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Where the landscape meets the garden gate: fire risk perception and garden adaptation in Tasmania's wildland–urban interface

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ABSTRACT

Background. Wildfires increasingly threaten communities at the wildland–urban interface, where effective garden management is crucial for reducing house loss. **Aims.** To understand barriers and opportunities for implementing garden wildfire prevention strategies by examining how residents' risk perceptions align with assessed hazards and exploring factors influencing garden management decisions. **Methods.** We conducted a multi-modal study of 23 homeowners in Greater Hobart, Tasmania, Australia, combining quantitative survey, qualitative interviews, mapping exercises and photo-elicitation. Gardens were classified into risk categories based on biophysical assessments of both garden and landscape fire hazards, and the social data were analysed according to this framework. **Key results.** Significant discrepancies existed between perceived and actual hazards, particularly in zones closest to houses (0–1.5 m). While participants recognised landscape-level fire risks, they underestimated hazards in their own gardens and focused on plant flammability rather than spatial arrangement. Personalised garden hazard assessment reports effectively motivated change, especially among residents in high landscape-risk areas. Implementation barriers included knowledge gaps, resource constraints and emotional attachment to garden elements. **Conclusions.** Garden fire risk reduction requires flexible frameworks that respect resident values while emphasising critical near-house zones. **Implications.** Future interventions should combine property-specific assessments with community-based support systems to bridge the gap between awareness and implementation of garden safety measures.

Keywords: biophysical assessment, bushfire, defensible space, garden management, interdisciplinary research, pyrogeography, risk perspective, vegetation management, wildfire adaptation, wildfire risk mitigation.

Introduction

Wildfires have shaped dynamics of terrestrial ecosystems for 420 million years (Bowman *et al.* 2009), and subsistence and agricultural economies have utilised landscape fires for thousands of years as a tool for hunting, vegetation management and cultural practices (Bowman *et al.* 2011; Huffman 2013). More recently, wildfires have become increasingly catastrophic, especially where dense human settlements meet flammable vegetation because of climate change and urban expansion (Fox-Hughes *et al.* 2014; Bowman 2024; Cunningham *et al.* 2025). Fire disasters can have far-reaching consequences, impacting communities, natural environments and economies (Johnston *et al.* 2024), particularly at the Wildland–Urban Interface (WUI), where human developments, such as suburban and semi-rural communities, border or mix with natural vegetation (Mell *et al.* 2010; Eriksen and Prior 2011; Bardsley *et al.* 2018; McCaffrey *et al.* 2020; World Bank 2023).

Human behaviour plays a pivotal role in both the creation and mitigation of fire risks. From land use decisions to daily activities, human actions can either exacerbate fire dangers or contribute to their prevention (Bowman *et al.* 2011), such as heightening probability of ignition (Syphard and Keeley 2015) or, conversely, maintaining fire-resilient landscapes (Gjedrem and Log 2020). The dominantly modern Western approach has focused on wildfire prevention and suppression (Doerr and Santín 2016), failing to recognise how wildfires can contribute to ecological health and species diversity (Rose 1996). This approach has created feedbacks that are exacerbating the wildfire crisis (Bowman 2024). For instance, wildfire risk has intensified due to the proliferation of flammable vegetation and the development of settlements (Bénichou et al. 2021; Tampekis et al. 2023). As governments struggle with escalating firefighting costs and socio-economic destruction (McWethy et al. 2019; Clarke et al. 2023; Gjedrem and Metallinou 2023), an emerging insurance crisis further highlights wildfires as a fundamentally social problem with ecological consequences (Lucas et al. 2020). When fires do occur, they tend to be more devastating and harder to manage, leading to increased ecological and societal destruction and higher carbon emissions (Bowman et al. 2020; Iglesias et al. 2022; Bowman 2024).

A key approach to wildfire risk reduction focuses on adapting WUI environments through mitigation initiatives that create fire-safer zones between settlements and natural environments (Paton et al. 2008; McWethy et al. 2019; WHO 2019; Metallinou 2020; Log et al. 2022; Tampekis et al. 2023). These initiatives emphasise both structural improvements to buildings and the establishment of 'defensible spaces' around residences, such as in garden spaces (Gibbons et al. 2018; Ondei et al. 2024).

