PROJECT VESTA

The prediction of high-intensity fire behaviour in dry eucalypt forest

Progress Report: January 1997

Executive Summary

1. Two areas of dry forest with different fuel characteristics have been identified. Each has a range of fuel ages between 2 and 20 years.

2. 110 experimental plots of 200 x 200 m have been located and surveyed. Construction of firebreaks began in December 1996 and will be completed in March 1997.

3. Preliminary fuel studies have been undertaken to test fuel sampling techniques.

4. Non-destructive sampling techniques tested did not adequately describe fuel structure. The intensity of sampling required would significantly change the structure of the fuels prior to burning.

5. The number, size and design of sampling techniques to estimate the surface and near surface fuels to within 10% of the mean have been established.

6. A scoring system to numerically describe the fuel structure has been designed and will be tested in the field during March, April 1997.

7. Field work will be conducted between February 24 and April 11, 1997. The following tasks will be undertaken:

    - Undertake 50% of the specified fuel sampling workload on all plots.

    - Field test anemometry designed to measure in-forest wind profiles.

    - Pilot study experimental fires to test ignition systems, data recording systems and the logistics for carrying out experimental fires.

Experimental Site

Two areas in Western Australia have been identified suitable sites for the research project. At each site it is proposed that fuel of different ages will be burnt simultaneously in 200 x 200 m or 200 x 100 m fire plots. Demarcation of the fire plots was completed in November 1996 and construction of the plots started in December 1996 and to be completed by March 1997. The two sites and number of proposed fire plots are:

(1) *McCorkhill Block*: (west of Nannup) The vegetation and fuels in this block are considered reasonably representative of dry eucalypt forest with low understorey shrub component. Jarrah (*Eucalyptus marginata*) is commonly associated with mari (*E. calophylla*) forming the overstorey of 30 - 60 percent canopy cover with a top height of 25 - 30 m. Intermediate-canopy trees consist of primarily casuarina and banksia species. The understorey scrub height ranges from 0.2 - 3 m and cover range from sparse to near-continuous. The fire plots are orientated to conduct the experimental fires under a south westerly sea breeze between 1200 and 1500 hours to achieve a relatively uniform wind field across the fire plot. All fire plots are located on positive slopes for the proposed head fire to spread up slope. Ground truthing for slope changes in each fire plot is required before experimental burning.

The study site has five fuel ages which by 1998 will be:

Fuel age	# Fire Plots
1. 2-year old	5- 200 x 200 m fire plots
2. 4-year old	10- 200 x 200 m fire plots
3. 7-year old	14- 200 x 200 m fire plots
4. 10-year old	14- 200 x 200 m fire plots
5. 15-year old	13- 200 x 200 m fire plots

(2) *Dee Vee Block*: (east of Harvey) The second site is also jarrah-mari forest type. The importance difference between the sites is that the fuels here are primary litter with only a small proportion of shrubs. The demarcation of the fire plots in the Dee Vee site are for the experimental fires to burn under south easterly and easterly winds on some experimental plots have slope will have a significant effect on fire spread because of the slope is $> 5^{o}$. The relationship between slope and spread is robust for a variety of fuels so we can normalise for slope during analysis.

This site has four fuel ages class which by 1998 will be:

Fuel age	# Fire Plots
1. 2-year old	12- 200 x 200 m fire plots
2. 5-year old	12- 200 x 200 m fire plots
3. 8-year old	13- 200 x 200 m fire plots
4. 19-year old	17- 200 x 200 m fire plots

The locations of the fire plots, major roads and fire trails in the vicinity of the study site are shown on the project maps.

Preliminary Fuel Surveys

Preliminary trials were conducted to determine methods by which fuel load, structure, composition and continuity for the different fuel ages could be quantified numerically. Two nondestructive sample designs were trialed to quantify the fuel structure, continuity and cover of the different fuel layers by fuel age. Standard methods of destructive sampling were used to estimate fuel load.

