The Effect of the Degree of Grass Curing on the Behaviour of Grassland Fires – an Experimental Study

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Project intent statement

Combustion of **live fuels** in a natural fuel complex and how those fuels affect fire propagation, more specifically, how the **proportion of live fuels in grasslands reduces rate of spread**

- Curing (%) *= dead fuel load / total fuel load*
- d/l ratio *= dead fuel load / live fuel load*



Grassland fire behaviour research

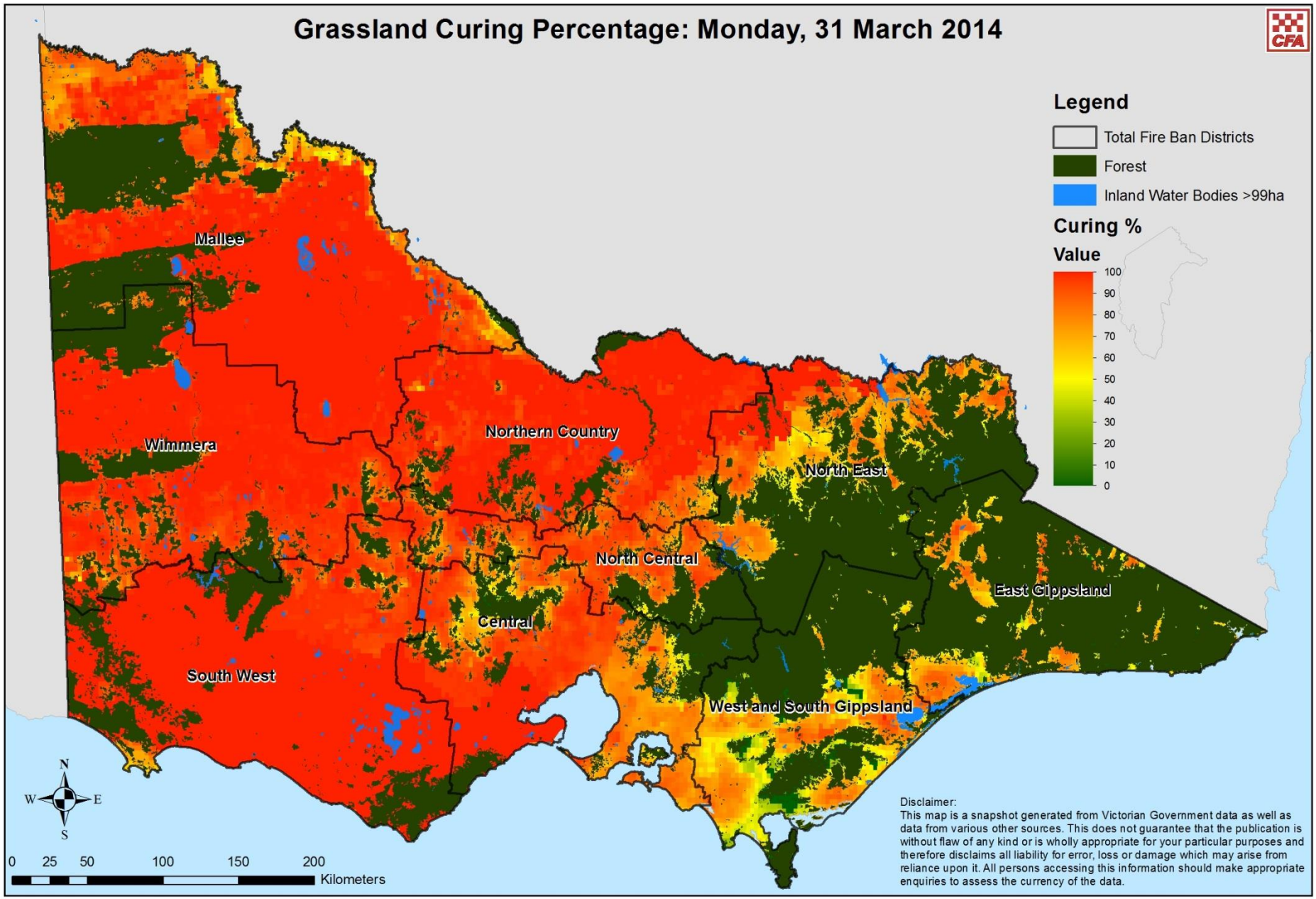
Study main objectives:

1. To quantify the effect of curing on rate of fire spread:
    - Damping effect
    - Fire sustainability (go/no-go thresholds)
    - Percentage curing impact
2. Relationship to current curing processes

Satellite observation methodology

- New Satellite Model “MapVictoria”
  - Derived from **historical visual observations** and **satellite observations**
- New Combined Model “VISCA” (Victorian Improved Satellite Curing Algorithm)
  - Combines current **validated visual observations** with **satellite data**.
  - Under- and Over-estimates by <10%

