First IUFRO Working Party 7.02.13 meeting:

Improving forest health on commercial plantations.

Punta del Este, 21-23 March 2018.

BOOK OF ABSTRACTS.

Organizers:

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Index

WELCOME MESSAGE

Dear friends and colleagues,

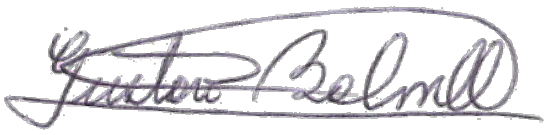
On behalf of the Organizing Committee, it is an honour for me to welcome all of you to the IUFRO first meeting of the recently created WP 7.02.13 “Forest Health in Southern Hemisphere commercial plantations”.

This meeting, under the main title “Improving forest health on commercial plantations”, focuses on pests and diseases affecting commercial hardwood and softwood plantations in the Southern Hemisphere, especially on commonly planted species such as eucalypts, acacias and pines. We have defined seven main topics, but our main objective is to broaden the discussion to other commercial plantations issues.

A one-day field trip in the southeastern region of Uruguay will allow participants to know intensively managed plantations of eucalypts and to see the most frequent pests and diseases affecting them, being an excellent opportunity to exchange experiences and discuss management alternatives.

Last but not least, this meeting will be a unique opportunity to enjoy the natural beauties of Uruguay.

I´m looking forward to a very fruitful meeting in Punta del Este!



Dr. Gustavo Balmelli
Leader of the Organizing Committee

ORGANIZATION

The organizers

IUFRO

IUFRO is "the" global network for forest science cooperation. It unites more than 15,000 scientists in almost 700 Member Organizations in over 110 countries, and is a member of ICSU. Scientists cooperate in IUFRO on a voluntary basis. (www.iufro.org)

Division 7 - Forest Health. This Division includes research on: physiological and genetic interactions between trees and harmful biotic impacts, including resistance mechanisms; biological and applied aspects of tree diseases; environment/ pathogen interactions in forest decline; the biology and control of forest tree insects; and impacts of air pollution on forest trees and forest ecosystems, including diagnosis, monitoring, biology, genetics and treatment of polluted forests and other wooded lands. (www.iufro.org/science/divisions/division-7)

7.02.13 - The Forest Health in Southern Hemisphere Commercial Plantations Working Party aims to improve the management of forest health issues through increased contact and collaborations between forest health professionals. The Working Party will focus on forest health issues affecting commercial hardwood and softwood plantations in the Southern Hemisphere; in particular the focus will be on commonly planted species such as eucalypts, acacia and pines. However, we welcome any individuals from Northern Hemisphere countries who are working on the same forest species, pests and pathogens, with similar style plantation and silvicultural processes. (www.iufro.org/science/divisions/division-7/70000/70200/70213/)

INSTITUTO NACIONAL DE INVESTIGACIÓN AGROPECUARIA (INIA) (Uruguay)

INIA is the National Agricultural Research Institute of Uruguay, a non-public governmental institution. Its mission is to contribute to the integral development of farmers and the national agricultural sector, generating, incorporating and adapting knowledge and technologies considering the state policies, the economic and environmental sustainability and the social equity. Over 160 scientists work for 11 research programs, using facilities at five experimental stations. (www.inia.uy/en)

UNIVERSIDAD DE LA REPÚBLICA (UDELAR) (Uruguay)

Universidad de la República is the leading institution of higher education and research in Uruguay. It was founded on 1849 in Montevideo, having nowadays a student body of 108,886 students (2012). In collaboration with a wide range of institutional and social actors, also performs multiple activities aimed at socially valuable use of knowledge and dissemination of

culture. It is a public institution, autonomous, with a board integrated by Faculty, students and Professionals. (http://www.universidad.edu.uy/)

FOREST PROTECTION RESEARCH GROUP (GIPF) (Uruguay)

The GIPF is integrated by researchers from INIA and UDELAR, and includes pathologists, entomologists, breeders, mycologists, physiologists, and statisticians. It aims to coordinate efforts to develop the forest protection at a national level, with a strong interaction with the industry, and other national agencies involved with forest resources, including both native and exotics.

NSW PRIMARY INDUSTRIES (Australia)

The Department of Primary Industries (DPI) is part of the Department of Industry, Skills, and Regional Development, also known as the Department of Industry. DPI works to increase the value of primary industries and drive economic growth across NSW. DPI manages a broad range of initiatives from resource to industry, including natural resource management, research and development, pest and disease management, food safety, industry engagement, and market access and competition. (www.dpi.nsw.gov.au/)

BIOFOREST SA (Chile)

Bioforest was founded in 1990 with a mission to develop and apply technologies to maximize production of ARAUCO's industrial and forestry resources. Today it is recognized as a scientific-technological research center of excellence, the only one of its type in Chile and South America. Recognized for its leadership in the development of technological forestry and industrial development, Bioforest employs highly specialized personnel, applying the latest technology in its labs, plant nurseries, and the company's forestlands and industrial facilities. In addition, Bioforest is part of a technological network of open collaboration among national and international organizations that are up-to-date on the latest industrial forestry scientific knowledge, generating an exchange of information that nourishes the company and the forestry industry as a whole. (www.bioforest.cl)

SCION (New Zealand)

Scion is a Crown Research Institute (CRI), which is a government-owned company that carries out scientific research for the benefit of New Zealand. Each of seven CRIs is aligned with a productive sector of the economy or a grouping of natural resources. We specialize in research, science and technology development for the forestry, wood and wood-derived materials and other biomaterial sectors. We are the leading CRI in: Sustainable forest management and tree improvement; Forestry biosecurity, risk management

and mitigation; Wood processing, wood-related bioenergy, waste streams and other biomaterials; Forestry and forestry-based ecosystem services to inform land-use decision making. Also, we collaborate with other research providers and end-users to develop: Land-based biosecurity, soil and freshwater management; Climate change adaptation and mitigation; Indigenous forestry; Industrial biotechnology and high-value manufacturing. (www.scionresearch.com)

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PLENARY SESSIONS

Insect pests of plantation trees: challenges and responses.

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There has been a concerning decrease in the world's total forest area over the last number of decades, combined with an increasing world population and the associated rise in the demand for products from trees such as timber, fuel and fibre. Plantations of non-native trees are rapidly expanding in many areas to meet these demands; however, the productivity of these plantations is often reduced due to losses from insect pests. Studies have shown that there is an exponential increase in the rate of introduction of invasive insect pests of plantation trees, originating from the native range of their host trees. In addition, there are increasing reports of new host associations of native insects on the non-native tree hosts, in some cases resulting in substantial losses. To develop management strategies for these insect pests, it is important to not only determine the distribution of the insect, but also the genetic diversity within and between populations. Studies into the genetic diversity of important insect pests such as the Sirex woodwasp, *Sirex noctilio*, the bronze bug, *Thaumastocoris peregrinus*, and the *Eucalyptus* snout beetle, *Gonipterus* spp, have revealed multiple and continued introductions of the pests into the same region, and in some cases the presence of cryptic species. A more recent study is using sequence data from eucalypt insect pests collected across sub-Saharan Africa to provide important information on the movement of eucalypt insect pests into and within the region. In addition to understanding diversity, the use of DNA markers can also be used to examine the biology of insect pests, such as with the gall wasp *Leptocybe invasa*, where restriction enzymes and species-specific primers have been used to unravel the interactions within the *L. invasa* gall community. There are a number of strategies to manage insect pests of plantation trees. Of these, biological control remains one of the key strategies, with biological control agents released for many of the more serious insect pests. However, it is important to understand the influence of genetic diversity of both the agent and the pest, as well as the influence of the environment, on the effectiveness of the biological control programme. Although much of the past work has focused on a classical biological approach, there is much opportunity to use biological control in an augmentative approach and for native insect pests. In addition to biological control, the use of other methods such as behavioural control can also be very successful. For example, a project to use over 6 000 pheromone based traps to reduce populations of the native cossid moth, *Coryphodema tristis*, in South Africa, has shown promising results. Strong collaborations and the adoption of new technologies are often necessary to ensure the success of any management strategy.

The Sirex woodwasp in South America: research on the best known pest of pine plantations.

Juan Corley[1]; Victoria Lanstchner[2]; Andres Martinez[2]; Deborah Fischbein[2]; Jose Villacide[3]

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Plantation forestry with non-native trees is steadily increasing in many developing countries of the Southern Hemisphere. In South America, more than 12 million hectares of land are planted mostly with non-native species such as *Pinus* spp., *Eucalyptus* spp. and *Populus* spp., and the rate of change in the planted forest area in the last years for some countries such as Chile or Brazil, ranks among the highest reported. While disease problems and insect pests affect a small proportion of forest worldwide, it has been noted that through accidental introductions, alien forest insects and pathogens have become the most important threat to plantation forestry in the region. A recent report jointly produced by 6 South-American countries, states that there are at least 58 non-native insects established in cultivated forests. Among these, and likely the most damaging and widespread pest of pines, is the Sirex woodwasp. Since it first detection in South America in 1980 (*S. noctilio* is a Hymenopteran native to Eurasia and Northern Africa), extensive data has become available, allowing us to provide a retrospective overview of the ecology and management of this forest pest. Firstly, I focus here on the factors that may explain the observed population outbreaks in South America. I then review the monitoring and management strategies deployed in the region, centering on the success rates achieved through biocontrol programs. Notably, the occurrence of woodwasp population eruptions has been described for almost all regions where it has established in South America, reaching tree mortalities of up to 70% in Uruguay, 60% in Brazil, 75% in southern Argentina and 50% in central Chile. It has been suggested that outbreaks may be mostly related to bottom-up factors, especially those that influence individual tree vigor. Outbreaks in South America have been found to be more likely in pine stands that are to overstocked and unmanaged, grown under drier conditions and that the planted pine species may also be an important trigger. The end of the outbreaks, appear to be determined by strong negative density-dependence, probably as the result of widespread food depletion. A variety of natural enemies (several parasitoids and the entomopathogenic nematode *Deladenus siricidicola*) have been introduced to manage *S. noctilio* in South America. However, the role of top-down factors in regulating the woodwasp population growth during outbreaks remains unclear. Although parasitism levels achieved by the biocontrol agents have been high in several pest populations at endemic levels, there is no available information on their impact in preventing and/or during outbreaks. Some of us have suggested that synchrony in *S. noctilio* eruptions, triggered by broad scale changes in drought levels, results in a regionalization of population fluctuations, which may dilute the regulating effects of natural enemies that could otherwise provide local-level control. However, the lack of appropriate regional-scale monitoring techniques, preferably based on insect trapping using

semio-chemicals, rather than lagged estimations of tree damage, will allow “real-time” information of the pest populations and of the true impact and role of natural enemies versus forest management and environmental factors on population regulation. Unravelling the factors influencing woodwasp population ecology, including appropriate standardized sampling methods, is not only central to managing their populations under expanding afforestation policies and under global change scenarios for South America, but may also help us improve our abilities to prevent and manage new alien pests in plantation forestry in the region.

