Strategy

Australian sirex management strategy

INTRODUCTION

Sirex noctilio, a native of Europe, is the only one of a large number of woodwasp species able to kill relatively healthy pine trees. One of the tree species most susceptible to this insect, *Pinus radiata,* from California, was introduced into Australia during the nineteenth century and now forms the bulk of this country's one million hectares of softwood plantations. After being accidentally introduced into New Zealand and causing epidemic outbreaks during 1945–1949, sirex was discovered near Hobart during 1952 and then near Melbourne during 1961.

Since then, sirex has spread throughout Tasmania, South Australia, Victoria and New South Wales. In 2009 sirex reached the southern border region of Queensland (Passchendaele). The combination of a particularly susceptible tree species and a very damaging woodwasp, brought together in drought-prone Australia is a recipe for disaster and indeed serious outbreaks have occurred in Tasmania, Victoria, and South Australia. If the control measures outlined in this document had been implemented, the impact of these outbreaks may have been greatly reduced.

Sirex control efforts in Australia were initially managed and funded by the National Sirex Trust Fund through a compulsory grower levy and government funding from 1962–1977. An initial focus on eradication was replaced by a policy of containment in parallel with research on biocontrol control options. Between 1978 and 1987 the culture and supply of biocontrol agents was funded by the Australian Forestry Council.

The National Sirex Coordination Committee (NSCC) is a group of pest management scientists drawn from Australian plantation growers who contribute to the voluntary sirex control levy, and sirex specialists. It commenced oversight of the sirex biocontrol effort in 1988, and now operates as an independent self-governing committee. Its charter includes keeping the sirex management strategy current, overseeing the technical standards for control operations, and commissioning research to improve the effectiveness of the program.

The NSCC developed the *National strategy for the control of Sirex noctilio in Australia* in 1990, first published in *Australian Forest Grower*, Winter 1990. The *Australian sirex management strategy* updates the former strategy and includes operations worksheets, training videos and field checklists which provide more detail on the essential tasks necessary for effective management of sirex.

LIFE CYCLE

In Australia, sirex normally completes one generation per year, with a small proportion of the population taking two years. Adults, which live for only a few days, have been recorded emerging from October through to May, with peak emergence occurring from January to the end of March, depending on climate. The female wasp drills her ovipositor through the bark and into the outer sapwood of trees to lay eggs (Figure 1).

Figure 1: Female sirex ovipositing into a log.

At the same time, she injects a symbiotic fungus (*Amylostereum areolatum*) and a toxic mucus/venom which together cause the death of the tree. Sirex larvae feed on the fungus as they tunnel through the wood. Mature larvae pupate close to the bark surface and adults emerge about three weeks later. However, some trees, especially if healthy and vigorous, may resist sirex attack.

Trees successfully attacked by sirex generally begin to show conspicuous dieback symptoms from April onwards. The entire crown turns light green to yellow then to reddish brown. Beads or dribbles of resin, resulting from oviposition (egg laying) holes, may be visible on the bark. As the fungus grows from the oviposition drill, fungal stains appear in the cambium as long, narrow, brown bands along the grain (Figure 2), and eventually the fungus permeates every part of the tree.

Larvae, galleries, or exit holes provide conclusive evidence of successful sirex attack. After a tree has been killed, the wood degrades rapidly and, if salvage is feasible, it should be done within four months of sirex attack.

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Figure 2: Exposed *Amylostereum* fungal staining at three separate oviposition sites

MANAGEMENT TECHNIQUES

Pinus radiata is highly susceptible to sirex attack, but other *Pinus* species are also attacked. Susceptible plantations are generally 10–20 years old, and unthinned stands are more susceptible than thinned stands. Trees under stress (e.g. over-stocked stands, drought, during harvesting), also appear to be more susceptible to attack. Therefore, a major preventative measure is to maintain vigorous stand growth by timely thinning and protection from fire, pests and diseases which may stress and weaken the trees (e.g. Dothistroma needle blight).

