PREDICTING RESIN POCKETS IN RADIATA PINE LOGS FROM BLEMISHES ON LOG ENDS

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ABSTRACT

More than 120 radiata pine (*Pinus radiata* D. Don) sawlogs, from two sites, were assessed for resin pockets and blemishes (resin streaks, bark pockets, colored marks, and other grain deviations) on the log ends. At both sites, the assessment of blemishes on the log ends improved the prediction of resin pockets on the lumber after sawing (r^2 = 0.29 and 0.49), beyond the prediction achieved by assessing resin pockets on the log ends alone (r^2 = 0 and 0.24). Noting only the presence or absence of blemishes on the log ends enabled explanation of half the variation between logs in loss of clear cuttings due to docking out resin pockets from the lumber (r^2 = 0.50, P < 0.001). Since the log ends were assessed after ordinary chainsaw cuts were made, we believe that blemishes could be recognized by log graders, and that it should be possible to develop selection procedures for sawlogs that minimize the value losses associated with resin pockets.

Keywords: Blemishes, log grading, log segregation, *Pinus radiata*, pitch pockets, resin pockets, wood quality.

INTRODUCTION

Resin pockets are naturally occurring characteristics in softwoods that can cause significant losses to appearance grade products when they occur frequently. For example, it is reported that some European customers purchasing lumber to be used for high-quality joinery avoid *Picea abies* due to the frequent occurrence of resin pockets (Peterson 1991, cited in Temnerud 1997). The occurrence of resin pockets in New Zealand grown radiata pine (*Pinus radiata* D. Don) has been documented by Cown (1973). In New Zealand, resin pockets usually have a low frequency of occurrence (i.e., <0.50 resin pockets per m² of sawn lumber surface); however, they are occasionally more abundant. An extreme example was the 18% reduction in log value reported for one radiata pine shelterbelt (Tombleson and Inglis 1988).

In New Zealand, there has been widespread application of pruning in the radiata pine plantations since the 1960s, with some companies pruning to a height of 9 m. The expectation is to manufacture long-length clearwood products such as moldings, joinery, furniture components, and veneers. New Zealand's pruned log harvests are forecast to increase fourfold (to 4.5 million m³) over the next decade (New Zealand Ministry of Forestry 1996). In addi-

tion to this, there is an expanding remanufacturing sector based on clearwood recovered from lower grade knotty lumber.

To minimize the losses associated with resin pockets, it is desirable to have an assessment methodology allowing logs to be graded for resin pocket incidence. In doing so, logs with a high incidence of resin pockets could be directed away from processing plants producing appearance products. Alternatively, sawmills producing a mixture of appearance and structural products could select sawing patterns to produce structural product sizes from logs with resin pockets. It is also conceivable that methodology for grading logs for resin pockets could be used by companies that sell logs, to eliminate logs with high resin pocket incidence. Such special log-grading procedures might be used to differentiate a log supplier in the market place.

In addition to this, a method of assessing resin pockets on logs would enable forest owners to develop a database of resin pocket incidence in their forest estate. The factors contributing to resin pocket formation are far from completely understood (Temnerud 1996a, b). A variety of contributing factors have been described, the most common two being flexing of the stem due to wind forces (Schumacher et al. 1997; Frey-Wyssling 1938, 1924; Clifton 1969) and drought stresses (Cown 1973). A database of resin pocket occurrence at the level of a company's forest estate would provide additional wood quality information valuable for long-term log supply forecasting and short-term production planning. Forestry companies already avoid pruning in some areas with high susceptibility to resin pocket formation, but this could be greatly refined (McConchie and Ridoutt 1997; Wiltshire 1997). Finally, a database of resin pocket incidence could be used to help understand the complex interactions between resin pockets and site factors, silvicultural practices, and genetics.