Improving forest health through biosecurity and diagnostics.

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Unwanted biosecurity pests and pathogens continuously threaten our forests and have the ability to reduce productivity of commercial plantations, or in the worst case, kill trees. Early detection of unwanted pests and pathogens is critical to mitigate the economic impact of new introductions, whether this is through eradication, slow the spread, implementation of pest and disease management, or addressing market access issues. Regular surveillance and diagnostics also give confidence in identifying new forest health issues, such as new introductions or behaviour changes in established species. Rapid changes in technologies are changing how we monitor and what we are able to detect, as well as providing ways to assess pathway risks. The cost of surveillance programmes can be considered costly, but the long-term financial benefits can often pay for such programmes times over. Biosecurity efforts to prevent unwanted pests or pathogens from entering the country or spreading to new locations are paramount as once established, the ongoing costs of managing pests and diseases or the impact on market access can be substantial.

Pest and disease management in commercial plantations of ARAUCO in Chile.

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Commercial plantations in Chile are composed mainly of *P. radiata*, *Eucalyptus globulus* and *E. nitens*, which together represent 94 % of the total commercial plantations. *Pinus radiata* constitutes the largest surface area of plantations, including about 1.4 million ha (58 %) while *Eucalyptus* spp. are about 860,000 ha (36 %) of the approximately 2.41 million ha of commercial plantations in the country. The majority of the commercial plantations in Chile belong to private industry. Currently, the most significant pests and diseases in *P. radiata* are two insects (bark beetles and *Sirex noctilio*) and four pathogens. The pathogens in particular pose tremendous challenges for forestry since they affect the three main parts of the trees, namely the root systems and collars in the case of *Fusarium circinatum* in nurseries, the stems by *Neonectria fuckeliana* and the foliage by *Phytophthora pinifolia* and *Dothistroma septosporum*. In the case of *Eucalyptus* spp., the main problem is *Gonipterus platensis* but in general these two *Eucalyptus* species are currently less affected than *P. radiata*. For these pests and diseases, a strategy has been developed based on Surveillance for early detection, Biology of the damage agent, Control of agents, and Improvements in the quality of the plants (selection for tolerance). Due to different constraints (for example, FSC, environmental and social risks) it is not easy to apply a curative treatment for pests and diseases damage and consequently various approaches have been tested to develop an integrated management program using different tools, according on the characteristics of each damage agent. Preliminary results have shown that it will be possible to reduce the damage caused by pests and diseases in both nurseries and plantations, using a combination of management strategies.

FOREST HEALTH FROM A COUNTRY PERSPECTIVE

Health status and threats to plantation forestry in Argentina.

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Plantation forestry in Argentina is dominated by the use of non-native conifers. Among a total of nearly 1.12 million ha of land, from the subtropical northeastern provinces to the colder conditions of Patagonia, pines cover more than 66% of this planted surface area, whereas eucalypts roughly 24%. Adequate soils, water and climate contribute to good growth conditions, but the fact that the pressure of herbivory found in the native range for most of these tree species is lacking in the planted areas, undoubtedly helps. A key issue is how long this preempted natural enemy free space will last for, as the movement of people and goods across the national border is increasing together with the arrival and establishment of alien pests. Added to this, there are a few native insects that adapt to the new forest environment. Several well-known non-native insects-many shared with other countries of South America- and the native leaf-cutting ants, are the main pest issues of both pines and eucalypts in Argentina. However, there is little if any quantification of damage for most of them in the country, and this is probably explained by the fact that perceived economic impact to date is low. To provide appropriate impact estimates, prevent new species establishment and consequently sustain tree growth rates, national-level monitoring and early programs are being started. Additionally, cross-border collaboration, including fundamental and applied research, are urgently needed.

Forest health in pine and eucalypt plantations in Australia.

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Systematic forest health surveillance of pine and eucalypt plantations began in Australia in the mid-1990s. Various methodologies are employed, including aerial and ground surveillance, ground plots, pest population monitoring, and *ad hoc* detections by forestry staff. The aim is to map the extent and severity of damaging agents (fungal pathogens, insect pests, vertebrate pests, nutritional imbalances, climatic disorders and weeds) to enable optimum management. Here we focus on the key pests and diseases in New South Wales for illustrative purposes, but include key health issues from other states in Australia. Drought-related tree mortality has been the primary damage agent in *Pinus* plantations in NSW over the past 20 years, with associated damage from ips bark beetle (*Ips grandicollis*) and *Ophiostoma ips* and diplodia canker (*Diplodia sapinea*). Other important pests include sirex wood wasp (*Sirex noctilio*), the Monterey pine aphid (*Essigella californica*), dothistroma needle blight (*Dothistroma septosporum*) and cyclaneusma needle cast (*Cyclaneusma minus*). These are managed by various means, including biological control, silviculture and chemical control. In eucalypt plantations in subtropical NSW, which are managed for long-rotation sawlogs, the key pests have been chrysomelid leaf beetles (*Chrysophtharta* and *Paropsisterna*), Christmas beetles (*Anoplognathus* spp.), lerp psyllids (*Cardiaspina* and *Creiis*), stem borers (*Phoracantha* and *Endoxyla*), mycosphaerella and kirramyces leaf diseases (*Teratosphaeria* spp.) and quambalaria shoot blight (*Quambalaria pitereka*). Management of these has often relied on tree breeding, and rarely chemical control (for *Creiis*). In southern temperate eucalypt plantations in Australia, chrysomelid leaf beetles and eucalyptus weevils (*Gonipterus* and *Oxyops*) are often key pests. African black beetle was an issue in young plantations in Western Australia, but is now managed with socks to protect young seedlings. Mycosphaerella and kirramyces leaf diseases are also key pathogens in temperate eucalypt Australia. Myrtle rust (*Austropuccinia psidii*) has not become a significant pest in eucalypt plantations in Australia.

Eucalyptus plantations health in Brazil: a perspective.

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Brazil has been affected by pests in forest plantations, mainly in *Eucalyptus*, since 1908. Besides the problems with leaf-cutter ants and termites (native pests), invasive pests are the most important in 21st century. The red gum lerp psyllid *Glycaspis brimblecombei* (Hemiptera: Aphalaridae), the bronze bug *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae), the blue gum chalcid *Leptocybe invasa* (Hymenoptera: Eulophidae) and the eucalypt snout beetle *Gonipterus platensis* (Coleoptera: Curculionidae) cause more than US$ 600 million of losses in wood production. The PROTEF (Forestry Protection Program), of IPEF works as research cooperative system, involving Universities, research institutions and forest companies, to work in solution of these problems. The main management strategy is based in classical biological control (CBC), with the introduction of Australian parasitoids. In the last 14 years, three species of parasitoids have been introduced (*Psyllaephagus bliteus*, *Cleruchoides noackae* and *Selitrichodes neseri*) to control the first three pest species and *Anaphes nitens* from Rio Grande do Sul (RS) state to Espírito Santo (ES) state (within-country introduction). To *G. platensis* in ES and *T. peregrinus* in South and Central Brazil. The CBC has been proved effective, with expressive population reduction of these pests. Regarding *G. brimblecombei,* the control has been partial, with good results in South Brazil. In central and North Brazil, the parasitoid has been established but cannot control this pest during the dry season (winter and early spring). In 2017, *G. brimblecombei* reached pest levels, and other strategies, as microbial insecticides, were needed to apply. With respect to *L. invasa*, the parasitoid *S. neseri* has been introduced and released in 8 states, becoming established in four states. The early results have been positive in pest level reduction and tree recovering. Since 2014, the participation in the BiCEP program (Biological Control of Eucalyptus Pests Alliance), with researchers of Australia, Brazil and South Africa, has been important to introduce or exchange natural enemies, and for discussing the results and challenges of CBC. Considering *Eucalyptus* diseases, myrtle rust *Austropuccinia psidii* and Ceratocystis wilt *Ceratocystis fimbriata* have been the most important diseases in field conditions and the main strategy control is based in plant resistance and chemical control for myrtle rust.

Health status of forest plantations in Chile.

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Commercial plantations in Chile are comprised of exotic *Pinus* and *Eucalyptus* species, which make up approximately 2.4 million ha. *Pinus radiata* is the main species with about 1.4 million ha and *Eucalyptus* spp. with close to 860,000 ha. Currently, this is the foundation of the forest industry in the country and the second most important economic activity in Chile after copper. Both species had been considered as relatively pest and disease free in Chile, despite their susceptibility to several agents, elsewhere in the world. Globalization has given rise to a very substantial increase in trade between countries and continents, greatly increasing the use of wooden containers. This pattern has increased the risk of introducing new pests and pathogens. During the last 30 years almost every year a new insect or disease has been detected in the country and that will continue in the future. Since 1985 when pine shoot moth was detected, several new pests and diseases have been detected and have caused damage in nursery and plantations. Among the most important species affecting *P. radiata* are; *F. circinatum* present only at nursery level, *S. noctilio* distributed in large part of the *P. radiata* plantations, *P. pinifolia* focused on humid areas, bark beetles damaging the establishment of plantations and export products. While among the most important species that affect *Eucalyptus* are; *O. maskelli* and *G. platensis* causing damage on the foliage. To prevent the introduction of new pests and pathogens that may affect forest productivity and cause severe damage to the ecology and economy of the country, quarantine measures to reduce the chance of accidental introductions of pathogens and insects are crucially important. The objectives of the development and implementation of such a plant quarantine strategy is not only to prevent the introduction of new pests and pathogens, but also to retard their later spread.

Important insect pest and diseases affecting plantation forestry in Colombia.

