

# RESIN POCKETS IN CANTERBURY RADIATA PINE

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## SYNOPSIS

*Resin pockets are more abundant in radiata pine on the Canterbury Plains than anywhere else in New Zealand.*

*The defect and the various stages in its development are described.*

*The effect of resin pockets on grade returns at Ashley Forest is examined and the conclusion is reached that second log pruning in this forest is not justified. It has now been discontinued.*

*Pruning on the Plains and on exposed downland slopes can only be justified for reasons other than the production of clean timber.*

*Possible causes of resin pocket formation are discussed. It is concluded that they are initiated when the cambium is ruptured during severe wind sway. This is in line with European findings.*

## INTRODUCTION

It has been known for some time that resin pockets are widespread in *Pinus radiata* D. Don from certain parts of the Canterbury Plains. It can now be stated with some confidence that they are more abundant in this area than anywhere else in New Zealand. This conclusion is based on results of inquiries made in Auckland, Nelson and Southland Conservancies, and on the writer's own observations in Nelson Conservancy (including a site near Murchison), the Tapanui district of Southland, in Westland (Mahinapua Forest), Manawatu, and the Central North Island — Bay of Plenty area.

As an indication of the level of incidence which may be encountered in Canterbury, a 17-year-old open-grown tree at Ashley Forest was found to contain over 400 resin pockets — 10 for every foot of tree height. Also, 107 pockets were counted in one 8 ft 6 in. length of 4 in. × 2 in. framing picked up in a Christchurch factory.

This situation has implications for forest management. Although half of the Conservancy's 100,000 acres of exotics is today on the plains, a higher proportion will in future be established on the foothills (Thomson, 1963).

Along with this shift of emphasis follows the hope of producing more clean timber through silvicultural treatment of stands on the better Down-land soils than would have been practicable on the plains.

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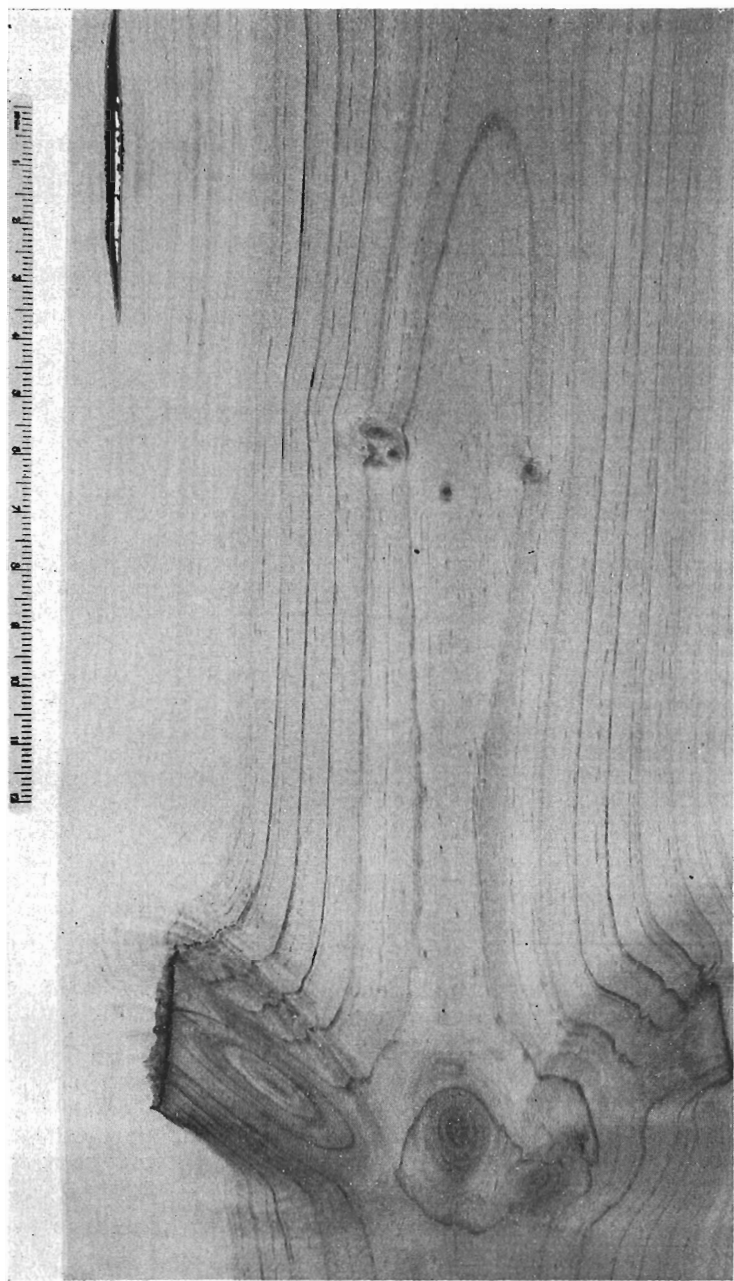