Grassland Curing Percentage: Monday, 31 March 2014

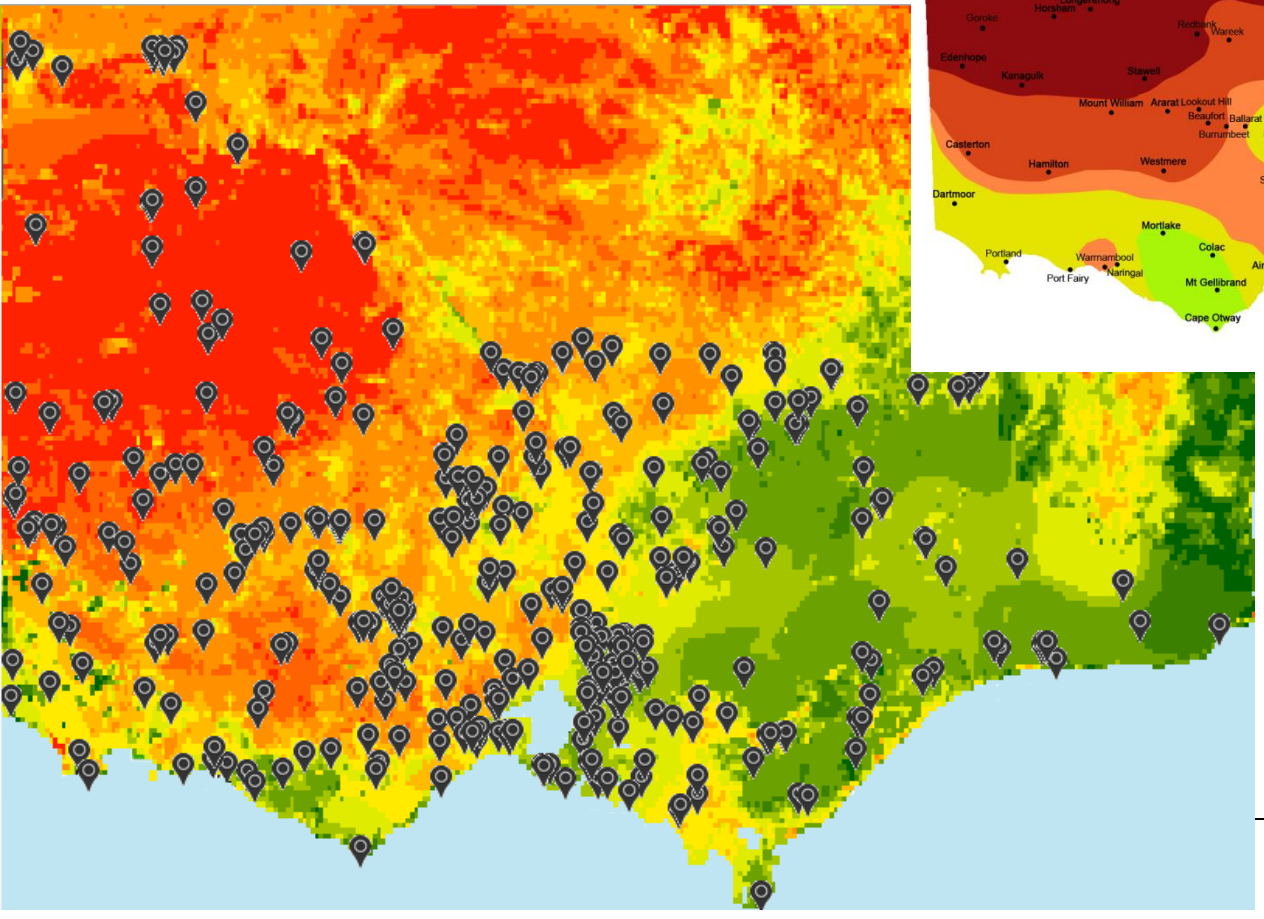


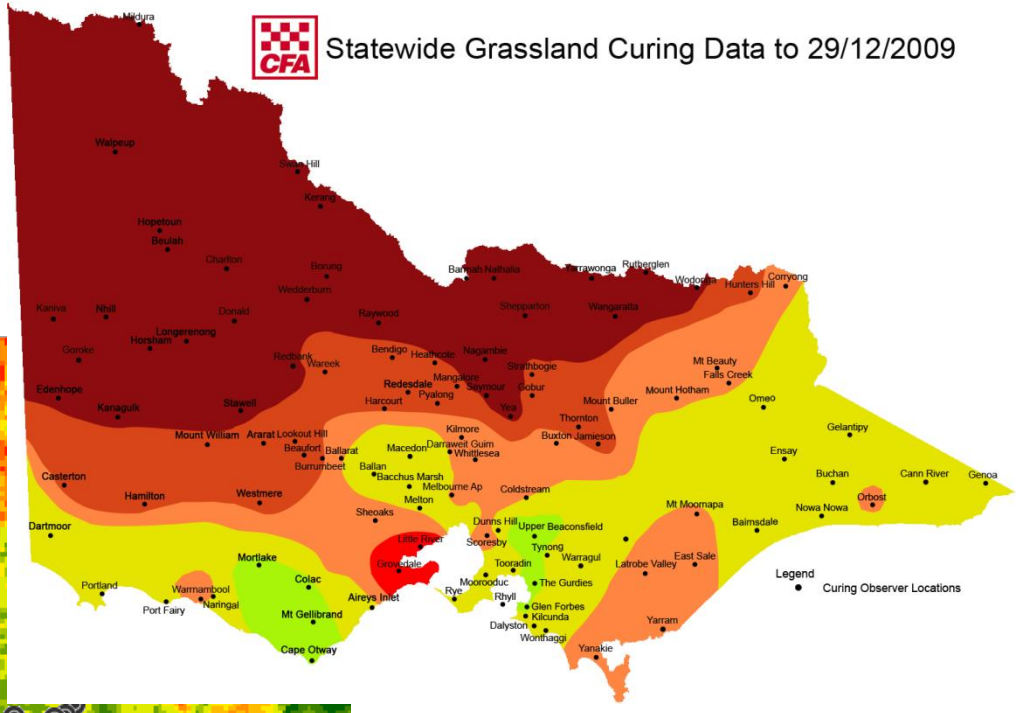
Disclaimer:
This map is a snapshot generated from Victorian Government data as well as data from various other sources. This does not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaims all liability for error, loss or damage which may arise from reliance upon it. All persons accessing this information should make appropriate enquiries to assess the currency of the data.

Current observation network

Pre-2010 there were many sites with no observers present

Now all sites have associated observers (with the exception of AWS locations)





Grassland fire behaviour research

- CFA contracted CSIRO to conduct grassland burn experiments, both laboratory and field based.
  - Pyrotron lab experiments (Canberra)
  - Landscape burns (Ballarat and Wangaratta)

Laboratory experimentation

Experimental design:

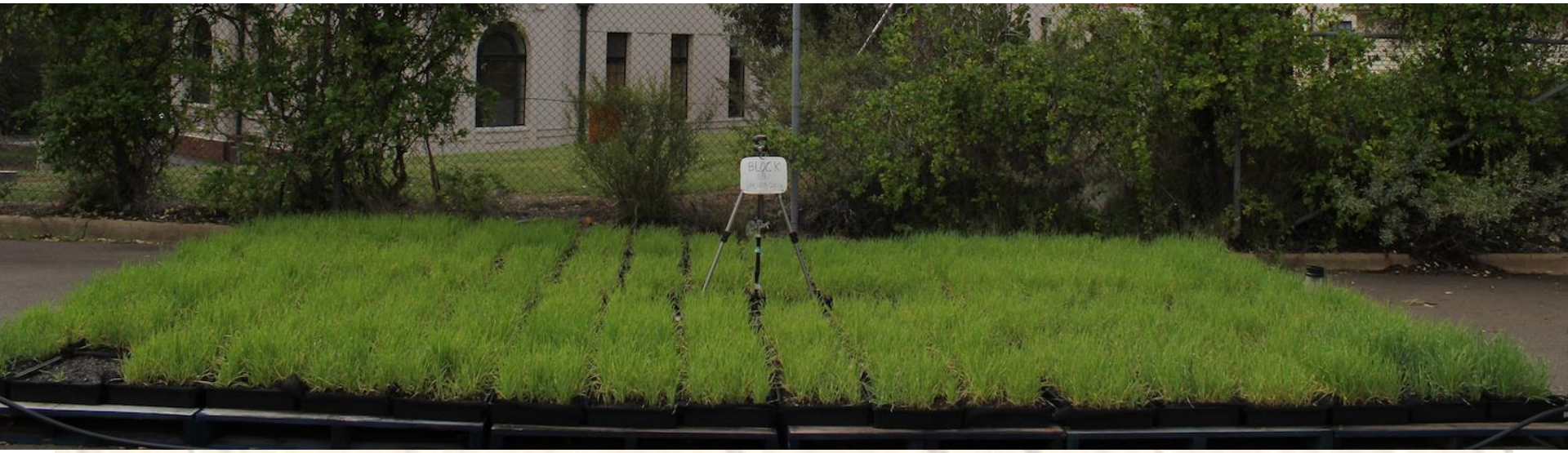
- Control: burns with 100 % cured grasses
- Treatment: burns with partially cured grasses:

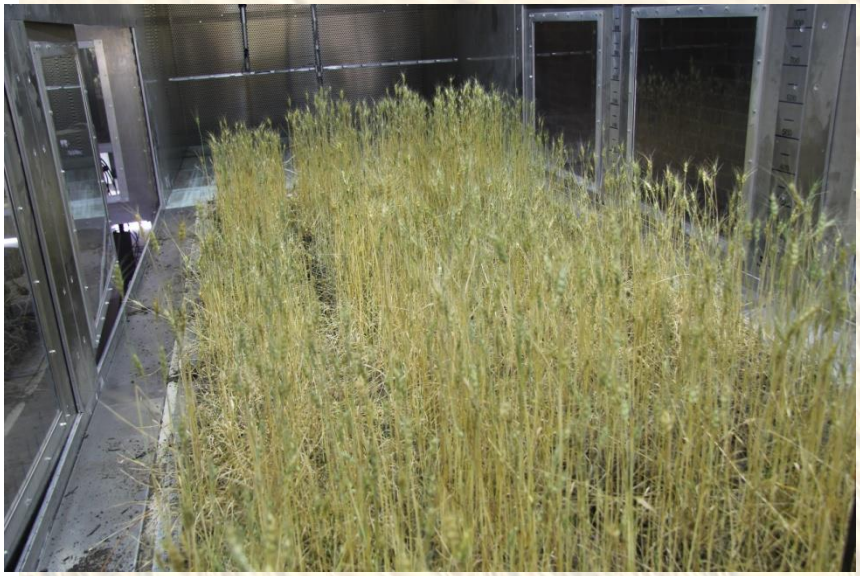
  ~30%, **~60%** and **~80%**

3 replicates

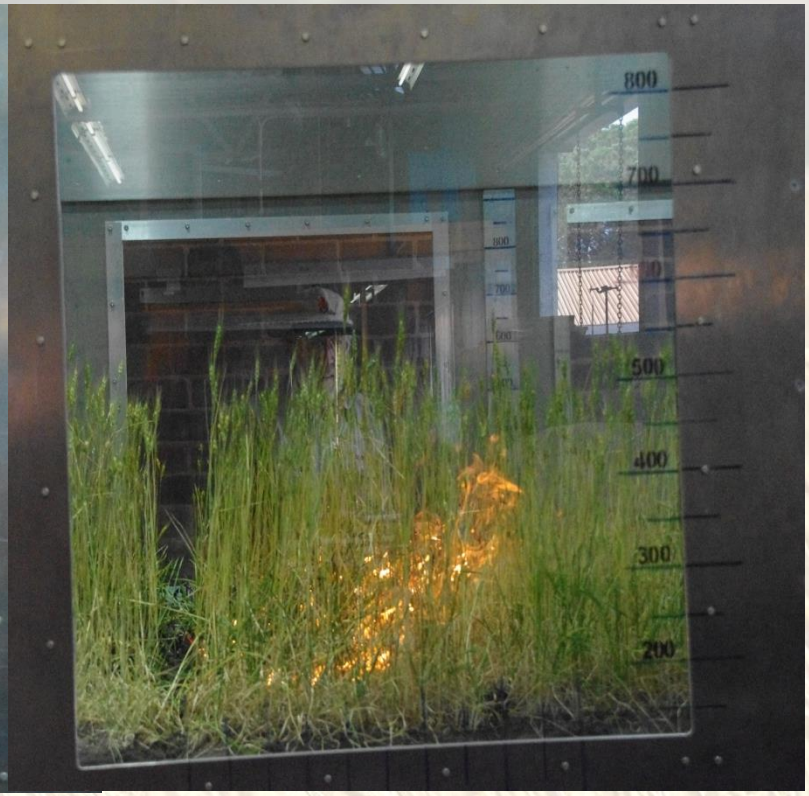
- Wind speed 1 m/s;
- Dead fuel moisture content hold constant

