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Measurements of Moisture Content in Decking Timbers Exposed to Bushfire Weather Conditions

Report to
Bushfire CRC

L. Macindoe
J. E. Leonard
P. A. Bowditch

CSIRO - Manufacturing and Materials Technology
Fire Science and Technology Laboratory

CSIRO – Sustainable Ecosystems
Urban Systems

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Please address all enquiries to:
The Chief
CSIRO Manufacturing & Materials Technology
P.O. Box 56, Highett, Victoria 3190

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Executive Summary

This report forms part of the work undertaken for the Bushfire CRC Project D1 to reduce the risk of building loss and injuries to occupants due to bushfires. It covers a preliminary investigation into the moisture contents in some decking timbers exposed to bushfire weather conditions. The timbers were placed on an exposure rack located at the CSIRO laboratories at Highett in Melbourne over the summer, December to February 2007.

The aim was to determine the approximate moisture content in timber decking during bushfire weather. This information can then be used to correctly condition decking specimens prior to testing according to bushfire conditions as well as for input into fire models. Guidance given in the Draft AS 1530.8.1 Bushfire Test Method recommends conditioning the timber at 25˚C and 45% RH for a week prior to testing. This would typically result in a moisture content of 10-15%.

The moisture contents reported in this report represent the average moisture content for the specimen (not the equilibrium moisture content) as the moisture content will vary through the cross-section due to the transient weather conditions. i.e. As the timber is dried out the moisture content will be lower on the outside than in the centre.

To provide continuous data, some of the timber specimens were placed on load cells and their masses logged at 10 minute intervals allowing a complete profile of the moisture content to be obtained. The specimens were 300 mm long and cut from lengths of decking boards typically used for domestic applications.

The following conclusions were found:

- Load cells can be used to monitor the moisture content in timber specimens provided appropriate monitoring is used.

- The average moisture content in decking timbers exposed to bushfire weather can be much lower than that implied in AS1530.8.1. Typical values during the peak of the bushfire weather experienced in Melbourne over the summer of 2006-07 were:

Species	**Dimensions**	**Moisture Content (%)**
Merbau	300x90x18	6-7
Blackbutt	300x85x19	7.5-8.5
Spotted Gum	300x85x20	7-8
Jarrah	300x85x20	8.5-9.5
White Cypress Pine	300x66x20	6-7
Mountain Ash*	300x100x10	6-7
Spotted Gum*	300x100x10	6-7

- During dry weather the moisture content can vary by 1% over a 24 hour period due to the variation in temperature and relative humidity. In addition the average daily moisture content can take a week to cycle down to a stable value. Similarly once the moisture content has dropped and the weather stays dry it can remain relatively low for days
- To condition timber to be used in testing to similar moisture contents as experienced during peak bushfire weather was found to take between 0.5 and 2 days conditioning at 45˚C and 18% RH depending on the dimensions and species.
- Matching specimens that were placed on a timber deck to provide a comparison with those on the exposure rack experienced significantly lower moisture contents. This may be due to the micro environment around the specimens. The exposure rack provided free airflow around the specimens while the deck would have limited the airflow and may have acted as a heat trap.
- While this was a preliminary study involving only a limited number of specimens the results across the specimens, timber species and over the 3 month time period were

consistent. A much better understanding would require more specimens, species and locations.

- During the recording period the Forrest Fire Danger Indices reached into the 40s on four occasions and did not exceed 48. Historic fire losses have typically occurred at FFDI's well above this level. Hence the observation of moisture content for the summer of 2006/07 can be considered highly conservative compared to years where iconic losses have occurred.

Contents

1. Introduction

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The aim was to determine the approximate moisture content in timber decking during bushfire weather. This information can then be used to correctly condition decking specimens prior to testing according to bushfire conditions as well as for input into fire models. Guidance given in the Draft AS 1530.8.1 Bushfire Test Method recommends conditioning at 25˚C and 45% RH for a week prior to testing. This would typically result in a moisture content of 10-15%.

The moisture contents reported in this report represents the average moisture content for the specimen (not the equilibrium moisture content) as the moisture content will vary through the cross-section due to the transient weather conditions. i.e. As the timber is dried out the moisture content will be lower on the outside than in the centre. From a fire risk perspective the lower outside moisture content may increase ignitability and flame spread potential further.

To provide continuous data, some of the samples were placed on load cells and their masses logged at 10 minute intervals allowing a complete profile of the moisture content to be obtained. The reasons for using this method were:

- Moisture meters generally operate over a limited range of 7-30% MC and require reading adjustments to allow for species and temperature [1]

- Instrumentation using moisture meters would have been much more expensive than using load cells with no guarantee of being any more reliable or accurate
- Other influences on the mass of the specimen such as debris on the specimens or wind load could be accounted for by the placement of the exposure rack in a clean area and smoothing of the data to filter out the wind load. The smoothing assumes the wind load is fluctuating in direction and/or magnitude and the changes are happening over a much shorter time frame than for the moisture content.
- Controls such as manually checking the specimen mass can be used to ensure accuracy.
- Recording the specimens mass allows calculation of oven dry moisture contents down to a few percent to be determined.

2. Experimental Procedure

2.0 Summary

The timber specimens were left exposed to the weather over the summer months on a purpose built rack. Some of the specimens were mounted on load cells so their mass (and hence moisture content) could be logged continuously. Other specimens were placed on wire mesh supported off the ground and their masses manually recorded. Periodic manual checks of the logged specimen masses were also made to correct for any errors that occurred due to drift in the load cells. A northerly aspect adjacent to a building wall was used to ensure exposure to full sun and drying winds but partly shielded from the southerly cooler, wet weather. Some extra specimens were placed on some timber decking close by to act as a control and provide a comparison of the environment used.

The recorded masses were converted to moisture contents at the end of the period using the oven dried mass of the specimens and in the case of the logged specimens, smoothing to eliminate the wind loads as much as possible. The environmental conditions were recorded using temperature and relative humidity probes.

2.1 Parameters Varied

As this was a preliminary investigation only a limited number of parameters were considered. These included:

- Timber Species

  A selection of timber species representing the typical timbers used for decking in Australia were used. The main ones being:

  - Spotted Gum
  - Blackbutt
  - Jarrah
  - Merbau

  Others also included were:

  White Cypress Pine and Mountain Ash (not treated, although it would be in use)

  The density of the timbers used are given in *Table 2-1*

Table 2-1 Typical Densities of Decking Timbers

Timber	Density (kg/m^3)
Merbau	750
Blackbutt	950
Jarrah	800
Spotted Gum	1050
Cypress Pine	700
Mountain Ash	650

- Weather Conditions

  The specimens were exposed to the weather over the summer months from December 2006 to February 2007. The specimens mounted on load cells were logged continuously during this time. Manual measurements were made 1-2 times a month generally during periods of hot weather. The temperature range was 15-41°C and the relative humidity (RH) range was 15-100%. Only the top surface and the edge of the specimen was exposed to the sun.

- Thickness

  The majority of the specimens were nominally 20mm thick, however a few were reduced to 10mm to investigate what effect the thickness might have on the moisture content. The species used for the 10mm thick specimens were Spotted Gum and Mountain Ash as examples of heavy and a light weight timbers respectively. Only for the Spotted Gum were specimens of both thicknesses used.

2.2 Parameters Held Constant

A number of parameters were kept constant. These include:

- Orientation to the Weather

  The exposure rack was placed against a north facing wall (see *Figure 2.1*) with the timber specimens aligned with their lengths north-south. This provided full sun exposure from early morning to late afternoon as well as exposure to the dry north and north-westerly winds but shelter from the dominate south and south-westerly rain directions. However the later had little influence as the dry summer resulted in only two short rain storms which occurred between 23-27 December and 19-22 January.

- Size of Specimen

  The majority of the specimens were 300mm in length and cut from a stock of decking boards store under cover for over 12 months. The width and the thickness of the decking boards and hence the specimens varied between timber species. However the width was generally between 66 and 100mm and the thickness was nominally 20mm but varying with species between 18 and 20mm. The 300mm length was selected for the following reasons:

  - Sufficiently long enough to reduce the end effects of drying, but short enough to reduce the effect of the wind load on the load cells supporting the logged specimens
  - The mass of the specimens, which ranged from 250-500g, were sufficiently heavy to absorb the wind load and allow the change in mass due to moisture movement to be measured.
  - The loose specimens were heavy enough not to be blown off the exposure rack in strong winds.
  - The mass of the specimen could be measured using the balances and load cells available, to the resolution required.
  - The specimens could fit into the oven available for final oven dry moisture measurements

- Timber quality

  The specimens were cut from clear, straight grain decking timber with no or minimal defects to give as close as possible to an even material. The decking timber had been stored under cover in racks for 12 months prior to use. The specimens were unweathered when first placed on the exposure rack at the start of the summer.

- Location

  Due to limited resources only the one exposure rack was used. However as a control some additional specimens were placed on a timber deck nearby (see *Figure 2.2*). These were used to verify that the location of the exposure rack, on bitumen covered ground next to a large north facing brick wall (refer to *Figure 2.1*), didn't adversely affect the moisture contents of the specimens. The additional specimens placed on the timber deck were exposed to a similar northerly aspect as the exposure rack but were surround by grassy ground and an adjacent large gumtree.

Figure 2.1 Location of exposure rack on the north face of the building

(a) View looking west

(b) View looking south

Figure 2.2 Location of additional control specimens

2.3 Exposure Rack

To provide a means of supporting the specimens in a horizontal orientation in a similar way to timber decking, a purpose built exposure rack (see *Figure 2.3*) as constructed with the following characteristics.

- Specimens were mounted horizontally, approximately 500mm from the ground with free air flow
- Various shading/sheltering configurations possible
- Ability to remove specimens and manually weight them
- Allowance for some specimens to be mounted on load cells for continuous logging

The exposure rack used is an open timber frame with steel mesh for supporting loose specimens and a 45º angled awning to provide partial/full shading/shelter over half the area.

Figure 2.3 Purpose built exposure rack for moisture content monitoring

2.3.1 Logged Specimens

The exposure rack was designed to allow up to 4 rows of 6 load cells (see *Figure 2.4*) to be mounted, permitting 24 specimens to be logged in total.

The 4 rows were designed so:

- 2 rows would be in full sun
- 1 row would be mostly sheltered from the rain but in morning sun and afternoon shade
- 1 row would be fully sheltered from the rain but in shade for most of the day
- all rows would be exposed to the hot northerly wind

However for this project only 2 rows of load cells were utilised, one in full sun and one in full shelter (see *Figure 2.5*). Hence a total of 12 specimens were logged.

The specimens exposed to full sun are shown in *Figure 2.6*. From left to right they are:

1. Spotted Gum 300Lx85Wx20D
2. Jarrah 300Lx85Wx20D
3. Spotted Gum 300Lx100Wx10D
4. Mountain Ash 300Lx100Wx10D
5. Blackbutt 300Lx85Wx19D
6. Merbau 300Lx90Wx18D

The same species were used for the fully sheltered specimens. However only limited data for the fully sheltered specimens is presented in this report for the following reasons:

- Reliability of the load cells
- Adverse wind loading due to the awning

2.3.2 Loose Specimens

The loose specimens were placed on the steel mesh. They were periodically removed and manually weighted. The mesh support ensured good airflow around the specimens as would occur around a well ventilated timber deck. Typical placement of loose specimens is shown in *Figure 2.4* either side of the row of logged specimens.

Figure 2.4 Row of 6 specimens mounted on load cells (centre) with loose specimens on either side

Figure 2.5 Exposure rack with a row of specimens exposed to the full sun on the far right and a row of specimens fully sheltered from the rain in the centre under the shade of the awning

Figure 2.6 Logged Specimens exposed to full sun after removal for oven drying at the end of the summer

2.4 Instrumentation

The instrumentation used consisted of:

- Load cells (2.5kg)
- Temperature/Humidity Meter
- Scale (0-1500g)
- Weather station including wind speed and direction, temperature, humidity and rainfall
- Data acquisition hardware including a laptop and load cell conditioning

2.4.1 Load Cells

The load cells were selected based on the following requirements:

- Temperature Sensitivity. The operating range for the loads cells during the summer is from 15 to 45ºC.
- Capacity and Accuracy. The load cells need to have a capacity sufficient to prevent damage from accidental loading, wind loading or forces applied while installing and removing the specimens which could be 2 or 3 times greater than the weight of the specimen. However the capacity must be kept as small as possible to ensure that the mass and hence moisture content of the specimen can be measured accurately.
- Mounting requirements. The profile should be low to reduce wind loads. Also a low profiled load cell can be reasonably sheltered from the weather by the specimen mounted on top of it. The mounting should allow the specimens to be easily removed for manual weighing. The load cell needs to hold the specimen reasonably firm to prevent excessive vibration due to wind
- Cost. Due to limited resources and the fact that the load cells were unprotected from the weather and over loading the cost needed to be kept low.

The load cells used were:

Model: Elane ELC-L108, Single point cantilever beam, aluminium alloy, colourless anodized and adhesive sealed.

Capacity:	2.5 kg
Non-linearity:	0.02 % FS
Hysteresis:	0.02 % FS
Non-repeatability:	0.01 %FS
Temperature effect on span:	0.017 %FS/10°C
Temperature effect on zero:	0.02 %FS/10°C
Compensated temperature:	-10 – 40°C
Operating temperature:	-20 - 65°C
Safe overload:	150%

A typical load cell mounting is shown in *Figure 2.7* and *Figure 2.8*. The load cell is bolted to the aluminium channel supporting beam with a 1.6mm spacer in between to provide clearance. Similarly the specimen is bolted to the load cell with a 1.6mm spacer in between them. A 3mm thick piece of rubber is used to provide a seal between the head of the bolts and the top of the specimen. It also allows for the specimen thickness to change over time (e.g. shrinkage due to moisture movement) without affecting the fixing. The bolts used were stainless steel with hexagonal slots to allow for easy removal. The spacers used were cut from a sheet of 1.6mm bakelite. A piece of spacer material was used as a washer between the head of the bolts and the rubber seal. The 1.6mm thickness of the spacer was chosen to ensure water and dirt could not bridge the gap between the load cell and the supporting beam and affect the reading. This also meant that the load cells had no mechanical overload protection.

Figure 2.7 Typical load cell mounting (under awning)

Figure 2.8 Bolting detail of specimen to load cell

Prior to installation, the load cells were checked using calibrated weights. One of the load cells was found to be defective and replaced with a larger capacity 3kg load cell with otherwise identical specifications.

2.4.2 Temperature/Humidity Meter

The temperature/humidity meter used was:

Model: Center 311 Humidity Temperature Meter

Humidity Range:	0 to 100%RH
Temperature Range:	-20 to 60°C
Humidity Resolution:	0.1%RH
Temperature Resolution:	0.1°C
Humidity Accuracy:	±2.5%RH at 25°C
Temperature Accuracy:	±0.7°C
Operating Temperature:	0 to 50°C

The probe of the Center 311 Humidity Temperature Meter was mounted on the underside of the exposure rack (see *Figure 2.9*) in the shade. The meter itself was placed in the instrumentation cabinet mounted on the side of the exposure rack (see *Figure 2.10*). An additional thermocouple input on the meter was used to monitor the temperature inside the instrumentation cabinet.

Figure 2.9 Temperature humidity meter probe mounted on the underside of the exposure rack in the shade

Figure 2.10 Instrumentation cabinet mounted on rear side of exposure rack

2.4.3 Weather Station

The weather station used was:

Model:	Oregon Scientific WMR928NX
Gauges:	Air temperature
	Relative humidity
	Barometric pressure
	Wind speed and direction
	Rainfall

The instruments were mounted on or near the exposure rack (see *Figure 2.11*) and logged remotely via wireless communications. The readings were recorded at 10 minute intervals.

Figure 2.11 Weather station instrumentation mounted on pole and on the frame of the exposure rack

2.4.3 Data Acquisition Hardware

The data acquisition hardware was split into two parts. The load cell conditioning modules and temperature/humidity meter were placed in a weatherproof cabinet mounted on the rear end of the exposure rack while the laptop running the acquisition software and the power supplies were placed inside the adjacent building

This had the following advantages:

- The cables for the load cells could be kept short as they only needed to reach the weatherproof cabinet
- The cabling from the building to the exposure rack required only a couple of low voltage cables (RS232 serial communication and DC power)
- The power supplies and laptop were kept secure and out of the weather

The advantage of using a laptop for the acquisition was, having a battery, it would continue to log even if a power interruption occurred

2.5 Data Acquisition

The data acquisition included:

- Manual recording of specimen masses using a scale, for both logged specimens and loose specimens.
- Continuous recording of logged specimens masses and air temperature and humidity
- Continuous recording of weather station data

Both manual readings and continuously logged reading were taken to:

- ensure the accuracy of the logged reading
- provide some redundancy if a load cell failed
- monitor the additional control specimens placed nearby
- check for the effect of the wind load

2.5.1 Manual recordings

After a initial two week monitoring of the logged specimens to ensure the system was operating correctly the manual readings were only taken once or twice each month during days of high temperatures. The need for manual readings was justified when the zero creep in the majority of the load cells became worse after about one and a half months in service with only the 3kg replacement load cell having a stable negligible (1-2g) zero creep.

The manual checking of the mass of the logged specimens and the zero creep in the load cells was achieved by

- Recording the logged mass while a cover was placed over the specimen to reduce the wind load
- Removing and manually recording the mass using a scale located inside the building adjacent to the exposure rack
- Recording the zero mass while the cover was placed over the load cell
- Calculating the zero offset and also checking it against the zero mass recorded from the load cell

The mass of the loose specimens were record using the same scales.

2.5.2 Continuous recordings

The mass of the logged specimens and the air temperature and humidity were recorded every 10 minutes using a laptop computer. The weather station data was recorded using a separate desktop computer running proprietary software supplied with the weather station. In the later case some loss of data occurred due to power outages or computer failure. Fortunately the bureau of meteorology station data at Moorabbin Airport provided a good backup.

The 10 minute sample interval was selected to:

- provide sufficient data to allow for smoothing out of the wind loading
- restrict the size of the data so it could be easily managed
- give sufficient accuracy of the change in mass and hence moisture content with time. In reality a sample interval of up to 1 hour would probably be sufficient if wind load could have been ignored as the moisture content only varied slowly for the size of specimens used.
- give sufficient accuracy of the change in temperature and humidity with time

2.6 Data adjustment

The three main adjustments that were required to be made to the logged readings were:

- Smoothing to account for the wind load
- An offset to allow for the zero creep in the load cells
- Calculation of moisture content from the logged mass and the oven dry mass

2.6.1 Smoothing to account for wind load

The smoothing was applied using a spreadsheet as follows:

- The raw data for the period of interest was extracted from the data. As the periods of interest all concerned days of high fire danger, this excluded data associated with wet weather and hence any artificially high mass due to water on the specimen.
- The raw mass values were banded so that any values more than 5% away from the average were assumed to be wrong and were trimmed back. Since the average moisture content was around 9%, this effectively assumes the moisture content of the timbers will lie within an approximate 4-14% range for the period of interest.
- A 10 point moving average is applied to the banded data. This equates to averaging the data over a 1hr and 40 minute period. From trial and error it was found that applying 3 consecutive 10 point moving averages (i.e. a second average is applied to the result of the first and so on) produced the best visual fit.

An example of smoothing is shown in *Figure 2.12*

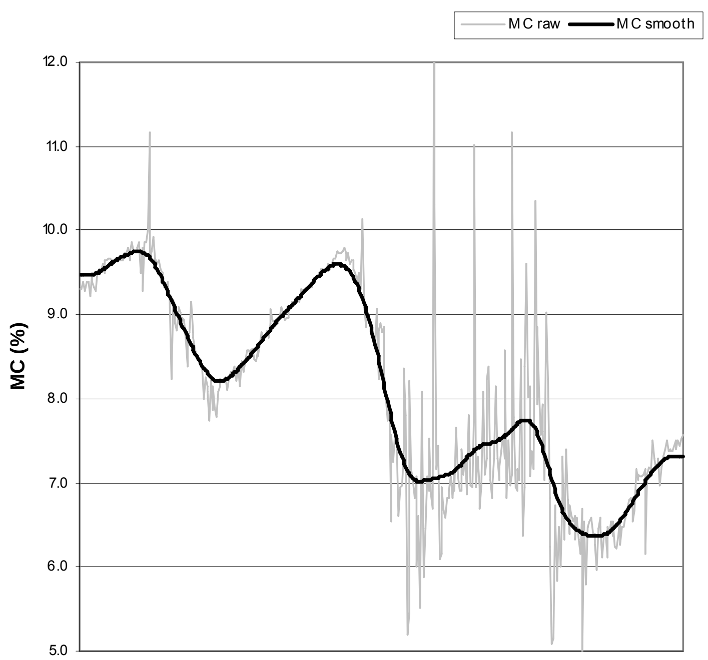


Figure 2.12 Example of smoothed data

2.6.2 Offset to allow for the zero creep in the load cells

The zero creep in the load cells varied between load cells and with time in service. Initially this was small and could be ignored but by about a month and a half of service in some load cells it was >1% of the mass of the specimen. Only the 3 kg replacement load cell had a stable zero less than 0.5% or approximately 2g of the specimen mass.

To correct for the zero error the specimens were removed from the load cells and weighted manually allowing the zero offset to be determined. When calculating the moisture contents of the specimens these offsets were applied to the raw data to give the corrected mass values. As an additional check a comparison of the moisture contents from loose specimens and the logged specimens were made.

To further improve the load measurents, the load cells were calibrated when the air temperature was near 30ºC , i.e. mid range of the summer temperature variation

The linearity of all but one of the load cells were stable over the service period. The data from the faulty load cell (Spotted Gum 300Lx85Wx20D specimen) could not be used.

2.6.2 Calculation of moisture content from the recorded mass and the oven dry mass

Once the specimen mass has been corrected for wind load and zero creep it can then be used to determine the moisture content (MC). This is done by oven drying the specimen at 100ºC until it reaches a stable mass (oven-dry mass).

The moisture content is then calculated using the method given in [2]:

$$MC = (M_i / M_{OD} - 1) \times 100$$

where:

MC = the percentage moisture content of the specimen

M_i = the recorded mass of the specimen

M_{OD} = the oven-dry mass of the specimen

Due to the corrections required to calculate the recorded mass, the accuracy of MC is likely to be in the range ±1.0%.

Generally the oven drying for the recommend specimen size (15 - 30mm long in the direction of the grain) takes approximately 24 hours. However since the specimens used were approximately 300mm long and included some dense timbers the drying time was much longer. For some of the Spotted Gum specimens it took over a month to reach the oven-dry mass.

It should be noted that the moisture contents calculated using the method above give an average moisture content for the specimen as a whole. As weather conditions change so does the gradient of moisture content across each specimen. i.e. as the specimen is drying the outside is likely to have a lower moisture content compared with the inside. The gradient will also depend on the species and the specimen dimensions.

