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Neighbourhood bushfire hazard, community risk perception and preparedness in peri-urban Hobart, Australia

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ABSTRACT

Background. Information campaigns about bushfire preparedness are often based on the assumption that residents of bushfire-prone neighbourhoods underestimate their risk. However, there are complex relationships between bushfire hazard, perceived risk and adaptive action. **Aims.** We investigate how residents' understanding of bushfire risk relates to biophysical risk in the City of Hobart, Tasmania, Australia's most fire-prone state capital. **Methods.** A transdisciplinary case study using a survey of 406 residents living close to the wildland–urban interface, focus groups in four bushfire-prone neighbourhoods, and geospatial fire risk assessment. **Key results.** Neighbourhood concern about bushfire is statistically associated with biophysical measurement of local bushfire risk. This awareness does not necessarily translate into adaptive action, in part because residents underestimate the risk to their homes from fuels on their own property and overestimate the risk from bushland and neighbouring properties, leading to a common response that preparing for bushfire is futile if your neighbours do not also prepare. Neighbourhoods with high levels of positive community interaction, however, are more likely to access preparedness information, and develop fire-adaptive behaviours. **Conclusions/Implications.** Our findings highlight the need for social adaptation pathways using local communication interventions to build the neighbourhood knowledge, networks and capacities that enable community-led bushfire preparedness.

Keywords: bushfire, community bushfire preparedness, Hobart, pyrogeography, risk communication, risk perception, social adaptation to climate change, Tasmania, wildfire.

Introduction

Bushfire (known internationally as wildfire) is a perennial threat to the homes and lives of people living in peri-urban Australia. Fire is understood as necessary to both the nature and culture of most Australian landscapes, and other similar fire-prone settings elsewhere in the world (Bowman *et al.* 2014; Smith *et al.* 2016). However, colonial societies such as Australia and the US have suppressed both natural and cultural burning, resulting in patterns of vegetation that have become, paradoxically, more prone to dangerous bushfires (Calkin *et al.* 2014; Mariani *et al.* 2022). Global climate change further exacerbates the likelihood of larger high-intensity fires (Ellis *et al.* 2022). Global climate projections suggest that drier landscapes and longer fire seasons will lead to a 20–50% increase in extreme bushfire events (Bowman *et al.* 2017). This is not a threat that state fire management authorities can handle alone. In Australia, residents of fire-prone areas are described in government policies and strategies as having 'shared responsibility' for reducing bushfire risk on their properties (e.g. Council of Australian Governments 2011; Australian Institute for Disaster Resilience 2014). This involves managing vegetation and other sources of fuel, making structural adaptations to buildings, and planning for emergency scenarios. For people living in bushfire-prone environments to be able to meet this responsibility, they must be equipped with the knowledge, capacity and resources to do so (McDonald and McCormack 2022). In addition, they need to recognise and accept this responsibility, and be motivated to act on it.

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Public information and community engagement campaigns by state-based fire management agencies, emergency services and local governments, among other organisations, aim to generate action by building residents' knowledge of bushfire risk and preparedness. Many public information campaigns take as their starting point the assumption that most people underestimate or are complacent about bushfire risk (Ellis *et al.* 2004; Brown 2018; Shepherd 2020; Elliott 2021). Research in Australia and internationally suggests that despite such campaigns, only a small proportion of residents of fire-prone areas are sufficiently prepared to reduce the risk of losing their home in the event of a fire (McGee 2011; McLennan *et al.* 2015; Muir *et al.* 2017; Bodas 2019; Every *et al.* 2019).

Communities in suburbs on the forested edges of major Australian cities are at high risk from bushfire (Crompton *et al.* 2010). However, processes of local engagement with bushfire risk information in peri-urban environments are still not fully understood (Cooper *et al.* 2020), and there have been few empirical studies of social learning in relation to bushfire risk and preparedness (Haghani *et al.* 2022). In response, this transdisciplinary pyrogeographical study investigates how residents of four bushfire-prone neighbourhoods of the City of Hobart Local Government Area understand their local bushfire risk, and their responsibility to mitigate this risk. The case study involves three research components: a biophysical measurement of bushfire risk using a novel bushfire risk index; a geospatially targeted survey of residents' attitudes and understandings of bushfire risk and risk management ($n = 406$); and a series of four focus groups held in each of the neighbourhoods ($n = 30$). We use these methods to compare the different local risk profiles, information streams and bushfire preparedness practices of these neighbourhoods.

The article is structured as follows: we first very briefly review research literature on bushfire preparedness and communication, and drawing on this literature, describe a conceptual model of the pathway to adaptive action by residents to manage bushfire risk. We then describe the biophysical and social research methods used in this study. In the Results section, we present statistical analyses of biophysical and survey data, supported by focus group data. We then discuss the implications of these findings for fire management agencies, local governments and communities in places of growing bushfire risk.

Factors underpinning bushfire preparedness

The Australian Productivity Commission estimates that only 3% of disaster funding is spent on community preparedness and risk reduction (Productivity Commission 2014). To reach the broadest audience, funding for community preparedness is most often allocated to public education campaigns using mass media such as television, digital and print advertising (Johnston *et al.* 2019). These public education campaigns tend to focus on describing the danger of bushfire, with the intended aim of motivating residents of bushfire-prone areas to make a survival plan and prepare their property for fire. While prior research has found that individuals' level of perceived risk from bushfire does increase their likelihood of preparing for fire, it is considered to have only a partial effect (e.g. Martin *et al.* 2009; McFarlane *et al.* 2011; Brenkert-Smith *et al.* 2012; Fischer *et al.* 2014; Dickinson *et al.* 2015; Olsen *et al.* 2017). A meta-analysis of 10 studies by Koksal *et al.* (2019) found the average correlation between risk perception and risk mitigation actions to be statistically small: $r = 0.17$.

Research from psychology, sociology and disaster studies has established that risk perception is just one ingredient in a complex recipe of factors that influence people's (in)decision to prepare (Eriksen and Gill 2010; McFarlane *et al.* 2011; Koksal *et al.* 2019). Other factors include: evaluations of what is at risk (from action or inaction) (e.g. Sturtevant and McCaffrey 2003; Kyle *et al.* 2010; McCaffrey *et al.* 2013; Reid and Beilin 2015); information about the risk and about how to prepare (e.g. Jakes and Langer 2012; Ryan *et al.* 2020); experience of fire or intersecting personal experiences (e.g. Bradstock *et al.* 2014; Champ and Brenkert-Smith 2016); capacity to act (e.g. Collins and Bolin 2009; Penman *et al.* 2013); positive expected outcomes from taking action (e.g. Paton 2003; Paton *et al.* 2008); perceived responsibility (e.g. McFarlane *et al.* 2011; Reid *et al.* 2020); and the social context in which decisions are made (e.g. Jakes and Langer 2012; Prior and Eriksen 2013; Carroll and Paveglio 2016; Paveglio *et al.* 2016).

