INCIDENCE AND SEVERITY OF CYCLANEUSMA NEEDLE-CAST IN FIFTEEN PINUS RADIATA PLANTATIONS IN NEW ZEALAND

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ABSTRACT

Fifteen forests totalling 70 000 ha of **Pinus radiata** D. Don were surveyed for Cyclaneusma needle-cast in 1983, 1984, and 1985. Disease severity was highest in the 11- to 20-year-old stands and lowest in the 1- to 5-year-old and over 25-year-old stands. Disease severity generally increased from 1983 to 1984 and again to 1985 but there was significant variation between regions. No difference in disease incidence between years could be demonstrated. Losses in wood volume, due to the disease, of 5% per annum in the forests sampled were predicted for stands aged between 6 and 20 years old.

Keywords: needle-cast; growth loss; disease incidence; disease severity; **Cyclaneusma minus**; **Pinus radiata**.

INTRODUCTION

Premature needle-cast caused by *Cyclaneusma minus* (Butin) DiCosmo, Peredo & Minter occurs widely in plantations of *Pinus radiata* throughout New Zealand. Years of severe needle-cast have been recorded since 1952 (Gadgil 1984). Van der Pas, Slater-Hayes, Gadgil, & Bulman (1984) have shown that the same individual trees suffer heavy needle-cast year after year, but no detailed information was available on the annual variation of disease incidence and severity on a stand basis for consecutive seasons. Results were reported (van der Pas, Bulman, & Slater-Hayes 1984) from an aerial survey conducted throughout New Zealand in 1983. Follow-up surveys were completed in 1984 and 1985 and data from these surveys are presented in this paper along with estimates of the impact of the disease over consecutive seasons.

METHODS

Forests Sampled

Selection of forests for the 1984 and 1985 surveys was based on the forests surveyed in 1983. Initial selection in 1983 aimed for a uniform geographical spread of forests throughout New Zealand, and a range of soil types and climate. Five forests selected in 1983 – Woodhill, Santoft, Balmoral, Karioi, and Ashley – were omitted in 1984 and 1985 because of difficulties experienced in distinguishing between the symptoms of other damage (salt spray, drought, snow damage) and those of Cyclaneusma needle-

cast. Otago Coast Forest and Whakarewarewa Forest Park, not surveyed in 1983, were included in 1984 and 1985. Fifteen forests were surveyed in 1984 and 1985 (see Table 1). Location, altitude, and mean annual rainfall data are given in Table 2. Forests and areas sampled in 1983 have been recorded by van der Pas, Bulman, & Slater-Hayes (1984).

TABLE 1—Area of *Pinus radiata* plantations (ha) in 1984 and 1985 surveyed for incidence and severity of Cyclaneusma needle-cast

Forest	Year	Age-class (years)					Total
		1–5	6–10	11–20	21–25	>25	
Glenbervie	1984	172	629	1 136	83	109	2 129
	1985	0	204	1 548	245	80	2 077
Tairua	1984	108	839	1 614	99	106	2 766
	1985	60	430	1 695	207	48	2 440
Mangatu	1984	0	2 691	2 737	187	0	5 615
	1985	40	1 917	2 921	447	0	5 325
Ruatoria	1984	419	4 907	1 550	0	0	6 876
	1985	111	4 123	2 555	0	0	6 789
Kaingaroa	1984	2968	9 203	9 432	891	1172	23 666
	1985	1097	10 245	12 351	1590	1290	26 573
Whakarewarewa	1984	106	605	660	0	0	1 371
	1985	35	548	788	0	0	1 371
Pureora	1984	264	1 106	160	36	0	1 566
	1985	19	1 183	238	36	0	1 476
Patunamu	1984	16	674	443	167	35	1 335
	1985	0	663	524	85	61	1 333
Wharerata	1984	686	1 087	348	122	0	2 243
	1985	227	1 456	480	122	0	2 285
Mohaka	1984	0	1 012	1 436	134	0	2 582
	1985	0	903	1 418	175	0	2 496
Gwavas	1984	76	311	1323	287	21	2018
	1985	39	486	1091	242	59	1917
Golden Downs	1984	735	2 739	6 542	629	218	10 863
	1985	196	2 535	7 464	906	111	11 212
Mawhera	1984	0	1 006	982	0	0	1 998
	1985	0	944	1 160	75	0	2 179
Otago Coast	1984	81	1 921	2 669	304	0	4 975
	1985	81	1 367	3 216	401	0	5 065
Berwick	1984	0	67	1 794	160	0	2 021
	1985	0	0	1 590	274	0	1 864
Total	1984	5631	28 797	32 826	3099	1661	72 014
	1985	1905	27 004	39 039	4805	1649	74 402
Area (%)*	1984	11.4	50.4	52.7	26.5	8.9	36.2
	1985	4.0	48.8	55.8	33.4	9.0	36.3

