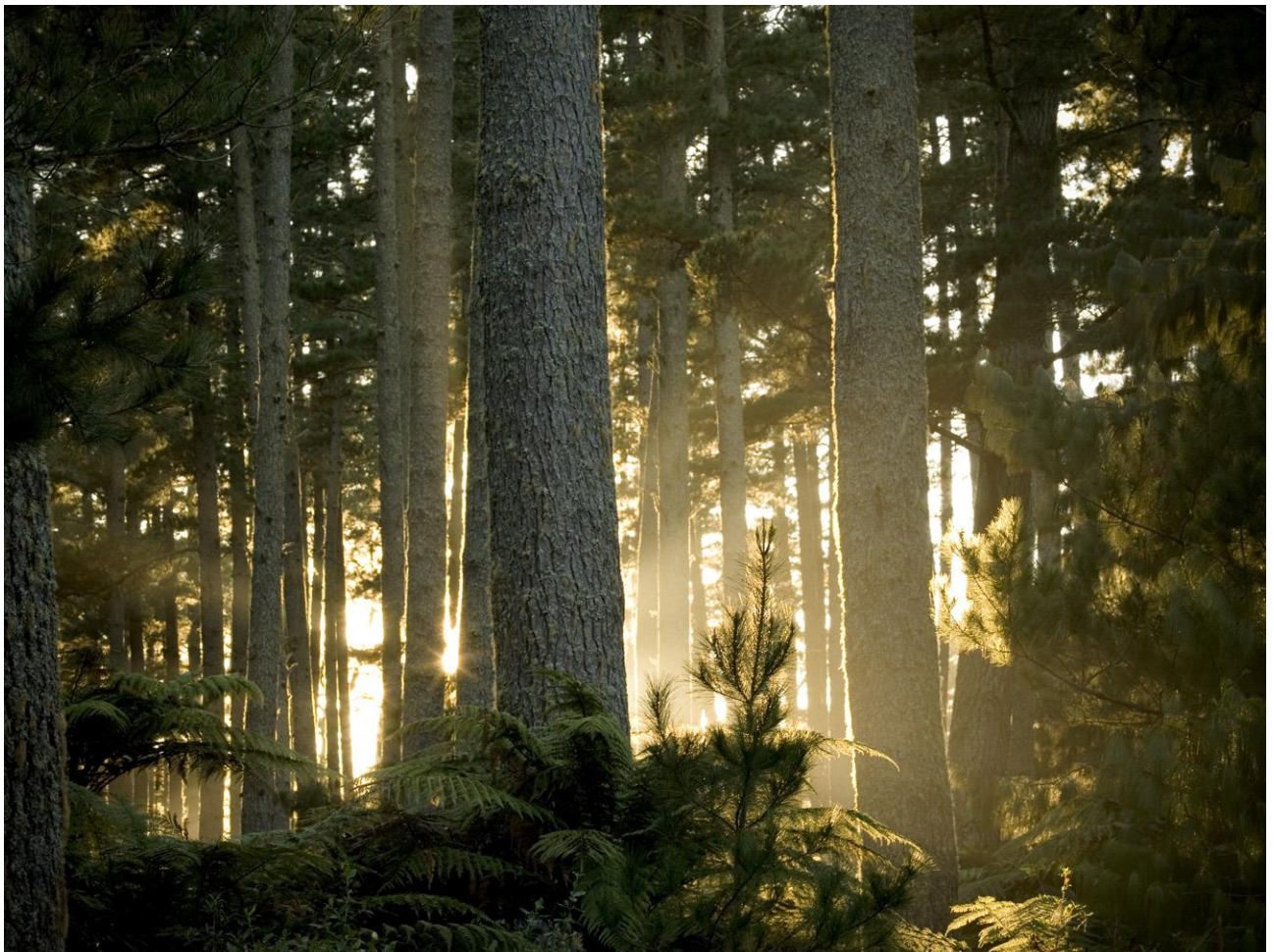


# The decay resistance of some wood species used as framing

## Final report on the condition of samples

Ian Simpson and Tripti Singh



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# Executive summary



Sets of framing samples were exposed in high humidity conditions of 85-90% relative humidity and 25 – 27°C. The species included in this test were:

- Untreated *Cupressus lusitanica*.
- Untreated Douglas fir.
- Untreated *Eucalyptus nitens* (installation was delayed by approximately six months).
- Untreated *Eucalyptus regnans*.
- H1.2 treated radiata pine.
- Untreated radiata pine.

