The evolution of forest health surveillance in Tasmania

T. Wardlaw
Forestry Tasmania, GPO Box 207, Hobart 7001
e-mail: tim.wardlaw@forestrytas.com.au

Abstract

Formal health surveillance of Tasmania's State-owned forestry plantations commenced in 1997. The surveillance program had multiple objectives at the time of its introduction: to detect new incursions of exotic insect pests and pathogens, manage the risk of unacceptable losses from insect pests or diseases, initiate operational responses to remedy detected health problems as required, and provide evidence of sustainable forest management. Initially, annual surveys of the entire plantation estate were carried out using a mixture of aerial, roadside and ground inspections to detect problems. This was believed to provide a good balance, with a breadth of coverage to detect gross problems and sufficient resolution to detect cryptic symptoms at a low incidence, typical of a new pest incursion.

In the ensuing ten years, our expectations of the outcomes from health surveillance of plantations have matured. Visual inspection from helicopters and roadsides has been found to provide sufficient resolution to detect 'operationally relevant' damage caused by established pests and pathogens. Intensive ground inspections of young plantations were initially used to augment the aerial and roadside surveys and provide a detailed description of health status, and were also thought to improve the capacity of routine surveillance to detect new incursions of exotic pests or pathogens. However, research showed this not to be the case so ground-based inspections of young plantations are no longer included in routine surveillance.

The new approach for detecting new incursions is to use static traps that can attract and capture forest insects and that are able to detect the presence of insect pests at very low densities. Deploying such traps around focal points of international trade such as ports and container depots can provide a very high level of protection against new incursions. Quarantine staff regularly conduct surveys at such focal points, and the expansion of their surveys to include static traps targeting exotic insect pests of importance for forestry can be done at relatively little extra cost and effort. The benefit from greater protection against these exotic insect threats extends beyond the commercial forestry sector to include all those interested in maintaining the health of our urban and rural treescape.

Introduction

Native and exotic insect pests and pathogens provide an ongoing threat to our production, conservation and amenity forests and trees. Effective management of threats posed by these pests and pathogens depends upon detecting problems before significant damage occurs. Formal surveillance of forests, undertaken by people with expertise in recognising pest and disease problems, has been shown to be an effective way to detect pest and disease problems (Carter 1989; Bulman *et al.* 1999). In 1997, Forestry Tasmania introduced formal surveillance of its plantation estate for the purposes of detecting health problems. The ten years since the introduction of surveillance has been a voyage of discovery. What do we want health surveillance for? How should it be carried out? Is health surveillance working? It is important that these questions are asked, not just once but repeatedly. The environment in which we operate is ever-changing, the circumstances change, the issues change and expectations change.

Forestry Tasmania commenced formal health surveillance with the expectation that it would meet a range of objectives. Those objectives included:

- Detecting new incursions of exotic insect pests and pathogens;
- Identifying emerging threats from native pests and pathogens;
- Managing the risk of unacceptable losses from insect pests and diseases;
- Recommending operational responses to detected health problems;
- Evaluating the effectiveness of control operations against particular insect pests and pathogens;
- Contributing towards demonstrating that forest management is sustainable.

This paper reviews the history of forest health surveillance of State forests in Tasmania, focussing on the pine and eucalypt plantation estate. It evaluates whether the original objectives of health surveillance are being met and explores how surveillance is being refined to better meet those objectives.

The 1990s: a time of change for forestry in Australia

Prior to 1997, Tasmania relied heavily on general forestry workers and members of the public to find and report new forest health problems. Illustrated manuals and booklets (e.g. Elliott and de Little 1984; Wardlaw 1989) were produced to help forest workers recognise pest and disease problems. This approach was considered appropriate for the times because most wood production was from extensive areas of relatively slowly growing native forests. Consequently, there was little benefit, economically, in detecting pests and pathogens at an early stage of an outbreak or epidemic. Moreover, most of the pest and pathogen threats were from native species: an aggressive response to controlling these pests and pathogens was neither justified nor practical. This system was very cheap to run. However, some forest areas were not seen regularly and most observations were through untrained eyes. Research in New Zealand has shown that the efficiency of detection of health problems by general forestry staff is very low (Carter 1989).

