PROGRAM A

Project Vesta

Fire in Dry Eucalypt Forest:

fuel structure, fuel dynamics and fire behaviour

Jim Gould
Ensis- CSIRO Bushfire Research Group, ACT
Lachie McCaw
Department Environment and Conservation, WA
Phil Cheney
CSIRO Honorary Research Fellow, ACT

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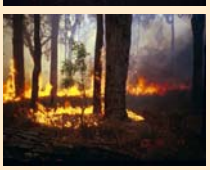

Project **Vesta** was a comprehensive research project to investigate the behaviour and spread of high-intensity bushfires in dry eucalypt forests with different fuel ages and understorey vegetation structures.

Collaborative research between CSIRO, Department of Environment and Conservation, WA and other State agencies

Coordinated through Australasian Fire Authorities Council (AFAC)

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Research aims

1. To quantify the changes in the behaviour of fire in dry eucalypt forest as fuel develops with age (i.e. time since fire).
2. To characterise wind speed profiles in forest with different over-storey and understorey vegetation structure in relation to fire behaviour.
3. To develop new algorithms describing the relationship between fire spread and wind speed, and fire spread and fuel characteristics including load, structure and height.
4. To develop a National Fire Behaviour Prediction System for dry eucalypt forest.

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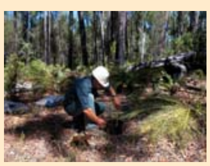
Methods



1. **Detailed fuel assessment to quantify the different fuel parameters:**
   - fuel sampling- fuel load, height
   - visual assessment that numerically characterises the different fuel strata
   - forest structure
2. **Key attributes for fuel assessment**
   - the degree of horizontal and vertical continuity
   - proportion of dead fire material in the fuel strata
   - the height of the most continuous fuel stratum
   - the height of the most continuous fuel stratum

Fuel layers

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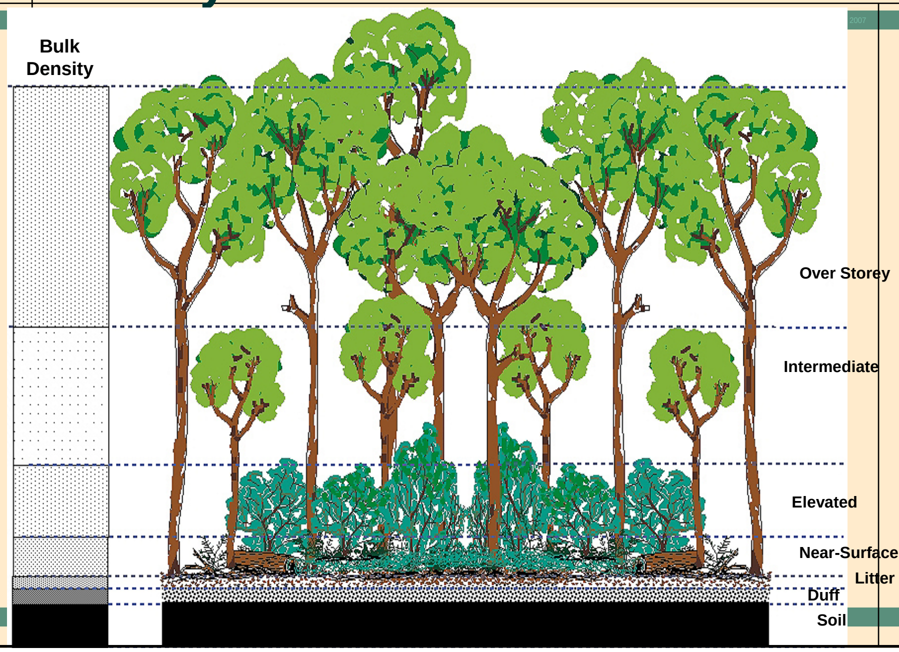

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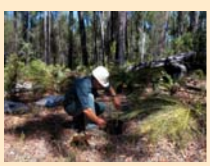
Methods



3. **In-forest wind**
   - Sensitive cup anemometers (5 second intervals) re-calibrated daily
   - Anemometer exposure (5 m) up wind (20m)
   - Establish a relationship between wind at the fire front and wind measured behind the fire
   - Determine best array for wind measurement
4. **Wind and weather observations**
   - Weather observations made at a central location for each site (1 km radius of plots)
   - Upper atmospheric conditions (balloon and radiosonde)

