Department of Environment and Conservation

Please note: This field report is produced as an internal document for distribution within the Department of Environment and Conservation, WA. It is not intended to report on the three year suite of experiments undertaken at Ngarkat Conservation Park and other localities, only provide details of activities and observations undertaken during DEC's (2008) participation in these specific events.

Project FuSE South Australia
Ngarkat Conservation Park Experimental Fires
Part of Bushfire CRC Project A1.1 - Fire Behaviour Modelling
February - March 2008

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Abstract

In February and March 2008 a number of fire related experiments were undertaken in mallee heath shrublands of Ngarkat Conservation Park, South Australia. The final output of this study will be prescribed burning and fire behaviour models for areas of similar vegetation type around Australia. Research data collected at this time adds to results collected during fire experiments undertaken in milder conditions over the course of the preceding three years.

Introduction

Mallee heath shrublands are an important and widespread vegetation type in Western Australia covering more than 3.4 million hectares of the state. These fuels are highly flammable and prone to high frequency fire events. Fire within these fuels exhibit extreme fire behaviour impacting on public and fire fighter safety. This field report outlines activities and observations undertaken from 27th February to 7th March 2008 while assisting the CSIRO and Bushfire CRC science team collect and record data associated with experimental fire trials in Ngarkat Conservation Park, South Australia.

Objectives

The aim of this project is to provide data to facilitate the development of a better fire behaviour prediction system (model) for rates of spread and fire intensity in a range of burning conditions in mallee and heath vegetations. This model will assist fire practioners in predicting bushfire behaviour during wildfire events, plan suppression and allow them to safely conduct prescribed burning for effective hazard reduction and ecologically sensitive management in mallee and heath vegetation.

The specific objectives of the project are:

1. Characterise changes in the fuel complex since last fire;
2. Model the seasonal and diurnal fuel moisture dynamics of live and dead fuel components;
3. Determine the vertical wind profile in these fuel types;
4. Model the fire environment conditions that will sustain fire spread (propagation thresholds); and
5. Model rate of fire spread and flame characteristics.

The 2008 experimental burning program included additional experiments in larger plots (AS1, AS2 and AS3 – See Appendix 1 Map) to evaluate the effectiveness of aerial suppression in assisting the control of wildfires in mallee heath fuels and provide additional fire behaviour data for model development. The main aim of this additional research is:

6. Evaluate the effectiveness of different chemical suppressants (retardant, foam and gel) delivered by aircraft under a narrow range of fire intensities.

Photo 1: Water Bomber releasing chemical suppressant (Phoscheck) prior to ignition.
Photo Source: Greg McCarthy – DSE, VIC

Fire Trials

Methods

With the first (May 2006) and second (April 2007) phase of the three year project complete, the third (March 2008) and final phase undertaken during warmer, drier conditions commenced. A series of plots (Appendix 1 - Map) in mallee and heath vegetation types were established to conduct a range of fire intensity experiments in the two major vegetation types. A range of fire intensities were required to improve the data already collected, this was achieved by burning under different diurnal weather conditions. The data recorded during the experiments included:

Fire Behaviour

- Fuel load and structure - destructive/non-destructive sampling
- In-forest winds and wind profiles - windsonic anemometers
- Temperature / relative humidity - Psychrometer, weather station
- Fuel moisture - oven dry samples
- Fire spread - Fire spread thermal loggers, fire line markers, tags
- Flame height/angle/depth - Ocular estimates, in-fire video
- Thermal environment - Radiometer, thermocouples

Aerial suppression evaluation

- Fire intensity - Fuel and fire behaviour data
- Drop effectiveness - Ground and aerial observation
- Drop durability - Ground and aerial monitoring
- Aircraft productivity - Flight logs, satellite navigation systems, GPS data, and airbase log data

Photo 2: Thermal Environment Radiometer and camera in fire proof box - Block AS3

Photo 3: Thermal Logger's were buried in a grid pattern in each of the plots to record fire intensity and spread.

Fuel assessment

Photo 4: Mallee – Heath Vegetation in Ngarkat Conservation Park Block AS3

Fuel load and structure in the burn plots were quantified through a combination of destructive and non-destructive sampling (2m x 1m quadrats) and visual systems of scoring structure and hazard (See Appendix 2). This fuel assessment characterised the changes in the fuel complex with time and assisted in the comparison of mallee and heath fuel types.

Photo 5: Destructive fuel sampling in 2 x 1m quadrat.

