Forest health surveillance in South Australia

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Summary

South Australia has about 124 000 ha of softwood (*Pinus radiata*) and 48 000 ha of hardwood (*Eucalyptus globulus*) in plantations. Forest health surveillance is an important part of risk management in these plantations. Until recently the only formal forest health surveillance conducted in the state was surveillance for *Sirex noctilio* as part of the National Sirex Control program. The South Australian Forestry Corporation (ForestrySA) now conducts formal surveys of its *P. radiata* plantations annually or more frequently if necessary. Surveillance in *P. radiata* plantations consists of aerial and drive-through surveillance with follow-up on-ground inspection to identify and confirm diagnosis of problems. Information is entered in a database and reports on the general health of the forest, as well as on specific forest health issues, are given to forest managers, together with recommendations for remedial action if necessary. Forest health surveillance in eucalypt plantations has tended to be reactive rather than proactive, but now operations staff monitor for insect pests, diseases and nutritional disorders as part of everyday management. Currently there is no formal surveillance of native vegetation in South Australia and there is no harvesting of timber from native forests. Surveillance of urban trees is conducted on an ad hoc basis in response to an incursion of a forest pest or disease. Primary Industries and Resources South Australia (PIRSA) uses a variety of methods in urban forest health surveillance, depending on the pest or disease being targeted. In South Australia a hazard site surveillance program was established in 2006–2007 as part of the National Plant Health Surveillance Framework. This involves surveillance for exotic pests and diseases in and around targeted hazard sites in urban areas adjacent to key entry points, and is based on risk and pathway analysis. Forest health surveillance provides a valuable base for management of pests, diseases and nutritional disorders, and for strategic research on the impacts of forest health problems on timber production.

Keywords: forest health; surveillance; methodology; disease surveys; insect pests; nutrient deficiencies; plantations; native forests; *Pinus radiata*; *Eucalyptus*; South Australia

Introduction

With increasing investment in forestry, uncertainty with climate change and emphasis on sustainability and compliance with certification standards, formal surveillance and reporting of forest health issues is an important part of forest risk management. Detecting and accurately diagnosing insect pest and disease outbreaks and nutritional disorders in plantations before they cause significant damage is vital if management actions are to be effective. Forest health surveillance, as part of a formal forest health program, enables forest managers to be proactive and to maximise survival, growth and productivity of their plantations.

Surveillance examines not only the general health of the forest, but can target specific issues so as to provide information early in rotations for more effective management (including remedial actions such as fertiliser application and weed control). Of particular benefit is the ability to ensure nutritional disorders are recognised before significant damage occurs (e.g. tree deformity due to boron deficiency). This has financial benefits throughout the whole rotation.

A forest health surveillance program also demonstrates that risks to forest health are being managed, which is important for certification and reporting (e.g. Australian Forestry Standard and Forest Stewardship Council criteria), and provides confidence to customers that products are derived from healthy, sustainable forests. Such a program ensures greater awareness of forest health issues and forest health status.

Forestry in South Australia

Plantation forestry in South Australia (SA) is concentrated in the south-east of the state in part of a region known as the Green Triangle (which covers the south-east of SA and western Victoria). There are also plantations in the Mount Lofty Ranges (Mount Crawford, Kuitpo and Second Valley), at Wirrabara and Bundaleer in the Mid-North and on Kangaroo Island (Fig. 1).

In SA there are about 124 000 ha of softwood and 48 000 ha of hardwood in plantations. Of these about 104 000 ha of softwood (mainly *Pinus radiata*) and 38 000 ha of hardwood (mainly *Eucalyptus globulus*) are grown in the south-east of the state in the Green Triangle (Parsons *et al.* 2006; Parsons and Gavran 2007).

South Australia also has about 10 800 000 ha of native forest. No timber is harvested from ForestrySA native forests as they are managed primarily for the conservation of biodiversity.