3.Results

3.0 General

The results have been separated into the following sections:

- Weather conditions
- Variation in moisture content during the summer
- Periods of high fire risk weather conditions.
- Loose Specimens
- Comparison of full sun and sheltered conditions
- Drying of timber specimens

Some results could not be used due to:

- The load cell measuring the mass of the Spotted Gum specimen (300L x 85W x 20D) exposed to full sun became faulty
- The load cells measuring the mass on the sheltered specimens being adversely affected by wind load due to the awning and larger than expected zero creep which wasn’t monitored sufficiently to allow accurate correction.

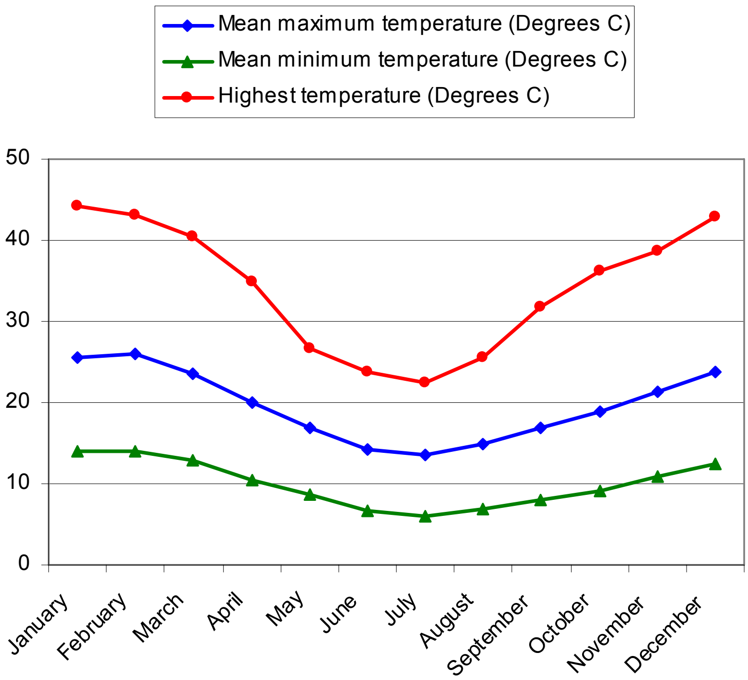
3.1 Weather conditions

The summer of 2006-7 was one of the driest on record and followed a dry winter and spring. As a result severe bushfires occurred and almost 20% of the area of the state of Victoria was burnt over the summer, occurring mainly in the hard to access mountainous forestry regions.

3.1.1 Historical Data

The CSIRO Highett site is located in the south east suburbs of Melbourne and is a few kilometres east of Port Phillip Bay. The Bureau of Metrology has a weather station close by at Moorabbin Airport. The following historical data for Moorabbin Airport was downloaded from the web site (http://www.bom.gov.au/climate/averages/tables/cw_086077.shtml).

Weather station details:
MOORABBIN AIRPORT
Commenced: 1950
Last Record: 2007
Latitude: 37.98 Degrees South
Longitude: 145.10 Degrees East
Elevation: 12 m



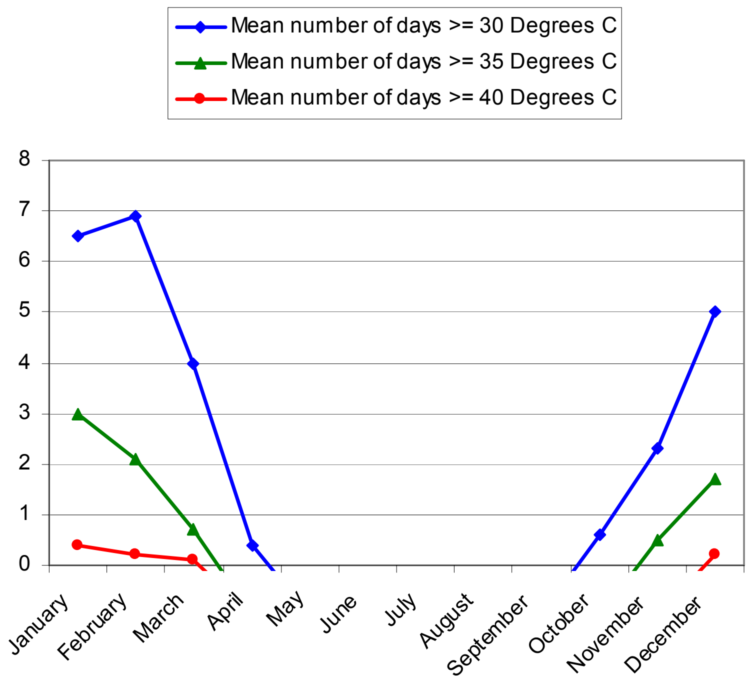


Figure 3.1 Historical temperature data

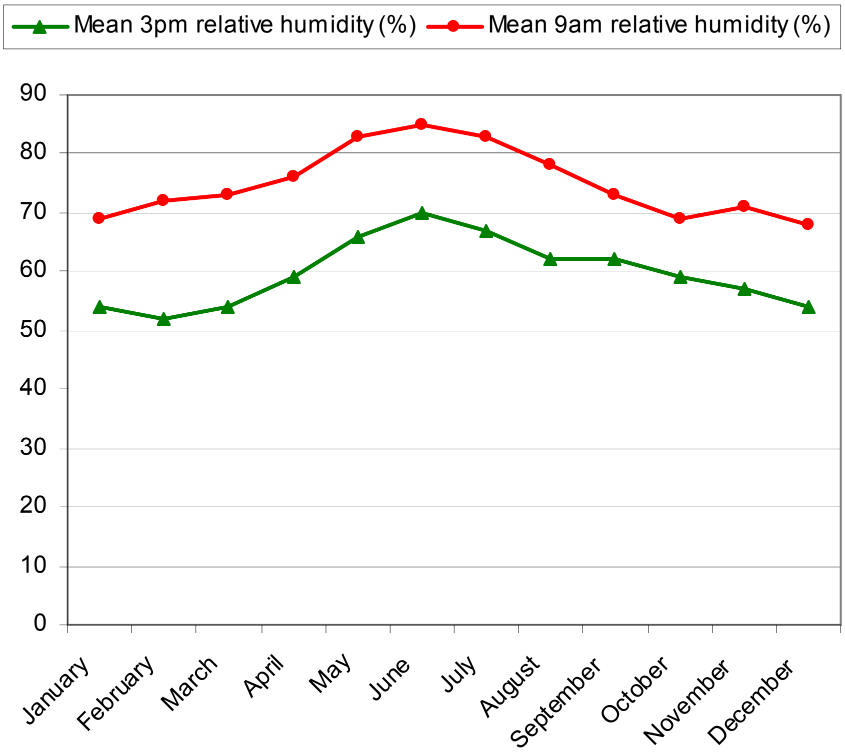


Figure 3.2 Historical humidity data

3.1.2 Weather conditions during the summer of 2006-7

Three sources of weather data were used:

- Air temperature and relative humidity logged on the laptop (refer to section 2.4)
- Weather data record by the weather station along side the exposure rack
- Bureau of Metrology data downloaded from their web site (http://www.bom.gov.au)

This provided both cross checking of the data and redundancy. The weather station at the exposure rack proved the least reliable for the following reasons:

- Wind direction and speed were affected by localised wind effects due to the building
- The wireless communications sometimes dropped out
- Data was lost due to power or system failure

While it did provide data for cross checking and backup only the data from the laptop and the Bureau of Metrology are presented here. The daily summer weather data downloaded from the Bureau of Metrology web site (http://www.bom.gov.au/climate/averages/) are given in Table 3-1, Table 3-2 and Table 3-3.

Plots of the air temperature and relative humidity at the exposure rack recorded on the laptop (using the probe in Figure 2.9) are shown in Figure 3.3.

Also provided by the Bureau of Meteorology and included in the tables and in Figure 3.4 are the Forrest Fire Danger Indices (FFDI) related to the 3pm weather conditions. The FFDI is used by fire authorities as a method of fire weather quantification.

Table 3-1 Daily weather data for December 2006

Date	Temperature (°C)		Rainfall	Max Wind Gust	Wind Gust	Time of Wind	9am		3pm		
	Min	Max	(mm)	(km/h)	Dir.	Gust	Temp (°C)	RH (%)	RH (%)	Temp (°C)	FFDI
1	15	27.7	0	41	W	22:29	16.4	68	32	24.5	12
2	12.4	17.9	0	50	SSW	16:45	14.4	52	46	16.2	8
3	12.3	18.5	0	44	SSW	15:56	12.4	**81**	52	17.3	6
4	8.1	25.3	0.8	35	S	15:18	14.9	51	37	23.4	11
5	9.8	34.2	0	57	NNW	10:49	23.5	30	15	32.1	41
6	15	20.1	0	48	SW	7:16	15.7	68	46	18.5	8
7	7.9	20.3	0	39	SW	15:43	15.5	56	39	19.1	10
8	8.6	29	0	35	ESE	19:05	16.5	65	54	23.4	7
9	11.7	37.9	0	**31**	N	11:34	20	59	**10**	37.1	35
10	15.9	**41.9**	0	57	SW	14:29	32.2	19	51	25.7	16
11	17.6	20.4	0	61	SSW	14:26	17.7	49	43	18.8	11
12	8.2	20.5	0.2	43	S	15:40	14	41	36	19.2	11
13	7.2	26.4	0	31	E	18:45	10.9	66	45	21.4	7
14	10.9	34.3	0	61	SSW	13:56	26.4	**18**	55	21.1	13
15	11.7	19.4	2.6	46	SSW	10:56	14.4	46	37	17.5	10
16	9.5	20.5	0	43	SSW	14:28	15.3	54	45	19.2	9
17	7.4	25.2	0	37	SE	16:22	14.8	61	34	22.1	13
18	8.4	24.8	0	39	SSW	18:07	16.5	64	49	21.5	9
19	14.2	22.4	0	44	SSW	14:35	16.6	56	37	20.2	12
20	12.7	27.9	0	46	ESE	20:02	16.8	58			
21	11.6	37.6	0	39	NNE	11:22	20.5	61	13	36.1	36
22	**20.2**	32.5	0	**83**	N	14:28	29.3	36	36	29.9	19
23	14.6	19.1	13	44	SW	14:41	15.7	62	48	17.5	1
24	12.7	19.5	0.2	54	WSW	16:17	14.5	51	37	18.6	2
25	7.4	14.8	**20.2**	69	SW	13:22	10.7	69	**77**	12.2	0
26	8.5	18	4.8	54	SW	1:51	14.4	50	63	17.1	0
27	12.1	18.7	2.8	33	SSW	19:44	14.1	80	63	16.8	1
28	13	19.6	0	37	SSW	14:55	14.7	64	62	18.3	2
29	11.3	21.8	0	39	ESE	20:21	14.7	76	67	19.9	2
30	12.1	29.8	0	48	ESE	18:54	18	68	36	27.9	9
31	16.2	27.8	0	39	E	20:11	21.2	55	45	26.1	7

Table 3-2 Daily weather data for January 2007

Date	Temperature (°C)		Rainfall	Max Wind Gust	Wind Gust	Time of Wind Gust	9am		3pm		
	Min	Max	(mm)	(km/h)	Dir.		Temp (°C)	RH (%)	RH (%)	Temp (°C)	FFDI
1	17.3	27.4	0.2	52	ESE	17:18	19.1	90	24	55	5
2	15.6	30	0.4	43	SSE	17:15	20.8	74	27	44	8
3	16.1	31.7	0	50	SSE	16:25	23.4	64	29	38	14
4	18.8	34.6	0	43	NNW	11:27	26.4	38	32.9	28	18
5	22.2	36.6	0	70	N	11:01	27.5	36	34.6	23	36
6	21.2	35.6	0	**76**	N	17:12	29.8	**30**	33.9	24	43
7	20.9	23.8	0	61	W	12:18	22.7	59	19.6	67	5
8	12.8	19.2	0.2	44	SSW	2:26	15	63	18.4	50	6
9	**9.5**	24.5	0	**26**	SE	18:56	15.9	64	24.5	44	8
10	11.3	36.8		50	N	17:38	21.8	49	35.1	**11**	44
11	**27.8**	32.1		57	NW	8:12	28	32	24.5	53	9
12	15	24.8	0	35	SSW	10:27	19.8	59	22.3	38	9
13	15.4	21.6	0	48	SW	14:07	17.3	50	19.5	52	9
14	10.9	21.9	0	43	SSW	15:37	17.1	70	20.4	65	5
15	15.6	25.9	0	35	S	16:26	16.7	80	21.1	65	4
16	15.5	**41.5**	0	52	N	16:13	20.1	81	40.3	22	48
17	19.9	32.5	0	37	SSW	16:54	29.9	32	22.1	77	3
18	17.7	32.8	0	33	ESE	19:23	18.6	85	30.2	48	8
19	18.3	28.6	3.4	30	ENE	19:31	20.2	**99**	26.6	80	2
20	20.1	27.9	2.8	48	NNE	20:46	23	**99**	24.9	**87**	1
21	15.3	24.6	**16.4**	63	W	16:29	17.9	80	23	46	0
22	14.9	21.3	1.8	39	WSW	3:26	16.3	76	19.9	56	0
23	11.3	25.2	0	37	SSW	16:28	17.6	77	22.5	61	2
24	15.3	22.4	0	39	SSW	12:33	18	75	20.3	43	6
25	12.6	20.9	0	35	SW	13:30	17.1	64	19.3	48	6
26	12.3	23.5	0	44	SW	18:04	16.2	70	21.9	47	6
27	11.8	**17.9**	2.6	61	SSW	3:41	13.5	62	15.6	53	6
28	13.3	20.9	0.4	50	SW	14:28	15.5	78	20	53	7
29	15.4	25	0	37	W	13:49	16.2	73	21.8	63	4
30	13.7	24.5	0	46	SSW	17:21	19.6	81	21.1	64	4
31	11.2	21.2	0.4	46	SE	17:27	15.3	52	19.6	41	11

Table 3-3 Daily weather data for February 2007

Date	Temperature (°C)		Rainfall	Max Wind Gust	Wind Gust Dir.	Time of Wind Gust	9am		3pm		
	Min	Max	(mm)	(km/h)			Temp (°C)	RH (%)	RH (%)	Temp (°C)	FFDI
1	11.2	28.4	0	41	ESE	19:39	14.7	68	25.8	37	13
2	12.3	33.1	0	**28**	SW	17:00	19.9	81	30.8	30	19
3	14.7	24.8	0	41	SSW	14:34	17.8	98	21.5	73	4
4	14.3	28.9	0	30	SE	18:46	18.6	83	24.8	57	6
5	14.2	33.8	0	54	SSW	16:25	22.9	72	32.8	21	27
6	15	**21.3**	0	46	S	14:44	15.7	66	19.7	56	6
7	15.7	22.5	0	44	SSW	16:53	18.5	71	21.4	54	6
8	14.9	23.1	0	44	S	14:56	17.2	60	21.5	46	10
9	**10.9**	32.1	0	48	SW	22:21	18	78	31.5	31	15
10	17.5	21.7	0	44	WSW	23:23	17.9	87	19.9	**99**	1
11	17	27	2.2	**85**	ESE	15:24	20.6	88	25	58	13
12	17.7	30.8	0	69	ESE	23:02	20.9	76	30	34	18
13	14.8	32.1	0	50	N	9:41	23.1	52	30.8	31	14
14	16.2	26.7	0	35	WSW	15:45	21.7	82	25.8	58	5
15	18.5	34	0	33	S	16:45	21.1	86	32	32	18
16	18.4	36.8	0	52	ENE	16:57	28	34	36.2	19	32
17	**23.1**	37.7	0.4	48	N	9:05	27.5	38	36	22	29
18	19.3	**39**	0	69	SSW	17:40	29	**32**	37.6	**21**	39
19	20.2	27.9	3	33	SSE	14:15	21.1	98	25.6	76	3
20	18.8	29	0	43	SW	22:42	20.7	97	24.9	75	3
21	20.2	29.2	0	44	SW	23:04	21.5	96	26.1	74	4
22	19.9	28.3	0	30	SW	15:56	22.3	84	26.2	66	4
23	19.9	26.8	0	35	SSW	22:40	21.8	90	26.1	68	4
24	17.5	23.6	2	39	SSW	18:13	18.3	99	23.1	62	5
25	16.1	23.4	0	48	SSW	15:26	19.1	73	22.1	67	5
26	15.2	31.2	0	59	ESE	18:44	18.7	87	26.5	53	8
27	17	25.4	0	52	ESE	16:02	18.7	74	24	47	12
28	17.8	28.1	4.6	37	WSW	16:45	19.4	100	25.1	63	4

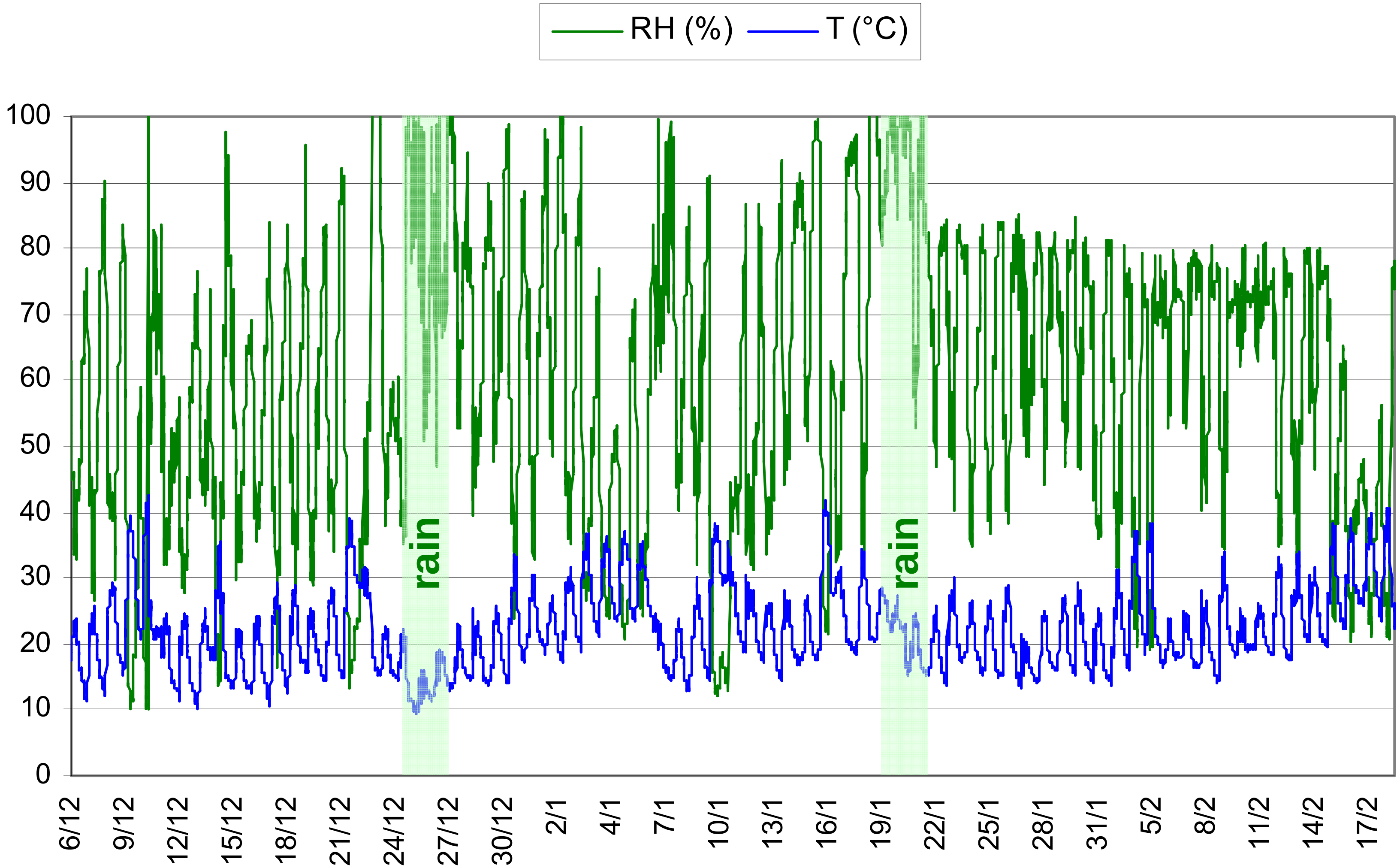


Figure 3.3 Air temperature and relative humidity values at exposure rack , summer 2006-7

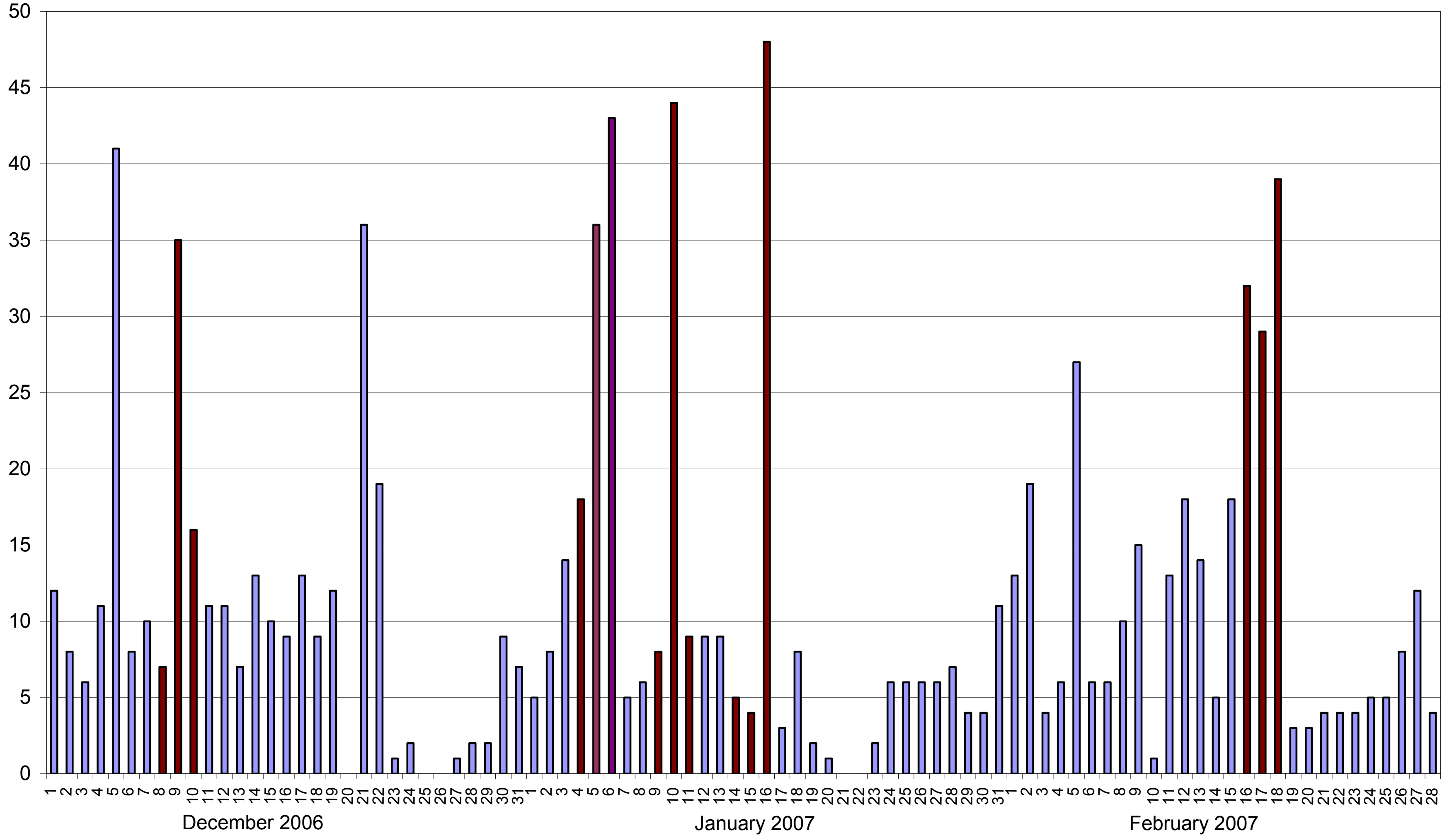


Figure 3.4 Daily 3pm Forest Fire Danger Indices (FFDI), summer 2006-7

(The columns shown in brown represent the periods of high fire risk weather conditions referred to in Section 3.3)

3.2 Variation in moisture content during the summer

Two illustrations of the variation in the moisture content in the timber specimens during the summer are presented:

- Plots of the moisture content in the Blackbutt specimen
- Variation in moisture content with temperature and relative humidity

3.2.1 Plots of the moisture content in the Blackbutt specimen

To give a general indication of how the moisture content varied during the summer, two time periods have been selected, 1-18 January and 9-18 February. These have been select because they roughly span between rain periods (occurring on 27/12 and 19/1, and on 11/2 and 19/2) The values relate to the Blackbutt timber specimen exposed to full sun as it was mounted on the most stable load cell and hence gave the most accurate values. Other timber specimens followed similar profiles as can be seen in the later section - 3.3 Periods of high fire risk weather conditions. Plots of the variation in the moisture content in the Blackbutt specimen, during the two time periods are shown in Figure 3.5 and Figure 3.6.

