SOME ASPECTS OF FIRE RATE OF SPREAD IN KARRI LITTER

by

David Ward

Part I – Measuring R.O.S.

1. Linear and Area R.O.S.

It is normal at present to describe fire R.O.S. in linear terms, i.e. feet per minute, or chains per hour. An alternative however, would be to describe R.O.S. in terms of area burnt in any period of time, and this may offer some practical advantages for controlled burning or wildfire suppression operations.

2. Relationship of Area to Time since Ignition

Data obtained from experimental fires in Karri has shown that for low intensity fires burning under constant weather conditions, area is in constant proportion to the square of the time since ignition, i.e. where A = Area, and T = Time

$$\frac{A}{T^2} = K$$

3. Use of $\frac{A}{T^2}$ in Fire Area Prediction

If we designate the area of a fire as "A" at time "T", and "a" at another time "t", then

$$\frac{A}{T^2} = \frac{a}{t^2}$$

$$\therefore \quad a = \frac{At^2}{T^2}$$

Therefore, if we know "A", "T", and "t", we can calculate "a".

Example

A fire has burnt an area of 6,400 sq. ft. in 40 minutes since ignition. What will be its area one hour later (i.e. at 100 minutes from ignition)?

Using above formula:–

$$a = \frac{6400 \times (100)^2}{1600}$$

$$= 4\ (100)^2$$

$$= \underline{40{,}000 \text{ sq. ft.}}$$

It must be emphasized that this formula is only proven for small, low-intensity fires. Its application to high-intensity wildfires needs investigation.

For those interested in things mathematical, it can be shown that $\frac{2A}{T^2}$ is the rate of area acceleration in terms of unit area per (unit time)^2 (van Wagner, 1969).

4. Prediction of Perimeter from Area

It is possible, given area and shape of a fire, to calculate the length of perimeter. A.R. Pirsko of the U.S. Forest Service produced a chart for this purpose in 1961. This could be useful for logistic purposes in fire suppression.

Part II – Factors Controlling R.O.S. in Karri litter

1. Source of Data

During the season 1969/70 a total of 166 experimental fires was burnt in Karri scrub at Strickland Road near Manjimup.

2. R.O.S. and Flame Height

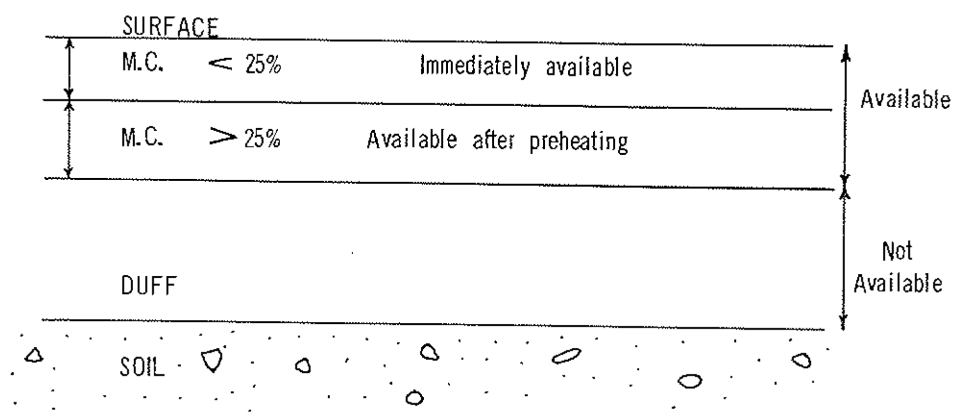
Amongst the Strickland Fires, a correlation was noted between Flame Height at any point of the perimeter and linear R.O.S. in that direction. It would seem to be axiomatic that the height or length of a flame is mainly dependent upon the fuel supply. One source of fuel is the oxygen brought by the wind: the other is organic matter available in the litter. Disregarding wind for the moment, let us examine litter fuel quantity.

3. R.O.S. and Fuel Quantity

In attempting to predict R.O.S. in leaf litter, some attention has been given in the past to fuel quantity. The system used up to the present has been to describe two different fuel quantities, the first being T.P.A. present before burning; the second T.P.A. consumed during the burn (termed "available" fuel).

Neither of these quantities, however, has shown much correlation with R.O.S. and this leads to the suspicion that some other measure of fuel quantity is needed.

