Natural Hazards Research Australia

PREDICTIONS IN PUBLIC UNDERSTANDING THE DESIGN, COMMUNICATION AND DISSEMINATION OF FIRE SPREAD PREDICTION MAPS TO THE PUBLIC

Work Package 8: Focus Groups

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We acknowledge the Traditional Custodians across all the lands on which we live and work, and we pay our respects to Elders both past, present and emerging. We recognise that these lands and waters have always been places of teaching, research and learning.

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Executive summary

Research in Australia has been conducted on the public's response to risk and warning communication (Dootson et al. 2019, 2021). However, less research effort has focused exclusively on maps, and even less has focused on fire spread prediction maps and the Australian context. The purpose of the research reported here is to explore how community members comprehend, use, perceive, and intend to act upon fire spread prediction maps, in bushfire events. Building on previous work in the *Predictions in Public* research project, including interviews with communities impacted by bushfires and their use of maps (Work Package 4), a nationwide survey of maps currently used in Australia, across all States and Territories (Work Package 5), research that co-designed evidence-informed map concepts for fire spread prediction maps (Work Package 7), and a nationwide survey examining comprehension of those fire spread prediction maps (Work Package 9), a series of focus groups were conducted to explore participants' underlying perceptions of risk, uncertainty, their comprehension of the maps, and what actions they would intend to take.

Six focus groups were run across three States in peri urban and regional areas of each State: Western Australia (Roleystone), South Australia (Mount Barker), and Queensland (Esk), with a total of 34 participants. Each focus group ran for 90 minutes, was audio recorded, and was professionally transcribed. The moderator's guide used in each focus group was divided into four parts. In Part One, moderators provided a welcome, introduction, and background about the funded project. Part Two involved testing the first set of stimuli, including a video introducing the fire spread prediction map and the map itself. The first video and map seen by the focus group participants was based on a simulated bushfire scenario in the location where the focus group was being held. This constituted the 'familiar' map. Participants were then asked questions about their comprehension of the familiar map, attitudes, risk perceptions, emotions, protective action intentions, and expectations and preferences. Part Three replicated the process and questions of Part Two but used a video and map of a simulated bushfire scenario in another location. This constituted the 'unfamiliar' map. Part Four involved researchers providing an explanation of next steps with the data collected.

The set of stimuli used in the focus groups was co-designed by the research team and the project's Steering Committee members. The video involved a local public information officer or agency staff member reading a co-designed script to camera, introducing the fire spread prediction map, and contextualising the bushfire scenario. This replicated what might be seen in a press conference or what might be disseminated via social media. The information provided on the fire spread prediction maps used in the focus groups varied slightly depending on the operational context in which the scenario was located. Two of the fire spread prediction maps tested overlaying warning areas onto the predicted fire spread, while one map displayed only the predicted fire spread. The predictions on all the maps involved predictions over three time frames (e.g., predictions for 0-3 hours, 3-6 hours, and 6-9 hours for South Australia map and predictions for 0-6 hours, 6-12 hours, and 12-24 hours for the Queensland and Western Australia maps). The script and maps used in the study are provided in Appendices 2-5.

The sample comprised participants over 18 years old, of which, 44% were female, and 56% were living in an area on the map used in the focus groups, with the remaining 44% residing in a nearby area. Sixty-two percent of the sample were employed (versus homemaker, student, unemployed, or retired). At various points during the focus groups, participants described having direct or vicarious experience with bushfires. A summary of the findings is provided below.

Attention. Participants attention was first drawn to the use of the colour red on the map, leading to some initial inaccurate interpretations of red as a representation of where the fire is currently burning. Attention was also paid to (in no particular order): the threat of a bushfire (i.e., its scale, the danger, the imminency of it), the evacuation routes and centres and thoughts about how to navigate away from the affected area, the presence or absence of road closure information that could support navigation away from affected areas, the locations where participants resided if the map was local to them, and the temporal elements of the map and bushfire scenario (i.e., time of map issuance, time to impact for three fire spread predictions). The map element that

first drew their attention typically anchored how they interpreted the rest of the map, for example, the colour red inaccurately representing an incident area. As some participants missed noticing the fire front and/or the burnt area on the maps, participants raised the importance of better highlighting where the fire has been, and where it is now, to support community interpretation of the predicted fire spread depicted on the map.

Comprehension. Broader understanding of the intent of the map first required participants to comprehend numerous elements on the map. Elements such as evacuation routes, evacuation centres, and base map elements like roads, suburbs, rivers, and vegetation, were typically understood across the focus groups. Road closures were only understood in one map that labelled them 'outbound traffic only'. The technical terms used for 'incident area' and 'fire incident' were not as easily understood as 'burnt area' or 'active fire front'. Technical elements of the base map such as topography and other geographical features were not universally understood by the participants on familiar and unfamiliar maps, which had a secondary impact on their interpretation of the shape and direction of the predicted fire spread, for example, does it make sense the fire would move in this direction based on the hills present/absent on the map. Finally, the warning areas and fire spread predictions were not always seen as distinct map elements with separate purposes. While there was understanding of what the warning areas were communicating as participants were familiar with them from past bushfires, sometimes this familiarity was incorrectly transposed to the predicted fire paths. For example, sometimes the predictions were referred to as "essentially a Watch and Act area". Some participants understood the intent of layering the warning areas over the predictions, while others believed it was too much information, making the map hard to understand.

Uncertainty. When exploring whether the participants believed the fire would spread as predicted, participants acknowledged that the modelling used the best available science, was prepared by experts in the fire agencies, and in the absence of conflicting information, the model was trusted. However, the certainty that the fire would spread as modelled on the map was dependent entirely on the participants' understanding of how inherently unpredictable the weather can be, especially changes in the wind. Wind was a critical component to assessing the certainty of the predicted fire spread. The spread of the fire during the initial time frame depicted in each map (e.g., prediction for 0-3 hours/0-6 hours) was perceived as more likely to occur as modelled, than the predicted spread in the second- and third-time frames (e.g., predictions for 3-6 hours/6-12 hours, 6-9 hours/12-24 hours). The difference in certainty of the fire moving as predicted across those three time frames was because participants believed there was less time for changing weather conditions in that initial prediction, especially the wind, to alter the trajectory of the fire. There was more uncertainty around whether the spread would occur as predicted during the second- and third-time frames because of greater potential for weather (and wind) changes. Participants expected there would be updates as weather conditions evolved and subsequently changed the shape and direction of the fire's spread during the second- and third-time frames. Further, the more specific the prediction appeared to be (e.g., more jagged lines, peninsula shapes), the more accurate and certain the prediction was perceived to be.

Risk perceptions. Explorations of how much risk people felt based on where the research team had located participants on the map surfaced a complex suite of insights. Risk perceptions were very personal and shaped by multiple combinations of their experience of bushfire previously, their understanding of bushfire behaviour, their confidence in map reading, their location on the map, whether the map was of a familiar area, and some design elements of the map. Cumulatively, these factors shaped perceptions of uncertainty, which led to a perception of risk. For example, where there was higher perceived certainty of the fire progressing as predicted, there were also higher levels of perceived risk. All participants acknowledged that there was a risk of bushfire across all the maps they viewed, however, the difference was in the degree of risk, which was typically related to time frames. Where there was a shorter time frame to predicted impact, there was a higher level of perceived risk. In these shorter time frame scenarios, the question was about *when* the fire would reach the participants. Participants raised the same question (i.e., *when* the fire would arrive) when they were located on the map inside the fire's predicted spread. Whereas slightly longer time frames typically led to lower levels of perceived risk as the question became not *when* the fire would reach them but *if* the fire would reach them,

before weather conditions changed the direction of the fire or the response teams would get the fire under control. These same insights were held when participants were located on the map at the edge or just outside of the predicted fire spread with a question of *if* the fire would reach them, weakening risk perceptions for some participants.

Protective action. For maps that overlayed the warning areas on the fire spread predictions, intended actions discussed by participants included those aligned with the 'Watch and Act' and 'Emergency Warning' warning levels as outlined by the Australian Warnings System. However, when viewing a map without the warning areas, participants indicated taking actions similar to those under a 'Watch and Act' warning. This reflected some misunderstanding of the intent of the fire spread prediction map, which is arguably to trigger further information seeking. When the focus group moderator pointed to different locations on the map for participants to comment on, participants were more likely to evacuate when the risk was more imminent, which typically meant when they were in a 'red' area (i.e. the first predicted fire spread or Emergency Warning area overlayed on the first predicted fire spread). Some participants were more likely to be preparing (to defend or evacuate) when they were located inside the predicted spread of the fire during the third time frame or just outside it. While others, at the same locations, were waiting. When exploring what would motivate those waiting to then act, some were waiting for environmental cues (e.g., smoke, flames), others were waiting for an update to the map, and some were waiting for a direct engagement with emergency services. When participants viewed a map of a location unfamiliar to them, they were more likely to state that they would prepare to leave or just leave straight away, with fewer caveats than if they were located on a map familiar to them. The unfamiliar location typically meant participants felt little reason to stay and believed they should mobilise faster to get out of the way of locals who may need support during the bushfire.

Map expectations and use. There were mixed intentions to seek out and use a fire spread prediction map, which typically reflected participants' existing use of incident warning maps. Some found the fire spread prediction maps more helpful than the incident warning maps (i.e., maps that only showed the warning areas), as they preferred the temporal nature of the map, using time to guide their preparation and evacuation/defence. Participants all expected to find these maps on official agency channels while acknowledging that digital access cannot be the only way to access it, and TV or radio stations had an obligation to share the information for certain members of the community. All expected the map to be updated frequently and as the situation changes. None expected to receive the map at a community meeting, citing the situation modelled on the map as being too late in an event to hold a community meeting[1]. The participants indicated the value of having someone explain the map when it is released to the public (e.g., agency representative explaining it on TV or social media channels). There were also calls for making the map dynamic, with the ability to see wind and toggle between information that is relevant to them to meet their individual informational needs.

The results from this study will be combined with the other work packages in the *Predictions in Public* research project to cumulatively underpin the future design of maps for use in the public information and warnings milieu in Australia, under the Australian Warning System. This report should not be read in isolation to other work packages in the research project.

[1] Also, no one indicated they would attend a community meeting during a fire, but they might do so in preparation season. However, in a previous piece of work (Work Package 4), interviewees indicated they were interested in attending community meetings.

End-user statement

Simeon Telfer, Strategic Operations, South Australian Country Fire Service, South Australia

Communicating complex information to members of the public during bushfires is a critical responsibility of fire agencies in Australia, and indeed the world. However, uncertainty in fire predictions is difficult to convey while keeping a simple and effective message to the public. The *Predictions in Public* research project is an exciting chance to test the effectiveness of maps, messaging and other communications in a detailed and systematic way. The project team have engaged regularly with end-users and participants, to an extent rarely seen in research projects. This high level of engagement has led to tailored workshops which replicate fire scenarios and elicit a huge wealth of data about members of the public's understanding of information provided during an emergency. The outcomes of this research will have direct and profound influence on the way fire agencies display predictions on maps, websites and other forms of communication.

Introduction

This research is a component of a wider program of research called *Predictions in Public: understanding the design, communication and dissemination of predictive maps to the public*[2]. The overall aim of the three-phase research program is to optimise fire spread prediction map design, dissemination, and communication to ensure that these maps will support community protective action decision-making during a bushfire.

The research program objectives are:

- **Objective 1:** To understand how members of the fire and emergency services sector would prefer predictive maps to be distributed and used by members of the public.
- **Objective 2:** To understand how members of the public use, comprehend, perceive, and take-action in response to existing predictive map designs and other types of maps used by agencies across Australia.
- **Objective 3:** To develop a set of evidence-based guidelines/principles for the design and dissemination of predictive maps to the public based on existing research on hazard mapping.
- **Objective 4:** To work with the fire and emergency services sector to develop practical project outputs to translate the research findings into fire agency policy and practice.

The research program has three phases:

- **Phase One:** Existing agency use and public awareness of predictive service products in public information and warnings
- **Phase Two:** Standardised design, dissemination, and communication for predictive maps
- **Phase Three**: Communication, evaluation, and learning framework

The research project reported here addresses Objective 2. The intended audience for this report is the project team, the Steering Committee, and agency staff involved in map production and disseminating public information and warnings.

[2]Find more information here: https://www.naturalhazards.com.au/predictions-in-public

Background

Research in Australia has been conducted on the public's response to risk and warning communication (Dootson et al., 2019, 2021). However, less research effort has focused exclusively on maps and even less has focused on fire spread prediction maps. While some studies have focused on the public's response to general bushfire map design (Cao et al., 2016, 2017; Cheong et al., 2016), currently missing from the literature is a clear understanding of how Australian community members use, comprehend, perceive, and act upon maps, including fire spread prediction maps. Foundational research has recently been conducted in New South Wales after the 2019–20 Black Summer Bushfires (Whittaker et al., 2020); however, data for other Australian jurisdictions is currently lacking. The Australia Institute Disaster Resilience (AIDR) Public Information and Warnings Handbook (AIDR, 2021), which is national doctrine guiding the design of warnings and public information, is currently limited in its advice on the use of maps. To date, only broad information about what a map needs to include (e.g., location of hazard, route closures, prediction) and the use of a legend and consistent symbols and colours, is recommended. We believe that findings from this research program will cumulatively provide greater detail on how maps, including fire spread prediction maps, should be designed, communicated, and disseminated under the new nationally standardised approach to public information and warnings required by the implementation of the Australian Warning System[3].

