© BUSHFIRE CRC LTD 2010

Assessing Potential House Losses using PHOENIX RapidFire

Kevin Tolhurst & Derek Chong
Department of Forest and Ecosystem Science, University of Melbourne

---

Program: “Understanding Risk”

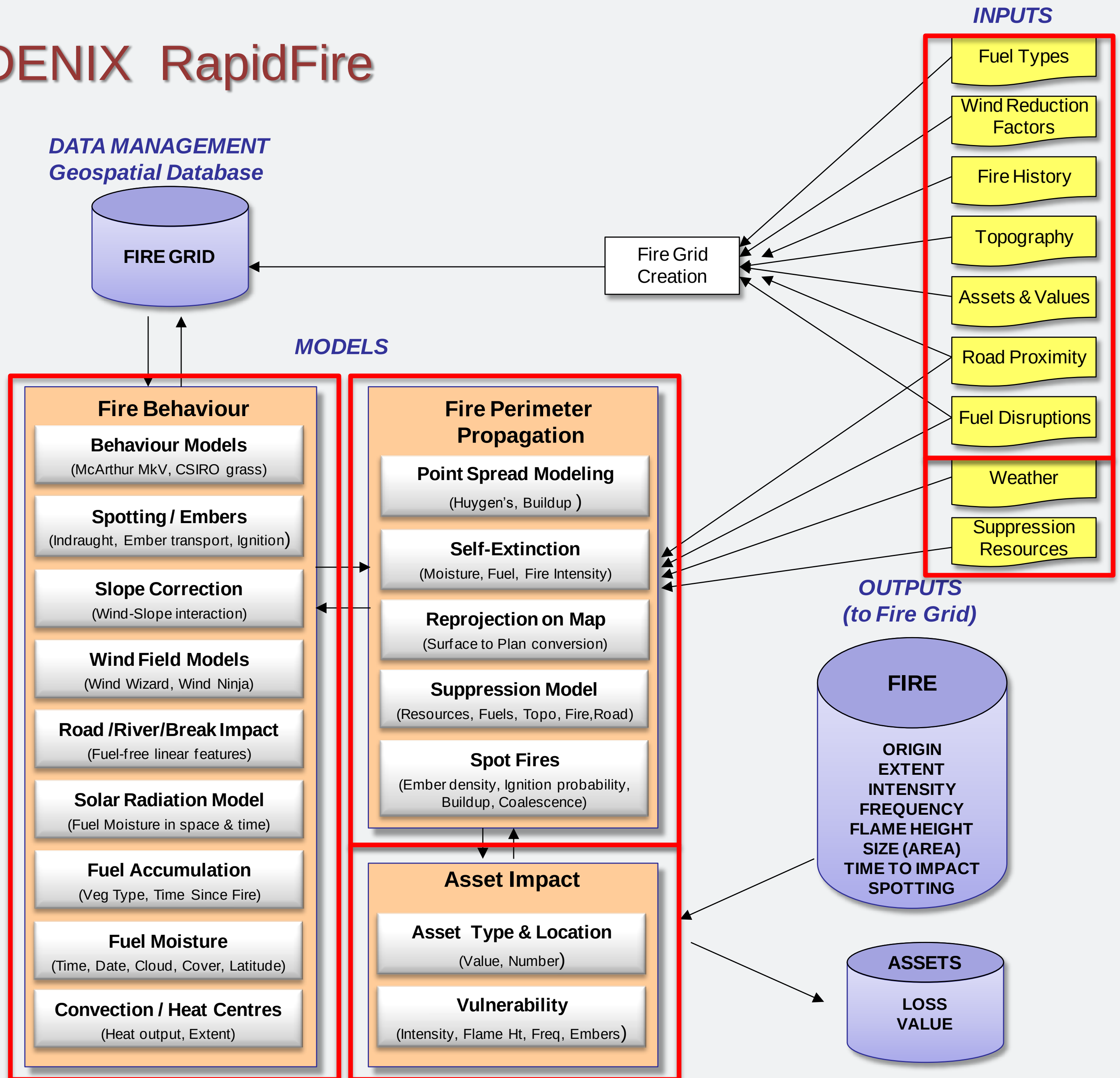
Project: “Fire Impact and Risk Evaluation - Decision Support Tool (FIRE-DST)”

AFAC / Bushfire CRC Annual Conference – Science Day
1st September 2011, Sydney Convention and Exhibition Centre, Darling Harbour

