12421. Neumann

Conservation and Natural Resources

April 1994 Forests Service No. 25

RESEARCH & DEVELOPMENT

Pine Needle Blight and the Sirex Wasp in unthinned plantations of Radiata Pine

In Victoria, Pine Needle Blight (PNB), a foliage disease caused by the needle-cast pathogen *Dothistroma septospora*, and the wood-boring Sirex Wasp (*Sirex noctilio*), pose the greatest potential threat by destructive organisms to pulpwood and sawlog production from Radiata Pine (*Pinus radiata*) plantations. Both were accidentally introduced, *Dothistroma* probably around 1979 from South America via New Zealand and New South Wales, and *Sirex* during the late 1950s from the Mediterranean region via New Zealand and Tasmania.

This Research & Development note reports on a study from October 1989 (a year of a PNB disease epidemic) to June 1991 that focused primarily on assessing PNB and *Sirex* population levels, and testing the possibility of interactions between them and mean stem diameter at breast height (1.3 m) over bark (DBHOB), within unthinned 14 to 15-year-old Radiata Pine stands.

The results showed that *Sirex* responded to a one-off widespread severe needle-cast, and that this response could occur independently of the adverse effects of inter-tree competition — the main factor (apart from protracted drought) of *Sirex* build-up in pine plantations. Such an economically important latent side-effect of widespread severe needle-cast should prompt urgent action to either prevent PNB or reduce its severity in susceptible Radiata Pine plantations of intermediate age.

Distribution and economic importance of Pine Needle Blight and *Sirex*

Outbreaks of PNB have occurred where the annual rainfall exceeds 1100 mm, and are favoured by topographic features that induce high humidity by impeding the drainage of moist air. Plantations near Tallangatta, Myrtleford, Bright, Benalla and Narbethong have been severely affected by PNB, and disease is building up in the Otway Ranges. In contrast, *Sirex* has already spread to all major pine-growing regions of Victoria and beyond.

Dothistroma is a fungus that infects and kills pine needles, resulting in defoliation of part or all of the crown. The extent of defoliation depends on tree resistance, ambient air temperature, needle wetness and spore load. In Victoria, plantations up to 20 years old are susceptible. New Zealand studies have indicated that:

- the effect on stand growth becomes economically significant when foliage infection is greater than 25%;
- 50% defoliation can cause a 50% reduction in volume increment and a 20% reduction in height growth among trees;
- tree death may result from severe infection over two to three consecutive growing seasons; and
- a high infection level may induce attack by secondary (weaker) pathogens.

In contrast, *Sirex* is essentially a 'secondary' insect pest capable of causing up to 80% tree mortality and a reduction in stand density to around 400 stems/ha in unthinned plantations where conditions are adverse for the growth of Radiata Pine. The quality of the wood in killed trees is degraded through the drilling activity of *Sirex* larvae. Within six months from tree death the wood becomes totally unmerchantable due to widespread dry rot caused by the Sirex Fungus (*Amylostereum areolatum*) introduced by the female wasps during oviposition into the outer sapwood. Unthinned stands of Radiata Pine over 12 years old tend to be most susceptible to *Sirex* attack, which usually commences in late spring, peaks in mid-summer and ceases by mid-autumn.

Study sites and survey procedures

The research was carried out in two valleys between 300 and 1100 m above sea level within the CNR (now the Victorian Plantations Corporation) Cropper Creek and Running Creek management

blocks near Myrtleford and Bright respectively in north-eastern Victoria. The Cropper Creek site carried 1977 plantings of Radiata Pine, whereas the Running Creek site had 1976 plantings. Both remained unthinned during the study; stocking therefore approximated 1700 stems/ha. An outbreak of PNB occurred at both sites during spring 1989, but there was no recurrence in 1990 or 1991.

PNB severity was assessed at the height of the 1989 epidemic by scanning the periphery of the study sites and surrounding stands and estimating the percentage of visible crowns infected by *Dothistroma* on a 0 to 6 scale (0 = nil crown infection, 1 = trace to 5%, 2 = 6–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–95% and 6 = >95%). In variously defoliated stands, PNB severity was expressed in terms of the sum total of the percentage infection among the foliage still present and the percentage of cast needles. Where shading had killed the lower foliage, only the level of disease in the upper crown portion was assessed. Spot examinations were used to confirm the presence of PNB in stands where 'secondary' needle cast pathogens (e.g. *Cyclaneusma* sp.) were prolific and masked PNB symptoms. Whole trees were examined closely at specific inspection points selected on the basis of topographic features considered to provide a range of possible PNB severity. Where PNB ratings were low around inspection points of greatest disease hazard (e.g. within a moist gully), the stand around the site was ranked as 'low' for disease severity.

