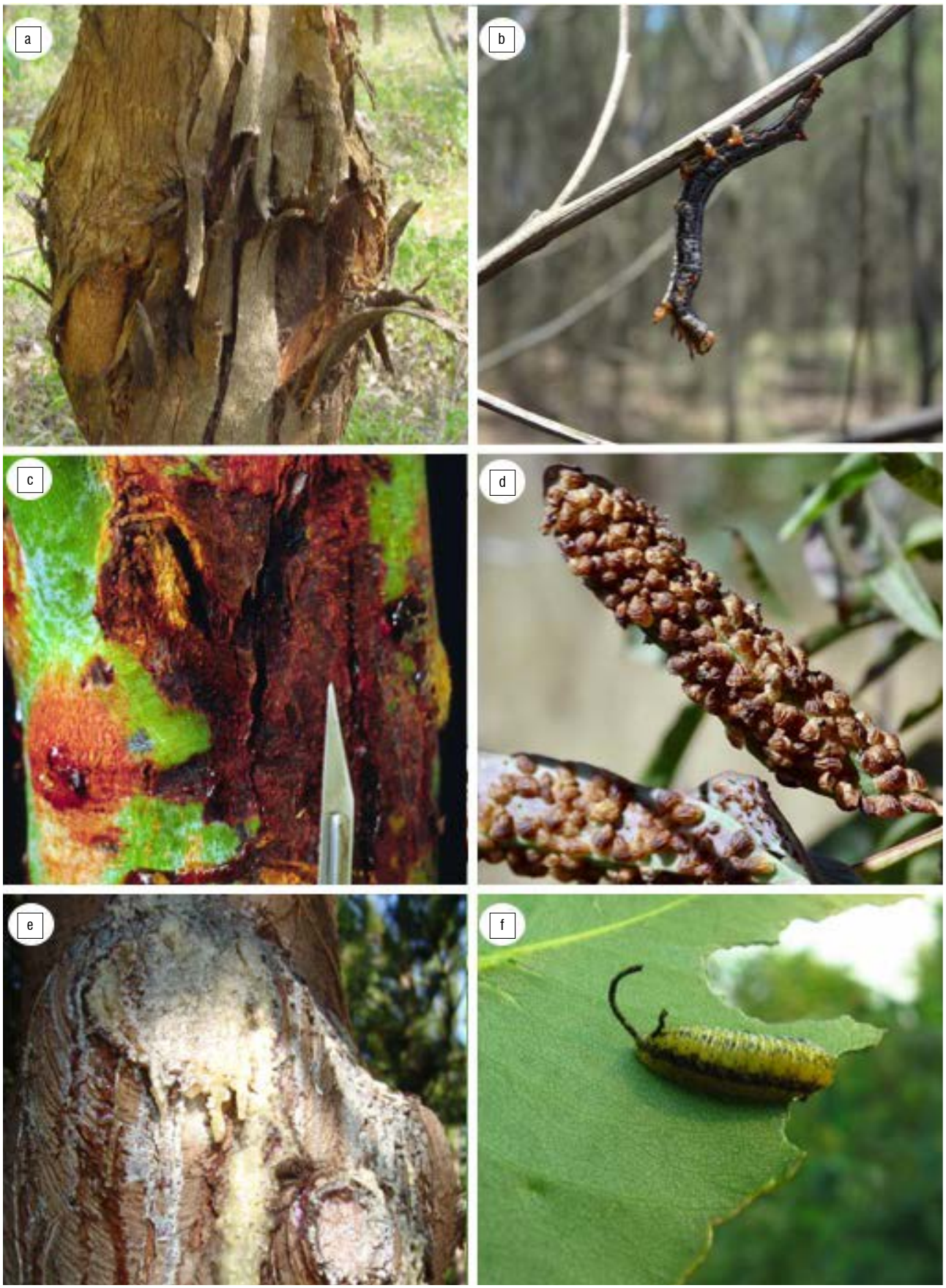

Figure 1: Pathogens and insect pests of plantation trees in South Africa: (a) *Cryphonectria* canker on *Eucalyptus* – one of the first serious diseases to emerge in South African clonal forestry; (b) the wattle semi-looper, *Achaea lineardi*, a native insect and sporadic pest of *Acacia mearnsii*; (c) symptoms of *Coniothyrium* canker caused by *Teratosphaeria zuluensis* on a susceptible *Eucalyptus* clone; (d) the shell lerp psyllid, *Spondyliaspis* c.f. *plicatuloides*, a recently introduced pest of *Eucalyptus*; (e) canker on pine stem with resin bleeding caused by the pitch canker fungus *Fusarium circinatum*; (f) larva of the eucalypt snout beetle, *Gonipterus* sp. n. 2, feeding on *Eucalyptus*.

Non-native insects and fungi

While native pests and pathogens can clearly cause very serious damage to non-native trees in plantations, it is generally recognised that the outstanding growth of these trees is largely due to the fact they have been separated from their natural enemies. In this respect, they behave much like weeds with their superior performance being attributed to 'enemy release'.[39] It is for this reason that the accumulation of insects and pathogens and the accelerating rate of introduction into the non-native plantation resource of South Africa represent a serious threat to the local industry.[8,9,11,29,40]

Host-specific insect pests and pathogens of species of *Pinus*, *Eucalyptus* and *Acacia* known to occur in the areas of origin of these trees have appeared in South African plantations with increasing frequency. When cumulative data for insects and pathogens of any of these trees are examined, there is a clear trend of an accelerating problem and it is one that is likely to continue in the foreseeable future.[9,29,40] Risk abatement and management strategies must clearly take this growing threat into serious consideration.