Gardens and house loss in the WUI

Post-fire studies have highlighted the significant impact of garden design on house survivability during wildfire events (Wilson and Ferguson 1986; Syphard et al. 2014; Penman et al. 2019; Price et al. 2021). Key factors include the type and density of vegetation near buildings, along with the presence of non-vegetative flammable materials (Ondei et al. 2024). When properly designed and maintained, defensible space (up to around 30 m from the house (Ondei et al. 2025)) not only serves as passive protection, but also improves safety for residents and firefighters defending properties. Despite the existence of risk mitigation guidelines for garden maintenance for flammable regions around the world (Ondei et al. 2024), their adoption remains predominantly voluntary. However, garden wildfire mitigation represents an accessible solution that relies on residents' own agency and provides an affordable solution complementary to structural adjustments (Syphard et al. 2014; Gibbons et al. 2018; Ondei et al. 2024).

Previous studies have shown that wildfire adaptation is not only an issue connected to individual gardens, but is also a community-wide issue (Price et al. 2021; Lucas et al. 2022). Creating continuous defensible space across neighbouring properties and wildland will increase overall community wildfire resilience and adaptation (Gill and Stephens 2009; Prior and Eriksen 2013; Kwok et al. 2016; Penman et al. 2017).

Understanding barriers and pathways to 'fire-wise' gardens requires examining the complex interplay between risk perception, behaviour and agency (Winter et al. 2000). Furthermore, establishing a baseline understanding of biophysical factors (the biological and physical variables such as fuel characteristics, topography, weather and fire behaviour) that determine fire risk enables us to compare social perceptions with actual hazard conditions. Risk perception involves assessing probability, consequences and uncertainty (Hansson and Aven 2014), often leading to trade-offs between different priorities (Slovic et al. 2013). Studies show that biophysical assessments of risk frequently conflict with residents' subjective perceptions (Martin et al. 2007; Carroll and Paveglio 2016; McCaffrey et al. 2020; Lucas et al. 2022), as seen in evacuation decisions where people may choose to stay and defend their property against official advice (Campbell et al. 2024). Furthermore, while residents often recognise landscape-level fire hazards, they frequently underestimate risks in their own gardens, creating an 'action-awareness gap' (Lucas et al. 2022). This gap persists despite evidence that effective garden design and management can significantly reduce wildfire vulnerability and enhance community resilience (Ondei et al. 2024). There is limited focus on garden-, zoning- and hazard specific approaches and risk perception to bushfire mitigation among residents.

Multiple factors contribute to limited implementation of garden mitigation strategies: lack of resources and skills (Ryan et al. 2020); limited access to information (Ryan et al. 2020); insufficient experience with mitigation practices (Eriksen and Prior 2011); conflicting worldviews (Howe et al. 2024); top-down institutional approaches (Haynes et al. 2020); conflicting priorities between natural aesthetics and safety (Bradstock et al. 2014); lifestyle choices (Freeman et al. 2012; Williams et al. 2018); socio-economic constraints (Penman et al. 2013; Koksal et al. 2019); and gender roles (Eriksen and Gill 2010). Research indicates that communities with strong social interactions are more likely to develop fire-adapted behaviour than isolated individuals (Champ et al. 2013; Prior and Eriksen 2013; Dickinson et al. 2015; Lucas et al. 2022; Hallsworth 2023). Hence, success in garden wildfire mitigation often depends on community participation (Robinson et al. 2018), local knowledge integration (Halliday et al. 2012; Edwards and Gill 2016), flexible support systems (Gill and Stephens 2009) and practical assistance beyond traditional education campaigns (Bradstock et al. 2014). Deeper understanding of these dynamics is crucial for developing effective policies and programs that enhance both individual and community resilience to wildfire threats (Lohm and Davis 2015; Log et al. 2020; Bowman 2024).

