... amenity benefit ... er land values to the owner. This may be one explanation of the graziers' preference for a research programme over plantations or woodland preservation.

9. We added the words in parenthesis to the quotation.

Acknowledgements

The research for this paper was undertaken while both junior authors were students at the Department of Agricultural Economics and Business Management, University of New England. The comments of P. J. Greig and another, anonymous reviewer are appreciated. The views expressed in the paper, and the errors, remain the sole responsibility of the authors.

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Aust. For., 1982, 45 (2), 117-124

An improved technique for early detection and control of the Sirex wood wasp in radiata pine plantations

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Summary

Basal stem injection of Dicamba herbicide (20% 3,6-dichloro-2 methoxybenzoic acid) into the outer sapwood was tested as a technique for predisposing conveniently placed groups of *Pinus radiata* trees to attack by the European tree-killing wood wasp *Sirex noctilio*. The trials included injection of Dicamba during spring and summer, injection of de-ionised water during spring and untreated controls, and were undertaken in unthinned plantations of two ages, 8 and 15 years.

Sirex noctilio was attracted almost exclusively to the Dicamba-treated trees, which provided suitable breeding habitats for the pest and its introduced natural enemies, both wasp parasitoids and nematode parasites. Spring injection gave more satisfactory results than the summer injection. The trees in the older stand were more susceptible to attack, as were the trees in the smaller diameter classes in both stands. Infested treated trees contained an average of 275 wasps irrespective of tree age. Dicamba injections did not induce major attacks on any nearby untreated trees.

The practical importance of these findings is that *S. noctilio* can now be readily detected, its populations periodically monitored, and control improved in plantations, by attracting the pest, and its lethal wasp parasitoids, to strategically placed and widely distributed groups of Dicamba-treated 'trap' trees. Inoculation of the trees with the nematode parasite, *Deladenus siricidicola*, which infests *S. noctilio* larvae, will cause the infested females which subsequently emerge to be sterile and, as a result, the population is expected to fall.

Introduction

The European wood wasp, *Sirex noctilio* Fabricius (Hymenoptera: Siricidae), is a serious pest of introduced radiata pine, *Pinus radiata* D. Don, in south-eastern Australia (Neumann 1979). Trees may die a few weeks after female wasps have injected phytotoxic mucus and spores of the nutritive pathogen *Amylostereum areolatum* (Fr.) Boidin into the sapwood (Coutts 1969 a, b). Wood degrade occurs mainly after tree death as a result of the tunnelling activity of the larvae which feed on *A. areolatum*.

Since the early 1970s, the control strategy for the wasp in south-eastern Australia has been based on the release of introduced sirex-specific ibaliid, ichneumonid and stephanid wasp parasitoids, and on the artificial inoculation of infested trees with *Deladenus siricidicola* Bedding (Neotylenchidae), a nematode parasite which infects *S. noctilio* larvae in the wood, and subsequently sterilizes female adults prior to emergence (Zondag 1962, Bedding and Akhurst 1974, Taylor 1976, 1978, 1980). Biological control of *S. noctilio* continues naturally, when the wasp parasitoids become established, and when nematode-infected sterile female *S. noctilio* introduce *D. siricidicola* into the wood of new trees containing healthy female *S. noctilio* larvae.

In Victoria, biological control alone has not always been effective in preventing *S. noctilio* from causing substantial damage to pine (McKimm and Walls 1980, Neumann and Minko 1981), probably as a result of very slow dispersal of the nematodes.

Madden (1971) proposed the use of 'trap' trees to supplement biological control. He found that the stems of *P. radiata* trees, pruned to 5.5 m above the ground, and girdled by removal of a 5 cm band of bark at heights between 1.2 and 4.9 m, became highly susceptible to *S. noctilio* attack below the girdle, either one or two years after treatment. The efficacy of these 'trap' trees was demonstrated in a small Victorian

Revised manuscript received 6 April 1982.

plantation, in which 76% of 55 girdled trees became infested by *S. noctilio*, compared to less than 2% of several thousand nearby untreated trees (Madden and Irvine 1971). However, this technique is slow, labour intensive, and hence expensive. Furthermore, only few *S. noctilio* can breed in the short length of susceptible stem below the girdle.

