

Forest health surveillance methodology in hardwood plantations in Queensland, Australia

Simon A. Lawson^{1,2}, Janet M. McDonald¹ and Geoffrey S. Pegg¹

¹Horticulture and Forestry Science, Department of Primary Industries & Fisheries, Forestry Science Building, Gate 3, 80 Meiers Rd, Indooroopilly, Queensland 4068, Australia

²Email: simon.lawson@dpi.qld.gov.au

Revised manuscript received 1 July 2008

Summary

Forest health surveillance (FHS) of hardwood plantations commenced in Queensland in 1997 as plantations expanded following a state government planting initiative arising from the national 2020 forest policy vision. The estate was initially characterised by a large number of small plantations (10–50 ha), although this has changed more recently with the concentration of larger plantations in the central coast and South Burnett regions. Due to the disparate nature of the resource, drive- and walk-through surveys of subsets of plantations have been undertaken in preference to aerial surveys. FHS has been effective in detecting a number of new hardwood pests in Queensland including erinose mites (*Rhombacus* and *Acalox* spp.), western white gum plate galler (*Ophelimus* sp.), *Creiis* psyllid and bronzing bug (*Thaumastocoris* sp.), in evaluating their potential impact and assisting in focussing future research efforts. Since 2003 there has been an increased emphasis on training operational staff to take a greater role in identifying and reporting on forest health issues. This has increased their awareness of forest health issues, but their limited time to specifically survey and report on pests and diseases, and high rates of staff turnover, necessitate frequent ongoing training. Consequently, common and widespread problems such as quambalaria shoot blight (*Quambalaria pitereka*), chrysomelid leaf beetles (mainly *Paropsis atomaria*) and erinose mites may be under-reported or not reported, and absence data may often not be recorded at all. Comment is made on the future directions that FHS may take in hardwood plantations in Queensland.

Keywords: forest health; surveillance; methodology; costs; plantations; hardwoods; insect pests; pathogens; diseases; Queensland

Introduction

Contracted systematised forest health surveillance (FHS) conducted by the Department of Primary Industries and Fisheries (DPI&F) on behalf of Forestry Plantations Queensland (FPQ; formerly DPI Forestry) commenced in Queensland in January 1996 (Speight and Wylie 2001). It was aimed primarily at:

- detecting incursions of exotic organisms
- providing a reference database of forest pests and diseases in Queensland

- detecting outbreaks of existing pests
- providing advice to forest managers.

Since July 2006, softwood and nursery surveys have been undertaken internally by FPQ staff, with FPQ Corporate hardwood, joint venture and land rental surveys retained by DPI&F. Prior to 1996, detection and management of forest health problems was undertaken on an ad hoc basis by specialist entomologists, pathologists and forestry operational staff as part of their routine work.

The Queensland FHS system was based on one established in New Zealand in 1956 (itself based on a Canadian model, see Flux *et al.* 1993). It is also similar to programs established in 1996 in New South Wales (Carnegie 2007; Carnegie *et al.* 2008) and Tasmania (Wotherspoon 2008). Since their establishment, FHS methods have evolved in response to experience, data derived from surveys, technology availability and advances, and operational circumstances including hardwood plantation expansion in Queensland since 1997, and budgetary and other operational constraints.

In general, hardwood surveillance has been based on a number of complementary methods and includes drive- and walk-through surveys, and the establishment of monitoring transects and plots. More details on these methods are given in Speight and Wylie (2001) and below in the methods section. To aid in the recording and reporting of the survey data, a standard field form was designed and integrated with a robust Unix-based database for storage and retrieval of survey data. Forest pest and disease collection records going back to the 1960s were also incorporated in this database to provide baseline information on recorded biotic agents in Queensland forests. The original database was transferred in 2001 to a more user-friendly and adaptable Microsoft Access format.

Forest health surveillance of the about 190 000 ha of softwood (150 000 ha of *Pinus* and 40 000 ha of *Araucaria* species) plantations in Queensland has been reported previously (Speight and Wylie 2001). Aerial surveys using fixed-wing aircraft have been conducted over most of the softwood estate annually from 1996. Initially aerial surveys used typical sketchmapping techniques,

but in recent years laser technology has enhanced aerial surveys, with laser rangefinders linked to palmtop computers with GPS capabilities for accurately locating damaged areas on the ground (Ramsden *et al.* 2005). Follow-up ground surveys (road-side and random-point inspections) are then conducted.