Methods



5. **Fuel moisture:**
   - Oven dry weight pre and post fire fine fuel moisture contents
6. **Fire behaviour**
   - Simultaneous fires in fuels of different ages
   - Detail measurements of rates of spread, flame height, flame temperature, spotting, etc
7. **Plume and smoke studies**
   - Smoke plume rise and dispersal were monitored by spotter aircraft
   - Data have been used to validate a model for smoke transport and dispersion (BoM – AFAC)

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Experiments: fire behaviour

1. 2 fuel types:
   a) Low shrub understorey
   b) Tall shrub understorey
2. 5 fuel ages:
   a) 2 - 3
   b) 5 - 6
   c) 8 - 9
   d) 11
   e) 16 - 22
3. Simultaneous fires - 120 m "instant" ignition
4. 10 replications:
   a) 5 light winds (< 12.5 km/h)
   b) 5 moderate (12.5 - 25 km/h)
5. 116 experiments

Fire behaviour observations

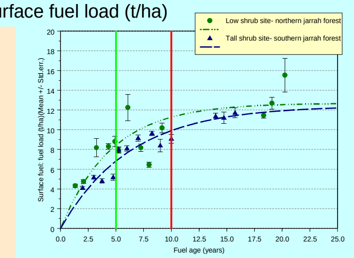


Fuel age (years)	Rate of spread (m/hr)	Flame height (m)	Fire Intensity (kW/m)
2 -3	0 – 390	0.1 -3.0	0.0 – 1340
5 – 6	112 – 1364	0.1 – 15.0	400 – 6160
8 – 9	66 – 974	0.2 – 20.0	385 – 4200
11 – 16 (MC)	295 – 1240	0.5 – 22.0	2320 – 10570
19 – 22 (DV)	47 - 800	0.2 – 8.0	275 - 5430

Results: *Fuels*

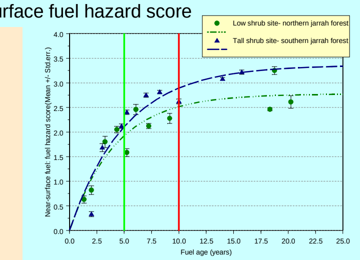
1. Hazard score provided an effective way to quantify changes in fuel structure as fuel develops with time since burning.

Surface fuel load (t/ha)



2. There was no evidence of any fuel characteristics declining within 22 years of burning

Near-surface fuel hazard score



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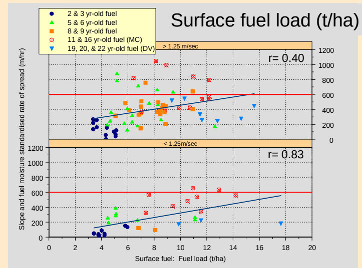
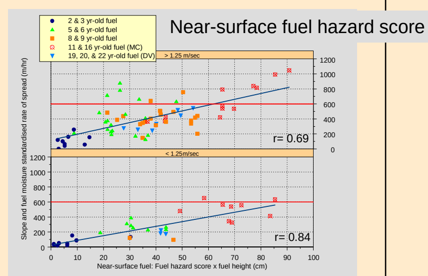
Results: *Fuels*

3. Robust and practical hazard scoring system have been developed the numerically characterises the identifiable fuel strata.

4. Numerical values of fuel structure correlate with fire spread and flame height.

5. Fuel hazards scoring/rating system can be used to provide inputs for predicting fire behaviour and suppression difficulties





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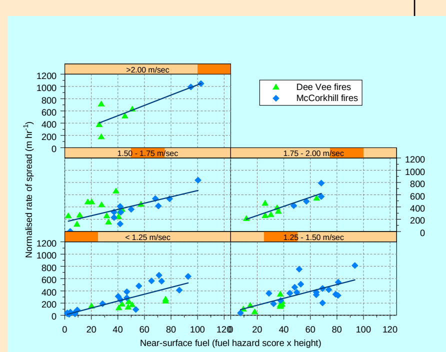
Results: *Fire Behaviour*

1. Established line of fire, such as when a wind change turns a flank fire into a head fire will immediately burn at its potential rate of spread. However, flame height will increase progressively as elevated fuel is consumed.