Maps are just one visual tool in the public information and warnings milieu. Visuals help convince people of the risk associated with a hazard and whether any protective action should be taken (Liu et al., 2020; Morss et al., 2018). Visuals are a critical part of that information mixture, bringing order to the uncertainty the community experiences by documenting the event; communicating the possible risk, impact, and severity of the event; and showcasing the desired action(s) and action(s) of others (Liu et al., 2020; Morss et al., 2018). Often paired with text-based content, visual media help anchor text meaning and make the relevant information more salient, trusted, and easier to interpret and remember (Mortensen et al., 2017; Zhao et al., 2018). Photographic visuals can effectively capture 'the totality of the event' (Mortensen et al., 2017, p. 221), with users perceiving visuals to be a truthful representation of reality in that moment (Feldman & Hart, 2018).

Maps are a specific type of visual that offer a representation of an emergency or hazard event, such as a bushfire, to assist agency planning and/or response operations (e.g., Fiedrich & Zlatanova, 2013) and community sense-making and protective action decision-making (e.g., Cova, 1999). Where maps are not provided or are inaccurate, they can put emergency management workers as well as those in the community that they are assisting in harm's way (Dwyer, 2022). While reliance on maps used for emergency communication has increased, studies suggest that the format, content, and accuracy of emergency maps vary, which implies that there is scope for improvement in the development, design, and dissemination of these maps (Cao et al., 2016; MacPherson-Krutsky et al., 2020).

Previous work in this research program has developed a series of map design and dissemination principles that will be iteratively tested and revised throughout the life of the project. A critical element to good practice map design and dissemination, however, is to consider the recipient's cognitive processes and comprehension when viewing and interpreting a map (Cao et al., 2016; Lindell, 2020). To do so, we draw on the protective action and decision-making model (Lindell & Perry, 2012) to examine the extent to which the community are exposed to maps in use across Australia during bushfires, how well they grab attention, and the extent to which the community comprehend what the map is communicating about the hazard and the associated risk. Further, the research seeks to understand the extent to which a map can signal threat and inform protective action intentions by influencing map users' risk perceptions. These risk perceptions then form the basis for decisions about how to respond to an imminent or long-term threat. The outcome of the protective action decision-making process, together with situational moderators and impediments, produces a behavioural response

[3] See for more information: https://www.australianwarningsystem.com.au/

(Lindell & Perry, 2012, p. 616) comprising further information-searching, emotion-focused coping, and/or protective action.

Research approach

This research was conducted in Australia for bushfire hazards, one of the deadliest hazards in the country (Royal Commission, 2020). Bushfires are events with imminent threat, requiring timely execution of advised protective actions to avoid immediate negative outcomes (AIDR, 2018). The research aim was to explore how community members comprehend, perceive risk and uncertainty, intend to act on, and expect to use fire spread prediction maps. The data were collected in July-August 2024. The research was designed in close collaboration with agencies across Australia, including: Queensland Fire Department (QFD), New South Wales Rural Fire Service (NSW RFS), Australian Capital Territory Rural Fire Service (ACT RFS), Country Fire Authority Victoria (CFA VIC), Emergency Management Victoria (EMV), Tasmania Fire Service (TFS), South Australia Country Fire Service (South Australia CFS), Western Australia Department of Fire and Emergency Services (DFES), and Northern Territory Bushfires NT. Representatives from these agencies form the Steering Committee guiding the project design and utilisation.

Recruitment and respondents

Six focus groups were held in three peri urban and regional locations across Australia (Esk, Queensland; Roleystone, Western Australia; and Mount Barker, South Australia). Participants were recruited through Q&A Market Research for each of the locations. The sample included 34 participants (N=34; approximately 6 per focus group) over 18 years old, with 50% between 18-59, 44% female, 56% were living in an area on the map used in the focus groups, with others living nearby, 62% were employed, 23% retired. Participants received an incentive for participation in line with Q&A Market Research policy. One participant had experience as a volunteer with a fire brigade. While it was not required for participants to have had bushfire experience, during the focus groups, participants discussed their experiences with bushfires in the past (personally or vicariously), and some of that experience was in the location where the focus group was being held or on the map used in the focus group discussions.

Design and stimulus

The focus groups were designed to explore how community members understood, perceived, intended to act upon, and expected to use fire spread prediction maps. Three maps were tested across the six focus groups in the three locations. Each focus group lasted 90 minutes. The focus group moderator guide comprised four parts: Part One – introductions, Part Two – Familiar Map Stimuli, Part Three – Unfamiliar Map Stimuli, and Part Four – next steps discussion. Parts Two and Three followed the same process of data collection. First, each focus group was shown a 90-second video of a Public Information Officer or agency representative introducing the first map that participants would examine together. This was a familiar map, showing a fire spread prediction in their local area. Then, participants were handed the map and asked to silently study the map for one minute. Next, the moderator took participants through questions about what drew their attention on the map, their comprehension of the map, perceptions of risk and uncertainty, protective action intentions, and feedback on the map (Appendix 1). These questions reflected those asked in the interviews with community members in Work Package 4 of the *Predictions in Public* research program. This process was repeated for a second video and map showing a fire spread prediction in a different jurisdiction to where the focus group was being held, constituting the 'unfamiliar map'.

The script used in the video was co-designed by the research team and the Steering Committee using transcripts from past press conferences, text from past dissemination and communication of a fire spread prediction map, and the agencies' communications teams. Once the base script was endorsed by the Steering Committee, each jurisdiction added the information (e.g., road names) relevant to the scenario they were

testing in their jurisdiction. Agencies then recorded a video of their Public Information Officer reading the script to camera with a relevant bushfire/agency background visible. See Appendix 2 for the script.

The fire spread prediction maps were designed in close collaboration with Western Australia Department of Fire and Emergency Services (DFES), South Australia Country Fire Service (South Australia CFS), Queensland Fire Department (QFD)[4] and the *Predictions in Public* research project team. The maps were designed using scenarios and modelling provided by each of the three jurisdictions. Consistent design elements were used across each map; while allowing for operational differences (e.g., preferred terminology). Validation and endorsement of the stimuli and moderator guide was provided by the broader project Steering Committee prior to data collection. See Appendices 3-5 for the maps tested.

Data analysis

The focus groups were audio recorded and then transcribed by a Pacific Transcription. Participants were anonymous in the transcriptions. The transcriptions were entered into Nvivo v14 software for analysis. Thematic analysis was undertaken using a predefined coding framework. A coding framework was developed using past qualitative work in the *Predictions in Public* research project, including interviews (Work Package 4) and qualitative insights from two national surveys (Work Packages 5 & 9). The themes included in the coding framework evolved during the analysis process. A finalised coding framework was established after coding was completed from one focus group by two researchers. The finalised coding framework was then utilised for the remaining focus groups. Archetypal quotes from participants that explain and illustrate these themes were identified and recorded for each theme. Overall, the analysis was interpretive, meaning we drew on descriptive, analytical, and inferential coding processes.

In this report, we present the findings from this analysis, exploring how participants interpreted and comprehended the fire spread prediction maps, their attitudes towards the maps, their risk perceptions, emotions, perceptions of uncertainty, their intended actions, and their expectations and preferences related to using the maps in the future.

Ethics clearance

The QUT ethics approval number for this research project is LR 2024-8647-19896.

[4] The stimulus used from Queensland Fire Department was developed prior to their name change and as such refers to Queensland Fire and Emergency Services (QFES).

Findings

In this section we provide the findings from the focus groups across the following themes of (i) attention, (ii) comprehension, (iii) perceived uncertainty, (iv) perceived risk, (v) protective action, and (vi) map expectations and use.

To frame the findings, one participant articulated an ever-present tension agencies face when releasing information to the public during an emergency:

> *"I think the difficulty is litigation. Like people complain that it's a nanna state and we shouldn't be told what to do, but when there's a fire or a flood, we're desperate for people to tell us what to do. Then a thing like this comes out, and maybe that doesn't happen, and that person will say, well, you told me not to get out, or, you told me I wasn't in a danger area. So I think you've got to be really careful who gets these things, and how they're going to use them."* (Queensland FG2, both maps, Female)

The findings presented below offer insight into how the community might interpret and use these fire spread prediction maps and the implications for map design, dissemination, and communication. However, findings need to be triangulated with insights from the broader *Predictions in Public* research project as they are only one data point on a complicated topic of communicating risk and uncertainty and its implications for offering a new product to the public in the public information and warnings milieu in Australia.

Attention

Once participants had watched the video introducing the bushfire scenario, and then taken time to look over the map, they were asked what first drew their attention on the map. The most common elements of the map that initially drew participants' attention were: colour, closely followed by the hazard, then evacuation, self-localisation, road closures, and the time frames.

Colour was repeatedly acknowledged as what first drew their attention, specifically, the colour red. For each of the maps, red was the colour used for both the predicted spread of the fire over the first time frame [0-6 hours (Western Australia and Queensland map), 0-3 hours (South Australia map)] and for the Emergency Warning area (Western Australia, Queensland maps) overlayed on the predicted fire spread. The comment about the colour red drawing their attention first was immediately followed up by some verbalised interpretation of what the colour red could mean, with or without consultation of the legend. Some indicated they interpreted the red to broadly mean there was danger. Others interpreted red as where the fire was 'currently burning', despite the active fire edge and incident areas being marked with different colours and symbology.

> *"...main red part there because obviously, that's the centre of the fire, ...and the rest seems to be like obviously danger and just expanding out from that."* (Western Australia FG1, familiar Western Australia map, Male)

> *"...that's what I thought too, that the red was where it was already burning, and the black was just this is where it might be. But...that was the first thing I saw... the great big colour, bang, right in the middle of the map."* (Western Australia FG2, familiar Western Australia map, Female)

Having this initial, incorrect interpretation of the red colour as where the fire was currently burning sometimes led to participants to disengage or not accurately interpret what the active fire edge and incident/burnt areas were on the map and legend. Some participants self-corrected once a discussion was had about these elements of the map later in the focus groups.

Various evacuation elements were also discussed as having caught their attention when viewing the map. Participants either indicated that the evacuation centre and or the evacuation route marked on the map was

what initially drew their attention. On a map that did not provide evacuation routes or centres, if a participant indicated an urgency to evacuate the area, and they were unfamiliar with the area, they followed up with comments around not knowing where to go:

> *"There's no evacuation route. Like, where do they want me to be?"* (Queensland FG1, South Australia unfamiliar map, Female)

In maps with road closures or Vehicle Control Points marked on them, some participants said these drew their attention as it related to how they would get out or navigate their way around the fire. Others said road closure symbols first drew their attention as there were a lot of them placed on the map:

> *"The first thing I noticed was the road closure...and how many there is"* (South Australia FG2, familiar South Australia map, Male)

> *"...there's an awful lot of road closures and there really is only, again, one or two roads out"* (Western Australia FG2, Queensland unfamiliar map, Female)

Self-localisation also drew the attention of the participants. Some participants, if they could immediately see their home on the map they were viewing, stated that was what initially drew their attention:

> *"I think I'm going to lose my house."* (South Australia FG2, familiar South Australia map, Male)

> *"It's close to my house and my sister's house"* (South Australia FG2, familiar South Australia map, Female)

Others went on to state that what first drew their attention was that they were not in the affected area:

> *"Funny, my first thought was quite the opposite of yours. I'm way over here. So although I notice it's a bad area, but the immediate thought was, okay, yes, I'm not in any immediate danger."* (South Australia FG2, familiar South Australia map, Male)

The temporal nature of the event also drew participants' attention. This comprised comments about *"the tight time frames"* (Queensland FG1, South Australia unfamiliar map, Male), how fast the fire appeared to be moving, how much time until the fire was expected to arrive (i.e., first prediction time frame), and how much time they felt they had to act:

> *"I can see where we are, where the fire is, where you need to be careful and where you need to be careful later."* (Western Australia FG2, familiar Western Australia map, Male)

Finally, it was not always a singular element of the map that initially drew their attention. Some participants indicated that all the elements presented on the map drew their attention, leaving them to feel overwhelmed or confused: *"I thought, ok there's a lot of things to look through"* (Queensland FG1, familiar Queensland map, Female); or that they immediately felt they had to leave: *"Get me out"* (South Australia FG1, familiar South Australia map, Female).

After exploring what initially grabbed their attention on the map, the focus groups explored the participants' level of comprehension of the map and the elements within it.

Comprehension

Immediate interpretations of the map ranged from a straightforward understanding of *"there's a big fire in the middle of the forest"* (Queensland FG1, familiar Queensland map, Female), to a more considered, detailed interpretation of the map: *"right now, it's trying to show the possible location where the fire's going to go and the most dangerous section of the fire"* (Queensland FG2, South Australia unfamiliar map, Male). The diversity in accurate and nuanced interpretations of the intent of the fire spread prediction maps was potentially due to

there being a significant number of map elements that required comprehension before an overall comprehension of the intent of the map could be established. The elements in the map discussed by the focus group participants comprised the legend, base map, burnt area, active fire edge, evacuation information, information source, road closures, scale, text provided around the map, warning areas, predicted fire spread, and at a more abstract level, the symbols, shapes, and colours used in the map, which may reflect one or more of the former map elements listed. Insights for comprehension of each of these map elements are provided below.