Two kinds of biological agents are used to control sirex. The parasitic nematode, *Deladenus* (*Beddingia) siricidicola,* is of greatest importance. This nematode has an extraordinary life cycle which enables it to breed up in vast numbers throughout the tree while feeding on the fungus; then it enters a sirex larva and begins reproduction as its host pupates. Nematode reproduction within the developing pupa now produces "infective" juvenile forms of the nematode. These infective nematodes subsequently enter sirex eggs within pupating female sirex, rendering entered eggs sterile (Figure 3).

When nematode-infected sirex emerge and attack other trees, they transmit/lay eggs which are now packets of nematodes instead of fertile eggs. Once a significant proportion of the sirex population becomes infected with the nematode — levels can approach 100% — the sirex population will collapse. At low sirex levels, the nematode may not be reliably transmitted between isolated sirex populations, therefore, the regular release of nematodes appears to be necessary.

Some parasitic wasps (parasitoids) have been imported and released for sirex control. The parasitoid *Ibalia* lay their eggs down the drill holes in the tree made when the sirex female laid her eggs, and into the developing sirex larvae. The parasitoids *Rhyssa*, *Megarhyssa* and *Schletterarius* drill deep into the wood to locate, paralyze and then lay their eggs on sirex larvae, and the parasitoid larvae consume and kill the sirex larvae from the outside. One native parasitoid, *Certanotus tasmaniensis,* is also active at low levels in some areas.

The combined activity of these parasitoid wasps usually kill 30–60% of a sirex population. However, parasitoid activity alone is not enough to prevent sirex from reaching outbreak levels.

CONTROL RECOMMENDATIONS

Before sirex is detected in a region:

- Consider whether quarantine measures will be effective and economically justified and invoke where appropriate.

- Train forest, logging, and sawmill personnel to recognise sirex symptoms (with annual refresher sessions) and promote vigilant forest surveillance.

- Install trap tree plots to detect whether sirex is present in susceptible plantations (i.e. 10–20 years old and more than two years past the prescribed thinning age), near mills, major transportation routes, and the leading edge of expected natural sirex dispersal. The number of plots should be proportional to the risk of sirex introduction. (Refer to Worksheet 2 for further detail).

- Review the status of plantation thinning and comply with the optimum thinning guide for first and second thinnings.

Figure 3: Microscopical image of dead infective juveniles of *Deladenus* (*Beddingia*) *siricidicola* nematodes extracted from the egg sacks of a parasitised female sirex.

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Annual program once sirex is first detected:

- Map sirex distribution within the region (from forest surveillance and trap tree data).
- Estimate sirex-associated tree mortality in selected compartments by ground surveys along transects.
- Review the status of plantation thinning and comply with the optimum thinning guide for first and second thinnings.
- Establish trap tree plots during November to early January for later inoculation with nematodes. Select a plot density of at least one plot per 25 ha of susceptible plantation within the sirex distribution.
- Inoculate the sirex-attacked trap trees with nematodes during May–June depending on seasonal conditions. Naturally struck trees can also be inoculated.
- Release parasitoids in appropriate compartments; record and map the pertinent information (compartment, species, number of males and females released, and date).
- Determine the percentage of sirex infected with nematodes and population levels of each parasitoid species by caging logs from sirex infested trees struck in specific compartments, and then assessing emergent wasps from October through to May.
- Review data and reports of the sirex control program from the current (and previous) year and plan a work schedule for the following year.

Assessment of naturally struck trees will provide information on background levels of biocontrol agents, and assessment of inoculated trap trees will provide information on the effectiveness of the inoculations done.

After the biocontrol agents are well- established in a region and the sirex population has declined:

- Select plantations for sampling that are 10-12 years old and geographically isolated from current populations of the biocontrol agents.
- Install trap tree plots in these plantations to confirm the presence of sirex.
- Evaluate logs from these trap trees to determine the percentage of sirex infected with nematodes and the presence of parasitoids.
- Make further releases if the biocontrol agents are deficient.

These recommendations are summarised in the illustration on page 7.

IMPLEMENTATION

Quarantine

Where sirex has not been detected within a state, the state agency responsible for biosecurity would be expected to take the lead on maintaining quarantine and monitoring for detections in the vicinity of likely entry pathways. As sirex has historically travelled less than 50 km per year, the biggest risk is transport of sirex-infested logs into new areas. Sirex can even emerge from air dried timber and CCA-treated products (copper-chrome-arsenate preservative applied under vacuum/pressure).