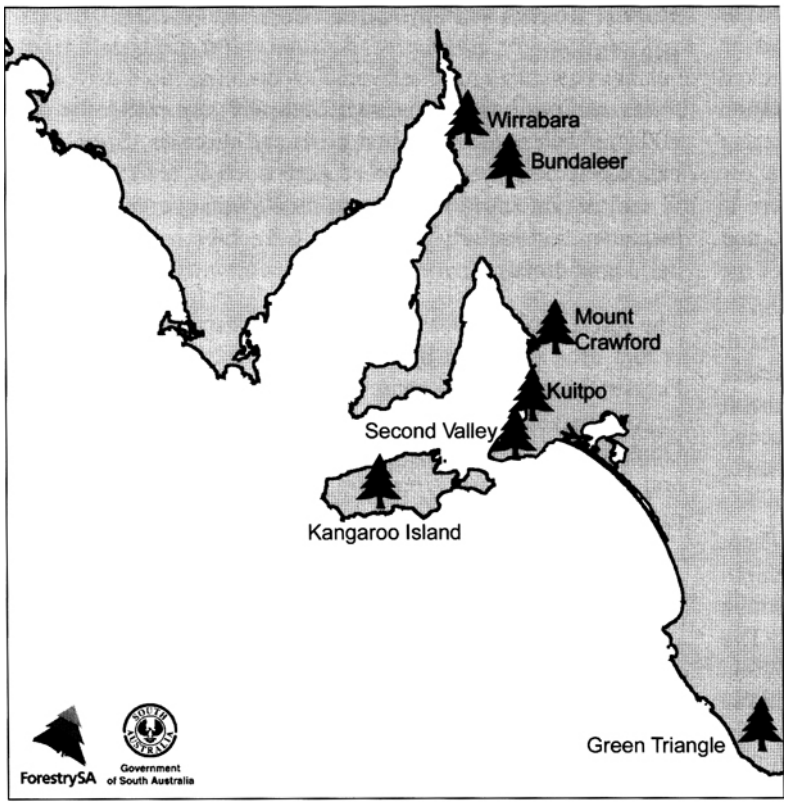

Figure 1. Forest areas of South Australia

The South Australian Forestry Corporation, trading as ForestrySA, manages the state-owned forest resource in SA. This primarily consists of *P. radiata* in the Green Triangle, the Mount Lofty Ranges and the Mid-North Regions.

ForestrySA manages about 70 000 ha of plantation in the Green Triangle and 14 500 ha in the Mount Lofty Ranges and Mid-North Regions of the state. The remaining areas of plantation are owned and managed by private companies. ForestrySA also manages some 26 800 ha of native forest.

History of forest health surveillance in South Australia

In the past, apart from the sirex control program, forest health surveillance in SA was primarily reactive, with little general surveillance (or monitoring) of forest condition. Forest health issues were investigated only when a problem was noted by field staff in the course of their normal duties.

In 1987–1989, an outbreak of *Sirex noctilio* occurred in the Green Triangle Region of SA. It was not detected until considerable damage had been done, by which time it was too late to prevent significant economic losses. About five million trees were killed (Haugen *et al.* 1990), with up to 80% mortality in some plantations. As a result of this, surveillance of susceptible trees and monitoring of sites where sirex was or had been became a routine annual activity.

Following this outbreak, the National Sirex Coordination Committee was set up to develop a national strategy for the control of sirex which included annual aerial surveillance of susceptible pine plantations (Haugen *et al.* 1990). This strategy was adopted by pine-growing companies in SA (and other states where sirex was present). However, these flights surveyed only plantations that were considered susceptible to sirex attack (in general, unthinned plantations, 10–25 y old (Haugen *et al.* 1990)) and plantations where sirex had been found previously. They were not used to detect other forest health issues. This was the only formal surveillance done in SA.

The Monterey pine aphid, *Essigella californica* (Essig), was first detected in Australia in 1998 (Carver and Kent 2000). Subsequent surveys across Australia revealed it to be widespread throughout plantations in several states, where it caused considerable defoliation and growth loss. It had been present in Australia for some time but had not been recognised until accidentally detected in Canberra in an urban situation. Following its detection in SA, essigella was formally monitored for a number of years as part of a study to determine its impact (May and Carlyle 2003) but there are now no regular surveys or specific monitoring for essigella in SA.

With the establishment of *E. globulus* plantations in the Green Triangle, forest health surveillance became more crucial. A forest health specialist was employed by the then Woods and Forests Department (now ForestrySA) in the early 1990s, initially to work on insect pest and disease problems in hardwood plantations but also on allied problems in pine plantations.

