MAPPING IT OUT

Understanding the effectiveness of maps for delivering bushfire warning information

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Australian Government
Department of Industry and Science
Business Cooperative Research Centres Programme

THE BACKGROUND

Traditional warning approach

Bushfire WATCH AND ACT for Araluen Estate in Roleystone in the City of Armadale

Monday 5 January 2015 - 11:16 AM

A bushfire WATCH AND ACT remains for people in Araluen Estate in Roleystone in the City of Armadale.

- There is a possible threat to lives and homes as a fire is burning in the area and conditions are changing.
- You need to leave or get ready to actively defend.
- The fire is burning in inaccessible bushland along Canning Dam Road near McNess Drive and has been burning towards Heritage Drive.

BUSHFIRE BEHAVIOUR:
- The bushfire is currently stationary, however easterly wind speeds have increased this morning and firefighters are managing flares ups.
- This means homes west of the fire on Heritage Drive, Protector Grove and Sophia Grove may be threatened by the fire.
- It is under control but not yet contained.

WHAT TO DO:
- If you are not prepared or you plan to leave, leave now if the way is clear.
- There is ember attack ahead of the fire, so close all doors and windows, and turn off evaporative air conditioners, but keep water running through the system if possible.
- If you are well prepared and plan to actively defend your home, make final preparations now.
- Do not rely on mains water pressure as it may be affected. If you have access to a water tank and plan to defend your home, start patrolling with your hose and put out spot fires.
- If you are not at home, do not try to return as conditions in the area could be very dangerous.

SAFER PLACE:
- Your safest option may be to visit family or friends who live away from the area.

SAFEST ROUTE:
- It is safest to leave via Heritage Drive in a northerly direction.

ROAD CLOSURES:
Avoid the area and be aware of fire and other emergency services personnel working on site.

McNess Drive is closed between Canning Dam Road and Gardiner Road.

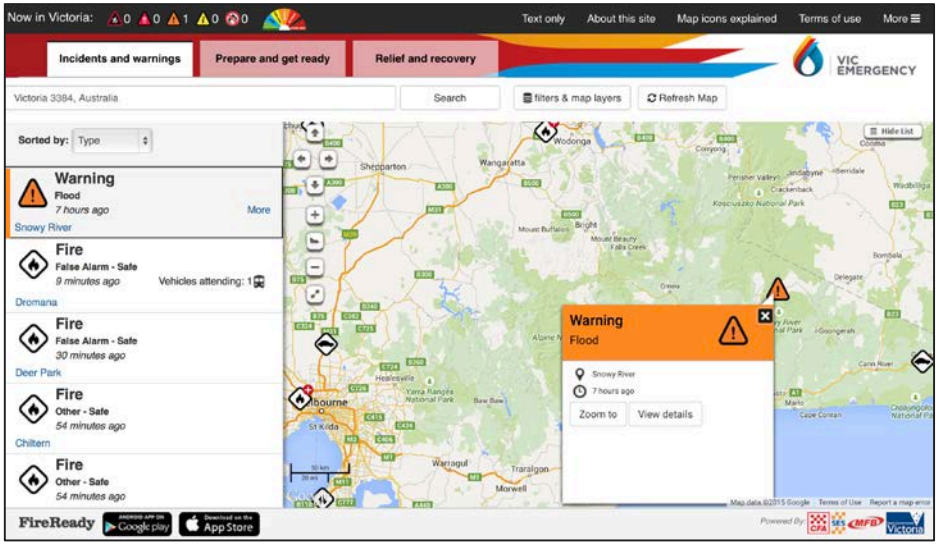
WHAT FIREFIGHTERS ARE DOING:
- Seventy career and volunteer firefighters from DFES, Local Government and Department of Parks and Wildlife are managing flare ups and working to strengthen containment lines.
- Aerial support has been sent to assist ground crews.
- An Aerial Intelligence helicopter has assisted firefighters this morning.

EXTRA INFORMATION:
- The fire was reported at 4.02pm on 4 December 2015.
- The cause of the fire is unknown.
- The fire has burnt through approximately four hectares.
- The City of Armadale is managing the fire.

KEEP UP TO DATE:
Visit www.dfes.wa.gov.au, call 13 DFES (13 3337), follow DFES on Twitter @dfes_wa, listen to ABC local radio, 6PR or news bulletins.

Updates will be provided every two hours unless the situation changes.

