Fire Severity Patterns in the Victorian Fires of February 7th 2009: influences of weather, terrain and land use history

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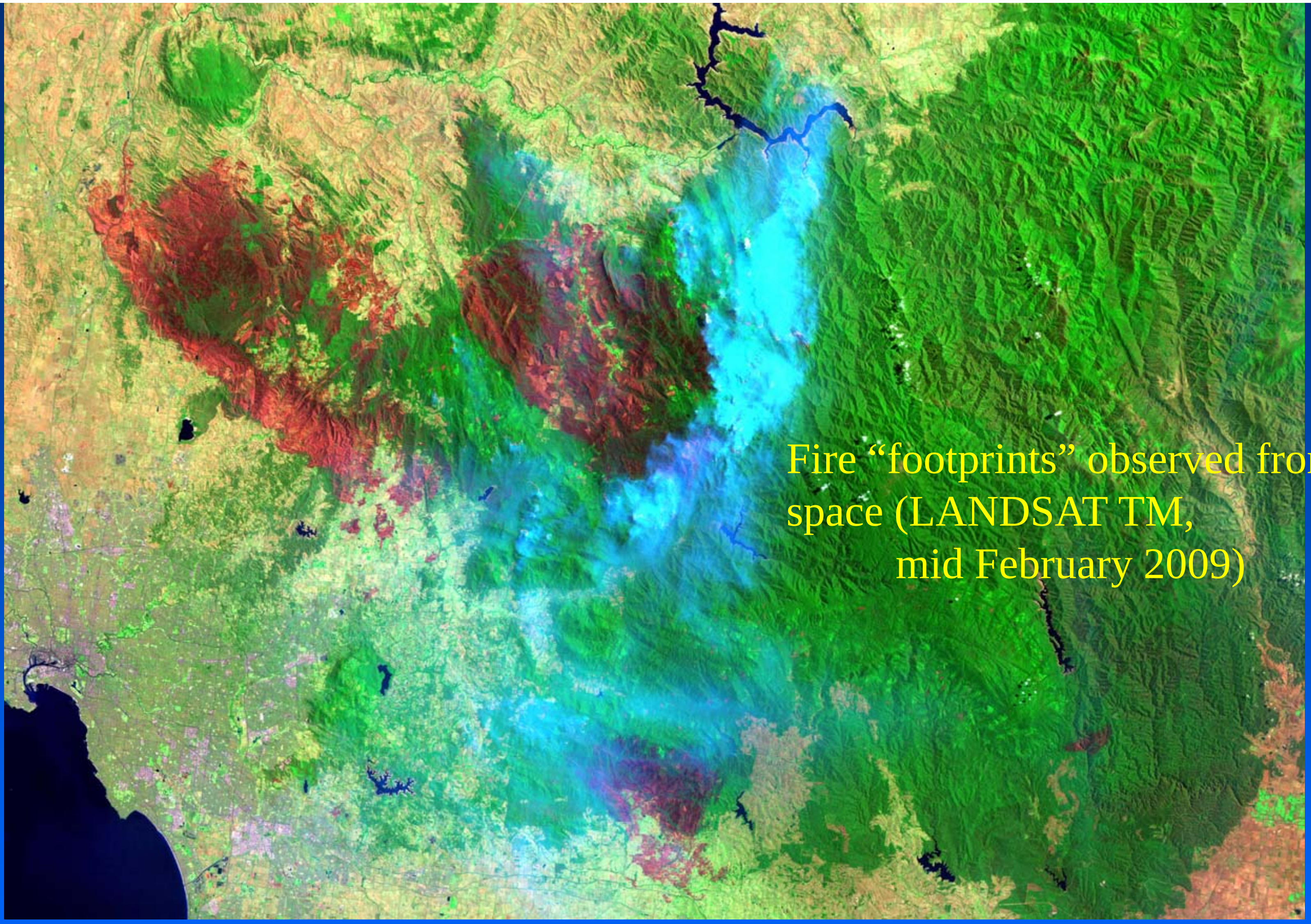
Land use and fires (planned & unplanned) can alter the quantity, arrangement and spatial configuration of bushland fuels.