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Colombia has a surface area of 114 million ha, of which natural forests make up 60.7 million ha representing 53% of the total area. Approximately, 500 000 ha are used for commercial plantations forestry based mainly on non-native species of *Pinus* and *Eucalyptus*. The varied geography in Colombia offers many agroecological advantages for planting *Pinus* and *Eucalyptus*. These provide both genera with optimal and varied conditions that allow rapid grow, adaptability and high potential to increase yields. Since 1950´s, these plantations have been seriously challenged by a large group of insect pests and pathogens, including those native to the country and others that have been introduced from elsewhere in the world. Native insects belong to Lepidoptera (Geometridae), the walking stick insects (Phasmatodea: Heteronemiidae) and the leaf-cutting ants (Hymenoptera: Formicidae) orders, have caused severe defoliation resulting in substantial economic loss in different provinces in Colombia. In recently years, the appearance of introduced insects, such as *Glycaspis brimblecombei*, *Pineus boerneri* and more recently *Gonipterus platensis* have had a negative impact of the productivity of plantations. Emerging diseases caused by *Diplodia sapinea, Dothistroma septosporum, Lecanosticta spp., Fusarium circinatum* and *Calonectria* spp. represent serious threats to *Pinus* species. In the case of *Eucalyptus*, damage due to *Chrysoporthe cubensis*, *Botryosphaeria ribis*, *Cylindrocladium spathulatum*, *Ceratocystis neglecta and Austropuccinia psidii* have increased dramatically in recent years. These diseases and pests have become a matter of national concern because they threaten the economic viability and long-term sustainability of the forestry industry as well as environmental and social stability. As consequence, the forestry sector has re-structured the National Forest Health Programme, including a vision for preventing new outbreaks and to implement control measures. This is mainly focused on breeding and selection of tolerant planting stock and Integrated Pest Management (IPM).

Indonesian forest health status.

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Indonesia is located in the equator zone of South East Asia. The country is characterized by the high rainfall, which can be over 2000 mm per annum and high humidity above 80%. These climatic conditions that promote the fast growth of trees, and a strategic location close to relevant pulp and paper markets have allowed the development of an important forest industry that export more than US$ 5.61 billion per year. To sustain this industry, there is more than 3 million hectares established with fast-growing species in Indonesia. This area, previously occupied by degraded native tropical forest, currently is mostly planted with two genera. The genus *Acacia*, suitable for peatland soil, where the species *A. crassicarpa*, *A. mangium* and its hybrid with *A. auriculiformis* are the most relevant. The second is *Eucalyptus* where the species *Eucalyptus pellita* and its hybrid with *E. grandis* and *E. urophylla* are the most common species planted in mineral soil. Several major pests and diseases have been recorded affecting *Acacia* and *Eucalyptus* plantations in Indonesia. These include sap sucking and defoliator pests, leaf blight diseases, stem borers, vascular wilt diseases, and root rot diseases. The impact of the diseases in the forest plantations can be illustrated with the high level of mortality on *A. mangium* due to animal damage followed by *Ceratocystis* infection that forced the forest companies to replace those areas with *Eucalyptus* spp. plantation over the last few years. Nevertheless, recent surveys on this plantation, reported the presence of new pests and diseases exhibiting several damage levels, including the gall wasps *Leptocybe invasa*, *Ophellimus maskelli*, *O. eucalypti* and leaf rust disease *Austropuccinia psidii*, exemplifying the challenges for the establishment of forest plantations in tropical area. To reduce the losses due to pest and diseases, the Indonesian forest industry have implemented integrated pest and disease management based on the selection of tolerant genotypes, the release of biological control agents and pesticide application. Regular monitoring of pests and diseases must play a fundamental role to detect and understand pest and disease status and its risk and, when it is possible, to direct the required control action.

Forest health status of New Zealand's commercial plantations.

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New Zealand's forestry sector is the country's third largest export industry and ensuring these forests remain resilient to current and future pests and pathogens is a top priority for New Zealand forestry. The status of pests and pathogens of international importance for three of the most economically important plantation species in New Zealand (*Pinus radiata*, *Eucalyptus* spp. And *Pseudotsuga menziesii*) will be presented. This will include the status of pests and pathogens that have been established in the country since the 1960's, such as *Sirex noctilio*, *Phaeocryptopus gaeumannii* and *Dothistroma septosporum*, through to more recent arrivals, such as *Thaumastocoris peregrinus*, *Phytophthora pluvialis* and *Austropuccina psidii*. The economic impact and management of these species in New Zealand's plantation forests will also be discussed.

Pests and pathogens increasingly threaten plantation forestry in South Africa.

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Plantation forestry covers 1.2 % (1.2 million ha) of land in South Africa, and is an important contributor to employment, the gross domestic product and foreign trade. Plantations are primarily planted with species and hybrids of *Eucalyptus* and *Pinus*, and *Acacia mearnsii* that are all exotic to South Africa. Insect pests and pathogens pose a serious threat to the sustainability of plantation forestry in South Africa. These include a number of non-native species that have been accidentally introduced, but also an increasing number of native insects and pathogens that have adapted to the plantation tree species. Some of the invasive species were introduced in the country decades ago, but despite management efforts they remain responsible for considerable losses. These include the eucalypt snout beetle, *Gonipterus* sp. 2, and the pine pitch canker fungus, *Fusarium circinatum*. There have also been a number of introductions of serious pests and pathogens in the last decade. They for example include the leaf blight pathogen, *Teratosphaeria destructans*, the rust pathogen *Uromycladium acaciae*, and the bluegum chalcid, *Leptocybe invasa*. Some of the newly introduced pests such as the eucalypt gall wasp, *Ophelimus maskelli*, have not yet been reported infesting trees in commercially propagated plantations, but it is likely just a matter of time before they too become important. Of further concern is the threat that various of these introduced pests and pathogens, such as myrtle rust, *Austropuccinia psidii*, and the polyphagous shot hole borer, *Euwallaceae fornicatus*, pose to native trees species. Strong international collaborations and adopting novel techniques to optimise management strategies will be increasingly important in order to respond to these growing threats.

Forest health in commercial plantations in Uruguay

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Uruguayan commercial forestry is based mainly on non-native *Eucalyptus* and *Pinus* plantations. Currently, it covers approximately 1000000 ha, forestry products representing one of the top exports of the country. Over the last two decades, the number of reported pest that threatens commercial plantations has increased regularly not only due to the accidental introduction of exotic pests, but also because of the host shift of native pests and diseases from the local flora to the exotic forestry species. Some of the introduced pests have impacted dramatically on the plantations. As an example, *Teratosphaeria nubilosa* (introduced in 2007) has forced the change of species in some areas formerly planted with *Eucalyptus globulus*. The recent introduction of *Teratosphaeria pseudoeucalypti,* which affects many eucalypt species, distributed very fast over the country, causing great concern. *Austropuccinia psidii* originally from native Myrtaceae has shifted to eucalypts and may seriously affect young plantations. Native leaf-cutting ants represent one of the most important insect pests affecting plantations but exotic insect pests, such as *Gonipterus* spp., *Leptocybe invasa*, *Thaumastocoris peregrinus* and bark and ambrosia beetles, also have a significant negative impact. Research efforts are coordinated within the inter-institutional group of researchers on forest health GIPF (Forest Health Research Group) which also aligns strategies with government and forestry companies. Tree breeding and biological control are the major management strategies used to minimize the impact of forestry diseases and insects, respectively.

ROUND TABLE

Inter-institutional cooperation for forest health management

Academy and forestry sector: synergy to solve forest health challenges

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The planted forestry sector in Brazil has experienced an increase in productivity on the last 40 years. Aligned with the history of the development of the Brazilian forestry sector, there is the history of IPEF – Forestry Science and Research Institute. Founded in 1968, IPEF has consolidated over the years as an example of the model of cooperation and integration among universities, research centers and forestry companies. Through its Cooperative Programs, major themes are discussed and researched cooperatively and the knowledge generated has wide application in practical situations. The beginning of researches with forest protection theme in IPEF was in 1988, since then, this research group has been in continuous development, adding new partnerships in their researches. Since 1988, several challenges have been overcome using the best integrated pest management practices but there are new challenges, with the introduction of new exotic pests. The main research line in PROTEF – Forest Protection Cooperative Program, is the development of biological control programs, generating technologies and information for pest control. Currently, PROTEF stands out for the high quality of its research, a direct reflection of the quality of the academy and forestry companies professionals involved in the Program. Among the main benefits of this cooperation is the experience and training acquired by the students, making them capable professionals aligned with field challenges. The long sight view of forestry companies, believing and investing in scientific research for a responsible forest management, together with the expertise and refined knowledge of the academy, promote numerous benefits for all society and science, making engaged people, capable professionals and producing high quality science, impacting directly an important sector of the economy, benefiting all.

Cooperation and engagement for the benefit of forest health

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Some important demands are common to all forest companies. So, instead of addressing it separately, why not strengthen a unique position and voice? For this reason, Brazilian Tree Industry and the forestry defense committee have worked in cooperation with other entities such as companies, research institutes and government agencies for the management of forest's health issues. This cooperation has achieved results more efficiently, increased the access to stakeholders and provided technical and institutional representation for the Brazilian planted tree sector.

ORAL PRESENTATIONS

Biosecurity and biological invasions

58. The risks and costs of exotic pests to Australia's forest industry.

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Australia's 123 million ha of native forest and woodlands provide a wide range of benefits, including social (recreation), environmental (conservation) and commercial (e.g. forestry, tourism, honey). What is often overlooked is the ecological, economic and social value of our amenity forests and trees in urban and peri-urban environments, and these trees are often the first point of establishment of exotic pests. Here we investigate the risk of exotic pests to Australian forests and calculate the economic costs when they establish. A review of current biosecurity activities and a survey of industry personnel revealed that forest biosecurity in Australia is currently under-resourced, but there are opportunities for greater involvement from industry, government and other stakeholders. Over 125 exotic pests and pathogens of arborescent hosts have established in Australia since 1900, with 15% of these causing significant damage or ongoing management costs. Border interception data was analysed along with trade data (commodities that vector pests) to gain an understanding of the risk of further exotic pests arriving to Australia. We found an increase in interceptions of important pests over the past 15 years, concomitant with an increase in trade. The control program for the primary *Pinus* pest in Australia (Sirex wood wasp) has cost AU$16.5 million over the past 65 years, with the Green Triangle outbreak costing $23.8 million. We conducted an exotic pest incursion scenario, using pine wilt disease, to explore the financial impact of exotic pests establishing in softwood plantations in Australia, and the benefits of conducting biosecurity activities to lower the chance of them establishing. The outcomes from this project will be used to get greater stakeholder engagement and involvement in forest biosecurity in Australia.