CRC

THE UNIVERSITY OF MELBOURNE

PHOENIX RapidFire



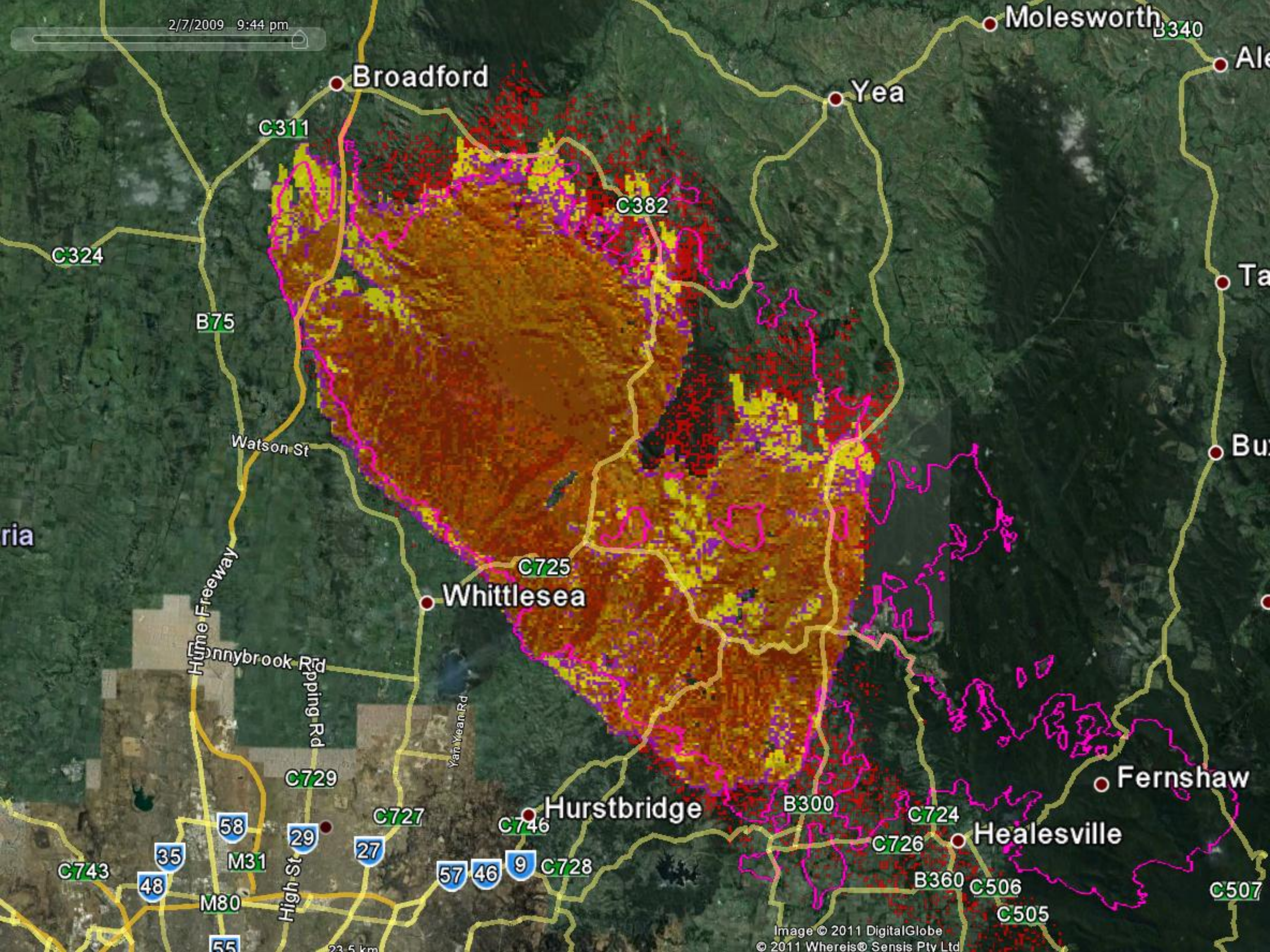
© BUSHFIRE CRC LTD 2010

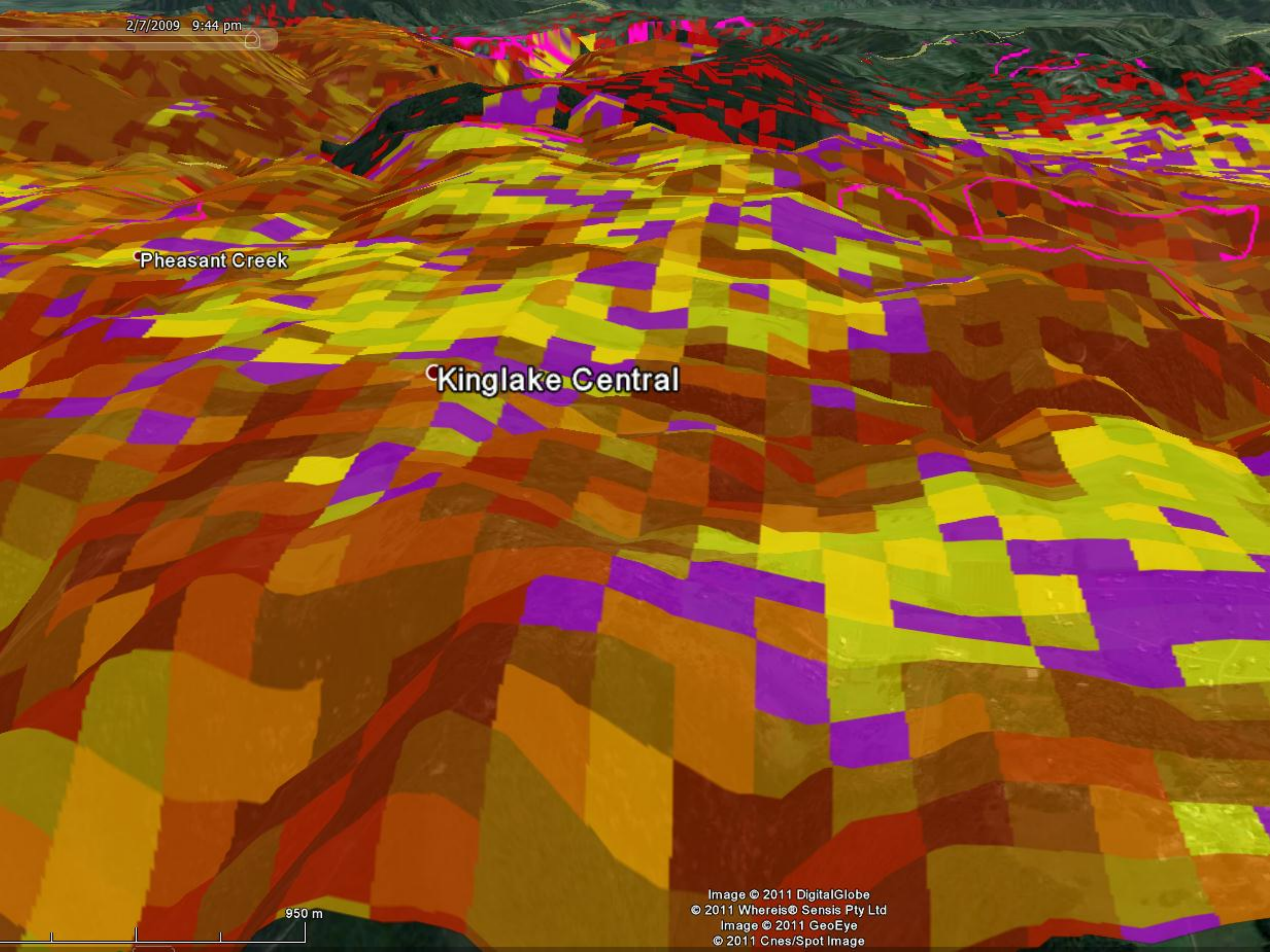
A deterministic, dynamic, continuous, empirical fire characterization model

a) **Deterministic –** combines mechanistic and empirical elements (not stochastic or physical)
b) **Dynamic –** inputs conditional on base fire behaviour conditions (not steady-state).
c) **Continuous –** fire spread is a continuous process calculated as perimeter point vectors (not discrete event or transition model, not CA).
d) **Empirical** – dynamics in model have been tuned to observed fire behaviour patterns over a range of wildfire situations

