Fire Growth

A fire has no mass. Therefore, it cannot accelerate but rather it reacts directly to force driving it – the wind pushing the flames forward. As the fire spreads we say it grows as it gets larger. The fire produces hot combustion gasses which rise and interact with the wind field above and around all parts of the fire perimeter. This interaction determines the strength and direction of the air movement that impacts the flames at specific parts of the fire perimeter: in places the wind on the flames will be very different to the strength and direction of the prevailing wind in the open.

As a fire grows its size, shape and speed influences determines the amount energy released from combustion. About 75% of the total energy is transferred as convective energy and the size and strength of the convection column and its interaction with the windfield around the fire and the resultant wind speed and direction will determine the potential rate of spread for the prevailing conditions.

It is critical to understand the growth phase of the fire to ensure the safety of firefighters during initial attack.

(*When I have mastered windows paint I will illustrate the process in diagrammatic form*)

Fire growth in Grassfires

Any fire, starting at a point from a single ignition goes through a growth process described above before it reaches a size where it can spread at the potential rate of for the prevailing weather conditions. This section describes the process in a in a uniform grassland and is based on CSIRO experiments at Annaboroo in the Northern Territory.(Insert Reference) Figure 1 is an example of a grass fire measured by defining the perimeter with metal markers every 2 minutes for 48 minutes. The fire is burning under a relatively uniform wind speed measured at 2m of 6 - 7km/h.

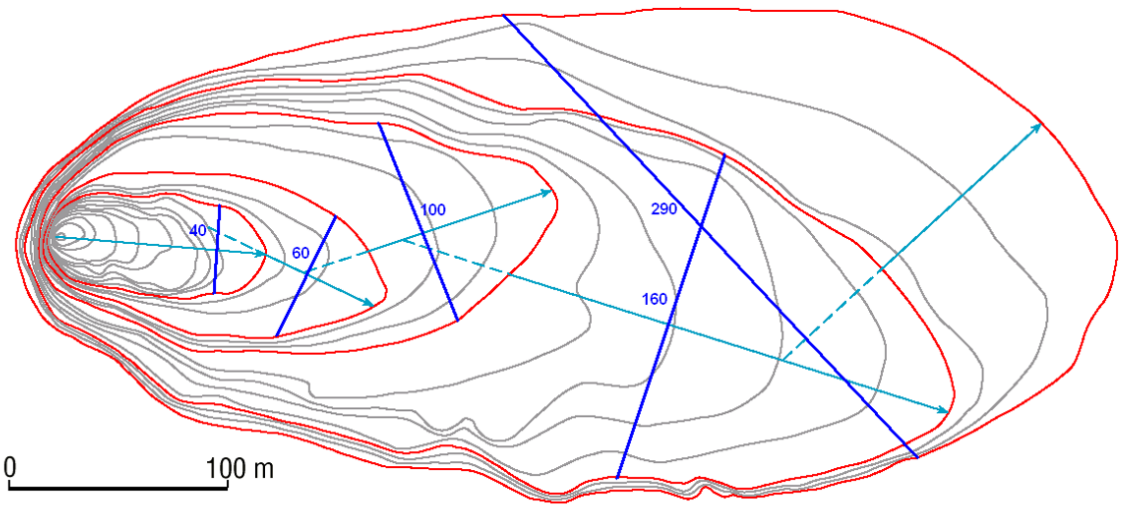

Figure 1. The progress of an experimental fire, ignited at a point. The red perimeters show the size of the fire at the time the wind direction changed; the light blue lines show the direction of the wind and the axis along which head-fire spread was measured.

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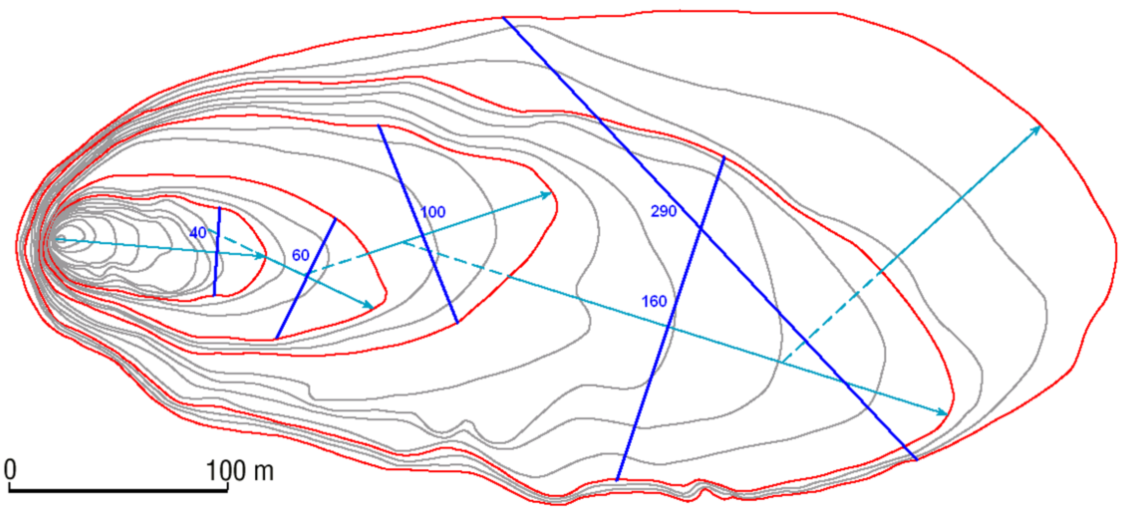