All the samples were periodically sprayed with water at approximately two weekly intervals to maintain the wood moisture content at a level suitable for decay to progress. Before exposure in the high humidity condition, samples were also soaked in water for two hours.

The method of testing followed the procedure described in Australasian protocols, in this case for the Hazard class H1.2. This test method simulates the common framing joint in house framing between studs and plates, where in a leaky building, moisture may become trapped and provide suitable conditions for fungi to establish.

After twenty-four month's exposure (in high humidity condition and including regular spraying with water on the test samples);

- Active mycelium had developed on all of the samples of *Cupressus lusitanica*, Douglas fir and *Eucalyptus regnans*.
- Decay had developed in all of the *Cupressus lusitanica*, Douglas fir and *Eucalyptus regnans* samples, and samples in each group had failed due to decay.

After eighteen month's exposure (in high humidity condition and including regular spraying with water on the test samples);

- Decay had developed in all of the *Eucalyptus nitens* samples, and sixteen of the twenty samples had failed due to decay.
- Decay had developed in all of the untreated radiata pine samples, and six of the ten samples had failed due to decay.

This study shows that untreated *Eucalyptus nitens*, *E. regnans* and Douglas-fir are susceptible to decay and unlikely to meet a 50-year durability requirement for house framing where there is risk of prolonged exposure to moist conditions and high humidity. Further testing of these species including H1.2 boron treated timber is recommended.

Other durability testing, including stake test conducted at Scion showed *Cupressus lusitanica* and *Macrocarpa* (*Cupressus macrocarpa*) heartwood to be moderately durable and classified as class 3 (towards the upper end) of the Australasian natural durability classification system. (Page and Singh; 2014). The *Cupressus lusitanica* framing in this study, including heartwood, showed some susceptibility to decay in prolonged damp and humid conditions. It is recommended that further testing of *Cupressus lusitanica* and *C. macrocarpa*, including H1.2 treated timber, be conducted to determine whether *C. lusitanica* is less durable than *C. macrocarpa* and hence less suitable for use as framing in situations where wetting is likely.

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# Introduction

This trial was established to determine the decay resistance of four New Zealand grown species using an accelerated decay test developed by Scion (Hedley et al, 2009; Singh et al 2014) and described in the Australasian protocols for assessment of wood preservatives (Australasian Wood Preservation Committee; 2015). The species included in the test were *Cupressus lusitanica*, Douglas fir, *Eucalyptus nitens*, *Eucalyptus regnans*, and Boron treated radiata pine and untreated radiata pine were included as controls. This test method simulates the common framing joint in house framing between studs and nogs, where in a leaky building, moisture may become trapped and provide suitable conditions for fungi to establish.

## Materials and methods

### Preparation of samples

Timber species included in the trial and the source of the timber are listed in Table 1. Timber was selected to be either heartwood, sapwood or mixed heartwood/sapwood, by visual assessment. The wood colour and the presence of wane or pith was used to identify the type of wood. Preservative retention and penetration was not analysed for the H1.2 treated radiata pine.

**Table 1:** Summary of the groups of samples and types of wood (10 samples in each group)

Timber species	Source of timber	Size (mm)	Type of wood
<i>Cupressus lusitanica</i>	South Auckland sawmill, logs were between 25 and 34 years old from Tairua forest	95 x 50	Heartwood
			Heartwood\sapwood
Douglas fir	Stock held by Scion	90 x 40	Heartwood
			Heartwood\sapwood
<i>Eucalyptus nitens</i>	18 year old trees from a Southland forest	100 x 25	Heartwood
			Heartwood\sapwood
<i>Eucalyptus regnans</i>	30 year old trees from the King Country	105 x 50	Heartwood
			Heartwood\sapwood
H1.2 treated radiata pine	Rotorua retailer	90 x 45	Heartwood\sapwood
Untreated radiata pine	Retailer	90 x 45	Sapwood

Ten 900 mm long samples were cut for each group. A 100 mm long block was cut from both ends of the samples and both ends of the 100 mm blocks were end coated. The 100 mm blocks were then stapled across the ends of the 700 mm sample to form an “I” shape (Figure 1). The “I” shaped samples were soaked in a tank of water for two hours to raise the moisture content and to simulate rain wetting that may occur during building construction. Moisture meter measurements taken on the timber after water soaking were around 30% moisture content.

