Preburnt and Postburnt Fynbos Standing Crop at Pella, Cape.

M. O'Callaghan.

Botany Honours.

1981.

Preburnt and Postburnt Fynbos Standing Crop at Pella, Cape.

Abstract.

At Pella research station, 20 year-old fynbos standing crop was determined by cropping eight 2m x 2m plots and felling five Protea repens trees in an unburnt area. A regression was also performed between the dry mass of **the P. repens trees (kg) and** their stem diameter (cm). It was estimated that the total preburnt P. repens plant material was 24 125,34 kg/ha dry mass and the total plant material for the other shrubs was 15 149 kg/ha dry mass. The 20 year-old postburnt standing crop was determined by cropping three 2m x 2m plots and felling three P. repens in a burnt area. It was found that the postburnt P. repens material was 9 409 kg/ha dry mass and the other shrubs was 2 kg/ha dry mass. The total preburnt plant material was 39 274,34 kg/ha dry mass and the total postburnt plant material was 9 411,76 kg/ha dry mass. Thus, 29 862,58 kg/ha dry mass was consumed by the fire, an equivalent of 76,04 %.

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Introduction.

It is commonly believed (Klein,1977) that fire has played an important role in the fynbos since the development of a pastoralist human culture in the south western Cape, i.e. for at least the last 2 000 years (Schweitzer and Scott, 1973). The fire régimes of the south western Cape before C1650 is largely unknown, but it is documented (Sim, 1907) that the early European settlers burnt the vegetation frequently to provide 'succulent' grazing for domestic stock. It can thus be assumed that the majority of the fynbos has been subjected to fire once every 10 to 20 years for the last 300 years (Moll, McKenzie and McLachlin, 1980).

During the early part of this century, botanists expressed deep concern about the detrimental effects of fire on fynbos (see Marloth, 1924; Pillans, 1924; Adamson, 1935). Since this time, however, it has been found that, not only is fire necessarry for the reproduction of some fynbos species (see Taylor, 1972),but after protection from fire for 20 years or more, the vegetation becomes moribund (Le Roux, 1966) with an increased accumalation of litter which is an additional fire hazard (Taylor, 1969). For these reasons, the Department of Forestry has imposed managerial fire régimes on an 8 to 12 year rotation (Van Wilgen, 1980), although some authors maintain that these régimes should be lengthened (Moll, McKenzie and McLachlan, 1980; McLachlan and Moll, 1976).

The veiw is widely held that the fynbos is a fire-adapted vegetation type (Moll, McKenzie and McLachlan, 1980) and the aim of this project is to ascertain the amount of fuel available for a fire in twenty year-old vegetation by comparing the standing crop of twenty year-

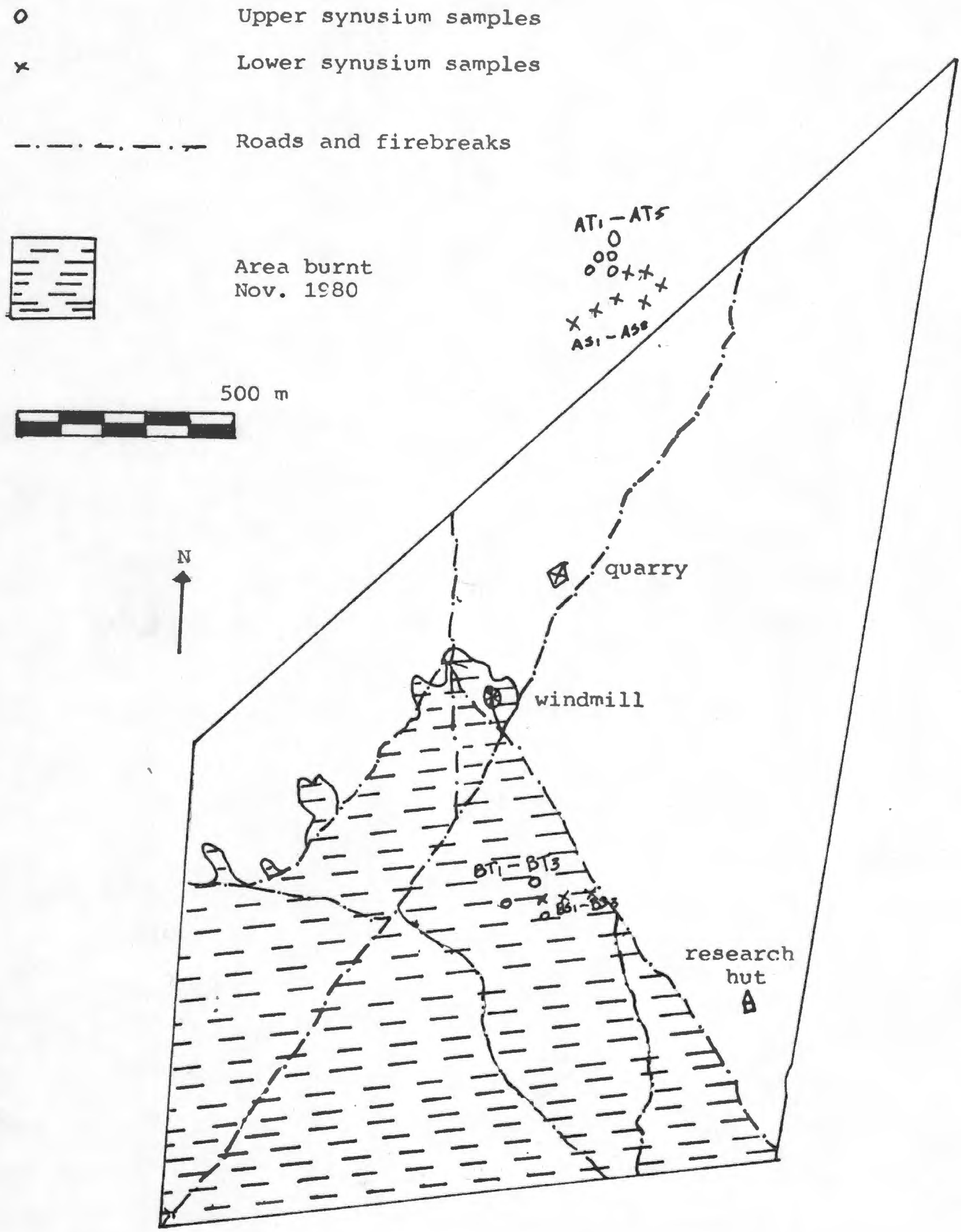

fig.1. Pella research site.

old fynbos to the standing crop of twenty year-old vegetation remaining after a fire had occured.

The Study Site.

This study was conducted on land leased by the C.S.I.R. near Pella mission station (Approximately 33°33'S ; 18°31'E and 70 km north of Cape Town) and adjacent farmland (see fig.1.). The soils of this area are deep alluvial sands, underlain mainly by Malmmesbury formation phyllites (Lambrechts, 1979). This area has an average rainfall of approximately 800 mm per annum (W. Stock, unpubl. data).

The vegetation of this area corresponds to Acocks veld type 47, coastal fynbos (Acocks, 1953). For the sake of convenience, this vegetation was divided into two basic synusia. The lower synusium, with an average height of 60 cm, consists of a restioid component (mainly Thamnochortus punctatus) and an ericoid component (mainly Phylica spp and Erica spp), intersperced with Leucospermum parile. The upper synusium consists mainly of Protea repens and P. burchelii shrubs and it was noted that very little plant growth occurs under the canopy of these Protea shrubs.