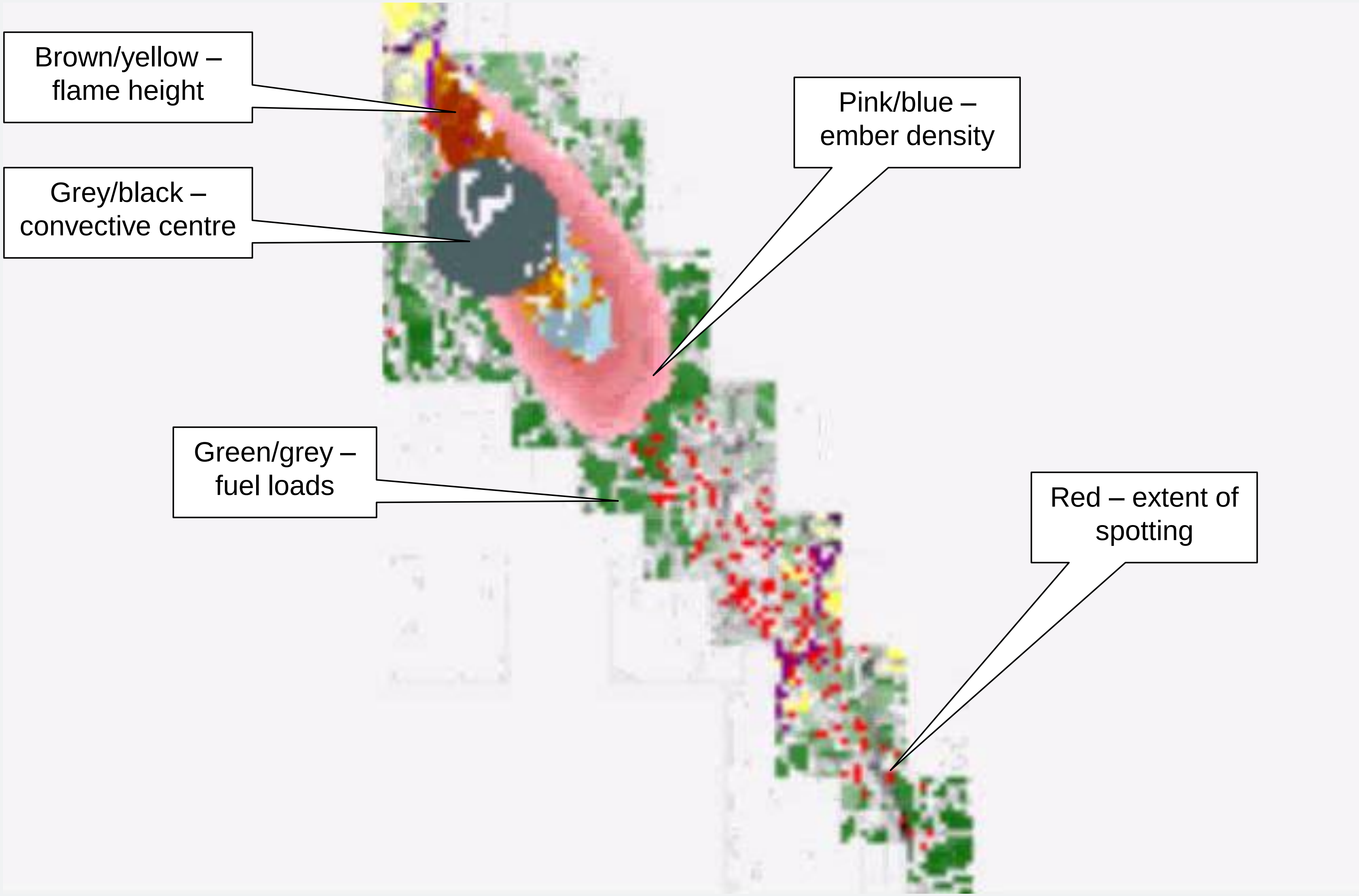
"Modelling is an abstraction of a complex reality in the simplest way that is adequate for the purpose." (Mulligan, M. and Wainwright, J. (2004). Modelling and model building.)

© BUSHFIRE CRC LTD 2010


2/7/2009 9:44 pm
Molesworth
B340
Broadford
Yea
C311
C382
C324
B75
Watson St
C725
Whittlesea
Hume Freeway
Donnybrook Rd
Epping Rd
Yan Yean Rd
C729
Hurstbridge
C727
C746
B300
C724
Healesville
Fernshaw
C726
58
29
27
35
M31
C743
48
57
46
9
C728
B360
C506
C505
C507
M80
High St
55
Image © 2011 DigitalGlobe
© 2011 Whereis® Sensis Pty Ltd


2/7/2009 9:44 pm
Pheasant Creek
Kinglake Central
950 m
Image © 2011 DigitalGlobe
© 2011 Whereis® Sensis Pty Ltd
Image © 2011 GeoEye
© 2011 Cnes/Spot Image

CONVECTIVE CENTRES



© BUSHFIRE CRC LTD 2010

STUDY DATA (HOUSES)

	Lost	Survived	Total	Pr(Loss)
Churchill	225	146	371	0.61
Kilmore	1751	1836	3587	0.49
Murrindindi	664	400	1064	0.62
Stawell	14	46	60	0.23
Total	**2654**	**2428**	**5082**	**0.52**