Feeder blocks were inoculated with *Antrodia xantha* and *Oligoporus placenta* fungus and grown in the laboratory until the fungi were established. The strain of these two fungi were isolates from the leaky buildings (Stahlhut 2008). The feeder blocks were nailed to each “I” sample, with *A. xantha* fungus attached approximately 5-10 mm from one end of the sample and *O. placenta* fungus attached approximately 5-10 mm from the other end of the sample (Figure 1).

The “I” frame samples were stacked in the Accelerated Decay House (a controlled environment room maintained at 25-27°C with more than 85% relative humidity). All the samples were periodically sprayed with water at approximately two weekly intervals to maintain the wood moisture content at a level suitable for decay to progress. The intention is to keep the moisture content of the timber above 30% to ensure fungal growth, as would be the case with a weather



tightness failure or leaks from water pipes. Installation of the “I” shaped samples for *Eucalyptus nitens* was delayed by approximately six months due to delays in receiving samples.

## Assessment methods

All samples were assessed for mould, mycelium and decay using the ASTM D 1758 based rating systems. Decay assessment was conducted both on the surface and at the end joints. The assessment was conducted after twenty-four months exposure for *Cupressus lusitanica*, Douglas fir, *Eucalyptus regnans* and H1.2 treated radiata pine. The *Eucalyptus nitens* and untreated radiata pine was assessed after eighteen months exposure due to delays in receiving samples.

Mould and surface mycelium is common in a damp environment. Mould and mycelium can be hazardous to health. Presence of mould and surface mycelium can provide an optimal environment for the initiation of decay. However, the presence of surface mycelium or mould does not always indicate that decay is present or likely to occur.

The rating systems (ASTM D 1758) for the deterioration were as follows:

### Description of assessment rating's

#### **Mycelium spread**

- 1 No mycelium development onto the sample surface from the feeder block
- 2 Mycelium growth from the feeder block onto the surface, spread less than 5 mm.
- 3 Mycelium from the feeder block on the surface, spread 5-50 mm.
- 4 Active mycelium from the feeder block on the surface, spread greater than 50 mm.
- 5 Extensive mycelium over the sample surface, less than 50% of the surface area.
- 6 Extensive mycelium over the sample surface, more than 50% of the surface area.

#### **Decay ratings**

- 10 No decay or insect damage.
- T Trace, discolouration, mycelium or softening, not positively identified as decay.
- 9 First stages of decay, small areas, not more than 1 mm deep.
- 8 Lightly established decay, patches 1-5 mm deep.
- 7 Well established decay, extensive surface decay or patches to 20 mm deep.
- 6 Established and progressive decay over wide areas with patches greater than 20 mm deep.
- 4 Severe decay over the majority of the surface with patches more than 40 mm deep.
- 0 Failed. Decay completely through the sample.

#### **Mould ratings**

- 1 No perceivable mould.
- 2 Light mould in small patches or widely scattered spots.
- 3 Extensive mould as numerous scattered spots or widespread light mould.
- 4 Severe mould, up to 50% of the surface covered.
- 5 Severe mould, more than 50% of the surface covered.

At assessment time, the stacks were dismantled, samples were removed, weighed and visually assessed for spread of mould, and spread of mycelium from the feeder blocks. The surfaces of each sample were tested with a blunt probe to determine whether decay fungi were damaging the framing. Staples were removed from one side of the sample so that end joints could be opened and the internal joint area could also be assessed for decay.

# Results

Assessment results after twenty-four month's exposure are summarised in Table 2. Full assessment results for individual samples are in Appendix 1.

**Table 2:** Summary of assessment results after twenty-four month's exposure (Average of 10 samples)

Timber species	Type of wood	Mycelium (Lower rating is better)		Decay - Surface (Higher rating is better)		Decay - Joint (Higher rating is better)		Mould (Lower rating is better)	
		Op <sup>1</sup>	Ax <sup>1</sup>	Op	Ax	Op	Ax	Op	Ax
<i>Cupressus lusitanica</i>	Heartwood	4.8	4.7	7.1 (1) <sup>2</sup>	7.3	5.5	6.6	1.8	1.4
	Heartwood\sapwood	5.9	5.9	3.9 (2)	5.9	2.8	3.8	2.4	1.9
Douglas fir	Heartwood	5.8	5.7	1.1 (8)	0.0	0.6	0.0	2.7	1.9
	Heartwood\sapwood	6.0	5.9	0.8 (8)	0.0	0.0	0.0	2.8	1.8
<i>Eucalyptus regnans</i>	Heartwood	5.4	5.0	6.5 (1)	4.6	5.0	2.8	3.4	2.2
	Heartwood\sapwood	4.6	4.3	5.2	5.0	3.8	3.8	3.2	3.0
H1.2 treated radiata pine	Heartwood\sapwood	1.1	1.6	9.9	9.9	9.9	9.7	4.4	4.5