Methods.

In the unburnt area, the lower synusium was sampled by determining the total percentage cover of the vegetation and the relative percentage cover of each family present in eight 2m x 2m plots (AS1 to AS8, see fig.1.). The plots were then cropped and the wet mass of each family was determined in the field by using a 10 kg 'Pesola' spring balance. The dead standing crop and litter was also collected and weighed in the same way. If these vegetative samples were in excess of 2 kg, subsamples of approximately 10% were taken. All samples and/or subsamples were returned to the laboratory and dried for 24 hours at 100°C to determine their dry mass.

In the unburnt area, the canopy height and circumference of five Protea repens trees were measured (AT1 to AT5, see fig.1.). After the stem diameter at 10 cm below the lowest branch of each of these trees was measured, they were felled and the foliage was divided and/or separated into leaves, wood, open flower heads and closed flower heads and the wet mass of each component was determined in the field by using a 10 kg 'Pesola' spring balance. A subsample of approximately 10% by mass of each component was returned to the laboratory and dried for 24 hours to 48 hours at 100°C.

In the burnt area, the lower synusium was sampled by cropping and collecting all charred and/or remaining plant material from three 2m x 2m plots (BS1 to BS3, see fig.1.). The plant material collected in this way was weighed in the field by using a 10 kg 'Pesola' spring balance and returned to the laboratory for the determination of dry mass by drying the samples for 24 hours at 100°C.

In the unburnt area, the remnants of three P. repens trees (BT1 to BT3, see fig.1.) were measured in the same way as those in the unburnt area (see above). The trees were then felled and the mass of each tree was determined in the field by using a 10 kg 'Pesola' spring balance. Each tree was then sawed into approximately 30 cm lengths and approximately 10% by mass subsamples **of each tree** were returned to the laboratory and dried for 24 hours to 48 hours at 100°C.

In addition, the number of P. repens trees in a 50m x 50m plot were counted in the burnt area (see fig.1.).

Table.1. The average standing crop (kg/ha), cover (%), frequency (no. of plots, ex 8, in which the family was found), range (largest standing crop to smallest standing crop, in kg/ha), $\frac{\text{wet weight}}{\text{dry weight}}$ ratios and total live standing crop, total dead standing crop and total litter of the lower synusium in the unburnt area (plots AS1 to AS8)

Family	Cover (%)	Frequency (ex 8)	Dry Mass (kg/ha)	Range (kg/ha)	Wet Weight / Dry Weight
Restionaceae	25	8	3674	1485-9894	1,42
Rhamnaceae	7	8	3380	179-3559	1,41
Leguminosae	3	7	386	0-700	1,32
Compositae	3	6	552	0-1812	1,28
Ericaceae	5	5	127	0-307	1,33
Rubiaceae	0,5	4	53	0-117	1,50
Graminae	2	3	147	0-432	1,24
Proteaceae	4	2	1087	0-8647	2,01
R[illegible]ceae	0,1	1	40	0-320	1,25
Bruniaceae	0,1	1	4	0-35	1,41
Lilliaceae	0,1	1	3	0-27	1,12
	49,8				
Total live standing crop			6028	3066-12670	1,40
Total dead standing crop			4811	1667-9064	1,10
Total litter			4310	820-7790	1,08

Table.2. The total preburnt standing crop and litter (kg/ha), and the total postburnt standing crop (kg/ha) of the lower synusium.

Preburnt	: 10 839 kg/ha	Postburnt	: 2 kg/ha
Litter	: 4 310 kg/ha		

Total lower synusium shrub material consumed by the fire: 15 147 kg/ha, which is equivalent to 99,98 %.

Table.3. The theoretical preburnt upper synusium standing crop and *P. repens* litter (kg/ha), and postburnt *P. repens* standing crop

Preburnt	: 19 250,08 kg/ha	Postburnt	: 9 409,76 kg/ha
Litter	: 4 875,26 kg/ha		

Total upper synusium plant material consumed by the fire: 14 715,58 kg/ha, which is equivalent to 61 %.

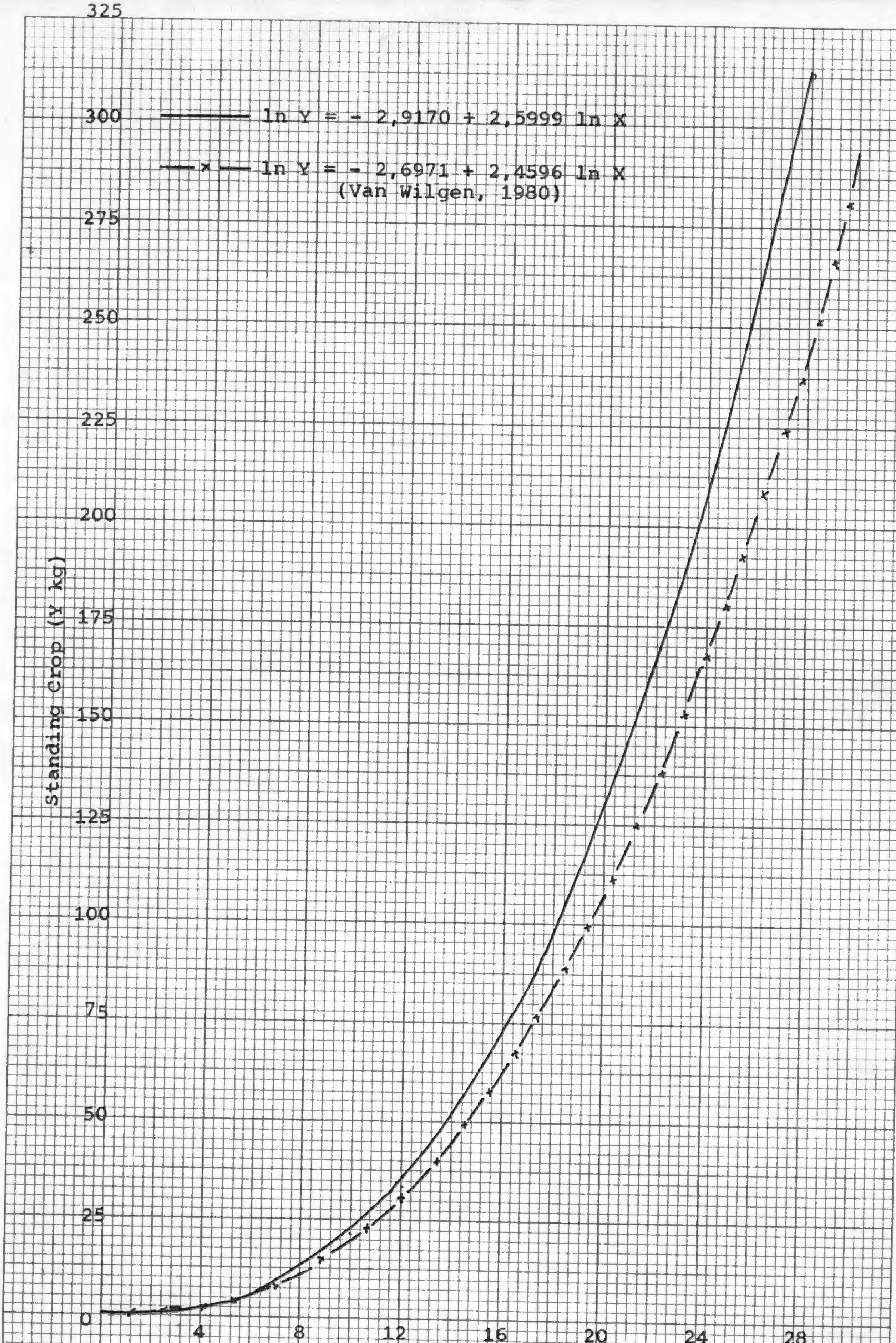

fig .1. The regressions between stem diameter (cm) and standing crop (kg) of 20 year old *P. repens* trees.