Laboratory experimentation





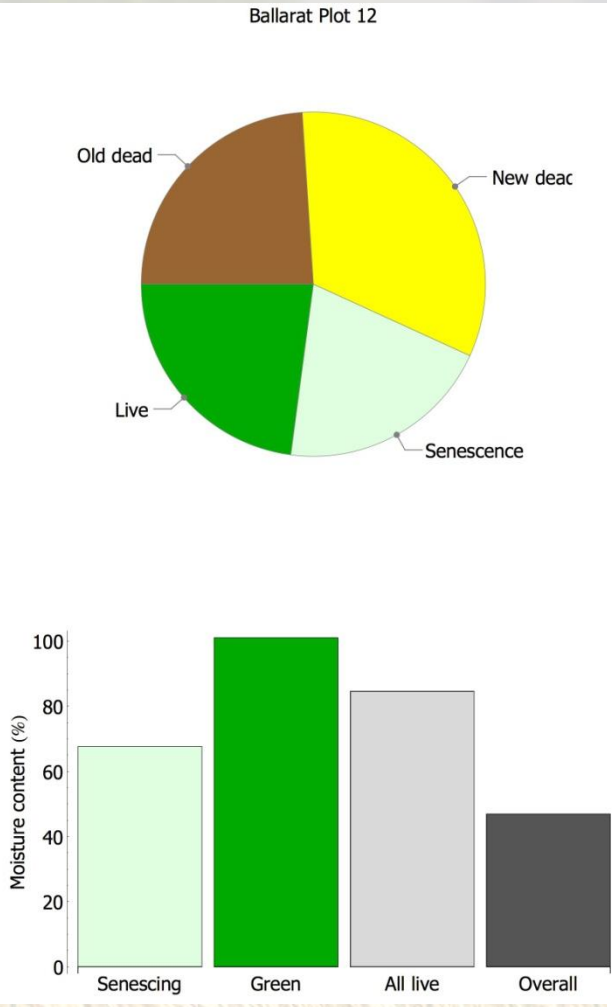
Laboratory experimentation



100% cured

30% cured
(self-extinguished)

Laboratory experimentation

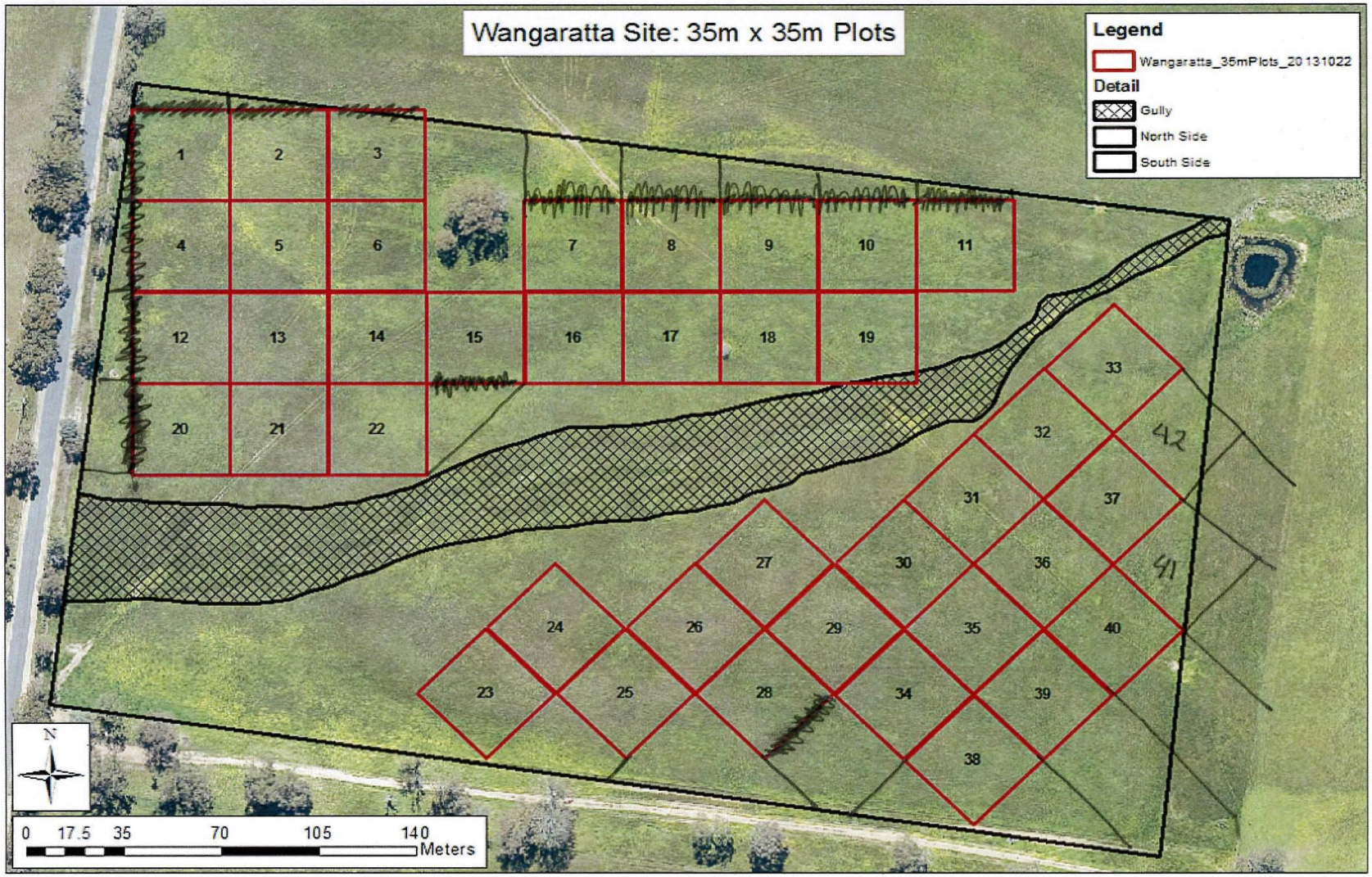


80% cured – self extinguished

Field experimental design

- Two experimental sites in Victoria / two grass types
  - Ballarat - fine grass **/ lower fuel load** (mean=0.34 kg/m^2)
  - Wangaratta - coarse grass / **higher fuel load** (mean=0.48 kg/m^2)
- **Simultaneous fires** burning in ~35m x 35m plots
  - Control plots: 100% cured (herbicide treated to mimic 100% cured)
  - Curing/treatment plots: ~**60% and ~80% curing level**
  - 6 replicates (to account for range in wind speed; different dead fuel moisture content)
- Fuels sampled and partitioned into 4 classes
  - 1. Old dead, 2. Current year dead – **Dead fuel component**
  - 3. Senescing, 4. Green; – **Live fuel component**

