

INTRODUCTION

In the fuel quantity estimation of large areas for prescribed burning and fire control operations, use is made of the well established relationship between forest canopy type and cover and period since last burn. This information is usually available from A.P.I. maps and burning plans of the area.

The fuel quantity estimate derived from this may often be unreliable due to the uncertainty of past burning operations, logging activity and leaf insect infestations.

In the past, field checks of fuel quantity estimates have had to be subjective and based only on assessors' experience and knowhow. The need to make this estimate objective has led to the development of a rapid reliable technique of litter depth measurement.

These notes describe the depthing technique and outline the steps to be followed in using this method to assess fuel quantities within large controlled burns. Litter fuel mapping of important, high risk areas, is also described.

The Litter Depth Gauge.

The litter depth gauge consists of a wooden slide between metal rails attached to scaled stand. The instrument is used by inserting the slide into a small hole in the litter, and the depth is then read off the rule.

Figure 1 shows the design of the depth gauge.

The depthing Technique.

To use the gauge a small hole (1 x 1½ inch) is made down to soil level in the litter bed so that there is no disturbance or moulding of the surrounding litter. The gauge slide is inserted, and the base of the gauge is rested on the litter surface.

It is necessary to ensure that the base does not rest on surface twigs, scrub debris, stones, cones etc. so that only leaf or needle material is measured. If surface twigs, debris etc. is present, either remove it or move to a more suitable site nearby.

A gentle pressure is placed on the gauge before reading to ensure that the instrument is not suspended on top of curled-up leaves, bark, or tiny twigs, and is lying level with the adjacent litter bed.

Conversion of Litter Depth to Litter Weight (T.P.A.)

Litter weight sampling of the common hardwood and softwood forest types has led to the identification of a close relationship between litter depth and weight for each type. All the relationships obtained were significant to at least a 95% level, the standard errors did not exceed 15 per cent of the mean weight.

The litter types sampled are:

- | | | |
|----------------|-----|---------------------------|
| Hardwood types | (a) | karri dominant |
| | (b) | jarrah dominant |
| | (c) | marri in karri surrounds |
| | (d) | marri in jarrah surrounds |

Softwood types (a) Monterey pine (*P. radiata*)
(b) maritime pine (*P. pinaster*)
(c) Karri-oak (*Quercus decussata*)

Tables 1 and 2 list the tons per acre (oven dry weight) corresponding to the depths for each of the hardwood and softwood litter types respectively.

Prescription of Large Controlled Burns

The litter depthing technique is a rapid means of obtaining reliable estimates of litter quantities present within large, proposed controlled burns.

The intensity at which sampling is conducted depends on:

- (i) the importance of the area in respect to quality of timber, difficulty and risk involved in burn, vicinity of private property and aesthetic value,
- (ii) fire history of area and confidence with which it is possible to determine age, extent and quality of last burn,
- (iii) number of different forest types,
- (iv) variation of canopy cover within forest types,
- (v) accessibility within area.

Planning

In the planning of large area fuel assessments the following steps must be followed.

- (i) On the A.P.I. plan of the area, outline all the major forest types present, e.g. karri dominant, jarrah-karri, jarrah dominant, ti-tree swamp.
- (ii) Within each forest type mark the upper and lower extremes in canopy cover present.
- (iii) Select sites for three sample lines within each canopy extreme for each forest type, so that there is a uniform scatter of sites throughout the assessment area.
If there are only two or three major forest types within a large area, add several more sites so that the sampling rate is at least one site per 1000 acres.
For karri dominant forests this rate may need to be increased to 5 sites per 2,000 acres because of the higher variability within karri litter types.
- (iv) Locate the sample lines so that these are not closer than 5 chains from the edge of roads or compartments as these edge zones may have different fire histories to the remaining interior areas.

Field Assessment in Large Areas

From sampling tests conducted in various litter types it has been determined that a reliable depth estimate may be obtained by taking twelve depth measurements along a line at 10-yard intervals. The sampling rate is such that the mean depth value obtained is not biased greatly by small local fuel irregularities (e.g. forest openings, rock outcrops).

An example of the Fuel Assessment Sheet is attached in Appendix 1. The sheet is used to record the 12 depths per line as well as such items as estimates of forest canopy cover, tree height, major scrub types, scrub top height and density, grass presence and trash height and density. Space is provided to add comments which will assist in the fire prescription. It is important that the locations of the area and sample lines are fully described on the field sheet.