Study setting

Tasmania, the island state of Australia, has a long and complex history of societal impacts from wildfires (Power and Wettenhall 1970; Leivesley 1980; Britton 1984;

Eriksen and Prior 2011; Prior and Eriksen 2013; Rickards 2016; Owen 2018; Bowman *et al.* 2022; Lucas *et al.* 2022; Tasmanian Museum and Art Gallery n.d.). The state experienced its worst wildfires in 1967 in terms of loss of life and number of structures destroyed, and also had substantial adverse effects on forests and natural values surrounding the greater Hobart area (Fensham *et al.* 2025). 64 people perished, around 1400 buildings were destroyed and 265,000 ha burned over just 5 h (Power and Wettenhall 1970; Haynes *et al.* 2008; Richards *et al.* 2014). Since the early 2000s, Tasmania has faced four significant fire seasons with severe impacts: 2012–2013, 2015–2016, 2018–2019 (Bowman *et al.* 2022) and 2025 (Balen 2025). These seasons, marked by high temperatures, drought and lightning storms without rain, resulted in considerable property and forest damage and detrimental smoke pollution (Johnston *et al.* 2024). The extraordinary nature of these events led to multiple government inquiries and emphasised the need for improved management and adaptation strategies (Bowman *et al.* 2022). Hobart, state capital of Tasmania, has a very long and convoluted WUI (Bardsley *et al.* 2018; Fensham *et al.* 2025) with numerous suburbs in close proximity to highly flammable wet and dry *Eucalyptus* forests (Furlaud *et al.* 2023).

Aims and objectives

While the devastating impacts of wildfires in Tasmania, particularly in Hobart's WUI, are well-recognised, there remains a concerning gap between residents' awareness of fire risks and their actual mitigation actions. This research examining how homeowners perceive and respond to garden fire hazards, aims to identify practical solutions that can enhance both individual and community resilience, in addition informing policies and interventions that can support residents. By focusing on garden management – an accessible and cost-effective approach to fire preparedness – this study seeks to bridge the divide between scientific understanding and practical implementation of wildfire safety measures. We investigated individual attitudes, understanding and capacity to change garden wildfire hazards among a small, self-selected group of homeowners in Greater Hobart who had previously volunteered to have their gardens assessed to identify biophysical fire hazards. We used in-depth and multi-modal interviews to record quantitative, qualitative, geographical and photographic data to gauge the participants awareness, perception and response to the assessed garden wildfire hazard. This multi-modal approach was designed to capture impressions beyond verbal responses, allowing for a more comprehensive understanding of participants' perceptions and behaviours. Specifically, we addressed the following questions:

- How does the participants' perception of garden hazard align with the garden hazard score and landscape hazard score assessed and provided by experts?
- How does the perceived garden and landscape wildfire hazard influence the participants attitude and management of their gardens?
- Did learning the assessed biophysical garden hazard motivate participants to change garden management to reduce wildfire risk?
- What are the main challenges that participants face in mitigating the wildfire hazards in their garden?

Methods

Study domain

The study was conducted in the suburban area of the city of Hobart, Tasmania (Fig. 1). This study comprised a subset ($N = 23$) of the 32 residents who previously volunteered to have the fire hazard of their gardens assessed using a structured biophysical survey method (Ondei *et al.* 2025), for which participants were recruited by advertising on local media. Note that the number of gardens included in this study is 21 (Fig. 1), as in two instances more than one resident was interviewed about the same garden. Most participants ($N = 16$) resided in the Local Government Area (LGA) of Hobart, the remainder in LGAs within the Greater