An unexpected side effect of trials near Myrtleford in north-eastern Victoria with several herbicides for non-commercial thinning of *P. radiata* by basal stem injection was the occurrence of *S. noctilio* larvae in many of the treated trees, even though the *S. noctilio* population in the area was low (Minko 1981). Following the discovery of this link between herbicide injection and the occurrence of *S. noctilio* in trees, it was proposed that strategically-placed and widely separated groups of herbicide-treated 'trap' trees might be useful for the early detection, periodic monitoring and control of *S. noctilio* in susceptible pine plantations (Neumann and Minko 1981).

In this paper the results of research carried out to investigate the efficacy of such herbicide-treated 'trap' trees are presented.

Methods

The study was carried out between 1979 and 1981 in the Hurdle Creek and Running Creek Plantations near Myrtleford in north-east Victoria. Plots established in the former plantation had been planted in 1971, and those in the latter in 1964. Both plantations had not been thinned, and stocking was approximately 1700 trees ha^{-1}. The trees in these plantations will be referred to throughout this paper as 8 years and 15 years of age respectively (from year of planting to time of initial treatments), for convenience of reading, although the work was carried out over a period of almost two years.

Sixteen plots of 448 trees (16 rows of 28 trees) were established at about 0.5 km apart in each plantation, thus comprising a total of 14 336 trees. Twenty adjacent trees in every 8th and 9th row (commencing four trees in from the edge) of each plot were subjected to one of four treatments (Table 1). Each treatment was replicated four times. Trees below 3 cm diameter at breast height over bark (DBHOB) were not treated, but pooled with the 408 untreated trees in each plot which were used for estimating the frequency of old and current *S. noctilio* infestations in the vicinity of the treated trees.

Dicamba herbicide was chosen in preference to other herbicides because of its slower rate of action on pine than that of alternatives, such as 2,4-D, or Picloram + 2,4-D (Minko 1981). Slow herbicidal action was considered desirable, as slow-dying trees appear to remain attractive to *S. noctilio* over a much longer period than rapidly killed trees. The deionized water treatment was prescribed to test whether the injury caused by the injection, as distinct from the herbicide effect, predisposed the trees to *S. noctilio* attack.

The injection treatments with Dicamba were carried out in spring (October 1979) and summer (January 1980) and that with deionized water in spring (October 1979) only.

During winter 1980 the DBHOB of all treated trees was measured, and the condition of the trees was assessed as follows:

(a) healthy, apparently unaffected by treatments or by *S. noctilio*;
(b) dead-topped, upper crown dying or recently dead, lower crown healthy, and *S. noctilio* unlikely to be implicated; and
(c) dead, foliage either absent, completely chlorotic or brownish, and *S. noctilio* probably implicated.

All dead trees were felled between June and October 1980, and examined for the presence of *S. noctilio* by cross-cutting the stems at intervals of 1 m. Infested billets from plots in the 15-year-old plantation were end-coated with wax and suspended vertically from trees in that plantation until retrieved in November 1980 just prior to insect emergence for laboratory studies of the extent of oviposition and parasitism. In addition, all billets from each of five infested 8-year-old and six 15-year-old trees were individually caged in order to determine the abundance and distribution of *S. noctilio* within whole trees.

During the autumn of 1981 evidence of further infestations was observed. Between late-autumn and mid-winter 1981 all treated trees which had died during the second year of the study were felled and examined for symptoms of *S. noctilio*. Infested billets were treated and studied as before. In addition, the DBHOB of all 408 untreated trees in each plot was measured, and the trees categorized as follows:

(a) healthy;
(b) dead-topped;
(c) foliage extensively chlorotic, recovery potential slight;
(d) foliage extensively brownish, no chance of recovery;
(e) dead prior to spring 1979, with or without *S. noctilio* flight holes; and
(f) dead after spring 1979, with or without *S. noctilio* flight holes.