The importance of forest health surveillance is now recognised by the forest industry. Surveys in government-owned pine plantations are conducted on an annual basis by personnel trained to recognise symptoms of damaging pests and diseases. These surveys are the primary means of detecting health problems early. Private companies growing pines also carry out some surveillance, particularly for sirex. Surveillance in eucalypt plantations, however, is still reactive rather than proactive, but certain pests are targeted for surveillance at specific times of the year (e.g. *Heteronyx* beetles).

Currently there is no formal surveillance of native vegetation in SA.

Why is forest health surveillance necessary?

Forest health surveillance is necessary to:

- *Ensure the early detection of threats to tree health (insect pests, diseases, nutritional disorders) to enable management to respond before there is a significant impact on health and productivity.* Reliance on opportunistic detection by field staff during the course of their normal duties means many problems may not be detected in time to prevent significant damage and

associated growth loss or death of trees. In general, field staff have neither the expertise nor time to survey and report on forest health issues. Consequently, problems may be overlooked or reported too late for effective remedial action. Common problems are often not reported at all as they are always present and are seen as 'normal'. Often reporting systems do not allow for general observations on forest health status and there is no provision for noting absence of problems. It is important to include such information to give an accurate picture of the health status of the plantation estate.

- *Detect changes in forest health over time.* A forest health surveillance program helps identify risks to forest health and productivity and alert forest managers to emerging issues. It provides site-specific knowledge of insect pests, diseases and nutritional disorders likely to detract from production. In some situations it may enable prediction of future problems.
- *Ensure early detection of new forest pests and diseases.* There are a number of forest pests and diseases with the potential to devastate forests if they were to become established in Australia (Agriculture, Fisheries and Forestry – Australia 2000). The early detection of these species is vital. For example, by the time *E. californica* was detected in softwood plantations, it was already widespread and causing significant damage.

  Early detection of the sirex outbreak in the Green Triangle in 1987 may have prevented, or substantially reduced, the enormous economic losses that followed.
- *Identify risks to forest health and productivity.* A formal surveillance program can determine the cause, severity and extent of pests, diseases, nutritional disorders and other factors likely to affect production. Benefits include site-specific knowledge of such factors which will assist in predicting the impact on wood volume and enable management practices to be adjusted (at an operational level) to minimise the impact and improve growth and productivity.
- *Determine the status of pests and diseases.* A formal surveillance program enables reporting on the general health of the forest estate as well as on specific health problems. This is necessary to satisfy requirements for Forest Stewardship Council (FSC) (Forest Stewardship Council 2002) and Australian Forestry Standard (AFS) (Australian Forestry Standard 2007) certification and to demonstrate that wood has originated from sustainably managed plantations.
- *Monitor the effectiveness of operational control programs and fertiliser regime*: for example, the effectiveness of the sirex control program and the essigella biological control program.

Another benefit of formal forest health surveillance is that it provides greater awareness of forest health issues and forest health status both within organisations and the community.

A forest health surveillance program needs to be operationally practical, relevant, cost effective and comprehensive, and allow site-specific issues to be addressed.

Various surveillance methods are used in SA, the choice depending on the situation and the needs of forest managers. The protocols used in pines are different from those used in eucalypts, but they address similar forest health issues.

Forest health surveillance in *Pinus radiata* plantations

Pinus radiata has been grown commercially in SA for over 100 y and has relatively few pests and diseases. Sirex is the major pest but other introduced pests such as *Ips grandicollis*, *E. californica* and diseases such as *Diplodia sapinea* are also important, particularly when trees have been stressed by long periods of drought.

The forest health surveillance program described in this paper is that used currently by ForestrySA. In the Green Triangle, ForestrySA surveys its entire pine estate annually, with further targeted surveillance as required if specific problems are detected. Other forest companies in the region carry out annual monitoring and surveillance for sirex, but have no formal surveillance programs for forest health in general.

Surveillance methods

ForestrySA uses both aerial and drive-through surveillance in the Green Triangle Region, with follow-up on-ground inspection (ground truthing) to identify and confirm the diagnosis of symptoms seen from the air. Plantations are assessed for damage or mortality, discoloration and poor performance. Young plantations (<3–4 y old) are not targeted in aerial surveillance. These are assessed using drive-through methods. All information collected is entered into the forest health layer of the ForestrySA GIS database and used to make recommendations to minimise the effects of these threats on production.

Forest health surveys record:

- the presence (and absence) of damage (by pests, diseases and nutritional disorders)
- the location of damage or problems (mapping)
- the extent (area affected), incidence (proportion of trees affected) and severity of the damage or problem for each different health condition identified
- other attributes which may be associated with specific health problems (e.g. soil types, topography etc.).