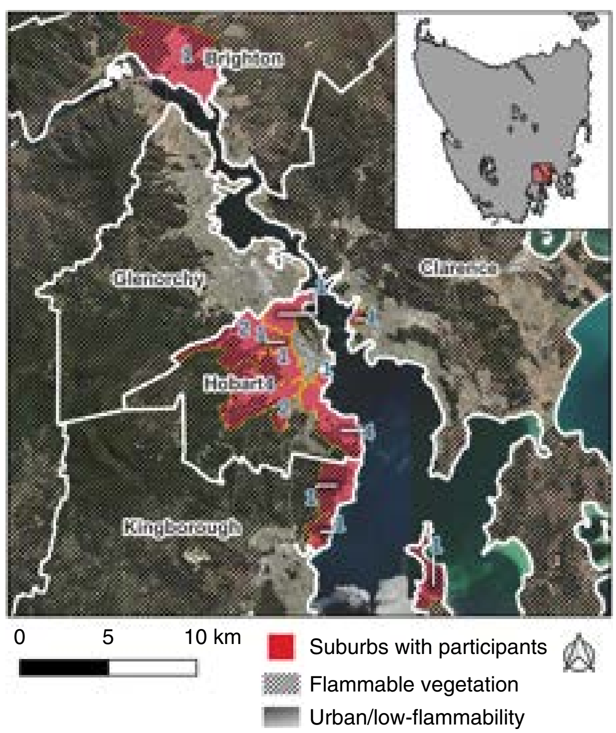


Fig. 1. Area of study. Map of the Local Government Areas included in this study and the suburb areas where the 21 gardens are located, with number sampled in suburb indicated. Areas with black hashing shows flammable/highly flammable *Eucalyptus* forests. Areas with no hashing illustrates urban areas or low-flammability areas. The inset shows their location in the Australian island State of Tasmania.

Hobart area (Clarance, $N = 2$; Brighton, $N = 2$; and Kingborough, $N = 3$) (Fig. 1).

Biophysical hazards and data analysis

Garden hazard score

For each of the 21 gardens used in this study we used a structured proforma to quantitatively assess garden fire hazards, recording hazard type, their location and abundance (Ondei *et al.* 2025). During the assessment, the garden was divided into three zones, as commonly recommended by guidelines for the creation of defensible space (Ondei *et al.* 2024): the Fuel-Free Zone (henceforth FFZ: 0–1.5 m from the house), where fuel should be minimised as much as possible; the Open Zone (henceforth OZ: 1.5–10 m from the house), where vegetation should be organised in separate patches, to prevent flames from spreading towards the house; and the Tree Zone (henceforth TZ: 10–30 m from the house or to the edge of the property if closer than 30 m), where trees can act as a barrier from embers, but ground litter should be kept to a minimum. Assessments recorded garden hazards or hazard-protecting features. The individual hazards were then combined using an expert system (Ondei *et al.* 2025) yielding an overall garden fire hazard used to classify the gardens into two risk groups: low garden risk (LG), which included gardens whose hazard was considered lower or moderate ($N = 8$), and high garden risk (HG) for gardens with hazard 'moderate-high' or higher ($N = 15$). A customised report was prepared for the homeowners with recommendations for reducing garden fire risk, based on the specific hazards identified in each garden.

Landscape hazard score

For each garden, fire hazard originating from the surrounding landscape was estimated using an index of likely radiant energy that each garden would receive from a wildfire under extreme fire weather conditions (Forest Fire Danger Index 50), controlling for terrain and vegetation type as described in detail in Supplementary Appendix S1. This methodology is based on that applied in AS-3959 (Australian Standard 2009) based on Hilton *et al.* (2020). Building locations for every non-study residential property in the Hobart LGA were obtained from the Tasmanian Land Information System Tasmania (LIST) (Land Tasmania 2020), and a landscape hazard score was calculated for each of them according to this same methodology, for comparison to those of the selected properties to ensure our sample was unbiased.

Landscapes fire hazard scores were binned into low landscape risk (LL; < -25) and high landscape risk (HL; > -25) categories, and a Chi-squared test was used to determine whether the proportion of our sampled gardens in each hazard category differed from that of all residential properties in the Hobart LGA. Additionally, for those gardens in the high hazard category, we used a Kruskal–Wallis test (Kruskal and Wallis 1952) to determine if the distribution of continuous landscape fire hazard scores in our sampled gardens differed from that of all high hazard properties in the Hobart LGA.