Results.

1) The lower synusium.

The average standing crop of each family, together with the total live standing crop, total dead standing crop and total litter, from plots AS1 to AS8 are shown in table 1.

Table 2 shows the total plant material of the lower synusium from the unburnt area (plots AS1 to AS8) and the total plant material of the lower synusium that remained after the fire (plots BS1 to BS3). By subtracting the latter from the former, an indication can be obtained of the amount of lower synusium plant material that was consumed by the fire. (More detailed data for each plot are given in appendix A).

2) The regression between P. repens standing crop and stem diameter.

The relationship between stem diameter and dry standing crop of live 20 year-old P. repens trees is shown by:

$$\ln Y = -2{,}9170 + 2{,}5999 \ln X$$

$$\text{Correlation} = 0{,}9657$$

where Y = dry standing crop (kg)

X = stem diameter (cm).

This relationship, together with the relationship of stem diameter vs standing crop formulated by Van Wilgen (1980) , is depicted by fig.2. (The data for the upper synusium are depicted in appendix B and the statistical methods in appendix C).

From appendix B, it can be seen that the average stem diameter of the three burnt P. repens trees is 14,07 cm. From the above relationship, the average standing crop of these trees was 52,31 kg per tree. It was found that there were 92 trees in a 50m x 50m plot and thus the trees of this area had a total preburnt standing crop of

$$52,31 \text{ kg} \times 92 \text{ trees} \times \frac{10\ 000}{2\ 500} = 19\ 250,08 \text{ kg/ha}.$$

Table 3 shows the theoretical P. repens standing crop before and after the fire, together with an estimation of the amount of P. repens plant material consumed by the fire.

Discussion and Conclusions.

Although the correlation between P. repens stem diameter and standing crop is good, the relationship between these two parameters differs from that of Van Wilgen's (1980) slightly (see fig. 2.). The reasons for this difference could be numerous. Firstly, the P. repens stem diameter was measured at 20 cm above the ground by Van Wilgen. Unfortunately, in the present study, it was found that the P. repens stems branched at or below 20 cm from the ground and thus the diameter at this point might give an erroneous impression of the true stem diameter.

Secondly, the size of Van Wilgen's sample was a lot larger (approximately 280 trees) whereas only five trees were sampled for the present study.

Thirdly, the 10 kg 'Pesola' spring balance used to weigh the plant material in the field, is only graduated in 100 gram divisions. Thus, although it is improbable, it is possible to make an error of up to 100 grams each time this balance is used, a total error of 5 kg per tree is thus possible.

Finally, the difference could be due to environmental differences between this coastal fynbos and the mountain fynbos of the Stellenbosch area (see Kruger, 1977; Rutherford, 1978 and Van Wilgen, 1980).

Similar criticisms apply to the lower synusium measurements and the small number of samples in the burnt area could lead to a definite error in the estimation of standing crop in this area.

As can be seen from table 1, there is much variation in the live and dead standing crop and litter between the plots at this site. It must thus be realized that, for the sake of convenience, this standing crop data is referred to in terms of mean data and is thus only an estimate of the actual aerial biomass.

As can be seen from table 1, the wet weight:dry weight ratios are all, with the exception of L. parile (Proteaceae), below 2. This low water content, together with the possible inclusion of semi-inflamable oils (McLachlan and Moll, 1976) and the fine structure of the leaves and branches of the lower shrub vegetation (Kruger, 1977) could result in a fierce, uncontrollable fire at this time of the year (autumn). It must also be noted that the dead plant material of 20 year-old shrub vegetation is approximately 1,5 times more than the live material. Thus, it would seem, there is an accumalation of litter (see Van Wilgen, 1980) and this vegetation would ignite and burn easily with a high temperature (Taylor and Kruger, 1978). Under the canopy of the P. repens trees, however, the litter is more robust and could smoulder for a relatively long time and could thus be more damaging to the seeds, roots and microbes ususally found in the surface layers of the soil under these trees (E.J. Moll, pers. comm.).

From table 2 and table 3, it can be estimated that the total preburnt plant material in a 20 year-old coastal P. repens site would be 39 274,34 kg/ha. As very few shrubs grow under the P. repens canopy per se, this is an overestimation, but is lower than the aerial biomass of 21 year-old vegetation at Jonkershoek (see Van Wilgen, 1980). Nevertheless, the aerial biomass at Pella seems to be far higher than that of analogous communities in other parts of the world (see Rutherford, 1978; Kruger,1977) with the possible exception of garrigue (France) and older chaparral (California) vegetation (Kruger, 1977). However, Louw (unpubl. data) obtained an aerial biomass of only 815 kg/ha for 17 year-old coastal vegetation at Mamre.

The estimated total plant material consumed by the fire is 29 862,58 kg/ha or an equivalent of 76,04%, the majority of which is lower shrub material and/or litter.
Van Wilgen (1980), however, estimates the fuel content of 21 year-old mountain fynbos as being 53,58% of the total aerial biomass. This estimation is, however, based on the assumption that only plant material with a diameter of less than 6 mm is available as fuel and it would seem that the higher estimation obtained in the present study is more accurate for the 'hotter' fire which could occur in this drier area.

Acknowledgements.

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Appendix.A. Lower synusium data

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
AS1	Restionaceae	25	4 052	1,35
	stems		3 860	1,58
	flowers		192	1,12
AS1	Rhamnaceae	25	3 559	1,42
	leaves		842	1,40
	stems		2 717	1,44
AS1	Graminae	5	335	1,23
AS1	Leguminosae	1	340	1,17
AS1	Rubiaceae	1	177	1,40
AS1	Rutaceae	1	320	1,25
	leaves & twigs		45	1,18
	wood		275	1,31
AS1	Ericaceae	1	15	1,27
AS1	Compositae	1	27	1,06
AS1	Standing Dead		8 012	1,04
AS1	Litter		5 467	1,07

AS1 Height : 60 cm.

Appendix.A. Lower synusium data (cont.)

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
AS2	Restionaceae	25	9 894	1,43
	stems		9 692	1,56
	flowers		202	1,28
AS2	Rhamnaceae	1	160	1,28
	flowers & leaves		52	1,24
	wood		127	1,33
AS2	Graminae	2	432	1,24
AS2	Leguminosae	1	160	1,31
AS2	Rubiacea	1	122	1,55
AS2	Ericaceae	3	307	1,40
AS2	Standing Dead		4 227	1,07
AS2	Litter		6 397	1,07
AS2	Height : 60 cm			
AS3	Restionaceae	20	5 644	1,43
	stems		2 212	1,71
	flowers		187	1,16
AS3	Rhamnaceae	1	485	1,34
	leaves		125	1,38
	wood		262	1,22
AS3	Graminae	5	410	1,25
AS3	Leguminosae	2	319	1,17
	leaves		57	1,12
	wood		262	1,22
AS3	Rubiaceae	1	14	1,09
	leaves		7	
	wood		7	
AS3	Ericaceae	2	194	1,26
	leaves		97	1,24
	wood		97	1,29

Appendix.A. Lower synusium data (cont.)