- To what degree will this subsequently alter the behaviour (e.g. intensity, size) of major bushfires?
- Under what conditions?

Potential methods

- Predictions from fire behaviour models
- On-ground observation during fires
- On-ground observation after fires
- Remote measurement (during and after fires)

- Opportunistic or systematic
- Qualitative or quantitative
- Small or large number of samples



– Remote sensing of fire severity patterns (profiles of biomass loss/damage related to variations in fire intensity)

- An opportunity for systematic, large scale sampling and quantitative analysis

Classification of fire severity (Vic DSE)

Department of Sustainability and Environment

Table 1.1 Fire Severity Classes and Descriptions

Code	Severity Class	Severity type	Description
1	1	Crown burn	*70 - 100% of eucalypt and non-eucalypt crowns are burnt* an intense overstorey burn with widespread crown removal with 100% understorey burnt
2	2	Crown scorch	*60 - 100% of eucalypt and non-eucalypt crowns are scorched, some crowns are burnt* an intense understorey fire with complete crown scorch of most eucalypt and non-eucalypts
3	3	Moderate crown scorch	*30 - 65% of eucalypt and non-eucalypt crowns are scorched* a variable intensity of fire ranging from a warm ground burn with no crown scorch to an intense understorey fire with complete crown scorch of most eucalypt and non-eucalypts. This type is often represented as a mosaic of apparent scorched and unscorched crowns.
4	4	Light crown scorch	*1 - 35% of eucalypt and non-eucalypt crowns are scorched* a light ground burn with isolated patches of intense understorey fire and some crown scorch. This type is represented as a mosaic of mostly unscorched crowns, with isolated and generally small patches of crown scorch. Areas of unburnt forest may occur in this class.
4	5a	No crown scorch	*< 1% of eucalypt and non-eucalypt crowns are scorched (Class 5)* *> 1% of understorey burnt or scorched* Understorey burnt or scorched (to any degree) There may be areas of low intensity ground fire within this type.
5	5b	No crown scorch	*< 1% of eucalypt and non-eucalypt crowns are scorched (Class 5)* *100% of understorey unburnt and unscorched* Understorey completely unburnt and unscorched
6	6	Burnt woodlands - unclassified	Burnt woodlands unclassified
7	7	Grassland burnt	Burnt Grassland
8	8	Potentially unburnt grassland	Potentially Unburnt Grasslands

This study used the high resolution severity map of the 2009 fires provided by DSE, based on this classification

Study questions

1. What was the predominant influence on fire severity and inferred fire intensity?
2. Was fire severity affected by time since fire and inferred fuel age?
3. Was fire severity affected by time since logging?
4. Was fire severity affected by terrain?

Implications for management: use of prescribed fire for risk mitigation?

Methods

- 4 fires sampled (E. Kilmore, Murrundindi, Bunyip, Churchill)
- 4566 sample points (500 m spacing)
- 3 weather classes (Extreme, Moderate, Low fire danger)
- DSE vegetation (EVC – 3 main forest types only), logging and fire history maps
- Terrain model (DSE)
- Half the samples used for initial statistical analyses (logistic regression, AIC model selection)
- Other half used for testing of derived statistical models (ROC AUC)
- We assumed the DSE severity classification was robust, compiled and verified on the ground in a competent manner (see DSE Fire Severity SOPs).

Methods (cont.)