Table 1. The treatments used in the study.
(Both Dicamba herbicide and deionized water were applied with a tree injector (INVjector[1]) into the outer sapwood at a rate of 1 ml per 10 cm of circumference at the base of the trees).

Treatment	No. of trees (40 x 2 age classes x 4 replications)	Time of year of injection	Chemical injected and concentration
1	320	spring (29-31 Oct '79)	Dicamba[2] (200 g a.i. L^{-1})
2	320	summer (14-15 Jan '80)	Dicamba (200 g a.i. L^{-1})
3	320	spring (29-31 Oct '79)	deionized water
4	320	nil	nil (control)

[1] Registered Trade Name.
[2] 3,6-dichloro-2-methoxybenzoic acid.

Results and discussion

Effects of basal stem injection on the occurrence of S. noctilio *in trees*

The condition of treated trees within the study plots at Hurdle Creek and at Running Creek during 1980 and 1981 is summarised in Table 2. It was also observed that the Dicamba injection caused the exudation of numerous tiny resin globules on the bark surfaces of trees within six weeks of treatment.

The means and the variances of the DBHOB measurements of all trees in each of the four treatments were not significantly different, therefore the variously treated trees were comparable in size. It was therefore valid to compare, in Table 2, the proportions of trees in each treatment infested by *S. noctilio*, to obtain a relative measure of the relationship between the different treatments and the incidence of *S. noctilio*.

Analyses of variance, carried out on the percentages (transformed to angular degrees) of treated trees found to be infested by *S. noctilio* in 1980 and 1981, showed that the occurrence of *S. noctilio* in both plantations was significantly affected ($P < 0.001$) by the treatments, but not by the year of inspection. In each case, the treatment effects were exclusively due to the basal stem injection of Dicamba. Both the October and January injections with Dicamba significantly increased ($P < 0.01$) the incidence of *S. noctilio* in trees compared with that in untreated trees. The deionized-water injection had no effect.

Sirex noctilio was found more frequently in trees injected with Dicamba during October, though this trend was significant ($P < 0.01$) only for the 1980 data from the 15-year-old trees. The incidence of *S. noctilio* in the 8-year-old Dicamba-treated plots was significantly less than that in the older (15-year-old) treated plots.

In both age classes of pine Dicamba-treated trees were attacked by *S. noctilio* mainly during the first summer/autumn period following injection. However, in the older plantation, although about 22% of trees injected during January became infested in the same year, a further 23% became infested during the following year. Thus, Dicamba injections during summer were too late to be fully effective during that summer/autumn *Sirex* flight season and the trees remained susceptible for another year. This suggests that summer-injected trees need to be examined for the presence of *S. noctilio* during at least two consecutive winters, to ensure that all infested trees are inoculated with nematodes prior to the emergence of wasps.

The health status of untreated trees in all study plots during autumn/winter 1981 is shown in Table 3. It appears that *S. noctilio* had killed none of the untreated trees in the 8-year-old plots during the study period, and that very few of the untreated trees in the 15-year-old plots had died from attack by *S. noctilio*. Populations of the pest within untreated trees in both plantations were therefore economically unimportant before and during the study period. Conditions were thus ideal for testing the effectiveness of Dicamba-injected 'trap' trees in attracting *S. noctilio*. Another result was that the incidence of *S. noctilio* in Dicamba-treated trees was unrelated to the orientation of the rows in which the trees were planted.