Social survey

Participants were engaged using a semi-structured interview method (Bryman 2016), to explore emergent themes significant to the research topic. The interview technique focused on empowerment, and provided participants with a platform to express their concerns and identify opportunities for improvement (Rosenberg and Chopra 2015). Residents were interviewed at their property (the interview guide is presented in Supplementary Appendix S2). The interview process comprised four sequential steps taking between 45 min and 2 h 30 min in total:

1. Mixed-method questionnaire (Johnson and Onwuegbuzie 2004): a combination of Likert scale items and open-ended questions assessed participants' attitudes towards fire hazards and their place-based attachment to their gardens and surrounding landscape.
2. Garden hazard mapping (Bradstock *et al.* 2014; Haworth *et al.* 2016): participants were provided with a blank map of their house and property boundary in which they pinpointed specific fire hazards within the garden (e.g. flammable vegetation).
3. *In-situ* photo-elicitation garden walk (Sutton-Brown 2014; Boucher 2017): participants engaged in a walking interview in their garden, documenting key elements through photography. The participants were requested to capture photos, that among other things, represent places or objects of emotional importance to the participant and elicited their meaning by commenting on the importance of these elements to the researcher.
4. Cognitive debriefing (Blair and Brick 2010): the interview concluded with a presentation of the garden assessment report to the participants. Using 'think-aloud' techniques, the researcher prompted reflections on novel insights regarding wildfire risks in participants' gardens.

Our social science questionnaire design was trialled with three participants, and then applied to the remaining 21 gardens.

Social survey data analysis

Mixed-method questionnaire data analysis

Interviews were audio-recorded, transcribed and analysed using NVivo software (Lumiverno 2022), Miro board (Miro n.d.) and Microsoft Excel (Blaikie and Priest 2019). We collected qualitative and quantitative data on risk perceptions, behaviours and attitudes towards garden bushfire mitigation. All respondents were given new names to protect their privacy.

The biophysical categorisation of the fire hazard of garden and surrounding landscapes enabled the classification of

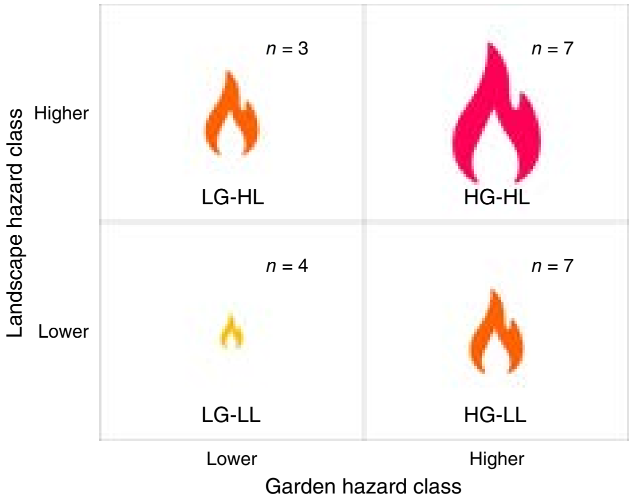


Fig. 2. Garden and landscape hazard matrix. The garden and landscape hazard matrix that shows a two-way categorisation of garden hazard and surrounding landscape hazard, with the number (*N*) of gardens indicated. The hazard category codes are: LG-LL low garden – low landscape; HG-LL high garden – low landscape; LG-HL low garden – high landscape; HG-HL high garden – high landscape.

the 21 gardens into a two-by-two garden and landscape hazard matrix (Fig. 2), representing four combinations of the two hazard scores which we used as theoretical framework for qualitative and quantitative analysis. The resulting biophysical hazard categories were: LG-LL low garden – low landscape; HG-LL high garden – low landscape; LG-HL low garden – high landscape; HG – HL high garden – high landscape (Fig. 2).

Qualitative data were analysed through thematic using deductive (i.e. the hazard scores) and inductive (i.e. generating coding from the data) approaches. We systematically coded and categorised open-ended questionnaire responses, interview transcripts and cognitive debriefing sessions to identify recurring patterns and themes across participants' experiences and perceptions (Maguire and Delahunt 2017).