Wangaratta site layout



Field based experimentation

Ballarat site – 10 January 2014

100% Cured plots

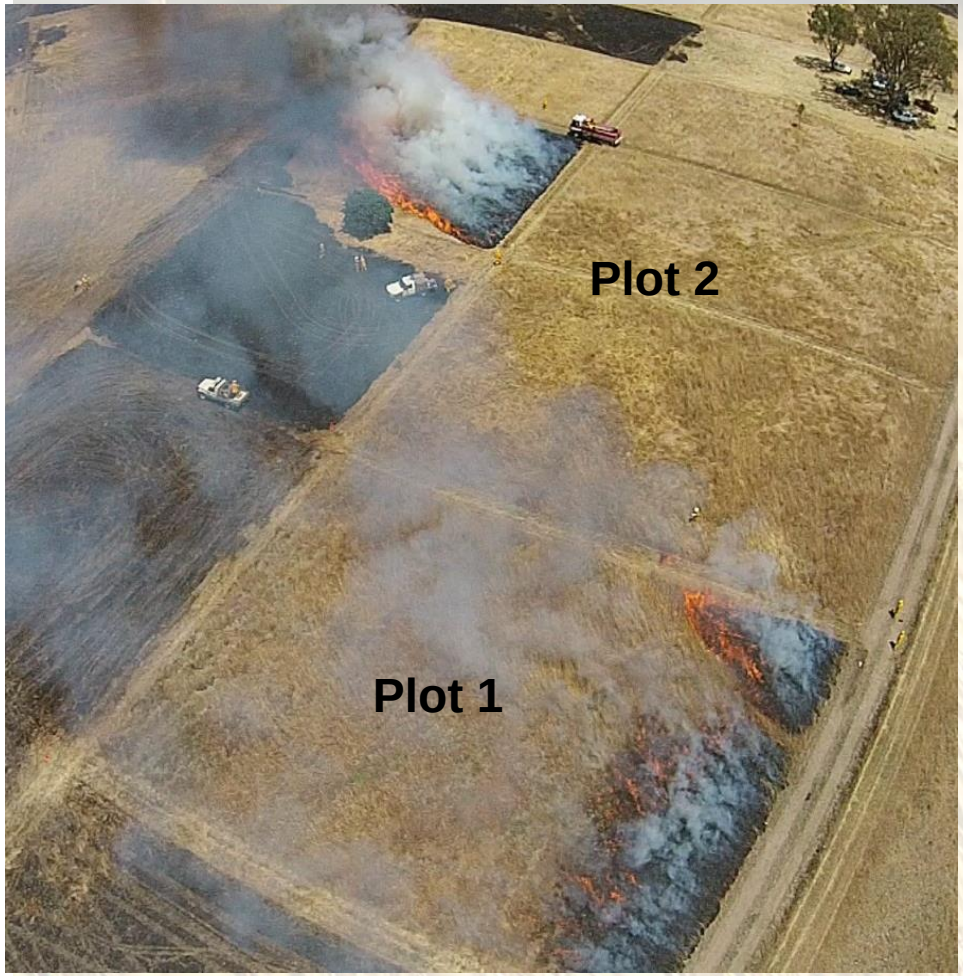
Grass curing comparison

80% cured

30% cured

Paired burns: 100% Cured, 40% Cured

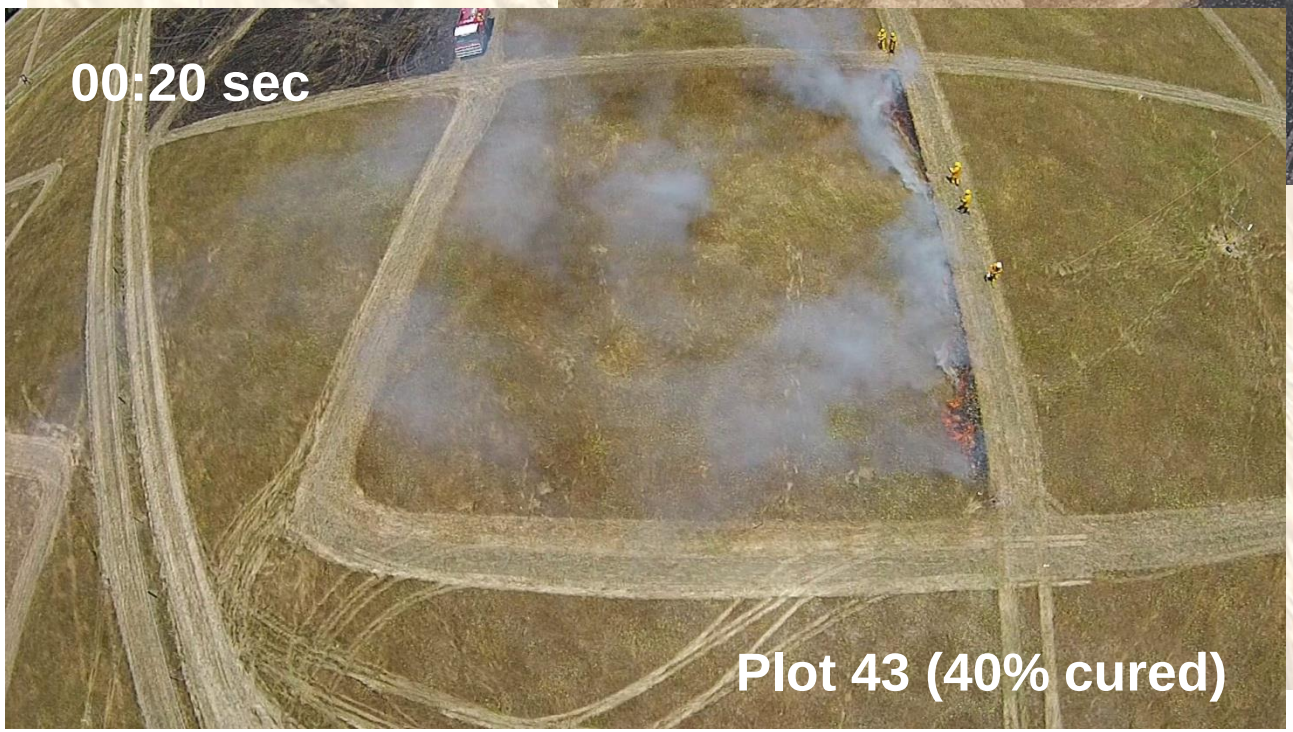
Grassland fire behaviour research



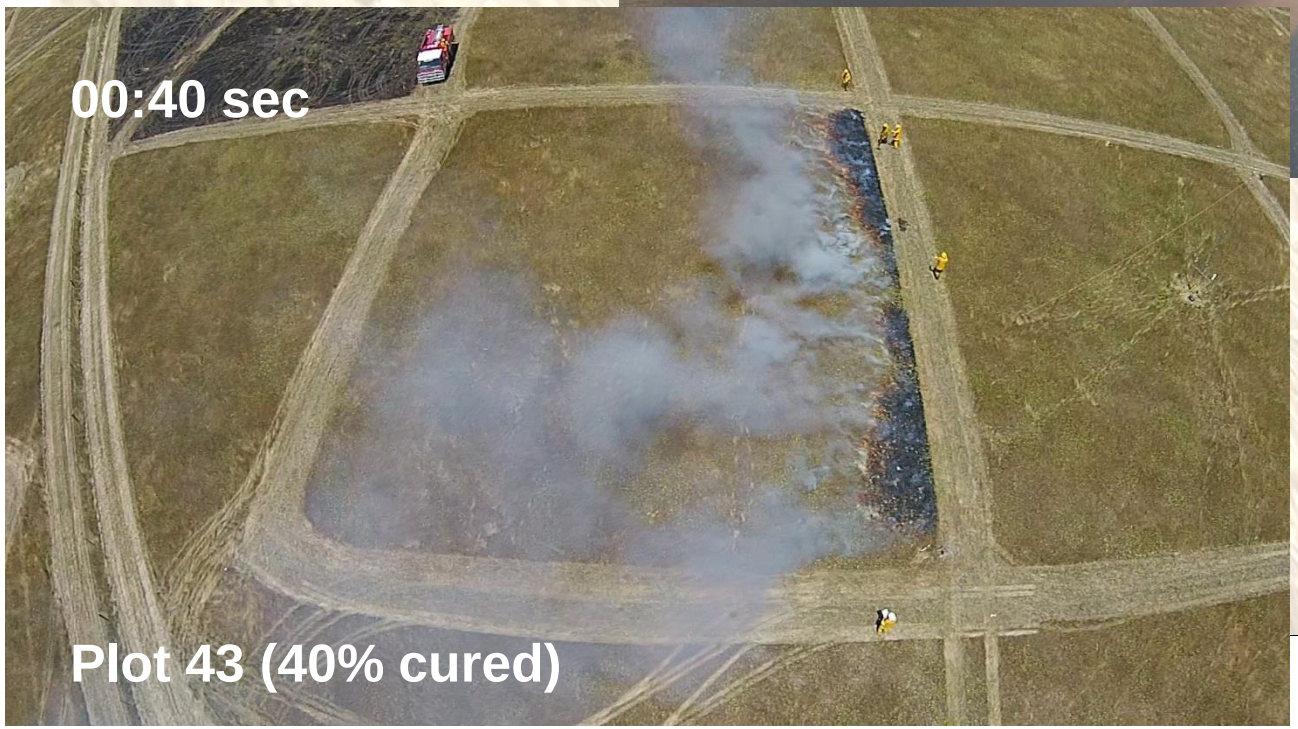
	Plot 1	Plot 2
Temperature (°C)	30	30
Relative Humidity (%)	22	22
2m Wind Speed (km/h)	15	15
Visual Curing (%)	***80***	***100***
Overall FMC (%)	***51***	***7***
Dead FMC (%)	***17***	***5***