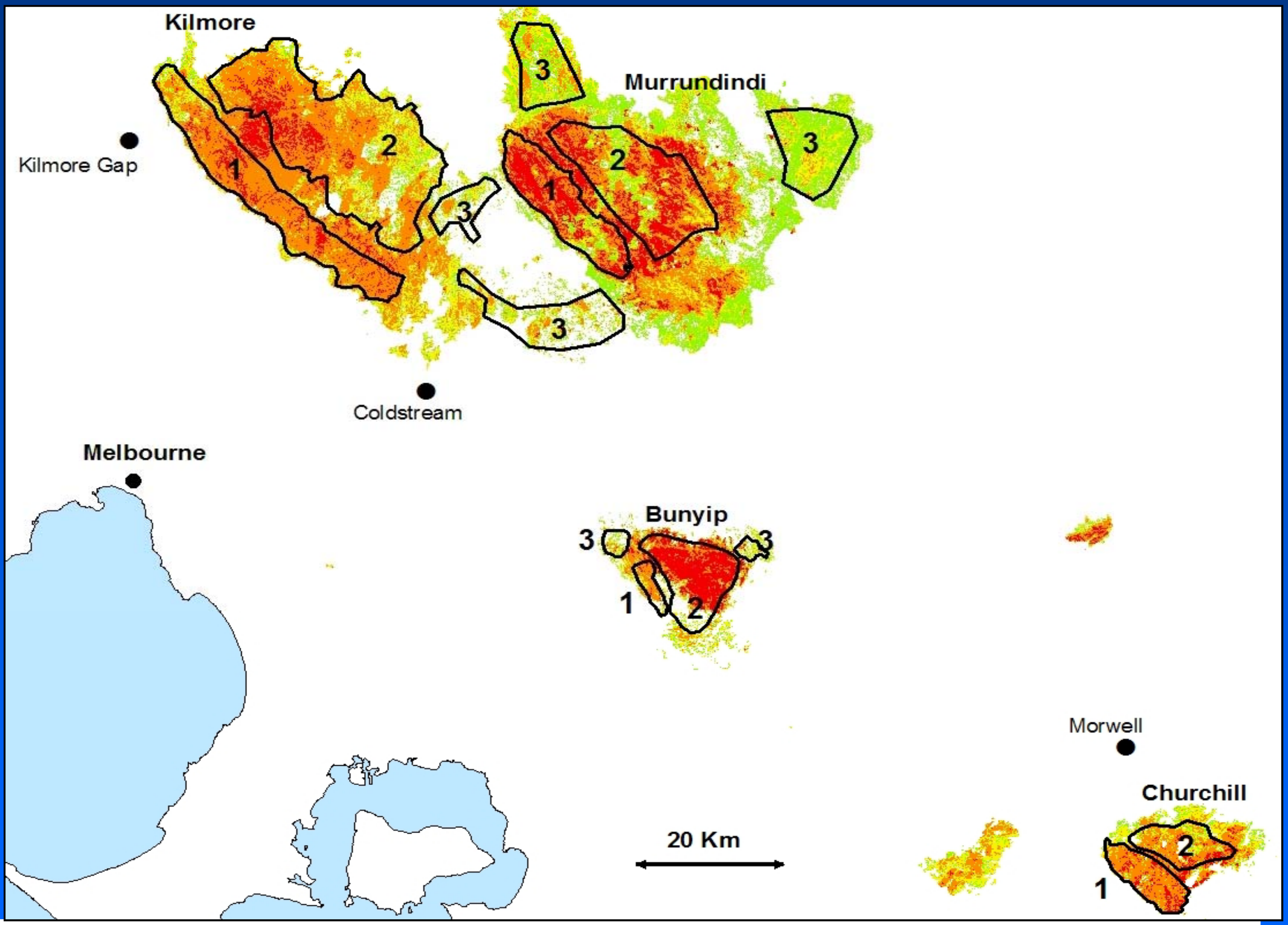


Figure 1: Fires, severity map and time periods used for analysis. The severity map is shaded from green (no understorey burnt) to red (crown burn). The numbered areas are defined as: 1 = Feb. 7th before southerly change; 2 = Feb. 7th after change; 3 = subsequent days. The weather stations Kilmore Gap, Coldstream and Morwell are also shown.

FFDI Range

1) (Extreme) 67 to 189
2) (Moderate) < 25
3) (Low) < 8

Methods (cont.)