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The width of the headfire was defined as the width of the fire measured normal to the direction of the wind where the flames were leaning over the unburned fuel. This is quite distinct from the flanks of the fire where flames were parallel to the perimeter or leaning over the burnt ground.

Figure 2 shows how the spread of this fire increased in a stepwise fashion whenever the wind direction changed, while the mean prevailing wind speed remained relatively constant.

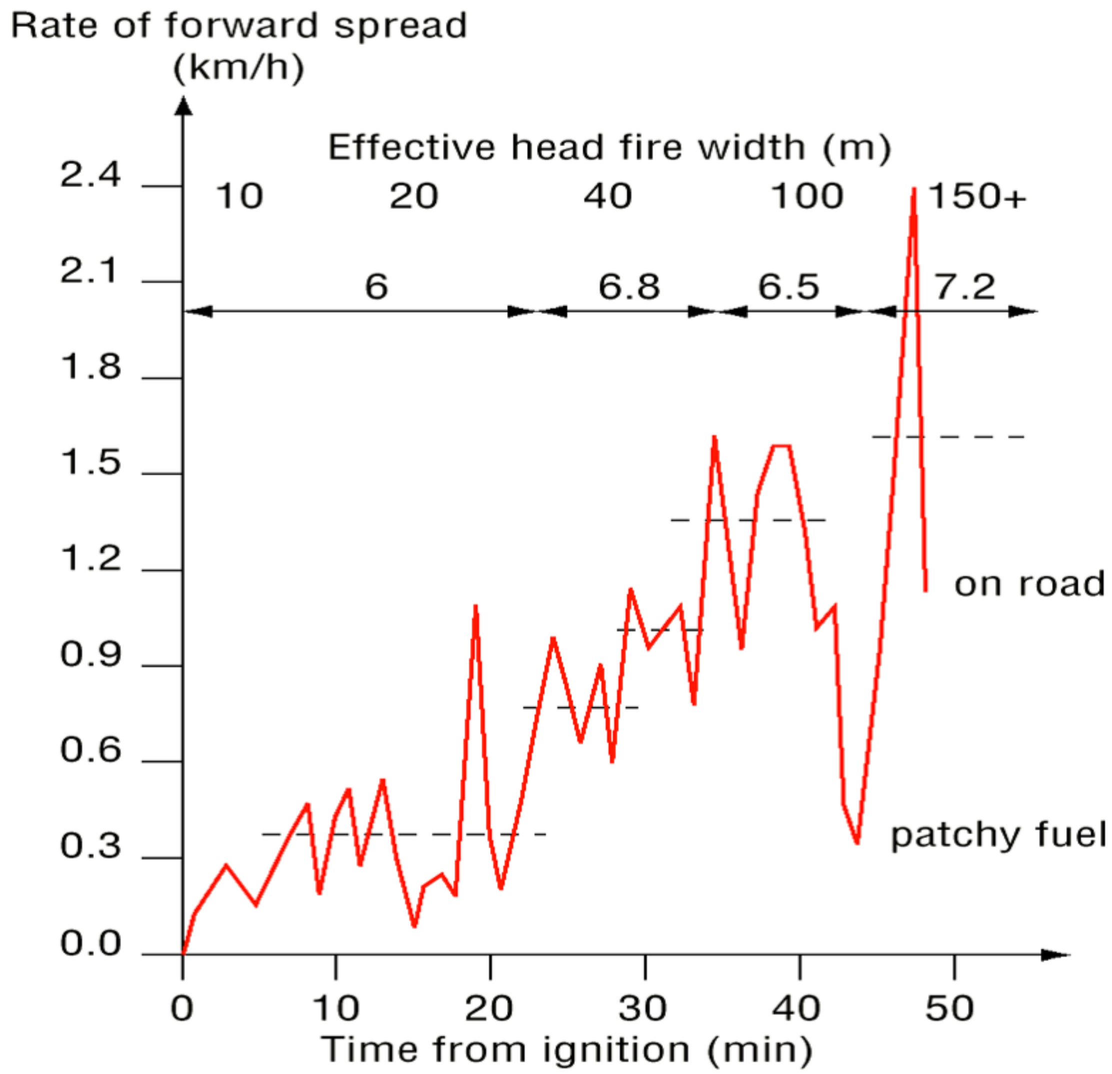

Figure 2. The 2-minute rate of spread increasing in a stepwise fashion. **(***a little more material needed on this graph Such as identifying the wind speed)*

An analysis of more than 50 fires which excluded the headfire-width as a variable showed that the rate of spread was not statistically related to wind speed – a result that would be difficult to sell to anyone.