Emerging warning approach



THE DIVERSE MAP-BASED APPROACHES ADOPTED

VicEmergency: http://emergency.vic.gov.au/map#now

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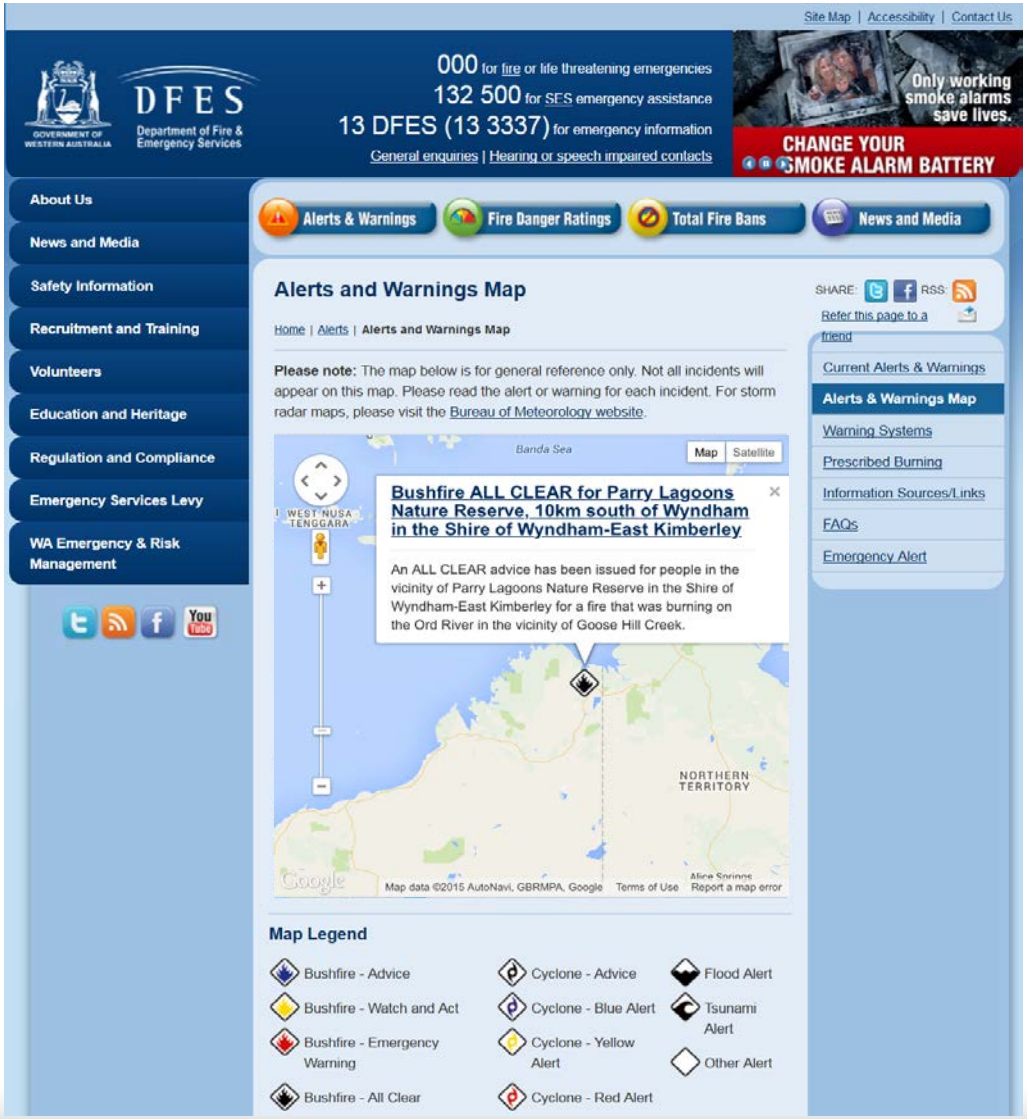

WA's DFES: Alerts and Warnings map

http://www.dfes.wa.gov.au/alerts/Pages/alertsmap.aspx

"Community expectations for information are high. As one community member has explained, "They must know where the actual fire is. Why don't they show us a map with more than a 'pin point' on it?" "

"At the Review's workshop, participants noted that … across the sector current warnings are largely text-based." "The diversity of spatial information or geographic information systems across agencies is seen by some to be an inhibitor to consistent solution design."

"Further research on the benefits of how people receive, understand and respond to additional visual and spatial information within a warning might provide incentive to invest in advancing warnings in this form. "

"In short, waiting for the 'perfect' system or assuming that community members won't understand spatial information only delays the inevitable effort required."

- Emergency Management Victoria (2014, p.49-50)

A COMPARATIVE STUDY: TEXT VS. MAPS

To answer the following research questions:

1) Are maps more effective than text for delivering bushfire warning information?

2) Which cartographic representation is the most effective?

