GIBSON DESERT NATURE RESERVE FIELD TRIP

August 10th - 26th, 1987

PRELIMINARY REPORT

N. Burrows, B. Ward, A. Robinson & Y. Woods

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Introduction

Planning is underway to conduct operational aero burning trials within the Gibson Desert Nature Reserve (GDNR) some 500 km NE of Wiluna. Background to this operation has been presented by Burbidge (1985), Burbidge *et al.* (1987) and by internal reports (Pearson, Burrows, Burbidge *et al.*) so will not be discussed in detail here. In summary, there is a recognised need to re-introduce a fire regime similar to that practised by aborigines in the past. Many thousands of years of aboriginal occupation and use of fire on desert lands has seen the co-habitation of man and the desert biota. However, a dramatic and rapidly changed fire regime since aborigines left these lands in the last 5 or so decades has contributed to loss of vegetation, floristic, structural and successional diversity. Today, the desert landscape is typified by vast tracts of homogenous, degenerate spinifex plains and vast tracts of herb fields as a result of large, intense and infrequent wildfires. There no longer exists the small grained mosaic of various successional (post fire) stages that is likely to have existed many years ago. The new fire regime is an important factor contributing to the diminishing desert fauna (Burbidge 1985, Burbidge *et al.* 1987).

Deliberate fire management using modern technology is aimed at re-introducing historic fire regimes. However, to achieve this, we need a firm understanding of fire behaviour and fire effects. Here, we report on our findings from a recent field trip to GDNR which aimed to:

i) locate, demarcate and describe suitable sites for conducting aero burns on May 1987.
ii) measure and map fuels/vegetation within these sites.
iii) monitor fuel moisture and weather conditions during the study period.
iv) study the behaviour and fire spread thresholds in each of the fuel/vegetation types for the weather conditions during this study.
v) conduct a fire history survey of the burn sites.
vi) evaluate our ability to provide weather forecasts for the area.

1 Locating Aero Burn Sites

Criteria set for locating sites for aero burn trials in the GDNR in May 1987 were as follows:

i) sites should be accessible from the ground to enable pre-burn, burn and post-burn assessment.
ii) sites should be representative of the major landform/soil units and vegetation types within the Reserve, regardless of pyric characteristics..
iii) burn block size should be operational scale, about 7000 ha each.
iv) blocks should contain prominent features or landmarks to facilitate ease of mapping.
v) sites should be no more than 20 minutes flight time from airstrip.
vi) sites should be in close proximity to facilitate ground travel between sites.

There are several potential sites which meet these criteria. One possible site is along Gary Hwy, as shown in figure 1. The main advantage of this site is that there is sufficient distance along Gary Hwy to locate a number of large aero burns and the major vegetation types are included. The main disadvantage is the distance from Beadell airstrip. This will mean considerable travel for the aircrew to and from the study site where the ground party would be camped or two well separated camp sites. Another appealing site is along the grid line heading north-east from near Mt Beadell, towards Lake Gruszka. The main advantage of this site is poor knowledge of vegetation types in the area. Thematic mapping of vegetation and ground validation is currently being undertaken to assist with site selection.

Initially, we used a 1:250 000 Landsat scene as a first basis for classifying landform and vegetation. Our scene did not cover the Lake Gruszka area, so we concentrated on the site west of Gary Hwy. We found the Landsat image useful for determining broad landform/vegetation units but it was difficult to determine boundaries and to determine differences in vegetation types or similar landform units. However, we were able to identify at least four distinct landform units based on colour and textural differences. Ground inspections confirmed and verified these types and it was gratifying to be able to use the Landsat image while traversing Gary Hwy, to predict changes in landform and hence major vegetation types. In the absence of any other maps, Landsat images proved valuable.

2. General Descriptions of Major Landform Units and Associated Vegetation

The four types presented here, may be further sub divided on floristic and geomorphological characteristics, but they adequately describe the major pyric or fuel complexes along Gary Hwy.

2.1 Sand Plains

These are the flow-on areas or low lying depositional surfaces of deep red sands with a minor gravel component. The plains are often extensive, up to 5 km or more and are typified by a cover of *Plectrachne schinzii* with sparse occurrences of woody shrubs (Myoporacae, Proteaceae especially). The sandplains are often fringed by *Triodia basedowii* dominated by gravelly sands (light buckshot plains). There are frequently ecotones and intrusions of *Triodia basedowii* into the *Plectrachne* plains. A more detailed description of fuel structure is presented in Table 1.

2.2 Light Buckshot Plains

These plains are normally adjacent to the *Plectrachne* sandplains. The red sandy soils have a higher component of small gravels (buckshot). *Triodia basedowii* is the dominant ground cover. Other vegetation include woody shrubs and small trees (Table 2).

2.3 Heavy Buckshot Plains

These plains are higher in the profile than both the sandplains and the light buckshot plains. They are characterised by a ground cover of *Triodia basedowii* on sandy gravels. The load of gravel is noticeably higher on these sites than on the light buckshot plains. Belts of mulga are also a feature on these plains, together with a range of other woody shrubs.

2.4 Laterite Ridges and Slopes

This is the hill country of stripped laterised surfaces further characterised by very shallow, stony soils and rocky scree slopes. The tops of the breakaways are often hardened rock with little or no soil cover and with caverns and ledges. Erosional gullies are common with bed loads of cobbles or sand further down the profile. Ground cover consists of sparse *Triodia basedowii* with patches of *Plectrachne* and soft grasses occurring on inter-hill floors and erosional gullies.

Mulga and other acacias are more common here than on the plains (Table 1). This represents the least

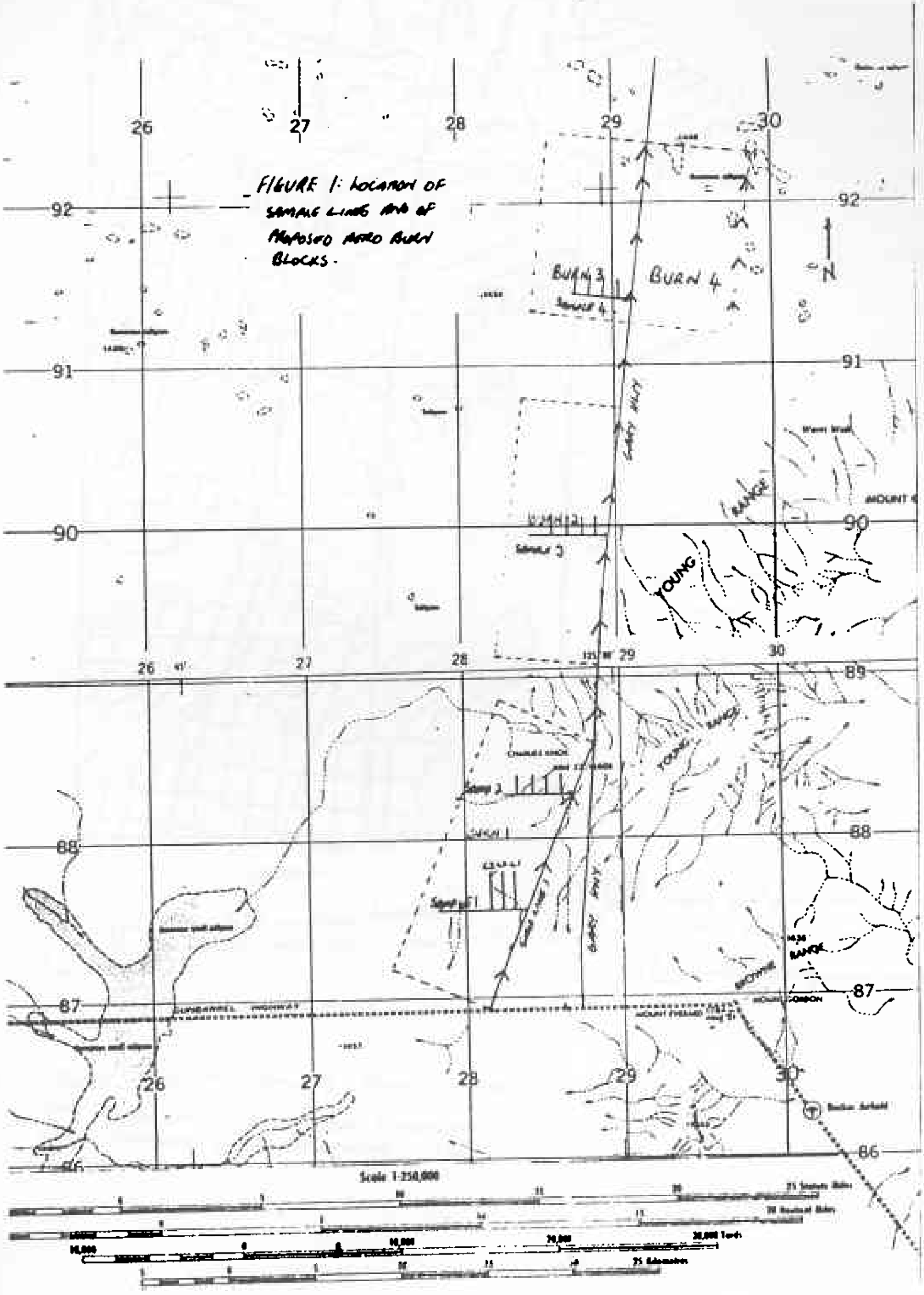
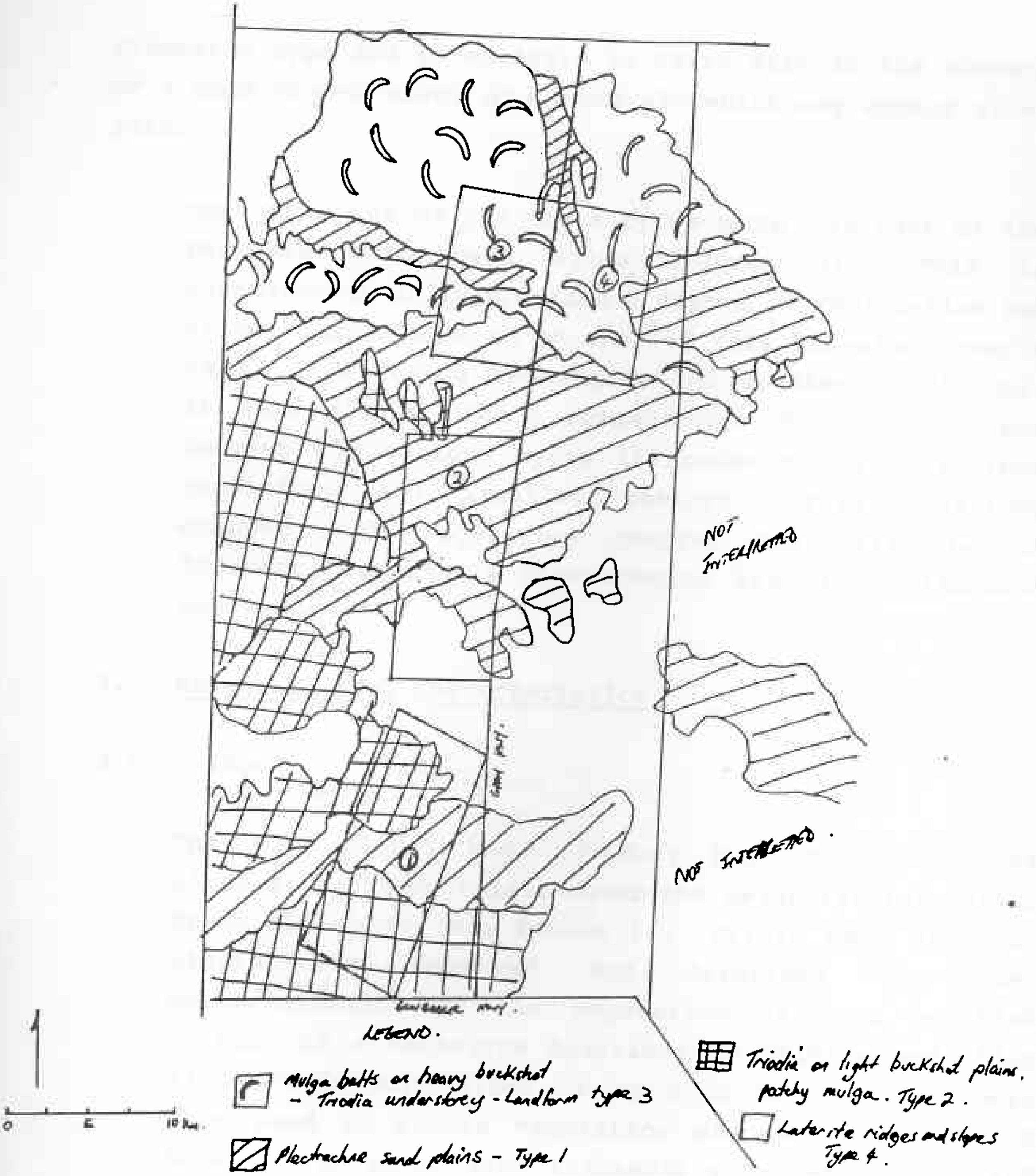


FIGURE 1: LOCATION OF SAMPLE LINES AND OF PROPOSED AERO BURN BLOCKS.