* Area (%) is the percentage surveyed of the total area (total area was obtained from the Stand Record System, *see* Table 5) in each age-class for the 15 forests.

TABLE 2—Geographic particulars of the surveyed forests

Forest	Latitude (S)	Longitude (E)	Altitude (m a.s.l.)	Annual rainfall* (mm)
Glenbervie	35° 39'	174° 21'	100–200	1923
Tairua	37° 10'	175° 51'	1–250	1789
Ruatoria	37° 54'	178° 19'	60–300	2637
Whakarewarewa	38° 10'	176° 16'	300–450	1439
Mangatu	38° 17'	177° 51'	170–280	1341
Kaingaroa	38° 24'	176° 34'	540–760	1491
Pureora	38° 31'	175° 53'	550–600	1803
Patunamu	38° 56'	177° 14'	100–160	2055
Wharerata	38° 56'	177° 48'	50–350	2341
Mohaka	39° 04'	177° 02'	220–340	1394
Gwavas	39° 44'	176° 27'	320–420	1096
Golden Downs	41° 33'	172° 53'	270–340	1295
Mawhera	42° 27'	171° 30'	220–350	2480
Berwick	45° 55'	169° 58'	380–450	726
Otago Coast	46° 05'	170° 06'	50–240	728

* New Zealand Meteorological Service 1979

Assessment

Disease severity was assessed using the 5% step method used for the assessment of Dothistroma needle-blight (Kershaw *et al.* 1982). Disease incidence was assessed by estimating the percentage of trees in the stand that were infected by the disease (also using a 5% scale). From this estimate, the area occupied by infected trees in the stand was calculated. For all three surveys stands were scored by the same two assessors from a Cessna 180 aircraft flying at about 100 m above ground-level at about 80 knots airspeed. "Disease Incidence" is defined as the percentage of the stand area occupied by trees showing the yellowing foliage characteristic of Cyclaneusma needle-cast, while "Disease Severity" is the average percentage of the tree crown with disease symptoms (van der Pas, Bulman, & Slater-Hayes 1984).

Analysis of Data

Where data from all three surveys were to be analysed, disease incidence and severity data from 1983 were recalculated excluding the five forests omitted in 1984 and 1985 to eliminate bias when comparing 1983 results with the 1984 and 1985 results. The stands in each forest were classified into age groups: <5 years old, 6–10 years old, 11–20 years old, 21–25 years old, and >25 years old. Sample size in each age-class was estimated as approximately proportional to disease prevalence, based on data from the 1983 survey. This initial survey indicated disease prevalence was low in the 1- to 5-year-old and >25-year-old stands, so approximately 10% of these age-classes and 50% of the 6- to 20-year-old stands in each forest were randomly selected for assessment. This stratified random sampling technique, with proportional allocation, increased efficiency without a loss of accuracy and precision – an important factor because flying costs were high. The percentage of total area sampled in the 1- to 5-year-old age-class decreased each year owing to shifts in the age-class distribution for the successive surveys.