Existing log grades in New Zealand are based primarily on small-end diameter, length, sweep, and maximum branch size. Some grades also limit the distance of the pith from the log's geometric center and one local company is now excluding logs with any resin pockets on log ends from allocation to veneer production. The objective of this project was to develop statistical relationships between features that can be observed on log ends and the occurrence of resin pockets in lumber after sawing. The overall aim is to improve visual grading of radiata pine logs.

MATERIALS AND METHODS

Forest sites and log selection

The experimental work was completed in two stages. In stage one, 95 logs, each 4.9 m in length, were taken from the 23-yr-old Puruki experimental forest (Beets and Brownlie 1987) in the central North Island of New Zealand, approximately 30 km south of Rotorua. The logs came from the butt, second, and third log positions of radiata pine trees grown under a variety of silvicultural regimes, with stand densities ranging from 60 to 750 stems ha^{-1} prior to harvest. (McConchie 1997). As a group, the logs were highly variable, with small-end diameters ranging from 21.0 to 58.2 cm, log densities ranging from 283 to 431 kg m^{-3}, and juvenile wood contents ranging from 19 to 75% based on the first 10 annual rings from the pith (Cown 1992).

In stage two, 27 pruned butt logs were taken from a privately owned farm-forest at Winirana, on the east coast of the North Island, near the settlement of Napier. These logs had small-end diameters ranging from 31.0 to 66.7 cm and lengths ranging from 4.6 to 5.5 m. They were deemed typical of commercial pruned logs grown in this region.

Log assessment

In all cases, log ends were assessed after normal chainsaw cutting, i.e., there was no special surface preparation. We therefore believe that the observations made in this study are capable of being repeated operationally by log graders with appropriate training and exercising necessary care. For each log from the
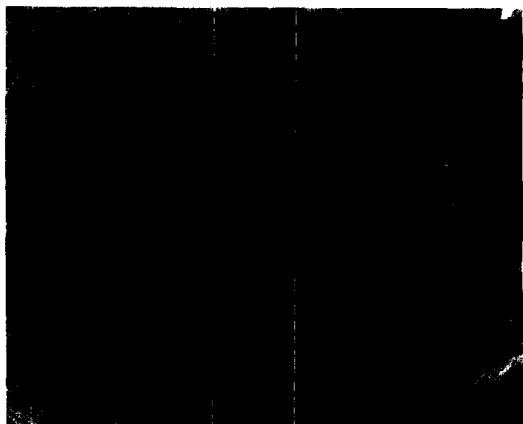
FIG. 1. Blemishes were visible on the ends of logs without any special preparation. Shown is a typical clean log end. Blemishes are marked with arrows.

Puruki forest, the number of resin pockets was counted on the large and small end of each log. Also noted was the presence or absence of blemishes (resin streaks, bark pockets, colored marks, and other grain deviations not associated with knots; Ridoutt et al. 1998). An example of blemishes is illustrated in Fig. 1. For logs from the Winirana forest, resin pockets and blemishes were both counted on each log end.

Sawn lumber assessment

The Puruki logs were sawn to maximize the recovery of 100- × 50-mm lumber that was kiln-dried, gauged to 90 × 45 mm, and visually graded. For each board, the total number

of resin pockets on all faces was recorded as well as the presence or absence of blemishes (Fig. 2). In addition, the loss of clear cuttings due to resin pockets was measured to the nearest cm (compared with nominal docking for knots alone). The minimum length of cuttings permitted was 300 mm.

The Winirana logs were grade sawn to produce random width boards of 25- and 40-mm thickness. Each board was given a score of 0 to 3 based on visual inspection. A score of 0 applied to boards with no resin pockets, 1 referred to light resin pockets with clears recoverable, 2 referred to boards with resin pockets dispersed throughout and severely limiting the recovery of clears, and 3 referred to serious resin pocket occurrence with virtually a total loss of clears. For each log, a log factor was derived that was the sum of scores for all boards from that log (without volume weighting) divided by the total number of boards. Despite lacking some quantitative rigor, this log factor is considered to be a simple and practical measure of the loss of recoverable clearwood from a log due to resin pockets.