THE THEORETICAL FRAMEWORK

What is an 'effective' public warning?

Objectives:

Receive ⟶ Understand ⟶ Perceive ⟶ Respond

Message structure

- Content
  - Hazard type, time & location
  - Response guidance
  - Credible source
- Style
  - Accurate, sufficient, specific, consistent, clear

Mileti and Sorensen (1990)

TESTING MATERIALS


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SAFER PLACE:
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SAFEST ROUTE:
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ROAD CLOSURES:
Avoid the area and be aware of fire and other emergency services personnel working on site.

McNess Drive is closed between Canning Dam Road and Gardiner Road.

WHAT FIREFIGHTERS ARE DOING:
- Seventy career and volunteer firefighters from DFES, Local Government and Department of Parks and Wildlife are managing flare ups and working to strengthen containment lines.
- Aerial support has been sent to assist ground crews.
- An Aerial Intelligence helicopter has assisted firefighters this morning.

EXTRA INFORMATION:
- The fire was reported at 4.32pm on 4 December 2015.
- The cause of the fire is unknown.
- The fire has burnt through approximately four hectares.
- The City of Armadale is managing the fire.

KEEP UP TO DATE:
Visit www.dfes.wa.gov.au, call 13 DFES (13 3337), follow DFES on Twitter @dfes_wa, listen to ABC local radio, 6PR or news bulletins.

Updates will be provided every two hours unless the situation changes.

Spatial Information Elements (IE)

- IE1. Fire location (origin & perimeter)
- IE2. Fire control status
- IE3. Wind direction and speed (current and forecast)
- IE4. Fire spread prediction
- IE5. Fire alert levels and areas
- IE6. Road closure
- IE7. Evacuation centre

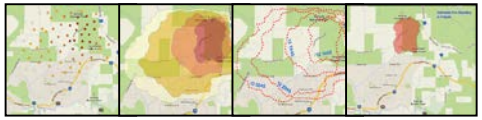
Warning Design Candidates: Text vs. maps

A fire is burning in the area around Canning Mills Rd, west of Canning Rd within Korung National Park.

The fire is currently burning out of control.
Most of the northern boundaries of the fire have been contained.

Winds are forecast to be northerly and north-easterly for the rest of this morning at around 20km/h, and will change to easterly this afternoon around 3pm with higher winds speed at around 30km/h.

It is moving in a south-westerly direction at a speed of around 300 meters per hour.



A bushfire Emergency Warning has been issued for people in the eastern part of Martin, northern part of Roleystone, southern part of Canning Mills and western part of Karragullen.

Canning Mills Rd between Mills Rd East and Canning Rd is closed.

An evacuation center has been opened at Roleystone Neighborhood Family Centre at 19 Wygonda Rd, Roleystone.

DEFINING 'EFFECTIVENESS'

1) Accuracy of understanding
   a. locating
   b. orientation
   c. map comprehension

2) Risk perception
   a. Likelihood
   b. Severity

3) Efficiency

4) Subjective preference & rating of usefulness

Specific Research Questions Tested:

1) Do maps facilitate more accurate understanding of wildfire warning information when compared to texts?

2) Do bushfire warning maps stimulate higher level of risk perception when compared to texts?

3) Are maps more efficient for situation interpretation than the text?

4) Do participants prefer text or map based communication of wildfire warning information?

5) What is the optimal map design for communicating each IE?