© BUSHFIRE CRC LTD 2010

PRINCIPAL COMPONENT ANALYSIS

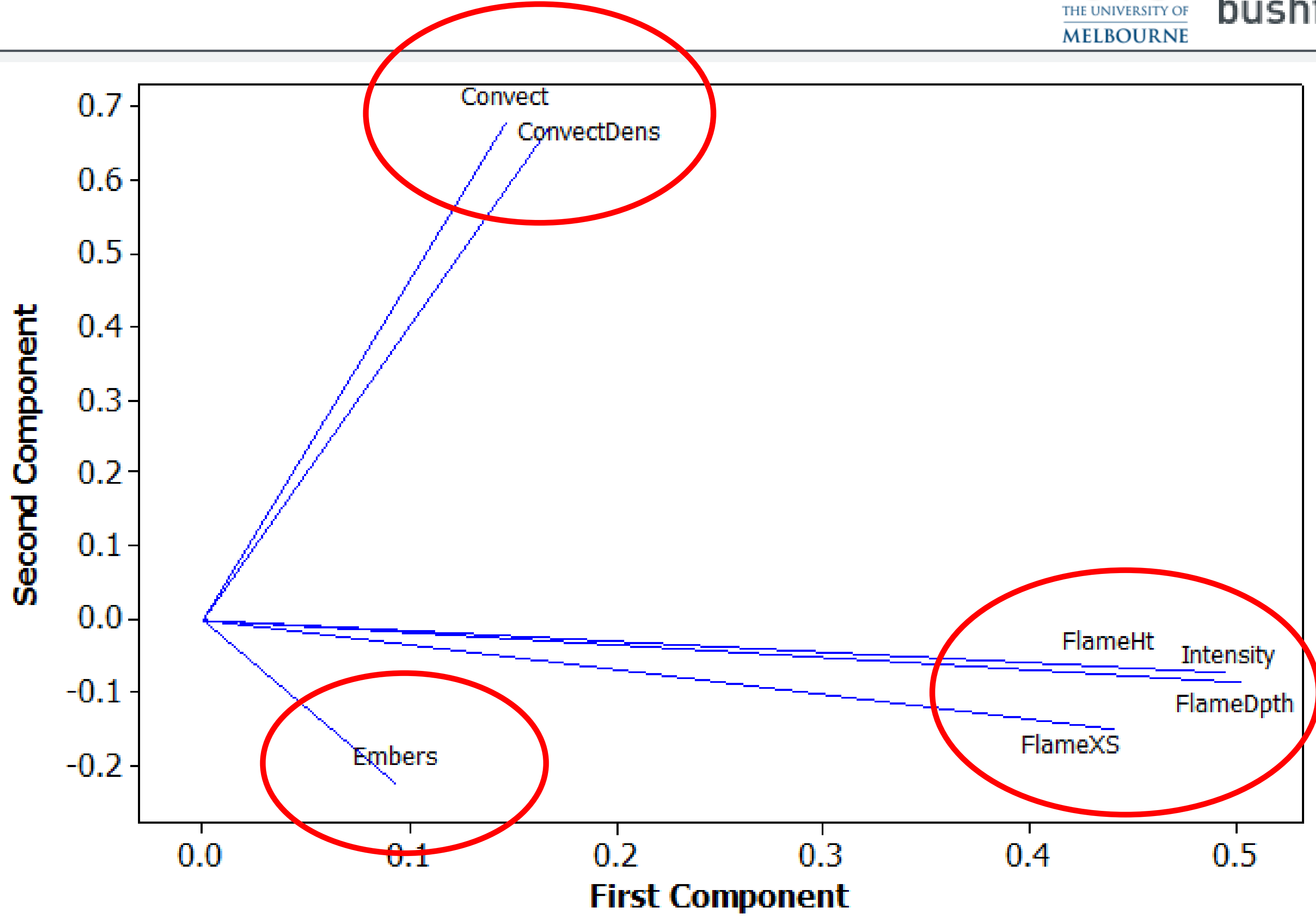


Figure 1. Principal Component Analysis of predicted fire variables for houses destroyed in the Kilmore East, Murrindindi and Churchill fires on Black Saturday 2009.

© BUSHFIRE CRC LTD 2010

"FLAME HEIGHT"

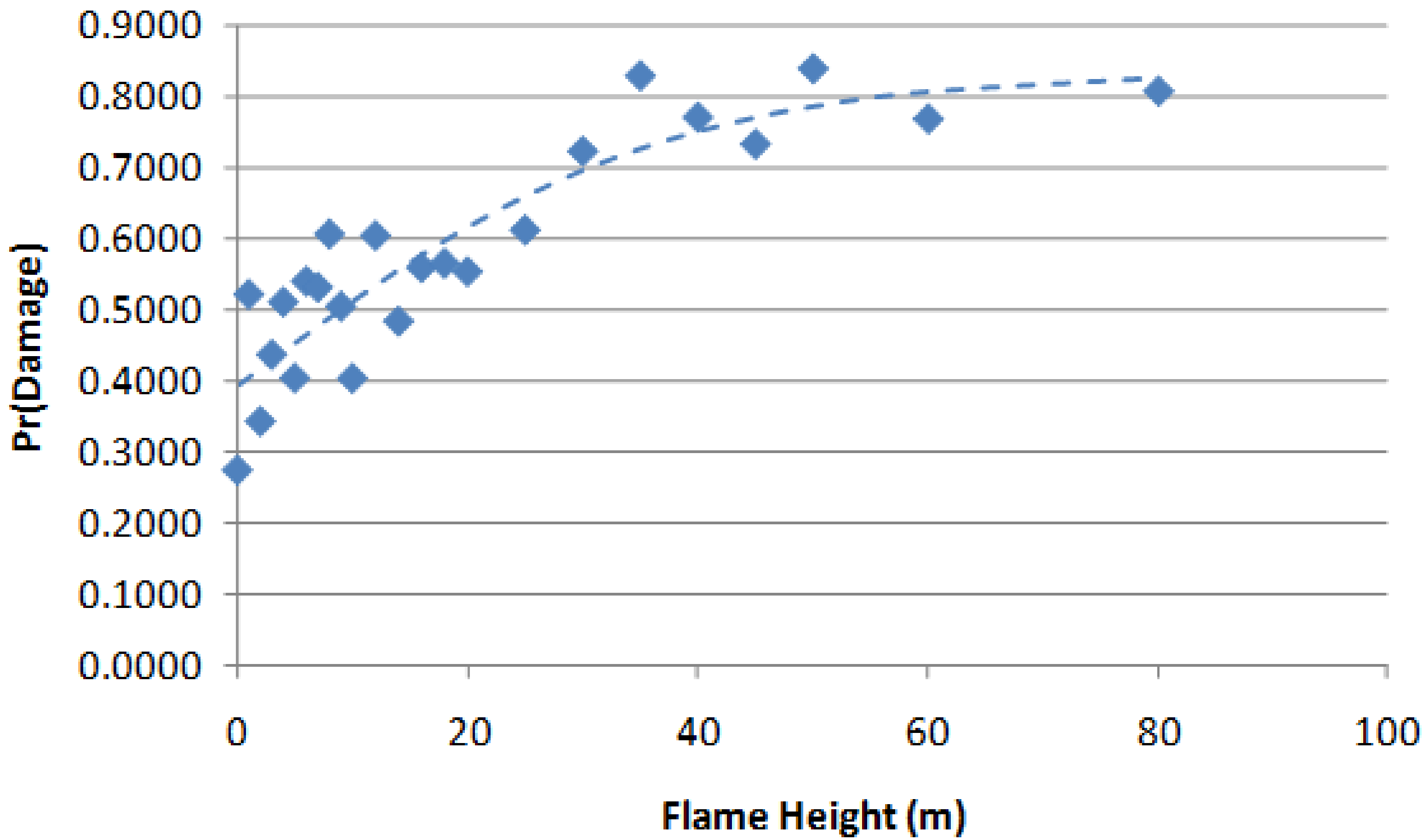


Figure 2. Probability of house loss when associated with predicted flame height.