Burn 13

Temperature 30°c
Wind speed=6.1 km/h
Relative humidity=22%



Burn 13



Burn 13

Burn 13

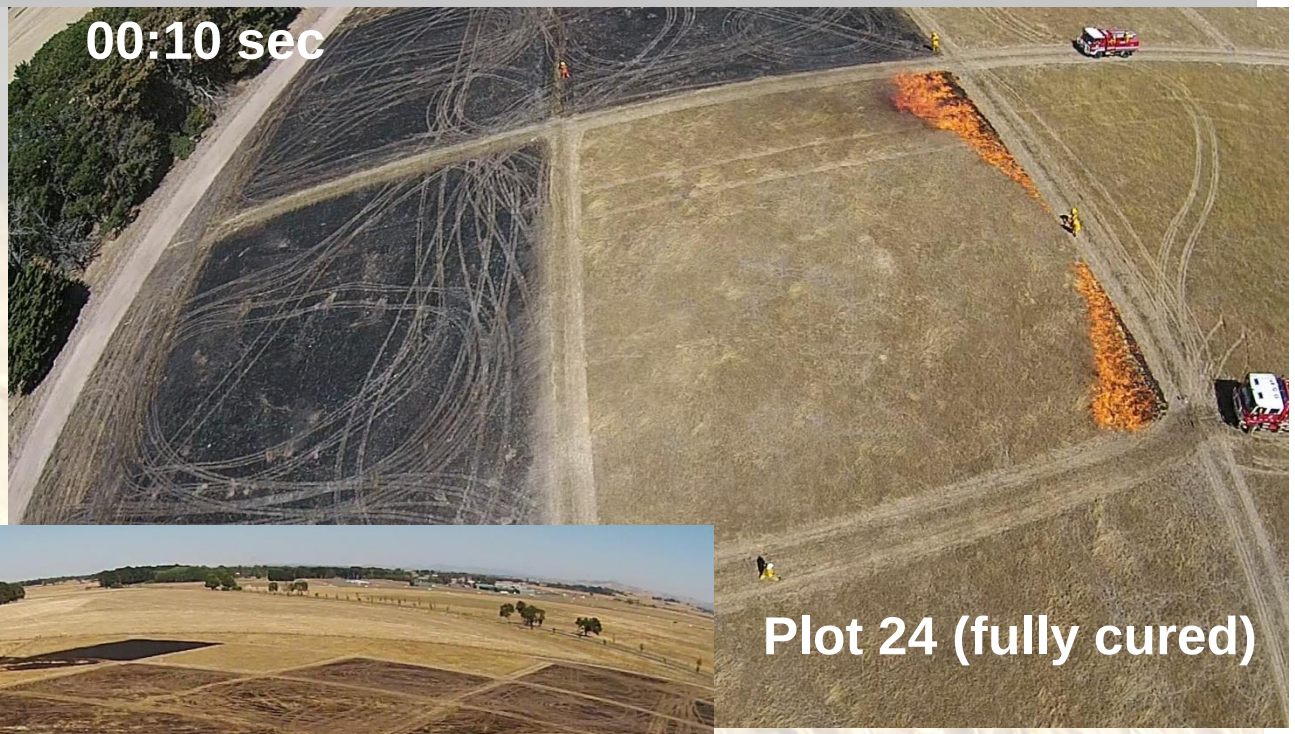
Fully cured
ROS=50.5 m/min

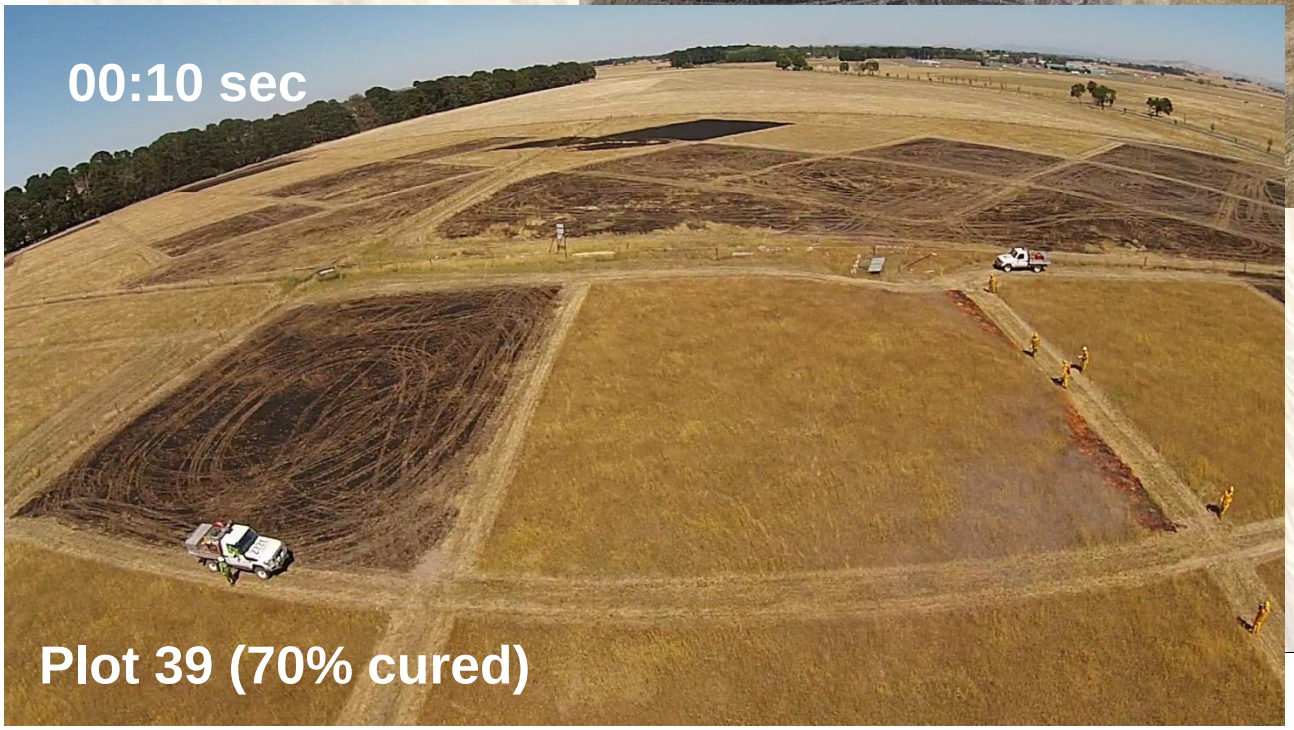
Curing effect = 0.18

40% cured
ROS=9 m/min

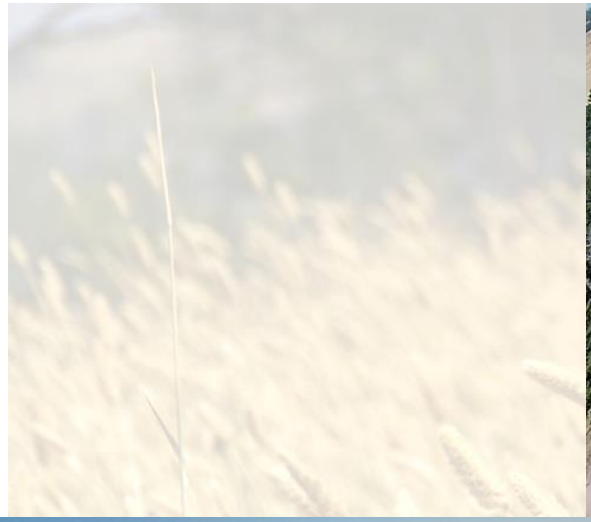
Burn 20

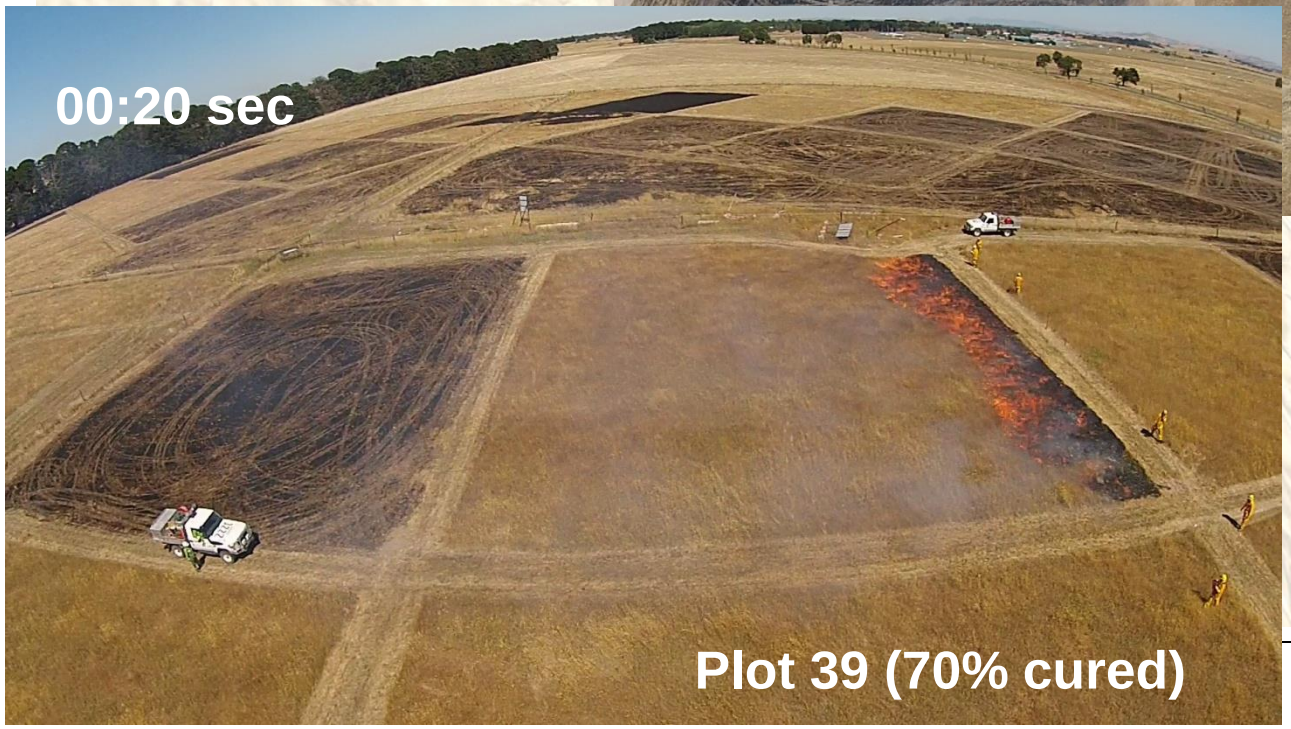
Temperature 32°c
Wind speed=9-10 km/h
Relative humidity=18%