Drawing on social science literature of bushfire risk, we describe a conceptual model for a pathway toward fire-adaptive action by residents of areas at risk of bushfire (Fig. 1). Our intention in this paper is not to test this model, but to use it to explain our methodology and to inform our interpretation of the Hobart case study. In accord with Eriksen and Gill (2010), we see decisions about preparing for bushfire as embedded in everyday life – the product of social processes of learning in which knowledge and action are co-constructed through complex interactions and entanglements within social–ecological systems. Thus, local differences, for example in climate, landscape, social values, knowledge and experience, economics, demographics, tenure types and networks, can lead to diverse decisions and actions in response to bushfire risk. The usefulness of a case study is therefore not to be prescriptive, but to shed light on the ways in which understanding local bushfire socio-ecological conditions can help to shape conversations about preparing and adapting with and within communities.

Communicating for preparedness

How exactly to become prepared is often unclear to people living in bushfire-prone areas (Penman *et al.* 2013).

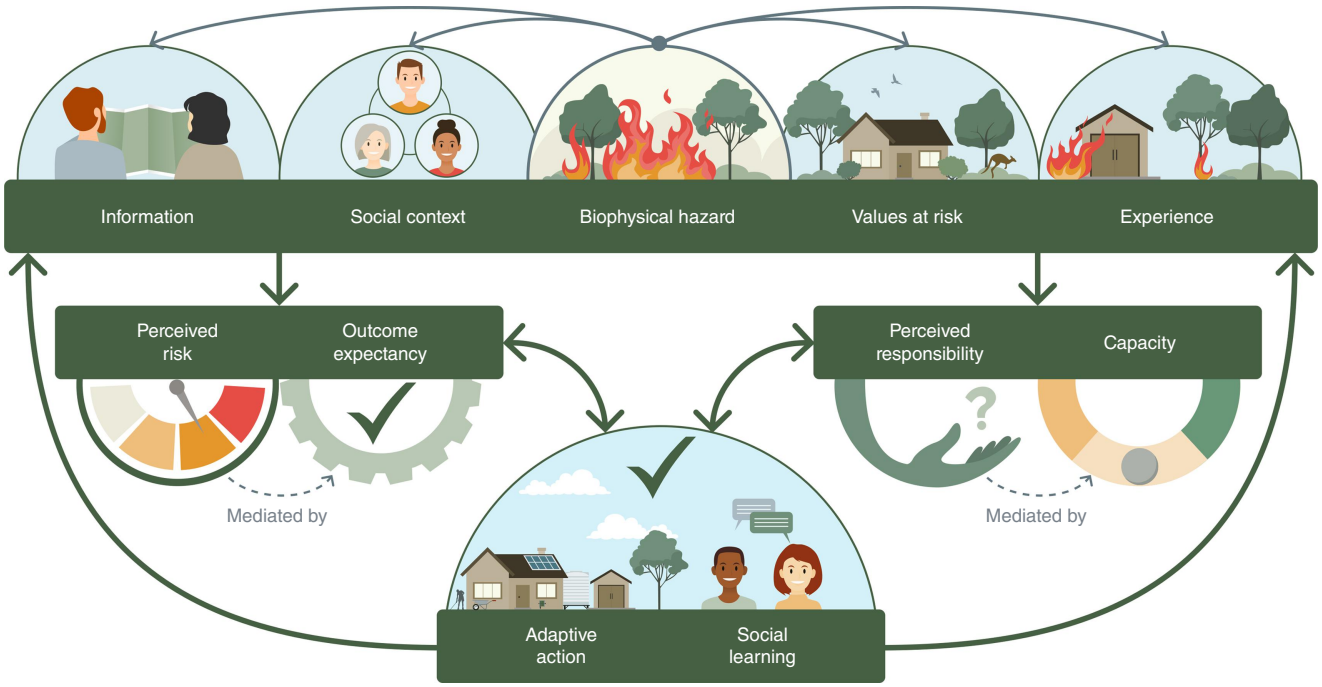

Fig. 1. Conceptual model for a pathway to fire-adaptive action by residents of bushfire-prone areas. The desired goal of adaptive action and social learning is directly related to perceived risk (mediated by outcome expectancy), and perceived responsibility (mediated by capacity to act). These are influenced by multiple interactive and compounding factors comprising the local neighbourhood context (in the top line).

Communication about bushfire preparedness frequently identifies a checklist of preparations such as clearing gutters, keeping grass short, removing fine fuels from around the home and making a bushfire survival plan. While some studies understand preparedness as compliance with these activities, others suggest that being able to tick off these items on a list can give people a false sense of preparedness that may lead them to stay and defend the property when it is not safe to do so (Penman *et al.* 2013; Koksal *et al.* 2019). Simplified, expert-led technocratic models of bushfire preparedness communication privilege technical preparedness behaviours while marginalising other forms of knowledge and action (Reid *et al.* 2020). Considerations and actions that are under-represented in preparedness communication include community networks and mental preparedness, as well as mitigating risks from neighbouring property, mitigating risks of evacuation in an emergency, and building design and retrofitting (Every *et al.* 2019; Haghani *et al.* 2022). Given the complexity of all these aspects of reducing risk in a bushfire-prone community, preparedness is very difficult to measure quantitatively, and surveys of preparedness tend only to report simpler, checklist-type actions (Prior and Eriksen 2012).

Preparing for bushfire includes not only planning one's actions in an emergency, but making adaptive changes to gardens and built structures in order to reduce the risk to one's home. Research using post-fire data has explored the effectiveness of different strategies for protecting homes. Several studies have concluded that the loss of homes is strongly dependent on fuel in the surrounding 40–50 m (Cohen 2000; Gibbons *et al.* 2012; Price and Bradstock 2013). Syphard *et al.* (2014), using Californian wildfire data from 2001 to 2010, found that managing vegetation up to 30 m from properties was most effective in reducing risk to housing. Burning houses can provide enough radiant heat to ignite those on neighbouring properties (Leonard *et al.* 2016). Studies of the 'Black Saturday' bushfires of 2009 in Victoria found that houses lost from radiant heat were either in the flame zone (with no separation from the bush) or ignited by neighbouring houses closer than 50 m (Price and Bradstock 2013). As housing lots in peri-urban Australia are relatively small compared with those in rural areas, most homes would be within 50 m (and often within 10 m) of their neighbours' homes. This means that collective participation in bushfire preparedness is particularly important in peri-urban environments.

Several authors have called for a paradigm shift to enable communities to see themselves as active participants in managing fire risk, effectively collaborating and sharing responsibility with government agencies (Smith *et al.* 2016; Head 2020). Pioneering community-led initiatives such as Bushfire Ready Neighbourhoods in Tasmania, and the Community Fireguard program in Victoria, have been shown to be more effective in generating preparedness than transmission communication models (Frandsen *et al.* 2011), and are now considered best practice by agencies (Ryan *et al.* 2020).

Tensions, however, between existing organisational cultures and hierarchies in emergency management and programs designed to shift decision-making power and agency to communities often mean that these programs are under-resourced and marginalised politically and bureaucratically (Gibbs *et al.* 2015; Cook and Melo Zurita 2019).