1. Point quadrat sampling (pqs): The fuel layers were sampled by a point quadrat sample based on Levey and Madden (1993) and Sneeuwjagt (1971) at selected intervals along a transect line. At each point quadrat the contact or touch of each of the fuel layers to the sampling rod (Levey Rod) was recorded. The surface fuel was recorded as litter present or absent, i.e. bare ground. The average top height of the other three layers near the levey rod touches were recorded.

2. Line intercept sampling (lis): The line intercept method was used to measure the aerial cover of the different fuel layers. Its principle use was to estimate the canopy coverage of shrubs and other low-growing vegetation. The length of the canopy or fuel layers that intercept the transect line was measured. An estimate of the proportion of the study area covered by the different fuel layers was obtained by calculating the fraction of the total length of the transect line that is covered by fuel layer canopies.

3. Destructive sampling: The most effective technique for sampling fuel loads is destructive sampling. Fuels were stratified into the different fuel layers and to sampled make an estimate of the mean fuel load of each layer. Different sampling techniques and plot sizes used were to estimate the variability of the fuel distribution and the sampling intensity required to obtain a good estimate of the mean.

Results

The fuel assessment data collected from the preliminary fuel survey were evaluated by several statistics to determine the sample size and sampling techniques to best describe the fuel quantity, structure, composition and continuity for each of the different age classes.

The results obtained from the point quadrat sampling indicated that there is high degree of dispersion or variability in the percent cover of the elevated and near-surface fuel layers within each age class and between age classes. The point quadrat sampling is very repetitive and time consuming to collect data and requires a large number of sample points (up to 2000 sample points in each fire plot) to obtain a reasonable estimate of percent cover of the different fuel layers ie. reasonable error to estimate the mean within 10 percent.

The line intercept sampling did not show significant difference in the mean fuel layers percent cover and chord intercept length (length of the fuel layer intercept along the transect line) between the different ages of the three main fuel layers (upper elevated, lower elevated and near-surface fuel layers). The line intercept sampling was more efficient than the point quadrat sampling technique but it did not adequately describe the fuel structures by age compared to the visual difference that can bee seen in fuel structure and composition of the different fuel ages since last burnt (ie. density and senescence of vegetation over time).

Both point quadrat sampling and line intercept sampling technique gave reasonable estimates of fuel height and requires less than 60 samples to estimate within 10 percent of the mean.

Operator bias in destructive sampling of the surface fuels was removed by visually ranking the samples in order of fuel loads of light, medium and heavy. The litter depth and small 0.05 m^2 samples of the surface fuels were taken for each of the rank sampling. There was no significant difference between the mean of the three ranked samples and the mean of the medium samples alone. Therefore, the surface fuels can be sampled accurately by taking only the medium ranked sample. Summary of the medium ranked sample of the surface fuel load < 10 mm are as follows:

Site	Fuel age	Mean fuel load ($t\ ha^{-1}$)	Coefficient of variation (%)
Dee Vee	3	6.85	26.6
	6	6.68	20.5
	16	11.61	39.4
McCorkhill	5	7.92	29.4
	8	8.29	39.9
	13	9.43	39.8

The near-surface fuels sampled from a small quadrat of 0.05 m^2 resulted in a high variation of fine fuel loads. This high degree of variability could be contributed to the small sample size and/or the size of the sample quadrat. For a given number of sample units, accuracy can be increased by enlarging plot size. However, time requirements often restrict the number of plots that can be destructivity sampled and, consequently, the precision of estimates. Therefore, it is recommended to increase the size of the sampling quadrat for the near-surface fuel destructive sample to 0.20 m^2 circular quadrat (0.505 m diameter quadrat).

The live fine fuel loads in the near-surface layer contribute less than 10 percent of the near-surface fuel load. Sorting of the live and dead fuel was time consuming and separating the live and dead material of the near-surface samples is not recommended at this time.

The 1 x 2 m destructive samples of the elevated layers were large bulky samples which had to be sorted and dried. The fine fuel load < 6 mm only added less than 1 $t\ ha^{-1}$ to the total fine fuel load. Also, a large number of samples are required to obtain a reasonable estimate of the mean load ie. 1080 samples within 10 percent, or 270 samples within 20 percent of the estimated mean.