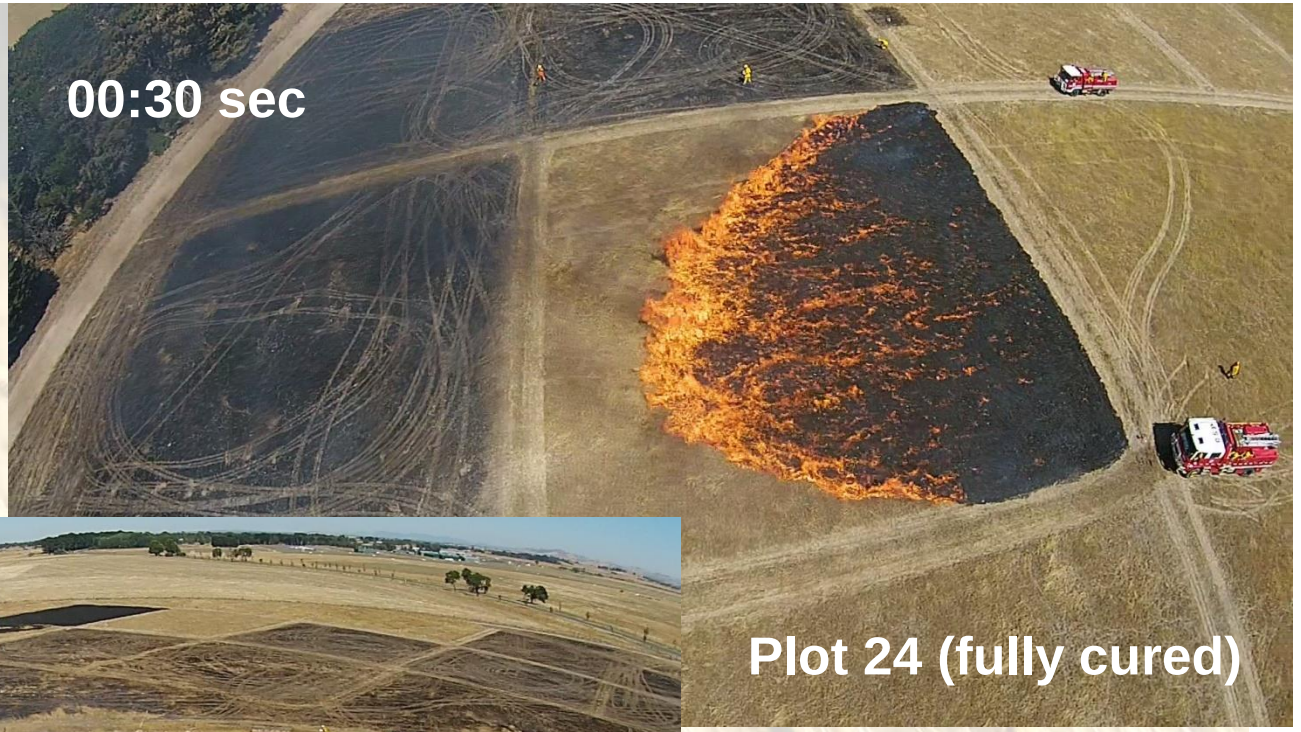


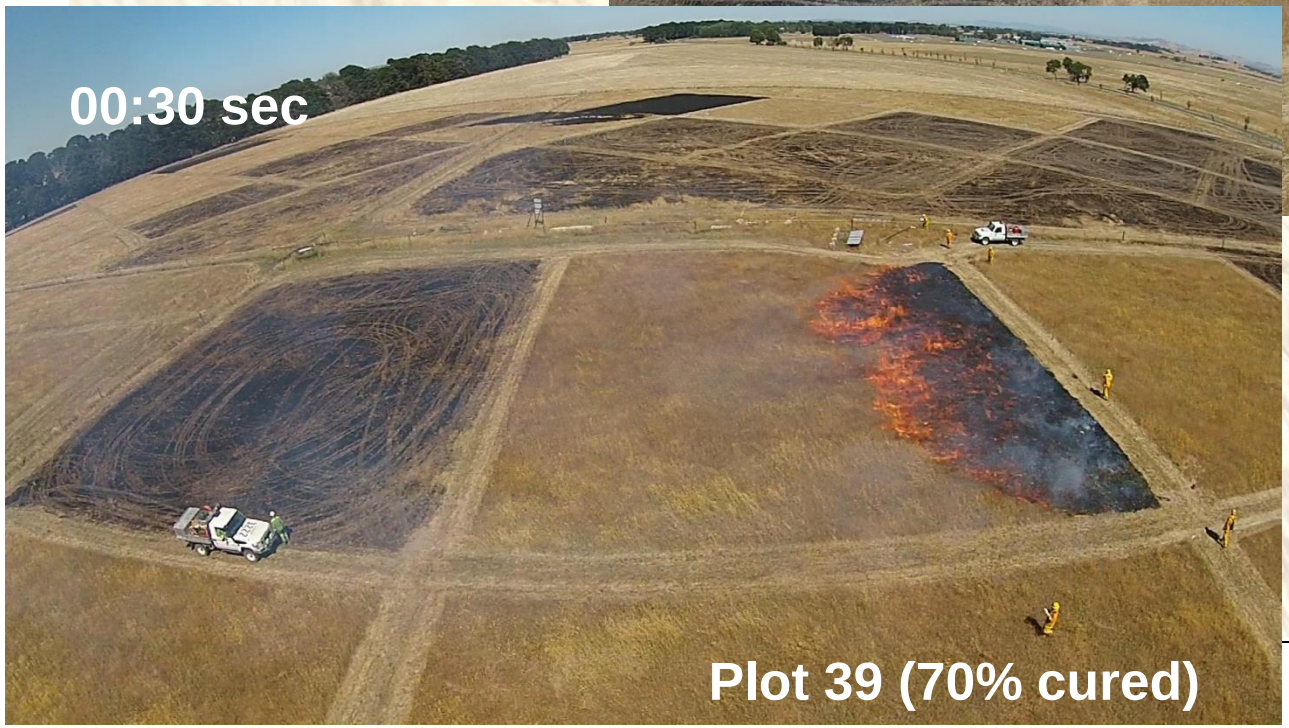
Burn 20



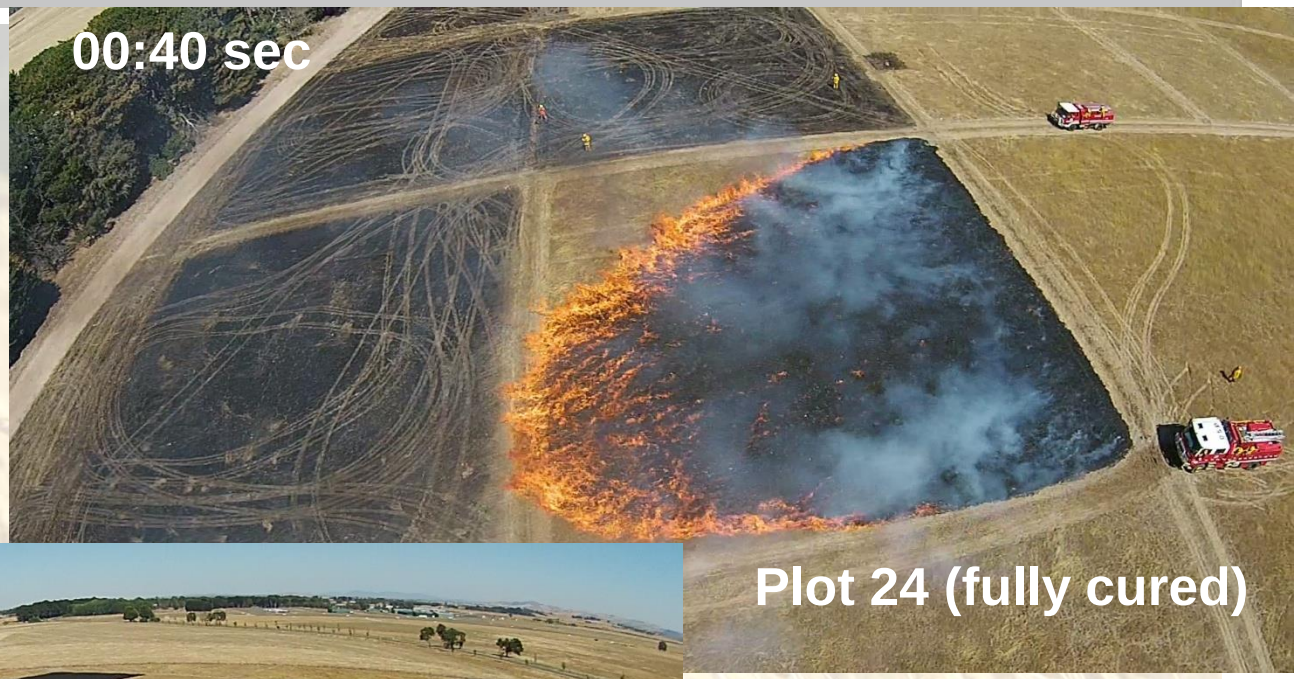


Burn 20

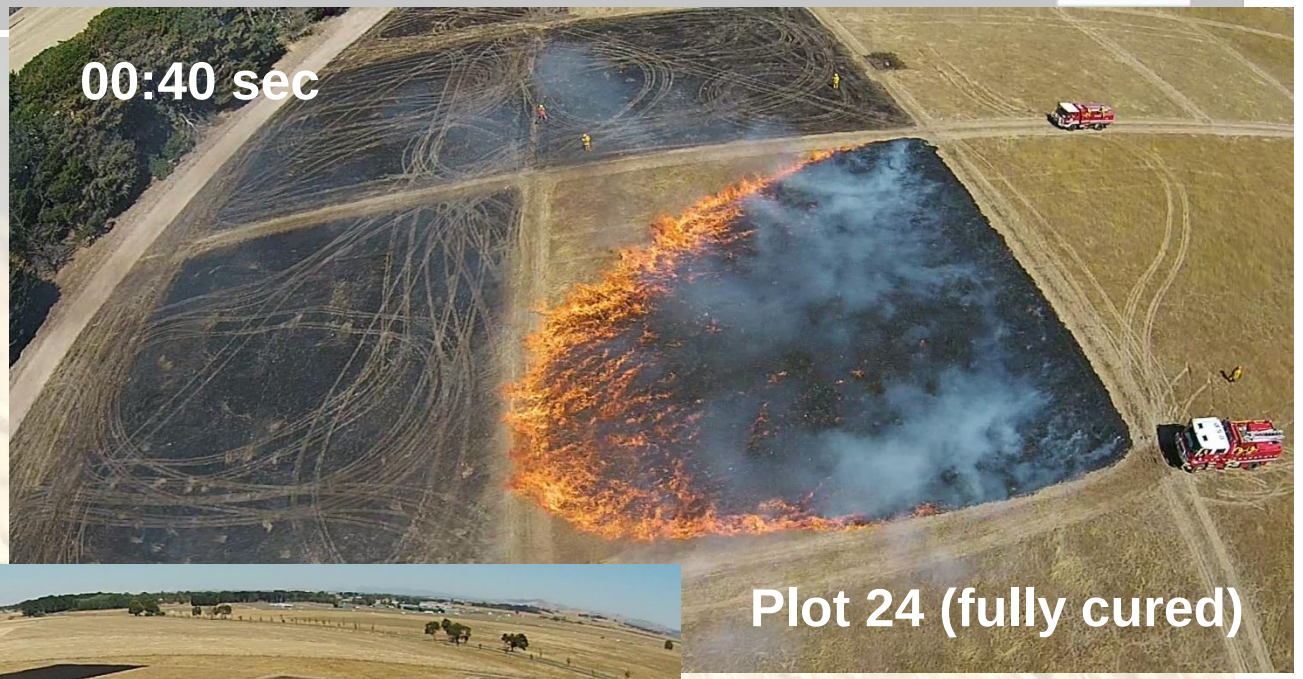




Burn 20



Burn 20



Burn 20

Fully cured
ROS=69 m/min

Curing effect= 0.63

70% cured
ROS=43 m/min

Summary statistics for dataset (n=44 fires)