Importantly, community-led approaches cannot be represented as a panacea because they are variable in their effectiveness, being shaped by the social context of the communities in which they are situated. Akama and Ivanka (2010) find that government agency assumptions of harmonious and homogeneous communities can mask actual diversity and difference, and that social fragmentation can lead to the exclusion of community members from these programs. In Victoria, for example, the Community Fireguard program has been limited by existing social networks and hampered by a lack of clear mechanisms to recruit new members outside these networks (MacDougall *et al.* 2014). Additionally, community-led bushfire preparedness programs can place unwelcome pressure on social networks and particularly on specific members with designated or implied roles within them (Akama *et al.* 2014). To communicate effectively and dialogically with communities at risk, it is vital to find out how local narratives of bushfire risk and preparedness are constituted (Cooper *et al.* 2020). This involves engaging at a neighbourhood level to understand each of the elements described in our conceptual model (Fig. 1). The City of Hobart case study presented below aims to do this, and as a result to inform processes of bushfire communication in local contexts more broadly.

Methods

The City of Hobart is a local government area (LGA) comprising the summit and eastern side of kunanyi/Mount Wellington and bounded by the estuary of the River Derwent. The city's suburbs are intermixed with wet eucalypt forest growing on the flank of the mountain and on polar-facing slopes and gullies, and dry eucalypt forest on lower slopes and equatorial-facing slopes (Fig. 2*a*). Dry forests are highly flammable with decadal-scale fire frequencies, whereas wet forest burn less frequently but at very high intensities (Furlaud *et al.* 2018). The whole city is at risk from bushfire; for example, in 1967 a catastrophic fire destroyed homes across the city and claimed 62 lives, left 900 injured and 7000 homeless (Australian Institute for Disaster Resilience n.d.; McAneney *et al.* 2009; Blanchi *et al.* 2014). Nonetheless, local bushfire management is focused on neighbourhoods with populations at greatest risk from both radiant heat and ember attack, which are those closest to the edge of Wellington Park and Bicentennial Park on the western boundaries of the LGA: Fern Tree, South Hobart, West Hobart, Lenah Valley, Mount Nelson and Sandy Bay. This study, undertaken in partnership with the City of Hobart, aimed to understand the risk profiles, risk perception and factors involved in the bushfire preparation decisions and practices of residents at greatest risk from bushfire across the city. It also aimed to explore the effect of local neighbourhood differences in geography and community culture on these decisions and practices.

Social data collection

A letter of invitation to participate in an online survey was mailed in early 2021 to residents of every household (including detached houses and apartments) identified by geographic information system as within one house block of the bushland interface in the Hobart suburbs of Fern Tree, South Hobart, West Hobart, Lenah Valley, Mount Nelson and Sandy Bay. Postal invitations were necessary in order to target the population of residents at greatest risk from bushfire based on their proximity to bushland, in the absence of a directory of phone numbers or email addresses for such residents. Invitations targeted resident householders as opposed to property owners, in order to exclude non-resident property owners and non-residents visiting properties, but include long-term rental tenants (including those in public housing). Invited residents were each sent a unique code that enabled their survey results to be geolocated. The code was embedded in a QR code, and a simple URL was included as an alternative; residents of Hobart had become familiar with QR codes during the pandemic as they were strongly encouraged by the Tasmanian Government to use them to register visits to shops and venues. Residents who were not able to use the QR code or URL were invited to contact the research team for a paper copy of the survey, using their numeric code for geolocation. A total of 3728 invitations (one to each household in the defined area) were sent, eliciting 406 responses. This indicates an 11% response rate, although it should be noted that this rate is artificially diminished by a significant number of invitations sent to properties that were unoccupied or used for short-term tourism rental. *A priori* calculations yielded a required sample size of 349 for the population targeted with a 95% confidence interval and a 5% margin of error. While the response rate was fairly low, previous research has shown little relationship between the response rate and measured non-response bias (Hendra and Hill 2019). The sample was fairly evenly distributed across the target neighbourhoods (see Fig. 2*c*), with a reasonable balance of genders (44% female) and adequate representation of each age group over 18 (for a comparison with census data, see Supplementary Materials). The sample skews slightly more toward older age groups when compared with census data, likely because the areas surveyed contain mostly larger family homes, rather than apartments.

For the purposes of analysis, participants from suburbs that are geographically adjacent and share similar built environments, vegetation types and risk profiles were grouped together as 'neighbourhoods'. Fig. 2*c* shows the geography of these neighbourhoods and the locations of participants. Participants in West Hobart and Lenah Valley, both

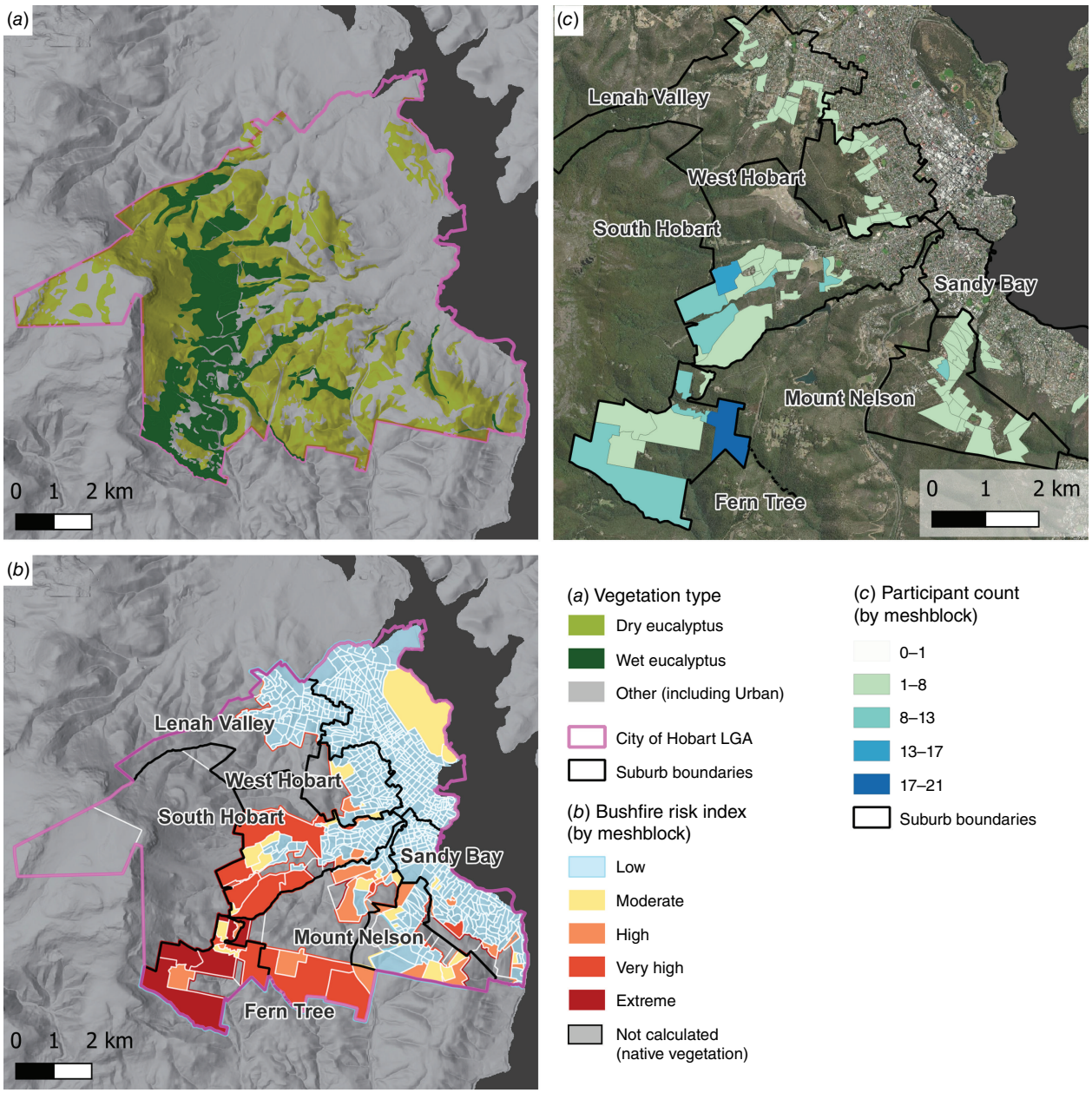

Fig. 2. (*a*) Forested areas of the City of Hobart Local Government Area. (*b*) Bushfire risk by meshblock for City of Hobart suburbs. (*c*) Participant count by meshblock.