<sup>1</sup> Op and Ax represent different ends of the "I frame" samples with feeder blocks inoculated with *Oligoporous placenta* and *Antrodia xantha*.

<sup>2</sup> Number in brackets shows the numbers of samples failed due to decay at both ends.

Assessment results for *Eucalyptus nitens* and untreated radiata pine after eighteen month's exposure are summarised in Table 3. Full assessment results for individual samples are in Appendix 1.

**Table 3:** Summary of assessment results after eighteen month's exposure (Average of 10 samples)

Timber species	Type of wood	Mycelium (Lower rating is better)		Decay - Surface (Higher rating is better)		Decay - Joint (Higher rating is better)		Mould (Lower rating is better)	
		Op <sup>1</sup>	Ax <sup>1</sup>	Op	Ax	Op	Ax	Op	Ax
<i>Eucalyptus nitens</i>	Heartwood	5.8	5.2	1.0 (8) <sup>2</sup>	0.4	0.6	0.4	4.1	1.5
	Heartwood\sapwood	5.8	5.3	0.8 (8) <sup>2</sup>	0.0	0.4	0.0	4.6	1.4
Untreated radiata pine	Sapwood	6.0	5.9	1.0 (6) <sup>2</sup>	0.7	1.1	1.1	4.0	1.6

<sup>1</sup> Op and Ax represent different ends of the "I frame" samples with feeder blocks inoculated with *Oligoporous placenta* and *Antrodia xantha*.

<sup>2</sup> Number in brackets shows the numbers of samples failed due to decay at both ends.

## ***Cupressus lusitanica* after twenty-four months exposure**

After twenty-four months exposure, extensive mycelium was observed on the surface of many of the *Cupressus lusitanica* samples. The presence of mycelium does not necessarily indicate the presence of wood decay. Established decay was observed in most samples, either on the surface or in the joint and some of the samples had decay through the sample (decay rating of zero). Two of the untreated heartwood\sapwood samples failed due to decay at both ends of the sample (samples 206 and 209), and one of the untreated heartwood samples failed due to decay at both ends of the sample (sample 235). The levels of decay were higher in the samples with mixed heartwood\sapwood (Figure 2) than the heartwood samples (Figure 3). Low levels of mould were observed on *Cupressus lusitanica* samples.

### **Douglas fir after twenty-four months exposure**

After twenty-four months exposure extensive mycelium was observed on the surface of all of the Douglas fir samples. Decay was observed in all of the Douglas fir samples with most of the samples having severe decay (Figures 4 and 5). Eight of the untreated heartwood samples and eight of the untreated heartwood\sapwood samples failed due to decay at both ends of the sample. Low levels of mould were observed on both heartwood and mixed heartwood/sapwood samples.

### ***Eucalyptus regnans* after twenty-four months exposure**

After twenty-four months exposure extensive mycelium was observed on the surface of many of the *Eucalyptus regnans* samples. One of the heartwood samples failed due to decay at both ends of the sample. Decay was observed in all of the samples either on the surface or in the joint (Figures 6 and 7). Low levels of mould were observed on *Eucalyptus regnans* samples.

### **H1.2 treated radiata pine after twenty-four months exposure**

After twenty-four months exposure low levels of mycelium were observed on the H1.2 boron treated radiata pine samples. The first stages of decay were observed on two of the boron treated radiata pine samples (Figure 8). No decay was observed in the other samples. High levels of mould were observed on all the samples.

### ***Eucalyptus nitens* after eighteen months exposure**

After eighteen months exposure, mycelium had extended from the feeder blocks onto the surface of all of the *Eucalyptus nitens* samples. Decay was present on the surface and in the joint of all samples (Figures 9 and 10). Eight of the heartwood samples and eight of the heartwood\sapwood samples failed due to decay at both ends of the sample. High levels of mould were observed.