Conclusions

1. Both non-destructive sampling techniques tested were impractical. The intensity of sampling required to quantify visual differences in the fuel structure would significantly alter the structure of the fuel on the plots by trampling and be very costly to carry out.

2. A visual scoring system together with a measure of the top-height only of each layer will be used to evaluate fuel structure.

3. Fine elevated fuels contributed 10-15% of the total fine fuel load. The number of samples required to obtain a reasonable estimate of the mean would also significantly alter all the fuels on the plot and be time consuming and costly to collect. This sampling is to be discontinued.

4. Sorting of live and dead fuels from all samples was time consuming and showed little difference in fuels of different ages. The spatial variation of the samples meant that any difference in live to dead ratio would be difficult to correlate with fire behaviour. A better understanding of live to dead ratio may be obtained by sub-sampling the dominant species only and examining how live to dead ratio changes with life form and age.

5. It is feasible to sample the surface litter and near-surface fuels to obtain an estimate of the mean with a standard deviation within ± 10%. The number of samples required for this estimate have been determined by each fuel age.

6. A subjective ranked sampling method using samples from the medium ranking only is the most efficient way of sampling near-surface and litter fuels.

7. A quadrant size of 0.05 m^2 is suitable for sampling litter fuels. A large quadrant of 0.20m^2 is required for sampling near-surface fuels.

8. Random, systematic or subjective sampling may be used to estimate fuel loads. Random sampling is time consuming and often a large number of samples are required to obtain an estimate of the mean with reasonable confidence limits. To avoid disturbance to the central plot area systematic grid sampling will be used. 2 lines will be placed at 50 m from the plot boundaries.

Proposed sampling design

Nondestructive Sampling

There are 110 fire plots need to be assessed for fuel quantity, structure, composition and continuity. A cost effective sampling technique is required to assess fuel structure, composition, continuity and height. Therefore, an ideal sampling design for estimating fuel structure, composition and continuity that can:

1. permit seasonal and pluriannual evaluations that are nondestructive,
2. provide a clear three-dimensional representation of the vertical and horizontal structure of the fuel,
3. provide specific composition of the fuel layers, and
4. be sufficiently rapid and practical to make field work as easy as possible over a wide area.

A nondestructive sampling technique to meet these objectives called "***Fuel Combustibility Score***" (FCS) was devised from:

Wilson, A A G (1993) Elevated fuel guide. Dept of Conservation and Natural Resources, Victoria. Research Report No. 35.

Wilson, A A G (1992) Eucalypt bark hazard guide. Dept of Conservation and Natural Resources, Victoria. Research Report No. 32.

Tolhurst, K, McCarthy, G, and Chatto, K (1996) Estimating overall fuel hazard for forest fuels. Dept of Conservation and Natural Resources, Victoria. (Unpublished report).

Cheney, N P, Gould, J S and Knight, I (1992) A prescribed burning guide of young regrowth forest of silvertop ash. (Appendix 1) Forestry Commission of New South Wales. Research Paper 16.

At each sample point a fuel combustibility score will be given for the fuel structure within a 15 m radius from sample point on the basis of cover and fuel hazard for the five fuel layers: (1) overstorey trees, (2) intermediate trees, (3) elevated fuel, (4) near-surface fuel and (5) surface fuel. Definition of each fuel layer is given in Table 1.

Each fuel layer is rated for percent cover (Percent Cover Score- PCS) and fuel hazard (Fuel Hazard Score- FHS) on a scale of 0 - 4. The criteria for the PCS and FHS scores are outlined in Tables 2 and 3. The two scores for each layer are combined and tallied to get a total fuel combustibility score (FCS) for the fuel structure at the sample point. The multiplied PCS and FHS can range from 0 - 16, with total FCS ranging from 0 - 80.

The hypothesis is a high FCS fuel structure will have higher or greater fire behaviour characteristics (ie. high rates of spread, high flames and high fire intensity) than a low FCS fuel structure burning under the same environmental conditions. A second hypothesis is higher the FCS score, the older the fuel structure (ie. high FCS scores are in the old age class fuels). These hypothesis need to be tested.