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
AS3	Compositae	0,5	60	1,32
	leaves		23	1,10
	wood		37	1,54
AS3	Lilliaceae	1	27	1,12
AS3	Standing Dead		3 245	1,16
AS3	Litter		4 465	1,05
AS3	Height : 50 cm.			
AS4	Restionaceae	20	4 205	1,58
AS4	Rhamnaceae	10	1 385	1,51
AS4	Leguminosae	5	82	1,38
AS4	Compositae	10	1 020	1,23
AS4	Standing Dead		9 064	1,05
AS4	Litter		7 790	1, 11
AS4	Height : 65 cm.			
AS5	Restionaceae	20	1 485	1,40
AS5	Rhamnaceae	5	780	1,46
AS5	Leguminosae	5	700	1,65
AS5	Ericaceae	5	285	1,42
AS5	Rubiaceae	2	112	1,55
AS5	Standing Dead		6 535	1,21
AS5	Litter		3 845	1,06

Appendix.A. Lower synusium data (cont.)

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Dry Wt (kg/ha) / Wet Wt (kg/ha)
AS6	Restionaceae	10	2 285	1,58
AS6	Rhamnaceae	5	480	1,47
AS6	Leguminosae	10	842	1,40
AS6	Compositae	5	415	1,33
AS6	Proteaceae	30	8 647	2,17
	leaves		1 935	2,01
	wood		6 712	2,33
AS6	Standing Dead		2 334	1,15
AS6	Litter		1 272	1,08
AS7	Restionaceae	10	2 437	1,56
AS7	Rhamnaceae	5	370	1,45
AS7	Ericaceae	2	212	1,35
AS7	Compositae	10	1 812	1,40
AS7	Proteacea	1	55	1,71
AS7	Standing dead		1 667	1,10
AS7	Litter		4 430	1,11
AS8	Restionaceae	45	2 600	1,57
AS8	Rhamnaceae	10	507	1,53
AS8	Leguminosae	10	642	1,48
AS8	Compositae	10	1 082	1,31
AS8	Bruniaceae	1	35	1,41
AS8	Standing Dead		3 405	1,12
AS8	Litter		820	1,12

Appendix.A. Lower synusium data (cont.)

Plot	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
BS1	3,58	1,39
BS2	0,62	0000
BS3	1,78	1,13

Appendix.B. Upper synusisum data

P.repens tree no.	Plant Part	Dry Mass (kg)	Wet wt (k / Dry wt (k
AT1	Wood	45,97	1,89
	Leaves	6,63	2,21
	Open Flowers	10,99	1,20
	Closed Flowers	2,63	2,40
	Total	66,22	
	Litter	17,77	1,21
	Stem Diameter : 12,25 cm		
AT2	Wood	139,91	1,91
	Leaves	24,45	1,85
	Open Flowers	15,49	1,17
	Closed Flowers	18,78	1,57
	Total	196,63	
	Litter	40,18	1,19
	Stem Diameter : 25,25 cm		
AT3	Wood	19,63	1,86
	Leaves	2,13	2,03
	Open Flowers	3,36	1,25
	Closed Flowers	0,87	1,72
	Total	25,99	
	Litter	5,51	1,21

Appendix.B. Upper synusium data (cont.)

P.repens tree no.		Plant Part	Dry Mass (kg)	Wet wt (k / Dry wt (k
AT4		Wood	7,50	1,88
		Leaves	0,62	2,03
		Open Flowers	2,29	1,17
		Closed Flowers	0,11	1,36
	Total		10,52	
	Litter		1,42	1,20
	Stem Diameter	: 7,75 cm		
AT5		Wood	5,61	1,87
		Leaves	0,87	2,07
		Open Flowers	1,55	1,19
		Closed Flowers	0,51	1,66
	Total		8,54	
	Litter		1,36	1,21
	Stem Diameter	: 7,65 cm		
BT1	Total		44,14	1,28
	Stem Diameter	: 18,6 cm		
BT2	Total		22,52	1,07
	Stem Diameter	: 11,6 cm		
BT3	Total		10,06	
	Stem Diameter	: 12,0 cm		

Appendix.C. Statistical Data.

1) Correlation of *P. repens* stem diameter (X cm) and live standing crop (Y kg)

X = Stem Diameter cm Y = Live Standing Crop (kg)

P.repens tree no.	X (cm)	lnX	Y (kg)	lnY
AT5	7,65	2,0347	8,45	2,1448
AT4	7,75	2,0477	10,52	2,3533
AT3	11,25	2,4204	25,99	3,2577
AT1	12,25	2,5055	66,22	4,1930
AT2	25,25	3,2288	196,63	5,2813

$\Sigma \ln X = 12,2371$ $(\Sigma \ln X)^2 = 149,7466$

$\Sigma \ln Y = 17,2301$ $(\Sigma \ln Y)^2 = 296,8764$

$\Sigma \ln X . \ln Y = 44,6257$ $\Sigma (\ln X)^2 = 30,8941$

$n = 5$ $\Sigma (\ln Y)^2 = 66,2242$

$$r = \frac{n\Sigma(\ln X.\ln Y) - \Sigma(\ln X).\Sigma(\ln Y)}{\sqrt{\left[n\Sigma(\ln X)^2 - (\Sigma \ln X)^2\right]\left[n\Sigma(\ln Y)^2 - (\Sigma \ln Y)^2\right]}}$$

$r = 0,9657.$

Appendix. C. Statistical Data (cont.)

2) Regression of P. repens stem diameter (X cm) against live standing Crop (Y kg).

$\Sigma \ln X = 12,2371$

$\overline{\ln X} = 2,4474$

$\Sigma \ln Y = 17,2301$

$\overline{\ln Y} = 3,4460$

$\Sigma (\ln X)^2 = 30,8941$

$\Sigma (\ln Y)^2 = 66,2242$

$n = 5$

$(\Sigma \ln X)^2 = 149,7466$

$(\Sigma \ln Y)^2 = 296,8764$

$\Sigma (\ln x)^2 = 0,9448$

$\Sigma (\ln y)^2 = 6,8489$

$\Sigma (\ln x)(\ln y) = 2,4564$

$\Sigma (\ln X)(\ln Y) = 44,6257$

where $\Sigma (\ln x)^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$

$$\Sigma (\ln y)^2 = \Sigma Y^2 - \frac{(\Sigma Y)^2}{n}$$

$$\Sigma (\ln x)(\ln y) = \Sigma (\ln X)(\ln Y) - \frac{(\Sigma \ln X)(\Sigma \ln Y)}{n}$$

To give the form $\ln Y = a + b.\ln X$

$$b = \frac{\Sigma (\ln x)(\ln y)}{(\Sigma \ln x)^2} = 2,5999$$

$$a = \overline{\ln Y} - b.\overline{\ln X} = -2,9170$$

$$\ln Y = -2,9170 + 2,5999 \ln X$$

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Preburnt and Postburnt Fynbos Standing Crop at Pella, Cape.