The 1990s saw a dramatic expansion in the establishment of plantations in Tasmania, particularly of *Eucalyptus* species. This expansion was being mirrored throughout southern Australia in response to the Plantation 2020 Vision—a Federal Government initiative to treble Australia's plantation area in an attempt to reduce the nation's two billion dollar trade deficit in wood products. The overwhelming majority of plantation establishment during this period was carried out in the expectation that the plantations would be managed on short rotations to produce wood fibre for manufacturing into paper and reconstituted wood products such as medium density fibreboard.

The impetus behind the expansion of plantations on State-owned land in Tasmania was different from that influencing the rest of the nation. The expansion was to compensate for a reduced land-base for production forestry after several hundred thousand hectares of State forest were added to reserves (Forests and Forest Industry Council 1990). The Tasmanian State Government has legislated for a minimum sustainable hardwood sawlog supply from State forests. To maintain this supply from the reduced land-base available for wood production on State forest required plantations to be established for the purpose of producing solid-wood products such as sawn timber and veneer.

The stage was set for changed forest management in Tasmania. The greater growth rates that could be achieved in plantations justified a more aggressive approach to management to protect those plantations from damaging outbreaks or epidemics of pests and pathogens. It became economic to spend $50 or more per hectare spraying eucalypt plantations with insecticide to prevent severe defoliation by high populations of leaf beetles (Candy 1999). The vigour of the trees could be controlled through fertiliser application, and management of stocking could be controlled through thinning. Site-specific species or genotypes could be selected for planting.

Forest health surveillance in Australia: following New Zealand's lead

Queensland, New South Wales and Tasmania all commenced formal health surveillance of their plantations between 1995 and 1997. The surveillance system adopted by the three States was modelled closely on New Zealand's system. This was centred around aerial, roadside and ground inspections to detect, map, identify and quantify the incidence and severity of damage caused by pests and diseases (Ashley and Hosking 1981; Kershaw 1989). A critical component of New Zealand's system that was not adopted by these Australian States was hazard-site surveys—intensive ground-based surveys in areas that historically had a higher risk of experiencing new pest or pathogen incursions.

The primary objective of New Zealand's forest health surveillance was the early detection of new incursions of exotic pests and pathogens (Carter 1989; Bullman *et al.* 1999). Their commercial forest estate is wholly composed of exotic tree species, predominantly *Pinus radiata, Eucalyptus* species and *Pseudotsuga menziesii*. Obviously Australia, New Zealand's nearest neighbour, is the main reservoir for pests and pathogens of eucalypts. It is not surprising therefore that many significant incursions of importance to New Zealand's forest biosecurity are eucalypt pests from Australia: three significant incursions of this type have occurred in the past decade (Self 2003).

In Australia, the situation is different. Native species have become an important component of the commercial plantation estate following the rapid increase of eucalypt plantings over the past decade. Most of the pest and disease threats to the eucalypt plantations will come from native species rather than exotics. Because of this, the primary objective of health surveillance in eucalypt plantations is to help reduce the risk of unacceptable damage from severe outbreaks or epidemics of these native species.

A small number of the native species have the potential to develop into pests or pathogens that cause significant damage with sufficient regularity to justify inclusion of their management in routine forest operations. For these species, annual surveillance to detect the presence of the pest contributes little to informing a decision for the need to control. Instead, a pest-specific monitoring program involving one or more precisely timed inspections to assess the size of the pest population is a more appropriate way of informing a control decision. Such an approach is used to manage the eucalypt leaf beetle, *Chrysophtharta bimaculata* (Elliott *et al.* 1992). While surveillance might not be useful for informing control decisions for such pests, it does have a useful role in quality assurance to monitor the effectiveness of pest-specific management programs.

It is difficult to predict when and where damaging outbreaks of native pests and pathogens of eucalypts will occur. The regular, estate-wide coverage offered by forest health surveillance is an effective way of detecting outbreaks of such native insect pests and pathogens. While detection will not prevent the initial outbreak, it provides, for defoliators at least, an opportunity to direct additional effort towards protecting affected areas from repeat episodes of damage.