Fuel Mapping of Valuable High Risk Stands

High risk areas such as pine plantations require more accurate assessment of fuels present within individual compartments. A fuel mapping technique was developed which provides a quantitative measure of risks from change in fuel.

Litter depths are measured on a grid basis, the spacing of which depends on the uniformity of the fuels. Most stands are measured on a 3 x 3 chain grid, whereas those areas with rapid changing fuels need to be sampled at a somewhat higher intensity (e.g. 2 x 2 chain).

Because compartmental edge areas have more space in which to grow, they have larger healthier crowns than inside trees. Consequently the litter along edge rows is deep, and this, along with the fact that compartmental edges dry faster, means that burns that are normally mild inside, flare up at the edges causing excessive scorch and butt damage. Hence it is important to assess the edge litter as well as the interior fuels.

Mapping can be done directly onto the field sheet which is ruled into $\frac{1}{2}$ x $\frac{1}{2}$ inch squares (Appendix 2). The field sheet is orientated to the planting line and the north-directing arrow marked in, so that the depth measurements may be recorded within each square commencing at the appropriate corner of the field sheet. It is normal procedure to assess and map the compartmental edge first.

At each sampling point the following items are recorded in each appropriate square; litter depth to fourths of an inch, scrub code, litter, height and percentage area ground cover, e.g. .06 / H-1-20 could mean - litter depth 0.6 inch, with a one-foot high, 20% ground cover of *Hibbertia hypericoides*.

Space is provided on the field sheet for such important details as age, spacing, stocking and crown height of stand; pruning and thinning history; scrub type, height and density; location, size, slope and aspect of compartment, and date and extent of previous burn. See Appendix 2.

The fuel contours at selected depth/fuel quantity intervals are shaded in, and scrub areas containing details of scrub type, height and density are marked in with a broken line. Any areas requiring special attention (e.g. areas of excessive "hangup", hardwood coppice etc.) are noted for possible exclusion or special treatment.

In thinned stands it is necessary to assess the fuel present on thinning tops. The method developed requires a butt girth measurement of 50 thinning crowns throughout the compartment. The mean girth value is used in Table 3 which gives the tonnage of needles and brigs per hundred tops. The number of tops present per acre is naturally equal to the number of trees thinned.

The Burning Prescription

The depths are converted to tonnages (oven dry) and used in conjunction with the fire danger tables to develop a burning prescription for the proposed area. The variation in the fuel type and fuel quantity will determine the number and sequence of burning treatments required.

The accurate assessment of fuel quantities in the form of litter, slash and scrub makes it possible to specify more confidently the fuel and weather conditions required to ensure burns of acceptable quality and minimum scorch and butt damage.

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Figure 1.