FIG: 2: BROAD VEGETATION TYPES INTERPRETED FROM 1:250 000 LANDSAT IMAGE. NOT RELIABLE.



NOTE: MOORE RECENT ATTEMPTS USING THEMATIC MAPPING PROCEDURES HAVE PROVED FAR MOORE SUCCESSFUL. DAVID AARREN IS UNDERTAKING THIS WORK.

flammable type and is unlikely to carry fire in the absence of a good ground cover of ephemerals which may appear after rain.

More than one of the above types occurs in each of the proposed aero burn sites (Figure 2). This is advantageous as it provides a degree of replication and allows comparisons to be made of fire behaviour over a range of lighting techniques and weather conditions. It also allows direct comparisons of fire behaviour between the various types lit under the same weather conditions and lighting pattern. Fire behaviour changes with vegetation changes will also be of interest, especially fire running into less flammable types.

3. Measuring Fuel Characteristics

3.1 Methods

The four blocks west of Gary Hwy chosen for the aircraft ignition trials cover the major landform units described above (see Figure 1). Within each of these blocks, we measured and described the fuel characteristics of the vegetation using a modified version of a technique described by Griffin and Allan (1984). In each block, 4 or 6 km of line transects were used to sample vegetation at 1 m intervals. A total of 18 km of line transects provided some 18 000 sample points. Using a modified wheel point recorder and a Husky data capturing device, a team of two people was able to move down line transects at a rate of about 1 km/hr. Data fed into the Husky was loaded onto floppy disks for storage at the end of each day. A portable printer enabled hard copy printouts to be generated. Data collected during the day were then scanned for errors and corrected. In the office, an Olivetti M24 micro-computer was used to transfer data files across to the Perkin Elmer mainframe for analysis using the SPSSX package. This procedure for gathering, storing, checking and analysing data proved highly successful both in terms of speeding up the operation in the field and preparing data for analysis on the mainframe. Time savings in the field allowed us to increase our sampling intensity, thereby improving the accuracy and precision of our database.

In order to estimate oven dry biomass (in tonnes/ha) within each of the four major landform units, we clipped and weighed all vegetation in 40, 1m² quadrats and sub-sampled to determine moisture content.

The structural characteristics of each vegetation type were described using Griffin's (1984) patchiness ratio measure and by determining % ground cover from the line transect data.

3.2 Results and Discussion - Fuel Characteristics

Tables 1 and 2 summarise main structural and biomass characteristics of fuels within each of the proposed aero burn sites and within each of the landform classes. Note that the 18 km of sample lines do not cover the entire burn area, but merely sample major landform types within the burn area. The very large number of point samples (18,000) provided a high degree of accuracy and precision. Between sample lines and within landform/vegetation types the standard error of estimates of variable means rarely exceeded 10%. Tables 1 and 2 summarize fuel characteristics.

TABLE 1: Mean cover, quantity and patch size of vegetation along sample lines shown in Figure 1.

	1	2	3	4	Blocks Combined
Triodia cover (%)	15.3	7.1	18.9	38.4	15.3
Plectrachne cover (%)	32.0	4.2	26.9	1.2	18.1
Bare ground (%)	50.3	72.1	51.8	56.0	62.0
Mulga cover (%)	0.0	12.4	0.3	2.5	2.5
Other species cover (%)	2.4	4.2	2.1	1.9	2.1
Triodia Ht (cm)	26.1	25.0	23.1	19.0	-
Plectrachne ht (cm)	34.6	30.0	28.3	25.0	-
Fuel wt (t/ha o.d.w.)	8.2	2.8	7.4	5.5	-
Triodia patchness	0.32	0.47	0.35	0.52	0.36
Plectrachne patchiness	0.36	0.32	0.38	0.32	0.37
Bare ground patchiness	1.48	14.6	1.12	1.24	5.89
Triodia clump size (m)	1.35	1.31	1.31	1.31	1.34
Plectrachne clump size (m)	1.44	1.48	1.32	1.28	1.45
Bare ground patch size (m)	2.37	7.04	2.10	2.34	2.76

Note: Patchiness = variance/mean (after Griffin and Allan, 1984).

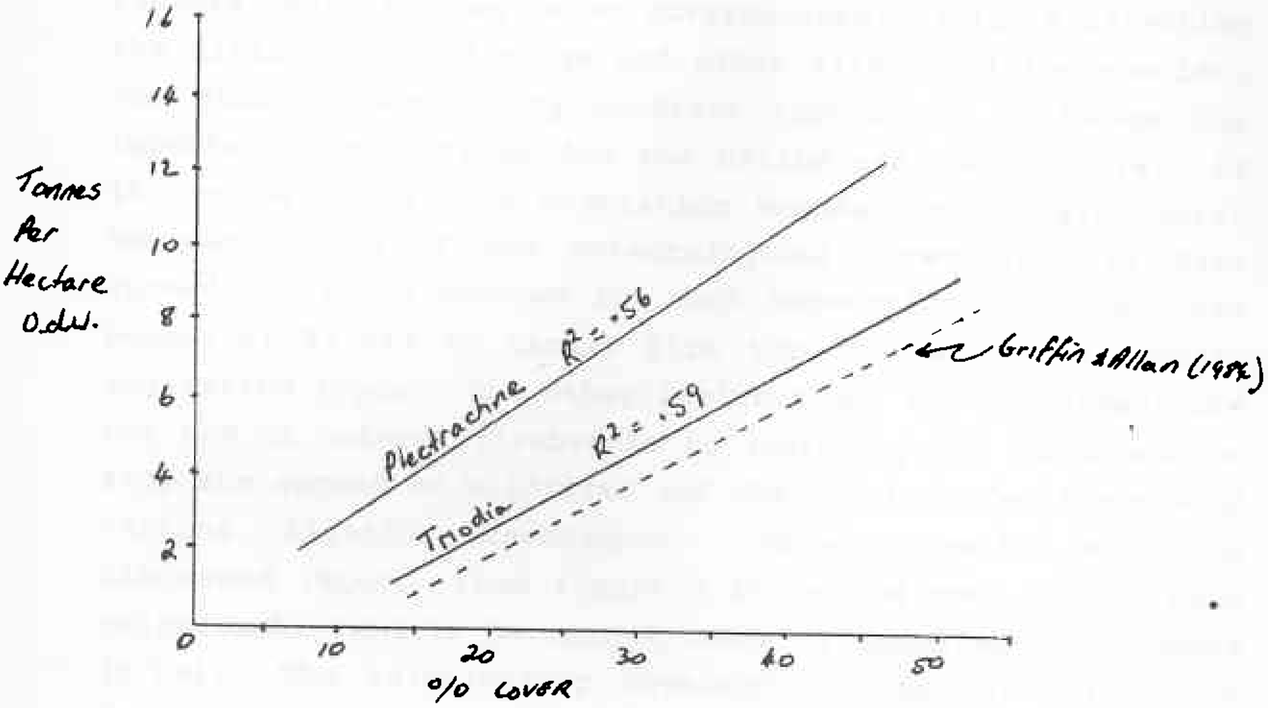
TABLE 2: Vegetation cover within the four major landform units at the study site.

	Landform Unit			
	Type 1	Type 2	Type 3	Type 4
Triodia cover (%)	2.0	39.6	35.1	7.1
Plectrachne cover (%)	44.3	1.1	0.8	4.2
Bare ground (%)	52.8	56.2	55.4	72.1
Mulga cover (%)	0.0	1.0	6.1	12.4
Other species (%)	0.9	2.1	2.6	4.2
Mean fuel wt (t/ha)	9.8	5.6	5.3	2.8

Note: Cover includes live and dead material (fuel).
Type 1 = Deep sandplains

Type 2 = Light buckshot plains
Type 3 = Heavy buckshot plains
Type 4 = Laterite ridges and rocky slopes

Figure 3 shows the relationship between spinifex cover and biomass (t/ha).



The structure, distribution and quantity of vegetation will directly effect flammability and fire behaviour. Spinifex is the dominant fuel component due to its distribution, biomass and flammability. Other species contribute little to the overall flammability and fire behaviour at sites studied here.

Landform unit 1 (deep sandplains) carried heaviest fuel loadings (mean 9.8 t/ha) and had the highest spinifex cover (mean 44.3%). Landform unit 4 (laterite ridges and rocky slopes) carried very light ($\bar{x}$ = 2.8 t/ha) and patchy ($\bar{x}$ 15.5% cover) fuels. It is worth noting that an inverse relationship exists between pyric characteristics such as vegetation flammability, distribution and biomass and the proportion of fire sensitive species, especially mulga. In the most flammable vegetation type (Plectrachne plains) mulga was not recorded along our sample lines. The proportion of mulga (% cover) steadily increased with decreasing flammability of understorey vegetation to peak on the heavy buckshot plains and laterite ridges at a level of 6.1% cover and 10.6% cover respectively.

This would indicate that not only edaphic and drainage factors, but fire may be an environmental variable affecting the distribution of mulga and other fire sensitive species. The strong flammability gradient across the landscape has important implications for the deliberate use of fire. If it can be shown that vegetation boundaries are also pyric boundaries and if the meteorological thresholds for fire spread can be determined for each vegetation type, then the potential exists to target fire into or away from certain vegetation types. The other implications for management are the use of natural firebreaks to achieve patch burns and to stop the spread of wildfires and the likely effectiveness of various lighting techniques. These aspects will be discussed later. From figure 3 it can be seen that a weak relationship exists between % cover of spinifex and biomass (t/ha). The relationship developed during this study for *Triodia* spec. is similar to that reported by Griffin and Allan (1984). However, *Plectrachne* is considerably heavier for the same cover, which means that this fuel array has a higher bulk density, or is taller, or both. In fact, this study showed that, on average, Plectrachne clumps are up to 10 cm taller than *Triodia* clumps. The height of both species varied both within and between sites, which probably explains the poor R^2 values in Figure 3.

Plectrachne schinzii was largely confined to deep sands but *Triodia basedowii* was found on all landform units. It was poorly represented on the deep sands and reached its best development on light buckshot plains adjacent to the plectrachne plains. Prior to aircraft burning trials in May 1988, it will be necessary to accurately map landform units and associated vegetation. Mapping should be at a resolution to enable the discrimination of the various spinifex plains, identify ecotones and map mulga belts. Remote Sensing - thematic mapping has most potential and will be evaluated over the coming weeks. Ideally, we should develop quantitative relationships between thematic maps and fuel and vegetation characteristics such as cover, *patchiness, biomass and moisture content.*

4.0 Weather Conditions During Study Period

Weather information was recorded using an electronic weather station. Records included mean speed and directions (at 2 m), temperature, relative humidity and solar radiation. Weather conditions over the study period are presented in Figures 4-8. Weather measurements were made electronically and at 10 minute intervals. No rain was recorded.

Wind strength, direction and duration are critical factors effecting the spread and behaviour of fire in live aerated and patchy fuels such as spinifex. A threshold level of windspread exists below which fires will not spread. This is discussed later. To control or predict the behaviour and pattern of fires requires reliable wind speed and direction predictions. In conjunction with this study, a comparison was made between winds experienced at the study site and those forecast from Perth. The results of these studies are encouraging (see Table 3).