While limited surveillance of native forest (mainly cypress *Callitris glauca*, brigalow *Acacia harpophylla* and mixed eucalypt forest) was carried out early in the surveillance program, the main focus for forest health surveys has been on plantations as well as on some associated nurseries. The present paper focuses on the methods used in plantations.

Plantation forestry in Queensland

In 2006, the plantation forest estate (government and private) in Queensland totalled over 230 000 ha, making it the fifth largest plantation estate in the country. This area consisted of 190 000 ha of softwood plantations and 43 000 ha of hardwoods, mostly eucalypts (Parsons and Gavran 2007). Hardwood plantations in Queensland include *Eucalyptus grandis* × *E. camaldulensis* hybrids, *E. dunnii* and *E. grandis*, which are predominantly planted for pulp, and *Corymbia citriodora* subsp. *variegata*, *E. cloeziana* and *E. argophloia*, which are used mainly for solidwood production. Plantings of the high-value exotic hardwood species *Tectona grandis* (teak) and *Khaya senegalensis* (African mahogany) have recently begun to expand in tropical northern Queensland, while smaller plantings of mixed cabinet wood species such as *Elaeocarpus grandis* (silver quandong), *Flindersia brayleyana* (Queensland maple) and others have also occurred in the tropics and subtropics.

The hardwood estate

Most of the current hardwood estate in Queensland has been established since 1997, with only small areas planted prior to this (Wylie and Peters 1993). The Private Plantations Initiative (PPI) of 1996 was the first scheme in Queensland to target hardwood plantation development in line with the national 2020 vision for plantation expansion (Plantations 2020, 2001), and resulted in the establishment of about 2000 ha of hardwood plantations by 1999. The PPI was followed in 1999 by the Southeast Queensland Forest Agreement (SEQFA), which provided for further expansion of hardwood plantations by linking the establishment of an additional 5000 ha by 2003 to the phasing out of native forest logging in 425 000 ha of Crown native forests in south-eastern Queensland by 2025 (Queensland Government 1999, 2000).

Between 2002 and 2006 the hardwood plantation area in Queensland expanded by 32 000 ha, mostly driven by managed investments scheme (MIS) companies which establish plantations predominantly for pulp production. The hardwood plantation area reached 43 000 ha in 2006 (Parsons and Gavran 2007), making up just 5.3% of the national hardwood estate. Figure 1 shows the regions in south-eastern Queensland where hardwood plantation development is concentrated. Two regions, the South Burnett (centred on Kingaroy) and central Queensland (centred on the port of Gladstone) are the main centres of current development, with the former focussing on sawlog production and the latter on pulpwood.

FHS in Queensland hardwood plantations

Systematised FHS of hardwood plantations began in 1997 with the establishment of the first plantations under the PPI and run as joint ventures between private landholders and the state. Because of the relatively small number of initial plantations established from 1997 to 1999, it was possible to survey each plantation at least once per year. With the subsequent increase in the number of plantations and their disparate geographical distribution, however, this became logistically impossible. Surveys since 2000 have mainly concentrated on a subset of plantations 1–2 y of age with a previous history of insect or fungal problems, and on call-outs from forest managers to investigate emergent problems identified by operational staff. With the earliest plantings now over 10 y of age, surveys of these older plantations for insect stem borers and