relatively urban environments on the edge of Wellington Park, are grouped together (n = 114), as are participants in Mount Nelson and Sandy Bay, whose properties border Bicentennial Park (n = 113). Responses of participants from South Hobart, which runs along the Hobart Rivulet as it descends the mountain and contains some wet forest (n = 113), were analysed separately from those in Fern Tree (n = 57), which is less suburban and more densely vegetated, with on average larger block sizes.

Survey participants were asked if they would like to participate in a follow-up focus group; four such focus groups consisting of 7–10 participants were held in community centres, one in each of the neighbourhood areas. These meetings were video-recorded and transcribed, and coded in NVivo. The study (including both the survey and focus groups) was given ethics approval by the University of Tasmania Human Research Ethics Committee (Ref. 24427). Qualitative data were interpreted by a single researcher, using a reflexive, inductive approach (Braun and Clarke 2021) to conduct thematic analysis of both focus groups and survey comments. While the full thematic analysis is not presented in this article, selected qualitative data are used below to illustrate how the results shown in the survey data contributed to local bushfire narratives articulated by

individuals in diverse neighbourhood contexts. All participants' names given below are pseudonyms.

Biophysical index of bushfire risk

A landscape-level bushfire risk index was developed to contextualise the biophysical risks of the neighbourhoods used to conduct social science surveys using a geographic information system. The bushfire risk index was based on an estimation of radiant heat from a bushfire, following the approach used to determine Bushfire Attack Levels (BAL) that is used to certify fire risk to structures under Australian planning regulations (Standards Australia 2021). The index was standardised assuming a bushfire occurring on a high fire danger day (Forest Fire Danger Index (FFDI) = 25) for the City of Hobart LGA meshblocks, which are small geographical areas used in Australian Bureau of Statistics census data. The risk index was calculated based on the difference in metres between the recommended distance (based on Tasmania Fire Service guidelines) and the actual distance between a built property and vegetation. A geolocation was established for each property by placing a sample point over the building footprint centroid. Calculation of the distance to flammable vegetation was automated, by extending lines of 150-m length in eight cardinal directions around each property centroid and extracting zones of vegetation presence along those lines based on City of Hobart vegetation class mapping. An elevation profile along each line was also extracted from the Tasmanian digital elevation model, and the slope of each line as well as a classification as upslope, downslope or level using a linear regression of elevation by distance. Sample lines that were entirely within urban or unvegetated areas were given the 'urban' vegetation class, while sample lines that contained some flammable vegetation were classified as 'fringe'. For fringe lines, the class of vegetation comprising the longest distance along the line, and the distance from the property to the start of that vegetation, were determined, as well as the presence of continuous vegetation of >300 m length in the north-westerly direction, from which significant fire runs are assumed to approach. The attributes for each sample line were then processed through an adaption of the Tasmania Fire Service's fuel break width guidelines using a bespoke calculator algorithm, which determines the recommended distance from the property to the line's primary vegetation type based on vegetation, fire run distance and slope. For each property, the line with the maximum recommended fuel break width, representing the highest risk, was selected, and the difference between that recommended distance and the actual distance to flammable vegetation calculated. Each property centroid was then assigned this difference as a representation of landscape-level radiant heat risk, with negative values indicating properties with distances from vegetation that exceeded the recommended minimum, and positive values indicating properties closer to vegetation than recommended. These values were grouped as follows: Low <0 (Negative), Moderate 0–10, High 10–20, Very High 20–30, and Extreme >30.

Statistical analyses

Questions and analyses relating to the constructs described in our conceptual diagram (Fig. 1) are described in Table 1. A description of scales created for these analyses can be found in Table 2. Differences in bushfire risk index between neighbourhoods, and annual preparedness index against neighbourhood were analysed using a one-way ANOVA and a Tukey HSD (honest significant difference) test, owing to the approximate conformity of the response variable to a normal distribution. Differences in bushfire risk concern between neighbourhoods was analysed using a non-parametric Kruskal–Wallis test with Dunn test to identify pairwise differences, owing to the ordinal data generated by Likert scale questions. A generalised linear mixed effects model (GLMM) was used to analyse differences in perceived risk between both neighbourhood and local fuel source, with participant ID as a random effect to help control for non-independence of individuals, using the R package *lme4* (Bates *et al.* 2015). A GLMM model was selected despite the ordinal data as non-parametric tests capable of analysing two-way effects are not available, and the survey data appeared close to normal in distribution. The relationship between various preparedness information sources and the association with neighbourhood groups was analysed using a logistic principal components analysis, owing to the binary nature of the data, using the R package *logisticPCA* (Landgraf and Lee 2015).

Results

Survey results showed that residents of peri-urban Hobart are well aware of bushfire risk, with 83% of survey participants expecting a serious bushfire to affect them in their lifetime. On average, they see the probability of a bushfire directly affecting their neighbourhood as 42% in the next 12 months, 58% in the next 5 years, and 71% in the next 10 years.

Bushfire risk to participants' homes, as measured by our bushfire risk index, differs across the four neighbourhoods (Fig. 2*b*), with neighbourhoods adjacent to wet eucalypt forests at greatest risk from bushfire. In some areas, this is mitigated by increased distance of buildings from vegetation although there are some high and very high levels of bushfire risk in neighbourhoods closer to urban centres (Fig. 3*a*). Overall, Fern Tree participants are at highest risk, followed by South Hobart, then Mount Nelson/Sandy Bay, with Lenah Valley/West Hobart residents experiencing the lowest relative risk.

We asked survey participants how concerned they were about the risk of bushfire affecting their home and found the mean concern for each neighbourhood (Fig. 3*b*) was closely

Table 1. Survey measures and analysis methods for constructs described in the conceptual model (Fig. 1).

