Australian Government
Bureau of Meteorology

AFDRS Buttongrass Model

The AFDRS Buttongrass Model is used for buttongrass moorlands. Buttongrass fuels are found mainly in Tasmania, covering 10% of the state but significant in only 1 FWA.

What is the AFDRS Buttongrass Model?

AFDRS uses the buttongrass moorland model developed by Marsden-Smedley and Catchpole in 1995. This model was created using data from 44 experimental fires, 11 prescribed burns, and 5 wildfires. It is potentially applicable to other areas in Australia, such as coastal swamps, but for the initial implementation of AFDRS, it is used exclusively for moorlands with a significant proportion of buttongrass.

Inputs and outputs

The buttongrass model requires inputs of 10m wind speed, relative humidity, dewpoint temperature, rainfall/dewfall in the past 48 hours, time since rainfall/dewfall ceased, fuel age and site productivity. Fuel age (time since fire) is used as a surrogate for fuel load and the proportion of dead fuels in the fuel bed.

This model has a go/no-go threshold; it first calculates the likelihood a fire will self-sustain and if this is above 50% it will then calculate ROS.

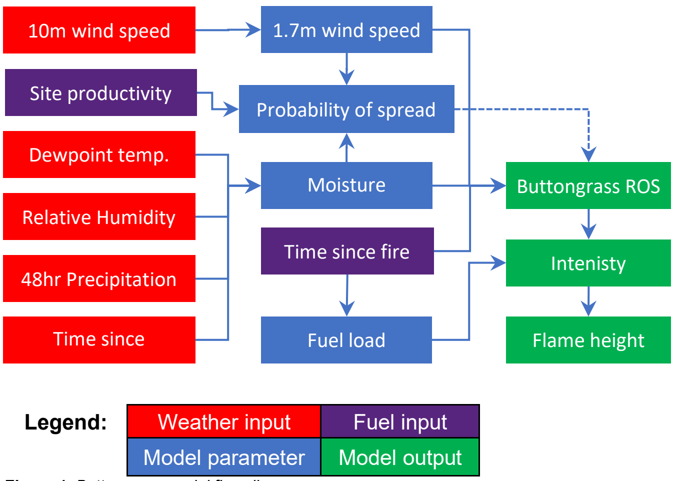

***Figure 1:** Buttongrass model flow diagram*

Model equations

Fuel moisture content, MC, is calculated first:

$$MC = 67.128(1 - e^{-3.132r})e^{-0.0858t} + e^{(1.660+0.0214RH-0.0292T_d)}$$

Where r is the total rain/dewfall in the last 48 hours, t is the time since rainfall/dewfall ceased, RH is the relative humidity, and T_d is the dewpoint temperature. The unusual use of both RH and T_d in this equation is because temperature and RH were correlated in the original research dataset.

The probability of sustained fire spread is calculated using:

$$P_{spread} = (1 + e^{1-0.68U_2+0.07MC+0.0037U_{1.7}MC-2.1Prod})^{-1}$$

Where U_2 is the 2m wind speed, derived from 10m wind speed by dividing by 1.2 and $Prod$ is the site productivity which is set to 1 for low productivity sites and to 2 for medium productivity sites with each pixel mapped to a fuel type with a productivity parameter, based on data supplied by Tasmanian fire agencies. Note: productivity indicates the amount/rate of accumulation of fuel driven by edaphic and/or climate factors.

If $P_{spread} > 0.5$, the fire is likely to spread, and the Rate of Spread is then given by:

$$ROS_{buttongrass} = 40.68(U_{1.7})^{1.312}e^{-0.0243MC}(1 - e^{-0.116TSF})$$

Where TSF is the time since fire in years. If $P_{spread} \leq 0.5$ then we set the rate of spread to zero.

We then calculate the total fuel load from time since fire:

$$FL_{ns} = \begin{cases} 11.73(1 - e^{-0.106TSF}) & \text{for } Prod = 1 \\ 44.61(1 - e^{-0.041TSF}) & \phantom{\text{for }} Prod = 2 \end{cases}$$

Note that the original research papers also propose equations for dead fuel load, however these are currently not used for AFDRS.

As with the other fuels, fuels, fireline intensity, I_B, uses Byram's (1959) equation:

$$I_B = h \times w \times ROS$$

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

We can then find flame height using:

$$F_{height} = 0.148\, I_B{}^{0.403}$$

Model behaviour and limitations

The two key components of fire spread in buttongrass moorlands are the openness of the moorlands (is it of a non-forested nature and therefore the exposure to wind), and the quantity of suspended dead fuels. This is a simple model and could be considered well-balanced as is not overly sensitive to any of the inputs:

- Wind speed has the strongest effect on rate of fire spread, accounting for approximately 40% of the observed variation in ROS in the data set used to develop this model.
- Moisture content of suspended dead fuels and time since fire also have a significant effect, though to a lesser extent than wind, each accounting for 15-20% of the variation in observed ROS from the dataset.
- Model is sensitive to small amounts of recent rainfall as this will significantly increase MC and therefore decrease the probability of spread and the rate of spread.
- The model is less sensitive to changes in temperature/humidity.

For this model, AFDRS assumes all of the fuel (not just dead fuel load) will burn, which could lead to an overestimation of intensity, particularly near fast moving fire fronts. This assumption is reflected in the moisture content variable which, unlike in other fire spread models, is a measure of the moisture content of both the live and dead fuels. The threshold of MC at which fires can be sustained is much higher (70%) compared to other fuels (~20% for eucalyptus and 30% for pine). If $MC < 70\%$ and $TSF > 3$, fires have been reported to spread, even over standing water and with little or no wind speed.

This model was developed mostly for prescribed burning conditions, but it has been shown to perform adequately for wildfires. The go/no-go threshold is mostly determined by the site quality (such as time since fire), which is most accurately determined on-site rather than estimated from other parameters.

Fuel sub-types

This model was developed specifically for buttongrass and so has just the one fuel sub-type. However, there is potential to apply it to other vegetation such as coastal swamps in future updates.

Buttongrass moorland

Buttongrass (Gymnoschoenus sphaerocephalus) is a species of tussock-forming sedge mainly found in Tasmania. For AFDRS, buttongrass moorlands are defined as treeless communities of mainly sedges and low heaths in which this species is a significant proportion, and at the AFDRS landscape scale, this fuel is confined entirely to Tasmania and Flinders Island. Approximately 10% of Tasmania is classed as buttongrass moorlands, the majority of which is in the Western Fire Weather Area.

Figure 2: *Buttongrass, Tasmania, image courtesy of AFDRS project*

Figure 3: *Buttongrass, Tasmania, image courtesy of AFDRS project*

Original research paper: Marsden-Smedley, J.B., Catchpole, W.R., 1995. Fire modelling in Tasmanian buttongrass moorlands II. Fire behaviour. International Journal of Wildland Fire 5, 215-228.

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.