Legend (including text provided around the map, scale, sources of information)

While not everyone engaged systematically (at length, paying attention to detail) with the legend when they first saw a map to interpret what was on the map, some participants did move their finger across from the legend to the map to unpack all the information. The divergence in, reliance on, and engagement with the legend within and across the focus groups was observed when a participant would make a comment about a specific element (e.g., the active fire edge) and other participants would need guidance from one another to find that information in the legend and then on the map.

As each map provided slightly different information in the legend and in a different order, participants indicated their preferences for the legend to include (a) exact symbols or shapes in the legend as what is modelled on the map, (b) non-technical language, and (c) a prioritisation of information. Commentary about the exact shapes and symbols arose for the Queensland and Western Australia maps where warnings and predictions were overlayed and it was hard to differentiate between the two:

> *"Yeah, so if you look under bushfire warning areas, and when we were talking about the Esk map, I don't know if everybody else had the same feeling, I couldn't figure out what the actual rectangle was, because I didn't think it was on the legend. But that's not true. It is on the legend. It's under bushfire warning area, but the reason I didn't connect it was because it's not a bloody rectangle."* (Queensland FG1, familiar Queensland map, Female)

This was one example of where misinterpretation of something in the legend derailed the rest of the participants' understanding of the information presented in the map.

> *"I just don't like how long it took me to figure out what it meant, because it took like an hour and a half for me to really figure out the boxes."* (Queensland FG1, familiar Queensland map, Female)

There was a preference for non-technical language in the legends, for example, 'area burnt' or 'burnt area' were more intuitive terms than 'incident area' to describe where the fire had already burnt. Similar reactions were made about road closures and Vehicle Control Points. Participants indicated that 'outbound traffic only' was a more intuitive term for inclusion in the legend to explain the road closure symbols on the map. The legend was also the place participants expected to find sources for where they could find out more information about the fire, what action to take, and where updates would be. The inclusion of clear links to where the community can find additional information about the fire is especially important when they are in an unfamiliar area (e.g., when travelling).

When it came to other text around the map, either in the legend on the left-hand side or below the map, limited attention was paid to disclaimers, the amount of area burnt, the source of the map, and data inputs to generate the map, unless the moderator brought it up for explicit discussion. More attention was paid to the information sources, the timing of predictions, and the scale for the map. Those participants who came across as having a reasonable understanding of reading maps, based on their ability to voluntarily describe geography, topography, and elements shown in the base map, were more likely to utilise the scale to make inferences about the size of the fire (now and as it progresses) and to assess how far away they were located from the active fire edge and the different fire spread predictions.

Finally, there was agreement that the ordering of information in the legend had an impact on what initially drew your attention and how one comprehended the information in the map:

> *"I think the other thing I noticed as well, just when you guys were pointing it out, is you were referring to the different times of the different shades of the reds, being like, it could arrive as this, this, this. I think the reason, potentially, that you missed it the first time is because that's at the bottom of the legend (Queensland map), whereas on this one (South Australia map), it's at the top of the legend. So I think the legend should...reorganise what comes first on the legend."* (Queensland FG1, comparison of maps Queensland and South Australia, Female)

Regarding the prioritisation of the information in the legend to support comprehension, there was no consensus on what that prioritisation should be. However, the active fire edge and where the fire had burnt appeared to be a natural starting point for interpreting the fire activity. Road closures and evacuation information were often discussed together, suggesting that information should be presented close together on the legend as it is used as a tool to assess how to get out of danger. There was little agreement on whether the warning areas or the predictions should appear first on the legend, for maps that contained both layers (Queensland and Western Australia maps). Preferences for what came first in the legend typically reflected the individual participant's preference for using the warnings versus the predictions to guide their understanding of the threat and what action to take next.

Burnt area and active fire edge

The map elements of burnt area (Queensland map)/area burnt (South Australia map)/incident area (Western Australia map) and the active fire edge (Queensland and South Australia maps)/fire incident (Western Australia map) were considered related pieces of information when comprehending the maps. They were also sometimes misunderstood. The initial reason for misinterpretation was technical language. In the Western Australia map, 'incident area' and 'fire incident' were used and not understood as clearly or as quickly as when participants saw a 'burnt area' or 'area burnt' and 'active fire edge' labels on the Queensland and South Australia maps:

> *"I do like the active fire edge, and I also like the fact that the burnt area is labelled burnt area not fire incident or whatever it was on the other one. I like that."* (Western Australia FG2, Queensland unfamiliar map, Female)

Another driver for not understanding what the 'black area' (burnt area (Queensland map)/area burnt (South Australia map)/incident area (Western Australia map)) was on the map, was because of the legend. Some participants could not connect the black hatched area on the map to what it looked like on the legend. Once the 'black area' had been located and understood to represent where the fire had already burnt, the next misunderstanding came from either a lack of bushfire experience or bushfire knowledge, where participants perceived that area to be 'safe' and maybe somewhere they would go to, to get out of the fire path because the fire had already been there:

> *"...because fire can't burn things that are already burnt, so it's better to go through the burnt part than it is to go in the direction of where the fire's going".* (Queensland FG1, South Australia unfamiliar map, Female)

Others in the focus group corrected this misconception and explained that there was still risk of embers and the fire reigniting. Not all participants understood the embers and the threat they posed despite it being an important piece of hazard information that can shape an understanding of how the map is designed:

> *"The guy on the video said something about spot fires, and we're not even - we haven't even talked about those, because even though this is burned out over here, it's still burning to a degree." (*Queensland FG1, both maps, Female)

Another point of confusion was with the Western Australia map's use of a black and white fire symbol to represent the fire front and where the fire was currently:

> *"...in this map, I actually appreciate having the active fire edge." ..."Oh, that's a good - yeah, absolutely. You don't know where it is at that point in time."... "I took it to be that black..." ..."Yeah, is that that black...with the white; is that what that means?"* (South Australia FG1, unfamiliar Western Australia map, multiple participants)

As mentioned under the 'Attention' section of the Findings, most confused the red Emergency Warning area and/or the red predicted fire path as where the fire was currently located, which caused participants to miss looking for the 'active fire edge' in the legend. Putting it up the top with the 'burnt area' symbol in the legend might draw people's attention to their incorrect interpretation of the red on the map. Only a few participants were able to quickly and easily locate the active fire edge. Most required assistance to find it from others around the focus group table.

> *"Yeah, but now that I can - now that I've done it, next time, it would be obvious if that makes sense?"... "That's a good point. It didn't jump out at me either those dots and red marks."* (South Australia FG1, familiar South Australia map, multiple participants)

Ultimately, the community needs to be able to find where the fire is currently burning to understand the fire spread predictions and understand the boundaries of the affected areas.

Evacuation information

Both the Queensland and Western Australia maps included an evacuation route(s) and an evacuation centre on the maps. Participants accurately understood the routes to be a guide of how to leave the affected area and how to reach safety at the evacuation centre.

Participants discussed how including one or two evacuation routes could be a way for agencies to guide traffic around the affected areas, but *"there's going to be a lot of congestion"* (South Australia FG1, unfamiliar Western Australia map, Female). Some participants explained their experience with congestion in past bushfires:

> *"...and we're talking about the congestion of cars trying to get out of an area, you only need an accident and everyone's stopped, stuffed into - it's about I guess education as well as the people because that is right on the edge of a massive population area now and I happened to be in Bridgewater in the '80s when those fires came through. To have this knowledge, it would be great because no one knew much about what was happening then."* (South Australia FG1, unfamiliar Western Australia map, Male)

No participants commented on why this evacuation information was provided in the Queensland and Western Australia maps (overlayed warnings and predictions) but not the South Australia map (predictions only). Comments were made, however, on preferences for including this evacuation-related information, especially in unfamiliar areas. This might suggest the participants did not perceive a fundamental difference between the purpose of the layered maps and the fire spread prediction map as it related to evacuation guidance.

Road closures

Building on the commentary about road closures from the legend findings above, road closures were a broadly welcomed map element to guide participants' understanding of where the risk was and how they could navigate themselves away from the affected areas. In the South Australia map where the symbol was a circle and a cross and the legend stated it was a 'road closure', participants spent time discussing whether they

should interpret that as the entire road being closed or whether outbound traffic would be allowed through to filter people out of the affected area while deterring people from entering an affected area.

One participant explained to the group the reason for a road closure on the South Australia map, demonstrating an understanding of bushfire behaviour:

> *"Within 500 – your head is getting smacked with embers and crap and crud and everything else that you can think of. If you're on a road there, you won't see anything. So if you've got a lot of burning embers going, the road's closed because you can't see anything. The smoke will be various colours, from dark brown to black to gold. It'll tumble. [Watch it change] with four or five different colours of [unclear] and watch that tumbling. That's what bushfire smoke will do. Other bits will just come at you, just be different colours hitting your window. It's closed because you won't be able to see that fire in front of you."* (South Australia FG1, familiar South Australia map, Male)

Some participants across all the focus groups indicated they assumed road closures to mean they could always get out of an affected area but not into an affected area. Others were concerned about where they would find information about why it was closed (e.g., was it a tree over the road, were police there, was it still closed, etc.). For participants viewing the Queensland map, they welcomed the clarity of the road closure being marked as 'outbound traffic only'. However, the other symbol on the map was a Vehicle Control Point, which participants seemed unsure of: *"what exactly does a Vehicle Control Point involve?"* (Western Australia FG2, Queensland unfamiliar map, Female), especially when they were not from Queensland. Some inferred it was a point where *"police are situated"*, *"to deter people using the roads"*, or *"to stop people from going in"* (Queensland FG1, familiar Queensland map, various participants).

For the Western Australia map, where road closures were not incorporated into the map design, participants commented they would rely on Google maps in lieu of not knowing where to go for information about road closures, irrespective of whether the participants were from Western Australia or not.

If road closures are included on the map, the community needs to be able to quickly interpret what the road closure means (e.g., outbound traffic only). Road closure symbols and associated wording used in the legend varied across the maps tested and there was a preference for (a) using road closure information on the map, (b) indicating whether it is inbound or outbound closures, (c) an explanation for what a Vehicle Control Point was and what the community should expect to see at that point when they got there in their car, and (d) indicate where to find more information about road closures and the reasons behind the road closures (e.g., burnt area, fallen tree, etc.).

Base map

The base map was used in one of two ways by the participants to aid their understanding of the information being visualised on the maps. One use was as a tool that provided clear, easy to read road names, suburb names, and key locations. In this case the base map helped participants locate themselves, orient themselves relative to known areas (if the map was a familiar map), and to understand how to get away from the fire either to an evacuation centre or safer location. Participants who used the base map in this manner demonstrated a limited understanding of reading maps, where maps are largely used in everyday life for self-localisation and navigation.

Insufficient labelling had an impact on how participants understood the map. For example, on the Queensland map, there were lots of questions from participants familiar or unfamiliar with the Queensland map, about where Esk was on the map. It took a discussion to realise that the town of Esk was 'underneath' the overlayed warning areas and predicted fire paths.

Another use of the base map was as a tool to interpret fire behaviour beyond what was modelled in the predictions. It was used to identify built up areas (with houses, population density), where there was fuel for the fire (e.g., densely vegetated areas), where the fire might change behaviour (e.g., race up a hill or move slower in a gully), and where there was relief from the fire (e.g., lakes, rivers):

> *"Most maps are orientated anyway. I mean I would have liked to have seen some topography on it really personally myself being a person who likes maps, but you know, so you know just where are the high [*points*] - how much travelling through a valley or whatever. Also, a secondary thing was sort of you see where it's going, but then you see oh, hold on, there's a population centre there which is in danger. So all those ideas - those houses and hills are small ones which initially, you might worry about become oh, hold on a second, there's - this one's going through a population which you quite often see on television when reporting it of fires going through a densely populated area."* (South Australia FG1, both maps, Male)

Participants who used the base map in this manner demonstrated experience with bushfires, an understanding of bushfire behaviour, and a competency in thinking with maps. When the participants were viewing a map they were unfamiliar with, there was universal preference for the base map to have clearly marked roads, suburbs, and, where it was not clear, if somewhere was populated or if it was 'empty, unvegetated land', participants wanted to know more about that space on the base map (e.g., were houses or grasslands there).

Despite the two dominant approaches for how the base map was being used, all participants agreed on the value of legible road names and suburbs/landmarks to support self-localisation and navigation out of the affected area.

Finally, a challenge with the base map and the colours placed on top of the base map was visual accessibility.

> *"I'm going to throw a complete spanner in the works and say like - both of my sons are colour blind or colour different. Yeah, colour blind's well known to have all sorts of massive difficulties like with this* (Western Australia map). *...Maybe not as much because of the shading* (on the South Australia map). *That would be a lot easier to sort of work the shadings. Like that's - that* (the Western Australia map) *would be impossible, but yeah, with the shading, that could work* (the South Australia map)*".* (South Australia FG1, both maps, Male)

Other colour related challenges are discussed when reporting on the layering of warning areas over fire spread predictions element below.