Relationships between stem diameter and occurrence of S. noctilio

In both plantations, the occurrence of *S. noctilio* in Dicamba-treated trees was significantly related to the DBHOB ($P < 0.001$) (Figure 1). In the younger plantation, a greater proportion of trees in the 5.0-9.9 cm DBHOB range than in the 10.0-14.9 cm range was infested with *S. noctilio* ($P < 0.01$), which in turn was greater than that in trees above 14.9 cm ($P < 0.05$). In the older plantation, there was a much higher incidence of *S. noctilio* in trees below 20.0 cm DBHOB than above this level ($P < 0.001$).

Further examination of Figure 1 indicates that in the eight-year-old plots most of the infested Dicamba-treated trees (54.6% of total infested) fell within 5.0-9.9 cm DBHOB, whereas in the 15-year-old plots 75.6% of infested trees had a DBHOB between 10.0-19.9 cm. For these two diameter classes, about 49% of total Dicamba-treated trees in the younger plantation became infested within 20 months of spring-injection, compared to only 16% following summer-injection. In the older plantation, the corresponding infestation levels were about 81%

Table 2. The condition of *P. radiata* trees treated by basal stem injection of Dicamba herbicide during autumn/winter 1980 and 1981.

Treatment	No. of plots	Mean no. of treated trees per plot	Proportion (%) of treated trees assessed in the following categories: Healthy 1980	Healthy 1981	Dead-topped[1] 1980	Dead-topped[1] 1981	Dead without *S. noctilio* 1980	Dead without *S. noctilio* 1981	Dead with *S. noctilio* 1980	Dead with *S. noctilio* 1981
(a) Trees treated at about age 8 years (Hurdle Creek Plantation)										
Dicamba-injection (Oct 1979)	4	36[2]	8.0	9.3[3]	46.9	43.7	19.9	21.8	25.2	25.2
Dicamba-injection (Jan 1980)	4	40	38.6	12.6	48.9	63.6	3.1	11.9	9.4	11.9
Deionized water-injection (Oct 1979)	4	40	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Control	4	40	99.4	99.4	0.0	0.0	0.6	0.6	0.0	0.0
(b) Trees treated at about age 15 years (Running Creek Plantation)										
Dicamba-injection (Oct 1979)	4	40	18.6	14.8	8.3	6.4	17.1	20.9	56.0	57.9
Dicamba-injection (Jan 1980)	4	40	66.0	41.6	8.0	3.1	4.3	10.5	21.7	44.8
Deionized water-injection (Oct 1979)	4	39[2]	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
Control	4	40	98.8	98.2	0.0	0.6	0.0	0.0	1.2	1.2

[1] None of these trees were infested by *S. noctilio*.
[2] Some trees windthrown and severely damaged during 1981.
[3] Two trees with chlorotic tops had recovered.

for spring-injection and 45% for summer-injections.

Within the Dicamba-treated eight-year-old plots 19.7% of the untreated trees had a DBHOB within the high susceptibility range of 5.0-9.9 cm, yet none of these trees became infested. Untreated trees in the 15-year-old Dicamba-treated plots were likewise infrequently attacked by *S. noctilio* during the study period, though 45.5% of them fell within the most susceptible DBHOB range in that age class (10.0-19.9 cm). In both plantations, *S. noctilio* had therefore shown a remarkable preference for Dicamba-treated trees compared to nearby untreated trees, even when these were of small diameter.

In the 15-year-old stand the trees attacked by *S. noctilio* before 1980 had significantly smaller mean diameters ($P < 0.05$) than those attacked during the study period (except for trees in the control plots) (Table 4), and the Dicamba-treated trees infested in 1981 tended to be marginally larger than those infested in 1980. These results confirm observations by McKimm and Walls (1980) that the range of susceptible tree sizes increases progressively when attack by *S. noctilio* is sustained over several seasons.