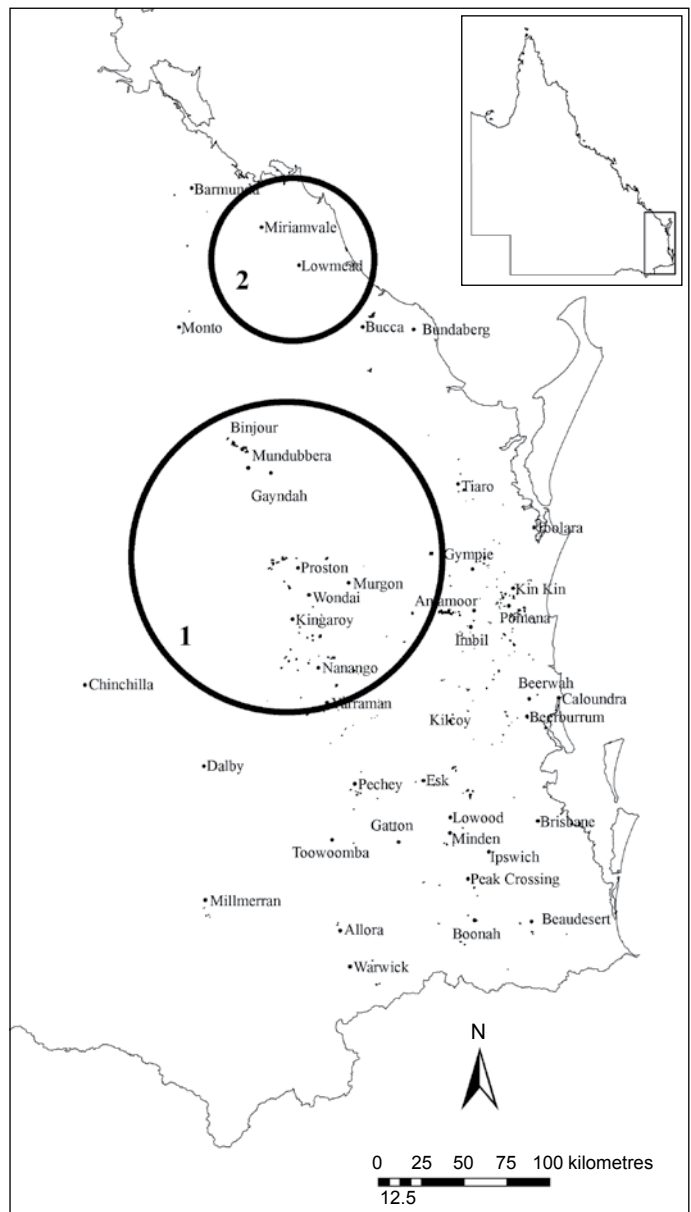


Figure 1. Location of centres of hardwood expansion in south-eastern Queensland (circles). 1 – South Burnett. 2 – Miriam Vale (Gladstone).

other stem degrade agents such as fungal cankers, stains and rots are becoming a priority.

To date, systematic hardwood surveys by professionally trained forest health staff have been carried out only in state-owned or state-managed plantations via funding provided by FPQ. Private hardwood plantation owners in Queensland have tended to rely on ad hoc detection by forest operational staff, and formal and informal consultation with forest health professionals once problems have been detected.

Methodologies

The primary method used in hardwood plantation surveys has been drive-through surveys (Speight and Wylie 2001), complemented by more intensive walk-through assessments within plantations using the Crown Damage Index method (CDI; Stone *et al.* 2003) and transects to determine the incidence and severity of health issues. Due to the disparate, small-scale nature of plantations (generally 20–50 ha in area), aerial surveillance has to date not been an economically viable method for surveying the Queensland solidwood plantation estate. This situation may change in the future with the current expansion and consolidation of plantation management units to reach more than 100 ha in the South Burnett and Gladstone regions. In privately owned pulpwood plantations in the Gladstone region, where plantation compartment sizes are generally larger and the resource more concentrated, aerial surveillance may already be feasible.

Since 2003, the surveillance program in Queensland's state-owned or managed plantations has evolved with an increased emphasis on training operational staff to take a greater role in identifying and reporting on forest health issues detected during their normal plantation management duties. Theory and field-based workshops were provided in 2003 for FPQ staff, and in 2006 for all hardwood growers in the regions through the Subtropical Forest Health Alliance (SFHA; a group of plantation growers and R&D providers in northern NSW and south-eastern and central coastal Queensland). This provided field staff with basic skills in the identification of key insect pests, diseases and nutritional deficiencies, usage of field forms for data collection, protocols for sample collection and preparation, and in use of the CDI. This has been accompanied by a greater emphasis by professional forest health surveillance staff on monitoring the impact on plantation growth of emerging pests such as erinose mites (*Rhombacus* and *Acalox* spp.), western white gum plate galler (*Ophelimus* sp.) and psyllids (*Creiis lituratus*) through the establishment of short-term monitoring plots.

Reporting

FHS survey data in Queensland are used in several different ways for reporting purposes. Reports on individual surveys of plantations are provided as rapidly as possible to clients so that management action on identified health issues, where feasible, can be carried out in a timely manner. Annual reports on plantation health have been produced by DPI&F for Forestry Plantations Queensland hardwood plantations since 1997. These reports are used by the client to plan and implement management strategies for key pests and diseases, and are used as part of the client's due diligence obligations to joint-venture plantation partners. They

also assist in demonstrating compliance with obligations under certification schemes such as the Australian Forestry Standard, particularly in relation to Criterion 5 of the Standard that states that 'Forest management shall maintain forest ecosystem health and vitality'.