Population levels of *Sirex* were assessed about 20 months after the 1989 PNB epidemic in terms of the cumulative percentage tree mortality induced by *Sirex* among 5200 trees (13 plots of 400 trees) at the Cropper Creek site, and 3200 trees (8 plots of 400 trees) at Running Creek. Each tree was scanned with 8 × binoculars and placed into one of six health categories (Table 1).

Occurrence and ratings of PNB and *Sirex*

In spring 1989, PNB severity varied at the study sites from a rating of 1 to 6 (Table 1). High infection levels (ratings 3–6) occurred between 430 and 550 m above sea level, and low infection levels (ratings 1–2) above these elevations. By winter 1991, most of the severely damaged trees had regenerated their foliage.

Four generations of *Sirex* were evident at the study sites. The oldest generation had caused some tree mortality during 1989 as evidenced by the presence of a few trees with 1989–90 vintage flight holes, while the youngest generation was present as larvae within the sapwood of dying or recently dead trees (Table 1). From 1988 to 1991, a near exponential increase in the *Sirex* population occurred within severely to totally defoliated stands (Table 2), whereas the pest had not responded to low PNB severity ratings (Table 1).

Effect of tree diameter on PNB and Sirex rating

A positive correlation was demonstrated between mean stem diameter and the 1989 PNB severity ratings for trees assessed in winter 1991 (Figure 1a). PNB severity was maximal in unthinned stands of intermediate age whose trees had grown quickest. These stands were of a high site quality and as they had not been thinned were very crowded and poorly ventilated. They therefore provided conditions conducive to the spread of the disease.

The mean stem diameter was also positively correlated to *Sirex* population levels in stands with very low PNB ratings (Figure 1b). *Sirex* had therefore responded to increased inter-tree competition in unthinned stands relatively free of PNB.

Moreover, Figure 2 shows that an exponential relationship was established between the means of DBHOB and PNB severity plus *Sirex* ratings, with a threshold of 15 cm DBHOB, above which the gradient of the curve became very steep. Unthinned stands with a mean DBHOB greater than or equal to 15 cm are therefore expected to deteriorate more rapidly over several seasons from the combined effect of PNB and *Sirex* than those below this diameter.

Relationship between PNB severity and *Sirex* population ratings

Testing for a possible correlation between PNB severity and *Sirex* population levels required analysing data from plots covering a range of PNB severity and *Sirex* levels whose mean DBHOBs did not differ significantly. This ensured that the effects of inter-tree competition on the distribution and abundance of both agents were excluded.

For nine of the 21 study plots which had statistically similar DBHOBs, there was a positive linear correlation between PNB severity and *Sirex* population ratings (Figure 3). This indicates the possibility of high levels of *Sirex* occurring in response to high ratings of PNB independent of crowding effects within unthinned plantations of intermediate age. Thus, there was evidence of an interaction between PNB severity and *Sirex* population ratings.

Conclusions and recommendations

The most important outcome of the research is that unthinned Radiata Pine plantations of intermediate age, stressed through a one-off severe outbreak of PNB, seem to favour a rapid build-up of *Sirex* in the following years. This appears to be independent of crowding or drought effects. However, in high site quality stands, the *Sirex* build-up is accelerated as greater inter-tree competition imposes additional

TABLE 1: Health status of 8400 Radiata Pine trees assessed during autumn–winter 1991 (percentage in each of the six health categories).

Study site	PNB severity rating, Oct 1989 [a]	Mean DBHOB (cm)	Healthy crowns	Dead-topped, lower crowns healthy	Dying or recently dead trees from *Sirex* attack in summer 1990–91 [b]	Dead trees with 1990–91 flight holes	Dead trees with 1989–90 flight holes	Dead trees without *Sirex* symptons	Cumulative tree mortality from *Sirex* attack (%)
Cropper Creek	5–6	21.5	88.6	0.1	5.4	1.2	0.7	4.0	7.3
	3–4	16.1	97.3	0.9	0.4	0.1	0.1	1.3	0.6
	1–2	12.8	96.1	2.5	0.5	0.2	0.2	0.5	0.9
Running Creek	5–6	20.2	90.1	0.3	6.2	0.1	0.0	3.3	6.3
	3–4	16.8	95.9	0.7	2.0	0.1	0.0	1.3	2.1
	1–2	18.8	97.0	1.0	1.5	0.0	0.0	0.5	1.5