Warning areas and predicted fire paths

Despite warning areas and predicted fire paths being two operationally distinct map elements, insights about participant comprehension of these map elements are presented together as participants frequently discussed them together. Some participants also took a while to realise they were in fact two separate elements of the map.

Broadly, there was evidence that participants were largely familiar with and understood the Emergency Warning and Watch and Act areas overlayed on the Queensland and Western Australia fire spread prediction maps. Participants appeared familiar with the terminology, familiar with the orange and red colours, and were familiar with the associated actions as per the Australian Warning System guidelines[5]:

> *"Where - for me, it's... do I live in the red zone and if I do, I need to get out. If I live in the orange*

[5] Watch and Act: There is a heightened level of threat. Conditions are changing and you need to start taking action now to protect you and your family. Emergency Warning: This is the highest level of warning. You may be in danger and need to take action immediately. Any delay now puts your life at risk. See more here: https://knowledge.aidr.org.au/media/9105/aidr_australian-warning-system_companion_2022-03-11_v12_web.pdf

zone, I need to watch and act...that's all I would look at." (Western Australia FG1, familiar Western Australia map, Female)

The only confusion that arose for the warning area information was why there were Emergency Warning and Watch and Act symbols placed on top of the shaded warning areas. Some felt this was duplicate information to what was already indicated by the shaded area:

"I feel like that little symbol's useless, because it's already told by the - sorry, I'm referring to the Esk map. The little emergency symbol under bushfire warnings is essentially saying the same thing as the bushfire warning area." (Queensland FG1, familiar Queensland map, Female)

When comparing maps and their predictions, participants identified differences in the time frames of the predictions, understanding that one fire was being predicted to move faster (e.g., South Australia) than another fire (e.g., Queensland). Participants described all the time stamps used on the map, including (a) when the map was issued, (b) when the map was valid from and until, and (c) the three time frames by when the fire was predicted to arrive, as useful pieces of information to the share with the community. However, some participants acknowledged that it required a lot of triangulation effort on their part to calculate how long from when the map was issued until the first predicted fire path would occur and the subsequent two fire paths modelled on the maps. Some articulated that breaking it into three time frames was unnecessary and perhaps one fire prediction would suffice. This is discussed further under 'Risk Perceptions'.

When it came to understanding predictions and warning areas when they were overlayed, the participants had mixed reactions. For example, in the South Australian focus groups they were first shown the South Australia map which included only fire spread predictions, then they were shown the Western Australia map with the warning areas overlayed on the predictions. This caught the participants off guard, requiring some pauses and contemplation of the information that was being presented:

"It gives more information once you understand how to read it." ... "Yeah, it just takes a minute to sort [it]..." (South Australia FG2, unfamiliar Western Australia map, multiple participants)

"It's mixing two things together that's causing the problem. So you've got the shaded areas which are like before, so it's when the fire could arrive, but then they've done this other thing which is put these boundaries around things which aren't that - because all the colours there, it's not that easy to see, but clearly, the one on the right is the emergency area and then the big area on the other side is the watch and act area. So but the trouble is, then they've got this where the fire is going to go at the same time. So it's mixing two things together it seems to me which makes it - the point that you were making about how can you have that red blob in the watch and act area, but that's because that's not going to get there until 12:00. Then that might change the shape of that watch and act area. I don't know, it may be trying a bit too hard to give everybody everything in one easy map and it's a bit difficult, but I like the evacuation or recommended routes. I just noticed there's an evacuation centre as well which is probably good. Yeah, a bit too much going on there." (South Australia FG1, unfamiliar Western Australia map, Male)

The layering felt to some like there was too much information being put on one map:

"...putting them on top of each other just makes - oh, there's too much - I think there's too much - it's too hard". (South Australia FG1, unfamiliar Western Australia map, Male)

"I think there's too much information there...on both of them." (Queensland FG1, both Queensland and Western Australia map comparison, Male)

"This (South Australia map) feels a bit less – this feels a bit more technical somehow (Western Australia map). Not so user-friendly. It's not so user-joe-public-friendly. It's more..."... "Leaning towards operators and firefighters?"..."Yeah, that's what it feels like to me." (South Australia

FG2, unfamiliar Western Australia map, multiple participants)

Some participants perceived the fire spread predictions as complementary to the warning areas found on an incident map. Some preferred just the predictions, others preferred just the warning areas. They all agreed that the predictions were providing more detailed information and some welcomed that level of detail as it was relevant to their informational needs and a belief it would support their protective action decision making in future bushfire events.

There was some agreement among the participants that where a warning area was shaded, but there was no predicted fire path immediately underneath it, that this was the agency's way of accounting for 'the worst-case scenario' if the fire path was changed due to change in weather conditions:

> *"I think a lot of the information the governments give us now, they put a lot of salt and pepper on, that's the worst-case scenario, so then they don't get accused of, well, it's not that we didn't warn you, and we had these maps out."* (Queensland FG2, both maps, Male)

In the Western Australia map, the layering led to questions about how the predicted fire path was related to the warning areas, which for some participants, reflected their misinterpretation of their distinction between the two. Some expected to only see the initial red fire prediction to be within the Emergency Warning area, and the second prediction would only be found in the Watch and Act area, while the third prediction would appear with an Advice warning area:

> *"...that's my only - the only confusing part for me from it was the fact that the red blob [the first predicted fire path in red] goes into the orange watch and act...So the prediction is red danger and yet it's still only watch and act. That just makes me a bit confused. I like the fact that it does give the modelling and that idea of the scientific, but then you start to question yourself; why is that - but then it makes it clearer to go yeah, within this area, just you don't have to know the modelling that much to just go if you're in the red area, it's time to act. If you're in the orange area, it's time to watch and it's just a nice broad sort of path."* (South Australia FG1, unfamiliar Western Australia map, Male)

The inaccurate interpretation of the prediction versus the warning area was further apparent when exploring the South Australia map, which did not include warning areas. When viewing the South Australia map, some participants were inferring the predictions to be equivalent to a Watch and Act warning area, and based on their experience, they believed they knew what was expected of them, under that level of warning during a bushfire (i.e. prepare and get ready to leave as the bushfire event evolves):

> *"...hey, every part of that is a watch and act area* (South Australia map). *We don't need to overlay it [the warning areas]. If I'm at that - I'm presuming there, I can see that those roads around me are closed, I need to work out where I'm going if it gets any closer. Again, it gives me a time frame to work on. So I just prefer this one* (South Australia map) *to the other* (Western Australia map)." (Western Australia FG1, both maps, Male)

> *"I think it's important to label it as Watch and Act, which we don't have on this one, it's just a colour and it doesn't say the words, Watch and Act. I think because so much of the messaging on like TV ads and stuff and even on the news, they'll say, if you're in the Watch and Act area, be ready. Because it doesn't have those words on this one, that could maybe delay some people in acting, potentially."* (South Australia FG1, both maps, Female)

Some challenges to interpreting the layers were raised by the participants, including not being able to see, or entirely missing, one of the map elements. For example, the Queensland map had the third light coloured prediction underneath an Emergency Warning area and a Watch and Act warning area, leaving it hard to see and some participants missed it entirely:

> *"...but this other one's too light. You can't - I had trouble seeing that, the one that comes around*

underneath, the real light one. You can't see it through the orange, either, so…" ... "I didn't even notice that." ... "Yeah. See, there you go." (Queensland FG1, familiar Queensland map, multiple participants)

The same issue occurred in the Western Australia map when the base map included high green saturation on which the predictions and warning areas were placed on top of:

> *"You know, and the other thing that's confusing is too because then when the colour goes over the green area on the map, it changes* (Western Australia map). *So whereas that was - this is clear because you haven't got a green area underneath your different colours* (South Australia map)*...when you're looking at this, it all gets a little bit more confusing because the colour of the pink changes because it's got green underneath it* (Western Australia map)." (South Australia FG1, both maps, Female)

When exploring the South Australia map that only showed the fire spread predictions, participants largely understood the map to be visualising where the bushfire might go over a specified time outlined in the map legend. When making comparisons between the South Australia map and the other two maps that included the warning areas, some participants accurately acknowledged that the fire spread prediction map did not tell them what action to take, which was inferred from the maps with the warning areas. Some preferred the inclusion of this information on guiding protective actions:

> *"This one gives you the Watch and Act, the see-through bit. It's more directive that way...So there's benefits with both of them...The first one doesn't give you any indication of anything to do* (South Australia map). *But then this one has got the emergency area. It's got a Watch and Act area* (Western Australia map)." (South Australia FG2, comparing maps, Male)

One participant articulated the challenges with having many map elements to comprehend before understanding what the map is telling you:

> *"A map's a great tool, but you've got to make a tool easy to navigate, and give you instant information, rather than having to analyse what this means, and what that means, and how big an area is it, and things like that. So something really simple, and gives you instant information, would probably be a better tool for something like this."* (Queensland FG2, both maps, Male)

Following the discussion of how the participants comprehended elements of the map, the discussion turned to understanding uncertainty and how the map elements shaped their perceptions of the inherent certainty in the predicted fire paths.

Uncertainty

The purpose of the fire spread prediction map is to provide information to the public about where the fire is likely to spread, while simultaneously acknowledging that it is a prediction and conditions can change, which can then change the trajectory of the bushfire. For the most part, participants across the focus groups understood this.

When exploring whether participants believed the bushfire would move as predicted on the map, some participants indicated they had confidence in the modelling. They acknowledged that the modelling came from 'the best scientific information' as was quoted from the video:

> *"Sort of going you know what, we don't all have to panic right now. This is based on real knowledge, real science and you do have this amount of time knowing that things could change."* (South Australia FG1, unfamiliar Western Australia map, Male)

A prediction was perceived as more certain or more accurate when "jagged lines" or “peninsulas” were used (e.g., South Australia map) as opposed to less specificity in the predicted fire path shape and lines (e.g., Western Australia map and Queensland map). The assumption was that if the scientific model could predict that level of specificity then it must be more accurate:

> *“Because it's a jagged edge. It seems very specific.” (South Australia FG1, familiar South Australia map, Female)*

The accuracy and specificity of the predictions were not always welcomed:

> *“The colours are throwing her off - us - well, me off a bit. I think it's the specifics of the prediction that it's got all these minute details and then there is a thing that says well, it could all change anyway which it can depending on weather conditions...you're almost saying well, you're safe in that paddock or if you're in that paddock, you're not safe. I mean if I lived around Echunga, it's you just get out. So you don't need - those other bits are almost there [the peninsulas and jagged edges of the fire path], I think they are just almost a bit of a distraction in some ways. As you say, it breeds a false sense of security.”* (South Australia FG1, familiar South Australia map, Male)

However, where participants saw straight lines in the warning areas, they questioned the modelling behind that too. The participant below even interpreted the warning area to be a prediction of a possible affected area:

> *“One thing that seems a little bit strange to me, and obviously I don't know the terrain, maybe there's some kind of natural barrier, but the fact that the Emergency section and the Watch and Act section has such a straight line at the bottom of it, seems a bit weird. How can they predict it like that?”* (South Australia FG2, unfamiliar Western Australia map, Female)

Participants did report feeling more confident that the fire would move as predicted when the predictions involved shorter time frames. Predictions that were shorter (e.g., three-hour predictions versus six-hour predictions) because the situation was more immediate with less chance for a change in conditions (e.g., wind or bushfire changing direction or being impacted by changes in fuel, etc.):

> *“The South Australia map feels more accurate, because it’s less time.”* (Queensland FG, South Australia unfamiliar map, Female)

Participants discussed how the weather conditions would be more likely to change by the third predicted fire path than the first predicted fire path. Therefore, the initial predicted spread on each map was perceived as more likely to occur as modelled than, for instance, the third predicted spread:

> *“Preference is the South Australia one. It's the prediction short-term. They can predict short-term much better than they can predict long-term. They go in six hours, it will be here, two days, it could be anywhere. So I think this - the short-term prediction's good.”* (South Australia FG1, comparing maps, Male)

Finally, predictions were also perceived as more certain or more accurate when participants interpreted the map information (e.g., mountain, valley, river, fuel availability) as supporting the prediction. For example, if predictions fell over a green area on the base map, it was assumed the fire would follow that path because the green represented ‘fuel’ that the fire would burn through:

> *“Well, I feel like because it's got lighter in there, ...maybe it's a little bit more built-up, so there's a bit more chance to survive... Whereas it's very green down there. Maybe it'll burn more easily.”* (South Australia FG1, South Australia unfamiliar map, Female)

When exploring trust in the modelled predictions, most participants indicated they trusted the predictions. Perceptions of trust appeared to be informed by references to the video script and or text in the map legend (where applicable) saying it was the best available science. Some participants indicated they trusted the

modelling because they understood it was prepared by the agencies and was potentially being used by the agencies themselves to guide deployment of their own firefighting resources:

> *"I was just going to say, if you were fairly certain, though, that it wasn't just mocked up by a newsroom somewhere, that it was actually the product of the CFS and of people who actually know this plan and model it, then I'd go, okay, that's their genuine prediction of what they're expecting to happen with wind conditions and with the local conditions. Then, yeah, that would be a good map to look at with these."* (South Australia FG2, familiar South Australia map, Male).

One participant stated: "*We have no reason not to trust it"* (Western Australia FG2, familiar Western Australia map, Female), another stating *"I'm not trusting it, but hoping it is right"* (Western Australia FG1, familiar Western Australia map, Male) suggesting, in the absence of no competing or conflicting information it was trusted and valid modelling.