The eucalyptus snout beetle, *Gonipterus* sp. n. 2 (originally recorded as *G. scutellatus*)[41], recorded in South Africa in 1916 (Figure 1), was the first serious non-native pest to affect non-native plantations in the country[42,43]. Numerous other non-native insect pests, especially those on *Pinus* spp. and *Eucalyptus* spp., have subsequently entered the country, with varying impact. These include various guilds of insects, including sap-suckers, gall formers, bark and wood borers, and defoliators.[12,33] The more recent arrivals are the bronze bug (*Thaumastocoris peregrinus*), bluegum chalcid (*Leptocybe invasa*), red gum lerp psyllid (*Glycaspis brimblecombei*), shell lerp psyllid (*Spondyliaspis* c.f. *plicatuloides;* Figure 1), and the eucalypt gall wasp (*Ophelimus maskelli*) – all pests of *Eucalyptus* and recorded in 2003, 2007, 2012, 2014 and 2014, respectively.[44-46]

Non-native pathogens have had a very substantial impact on plantation forestry in South Africa. It can be reasonably argued that they have substantially influenced the choice and distribution of species planted. The pine shoot and dieback pathogen *Diplodia sapinea* was the first non-native pathogen recorded in South African plantations[47,48] and was rapidly recognised as leading to the death of large numbers of trees after hail damage[49,50]. Thus, susceptible species, such as *P. radiata* and *P. patula,* were specifically not planted on sites prone to hail storms. Likewise, leaf blotch caused by *Teratosphaeria nubilosa* (originally recorded as *Mycosphaerella molleriana*) is thought to have contributed to the failure of *E. globulus* as a plantation species in South Africa.[51] From the insect side, the eucalyptus snout beetle is at least in part responsible for the discontinued planting of *Eucalyptus viminalis* and *E. globulus* in the country.[40,42,43] And the recent introduction of the gall wasp *L. invasa* has already substantially influenced the *Eucalyptus* genotypes that can be planted in affected areas due to considerable differences in host resistance.[45,52]