Understorey fire (UF)
Potentially suppressible (low intensity)
Severity classes 4 & 5

Crown fire (CF)
Non suppressible (v. high intensity) Severity class 1

Probability (UF or CF) = *f* (predictors)

Predictors: weather, terrain, forest type, time since fire, time since logging

Results

Models selected via analysis

Probability of a crown fire:

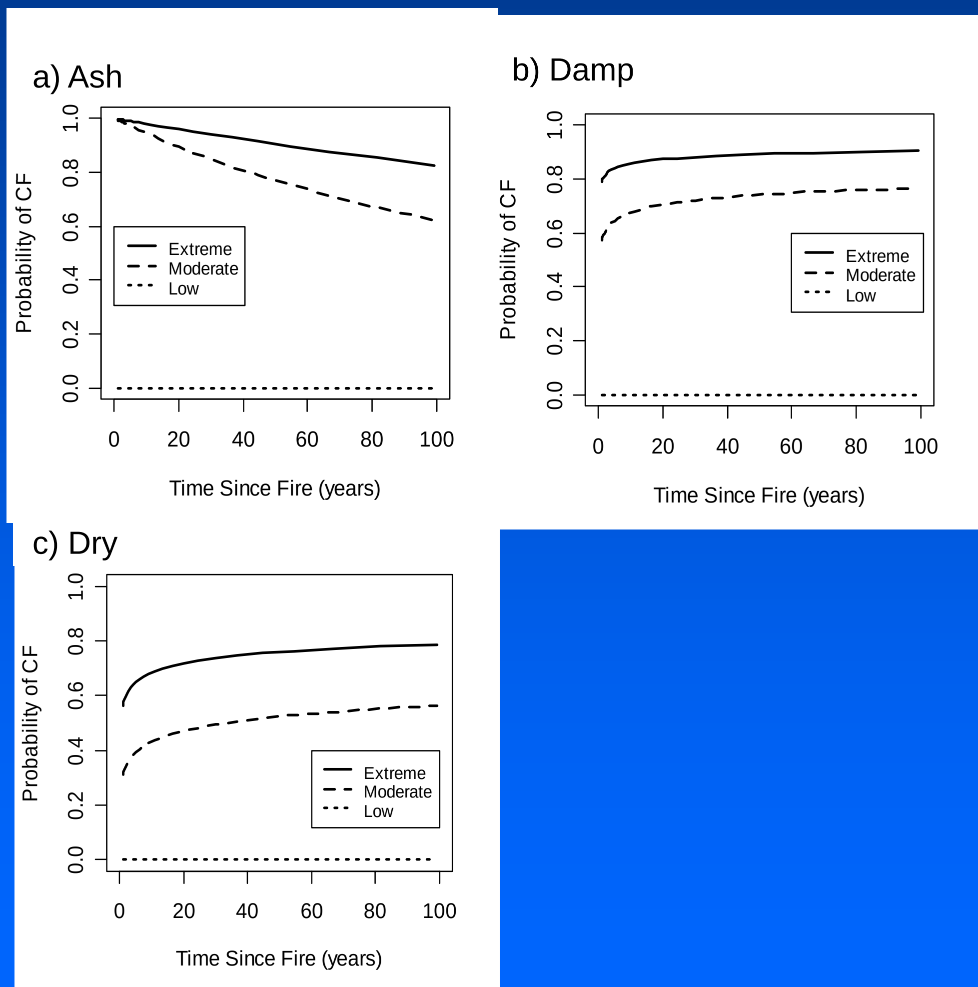
p CF = *f* (weather, TSFire, Forest Type ,TSLogging, Aspect, Topographic Position)

Probability of an understorey fire:

p UF = *f* (weather, TSFire, Forest Type)

Models: were highly significant; accounted for moderate amount of data variation; had high predictive performance.