A few people in different focus groups mentioned the fire spread prediction map looked like a bushfire they had seen in the area in the past, which lent credibility to the modelling:

> *"There is no topography showing on it, but the way it looks like that, if it's anything like the way it burns in fingers. If anyone's had a look at the Blue Mountain fires back in the '70s, they burnt up the gullies." (Western Australia FG1, South Australia unfamiliar map, Male)*

When discussing why the fire may not progress as modelled in the fire spread prediction map, two primary reasons emerged: weather conditions and bushfire behaviour. Participants across all focus groups, and irrespective of which map they viewed, indicated an understanding that weather is inherently uncertain, especially the wind, and wind changes can have significant impact on the direction and ferocity of a bushfire:

> *"The others are the best closest projection to what's going to happen next. That's like the step - this is where we think it's going to go after that. I've got confidence in these two areas here [first predicted spread area and emergency warning area]- these ones here [the remaining predictions and warning areas], like I said, it's a matter of watch and see."* (Western Australia FG1, familiar Western Australia map, Male)

Wind, experience with wind, requests for more information about wind conditions, reflected a significant amount of conversation throughout the focus groups. Related to conversations about wind changes impacting the modelled fire spread, was an apparent understanding about bushfire behaviour, and how it changed the prediction:

> *"You can't trust the wind..." "You've got a number of factors...the vegetation" "Yeah, the vegetation, the dryness of everything."* (Queensland FG1, familiar Queensland map, multiple participants)

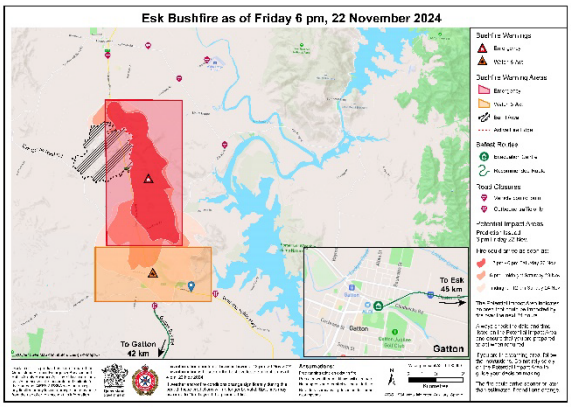
> *"I think I'd also like to see maybe some information - and I'm sorry to say, because I think you said there was a lot of information. I want more information. I want to know more about what the wind's doing and what they're predicting the wind to do, because that's going to change the direction of what's happening."* (Queensland FG1, both maps, Female)

Where wind cannot be modelled or overlayed, participants suggested including information sources in the legend or supporting communication materials for where they would find out more about wind changes.

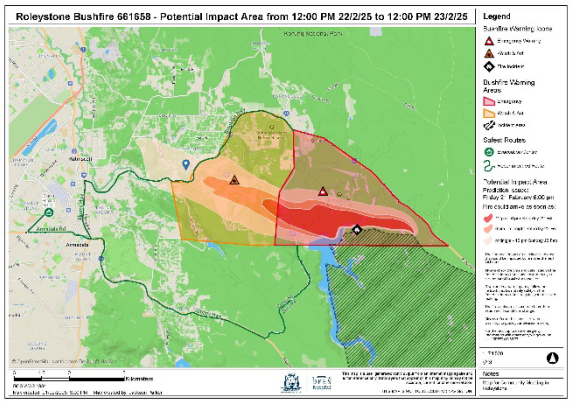
Understanding what factors shaped perceptions of uncertainty then led to a discussion of understanding participants' risk perceptions.

Risk perceptions

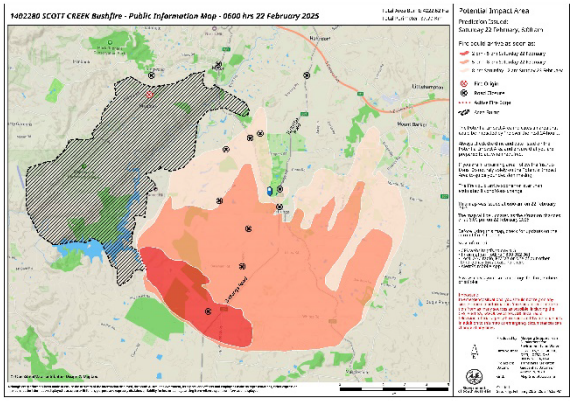
Risk perceptions were explored in the focus groups in three ways. First, participants were located at the blue and white icon on each map and asked how at risk they felt (Figure 1). In the South Australia map, the participant was located on the edge of the predicted fire spread. In the Western Australia map, the participant was located inside of the third time frame's spread prediction but was outside of a Watch and Act warning area. In the Queensland map, the participant was outside of the fire spread prediction but inside a Watch and Act warning area. Second, participants were asked if they could imagine themselves at the blue and white icon on the map, but later in the event, and asked to discuss how at risk they felt. Third, participants were asked if they could imagine themselves at a different location on the map, to see if their perceptions of risk would change in comparison to them being located at the blue and white icon on the map. Other emotions and feelings came up organically around these discussions.



Queensland: Participants were located at the blue and white marker, in the Watch and Act warning area, but outside of the third time frame's fire spread prediction, near an outbound traffic only road closure and close to an evacuation route.



Western Australia: Participants were located at the blue and white marker, in the third time frame's fire spread prediction, outside of any warning areas, near an evacuation route.



South Australia: Participants were located at the blue and white marker, at the edge of the third time frame's fire spread prediction, inside the peninsulas of the third time frame's fire spread prediction, surrounded by road closures.

FIGURE 1. LOCATION OF PARTICIPANTS ON THE FIRE SPREAD PREDICTION MAPS INDICATED BY A BLUE AND WHITE MARKER.

Risk perceptions were found to be very personal and were shaped by multiple combinations of participants' experience of bushfires, their understanding of bushfire behaviour, their confidence in map reading, their location on the map, whether the map was of a familiar area, and some design elements of the map. Cumulatively, these factors shaped perceptions of uncertainty, which influenced risk perceptions. Where there was higher perceived certainty of the fire progressing as predicted, there were also higher levels of perceived risk. For instance, where specific map elements appeared to inform participants' perceptions of uncertainty, they also informed perceptions of risk. As described above, where the 'jagged shapes' and 'peninsulas' used in predictions were perceived as more accurate, it meant participants felt more certainty in the modelling and therefore, higher levels of perceived risk.

All participants acknowledged that there was a risk of bushfire across all the maps they viewed. Initial comments about risk in the earlier part of the focus group where participants were reflecting on what initially drew their attention on the map, participants described being 'safer' when being located outside of the predicted fire spread as they were initially paying attention to the colours on the map. On the South Australia map, participants were not only located outside of the fire path (like the Queensland map), but there was no warning area on top of their location (like the Queensland map). Participants initially reported feeling safer, whether they were familiar or unfamiliar with the area:

> *"it's easy to fool myself and go oh, that's not a problem because I'm only in a pink bit, that's not bad. Pink isn't as bad as red. I've got to actually go up here and go oh, okay, that's to do with time."* (South Australia FG1, familiar South Australia map, Male)

Participants were quick to correct their lower perceived risk with comments about it being a 'false sense of security' as the timestamps signaled the fire was moving quickly and would reach them quickly:

> *"...it gives me a false sense of hope or a false sense of security, because I'm not in the red, currently."* (Queensland FG1, unfamiliar South Australia map, Female).

> *"I think we're starting to put our own interpretations and what these colours mean and I think we're going red is very bad, the pinky one is not too bad and the light pink is pretty safe, but the reality is, that's - according to that legend at the side, that's all going to go dark red." ... "Yeah, it just depends on what time." ... "Here you've got X amount of time, here you've got more and then yeah..."* (South Australia FG1, South Australia familiar map, multiple participants).

Related, some participants noted having three timestamps was creating that false sense of security. One suggestion to overcome this was to show a dynamic map, like that of the Bureau of Meteorology rain radar that shows severity of rain as well as direction and timing of rain to show how the hazard is moving:

> *"I reckon there definitely needs to be a sense depicting a show of dynamism or movement because I think we're still - I'm doing it myself and I'm going oh, I'm okay there [at the edge of the third prediction on South Australia map], but it's no different. It's - what it's saying is that's going to get to what that is in a certain period of time. So if I'm just looking at that in that hour and I'm only in a pink bit, I'm okay, but I'm not going to be in a pink bit in 12 hour's time. I might be in the middle of a red bit by then, so the idea - like the BOM thing, if that started down there and then just went red and you just knew that that was a 12-hour period, then again, it makes much better sense of what's going on."* (South Australia FG1, familiar South Australia map, Male)

Beyond the close relationship between perceptions of uncertainty and subsequent perceptions of risk, the temporal nature of the map was a driving factor in how risk was perceived. Where there was a shorter time frame for the predicted fire spread to reach where the participants were located on the map, there was a higher level of perceived risk. In these shorter time frame scenarios, the question was about *when* the fire would reach the participants:

> *"I'm not feeling overly safe. I'm feeling like I need to pack, prepare, prepare the house, clean up. I'm not sleeping tonight. I am rushing through everything and getting it all done and getting out ASAP." ... "I would be the same, because it feels like it's closing in. It's closing around, especially like the 8:00 p.m. one. It's right around, and then - yeah. I'd be getting out probably before the 5:00 p.m. because of the fact of - yeah, it's closing around. Even though the fire's over here, it still has the potential to come around."* (Queensland FG1, South Australia unfamiliar map, multiple participants)

> *"Yeah, it's a lot faster moving than the other one. Prediction's a lot...It's not like oh, you've got 24 hours. It's you've got very few hours. I'd be concerned."* (Western Australia FG1, South Australia unfamiliar map, Male)

This insight was the same for situations where the participants were located on the map inside the predicted fire spread. They were questioning *when* the fire would reach them and that guided their perception of risk.

Slightly longer time frames typically led to lower levels of perceived risk as the question became not *when* the fire would reach them but also *if* the fire would reach them, before weather conditions changed the direction of the fire. As each participant was located in the predicted spread over the third time frame, they indicated they all felt they had some time to prepare (with varying expressions of urgency across the group depending seemingly on their past experience, individual risk propensity, and the need to stay (e.g., if in the unfamiliar area on holiday there was no perceived reason to hang around, they just 'got out')):

> *"I think because something like this is in place and you kind of know and have an idea of what could potentially happen when, so you're not in the high risk area, unless you say, you've got maybe 24 hours to kind of come up with a plan or the fire may or may not shift, but at least you're kind of rest assured that there is a plan in action, there is a plan, there are services and potential impact on what could happen."* (Western Australia FG2, Western Australia familiar map, Male)

> *"Granted we know that this is all speculation basically, sure it's got a certain amount of maths and science behind it, we all understand that, but we also understand that it could go absolutely pear shaped in a minute. So we're already there because we're so close to it. But we've got - then we've got a little bit of breathing room, not heaps but a bit."* (Western Australia FG2, Western Australia familiar map, Female)

These same insights held for being located on the map at the edge or just outside of the predicted fire spread where participants questioned *if* the fire would get to them and then *when* it would get to them.

When comparing the South Australia map (located on the edge of the fire path) and the Queensland map (located just outside the fire path), the South Australia map elicited more visceral responses from some of the participants, irrespective of whether they were familiar or unfamiliar with the area. This was attributed to the shape of the predicted fire spread combined with the road closures that surrounded where the participant was located. Participants described feeling *'claustrophobic'* (Queensland FG1, South Australia unfamiliar map, multiple participants; South Australia FG1, familiar South Australia map, multiple participants), because the fire looked like it was 'closing around' them and they were also surrounded by road closures on the map suggesting no way out:

> *"It would make you feel rather uncomfortable. I don't think I'd play around with that one. With the experiences that I've had so far, one was right on my backdoor, and the other one I'm watching. This one, it looks like this one could close in on you, and where do you go, if the road's closed?"* (Queensland FG1, South Australia unfamiliar map, Female)

Showing a way out helped participants navigate feeling at risk but also knowing they can do something about it:

> *"There is time, but a clear way out (routes marked) I feel more comfortable here because I've got a route quite close to where I am."* (South Australia FG1, unfamiliar Western Australia map, Female)

Some participants used their interpretation of the base map and how it might impact bushfire behaviour to assess their level of risk:

> *"The two situations are this, there's - the two different scenarios - this is - apart from the scale, these are two different areas. The topography of both of them are different, the concentration of populations are different, the fire is going to behave differently..."* (Western Australia FG1, both maps, Male)

For example, on the Queensland map, there appeared to be little vegetation and therefore, there was a chance that the fire might not progress as quickly. If the fire did move as modelled on the Queensland map, participants again referred to the benefit of having an evacuation route and outbound traffic markers included, to show a way out, balancing their perceived risk with an understanding of how to reduce their risk through action. Another example is when participants inferred an area on the map had hills, they understood fires move more rapidly up hills, therefore, they felt more at risk. Further, if they inferred an area on the map was populated, they perceived less risk because firefighting efforts would be increased to protect the densely populated area and that there was less vegetation to fuel the fire.