For quantitative analysis we used Kendall's tau correlation coefficient (McLeod 2022) that is suitable for ordinal data and can handle tied ranks. To identify statistically significant differences in garden characteristics between HG and LG, we conducted a Wilcoxon rank test using the R package exactRankTests (Hothorn and Hornik 2022) to obtain correct *P*-values in the presence of ties. We also used Chi-square or Kruskal–Wallis test, depending on whether the data were categorical or continuous, to test if there were differences among residents age, gender, employment and duration of occupancy among these four groups.

Garden hazard mapping analysis

We used the garden hazard maps created by the participants to associate each hazard they identified with its corresponding defensible space zone (FFZ, OZ or TZ) and compared the results with those of the biophysical garden assessment. The mapped hazards were grouped in broad categories (vegetation, ground and objects), adapted from the list of variables used in the biophysical garden assessment (Supplementary Table S1 in Supplementary Appendix S3) (Ondei *et al.* 2024).

In-situ photo-elicitation garden walk analysis

We analysed the photographs taken during the garden walks and the garden hazard maps used by participants to elicit social meanings from visual data, and focus on elements that participants identified as significant (Sutton-Brown 2014; Boucher 2017).

Cognitive debriefing analysis

To understand if the report provided to the participants increased their motivation to mitigate garden hazards, we undertook qualitative analysis employing an Attention, Relevance, Confidence and Satisfaction (ARCS) model (Keller 1987). We investigated four main questions: (1) did the reports capture and maintain the interest of the recipients? (Attention); (2) did the recipients perceive the information in the reports as relevant to their personal situation? (Relevance); (3) did the report make recipients feel confident in their ability to mitigate the wildfire hazards? (Confidence); (4) were the recipients satisfied with the information and motivated to act based on the report? (Satisfaction).

Ethics

This study received ethics approval from the University of Tasmania Human Research Ethics Committee (Ref. 29988).

Results

Socio-demographic characteristics

Most interviewee participants identified as female ($N = 17$), the remainder male ($N = 6$) (Supplementary Fig. S1). The age of the participants ranged between 38 and 83, with a median age of 69 (Supplementary Fig. S1 in Supplementary Appendix S4), substantially older than the median age of the Tasmanian population (42 years) (Australian Bureau of Statistics 2022). Of the total of 23 respondents in this study, 14 were retired (all the males and nearly half (8) female) and the remainder (9) employed (all female). Eight of the participants lived alone, 11 lived with their partner, and four households were family units (children and partner), including three households with young children. Many ($N = 15$) of the participants lived with pets, and two kept poultry.

All of the participants owned the property that was the subject of this study. We classified participants who had lived in their current home for 9 months to 4 years as 'newly established residents' ($N = 5$), those who have lived at their current home for 5–30 years as 'established residents' ($N = 14$), and the remainder who have lived in their property for 31 to 60 years as 'long-term dwellers' ($N = 4$) (Supplementary Fig. S1). There was a positive correlation between the length of residency and age (Supplementary Fig. S1). Most ($N = 18$) of the participants planned to stay in their current home long term, including all the five newly established residents. There were no significant differences among the four biophysical hazard categories for the residents age (Kruskal–Wallis test $P = 0.26$), gender (Chi-squared test $P = 0.617$), employment (Chi-squared test $P = 0.652$) and duration of occupancy (Chi-squared test $P = 0.30$).

Landscape and garden wildfire hazard

The wildfire hazard scores in our sample of gardens at the WUI was slightly higher than the whole urban areas (Fig. 3*a*, *b*). However, the landscape fire hazard scores of sampled gardens were not statistically different from gardens on the WUI of the whole Hobart LGA (Fig. 3*a*, *b*). The overall garden hazard scores ranged from low to very high, with the majority in the mid-range (Fig. 3*c*).