From the January plot it can be seen that there are three periods in which the moisture content dropped significantly.

- **2-6 January**. This period is characterised by four days of maximum daily temperatures in the high 30s and minimum daily relative humidities below 30%. As a result the moisture content in the timber steadily decreases from a high of almost 11% to below 8%. The trend is broken by a cold change in the weather followed by some light rain. The FFDI reached 43 on the 6th.
- **8-11January**. This period is much shorter and is characterised by gradually increasing average temperature and decreasing average relative humidity. In the last two days there is a sharp increase in temperature (peaking at ~38ºC) followed by sustained temperatures above 30ºC for 24 hours before a cool southerly change occurs. Similarly the relative humidity drops to ~13% and remains below 20% for the 24 hours prior to the change.
  The FFDI reached 44 on the 10th.

- **16 January**. There is a rapid 24 hour change in the weather from days of mild, mid to high 20s temperatures and increasing relative humidity (above 50%) to a peak temperature above 40ºC and relative humidity dropping to near 20%. The period ends with a cool change dropping temperatures and eventually resulting in rain.
  The FFDI reached 44 on the 16th.

It is interesting to note that:

- Between the second period (8-11 January) and the last period on the 16 January the moisture content in the timber only increases slightly. This is likely to be due to the cool change on the 11 January being dry and the average daily humidity only gradually beginning to increase in the days following. Hence the moisture content can remain low for days following a peak in the weather conditions.
- The minimum moisture content in the specimen during each of the three periods is approximately the same (7.7-7.9%)
- Maximum daily variation in the moisture content can be up to 2%
- The average daily variation in the moisture content is around 1%
- During hot weather daily variation in the relative humidity can typically be between 20-80% RH.

The variation in the moisture content should be viewed in the context of the timber species used and the geometry of the specimens, particularly its length parallel to the grain.

The February plot spans the period between light rain on the 11th February and again on the 18th February. During the first half of the period (12-15 February) the weather is mild with maximum temperatures around 30°C and relative humidity staying above 30% during the day and up to 80% overnight. However during the last half of the period (16-18 February) the weather is much hotter with maximum daily temperatures near 40°C and relative humidity dropping to near 20% during the day and staying below 55% overnight.

The moisture content in the specimen gradually drops over the period from a starting high of around 11% on the 11th February to a low of around 7.6% on the 18th February. The greatest drop, (from 10.5% overnight to 8.5% the next day), occurs on the 15th when the weather turns hot and dry. The drop in moisture content is halted when a wet southerly change occurs. It is interesting to note that the January and February low points in moisture content are all in the 7.5-8% range.

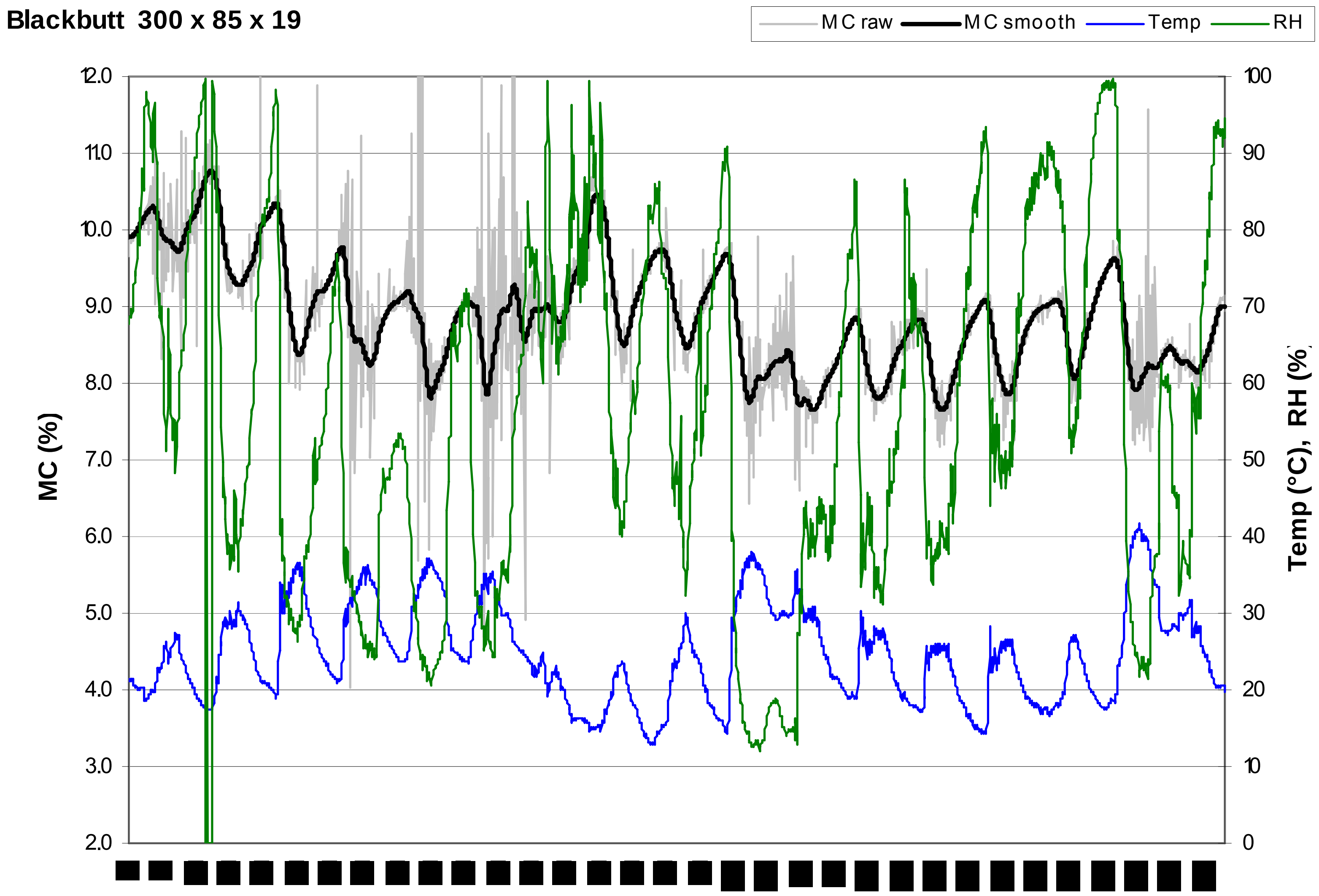


Figure 3.5 Moisture content in Blackbutt specimen (full sun exposure), January

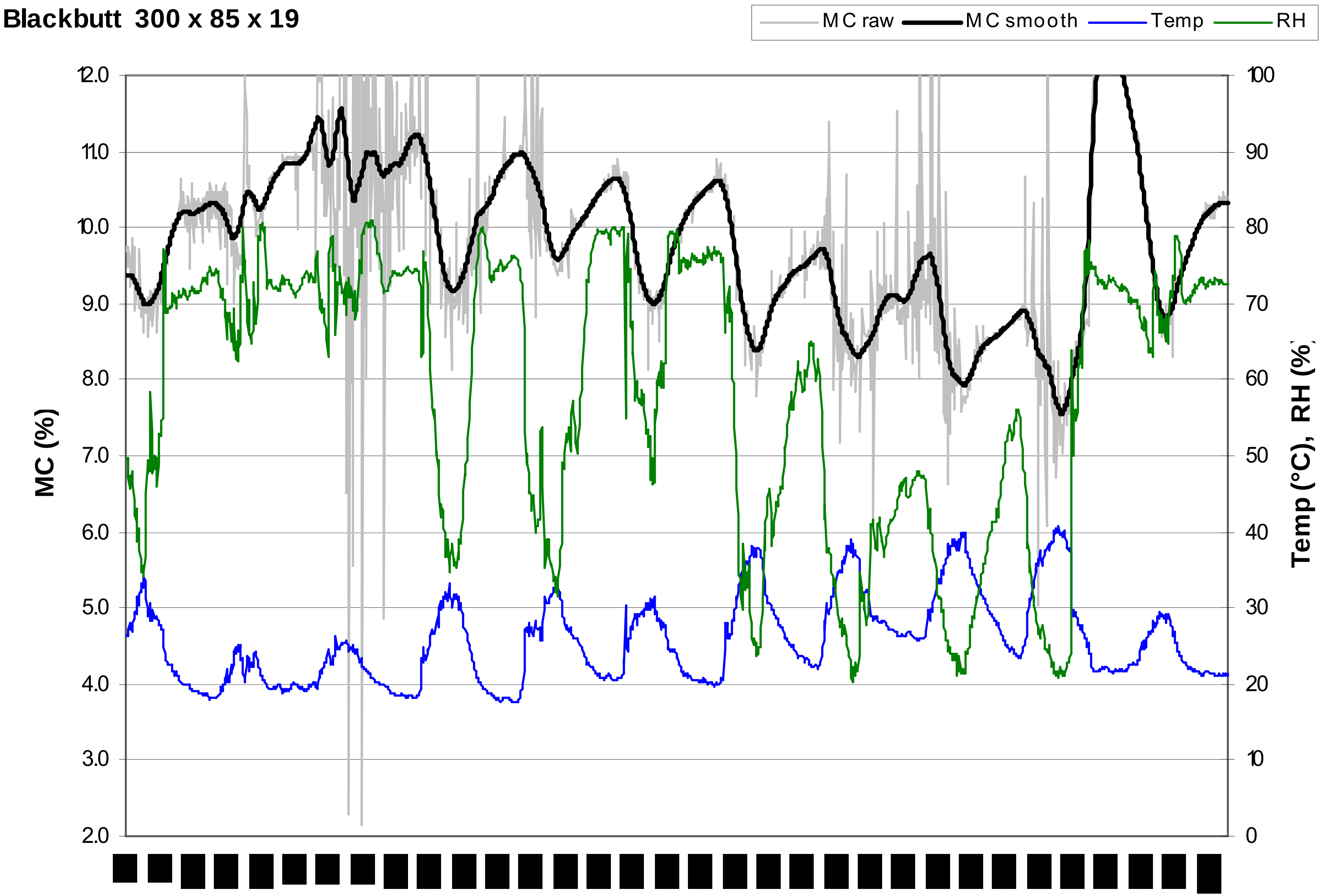


Figure 3.6 Moisture content in Blackbutt specimen (full sun exposure), February

3.2.1 Variation in moisture content with temperature and relative humidity

Plots of the variation in the moisture content of five timber specimens exposed to full sun between 1st January to 5th February 2007 are given in Appendix A. Data relating to rainy days has been removed. Only the moisture contents of five of the six timber specimens exposed to full sun are shown because one, (Spotted Gum 300L x 85W x 20D), had a faulty load cell and the data could not be used.

The range in the temperature and relative humidity over the period are shown in *Figure 3.7*. For the majority of the values (bordered in blue):

- The temperature range is 15-40°C
- The relative humidity range is 10-90% RH
- The extreme conditions are:
  - 15°C and 90% RH
  - 40°C and 10% RH

The following points can be noted from the plots in Appendix A.

- The two thinner (10mm thick) specimens experienced the greatest range in moisture contents
- The Mountain Ash specimen (300L x 100W x 10D) experienced moisture contents below 5.5%
- The lowest moisture contents generally occurred when temperatures were above 25°C and relative humidity was below 40%.
- The Jarrah specimen had moisture contents that rarely dropped below 8.5%

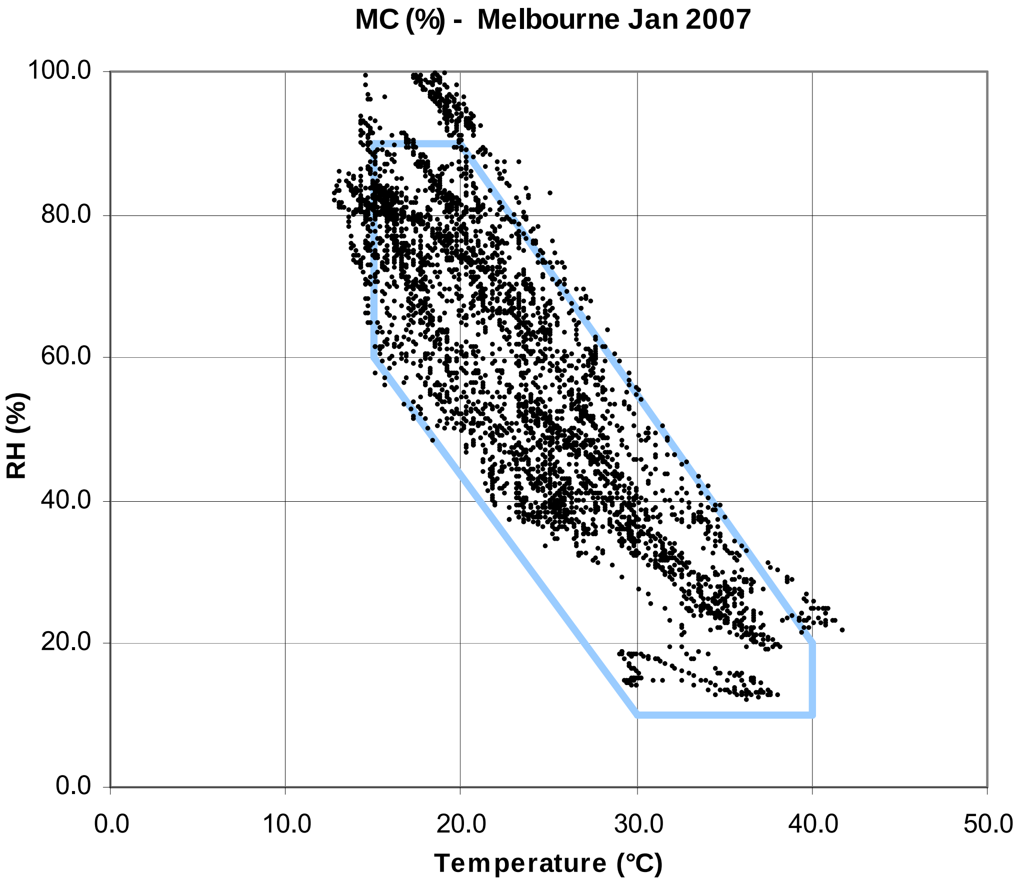


Figure 3.7 Weather conditions during January 2007

3.3 Periods of high fire risk weather conditions

A reasonable assumption in designing a timber deck or building component for bushfire is that it could to be exposed to high fire risk weather conditions prior to the fire front or ember attack. Hence, as input for design testing or software, it is important to know the likely moisture content in the timber under these conditions.

Five periods of high fire risk weather over the summer are considered.

- 8-10 Dec
- 4-6 Jan
- 9-11 Jan
- 14-16 Jan
- 16-18 Feb

The periods have been kept to only a few days in length to improve the readability of the plots and to focus on the critical peak values.

The data used here is based on the logged timber specimens exposed to full sun. Prior to the last period, (16-18 Feb), the original 6 timber specimens were removed from the load cells for analysis and replaced with similar specimens that had been exposed under the same conditions over the summer. However the mountain ash (300L x 100W x 10D) specimen was replaced with a cypress pine (300L x 66W x 20D) specimen.

The plots of the moisture content, air temperature and relative humidity for each timber species/period are given in Appendix B. Table 3-4 summarises the lowest moisture contents recorded during each period. In the table each period has been ranked from lowest to highest moisture content based on the average moisture content in the specimens for the period. Also the lowest moisture content recorded for each timber species over all the periods is given.

The following points can be noted from Table 3-4.

- Low moisture contents down to 6% were possible especially with thinner sections
- The moisture content depends on the species and sample dimensions.
- The moisture content in the Jarrah specimen remained above about 9% for all of the summer.

Plots of the air temperature and relative humidity during each period are shown in Figure 3.8. The ranking given to each period in Table 3-4 has been added in the lower left hand corner of each plot. Two lines have also been added to the plots:

- The green line illustrates the dryness of the conditions at the time the lowest moisture content occurs. The shorter the line the dryer the conditions
- The orange line illustrates the variation in conditions over the proceeding 24 hours prior to the lowest moisture content occurring. The shorter the line the less the conditions varied.

It can be seen that there is a correlation between the length of the lines and the ranking value, i.e. generally the longer the lines the higher the ranking, with the length of the green line more critical than the orange line.

Table 3-4 Lowest moisture contents recorded for each period of high fire risk weather

Timber Species	8-10 Dec	4-6 Jan	9-11 Jan	14-16 Jan	16-18 Feb	Low MC
Merbau 300x90x18	6.0	6.8	6.3	7.3	6.2	**6.0**
Blackbutt 300x85x19	8.7	7.9	7.6	7.8	7.7	**7.6**
Mountain. Ash 300x100x10	6.5	6.5	5.8	7.4	5.8	**5.8**
Spotted Gum 300x100x10	6.0	6.5	6.1	6.5	6.1*	**6.0**
Jarrah 300x85x20	9.5	9.0	9.5	8.8	8.8	**8.8**
Average	7.34	7.34	7.06	7.56	6.92	
Ranking lowest to highest MC	**3**	**3**	**2**	**4**	**1**	

* predicted value used as specimen was not available.

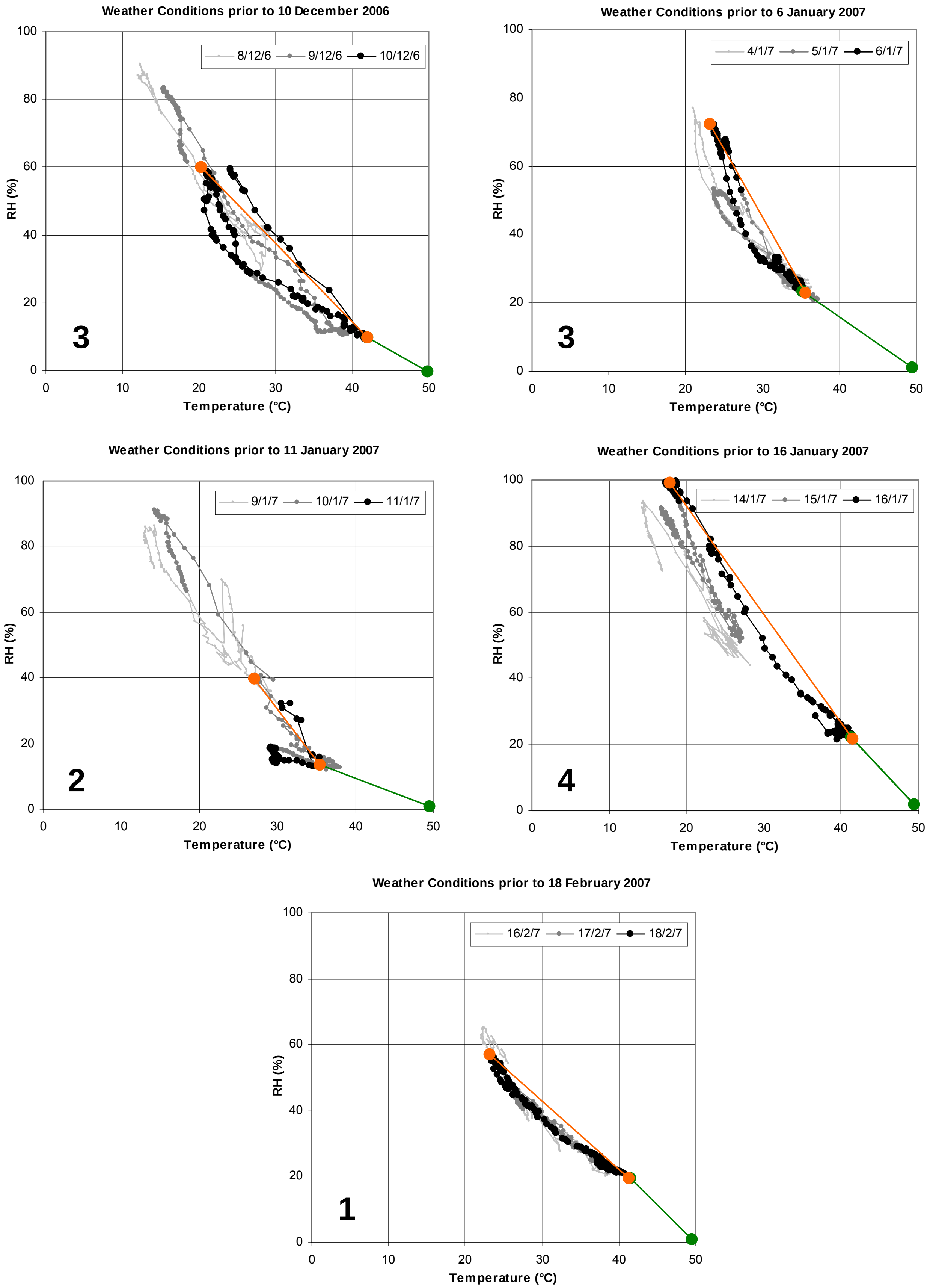


Figure 3.8 Periods of high fire risk weather conditions

3.4 Loose Specimens

The loose specimens are those that were positioned on the:

- wire mesh next to the logged specimens on the exposure rack
- timber deck nearby.