To calculate the Fuel Combustibility Score (FSC) by the following equation and an example is shown below:

$$FCS= (PCS_i \times FHS_i)$$

Fuel Layer	PCS*i*	FHS*i*	FCS*i*
Overstorey canopy	2	3	6
Intermediate canopy	0	0	0
Elevated fuel layer	2	2	4
Near-surface layer	2	1	2
Surface fuel layer	4	1	4
		Plot FCS=	**16**

Table 1. Definition of the forest fuel layers.

1. **Overstorey Trees -** dominant and co-dominant trees forming the uppermost canopy layer of the forest. Trees are pole size or greater. The crowns are receiving full light from above and partly from the side.

2. **Intermediate Trees -** Trees shorter than the overstorey tress with crowns either below or extending into the crowns of the formed overstorey trees. They can be trees of overstorey species of sapling size and trees of other understorey species (eg casurina) which form a distinct layer beneath the co-dominants of the overstorey. Patches of eucalypt regrowth in the open or around scattered dominants may be classed as intermediate until they reach pole size.

3. **Elevated fuel layer -** shrubs and other understorey plants usually 2- 3 m high. This layer may include regeneration of the overstorey species intermixed with shrubs. The individual fuel components generally have an upright orientation and spatial variability is high.

4. **Near-surface fuel layer -** grasses, low shrubs, trailers, and collapsed understorey usually containing suspended leaves, twigs and bark from the overstorey vegetation. The height of this layer can vary from just centimetres to over a metre above the ground. The orientation of the fuel layer components includes a mixture ranging from horizontal to vertical. and capable of supporting leaf, twig and bark material above the ground.

5. **Surface fuel layer -** leaf, twigs and bark of the overstorey and understorey plants. The fuel components are generally horizontally layered. This layer usually makes up the bulk of the fuel load and determines the flame depth of a surface fire.

Table 2. ***Percent Cover Score (PCS)***- visual estimate of the percent cover for the five fuel layers into five score classes.

Overstorey Trees Percent Cover Score *(Estimate canopy cover within 15 m radius from the sample point)*				
0	1	2	3	4
0	>0-25%	25-50%	50-75%	>75%
-canopy cover absent, - no vertical projection of live overstorey canopy onto the ground within 15 m radius from sample point.	- very sparse isolated crowns, - <25% of skylight is intercept by crown foliage , ie. > 75 % gaps in the canopy.	-open forest with well separated crowns, - 25 - 50% of skylight is intercept by crown foliage, ie. > 50 % gaps in the canopy.	-open forest with clearly to slight separation of crowns, -50 - 75% of skylight is intercept by crown foliage, ie. < 50 % gaps in the canopy	-close or dense live canopy cover, - all overstorey trees canopy within 15 m radius from sample point are touching or overlapping, -more than 75% of skylight is intercept by crown foliage , ie. <25 % gaps in the canopy
Intermediate Tree Percent Cover Score *(Estimate canopy cover within 15 m radius from the sample point)*				
-intermediate tree canopy absent, - no vertical projection of live intermediate canopy onto the ground within 15 m radius from sample point.	- very sparse / isolated intermediate trees, - <25% of the canopy layer is crown foliage , ie. < 75 % gaps in the intermediate canopy.	-intermediate tress with well separated crowns, - 25 - 50% of the canopy layer is crown foliage, ie. > 50 % gaps in the intermediate canopy.	-intermediate trees with clearly to slight separation of crowns, -50 - 75% of the canopy layer is crown foliage, ie. < 50 % gaps in the intermediate canopy	-close or dense intermediate canopy cover, - all intermediate trees canopy within 15 m radius from sample point are touching or overlapping, -more than 75% of of the canopy layer is crown foliage , ie. <25 % gaps in the intermediate canopy