FIG. 1: Resin pocket in pruned zone of *radiata* pine, Ashley Forest.

Ashley Forest is one of the recently established foothills forests for which such high hopes have been held. The discovery of significant numbers of resin pockets in the "clear-wood" zone of pruned trees at Ashley (see Fig. 1) has necessitated a reappraisal of the position.

The implications are also serious as regards implementation of the forestry encouragement loan scheme in Canterbury. Under this scheme farmers and local bodies are being encouraged to treat their stands silviculturally, with the object of producing high-quality sawlogs and/or peelers for veneer manufacture.

Stands of radiata pine grown on the plains are producing high-quality framing timber without intensive silvicultural treatment. Knots are small because of the slow growth rate on these sites. Pith, and the zone of troublesome low density wood associated with it, is small for the same reason. Resin pockets are common in most of these stands. In framing, however, they are of no account as they have no significant effect on strength.

With regard to board grades, Canterbury's requirements for defect-free material have been traditionally supplied in rimu from Westland. This situation will hold for some time. It is hoped that imports of clean timber will eventually be supplemented by locally grown radiata pine from tended stands.

## THE DEFECT

The defect in question is a lens-shaped opening in the wood, measuring typically  $1\frac{1}{2}$  to 2 in. in length (*i.e.*, vertically),  $\frac{3}{4}$  to 1 in. in the tangential direction and  $\frac{1}{8}$  to  $3/16$  in. deep radially. The inner border is parallel to the annual growth rings. The same type of resin pocket has been reported from Europe as occurring in various species of *Pinus*, in larch, and in spruce (Frey-Wyssling, 1942; de Carvalho, 1957).

## METHOD

### (1) Ashley Forest Grade Study

To test the effect of resin pockets on grade recovery and on the economics of pruning, an investigation was carried out on a sample of logs from Ashley.

The oldest planted stands of radiata pine in the forest are as yet too young to provide logs larger than 14 to 15 in. d.b.h. However, self-sown trees of expected final crop size were available. The bottom two 16 ft logs of twenty such trees (mean d.b.h. 21 in.) were sawn to one inch boards. These were graded according to N.Z.S.S. 169, 1962, except that the following additions and modifications were made:

- (a) Three grades were added, namely: clears, clear one face one edge, and box.
- (b) Factory grade was taken out on the basis of 75% of the length in clear cuttings of 2 ft or longer in lieu of 50% of the length.

- (c) Resin pockets up to  $\frac{1}{4}$  in. in width were allowed in merchantable grade, in lieu of  $\frac{1}{8}$  in.

The effect of pruning was deduced from discs 9 in. in diameter painted on the ends of each log to simulate knotty core zones.

Each board was graded four times — *i.e.*, according to whether the log had been pruned or unpruned and according to whether resin pockets were present (the actual condition) or absent.

Realizations based on the Canterbury Sawmillers' Association wholesale price list as at January, 1967 were equated with costs of pruning compounded (at 5%) to rotation age of 40 years.

The location of every resin pocket revealed in sawing was recorded on board diagrams. From these data a picture was built up of the distribution of the defect with height up to 32 ft and with aspect.

## *(2) Effect of Topography*

To test the effects of degree of exposure and topography on incidence of resin pockets, 57 trees from a 27-year-old planted stand at Ashley were examined. Samples comprising 18, 20 and 19 trees were taken from a ridge top, mid-slope, and valley bottom, respectively.

The bottom 16 ft log was sawn to one inch boards and the number of resin pockets per 100 bd. ft was recorded.

