Australian Government
Bureau of Meteorology

AFDRS Shrubland Model

The AFDRS Shrubland Model is used for temperate shrubland fuels. Shrubland fuels are most prevalent in Tasmania, covering approx. 7% of the state. They only influence Fire Weather Area ratings in TAS and WA, but they are found in all other jurisdictions except NT.

What is the AFDRS shrubland model?

The Shrubland Model, also known as the Heath Model or Heathland Model, by Anderson et al (2015), is used for temperate shrublands and heathlands. It improves upon previous shrubland models by using a data set from fires in Australia, New Zealand, Europe, and South Africa, and covers a broader range of species and vegetation structures. Whilst the model was originally developed for temperature heathlands, it has been extended to include a wide range of heathland and shrubland structures.

Inputs and outputs

This model requires input values for 10m wind speed, temperature, relative humidity, sky, precipitation in the past 48 hours, time since rain or dew stopped, vegetation height, and whether there is an overstorey (i.e. if the shrublands are below a woodland) see Figure 1.

Model equations

Moisture content, *MC*, is calculated similarly to the mallee heath model:

$$MC = 4.37 + (0.161 - 0.027\Delta)RH - 0.1(T - 25) + 67.128(1 - e^{-3.132 r_{48}})e^{-0.0858 t_{rain}}$$

Where RH is relative humidity (%), T is temperature (°C), r_{48} is the precipitation in the last 48 hours (mm), t_{rain} is the time since rain or dewfall stopped (hours), and Δ is 1 for sunny days from 12-5pm during October to March and otherwise 0. As the cloud cover is not always known, Δ is set to be 1 if $RH < 60\%$.

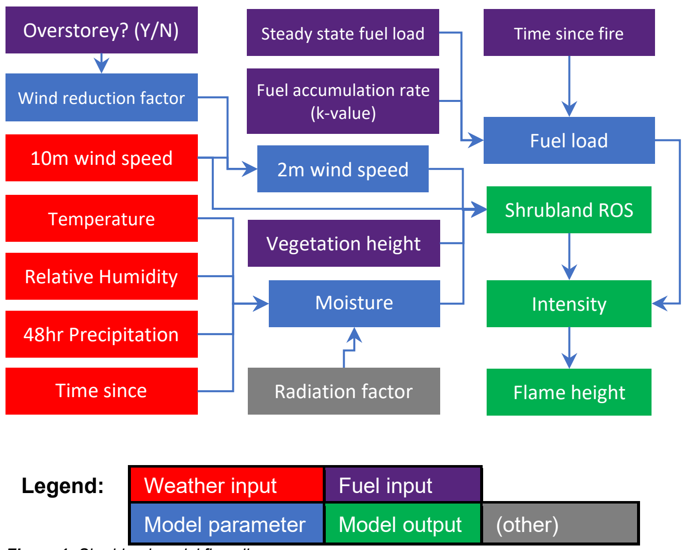

Figure 1: *Shrubland model flow diagram*

The rate of spread is given by:

$$ROS = 340.29(U_2)^{0.9102} e^{-0.0762MC} H_{el}^{-0.2227}$$

Where H_{el} is the shrubland vegetation height in metres (so for shrubby woodland it would be the height of the shrub understorey, not the height of the overstorey trees), U_2 is the is the 2m wind speed calculated from the10m wind speed by multiplying by the wind reduction factor:

$$WRF = \begin{cases} 0.667 & \text{for shrublands without a canopy} \\ 0.35 & \text{for shrublands below a woodland} \end{cases}$$

During the testing phase of AFDRS research prototype it was found that the lack of a probability of spread in this model let to unrealistically high rates of spread in more moderate conditions such as light winds or moist fuels. To compensate for this, an adjusted ROS is applied in AFDRS:

$$ROS_{shrubland} = ROS \times \left(1 + e^{-(16.57 + 1.188U_{10} - 2.705MC)}\right)^{-1}$$

Fuel load, $FuelLoad$, in tonne/ha is calculated based on Olson Curves:

$$FuelLoad = FL_{total}\left(1 - e^{-k_{total}t_{fire}}\right)$$

Where FL_{total} is the steady state fuel load, k_{total} is the total accumulation rate (k-value in the fuel table in Chapter 4 of the NFDRS report), and t_{fire} is the time since fire (in years).

Then to estimate fireline intensity, I_B, we use Byram's equation:

$$I_B = h \times w \times ROS_{shrubland}$$

Where h is the heat yield, assumed to be 18,600 kJ/kg and w is the fuel load converted to kg/m^2.

Lastly, the model calculates a flame height:

$$F_{height} = e^{-4.142} {I_B}^{0.633}$$

Note that the flame height calculation is taken from Cruz et al. 2013 as no equation for flame height was given in the original research paper.

Model behaviour and limitations

This model is most applicable to open shrubland or shrubland within open woodland and assumes a constant wind reduction to the 10m wind speeds. Shrublands are a fine (<6mm diameter) fuel that are highly flammable and remain so for a much longer portion of the year than forest fuels.

It has potential for very rapid growth and high fire intensity, particularly on windy days, however dangerous conditions in this fuel type may not be reflected in Fire Weather Area ratings due to its limited geographic extent.

The effect of wind speed on fire spread is approximately linear and the model is most sensitive to this parameter until fuels reach high levels of moisture.

This model does not have a go/no-go threshold, so it may propagate fires in marginal conditions (higher fuel moisture and/or lower wind speeds) where in reality it would self-extinguish. This is the biggest limitation of this model, because fire propagation and intensity can escalate dramatically in this fuel type.

Fuel sub-types

This model is applied to two sub-types: Heath and Wet heath.

Heath

This sub-fuel consists of shrublands in temperate parts of Australia, including coastal heathlands, which tend to have a more continuous fuel structure than those found in arid areas. It includes heathland, tall closed shrubland, low closed forest and open woodland with a heath understorey. Open woodlands with a dominant heath understorey are included in the Heath fuel type and not Forest, as are some low closed forests.

Figure 2: *Top left: heathland with understorey of Buttongrass, Southwest TAS. Top right: Coastal shrubland, VIC. Bottom left: Semi-arid shrublands of southwest WA. Bottom right: Shrubland typical of central Australia, Uluṟu-Kata Tjuṯa National Park. From a hierarchical classification of wildland fire fuels for Australian vegetation types, Cruz et al. 2015*

Wet heath

This sub-fuel consists of wetlands with a medium to tall shrubland structure; for example, swamp heath or melaleuca shrubland. Wet heath is included as a separate sub-fuel, but no variation to the model has been applied at this stage.

Original research paper: Anderson, W.R., Cruz, M.G., Fernandes, P.M., McCaw, L., Vega, J.A., Bradstock, R.A., Fogarty, L., Gould, J., McCarthy, G., Marsden-Smedley, J.B., Matthews, S., Mattingley, G., Pearce, H.G., van Wilgen, B.W., 2015. A generic, empirical-based model for predicting rate of fire spread in shrublands. International Journal of Wildland Fire 24, 443-460.

FIND OUT MORE

For more information about the Buttongrass Model, contact the **Fire Weather, Heatwave and Air Quality Environmental Prediction Services Team** at fireweather@bom.gov.au.