FHS data also form the backbone of Queensland's national and international reporting obligations on forest health issues. Data gathered by FHS in Queensland are provided to Research Working Group 7 (Forest Health) for an *Annual Pest and Disease Status Report for Australia and New Zealand*, and thus these data flow through to the national Primary Industries Standing Committee. FHS also provides Queensland's only source of data on forest pest and disease status for the five-yearly national *State of the Forests Report*, part of Australia's commitment to the Montreal Process.

Discussion

An important outcome of FHS over the last ten years has been its positive impact in increasing the awareness of forest health issues by plantation managers and operational staff. This has especially been the case in hardwood plantations where insect pests and fungal diseases are almost constant threats to plantation productivity. In softwood plantations, the number of established threatening biotic agents is much smaller. Training operational staff has been valuable in increasing their ability to recognise forest health damage symptoms and causal agents, and to collect samples with the required data for specialist identification and advice.

As well as raising awareness of forest health issues, FHS has also been very effective in detecting new and emerging health issues in an efficient and timely manner, evaluating their potential impact and assisting in focusing future research efforts. The detection of new pests such as erinose mites, western white gum plate galler and bronzing bug (*Thaumastocoris* sp.) are just a few examples of this (Fig. 2).

In terms of the management of recognised forest pests and diseases, however, it appears that:

- problems are often detected too late for remedial responses to be taken, particularly when cryptic pests such as borers and cankers are involved (Wardlaw *et al.* 2008)
- effective control methods are not available for many key pests and diseases even when problems are promptly detected.

While lack of effective management methods that fit into environmental certification schemes (Carnegie *et al.* 2005) is an issue being addressed by current research projects, these necessarily have a long lead time because of the lack of detailed baseline knowledge of the biology, ecology and host tree relationships of the key pests and diseases.

In addition, while training programs for plantation managers and operational staff have increased awareness of pests and diseases, these staff often have limited time to specifically survey and report on FHS issues because of their heavy work loads in plantation establishment and management. High rates of turnover of these staff also mean that training programs need to be carried out frequently to cover new staff and to refresh the skills of others.



Figure 2. Emerging pests of hardwood plantations in Queensland: (a) erinose mite leaf damage on *Corymbia citriodora* subsp. *variegata* (*Rhombacus* sp., *Acalox* sp.); (b) bronzing bug damage symptoms in *C. citriodora* subsp. *variegata* plantation; (c) *Ophelimus* sp. plate galls on *Eucalyptus argophloia*.

These factors can result in common and widespread problems such as quambalaria shoot blight (*Quambalaria pitereka*), chrysomelid leaf beetles (mainly *Paropsis atomaria*) and erinose mites (*Rhombacus* and *Acalox* spp.) being under-reported or not reported, and for absence data to often not be recorded at all. These issues are of particular importance since FHS data in the future will be used in the development of hazard risk models for plantations, requiring reliable presence and absence data. It is important to know why some plantations are healthy and others not, and to be confident that the absence of reported problems is just not an absence of data.

Furthermore, despite rapid expansion in the private hardwoods estate in Queensland in recent years, there has so far been little professional and systematic FHS carried out in these plantations. Wardlaw *et al.* (2007) suggested that while this may be a relatively low-risk strategy during plantation establishment when frequent tending operations dictate regular visits and a consequently higher probability of detecting emerging problems, once plantations age and these visits become less frequent the risk of significant problems remaining undetected also increases. This is especially the case for stem borer, canker and fungal stain and rot problems which characteristically become more frequent and severe as plantations age (Lawson *et al.* 2002).

A factor in the low uptake of systematic FHS by private hardwood growers may be related to the current higher unit costs of this surveillance compared to that of the broader-scale aerial-based surveillance undertaken in softwood plantations. Speight and Wylie (2001) estimated that the per-hectare cost of hardwood surveillance in Queensland was about ten times that of softwood surveillance (about \$10 ha⁻¹ versus \$1 ha⁻¹). As hardwood plantation unit size and aggregation increase, however, cost efficiencies may be achieved in future by aerial surveillance of at least part of the hardwood estate (as occurs with FHS in NSW and Tasmania — Carnegie *et al.* 2008; Wotherspoon 2008). FHS of these plantations will probably still be more costly than for softwoods because of the diversity of biological agents involved and their long active season in the subtropics. Also — although depending on the timing of the survey — a single survey per season of a hardwood plantation is unlikely to detect all the problems that may occur during the season. Timing of surveys is also crucial for management decisions, as surveys undertaken late in the season offer limited opportunity to apply remedial treatments should these be available, because damage has already occurred.