Dicamba-treated trees as host habitats for S. noctilio *and its biological control agents*

Sirex noctilio oviposited abundantly into Dicamba-treated trees; as well, the development to maturity, and the subsequent emergence of male and female *S. noctilio* and of its parasitoids, and the infective capacity of *D. siricidicola*, were not adversely affected by the herbicide treatment (Table 5). In this Table, the ratios of total insect emergence to the number of larval galleries associated with oviposition punctures indicate that the mortality of larvae, pupae and pharate adults of *S. noctilio*, and of its parasitoids, was very low to

Table 3. The condition of peripheral (untreated) *P. radiata* trees, as assessed during the autumn/winter 1981.

Plantation	Identity of study plots by treatments	No. of plots	Mean no. of untreated trees per plot	Proportion (%) of the untreated trees assessed in the following categories: live: Healthy	live: Dead-topped	live: Chlorotic foliage	live: Brown foliage	dead: Without *S. noctilio*	dead: With pre-1979 *S. noctilio* symptoms	dead: With post-1979 *S. noctilio* symptoms
Hurdle Creek, treated when eight years of age	Dicamba-injection (Oct '79)	4	408.0	99.5	0.1	0.0	0.0	0.4	0.0	0.0
	Dicamba-injection (Jan '80)	4	408.0	99.6	0.0	0.0	0.0	0.4	0.0	0.0
	Deionized water-injection (Oct '79)	4	400.0[1]	99.3	0.1	0.0	0.0	0.6	0.0	0.0
	Controls	4	408.0	98.7	0.1	0.0	0.0	1.2	0.0	0.0
Running Creek, treated when 15 years of age	Dicamba-injection (Oct '79)	4	402.5[1]	93.3	0.0	0.3	0.0	4.4	1.5	0.5
	Dicamba-injection (Jan '80)	4	403.7[1]	88.9	0.2	1.2	0.6	6.0	2.7	0.4
	Deionized water-injection (Oct '79)	4	391.5[1]	88.4	0.2	0.6	0.2	6.0	2.8	1.8
	Controls	4	394.5[1]	94.2	0.3	1.0	0.1	3.2	1.0	0.2

[1] Missing trees were badly damaged by windthrow during 1981.

negligible within the wood of Dicamba-treated trees.

The 'trap' trees which were treated when 8 years of age contained about as many *S. noctilio* individuals as those treated at 15 years of age (mean values for the number of emergents were 277.2 and 272.7 per tree respectively), but the distribution of insects within tree stems varied with tree age (Figure 2). In the younger trees, *S. noctilio* could be found almost along the entire stem, though insect density was greatest between 2-3 m above the ground, whereas in the older trees the pest occurred between 2-16 m, with maximum density between 3-14 m.

The observations that (a) *S. noctilio* and its wasp parasitoids can be attracted successfully to Dicamba-injected trees in eight-year-old Sirex-free plantations, or to injected older trees of larger diameter, and (b) many of the Dicamba-injected trees become naturally infected by parasitic nematodes, suggest that the injected trees emit powerful volatiles to which both fertile and nematode-infected *S. noctilio* adults, and also adult wasp parasitoids, respond from areas possibly as far as several kilometres away. The attractant volatiles probably emanate from the numerous tiny globulus of resin, that become visible on the bark surfaces of stems of injected trees.