(a) Rating 1 = trace to 5% crown infection; 2 = 6–25%; 3 = 26–50%; 4 = 51–75%; 5 = 76–95%; 6 = >95%
(b) These trees contained larvae of the 1991–92 *Sirex* generation, which was expected to produce flight holes in summer 1991–92 and cause additional tree deaths during 1992

TABLE 2: *Sirex* population levels as percentage cumulative tree mortality from *Sirex* by 1991 within four low-elevation plots which had a PNB rating of 6 in spring 1989 but had improved to 0–1 by 1991.

	Population level in plot				
Sirex generation	1	2	3	4	mean
1988–89	0.50	0.00	1.50	0.50	0.63
1989–90	2.00	0.50	3.75	1.75	2.00
1990–91	6.00	6.25	8.50	11.25	8.00

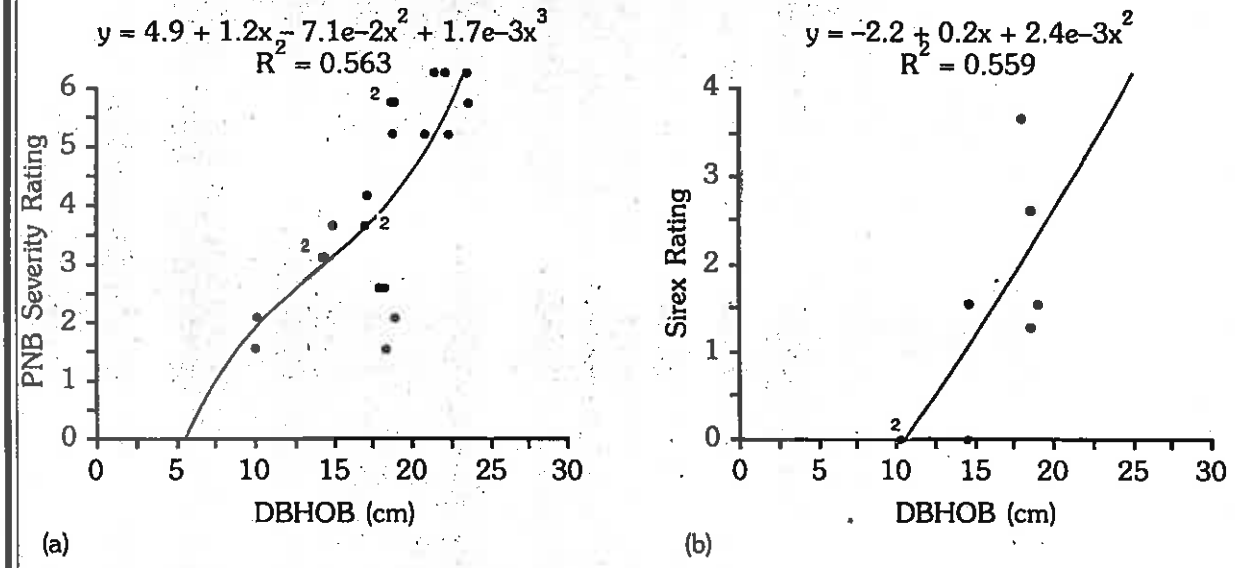

FIGURE 1: Relationships between mean tree diameter at breast height over bark (DBHOB) and (a) severity rating for PNB (0 = nil to 6 = >96% crown infection), as assessed in October 1989, for 21 plots each of 400 trees, and (b) *Sirex* rating in terms of the cumulative percentage tree mortality caused by this pest, as assessed during autumn/winter 1991 for eight plots each of 400 trees with <25% of crown affected by PNB, at two study sites in north-eastern Victoria. Coincidental points on the graphs are marked with the digit 2.

stress on trees. It is predicted that repeated severe needle cast in successive years, combined with an escalating rate of tree mortality from *Sirex* attacks and adverse effects from secondary pathogens, could devastate a plantation fairly rapidly.

Large outbreaks of PNB in unthinned Radiata Pine plantations of intermediate age should therefore be prevented or promptly controlled by timely spraying with copper-based fungicides unless thinning has been scheduled in the immediate future. Thinning effectively lowers the susceptibility of pine plantations to both PNB disease and *Sirex* by facilitating the drainage of moist air between tree crowns and alleviating the stress effects of crowding (and of protracted drought). Priority for control with fungicides should be given to high quality stands at low elevations, as the effect of PNB and *Sirex* on plantation health is likely to be most pronounced in these stands.