Elevated Fuel Layer Percent Cover Score: *(Estimate percent cover within 5 m radius from the sample point)*				
0	1	2	3	4
0	>0-25%	25-50%	50-75%	>75%
-elevated fuel is absent within 5 m plot radius.	- shrubs are very sparse or in small isolated clumps within 5 m plot radius.	- scattered shrubs or well separated clumps, - gaps or openings >50% of the 5 m plot radius.	-discontinuous shrub cover or clumps, -gaps or openings < 50% of the 5 m plot radius.	- continuous cover of shrubs within 5m plot radius, -shrub crowns are touching or overlapping.
Near-Surface Fuel Layer Percent Cover Score: *(Estimate percent cover within 5 m radius from the sample point)*				
-near surface layer is absent within 5 m plot radius.	- very sparse or small isolated clumps of near-surface fuel within 5 m plot radius .	- scattered well separated clumps of near-surface fuels, - gaps or openings >50% of the 5 m plot radius.	-discontinuous cover or large clumps of near-surface fuel covering over 50 % of the plot area, -gaps or openings < 50% of the 5 m plot radius.	- continuous cover of shrubs within 5m plot radius, -gaps are very small (<25% of plot area) or touching between clumps of near-surface fuel.
Surface Fuel Layer Percent Cover Score: *(Estimate percent cover within 5 m radius from the sample point)*				
0	>0-25%	25-50%	50-90%	>90%
-no litter present, -5m plot radius is completely bare soil or rock outcrops.	- litter is very sparse or in small isolated patches within 5 m plot radius, - 5 m plot is > 75% bare soil or rock outcrops.	- over 50 % of the 5 m radius plot is bare soil or rock outcrops, -scatter patches of litter between bare soil or rock outcrops.	- scatter, discontinuous and light cover of litter fuel with >10 % of the 5 m radius plot is bare soil or rock outcrops.	- continuous cover of litter fuel within 5m plot radius, -<10 % of the plot area is bare soil or rock.

Table 3. ***Fuel Hazard Score (FHS)***- visual estimate of the potential fuel hazards for the five fuel layers into five score classes.

Fuel Layer	Fuel Hazard Score (FHS): *Description of the overstorey trees bark type and bark fuel.*				
Score	0	1	2	3	4
Overstorey Canopy	Absent	- stringy bark where bark is well charred and tightly held on whole trunk, - ironbarks with very tight, platy or fibrous bark, -smooth barks which do not produce long ribbons of bark.	- stringybark where most of bark is black on the lower trunk but not recently burnt, - few pieces of bark are loosely attached to trunks, - bloodwood and box bark with tight fibrous bark which has not been burnt for some years, -smooth / candle bark which shed long ribbons of bark but have smooth bark down to ground level.	-stringy barks where < 50% of surface area of the trees is black, -upper parts of trunk may not be charred, -smooth / candle barks with long ribbons of bark which are loose, -fibrous or platy or box type bark on lower trunk which have not been burnt for many years (maximum number for these bark types).	- stringy bark with large flakes of bark that can be easily dislodged, - huge amounts of bark are available for spotting, - outer bark on the trees is attached weakly, - minimal evidence of charring (complete grey appearance on trunks).
Intermediate Canopy	Fuel Hazard Score (FHS): *Description of the intermediate trees bark type and bark fuel.*				
Intermediate	Absent	- stringy bark where bark is well charred and tightly held on whole trunk, - ironbarks with very tight, platy or fibrous bark, -smooth barks which do not produce long ribbons of bark.	- stringy or paper bark mostly black on the lower trunk, - few pieces of bark are loosely attached to trunks, and upper branches, - bloodwood with tight fibrous bark which has not been burnt for many years, juvenile forms of stringy bark becoming loose and flaky.	-stringy or paper barks where < 50% of surface area of the trees is black, - upper parts of trunk not charred, juvenile type stringy barks well developed platy nature becoming stringy and unburnt for many years.	-stringy or paper bark with large flakes of bark can be easily dislodged, - huge amounts of bark are available for spotting, - outer bark on the trees is attached weakly, - minimal evidence of charring (complete grey appearance on trunks).