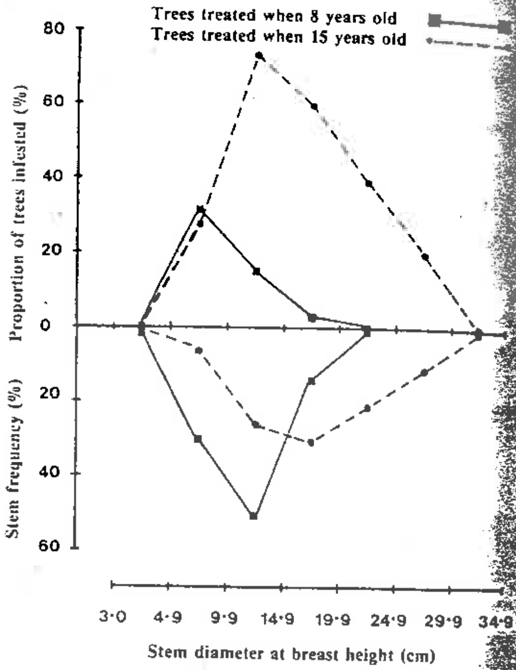

Figure 1. Proportion of *P. radiata* trees treated with Dicamba herbicide when 8 years old or 15 years old in October 1979/January 1980, arranged by DBHOB class, and the proportion of each class found to be infested with *S. noctilio* in winter 1981.

Table 4. Diameter at breast height over bark (DBHOB) of *P. radiata* trees infested by *S. noctilio* in study plots aged 15 years at time of treatment.

Identity of study plots by treatments	DBHOB of untreated trees (Mean ± SE; range)		DBHOB of treated trees (Mean ± SE; range)	
	Infested before 1980	Infested during 1980	Infested during 1980	Infested during 1981
Dicamba-injection (Oct '79)	8.1 ± 0.5[e] 4.5 – 14.9	13.9 ± 1.3[bc] 6.6 – 19.8	16.7 ± 0.7[ab] 7.7 – 27.1	22.4 ± 2.2[a] 19.8 – 26.8
Dicamba-injection (Jan '80)	9.0 ± 0.4[e] 4.3 – 19.2	14.4 ± 1.8[b] 10.3 – 23.5	14.9 ± 0.7[b] 9.5 – 26.7	16.3 ± 0.5[b] 10.5 – 23.1
Deionized water-injection (Oct '79)	8.7 ± 0.4[e] 4.1 – 14.9	11.2 ± 0.5[d] 5.9 – 18.7	*	*
Control	9.7 ± 0.7[de] 5.5 – 14.7	12.2 ± 1.5[cd] 9.5 – 14.6	12.0 ± 2.5[cd] 9.5 – 14.6	*

* No trees infested by *S. noctilio*.

SE = Standard error.

The means designated by the same letter do not differ significantly at the 5% level of confidence.

Conclusions

The basal stem injection of 20% Dicamba herbicide into the outer sapwood at a rate of 1 ml per 10 cm of circumference at the base of young and intermediate-age *P. radiata* trees, was followed by a high incidence of *S. noctilio* infestation among the treated trees, but not among nearby untreated trees, even though some of these were suppressed. Spring-injections were far more effective than summer-injections in attracting *S. noctilio* during the flight season following treatment. The most susceptible of the treated trees were those in the 15-year-old stand (at time of treatment) with DBHOB in the range 10-20 cm.

The high level of emergence of both fertile and nematode-infected *S. noctilio* and of its

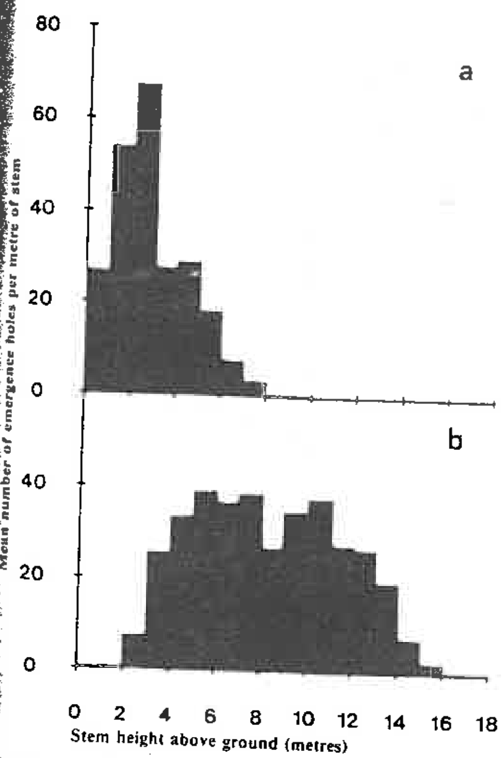

Figure 2. The distribution of *S. noctilio* within stems of *P. radiata* 'trap' trees:
(a) in trees treated when eight years old, and
(b) in trees treated when 15 years old.