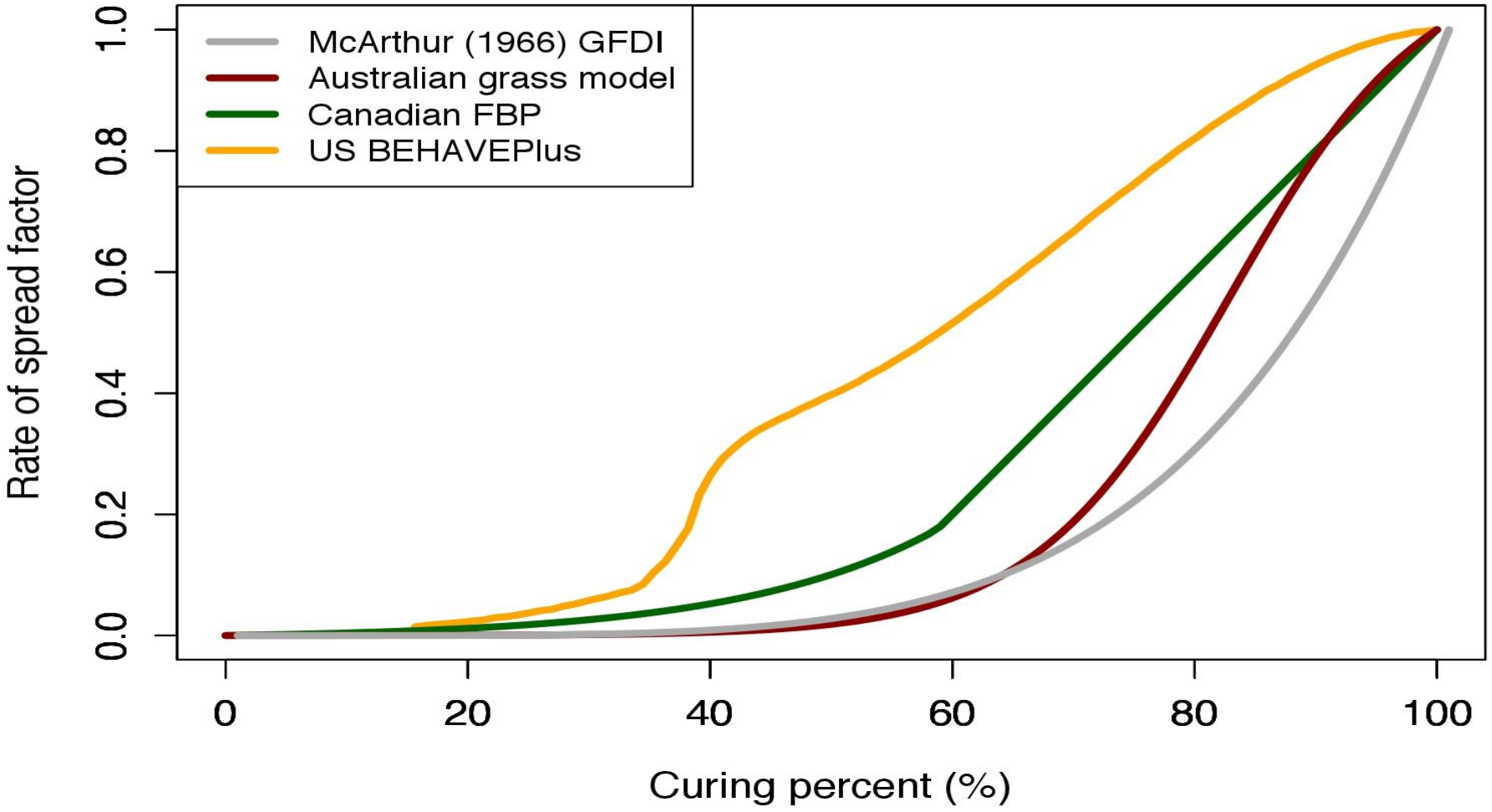
Variable	Min	Max
10-m open wind speed (km/h)	9	28
Dead fuel moisture content (%)	3.5	13.3
Live fuel moisture content (%)	60	119
Curing (%) (Destructive)	33	86
Fuel load (kg/m2)	0.27	0.64
Rate of fire spread (m/min)	**6.2**	**102**
Degree of curing effect	**0.04**	**0.89**

The results

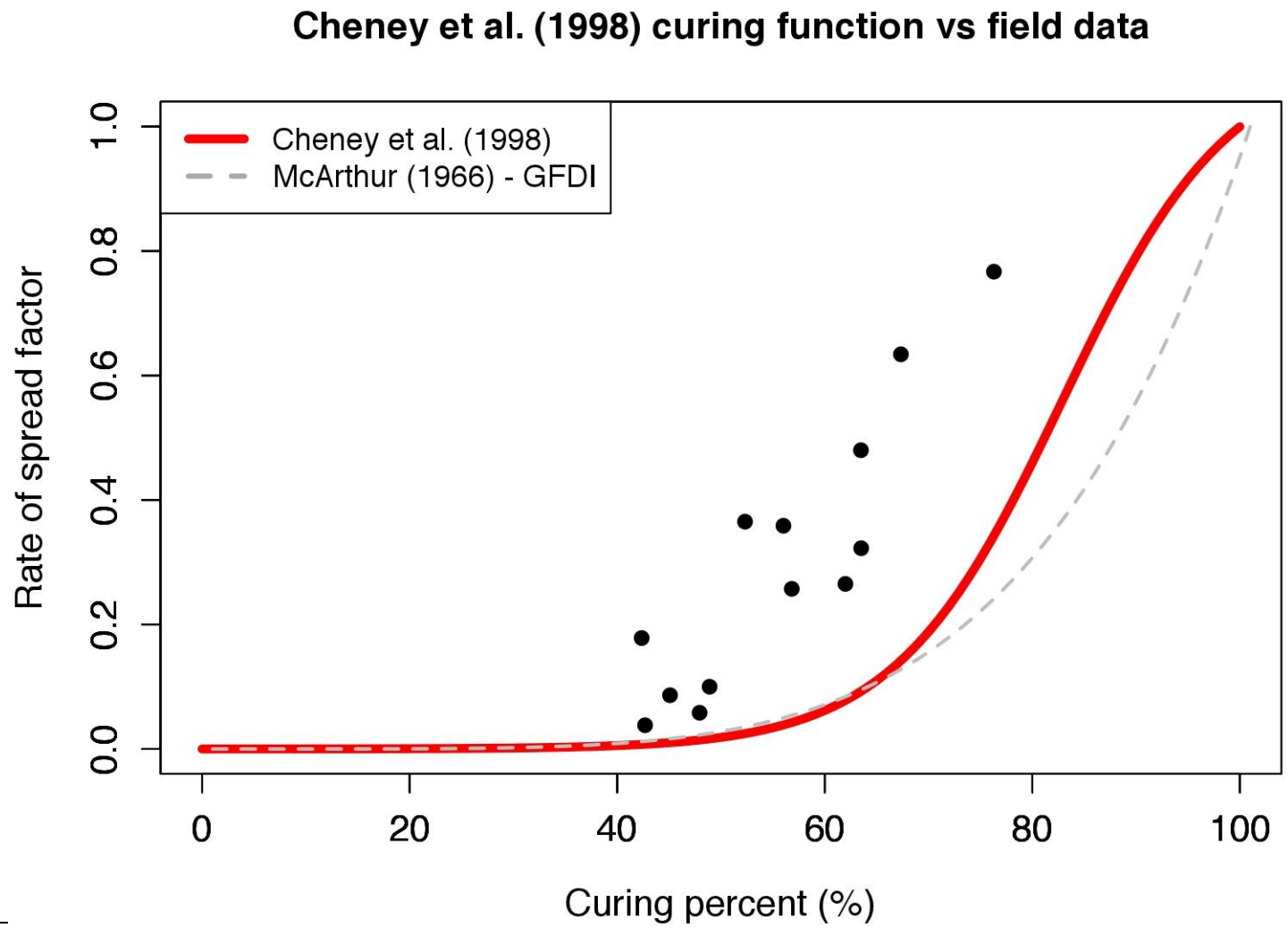
Correlation between ROS factor and environmental variables

Variable	correlation	p-value
Curing level (%) - destructive	0.90	<0.001
Curing level (%) - visual	0.85	<0.001
Overall fuel moisture content (%)	-0.63	0.02
Proportion of green fuel (dry mass)	-0.62	0.02
Proportion of senescing fuel (dry mass)	-0.43	0.14
Live fuel moisture content (%)	-0.29	0.34
Green fuel moisture content (%)	-0.25	0.42
Senescing fuel moisture content (%)	-0.06	0.83