Over the study period, winds from all quarters were experienced and were generally between 1.5-4.0 m/s with gusts up to 8 m/s and periods of calm. While under the influence of a high pressure system centred over central Australia, winds during the day were easterly. Wind speed peaked at about noon and eased during the afternoon to a minimum speed of around 1.5 m/s at sun

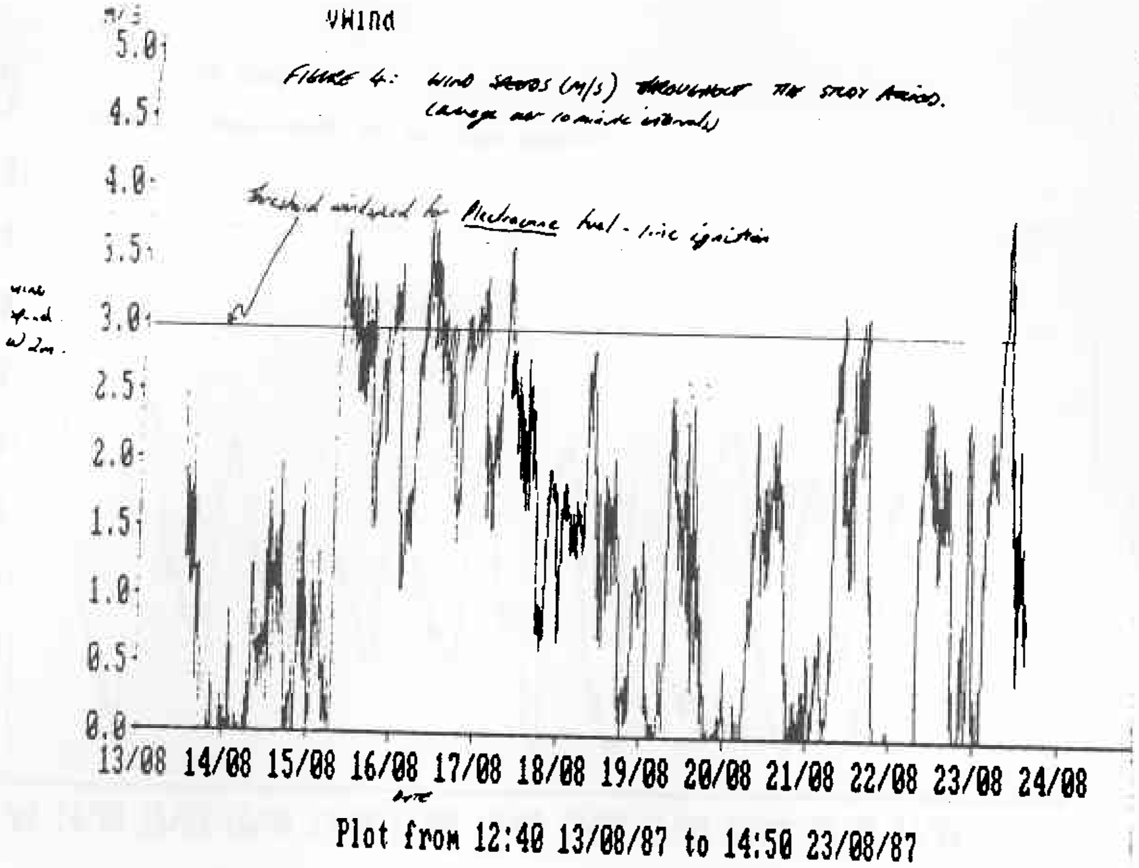


FIGURE 4: WIND SPEEDS (M/S) THROUGHOUT THE STUDY PERIOD. (average over 10 minute intervals)

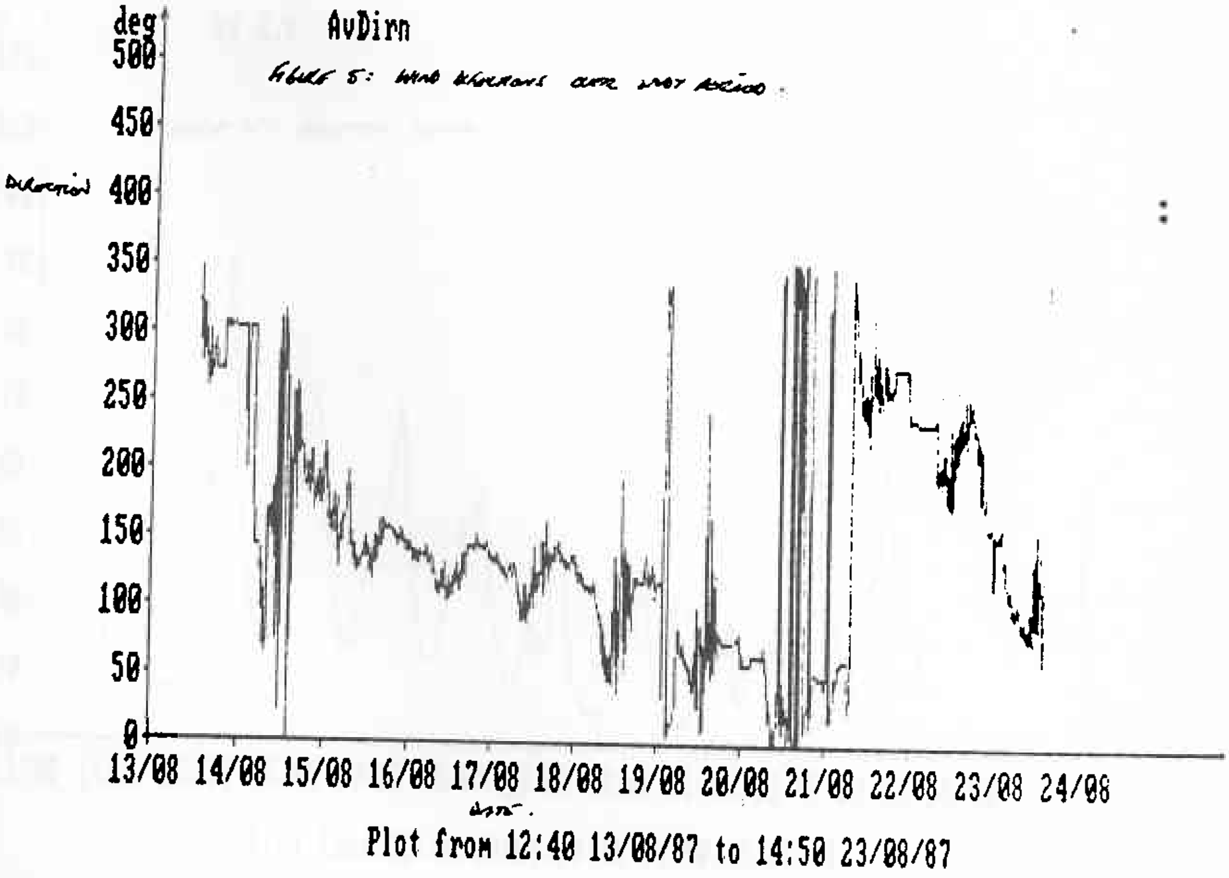


FIGURE 5: WIND DIRECTIONS OVER STUDY PERIOD.

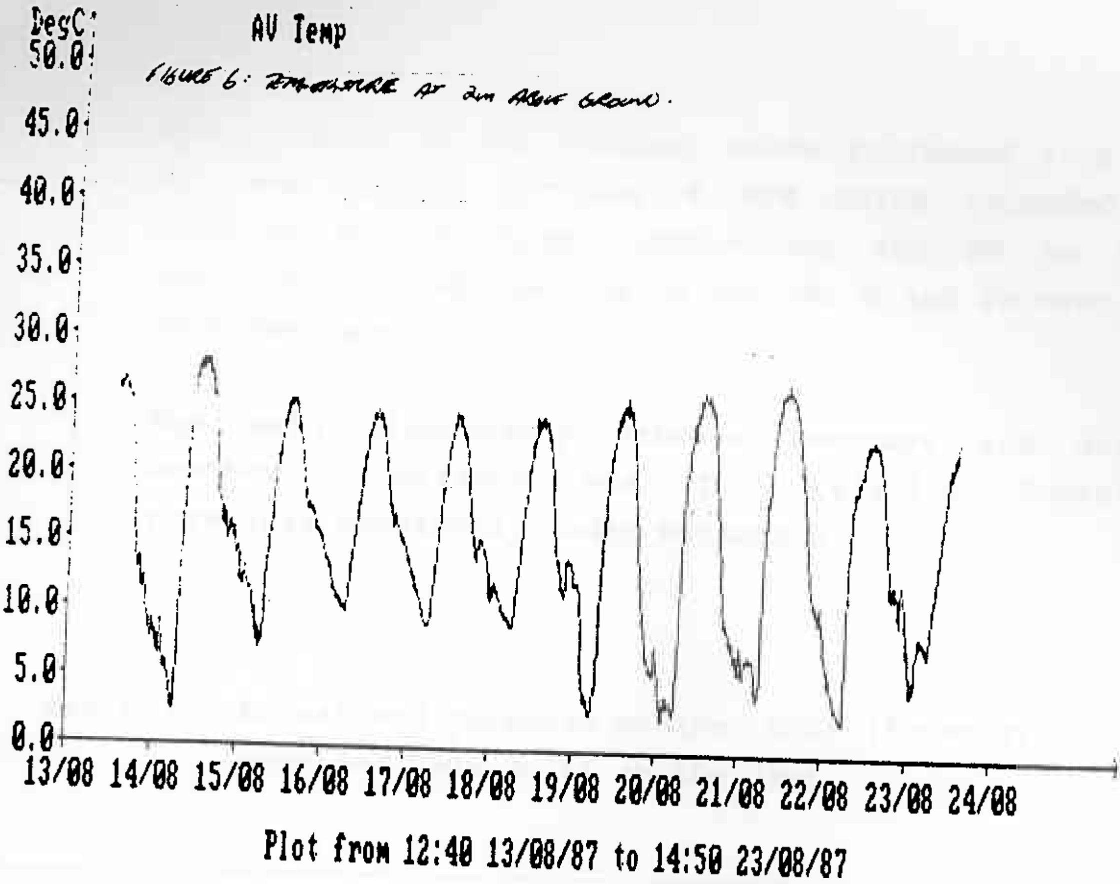


FIGURE 6: TEMPERATURE AT 2m ABOVE GROUND.

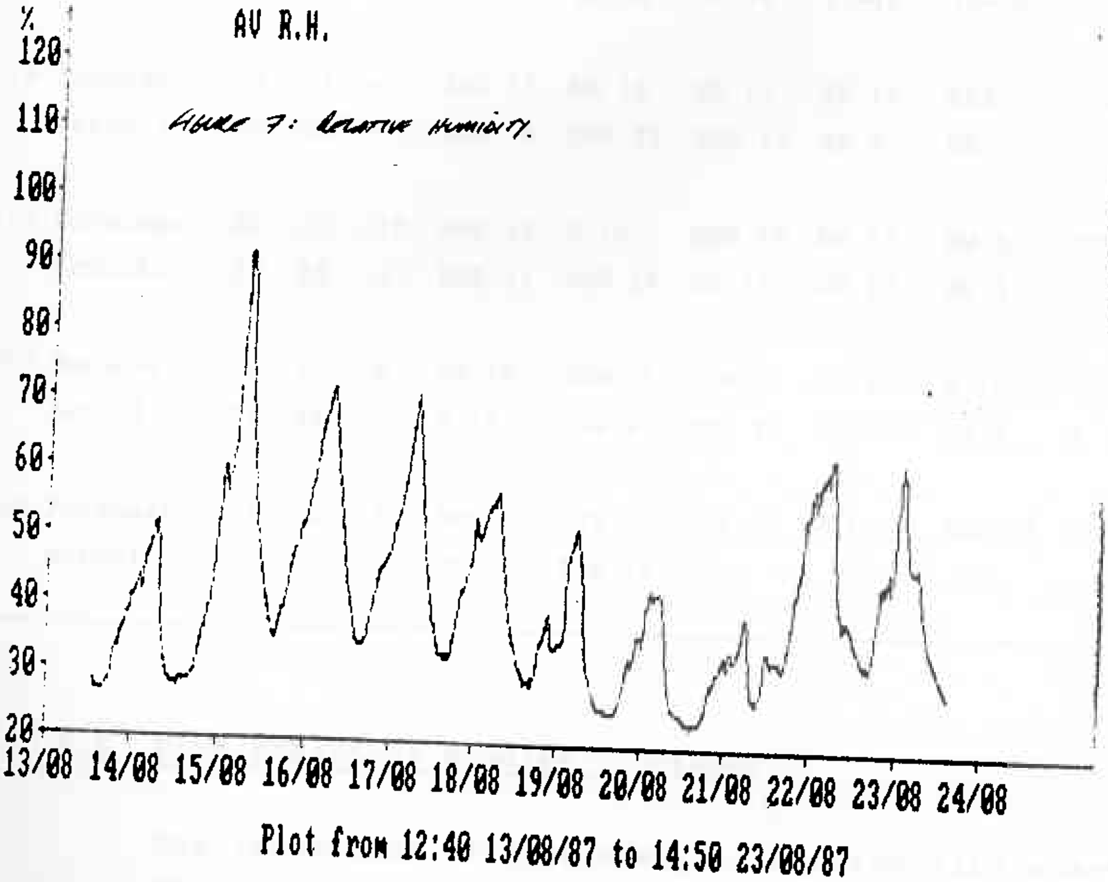


FIGURE 7: RELATIVE HUMIDITY.

down. Later in the evening, winds freshened from the SE with speeds of near 4 m/s being recorded at midnight. A Cold front approaching the SW on 20/8 resulted in winds backing to the NW, W and SW over the next few days.