Data from both assessors were averaged to provide one assessment figure for each compartment surveyed. The data were grouped into the five age-classes. For each age-class compartments were ranked according to disease severity in 10% steps, i.e., trace (disease present but less than 1%), 1–10%, 11–20%, 21–30%, etc. The disease incidence data were used to calculate the total area infected for each severity rank. For instance, if a compartment had a net stocked area of 100 ha and a rating of 20% incidence and 25% severity, a total of 20 ha would be added to the 21–30% severity rank. Total net stocked area for each rank was obtained from the Stand Record System (Shirley 1983). The total area occupied by diseased trees was related to the total net stocked area, by age-class, to give the average infection rating for each severity rank.

Regional severity data were calculated by grouping the forests surveyed as follows: Northland – Glenbervie Forest; Coromandel – Tairua Forest; central North Island – Kaingaroa Forest, Whakarewarewa Forest Park, Pureora Forest; East Cape – Mangatu Forest, Ruatoria Forest, Wharerata Forest; Hawke's Bay – Gwavas Forest, Patunamu Forest, Mohaka Forest; Westland – Mawhera Forest; Nelson – Golden Downs; Otago – Otago Coast Forest, Berwick Forest.

Individual observer assessments for the 1984 and 1985 surveys were compared using the paired comparison t-test. Differences among disease severity and incidence for the 15 forests by year were tested by analysis of variance.

RESULTS

Effect of Tree Age

Disease incidence and severity data by age-class are given for individual forests in Table 3 and summarised by age-classes in Table 4. Disease severity was low in the 1–5 years and >25-years age-classes, apart from one 5-year-old stand at Ruatoria with 61–70% severity in 1984, and two >25-years stands at Glenbervie with 51–60% and 71–80% severity in 1985. Disease severity was highest in the 6–10 years and 11–20 years age-classes with over 40% infection severity in 6% and 10% (1984) and 7% and 11% (1985), respectively, of the stands sampled. Disease incidence was highest in the >25-year age-class with 86% and 81% of the stands being infected in 1984 and 1985; however, 84% and 77% of the areas surveyed had only a trace of the disease. Disease incidence in the severity rankings between 41% and 90% increased from 1984 to 1985 in the age-classes 6–10, 11–20, 21–25, and >25 years by 4%, 4%, 2% and 2% respectively.

Effect of Forest Location

The disease was present throughout New Zealand, but with a considerable variation in disease incidence according to location (Table 5). In 1984 the forests surveyed in the East Cape and Otago regions were most severely infected, with 15% (East Cape) and 8% (Otago) of those areas having severity ratings over 40%. In 1985 Northland, the central North Island, and East Cape had the highest disease prevalence with severity ratings over 40% in 23%, 11%, and 20% of the areas surveyed respectively. Disease severity was low (not greater than 40%) in Westland and Nelson in both years and decreased in Otago from 1984 to 1985.

TABLE 3—Disease incidence for individual forests (%) for 6- to 20-year-old trees

Forest	Year	Disease severity (%)								
		1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90
Glenbervie	1983	1	4	3	6					
	1984		1	3	3	1	1			
	1985			1	2	4	3	9	6	1
Tairua	1983	8	3	1						
	1984	1	1	2	4	3	3			
	1985	1	1	2	4	5	2			
Mangatu	1983	4	7	1	4	5	2			
	1984	1	1	7		2	4	6		
	1985			3	2	3	7	10	1	
Ruatoria	1983	2	6	4	10	2				
	1984		1	1	2	3	2	14	8	
	1985		1	1	3	3	9	7	4	
Kaingaroa	1983	8	9	4	3	2	1			
	1984	3	4	7	8	3	1			
	1985	2	2	2	5	7	4	1		
Whakarewarewa	1984			1	14	7	4			
	1985			2	4	7	8	3		
Pureora	1983	1		12	6					
	1984	2	7	14	10					
	1985				1	8	18	6		
Patunamu	1983	7	2	2						
	1984	4	4		4	1				
	1985	6	1		1					
Wharerata	1983	8	3	6						
	1984	1	11	4	2		3			
	1985	2	4		3	1	4		3	3
Mohaka	1983	8	2							
	1984	2	5	4	2	1				
	1985	5	3	1	2	1				
Gwavas	1983	4	11	3	1					
	1984	3	4	4	3	1				
	1985	3	1	1	3	4				
Golden Downs	1983	9	7	1						
	1984	6	3	1						
	1985	6	3	1						
Mawhera	1983	9	11	4	2					
	1984	7	8	1						
	1985	3	7	2						
Otago Coast	1984	1	2	2	2	2	4	3	1	
	1985	5	3	1	1					
Berwick	1983	10	3	9	5					
	1984	1	6	9	7		1	2	1	
	1985	6	4	3						