2. Rate of spread is directly related to:
   a) Understorey fuel parameters
   b) Weakly related to fuel load alone
   c) Near-surface fuel layer is the principle layer for determining rate of spread



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Results: *Fire Behaviour*

Fire behaviour model for dry eucalypt forest:

3. Predicts forward rate of spread as a function of:
   - fine fuel moisture,
   - wind speed,
   - surface fuel hazard score, and
   - combined variable of near-surface fuel hazard and height

4. Represents potential rate of spread of an established line of fire.

5. Fires will burn below their potential rate of spread during initial stages of development:
   - until the headfire is at least 100 m wide (typically 1-2 hours), and
   - if the width of the headfire is constrained.

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Results: *Fire Behaviour*

6. A model to predict flame height from rate of spread and elevated fuel height has been developed to better describe suppression difficulty and to facilitate the prediction of maximum spotting distance.

7. Firebrand generation and spotting behaviour are intimately linked to the behaviour of the convection column, and hence fire behaviour.

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Implications for hazard reduction burning

1. Hazard reduction by prescribed burning will reduce the rate of spread, flame height and intensity of a fire, as well as the number and distance of spotfires by changing the structure of the fuel bed and reducing the total fuel load.

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Implications for hazard reduction burning

2. Even when the surface fuel and understorey layers have stabilised the hazard score rating of fibrous-barked trees will continue to increase and will increase the difficulty of suppression.

3. Reducing bark hazard from a hazard score of 3 to hazard score of 2 by prescribed burning reduces the density of firebrands by threefold.

What about the existing fire behaviour guides?

1. WA Forest Fire Behaviour Tables and McArthur prescribed burning guide remain valid for predicting the behaviour of prescribed burns lit from point ignition sources under mild burning conditions

2. Existing FFDI retained for
   - public warning of fire danger
   - setting preparedness levels (detection, standby)

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Outputs

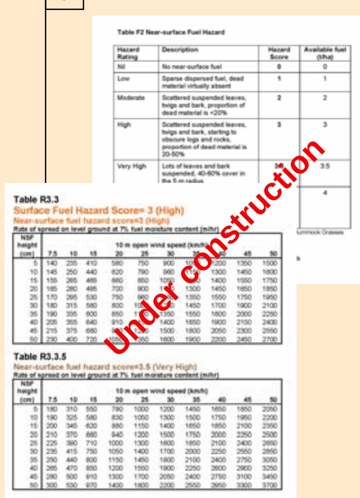


Table F2 Near-surface Fuel Hazard

Hazard Rating	Description	Hazard Score	Available fuel (t/ha)
Nil	No near-surface fuel	0	0
Low	Sparse dispersed fuel, dead material virtually absent	1	1
Moderate	Scattered suspended leaves, twigs and bark, proportion of dead material is <20%	2	2
High	Scattered suspended leaves, twigs and bark, starting to obscure logs and rocks, proportion of dead material is 20-50%	3	3
Very High	Lots of leaves and bark suspended, 40-60% cover in the 5 m radius	3.5	3.5
[illegible]	[illegible]	[illegible]	4

Table R3.3
Surface Fuel Hazard Score= 3 (High)
Near-surface fuel hazard score=3 (High)
Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h) 7.5	10	15	20	25	30	35	40	45	50
5	140	235	410	580	750	900	[illegible]	1200	1350	1500
10	145	250	440	620	790	960	[illegible]	1300	1450	1600
15	155	265	465	660	850	1050	[illegible]	1400	1550	1750
20	165	280	495	700	900	[illegible]	1300	1450	1650	1850
25	170	295	530	750	960	[illegible]	1350	1550	1750	1950
30	180	315	560	800	[illegible]	[illegible]	1450	1700	1900	2100
35	190	335	600	850	[illegible]	1350	1550	1800	2000	2250
40	205	355	640	910	[illegible]	1400	1650	1900	2150	2400
45	215	375	680	[illegible]	[illegible]	1500	1800	2050	2300	2550
50	230	400	720	[illegible]	[illegible]	1600	1900	2200	2450	2700