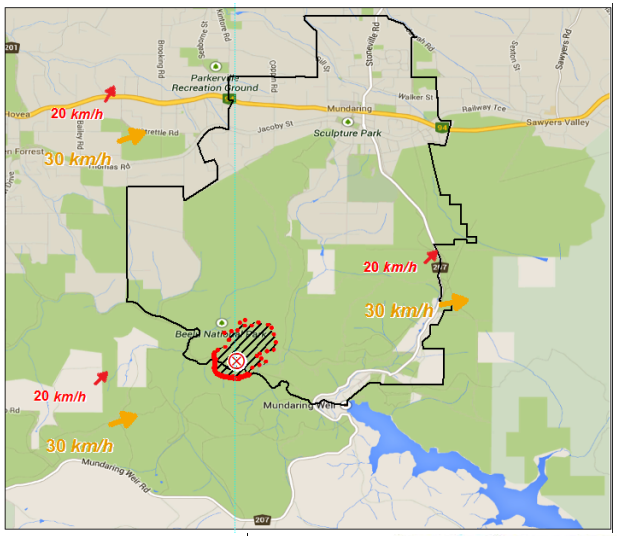
SAMPLING APPROACH

Mundaring, WA

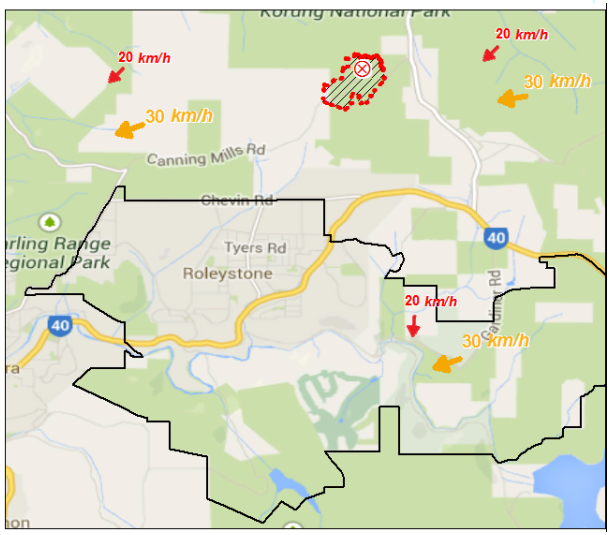
Roleystone, WA

Kelmscott, WA

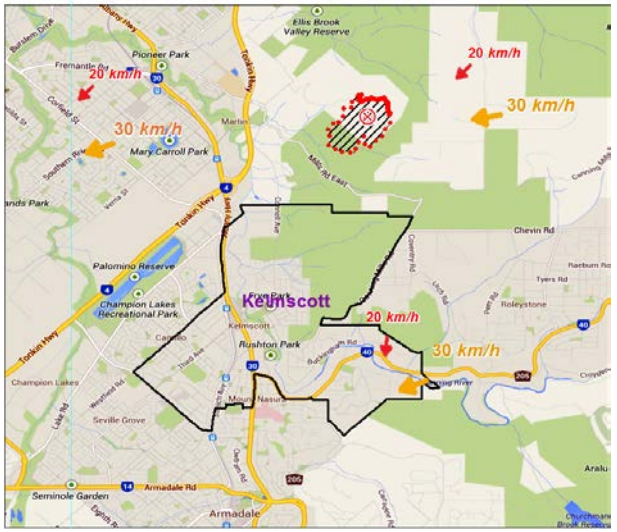
EXPERIMENTAL DESIGN: CONSTANT SCENARIO SIMULATION



Mundaring, WA



Roleystone, WA



Kelmscott, WA

SURVEY PROCEDURE

	Information Elements	Text-group	Map-group	Dimensions tested
Section 1	1. Fire origin & perimeter	Text1	Map1a	a) Understanding b) Risk perception c) Efficiency
	2. Fire control status	Text2	Map2a	
	3. Wind (current and forecast)	Text3	Map3a / Map3b	
	4. Fire spread prediction	Text4	Map4a / Map4b / Map4c / Map4d	
	5. Fire alert	Text5	Map5a / Map5b	
	6. Road closure	Text6	Map6a / Map6b	
	7. Evacuation centre	Text7	Map7a	
Section 2	• All designs for each Information Element • Exclusive preference • Rating of usefulness (1-7)			a) Subjective preference & rating of usefulness b) Open-ended comments on each design
Section 3	Demographic and personal information			

PARTICIPANTS

	Text	Map	Community profiles		
			Kelmscott	Roleystone	Mundaring
	N (%)	N (%)	%	%	%
Total	124[b]	118[b]	7612	4673	2306
Gender					
Male	54 (*44*)	47 (*40*)	*49*	*49*	*48*
Age					
<30	10 (*8*)	12 (*10*)	*20*	*13*	*11*
30-49	39 (*32*)	31 (*26*)	*34*	*38*	*32*
50-69	65 (*52*)	67 (*57*)	*33*	*41*	*38*
≥ 70	10 (*8*)	8 (*7*)	*13*	*8*	*19*
Qualification					
School qualification	27 (*22*)	23 (*20*)	*54*	*43*	*50*
Trade certificate/diploma	39 (*31*)	46 (*39*)	*35*	*37*	*33*
University degree	58 (*47*)	49 (*41*)	*11*	*20*	*17*
Rural/urban					
Rural	26 (*21*)	30 (*25*)	*7*	*22*	*31*
Urban	98 (*79*)	88 (*75*)	*93*	*78*	*69*
Years of residence in the suburb					
<2	18 (*15*)	15 (*13*)			
2- 9.9	27 (*22*)	26 (*22*)			
10-19.9	29 (*23*)	29 (*24*)			
20- 61	50 (*40*)	48 (*41*)			
Frequency of computer usage					
2-3 times a month		1 (*0.8*)			
2-3 times a week	5 (*4*)	8 (*7*)			
Daily	119 (*96*)	109 (*92*)			
e-map usage					
≤ once a month	24 (*19*)	27 (*23*)			
≤ once a week	37 (*30*)	30 (*25*)			
More than once a week/daily	63 (*51*)	61 (*52*)			

RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

IE1. Fire location

The fire is burning in the area around Canning Mills Rd, west of Canning Rd within Korung National Park.