Mean tree dimensions were:
(a) DBHOB = 11.1 cm, height = 9.0 m
(b) DBHOB = 15.8 cm, height = 17.3 m

Table 5. Oviposition and emergence data for *S. noctilio* and its parasitoids, and infection levels of the nematode *D. siricidicola* in adult *S. noctilio*, assessed in 1981 from billets (1 m long) from *P. radiata* trees injected with Dicamba 1½ years previously when 15 years of age.

No. of billets	Drill type frequency per billet: Single	Double	Treble	Quad-ruple	Quint-tuple	No. of *S. noctilio* emergents per billet: Male	Female	Total	No. of parasitoid emergents per billet[(4)]: Male	Female	Total	Ratio of total insect emergents to no. of larval galleries corresponding with oviposition drills	Ratio of parasitoid to *S. noctilio* emergents [(5)]	Proportion of female *S. noctilio* emergents sterilised by nematodes [(6)]
12[(1)]	20.3	27.9	11.0	2.3	0.3	23.4	9.6	33.0	6.3	5.2	11.7	1.00	0.40	0.00
15[(2)]	36.3	46.9	25.5	2.9	0.7	28.7	12.7	41.4	6.7	3.8	10.1	0.90	0.41	0.87
22[(3)]	—[(7)]	—	—	—	—	20.0	9.4	29.4	1.9	1.3	3.2	—	0.19	0.85

(1) Billets from trees attacked by nematode-free *S. noctilio* females.
(2) Billets naturally infected by nematode-sterilized *S. noctilio* females.
(3) Billets inoculated with nematodes at the rate of three to four 1 ml shots of 2500 nematodes per 1 m billet during the first winter after *S. noctilio* attack.
(4) Exclusively *Ibalia leucospoides* (Hochenwarth) and *Megarhyssa nortoni nortoni* (Cresson), which emerged in the ratio of 100:8 respectively (n = 1073).
(5) Commonly used measure of the level of biological control of *S. noctilio* parasitoids.
(6) Male and female emergents of *S. noctilio* were [illegible]

parasitoids, from Dicamba-injected trees indicated that the trees provide ideal habitats for *S. noctilio* and its natural enemies, and that biological control of the pest within trees is not impaired by the herbicide treatment.

Application

The practical applications of the research are the following:

1. The early detection of *Sirex noctilio* in unthinned plantations of intermediate age, and the periodic monitoring of its population levels, may be greatly facilitated by using strategically-placed and widely distributed groups of 'trap' trees, injected during spring with Dicamba herbicide. The injection of trees is inexpensive and takes about one minute per tree.
2. Large numbers of *S. noctilio* infesting the 'trap' trees can be destroyed by felling the trap trees and burning them.
3. Biological control of the *S. noctilio* population, in addition to that provided by the parasitoids, can be undertaken by felling the infested trees and inoculating them with the nematode *Deladenus siricidicola*, using the technique described by Bedding and Akhurst (1974). Female *S. noctilio* larvae which become infested with the nematodes subsequently emerge as sterile adults.
4. Inoculation can be undertaken soon after the end of the *S. noctilio* flight season in mid-autumn. As this is several months earlier than has been possible in the past due to the difficulty of early identification of infested trees, it should increase the level of nematode-induced sterility among female emergents of *S. noctilio*.
5. Nematode-infested sterile *S. noctilio* emergents from inoculated 'trap' trees will introduce nematodes by oviposition into new 'trap' trees and thereby cause rapid and widespread dispersal of nematodes within a plantation. The combined impact of nematodes and of parasitoids from 'trap' trees among new populations of *S. noctilio* is expected to cause the early collapse of pest populations after two or three years of treatment, and safeguard susceptible plantations from economic damage.