Introduction.

It is commonly believed (Klein,1977) that fire has played an important role in the fynbos since the development of a pastoralist human culture in the south western Cape, i.e. for at least the last 2 000 years (Schweitzer and Scott, 1973). The fire régimes of the south western Cape before C1650 is largely unknown, but it is documented (Sim, 1907) that the early European settlers burnt the vegetation frequently to provide 'succulent' grazing for domestic stock. It can thus be assumed that the majority of the fynbos has been subjected to fire once every 10 to 20 years for the last 300 years (Moll, McKenzie and McLachlin, 1980).

During the early part of this century, botanists expressed deep concern about the detrimental effects of fire on fynbos (see Marloth, 1924; Pillans, 1924; Adamson, 1935). Since this time, however, it has been found that, not only is fire necessarry for the reproduction of some fynbos species (see Taylor, 1972),but after protection from fire for 20 years or more, the vegetation becomes moribund (Le Roux, 1966) with an increased accumalation of litter which is an additional fire hazard (Taylor, 1969). For these reasons, the Department of Forestry has imposed managerial fire régimes on an 8 to 12 year rotation (Van Wilgen, 1980), although some authors maintain that these régimes should be lengthened (Moll, McKenzie and McLachlan, 1980; McLachlan and Moll, 1976).

The veiw is widely held that the fynbos is a fire-adapted vegetation type (Moll, McKenzie and McLachlan, 1980) and the aim of this project is to ascertain the amount of fuel available for a fire in twenty year-old vegetation by comparing the standing crop of twenty year-

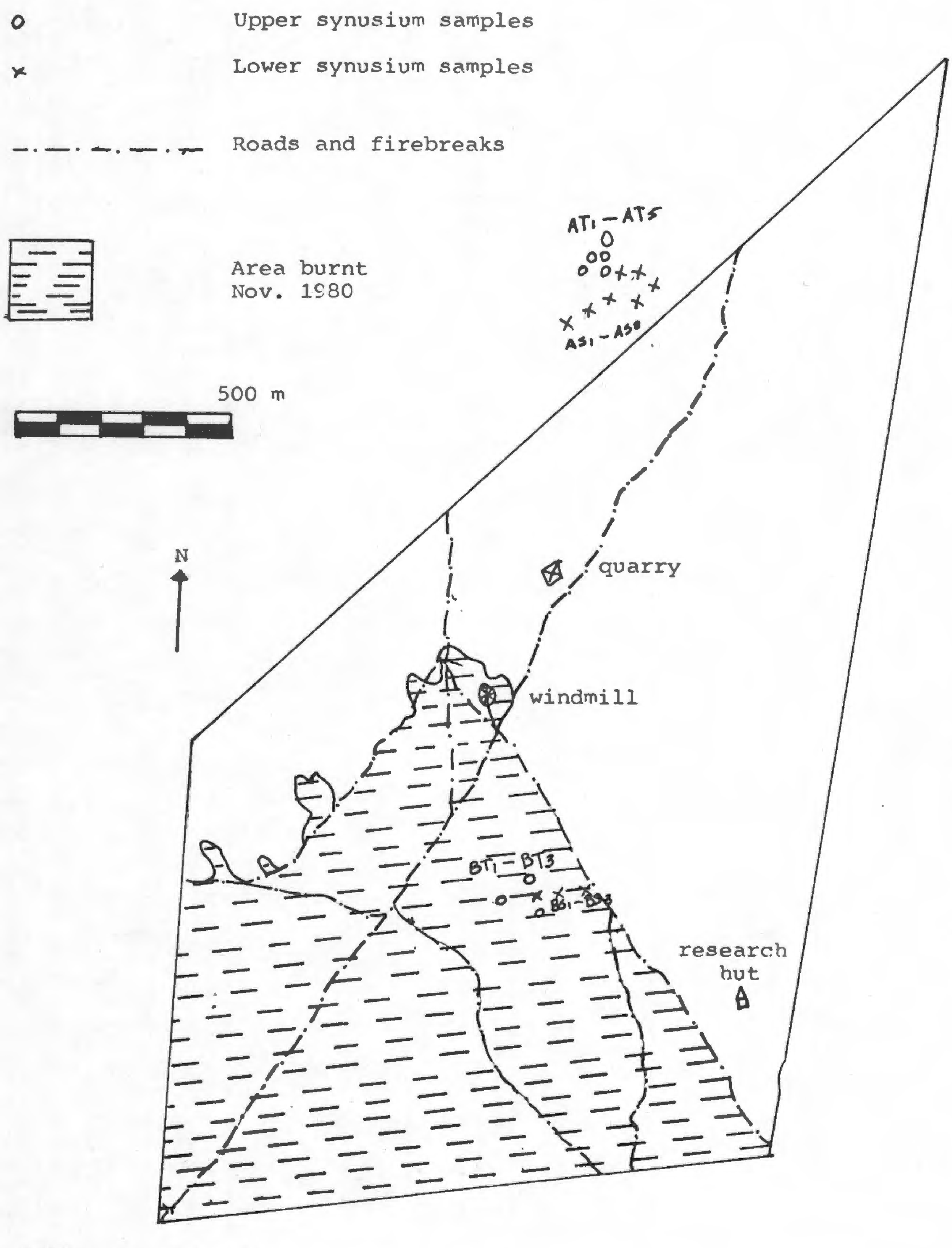

fig.1. Pella research site.

old fynbos to the standing crop of twenty year-old vegetation remaining after a fire had occured.

The Study Site.

This study was conducted on land leased by the C.S.I.R. near Pella mission station (Approximately 33°33'S ; 18°31'E and 70 km north of Cape Town) and adjacent farmland (see fig.1.). The soils of this area are deep alluvial sands, underlain mainly by Malmmesbury formation phyllites (Lambrechts, 1979). This area has an average rainfall of approximately 800 mm per annum (W. Stock, unpubl. data).

The vegetation of this area corresponds to Acocks veld type 47, coastal fynbos (Acocks, 1953). For the sake of convenience, this vegetation was divided into two basic synusia. The lower synusium, with an average height of 60 cm, consists of a restioid component (mainly *Thamnochortus punctatus*) and an ericoid component (mainly *Phylica* spp and *Erica* spp), intersperced with *Leucospermum parile*. The upper synusium consists mainly of *Protea repens* and *P. burchelii* shrubs and it was noted that very little plant growth occurs under the canopy of these *Protea* shrubs.

Methods.

In the unburnt area, the lower synusium was sampled by determining the total percentage cover of the vegetation and the relative percentage cover of each family present in eight 2m x 2m plots (AS1 to AS8, see fig.1.). The plots were then cropped and the wet mass of each family was determined in the field by using a 10 kg 'Pesola' spring balance. The dead standing crop and litter was also collected and weighed in the same way. If these vegetative samples were in excess of 2 kg, subsamples of approximately 10% were taken. All samples and/or subsamples were returned to the laboratory and dried for 24 hours at 100°C to determine their dry mass.

In the unburnt area, the canopy height and circumference of five <u>Protea repens</u> trees were measured (AT1 to AT5, see fig.1.). After the stem diameter at 10 cm below the lowest branch of each of these trees was measured, they were felled and the foliage was divided and/or seperated into leaves, wood, open flower heads and closed flower heads and the wet mass of each component was determined in the field by using a 10 kg 'Pesola' spring balance. A subsample of approximately 10% by mass of each component was returned to the laboratory and dried for 24 hours to 48 hours at 100°C.