Design of Litter Depth Gauge

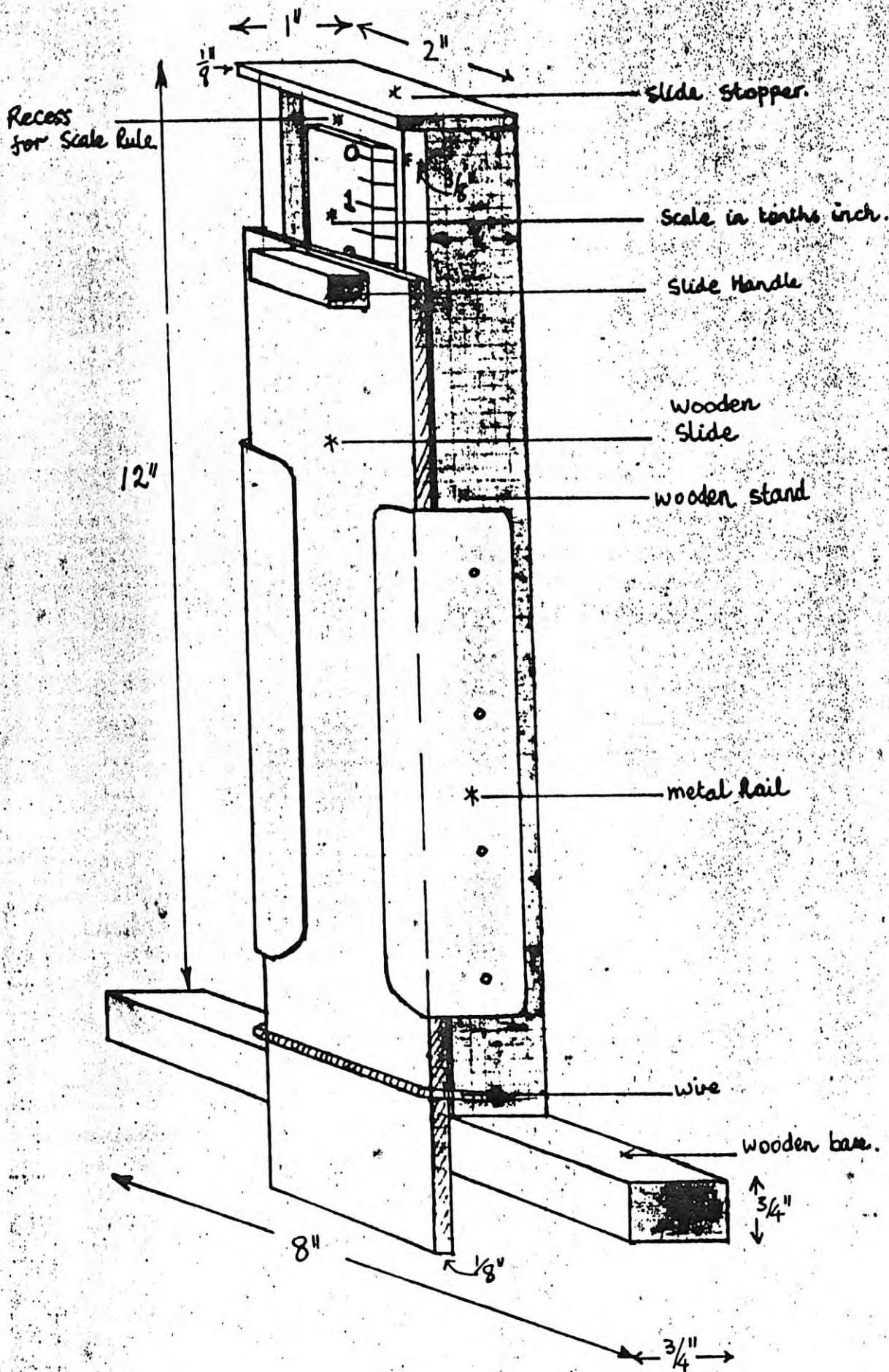


Table 1

Fuel Depth - Weight Table for Hardwood Forest Types

Litter Depth inches	Karri (K, KM, KMJ)	Jarrah (J, JM)	Marri near Karri MK	Marri near Jarrah MJ
Tons per acre (O.D. Wt.)				
0.1	0.7	0.7	0.7	0.7
0.2	1.3	1.3	1.2	1.2
0.3	2.0	1.8	1.7	1.7
0.4	2.6	2.3	2.2	2.1
0.5	3.3	2.8	2.7	2.5
0.6	3.9	3.3	3.2	3.0
0.7	4.5	3.8	3.7	3.4
0.8	5.2	4.4	4.1	3.7
0.9	5.8	4.9	4.7	3.9
1.0	6.5	5.4	5.2	4.2
1.1	7.1	5.9	5.7	4.4
1.2	7.8	6.4	6.3	4.6
1.3	8.4	6.9	6.8	4.8
1.4	9.1	7.4	7.4	5.1
1.6	10.4	8.4	8.2	5.5
1.8	11.7	9.5	8.8	6.0
2.0	13.0	10.5	9.4	6.5
2.2	14.3	11.5	10.0	7.0
2.4	15.6	12.5	10.6	7.5
2.6	16.9	13.5	11.2	7.9
2.8	18.2	14.5	11.8	8.4
3.0	19.5	15.5	12.4	8.9
3.2	20.8			
3.4	22.1			
3.6	23.4			
3.8	24.7			
4.0	26.0			
4.5	29.3			
5.0	32.5			
5.5	35.8			
6.0	39.0			

Table 2

Fuel Depth-Weight Table for Needle Litter Types

Litter Depth Inches	Monterey Pine (<i>P. radiata</i>)	Maritime Pine (<i>P. pinaster</i>)	Karri-oak (<i>Casuarina decussata</i>)
Tons per acre (O.D. Wt.)			
0.2	0.9	1.5	1.3
0.4	1.7	2.5	2.6
0.6	2.5	3.4	3.7
0.8	3.2	4.2	4.7
1.0	3.9	5.0	5.6
1.2	4.6	5.6	6.1
1.4	5.2	6.3	6.6
1.6	5.8	6.9	7.1
1.8	6.3	7.6	7.5
2.0	6.8	8.2 $\times 2.5 = 20.5$	7.9
2.2	7.3	8.9	8.3
2.4	7.7	9.5	8.7
2.6	8.1	10.2	9.0
2.8	8.4	10.8	9.4
3.0	8.7	11.5	9.7
3.5	9.4	13.1	10.5
4.0	10.0	14.7 $\times 2.5 = 36.7$	11.2
4.5		16.3	11.9
5.0		17.9 $\times 2.5 =$	12.5
5.5		19.6	13.1
6.0		21.1	13.7