Probability of a crown fire: effects of time since fire (TSF), forest type and weather

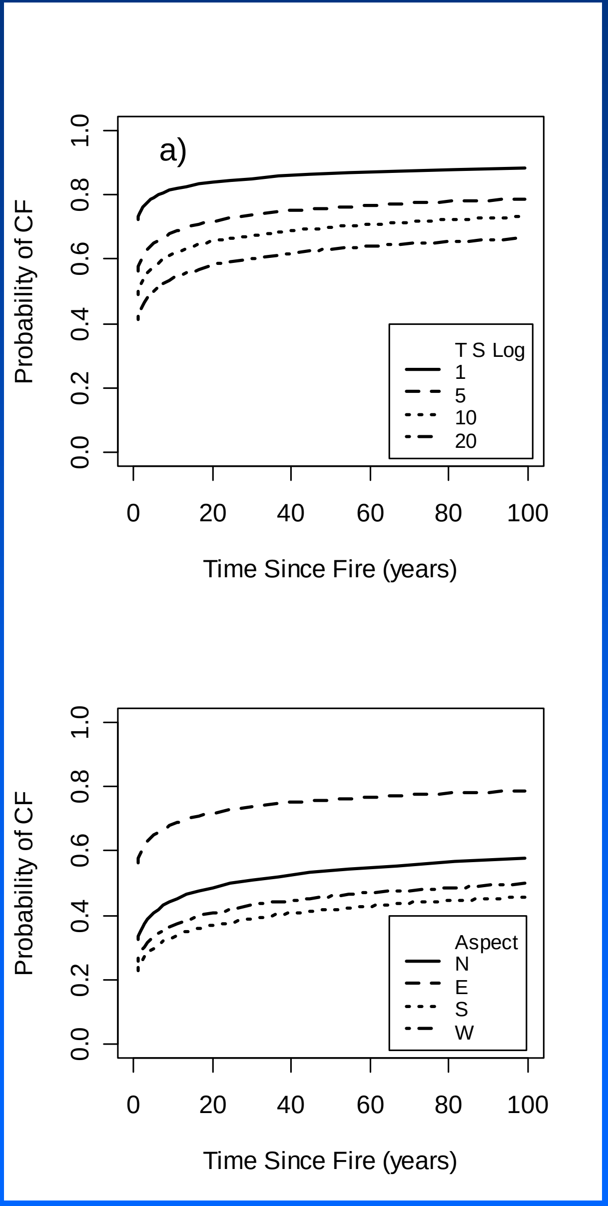


Strong effect of weather (high probability in Extreme weather cf. nil in Low weather)

Non-linear effect of TSF (probability increases with TSF but …….)

Divergent effect of forest types in relation to TSF (Ash forest)

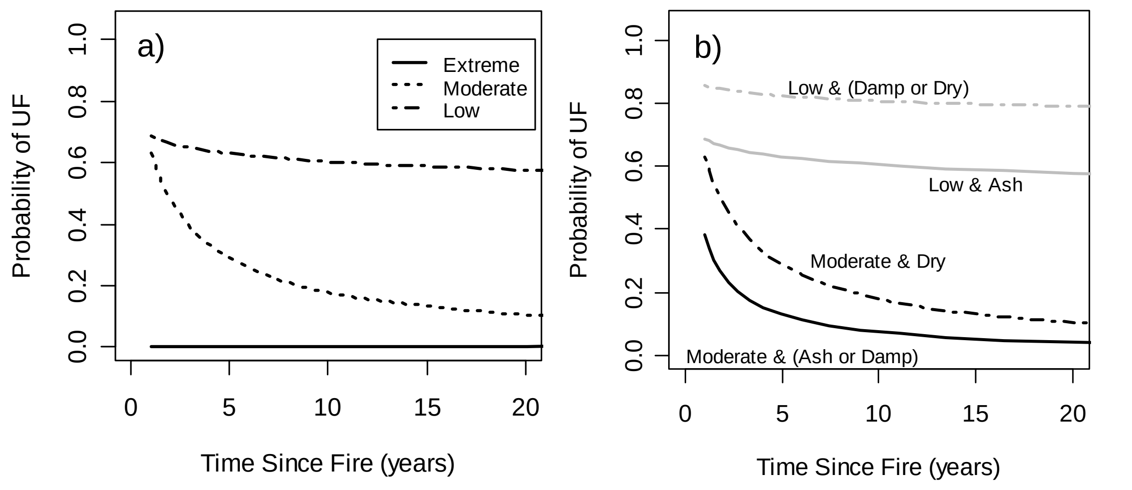
Probability of a crown fire: effects of time since logging & aspect