Fuel moisture content

Fuel moisture studies (utilising a drying oven) were carried out in the mallee and heath fuel types to characterise weather conditions in the air immediately above ground level and diurnal variations of dead, fine fuel moisture. In addition to intensive diurnal studies, fuel moisture was measured immediately before each experimental burn.

Fire Behaviour

Prior to the commencement of the third phase of fire experiments, 48 experimental burns were carried-out in Ngarkat Conservation Park across a range of fire intensities and environmental conditions (phase one and two of the project). Vegetation age class ranged between 7 to 48 year old mallee and heath fuels under wind speeds (at 10 m in the open) ranging from 6 to 25 km/hr; and surface fuel moisture contents between 5 and 20%. All data collected during the experimental fires, including data collected prior to the burn events, will provide information to assist in the production of the model.

Eight experimental burns were undertaken from the 3rd – 5th March 2008 (phase three). The combination of fuel structure and fire weather conditions that will sustain the propagation of fire (known as the go or no-go threshold) were tested. Six Go/No Go burns (plot sizes averaging 200m x 200m) and three Fire Behaviour and Aerial Suppression burns (plot sizes 900m x 1000m, up to 80Ha) were undertaken during this time. An additional 10 experimental burns were planned to occur in older (50+ years) mallee heath fuels from the 9th – 20th March 2008.

Photo 6: Active fire behaviour in block AS3 – Tuesday 4th March 2008.

Plots were lit with the wind using 100m (Go/No Go Burns - Plots R, A & E) and 200m (AS1, AS2 and AS3) continuous strip-line ignitions (See Appendix 1). Data on flame height, forward rate of spread, fire intensity and general fire behaviour was recorded and photographed at two minute intervals until the fire (estimated ROS >4000m/hr) reached the opposite boundary of the experimental burn (2 - 12 mins depending on plot size) and was suppressed by CFS (Country Fire Service) Crews. After the burn was deemed safe the science team re-entered the plot to collect equipment (e.g. thermo loggers, cameras, radiometry towers, etc).

Wind Structure

Studies of the vertical wind structure were also undertaken in the mallee and heath fuel types, during the burn program. Spatial variation in wind, as well as wind speed and direction during experimental burns were also recorded (See Appendix 3 for Weather Data on Day of Burn).

Photo 7: Windsonic anemometer (tower on RHS of photo) in plot adjacent to burn

Aerial Suppression

Experimental burns undertaken in plots AS1, AS2 and AS3 trialled the use of different chemical suppressants on intense fire behaviour. Retardant, foam and gel were all used on the active fire front and the effectiveness of the drop observed by air and on ground.

The most effective method for retarding the flame front was the indirect use of Phoscheck prior to the arrival of the flame front. Approximately three loads were dropped on the east/west grid line (containing research equipment) with an additional two loads delivered to the north/south grid line. The application of Phoscheck proved quiet successful (as evidenced on-site from infrared camera images) protecting all treated vegetation. The wind change however, highlighted the fact that sparsely treated areas of vegetation will succumb to an intensely burning flame front and penetrate weakened areas.

Photo 8: Water Bomber releasing chemical suppressant (Phoscheck) prior to burn trial.

The Aerial Suppression experiments showed that individual drops (using any of the trialled suppressants) can be effective in containing fire within mallee heath fuels. Suppression droplines will assist in the reduction of fire propagation and may reduce fire intensity in vegetation likely to cause spot fires. At a tactical level mallee heath shrublands are frequently located in remote areas and as such aerial suppression would experience long turnaround and delayed response times. This may result in larger fire areas being faced at first attack. Therefore, the use of suppressants in mallee heath shrublands during wildfire events to both assist in reduced fire behaviour and protect infrastructure would be recommended if viable.

Photo 9: Water Bomber releasing chemical suppressant (foam) during burn trial.
Photo Source: Bushfire CRC

Results

Mallee heath fuels can be relied upon to burn fiercely from at least eight years after fire under weather conditions that occur commonly during the summer months. Vegetation found within the target burn areas ranged from between eight years in the go/no go plots to 20 years in the larger aerial suppression plots. Surface fuels were discontinuous, while a moderate proportion of the elevated fuels were affected by drought. Even with discontinuous, drought effected fuels, fire intensity was significant under the trialled summer burning conditions. Wind direction @ 10 m from ground level was at times erratic and often reached gusts of up to 39 km/h; these influences often caused changes in fire behaviour and intensity. This short term wind variability has significant implications for fire behaviour, rate of fire spread and fire fighter safety in mallee heath fuels (see Appendix 3 – Weather Data).