Emerging pests and diseases: diagnostics and identification

38. Assessment of *Phytophthora pluvialis* infection of radiata pine in a fog-room experiment.

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Phytophthora pluvialis is a foliar pathogen for *Pinus radiata* and *Pseudotsuga menziensii*, two conifer species planted across the globe, with an important presence in the southern hemisphere. The red needle cast (RNC) disease was first recorded in radiate pine plantations in New Zealand in 2008, was subsequently shown to be caused by *P. pluvialis*. Recently, *P. pluvialis* has been associated with early defoliation in Douglas-fir plantations both in New Zealand and the US Pacific Northwest. In radiate pine, *P. pluvialis* infection starts by the bottom canopy and progresses up causing defoliation, in different degrees, and subsequently growth loss. The infection pattern is variable in space and across years, making it challenging to predict possible outbreaks. Understanding RNC epidemiology is crucial to improve forest management and reduce its impact. Controlled experiments were conducted in two fog rooms to understand the infection cycle and to evaluate different methods to assess infection. Forty-five grafts from four different susceptible radiate pine genotypes were sprayed with a *P. pluvialis* zoospore suspension in one of the rooms, and 45 more grafts were kept in another fog room as controls. Two fascicles were collected per plant, during 13 sampling points from 4 to 61 days after inoculation, and assessed for symptoms. One set of fascicles was plated for re-isolation of *P. pluvialis*, DNA extractions and qPCR aiming at quantifying both *P. pluvialis* and *P. radiata*. The presence of symptoms on needles increased gradually over time, whereas re-isolation and qPCR detection were positive earlier after inoculation. Both the assessment techniques and the suitability of fog-room experiments to understand the RNC disease will be discussed, together with insights into *P. pluvialis* infection cycle and challenges for further research on *Phytophthora* aerial pathogens.

39. Evaluation of the interaction between *Phytophthora pluvialis* and *Phaeocryptopus gaeumannii*, two foliar pathogens in Douglas fir, in Oregon and New Zealand plantations.

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Douglas-fir (*Pseudotsuga menziesii*) is considered one of the most important tree species in the timber trade worldwide. It is native from the US Pacific Northwest, where it is a dominant tree species. It is the second most important exotic plantation species in New Zealand, with 110 thousand planted hectares. In the last decades, Douglas-fir productivity has been threatened by the Swiss needle cast disease, caused by the widespread ascomycete fungus *Phaeocryptopus gaeumannii*, which causes defoliation and consequent growth reduction. In turn, recently, *Phytophthora pluvialis*, supposed to be native from Oregon (USA), has been associated with shoot dieback and early defoliation in Douglas-fir plantations both in New Zealand and the US Pacific Northwest. Recent studies highlight the co-occurrence and the similarity in symptoms produced by both pathogens at the needle level, raising the question about the interaction of both pathogens in the field, and the contribution of each to a given defoliation event. In order to analyse the pattern of the interaction of both pathogens, seven and six Douglas fir plantations were chosen in an environmental gradient in both Oregon (USA) and New Zealand, respectively. Five trees were selected in each site, and sampled fortnightly during late winter/spring, for needles that easily detached when low branches were shaken. Isolations in *Phytophthora* selective media and qPCR aiming at *Phy. pluvialis*, *Pha. Gaeumannii* and *Pseudotsuga menziensii* were performed in each tree sample to analyse the *Phy. pluvialis*/*Pha. Gaeumannii* ratio across the environmental gradient. The relative presence of each pathogen in both Oregon and New Zealand forest systems will be discussed and put into context of native-exotic environment for both the host and the pathogens, the ecological role of both pathogens and their interaction in terms of disease control and forest management.

61. Stem malformation as indication of *Ceratocystis manginecans* infection on *Acacia crassicarpa* pulpwood plantation.

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Ceratocystis manginecans is probably the most important pathogen affecting *Acacia mangium* plantations in Indonesia and other countries in Asia. The disease caused by *C. manginecans*, is characterized by tree wilting followed by death in a short period of time. The high level of mortality on *A. mangium* forced the forest plantation industries in Indonesia to replace those areas with *Eucalyptus* spp. plantation. Other *Acacia* species used for forest plantation industries, such as *A. crassicarpa* planted in lowland areas show good growth and tolerance to *C. manginecans*. Also, field inoculations trials carried out confirmed the tolerance, and the trees survived to the infection to *C. manginecans* different to *A. mangium* that die shortly after the inoculation. Recent survey in *A. crassicarpa* plantation, exhibited the presence of stem malformation mainly in the lower part of the stem. Samples collected from those trees show consistently the presence of *C. manginecans* associated with the malformation. The trees that are showing stem malformation were pruned at age of 6 to 7 months after field planting, to improve tree form and increase tree strength. Most of the deformations are associated with the pruning wounds, which is consistent with the biology of *Ceratocystis* spp. infection that is linked with wounds on trees. Those infected *A. crassicarpa* trees are alive a year after the natural infection, confirming the tolerance of *A. crassicarpa* materials to *C. manginecans*. Current research is focused on developing and implementing operational procedures to minimize wounds on the trees and improve singling practices that finally lead to a reduction in the incidence of stem malformation.

Epidemiology and population dynamics

40. Impact of seasonality and weather on the sporulation and occurrence of *Phytophthora pluvialis* and *P. kernoviae* in plantations of *Pinus radiata* in New Zealand.

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Phytophthora pluvialis and *Phytophthora kernoviae*, cause important needle diseases of *Pinus radiata* in New Zealand. *Phytophthora pluvialis* causes red needle cast (RNC), present in New Zealand since at least 2008. While, *P. kernoviae* has been linked to a disorder originally known as physiological needle blight (PNB), but now known as kernoviae needle blight (KNB), present since at least the 1970s. Early symptoms of both diseases consist of olive/khaki coloured lesions. These lesions frequently contain distinctive black/transparent bands or spots. Later, symptoms of the two diseases differentiate. Needles infected by *P. pluvialis* turn red and are readily cast. Needles infected by *P. kernoviae* are more likely to remain attached, wither and turn a greyish colour. Symptoms of both diseases are most apparent during winter months. Little is known about the epidemiology of either disease, making the development of disease control strategies challenging. An inoculum trapping experiment was, therefore, conducted between February 2012 and December 2014. Traps, consisting of pine needles floating on the surface of purified water in plastic containers, were exchanged fortnightly at four sites (three with RNC, one with KNB). Needles were plated onto CRN medium and the presence of the two species of *Phytophthora* recorded. Inoculum of *P. pluvilis* and *P. kernoviae* was detected between January-December and March-November, respectively. Inoculum of both species peaked in abundance in late-winter. A nationwide drought during the growing-period in 2012-2013 preceded a long period where neither pathogen was detected. The probability of detecting *P. pluvialis* and *P. kernoviae* was greater at lower temperatures. The probability of detecting *P. pluvialis* was also greater during periods of wet weather. We also present an analysis of the Scion Forest Health Database, which shows similar results to those from the inoculum traps. The implications of these results for disease management will be discussed.

68. Epidemiology of Ceratocystis wilt on *Eucalyptus grandis.*

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Eucalyptus is one of the most planted genera in Uruguay, being Ceratocystis wilt, caused by *Ceratocystis fimbriata* s.l. one restriction factor for solid wood production. Ceratocystis wilt, was first reported in Uruguay in 2003, however very little is known about its epidemiology. The objectives of this study were to determine the seasonality of infections, to evaluate the evolution of symptoms over time, and to determine whether there is a strict association between infection events and pruning. Between December 2012 and October 2014, tree traps were settled monthly, registering occurrence of *Ceratocystis* infections. Artificial inoculations were performed with mycelial plugs of the pathogen in a *E. grandis* clone, inoculated with one, three and five mycelial plugs per tree. In addition, surveys were conducted in *E. grandis* plantations, located in northern Uruguay. Results indicate the existence of seasonality on the infections, with no-infection observed in low temperature months. Dead trees were recorded after 120 days when inoculated in summer but not dead was observed for trees inoculated during the winter season. Results also suggest that multiple infection sites favor a rapid colonization and xylem block out, causing subsequent wilting and death of the tree. It was also determined that infections are not strictly related to pruning. Our results contribute to a greater understanding of the disease, and provide key elements for its management.

Forest health surveillance and monitoring

60. High risk site surveillance in Australia: past, present and future.

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Australia is recognised to have one of the most robust biosecurity and quarantine regimes in the world. Nonetheless, despite the existence of pre-border programs and border inspections, together with the implementation of international phytosanitary measures, such as ISPM 15, post-border incursions and establishments of exotic pests do still occur. High risk site surveillance is now a commonly recognised method to attempt to detect incursions early and enable rapid responses (early detection rapid response – EDRR) aimed at preventing establishment and spread from high risk sites into urban forests and subsequently planted or natural forests. The earlier a pest can be detected, the greater the chance for successful eradication or aggressive containment. Since the late 1990's a limited trapping program for gypsy moth (*Lymantria dispar*) at ports has been carried out around high-risk ports, and since the mid-2000s this was expanded to include bark and wood boring insects in some states. To date, trapping for bark and wood boring insects has been carried out on a somewhat ad hoc basis and has been driven by the interest and commitment of state-based forest health professionals, rather than as a nationally standardised and coordinated activity. Testing of methodologies has been carried out experimentally and proven systems are now available for deployment. Here we review these past results, a recently completed project in Queensland focussed on pests of pine, and the development of a nationally agreed and funded strategy to deploy high risk site surveillance across all Australian states.

Pest and disease damage and economic impact

36. An estimate of the economic impact of *Teratosphaeria nubilosa* on *Eucalyptus globulus* plantations in Uruguay.

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Commercial plantations area in Uruguay increased after the Forestry Law 15939 was passed in the late 1980s. The most planted species had been *Eucalyptus globulus* until 2007, when the foliar pathogen *Teratosphaeria nubilosa* was accidentally introduced in the country. The pathogen affects the tree at an early stage of its growth, but the impact remains under discussion. *E. globulus* only grows in some regions of the world and in Uruguay adapted well in the Southeastern part of the country. Furthermore, the species is very suitable for pulp production and in Uruguay it had been traditionally exported either as logs or chips. A project was carried out by a multidisciplinary group of the University of the Republic (UDELAR) to estimate the economic impact of the introduction of *T. nubilosa* in Uruguay. The method used was cost-benefit analysis and primary and secondary information were gathered. Primary information was collected from interviews to *E. globulus* producers, companies and informants in the forest sector. The analysis of secondary information focused on the analysis of exports, forest areas and *E. globulus* businesses. It was found that the decision-making process of the *E. globulus* producers seems to differ from the other producers in the sector, then the decision of replacing the species might result from a combination of economic results and other factors. Finally, the economic impact for an average producer showed that a decrease in the harvest volume by 5%, causes an economic loss of between 11 and 14% of the Net Present Value, depending on the age of harvest. The substitution of the species for *E. dunii*, assuming a loss of 5% in the first rotation, would require to more than double the production in order to compensate the loss.