Not all participants had enough bushfire knowledge to understand that even the burnt area posed an ongoing risk to the community. When describing the South Australia map where the burnt area was located to the west of the predicted fire spread, some participants discussed that reignition of the bushfire could render the spread predictions over the three time frames useless and the community located along that burnt edge could be at much higher risk than what is modelled:

> *"...also having that burnt-out area because then even though this here isn't a lighter area, you know that the fire front has come to there and it could still - if the winds change, it could still flare up...So even though that's a lighter colour, I would still be on lookout." ... "yeah, because it seems to be blowing that way [south] and yet these things [to the east] look like they're no danger." ... "Yeah, so but that's what that's saying is that this front is going to come this way [south east]... "yeah, but this burnt bit [up north] has logs or whatever that could still flare up."* (South Australia FG1, familiar South Australia map, multiple participants)

Where participants were unfamiliar with the area, it did not always lead to higher levels of perceived risk, but as one participant articulates:

> *"It puts you in a different frame of mind when you're in a strange country. That would frighten me."* (Queensland FG1, South Australia unfamiliar map, Female)

Again, all participants acknowledged that receiving this map meant there was some risk of bushfire and there was some understanding they might need to respond to reduce their risk. The next section explores the range of actions participants intended to take.

Protective action

The types of protective actions discussed throughout the focus groups included either preparing to defend, preparing to evacuate, and evacuating. However, there were also discussions of waiting, which in these bushfire scenarios could be considered a non-protective response. These intended actions were explored in the focus groups in three ways, similar to exploring perceptions of risk. First, participants were located at the blue and white icon on each map and asked about their risk perceptions, emotions, and then what action they would take. Second, participants were asked if they could imagine themselves at a blue and white icon on the map, but later in the event, and asked whether their intended response would change. Third, participants were asked if they could imagine themselves at a different location on the map as chosen by the focus group moderator, to see if their perceptions and actions would change in comparison to them being located at the blue and white icon on the map. Actions were also discussed without these prompts, sometimes as an initial comment reacting to the first viewing of the map (see Attention section) or discussing some other element on the map.

The critical step between viewing the map and indicating an intended action was an acknowledgement by most participants that they would seek out further information on the agency App, website, and or platform, where they would expect to find further instructions on what to do.

A few participants referred to enacting their bushfire plan, which related to either preparing to defend or preparing to evacuate, both of which involved a plan around setting up the property in a manner to mitigate the risk or severity of bushfire impact (e.g., turning on hoses, removing fuel, etc.).

Preparing to defend

Preparing to defend was discussed by a small number of participants who reported living on larger properties and had done so in previous bushfires in the area. These participants were clear on what actions they would need to take to defend their property and also indicated that they would have likely begun this preparation before this fire spread prediction map was issued. They believed the map was merely providing an update, with some more specific information about the direction of the fire expected over the coming hours, which was guiding the urgency and speed at which they were undertaking their activities to prepare to defend.

Prepare to evacuate

Where participants converged on a protective response of preparing to evacuate, differences were found in their perceived urgency of preparation based on how imminent the threat was perceived to be. Less urgent preparation was some participants' intended response when they were outside the predicted fire spread (i.e. Queensland):

> *"Yeah, I'm not leaving Friday. I would definitely be packing and worst-case scenario, yeah, what is it? Bloody - probably when I wake up Sunday morning, I'm like, I'm going to gauge it from there and be like, I'm probably out by then."* (Queensland FG1, Queensland familiar map, Female)

More urgent preparation to evacuate was discussed when the participant was in the fire path (Western Australia):

> *"I'd probably be trying to get everything organised in case things happen." ... "Just get ready" ... "If you're in a fire area, you should have things pretty well sorted..."* (Western Australia FG1, Western Australia familiar map, multiple participants)

For those located on the edge of the predicted fire path (South Australia), there were mixed senses of urgency to prepare to evacuate, potentially due to the familiarity with the area:

> *"Yeah, it's widespread. You're not just the - you're in the situation now. So everything just gets changed. You start cleaning, doing whatever in the house, throwing whatever you've got to move. We've got to get going now. That's the way I'm looking at it."* (Queensland FG1, South Australia unfamiliar map, Male)

> *"Whereas if I was on the edge of the lighter colour, I would be more inclined to still put my bushfire plan into action, but - and keep a watch on it before I - maybe I don't have to leave."* (South Australia FG1, South Australia familiar map, Female)

For participants indicating they would be preparing to evacuate, they also discussed the importance of monitoring the situation and checking the official channels for new information about the bushfire.

Evacuation

Some participants indicated that they would evacuate no matter what the evolving situation was on the map. If there was a bushfire in the area, they would evacuate:

> *"I'm leaving because I'm not risking it, because bushfires are monsters...as much as us as humans like to think that we understand things, we do not. We will do our best to predict things like this. ...a scientist that's studied it for 50 years...Thank you for letting me know that there is a risk. That's all I need to know. The minute I know that there's a risk, I'm like, cool, thank you. Let me pack my bags, get my stuff in order, prepare my house as best as I can, empty out - clean out all the stuff, to have my house best prepared to face the fire. But I'm getting - I don't even care if I have to sleep in my car. I will get out of there, not be caught in traffic, not overburden any other system and process and service in that area that needs to protect or whatever. I'm out of there. I'm out of people's space. I'm out of people's business, and everybody else can do what they want."* (Queensland FG1, familiar Queensland map, Female)

Other participants indicated they would already be gone by the time this type of map was released, usually due to experience with severe bushfires. When locating people in a red area on the map, i.e. immediately in the fire path or in the Emergency Warning area, it was universally agreed the response would be to evacuate:

> *"I'd be gone, only because you've got eight hours from there to there, and if the wind keeps going, then you're in a world of hurt, so I'd go."* (Queensland FG1, South Australia unfamiliar map, Male)

When it came to navigating one's way around or away from the affected area, the evacuation routes were welcomed by the participants. Both the Queensland and Western Australia maps provided evacuation route(s) and an evacuation centre to guide participants in leaving the affected (and predicted affected) area. The South Australia map did not provide this information. While the absence of this information on the South Australia map was not an issue for those focus group participants located in South Australia, it was an issue for those shown the South Australia map as the unfamiliar map in the Western Australia and Queensland focus groups.

However, just because an evacuation route is marked on the map it did not mean that the participants would follow that route. If familiar with the area, the participants took it on themselves to find their own way out that made sense for them and where they were travelling to (e.g., friends, family, the city).

When it came to viewing the unfamiliar map, evacuating the area was an immediate, almost universal response from participants. In the focus groups, because participants were situated on a hypothetical holiday in an unfamiliar affected region, the immediate 'get out' response appeared reflective of their lack of place attachment[6], the fact they had nothing to defend, and not a lot to pack up:

> *"If I'm on holidays, I'd be leaving. The beauty is everything's already packed up...Because you've got your van, and it's just folding the awning up, pulling your stairs in, shutting the door. Off you go."* (Queensland FG2, Western Australia unfamiliar map, Male)

This discussion of evacuating while in the unfamiliar location also included reflections on wanting to get out of the way of locals, an indication that as visitors they probably would not use an evacuation centre:

> *"Because you know it's going to be busy at the evacuation centre anyway, because they're going to have all the locals and things like that...Yeah, you're just taking up space that the locals need more than you do."* (Queensland FG2, Western Australia unfamiliar map, Female)

Some indicated they would either head back to the capital city and go home or head back to the capital city and continue their holiday outside of the bushfire affected area(s).

Guidance for how to get out of an affected area was welcomed when participants were in places unfamiliar to them. However, that guidance did not always need to be a specified evacuation route. Most participants indicated they would use Google Maps, their existing navigation tool, to find their way out of the affected area. Building on this, participants also discussed that the map did not always provide information about where to find road closure information (which impacted their ability to leave the area unencumbered). There were also comments about how specifying an evacuation route could lead to excessive congestion with 'lots of panicked people on the roads':

> *"I would say that the first thing I noticed was that there's only one evacuation option. I think that can be daunting as a resident, knowing that there's only one way, and it might get congested, and what impact that would have on me being able to get out on time and stuff like that. I feel like if I had more options, I'd feel less daunted about where I needed to go, I think."* (Queensland FG1, Queensland Familiar map, Female)

While most indicated they found the evacuation centre on the map useful, especially if they were unfamiliar with the area, participants explained they would prefer to find a safer place at a friend/family member's house outside the affected area as opposed to checking in at the evacuation centre.

Waiting and motivation to act

Waiting, an arguably non-protective response for being located at the blue and white dot on the maps, was likely to occur when participants perceived they had time until they were going to be impacted by the fire. When discussing what would motivate someone to transition from waiting to acting, the common responses were waiting on a social cue (e.g., neighbours telling them to act), or the next update from agencies to show the fire has progressed as modelled and an updated time to impact is provided. Problematic cues were also discussed as motives for action, such as waiting for an environmental cue:

> *"...the thick, real smoke, not just ground stuff, but actual real smoke coming down. So I'd be*

[6] Adedokun, O., Egbelakin, T., Sher, W., & Gajendran, T. (2024). Investigating factors underlying why householders remain in at-risk areas during bushfire disaster in Australia. Heliyon, 10(8).

watching to see it happen before I moved." (South Australia FG1, South Australia familiar map, Male)

Another problematic cue participants were waiting for was an emergency services representative (e.g., firefighter, SES) to tell them directly that they need to leave:

> *"A lot of the SES, because the firefighters are obviously fighting, but the SES will go around with megaphones and yell out, you need to evacuate now."* (Queensland FG1, Queensland familiar map, Female)

These problematic cues were discussed by participants who had some bushfire experience and were either successful at late evacuation previously or had engaged directly with emergency services in the past as part of their evacuation.

Finally, mobilising others was also discussed as intended action in response to receiving the fire spread prediction map. This included mobilising family, friends, and neighbours. Participants discussed the importance of taking on the responsibility for mobilising others (or even just informing others) if they did not think this group would have received or seen this fire spread prediction map:

> *"...my thing would be putting my hat on would be thinking, you know, how am I not going to get in the way of people and also, my neighbours as well. Does any of my neighbours need help? Is there anybody elderly or not, you know? But also, basically listen to the radio, what's the plan of attack, where are the fire units, I don't want to encumber anybody."* (Western Australia FG1, Western Australia familiar map, Male)

> *"I'm thinking my parents are a bit older, they can't get on the app necessarily as quick, but just have a message bank, you're in that space, it's time to go..."* (South Australia FG1, South Australia familiar map, Male)

Following the discussions on what intended action participants might take on receipt of a fire spread prediction map, the focus groups explored participant expectations and preferences for map use.

Expectations and preferences for map use

Participants reflected on where they would expect to find a fire spread prediction map, how those information channels might present the map, whether they would attend community meetings to find out more about the map, how third-party information sources might be used, how often they expected the maps to be updated by agencies, and whether they would actively seek out a fire spread prediction map during a bushfire to inform their risk assessments and protective action decision-making.

Where to find fire spread prediction maps

The most common responses to where participants would expect to find a fire spread prediction map was the fire agency's website, platform, or App, usually reflective of how they currently seek out or receive bushfire information (e.g., *CFS website, Emergency WA, DFES website, AlertSA* were mentioned). Some mentioned receiving an SMS text message with a link to a map[7], or instructions on where to find the map. The SMS text message was described as either coming as a notification from an existing subscription to an agency or council for hazard information, reflective of their current experience receiving notifications via SMS text messages about bushfires and other hazards; or coming from an automated alert to all phones in range of specific telecommunication towers. The latter approach was deemed useful in the unfamiliar map scenario as they

[7] Participants noted that links in SMS text messages are sometimes perceived as scams.

indicated they might not be signed up to receive alerts from an inter-state agency. Finally, social media, especially community Facebook groups were identified as a potential source of information. Participants discussed either the map would make its way there from another community member or there would be information about the bushfire on the community groups and maybe it would link to a fire spread prediction map on an official agency page. These expectations of where to find the fire spread prediction map were consistent for the 'familiar' maps, where the bushfire scenario was in the area where the focus group was being held.