TABLE 4—Disease incidence (expressed as percentage of the area surveyed occupied by diseased trees) for severity rankings by age-class

Age (years)	Year	Disease severity (%)					Total incidence (%)
		Trace	1–20	21–40	41–60	≥61	
1–5	1983	20	9				29
	1984	22	7	2		1	32
	1985	1	10				11
6–10	1983	1	14	6	1		22
	1984	1	7	9	3	3	23
	1985		5	5	7	3	20
11–20	1983	1	13	9	3		26
	1984	3	5	7	4	1	20
	1985		4	4	7	4	19
21–25	1983	3	16	3			22
	1984	10	6	2	2	1	21
	1985	3	7	2	3	2	17
>25	1983	79	3				82
	1984	84	2				86
	1985	77	2		1	1	81

TABLE 5—Disease incidence (expressed as percentage of the area surveyed occupied by diseased trees) for severity rankings by region

Region	Year	Disease severity (%)			
		1–20	21–40	41–60	≥61
Northland	1983	5	9		
	1984	1	6	2	
	1985		3	7	16
Coromandel	1983	11	1		
	1984	2	6	6	
	1985	1	6	7	
Central North Island	1983	13	5	2	
	1984	6	13	4	
	1985	3	7	10	1
East Cape	1983	9	7	3	
	1984	3	4	4	11
	1985	3	5	10	10
Hawke's Bay	1983	12	2		
	1984	7	6	1	
	1985	6	3	2	
Nelson	1983	16	1		
	1984	9	1		
	1985	9	1		
Westland	1983	20	6		
	1984	15	1		
	1985	10	2		
Otago	1983	13	13		
	1984	4	8	5	3
	1985	8	2		

Effect of Survey Year

Mean disease severity for the 15 forests increased from 16% in 1983 to 31% in 1984 and 33% in 1985. Disease incidence remained constant at 18% in 1983 and 17% in 1984 and 1985. The difference in disease incidence by survey year was not significant, but changes in disease severity by survey year were significant at the 1% level (Table 6).

The degree of variation between assessors was low. Of the four variables tested – disease incidence and severity, in 1984 and 1985 – mean differences between assessors were not more than 3% (full details are available from the author).

TABLE 6—Analysis of variance on disease severity for the 15 surveyed forests by survey year (two values are missing as Whakarewarewa and Otago Coast were not surveyed in 1983)

Source	df	MS	F-value	CV	Severity mean
Model	16	380.95	4.36*	34.29	27.27
Error	26	87.42			
Corrected total	42				
Forest	14	4.04*			
Year	2	6.57*			