Statistical analyses

Linear regression analyses were performed using the software S-plus version 3.4 (MathSoft 1995). Logarithmic transformation was used to correct for non-normality in the data.
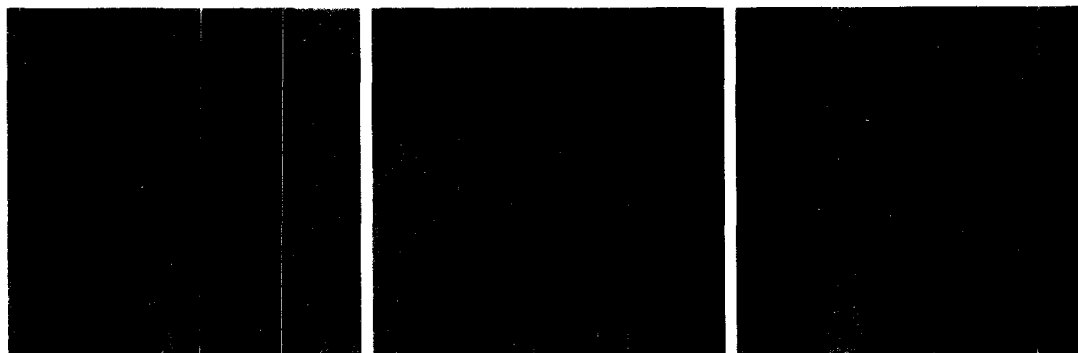

FIG. 2. Examples of blemishes on radiata pine lumber. Scale approximately 1:1.

TABLE 1. *Resin pockets on log ends and on lumber from 23-yr-old radiata pine grown at Puruki. Mean values are per log and piece of lumber, respectively.*

		Log ends					Lumber	
	n	Small end	Large end	Both ends	Mean	n	Mean	Range
Butt logs	33	3	5	2	0.24	736	0.39	0–7
2nd logs	32	1	3	1	0.13	575	0.54	0–14
3rd logs	30	2	1	1	0.09	407	0.59	0–10
All logs	95	6	9	4	0.16	1,718	0.49	0–14

RESULTS AND DISCUSSION

Predicting resin pockets in the logs from Puruki

As expected, resin pockets occurred quite infrequently on the log ends. Only 11 of the 95 Puruki logs had resin pockets visible and only 4 of these logs had resin pockets on both log ends (Table 1). The mean number of visible resin pockets per log was 0.16. Although resin pockets were individually recorded for the small and large ends of the butt, second, and third logs, the low incidence of resin pockets on the log ends meant that it was difficult to make comparisons between log height classes (Table 1). In contrast, the mean number of resin pockets on the 1,718 pieces of 100- X 50-mm X 4.8-m lumber was 0.49, and individual boards had from 0 to 14 resin pockets each (Table 1). The average number of resin pockets per board was lower for the butt logs (0.39) than for the second and third logs (0.54 and 0.59, respectively). This is consistent with the within-tree pattern of resin pocket distribution found by Clifton and reported in McConchie and Ridoutt (1997), whereby

resin pockets were found to occur less frequently in the butt log (volume weighted basis) than in the second log.

Blemishes (Figs. 1 and 2) were found to occur far more frequently than resin pockets on both the log ends and the lumber (Table 2). Thirty-three of the Puruki logs had blemishes visible on the ends and of these, 11 had blemishes present on both ends. Almost 60% of the lumber had at least one blemish (Table 2). For blemishes, there was no obvious trend with log height class; however, one possible reason for this is that the number of blemishes was not counted on each piece of lumber; only the presence or absence was recorded.