The accumulation of information obtained over a number of years from an ongoing surveillance program provides the opportunity for retrospective analysis to identify risk factors associated with the timing and location of, and reason for, severe outbreaks. An example is the study by Wotherspoon (2004) to identify factors associated with high incidences of bark stripping in radiata pine by wallabies. The accumulation of annual surveillance data also provides the basis for monitoring the change in status of different pests and pathogens. This satisfies the information need of one of the criteria for measuring sustainable forest management under the Montreal Protocol (Department of Primary Industries and Energy 1998).

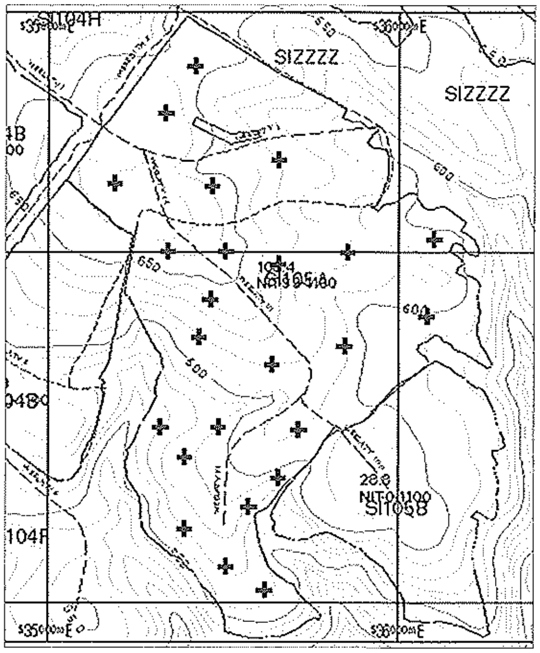

Figure 1. Example layout of nine-tree plots (+) used to assess the health status of 18-month-old eucalypt plantations.

Health status surveys

The commencement of health surveillance on State forest plantations in Tasmania in 1997 coincided with the period when pruning began in eucalypt plantations established during 1992–1996, the first wave of plantation expansion on State forest following the Helsham Enquiry (Helsham 1988). This was a period of learning. It was the first time in Australia that eucalypt plantations were managed for solid wood on a large scale. Guidelines for management existed but were still evolving as research to refine prescriptions was being conducted (Gerrand *et al.* 1997; Pinkard and Beadle 1998; Neilsen and Gerrand 1999).

Early guidelines for managing eucalypt plantations for solid wood had strict specifications for a range of stand attributes such as growth rate, stocking (overall, and of trees with suitable stem form for pruning) and the size and condition (dead or alive) of branches on trees suitable for pruning. Operational decisions about the suitability of stands for pruning needed to be made, but systems for assessing the suitability of stands were still evolving. In this climate, information was gold.

This need led to the development of a 'health status survey' (HSS) as part of the health surveillance program. An HSS was conducted in all 18-month-old eucalypt plantations and all three-year-old pine plantations, prior to pruning. In these age classes, aerial surveys were used not only to detect health problems but also to map areas within plantations that had obviously differing performance; for example, slower early growth, reduced survival or delayed phase change to adult foliage. Coupled with this were detailed assessments of health, growth and form of individual trees within nine-tree plots, which were spread regularly through the plantation at the rate of one plot every 2.5 ha (Figure 1).

An HSS provided very detailed information about the condition of the plantation (Table 1) but at a considerable cost: about ten times that of conventional detection surveys. That

Table 1. An example of the output from a health-status survey showing the percentage of trees with indicated descriptors of health in two patches of contrasting health status in an 18-month-old Eucalyptus nitens *plantation.*

Health descriptors	Patch A (ex-native forest)	Patch B (ex-pine plantation)
Premature leaf senescence: severe	14	71
Premature leaf senescence: moderate	45	9
Leaf loss (bottom-up): moderate	34	42
General chlorosis: obvious	0	13
General chlorosis: trace	52	69
Foliar reddening (photo-inhibition, hardening)	0	29

Table 2. An example of the output from a health-status survey showing the predicted consequence of assessed health problems and estimates of growth and variability in height of two patches of contrasting health status in an 18-month-old Eucalyptus nitens *plantation.*

Consequence of assessed health attributes	Patch A (ex-native forest)	Patch B (ex-pine plantation)
No significant impact (stems/ha)	289	24
Moderate growth reduction (stems/ha)	142	856
Form problems (stems/ha)	58	24
Multiple stems (stems/ha)	142	24
Missing, dead or dying (stems/ha)	26	49
Early branch senescence (% of trees)	35	53
Mean tree height (m)	3.2	2.3
Coefficient of variation of tree height (%)	21	32
Estimated mean dominant height (m)	4.2	3.5
Estimated mean annual increment (m^3/ha/yr)	20–25	15–20

high cost was justified on the basis that the HSS was providing critical information to assist the pruning decision (Table 2), which represented an investment of several hundred dollars per hectare. The surveys were discontinued in 2002 because the detailed information they provided was having a diminishing role in making pruning decisions.