A possible avenue for reducing costs of FHS to individual hardwoods growers is through a cooperative approach, pooling the existing expertise in the region through coordination by the SFHA. A major objective of the SFHA at its formation was to better coordinate and standardise forest health surveillance methodologies and reporting in the region across the growers. Standardisation of databases and information sharing across agencies is an important part of this, and the SFHA has already acted as a forum for prioritising forest health research and development in the region and coordinating responses to problems.

Acknowledgements

The support of Forestry Plantations Queensland (formerly DPI-Forestry) in funding FHS projects in Queensland since 1996 is gratefully acknowledged. Thanks to Drs Ross Wylie, Ian Hood and Judy King who were instrumental in initiating and negotiating the funding for FHS in Queensland, and to the staff who have contributed to the successful running of FHS in Queensland over the last ten years, including Mark Self, Michelle Deveze, Michael Ramsden, Murdoch DeBaar, Dr Mike Ivory, Tonya Hardaker, Rebekah Aigner and Jacinta Mills.

References

- Carnegie, A.J. (2007) Forest health condition in New South Wales, Australia, 1996–2005. II. Fungal damage recorded in eucalypt plantations during forest health surveys and their management. *Australasian Plant Pathology* **36**, 225–239.
- Carnegie, A.J., Stone, C., Lawson, S. and Matsuki, M. (2005) Can we grow certified eucalypt plantations in subtropical Australia? An insect pest management perspective. *New Zealand Journal of Forestry Science* **35**, 223–245.
- Carnegie, J., Cant, R.G. and Eldridge, R.H. (2008) Forest health surveillance in New South Wales, Australia. *Australian Forestry* **71**, 164–176.
- Flux, A., Gadgil, P., Bain, J. and Nuttall, M. (1993) *Forest Health: Forest Tree and Wood Protection in New Zealand*. Ministry of Forestry, Wellington, 173 pp.

- Lawson, S.A., Wylie, F.R., Wylie, R.L. and Ryan, P. (2002) Longicorn beetles (*Phoracantha* spp.) and giant wood moths (*Endoxyla* spp.): emerging threats in tropical and subtropical eucalypt plantations in Queensland, Australia. *FORSPA Publication* No. 30, 33–45.
- Parsons, M. and Gavran, M. (2007) *Australia's Plantations 2007: Inventory Update*. Bureau of Rural Sciences, Canberra, 8 pp. <http://www.affashop.gov.au/product.asp?prodid=13683>.
- Plantations 2020 (2001) *Plantations for Australia: The 2020 Vision*. <http://www.plantations2020.com.au/assets/acrobat/2020vision.pdf>.
- Queensland Government (1999) *Forestry Amendment Bill (1999)*. <http://www.legislation.qld.gov.au/Bills/49PDF/1999/ForestryAmdB99Exp.pdf>.
- Queensland Government (2000) *Nature Conservation and Other Legislation Amendment Bill (2000)* http://www.legislation.qld.gov.au/Bills/49PDF/2000/NatCon_OthLegAmdB00Exp.pdf.
- Ramsden, M., Hemmens, T.J. and Kennedy, J.F. (2005) Laser technology enhances aerial assessment of plantation health. *International Forestry Review* 7, 168.
- Speight, M. and Wylie, R. (2001) *Insect Pests in Tropical Forestry*. CABI, Wallingford.
- Stone, C., Matsuki, M. and Carnegie, A. (2003) *Pest and Disease Assessment in Young Eucalypt Plantations: Field Manual for Using the Crown Damage Index*. Parsons, M. (ed.) National Forest Inventory, Bureau of Rural Sciences, Canberra. <http://affashop.gov.au/product.asp?prodid=12783>.
- Wardlaw, T., Carnegie, A. and Lawson, S. (2007) The scorecard of a decade of forest health surveillance in Australia. *Institute of Foresters of Australia New Zealand Institute of Forestry Biennial Conference*, Coffs Harbour, NSW, 3–7 June 2007 (extended abstract). Institute of Foresters of Australia, Canberra.
- Wardlaw, T., Bashford, R., Wylie, R., Wotherspoon, K. and Elliott, H. (2008) The efficacy of routine forest health surveillance in detecting pest and disease damage in eucalypt plantations. *New Zealand Journal of Forestry Science* 38, (in press).
- Wotherspoon, K.P. (2008) Forest health surveillance in Tasmania. *Australian Forestry* 71, 182–187.
- Wylie, F.R. and Peters, B.C. (1993) Insect pest problems of eucalypt plantations in Australia. 1. Queensland. *Australian Forestry* 56, 358–362.