Fig. 1

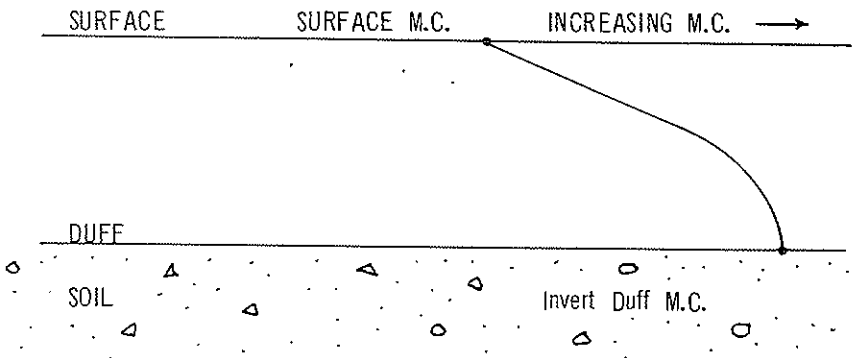


4. Immediately Available Fuel

From Strickland data it seems that Karri litter will not immediately burn at M.C. > 25%. Fuels at initial M.C. > 25% have eventually burnt, when they have been subject to preheating by already burning fuel, presumably because the preheating has reduced the M.C. to 25% or less.

Could it then be that our "available" or consumed fuel should be divided into two horizons – one at M.C. $<$ 25%, which will burn immediately, and another at M.C. $>$ 25%, which will burn after some predrying? The depth of the second horizon will depend, of course on its initial moisture content, and the amount of heat energy released by the initial horizon. Fig. 1 illustrates the idea.

Fig. II



With this in mind I have made tentative investigations into the M.C. gradient through the litter bed, with a view to predicting what fraction of that fuel-bed is immediately available for combustion, i.e. at what level a M.C. of 25% occurs.

Observations of electrical resistance at various levels in litter lead me to believe that the M.C. curve in leaf litter is of the logarithmic form shown in Fig. 11.

A more intensive study is needed to establish the shape of this curve, but since drying rate decreases with depth, it would seem rational to expect a curve of approximately the above shape.

5. Prediction of Fuel Quantity $<$ 25% M.C.

Once the shape of this curve is established, we can construct a chart from which, given surface M.C., Duff M.C., and Fuel Quantity before burning (Depth or Weight), we can predict Fuel Quantity $<$ 25%.

In Fig. IV I show such a chart, in which, for present purposes, I have drawn the moisture curve as an arc of a circle of radius equal to the fuel depth. I have accepted fuel depth and weight as synonymous, and graduated the chart in T.P.A. (tons per acre), since this is the measurement available from Stri ckland Road.

6. Relationship of Fuel Quantity $<$ 25% M.C. to R.O.S.

From Strickland data I have selected fires to give the greatest possible range of R.O.S., and by using the chart have established the T.P.A. $<$ 25% M.C., and, in Fig. 111, plotted this against R.O.S. $(\frac{A}{T^2})$.

This graph shows, I believe, a function of the form $f(x) = x^2$.

Conclusion

(i) For low-intensity fires under constant conditions in Karri litter, area burnt is in constant relationship to the square of the time since ignition. $\frac{A}{T^2}$ is, therefore, a useful parameter for experimental fires, since area progresses geometrically, and so is a more sensitive measurement than the arithmetic linear R.O.S.

Also, $\frac{A}{T^2}$ could be a useful prediction factor for controlled burning, and (with perimeter), in wildfire suppression. Its application to high-intensity fires needs investigation.

(ii) Present measures of fuel quantity do not appear to relate to fire R.O.S. in Karri fuels. The fuel horizon at a M.C. of less than 25% does appear to relate closely to R.O.S., and, together with wind, may be of prime importance in predicting R.O.S.

The shape and progress of the moisture curve through the litter profile under the influence of various rainfall and drying regimes needs investigation.