Model	R value
Pr(Loss) = 0.8348/(1+1.10667*EXP(-0.05726*FlameHt))	0.896

© BUSHFIRE CRC LTD 2010

"FLAME XS AREA"

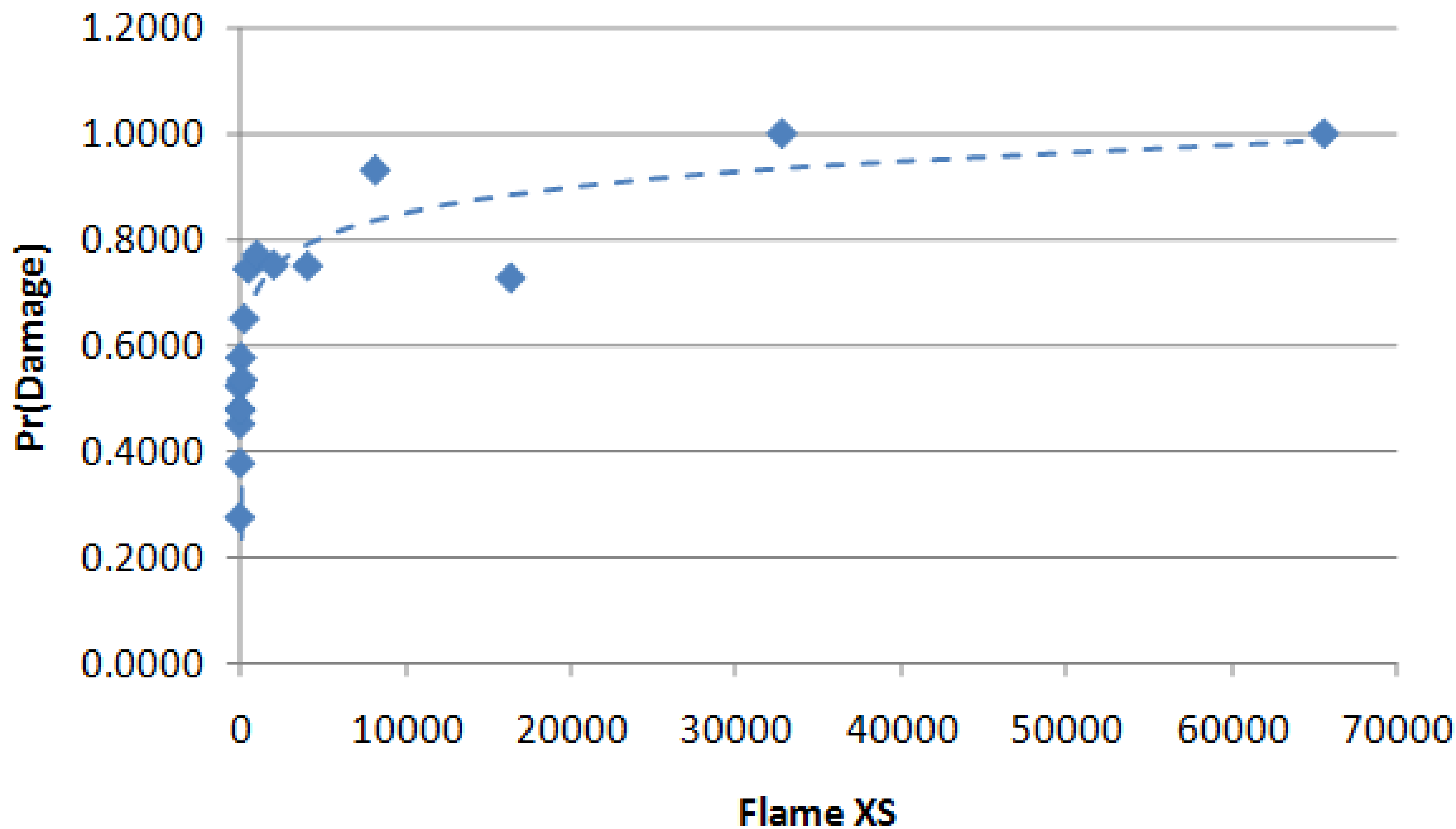


Figure 3. Probability of house loss associated with predicted flame cross-sectional area.

Flame cross-sectional area (m^2)	Pr(Loss) = 0.40935*FlameXS^0.0793	0.935

© BUSHFIRE CRC LTD 2010

"EMBER DENSITY"

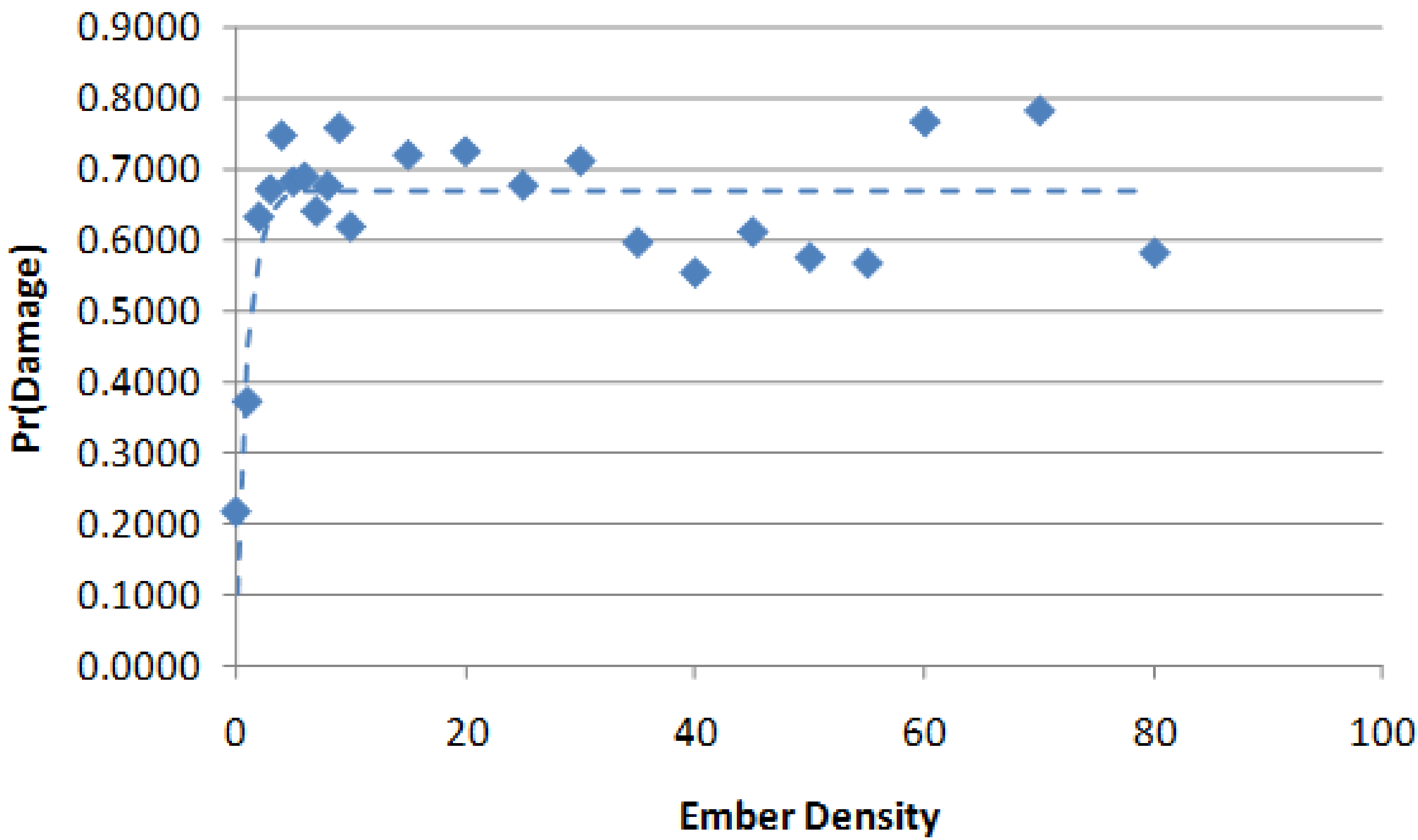


Figure 4. Probability of house loss associated with predicted ember density.