No significant differences were found between LG and HG for variables measured in the FFZ. There were few significant differences between LG and HG in the OZ and TZ. In the OZ of LG vegetation patches were more likely to be separated by non-flammable paths ($P = 0.012$; Table 1); in the TZ, shrub cover and presence of fuel under trees were significantly higher in HG ($P = 0.023$ and $P = 0.045$, respectively; Table 1). Similarly, we found only minor differences between gardens in HL and LL. Gardens in HL were characterised by the presence of more flammable plants, with a higher proportion of flammable trees in the FFZ

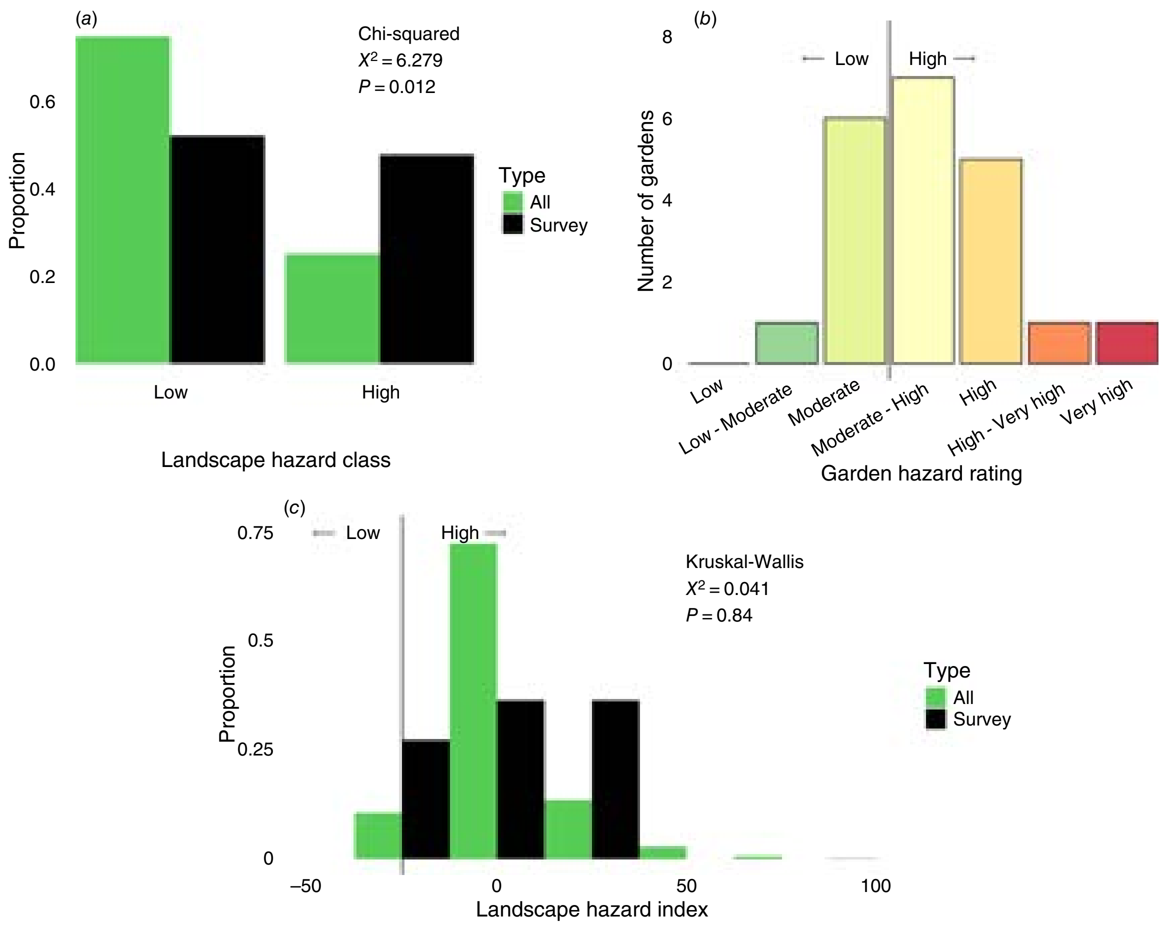


Fig. 3. Garden and landscape hazard. Landscapes fire hazard and garden fire hazard of the sampled 21 residential gardens sampled in this study. (*a*) Bar chart of landscape fire hazard for the surveyed residential gardens (black) compared to all residences in the Hobart Local Government Area (LGA) (green) showing proportions in the Low (risk < –25) and High (risk > –25) categories with Chi-squared test showing significant difference ($P < 0.05$) among these groups. (*b*) Histogram showing the distribution of garden hazard scores across 21 gardens with a line that classifies low and high-risk gardens. (*c*) Histogram of distribution of landscapes fire hazard surveyed residential gardens (black) relative to all other properties in the Hobart LGA (green) with > the –25-threshold indicated with a line. The continuous landscape fire hazard index is grouped into 25-unit wide bins. A Kruskal–Wallis test showed no significant difference in landscape hazard scores between the sampled gardens and Hobart LGA.

Table 1. Significant difference between high and low risk rating for garden and landscape.

Garden zone	Variable	Mean value		Significance
		Low risk gardens (*N* = 7)	High risk gardens (*N* = 14)	
Open Zone (OZ)	Vegetation patches separated by non-flammable paths (%)	Half (41–60%)	Some (1–40%)	0.017*
Tree Zone (TZ)	Shrub Cover (%)	Low (1–15%)	High (31–50%)	0.023*
	Fuel beneath trees (Yes/No)	No	Yes	0.045*
		Low risk landscapes (*N* = 11)	High risk landscapes (*N* = 10)	