50. Quantification of damages by *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae) in eucalypt.

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Eucalypt was introduced in Brazil in early 20th century and it adapted very well. The main uses for its wood are pulp, paper, charcoal and fiberboards. On the last 15 years eucalypt exotic pests were introduced in Brazil, finding proper climate, susceptible hosts and no competition or natural control, becoming major problems to commercial plantations. Among these exotic pests, *Thaumastocoris peregrinus* was detected in 2008 and since then attacked more than 500 thousand hectares of plantations. But, until now there are few information about economic losses caused by its attack. The loss in wood production caused by *T. peregrinus* outbreak was measure in two different eucalypt clones (*Eucalyptus urophylla* and *E. urophylla* x *E. grandis*). The test was conducted in twin plots with pesticide application on the control, protecting the plants from pest attack. The number of nymphs and adults of *T. peregrinus* were counted on tree leaves and in yellow sticky-traps monthly and the trees diameter and height were semiannually measured for volume calculations. The reduction in diameter and height growth rates during and after *T. peregrinus* attack period, impacted directly over the wood production, with control plants producing 14% more wood than attacked trees. The calculated loss in wood production during a single outbreak of the pest was US$ 380,00 per hectare.

30. From production to formulation: a multidisciplinary approach for pest control in Brazilian Eucalyptus plantations based on *Metarhizium anisopliae.*

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In Brazil, there are 7.8 million hectares of planted trees, 72 % of which belong to *Eucalyptus* spp. and provide 91% of all wood produced. However, several Australian insects have been invaded into Brazil, which caused serious damage and hugely economical losses in *Eucalyptus* production. In recent years, *Thaumastocoris peregrinus* Carpintero & Dellapé (Hemiptera: Thaumastocoridae) and *Glycaspis brimblecombei* Moore (Hemiptera: Aphalaridae) have been considered as key pests for causing damages to large areas of *Eucalyptus* plantation. The success for control of these Hemiptera involves the classical biological control with parasitoids, introduced from Australia, and the inundative biological control using entomopathogenic fungi (EPF). Since these microorganisms showed advantages in previous research, it has become a goal to bring this technology to the field. But many improvements are necessary to achieve from the production to the formulation. The application has to reach the target, attending the Brazilian forest conditions and focusing the expense reduction of product. Considering that Brazil does not have an oil-based formulation developed for EPF-based eucalypt plantations, the aim was to approach from the production to the formulation of *Metarhizium anisopliae sensu lato* (Hypocreales, Clavicipitaceae). For this purpose, an adapted solid-state production technology with different 5 substrates was tested. Then, the material was harvested for separation of pure conidia using Mycoharvester® Technology aiming to obtain a concentrated oil formulation for ULV application. Rice and barley (5:1) showed high yield of *M. anisopliae* with a concentration of 5.8 (±3.1) $x10^9$ conidia/g of dry weight that was adequate to be harvested. The Mycoharvester® Technology was effective to separate pure conidia making it possible to use as an active ingredient for the oil based ULV-formulation. Lab and field test will be carried out to verify the efficiency of this bioinsecticide for controlling the invasive eucalypt pests.

31. Blue-stain fungi from pine plantations in Patagonia and their control through management.

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Pine plantations in Argentinian Patagonia cover *ca.* 95,000 ha in Chubut, Río Negro and Neuquén provinces. Blue-stain fungi are the main post-harvest sanitary problem, hampering and restricting their use in international trade. We surveyed the species responsible of blue-stain and evaluated the optimal felling season and maximum storage period in order to set management control of the disease. Sawing mills and pine plantations were surveyed three consecutive years. Fungal isolates from stained logs, processed wood and insect galleries were identified based on morphological and DNA sequence comparisons of ITS and β-tubulin gene regions. Trees were felled in five representative afforested sites in winter, spring, summer and autumn, and left in the plantation; each three months a set of trunks were evaluated in order to measure blue-stain development, the causing agents and the associated bark beetles, if present. Fourteen species were recovered from isolations, the more frequent ones being *Ophiostoma piliferum*, *Ophiostoma peregrinum* sp. nov., *Diplodia pinea* and a *Graphilbum* sp. The exotic bark beetles *Orthotomicus laricis*, *Hylastes ater* and *Hylurgus ligniperda* and the weevil *Pissodes castaneus* were commonly associated to the different fungal taxa, the three first ones being associated to freshly cut logs, stumps and slash. At every site logs were stain-free for 3 months, no matter the season when they were harvested. After this period, harvest in spring (and sometimes autumn) was highly susceptible to 'ophiostomatoid' stain, coinciding with the beetle flying season. Summer harvest resulted critical if the stand was infected with *Diplodia*, because this endophytic fungus grows vigorously at high temperatures. Field trials indicated winter as the most favorable season to harvest. *Ophiostoma peregrinum* is possibly exotic and shows the case of a fungus that behaves aggressively in new areas, having also been recorded on logs of the native *Nothofagus dombeyi*.

33. Contributions of quarantine laboratory “Costa Lima” of EMBRAPA Meio Ambiente to the classical biological control of exotic Eucalyptus pests in Brazil.

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The quarantine laboratory “Costa Lima” (LQCL) of Embrapa Meio Ambiente has contributed to the classical biological control of several exotic forest pests in Brazil. The first of these was the red gum lerp psyllid, *Glycaspis brimblecombei*, present in Brazil since 2003. Between 2004 and 2006, the parasitoid *Psyllaephagus bliteus* was imported from three distinct regions in Mexico, sourced from Comisión Nacional Florestal (CONAFLOR), as part of the Forest Protection Cooperative Program from Forestry Science and Research Institute (PROTEF/IPEF) of Brazil. *P. bliteus* populations were reared and multiplied by LQCL and later by the UNESP (São Paulo State University) which released the parasitoid in plantations. Further releases were made in 2006, resulting in effective biological control of this pest. Since 2008, PROTEF and the LQCL have successfully achieved the biological control of the bronze bug, *Thaumastocoris peregrinus*. In 2009 and 2010, LQCL introduced from Australia the egg parasitoid, *Cleruchoides noackae,* for UNESP, with the assistance of the University of Sydney and the Queensland Department of Employment, Economic Development and Innovation. This parasitoid demonstrated great multiplication and dispersion potential in eucalypt plantations throughout the country. Another Australian exotic pest that entered Brazil in 2007 was the eucalyptus gall wasp *Leptocybe invasa*. In 2009, *Aprostocetus*, *Quadrastichus* and *Megastigmus* parasitoid species were requested from the Department of Entomology, Agricultural Research Organization, Israel. However, the importation could not be completed. Introduction of another parasitoid, *Selitrichodes neseri* from the University of Pretoria, South Africa, was then initiated in 2015. This biological agent has also been multiplied post release from quarantine, resulting in the production of 8,615 adults in 2016/2017, which were later shipped to forestry companies associated with PROTEF for release. The biological control of this gall wasp is currently in progress, with promising results.

42. Needing to be agile: Adaptive management of the eucalypt leaf beetle Integrated Pest Management over 25 years in Tasmania's publicly-owned plantations.

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The *Eucalyptus* leaf beetle Integrated Pest Management (IPM) (targeting *Paropsisterna bimaculata*) was conceived by the then Forestry Commission of Tasmania in 1992, well before the expansion of *Eucalyptus nitens* and *E. globulus* plantations on public land in Tasmania. It was, and remains, one of the few forestry pest management IPMs that bases the control decision on an assessment of pest populations against an injury threshold. In the 25 years since inception, the leaf beetle IPM has undergone periodic refinement in response to new knowledge gained from planned research and from evaluation of the performance of the operational program as the plantation estate developed and matured. These refinements to the IPM came in three phases: i) The first decade (1992-2001), punctuated by the beginning of the major phase of plantation establishment, involved operationalising the IPM, refining the monitoring method and establishing leaf beetle population thresholds to trigger control operations. ii) The second decade (2002-2011), spanned the main period over which the publicly-owned plantation estate was established. The IPM switched from a focus on protecting young (2-6 y.o.) plantations to a risk-based IPM that extended protection to older plantations (up to age 12 years) in areas with medium to high risk of supporting above-threshold leaf beetle populations. iii) The third decade (2012-2017) spans the maturing plantation estate. A sharp drop in leaf beetle populations, and the scale of the IPM, coincides with most of the plantation estate reaching the second half of their notional 25-year rotation Developing and sustaining an effective operational leaf beetle IPM involved strong links between researchers and field staff and the systems (database to capture operational activities and annual forest heath surveillance) that allowed the ongoing review of the performance of the IPM. Its analysis provides important insights into structures and systems for managing pests in commercial plantations.

54. The parasitoid *Psyllaephagus blastopsyllae* as control agent of *Blastopsylla occidentalis* in eucalypt plantations in Brazil.

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A research project was designed for evaluating classical biological control of the eucalypt psyllid *Blastopsylla occidentalis* Taylor, 1985 (Hemiptera: Aphalaridae) by the imported exotic parasitoid *Psyllaephagus blastopsyllae* Tamesse et al., 2014 (Hymenoptera: Encyrtidae). In 2015, the parasitoid was imported from South Africa and kept in the Quarantine Laboratory "Costa Lima" of Embrapa Meio Ambiente to make sure that the sample was pure and for preliminary bioecological studies in view of future release by the Ministry of Agriculture, Livestock and Supply (MAPA) following the request by Embrapa Florestas. The establishment and maintenance of greenhouse cultures of *B. occidentalis* were carried out for future mass rearing of the imported parasitoid. The pest was collected in eucalypt plantations in Minas Gerais State. Before infesting the plants, all the material collected in the field was examined under a microscope, in the laboratory of Embrapa Florestas, to clean the plants and prevent the entry of predators and other undesirable organisms into the colony. New field collections of *B. occidentalis* were carried out regularly to maintain the vigor of the colony. In one of the collections, some parasitised immatures were observed, from which adult parasitoids emerged. Specimens of the parasitoid from the field and the quarantine facility were sent to the specialist John Noyes, Natural History Museum, London, UK, who confirmed that the two populations belong to the same species, and are provisionally referable to *P. blastopsyllae* awaiting the examination of type material. With the presence of this parasitoid in the field, no new imports of *P. blastopsyllae* were requested, redirecting our project to monitoring the evolution of this exotic parasitoid in the field. As we found the parasitoid in the field before the arrival of the first shipment from South Africa, we assume that the parasitoid was introduced accidentally, along with the pest.