Acknowledgements

We would like to thank Forester M. Cavill, Technical Officer J. Morey, and Technical Assistants R. Beasley, T. Lambeth and S. Smith, for helping with the field work. Thanks are also due to Technical Assistant Gail Forward, for preparing the Figures, and to District Forester B. Evans of Myrtleford, for his co-operation during selection of the study areas.

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Aust. For., 1982, 45 (2), 125-131

Insect problems of Araucaria plantations in Papua New Guinea and Australia

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Summary

Several insect pests in established plantations of *Araucaria* are discussed, and the influence of tree age, site quality, provenance, climatic conditions and natural enemies on the severity of infestation and extent of damage are outlined. There are few insect pests in plantations of *A. bidwillii* and *A. hunsteinii*, but insect problems have been encountered with *A. cunninghamii*, particularly in Papua New Guinea. However, these problems should not deter trials of *A. cunninghamii* in other areas. Diversification of planting fronts, retention of areas of natural vegetation adjacent to plantations and avoidance of replanting marginal sites are recommended to minimise pest problems.

Introduction

Three species of *Araucaria* — hoop pine (*A. cunninghamii* Ait. *ex* D. Don), klinki pine (*A. hunsteinii* K. Schumann syn. *A. klinkii*) and bunya pine (*A. bidwillii* Hook.) — are native to the Australia/New Guinea region. *Araucaria cunninghamii* is widely distributed in Papua New Guinea, and in eastern Australia its range extends from Queensland down to northern New South Wales. *Araucaria hunsteinii* and *A. bidwillii* have a more restricted range in the highlands of Papua New Guinea and in south-east Queensland respectively (Nikles 1973, 1978, 1979, Gray 1973, Howcroft 1978). Plantations of these species have been established in Papua New Guinea (*A. cunninghamii* 3550 ha, *A. hunsteinii* 4060 ha) and in Australia (*A. cunninghamii* 39 000 ha, *A. bidwillii* 500 ha) (Nilkes 1979). Both *A. cunninghamii* and *A. hunsteinii* are of great economic importance in these countries and are receiving increasing attention as exotic plantation species. For this reason it is important to review some of the serious and potentially serious insect problems encountered in established plantations within their natural distribution, and to examine the possible insect threat to these species outside their natural range.

Based on a paper presented at the IUFRO Symposium and Workshop on Genetic Improvement and Productivity of Fast Growing Tree Species. Brazil, August 1980.

Revised manuscript received 5 May 1982.

Status of important insect pests of *Araucaria*

Papua New Guinea

The most serious pests of plantation-grown hoop pine are the branchlet-mining scolytid *Hylurdrectonus araucariae* Schedl (Coleoptera: Scolytidae) and the weevil *Vanapa oberthuri* Pouillaude (Coleoptera: Curculionidae). Minor pests include the termite *Coptotermes elisae* (Desneux) (Isoptera: Rhinotermitidae) and a caterpillar defoliator *Milionia isodoxa* Prout (Lepidoptera: Geometridae). No serious pests of klinki pine have been recorded and only *C. elisae* has been of any consequence (Gray and Buchter 1969, Gray and Wylie 1974). Because of the susceptibility of *A. cunninghamii* to insect attack, planting of this species in the Bulolo-Wau region, where the country's main hoop pine plantations are located, ceased in 1968 while planting of *A. hunsteinii* (including enrichment planting) was increased.

Hylurdrectonus araucariae has caused considerable mortality and loss of growth increment in hoop pine plantations at Bulolo and Wau (Figure 1). The initial invasion of these plantations by the beetle probably occurred in the late 1950s from nearby remnant hoop pine; however, the greatest population build-up took place between 1966 and 1970. By December 1971, the insect had infested approximately 47% of 3252 ha of plantations at Bulolo and 91% of