Elevated fuel layer	Fuel Hazard Score (FHS): *Description is fuel density and morphological development of plants.*				
Score	0	1	2	3	4
Record average top height (cm)	Absent	-patches of sparse / dispersed shrubs, - easy to walk straight through patches of shrubs, - vigourous new green growth from seed or sprouts.	- moderately dense patches of shrubs which can be easily walk through. Mostly easily to see where stepping but occasionally need to step over vegetation , -not much fine fuel present at base of shrubs	-dense patches of shrubs which are difficult to walk through, need to select paths around or step high, - some lower branchlets are starting to senescent.	-very dense patches of shrubs which are very difficult to see where you are stepping, need to use arm to push through tall vegetation, - plants are senescent, and starting to collapse -very fine fuel present from top to bottom of the vegetation.
Near-surface fuel layer	Fuel Hazard Score (FHS): *Description of accumulation and bulk density changes of the near-surface layer.*				
Record average top height (cm) and destructive sample	Absent	-near-surface fuel material is sparse/dispersed, - dead material is virtually absent, -sparse vegetation less than 0.2 m, - grasses short and green.	- scattered suspended leaves, twigs and bark, no impediment to walking - proportion of dead material is < 25%.	- suspended leaves, twigs and bark, on shrubs or trailers, - starting to obscure rocks, logs etc - proportion of dead material is 25% - 50%.	-large amounts of leaves, twigs and bark suspended in the layer, - difficult to see where stepping - NSF obscures logs, rocks, holes etc -high proportion of dead material >50 % - vegetation is senescent.
Surface fuel layer	**Fuel Hazard Score (FHS):** *Description of the stages of accession and decomposition of litter fuels.*				
Record litter depth (mm) and destructive sample	Absent	- very thin layer of litter on forest floor, - litter depth < 10 mm	- established litter cover with no signs of decompositions, - litter depth 10-20 mm	-established litter cover with decomposition present, -litter depth 15-25 mm	- very thick layer of litter on forest floor with a duff layer underneath litter layer, -litter depth > 25 mm.

Destructive Sampling

McArthur (1962) defined fine forest fuels as dead leaf, bark and twig litter <¼ inches (< 6 mm) in diameter and considered that the weight of fine fuel consumed was an important variable for predicting fire spread. The objectives of this research study is to quantify the effectiveness of low-intensity prescribed burning for modifying the behaviour of wildfires (ie. to quantify effects of fuel load in different fuel ages on fire spread). Therefore, it is important to get a good estimate of the available fine fuel on each fire plot. The main objects of the destructive sampling is achieve standard deviation of the samples within 10 percent of the mean. Analysis from the preliminary fuel surveys resulted in sample sizes for the medium ranked surface fuels as follows:

Site	Fuel age	Number of samples (to estimate within 10% of the mean)
Dee Vee	3	28
	6	17
	16	62
McCorkhill	5	35
	8	64
	13	63

The first stage of the fuel sampling program is to sample 50 percent of all the potential fire plots at both experimental sites in March / April 1997. The remainder of the plots will be done in the spring of 1997 approximately two to three months before the experimental fires.

At each sample point the surface fuel will be visually ranked light, medium and heavy within a 5 m radius from the sample point. The *medium* rank sample litter depth and fuels < 6 mm will be taken from a 0.05 m^2 circular quadrat (0.2523 m diameter).

At the sample point the present or absent of near-surface fuel will be recorded to give a non bias estimate of the percent cover of the near-surface fuel. If near-surface fuel is present in the CFS score assessment a destructive fuel sample will be taken. The near-surface fuel will be visually ranked light, medium and heavy within a 5 m radius from the sample point. At the *medium* ranked sample fuel height will be recorded and the fuels < 6 mm harvested down to mineral soil from a 0.20 m quadrat (0.505 m diameter).

All destructive fuel samples will be oven dried for at least 24 hours at 100^oC. The dried samples will be weighed and expressed in weight in per unit area.

Field Procedures

1. The sampling size for each fire plot by fuel age for the two experimental sites is listed in Table 4. The fuel plots will be systematic, located along two transect lines parallel to the proposed direction of the head fire spread. To minimise the disturbance of the fuel in the control of the fire plot the two transect line will be located 50 m from the plot edge.