Best predictive models for resin pockets on lumber using log-end characteristics are shown in Table 3. For the large Puruki data set (95 logs and 1,718 pieces of lumber), we found no statistical relationship between resin pockets on log ends and their occurrence on the lumber ($P = 0.6$). It would appear that the probability of intersecting a resin pocket at a log end is simply too low. Blemishes, however, appear far more often on log ends than

TABLE 2. *Blemishes on log ends and on lumber from 23-yr-old radiata pine grown at Puruki. +, — refer to presence, absence.*

		Log ends				Lumber		
	n	Small end	Large end	Both ends	Nil	n	+	—
Butt logs	33	6	14	4	17	736	446	290
2nd logs	32	6	5	3	24	575	316	259
3rd logs	30	6	6	4	22	406	257	149
All logs	95	18	25	11	63	1,717	1,019	698

TABLE 3. *Best predictive models for lumber characteristics using log-end features. Ninety-five logs were taken from a 23-yr-old radiata pine stand at Puruki and sawn to 100 X 50 mm lumber.*

Lumber	Log ends	r^2	P
Blemishes	Blemishes	0.13	0.01
Resin pockets	Resin pockets	—	0.6
	Blemishes	0.29	0.01
	Blemishes and resin pockets	0.29	0.37*

* P-value for addiational factor "Resin pockets."

TABLE 4. *Resin pockets and blemishes on log ends and on lumber from 22-yr-old radiata pine grown at Winirana. Log factor is a semi-quantitative rating system for the occurrence of resin pockets within logs based on assessments of random-width boards during sawing (see text for details).*

	Log ends			Log factor	
	n	Mean	Range	Mean	Range
Resin pockets	27	0.96	0–5	0.47	0.04–1.38
Blemishes	27	1.62	0–13		

resin pockets, and a highly significant relationship was found between blemishes on log ends and resin pockets on lumber ($r^2 = 0.29$, $P < 0.01$). With a two-factor model, where both resin pockets and blemishes on log ends were used to predict resin pockets on lumber, the predictive capability was not improved above the single-factor model using blemishes alone (Table 3).

Predicting resin pockets in the logs from Winirana

For the second stage of this study, logs were taken from a forest growing at Winirana, some 250 km from the Puruki site. We wanted to test whether the relationship found at Puruki between blemishes on log ends and resin pockets on lumber also existed at a completely different site. Unlike the log-end assessment method used at Puruki, where blemishes were noted only as present or absent, at Winirana the number of blemishes on each log end was counted. The Winirana logs also differed from those at Puruki by having a higher incidence of resin pockets on log ends (mean of 0.96 compared with 0.24 for the butt logs at Puruki). However, in similarity with Puruki, blemishes occurred more often on log ends at Winirana than did resin pockets (means of 1.62 and 0.96, respectively, Table 4).

At Winirana, resin pockets on the log ends explained 24% ($P < 0.01$) of the variation in log factor, the semi-quantitative log rating system for the occurrence of resin pockets on random width sawn boards. Blemishes on the log ends explained a similar level of the variation
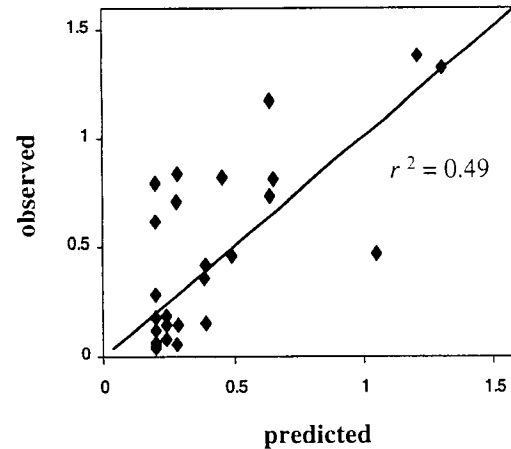

FIG. 3. Predicting resin pockets on lumber using resin pockets and blemishes observed on log ends. The logs were all pruned butt logs taken from a 22-yr-old radiata pine forest at Winirana.

in log factor ($r^2 = 0.20$, $P < 0.01$). However, a two-factor model, using resin pockets and blemishes on log ends, enabled almost half the variation in log factor to be explained ($r^2 = 0.49$, $P < 0.01$, Fig. 3).