A comparison of the moisture contents for the logged and loose specimens exposed to full sun are shown in Figure 3.9, Figure 3.10, Figure 3.11 and Figure 3.12. This covers the period 14-20 February which was the last high fire risk period recorded for the summer. Only four of the five species available are shown because the densities of the logged and loose specimens for jarrah were too different to make a fair comparison. In the plots the ‘MC mesh’ data (shown as ● ○ for specimen 1 and 2) refers to the specimens on the wire mesh while the ‘MC deck’ data (shown as ●) refers to the specimens on the timber deck. The ‘MC raw’ and ‘MC smooth’ refers to the logged specimens.

The following points are noted:

- The specimens (MC mesh) on the wire mesh had moisture contents which were consistent with the moisture content profiles of the logged (MC smooth) specimens.
- The specimens (MC deck) on the deck had moisture contents which were much lower than those for the logged specimens.
- 3/5 of the specimens on the wire mesh matched the logged specimens moisture contents very well, while none of the specimens on the deck matched the logged specimens.
- Where there was a difference between the loose specimen data points (●,○ or ●) and the logged specimens profile (solid black line) at the start of the period it is maintained throughout the period. i.e. confirms the profiles shape.

Possible reasons why 2/5 of the specimens on the wire mesh had moisture contents that were slightly offset from the logged specimens are:

- differences between the specimens e.g variation in density, grain etc
- position and placement on the exposure rack

The difference between the moisture content of the specimens placed on the timber deck and those on the exposure rack is harder to identify. It appears that the deck specimens had moisture contents over the summer that were consistently lower than those on the exposure rack.

Possible reasons are:

- The environment. While the macro environment in terms of orientation and exposure to the sun was the same, the deck was in a slightly more sheltered position in terms of airflow due to adjacent buildings and fences. However the micro environments were much different. The specimens on the deck were only exposed to the air on their face and sides while the exposure rack specimens are exposed on all faces. For the specimens on the deck, the surrounding deck could have acted as a heat trap resulting in the specimens being heated more than those on the exposure rack. It was observed that the deck specimens appeared hotter than the exposure rack specimens during measurements taken during the heat of the day.

- Differences between the specimens. This is unlikely as the comparisons were made between specimens of similar timber properties (generally cut from the same board or batch of boards)

Three other comparisons were made comparing the moisture content in the loose and logged specimens.

1. 10am 8th March. The moisture contents of the specimens when they were removed at the end of the summer for oven drying are shown in Figure 3.13. The moisture contents are high because they reflect the cooler conditions, being in the morning and into autumn. However the same relationship of the deck specimens having much lower moisture contents is still evident.

2. 1:30pm 16th January. The moisture contents of the specimens are shown in Figure 3.14. The Jarrah mesh value is missing as a specimen was not available. The moisture contents of the logged and mesh specimens (both on the exposure rack) are very similar except for the Mountain Ash which has about a 1% MC difference. However the deck specimens again have much lower moisture contents than the exposure rack specimens.

3. The moisture contents of the specimens on the 5th February are shown in Figure 3.14. The thick lines are the moisture contents for the logged specimens derived from the raw unsmoothed data. Insufficient data was available to warrant smoothing due to the specimens being removed at the start and the end of the day to check for zero creep in the load cells. The coloured in circles (●) represent the moisture contents from the loose specimens on the exposure rack while the circles (○) represent the moisture content of the specimens on the deck.
   The following points can be noted:

   - All species except Jarrah had fair to good correlation (all within ±1.0%MC, most within ±0.5% MC) between the loose and logged moisture contents. Note. Moisture content for a Jarrah specimen on the mesh was not available.
   - Mountain Ash was the only species showing a higher moisture content for the deck specimen compared to the mesh specimen.

In summary the moisture contents from the logged specimens are consistent with the manually recorded values from the loose specimens on the exposure rack. The maximum difference between the two is in the order of 1% MC, while the average difference is less than 0.5% MC. However the moisture contents from the control specimens placed on the deck nearby are consistently lower than the exposure rack values. Hence the environment around the exposure rack (bitumen and brick surfaces) has not caused moisture contents that are lower than might be expected.

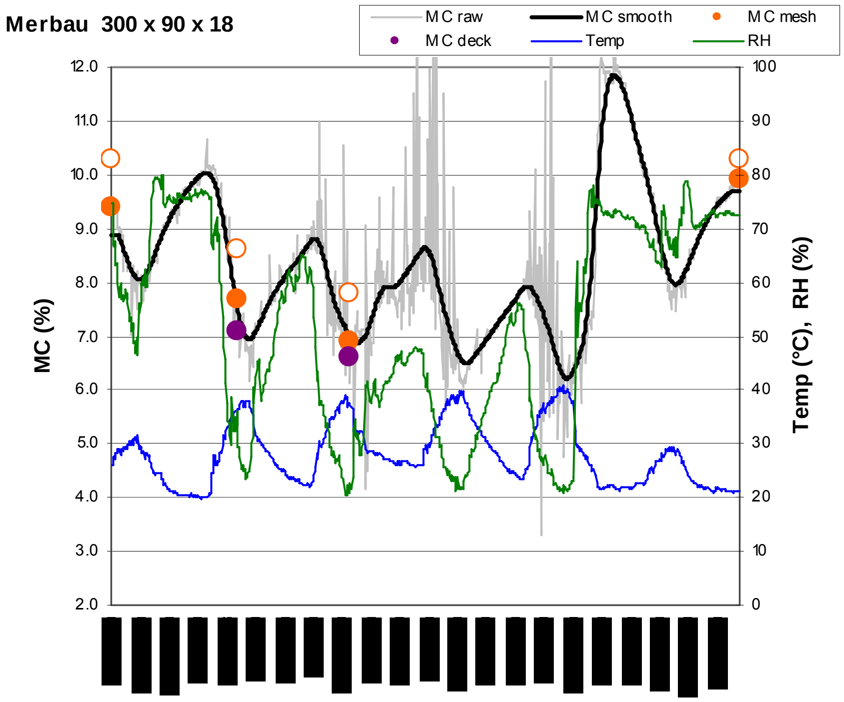


Figure 3.9 Comparison of moisture contents in Merbau

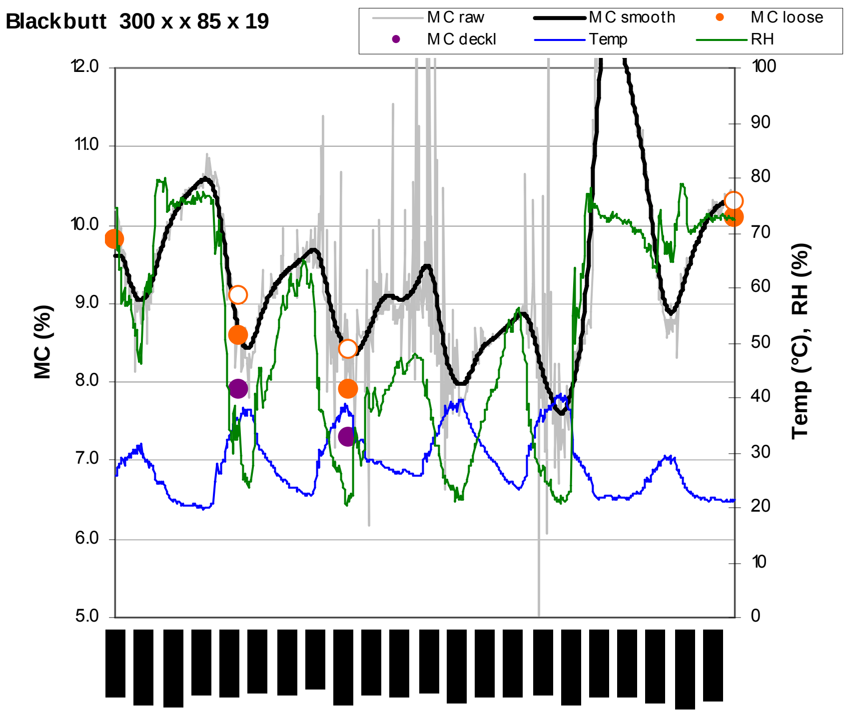


Figure 3.10 Comparison of moisture contents in Blackbutt

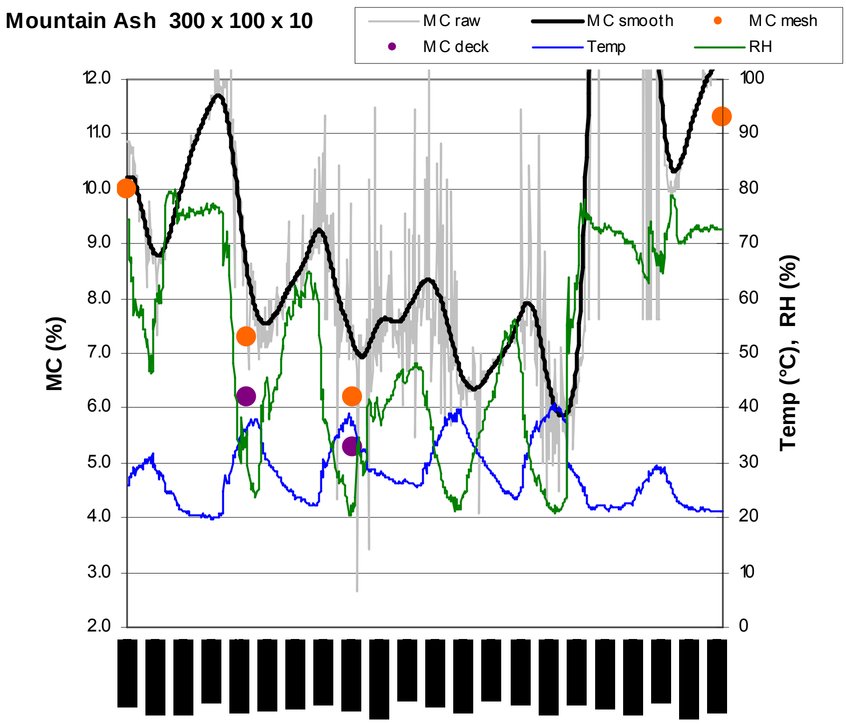


Figure 3.11 Comparison of moisture contents in Mountain Ash

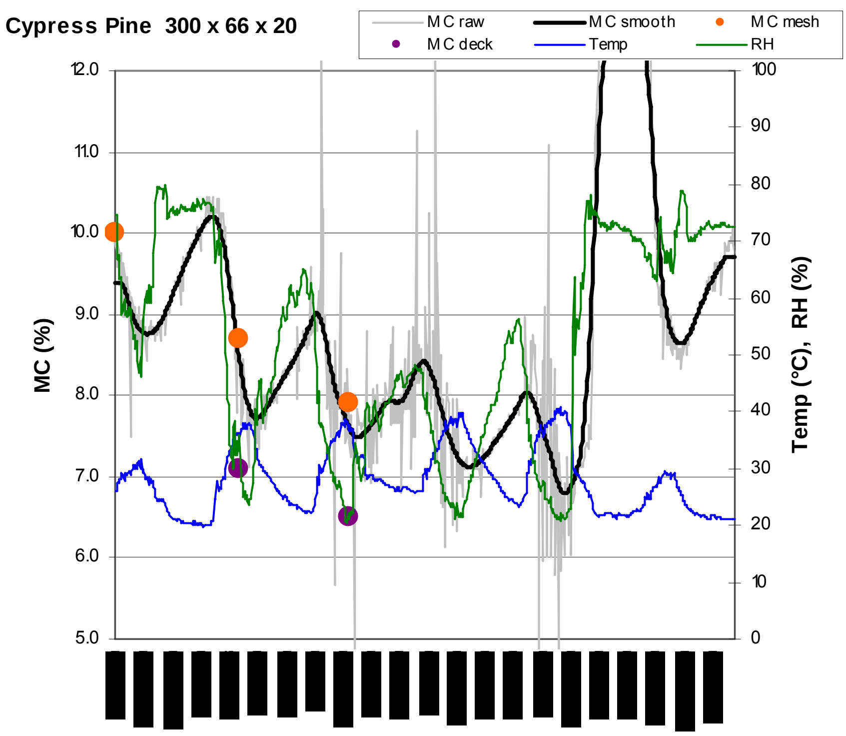


Figure 3.12 Comparison of moisture contents in Cypress Pine

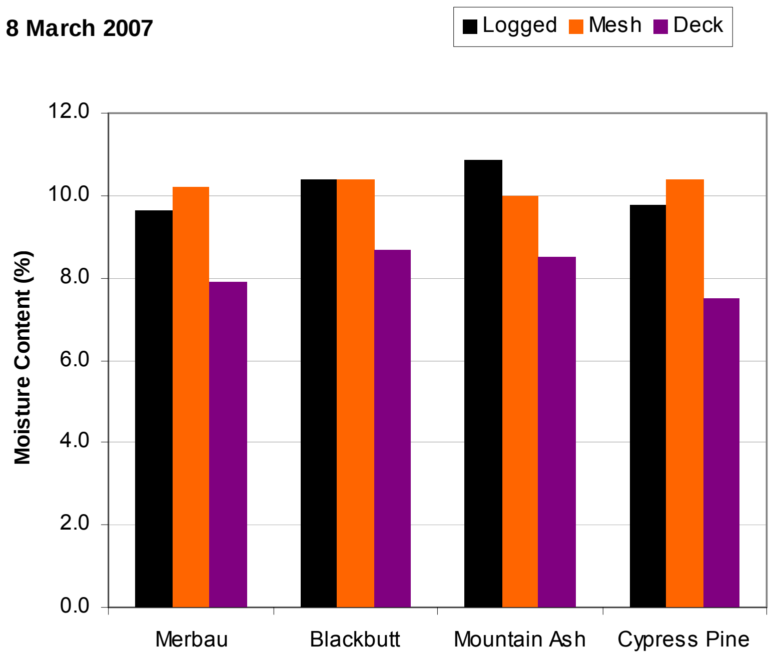


Figure 3.13 Comparison of moisture contents on 8 March at 10am

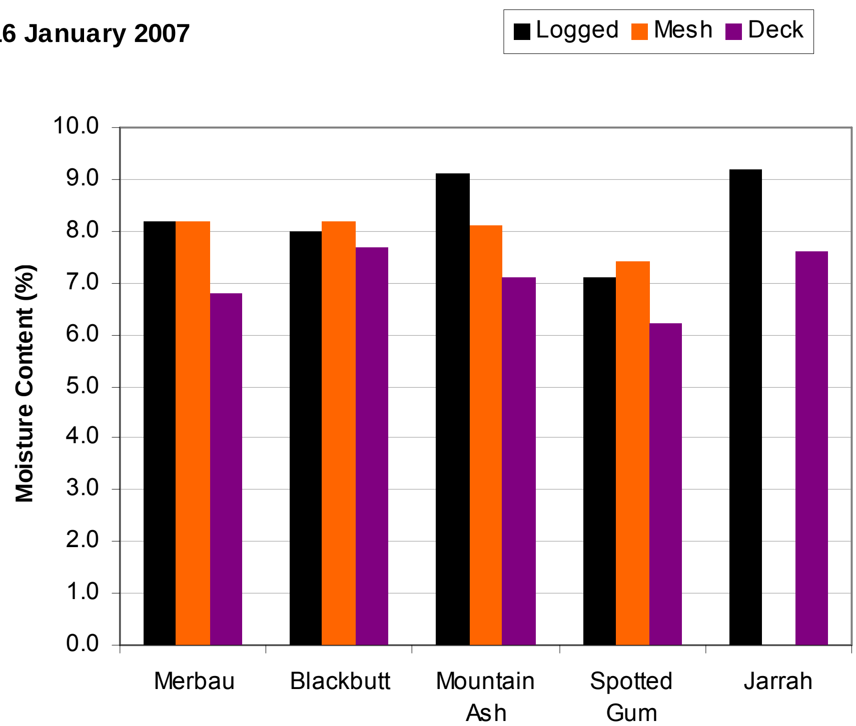


Figure 3.14 Comparison of moisture contents on 16th January 2007

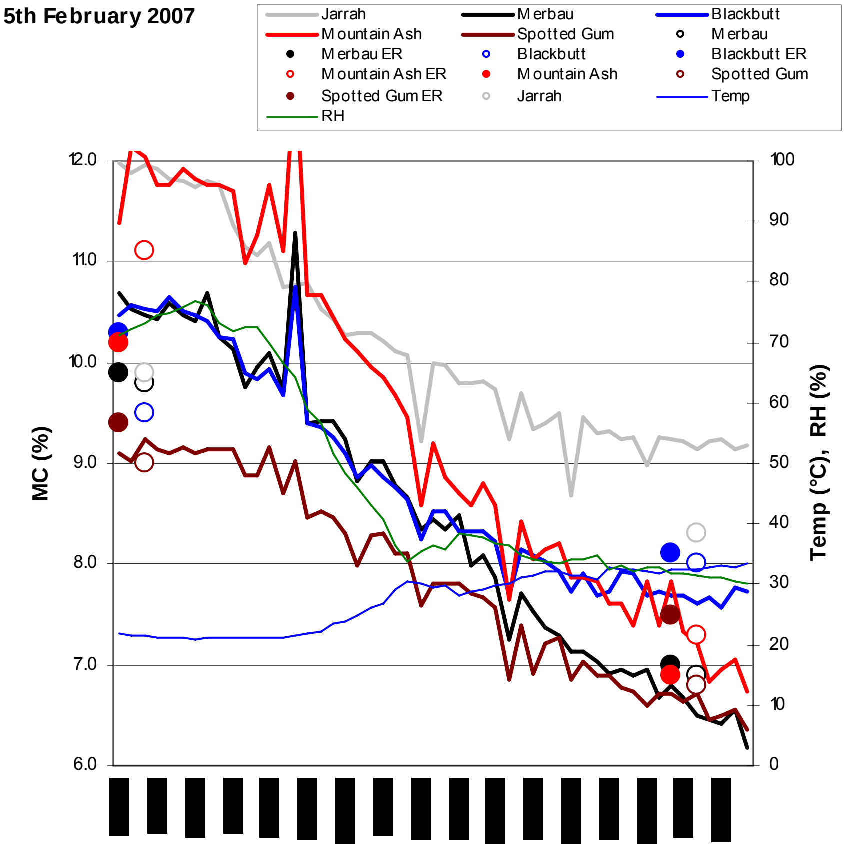


Figure 3.15 Comparison of moisture contents on 5th February 2007

3.6 Comparison of full sun and sheltered conditions

As mentioned before only limited data for the fully sheltered specimens was available due to problems with the load cells and adverse wind loading caused by the awning. Hence only a brief comparison is made here between the Mountain Ash specimens, one exposed to full sun and the other sheltered under the awning. The plots of the moisture content for each for the period 14-20/2/7 are given in *Figure 3.16* and *Figure 3.17*. *Figure 3.18*.

The main points are:

- The peaks on the 15/2 and 19/2 are due to high humidity and rain.
- The full sun specimen experiences a greater variation in moisture content.
- The minimum moisture content (5.9%) for the period is approximately the same for both specimens.

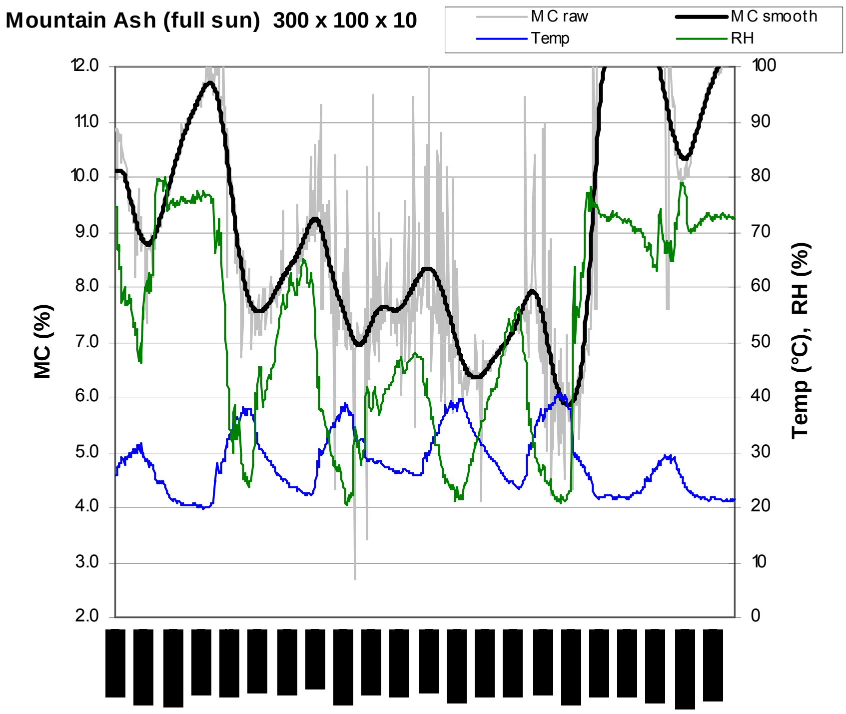


Figure 3.16 Mountain Ash exposed to full sun 14-20/2/7

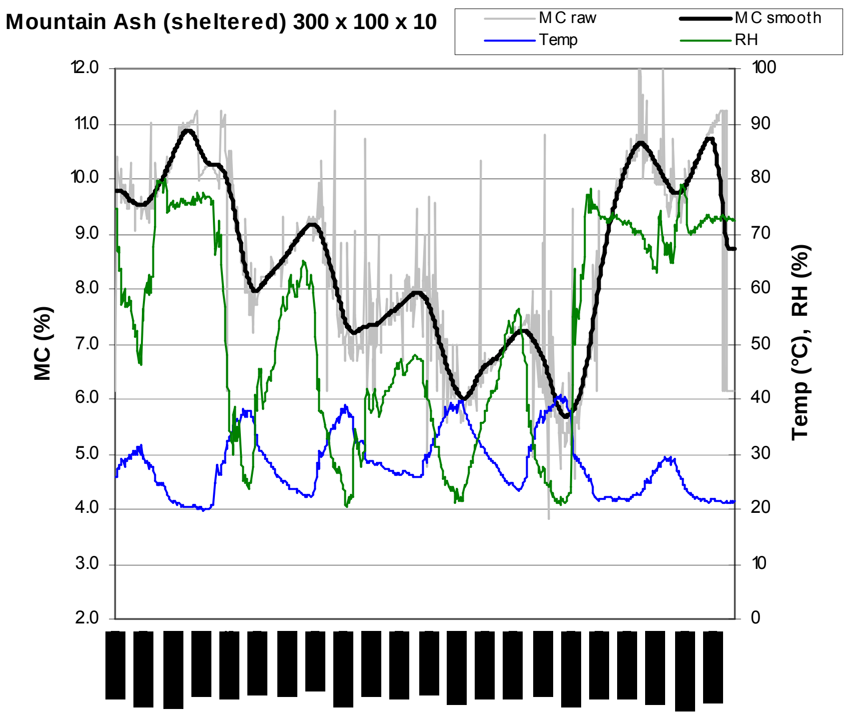


Figure 3.17 Mountain Ash sheltered from sun 14-20/2/7

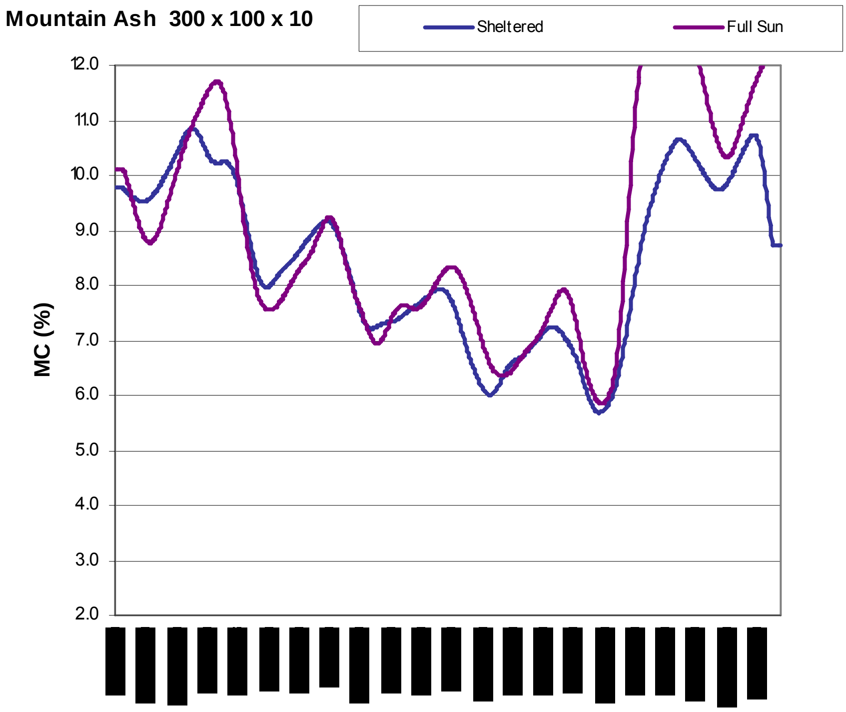


Figure 3.18 Mountain Ash, effect of shelter, 14-20/2/7

3.7 Drying of timber specimens

Additional work was undertaken when the loose specimens were removed at the end of the summer to determine how the moisture content in the specimens reduced during drying. This is helpful when test materials need to be conditioned to a moisture content (to reproduce actual conditions) prior to testing. The specimens include the deck and mesh specimens used in the preceding section.