Cooperation

Each plantation grower also needs to implement appropriate actions to protect its plantations. As sirex does not recognize boundaries, coordination of responses between growers within the one region is both desirable and sensible.

Training

Sirex awareness amongst forestry staff and timber processors is important regardless of whether sirex has not yet been detected or has been present for many years.

Education and training can use materials such as these worksheets, embedded videos and other resources available at australiansirex.com.au.

Good reporting needs to be encouraged and everyone in the supply chain should know where to report sirex observations.

Operations

Operations worksheets provide detailed explanation of the key operational and management components of a successful sirex management program which will minimize the economic loss to plantation owners.

Worksheets:

1. Monitoring sirex population
2. Installing trap trees
3. Nematode handling and inoculation
4. Evaluation of biocontrol agents
5. Breeding nematode-free sirex
6. Rearing of sirex parasitoids
7. Determination of nematode infectivity
8. Panel trap installation

Field checklists have also been prepared to assist briefing of field crews for the major tasks.

Field Checklists:

1. Trap tree plot establishment
2. Monitoring trap tree plots
3. Felling and inoculation of trap tree plots
4. Billet collection and emergence monitoring

These checklists are available at australiansirex.com.au.

Research

The NSCC is commissioning research projects to underpin ongoing successful biocontrol of sirex. As sirex moves across Australia, it will encounter different climatic regimes, insect interactions and other host *Pinus* species, any of which may introduce an unexpected change to a component of the complex interactions which make up this effective program.

Ongoing research and monitoring are essential, as previous experience has demonstrated that without continued vigilance, the effectiveness of biocontrol programs can wane unnoticed until a major outbreak occurs.

Current research projects are reported on the NSCC website: australiansirex.com.au.

Further assistance

Enquiries regarding any aspect of sirex management can be directed to the NSCC, and this is best done by email to nscc@australiansirex.com.au which available as a link on the NSCC website contact page.

Links to reference documents which provide further explanation of the sirex and its interactions with the plantation host and with its biocontrol agents can also be found on the NSCC website.

Training videos

A range of comprehensive short-format videos have been made. These videos cover all aspects outlined within this *Australian Sirex Management Strategy and Operations Worksheets* document including sirex history, objectives, research and control methodologies, and are available on the following vimeo channel:

https://vimeo.com/channels/1309879

- Sirex 01: Where did sirex come from?
- Sirex 02: Sirex life cycle overview
- Sirex 03: Sirex life cycle
- Sirex 04: Finding parasites to control sirex
- Sirex 05: Nematode life cycle overview
- Sirex 07: Managing the spread of sirex
- Sirex 08: Common causes of tree death
- Sirex 09: Recognising sirex signs
- Sirex 10: Trap tree overview
- Sirex 11: Recording details of trap trees
- Sirex 12: Selecting trap trees
- Sirex 13: Principles for establishing trap trees
- Sirex 14: Preparing trap trees with drill
- Sirex 15: Preparing trap trees with axe or spear
- Sirex 16: Felling trap trees
- Sirex 17: Preparing nematodes in gel solution
- Sirex 18: Inoculating trap trees
- Sirex 19: Inoculation hole quality
- Sirex 20: Punch maintenance
- Sirex 21: Dissecting sirex wasps
- Sirex 22: Naturally struck trees

Summary of major tasks necessary for effective management of sirex wasp

Before detection of sirex

Quarantine

Training of staff

Stand thinning and **health**

Reconnaissance including aerial survey, panel trapping and trap tree establishment

After detection of sirex

Training of staff

Stand thinning and **health**

Map and **monitor** tree mortality

Introduce nematodes by establishing and inoculating trap trees

Release parasitoids

Determine nematode inoculation **effectiveness**

After sirex population crash

Maintenance of staff skills

Stand thinning and **health**

Monitor susceptible plantations by aerial survey and trap trees

Release further biocontrol agents if required

Evaluate plantation and trap tree logs to determine nematode parasitism and parasitoid levels

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