## *(3) Sampling at Sawmills*

Although sawn timber from mills throughout Canterbury had earlier been sampled by Parrott, a second series involving a larger sample was begun. It was hoped by these surveys to build up a picture of the incidence of resin pockets on a conservancy-wide basis. No timber was sampled unless it could be positively identified with a growing site. The number of resin pockets per 100 bd. ft in a sample of 1,000 bd. ft was recorded.

This approach was abandoned after the sampling of 28 growing sites.

Because of various practical difficulties, it was decided to concentrate instead on investigation of possible causes of resin pocket formation. The intensive examination of individual trees as described below was a feature of this approach.

## *(4) Dissection of Individual Trees*

Two trees at Ashley, one open grown and one from a planted stand, were cross cut at intervals of approximately one inch. In this way information was obtained concerning dimensions of the defect, its location in the annual ring, and its distribution within the tree.

An attempt was also made to correlate year of occurrence with local meteorological records. Results were inconclusive, owing mainly to lack of adequate wind records.

Of particular interest was the dissection in the above manner of a 40-year-old tree which had been windthrown at Balmoral Forest 22 years previously. The tree had continued to grow while in the horizontal position, two branches having turned upwards as phototropic shoots.

## RESULTS

### (1) *The Ashley Grade Study*

It was found from statistical analysis of the incidence of resin pockets in this sample and that from the mid-slopes of the planted stand that aspect has a significant effect on their incidence at Ashley. (There are significantly more pockets on northern slopes than on southern slopes.) The grade study sample was therefore sub-divided.

The effects of resin pockets on the economics of pruning are summarized in Table 1.

TABLE 1: RETURNS AT ROTATION AGE 40 YEARS (PER ACRE)

| Operation         | With resin pockets        |                            | Without resin pockets     |                            |
|-------------------|---------------------------|----------------------------|---------------------------|----------------------------|
|                   | North aspect<br>(8 trees) | South aspect<br>(12 trees) | North aspect<br>(8 trees) | South aspect<br>(12 trees) |
| Pruned<br>0-16 ft | — \$21.00                 | + \$45.00                  | + \$103.00                | + \$97.00                  |
| Pruned<br>0-32 ft | — \$164.80                | — \$5.20                   | — \$14.80                 | + \$108.20                 |

Within the scope of the sample it will be noted that in no case can second log pruning be justified. According to this model, moreover, the economics of pruning the bottom log up to 16 ft on northern slopes is open to question. In the absence of evidence to the contrary, it is assumed that the situation as shown by this model applies to similar sites in the forest.

It can be accepted that the incidence of resin pockets in final crop trees in planted stands on exposed ridge-tops and northern slopes at Ashley is unlikely to be less than that found in the northern aspect trees under consideration. The mean incidence for these eight trees was 52 resin pockets per 100 bd. ft. The corresponding figure for the ten trees of the mid-slope sample which came from a northern aspect in the planted stand was 146 resin pockets per 100 bd. ft.

It was partly due to the results of this study that second log pruning was recently stopped at Ashley.

### (2) *Effect of Topography*

The incidence of resin pockets in the ridge-top, mid-slope, and valley bottom samples was found to be 82, 102, and 23 per 100 bd. ft, respectively.

The "t" test showed that the difference between the valley bottom sample and the other two was significant at the 1% level in each case. There was no significant difference between the ridge-top and mid-slope samples.

### (3) *Distribution in Canterbury*

It has long been widely recognized in the trade that the stands of radiata pine growing on the coastal sand immediately north of Christchurch (Bottle Lake) are virtually free from the defect.

Examination of the second series of sawmill samples (28 sites) along with those obtained earlier by Parrott (66 samples) yielded nothing to seriously challenge the view that resin pockets are more prevalent on the Plains than near the coast.

### (4) *Stages in Development of the Defect*

Useful information on this aspect was obtained from the dissection of individual trees. It is possible now to give a fairly complete account of the formation and development of the defect.

The pockets originate as tangential ruptures of the cambium. They have been found in the early stages of formation. Once formed, they do not increase in size.