Crown fire probability declined with increasing time since logging – lowest in unlogged samples

Crown fire probability was highest on leeward aspects (before & after the change on Feb. 7th - trends pre-change shown)

Understorey fire probability: effects of time since fire, weather and forest type



Understorey fire absent in Extreme weather irrespective of TSF

Understorey fire probability decreased with increasing TSF in Moderate & Low weather (most pronounced at TSF < 5 years)

UF probability lower in Ash & Damp forests

Synthesis

1. **What was the predominant influence on fire severity and inferred fire intensity?**

A: Weather > Forest type > TSFire > Aspect > TS Logging >> Topo. position

Why is this important? This is contrary to expectations derived from fire behaviour models.

(e.g. Intensity = $0.67*FFDI*(FUEL)^2$; Gill et al. 1987)

Synthesis (cont.)

2. Was fire severity affected by time since fire and inferred fuel age?

A: Yes – fire severity was affected in a non-linear manner partly reflecting fuel accumulation.

- fire severity was lower at low fuel ages
- effects strongly governed by weather (e.g. CF absent in Low weather, UF absent in Extreme weather irrespective of TSF)
- divergent patterns in Ash forest reflect different regeneration and growth attributes

Synthesis (cont.)

3. Was fire severity affected by time since logging?

A: Yes – recent logging elevated the severity of fires

This could reflect:

- changes to stand structure (e.g. increased dryness & wind)
- shorter trees in young stands
- increased post-logging surface fuel loads (residual slash)

Synthesis (cont.)

4. Was fire severity affected by terrain?

A: Yes – the chief effect was Aspect with higher probability of crown fires on leeward slopes

This may be due to strong tilting of flames on windward aspects and vortex/spotting effects on leeward slopes on Feb. 7th 2009.

Management implications

Aim: Manipulation of fuel to enhance the probability of safe & effective suppression.

Conclusion 1: probability of effective suppression was negligible under Extreme weather (i.e. prior to the change on Feb. 7th) irrespective of TSF (fuel age) and forest type.

Conclusion 2: probability of effective suppression was enhanced under Moderate weather (i.e. post the change on Feb. 7th) particularly at TSF < 5 years (low fuel age). Such an effect can also be inferred for Low weather.

Management implications (cont.)

Aim: Manipulation of fuel to reduce ember attack on people and property adjacent to bushland.

Conclusion 1: Low fuel ages (i.e. TSF) reduce crown fire probability & likely ember propagation, but the likely degree of ember reduction is unknown.

Conclusion 2: Fuel age effects on crown fire probability are longer lasting (e.g. up to 20 years) though degree of reduction at higher ages is v. small.

Conclusion 3: Crown fire probability & possible ember propagation was substantially higher in Extreme weather cf. Moderate weather irrespective of TSF (fuel age).

Research priorities

- Fire severity (implied ember attack) can be directly related to patterns of property damage as a function of fuel age, weather, terrain & distance – important for design of 'asset protection zones' in the future.

- Predictions of intensity derived from fire behaviour models can be directly related to severity patterns in order to test model performance. This may partially overcome limitations of *post hoc* field observations (e.g. low resolution of fire-spread isochrones) and yield greater insight into effects of fuel age, weather & terrain

Conclusion

- Fuel age effects are “non-linear” and strongly conditional on weather, terrain, vegetation type etc.
- “Effectiveness” of fuel reduction will be variable as a consequence (i.e. “low” to “high”).
- There is a need to move beyond “case studies” (no matter how valuable) toward a broader, integrated understanding of how risk will be shaped by differing treatment options over spatial and temporal scales that encompass variation in weather, terrain and vegetation.

Thanks

To staff of Victorian DSE & CFA who kindly provided information used in the analyses