Table 3

P. pinaster Thinning Crown Weights in Tons per
acre (O.D.Wt.) per 100 tops

Crown Butt Girth ins.	Foliage Weight T.P.A.	Twigs Weight T.P.A.	Crown Butt Girth	Foliage Weight T.P.A.	Twigs Weight T.P.A.
6.0	.17	.04	13.5	.95	.23
6.5	.22	.05	14.0	1.00	.24
7.0	.27	.07	14.5	1.07	.26
7.5	.32	.08	15.0	1.11	.27
8.0	.38	.09	15.5	1.16	.28
8.5	.43	.10	16.0	1.21	.29
9.0	.48	.11	16.5	1.27	.30
9.5	.53	.13	17.0	1.31	.31
10.0	.59	.14	17.5	1.37	.33
10.5	.63	.15	18.0	1.42	.34
11.0	.69	.17	18.5	1.47	.36
11.5	.74	.18	19.0	1.53	.37
12.0	.79	.19	19.5	1.58	.38
12.5	.85	.20	20.0	1.63	.39
13.0	.90	.21	20.5	1.68	.40

Enter Table 3 with mean butt girth of thinning crowns (from 50 measurements) and read off Foliage and Twigs weight in T.P.A. per 100 tops. To derive at total tons per acre multiply the table value by the number of trees thinned per acre, divided by 100.

Appendix I

FUEL ASSESSMENT SHEET

AREA LOCATION

DATE

LINE NO.

OBS.	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	average
Depth														
Type														

FUEL QUANTITY (T.P.A.) K = ... M = ... OTHER = ...

FOREST TYPE CANOPY % TREE HT

MAJOR SCRUB TYPES

SCRUB TOP HT. DENSITY GRASS DENSITY

TRASH (STICKS) HT.

COMMENTS (e.g.) Regen. presence

LINE NO.

OBS.	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	AVERAGE
Depth														
Type														

FUEL QUANTITY K = ... M = ... J = ... OTHER

FOREST TYPE CANOPY % TREE HT

MAJOR SCRUB TYPE

SCRUB TOP HT. DENSITY GRASS DENSITY

TRASH (STICKS) HT.

COMMENTS

LINE NO.

OBS.	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL	AVERAGE
Depth														
Type														

FUEL QUANTITY, K = ... M = ... J = ... OTHER

FOREST TYPE CANOPY % TREE HT

MAJOR SCRUB TYPES

SCRUB TOP HT. DENSITY GRASS DENSITY

TRASH (STICKS) HT

COMMENTS

Appendix 2

P. pinaster.

PINE PLANT DATA SHEET

Date

Location

Date P. M.

Species

Stocking

Fuel type

Galapagos 2
pruned

Green crown height

Scrub type

Height

Stems

Aspect

Area

Date thinned

Date of thinning

Type of burn

dw = 8.2 ha.

3 x 3 chs.

Legend

depth $\geq$ 2 inch.

(ie > 8.2 t.p.a)

depth 1 to 2 inch

(ie 5 to 8 t.p.a)

depth < 1 "

(ie < 5 t.p.a)

TDA

2.3 3.7 2.3 1.0 1.4 3.1 3.6

10.8

3.1 2.9 0.8 1.6 0.3 1.4 3.2

7.9

3.6 1.5 0.3 1.3 1.3 2.7

6.9

3.8 0.8 1.2 1.7 1.5 3.7 2.2

8.9

3.7 1.6 1.2 0.8 1.0 1.6 1.1

6.9

3.2 1.7 0.9 0.6 0.9 1.5 3.4

7.9

3.0 0.9 1.1 1.9 1.6 1.4 1.8

8.6

1.8 0.7 0.9 0.8 0.1 0.5 1.6

5.0

3.7 3.1 1.3 2.9 1.7 2.7 1.4

12.1

TDA 12.5 7.9 5.3 6.9 6.6 7.9 10.5