Further reading

CFL (1988) Identifying and controlling The Sirex Wasp in Radiata Pine plantations. Research & Development Note No. 6, Dept Conserv., Forests and Lands.

CNR (1992) Pine Needle Blight in pine plantations: some questions and answers. (revised) Research & Development Note No. 12, Dept Conserv. and Nat. Res..

CNR (1992) Controlling Pine Needle Blight in pine plantations: some questions and answers. (revised) Research & Development Note No. 18, Dept Conserv. and Nat. Res..

Edwards, D.W. & Walker, T. (1978) *Dothistroma* Needle Blight in Australia. *Aust. For. Res.* 8:125–37.

Marks, G.C. & Hepworth, G. (1986) Effects of certain features of a stand of *Pinus radiata* on *Dothistroma septospora* needle blight. *Aust. For. Res* 16:223–9.

Marks, G.C. & Smith, I.W. (1987) Effect of canopy closure and pruning on *Dothistroma septospora* needle blight of *Pinus radiata*. *Aust. For. Res.* 17:145–50

Marks, G.C., Smith, I.W. & Cook I.O. (1989) Spread of *Dothistroma septospora* in plantations of *Pinus radiata* in Victoria between 1979 and 1988. *Aust. For.* 52:10–19.

Smith, I.W. (1989) A survey of Pine Needle Blight in Radiata Pine plantations in north-eastern Victoria. Research Report No. 342. Dept Conserv., Forests and Lands. (unpubl.).

Neumann, F.G., Collett, N.G. & Smith, I.W. (1993) The Sirex wasp and its biological control in plantations of radiata pine variably defoliated by *Dothistroma septospora* in north-eastern Victoria. *Aust. For.* 56:129–39.

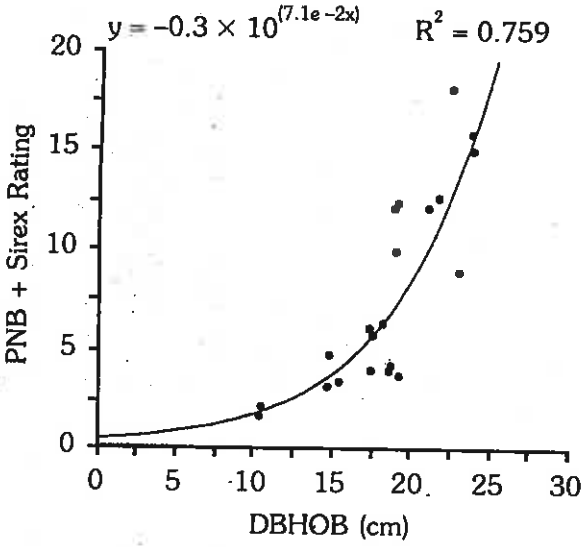

FIGURE 2: Relationship between mean diameter at breast height over bark and PNB severity plus *Sirex* ratings based on data from the 21 study plots.

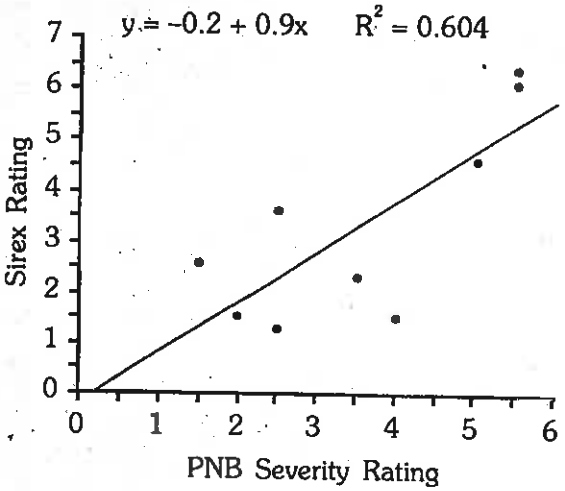

FIGURE 3: Relationship between PNB severity rating and *Sirex* rating (expressed as the cumulative percentage tree mortality from *Sirex* attack) in nine study plots, each of 400 trees, of similar mean DBHOB.

Text prepared by Dr. F.G. Neumann
Forests Service
Department of Conservation and Natural Resources

Produced by Scientific Publications Section
Forests Service
Department of Conservation and Natural Resources