### **Untreated radiata pine after eighteen months exposure**

After eighteen months exposure, extensive mycelium was observed on the surface of all of the untreated radiata pine samples. Established decay was observed on the surface and in the joint of all samples (Figure 11) and six of the samples failed due to decay at both ends of the sample. Extensive mould was observed on the samples.



# Conclusions

After twenty-four month's exposure;

- Established decay had developed in many of the samples of *Cupressus lusitanica*, Douglas fir, and *Eucalyptus regnans*. Samples had failed due to decay for each of these species with the highest number of failures occurring with the Douglas fir samples.
- For these three species, the level of decay rate is higher at the joints than at the surface of the samples.
- Boron treated Radiata pine samples were generally free from decay except two samples which are showing suspected soft rot.

After eighteen month's exposure;

- Established decay had developed in all of the *Eucalyptus nitens* samples with sixteen of the twenty samples failing due to decay.
- Established decay had developed on all of the untreated radiata pine sapwood samples.

Based on the results of this study of untreated *Eucalyptus nitens* and *Eucalyptus regnans* it is recommended that these species are not suitable for use as house framing. Untreated Douglas-fir is not suitable as house framing in medium and high risk designs under the building code. Further testing of boron treated *Eucalyptus nitens*, *Eucalyptus regnans* and Douglas fir could be conducted.

Other durability testing including stake test conducted at Scion showed *Cupressus lusitanica* and *Macrocarpa* (*Cupressus macrocarpa*) to be moderately durable and classified as class 3 towards the upper end, on the Australasian natural durability classification system (Page and Singh; 2014). However, this study has shown that *Cupressus lusitanica* is susceptible to decay in a leaky building situation. It is recommended that further testing of *Cupressus lusitanica* be conducted and compare the performance against *Macrocarpa* (*Cupressus macrocarpa*) and Totara. Further testing of boron treated *Cupressus lusitanica* could also be conducted.

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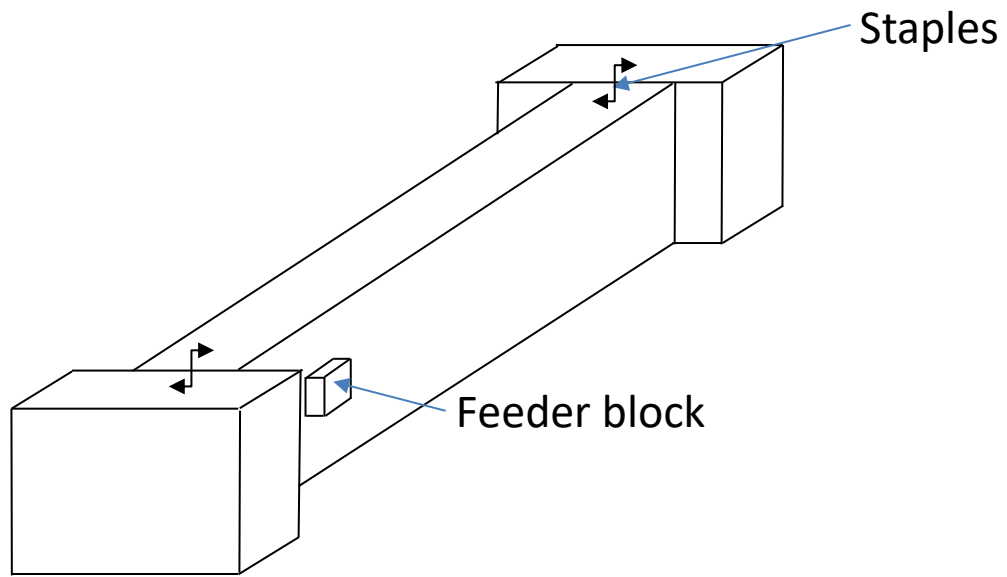
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**Figure 1:** Diagram showing I-frame



**Figure 2:** Decay on the surface of a mixed heartwood/sapwood *Cupressus lusitanica* sample after twenty-four months exposure (sample 207).



**Figure 3:** Decay in the joint of a heartwood *Cupressus lusitanica* sample after twenty-four months exposure (sample 231).



**Figure 4:** Severe decay on the surface of a Douglas fir heartwood sample after twenty-four months exposure (sample 501).