In the Mount Lofty Ranges, steep topography and smaller, fragmented plantations mean surveillance by aircraft is difficult. Consequently surveillance is done mainly by ground crews using drive-through and ground inspection techniques. The potential for future aerial surveillance in this region is being investigated.

Aerial surveys

Aerial surveys enable surveillance of large areas of plantation at relatively low cost. They detect health problems that cause highly visible damage (mortality, failed areas, thin crowns, discoloration). The location and extent of detected problems are recorded by observers using sketchmapping techniques on hardcopy plantation maps, supplemented with GPS location and photography.

Previously only plantations considered susceptible to sirex and those plantations where sirex was present the previous year were surveyed. Now aerial surveillance has been extended to include the whole ForestrySA pine estate to detect any forest health problems. Aerial surveys are conducted in June–July each year with additional flights in some years (for example in droughts) at other times (usually spring) to detect problems that are not apparent in June–July. Both fixed-wing aircraft and helicopters are used with two–three observers to map and document any health issues.

Drive-through

Roadside surveys enable identification of symptoms not apparent in aerial surveys (for example symptoms that appear in the lower crown). This type of surveillance is used in young plantations that have yet to reach canopy closure and involves driving through the plantation along existing roads or tracks and noting any forest health issues. This method is effective at detecting health issues in plantations up to 3–4 y old where visibility is good. In older plantations, roadside surveys are limited to inspecting edge trees in unthinned stands but can detect problems occurring further into thinned stands.

Ground inspection

Ground inspection involves the survey officer conducting an inspection or transect on foot. It is used to confirm the diagnosis or cause of symptoms detected by aerial and drive-through surveys and enables detection of symptoms that cannot be seen by other surveillance methods (such as cankers and symptoms caused by borers or bark beetles). It also enables samples to be collected and photographs of symptoms and damage to be taken.

Communication

Following surveillance, results are communicated to forest managers via written reports and tours of sites where forest health issues have been identified. This enables forestry managers and other staff to recognise and understand the implications of these issues, and management plans to be developed and implemented.

Reports are presented to forest managers on:

- The general health of the forest:
  - For state and national reports on forest health
  - To fulfil certification requirements
- Specific forest health issues:
  - Impact of insects and diseases — incidence, severity, etc.
  - Nutritional imbalances or disorders
  - Other impacts on forest health, e.g. by drought or frost

A typical report includes:

- details of the plantation (e.g. owner, species, age, site details, thinning history)
- description of the problem, area affected (including photos and maps), location, incidence and severity of damage, part of the tree affected, symptoms and any potential contributing factors that could be identified
- cause(s) of the problem (with relevant information)
- recommendations to control or manage the problem and or reduce the impact or damage (e.g. thinning, sanitation salvage, timing of operations).

The recommendations are discussed with management and operational staff to determine subsequent action to be undertaken, if any, to obtain the most cost-effective outcome. Factors such as operational feasibility, markets and costs involved are taken into account. Often additional monitoring is required before a decision is made. A flowchart of forest health surveillance in *P. radiata* plantations as carried out by ForestrySA is given in Figure 2.

Forest health surveillance in eucalypt plantations

In the last 10–15 y the area of *E. globulus* plantations in SA has rapidly expanded, mainly in the Green Triangle. Eucalypts, being native to Australia, have evolved with a range of invertebrates that feed on them in native forest environments, and some of these have become significant pests of eucalypts in plantations. Surveillance has been conducted almost from the time the first