Approximately 90 hectares have been burnt.

The fire started earlier this morning in the west of Canning Rd and north and Canning Mills Rd.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM

		Text	Map
Direction	What is the **direction** of the closest fire edge from your property at 10:45? (1 = wrong, 2 = close, 3 = correct)	2.40	2.58
Distance	Approximately **how far** is the closest fire edge to your property at 10:45? (1 = wrong, 2 = close, 3 = correct)	1.52	1.88***
Likelihood	Given the known information, how likely do you think it is for this fire to reach your property? (1-7)	3.85	4.32*
Efficiency	Time spent on the page (seconds)	169.01	167.78

*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

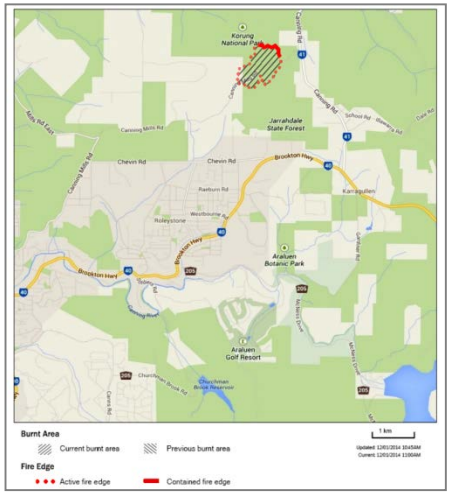
IE2. Fire suppression status

The fire is burning in the area around Canning Mills Rd, west of Canning Rd within Korung National Park.

The fire is currently burning out of control.

Most of the northern boundaries of the fire have been contained.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM



		Text	Map
Direction	The fire edge closest to your property has been: contained, partially contained, or not contained? (1 = wrong, 2 = close, 3 = correct)	2.77	2.90*
Impact	Do you expect the fire to spread towards your property: yes or no? (1 = wrong, 2 = correct)	1.85	1.89
Likelihood	Given the known information, how likely do you think it is for this fire to reach your property? (1-7)	3.83	4.02*
Efficiency	Time spent on the page (seconds)	76.82	71.57

*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

IE3. Wind

The fire is burning in the area around Canning Mills Rd, west of Canning Rd within Korung National Park.

Winds are forecast to be northerly and north-easterly for the rest of this morning at around 20km/h, and will change to easterly this afternoon around 3pm with higher winds speed at around 30km/h.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM

		Text	Map a - Arrow	Map b - Meteorological
Direction	Is the wind currently pushing the fire towards your property: yes or no? (1 = wrong, 2 = correct)	1.59	1.74*	1.68
Change	If the fire is not contained, will it be a greater threat to your property in 4hrs than it is currently: yes or no? (1 = wrong, 2 = correct)	1.64	1.60	1.56
Likelihood	Given the known information, how likely do you think it is for this fire to reach your property? (1-7)	4.01	4.44* (*)	3.90
Severity	If the fire does reach your property, how severe do you think the impact of this fire would be on your property? (1-7)	4.75	5.20 (***)	4.37
Efficiency	Time spent on the page (seconds)	86.41	91.85*	122.06***

*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

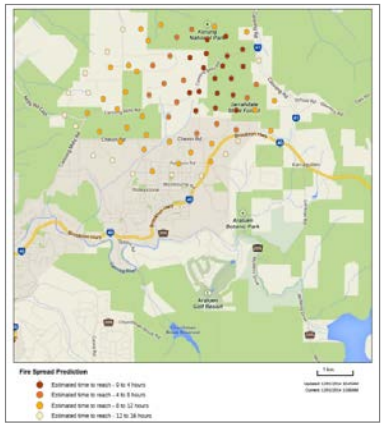
RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

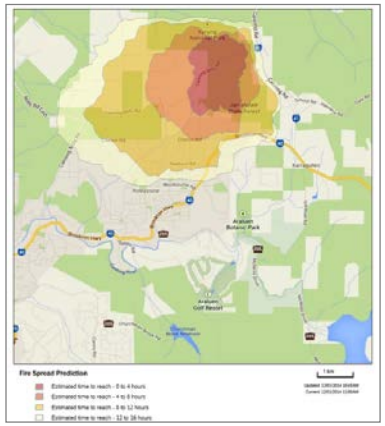
IE4. Fire spread prediction

The fire is burning in the area around Canning Mills Rd, west of Canning Rd within Korung National Park.