The role of health surveillance in plantations for biosecurity

The early detection of potential new incursions of exotic pests or pathogens remained one of the stated objectives of health surveillance in Tasmania, particularly to protect the *Pinus radiata* estate of some 75 000 ha. In April 1999, a routine HSS detected a three-year-old *P. radiata* tree with unusual gall-like swellings on its trunk and branches (Figure 2A). The symptoms were very similar to those of an early stage infection of western gall rust caused by the pathogen *Endocronartium harknessii* (Figure 2B), one of the main pathogen threats to *P. radiata* in Australia. This detection triggered an emergency quarantine response that followed the procedures outlined in the then recently completed incursion management plan for Australian forests (Gadgil 2000).

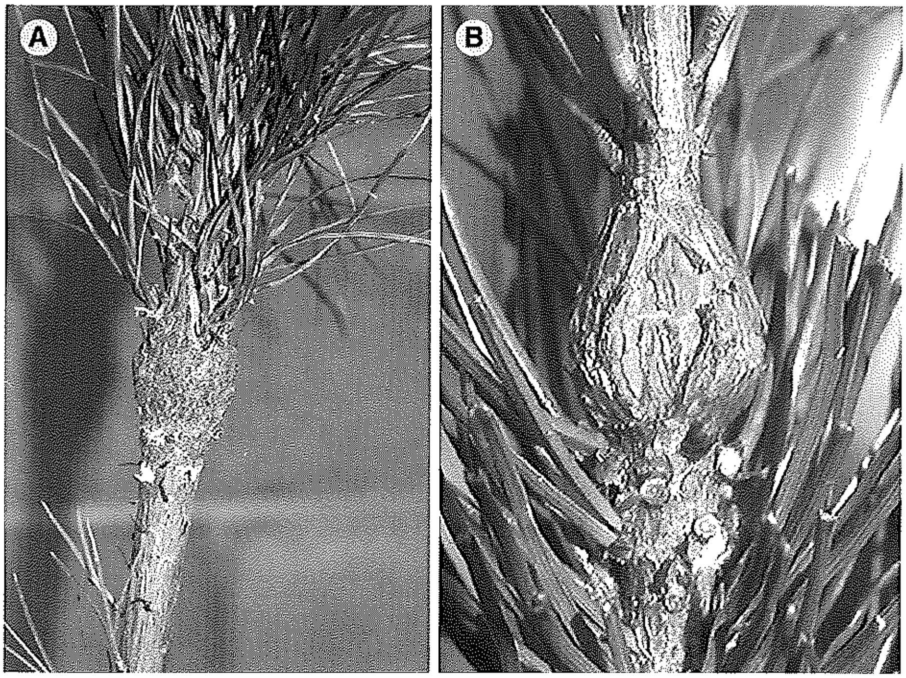

Figure 2. Stem and branch galls on Pinus radiata*: A, undiagnosed stem gall detected in a three-year-old Tasmanian plantation; B, early stages of symptom development of western gall rust (*Endocronartium harknessii*) in California. (Photo courtesy of Detlev Vogler.)*

Material was sent to the United States to confirm whether or not the galls were western gall rust. At the same time, more extensive ground surveys were carried out to establish the distribution of gall-affected trees across northern Tasmania. These surveys showed that the problem was mainly confined to three-year-old trees and was present in several widely separated plantations at an incidence of about one tree in 1000. DNA testing in the United States, using a protocol developed by Dr Detlev Vogler, was able to show that the galls were not western gall rust, or infection by any other rust fungus.