Initially they have "clean" borders — *i.e.*, no callus or nodules visible to the naked eye — and are filled with free resin. In most cases they appear to remain in this stage of development for at least two years. In due course a thin brownish zone of callus material appears on both inner and outer borders of the pocket. Small nodules are also apparent to the naked eye at this stage, initially on the inner surface of the pocket only, but subsequently on the outer surface as well. The callus may become darker, outlining the pocket more clearly, but most of the activity within the cavity appears to be confined henceforth to the nodules. These may increase in size until they almost fill the cavity. The very small pockets within a few inches of the pith in older wood are commonly completely filled with a bark-like or corky callus material within which, however, small nodules are frequently distinguishable. There may or may not be a trace of free resin in these pockets. They constitute a blemish rather than a defect in terms of grading rules for sawn timber (N.Z. Standards Institute, 1962).

As far as the very great majority of pockets is concerned, however, the position is more serious. Even if the nodules in these pockets increase in size until they more or less fill the cavity, the pockets are defects (which exclude affected boards from finishing lines) because (a) the nodules themselves are soft and friable in composition and (b) they remain saturated by, and the interstices between them remain filled with, free resin. On rare occasions an "average" sized pocket may contain a small amount of solidified resin.

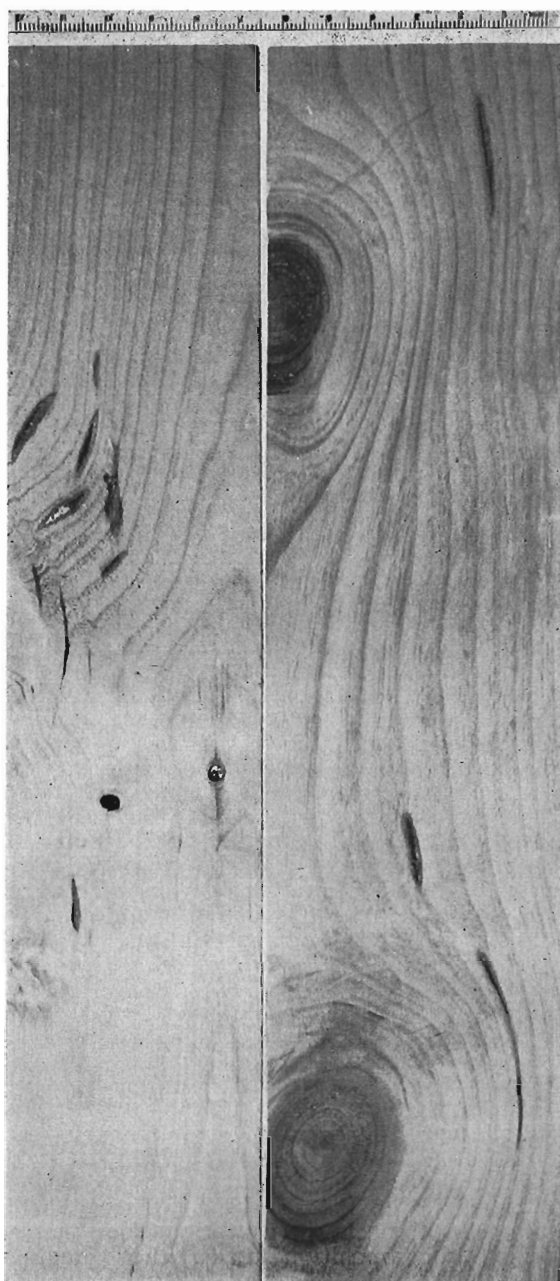


FIG. 2: *Resin pockets in the vicinity of branches.*

## (5) *Distribution within the Tree*

Data collected in conjunction with the Ashley grade study (*i.e.*, to a height of 32 ft, equivalent to one-third of tree height) showed that the number of resin pockets increased up to the 22 to 24 ft level, after which it remained comparatively constant. There was a 50% increase in the number of pockets in the second log compared with the bottom log.

Dissection of individual trees showed that the incidence of the defect begins to fall off at approximately half tree height.

The radial distribution of resin pockets in 14 of the worst affected logs from the grade study sample was examined. It was found that there was an increase in number with distance from the pith, followed by a decrease. Highest incidence was around the 6 in. diameter level.

As regards tangential distribution, the defects appear to be more or less evenly distributed on all sides of the tree. This is in line with Frey-Wyssling's observations in Europe (1942).

Resin pockets are occasionally found associated with large branches — *e.g.*, in trees from outer rows of shelterbelts (Fig. 2).