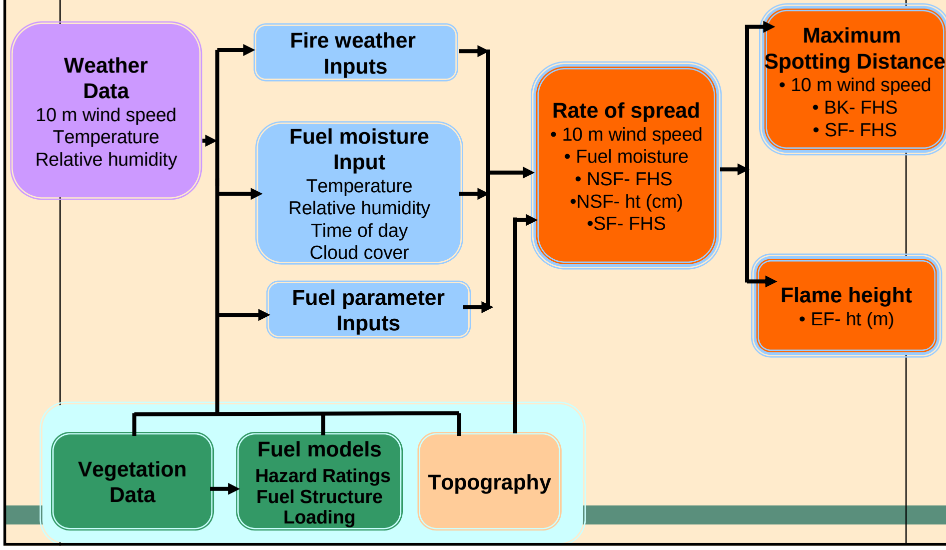
Table R3.3.5
Near-surface fuel hazard score=3.5 (Very High)
Rate of spread on level ground at 7% fuel moisture content (m/hr)

NSF height (cm)	10 m open wind speed (km/h) 7.5	10	15	20	25	30	35	40	45	50
5	180	310	550	780	1000	1200	1450	1650	1850	2050
10	190	325	580	830	1050	1300	1500	1750	1950	2200
15	200	345	620	880	1150	1400	1650	1850	2100	2350
20	210	370	660	940	1200	1500	1750	2000	2250	2500
25	225	390	710	1000	1300	1600	1850	2100	2400	2650
30	235	415	750	1050	1400	1700	2000	2250	2550	2850
35	250	440	800	1150	1450	1800	2100	2400	2750	3050
40	265	470	850	1200	1550	1900	2250	2600	2900	3250
45	280	500	910	1300	1700	2050	2400	2750	3100	3450
50	300	530	970	1400	1800	2200	2550	2950	3300	3700

1. Development of a Field Guide for fuel assessment and fire behaviour prediction tables for dry eucalypt forest
   a) Integrates Project Vesta research findings with the Victorian Overall Fuel Hazard Guide

2. Development of the fire spread component for a national fire spread prediction system for dry eucalypt forest.

Dry eucalypt forest fire behaviour prediction system



Publications

1. CD Training videos:
   - *The Dead Man Zone*
   - *Fire Behaviour in Dry Eucalypt Forest Fuels*
2. Publications
   - Brochure and final report (in print)
   - Field guide (Under construction)
3. Scientific papers
   - 1 under peer review
   - 4 in draft form and editing

Summary

Project Vesta…

1. *provides a robust and practical system for describing fuel characteristics in different forest types and identified better fuel parameters to predict the behaviour of fires*

2. *provides data to develop a better fire behaviour prediction system to predict the spread and intensity of wildfires.*

3. *demonstrates that hazard reduction by prescribed burning will reduce the rate of spread, flame height and intensity of a fire and reduce the potential for spotting. These effects may persist for a considerable time (up to 20 years) in forests containing rough-barked trees and shrubby understoreys.*

Acknowledgements

1. Scientific collaborators
   a) CSIRO
   b) Department of Environment and Conservation
   c) Canadian Forest Service
2. AFAC- Australasian Fire Authorities Council
   a) Rural and Land Management agencies
   b) Fire Brigades
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   a) Parks Victoria
   b) The International Decade of Natural Disaster Reduction
   c) Local Government- Shires of Harvey, Bridgetown-Greenbushes, Mundaring, Town of Kwinana
   d) SA Forestry
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   c) Bushfire CRC