In the burnt area, the lower synusium was sampled by cropping and collecting all charred and/or remaining plant material from three 2m x 2m plots (BS1 to BS3, see fig.1.). The plant material collected in this way was weighed in the field by using a 10 kg 'Pesola' spring balance and returned to the laboratory for the determination of dry mass by drying the samples for 24 hours at 100°C.

In the unburnt area, the remnants of three <u>P. repens</u> trees (BT1 to BT3, see fig.1.) were measured in the same way as those in the unburnt area (see above). The trees were then felled and the mass of each tree was determined in the field by using a 10 kg 'Pesola' spring balance. Each tree was then sawed into approximately 30 cm lengths and approximately 10% by mass subsamples **of each tree** were returned to the laboratory and dried for 24 hours to 48 hours at 100°C.

In addition, the number of <u>P. repens</u> trees in a 50m x 50m plot were counted in the burnt area (see fig.1.).

Table.1. The average standing crop (kg/ha), cover (%), frequency (no. of plots, ex 8, in which the family was found), range (largest standing crop to smallest standing crop, in kg/ha), $\frac{\text{wet weight}}{\text{dry weight}}$ ratios and total live standing crop, total dead standing crop and total litter of the lower synusium in the unburnt area (plots AS1 to AS8)

Family	Cover (%)	Frequency (ex 8)	Dry Mass (kg/ha)	Range (kg/ha)	$\frac{\text{Wet Weight}}{\text{Dry Weight}}$
Restionaceae	25	8	3674	1485-9894	1,42
Rhamnaceae	7	8	3380	179-3559	1,41
Leguminosae	3	7	386	0-700	1,32
Compositae	3	6	552	0-1812	1,28
Ericaceae	5	5	127	0-307	1,33
Rubiaceae	0,5	4	53	0-117	1,50
Graminae	2	3	147	0-432	1,24
Proteaceae	4	2	1087	0-8647	2,01
R[illegible]aceae	0,1	1	40	0-320	1,25
Bruniaceae	0,1	1	4	0-35	1,41
Lilliaceae	0,1	1	3	0-27	1,12
Total live standing crop			6028	3066-12670	1,40
Total dead standing crop			4811	1667-9064	1,10
Total litter			4310	820-7790	1,08

Table.2. The total preburnt standing crop and litter (kg/ha), and the total postburnt standing crop (kg/ha) of the lower synusium.

Preburnt : 10 839 kg/ha		Postburnt : 2 kg/ha
Litter : 4 310 kg/ha		

Total lower synusium shrub material consumed by the fire: 15 147 kg/ha, which is equivalent to 99,98 %.

Table.3. The theoretical preburnt upper synusium standing crop and *P. repens* litter (kg/ha), and postburnt *P. repens* standing crop

Preburnt : 19 250,08 kg/ha		Postburnt : 9 409,76 kg/ha
Litter : 4 875,26 kg/ha		

Total upper synusium plant material consumed by the fire: 14 715,58 kg/ha, which is equivalent to 61 %.

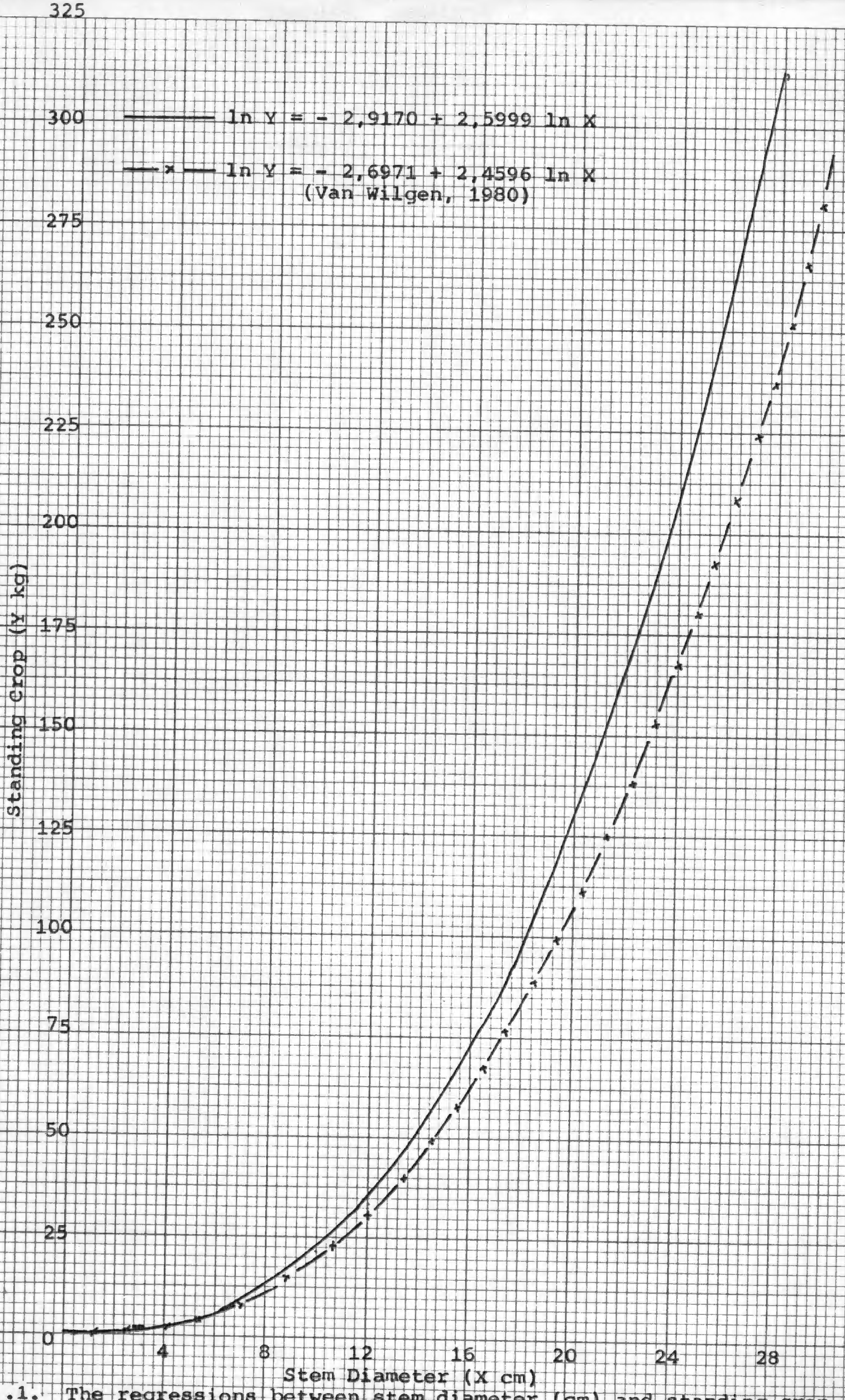

fig .1. The regressions between stem diameter (cm) and standing crop (kg) of 20 year old *P. repens* trees.

Results.

1) The lower synusium.

The average standing crop of each family, together with the total live standing crop, total dead standing crop and total litter, from plots AS1 to AS8 are shown in table 1.