* Significant at the 1% level

Calculated Growth Loss

Growth loss may differ substantially from year to year. However, an evaluation of loss of yield based on data over three successive seasons should be useful. Disease severity data were used to calculate the volume loss by age-class of the 15 forests surveyed. Percentage volume reduction was estimated using the formula:

$$V = \frac{426D}{537}$$

where V = volume loss (%) and D = disease severity. This formula was derived from the regression of Fig. 3 in the report by van der Pas, Slater-Hayes, Gadgil, & Bulman (1984). Total area of the 15 forests for each age-class from 1983 to 1985 was calculated using Program SAREA from the NZFS Stand Record System (Shirley 1983.) Annual volume loss for each age-class was calculated by multiplying the area occupied by diseased trees (calculated from Table 4) by the periodic annual increment (PAI), which gave the expected volume increment, and volume loss factors derived from the formula above. A nation-wide estimate of PAI for each age-class was obtained from J. W. Shirley. Areas for each age-class and estimates of volume loss, potential volume, and percentage loss are given in Table 7. Whilst the accuracy of the assumptions of PAI and volume loss is open to conjecture, the calculation of percentage loss for each age-class is dependent on disease assessment accuracy and the validity of the volume loss equation only. The PAI and area data are constants, which do not affect the final percentage loss figure. The mean difference between assessors was of the order of 3%, with the coefficient of variation about 5%. The volume loss formula was derived from a regression line with a coefficient of determination of 0.54.

TABLE 7—Volume loss from the forests surveyed from 1983 to 1985

Age-class	Year	Area* (ha)	PAI (m^3)	Vol. loss (m^3)	Pot. vol.† (m^3)	Loss (%)
1–5	1983	49 900	1	200	49 900	0.4
	1984	49 200	1	700	49 200	1.4
	1985	47 200	1	300	47 200	0.6
6–10	1983	52 600	5	7 500	263 000	2.9
	1984	57 100	5	15 800	285 600	5.5
	1985	55 400	5	16 800	276 800	6.1
11–20	1983	50 400	21	45 900	1 057 600	4.3
	1984	62 300	21	70 600	1 309 100	5.4
	1985	70 000	21	94 600	1 470 000	6.4
21–25	1983	9 500	34	7 000	322 660	2.2
	1984	11 700	34	8 300	397 800	2.1
	1985	14 400	34	16 700	489 600	3.4
>25	1983	20 000	32	1 300	639 400	0.2
	1984	18 700	32	1 100	597 100	0.2
	1985	18 300	32	7 700	585 300	1.3

* Total net stocked area of the 15 forests surveyed
† Potential annual volume increment if disease was at trace levels

The percentage loss figures are gross approximations, and cannot be extrapolated to the total *P. radiata* estate, but indicate that the volume loss in the 15 forests surveyed would have been of the order of 5% per annum over the 3 years for the age-classes 6–20 years. More stands will fall into the problem age-classes in the future as a result of the expanded planting programmes of the late 1970s.

DISCUSSION

Cyclaneusma needle-cast was most severe in stands aged 11–20 years. This confirms the findings of van der Pas, Bulman, & Slater-Hayes (1984). Disease severity increased from 1983 to 1984, and again in 1985, but there was no significant difference in disease incidence by survey year. Van der Pas, Slater-Hayes, Gadgil, & Bulman (1984) found annual severity levels of healthy and infected trees were highly correlated for up to 4 years' duration. This suggests that the proportion of trees affected by the disease within a given stand remains relatively constant from year to year, but the degree of infection of those susceptible trees may change significantly with time.

It is expected that stands within the age-classes 11–20 years, and to a lesser extent 6–10 years, will be most severely infected from year to year. Disease incidence was highest in the >25-year age-class, but was of little significance because disease severity in these stands was consistently low.

These data show that Cyclaneusma needle-cast is a damaging disease in some pine plantations. The East Cape forests were severely infected for three consecutive seasons, and severe outbreaks were recorded in Otago, Northland, and the central North Island.

Chemical control of these outbreaks seems too expensive on an operational basis (Vanner 1986). The best longer-term solutions are probably the selection and breeding

of disease-tolerant strains, and making disease rating one of the criteria when selecting final-crop trees during thinning to waste. The data also suggest the disease may not be such a problem in Nelson, Hawke's Bay and Westland. In those places planting of trees bred for genetic resistance to the disease may not be necessary.

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