**Figure 5:** Severe decay in the joint of a Douglas fir heartwood sample after twenty-four months exposure (sample 502).



**Figure 6:** Decay on the surface of a heartwood *Eucalyptus regnans* sample after twenty-four months exposure (sample 401).



**Figure 7:** Severe decay in the joint of a heartwood/sapwood *Eucalyptus regnans* sample after twenty-four months exposure (sample 418).



**Figure 8:** Suspected soft rot on a boron treated radiata pine sample after twenty-four months exposure (sample 604).



**Figure 9:** Decay on the surface of a heartwood *Eucalyptus nitens* sample after eighteen months exposure (sample 801).





**Figure 10:** Decay in the joint of a heartwood *Eucalyptus nitens* sample after eighteen months exposure (sample 810).



**Figure 11:** Decay on the surface of an untreated radiata pine sample after eighteen months exposure (sample U2).

# Appendix 1

**Table 4:** Individual sample rating after eighteen and twenty-four month's exposure in accelerated conditions

Sample ID	Op <sup>1</sup> Mould	Op Mycelium	Op Decay Surface	Op Decay Joint	Ax <sup>1</sup> Mould	Ax Mycelium	Ax Decay Surface	Ax Decay Joint
<i>Cupressus lusitanica</i> , Heartwood – after twenty-four months exposure								
231	2	6	6	0	1	6	7	6
232	1	3	T	6	3	5	10	7
233	1	4	10	7	1	6	10	10
234	1	6	T	10	1	5	10	10
235	1	3	0	0	1	5	0	0
236	1	3	10	10	1	4	8	8
237	3	6	9	7	2	4	8	8
238	4	5	7	7	1	3	0	0
239	1	6	8	8	1	6	10	10
240	3	6	7	0	2	3	10	10
<i>Cupressus lusitanica</i> , Heartwood/sapwood – after twenty-four months exposure								
201	3	6	4	4	1	6	7	4
202	3	6	6	4	3	6	9	6
203	2	6	7	4	1	6	10	6
204	2	6	6	4	2	6	7	0
205	3	6	4	4	2	6	9	6
206	1	6	0	0	1	6	0	0
207	2	6	0	0	3	5	4	6
208	3	6	6	4	3	6	7	6
209	3	6	0	0	1	6	0	0
210	2	5	6	4	2	6	6	4

<sup>1</sup> Op and Ax represent different ends of the “I frame” samples with feeder blocks inoculated with *Oligoporus placenta* and *Antrodia xantha*.



Sample ID	Op <sup>1</sup> Mould	Op Mycelium	Op Decay Surface	Op Decay Joint	Ax <sup>1</sup> Mould	Ax Mycelium	Ax Decay Surface	Ax Decay Joint
Douglas fir, Heartwood – after twenty-four months exposure								
501	2	6	7	6	2	6	0	0
502	1	6	0	0	1	6	0	0
503	4	6	0	0	1	6	0	0
504	3	5	0	0	2	5	0	0
505	4	6	0	0	3	6	0	0
506	3	6	0	0	3	5	0	0
507	4	5	0	0	1	6	0	0
508	2	6	0	0	2	6	0	0
509	2	6	4	0	3	5	0	0
510	2	6	0	0	1	6	0	0
Douglas fir, Heartwood\sapwood – after twenty-four months exposure								
511	1	6	0	0	3	5	0	0
512	3	6	4	0	1	6	0	0
513	2	6	0	0	1	6	0	0
514	4	6	0	0	3	6	0	0
515	2	6	0	0	1	6	0	0
516	2	6	0	0	1	6	0	0
517	3	6	0	0	2	6	0	0
518	4	6	0	0	3	6	0	0
519	3	6	0	0	2	6	0	0
520	4	6	4	0	1	6	0	0

<sup>1</sup> Op and Ax represent different ends of the “I frame” samples with feeder blocks inoculated with *Oligoporus placenta* and *Antrodia xantha*.