During the course of the fire experiments, wind speed was noted as the dominant factor in sustaining fire propagation particularly in fuels where surface fuels were discontinuous. Observations indicated that mallee and Callitris fuels were contributing firebrands with flare-ups noted as the head fire reached these fuels. Spotting distance and occurrence was minimal (approximately 20 - 40m) and comprised of leaf and bark embers.

Photo 10: Jim Gould (CSIRO) and Nicki Warnock (DEC) during Project FuSE burn experiments.

Weather conditions conducive to an effective burn result were observed during the entire course of burn operations. However, the most intense fire behaviour occurred during 1435 and 1445 on Monday 3rd March in block AS1. A Psychrometer weather station accurately recorded conditions during the burn - temperature of 35.4°C, relative humidity 8.1%, dew point of -4.0 and wind speeds between 15.3 km/h (average) to 26.4 km/h (max). Numerous 'fire whirls' were observed within minutes of ignition (ignition line of 200m), however an unusual phenomenon known as a 'fire tornado' (>15m diameter, 30+m flame height) was also observed at this time and had researchers impressed with the scale and intensity of the head fire (rate of spread during this phenomenon was approximately 16km/hr - *almost* faster than we could run!). This erratic fire behaviour and the ability to predict and understand it is an important issue for fire fighters and fire mangers in Western Australia

Significance of the Research for DEC

Data collected over the course of the three year study will contribute to the production of a model (early 2009) for the prediction of bushfire behaviour in mallee and heath fuels. This model will be suitable for use during wildfire suppression and lower fire intensity prescribed burning operations.

The working knowledge of fire behaviour gained from DEC participation in these experimental fires will assist in contributing to the development of operational practice for wildfire and prescribed fire operations in mallee and heath fuels of Western Australia from Esperance and Kalgoorlie to Geraldton. The experience working with fire behaviour scientists from the CSIRO and other states assisted in developing an understanding of what is necessary to collect, collate and interpret data on fire behaviour and to convert these observations into useful information for fire practitioners.