For the maps that were in an area unfamiliar to the participants, where they were told to imagine they were on holiday, most indicated they probably would not know who the lead agency was and, therefore, were unsure how they would receive this information. Most indicated they would either hear about the bushfire from their news sources, a fellow traveler, the management of their accommodation, or the friends/family they might be visiting in the scenario. It was through this source that the participants indicated they might be directed to an agency website, platform, or App to view the map. There was support for pairing the fire spread prediction map with information on how to interpret it, for example, someone explaining it to the public, on the channel that it was being disseminated:

> *"Or on TV, where you can actually get someone to explain that this is - this area, this, this. This is where you need to evacuate. You need to go on that road, and like you said, if you need to get fuel, you need to get it ASAP, and you need to get out of the area. So I think it being on the TV would explain that a lot quicker for people to be able to understand it."* (Queensland FG,1 both maps, Female)

> *"...could be like some training and things - examples from before like to get your head around using it. I think once you then have it on there and you've seen it, you'll - over time, that won't actually look so much information. It'll be very - it'll become quite easy to go in and you'll trust a lot more and you'll look at that boundary for anyone who's a tourist just jumping straight in and then as a local who uses it a lot, you'll look at the details, you'll understand the details and you'll work from them - from there. So maybe some examples leading in rather than expecting people to know straight off the bat."* (South Australia FG1, both maps, Male)

There were calls for fire spread prediction maps to be disseminated through more common channels, such as news media (TV) and radio to reach a wider audience, acknowledging that not everybody is online or has knowledge of an App, especially if they're in an unfamiliar area. Further, not all areas of the country have sufficient Internet coverage, making accessing these digital sources challenging. When it came to suggestions of disseminating via the radio, participants anticipated that presenters would describe the direction of the fire and alert people where to find more information:

> *"...there's still a lot of heavy broadcasting on the AM band on the radio, and FM and on local TV because that's where the older people are more likely to get their information from. They're not always going to be getting a text from DFES or checking the app."* (Western Australia FG2, both maps, Male)

> *"The trouble is that this is an old area, and half the people here are over 50. More than half the people are over 50, and they don't go on websites. Very few of them go on websites, unless there's something like a warning on TV, which says, Esk, get out."* (Queensland FG1, familiar Queensland map, Female)

All participants of the focus groups across all three locations, whether it was the familiar or unfamiliar map, indicated they would not expect to see this fire spread prediction map in a community meeting for three primary reasons. First, they indicated that at the time of the event being modelled in the map they were viewing, it seemed 'too late' in the event to be holding a community meeting in the area. This 'too late' insight could imply the participants inferred they would receive a fire spread prediction map under serious conditions,

serious enough that if they were located on the map they were reviewing, they would deem it too late to attend a community meeting:

> *"By the time you got to the community meeting, you'd either be dead or burnt, one of the two. The houses would be burnt, one or two."* (Queensland FG1, both maps, Female)

This suggests an understanding from the public of when they expect it to be disseminated. Participants discussed how they assumed that agencies would want them out of the area, or that agencies (depending on their roles) would be busy fighting the fire at the time of this map release in the scenario being tested. Second, participants indicated that even if a community meeting was held at this moment in the bushfire scenario, they believed they would be too busy to attend it. Participants reported they would be too busy preparing to defend, preparing to evacuate, or they would have evacuated already. Third, and possibly the main reason for not expecting to see the fire spread prediction map in a community meeting was their individual preferences for not attending one in the first place, which was especially so when viewing the unfamiliar map. Support, however, was provided for a community meeting at an earlier time in the event or in the fire season preparation time, to educate the public on how to read these fire spread prediction maps.

When it came specifically to evacuation, participants said they would likely source their own information about how and where to evacuate from an affected area. If agencies wish to or need to guide the community in a certain direction, information sources need to be provided to the community about routes, road closures, and where to find safer locations. In the absence of this information, third-party providers will be used to inform community member decision-making.

Third-party sources

Whether the map was unfamiliar or familiar, and whether it had an evacuation route marked or not, participants discussed how they would rely on Google Maps as a source of information to direct them out of the fire danger area to either the provided evacuation centre or a safer location. They assumed that Google Maps would show them the fire, show where roads were closed (and the reason for the closure), and would reroute them if conditions changed:

> *"Well, if I'm on holidays, I'm Google Mapsing everything, so I'd like to think that Google Maps might say, hey, there's a road closure up ahead because of active fires. Find out more here...you can be on your Google Maps, and it'll tell you that there's police up ahead or whatever...Or if there's an accident, and so people are updating it as they're driving past things, so yeah, that's a - Google Maps is a really good thing for that."* (Queensland FG1, unfamiliar South Australia map, Female)

Participants acknowledge that Google now provides a fire layer on their current maps. Other third-party sources mentioned were Waze and bushfire.io as offering similar or supporting information about bushfire activity across the country. Extending on these named sources, the Bureau of Meteorology were also named in the case where wind information was being sought.

Frequency of updates

When it came to how frequently participants expected the fire spread prediction maps to be updated, there was support for frequent updates (< 1 hour) and or as the situation changes. When participants called for frequent updates, it was usually in response to their understanding of how unpredictable the weather can be (especially wind changes) and how rapidly bushfires can change direction and size. This insight appeared reflective of past bushfire experiences, a reasonable knowledge of bushfires (i.e., hazard literacy), but also reflected little consideration for how much operational time and resourcing goes into these models. The calls for frequent updates were also raised alongside comments about the Bureau of Meteorology's rain radar, with

suggestions for turning a static PDF of the fire spread prediction map, into a live tool like the radar. A live tool that was satellite-driven and could be accessed as you navigated your way around the affected area was discussed:

> *"It's constant real time. Being able to see it while you're driving, you can watch the fire from a satellite. That would be cool."* (Queensland FG2, both maps, Male)

The familiarity of channels for dissemination and frequency of updates, supported whether a map would be used in a bushfire.

Intention to use maps

When asked their intention to use a fire spread prediction map, the findings were mixed. Some indicated they would use it, which appeared to reflect those participants that currently use the incident warning maps, their bushfire experiences in the past, and their own self-assessment of their bushfire risk where they live.

For those who wanted to use the fire spread prediction map, preferences for different functionality were discussed, including dynamic, live, toggled maps. This recommendation addresses the concerns of participants who indicated the layering of predictions and warnings was 'too busy', sometimes perceived as 'too much information', 'too technical', and there were differences in participants' informational needs, participants suggested being able to toggle between the predictions and warnings or be able to just choose to view one over the other via a platform would be valuable to them. Participants also discussed toggling as a function to enable people to add information not currently included on the maps, such as wind and other weather conditions. References were made to current platforms that allow information to be toggled and how other sources share information about weather including the Bureau of Meteorology rain radar and bushfire.io:

> *"But the other thing I'm looking at too, in today's environment, you can have this electronic, which says, I can turn this layer off, I can turn this layer on. I can then see where the roads are, I can see where the roads are not. It's the same with the weather maps. If you play with the weather maps on your phone, or on your thing, you can actually turn layers on, turn layers off, you can turn roads on, you can turn roads off. It gives you a better idea of what's really going on."* (Queensland FG2, both maps, Male)

Where participants indicated they might not actively seek out a map like this, they either supported its inclusion on the agency channels where current incident warning maps are published and found the fire spread prediction information to be a 'nice to have' addition to current maps:

> *"I mean my curiosity wants to know that information, but it does add complexity to it."* (South Australia FG1, unfamiliar Western Australia map, Female)

Alternatively, some indicated they would not seek it out as they did not find it added additional information they needed, which usually reflected a lack of map use or reliance in the past, or they did not intend to seek it out because they did not understand it.

Context for map use

Finally, it was mentioned in multiple focus groups that while the participants themselves had spent significant time investigating the elements of the map and discussing what they mean, that was not in practice what *'Joe Public'* or *'your average punter'* would do. While a systematic information processing approach has been taken during the focus groups, participants acknowledge this may not be replicated during a bushfire and instead, more heuristic-driven information processing could occur whereby participants skim the information, focus on

one or two elements of the map, and draw conclusions using rules of thumb from previous experience with bushfires and exposure to maps[8]:

> *"I can see a lot of people just not reading it that - you're reading - I mean we're sitting around an hour and a half intensive lessons about this map, but the vast majority are just getting this on their phone and just suddenly see a pink bit and go oh, that's not a problem then. That would be my concern I think."* (South Australia FG1, familiar South Australia map, Male)

> *"I think it's too much on there, I really do. If you've got this and you're having a quick look at it, because you've got to get out, I think it's too much."* (Queensland FG1, familiar Queensland map, Female)

Further, participants acknowledged that the community was likely receiving this map in a heightened emotional state, which could further reinforce their use of heuristics to make snap judgements that are potentially inaccurate:

> *"And when you're panicking...And you're frightened, or you're concerned, things aren't going to look as clear as they could, or you've left your glasses in the other room, or whatever. In the car or something, and you're panicking, definitely. Or kids are screaming. There's a lot of stress...Maybe you need someone with a cool head to say, this is what this map means, rather than jumping to conclusions that may or may not be right."* (Queensland FG2, familiar Queensland map, multiple participants).

Stepping the community through how to interpret the information in the map, in a way that is cognisant of their emotional state and mental fatigue, as discussed above, would be beneficial to supporting community comprehension of fire spread prediction maps.

[8] Systematic processing involves attempts to thoroughly understand any available information through careful attention, deep thinking, and intensive reasoning, whereas heuristic processing involves focusing on salient and easily comprehended cues that activate well-learned judgmental shortcuts. https://psycnet.apa.org/record/2011-21800-012

Discussion

With the convergence of increasingly frequent and severe bushfires due to our evolving climate crisis and the increased expectations from the community to provide comprehensive and timely information about threats and what protective actions to take, this research seeks to extend the empirical knowledge base for guiding the design, dissemination, and communication of fire spread prediction maps for future bushfire events across Australia. Specifically, the purpose of this study was to explore how community members comprehend, perceive risk and uncertainty, intend to act upon, and expect to use fire spread prediction maps.

The research presented in this report suggests that some community members could be ready for the release of fire spread prediction maps, some would welcome it, some value the temporal nature of the map to guide their protective response, while others in the community are going to require significant education. Maps are a critical component to warnings and public information. While incident warning maps are currently used across Australia to support warning messages by visualising the threat *and* providing guidance on how to respond, fire spread prediction maps only visualise the threat. This makes fire spread prediction maps a public information tool, supporting the warnings as a risk assessment tool. The absence of information about what action to take means fire spread prediction maps are to be used as a cue for pre-decisional processing of protective action decision making. According to the Protective Action Decision Making (PADM) framework, these cues for pre-decisional processing can alert an individual to a threat, prompting information seeking to personalise the threat and find out how to respond from additional sources of information. The research in this report suggests not all community members might understand the distinction between a public information tool focused on showing the threat only (fire spread prediction map with fire spread locations) and a warning that provides a visual indication of an affected area and guidance on protective action (incident warning map with warning areas). When the community cannot distinguish between both types of maps, it could lead to confusion over why both predictions and warning areas are being layered on the map (i.e. perceived redundancy in information) or it could result in confusion over the intent of a fire spread prediction map as it does not offer guidance like the maps they are currently used to seeing during bushfires. Key insights from this research that speak to this challenge of distinction while also highlighting the value of the fire spread prediction maps are as follows.

[1] Fire spread prediction maps offer some temporal certainty that is not currently available with incident warning maps. They offer estimated time to impact which can in turn guide staged preparatory or response actions like evacuation or staying to defend one's property. Currently, incident warning maps provide guidance on how to respond to a threat of bushfire, while fire spread prediction maps can provide an informational cue guiding risk assessment prior to protective action decision making. The time to impact allows for community members with more complicated evacuation arrangements (e.g., moving animals, helping the elderly or those with disability and complex medical issues), to prepare sooner and to potentially leave earlier. The time frames on the predicted fire paths are also intended to encourage the public to seek out emergency warnings earlier than if they wait for warning areas to be updated on incident warning maps.

However, the value of the temporal certainty is sometimes lost when the recipient of the map needs to triangulate multiple time points to assess when the fire will impact them. The AIDR Choosing your words Guidelines suggests using time of day when expressing future time (e.g., between 2pm and 4pm), to make it easier for people to visualise what they and their family will be doing at those times, and how they will be affected. The maps all used this approach in the legend for the three fire spread predictions included on the map and yet, the participants were still confused. This could have been attributed to participants looking at the time the map was issued and the time of the first predicted fire path and then expending considerable mental effort to figure out how far in the future the final predicted fire spread was to then figure out what actions they could take during that time to prepare and or evacuate the area. It is worth considering aligning the time the map is issued to the initial fire spread prediction.

Further, maps that model shorter time frame events are perceived as more certain, i.e. the community perceived the fire will progress as modelled. Where predicted fire paths occur over a longer time frame, the community believes there is more opportunity for a change in weather conditions, thereby rendering the prediction invalid. If the time frame of the map is directed by resourcing or policy, it is important to understand the unintended consequences of this design element as it shapes perceptions of risk, uncertainty, and intended actions.

[2] There is a risk of unintended consequences for design choices. Similar to the unintended consequences of time frames used, specific design elements can also have an unintended impact on perceptions and action. The shape of the predicted fire paths can connote a level of accuracy in the prediction that may or may not be intended by the agency releasing the map. The more precise the shape (e.g., jagged lines, peninsulas versus straight or broad wavy lines) the more certain the fire path appears to be, the more at risk the community feels. Again, there might be unintended consequences for comprehension and action based on the shapes generated from the software used to make the predictions that agencies should be aware of. If there is possibility for an unintended interpretation, agencies should address it when releasing the map. For example, explain why the fire spread predicted fire path is shaped the way it is. Or, if there is something important to note about the information present or absent in the base map (e.g., a gully), then notify the community.

[3] Uncertainty appears to be grounded in the weather, especially the wind, not in the prediction itself. There was an understanding that the predictions are based on science, and developed by experts in the fire agencies. However, confidence in the fire progressing as modelled in the map was largely dependent on weather conditions changing, especially wind conditions. Information about weather and wind conditions was provided very briefly in the introductory video, however, this was insufficient for the informational needs of the community members involved in this study. Weather is believed to be inherently unpredictable, uncertain, and can rapidly change. The absence of this information on the map, or a link to where this information can be found, can leave the fire spread prediction maps less valuable as a public information tool to assess the hazard threat.