59. Biological control of Australian-origin eucalypt plantation pests: an international collaboration.

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Australian-origin pests of eucalypts have been moving around the world since 1873. Since the 1990's, the invasion of new eucalypt pests has increased almost exponentially with rapid subsequent invasion of these pests into new countries and across continents. Traditional approaches to classical biological control, where individual countries or regions funded natural enemy searches and carried out the required specificity testing and released the agents, were effective when rates of invasion were low and with slow subsequent movement between countries and continents. These approaches are less able to cope with multiple new pests arriving in rapid succession. A more collaborative and coordinated approach to biological control of these pests was thus required, where funds and expertise can be more cost-efficiently pooled and shared to develop effective biological control for eucalypt plantation pests. The Biological Control of Insect Pests Alliance (BiCEP) was developed by industry and researchers worldwide to attempt to solve this problem. BiCEP carries out collaborative research in Australia and overseas on biological control of the key invasive pests prioritised by its industry partners. Approaches used in this collaboration include conventional surveys for endemic natural enemies in Australia, genetic characterisation of these agents and climate matching with invaded countries. Key outcomes from current research and future directions will be presented.

73. Biological control of the *Eucalyptus* bronze bug *Thaumastocoris peregrinus* with the egg parasitoid *Cleruchoides noackae* in Uruguay: a work in progress.

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Biological control is a major tool for forest insect pest management. We initiated a biological control programme for the *Eucalyptus* bronze bug, *Thaumastocoris peregrinus*, with the egg parasitoid *Cleruchoides noackae*. A first rearing colony was installed in Uruguay in 2013 with individuals from a mass rearing in Brazil. Rearing quality parameters were estimated for 30 generations, and compared against expected quality standards. For practical purposes, we developed two rearing protocols: one for the release season (summer rearing) and a maintenance protocol for the period when no wasp release is conducted (winter rearing). Field releases were made yearly during summer in *Eucalyptus* stands, starting in March 2013. Parasitized eggs were released in seven sites, covering the major forestry areas in the country. The first wild individuals were recovered from eggs collected in the field a year after the first release campaign. To date, wild populations have been established in three sites. Field monitoring was conducted regularly at the beginning and at the end of the population peaks of *T. peregrinus*. Surveys in two sites showed evidence of *C. noackae* survival for two years without parasitoid release. Field collected parasitoids exhibited similar quality indices than that from the laboratory rearing. Field parasitism fluctuated between 2.4 and 51.7 % and all sampled populations were female biased. The release of *C. noackae* is part of a broader strategy for the biological control of *T. peregrinus* that also includes the development of a fungal-based biopesticide. Future steps in the biological control programme for *T. peregrinus* should consider the optimisation of the logistics of the release campaigns, the measurement of its long-term efficacy and the potential interactions between the parasitoid and the biopesticide.

76. Genetic variation for resistance to *Teratosphaeria nubilosa* on *Eucalyptus globulus*

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Teratosphaeria nubilosa entered Uruguay a decade ago, causing from that moment devastating damages on young plantations of *Eucalyptus globulus*. As there is no local availability of resistant genetic stock, forest companies are replacing it with other species. This paper discusses the feasibility to obtain genotypes of *E. globulus* with good behavior against *T. nubilosa*. The genetic variation in disease resistance, in the timing of heteroblastic phase change, and in tree growth was examined on 194 open-pollinated families of *E. globulus* growing in a field trial naturally infected by *T. nubilosa* in SE Uruguay. Disease severity (% necrosis, % defoliation and damage index) was recorded at 14 and 21 months, and precocity of phase change (% of adult foliage) at 14, 21 and 26 months. Tree growth was assessed annually, from 14 to 74 months. The narrow-sense individual tree heritabilities for disease severity were moderate (from 0.23 to 0.36), and similar to that for growth traits (from 0.27 to 0.35). The proportion of adult foliage was the trait with higher genetic control, with heritabilities varying from 0.56 to 0.59. Genetic correlations between disease severity and the target trait (tree volume at 74 months) varied from -0.11 to -0.43. Genetic correlations between precocity of phase change and volume varied from 0.32 to 0.38. The estimated genetic parameters clearly indicate that through selection for early phase change, it is possible to obtain genetic stock of *E. globulus* more suitable for sites with high risk of *T. nubilosa* infection. Although tree height and DBH at 26 months presented high genetic correlations with volume (0.54 and 0.62, respectively), the proportion of adult foliage at 14 months is the selection criteria that would generate the greatest increase in productivity.

POSTERS

25. Predicting North American bark beetle invasions in the Southern hemisphere.

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Bark beetle species are recognized as one of the most important tree mortality agents in coniferous forests worldwide, and many are known invaders. Non-native trees planted in novel habitats often exhibit exceptional growth, in part because they escape herbivore pressure from their native range. Increasing accidental introductions of forest pest species as a consequence of international trade, however, is expected to diminish enemy-release of non-native forest trees. Consequently, there is need to characterize patterns of forest herbivore species invasion risks at global scales. In this study we analyze the establishment potential of 64 North American Scolytinae species in the Southern Hemisphere. We use climate-based ecological niche models (MaxEnt) to define the potential distribution of these species in the Southern Hemisphere. Our model predicts that all of the pine-growing regions of the Southern Hemisphere are capable of supporting some species of North American Scolytinae, but there are certain "hotspot" regions – Southeastern-Argentina, Bolivia, Chile, Peru and Southwestern-Australia- that appear to be suitable for a particularly large number of species. The species with the highest predicted risk of establishment were *Dendroctonus valens, Xyleborus intrusus, Hylastes tenuis, Ips grandicollis, Gnathotrichus sulcatus*, and *Ips calligraphus*. Given that global commerce is anticipated to continue to increase, we can expect that more Scolytinae species will continue to establish outside their range. Our results provide information useful for identifying a global list of potential invasive species in pine plantations, and may assist in the design of comprehensive strategies aimed at reducing pest establishment in Southern Hemisphere forest plantations.

28. Infection biology of the rust pathogen *Uromycladium acacia.*

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Uromycladium acacia causes a severe rust disease in plantations of non-native *Acacia mearnsii* (black wattle) in Southern Africa. Little is known about the biology of *U. acaciae*, making the development of disease control strategies difficult. Germination studies and artificial inoculations were conducted to identify the optimal conditions for infection by *U. acaciae*. Germination of teliospores, basidiospores, and urediniospores were assessed at seven temperatures (5, 10, 15, 20, 25, 30 and 35°C), with or without light (c. 15 µmol $m^{-2} s^{-1}$). The effect of temperature (15, 20 and 25°C) on infection was also assessed. As was the effect of dew period length on germination of teliospores, production of basidiospores and infection. Teliospores and urediniospores germinated between 5 and 30°C, with an optimum at 15–25°C. Basidiospores were produced and germinated at temperatures between 5 and 25°C, with an optimum at 15–20°C. The optimum temperature for infection by basidiospores was also 15–20°C. Under optimal conditions, all spore types germinated in 6–24 hours. Production of basidiospores was severely reduced if teliospore germination was interrupted by dry periods, even when teliospores were re-wetted. Symptoms and telia developed on only one plant exposed to a dew period of less than 12 hours, with a dew period of 48 hours found to be optimal. Artificial inoculation experiments showed that *U. acacia* was only able to infect young, growing tissues. Results of this research have been used to develop an artificial inoculation protocol for resistance screening. Results can also be used for disease risk modelling and forecasting.

32. Storing immature fase of *Cleruchoides noackae* Lin & Huber (Hymenoptera: Mymaridae) at 5°C.

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The egg parasitoid *Cleruchoides noackae* has been used in *Thaumastocoris peregrinus* biological control in *Eucalyptus* spp. plantations. To improve biocontrol efficiency, is necessary a high number of parasitoids released on field. Therefore, techniques using low-temperature to storage immature phases of parasitoids are an alternative to concentrate the emergence of these insects in a determinate period, providing some flexibility on lab rearing and making possible sending and releasing a huge quantity of insects in the field. The objective of this study was to analyze the effect of different periods of storage on low-temperature for *T. peregrinus* parasitized eggs by *C. noackae*, in order to increase its mass rearing. Therefore, *T. peregrinus* eggs were offered to females of *C. noackae* for 24 h and stored during 7 days at 5 ºC with zero (control), 3, 6, 9 and 12 days after parasitism. The emergence of the stored insects 6 days after the parasitism did not differ from the control and was superior to the other treatments. There was no difference between sex ratio and retained parasitoids. After determining the best development stage (6 days), it was used to store the immature phase of parasitoid for zero (control), 7, 14 and 21 days. After storing the parasitoids for 7 days (with 6 days after parasitism), there was a decrease in its emergence making it impossible to store *C. noackae* longer in these conditions.

34. Effects of mating status on the oviposition behavior of *Cleruchoides noackae* (Hymenoptera: Mymaridae) in eggs of *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae).

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Cleruchoides noackae (Hymenoptera: Mymaridae) native to Australia, is an egg endoparasitoid of *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae) introduced into Brazil in 2012. This parasitoid has been reared and released for biological control of *T. peregrinus* in *Eucalyptus* spp plantations in several countries around the world. The oviposition behavior variation can occur in parasitoids as a function of mating condition. The oviposition behavioral patterns (host found time, foraging time and ovipositor insertion time) and progeny biological parameters (parasitism, viability and sex ratio) of mated or virgin females of *C. noackae* in *T. peregrinus* eggs was investigated. The parasitoid behavior was observed over a one-hour period for ten females of *C. noackae* (mated and virgin) and ten *T. peregrinus* eggs in polystyrene vial (7,5 cm high and 3,0 cm diameter). Virgins and copulated females found the first host in 15.21 and 17.14 minutes, respectively, and the next hosts in 3.85 and 0.86 minutes, respectively, showing a decrease of this time due to the experience acquired after lay the first egg. The foraging time of virgin and copulated females was 24 and 21 seconds, respectively. The duration of ovipositor insertion into *T. peregrinus* eggs was 5.13 minutes (virgin females) and 3.69 minutes (females copulated). Virgin females inserted the ovipositor more frequently on the sides of the egg, with a mean of 55%, while copulated females inserted more often on the sides (50%) and operculum of the egg (46%). Virgin and copulated females of *C. noackae* inserted the ovipositor into 64 and 59% of the eggs of *T. peregrinus* offered in one hour, respectively, and of these, almost 100% were parasitized. The viability was above 75% for both females and the sex ratio of 0.00 (virgin females) and 0.68 mated females) confirming the arrhenotokous parthenogenesis of *C. noackae.*

35. Detection of microsporidium in parasitoids of pupa *Trichospilus diatraeae*, *Palmistichus elaeisis* (Hymenoptera: Eulophidae) and host *Diatraea saccharalis* (Lepidoptera: Crambidae).