Table 2 shows the total plant material of the lower synusium from the unburnt area (plots AS1 to AS8) and the total plant material of the lower synusium that remained after the fire (plots BS1 to BS3). By subtracting the latter from the former, an indication can be obtained of the amount of lower synusium plant material that was consumed by the fire. (More detailed data for each plot are given in appendix A).

2) The regression between P. repens standing crop and stem diameter.

The relationship between stem diameter and dry standing crop of live 20 year-old P. repens trees is shown by:

$$\ln Y = -2{,}9170 + 2{,}5999 \ln X$$

Correlation = 0,9657

where Y = dry standing crop (kg)

X = stem diameter (cm).

This relationship, together with the relationship of stem diameter vs standing crop formulated by Van Wilgen (1980) , is depicted by fig.2. (The data for the upper synusium are depicted in appendix B and the statistical methods in appendix C).

From appendix B, it can be seen that the average stem diameter of the three burnt P. repens trees is 14,07 cm. From the above relationship, the average standing crop of these trees was 52,31 kg per tree. It was found that there were 92 trees in a 50m x 50m plot and thus the trees of this area had a total preburnt standing crop of

$$52,31 \text{ kg} \times 92 \text{ trees} \times \frac{10\ 000}{2\ 500} = 19\ 250,08 \text{ kg/ha.}$$

Table 3 shows the theoretical *P. repens* standing crop before and after the fire, together with an estimation of the amount of *P. repens* plant material consumed by the fire.

Discussion and Conclusions.

Although the correlation between *P. repens* stem diameter and standing crop is good, the relationship between these two parameters differs from that of Van Wilgen's (1980) slightly (see fig. 2.). The reasons for this difference could be numerous. Firstly, the *P. repens* stem diameter was measured at 20 cm above the ground by Van Wilgen. Unfortunately, in the present study, it was found that the *P. repens* stems branched at or below 20 cm from the ground and thus the diameter at this point might give an erroneous impression of the true stem diameter.

Secondly, the size of Van Wilgen's sample was a lot larger (approximately 280 trees) whereas only five trees were sampled for the present study.

Thirdly, the 10 kg 'Pesola' spring balance used to weigh the plant material in the field, is only graduated in 100 gram divisions. Thus, although it is improbable, it is possible to make an error of up to 100 grams each time this balance is used, a total error of 5 kg per tree is thus possible.

Finally, the difference could be due to environmental differences between this coastal fynbos and the mountain fynbos of the Stellenbosch area (see Kruger, 1977; Rutherford, 1978 and Van Wilgen, 1980).

Similar criticisms apply to the lower synusium measurements and the small number of samples in the burnt area could lead to a definite error in the estimation of standing crop in this area.

As can be seen from table 1, there is much variation in the live and dead standing crop and litter between the plots at this site. It must thus be realized that, for the sake of convenience, this standing crop data is referred to in terms of mean data and is thus only an estimate of the actual aerial biomass.

As can be seen from table 1, the wet weight:dry weight ratios are all, with the exception of L. parile (Proteaceae), below 2. This low water content, together with the possible inclusion of semi-inflamable oils (McLachlan and Moll, 1976) and the fine structure of the leaves and branches of the lower shrub vegetation (Kruger, 1977) could result in a fierce, uncontrollable fire at this time of the year (autumn). It must also be noted that the dead plant material of 20 year-old shrub vegetation is approximately 1,5 times more than the live material. Thus, it would seem, there is an accumalation of litter (see Van Wilgen, 1980) and this vegetation would ignite and burn easily with a high temperature (Taylor and Kruger, 1978). Under the canopy of the P. repens trees, however, the litter is more robust and could smoulder for a relatively long time and could thus be more damaging to the seeds, roots and microbes ususally found in the surface layers of the soil under these trees (E.J. Moll, pers. comm.).

From table 2 and table 3, it can be estimated that the total preburnt plant material in a 20 year-old coastal *P. repens* site would be 39 274,34 kg/ha. As very few shrubs grow under the *P. repens* canopy *per se*, this is an overestimation, but is lower than the aerial biomass of 21 year-old vegetation at Jonkershoek (see Van Wilgen, 1980). Nevertheless, the aerial biomass at Pella seems to be far higher than that of analogous communities in other parts of the world (see Rutherford, 1978; Kruger,1977) with the possible exception of garrigue (France) and older chaparral (California) vegetation (Kruger, 1977). However, Louw (unpubl. data) obtained an aerial biomass of only 815 kg/ha for 17 year-old coastal vegetation at Mamre.

The estimated total plant material consumed by the fire is 29 862,58 kg/ha or an equivalent of 76,04%, the majority of which is lower shrub material and/or litter.
Van Wilgen (1980), however, estimates the fuel content of 21 year-old mountain fynbos as being 53,58% of the total aerial biomass. This estimation is, however, based on the assumption that only plant material with a diameter of less than 6 mm is available as fuel and it would seem that the higher estimation obtained in the present study is more accurate for the 'hotter' fire which could occur in this drier area.

Acknowledgements.
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Appendix.A. Lower synusium data

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
AS1	Restionaceae	25	4 052	1,35
	stems		3 860	1,58
	flowers		192	1,12
AS1	Rhamnaceae	25	3 559	1,42
	leaves		842	1,40
	stems		2 717	1,44
AS1	Graminae	5	335	1,23
AS1	Leguminosae	1	340	1,17
AS1	Rubiaceae	1	177	1,40
AS1	Rutaceae	1	320	1,25
	leaves & twigs		45	1,18
	wood		275	1,31
AS1	Ericaceae	1	15	1,27
AS1	Compositae	1	27	1,06
AS1	Standing Dead		8 012	1,04
AS1	Litter		5 467	1,07

AS1 Height : 60 cm.

Appendix.A. Lower synusium data (cont.)

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
AS2	Restionaceae	25	9 894	1,43
	stems		9 692	1,56
	flowers		202	1,28
AS2	Rhamnaceae	1	160	1,28
	flowers & leaves		52	1,24
	wood		127	1,33
AS2	Graminae	2	432	1,24
AS2	Leguminosae	1	160	1,31
AS2	Rubiacea	1	122	1,55
AS2	Ericaceae	3	307	1,40
AS2	Standing Dead		4 227	1,07
AS2	Litter		6 397	1,07
AS2	Height : 60 cm			
AS3	Restionaceae	20	5 644	1,43
	stems		2 212	1,71
	flowers		187	1,16
AS3	Rhamnaceae	1	485	1,34
	leaves		125	1,38
	wood		262	1,22
AS3	Graminae	5	410	1,25
AS3	Leguminosae	2	319	1,17
	leaves		57	1,12
	wood		262	1,22
AS3	Rubiaceae	1	14	1,09
	leaves		7	
	wood		7	
AS3	Ericaceae	2	194	1,26
	leaves		97	1,24
	wood		97	1,29

Appendix.A. Lower synusium data (cont.)