[4] Interpretation is grounded in what first catches their attention on the map. The findings suggest that the map element that first draws their attention drives their subsequent information processing. The use of red on these maps is what most participants paid initial attention to. If a community member were to incorrectly interpret the red fire spread prediction or warning area as where the fire is currently burning, their risk perceptions may be suppressed and or it could result in a failure to act in a timely manner. For example, if someone was in a red fire spread prediction and they looked outside and could not see any environmental cues to confirm the fire was burning, the conflicting cues could lead to delays in protective action and cause confusion (Dootson et al., 2022). An incorrect interpretation of what the red colour represents on the map can also lead to disengagement with other important elements of the map like the fire edge and burnt area. The legend information should be prioritised to show information about where the fire is, where it is going, when, and where people can go for further information. To mitigate the risk of individuals not reading the legend, supporting communication explaining the map should clearly highlight where the fire is now to support further interpretation of where the fire is predicted to go.

[5] The community needs education on what the fire spread prediction is intending to communicate versus what the incident warning areas are communicating. Community members might conflate the meaning of a fire spread prediction and a warning area without specific communication around the purpose, intent, and meaning of the fire spread prediction map. In the absence of a toggled, layering function of warning areas and fire spread predictions, where fire spread predictions are released independent of incident warning areas, the community should be directed to the related incident warning maps for information on protective action decision-making.

Further, when releasing fire spread prediction maps independent of incident warning maps, there is a risk the community will transpose their knowledge of warning areas to the fire spread prediction maps and incorrectly

assume the predictions are effectively representing a Watch and Act area. It is important to differentiate between a map communicating a threat and a map communicating protective action for potentially affected areas. If the desired response to a fire spread prediction map is to seek further information, this needs to be made clear when the map is disseminated to the public.

[6] The standardisation of maps is as important as the Australian Warning System standardisation of warnings. When it comes to specific map elements like colours, symbols, terminology used in the legends, agencies need to first rely on the Australian Warning System (AWS) guidelines. For example, how the active fire edge is visualised needs to be standardised. Moreover, agencies need to agree on which terminology, symbols, and colours are going to be used within what is outlined in the AWS and outside of the AWS guidelines. Similar to the language used in text-based warnings and public information, maps should avoid including operational or technical terms or icons not easily understood by the community, to aid in comprehension of the information being portrayed (AIDR, 2021). For example, 'burnt area' is more intuitive than 'incident area'. Finally, agencies should be consistent in providing information sources for community members to seek out relevant information about the event. This was not consistently supplied in the maps tested.

Cumulatively, the research offers evidence to support the future design of bushfire-related maps, including fire spread prediction maps, for jurisdictions across Australia, under the Australian Warning System. The results, to an extent, support the limited guidance in the AIDR Public Information and Warnings Handbook (AIDR, 2021) on map use and design and offer additional empirical insights to extend the national doctrine for map design, dissemination, and communication.

This research report should be read in conjunction with outputs from the rest of the *Predictions in Public* research project to attain a whole-of-phenomenon understanding of the design, communication, dissemination, and use of maps, including prediction maps, for bushfires in Australia.

Next Steps

This research provides critical insight into existing map design across all jurisdictions in Australia. The public continues to rely on maps, alongside text-based warnings, to inform their perceptions of risk and support their protective action decision-making. The results from this study combine with the other research in the *Predictions in Public* research project, to cumulatively underpin the future design of maps for use in the public information and warnings milieu in Australia under the Australian Warning System.

At time of submitting this report, the Steering Committee is supporting the data collection for remaining Phase Two research, including the eye-tracking experiments (Work Package 10). A review will be undertaken to identify gaps in evidence for the principles for design, dissemination, and communication of fire spread prediction maps to guide the design of remaining Phase Two research projects. Once primary data collection is complete, Phase Three of the *Predictions in Public* research project will explore how the results of Phases One and Two can be translated into agency policy and practice.

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Appendix 1: Moderator Guide

Moderator Guide

Start recording.

Introduction to yourselves (name and university), to research project.

Explain the *Predictions in Public* research project and funding body.

Provide trauma acknowledgement: "we are talking about bushfires today, as you know, so if this brings up any distress or you feel upset, please feel free to exit the room and come back or exit the room and leave. We have counselling support outlined on the Participant Information Sheet."

Show video introducing the familiar map.

Hand out familiar map printout and give them a minute to look quietly at the map.

Note observations about how they read the map.

Attention - pre-decisional process:

What captures your attention at first? Why? What do you see next?

Comprehension/perceptions of threat and risk:

Overall, what is this map telling you? What information are you getting from this map, if any? (Probe: information regarding their own safety, what they should do next, etc.)

Probe, if not previously raised, do they understand the difference between the incident map and fire spread prediction map and the burnt area?

Please walk me through each element on the map. [NOTE: where elements of the map are not organically raised by the group then ask about the element(s) directly.] *What does each mean to you?* (Probe specific things on the map – e.g., what do the polygons ('blobs') mean to you?)

Is the information in this map useful? Is it easy to understand? Why or why not?

Risk and uncertainty perceptions:

Based on where you have been located on the map, how at risk do you feel? (Probe emotions too)

How confident are you that the bushfire will move as modelling in the map? Why or why not?

Behavioural response/intention:

What would you do next and why? (Probes: seek additional information OR contact family members OR prepare the house/to leave OR leave immediately...or a combination of these?) (Probe, if seeking additional

information, where are they seeking it from and what are they looking for?) (Probe, if evacuating, are they following the route on the map?)

Attitudes towards the map:

Is the information in this map useful? Is it easy to understand? Why or why not?

How might you improve this map for future use? (e.g., Probe What types of (additional) information would be helpful to include in this map, in your opinion?)

Use and expectations:

Have you ever seen a map like this before? If so, where and when?

Where would you expect to fine this type of map? (If they don't say community meeting, ask "Would you ever expect to receive this in person?" Then note their facial expressions, like 'confusion'. Then if they don't get to a community meeting response on their own, say 'What about a community meeting?')

How might you use this map in a bushfire?

Repeat process for a second map, the unfamiliar map: video, hand out the map, follow through questions again.

End of focus group – thank participants and tell them how their insights will be used.

End recording.

Appendix 2: Script

Below is the script used by agencies for the introductory video presented at the beginning of the focus group and the middle of the focus group when introducing each of the maps the participants were examining. The information in yellow was made relevant to the local area prior to recording.

[Start of Script]

Hello, everyone.

As part of our ongoing efforts to manage and mitigate the risks associated with the current bushfire conditions, we have released a potential impact area map today.

The map shows where a bushfire has been burning and a prediction of where the bushfire could go over the next 24 hours.

The bushfire has been burning over the last four days near Jarrahdale State Forest, south of Brookton Highway in Ashendon.

The bushfire is currently moving in a northerly direction but a wind change is expected, which could move the direction of the bushfire towards Roleystone.

The potential impact area drawn on the map shows which communities may come under threat.

It is crucial for residents to stay alert as the bushfire could potentially impact Brookton Highway within the next 24 hours, impacting how people can leave the area.

We use the best science available for making these maps. The prediction is based on estimated weather and an assessment of the vegetation that will burn in the area. The actual bushfire might be bigger, or smaller, or even change direction.

The map is current from now until 12pm February 23rd 2025.

Surrounding areas could still come under threat if conditions change, or if bushfires breach containment lines.

New bushfires could start well ahead of the bushactive fire edge, which would change the potential impact area.

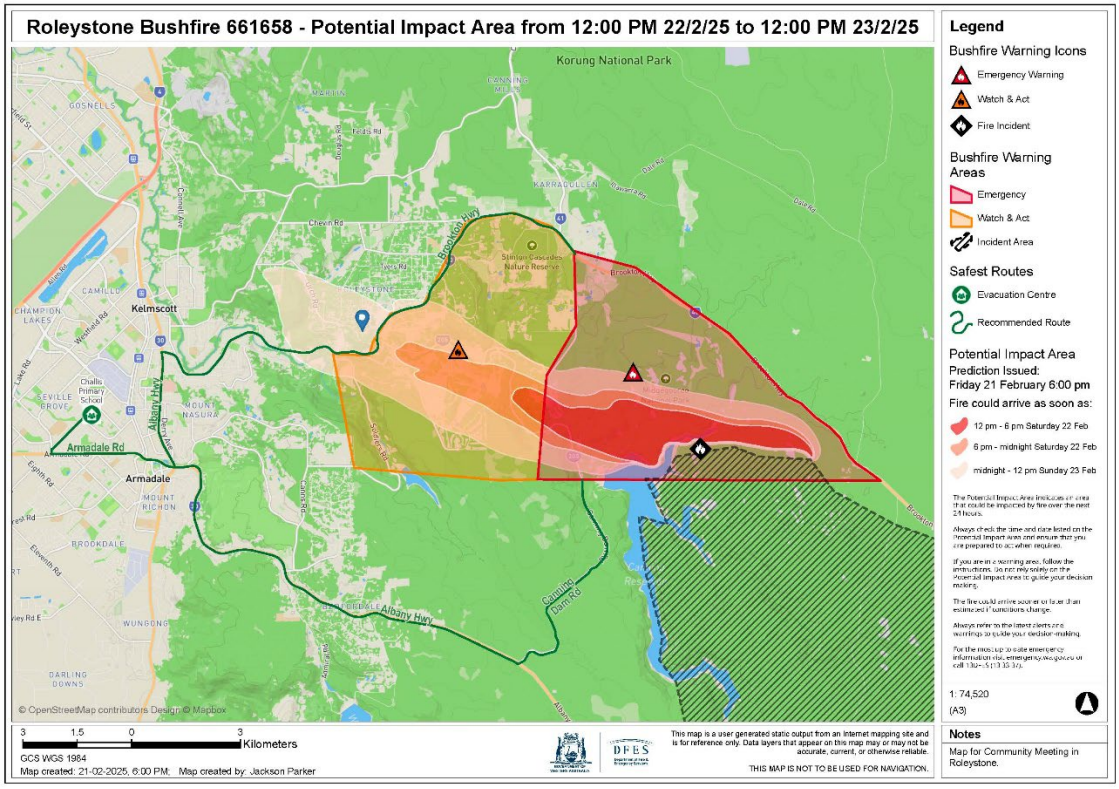
There may be new bushfires burning in areas that we don't know about yet, which could threaten you without warning.

It's essential for everyone in the potential impact areas to stay informed and be prepared for rapid changes.

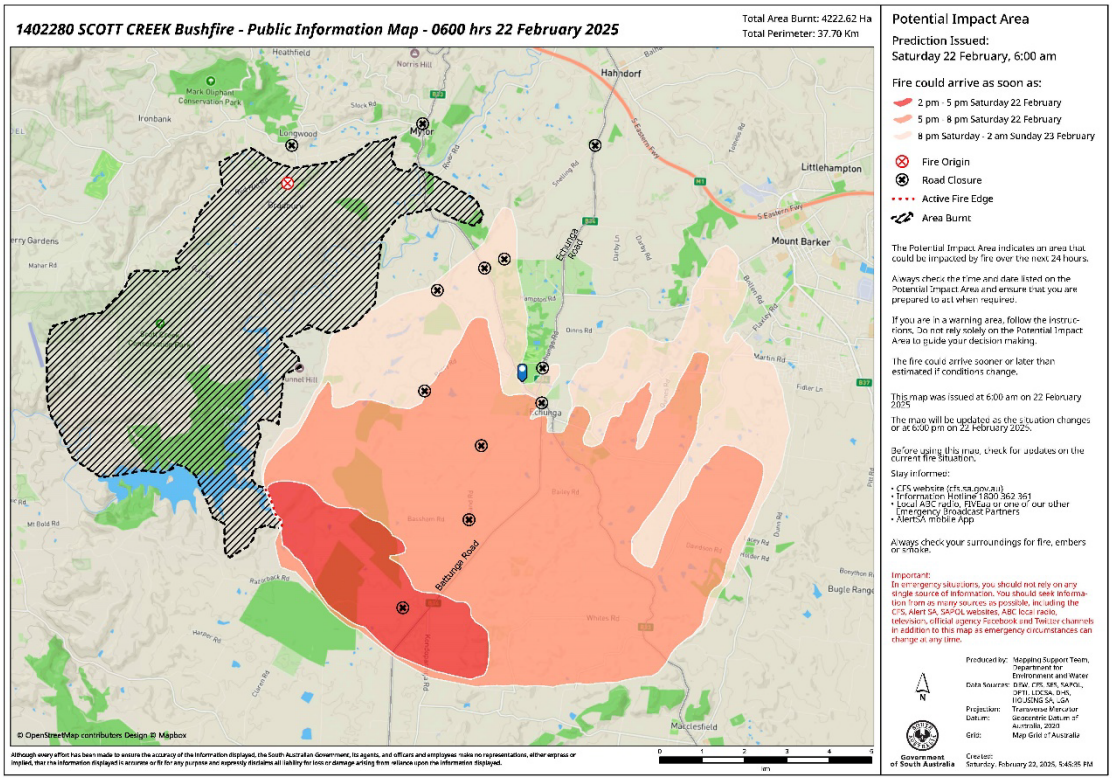
As we continue to monitor this situation closely, please keep up to date through our official channels.

[End of Script]

Appendix 3: Western Australia Map



Appendix 4: South Australia Map



Appendix 5: Queensland Map