The procedure used to dry the specimens was as follows:

- The specimens were removed from the exposure rack, weighed and then placed in a conditioning room for 11 days at 22˚C and 50% RH to return the specimens to room conditions, (e.g. typical storage conditions use for testing material).
- The specimens were reweighed and placed in a conditioning room for 16 days at 45˚C and 18% RH. Their mass was recorded each day.
- The specimens were placed in an oven at 100˚C for 6 days and then weighed.
- The specimens remained in the oven for up to another 38 days until a stable oven dry mass was achieved.

Figure 3.19 to Figure 3.25 show the moisture contents of the various timber species during drying. The species and specimen dimensions are given in the top, left corner of the figures. The first 3 figures (Merbau, Blackbutt and Spotted Gum) are based on data from 6 specimens each. Hence a minimum, maximum and average are shown. The next 3 figures (Mountain Ash, Jarrah and White Cypress Pine) are based on only 2 specimens each. Hence the specimens are identified by their oven dry mass and an average. The last figure, Figure 3.25, shows a summary of the average values for each of the species. In Figure 3.21 for Spotted Gum an addition line has been included to show the average (of two specimens) for the 10mm thick specimens.

While the plots are based on only a few specimens they do provide some idea of how the moisture content changes as the timber dries out. Obviously variations such as size, density, or timber source will affect the moisture content profiles.

3.7.1 Conditioning of decking material prior to testing

The range of moisture contents that occurred at the peak of the bushfire weather over the summer are given in Table 3-5. The approximate drying times at 45˚C and 18% RH required to reach these values are also given in Table 3-5. This indicates that between 1 and 2 days of conditioning is required.

It should be noted that these values are based on a small sample and that for other locations and/or decking material these times may be different.

Table 3-5 Moisture contents and drying times

Species	Moisture Content (%)	Drying Time (days)
Merbau	6-7	2
Blackbutt	7.5-8.5	1
Spotted Gum	7-8	2
Jarrah	8.5-9.5	1
White Cypress Pine	6-7	1
Mountain Ash*	6-7	1
Spotted Gum*	6-7	1

***10mm thick specimens, all other specimens are 18-20mm thick**

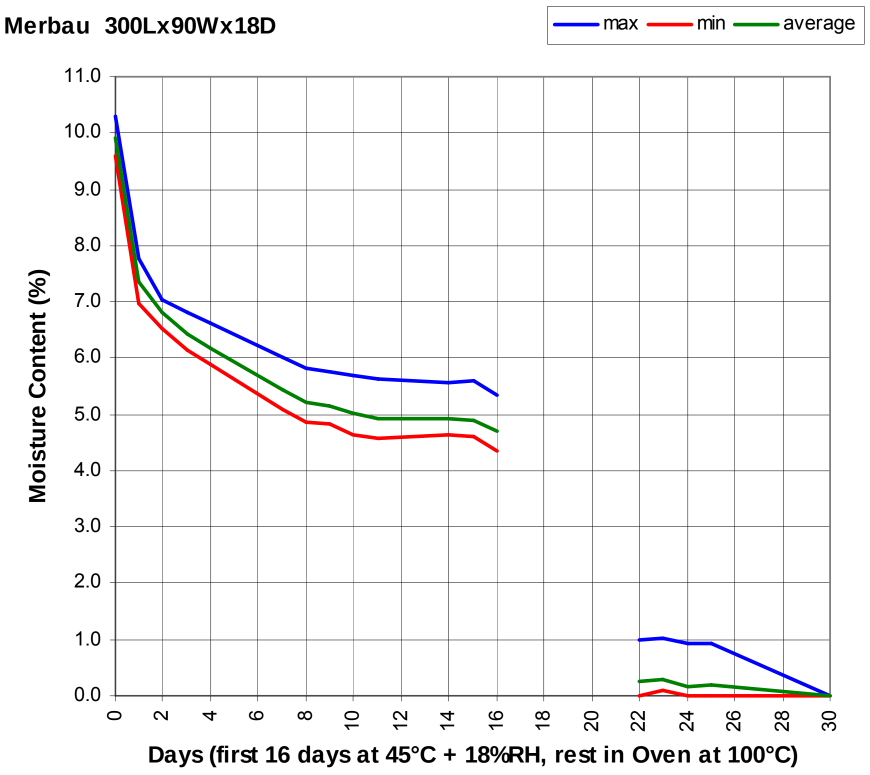


Figure 3.19 Merbau – Moisture Content during drying

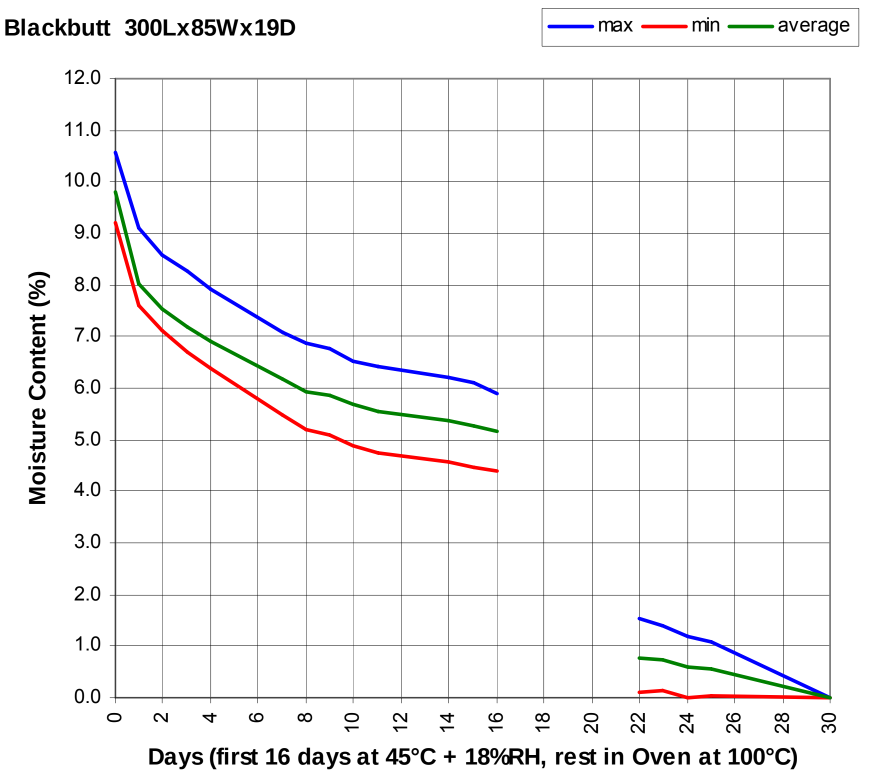


Figure 3.20 Blackbutt – Moisture Content during drying

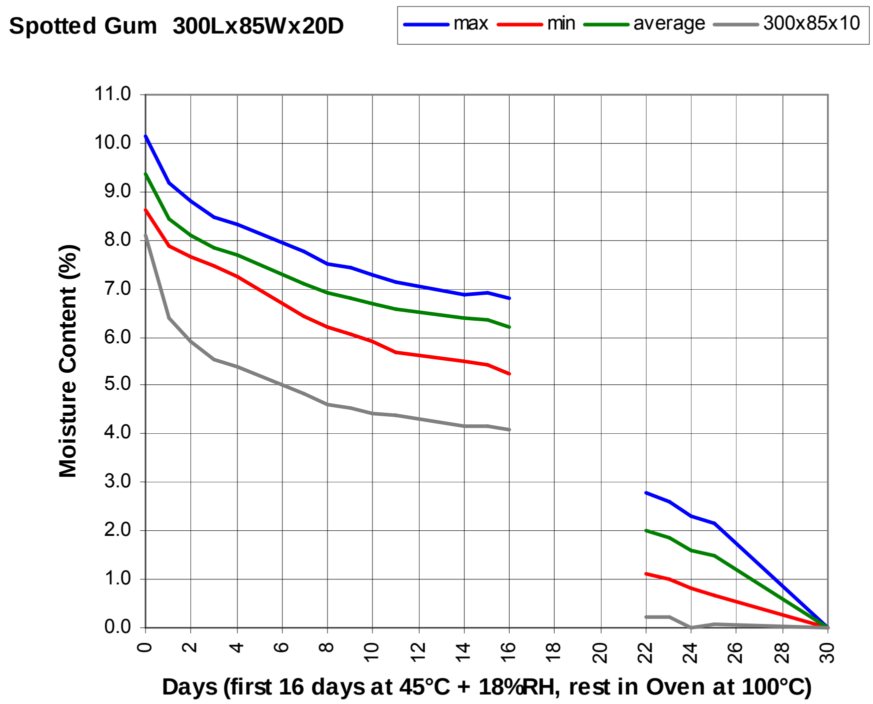


Figure 3.21 Spotted Gum – Moisture Content during drying

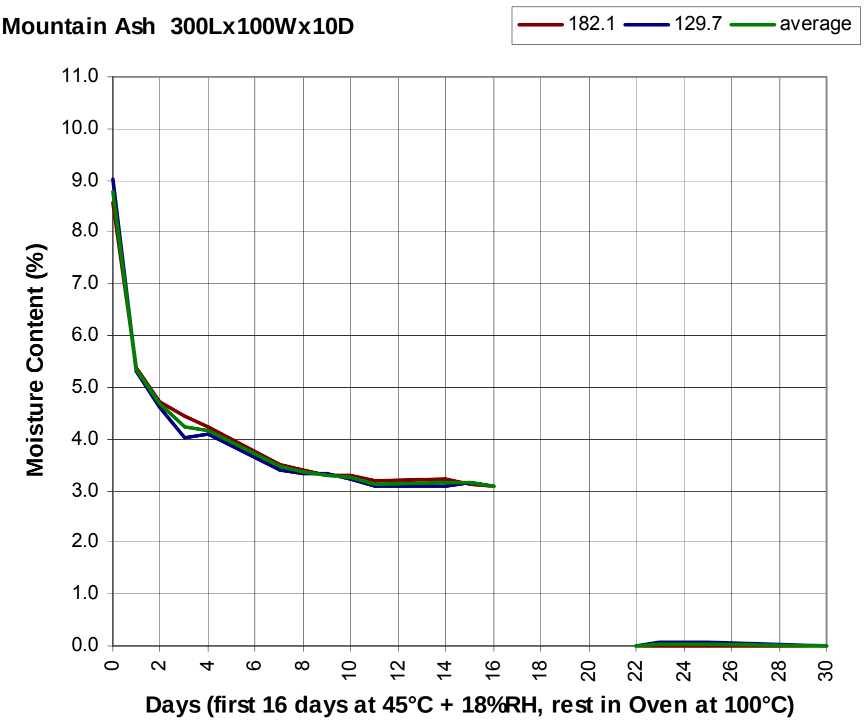


Figure 3.22 Mountain Ash – Moisture Content during drying

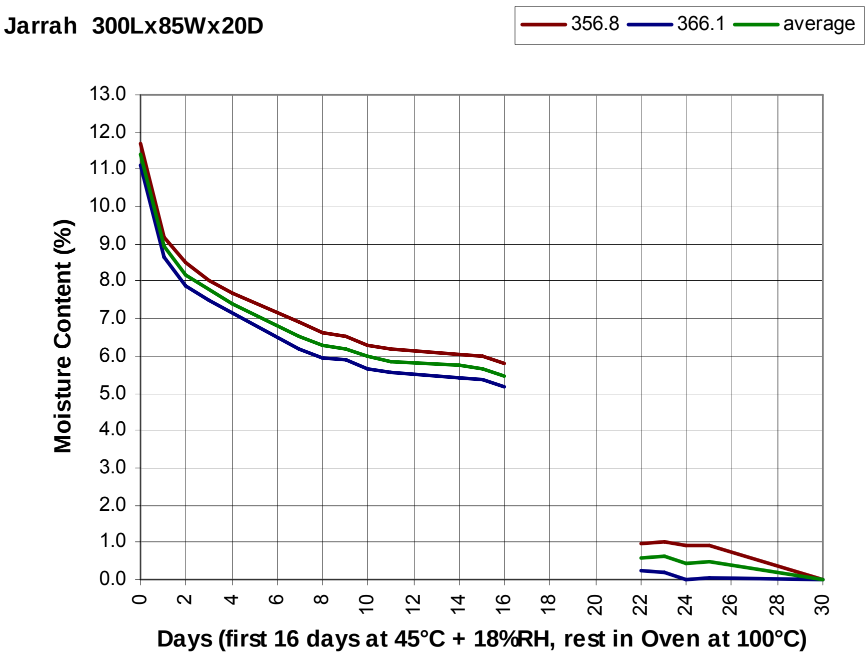


Figure 3.23 Jarrah – Moisture Content during drying

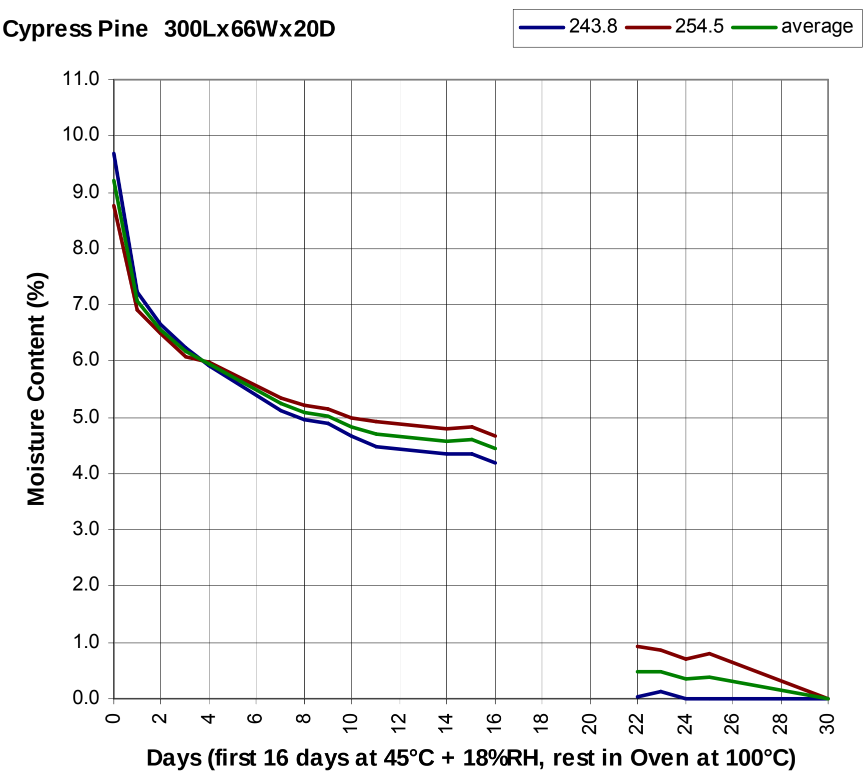


Figure 3.24 Cypress Pine – Moisture Content during drying

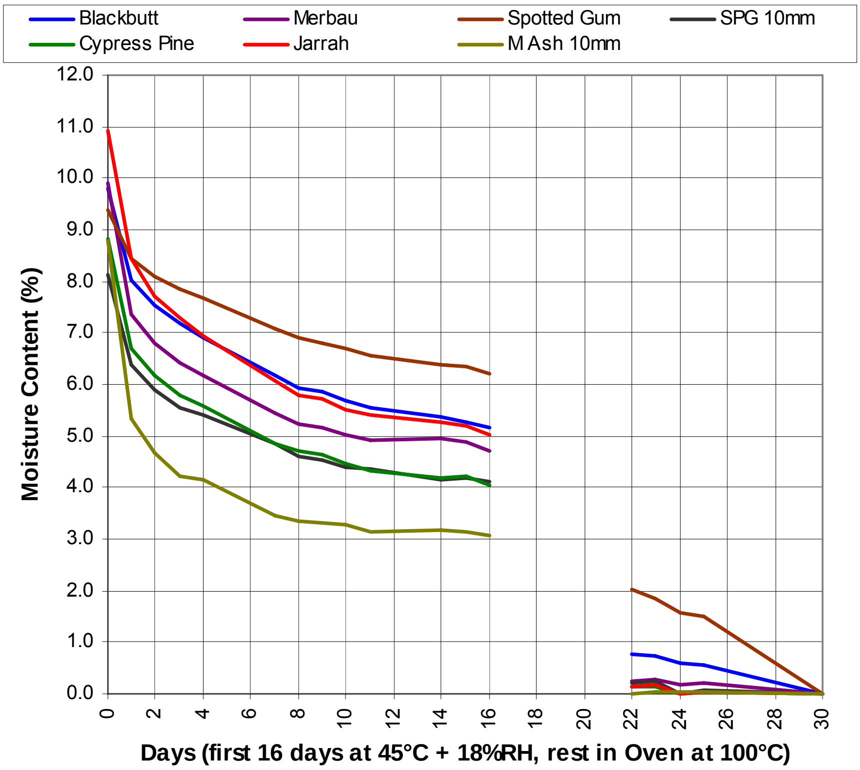


Figure 3.25 All Species– Average Moisture Contents during drying

4. Conclusions

The following conclusions were found:

- The use of load cells to monitor the moisture content in timber specimens can provide reliable data provided appropriate monitoring is used.
- The average moisture content in decking timbers exposed to bushfire weather can be much lower than that implied in AS1530.8.1. Typical values during the peak of the bushfire weather experienced in Melbourne over the summer of 2006-07 were:

Species	Dimensions	Moisture Content (%)
Merbau	300x90x18	6-7
Blackbutt	300x85x19	7.5-8.5
Spotted Gum	300x85x20	7-8
Jarrah	300x85x20	8.5-9.5
White Cypress Pine	300x66x20	6-7
Mountain Ash*	300x100x10	6-7
Spotted Gum*	300x100x10	6-7

- During dry weather the moisture content can typically vary by 1% over a 24 hour period due to the variation in temperature and relative humidity. In addition the average daily moisture content can take a week to cycle down to a stable value. Similarly once the moisture content has dropped and the weather stays dry it can remain relatively low for days
- To condition timber to be used in testing to similar moisture contents as experienced during peak bush fire weather was found to take between 0.5 and 2 days conditioning at 45˚C and 18% RH depending on the dimensions and species.

- Matching specimens that were placed on a timber deck to provide a comparison with those on the exposure rack experienced significantly lower moisture contents. This may be due to the micro environment around the specimens. The exposure rack provided free airflow around the specimens while the deck would have limited the airflow and may have acted as a heat trap.
- While this was a preliminary study involving only a limited number of specimens the results across the specimens, timber species and over the 3 month time period were consistent. A much better understanding would require more specimens, species and locations.
- During the recording period the Forrest Fire Danger Indices reached into the 40s on four occasions and did not exceed 48. Historic fire losses have typically occurred at FFDI's well above this level. Hence the observation of moisture content for the summer of 2006/07 can be considered highly conservative compared to years where iconic losses have occurred.

5. Acknowledgements

We would like to thank Chris Lucas from the Bureau of Meteorology for providing the FFDI calculation to the data comparisons.