The quarantine emergency was over, but the lessons from that experience were just starting. The detection provided hope that the health status surveys were able to detect cryptic symptoms at low incidences, thus providing some measure of early warning for new incursions. When these surveys were discontinued in 2002, plantation surveillance relied on aerial and roadside surveys, with follow-up ground inspections of any problems detected. It was believed that ground surveys were needed to increase the chances of detecting early stages of a developing outbreak when symptoms were cryptic and at a low incidence as, for example, would be expected for a recent introduction of a stem-boring or bark-boring insect.

A study was undertaken in 2003–2004 to test the efficiency of aerial, roadside and ground inspections in detecting a range of symptoms from obvious (e.g. tree mortality and top death) to cryptic (e.g. stem borer) at incidences between 0.1 and 2% in young *Eucalyptus globulus* plantations (Wardlaw *et al.* 2008). This work showed that ground surveys at the intensity previously used in the health status surveys were inefficient at detecting symptoms when they occurred at a low incidence, regardless of whether they were obvious or cryptic. It appeared that the detection of the radiata pine tree with stem galls was good fortune rather

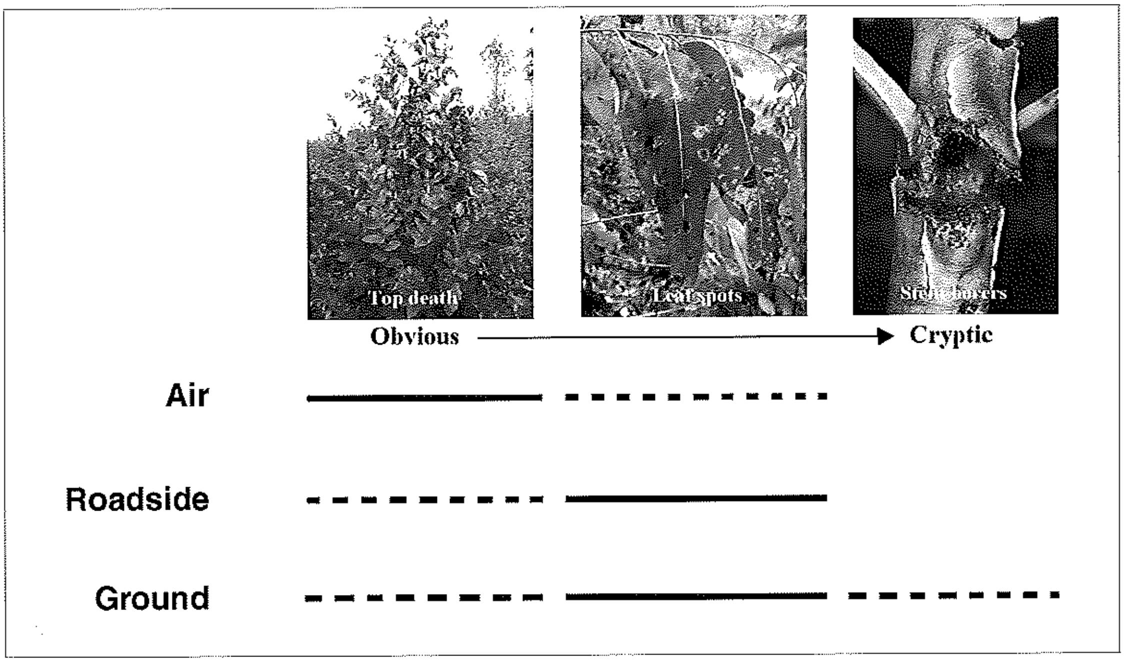

Figure 3. Capacity to detect damage symptoms ranging from obvious to cryptic in 18 month-old Eucalyptus globulus *plantations when viewed from the air (helicopter at 150 m above ground level), roadside, or a ground traverse within the plantation. Damage that can be reliably detected (incidences below 1%) is indicated by a solid line, while those that can only detected at higher incidence (> 3%) are indicated by dashed lines. (Based on data in Wardlaw* et al. *2006.)*

than a probable outcome of ground-based detection surveys. The study concluded that formal annual surveillance of plantations by aerial and roadside inspections was sufficient to detect damage by established pests and diseases at levels that may justify management intervention. The inclusion of ground surveys could not be justified because they did not markedly improve the chances of early detection, especially when symptoms were cryptic and at a low incidence (Figure 3). Currently, ground-based inspections of plantations are only done as a follow-up to identify the cause of problems that have been detected from the air or roadside.