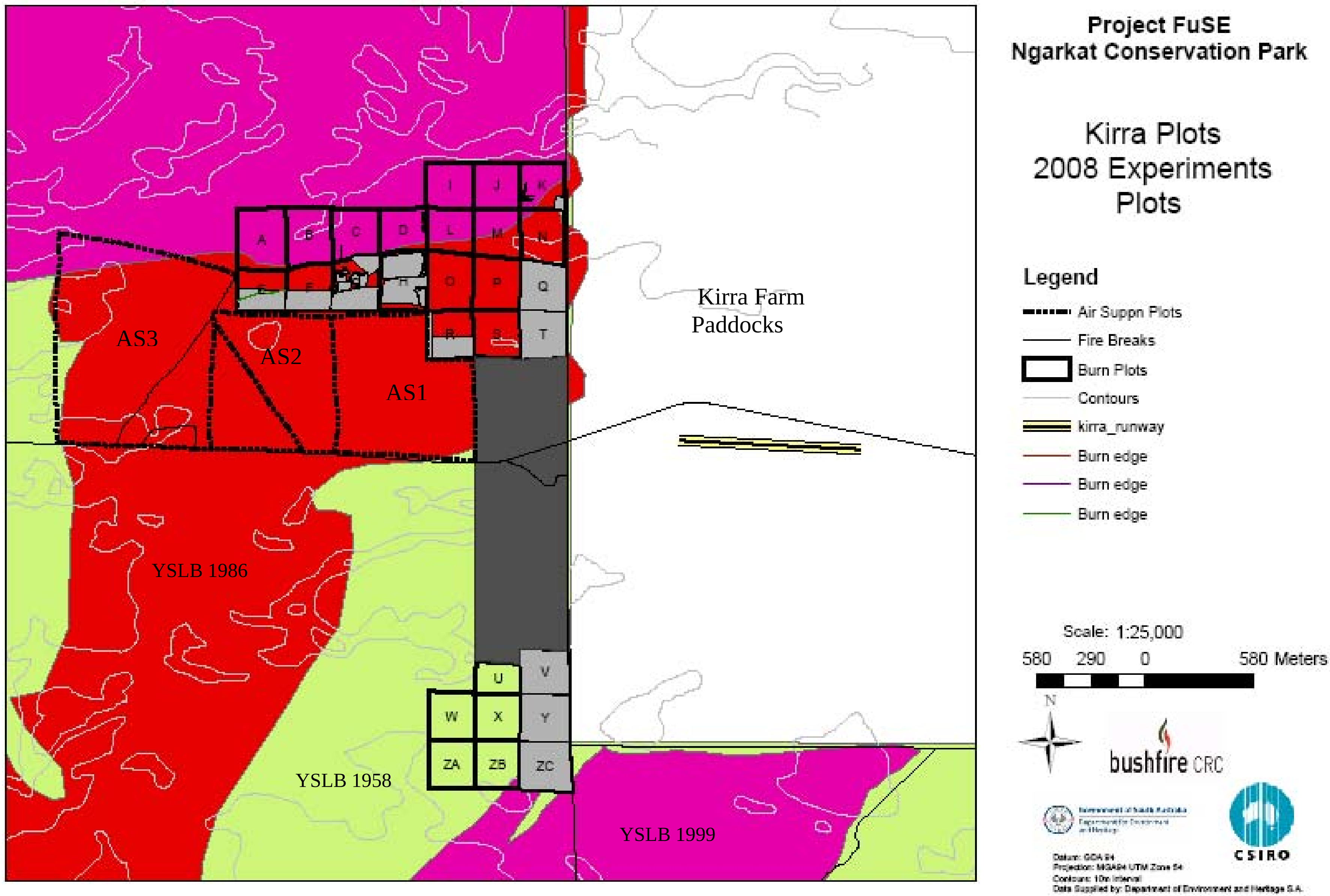
Participants

Agencies and research organisations involved in the Ngarkat research included: Department for Environment and Heritage (SA), the Country Fire Service (SA), the Country Fire Authority (VIC), the Department of Sustainability and Environment (VIC), the Department of Environment and Conservation (WA), New South Wales Rural Fire Service, CSIRO, Scion NZ, Deakin University, the University of Melbourne, the Bureau of Meteorology and researchers from Spain, New Zealand and Denmark.

Acknowledgements

Thanks to Jim Gould (CSIRO) and the Project FuSE researchers for providing me with an opportunity to obtain valuable experience in the methodology and instrumentation required for undertaking fire experiments. Thanks to Dr Lachie McCaw for facilitating the approval of my research travel application and to all FMS management and staff in supporting my participation in the burn trials.

Photo 11: Researchers in front of head fire observing fire behaviour.
Photo Source: Greg McCarthy – DSE, VIC



Appendix 1 – source: CSIRO

Appendix 2 – source: CSIRO

Ngarkat Lists – Fuel Sampling

Fuel sampling Backpack 1: folder, field notes, site map, plot notes with random selection start point and sample locations for sorting and FM, record sheets, pencils, sharpener, permanent marker, whiteboard marker, compass, marking tape, camera
Fuel sampling Backpack 2: secateurs, sorting tarp, bags for weighing fuel, tins and lids, 100m tape, flagging tape, mini-whiteboard
Fuel sampling extras: Bag (tins, lids), Quadrat 2m*1m, (Levy Rod)
Personal: water, lunch, hat, (sunscreen)
'Lab': oven, thermometers (+ cork), balances, standard weights, 400+ tins, lids, spare tarps, spare bags, spare secateurs)

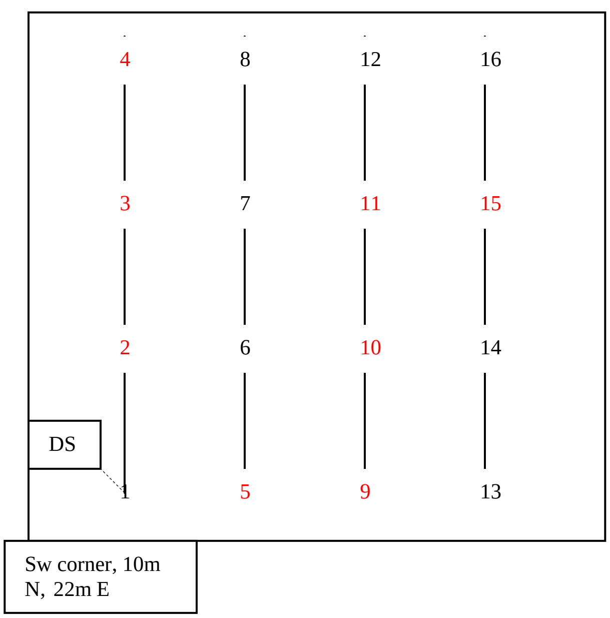
Field notes

- (mark quadrats for 16 LR points, and for centre position (gap size))
- maps of plots
- list of plots and priorities
- details of each plot (random starting position, random selection of sites for sorting and FMC sampling)
- general procedure plot sampling; Vesta Visual, Destructive, sort and FMC%, sheets to Peter, download cameras, weigh FMC samples and record
- Vesta and PCS score sheets
- Vesta bark pics
- Vesta Visual record sheet, incl Destructive Visual, Fuel Weights and Levy Rod record 'boxes'
- Vesta visual record sheet for additional samples within plot
- Patch size record sheets, for Surface and Near-Surface strata