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
AS3	Compositae	0,5	60	1,32
	leaves		23	1,10
	wood		37	1,54
AS3	Lilliaceae	1	27	1,12
AS3	Standing Dead		3 245	1,16
AS3	Litter		4 465	1,05
AS3	Height : 50 cm.			
AS4	Restionaceae	20	4 205	1,58
AS4	Rhamnaceae	10	1 385	1,51
AS4	Leguminosae	5	82	1,38
AS4	Compositae	10	1 020	1,23
AS4	Standing Dead		9 064	1,05
AS4	Litter		7 790	1, 11
AS4	Height : 65 cm.			
AS5	Restionaceae	20	1 485	1,40
AS5	Rhamnaceae	5	780	1,46
AS5	Leguminosae	5	700	1,65
AS5	Ericaceae	5	285	1,42
AS5	Rubiaceae	2	112	1,55
AS5	Standing Dead		6 535	1,21
AS5	Litter		3 845	1,06

Appendix.A. Lower synusium data (cont.)

Plot	Family and plant parts	Cover (%)	Dry Mass (kg/ha)	Dry Wt (kg/ha) / Wet Wt (kg/ha)
AS6	Restionaceae	10	2 285	1,58
AS6	Rhamnaceae	5	480	1,47
AS6	Leguminosae	10	842	1,40
AS6	Compositae	5	415	1,33
AS6	Proteaceae	30	8 647	2,17
	leaves		1 935	2,01
	wood		6 712	2,33
AS6	Standing Dead		2 334	1,15
AS6	Litter		1 272	1,08
AS7	Restionaceae	10	2 437	1,56
AS7	Rhamnaceae	5	370	1,45
AS7	Ericaceae	2	212	1,35
AS7	Compositae	10	1 812	1,40
AS7	Proteacea	1	55	1,71
AS7	Standing dead		1 667	1,10
AS7	Litter		4 430	1,11
AS8	Restionaceae	45	2 600	1,57
AS8	Rhamnaceae	10	507	1,53
AS8	Leguminosae	10	642	1,48
AS8	Compositae	10	1 082	1,31
AS8	Bruniaceae	1	35	1,41
AS8	Standing Dead		3 405	1,12
AS8	Litter		820	1,12

Appendix.A. Lower synusium data (cont.)

Plot	Dry Mass (kg/ha)	Wet Wt (kg/ha) / Dry Wt (kg/ha)
BS1	3,58	1,39
BS2	0,62	0000
BS3	1,78	1,13

Appendix.B. Upper synusisum data

P.repens tree no.		Plant Part	Dry Mass (kg)	Wet wt (kg) / Dry wt (kg)
AT1		Wood	45,97	1,89
		Leaves	6,63	2,21
		Open Flowers	10,99	1,20
		Closed Flowers	2,63	2,40
	Total		66,22	
	Litter		17,77	1,21
	Stem Diameter	: 12,25 cm		
AT2		Wood	139,91	1,91
		Leaves	24,45	1,85
		Open Flowers	15,49	1,17
		Closed Flowers	18,78	1,57
	Total		196,63	
	Litter		40,18	1,19
	Stem Diameter	: 25,25 cm		
AT3		Wood	19,63	1,86
		Leaves	2,13	2,03
		Open Flowers	3,36	1,25
		Closed Flowers	0,87	1,72
	Total		25,99	
	Litter		5,51	1,21

Appendix.B. Upper synusium data (cont.)

P.repens tree no.		Plant Part		Dry Mass (kg)	Wet wt (kg) / Dry wt (kg)
AT4		Wood		7,50	1,88
		Leaves		0,62	2,03
		Open Flowers		2,29	1,17
		Closed Flowers		0,11	1,36
	Total			10,52	
	Litter			1,42	1,20
	Stem Diameter		: 7,75 cm		
AT5		Wood		5,61	1,87
		Leaves		0,87	2,07
		Open Flowers		1,55	1,19
		Closed Flowers		0,51	1,66
	Total			8,54	
	Litter			1,36	1,21
	Stem Diameter		: 7,65 cm		
BT1	Total			44,14	1,28
	Stem Diameter		: 18,6 cm		
BT2	Total			22,52	1,07
	Stem Diameter		: 11,6 cm		
BT3	Total			10,06	
	Stem Diameter		: 12,0 cm		

Appendix.C. Statistical Data.

1) Correlation of *P. repens* stem diameter (X cm) and live standing crop (Y kg)

X = Stem Diameter cm   Y = Live Standing Crop (kg)

P.repens tree no.	X (cm)	lnX	Y (kg)	lnY
AT5	7,65	2,0347	8,45	2,1448
AT4	7,75	2,0477	10,52	2,3533
AT3	11,25	2,4204	25,99	3,2577
AT1	12,25	2,5055	66,22	4,1930
AT2	25,25	3,2288	196,63	5,2813

$\Sigma \ln X = 12,2371$ $(\Sigma \ln X)^2 = 149,7466$

$\Sigma \ln Y = 17,2301$ $(\Sigma \ln Y)^2 = 296,8764$

$\Sigma \ln X . \ln Y = 44,6257$ $\Sigma (\ln X)^2 = 30,8941$

$n = 5$ $\Sigma (\ln Y)^2 = 66,2242$

$$r = \frac{n \Sigma (\ln X . \ln Y) - \Sigma (\ln X) . \Sigma (\ln Y)}{\sqrt{\left[n \Sigma (\ln X)^2 - (\Sigma \ln X)^2\right]\left[n \Sigma (\ln Y)^2 - (\Sigma \ln Y)^2\right]}}$$

$r = 0,9657.$

Appendix. C. Statistical Data (cont.)

2) Regression of P. repens stem diameter (X cm) against live standing Crop (Y kg).

$\Sigma \ln X = 12,2371$	$(\Sigma \ln X)^2 = 149,7466$
$\overline{\ln X} = 2,4474$	$(\Sigma \ln Y)^2 = 296,8764$
$\Sigma \ln Y = 17,2301$	$\Sigma(\ln x)^2 = 0,9448$
$\overline{\ln Y} = 3,4460$	$\Sigma(\ln y)^2 = 6,8489$
$\Sigma(\ln X)^2 = 30,8941$	$\Sigma(\ln x)(\ln y) = 2,4564$
$\Sigma(\ln Y)^2 = 66,2242$	$\Sigma(\ln X)(\ln Y) = 44,6257$
$n = 5$	

where $\Sigma(\ln x)^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$

$$\Sigma(\ln y)^2 = \Sigma Y^2 - \frac{(\Sigma Y)^2}{n}$$

$$\Sigma(\ln x)(\ln y) = \Sigma(\ln X)(\ln Y) - \frac{(\Sigma \ln X)(\Sigma \ln Y)}{n}$$

To give the form $\ln Y = a + b.\ln X$

$$b = \frac{\Sigma(\ln x)(\ln y)}{(\Sigma \ln x)^2} = 2,5999$$

$$a = \overline{\ln Y} - b.\overline{\ln X} = -2,9170$$

$$\ln Y = -2,9170 + 2,5999 \ln X$$

Table.2. The total preburnt standing crop and litter (kg/ha), and the total postburnt standing crop (kg/ha) of the lower synusium.

Preburnt : 10 839 kg/ha	Postburnt : 2 kg/ha
Litter : 4 310 kg/ha	

Total lower synusium shrub material consumed by the fire: 15 147 kg/ha, which is equivalent to 99,98 %.

Table.3. The theoretical preburnt upper synusium standing crop and *P. repens* litter (kg/ha), and postburnt *P. repens* standing crop

Preburnt : 19 250,08 kg/ha	Postburnt : 9 409,76 kg/ha
Litter : 4 875,26 kg/ha	

Total upper synusium plant material consumed by the fire: 14 715,58 kg/ha, which is equivalent to 61 %.