The results at Winirana therefore confirm that blemishes on log ends help to predict resin pockets on lumber sawn from radiata pine logs. The greater predictive ability found at Winirana is also consistent with logs from this site having a higher incidence of resin pockets. The higher the incidence of resin pockets in a batch of logs, the higher is the probability that resin pockets and blemishes will be intersected by the log ends. This reduces the proportion of log ends without any resin pockets or blemishes, thereby improving the value of the log-end features for predicting lumber quality.

The consistency of results obtained for both the Puruki and Winirana sites is also significant considering the variety of theories concerning resin pocket formation. The most likely explanation for why blemishes help to predict resin pockets is that they likely share a similar origin. Although there are many theories about resin pocket formation (Temnerud 1997), all must originate through injury or disturbance to the cambial region and this is like-

ly true of most blemishes also. In fact, we have observed small features on the face of lumber that are difficult to characterize and can only be described as blemishes. However, ripping of the lumber has revealed that they were actually ends or edges of resin pockets. In other cases, ripping of the lumber has shown that some blemishes are not resin pockets, being instead tiny bark pockets, resinous wood, or other colored marks and grain deviations not associated with knots. Features of this kind were also described in Norway spruce by Temnerud (1997, Introduction Figs. 3, 8, and 10), and he also noted the difficulty in always differentiating these from resin pockets. In Norway spruce, these features were also related in occurrence to larger resin pockets and were found to contain similar traumatic tissue when examined microscopically (Temnerud 1997). This is further evidence that blemishes and resin pockets can be of similar origin.

Predicting loss of clear cuttings

While statistical relationships show the potential for resin pockets and blemishes on logs ends to be used to predict lumber quality with respect to resin pockets, these relationships alone do not provide a useful log-grading methodology. We recognize that any log-grading system for resin pockets needs to take into consideration the log resource available, the alternative products being manufactured, and the value losses associated with resin pockets. In going part way toward an industrial example, we found that for the Puruki logs, blemishes on log ends explained 50% of the variation between logs in the loss of clear cuttings due to resin pockets ($r^2 = 0.50$, $P < 0.001$). When logs had no blemishes on the ends, 2% of the cuttings obtained by docking out knots were lost due to resin pockets (minimum allowable length 300 mm). For logs with one or more blemishes on one end only, the average loss was 4%, and this increased to 17% when both log ends were affected by blemishes (Table 5). In contrast, there was no relationship

TABLE 5. *Percentage of clear cuttings lost due to resin pockets in lumber sawn from radiata pine logs with blemishes on the log ends.*

	Mean (%)	SE (%)
No blemishes on log ends	2	3
Blemishes on one log end	4	6
Blemishes on both log ends	17	9

between resin pockets on log ends and the loss of clear cuttings due to resin pockets ($r^2 = 0.005$, $P = 0.51$).

CONCLUSIONS

The assessment and sawing of more than 120 logs from 2 widely separated sites have shown that resin pockets on log ends are of limited value in predicting the incidence of resin pockets on lumber: the incidence of resin pockets on the log ends is simply too low. Blemishes, however, occur more frequently on the log ends than resin pockets and it was found that they help to predict resin pockets in radiata pine logs. Noting the presence or absence of blemishes on the ends of logs, it was possible to explain half the variation between logs in loss of clear cuttings due to resin pockets. Blemishes have never been recognized in log-grading rules in New Zealand, or to our knowledge elsewhere. Nevertheless, we have found that many local sawmillers routinely use the term "blemish" to describe the variety of small marks occurring on radiata pine lumber that cannot be described as resin pockets. In this study, the log-end assessments were done using regular chainsaw cuts, so we believe that the blemish features could be identified by log graders who had appropriate training and who exercised necessary care. In doing so, it should be possible to develop selection procedures for sawlogs that minimize the value losses associated with resin pockets.

ACKNOWLEDGMENTS

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