Construct	Measures	Data type	Analysis
Information	Survey question 44 on use of information sources.	Categorical	Logistic principal components analysis (Fig. 4)
Social context	Survey questions 45, 46, 47 comprising 'positive community interaction' scale	Ordinal	Linear regression (Fig. 5)
Biophysical hazard	Measured using novel biophysical index of bushfire risk (see above)	Continuous	One-way ANOVA of bushfire risk index by neighbourhood group (Fig. 3*a*)
Values at risk	Survey question 29 measured values of place identity, community, landscape beauty, connection with nature and wildlife, and way of life.	Ordinal	Descriptive univariate statistics for exploratory data analysis
Experience	Included in survey question 44, and in open question 50.	Categorical, qualitative	Used for exploratory analysis
Perceived risk	Concern about the risk of a bushfire affecting participants' homes measured in survey question 24. Perceived locus of fuel risk to homes measured in survey questions 25 and 26, used to create three 'locus of risk' scales describing perceived risk to own house from fuel sources on own property, neighbours' property and nearby bushland.	Ordinal	Kruskal–Wallis test of bushfire risk concern by neighbourhood group (Fig. 3*b*) Linear mixed effects model, with participant ID as random effect, showing perceived risk to own house from fuel sources at different locations (Fig. 3*d*)
Outcome expectancy	Survey questions 37 and 39 on benefits of preparing and whether it is worth preparing	Ordinal	Frequency reported in text
Perceived responsibility	Survey question 34 on responsibility of fire services, council and residents	Ordinal	Descriptive univariate statistics for exploratory data analysis
Capacity	Survey questions 38 and 39	Ordinal	Descriptive univariate statistics for exploratory data analysis
Adaptive action	Selected items from survey questions 35 and 36 on preparedness – see 'annual preparedness' scale	Continuous	One-way ANOVA of number of annual preparedness tasks undertaken in previous 12 months by neighbourhood (Fig. 3*c*)
Social learning	Not surveyed, but discussed in focus groups	Qualitative	Used for exploratory analysis

Survey question numbers refer to the questions in the Supplementary materials. Follow-up questions for each of these constructs were asked in the neighbourhood focus groups. Descriptive statistics for the questions listed below can be found in the Supplementary materials.

matched to the mean biophysical index of bushfire risk in these neighbourhoods (Fig. 3*a*). Comparing across neighbourhoods, concern about bushfire was lowest in West Hobart and Lenah Valley, where bushland is more separate from urban streets. There was moderate concern in areas of Mount Nelson and Sandy Bay surrounding Bicentennial Park, and slightly higher concern in South Hobart, where some parts of the neighbourhood are proximate to wet eucalypt forest. The highest concern was in Fern Tree, where the wet forest is in general closer to dwellings. These patterns were supported by a Kruskal–Wallis H test that showed an overall significant between-groups difference (d.f. = 3, $H = 27.9$, $P < 0.001$), with *post hoc* tests showing significant between-groups differences between West Hobart/Lenah Valley ($M = 2.69$, s.d. = 1.04) and both South Hobart ($M = 3.16$, s.d. = 1.11) and Fern Tree ($M = 3.51$, s.d. = 0.84). Mount Nelson/Sandy Bay ($M = 3.02$, s.d. = 0.94) is also significantly different from Fern Tree (Tukey HSD $P < 0.05$).

Preparedness, however, was not strongly related to either bushfire risk or concern about the risk. Across the whole sample, there was a small positive correlation between bushfire risk score and number of annual preparedness tasks undertaken in the last 12 months by residents ($r = 0.12$, $n = 394$, $P < 0.05$). A similarly small positive correlation was found between bushfire risk concern and preparedness (rho = 0.15, $n = 390$, $P < 0.01$). Fig. 3*c* shows that the mean number of annual preparedness tasks undertaken differed only slightly between neighbourhoods, ranging from a mean of 5.1 tasks undertaken in Lenah Valley/West Hobart to a mean of 7.4 in Fern Tree. A one-way ANOVA confirms this difference is statistically significant (d.f. = 3, $F = 9.274$, $P < 0.001$). *Post hoc* tests (Tukey HSD $P < 0.05$) show that Fern Tree ($M = 7.4$, s.d. = 2.5) is significantly different from all neighbourhoods except Mount Nelson/Sandy Bay ($M = 6.3$, s.d. = 2.9). Despite being close in bushfire risk and concern, West Hobart/Lenah Valley ($M = 5.1$, s.d. = 2.9) had significantly lower preparedness than Mount Nelson/Sandy Bay. South Hobart ($M = 5.9$, s.d. = 2.7) had higher concern than Mount Nelson/Sandy Bay but undertook slightly fewer annual preparedness tasks.

Using the three geographic risk perception scales outlined in Table 2, Fig. 3*d* shows that across all neighbourhoods, on average respondents rated nearby bushland as contributing the greatest risk, followed by neighbouring

Table 2. Scales.

Scale	Measure	Response scale and coding	Reliability (Cronbach α)	*n*
Your property risk (three items)	In your opinion, how much does each of the following factors contribute to the risk of a bushfire damaging your property in the next 5 years? • Trees or shrubs on your property • Leaves, bark, long grass, wood piles or other fuels on your property • Characteristics of your house (e.g. roof or wall cladding, gaps for embers)	0 = Not a risk 1 = Low risk 2 = Medium risk 3 = High risk 4 = Don't know (recoded as missing) Missing = excluded	α = 0.71 Scale = sum of coded responses/3	351
Neighbouring property risk (three items)	In your opinion, how much does each of the following factors contribute to the risk of a bushfire damaging your property in the next 5 years? • Characteristics of neighbouring buildings (e.g. roof or wall cladding, gaps for embers) • Trees or shrubs on neighbouring property • Leaves, bark, long grass, wood piles or other fuels on neighbouring property	0 = Not a risk 1 = Low risk 2 = Medium risk 3 = High risk 4 = Don't know (4 recoded as missing) Missing = excluded	α = 0.80 Scale = sum of coded responses/3	376
Nearby bushland risk (two items)	In your opinion, how much does each of the following factors contribute to the risk of a bushfire damaging your property in the next 5 years? • Trees or shrubs on nearby bushland • Leaves, bark, long grass, wood piles or other fuels on nearby bushland	0 = Not a risk 1 = Low risk 2 = Medium risk 3 = High risk 4 = Don't know (recoded as missing) Missing = excluded	α = 0.87 Scale = sum of coded responses/2	381
Positive community interaction (three items)	(a) How often do you communicate with your neighbours (by neighbours, we mean people who live in the houses within 100 m of your home)? (b) Do you share tools, food, or other goods with your neighbours? (c) Do you help out neighbours by offering physical labour (such as mowing, clearing leaves, putting out bins, caring for pets)?	(a) 1 = Daily (recoded = 3) 2 = At least once a week (recoded = 3) 3 = About once a month (recoded = 2) 4 = Rarely (recoded = 1) 5 = Never (recoded = 0) Missing = excluded (b and c) 0 = Never 1 = Rarely 2 = Sometimes 3 = Often Missing = excluded	α = 0.82 Scale = sum of coded responses	373
Annual preparedness (10 items) These were the 10 most frequently done preparedness items in the survey	I have done this in the last year: • Regularly clear leaves, twigs and long grass immediately adjacent to the house • Regularly clear leaves, twigs and long grass within 20 m of the house • Regularly clear the gutters of leaves • Water garden frequently during the bushfire season • Cut back overhanging tree branches close to the house • Move combustible materials such as firewood and wooden garden furniture away from the house • Make or review a bushfire survival plan • Thin shrubs or trees so that nearby plants and trees do not touch • Prune large trees by removing all branches that are close to the ground • Remove bushes immediately adjacent to house	Coded 1 if ticked 'I have done this in the last year', coded 0 otherwise. Responses that did not complete any item in this question excluded	α = 0.79 Scale = sum of annual preparedness actions undertaken in last year.	391

The scales combine responses from multiple questions. The Cronbach alpha coefficient is used to check the internal consistency reliability for the scale: values above 0.7 are acceptable.