Ember density ($\#/m^2$)	Pr(Loss) = 0.5715*(1.1747-EXP(-0.9513*Ember))	0.907

© BUSHFIRE CRC LTD 2010

"FIRELINE INTENSITY"

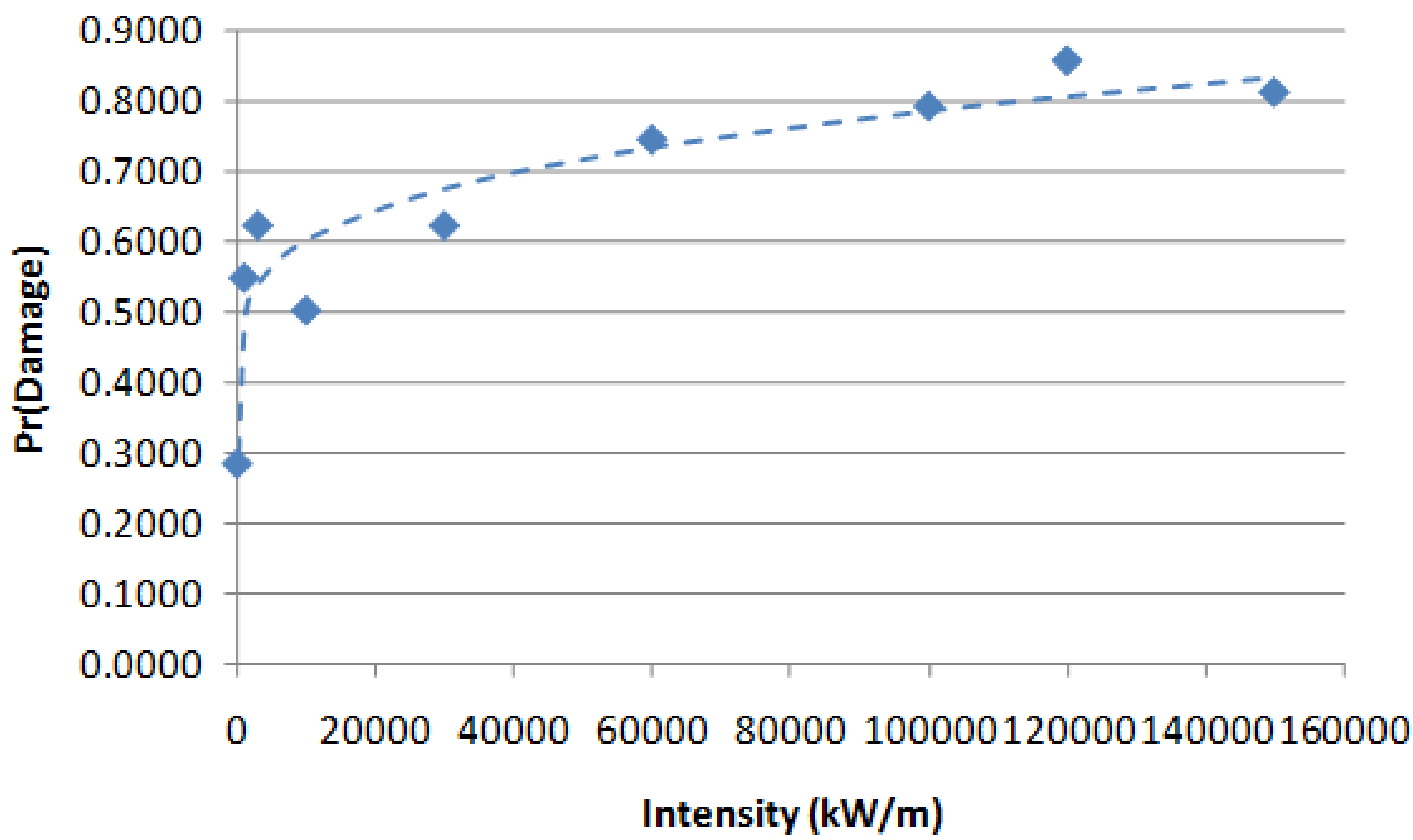


Figure 5. Probability of house loss associated with predicted fireline intensity.

Fireline Intensity (kW/m)	Pr(Loss) = 1/(4.5278-1.7366*Intensity^0.05456)	0.952

© BUSHFIRE CRC LTD 2010

"CONVECTIVE STRENGTH"