It is moving in a south-westerly direction at a speed of around 300 meters per hour.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM





		Text	Map a - point	Map b - contour	Map c - tinted contour	Map d - animated
Direction	Is the fire spreading towards your property: yes or no? (1 = wrong, 2 = correct)	1.73	1.89*	1.97***	1.97***	1.96***
Time	If the fire is not contained, approximately how long will it take for the fire to reach your property? (1 = wrong, 2 = close, 3 = correct)	1.83	2.71*** (***)	1.70	2.52*** (***)	2.11
Likelihood	Given the known information, how likely do you think it is for this fire to reach your property? (1-7)	4.01	4.25	5.24*** (**)	4.79***	5.19*** (***)
Severity	If the fire does reach your property, how severe do you think the impact would be on your property? (1-7)	4.67	4.54	5.76*** (***)	5.24	5.00
Efficiency	Time spent on the page (seconds)	84.18	91.67	111.03**	78.63	76.08

*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

IE5. Fire alert

A bushfire Emergency Warning has been issued for people in the eastern part of Martin, northern part of Roleystone, southern part of Canning Mills and western part of Karragullen.

A bushfire Watch and Act has been issued for people in the southern part of Roleystone.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM

		Text	Map a - Point	Map b - Polygon
Level	What is the fire alert level for your property at 10:45? (1 = wrong, 2 = close, 3 = correct)	2.37	2.37	2.62
Likelihood	Given the known information, how likely do you think it is for this fire to reach your property? (1-7)	4.42	4.77	4.89*
Severity	If the fire does reach your property, how severe do you think the impact of this fire would be on your property? (1-7)	5.07	5.07	5.15
Efficiency	Time spent on the page (seconds)	75.66	73.23	66.07* (*)

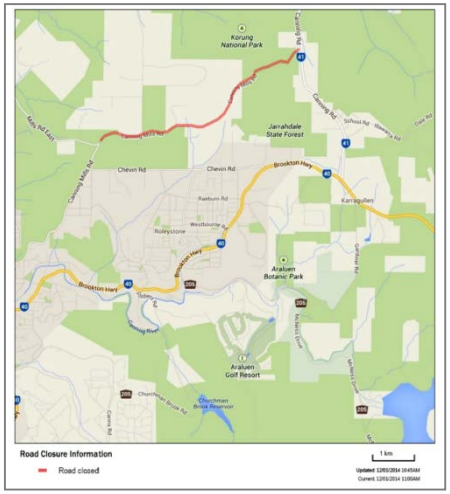
*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

IE6. Closed roads

Canning Mills Rd between Mills Rd East and Canning Rd is closed.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM



		Text	Map a - Point	Map b - Polyline
Direction	What is the general direction of the closed road from your property? (1 = wrong, 2 = close, 3 = correct)	2.52	2.47	2.76* (*)
Impact	Would you still be able to travel to the Post Office in your suburb from your property by car? (1 = wrong, 2 = correct)	1.99	1.95	2.00 (*)
Efficiency	Time spent on the page (seconds)	59.11	53.61	43.94 (*)

*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

RESULTS: ACCURACY, RISK PERCEPTION & EFFICIENCY

IE7. Evacuation centre

An evacuation centre has been opened at Roleystone Neighbourhood Family Centre at 19 Wygonda Rd, Roleystone.

Update Time: 12/01/2014 10:45AM
Current Time: 12/01/2014 11:00AM

		Text	Map a - Point
Direction	What direction is the evacuation centre from your property? (1 = wrong, 2 = close, 3 = correct)	2.65	2.58
Distance	Approximately how far is the evacuation centre from your property? (1 = wrong, 2 = close, 3 = correct)	1.51	1.83***
Efficiency	Time spent on the page (seconds)	42.01	51.81***