Much as in the case of introduced insect pests, a large number of host-specific pathogens of *Pinus*, *Eucalyptus* and *Acacia* species have been recorded in South Africa.[2,3,12] Many of these are relatively weak pathogens that have not caused serious damage, while others are much more important. Certainly, the most important pathogen affecting commercial forestry in recent years has been the pine pitch canker pathogen, *Fusarium circinatum* (Figure 1). This pathogen was first found in a single nursery in 1991 and it has subsequently spread to all pine production nurseries in the country.[53,54] For many years, it was known only as a nursery problem, but in 2005 it was first recorded on mature *P. radiata* trees on the Cape Peninsula.[55] While the canker disease on established trees is of concern, particularly in coastal plantations, the most important impact of *F. circinatum* has been that it has rendered *P. patula* virtually impossible to establish cost effectively.[56] Essentially, the most important *Pinus* species planted in South Africa will most likely need to be replaced due to this pathogen.

Non-native pests and pathogens entering South Africa may arrive from the native range of plantation trees. As these agents of disease are increasingly being moved around the world, the probability of establishment increases non-linearly.[2,9,11,40,57] Available evidence suggests that once a pest or pathogen has become established in a new environment, it is more likely to move again – a trend referred to by Lombaert and co-authors[58] as 'a bridgehead effect'. The worldwide movement of the Sirex woodwasp *Sirex noctilio*, one of South Africa's most serious pine pests, is one of many insects and pathogens that illustrates this effect.[29,59-62] Trees in urban environments often serve as a convenient bridgehead between regions, before pests and pathogens spread into natural or plantation forests.[63] For this reason, urban environments, and botanical gardens in particular, offer important opportunities to study and monitor invasive or potentially invasive pathogens.[63-65]

Management of pests and pathogens

Efforts to reduce the impact of insect pests and pathogens in South African plantations date back to the time of the first records of these problems.[5,6] Broadly, the available options include chemical control, biological control (mainly for insects), avoidance through planting non-susceptible species and efforts to reduce the populations/inoculum loads of the pests/pathogens. While chemical control was quite widely used in the early period of South African forestry (see for example Tooke[66]), the negative environmental and health effects, and consequently rules set by, for example, the Forestry Stewardship Council, have rendered this approach increasingly difficult.

South Africa has a long and well-established history of using biological control to reduce the impact of forest pests (Figure 2). This use dates back to the introduction of the parasitoid wasp *Anaphes nitens* for the biological control of *Gonipterus* sp. 2 (then known as *G. scutellatus*)[42,43], which remains one of the classic examples of successful biological control. Other examples of classical biological control for non-native insect pests include *Pauesia* sp. for the control of *Cinara cronartii*, various biological control agents for the control of *Phoracantha* species, *Deladenus siricidicola* and *Ibalia leucospoides* for the control of *S. noctilio* (Figure 2), *Selitrichodes neseri* for the control of *L. invasa*, and *Cleruchoides noackae* for the control of *T. peregrinus*.[6,67-70] Biological control remains the most effective option currently available to manage the impact of damaging introduced forest insects.[40,71]

Various strategies have been used to reduce the impact of diseases in South African plantations.[10] Silvicultural methods such as thinning to reduce stress and the removal of dead and dying plant material from plantations are commonly applied for both insect and pathogen management. But the most commonly used approach is planting resistant species or clones in areas prone to infection by fungal pathogens. The most notable and long-standing example is found in the case of the shoot and dieback pathogen *Diplodia sapinea.* This fungus is opportunistic and infections typically occur on stressed trees, as mentioned above. The most commonly encountered of these stresses is that associated with hail damage.[49,50] Thus, highly susceptible species such as *P. radiata* and *P. patula* have been confined to areas where the risk of hail is minimal. Likewise, damage due to pruning produces wounds for infection and, at least for some time, stress on the trees, which often results in infection. Thus, recommendations for pruning at times of the year when *D. sapinea* is unlikely to infect[50] have been implemented.

By far the most commonly used and effective means to deal with disease in plantations is to establish trees that are highly tolerant or even resistant to infection.[10,72] As mentioned previously, this approach has been very effective in reducing the damage caused by various pathogens. Particularly for *Eucalyptus*, the emergence of vegetative propagation and, thus, clonal forestry has had a remarkable impact on the ability to manage disease problems. Here, the selection of clones of single species, and increasingly hybrids, has allowed forestry companies to avoid disease problems (Figure 2).