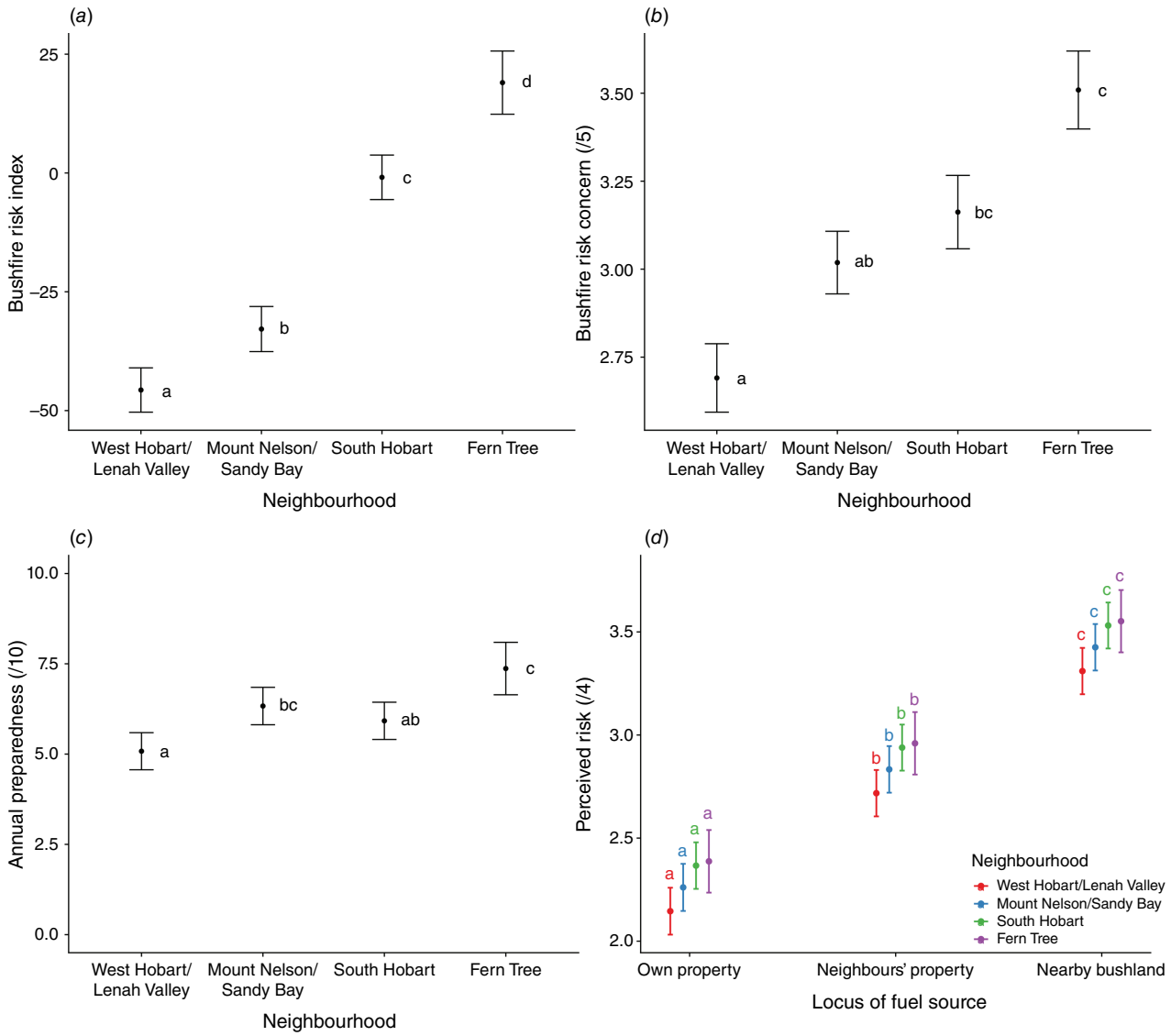

Fig. 3. (*a*) One-way ANOVA of bushfire risk index by neighbourhood group (d.f. = 3, $F = 114.2$, $P < 0.001$) with between-group differences determined by Tukey HSD test. (*b*) Kruskal–Wallis test of bushfire risk concern by neighbourhood group (d.f. = 3, $H = 27.9$, $P < 0.001$) with between-group differences determined by Dunn test. (*c*) One-way ANOVA of number of annual preparedness tasks undertaken in previous 12 months by neighbourhood group (d.f. = 3, $F = 9.274$, $P < 0.001$) with between-group differences determined by Tukey HSD test. (*d*) Linear mixed effects model, with participant ID as random effect, showing perceived risk to own house from fuel sources on own property, neighbours' property and nearby bushland, by neighbourhood group (see Table 2 for description of locus of risk scales) ANOVA shows significant difference in perceived risk of different fuel sources (d.f. = 2, $X^2 = 835$, $r^2 = 0.32$, $P < 0.001$), Tukey HSD shows no significant difference between neighbourhoods. Full table in Supplementary materials. Error bars on plots indicate standard error. Groups that are not significantly different from each other are labelled with the same letter, while groups that are significantly different from each other have different letter labels.

properties. They rated risk from their own property as low–medium. A mixed-effects generalised linear model confirmed significant differences in perceived risk by locus of fuel source (d.f. = 2, $X^2 = 835$, $P < 0.001$) and neighbourhood (d.f. = 3, $X^2 = 11.5$, $P < 0.01$), although a Tukey HSD test found no significant difference between neighbourhoods. That participants attribute more risk to fuel sources further from them, which are out of their direct control, is notable given that research shows that the greatest risk to houses comes from the area directly surrounding them.

We used ordination to plot participants' use of different forms of bushfire preparedness information by neighbourhood (Fig. 4). This analysis shows that Fern Tree residents used a greater number of information sources than all the other neighbourhoods, with West Hobart/Lenah Valley showing the least uptake of these resources. Arrows representing

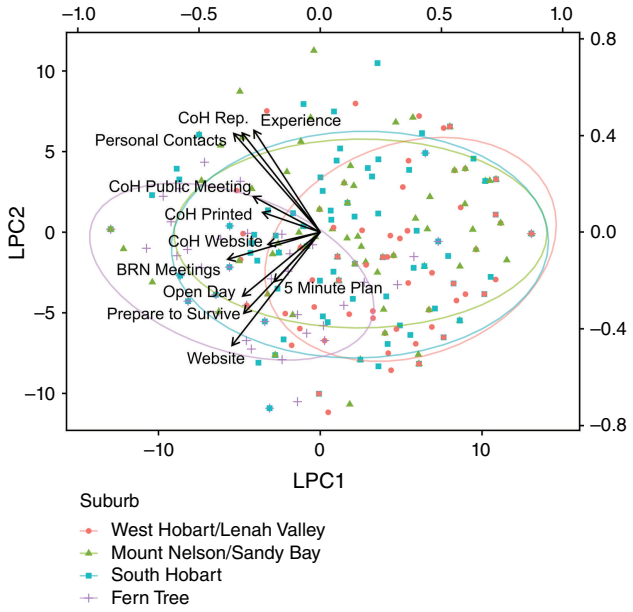

Fig. 4. Logistic principal components analysis (deviance explained 47% across two principal components) of study participants' use of different forms of bushfire preparedness information. Neighbourhood of each participant is denoted by colour code, and vectors show the strength (length) and direction (arrow) of the association of use of various sources of bushfire information. The analysis shows strong gradient, left-to-right, from strong use to low use of bushfire information sources.