Random numbers:

Plot 1 start (sw corner, 10m N, 22m E, sample points sorted and sub-sampled for FMC = 2, 3, 4, 5, 9, 10, 11, 15 (1, 6, 7, 8, 12, 13, 14, 16 not sorted , not sub-sampled for FMC%)- see diagram next page.

Plot 2 start (sw corner, 16m N, 3m E, sample points sorted and sub-sampled for FMC = 1, 3, 4, 5, 7, 10, 15, 16 (2, 6, 8, 9, 11, 12, 13, 14 not sorted , not sub-sampled for FMC%)



First Plot to be sampled:

- Transects and Vesta Visual sample points 50m apart
- Destructive samples (DS) located randomly from each VV sample point
- Red points: Destructive sample sorted Ll and Dd , weighed, sub sampled for FMC
- Black points: Destructive sample, weighed only
- (NB Fine fuel is Ll less than 3 mm, Dd less than 6 mm)

Random numbers for start of sampling grid and for quadrat location: start at a corner, proceed across row, then to adjacent column

1:30 for sampling grid start (from corner – K and L already selected)

1 to 30	1 to 30	1 to 30	1 to 30
22	7	27	4
4	4	17	23
18	27	14	8
23	27	22	23
3	12	12	9
18	16	24	11
22	18	22	22
25	12	2	27
20	24	13	11
23	23	6	6
20	20	17	27
2	17	22	11
15	8	25	5
23	27	29	6
17	13	26	27
30	29	7	5
22	17	24	12

1:60 replaces watch second hand; for quadrat location: a) bearing from Visual sampling point, b) distance from Visual sampling point to centre of quadrat, c) orientation of quadrat

1 to 60	1 to 60	1 to 60	1 to 60
26	36	1	36
2	31	15	29
12	15	39	18
39	32	1	54
13	14	39	42
50	4	20	8
49	29	35	50
19	4	43	33
42	31	33	43
28	19	31	35
30	37	46	43
2	46	22	41
45	16	8	33
39	26	50	32
34	5	28	19
34	28	59	26
34	5	1	3

Fuel Sample Record Sheet **Plot____________ Sample Point___________________**
Assessors____________________ **Date_______________**
GPS____

Vesta Visual		___m	___m
Duff	depth (mm)		
	%cover		
Moss/	depth (mm)		
Lichen	%cover		
Surface	depth (mm)		
Profile	PCS		
	FHS		
Surface Litte	depth (mm)		
Near Surface	ht (cm)		
	PCS		
	FHS		
Elevated	ht (m)		
	PCS		
	FHS		
	FHSbark		
Int Canopy	ht (m)		
	PCS		
	FHSbark		
OS Canopy	ht (m)		
	PCS		
	FHSbark		

VISUAL of DESTRUCTIVE sample			**Fire Plot #:**		**Sample**	
Site:			**GPSLocatio**			
Assessors:				**Pre-burn / Post-burn**		
Sample	**S=1 sq m (A or B), N-S = same sq m as S, E = 2 sq m**					
Date:	**% Cover**	**% Dead**	**# Stems**	**PCS**	**FHS**	**Ht/depth**
Duff						
Moss/Lichen						
Surface						
Near Surface						
Tussock grasses						
Low sedge/rushes						
Hummock grasses						
Low shrubs						
Elevated						
Shrubs						
Tall grasses						
Bracken						
Tall sedges						

Gap-size: Point to fine fuel measurements, dist (cm) to nearest, then 3 at right-angles (> 25 cm?)