The main discrepancy between forecast and actual weather conditions was for relative humidity. Forecasts constantly under estimated.

TABLE 3. Actual and forecast weather GDNR (forecast provided 0900 hours on the day)

Date	Max T	Min RH	Dew pt.	10-12	12-14	14-16	16-18	18-00	00-08
20/8 Forecast:	24	13	-7	ENE 15	NE 13	NE 13	NE 12	NNE 8	NNE 6
Actual:	26	24	-	ENE 14	ENE 12	ENE 12	NE 5	NE 5	0
21/8 Forecast:	24	10	-10	NNE 12	N 14	NNW 18	NW 15	NW 10	WNW 15
Actual:	27	28	-	NNE 14	WNW 18	NW 23	NW 12	NW 5	0
22/8 Forecast:	22	12	-8	SW 18	SSW 25	SSW 25	SW 15	E 10	ENE 10
Actual:	22	33	-	S 16	SSW 20	SSW 20	SSW 10	SE 5	E 5
23/8 Forecast:	23	16	-5	ESE 20	ESE 24	ESE 22	E 18	ENE 13	ENE 12
Actual:	23	29	-	ESE 18	ESE 18	-	-	-	-

5.0 Fire Behaviour Studies - Methods

The importance of accurately predicting fire start and fire spread to create patches in hummock grasslands has been described by Griffin and Allan (1984), Burrows (unpubl.), and Pearson (unpubl.).

Fires in spinifex fuels are wind driven. Therefore, it is important to know the thresholds for fire ignition and spread. Lighting method, whether by a single spot or by a continuous line will also influence thresholds for fire spread.

We set 26 experimental fires to examine the effect on fire spread of different lighting techniques (spot and line) and to examine minimum wind speeds for fire spread in different fuels on the various landform units.

Fires were lit using a drop torch. Line starts were continuous lines of fire up to 200 m and spot fires were single hummock ignitions. Prior to lighting, fuel moisture content was determined by destructive sampling and gravimetric analysis. Prior to and during the fires, weather conditions were continuously monitored. As wind speed is the critical factor affecting spread rate, observers with hand held anemometers made regulate (2-5 minute) observations of wind speed at (2m) near the headfire. The time, duration and strength of wind gusts near the headfire were also recorded. An electronic weather station was set up near the burn sites and mean wind speed, direction, temperature, RH and solar radiation (Wm^{-2}) were logged at 10 minute intervals. Initially, we attempted to tag the fires from outside the fire perimeter. However, this proved unwise as sudden wind shifts could place recorders in peril. We decided to tag the fires from inside the fire perimeter, thereby standing on burnt ground behind the headfire. Discomfort due to heat and smoke was alleviated by wearing goggles, face masks and full length clothing. As these spinifex fires consisted of a headfire only it was relatively easy to follow behind and tag the headfire at regular intervals (from 1-5 minutes, depending on spread rate). Fires were tagged until they self extinguished. Headfire run varied from 2 m to 4 km. A number of fires failed to spread. Weather conditions throughout the study period are shown above in figures 4 to 7.

Results and Discussion

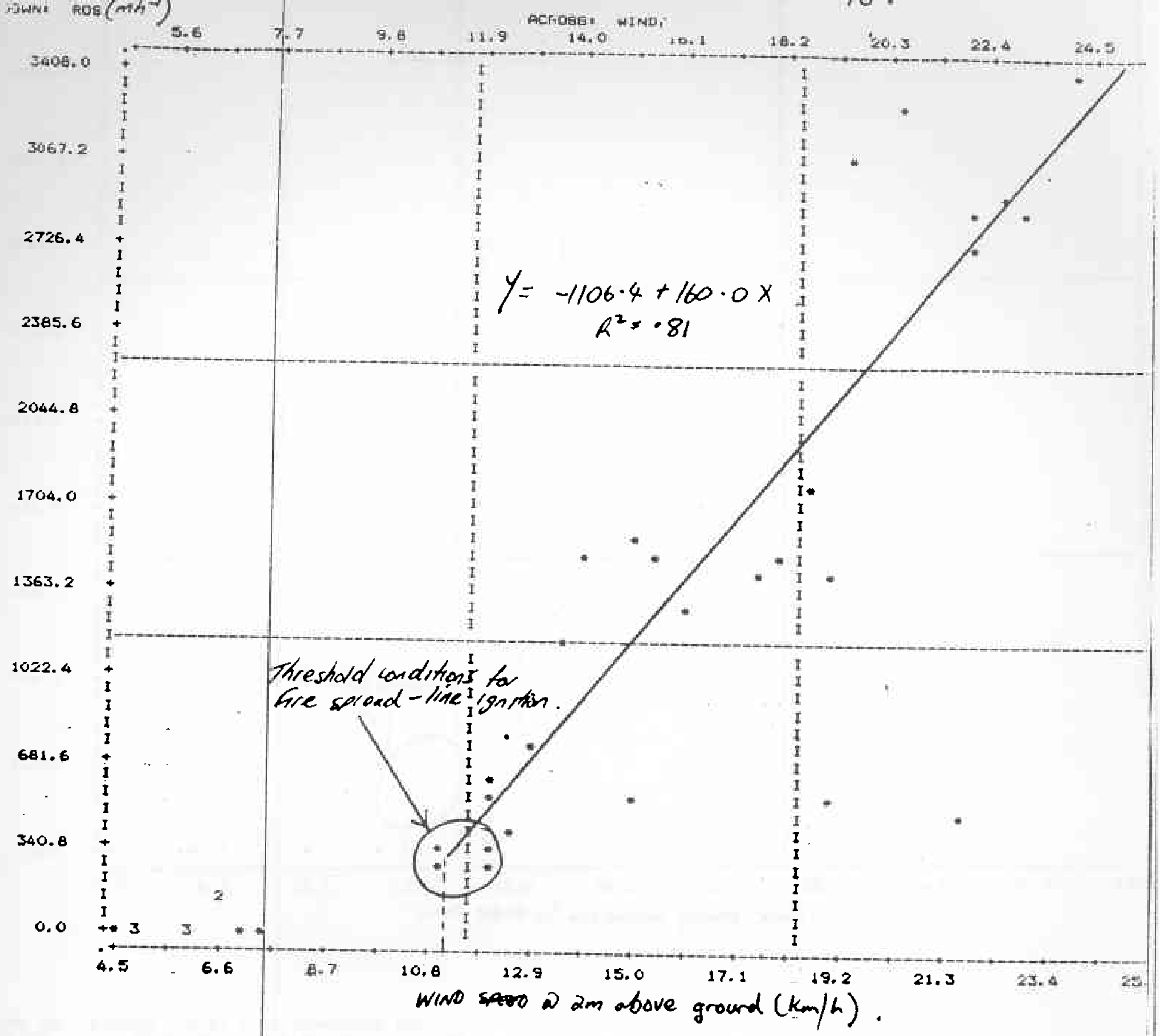
Fire spread in spinifex fuels is wind dependent. The threshold wind speed (to maintain fire spread) varied according to fuel physical characteristics and lighting technique. Line ignition increases the chance of fire burning in more or less continuous fuel and promotes the development of strong fire induced winds.

Plectrachne schinzii plains were most flammable. Using line ignition, a wind speed in excess of 10 kmh^{-1} (at 2 m above ground) was necessary for fire spread under the conditions of this study (Table 3). From figure 8, it can be seen that the minimum R.O.S. was about 340 mh^{-1} at a wind speed of around 11 kmh^{-1}. The threshold wind speed for fire spread from spot ignition was about 15 kmh^{-1} for *Plectrachne* fuels. The simple linear model (Figure 9) explained a high proportion of the variation in the dependent variable R.O.S., with an R^2 value of 0.81.

The less flammable *Triodia basedowii* on light buckshot plains, burnt with similar characteristics to *Plectrachne* fuels. Thresholds for fire spread were greater and for line ignition, wind speeds in excess of 15 kmh^{-1} were necessary for fire spread. This increased to 18 kmh^{-1} for spot ignition. Threshold conditions and linear regression statistics are shown in figure 10. Fires in *Triodia* burnt slower than those in *Plectrachne*, for a given wind speed.

We were not able to achieve fire spread in spinifex fuels occurring on the heavy buckshot plains or on the lateritic uplands. We estimate that winds in excess of 30 kmh^{-1} are necessary for fire spread on the heavy buckshot plains. It is unlikely that fire would spread onto the lateritic uplands. The exception to this may be following a succession of good rainfall seasons and the establishment of soft grasses, herbs and other annuals.

FIGURE 8: RATE OF SPREAD VS WIND SPEED FOR FIRES BURNING ON PLECTRACHNE PLAINS: MOISTURE CONTENT $\bar{Y} = 19\%$.



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5 JAN 88    GIBSON DESERT FIRE BEHAVIOUR 1987
4:34:38           DEPARTMENT OF C.A.L.M.          PE 3240         0832 7.2.5

STATISTICS..
  CORRELATION (R)-              .90136     R SQUARED        -          .81248        SIGNIFICANCE   -         .0
  STD ERR OF EST -           491.04325     INTERCEPT (A)    -     -1106.42815        SLOPE (B)      -       160.0
  PLOTTED VALUES -            41           EXCLUDED VALUES-          0               MISSING VALUES -          0

                 '*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.
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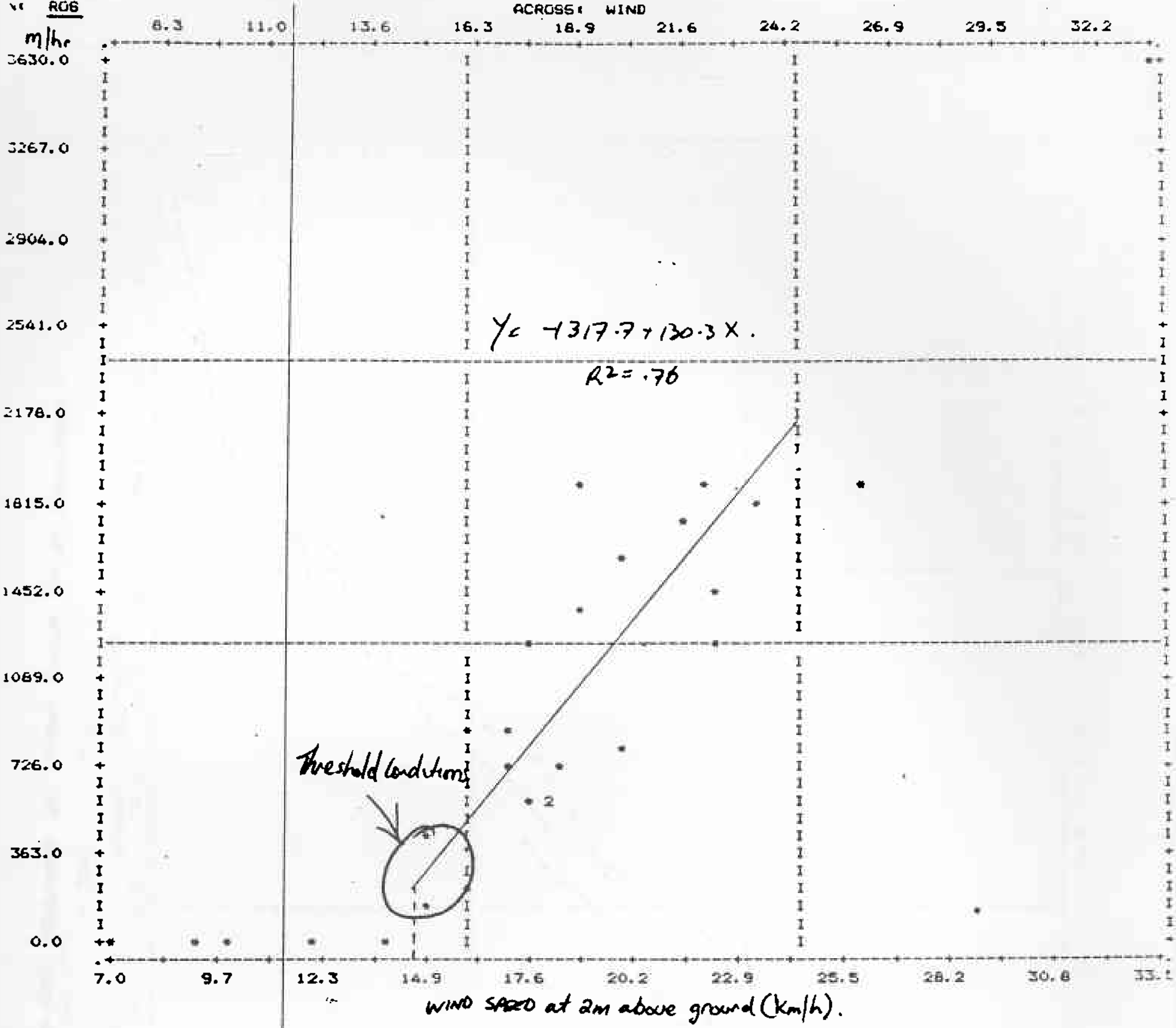
FIGURE 9: RATE OF SPREAD VS WIND SPEED - TROUGH (LINE 2). MC% = 18.5