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The parasitoids *Trichospilus diatraeae* and *Palmistichus elaeisis* Delvare & LaSalle (Hymenoptera: Eulophidae) are generalist natural enemies used in various biological control programs that can suppress populations of several lepidopteran pests in agriculture and forestry, mainly defoliator caterpillars in *Eucalyptus* plantations. These parasitoids are reared in the Laboratory of Biological Control of Forest Pests (FCA / UNESP) in the host *Diatraea saccharalis* (Fabricius) (Lepidoptera: Crambidae), but there is concern with the quality control of parasitoids *T. diatraeae* and *P. elaeisis* mass produced. In this context, the aim of this study was to detect the infection of microsporidia belonging to the Clado *Nosema*/*Vairimorpha* in the parasitoids *T. diatraeae*, *P. elaeisis* and in the host *D. saccharalis*. These microsporidia cause morphological and behavioral changes such as increased time needed to complete the larval and pupal stages, reduction of longevity in adults, decrease in the rate of emergence and fecundity and affecting the parasitism rates. The presence of the infection was verified by microscopy and was confirmed by the amplification of the small subunit region (SSU) of the ribosomal RNA using universal primers for microsporidia of *Nosema* sp. The purified PCR products were sequenced and the sequences obtained were edited and aligned with the sequences of the GenBank database. In this way, the presence of intracellular parasites in *T. diatraeae*, *P. elaeisis* and *D. saccharalis* belonging to Clado *Nosema*/*Vairimorpha* was verified. This is the first report of detection of microsporidia in the parasitoids *T. diatraeae* and *P. elaeisis* and studies to confirm effects in biological control of *Eucalyptus* caterpillars is ongoing.

43. Management of Ceratocystis wilt in Eucalyptus: initial studies using *Trichoderma harzianum*.

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The development of management methods of Ceratocystis wilt in the field of eucalyptus has great importance, since this fungus produces spores that can survive in the soil. Thus, this work aimed to study the effect of *T. harzianum* on *Eucalyptus* seedlings planted in soil infested with *Ceratocystis fimbriata*. A suspension of 10^6 spore mL-1 of *C. fimbriata* was incorporated in the soil, which was contained in pots. After a seven-days term, the *T. harzianum* ($7.5x10^{10}$ CFU/g of the commercial product) was applied to the soil at the planting time of seedlings. The following treatments were carried out: (A) *Eucalyptus* plants with roots immersed in the biological agent suspension; (B) Plants placed in the pot with hydrogel incorporated to the biological control agent; (C) Plants placed in the pot and irrigated with the biological control agent; (D) Plants placed in the pot in which the biological control agent was placed directly in the seedling´s; Two control treatments: (E) seedlings in pots with soil infested only with *C. fimbriata* and (F) in pots with soil without fungus´s infestation. The treatments were applied to 2 and 6-months-old seedlings, consisting of two experiments. After a sixty-days term, the following parameters were analyzed: percentage of wilted and dead plants, stem diameter, fresh and dry mass of aerial part and chlorophyll index. Only the treatment E (without the presence of *T. harzianum)* showed wilt plants (80%). No dead plants were observed in any treatment. The results indicate a higher chlorophyll index in plants treated with the biological agent. Treatments D and C displayed higher fresh and dry weight than the other treatments, independently on the plant age. Therefore, the use of *T. harzianum* can serve as a support in the management of areas where there have been cases of this disease.

44. Management of Ceratocystis wilt in Eucalyptus: initial studies using *Paecilomyces lilacinus.*

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The development of management methods of Ceratocystis wilt in the field of eucalyptus has great importance, since this fungus produces spores that can survive in the soil. Thus, this work aimed to study the effect of *P. lilacinus* on *Eucalyptus* seedlings planted in soil infested with *Ceratocystis fimbriata*. A suspension of 10^6 spore mL-1 of *C. fimbriata* was added to soil, which was contained in pots. After a seven-days term, *P. lilacinus* ($7.5x10^9$ CFU/g of the commercial product) was applied to the soil at the planting time of the seedlings. The following treatments were carried out: (A) *Eucalyptus* plants with roots immersed in the biological agent suspension; (B) Plants placed in the pot with hydrogel incorporated to the biological control agent; (C) Plants placed in the pot and irrigated with the biological control agent; (D) Plants placed in the pot in which the biological control agent was placed directly in the seedling´s orifice; Two control treatments: (E) seedlings in pots with soil infested with *C. fimbriata* and (F) in pots with soil without fungus´s infestation. The treatments were applied to 2 and 6-months old seedlings, consisting of two experiments. After a sixty days-term, the following parameters were analyzed: percentage of wilted and dead plants, stem diameter, fresh and dry mass of aerial part, and chlorophyll index. Only the treatment E (without the presence of *P. lilacinus*) showed wilt plants (75%). Dead plants were not observed in any treatment. The results indicated a higher chlorophyll index in plants treated with the biological agent. Higher values of fresh and dry weight were obtained on treatments D and C as compared to others treatments, independently on the plant age. Therefore, the use of *P. lilacinus* can serve as a support in the management of areas in which there have been cases of this disease.

46. Monitoring *Leptocybe invasa* Fisher & La Salle (Hymenoptera: Eulophidae) population with yellow sticky traps during five consecutive years in western Uruguay.

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With almost 1 million hectares of exotic forests, *Eucalyptus* is the most planted genus in Uruguay. *Eucalyptus* species, have been affected by an increasing number of pest and diseases since 2000. *Leptocybe invasa* (Hymenoptera: Eulophidae), was reported in 2013 affecting several *Eucalyptus* species primarily in western region, however very little is known about the population dynamics of this pest in Uruguay. Monitoring was performed based on a yellow sticky traps network located in *Eucalyptus* plantation in western Uruguay (including provinces of Paysandú, Rio Negro and Soriano). Data was monthly collected from nine sampling stations in *E. dunnii*, *E. grandis* and *E. benthamii* plantations, including an additional sampling station in a *Eucalyptus* nursery in the study area. Life cycle simulation was based on Zhu *et al.* (2015), using the proposed developmental zero temperature, effective cumulative temperature and simulated with daily mean temperature for the region. Field population was monitored from January 2013 to June 2017. Most adult´s captures begun in October up to June, from spring to fall, trapping different number of individuals depending on the year. Field captures were significantly lower than nursery captures, this may be due to the large number of shoots present in nursery areas and to its location, close to a red gum *Eucalyptus (E. camaldulensis and E. tereticornis)* plantation. A strong relationship between real captures and theoretical flights was found. For Uruguay conditions and based on accumulated degree-days method we could predict two generations per year, the shortest 79 days and the longest with 359 days-long, with the latter including the winter season, with temperatures below the developmental zero temperature. Our results indicate that simulation of population dynamics of *Leptocybe invasa* in Uruguay is possible using Zhu *et al*. (2015) parameters, and that yellow sticky traps represent a valuable tool to assist management and research.

47. Chlorophyll content and photosynthetic rate of two eucalypt clones in response to *Costalimaita ferruginea* attack and control.

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Technologies should be used to monitor forest plagues in Brazil to allow their diagnosis and control, avoiding economic damages. The objective of this work was to evaluate the response of two eucalyptus clones to *Costalimaita ferruginea* attack and control. Two clones: spontaneous hybrid of *Eucalyptus urophylla* - clone I144 and LW07 of *E. urophylla* × *E. grandis* planted on short rotation systems at 3 × 1 m, were evaluated. Fifteen plants per plot were randomly selected and evaluated monthly, from September (2016) to August (2017), using a chlorophyllometer (SPAD-502) and infrared gas analyzer - IRGA (LI-COR 6400) to estimate chlorophyll content and CO2 assimilation rate (A), respectively. The peak occurrence of *C. ferruginea* was observed in December 2016, and an insecticide application (Decis 25EC 200 ml ha^{-1}) was carried out. Data was submitted to analysis of variance and Tukey test at 5% of significance. The attack of *C. ferruginea* significantly affected the SPAD index and A values. When 100% of plague incidence occurred, 75% of severe defoliation was noted. Values of the SPAD and A reduced an average of 8.13% and 24.60%, respectively, when compared to the month before the plague attack. In January 2017, both clones registered average values similar to those obtained in November. The highest SPAD index and A values were observed in clone I144 and it was statistically superior to clone LW07, which shows that this clone was more resistant to plague attack. However, in general, clone I144 presented more accentuated falls of SPAD and A values in relation to clone LW07. One can conclude that both eucalyptus clones expressed different responses to the attack of *C. ferruginea*, which reduced significantly the values of SPAD and A. Thus, the use of equipment such as SPAD and IRGA can be used as tools to help in the characterization of genotypes relation to *C. ferruginea* attack.

48. Influence of *Pyemotes* sp. (Acari: Pyemotidae) in the parasitism of *Gonipterus platensis* (Coleoptera: Curculionidae) by *Anaphes nitens* (Hymenoptera: Mymaridae).

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The eucalyptus snout beetle, *Gonipterus platensis* (Coleoptera: Curculionidae), is a pest native to Australia invasive worldwide. Adults and larvae feed on the young leaves of eucalyptus trees and may cause complete apical defoliation. Although detected in Brazil since 1950, recent outbreaks have been more severe, causing loss of MAI of up to 42% in some hybrid clones. Use of the egg parasitoid *Anaphes nitens* (Hymenoptera: Mymaridae) is the main control strategy for *Gonipterus* spp. In the region of Botucatu (State of São Paulo / Brazil) mites of the genus *Pyemotes* (Acari: Pyemotidae) were found in *G. platensis* egg capsules. Mites of this genus are known to be ectoparasites of several species of insects and to cause dermatitis in humans, making their use unviable in a biological control program. The aim of this study was to identify the influence of *Pyemotes* sp. in the parasitism rates of *G. platensis* by *A. nitens* in the field. Sixty fresh egg capsules of *G. platensis* were collected in the *Eucalyptus urophylla* x *E. grandis* commercial plantation with the occurrence of the mite; the control consisted of 60 egg capsules collected in area free from mites. The egg capsules were taken to laboratory and kept in incubator at 25(±1) ºC; the emergence of larvae of *G. platensis* and adults of *A. nitens* was observed for 30 days to calculate the rate of parasitism. Contaminated egg capsules had a parasitism rate of 1.78%, against 49.02% of the control. During the evaluations, it was found that mites fed on any egg, regardless of age or whether or not they were parasitized by *A. nitens*. We conclude that feeding of *Pyemotes* sp. in *G. platensis* egg capsules affected the emergence of *A. nitens* drastically, which may be contributing to the increase of the pest outbreaks.

51. Populational dynamics of *Glycaspis brimblecombei* (Hemiptera: Aphalaridae) and their parasitoid in *Eucalyptus* spp plantation in Minas Gerais, Brazil.