Proposed lines are marked on the fire plot maps. Plot spacing varies by fuel age and are listed in Table 4.

Table 4. Number of fuel sample plots and plot spacing for each fuel age class for the Dee Vee Site and McCorkhill site.

Fuel age in 1998 (Block)	Total sample size	Stage 1 sample size	Number of Transect lines	Plot spacing
Dee Vee				
2 (Block 02)	20	10	2	20,55,90,125,160 (5 plots / line)
5 (Block 01)	28	14	2	20,45,70,95,120,145,170 (7 plots / line)
8 (Block 03)	17	9	2	20,55,90,125,160 (5 plots / line)
19 (Block 04)	62	31	2	20,30,40,50,60,70,80,90,100,110,120, 130,140,150,160,170 (16 plots / line)
McCorkhill				
2 (Block 10)	20	10	2	20,55,90,125,160 (5 plots / line)
4 (Block 9)	20	10	2	20,55,90,125,160 (5 plots / line)
7 (Block 7 & 8)	35	18	2	20,40,60,80,100,120,140,160, 180 (9 plots / line)
10 (Block 11)	64	32	2	20,30,40,50,60,70,80,90,100,110,120, 130,140,150,160,170 (16 plots / line)
15 (Block 12, 19,18)	63	32	2	20,30,40,50,60,70,80,90,100,110,120, 130,140,150,160,170 (16 plots / line)

2. Approach each sample point cautiously to avoid disturbance the vegetation around the plot. Record the near-surface fuel by presence or absence at the sample point only (Note the near-surface fuel can be absent at the sample point but still be present in the 5 m plot radius for the fuel combustibility score assessment).

3. Score the percent cover and fuel hazard for the five fuel layers. If the elevated fuel and near-surface fuel are present record the average top-height of these fuel layers.

4. Visually rank the surface fuel load light, medium and heavy within the 5 m radius of sample point. The medium sample point litter depth and litter fuel < 6 mm in size will be harvested from 0.05 m^2 sampling ring into labelled sample bag.

5. If near-surface fuel layer FCS is >0 and destructive fuel sample is required of this layer for the plot. Rank the near-surface fuel light, medium and heavy within 5 m radius of the plot centre and the medium rank sample fuel height (mm) recorded and fuel destructive sample from an 0.2 m^2 quadrat. All the fine fuel < 6 mm will be removed from the quadrat down to the mineral soil.

6. Slope and aspect at each sample plot to be noted.

7. Equipment required:

. Field plot maps and fuel sampling forms
. Clipboard, marking pens
. Compass and clinometer
. Hip-topo chain and cotton reels (at least 500 m)

. Sampling quadrats- 0.05 sampling ring for the surface fuel
0.20 sampling quadrat for the near-surface fuel
. Hand hedge clippers, secateurs, 2 m measuring tape
. Paper sample bags - A4 size bags for litter fuels
A3 (grocery) size bags for near-surface fuels
. Large plastic bags to carry and store fuel samples

Additional fuel information

Interpretation of project aerial photographs (scale 1:4500) and videography are being examined for mapping the fire plots. Interpretation of these images will stratify and map the fire plots by canopy cover, stand densities, and changes in the understorey density within the fire plots. The data collected from Stage 1 fuel survey and the remote sensing images (feasibility of project aerial photos or videography images are being examined) will be used to design a more efficient Stage 2 fuel survey in the November / December 1997.

Wind Profile and Weather Measurements

Wind profiles under the forest canopy at each experimental fire will be measure at 1, 2, 5, and 10 m above the ground. Anemometers with individual mini data loggers built in to a "C" vane which can be suspended in-line are being constructed and tested to log the wind profiles near the experimental fires.

A standard weather station was set up at each of the experimental site for the summer periods of 1996/97 (December to March). At each station the following weather data was recorded on to a data logger:

. Wind speed and direction at 10 m
. Temperature and relative humidity at 1.5 m
. Rainfall (tipping bucket)

In addition a standard rain gauge and a thermohygrograph was installed at each site.