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 JAN 88    GIBSON DESERT FIRE BEHAVIOUR 1987
:74:36          DEPARTMENT OF C.A.L.M.             PE 3240          0632 7.2.5

ATISTICS..
CORRELATION (R)-              .87092      R SQUARED        -          .75850      SIGNIFICANCE   -       .00
STD ERR OF EST -           407.05105      INTERCEPT (A)    -     -1317.72748      SLOPE (B)      -     130.3
PLOTTED VALUES -                  31      EXCLUDED VALUES-                0       MISSING VALUES -         0

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FIGURE 1Ø: DISTANCE HEAD FIRE TRAVELLED VS TIME SINCE LINE IGNITION

22 DEC 87 GIBSON DESERT FIRE BEHAVIOUR 1987
14:07:38 DEPARTMENT OF C.A.L.M. PE 3240 OS32 7.2.5

DOWN: DIST(meters) FIRE # 14 ACROSS: TIME (MINUTES)

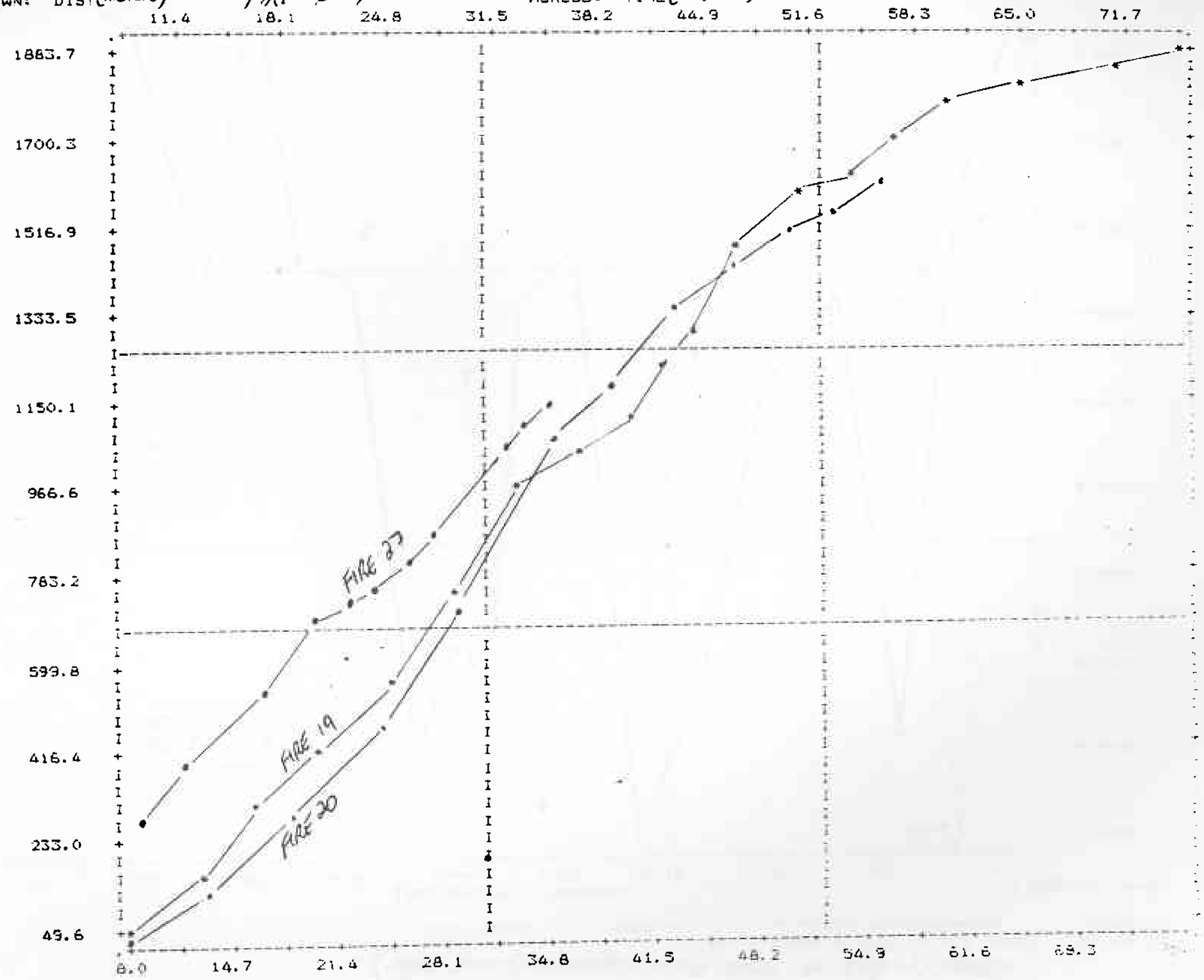


FIGURE 11: ROS vs TIME SINGLE IGNITION (LINE FIRE).

22 DEC 87 GIBSON DESERT FIRE BEHAVIOUR 1987
14:07:52 DEPARTMENT OF C.A.L.M. PE 3240 OS32 7.2.5

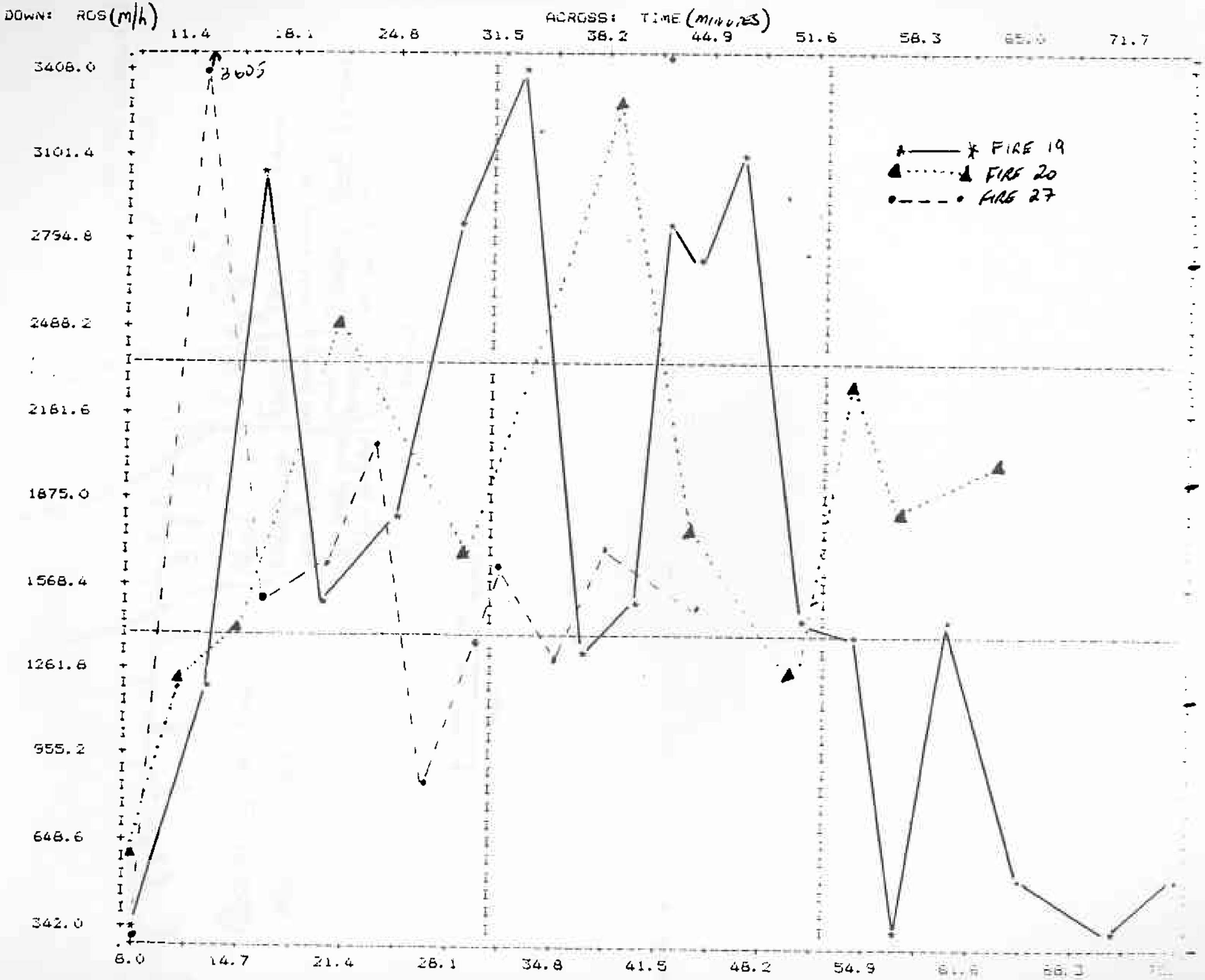


FIG 12: An example of head fire position and rate of spread in spinifex fuels – Gibson Desert Nature Reserve.

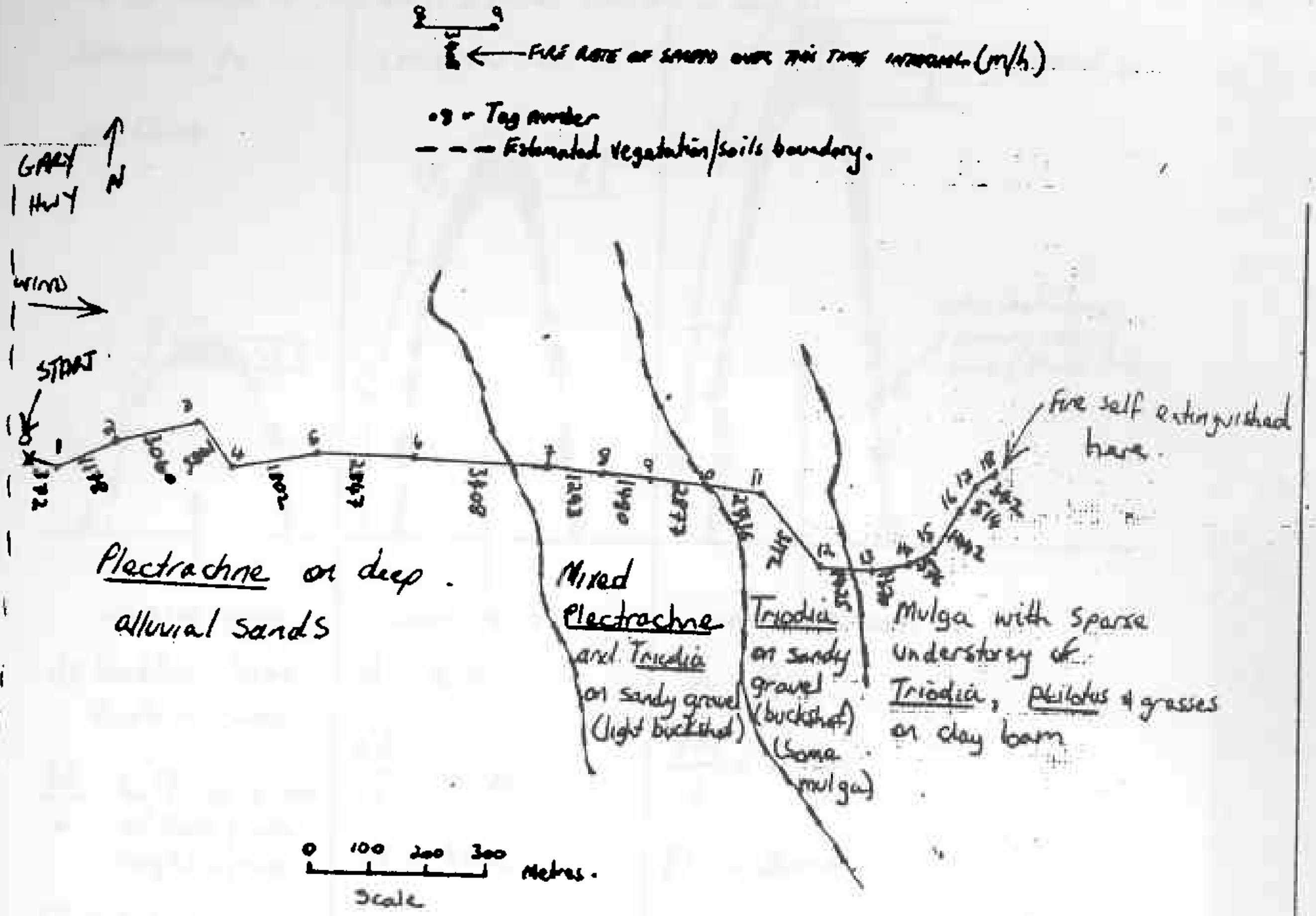
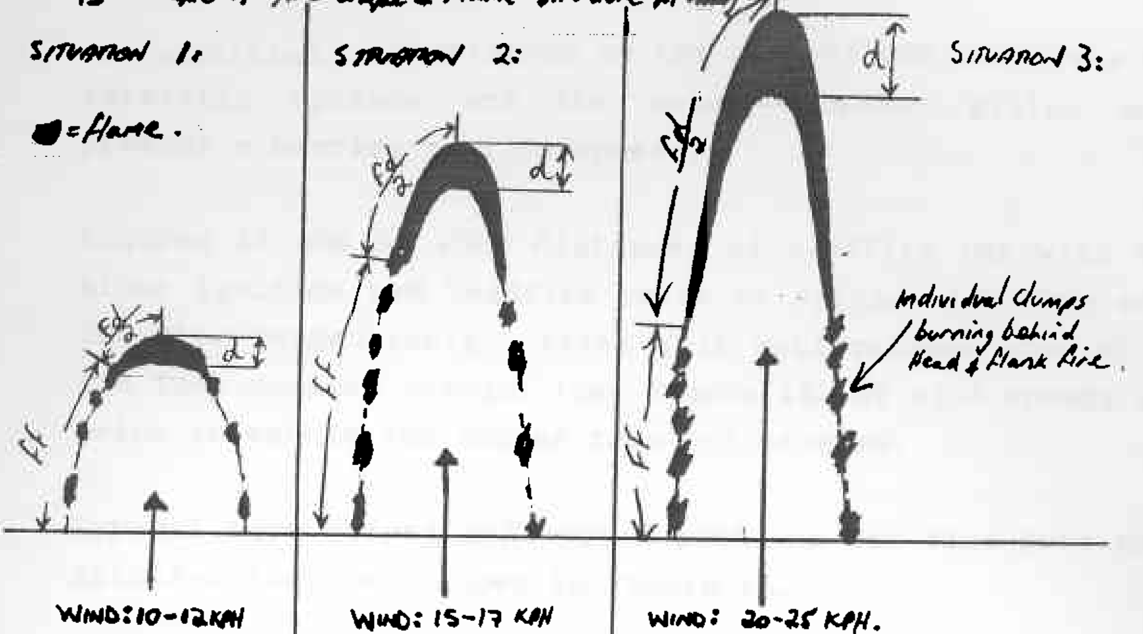