*$p \leq .05$; **$p \leq .01$; ***$p \leq 0.005$

RESULTS: SUBJECTIVE PREFERENCE

IE	Text	Map				Combine two or more methods[†]				No preference	Total
		Map a	Map b	Map c	Map d						
1. Fire location	18[a] (7.1)[b]	202 (79.2)				19 (7.5)				16 (6.3)	255
2. Fire suppression	20 (7.9)	189 (74.4)				33 (13.0)				12 (4.7)	254
3. Wind	25 (9.9)	202 (80.2)	3 (1.2)			T+a 16 (6.3)		T+b 1 (0.4)		5 (2.0)	252
4. Fire spread prediction	3 (1.2)	17 (6.7)	9 (3.6)	131 (52.0)	77 (30.6)	T+a 2 (0.8)	T+c 5 (2.0)	T+d 2 (0.8)		6 (2.4)	252
5. Alert	13 (5.2)	18 (7.2)	202 (81.1)			T+b 12 (4.5)				4 (1.6)	249
6. Road closure	16 (6.5)	33 (13.3)	157 (63.3)			T+a 3 (1.1)	T+b 7 (2.8)	a+b 10 (4.0)	T+a+b 2 (0.8)	20 (8.1)	248
7. Evacuation centre	92 (37.1)	73 (29.4)				40 (16.1)				43 (17.3)	248

[†] **T** = Text, **a** = Map a, **b** = Map b, **c** = Map c, **d** = Map d.

[a] Number of respondents preferring this design.

[b] Percentage of row total.

RESULTS: RATING OF USEFULNESS (1-7)

IE	Text	Map			
		Map a	Map b	Map c	Map d
1. Fire location	3.64	6.29***			
2. Fire suppression	3.85	6.12***			
3. Wind	3.91	6.12***	3.71		
4. Fire spread prediction	3.47	4.58***	4.33***	6.06***	5.43***
5. Alert	3.83	4.32***	6.37***		
6. Road closure	4.42	5.52***	6.40***		
7. Evacuation centre	5.81	5.54			

***$p \leq 0.005$

SUMMARY: IS A PICTURE WORTH A 1000 WORDS?

1) UNDERSTANDING

Map is better than text for…

- Assessing distance
- Understanding complex directional information
  (e.g. the active fire edge, wind direction, and their synergistic impact for one's location)

Map does not outperform text, but is not worse than text, for…

- Associating oneself with a warning area
- Identifying temporal change
  (e.g. impact of current vs. forecast wind)

2) RISK PERCEPTION

Map can elevate risk perception, especially likelihood

3) EFFICIENCY

Map is not significantly more efficient than text

Except for associating oneself with a warning area

SUMMARY: IS A PICTURE WORTH A 1000 WORDS?

4) SUBJECTIVE RATINGS

Map is predominantly favoured by participants

Contradicting the mixed results from the objective testing

5) POTENTIAL COMPLICATION OF USING MAPS

Enhanced spatial specificity may lead to 'complacency' of individuals

a) Communicate 'correct' and accurate information with timely updating

b) Coupled with push-alert when information is updated

c) Require adequate prior education

THE MOST EFFECTIVE DESIGN

Information Elements	The most effective design (out of the tested candidates)	Critical text descriptors
1. Fire origin & perimeter		Road/park names
2. Fire control status		'out of control'
3. Wind (current and forecast)		Wind direction and timing of wind change
4. Fire spread prediction		Rate of fire spread speed
5. Fire alert		Suburbs names
6. Road closure		Road names
7. Evacuation centre	An evacuation centre has been opened at Roleystone Neighbourhood Family Centre at 19 Wygonda Rd, Roleystone.	

TAKE-HOME MESSAGES

- Maps have great potential in improving warning outcomes.
- But some text descriptors are also critical.
- Therefore hybrid system may be the best approach. Interactive web mapping applications should be deliberately designed to effectively incorporate and present the important visual, textual, spatial and aspatial information elements.
- The key design principles (for content, presentation and functionalities):
  - Self-explanatory & easy to use
  - Iterative user-centred design process
- **On top of these, agencies need to build up data capacities.**