## CAUSES OF RESIN POCKET FORMATION

### (1) *Initiation*

It can be accepted that resin pockets originate as tangential ruptures in the cambium or in the partly differentiated tissue adjacent to it. Resin flows into the cavity from horizontal resin canals and causes it to open radially.

The meristematic function of the cambium is not greatly affected by the split, as the laying down of normal wood proceeds without interruption outside the newly-formed resin pocket. It has been demonstrated that it is some component of the resin within the pocket which stimulates division of ray parenchyma cells around its borders (Frey-Wyssling, 1938).

What causes the cambium to split? In Europe, wind is accepted as the main cause. The swaying of the tree in strong wind is believed to induce sufficient shear stress in the cambium to cause tearing of the cells in a tangential direction (Frey-Wyssling, 1942).

### (2) *"Abnormal" Resin Pockets*

As far as Canterbury is concerned, it is now known that there are a number of unrelated factors which can induce the formation of a small proportion of the resin pockets found. Pockets in this category are those associated with *Sirex* attack, fire injury and mechanical damage.

Resin pockets are so numerous and so widespread on the Canterbury Plains, however, that some more obvious, omnipresent feature or features of the environment must cause the overwhelming majority of the pockets. The two factors which immediately suggest themselves are wind and lack of readily available water — or some secondary effect of this.



### (3) *The Fohn Wind*

A feature of Canterbury's climate is the Fohn wind which sweeps the Plains from the north-west during the late spring and summer. It frequently reaches gale force. From time to time it has caused extensive damage to planted stands of radiata pine. The most disastrous of these windthrows occurred at Eyrewell Forest in March, 1964, when some 7,000 acres of mature radiata pine were completely flattened and a further 5,000 acres damaged.

In many cases this nor'-wester fails to reach the coast, as it is undercut there by a steady, moist, north-easterly breeze (Kidson, 1950). The former may build up out on the Plains and work back towards the foothills. It may reach such a velocity that it will drive back the north-easterly and penetrate, as a gale, to the coast. This is most likely to happen in the vicinity of the main river valleys, the Rakaia River area in particular (A. K. Brown\*, pers. comm.).

The Fohn wind occasionally produces relative humidities of 20 to 30% and lower.

### (4) *Precipitation*

Rainfall over the greater part of the Plains averages 25 to 35 in. per year. In summer and autumn evapotranspiration could exceed rainfall. Severe summer droughts have been recorded in Canterbury for the years 1907-8, 1916-7, 1925-6, 1931-2, 1932-3, 1934-5, 1943-4 and 1955-6. (A moderately severe drought was also recorded during the summer of 1964-5.)

### (5) *Soils*

Soils are mainly yellow-grey earths and associated stony soils of poor water-holding capacity. The Lismore series, which predominates, comprises silt loams, shallow silt loams, and some stony silt loams derived from greywacke gravels with a thin cover of loess. They are free-draining soils of low natural fertility.

### (6) *Modification of Resin Regime*

The environment of the plains is a harsh one. Apart from the buffeting by dry nor'-westers every summer, radiata pine has to contend with soils that are of low natural fertility and poor in water-holding properties. Rainfall is low. It would not be surprising if such an environment had the effect of modifying the normal physiology of the tree. In particular, the resin regime could be affected.

As the production of waste products by the tree is essentially a dehydration process, it seems conceivable that a tree growing in a very dry environment could produce an abnormally high percentage of such products — e.g., resin.†

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†A. B. Mount, Research Forester, Tasmanian Forestry Commission (pers. comm.).

There is some evidence to support this in Canterbury, namely:

- (a) Traumatic response to *Sirex* attack in radiata pine at Eyrewell Forest has been most spectacular. A complete ring of resin is often present. This has led to problems in the preservative treatment of round produce from this forest.
- (b) Tangential longitudinal sections from a seriously affected tree from Ashley and from a Bottle Lake tree growing on coastal sand (no resin pockets) were compared microscopically. The mean maximum diameter of horizontal resin canals in the former was found to be significantly larger than in the latter.
- (c) There are indications that the resin content of radiata pine in Balmoral Forest and in the Selwyn Plantation Board's stands is higher than that in the Bottle Lake plantations (Harris, 1965).