A-S					B-S			
A-NS					B-NS			

Elevated, Fuel Height (m)_____ Quadrat 2m x 1m								
Fuel component	**Bag+Wet (g)**	**Bag (g)**	**Net (g)**	**FMC tin #**	**Tin+Wet (g)**	**Date in**	**Tin+Dry (g)**	**Tin (g)**
Dead 0-6 mm								
Live 0-3 mm								
Unsorted								

Near-Surface, Fuel Height (cm)____ , Quadrat 1 m^2, 'A' or 'B' (random)								
Fuel component	**Bag+Wet (g)**	**Bag (g)**	**Net (g)**	**FMC tin #**	**Tin+Wet (g)**	**Date in**	**Tin+Dry (g)**	**Tin (g)**
Dead 0-6 mm								
Live 0-3 mm								
Unsorted								

Surface, Fuel Depth (mm)____ , Quadrat 1 m^2, 'A' or 'B' (the same quadrat as for N-S sample)								
Fuel component	**Bag+Wet (g)**	**Bag (g)**	**Net (g)**	**FMC tin #**	**Tin+Wet (g)**	**Date in**	**Tin+Dry (g)**	**Tin (g)**
Dead 0-6 mm								
Live 0 – 3 mm								
Unsorted								

Quadrat Location: From point on transect: Bearing = second reading * 6, distance = second reading/4 (nearest m), orientation=second reading * 3

NB Check tins are empty: Take care placing and removing lids:

Weather Data on Day of Burn

Monday 3 March — Plot R - West Ignition time 11:45
Plot R - East Ignition time 12:40
Plot AS1 - Ignition time 14:35

Project FuSE Weather Data Summary — **Monday, 3 March 2008**

(0600-1800)	Temp	RH	Dew Pt	Wind Direction	Wind speed 10min mean	Wind speed 10min max	FMC	FFDI	GFDI
	ºC	%	ºC	º	km/h	km/h	%		
Min	15.0	**8.2**	**-4.0**	2	8.1	17.5	**1.7**	10.4	5.3
Max	**35.5**	28.5	-0.7	359	**22.5**	**37.1**	4.7	**46.5**	**26.5**
Peak Time	15:50	14:40	17:30		9:10	11:00	14:20	17:20	17:20