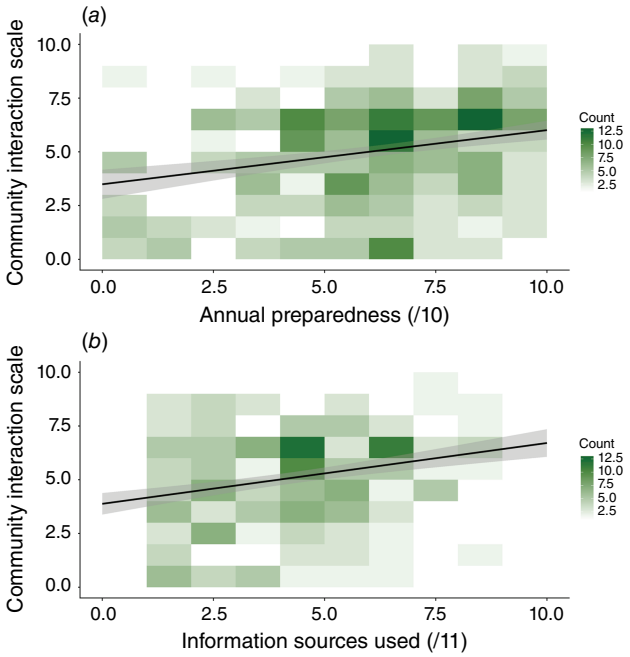

Fig. 5. (*a*) Two-dimensional histogram representing number of annual preparedness activities undertaken, by participants' level of community interaction. Linear regression showed a small significant effect ($r^2 = 0.06$, $P < 0.01$). (*b*) Two-dimensional histogram representing number of bushfire preparedness information sources accessed, by participants' level of positive community interaction. Linear regression showed a small significant effect ($r^2 = 0.04$, $P < 0.01$).

the relative influence and grouping of information resources show two influential groups of resources – one set of resources from the Tasmania Fire Service, including their website, a DVD called 'Prepare to Survive' shared with Bushfire Ready Neighbourhood (BRN) groups, Fire Brigade open days and BRN meetings, as well as the 'Five minute bushfire plan'; and another group containing participants' own experience, that of their personal contacts, and personal conversations with City of Hobart (CoH) fire and biodiversity representatives (CoH Rep.). The separation of these two sets suggest that people with experience of fire, or who have close contacts with fire experience, are less likely to bother with official guidance on bushfire preparation, but may respond to personal engagement with experienced council staff. Public meetings, printed and online information from the City was least used. Most participants in Fern Tree were part of BRN groups that valued official information from Tasmania Fire Service. Other neighbourhoods were more defined by their lack of engagement with bushfire preparedness information than by any particular source.

Using a 'community interaction scale' based on questions about how often participants communicate with neighbours, how often they share food and tools and how often they offer help or labour, we found that higher levels of positive community interaction are associated with higher levels of annual preparedness and use of information about how to prepare for bushfire (see Fig. 5). Linear regression modelling showed that level of community interaction had a small significant effect on participants' preparedness and on use of information sources.

We used focus group discussions in each of the areas sampled to further explore the survey results. Quotes are used below to illustrate key themes. There were notable differences in bushfire risk concern, community interaction and understanding of bushfire preparedness across the different neighbourhoods. Although participants in all focus groups expressed concern about bushfire, participants in South Hobart and West Hobart/Lenah Valley cited Fern Tree as an example of high risk, describing their relative risk as low because 'We're not Fern Tree' [Richard, West Hobart/Lenah Valley].

> If you're living in Fern Tree and there's a bushfire, your house will burn, 99 per cent chance of it. It doesn't matter whether you've got a 10-metre buffer or a 20-metre buffer, your house is just going to go… That's Fern Tree. It's a disaster waiting to happen. Enjoy it whilst it's there. [George, South Hobart]

Participants in all neighbourhoods were concerned about the effect of climate change on fire behaviour and on their ability to mitigate fire risks. In Fern Tree, this was made more pertinent by rapidly rising insurance premiums

attributed to climate risk. Some felt that the increased likelihood of catastrophic conditions limited the value of preparing, as no level of preparation was considered to make a difference in these circumstances.

> I think that the reality is in a catastrophic event, it doesn't matter what you do. You're just kidding yourself if you think you're going to save the place. It's going to be, you know, it's going to be out of control. [Neil, South Hobart]

Others felt that preparing was something they could do to help their local environment to adapt to the increased fire risk. Participants in the Fern Tree focus group were better-informed about bushfire risk and preparedness, and most had clear bushfire survival plans. In Fern Tree, bushfire planning is part of social life – almost all participants from this area were part of local community bushfire networks who meet socially.

> There's a very good community feel there and a few sort of annual events every year. Then we get together, yes, and we also have a bit of a fire plan as a street, get everyone's contact details. [Casey, Fern Tree]

This high level of community interaction focused on fire is supported by Fern Tree's local volunteer Fire Brigade, and by BRN groups that were set up in this area by the Tasmania Fire Service some years previously. In contrast, participants in the Mount Nelson/Sandy Bay focus group described the difficulty of meeting their neighbours, in part because of the built design of their neighbourhood.

> I've got neighbours I never speak to because … they're up a long drive, we're up a long drive, and there's no... it's very difficult to make that connection. [Joy, Mount Nelson/Sandy Bay]

The sense of community cohesion was very neighbourhood-specific. In South Hobart, several participants were part of community-led initiatives that had been started by friends or neighbours to prepare for bushfire. They described an appetite to self-organise within the community as one of its strengths, and emphasised the normative influence of neighbourhood groups on decisions to prepare.

> It was really handy when all our neighbours, we got together in this room and started talking about it. Your peer group does influence you fairly heavily. Your neighbours, your community does influence you, rather than TFS [Tasmania Fire Service] over there or something happened in the cloud. [Vanessa, South Hobart]

On the flipside, where relationships with neighbours are challenging, it can have the effect of discouraging people from preparing their own homes.

> I feel like I've tried to look at a few things and there's some basic information, but it's very individualised… I can clear up my yard and cut a few things back, but… well, I look at my neighbours' backyard, their bush and think, well, what's that going to do? [Erica, South Hobart]

> You feel like you're fighting a losing battle, doing a lot on your own property when possibly all their [neighbour's] trees are just going to fall on your property as well. [Casey, Fern Tree]

Reflecting greater perceived risk from neighbours' property than from their own property (Fig. 3), 29% of survey participants felt that there was no point preparing unless their neighbours also prepare. Participants in both the survey and focus groups stressed the importance of good neighbourly relationships, and overwhelmingly did not want to threaten these by complaining about fuel hazards.