FIG 13: Example of fire shape & flame structure in heavy Plectrache fuels.



d = headfire flame depth: = 1-2 metres.

$\frac{fd}{2}$ = half the distance of solid flame length: = 15m

FF = distance of fragmented flame along flank: = 30m

FIRE RATE OF SPREAD: 500 - 1000 m/h

d = 4m

$\frac{fd}{2}$ = 40m

FF = 90m

FIRE RATE OF SPREAD: 1000 - 2500 m/h.

d = 8m

$\frac{fd}{2}$ = 100m

FF = 200m

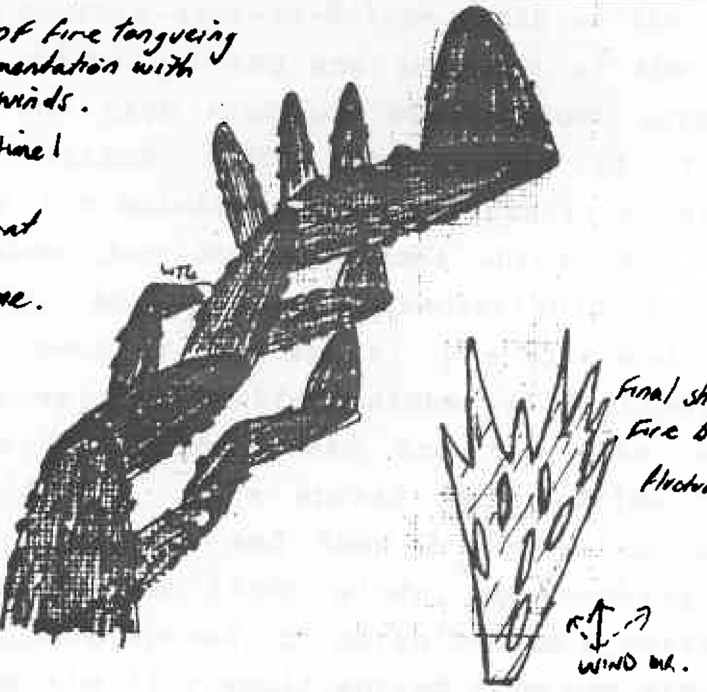
FIRE RATE OF SPREAD: 2500 - 3500 m/h

: Example of fire tongueing and fragmentation with shifting winds.

WT1 = Wind at time 1 etc.

● indicates burnt ground.

■ indicates flame.



Final shape of spinifex fire burning under fluctuating winds.

The condition of vegetation at the time of our visit was such that lateritic uplands and the heavy buckshot plains would present a barrier to fire spread.

Figures 10 and 11 show distances of headfire run with time since ignition and headfire rates or spread with time since ignition respectively. Fires self extinguished when either the fuel complex changed (see Figure 12) or wind speeds fell below threshold for longer than 5-7 minutes.

Typical fire shapes and spread patterns for fire burning in spinifex fuels are shown in Figure 13.

The degree of curing of the "live" spinifex was such that moisture content ranged from 16%-22%. Most experimental fires were conducted over this moisture content range. Dead, grey spinifex had a moisture content of between 3-6% during experiments.

Fire Behaviour Characteristics of Spinifex Fires

Spinifex is somewhat unique as a fuel. It is flammable even when green. This is due to i) the high resin content, ii) the high surface-area-to-volume ratio of the fuel particles, iii) the ideal packing and aeration of the fuel particles and iv) the high exposure of the fuel array to wind and solar radiation. The arrangement of individual fuel particles (or spinifex "spines") within a spinifex clump is more random than other grasses which tend to be arranged vertically. An important characteristic of spinifex fuel is its clumpiness or patchiness. The size and distribution of bare patches and spinifex patches will effect both the wind threshold for fire spread and the rate of fire spread (Griffin 1984). Fire spread is a series of particle to particle ignitions and then a series of clump to clump ignitions. Under light winds, approaching the threshold speed for fire spread, it often became a matter of chance as to whether the fire would spread from one clump to the next. The average size spinifex clump burnt out in 2-3 minutes. If wind speed was insufficient to bend the flames over to touch and ignite the next clump or if the next clump was further away than flame length, then the fire self extinguished. Threshold conditions probably vary according to fuel moisture.

Spinifex fires are wind driven and are very sensitive to wind shifts. As such, there is no backfire (except within a clump or a continuous fuel bed) and rarely any flank fire. This is mainly due to the structure and separation of spinifex fuels. Consequently spinifex fires do not burn in an elliptical shape, but tend to burn in fingers or tongues. Flame dimensions increase with increasing wind speed and spread rate. Flame height, flame depth and flame length increases with rate of spread. A deep flank fire would develop from a very fast moving head (see Figure 13). By nature, spinifex fires will mostly be long, narrow and often patchy. This inherent feature maximises edge effect (between burnt and unburnt vegetation) and promotes the "patch burn" or "mosaic" burn effect. However, under hot, windy conditions, spinifex fires can widen rapidly, particularly when wind direction changes, as it normally does. Evidence of this can be seen in the Great Victoria Desert and more recently in the Hamersley Ranges National Park.

We observed no long distance spotting associated with the burning of spinifex fuels. However, spotting is likely to occur under severe weather conditions or when fires burn through stands of mulga or mallee. Under these relatively mild conditions, fire spread was by direct flame contact. Flames of up to 4 m long were observed during these experimental fires.

Modelling fire spread in spinifex fuels has been attempted by Griffin and Allan (1984). We found serious discrepancies between observed and predicted (Griffin and Allan) fire behaviour for spinifex fuels in the Gibson Desert. The most serious differences were associated with minimum wind speed to achieve fire spread and the relationship between rate of fire spread and wind speed. Our studies revealed that winds in excess of 10-15 kmh^{-1} were necessary to maintain fire spread whereas Griffin and Allan reported wind speeds of 3-4 kmh^{-1}. Figure 14 illustrates the differences between observed and predicted rates of spread. THe fire model vastly over predicted spread rates for conditions of this study for spread rates less than about 2800 mh^{-1}. At higher wind speeds (25-30 mh^{-1}) the model was more accurate at predicting R.O.S. More studies are needed to refine or redevelop a fire behaviour model and to determine the importance of other factors such as degree of curing of spinifex on R.O.S. and fire shape.

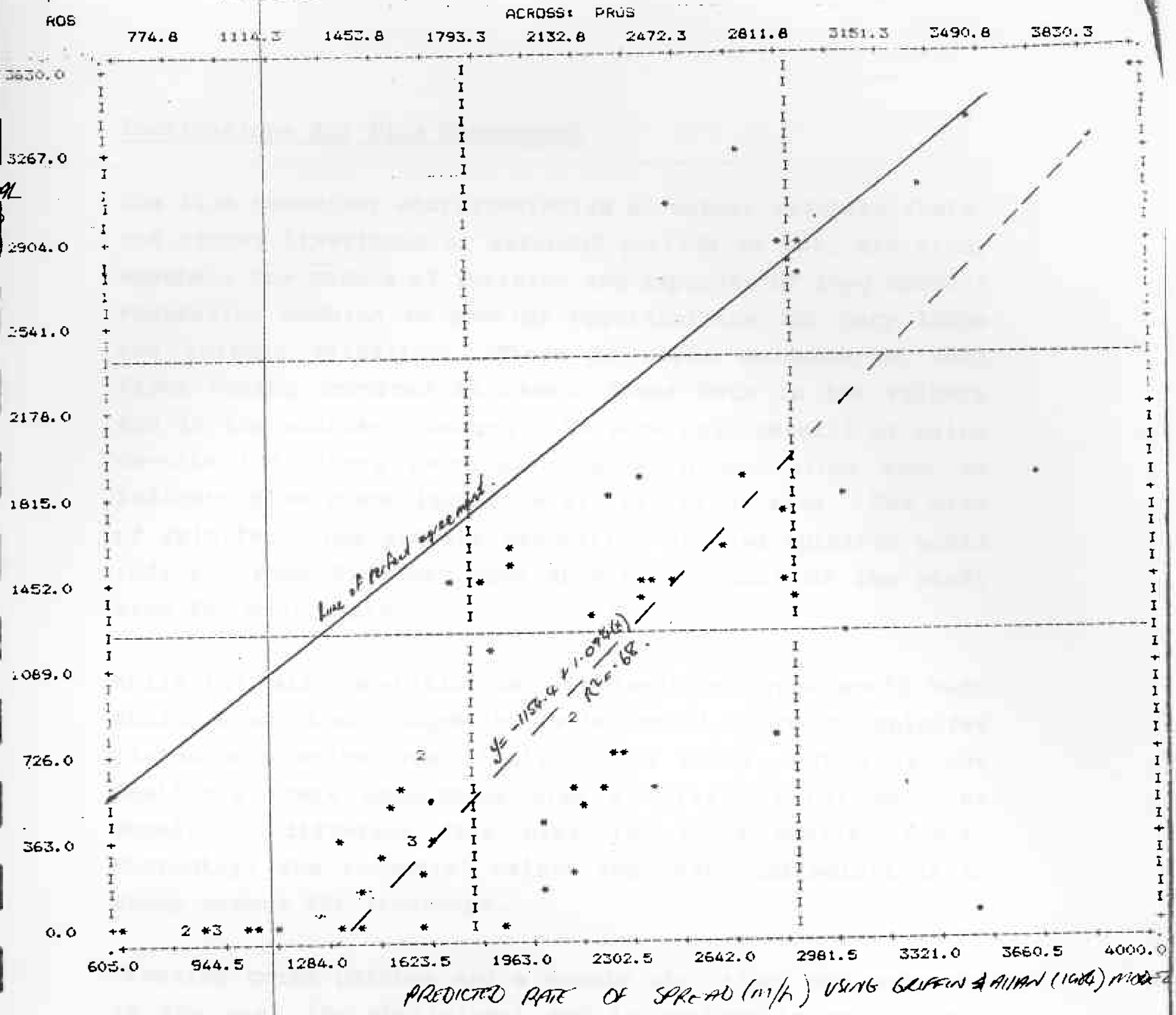
Reasons for the discrepancy between threshold levels reported by Griffin and Allan are those observed in the study may include:

- variations in fuel bulk density
- variations in fuel composition by species
- variations in technique used to measure windspeed
- variations in fuel calorific values.

