Australian Government
Bureau of Meteorology

AFDRS Spinifex Model

The AFDRS Spinifex Model will be used for the hummock spinifex grasslands of central Australia, which cover 26% of the nation. Spinifex dominates 16 FWAs across NT and WA and has an influence on FWAs in the arid regions of all mainland states.

What is the AFDRS Spinifex Model?

AFDRS uses the dessert spinifex model developed by Burrows et al in 2018. This model is the latest iteration of many years of work and uses data from 150 experimental fires in WA and QLD from 1991 to 2018. Because of the discontinuous nature of spinifex clumps, it has go/no-go threshold (in this case a spread index) to determine if a fire is likely to spread.

Inputs and outputs

The spinifex model is a simple model and outputs Rate of Spread (ROS), intensity, and flame height. It requires inputs of 10m wind speed, relative humidity, years since fire, and monthly relative soil moisture content.

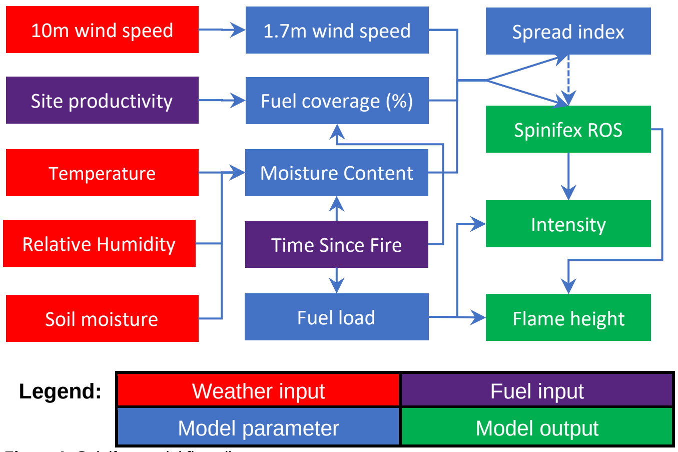

Figure 1: *Spinifex model flow diagram*

Model equations

The clump profile moisture content, MC, is estimated from the Time Since Fire and the monthly relative soil moisture (upper layer) fraction, $AWAP_{uf}$, from the Australian Water Resources Assessment Landscape (AWRA-L) model:

$$MC = 40(AWAP_{uf}) + 13 - \frac{x}{0.03RH}$$

Where x is chosen based on the time since fire (TSF), with minimum thresholds for MC applied:

TSF (years)	x	Minimum MC (%)
3 – 10	0	-
11 – 15	1.5	14
16 – 20	2.5	13
>20	3.5	12

For areas of less than 3 years since a fire, it is assumed there is no dead spinifex cover and that live spinifex is too sparse to carry a fire.

An additional fuel moisture model (Simard moisture) is used at low soil moisture to ensure that dead fuel moisture responds to relative humidity in a sensible way, based on field work conducted by WA DFES (Jackson Parker pers. Comm).

$$MC_{simard} = 2.2279 + 0.160107RH - 0.014784T + 7$$

The final MC content is the maximum of MC and MC$_{\text{Simard}}$.

Fuel productivity, based on the Carbon Farming Initiative mapping (CFI 2013), is set as 1 for arid fuels and at 2 or 3 for more productive fuels. The fuel coverage, Cov_{ns}, is then given by:

$$Cov_{ns} = \begin{cases} 26.2 \times TSF^{0.227} & \text{for productivity} = 1 \\ 39.3 \times TSF^{0.227} & \text{for productivity} > 1 \end{cases}$$

The model calculates if a fire is likely to spread using a spread index:

$$SI = 0.412U_{1.7} + 0.311Cov_{ns} - 0.676MC - 4.073$$

Where the 1.7m wind speed, $U_{1.7}$, is derived from 10m wind speed by dividing by 1.35. If $SI > 0$, the fire is likely to spread, and the Rate of Spread is given by:

$$ROS_{spinifex} = 40.982(U_{1.7})^{1.399}(Cov_{ns})^{1.201}(MC)^{-1.699}$$

The model also estimates fuel load, FL_{ns}, in tonnes/ha. For more productive fuels (i.e. productivity > 1) we use the table on the following page. Otherwise (productivity = 1) we use the equation:

$$FL_{ns} = 2.046 \times TSF^{0.42}$$

Time since fire (years)	Fuel load (tonne/ha)			
	Productivity = 2		Productivity = 3	
	Open spinifex	Spinifex woodland	Open spinifex	Spinifex woodland
<1	1.28	2.01	3.58	3.78
1-2	2.39	3.4	5.25	5.11
2-3	3.36	4.38	6.73	5.95
3-4	4.21	5.06	8.05	6.49
4-5	4.96	5.53	9.21	6.84
>5	5.6	5.86	13.34	7.38

Flame height is calculated using:

$$F_{height} = 0.097ROS^{0.424} + 0.102FL_{ns}$$

Fireline intensity, I_B, uses Byram's (1959) equation, with heat yield, h, assumed to be 18,600 kJ/kg, and fuel load, w, converted to kg/m^2:

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

Model behaviour and limitations

This is simple model and can be considered well-balanced as it is not overly sensitive to any of the inputs, though as Time Since Fire is used to estimate both moisture content and fuel coverage, it can have a large influence.

The strongest (10m) winds speeds in the experimental data were around 27 km/h and it is not known how well the model performs at stronger wind speeds.

Both live and dead spinifex are included and are not distinguished between by this model, but these two states of the fuel will respond differently to changing dewpoint and temperature.

Spinifex fuels are discontinuous and the spread index accounts for this however it assumes the distribution of fuel is uniform over an area with a single spread index value. Larger gaps in fuel, either natural or artificial (such as a road) may interrupt fire spread.

If there is a continuous (>70%) cover of cured soft grassy plants (e.g. after exceptional rainfall), the assumption of no fire spread within three years would be incorrect. Spinifex could be temporarily remapped as a grass type in this situation (if deemed important).

This model works best at the local scale as it relies on accurate inputs of "eye-level" wind speed and fuel moisture which in AFDRS are both estimated from other variables.

Fuel sub-types

All vegetation communities with a spinifex hummock grass understorey have been classified to the spinifex broad fuel type in AFDRS and they are split in two sub-types depending on overstorey coverage.

Spinifex

Spinifex hummock grassland with less than 5% tree/shrub cover.

Figure 2: *Different classes of Spinifex fuel. Top left: Fuel class 1, 0 to 6 years old. Top Right: Fuel class 2, 6 to 10 years old. Bottom left: Fuel class 3: 11 to 15 years. Bottom right: Fuel class 5, 21 to 25+ years old.*

Spinifex woodland

Woodland and shrubland with a hummock grass (spinifex) understorey. This includes vegetation described as mallee if the understorey is spinifex. ROS is reduced using a wind reduction factor based on canopy cover is applied, similarly to the Grassy Woodland (Savanna) adaptation of the CSIRO Grassland model.

Figure 3: *Semi-arid Mallee-spinifex shrubland characterised as tall open shrubland with a spinifex understorey*

Original research paper: Burrows, N., Gill, M., Sharples, J., 2018. Development and validation of a model for predicting fire behaviour in spinifex grasslands of arid Australia. International Journal of Wildland Fire 27, 271-279.

FIND OUT MORE

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