Data source: CSIRO MAWS, Plot C, 35º 45.297S, 140º 50.713E

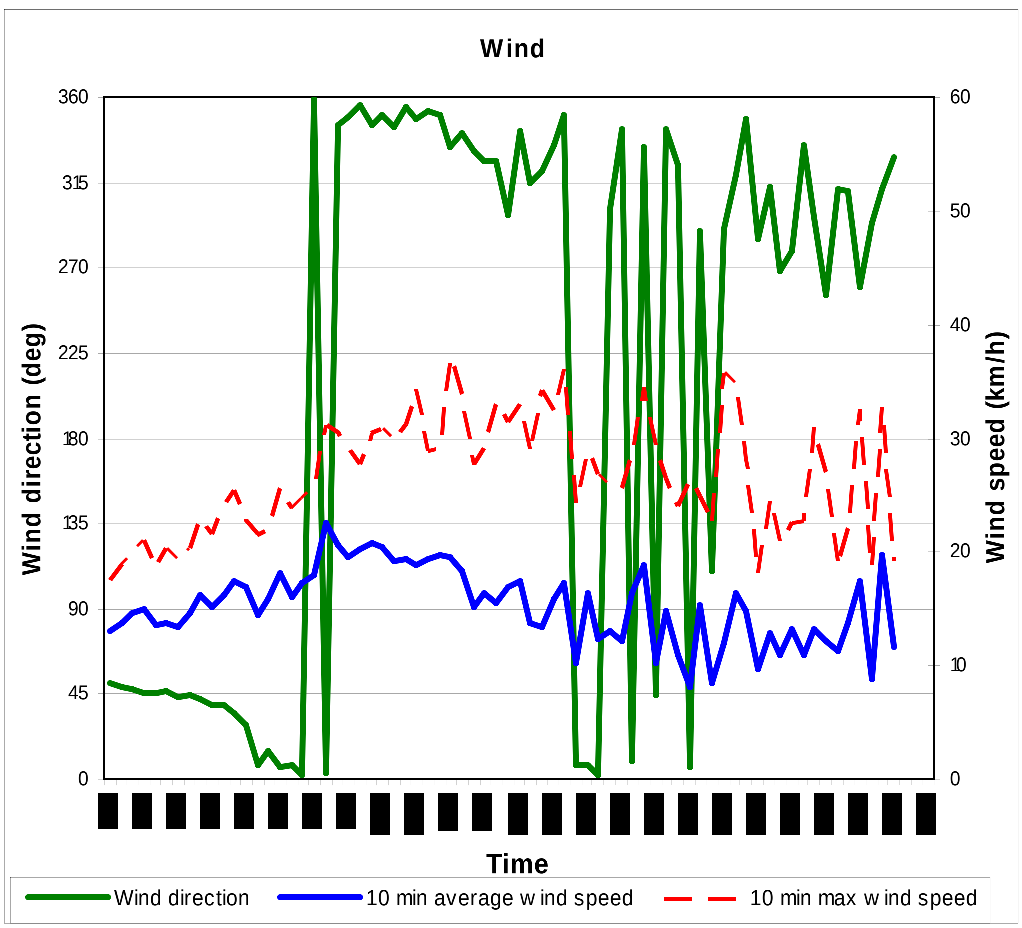


Table 3: Wind Speed and Direction (Plot C) – Monday 3rd March 2008

Tuesday 4 March Plot A - Ignition Time 14:00
Plot AS3 - Ignition time 15:50

Project FuSE Weather Data Summary **Tuesday, 4 March 2008**

(0600-1800)	Temp	RH	Dew Pt	Wind Direction	Wind speed 10min mean	10min max	FMC	FFDI	GFDI
	ºC	%	ºC	º	km/h	km/h	%		
Min	16.4	**21.9**	**3.4**	77	6.1	9.4	**2.8**	5.7	2.1
Max	**32.2**	43.3	9.7	196	**21.0**	**39.0**	7.7	**27.9**	**18.2**
Peak Time	16:30	16:50	6:00		17:30	17:00	15:37	16:40	16:40

Data source: CSIRO MAWS, Plot C, 35º 45.297S, 140º 50.713E

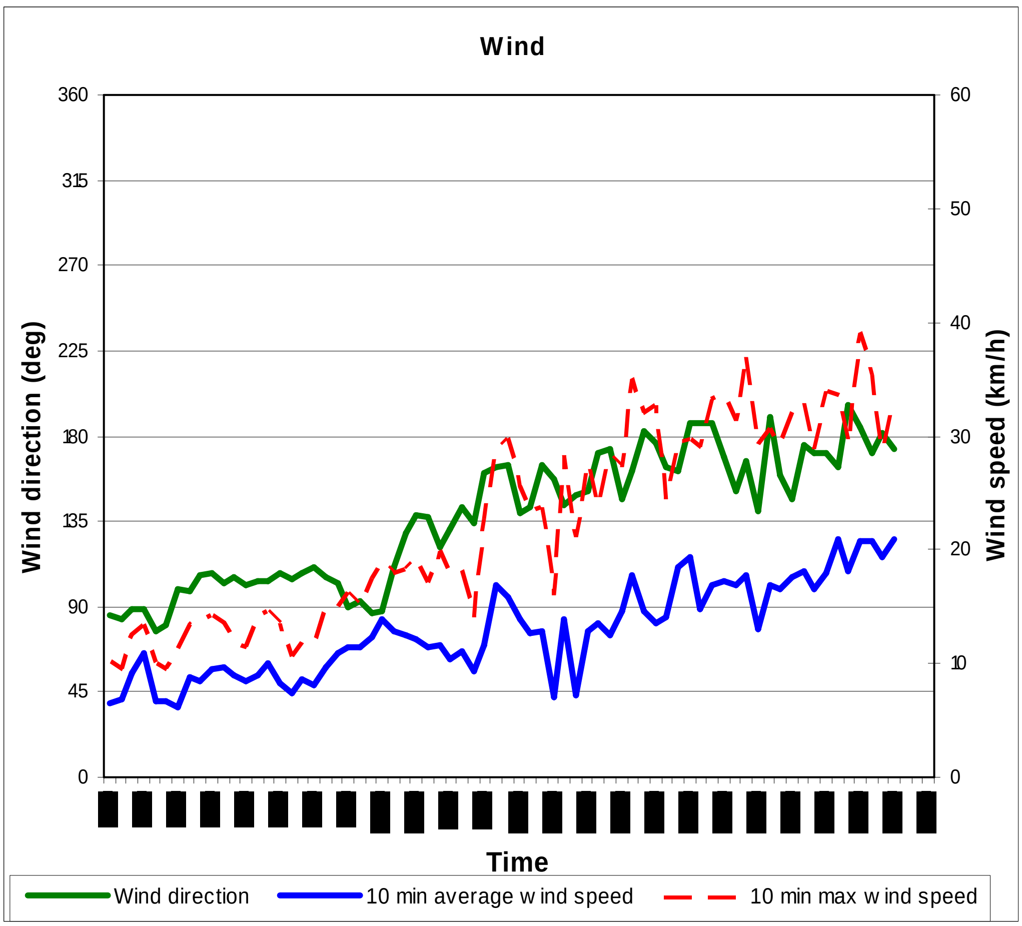


Table 6: Wind Speed and Direction (Plot C) – Tuesday 4th March 2008

Wednesday 5 March Plot E - East Ignition time 12:00
Plot E - West Ignition time 12:31
Plot AS2 - Ignition time 15:00