6. References

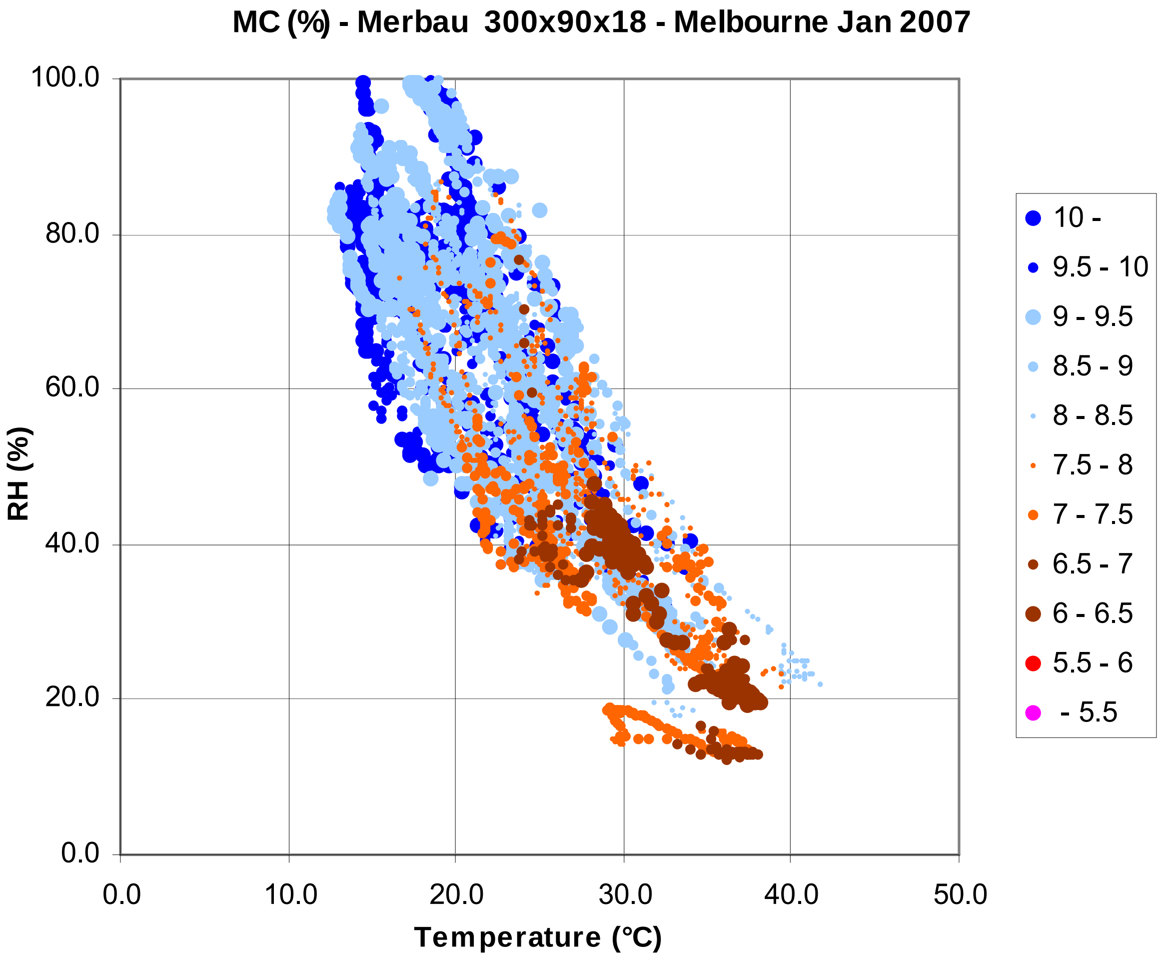
1. Leading Edge Volume 2 Issue 1 page 4, Forest and Wood Products Research and Development Corporation, December 2003, http://www.fwprdc.org.au/content/pdfs/Leading%20Edge/2003%20December.pdf

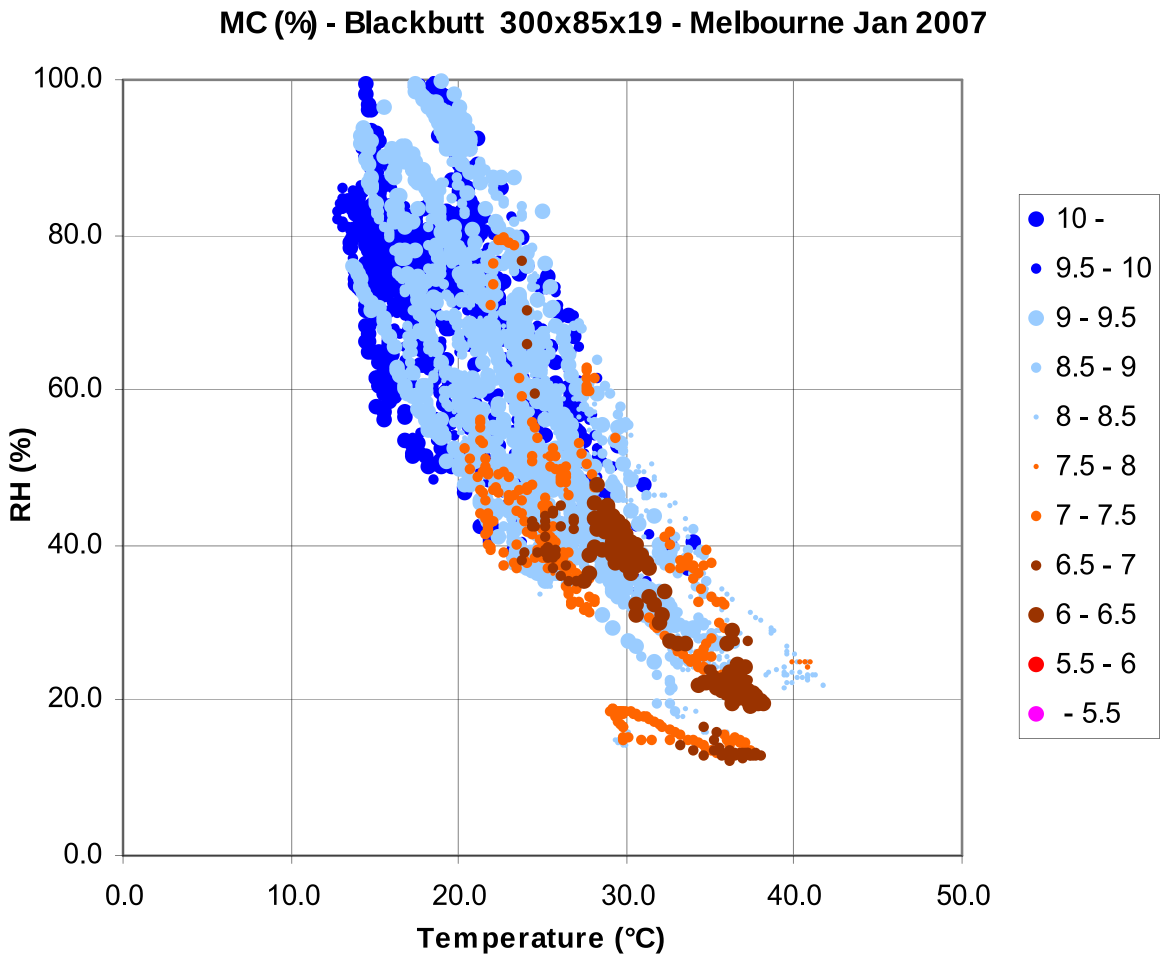
2. Standards Australia (1997) AS/NZS 1080.1 – Methods of Test, Method 1: Moisture content, Standards Australia, Sydney.

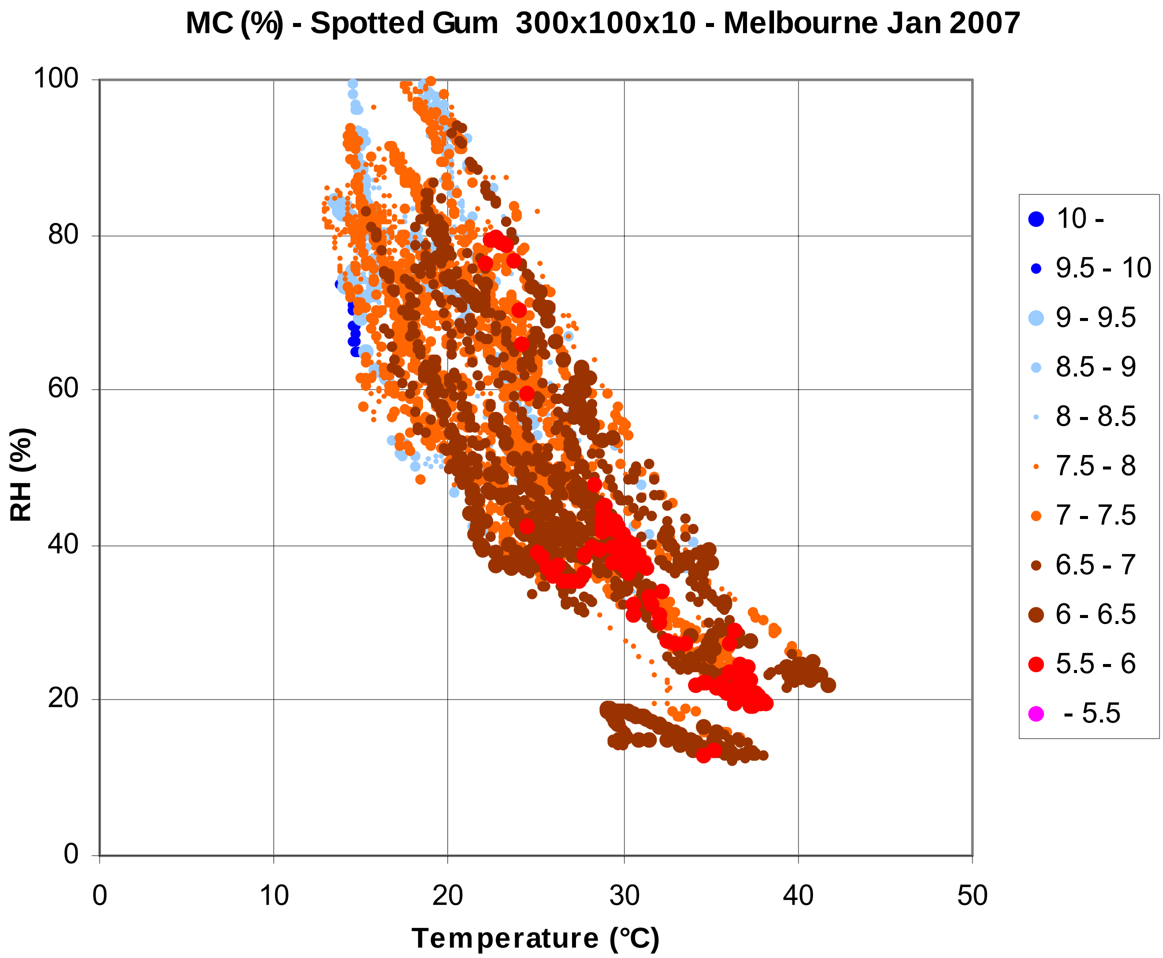
3. Fire Tests - Full-Scale Room Test for Surface Products, ISO 9705 International Organization for Standardization, Geneva, Switzerland, (1993).

4. Standards Australia (2006) Draft AS/NZS 1530.8.1 – Methods for fire tests on building materials, components and structures, Part 8.1: Tests on elements of construction for buildings exposed to radiant heat and small flaming sources during bushfires, (Short title: Bushfire Method), Standards Australia, Sydney.

APPENDIX A – Variation in moisture content with temperature and relative humidity




MC (%) - Blackbutt 300x85x19 - Melbourne Jan 2007
RH (%)
Temperature (°C)
0.0
20.0
40.0
60.0
80.0
100.0
0.0
10.0
20.0
30.0
40.0
50.0
10 -
9.5 - 10
9 - 9.5
8.5 - 9
8 - 8.5
7.5 - 8
7 - 7.5
6.5 - 7
6 - 6.5
5.5 - 6
- 5.5


MC (%) - Spotted Gum 300x100x10 - Melbourne Jan 2007
RH (%)
Temperature (°C)
0
20
40
60
80
100
0
10
20
30
40
50
10 -
9.5 - 10
9 - 9.5
8.5 - 9
8 - 8.5
7.5 - 8
7 - 7.5
6.5 - 7
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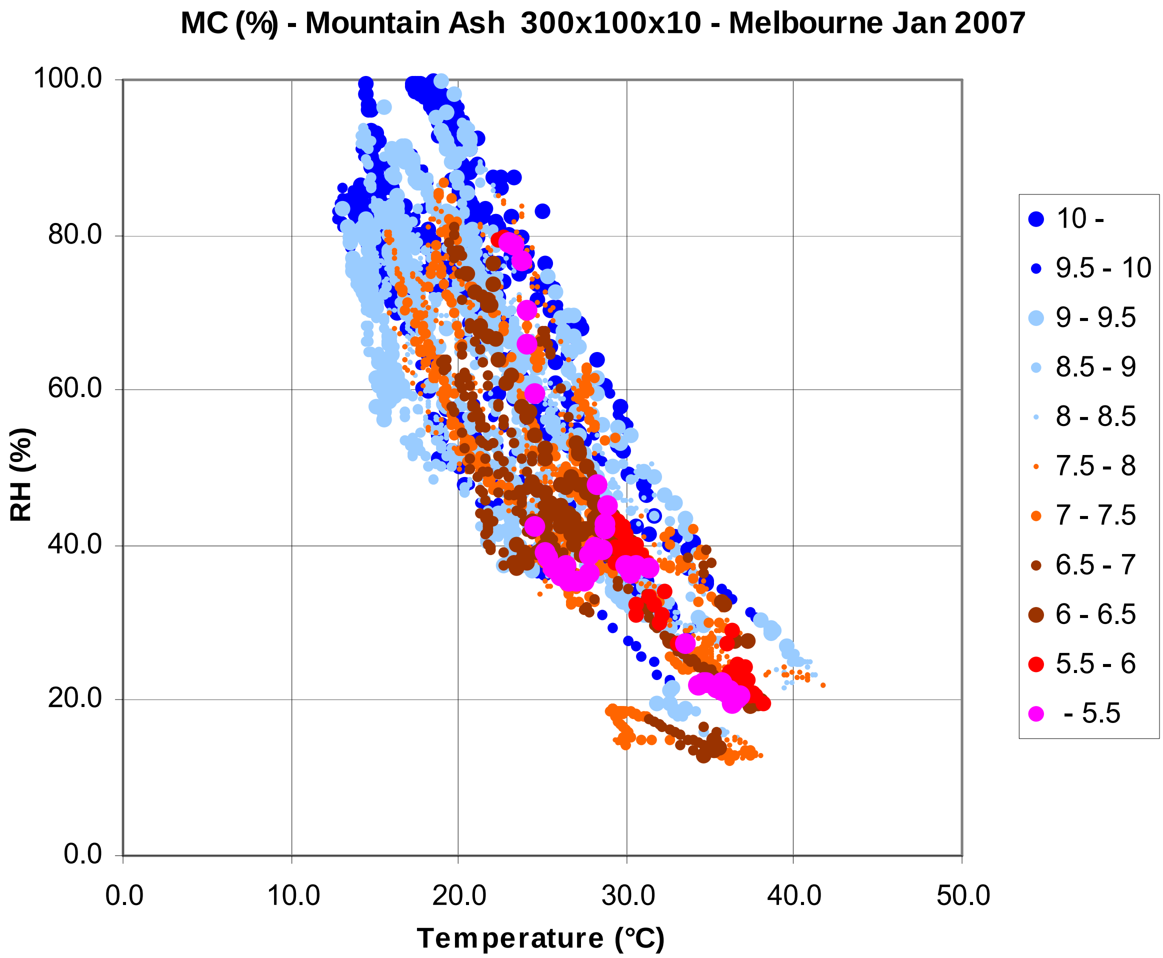
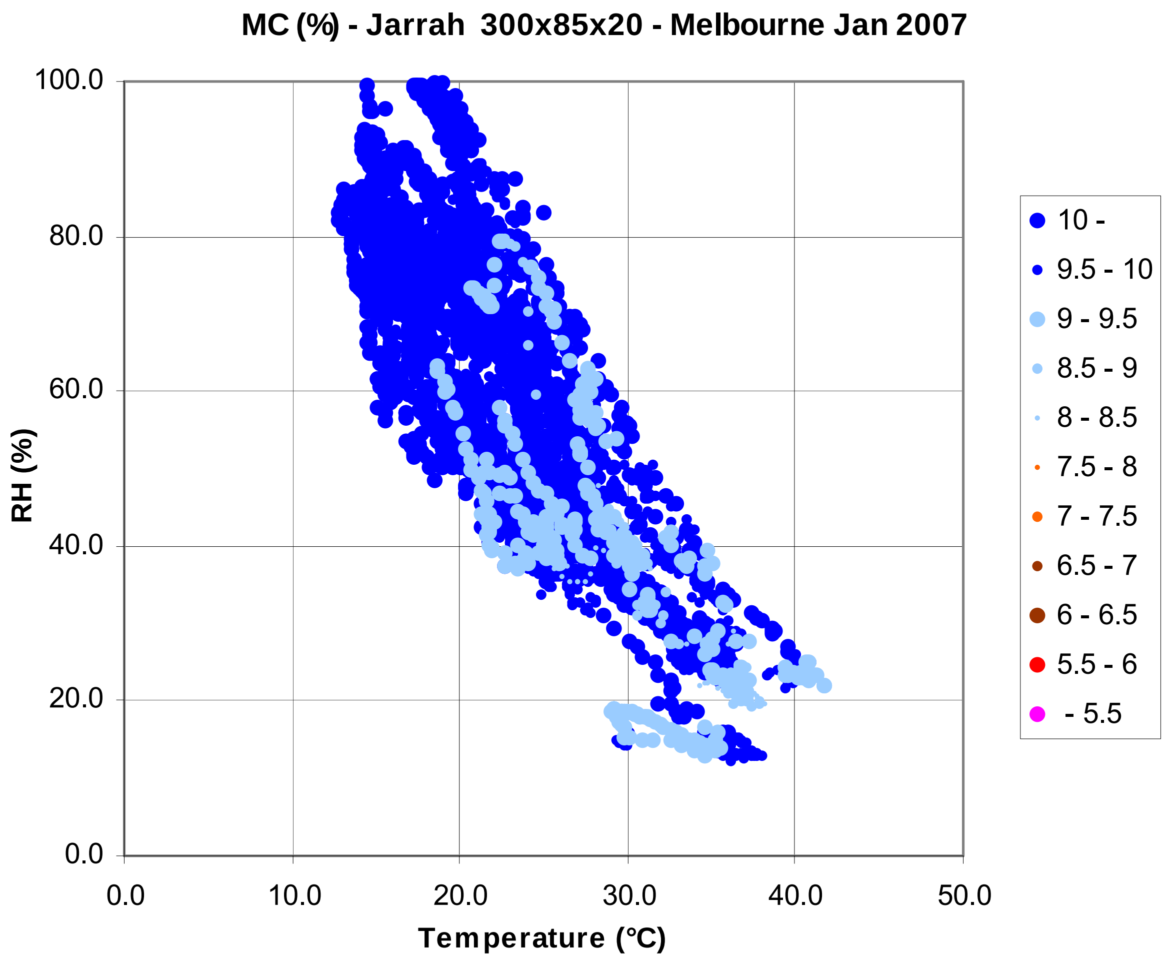
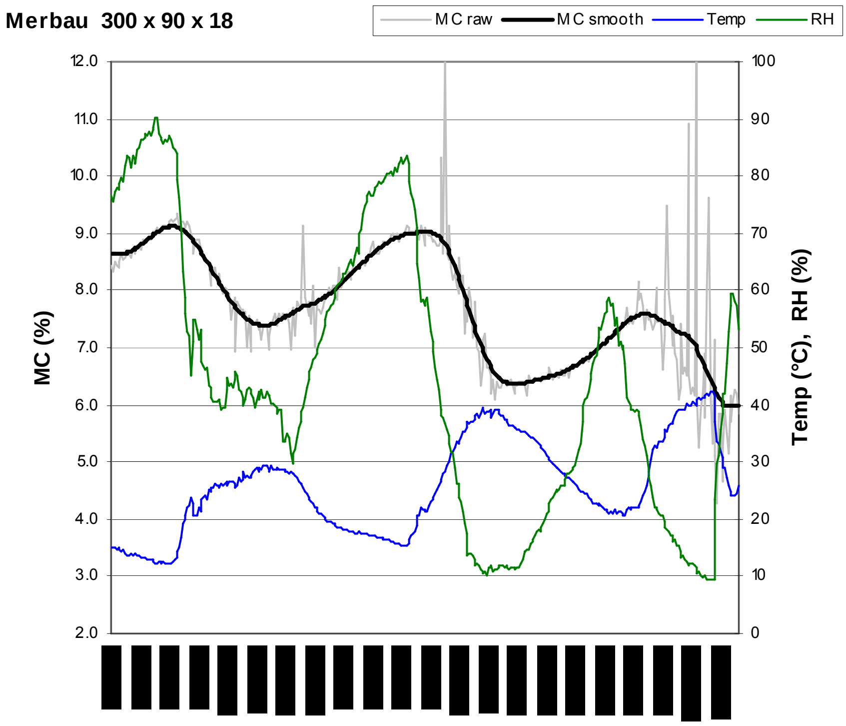
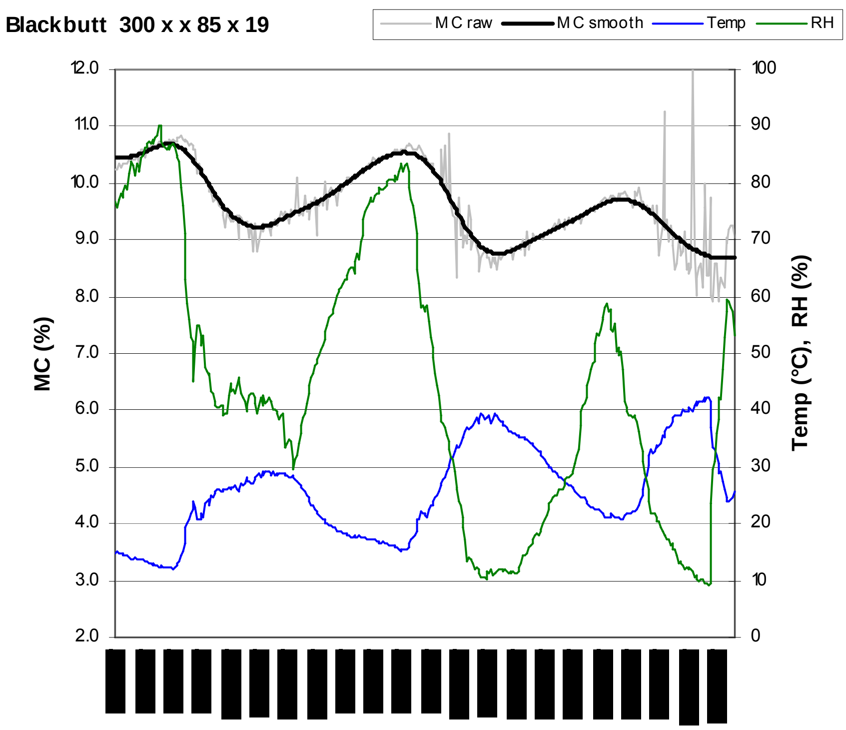
5.5 - 6
- 5.5