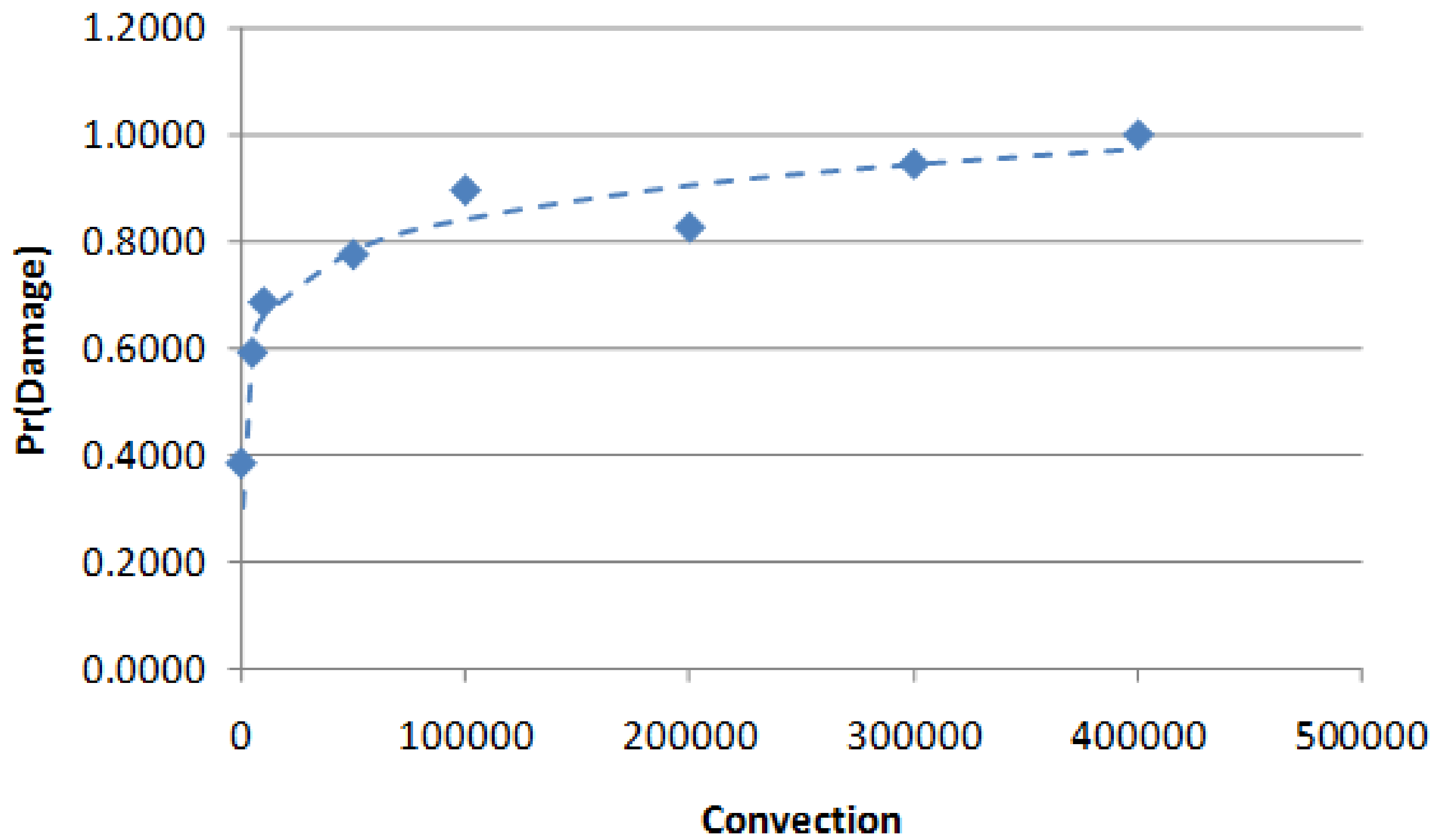
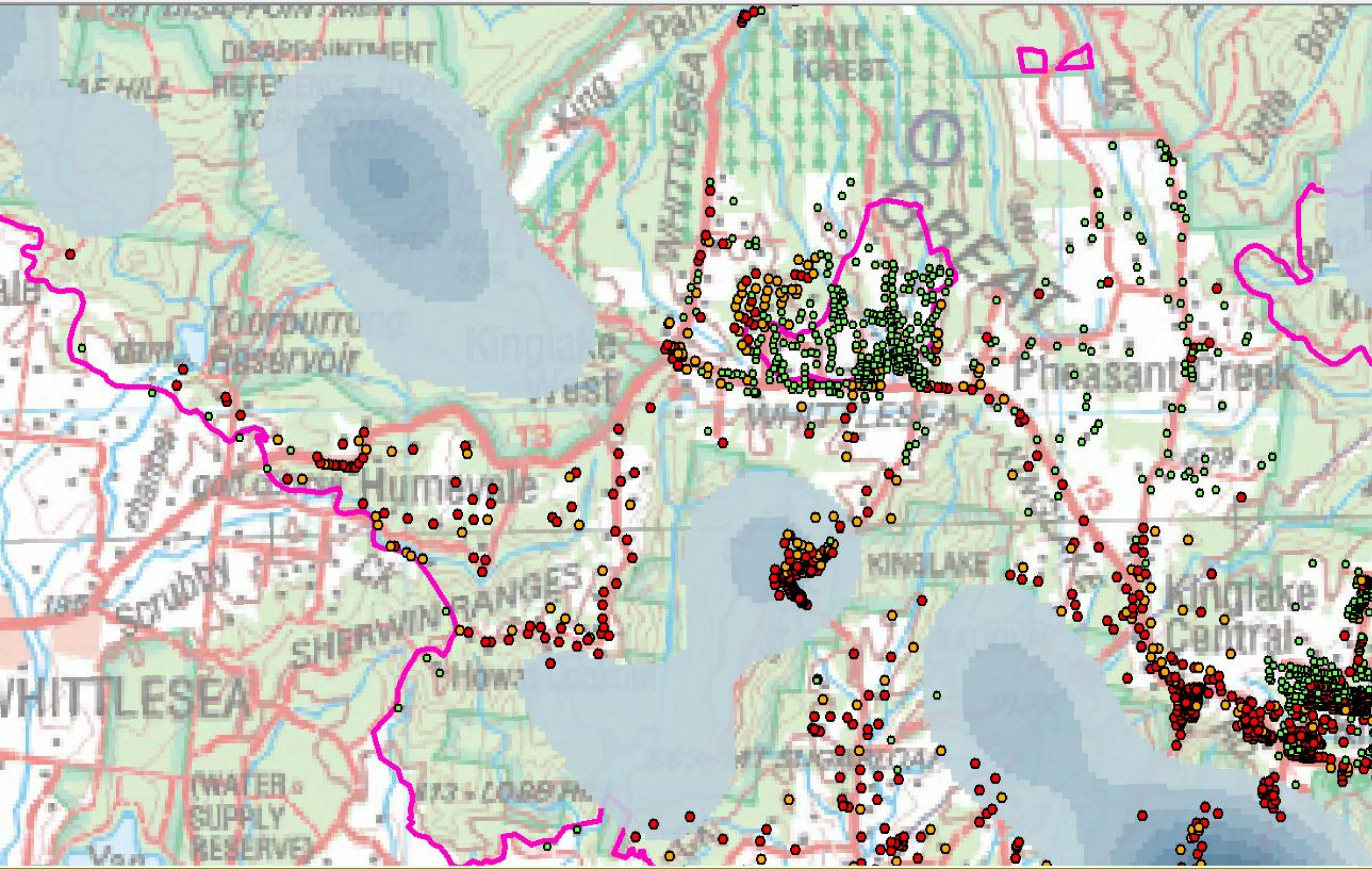


Figure 6. **Probability of house loss associated with predicted convective strength.**

Convection	Pr(Loss) = 0.2543*(Convect+5.6966)^0.104	0.981

© BUSHFIRE CRC LTD 2010

"CONVECTIVE DENSITY"



© BUSHFIRE CRC LTD 2010

"CONVECTIVE DENSITY"