Sample ID	Op <sup>1</sup> Mould	Op Mycelium	Op Decay Surface	Op Decay Joint	Ax <sup>1</sup> Mould	Ax Mycelium	Ax Decay Surface	Ax Decay Joint
<i>Eucalyptus regnans</i> , Heartwood – after twenty-four months exposure								
401	2	3	8	6	1	4	7	6
402	2	6	8	6	2	6	6	6
403	2	6	8	6	2	5	7	6
404	2	6	8	7	2	6	6	6
405	5	5	8	6	5	6	6	0
406	5	5	6	6	2	6	4	0
407	4	6	6	6	2	1	4	0
408	5	6	0	0	1	6	0	0
409	3	5	7	0	1	6	0	0
410	4	6	6	7	4	4	6	4
<i>Eucalyptus regnans</i> , Heartwood\sapwood – after twenty-four months exposure								
411	2	6	6	4	2	5	4	4
412	4	3	4	8	3	4	6	0
413	4	3	4	4	4	5	4	4
414	4	5	4	4	4	5	6	6
415	4	3	0	4	4	5	0	0
416	4	5	4	0	1	6	9	8
417	2	6	8	0	4	6	6	4
418	1	6	6	0	1	2	0	0
419	2	6	8	4	2	3	7	4
420	5	3	8	10	5	2	8	8

<sup>1</sup> Op and Ax represent different ends of the “I frame” samples with feeder blocks inoculated with *Oligoporus placenta* and *Antrodia xantha*.

Sample ID	Op <sup>1</sup> Mould	Op Mycelium	Op Decay Surface	Op Decay Joint	Ax <sup>1</sup> Mould	Ax Mycelium	Ax Decay Surface	Ax Decay Joint
H1.2 treated radiata pine, Heartwood/sapwood – after twenty-four months exposure								
601	2	1	10	10	3	1	10	9
602	5	1	9	10	5	1	10	10
603	5	1	10	10	5	1	10	10
604	5	1	10	10	5	3	9	9
605	5	2	10	9	5	1	10	10
606	5	1	10	10	5	1	10	10
607	5	1	10	10	5	1	10	10
608	4	1	10	10	3	3	10	9
609	4	1	10	10	5	1	10	10
610	4	1	10	10	4	3	10	T

<sup>1</sup> Op and Ax represent different ends of the “I frame” samples with feeder blocks inoculated with *Oligoporous placenta* and *Antrodia xantha*.

Sample ID	Op <sup>1</sup> Mould	Op Mycelium	Op Decay Surface	Op Decay Joint	Ax <sup>1</sup> Mould	Ax Mycelium	Ax Decay Surface	Ax Decay Joint
Untreated radiata pine – after eighteen months exposure								
U1	4	6	0	0	1	6	0	0
U2	4	6	0	0	3	6	0	4
U3	4	6	0	0	1	6	0	0
U4	4	6	0	0	2	6	0	0
U5	3	6	4	7	2	6	7	7
U6	5	6	0	4	2	6	0	0
U7	5	6	6	0	2	6	0	0
U8	5	6	0	0	1	6	0	0
U9	3	6	0	0	1	6	0	0
U10	3	6	0	0	1	5	0	0

<sup>1</sup> Op and Ax represent different ends of the “I frame” samples with feeder blocks inoculated with *Oligoporous placenta* and *Antrodia xantha*.

Sample ID	Op <sup>1</sup> Mould	Op Mycelium	Op Decay Surface	Op Decay Joint	Ax <sup>1</sup> Mould	Ax Mycelium	Ax Decay Surface	Ax Decay Joint
<i>Eucalyptus nitens</i> , Heartwood – after eighteen months exposure								
801	1	4	6	6	1	2	4	4
802	4	6	0	0	1	6	0	0
803	5	6	0	0	1	5	0	0
804	4	6	0	0	4	5	0	0
805	4	6	0	0	1	6	0	0
806	4	6	0	0	1	6	0	0
807	4	6	0	0	1	5	0	0
808	5	6	4	0	1	5	0	0
809	5	6	0	0	3	6	0	0
810	5	6	0	0	1	6	0	0
<i>Eucalyptus nitens</i> , Heartwood\sapwood – after eighteen months exposure								
811	5	6	0	0	1	6	0	0
812	5	6	0	0	1	5	0	0
813	3	6	4	4	1	4	0	0
814	5	6	0	0	1	6	0	0
815	4	6	4	0	1	6	0	0
816	5	6	0	0	5	3	0	0
817	5	5	0	0	1	6	0	0
818	5	5	0	0	1	6	0	0
819	4	6	0	0	1	6	0	0
820	5	6	0	0	1	5	0	0

<sup>1</sup> Op and Ax represent different ends of the “I frame” samples with feeder blocks inoculated with *Oligoporus placenta* and *Antrodia xantha*.