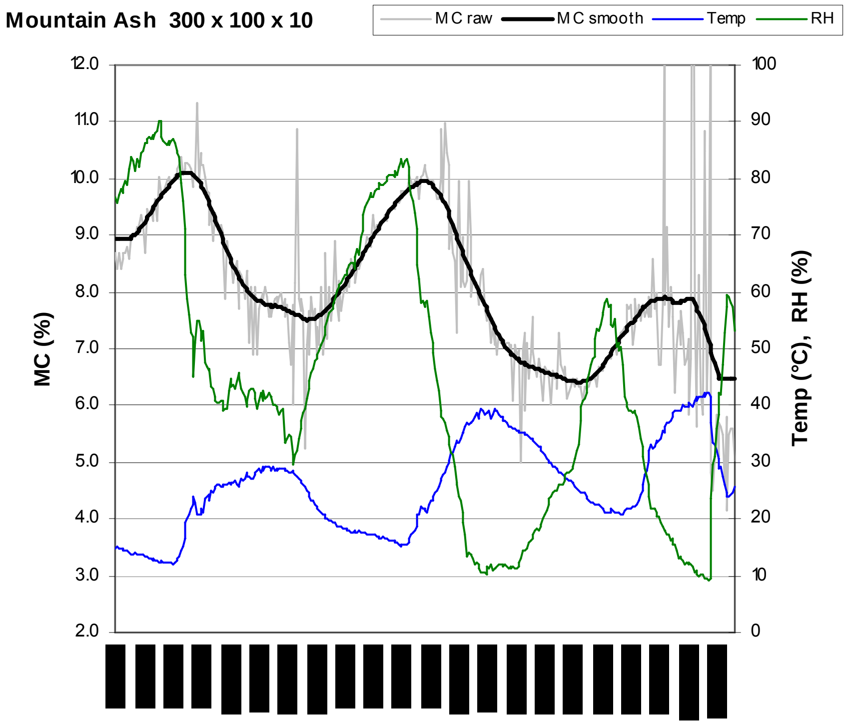

MC (%) - Mountain Ash 300x100x10 - Melbourne Jan 2007
RH (%)
100.0
80.0
60.0
40.0
20.0
0.0
0.0
10.0
20.0
30.0
40.0
50.0
Temperature (°C)
10 -
9.5 - 10
9 - 9.5
8.5 - 9
8 - 8.5
7.5 - 8
7 - 7.5
6.5 - 7
6 - 6.5
5.5 - 6
- 5.5

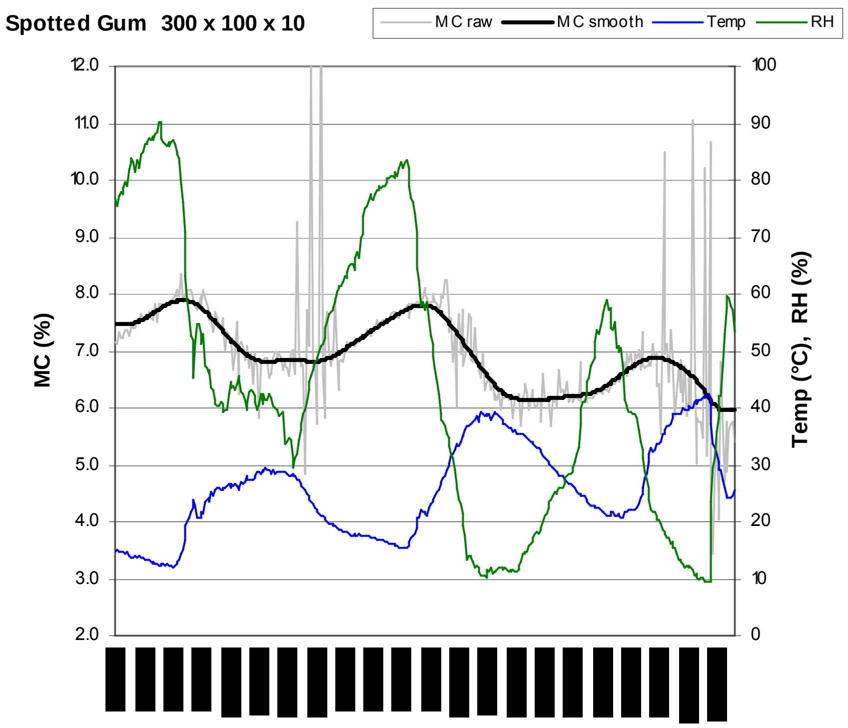

MC (%) - Jarrah 300x85x20 - Melbourne Jan 2007
100.0
80.0
60.0
40.0
20.0
0.0
RH (%)
0.0
10.0
20.0
30.0
40.0
50.0
Temperature (°C)
10 -
9.5 - 10
9 - 9.5
8.5 - 9
8 - 8.5
7.5 - 8
7 - 7.5
6.5 - 7
6 - 6.5
5.5 - 6
- 5.5

APPENDIX B – Moisture contents during periods of high fire risk weather conditions






Mountain Ash 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0
[redacted]


Spotted Gum 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0
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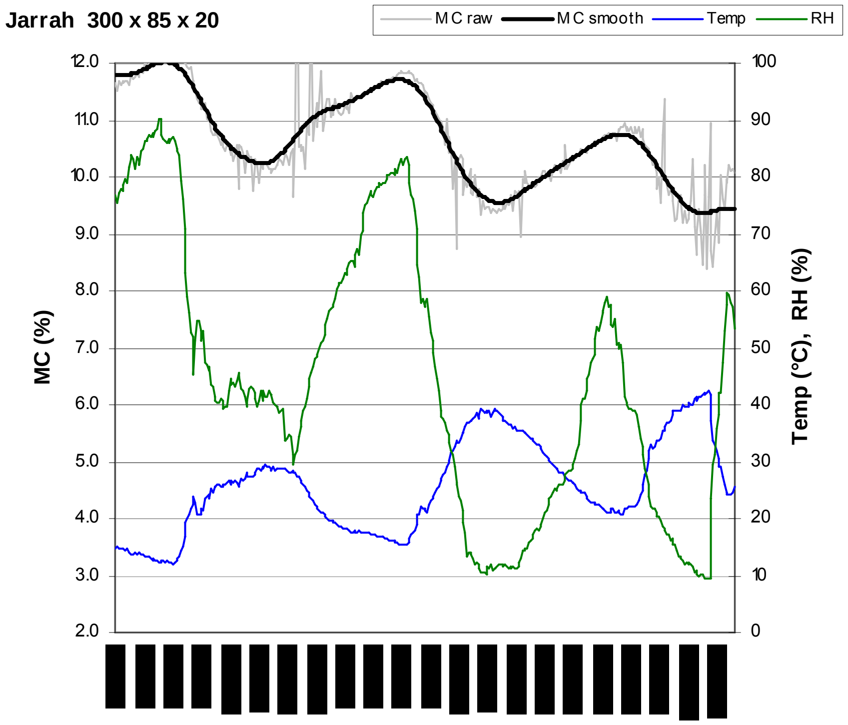
Jarrah 300 x 85 x 20
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0
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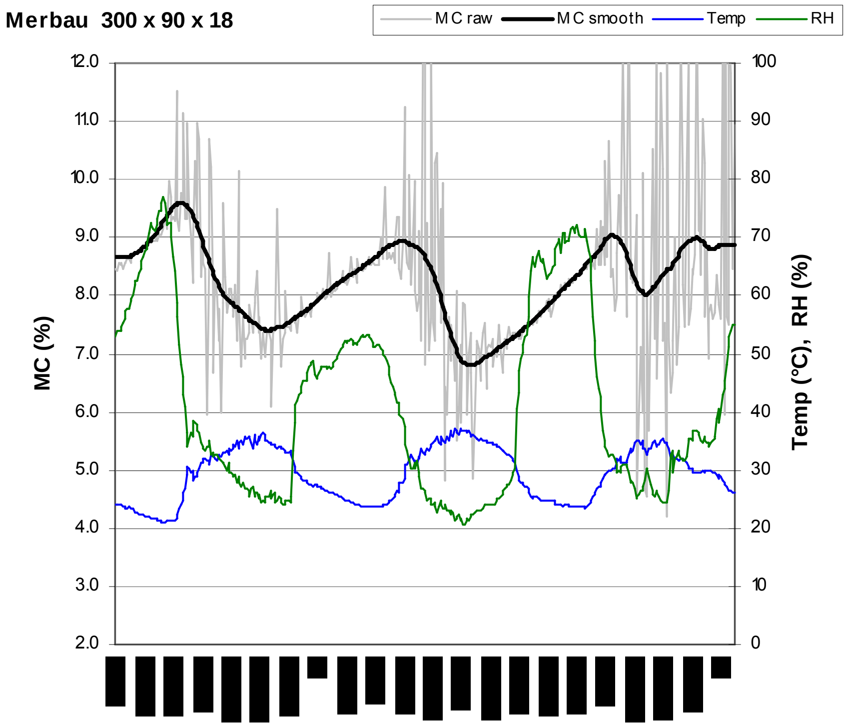
Merbau 300 x 90 x 18
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
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3.0
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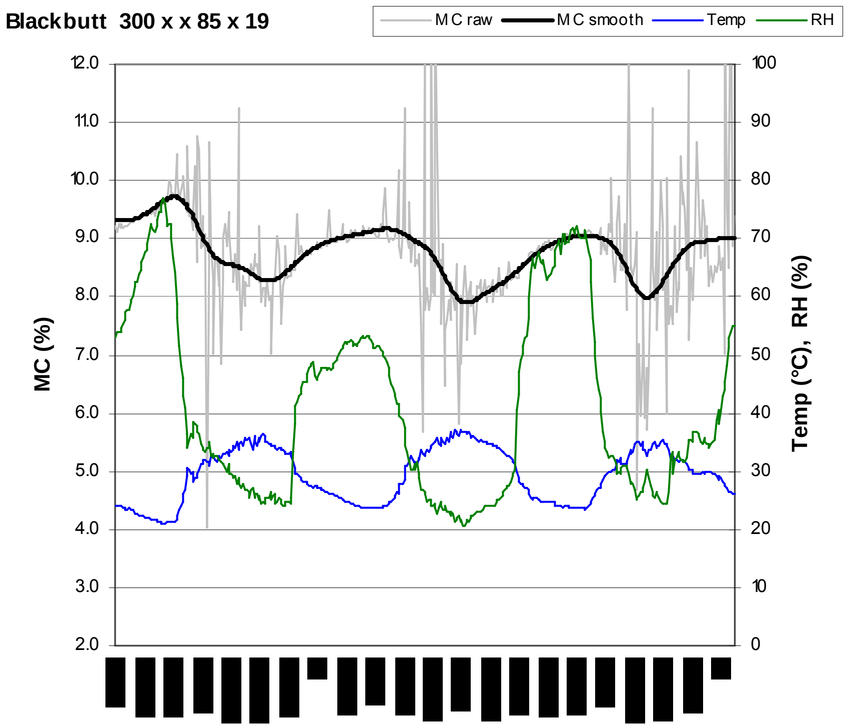
40
30
20
10
0


Blackbutt 300 x x 85 x 19
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
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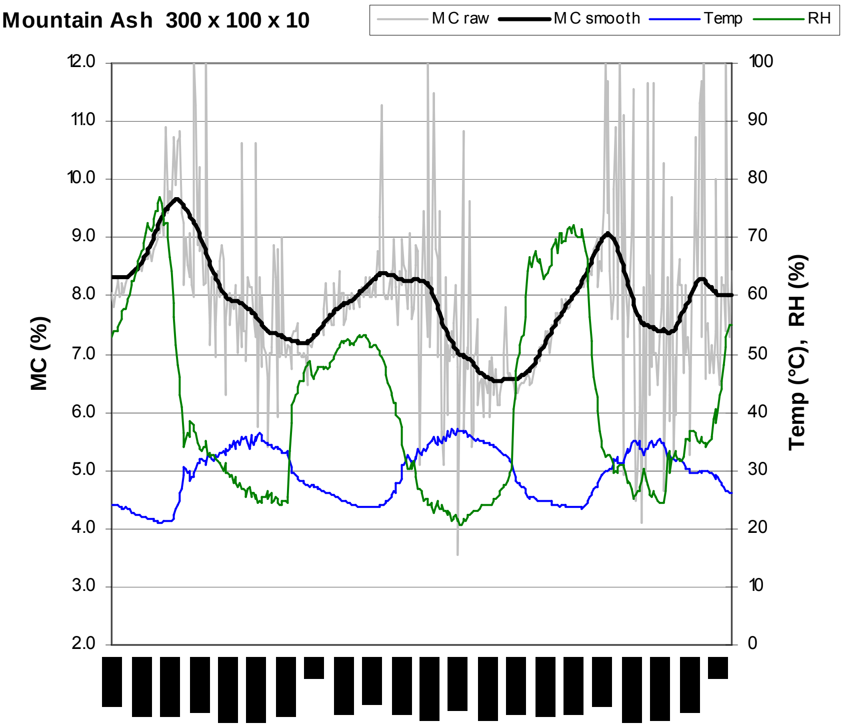
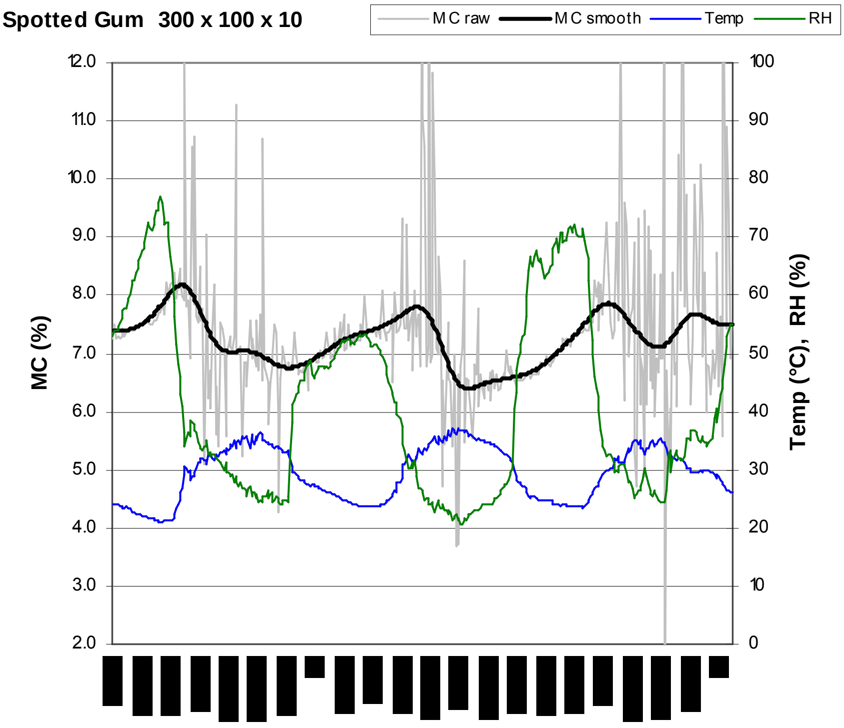
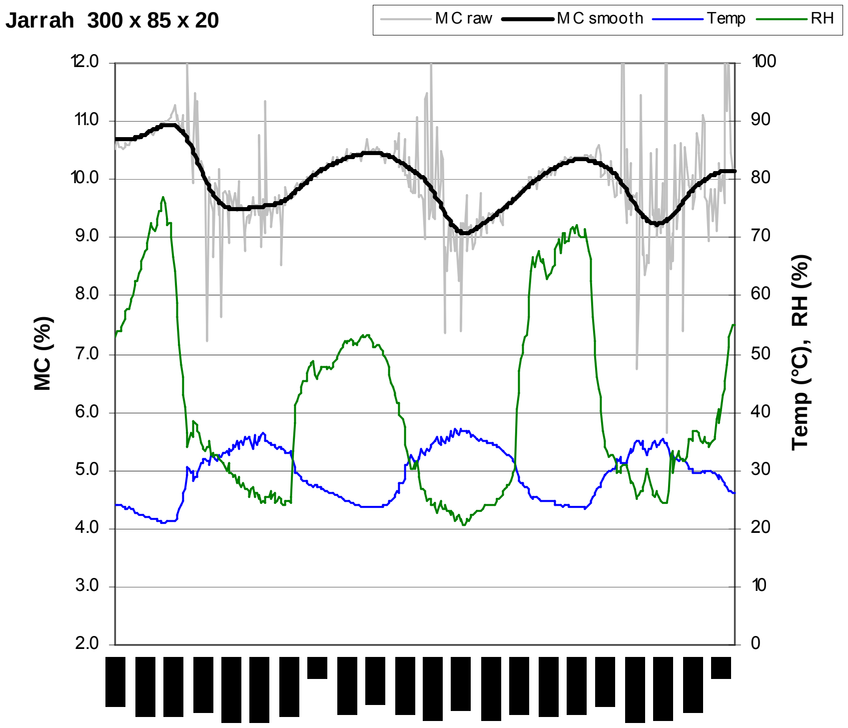
40
30
20
10
0


Mountain Ash 300 x 100 x 10
MC raw
MC smooth
Temp
RH
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
MC (%)
100
90
80
70
60
50
40
30
20
10
0
Temp (°C), RH (%)


Spotted Gum 300 x 100 x 10
MC raw
MC smooth
Temp
RH
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
MC (%)
100
90
80
70
60
50
40
30
20
10
0
Temp (°C), RH (%)


Jarrah 300 x 85 x 20
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
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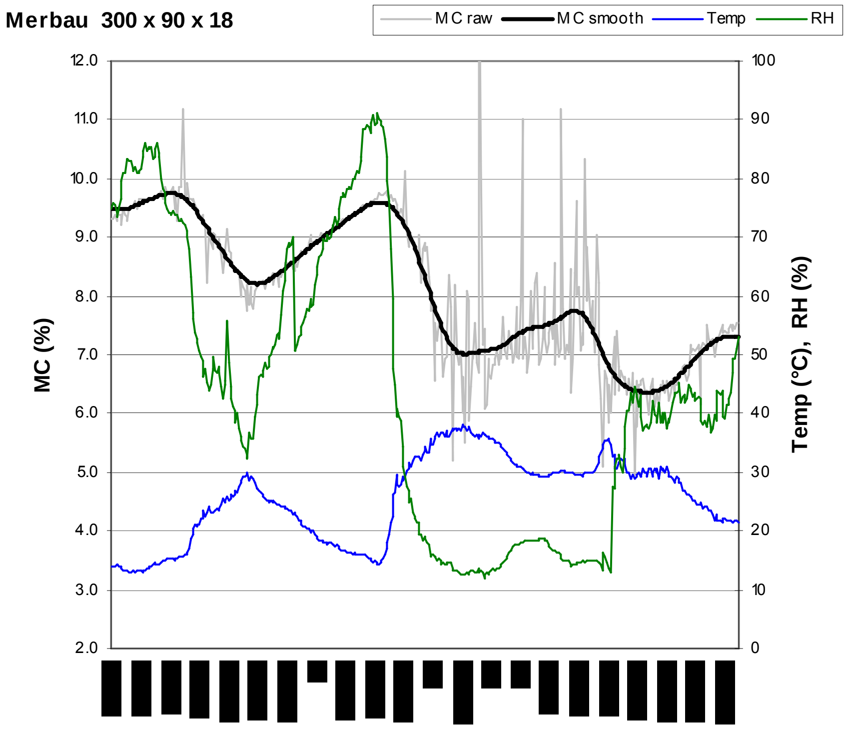
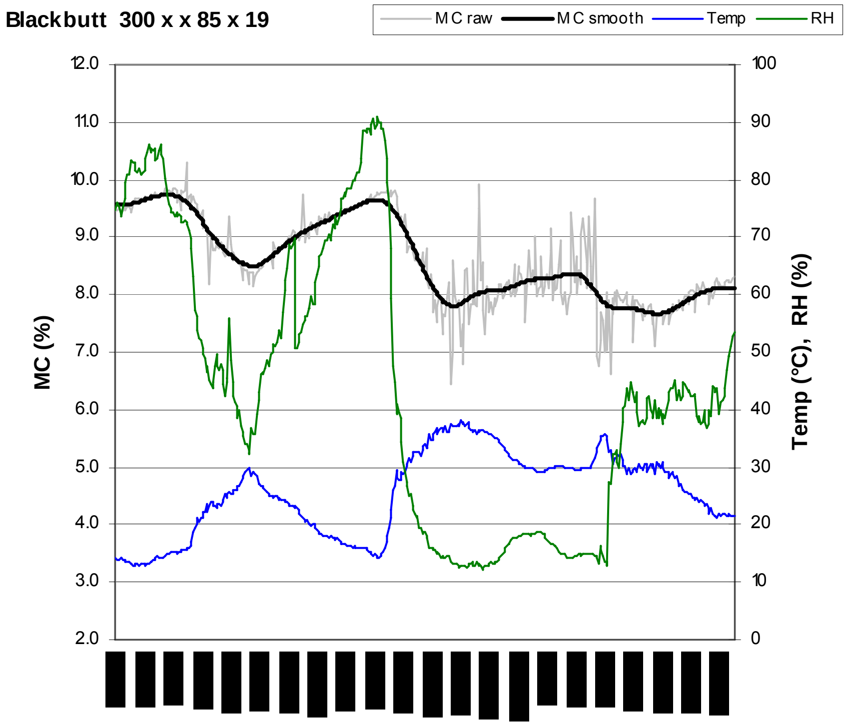
40
30
20
10
0


Merbau 300 x 90 x 18
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0


Blackbutt 300 x x 85 x 19
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
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40
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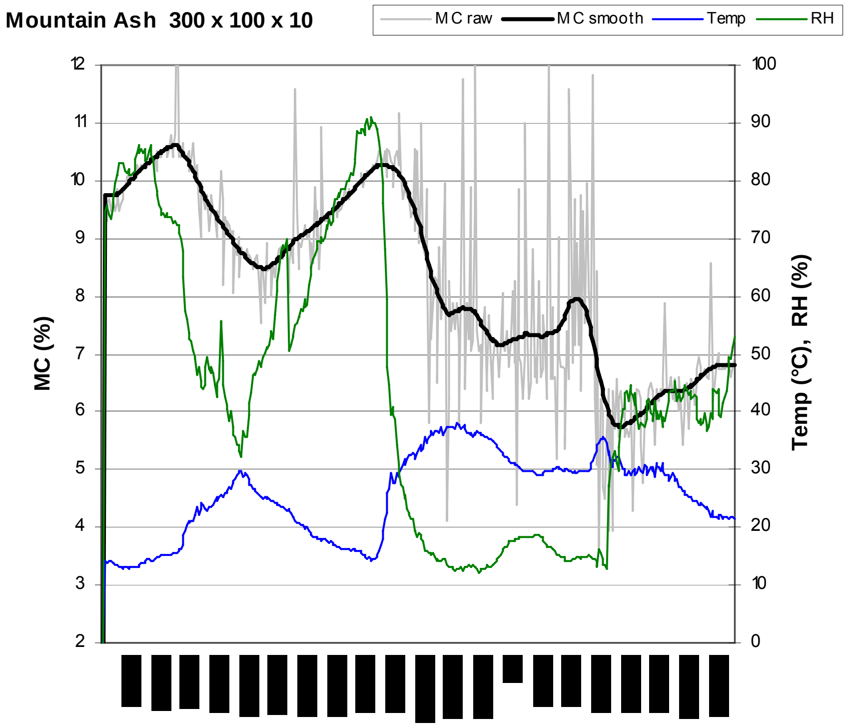
10
0