THE UNIVERSITY OF MELBOURNE

bushfire CRC

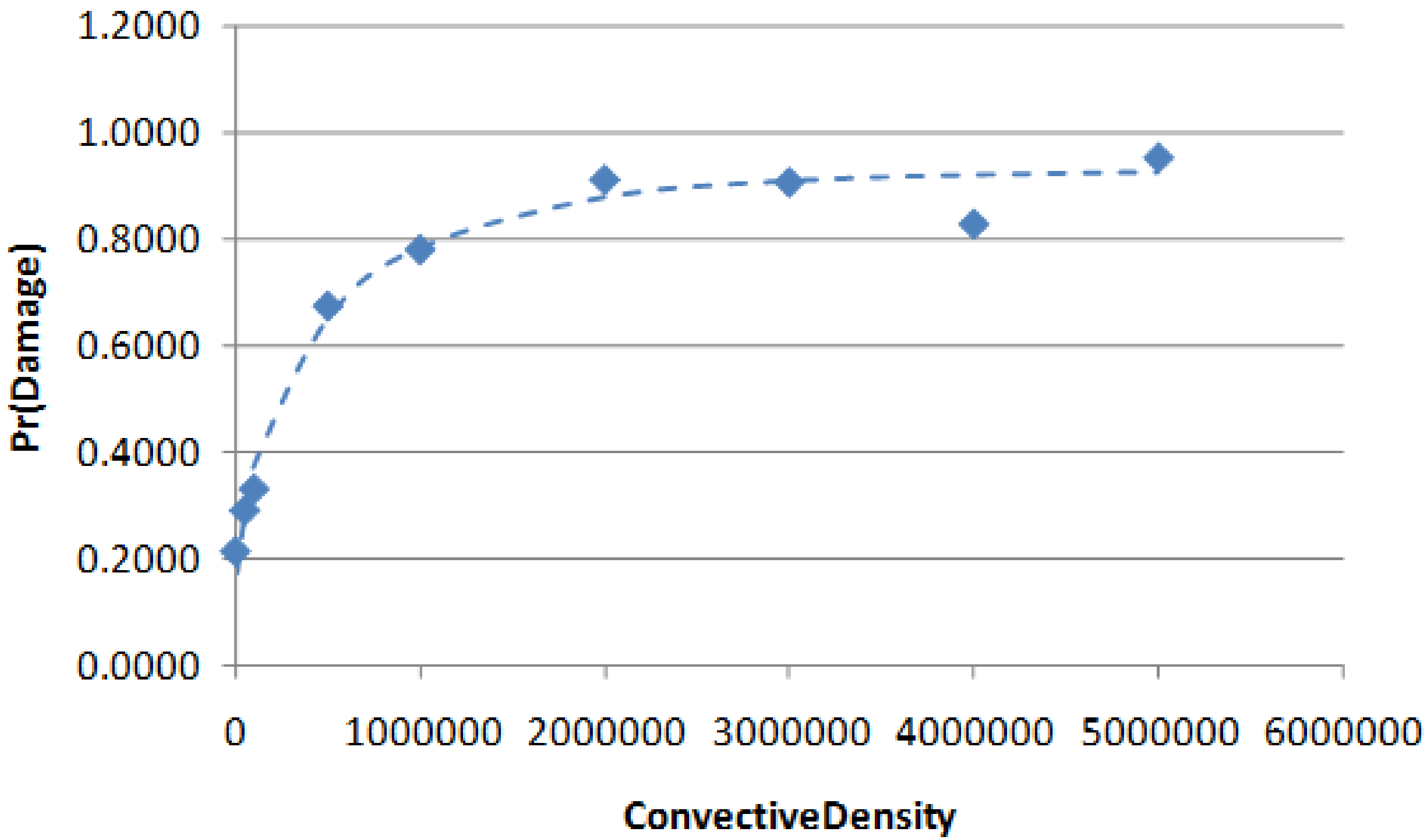


Figure 7. Probability of house loss associated with predicted convective strength smoothed over a 2000 m radius.

Convection Density	Pr(Loss) = 0.9303-0.7554*EXP(-0.0000926*ConvectDens^0.7085)	0.989

© BUSHFIRE CRC LTD 2010

50/50 THRESHOLDS

THE UNIVERSITY OF MELBOURNE

bushfire CRC

Table 2. 50% survival/loss threshold value for each fire parameter based on the line-of-best-fit regression lines in Table 1.

Fire Parameter	50/50 Survival Threshold Value
Flame height (m)	9 m
Flame cross-sectional area (m^2)	13 m^2
Ember density (#/m^2)	1.3 embers/m^2
Fireline Intensity (kW/m)	1,000 kW/m
Convection	700
Convection Density	220,000

© BUSHFIRE CRC LTD 2010

INTERACTIVE FACTORS

Logistic equation 1.

Pr(Loss)=1-EXP(0.63076-0.0000021*ConvectDens-0.0002662*FlameXS-0.01832*Embers)/(1+EXP(0.63076-0.0000021*ConvectDens-0.0002662*FlameXS-0.01832*Embers))

Somers D = 0.51

Logistic equation 2.

Pr(Loss) =1-EXP(0.2894-0.000487*FlameXS-0.02003*Embers-0.0000157*Convect)/(1+EXP(0.2894-0.000487*FlameXS-0.02003*Embers-0.0000157*Convect))

Somers D = 0.42

© BUSHFIRE CRC LTD 2010

FIRE BY FIRE PREDICTION

Table 2. Average probability of house loss predicted by each of the proposed models (Table 1 and Logistic equations) compared with the actual house status "Lost"/"Surv", subdivided by fire event.

FIRE	Logit1		Logit2		FlameXS		FlameHt	
	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv
Churchill	0.59	0.46	0.58	0.50	0.52	0.35	0.53	0.48
Kilmore	0.61	0.45	0.58	0.49	0.53	0.41	0.58	0.49
Murrindindi	0.54	0.41	0.50	0.45	0.48	0.33	0.50	0.46
Stawell	0.36	0.37	0.43	0.44	0.51	0.47	0.44	0.44
Total	**0.59**	**0.44**	**0.56**	**0.48**	**0.52**	**0.40**	**0.55**	**0.48**

Actual Pr(Loss)	EmberDens		Intensity		Convection		ConvectDens	
	Lost	Surv	Lost	Surv	Lost	Surv	Lost	Surv
0.61	0.61	0.34	0.58	0.47	0.50	0.39	0.52	0.35
0.49	0.53	0.37	0.57	0.48	0.49	0.38	0.52	0.35
0.62	0.52	0.24	0.54	0.43	0.40	0.34	0.52	0.33
0.23	0.13	0.15	0.60	0.57	0.33	0.38	0.25	0.27
	0.53	**0.34**	**0.56**	**0.47**	**0.47**	**0.38**	**0.52**	**0.34**

© BUSHFIRE CRC LTD 2010

SUMMARY

1. Fire characteristics modelled by PHOENIX RapidFire have provided a reasonable basis for predicting broad-level house loss statistics.

2. Modelled bushfire convective energy was a major factor is predicting house loss and this has not been included as a factor in previous house loss work even though the importance of wind damage has been noted.

3. Further work is needed to investigate the accuracy of "neighborhood" house loss predictions.

4. House design and maintenance, house-to-house ignition and the level of defense are important factors in house loss, but are not included in this approach.

© BUSHFIRE CRC LTD 2010