Opportunities to avoid disease problems by deploying *Eucalyptus* clones with low levels of susceptibility first emerged at the onset of the serious canker diseases caused by *Chrysoporthe austroafricana* and *Teratosphaeria zuluense* (=*Coniothyrium zuluense*). Over a 20-year period, the diseases caused by these serious pathogens have been reduced to a tolerable level.[10,34] This has necessitated extensive screening trials.[73-75] Planting resistant genotypes is also important for the control

of insect pests, where host resistance coupled with biological control is likely to be the main strategy for the management of pests such as *L. invasa*[45] and *G. brimblecombei*[45].

In the longer term, understanding the biology and global movement of insect pests and pathogens affecting plantation trees, including those in South Africa, will be facilitated by molecular genetic tools that are rapidly emerging for this purpose.[72,76] Sequencing of the genomes of trees such as *Eucalyptus*[77] as well as those of important *Eucalyptus* and *Pinus* pathogens[78-81], pests[61,82] and their biological control agents[83], is already providing important insights. Ultimately, DNA-based genetic markers will also be produced to detect traits such as susceptibility to a particular disease based on small tissue samples.[72]

Looking ahead

South Africa has had a long history of dealing with insect pests and diseases affecting plantation-grown trees. Initially, most work in this field was done by small groups of scientists working in research institutes (government and private) or at universities. Up until the early 1970s, the larger proportion of the forest plantation patrimony was in government hands and support for forest pathology and entomology came primarily from government. Later, as the private forestry industry began to grow, and together with growing numbers of emerging insect pest and disease problems, the need for a more unified forest protection resource has also grown. This need has been filled largely by the Tree Protection Co-operative Programme established in 1990 and representing a collaborative venture between university and private forest owners, together with financial support by various government funding agencies. In more recent years, private companies have also begun to support some field-level research and development 'in house' in order to increase their capacity to deal with the increasing threats due to pests and diseases. The Eucalyptus and Pine Pathogen Interactions Programme, together with the Forest Molecular Genetics Programme, is also increasingly supporting gene and genome based approaches to pest and pathogen management.

In the early 1960s, at a time when plantation forestry based on non-native species, particularly in the tropics and southern hemisphere, was growing rapidly, the pioneer South African forest researcher Dr J.A. Lückhoff made the point that South African forestry had been particularly fortunate in not having been severely affected by tree pests and pathogens.[84] Given the fact that there had been a number of serious disease and pest problems even at that time, Lückhoff's statement might better be interpreted as a recognition that the forest resource could easily have been much more seriously affected. The pool of potentially damaging species is vast, and only a fraction of possible invaders have established to date. If one considers the situation today with the growing numbers of new pests and pathogens that continue to appear, there is little doubt that these factors will challenge plantation forestry greatly in the future.

One of the reasons that plantation forestry has not been devastated by insects and diseases must be attributed to the fact that a wide variety of trees has been grown in South Africa over time, changing species and

Figure 2: Management strategies for pathogens and insect pests of plantation trees in South Africa: (a) a clone of *Eucalyptus grandis* seriously damaged by *Coniothyrium* canker caused by *Teratosphaeria zuluensis,* alongside a disease tolerant clone, illustrating the potential benefits of breeding for resistance; (b) inoculating the nematode *Deladenus siricidicola* into a pine tree infested with *Sirex noctilio*, as part of a successful biological control programme first implemented in South Africa in 1995; (c) releases of the parasitic wasp *Psyllaephagus bliteus* to control the red gum lerp psyllid, *Glycaspis brimblecombei*; (d) a lure-based trap used to monitor populations of *S. noctilio* and thus inform management strategies.

clones as disease and pest problems have arisen. This has provided a buffering effect and the absence of an undue reliance on any particular species over space and time. The available variability of planting stock to deal with changing pest and disease problems has come about, not so much as a result of careful planning to minimise risk, but rather due to the fortuitous fact that South Africa is a large country with hugely variable climatic and edaphic zones that are not suitable to any single species of *Pinus*, *Eucalyptus* or *Acacia*. Yet, in terms of risk, continuous attention must be paid to ensure the maintenance of a genetically variable, yet manageable planting stock. The heavy reliance on *P. patula* and the potential loss of this species due to the pitch canker pathogen provides a strong warning signal in this regard.