> Sometimes think it isn't worth bothering about as neighbours' houses are our biggest risk. I'd appreciate a bit of focus being put into considering your neighbours to at least start some thought and conversations, and give a bit of back up to my concerns as maintaining good relations is really important. [Survey respondent 39]

Focus group participants said that while they had read generic information about how to prepare, they found it difficult to access information that they felt was relevant to their situation. Some said that while the message that individuals should take responsibility for preparing for bushfire was clear, they felt unsupported in terms of how to prioritise and apply standard advice.

> Well, I don't know what's going to have an effect. I just feel like the lack of knowledge is really hard. You have to figure it all out yourself. If you're not super cashed up, you're like, well what thing do I do first? Do I do my gutters first? Or do I liaise with a neighbour around cutting that tree down? [Prudence, South Hobart]

However, a recurring theme in focus group discussions across the four neighbourhood areas was that residents choose to live in places close to native bushland because of the natural values of these places. Many are therefore concerned about strategies to reduce bushfire risk that might involve the loss of trees or wildlife. A number of participants described their love of the bush and their need to feel safe from bushfire as contradictory values, sometimes causing anxiety and ambivalence about bushfire preparedness, and sometimes sparking conflict within families or with neighbours.

> I wouldn't move anywhere just to try and safeguard my possessions because I value being where I am, and I love

> the bush where it is, and I don't want to see the bush disappear either. If my house burns down, yes, OK, I'm going to be devastated, but I don't want to see the bush taken down. I love it. That's why I'm there. [John, West Hobart/Lenah Valley]

Discussion

We found that residents of bushfire-prone suburbs in Hobart are well aware of and concerned about the risk of fire to their homes and lives. At a neighbourhood scale, their concern is statistically associated with our biophysical measurement of bushfire risk. While preparedness is hard to measure quantitatively, and our measures reflect only 'checklist' type annual preparedness actions, we found only a small positive correlation between risk perception and preparedness, in line with findings by Koksal *et al.* (2019). That concern about the risk of bushfire plays such a small part in people's decision to prepare suggests that public information campaigns about bushfire preparedness that emphasise the danger of bushfire may not be hitting the right notes to encourage community action. Such campaigns may in fact contribute to people seeing bushfire as an external risk, rather than one they can affect by preparing their property and themselves.

Despite research showing that fuels within 30–50 m contribute the greatest risk to homes, we found many residents see the risk from fuels on their own property as relatively low, and perceive the greatest risk to their own home as coming from fuels on nearby bushland. The City of Hobart has implemented fuel breaks where homes are adjacent to public land on all bushland it manages, to ensure the recommended defensible space between public bushland and private property. These fuel breaks, maintained annually by the City, actually provide defensible space for many participants' homes. That our participants attribute greatest risk to nearby bushland suggests that they either do not recognise the effectiveness of these fuel breaks, or they do not understand the importance of managing vegetation close to the house. Survey participants also saw fuels on neighbouring properties as creating the next greatest risk to their homes. In many cases, this is likely to be true, as housing in these neighbourhoods is relatively dense, and neighbouring properties may well contain fuels that are within 30–50 m of participants' homes. This finding underscores the importance of neighbourhood scale and community-driven approaches to communicating about bushfire preparedness. A recent study by Meldrum *et al.* (2021) found that offering neighbourhood-specific risk information to residents of a fire-prone area increased their likelihood of seeking further information about how to prepare. Providing personalised risk information to residents could be a useful first step in a conversation about reducing that risk.

Participants clearly understood that suburbs have variable biophysical risks with the highest danger in wet forests such as Fern Tree. But this awareness may lead residents of less fire-prone neighbourhoods to discount their own need to prepare. The need for bushfire preparedness was seen by residents of Fern Tree as something that helped to bring the community together – both exemplified and facilitated by the local volunteer Fire Brigade and the existence of Bushfire Ready Neighbourhood groups. Consequently, overall, Fern Tree residents accessed more information and were slightly better prepared for bushfire than other participants.

An emergent finding of our study is that collective, rather than individual perceptions and actions drive bushfire preparedness in flammable landscapes. This is an important finding because neighbouring properties not only affect one another's risk on a biophysical level, but neighbours affect one another's decisions about managing that risk socially and normatively. A challenge for fire agencies and local governments is to craft programs of communication and engagement that build social adaptation pathways to support community bushfire preparedness. This requires a careful blending of both generalised and local communication interventions that are aimed to motivate and empower residents to act on their understanding of bushfire risk. Interventions could include facilitating and fostering community neighbourhood groups and discussions, offering personalised hazard assessments and advice, and providing tailored education and training programs on bushfire risk and preparedness. To be effective this demands a shift from a 'command and control' model of bushfire risk management to more interactive and participative models of social learning and adaptation. For residents, sharing responsibility for managing bushfire risk not only means preparing their own property, but having conversations with neighbours and other local land managers and cooperating toward neighbourhood-scale fire adaptation that considers local ecological and cultural values, as well as reducing risk. Locally targeted and sustained two-way communication between agencies and residents will be key to the success of community-led bushfire adaptation.

Summary and conclusion

All Australian capital cities, and particularly Melbourne, Canberra, Adelaide, Perth and Hobart have complex wildland–urban interfaces in which neighbourhoods are interwoven with highly flammable landscapes (Smith *et al.* 2016). State and local governments, through their roles in planning, building regulation, public health and safety, and land management, have key responsibility to limit the risks of bushfire to residents and their homes. A vital part of this responsibility is communication with residents about *their* role in managing bushfire risk. Residential communities are typically seen by management agencies as external to the fire system. They are not encouraged to participate in management of local firescapes unless through organisations or

projects closely controlled by the agencies themselves (Johnston *et al.* 2019; McLennan 2020). Although they are considered to 'share' responsibility for bushfire preparedness, this responsibility is constrained to within the boundaries of their own private property (McLennan and Eburn 2015; Lukasiewicz *et al.* 2017). The City of Hobart case study illustrates the importance of facilitating neighbourhood conversations about bushfire preparedness, and collective action among groups of neighbours. Our findings highlight the need for social adaptation pathways using local communication interventions. We conclude that building the neighbourhood knowledge, networks and capacities that enable community-led bushfire preparedness:

- Demands conversations and communications about community fire risk management to be supported by locally relevant information, including information about how to reduce fire risk by managing fuels in the 30–50 m around the home.
- These conversations and communications should aim to involve communities collectively, reflecting the importance of both risk mitigation on neighbouring properties, and social norms of preparedness within neighbourhoods.
- They must also be sensitive to potential differences in values, priorities and capacities within and between neighbourhood communities.
- To facilitate these kinds of conversations across diverse communities and landscape types, local management agencies must themselves be open to a process of social learning, through being reflexive about their own assumptions, and engaging in dialogue and negotiation with communities.
- Further research is needed to understand how the multiple social and biophysical factors involved in community bushfire preparedness interact on a local scale, and how agencies can best work with communities to help them to adapt to increasing fire risk.

Supplementary material

Supplementary material is available online.

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Data availability. Meshblock level maps of biophysical risk, and vegetation type used to support this study are available in a data repository at https://dx.doi.org/10.6084/m9.figshare.20044733. The social data that support this study cannot be publicly shared owing to ethical or privacy reasons. De-identified data may be shared on reasonable request to the corresponding author if appropriate.

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