THANK YOU

Yinghui (Cathy) Cao

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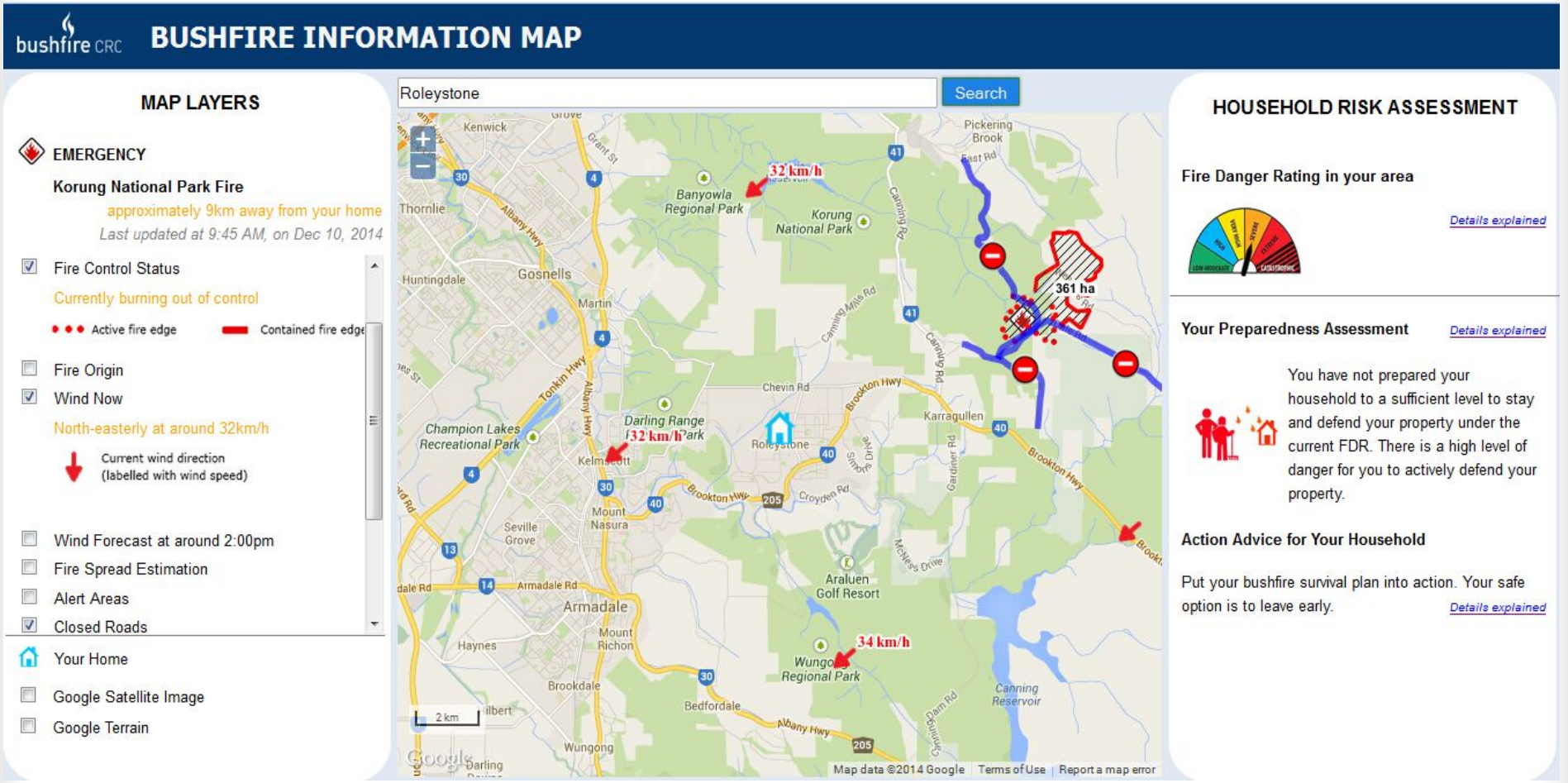
Acknowledgements

This work is a part of a PhD project supported by the former Bushfire Cooperative Research Centre and the current Bushfire and Natural Hazards Cooperative Research Centre in Australia, the University of Western Australia, Austraining, and Department of Education, Employment and Workplace Relations (Australia).

Thanks go to all the community members who generously contributed to the survey and interview!

A PROTOTYPED BUSHFIRE INFORMATION MAP TOOL



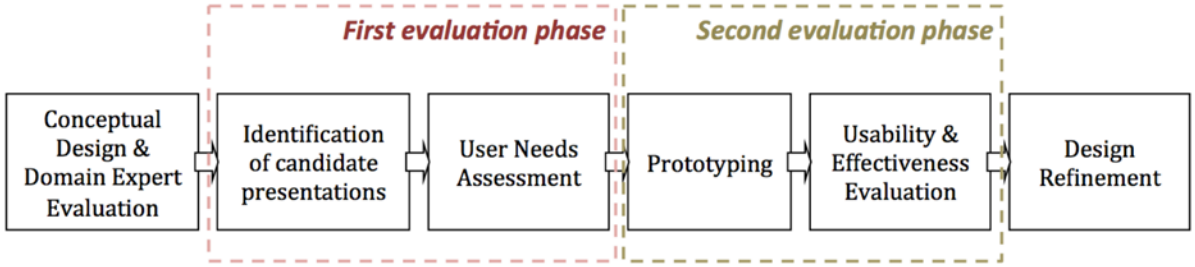
OVERALL OBJECTIVE OF THE PHD PROJECT

Designing an effective web-mapping tool for bushfire early warnings by addressing the following questions:

i) what information should be communicated?

ii) how to effectively present the information in the form of maps?

iii) how to design the interactive web map interface?



The user-centred research workflow