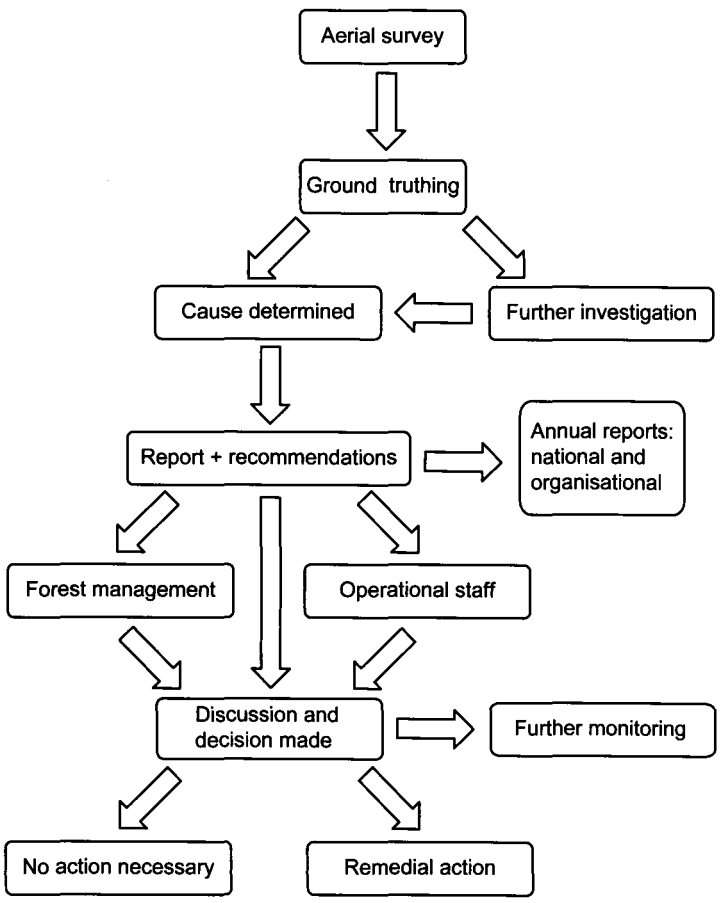

Figure 2. Forest health surveillance by ForestrySA in South Australian *P. radiata* plantations

eucalypt plantations were established in SA, but has tended to be reactive rather than proactive. Most companies now, however, conduct on-ground surveys of their plantations as part of their normal management practices.

Certain pests attack trees at particular stages of development, and plantation managers are aware of when to expect particular pests and diseases to be present in plantations. For example, *Mnesampela privata* (autumn gum moth) is a problem for the first 2–3 y after planting, so plantations in this age group are monitored for the presence of this pest and remedial action (i.e. spraying) undertaken as required. Eucalypt sawflies (*Perga* spp.) typically attack eucalypt plantations during winter, so plantation managers and operations staff regularly inspect plantations at this time of year for this pest. Operations staff also monitor for pests and diseases as part of everyday activities and contractors are often used to carry out surveys and monitor specific insect pests.

Major eucalypt-growing companies in the Green Triangle belong to the Industry Pest Management Group (IPMG) based in Western Australia (see www.crcforestry.com.au/research/programme-four/ipmg/index.html). In recent years, this group has conducted studies on the phenology, damage thresholds and distribution of the main insect pests in the region. This information is used by members of the IPMG to monitor these insects and take appropriate action before major damage occurs.

Forest health surveillance in native forests

There is neither commercial harvesting of timber in native forests in SA nor formal forest health surveillance of these forests. Outbreaks of insects or diseases, when they occur, generally run their course without intervention. The exception to this is the disease caused by *Phytophthora cinnamomi*. While this is rarely a problem in plantations, it is present and causes deaths of trees and other vegetation in native forests, mainly in the Mount Lofty Ranges near Adelaide. The South Australian Department for Environment and Heritage (DEH), in conjunction with local councils, surveys and monitors the spread of this disease. Areas where the disease is present, or suspected of being present, are mapped and recorded on a database maintained by DEH.

Urban forest health surveillance

Health surveillance of trees in urban areas is also important but is often overlooked. The incursion of *Hylotrupes bajulus* (European house borer) in Western Australia has highlighted the importance of surveillance in urban situations, as this pest has established in pine trees in home gardens as well as in plantations.

Methods used in urban forest health surveillance in SA depend on the pest or disease targeted but include methods used in hazard site surveillance (see later) and other methods such as those used in the existing Fruit Fly Surveillance program which involves surveillance of urban areas on a grid pattern. The current trapping grid in Metropolitan Adelaide consists of 3014 sites. Most traps at these sites are monitored fortnightly; those in high-risk areas are checked weekly all year round.

In SA, surveillance for forest pests (such as the European house borer) in urban situations is conducted only in response to the detection of an incursion by an exotic pest or disease. In such cases surveillance is carried out by Primary Industries and Resources South Australia (PIRSA) with assistance from other organisations as required.

Hazard site surveillance

In 2005 the National Plant Health Surveillance Framework was established by the Australian Commonwealth Government. Part of this program involves post-border surveillance for the early detection of exotic plant pests in urban areas in Australia.