Mountain Ash 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12
11
10
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8
7
6
5
4
3
2
100
90
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60
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40
30
20
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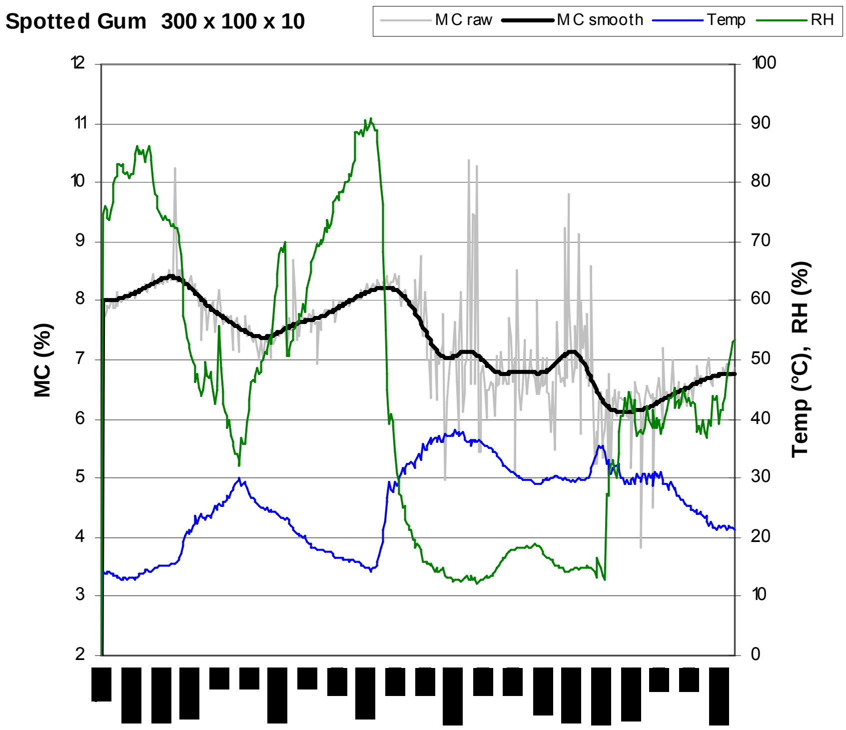
0


Spotted Gum 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12
11
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5
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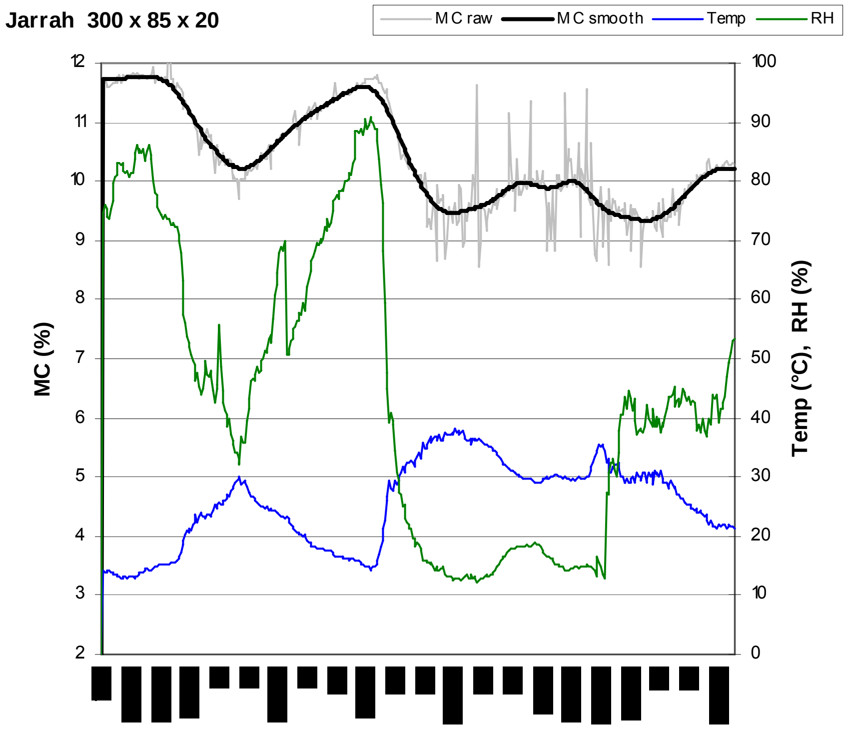
Jarrah 300 x 85 x 20
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12
11
10
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8
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6
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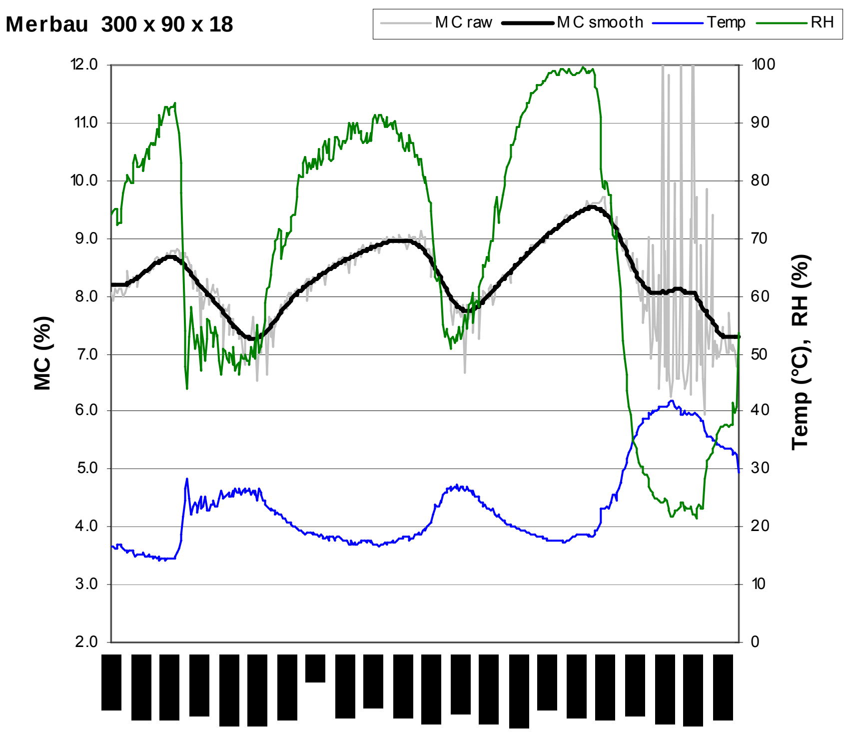
30
20
10
0


Merbau 300 x 90 x 18
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
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9.0
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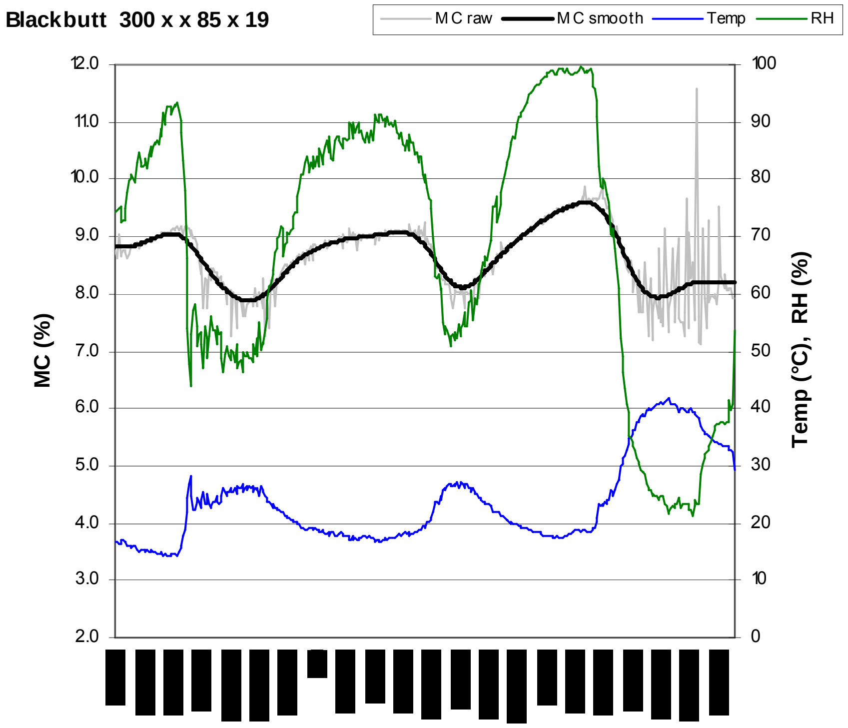
10
0


Blackbutt 300 x x 85 x 19
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
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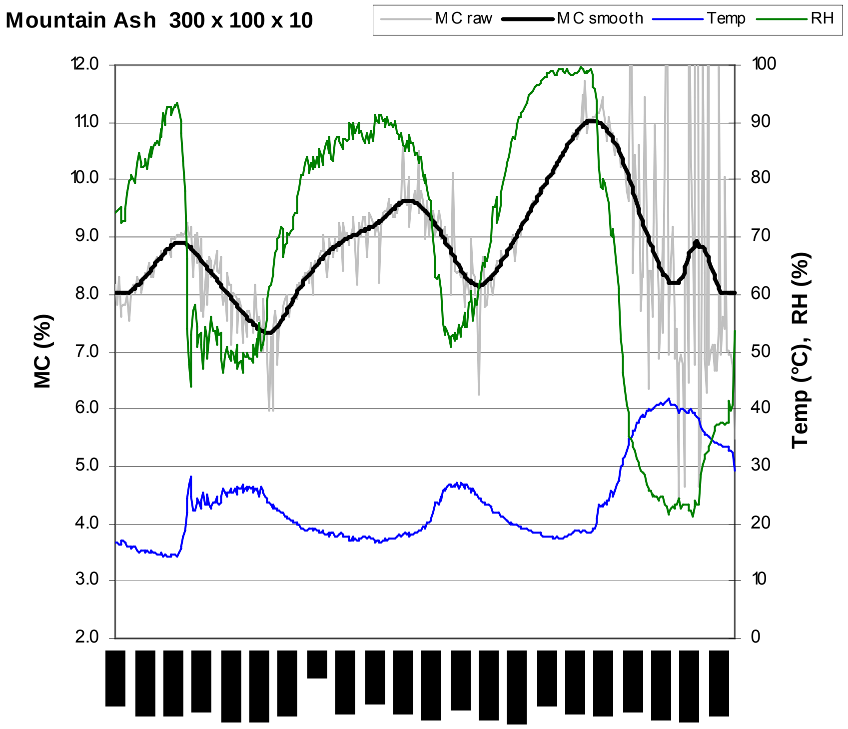
Mountain Ash 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
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30
20
10
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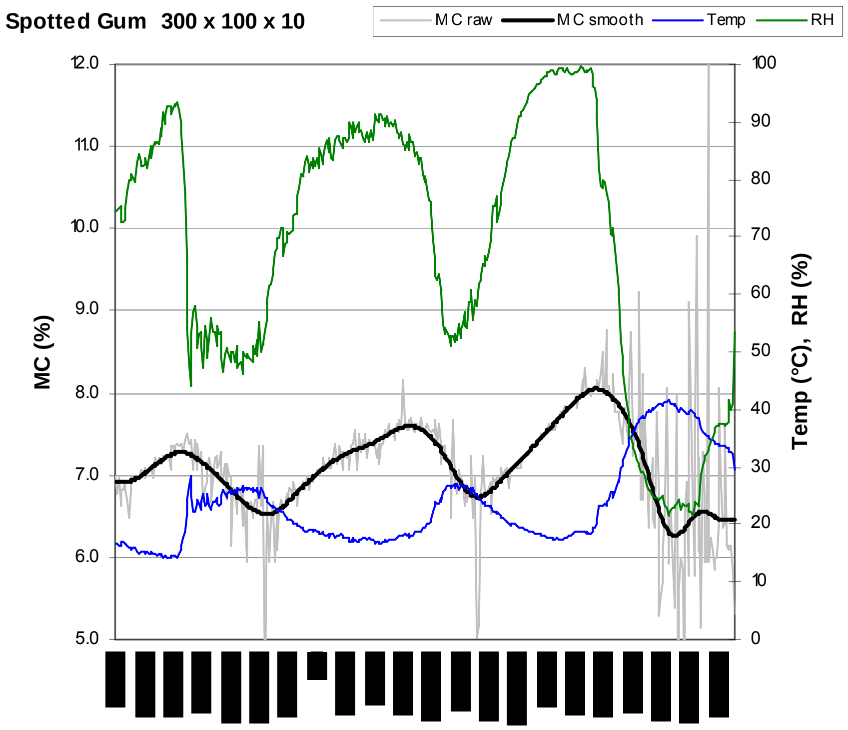
Spotted Gum 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
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11.0
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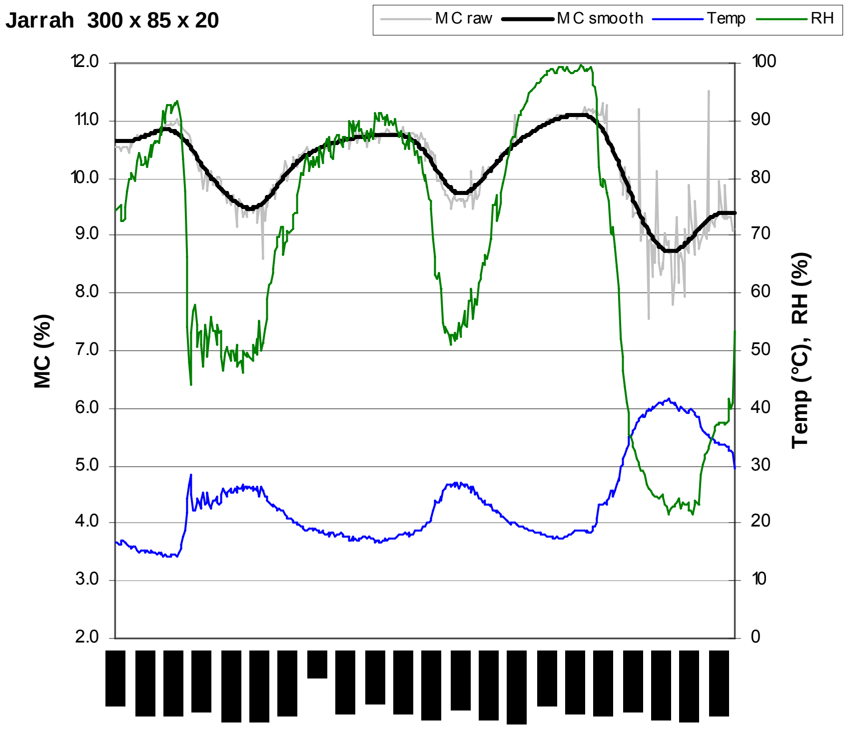
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MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
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10.0
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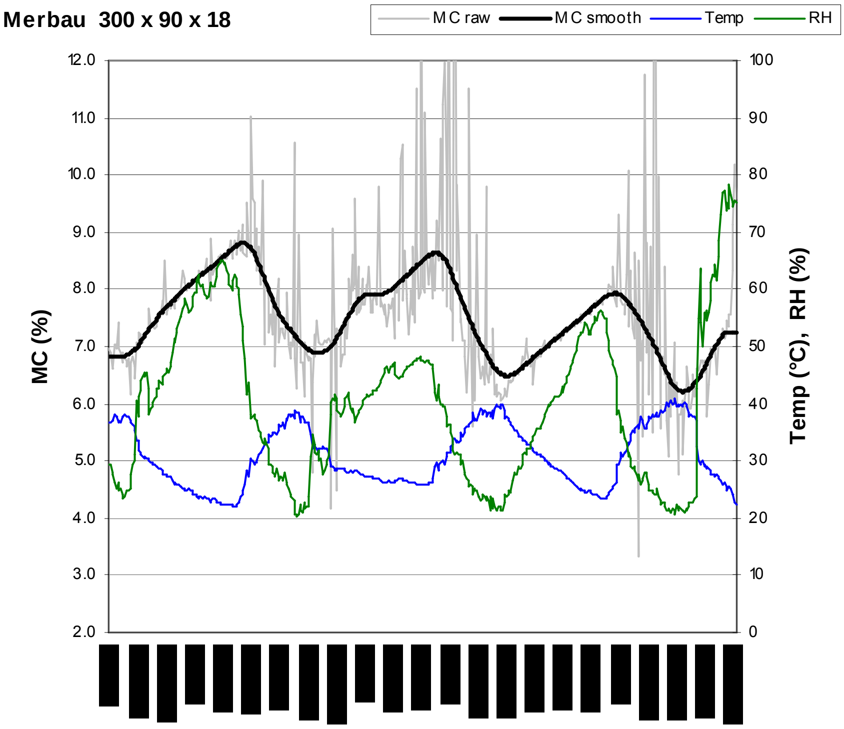
Merbau 300 x 90 x 18
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MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
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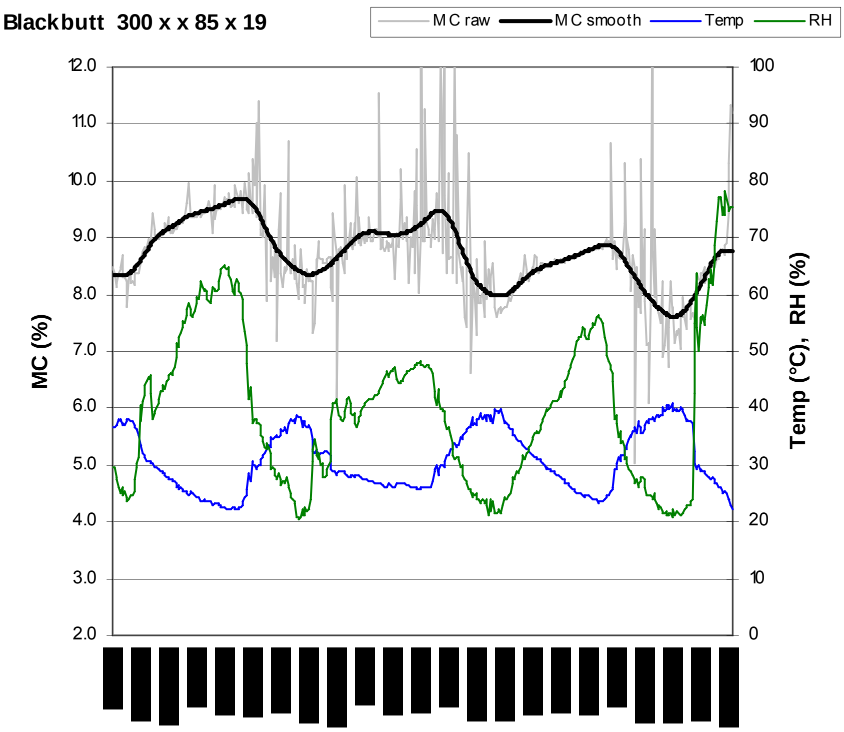
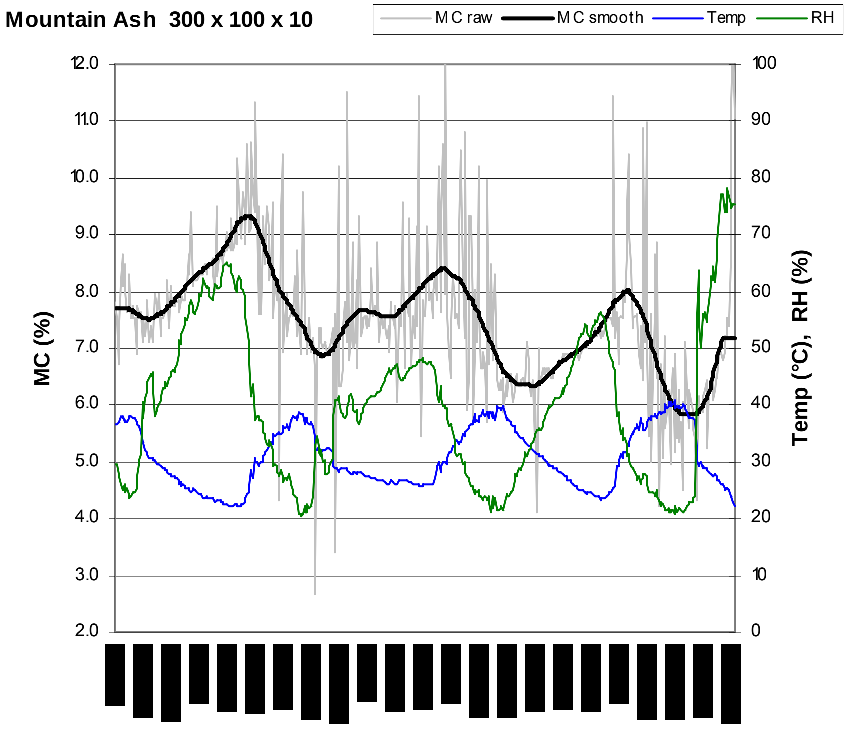
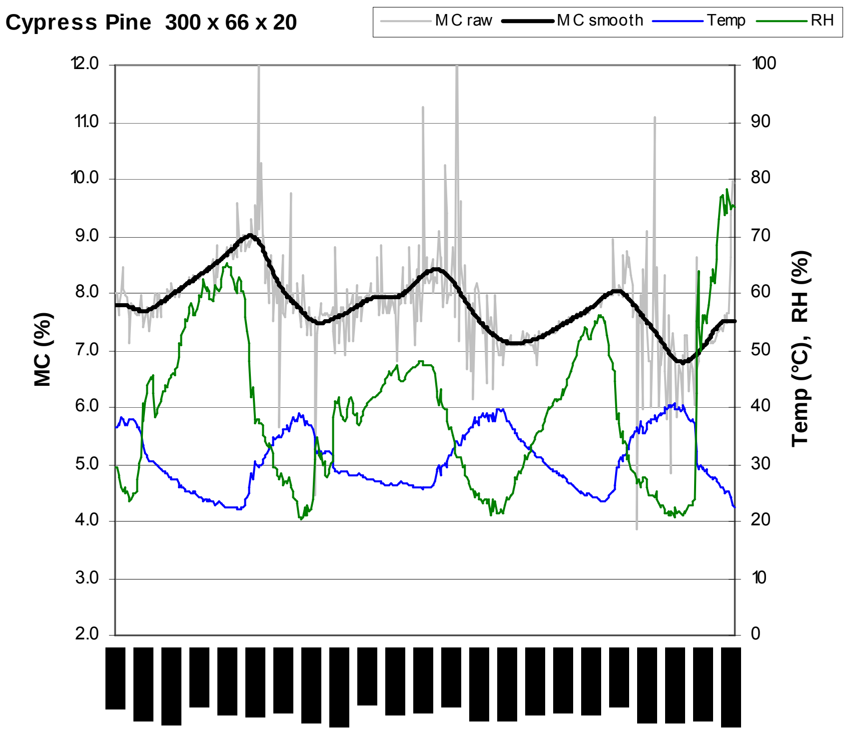

Blackbutt 300 x x 85 x 19
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0


Mountain Ash 300 x 100 x 10
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0


Cypress Pine 300 x 66 x 20
MC raw
MC smooth
Temp
RH
MC (%)
Temp (°C), RH (%)
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
100
90
80
70
60
50
40
30
20
10
0