Preliminary tests were also done on McArthers grassland meter but this model was found to be inadequate for use in discontinuous and randomly arranged spinifex fuels.

Predicting fire rate of spread and shape in discrete, patchy fuels such as spinifex is more difficult at lower spread rates or near threshold conditions. As the severity of burning conditions increase (i.e. decreasing fuel moisture content and increasing wind speed) then fire spread and shape is more predictable. In effect, under severe conditions, spinifex fuels are percieved as more continuous by the flaming zone. The flame shadow, or radiation "zone", merges the fuel clumps. The reverse is true of complex, continuous forest fuels, where predictability decreases with increasing severity of burning conditions.

FIGURE 14. PREDICTED [illegible]



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  JAN 88    GIBSON DESERT FIRE BEHAVIOUR 1987
:58:21           DEPARTMENT OF C.A.L.M.          PE 3240         0632 7.2.5

ATISTICS..
CORRELATION (R)-          .82570      R SQUARED      -        .68179        SIGNIFICANCE   -       .00
STD ERR OF EST -       568.84167      INTERCEPT (A)  -   -1154.41473        SLOPE (B)      -      1.094
PLOTTED VALUES -           71         EXCLUDED VALUES-         0            MISSING VALUES -      1
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Implications for Fire Management

The fire behaviour characteristics of mature spinifex fuels, the strong likelihood of extended periods of hot, dry windy weather, the chance of ignition and expanses of long unburnt vegetation combine to provide opportunities for very large and intense wildfires. There is ample evidence of such fires having occurred in recent times both in the Pilbara and in the southern deserts. We were unsuccessful at using on-site indicators (such as coppice, growth rings etc) to indicate time since last fire at this study site. The size of spinifex rings and the proportion of dead spinifex would indicate that fire has been absent from most of the study area for many years.

While not all vegetation on all landform types would burn during a major conflagration, substantial tracts of spinifex plains and mulga are likely to be burnt. This is not desirable where management aims to create a patchwork or mosaic of different fire histories on a smaller scale. Currently, the potential exists for vast conflagrations to sweep across the landscape.

Creating burnt patches and a mosaic with time, was achieved in the past (by aborigines) and is achievable again. The key to this lies in the fire behaviour characteristics of spinifex fuels as discussed earlier. Principally, fires burn in tongues or fingers, fires are wind driven and fuels are discontinuous and patchy. When spinifex flames are extinguished there is unlikely to be re-ignitions. At certain times of the year, weather conditions are such that there are only a few hours each day when fires will spread. The landscape consists of natural barriers to fire spread, such as breakaways, sand dune crests and clay pans.

The key to creating burnt patches lies in an ability to forecast weather conditions, especially wind, and knowing the period when fires will spread and when they will self extinguish. Preliminary studies have made estimates of wind threshold levels. Lighting technique and pattern will also influence the resultant patchiness. The most effective way of achieving this over a large area is by using aircraft. Spot ignition requires stronger winds to initiate fire spread than line ignition. This may prove to be a limiting factor on when and where aircraft can be used. Trials planned for May and September 1988 will provide valuable information on the effectiveness of fixed wing aircraft for ignition.

Historical Weather Data

Weather tapes were purchased from the Bureau of Meteorology and date back to 1956. Some preliminary statistics have been generated from these data and are appended. Later, it is our intention to determine seasonal and diurnal fire danger ratings based on our knowledge of fire behaviour and using historical weather. This will allow us to estimate the times when huge conflagrations are likely and the times when the prescribed patchy burns are possible.

As wind strength is the limiting factor to the spread of spinifex fires, an understanding of seasonal and diurnal wind behaviour is crucial to the success of patch burning in the Gibson Desert. Considerably more work remains to be done in this area, but it is encouraging to know that under stable conditions, diurnal winds can be forecast reasonably well. Two noticeable features about winds during the study period were i) the strong diurnal trend with winds easing over night and in all instances, falling below the threshold for fire spread (Figure 4) and ii) winds from the SE and E tended to be stronger during the day than winds from any other quarter.

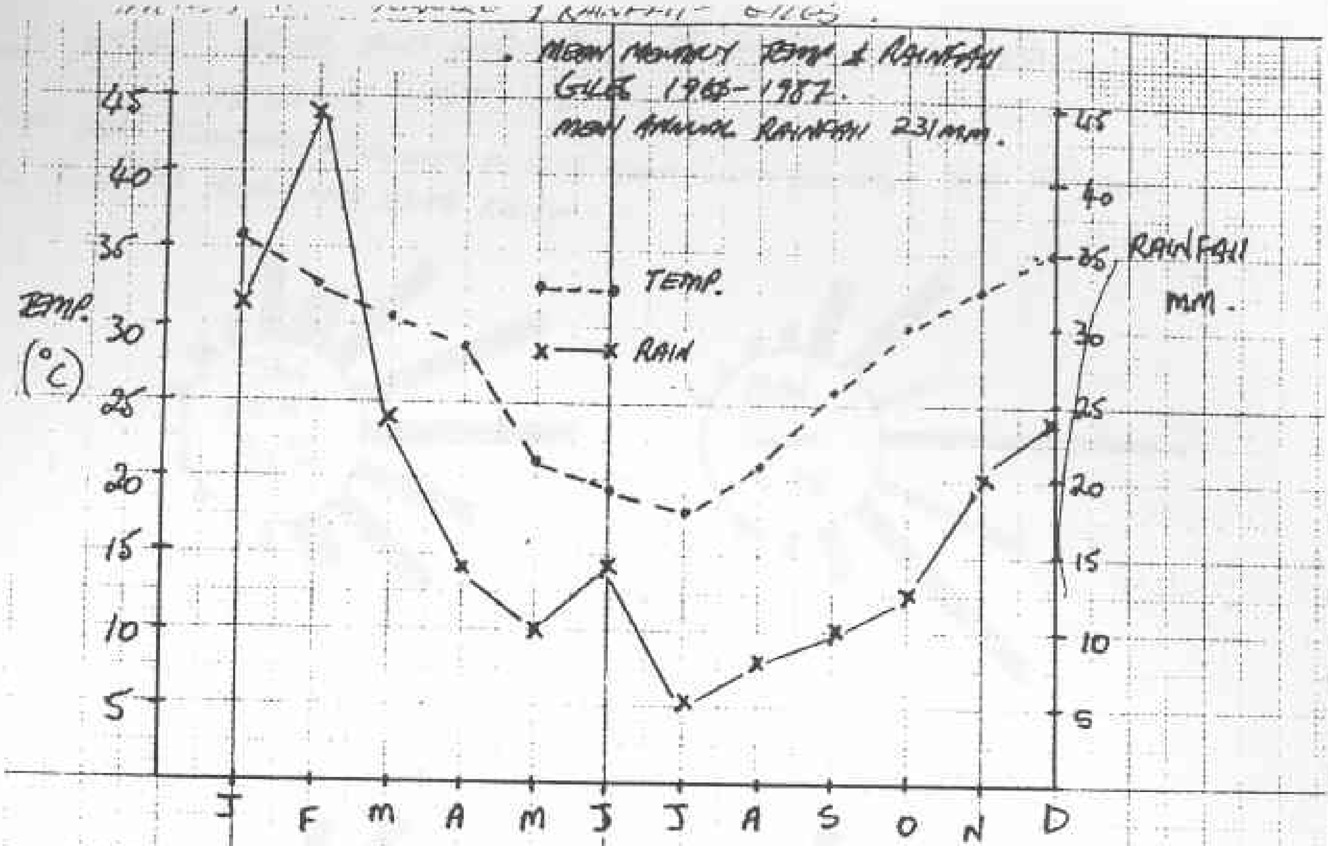
Historical wind data from Giles (1956-87) are presented in rose form in Appendix 2. Noticeable features of these wind roses are the diurnal variations in wind speed and the seasonal variations in both speed and direction. Winds are predominantly from the eastern hemisphere, especially overnight. The windiest months are September, October and November, when wind speed is in excess of 20 kph (mean over 3 hours) 60% of the time in the morning. Wind speed falls overnight in all cases but is generally stronger over September-November. During April through to July, morning winds are generally light (10-15 kph) and from the NE-SE (85% of the time). During these months, overnight winds are generally very light (10 kph) and from the east most of the time.

From the historical wind data, and knowing the importance of wind speed to fire spread, there is a good chance that burning in May using spot ignition from aircraft, may not be highly successful due to frequency of light winds. A better time would be in September when winds are usually stronger during the day and ease during the night. However, there is a likelihood (5% of the time) of strong overnight winds in September.

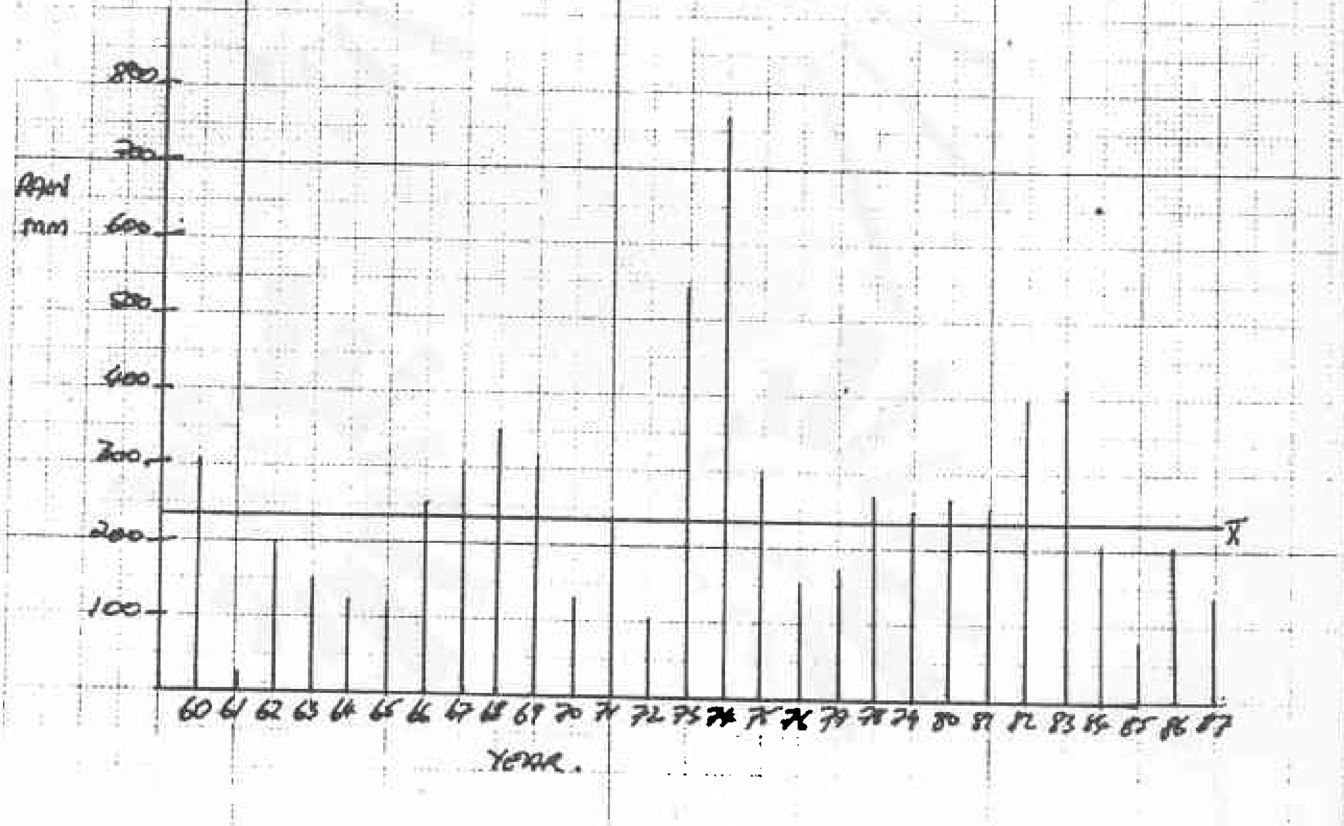
Conclusion

A management goal for desert reserves is to promote and maintain diversity of wildlife. We believe that fire has an important role in this process. Current studies are designed to i) understand fire behaviour so that managers can prescribe patch burns and ii) understand interactions between fire, plants and animals. We cannot delay action until we have perfect knowledge so we must implement best bet strategies which will be refined with more knowledge. In the near future we must attempt to simulate (with computers) temporal and spacial patterns and processes about desert ecosystems. This will allow a clearer vision of our hypotheses and help with research resource allocation.