Pilot Study

A pilot study is proposed in late March or early April 1997 to test the fire behaviour experimental design and wind profile measurements. Two or three paired 200 x 200 m fire plot will be established in CALM proposed buffer area burns near the McCorkhill site (east of Jalbarragup Road). These 200 x 200 m fire plots will be burnt simultaneously under prescribed burning conditions. The main aim of the pilot study are to:

Test the ignition procedures of lighting an instantaneously ignition line using SUREFIRE (mixture of aluminium stearate powder, methanol and petrol) and the ignition line lengths.

Test the 10 m wind profile tower measurements in different fuel ages and near the pilot study fires.

Investigate procedures to measure fire behaviour parameter:

(a) fire spread - fire spread timers and total time fire burn through the plot,
(b) flame and fire front characteristics- video cameras.

Standardise fuel moisture measurements and test fuel moisture meters.

Examine the data from the fuel survey in relationship to fire behaviour parameters .

Examine methods to measure bark fuel and fuel consumption (post fire fuel surveys).

Project Vesta Work Plan January - June 1997

Date	Activity	Action
Feb 24 - 28	Review: fuel sampling techniques establish calibration plots	CSIRO- J Gould CALM- L McCaw ADFA- W Catchpole
Mar 3	Pete H, Ian K and Sean C travel to Western Australia	CSIRO - 3 staff
Mar 4 - April 11	Appointment of causal Technical Assistance for fuel sampling (appointed by CALM and CSIRO Project Vesta funds will reimburse CALM	CALM
Mar 4 - 14	Fuel survey- Dee Vee Site	CSIRO- 4 staff CALM- 4 staff
Mar 17	Phil C travels to WA- pick up hire car in Perth, travel to Manjimup/Nannup	CSIRO
Mar 17 - April 11	Fuel survey- McCorkhill Site	CSIRO- 3/5 staff CALM- 4 staff
Mar 17 - Mar 27	Wind profile studies in different fuel age classes	CSIRO- 2 staff CALM- 1 staff
Mar 27	Pete H and Ian K return hire car and travel back to Canberra	CSIRO
Mar 24 - April 11	Pilot study fires McCorkhill Site buffer areas (weather permitting) Debriefing of pilot study	CSIRO-3/5 staff CALM- 5 staff
April 12	Phil C, Sean C and Jim G return to Canberra (pending on completion of field work)	CSIRO
Mar 24 - April 11	Project Vesta Seminars: Blackwood District (Nannup) Mornington District (Harvey) Perth: CALM / RFB	CSIRO- J Gould/ P Cheney CALM- L McCaw
Mar- April	Buffer strip burning	CALM
May	WASP Model analysis for the Dee Vee Site	CSIRO
April - June	Data Reduction: Fuel Wind Profiles Pilot study experimental fires	CSIRO CALM
April - June	Preparation of research proposal and fund grants	CSIRO CALM
June	Preliminary outline of work plan for 1997/98	CSIRO / CALM

Project Vesta
Fuel Sampling Form

Date:___/___/ 97

Location: Dee Vee McCorkhill   Block:______   Operators:__________

Fire Plot:_____   Line #:______   Transect Bearing:__________ (^{O})

Fuel Plot #:____ Plot Location:______ (m)

Aspect:______(^{O}) Slope:______(^{O})

Fuel Combustibility Assessment

Fuel Layer	Percent Cover Score *(0-4)*	Fuel Hazard Score *(0-4)*	
Overstorey			
Understorey			Average Top Height
Elevated Fuel Layer			Height________cm
Near-Surface Fuel Layer			Height:_______cm
Surface Fuel Layer			

Fuel Quantity

Near-surface Fuel:

Point Sample: Absent (0)
Present (1)

Fuel Combustibility Score: =0 no destructive sample
>0 destructive sample

Medium Rank Sample	Fuel depth	Fuel load (0-6 mm) grams	t/ha
Near-surface fuel (0.2 m^2 quadrat)	(mm)		
Surface fuel (0.05 m^2 quadrat)	(cm)		