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Glycaspis brimblecomblei (Hemiptera: Aphalaridae) is a small Australian *Eucalyptus* pest spread in North and South America, Europe, New Zealand, and Africa. The red gum lerp psyllid damages are: defoliation, sooty mould by honeydew and death of highly susceptible *Eucalyptus* genotypes. This pest causes important losses in Brazilian plantations, especially in the southeastern and northeastern regions of the country. The classical biological control with the nymph parasitoid *Psyllaephagus bliteus* (Hymenoptera: Encyrtidae) and plant resistance are the best methods for the maintenance of their populations in low levels. The objective of this work was to know the populational fluctuation of *G. brimblecomblei* and of its parasitoid in a *Eucalyptus* spp. plantation in Itamarandiba, Minas Gerais, Brazil. The study area was planted with *E. saligna* and three *E. cloeziana* clones (A, B, C) and one area with *E. camaldulensis*. The data set were obtained from 138 yellow sticky traps (YST) distributed in area of 4 ha, collected and replaced monthly from March to August 2016. A total of 768 adults of *G. brimblecomblei* and 1125 parasitoids were observed in the YST. March and August were the months with the highest catches of the pest and March and April were for the parasitoid. The pest was most abundant in *E. saligna* (n=398) and in *E. camaldulensis* (n=170). The parasitoid was more abundant in *E. saligna* and in the clone B of *E. cloeziana*, but presented fewer captures in *E. camaldulensis.*

52. Release and recovery of *Selitrichodes neseri* (Hymenoptera: Eulophidae), parasitoid of blue gum chalcid, in Brazil.

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One of the exotic pests reported in last decade for Brazil that has been causing damage to *Eucalyptus* plantations is *Leptocybe invasa* (Hymenoptera: Eulophidae). The females lay their eggs on *Eucalyptus* leaves and the larvae induce the gall formation. One of the methods for the management of *L. invasa* that has been studied is the classical biological control, performing inoculative releases in field with the parasitoid *Selitrichodes neseri* (Hymenoptera: Eulophidae). This parasitoid was imported to Brazil and has been mantained in laboratory for the management of this *Eucalyptus* pest since 2015. The aim of this study was to carry out inoculative releases of the *S. neseri* parasitoid in forest areas with *Eucalyptus* plantations highly infested by *L. invasa*, and to verify the establishment of this parasitoid in these sites. The releases of *S. neseri* were carried out in *Eucalyptus* plantations from the Brazilian states of Rio Grande do Sul, Paraná, São Paulo, Mato Grosso do Sul, Minas Gerais, Bahia, Tocantins and Maranhão. In these sites, areas with higher infestation were selected. Parasitoids were released in branches with mature galls of *L. invasa.* Parasitoid emergency was evaluated for ca 20 days. The amount of parasitoids released ranged from 22 to 1100 individuals per release point. Forest companies cut and sent *Eucalyptus* branches with galls from all studied sites between 17 and 175 days after *S. neseri* releases. All exemplars were counted, identified and fixed in ethanol. We found 517 parasitoids during this period. The establishment of *S. neseri* were observed in plantations from Bahia, Minas Gerais and São Paulo. These releases and evaluation are still ongoing until confirmation of the reduction of *L. invasa* infestations.

53. Prevention methods of damages caused by lagomorphs in plantations of *Prosopis alba*.

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The damage caused by Lagomorphs is one of the problems that affects the establishment of Prosopis alba plantations in the province of Chaco, Argentina. The objective of this study was to evaluate the effectiveness of simple and non-polluting methods to prevent damage caused by jackrabbit. Physical protections and organic repellent were evaluated, the protections consisted of using plastic bottles and woven wire mesh, the repellent used was oleoresin from Capsicum, in the control repellent and protections were not used. The number of cut plants was evaluated in linear plots of 5 plants with 4 replications at 15, 30 and 60. The response in diameter at the base and total height was measured on one year. The statistical analysis of the results showed that the effect of damage prevention methods is significant. The protection with physical barriers was 100% regardless of the time elapsed. The repellent was effective until 30 days and then decreased its effect being equal to the control after 60 days. The growth in diameter and height did not present significant differences, although it was slightly higher using bottle protection. The oleoresin of Capsicum repellent is suitable to prevent hare attacks in white carob plantations for periods of 30 days for its practicality for application on considerable surfaces.

55. Susceptibility of *Gonipterus platensis* to entomopathogenic nematodes.

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The *Gonipterus scutellatus* (Coleoptera: Curculionidae) complex has stood out among insect pest in Eucalyptus planted forests worldwide. The action of these insects can cause plant reduction growth above 30%, especially when the attack occurs on the tip of new shoots. *G. platensis* is the main species found in population outbreaks in Brazil. The control strategies traditionally adopted, biological control with egg parasitoid *Anaphes nitens* and entomopathogenic fungi *Beauveria bassiana*, have not showed satisfactory results; therefore, new control strategies have been studied. Entomopathogenic nematodes (EPNs) have shown to be promising in insect pest control, especially those that spend any stage in soil. This study aimed to evaluate the susceptibility of *G. platensis* pupae to *Heterorhabditis amazonensis*, *H. bacteriophora*, *Steinernema brazilense*, *S. feltiae* and *S. rarum*. Fourth-instar larvae of *G. platensis* were conditioned in plastic pots containing autoclaved and moistened sand to form the pupal chamber. After fifteen days of insect development in the sand pots, the EPNs were inoculated at the doses of 50, 100, 200 and 400 infective juveniles (IJ) per insect. Mortality was evaluated at four and eight days after the inoculation of the larvae. In the first evaluation, the best results were obtained on *H. amazonensis* and *S. feltiae* treatments, with mortalities above 80% and 50%, respectively. In the second evaluation, all EPNs caused mortality above 78%, even at the lowest doses, and reached 100% mortality at higher doses, except for *S. rarum*, whose maximum mortality was 90%. The results confirm the high potential of entomopathogenic nematodes as biological control agents for *G. platensis* during its stage in soil.

56. Initial evaluation of the fungal attack caused by *Gloeophyllum trabeum* and *Laetiporus sulphureus* on *Eucalyptus grandis* standing trees.

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The biological decomposition of lignocellulosic materials caused by basidiomycetes plays an essential role in the Carbon cycle. Brown rot fungi are the most important agents in the biodegradation of wood products and standing trees of natural ecosystems. In standing trees, there is a wide variety of antimicrobial defense mechanisms that act as effective barriers against fungal attack. These alterations include changes in the cell wall, induced antimicrobial compounds, necrotic responses of living cells and deposition of gummy materials. In this work, the effect of sapwood inoculation of *Eucalyptus grandis* trees with strains of two fungi causing brown rot, *Gloeophyllum trabeum* and *Laetiporus sulphureus*, and the initial response of the tree against fungal attack were evaluated. The contents of soluble/insoluble lignin and cellulose were quantified according to the TAPPI standards; and a qualitative evaluation was made of the damage caused by the fungi that cause brown rot, observing anatomical changes generated by the fungal attack in the initial stages using SEM and fluorescence microscopy. Differences in the structural polysaccharide contents and slight changes in the attacked wood were observed. The study of the process of deterioration over time is continued to know in depth the damage caused and the defense mechanisms of the trees.

63. Teratosphaeria leaf disease management in young *E. globulus* plantations.

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In Uruguay the area planted to *Eucalyptus* has been incremented in the last years. Together with this increment phytosanitary problems arose, mainly foliar diseases as Mycosphaerella Leaf Disease (MLD). *Eucalyptus globulus* was one of the main species planted until 2007 when a severe epidemic outbreak of the pathogen *Teratosphaeria nubilosa* had a significant impact on plantations resulting in a loss of 5000 ha in western Uruguay. Several products as chitosan, algal extracts, phosphites and fungicides have demonstrated to be effective to control fungal diseases in other plant species by direct effect on the pathogen, defenses activation or enhancing growth. The goal of this work was to evaluate the effect of chitosan, algal extracts, phosphites and fungicide application in young plants of *E. globulus* on disease control and tree growth. Trials were performed at different locations and consisted in randomized complete block design with 16 plots each with 10 plants. Treatments were applied at the 0, 3, 6 and 12 months after plantation. One seedling and one clonal genotype were tested. Disease incidence, severity and defoliation were evaluated 3, 6, 12 and 18 months post plantation, crown damage index was calculated, height and diameter at breast height were recorded. All the trees of the different trials were affected by *T. nubilosa* at different time depending on the region. Only the fungicide treatment applied strategically in autumn and spring showed significant disease control. The potassium phosphite also showed significant increase in tree height in some experiments. Differences between seedling and clonal germplasm were observed, being clonal less affected by MLD, probably due to the earlier change of foliar type. These results suggest the application of fungicides at the time of highest risk of infection, early autumn and spring, may be a useful tool to minimize the impact of MLD on *E. globulus.*

66. Natural parasitism of *Thyrinteina arnobia* (Stoll, 1782) (Lepidoptera: Geometridae) pupae in a *Eucalyptus cloeziana* (Myrtaceae) plantation in Minas Gerais State, Brazil.

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Commercial plantations are affected by pests that reduce their productivity and generate economical losses for the forestry companies. Although *Eucalyptus* plantations in Brazil were affected mostly by exotic pests in the past, in the last years native insect species are also causing important damages. *Thyrinteina arnobia* (Lepidoptera: Geometridae) is the most important native defoliator species that attack *Eucalyptus* plantations in Brazil. Biological control with predators and pupal parasitoids is the method commonly employed for their management. Parasitoid species of the families Chalcididae and Tachinidae have an important role in controlling lepidopteran pests. The aim of this work was to evaluate the natural parasitism of *Thyrinteina arnobia* pupae in a plantation of Eucalyptus *cloeziana*. The study area was located in Itamarandiba, Minas Gerais, Brazil. The pupae were collected on 21th February and on 23th March 2017, in an area of 4 hectares. The pupae were sexed, individualized in glass tubes and maintained in climatic chambers at 24°C and photoperiod 12:12 for 49 days to evaluate the emergence. A total of 355 *T. arnobia* pupae were collected in February (201 males, 152 females), whereas 277 pupae were collected in March (177 males and 57 females). Adult moths emerged from 79 % of the pupae collected in February and 74% of the pupae collected in March, respectively. Parasitization reached 4,8% and 13% of the pupae in February and March, respectively, being females more parasitized than males in both months (9:6 in February and 22:14 in March). Fifty-seven individuals in February, and 39 in March did not emerge as adults due to the attack by microorganisms or unknown causes. Parasitoid diversity increased in species and family numbers in March. Eight parasitoid species were found, belonging to families Tachinidae (4), Sarcophagidae (1), Ichneumonidae (1), Eurytomidae (1) and Chalcididae (*Brachymeria pandora*).