[illegible] RAINFALL GILES.



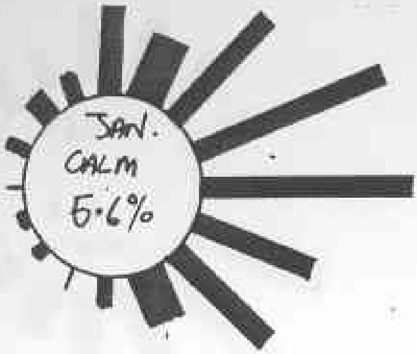
MEAN MONTHLY TEMP & RAINFALL GILES 1960-1987.
MEAN ANNUAL RAINFALL 231mm.

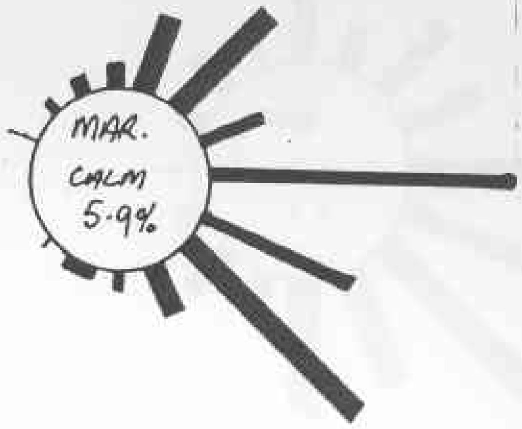


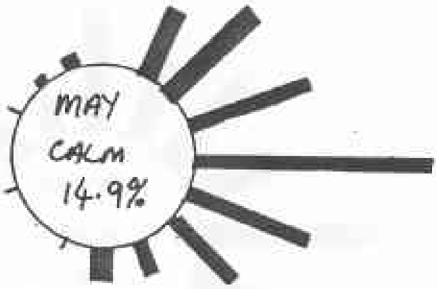
* SOURCE: BUR. MET. GILES.

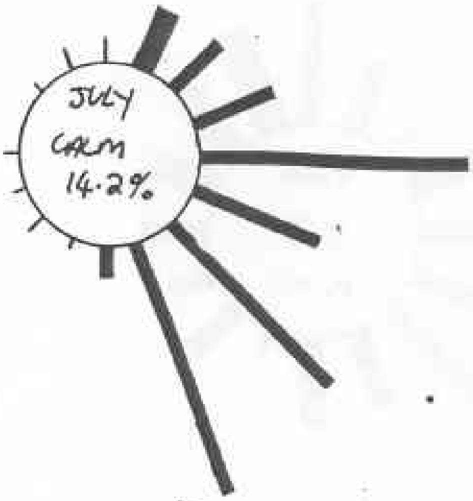
MEAN WIND SPEED AND DIRECTION AT GILES: 1960-1987.
0830 hrs – 1130 hrs.

LENGTH OF BARS INDICATES FREQUENCY OF WIND FROM GIVEN DIRECTION AND THICKNESS OF BARS INDICATES MEAN WIND SPEED RANGE.







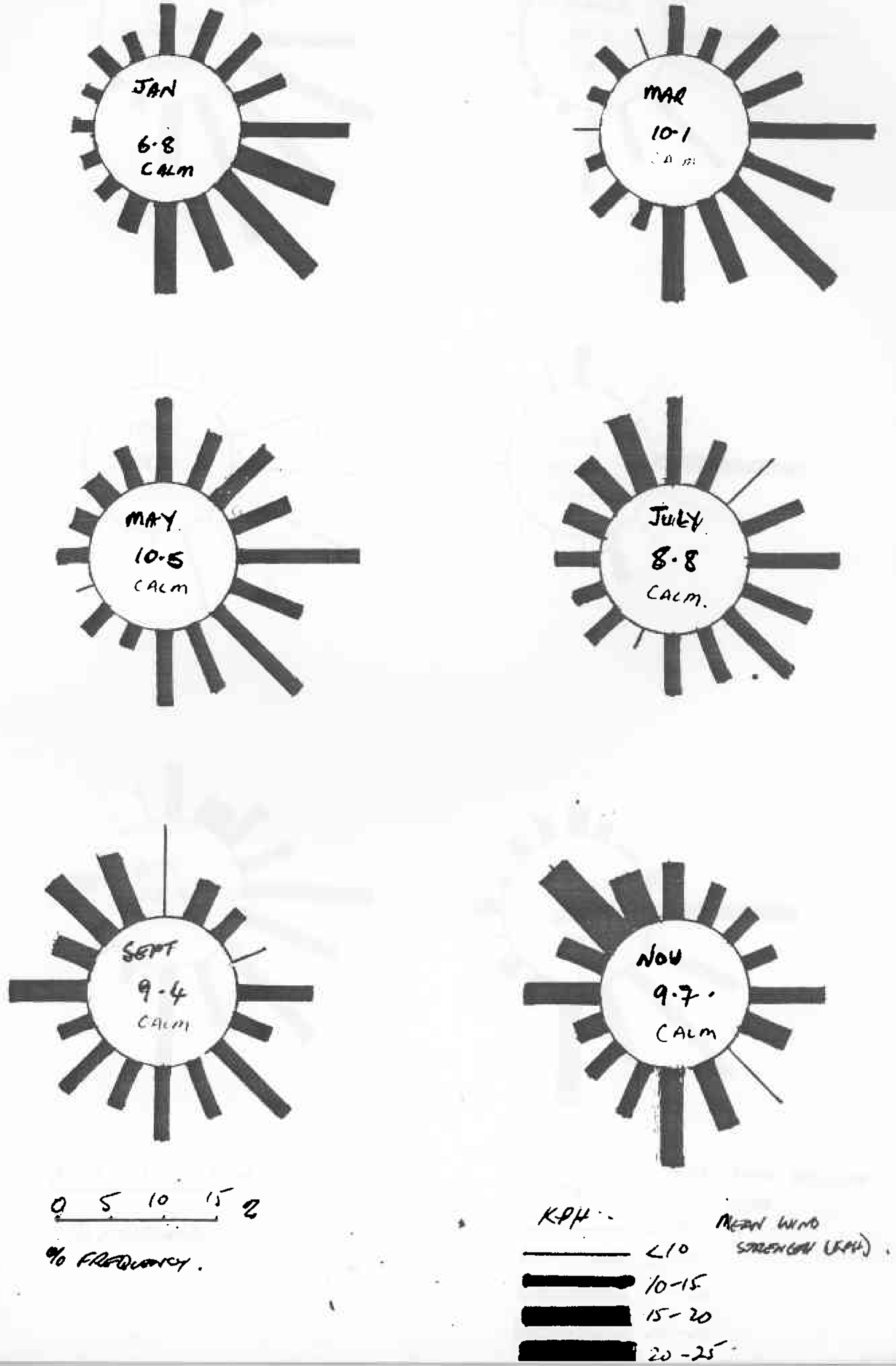


0 5 10 15%

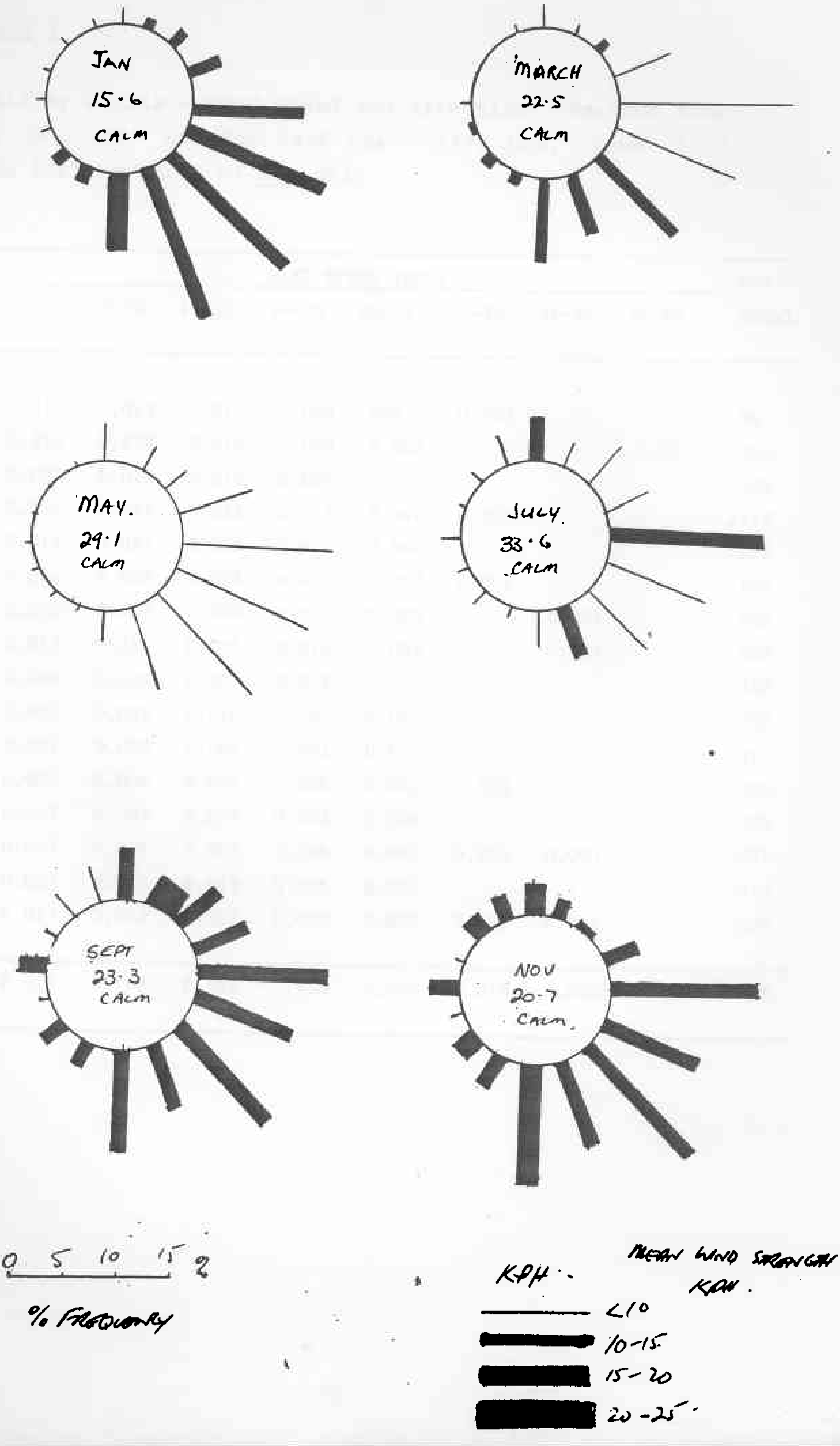
% FREQUENCY WIND IN GIVEN DIRECTION (MEASURE LENGTH OF SPOKE).

MEAN WIND STRENGTH (KPH) OVER 3 hour period.
— <10
▬ 10–15
▬ 15–20
█ 20–25

Appx. 4a. WIND SPEED & DIRECTION BY MONTH – GILES: 1430hrs – 1730hrs.



GILES WINDS - 20·30hrs - 02·30hrs 1961-1987.



APPENDIX 3

Probability matrix - wind speed and direction. Records from Giles, 1956-1987 and for 1430 hrs - 1730 hrs. Total 1297 records for the Month of <u>May</u> only.

Wind Direction	WIND SPEED (KPH)								Row Total
	5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	
1. NNE	.012	.013	.017	.009	.004	0.001			.56
2. NE	0.016	0.019	0.019	0.009	0.004			0.001	.068
3. ENE	0.002	0.016	0.016	0.006					.040
4. E	0.027	0.031	0.032	0.018	0.007	0.003			.118
5. ESE	0.015	0.021	0.023	0.010	0.004				.073
6. SE	0.014	0.023	0.038	0.023	0.007	0.001			.106
7. SSE	0.010	0.009	0.030	0.010	0.003		0.001		.062
8. S	0.012	0.011	0.025	0.016	0.003		0.001		.069
9. SSW	0.006	0.003	0.007	0.002					.018
10. SW	0.003	0.009	0.010	0.005	0.005				.032
11. WSW	0.001	0.005	0.004	0.002	0.001				.013
12. W	0.008	0.004	0.006	0.006	0.001	0.001			.025
13. WNW	0.003	0.003	0.007	0.008	0.004				.025
14. NW	0.007	0.006	0.007	0.006	0.007	0.003	0.001		.037
15. WNW	0.007	0.007	0.013	0.005	0.004				.073
16. N	0.017	0.018	0.027	0.010	0.006	0.001	0.001		.080
OL. TOTAL	0.017	0.208	0.282	.155	0.060	0.010	.004	.001	.895

ALM = 0.105