REFERENCES

1. Wagner van, C.E. (1969) – A Simple Fire Growth Model. For Chronicle 45 : 103–104.

2. Pirsko, A.R. (1961) – Alignment Chart for Perimeter Increase of Fires. Fire Control Notes. 22 : 1–4.

Fig. III

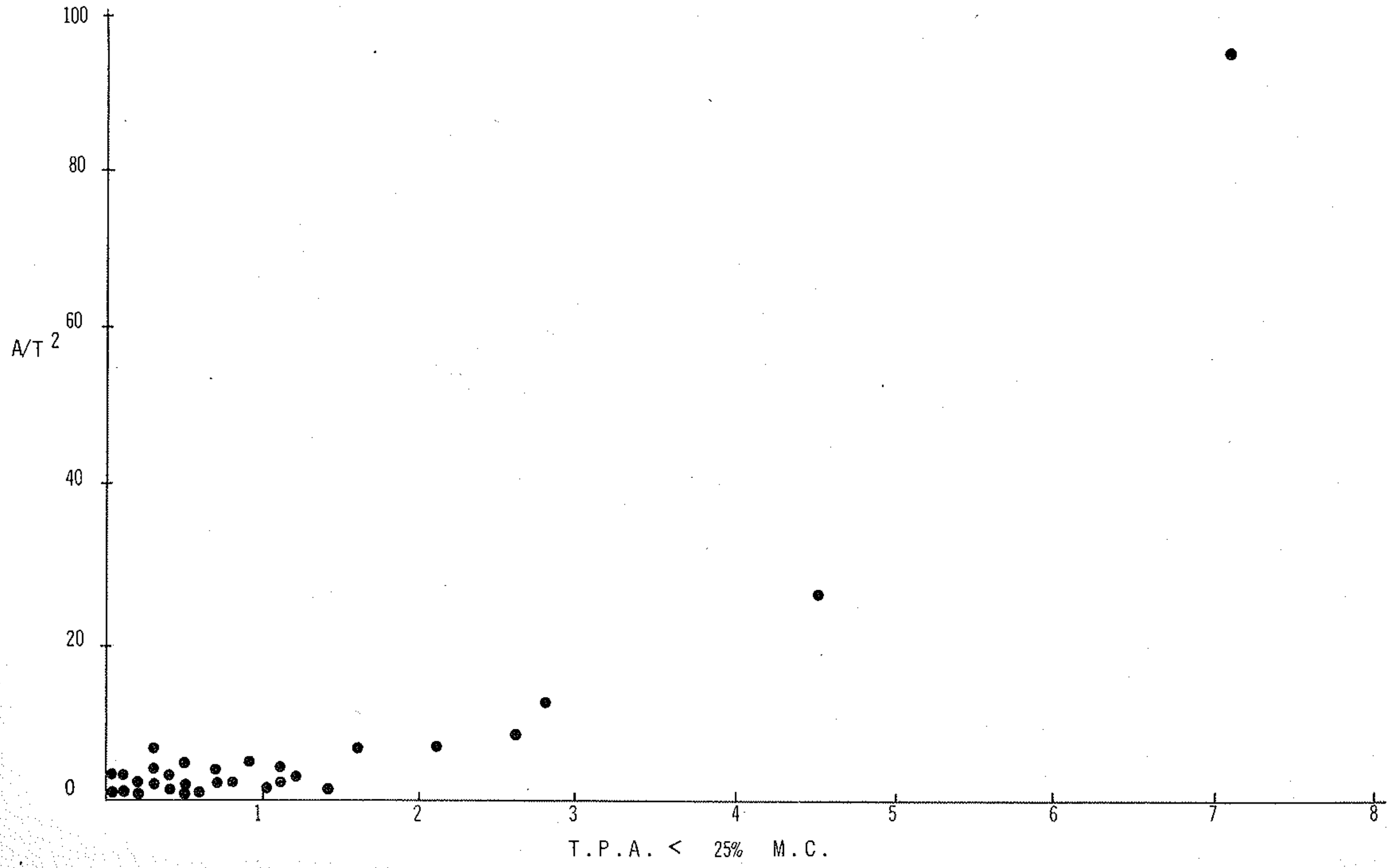


Fig. IV

INSTRUCTIONS

1. Select curve appropriate to fuel T.P.A. present.
2. The y-intercept of the top of this curve represents Duff M.C., the y-intercept of bottom of curve (i.e. origin of axes) represents surface M.C.
3. Interpolate position of 25% M.C. on y-axis by using ruler.
4. From 25% M.C. position, find T.P.A. < 25% M.C. on x-axis.