Do we need a better way of detecting new forest pest incursions?

As an island continent, Australia remains free of a large number of pests and pathogens that could have a serious adverse impact on commercial, amenity and conservation values of forests and trees. The threat is not restricted to pests or pathogens of introduced exotic species important for wood production or amenity. A small but growing number of exotic pests and pathogens are known to cause significant damage to native Australian species, particularly eucalypts, when planted in overseas countries. Examples are guava rust (*Puccinia psidii*), Coniothyrium canker (*Coniothyrium zuluense*) and Asian Gypsy Moth (*Lymantria dispar*). International trade and an increasingly mobile population provide an ongoing threat of carrying exotic insect pests or pathogens into the country. Wood-boring and bark-boring insects are a particular concern because certain life stages can remain hidden within wood products and packaging for long periods.

Australia has a sovereign right to defend itself from exotic pests and pathogens using quarantine restrictions, provided those restrictions are scientifically defensible. The import risk assessment (IRA) process (Australian Quarantine Inspection Service 1998) scientifically evaluates the risk of introducing exotic pests and pathogens with a particular commodity from a particular country. Through the IRA process, conditions are set under which goods can enter Australia. Phytosanitary Certificates issued by the exporting country verify that stipulated conditions have been met. As a final safeguard, quarantine and Customs inspectors examine shipments at ports of entry before approving the release of those shipments. In the past, this final inspection has yielded an average of about 700 interceptions of wood and bark insects per year by quarantine officers at Australian ports (P. Caley, pers. comm.), but this number has increased recently (R. Bashford, pers. comm.).

Despite these efforts, a steady stream of insect pests and pathogens escapes the quarantine barrier. A majority of these escapes becomes established in the port environs before spreading out into the wider area. An analysis of four decades of records of the detection of new forest insect pests in New Zealand clearly showed that port environs have a much higher risk of new incursions than the rest of the country (Ministry of Forestry 1993). In response, these high-risk areas receive more regular and intensive surveys to detect new incursions of exotic pests and pathogens.

Until recently, the Asian Gypsy Moth (AGM) Trapping Program, co-ordinated by the Office of the Chief Plant Protection Officer, was the only formal survey done in Australia to detect new incursions of a forestry pest in these high-risk port environs. The AGM trapping uses a Delta trap with a pheromone wick (Figure 4A) to attract and trap male moths. Although AGM poses a serious threat, there are many other exotic insect pests that threaten Tasmanian forests. The inclusion of two additional traps, Lindgren funnel traps (Figure 4B) and intercept panel traps (Figure 4C), in a port-environs monitoring program can greatly expand the number of exotic wood-boring and bark-boring insect pests that can be monitored (Bashford 2003). These traps, like the Delta trap used for AGM, are able to detect insect populations of very low densities. Sentinel plantings of a representative range of species of commercial, amenity or environmental importance (Figure 4D) augment static traps. Sentinel trees can be rapidly screened for damage symptoms that could be caused by exotic pests or pathogens. A pilot port-environs monitoring program combining static traps and sentinel trees was conducted at the port of Bell Bay, northern Tasmania, in 2004–2005. This demonstrated that the range of insects and pathogens targeted in port-environs monitoring could be expanded for little additional cost above that currently incurred for pest-specific surveys. The Federal government and three State governments, including Tasmania, have recently adopted this port-environs survey, with the launch in late 2005 of a three-year urban surveillance program.

Conclusions

In the ten years since forest health surveillance began in Tasmania, we have done much to clarify the objectives of particular elements of the surveillance program. Detection surveys involving annual inspections of plantations from the air and roadside have been simplified and made more cost-effective because we no longer rely on them for the early detection of new insect pest or pathogen incursions. Of the six initial objectives of health surveillance listed in the introduction, all except the early detection of new incursions are being met through these detection surveys. Static traps and sentinel trees monitored in hazard sites provide a capability for early detection. Their use in an ongoing hazard-site surveillance program is crucial to providing this early warning of new incursions of forest or tree pests. The beneficiaries of such a program are all those with an interest in forest and tree health.