### THE EVIDENCE FOR WIND AS A CAUSE

This can be summarized as follows:

- (1) North-facing slopes in Ashley Forest produce significantly more resin pockets than southern slopes.
- (2) Stands on the Plains, exposed to the full force of gale force winds, produce more resin pockets than stands on the coast — where the prevailing wind is the north-easterly breeze.
- (3) The defect occurs mostly in the spring-summer period — *i.e.*, the nor'-wester season.
- (4) The distribution of the defect within the tree suggests a mechanically-induced rather than a physiological cause — *i.e.*, *Vertically*: it is predominant in an area representing zone of maximum wind sway (Chladek, 1965). *Radially*: incidence decreases once the tree reaches a size more able to resist wind sway.
- (5) Resin pockets are sometimes found associated with branches or with whorls of branches, suggesting, again, mechanically induced stresses.
- (6) Increase in size of the defect with diameter is consistent with increased momentum in larger trees, producing larger splits in the cambium during wind sway.
- (7) An open-grown tree at Ashley Forest, only 40 ft in height but fully exposed to gale force winds, was found to contain 400 resin pockets.
- (8) The windthrown Balmoral tree was found to contain "normal" resin pockets in the two vertical (phototropic) stems and in the vicinity of their junction with the horizontal stem. An "abnormal" type of pocket which could

be associated with mechanical damage was found along the underside of the horizontal stem.

- (9) Numerous resin pockets were found in firewood cut from a stand at the eastern end of Lake Coleridge. This was a very moist site — only a few feet above lake level. The trees showed by their form that they had been fully exposed throughout their life to nor'-westerly gales funnelled down the lake.
- (10) Timber from a 50-year-old shelterbelt near Woodstock Station homestead, Waimakariri Gorge, yielded 50 resin pockets per 100 bd. ft. That this is a good growing site from a soil point of view is shown by the fact that the trees measured 36 in. d.b.h. when felled. This is, however, an extremely windy site (a New Zealand Electricity Department anemometer in a comparable position in the Rakaia Gorge registered 79 days with gusts above 60 mph for the year ended September, 1967 (see Table 2)).

TABLE 2: WIND RECORDS

| <i>Station</i>                 | <i>No. of days with gusts<br/>of 40 mph and above</i> | <i>60 mph<br/>and above</i> |
|--------------------------------|---|-----------------------------|
| Tower 526                      | 136.0   | 79.0                        |
| Tower 176                      | 86.0  | 17.0                        |
| Wellington (1953-64)           | 146.3   | 30.3                        |
| Ohakea (1939-57)               | 75.4  | 6.3                         |
| Invercargill Airport (1942-57) | 90.5  | 9.6                         |
| Christchurch Airport (1942-64) | 54.6  | 3.1                         |

- (11) There is reason to believe that parts of inland Canterbury are subjected to more persistent and regularly recurring gale force winds during the growing season than any other part of the country in which stands of radiata pine of any extent have been established. In September, 1966, anemometers were set up by the New Zealand Electricity Department on two transmission towers near the Rakaia River. Tower No. 526 is situated five miles down-river from the Rakaia Gorge and tower 176, 18 miles down-river. Number of days with gusts of 40 mph and above and 60 mph and above, respectively, for the year ended September, 1967 are given in Table 2. Wellington (Kelburn), Ohakea and Invercargill Airport figures are included for comparison.

Although the transmission tower figures must be regarded as indicative only, the number of days with gusts 60 mph and over recorded at tower 176 may prove to be representative of conditions over most of the inland Plains area. It is this figure that is considered to be the more important as far as resin pocket formation is concerned.

The data for Christchurch Airport serve to illustrate how rapidly the effect of north-westerly gales falls off nearer the coast.

### CONCLUSIONS

- (1) Resin pockets are more numerous and more widespread on the Canterbury Plains than elsewhere in New Zealand.
- (2) They are initiated when the cambium is ruptured during severe wind sway.
- (3) Resin pockets are likely to have a serious effect on grade returns from tended stands in Canterbury where these are exposed to regularly recurring gale force winds. Because of this, pruning of radiata pine on the Plains and on exposed downland slopes can only be justified for reasons other than the production of clean timber.
- (4) Second log pruning at Ashley Forest is shown to be unjustified.

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