Further experiments involved lighting lines of fire of different width See Figures 3,4,5. These experiments have shown that the rate of spread is indeed related to the width of the headfire and that, depending on the speed of the prevailing wind, a certain width must be reached to produce the potential rate od spread for the prevailing conditions of temperature , relative humidity, fuel moisture content and mean wind speed.

The following photos illustrate shows the development of simultaneous fires burning under similar wind speed (Wind speed @ 2 m was measured at the four corners of the block)

Figure 3. Grass fires lit at a point, 50 m line and 100 m line after 40 seconds. The 100 m line is not yet complete. The point ignition is barely visible at the top centre of the plot. *(need to insert arrows)*

Figure 2: Simultaneously lit grass fires 100 seconds after ignition.

In Figure 2 the 100 m line is now travelling at its potential rate of spread for the prevailing conditions. If the line had been ignited instantaneously it would have immediately spread at its potential rate. The width of the headfire from the 50m ignition line has decreased and this fire is slowing.

Figure 3: Simultaneously lit grass fires 160 seconds after ignition

In Figure 3 the fire from the 50 m line has now developed a head fire that is narrower that the fire originating from the point ignition and is now spreading slower than the headfire from the point ignition. The 100 m line fire has also developed a pointed head but a slight shift in wind direction is turning the left flank into a broad heading fire which will soon expand the width of the head fire.

Under uniform conditions of fuel and fuel moisture content, the point at which the fire reaches it potential rate of spread is defined by the width of the head fire and the mean wind strength (Table 1).

Wind Strength (km/h)	Headfire width (m)	Potential rate of Spread (km/h)
0	any	0.06
7	20 +	1.5
14	100 +	4
21	150	7

Table 1 Relationship between wind strength and the width of the head fire for a fire to reach its potential rate of spread for uniform grassland and a moisture content of 4.5% (Annaburroo) NT

Under strong wind the potential rate of spread may not be reached until the head fire width exceeds 200m. The convective interaction with the atmosphere above the fire determines the shape of the head fire. If the fire forms a pointed head and the fire will spread at a rate that is well below its potential. This is illustrated in Figure 6.

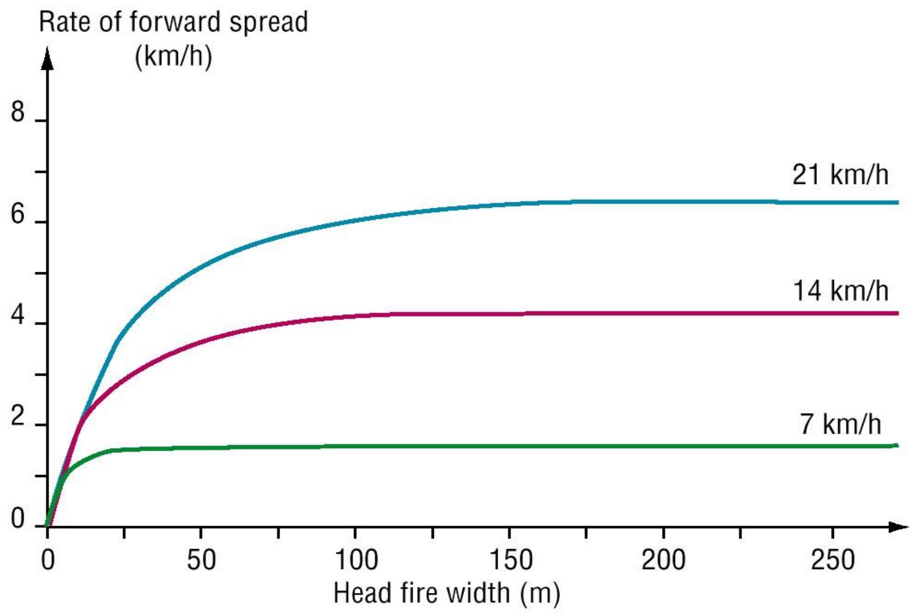

Figure 6. Relationship describing the rate of spread that will be attained by grassfires burning at different head fire widths at increasing wind speeds.

If for example a fire burning under 21 km/hr wind speed has a pointed head of only 20 m then it will maintain a rate of spread of 3 km/h. this is less than half the potential rate of spread for the prevailing conditions and maintain this rate until the width increases. Above the nominated head fire width the fire will continue to spread at its potential ROS for the nominated wind speed.

The time that a fire takes to reach its potential rate of spread in continuous fuel under strong winds depends on the frequency of significant changes in wind direction. This is unpredictable. The fastest of the experimental fires took only 14 minutes while the fire illustrated in Figure 1. was still increasing after 40 minutes.

The really important safety issue is that firefighters attacking the flank of a slow moving head fire may be deceived about the potential rate of spread. If there is a 90°change of wind direction the flank will **IMMEDIATELY** spread at the maximum potential rate of spread.