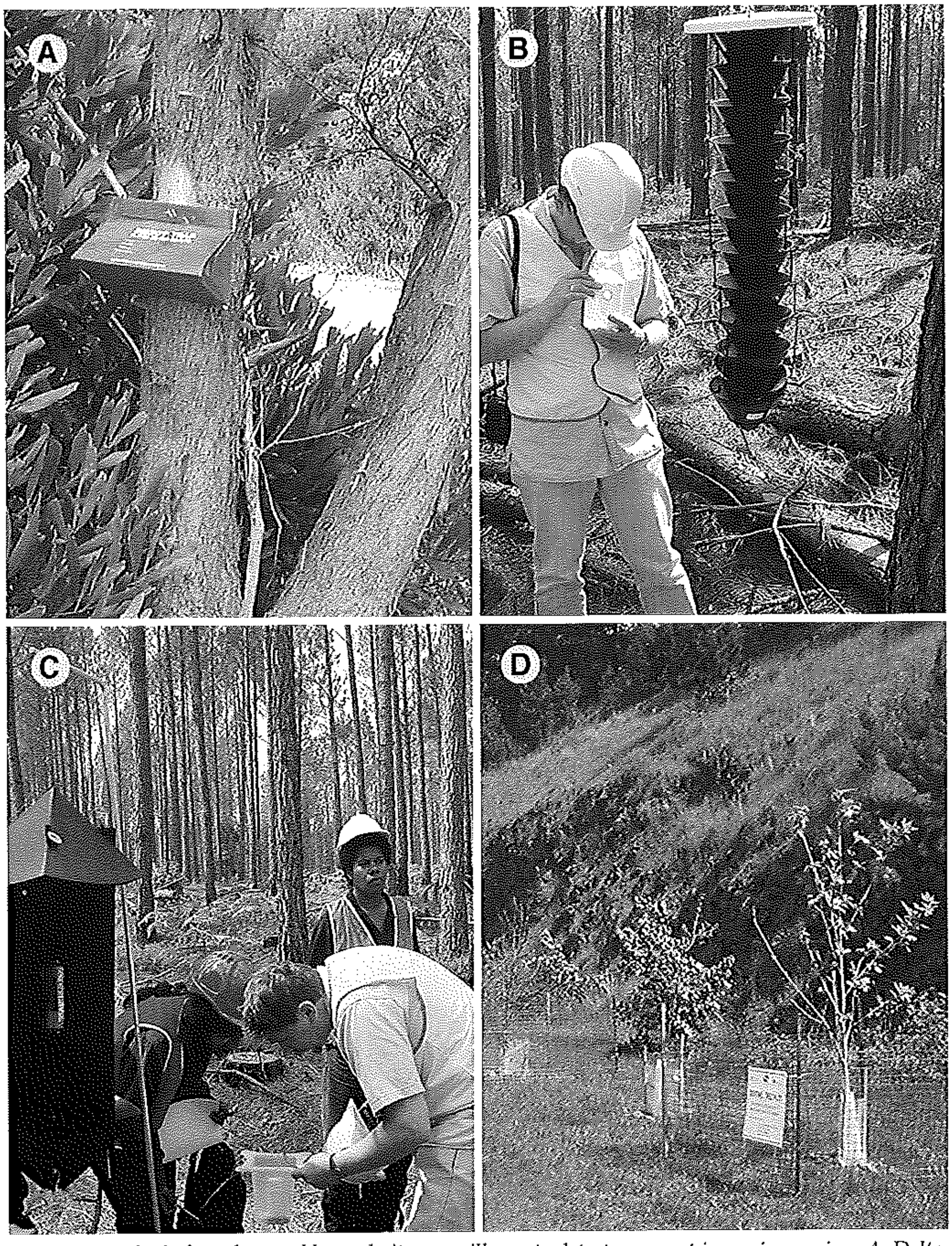

Figure 4. Methods for urban and hazard-site surveillance to detect new pest incursions using: A, Delta traps with pheromone lures (to trap Asian Gypsy Moth); B, Lindgren funnel trap (to capture wood-boring and bark-boring insects); C, intercept panel trap (to capture wood-boring and bark-boring insects); D, sentinel planting (to detect damage symptoms in representative species of commercial, amenity or environmental importance).

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