Intensive commercial forestry practices such as those employed in South Africa can, of themselves, elevate the threat of damage due to insect pests and pathogens. Large-scale planting of single species, and especially blocks of identical clones of trees, can allow populations of insects and pathogens to build up rapidly. Planting disease- or insect-tolerant clones can also produce genetic adaptation, resulting in new and potentially more damaging pest or pathogen strains in the environment. Likewise, short rotations of trees planted on the same sites can result in the build-up of populations of soil-borne insects and microbial pathogens.

While plantation forestry based on non-native species might be considered a relatively high-risk enterprise, there are also many options to combat pest and pathogen problems. New technologies continue to emerge that promise to improve our ability to deal with these problems.[72] The introduction of vegetative propagation and the ability to hybridise between species has thus provided many examples of solutions to pest and pathogen problems.[10] Molecular genetic techniques which have made it possible to 'fingerprint' clones and thus to select and more carefully deploy planting stock, have already had a significant positive effect on dealing with diseases and insect problems.[10,72] In the longer term, there seems little doubt that genetic modification will become an important tool for this purpose. In effect, the intensive propagation of fast-growing trees represents a conflict between pests, pathogens and the successful production of timber and timber products. Recognising the challenge is perhaps the most important part of overcoming the enemy and ensuring forest plantation sustainability.

Native forests and woody ecosystems are particularly vulnerable to invasive alien pests and pathogens. Once a serious invasive alien organism becomes established in these heterogeneous and sensitive environments, there is little chance of recovery. There are many examples, particularly in the boreal region, that illustrate this fact.[85,86] Although there are some very worrying examples, South Africa has been relatively fortunate in not having been severely affected by disease problems in natural woody ecosystems. Unfortunately, this situation is also likely to change, well illustrated by the recent report of the polyphagous shot hole borer *Euwallacea fornicatus*[28], a stem canker disease of *Rapanea melanophloeos*[87] and the recent arrival of the myrtle rust pathogen *Austropuccinia psidii*[88]. *Austropuccinia psidii* is likely to cause serious issues for *Eucalyptus* forestry in South Africa, but these problems can be resolved through breeding and selection. It will most likely also severely impact some native Myrtaceae to varying degrees, and may even drive highly susceptible species such as *Heteropyxis natalensis* to extinction. *Euwallacea fornicatus* might have even more serious consequences, and might also threaten certain species with extinction should a biological control management option not be found.

Every effort must be made to strengthen quarantine measures and to ensure that new and damaging insect pests and pathogens of trees are not accidentally introduced into South Africa. At the same time, the capacity to deal with pests and pathogens after their introduction should be strengthened. Yet, as history has shown, even the best quarantine does not provide complete protection. Given that the current quarantine systems are far from effective, South African forestry is likely to have to deal with many more serious pests and pathogens affecting forests and forestry in the future.

Acknowlegements

We are grateful to the members of the Tree Protection Co-operative Programme, the DSI/NRF Centre of Excellence in Tree Health Biotechnology, the Department of Environmental Affairs, Rural Development, Forestry and Fisheries (previously Department of Agriculture, Forestry and Fisheries), and the University of Pretoria for sustaining one of the world's strongest programmes focused on the health of forest trees. This support provides some confidence in ensuring the long-term sustainability of forests and forestry in South Africa.

Competing interests

We declare that there are no competing interests.

Authors' contributions

All authors contributed to the conceptualisation and writing of the article; M.J.W. produced the initial draft.

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