Project FuSE Weather Data Summary **Wednesday, 5 March 2008**

(0600-1800)	Temp	RH	Dew Pt	Wind Direction	Wind speed 10min mean	10min max	FMC	FFDI	GFDI
	ºC	%	ºC	º	km/h	km/h	%		
Min	15.6	**13.0**	**3.1**	5	6.1	13.7	**3.3**	2.8	3.0
Max	**37.1**	69.5	11.2	360	**22.9**	**34.2**	7.5	**41.5**	**23.3**
Peak Time	15:10	15:10	17:10		8:20	16:50	14:52	15:30	17:30

Data source: CSIRO MAWS, Plot C, 35º 45.297S, 140º 50.713E

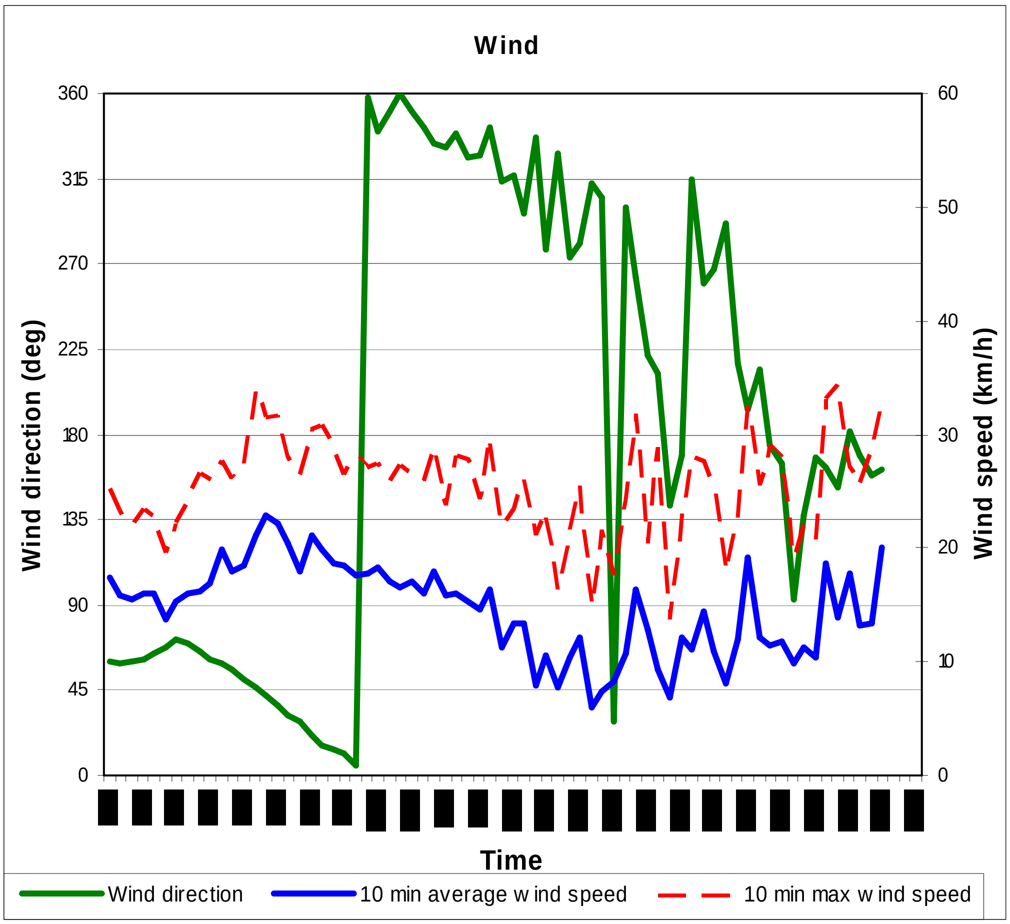


Table 9: Wind Speed and Direction (Plot C) – Wednesday 5th March 2008