In SA the program was implemented by PIRSA in 2006–2007. The aim of the program is to provide early detection, identification and subsequent management of incursions of specific exotic plant pests within the greater Adelaide metropolitan area. It provides surveillance capability for exotic plant pests linked to international trade movements in and around targeted hazard sites in urban areas adjacent to points of entry into Australia. The program targets ten exotic plant pests (including two forest or timber pests and diseases) and involves staff training and awareness combined with a comprehensive community and industry awareness program incorporating media, plant pest fact sheets and community meetings. It also involves electronic data management and analysis, and regular review of site selection and surveillance methods.

Survey site selection and pathway analysis

Selection of survey sites is based on pathway analysis and the target plant pest list. A total of 592 Unregulated Pathway sites (UPs) and 23 Quarantine Approved Premises (QAPs) have been identified in SA as major receivers of goods imported from overseas. The sites include timber mills, timber pallet manufacturers and re-conditioners, university campuses and research establishments, grain and fodder stores, public and botanic gardens, wharves and container terminals, rail yards, airports (domestic and international) (Adelaide Airport, Parafield Airport, RAAF Base at Edinburgh), military establishments, transport carriers of international freight, refuse or waste-disposal businesses, wholesale nurseries and plant importers and also several non-agricultural sites. These are all significant in terms of general plant pest incursions, not just the plant pests targeted by this program. The survey sites chosen are based on the level of threat, activity and the abundance of suitable host plant material. Most of the sites are located within 1 km of known importers, but additional sites, not directly related to import pathways, may also be targeted. The type of surveillance undertaken depends on the risk at each site and the characteristics of the particular plant pest. Senior Plant Health Inspectors, with experience in field survey work and training in the identification of plant pests, supervise and undertake monitoring and surveillance activities, mapping, reporting, identification and database entry. All surveillance is authorised under the South Australian Fruit and Plant Protection Act 1992.

Survey methods depend on the specific pest targets and include:

- inspection, sampling and trapping
- diagnostics

- stakeholder liaison activities (access, awareness, enquires and complaint handling)
- recording and management of data.

Samples are collected in accordance with established PIRSA Plant Health Operations procedures. All samples are recorded on an Urban Pest Surveillance Report and include details on when and where the sample was collected (including GPS co-ordinates), diagnostic results and information on follow-up action undertaken.

The data collected from each survey is maintained by PIRSA Plant Health Operations on a regularly updated central database accessible to plant health staff. This ensures a systematic approach to current and future surveillance of exotic pests within the state.

All insect and disease specimens are accompanied by a 'Specimen Identification — Exotic Pest, Plant or Disease Form' and submitted to South Australian Research and Development Institute (SARDI) Entomology or Plant Pathology sections for formal identification.

The general public is also encouraged to call Plant Health Operations on the Plant Pest Hotline to report any suspect exotic pest.

Two exotic pests on the Target Pest List and of particular importance to forestry are eucalypt rust (*Puccinia psidii*) and European house borer (*Hylotrupes bajulus*). For eucalypt rust, sites where there are individual and multiple plantings of eucalypts are identified and the leaves are visually inspected for evidence of the disease. Periodic surveys are carried out during warmer months of the year, commencing in early spring.

For European house borer, sites where there are individual and multiple plantings of *Pinus* spp. are identified as well as premises where imported seasoned softwood timber and packaging are present. Trees and timber are inspected visually, with destructive sampling of seasoned timber including dead or dying limbs of trees. Initially surveys are conducted one week per month for a period of 12 months. Traps are installed at various locations identified as high-risk areas, and monitored on a weekly basis.

Discussion

The benefits of a formal forest health surveillance program are difficult to evaluate economically. Cost benefits, however, are gained by being proactive with regard to managing pests, diseases and nutritional disorders, and in being able to make better-informed management decisions that are site specific. This is especially the case with respect to management of nutritional disorders and fertiliser application. Losses in productivity and or wood quality from pest, disease and nutritional disorders are often overlooked or underestimated.

The information collected from forest health surveys provides a valuable base for management, including operational procedures, and also for strategic research on the impacts of forest health problems.

Currently research is in progress on the use of remote sensing in forest health surveillance in both pine and eucalypt plantations. This will further enhance the capability for early detection (and subsequent management) of threats to forest health and productivity across Australia.

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