Results: Model Comparison

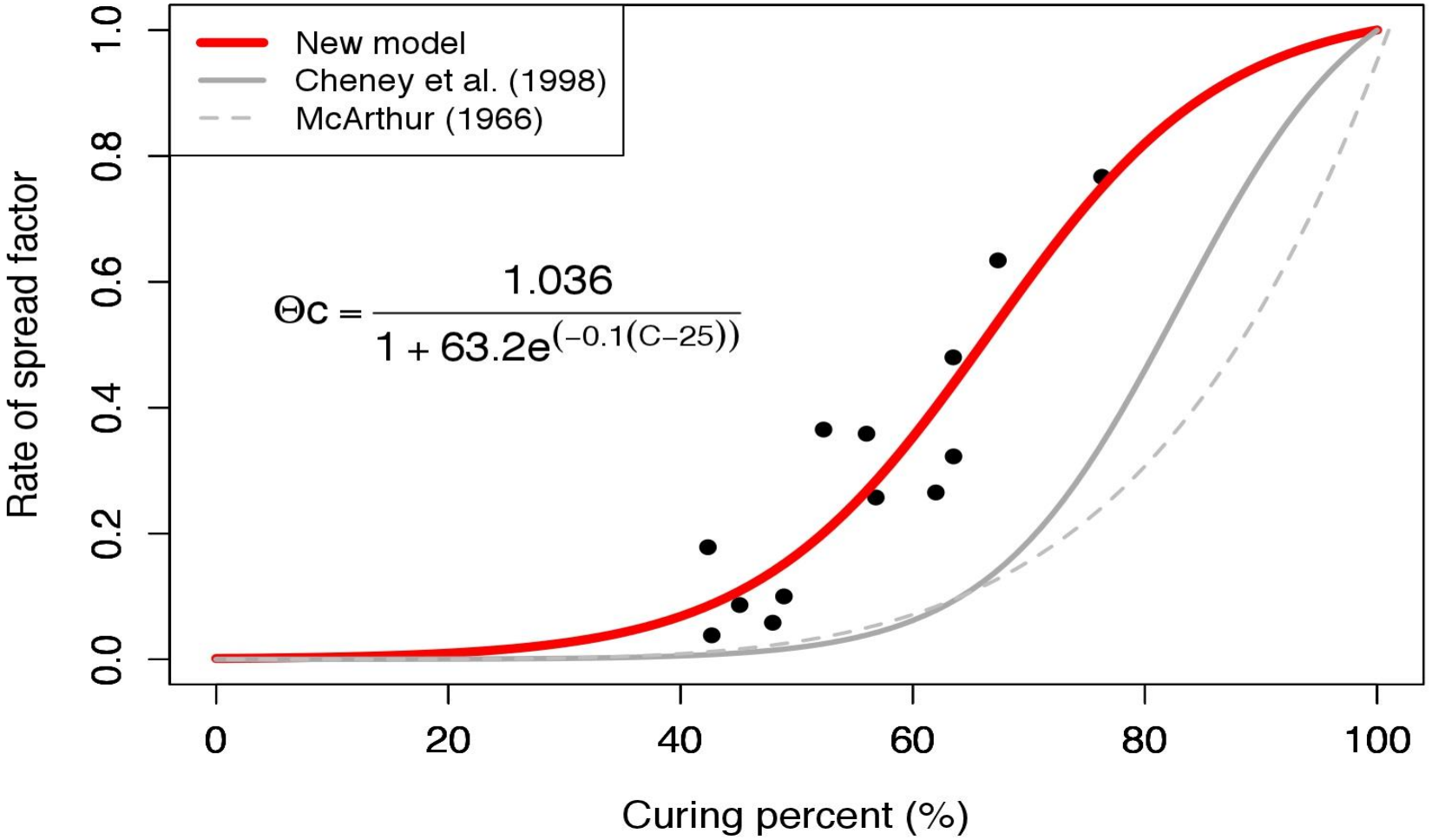


Results – Model Comparison

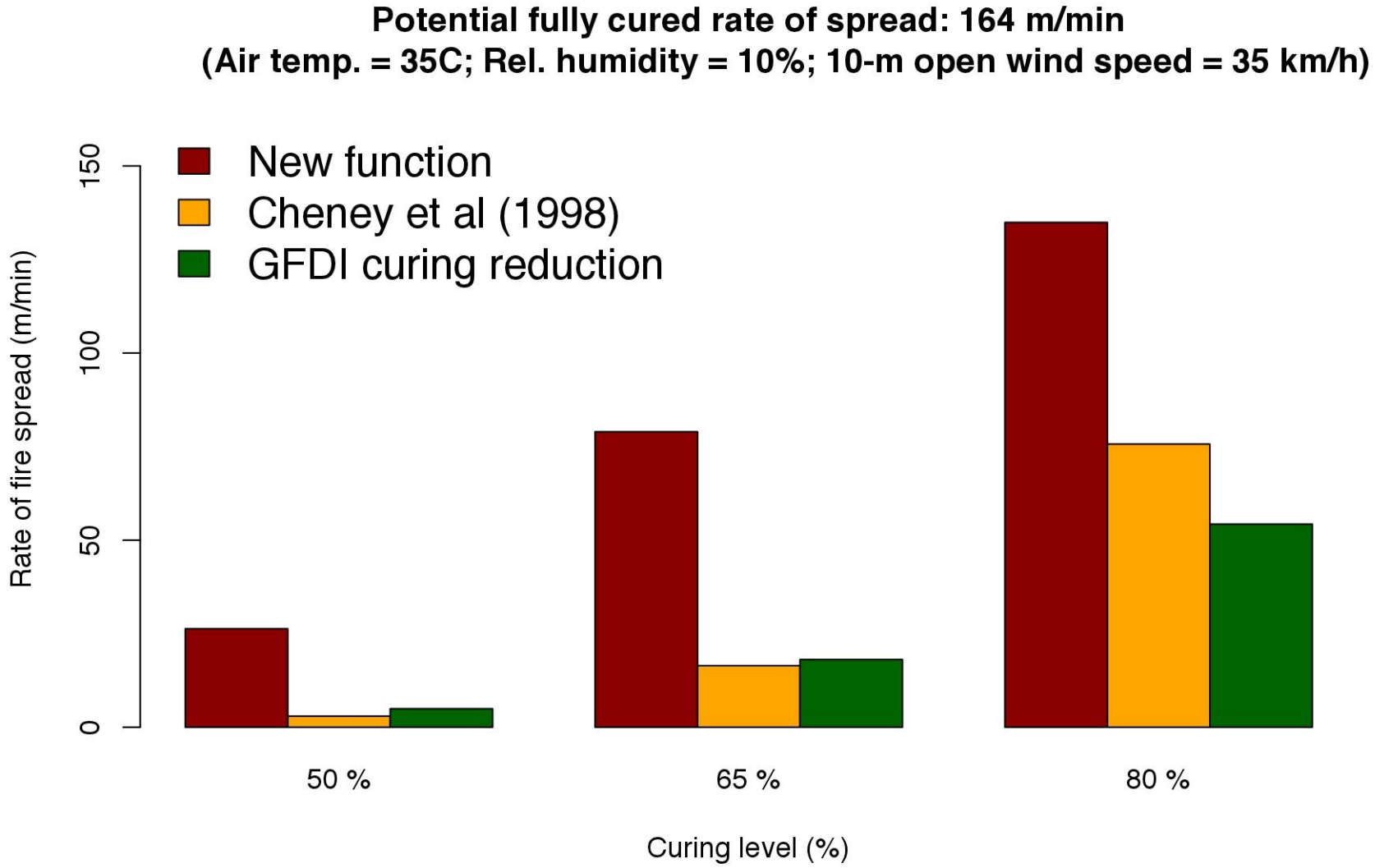


Results – Model Comparison

– New function for curing level in Australian grasslands



The results


Potential fully cured rate of spread: 164 m/min
(Air temp. = 35C; Rel. humidity = 10%; 10-m open wind speed = 35 km/h)
New function
Cheney et al (1998)
GFDI curing reduction
Rate of fire spread (m/min)
0
50
100
150
50 %
65 %
80 %
Curing level (%)

The results

- Fire sustained propagation down to curing levels of 25%
- Current curing effect functions result in an under prediction bias
- Fuel dynamics, namely linkages between curing level and dead fuel proportion and overall fuel moisture content being developed

The legacy of current project

Research outcomes:

- Two academic papers:
    1. Fuels dynamic paper
    2. Curing and fire behaviour paper
- Updated fire behaviour model incorporating updated curing function (CSIRO)

The legacy of current project

Safer communities:

- Fire Danger Ratings based on accurate and validated data
- Awareness of the impact of grassland fire on rural and urban interface
- Increased preparedness assist with accurate resource allocation and warnings
- Fire behaviour models enhanced through valid consistent data

The future

Research:

- Validate results in distinct grass fuel types in larger burn plots
- Investigate the effect of regrowth in damping fire spread
- Establish physical explanation to live fuel damping effect

The future

- Attorney General's Dept. - NEMP Project Grant
  - Victoria to lead the way to develop a national grassland curing system
  - Further grassfire behaviour field research likely to lead to development of new fire behaviour models
- Improving Fire Danger Rating determination, to be fuel type based rather than per TFB district

QUESTIONS?