Fuel-Free Zone (FFZ)	Presence of flammable trees (%)	Not present (0%)	Some (1–40%)	0.029*
OZ	Presence of ferns and tussocks (%)	Not present (0%)	Some (1–40%)	0.018*
TZ	Distance from fuel to lower tree branches	<2 m	2–3 m	0.045*

Significant differences in garden fire hazards between high and low risk gardens and landscapes and their mean values. The significance of the pairs of contrasts is reported (*$P < 0.05$).

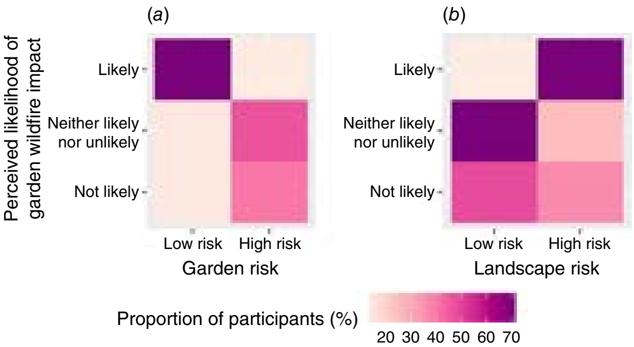


Fig. 4. Perceived likelihood of garden wildfire impact according to hazard score. Estimated perceived likelihood of a garden being impacted by wildfire expressed by participants associated with high and low (*a*) biophysical garden risk, and (*b*) biophysical landscape risk. For simplicity, responses from the 5-point Likert scale were grouped in three categories.

($P = 0.029$) and of ferns and tussocks in the OZ ($P = 0.018$; Table 1). In the TZ of LL there was a marginally lower distance between tree branches and fuel underneath them ($P = 0.045$; Table 1).

Quantitative survey results

The only significant difference in quantitative questionnaire responses across LG and HG and LL and HL was the perceived likelihood of garden wildfire impact (Supplementary Table S2 in Supplementary Appendix S5). There was a higher risk awareness for participants with a LG-level hazard ($P = 0.02$), and marginally significant for participants in a HL hazard setting ($P = 0.055$; Fig. 4), noting the low sample size. There was insufficient statistical power to determine if there was an interaction between HG and HL. Following the provision of the garden hazard assessment report, retirees were the most motivated to reduce garden hazard ($X^2 = 4.71$ $P = 0.03$).

Qualitative survey results

The qualitative results have been ordered according to hazard categories (LG-LL, HG-LL, LG-HL and HG-HL) to investigate major differences and similarities of people's garden wildfire hazard perspective, management efforts, understanding and helpfulness of the biophysical garden hazard reports and main challenges for garden wildfire adaptation (Supplementary Table S3 in Supplementary Appendix S6).

Analysis of the data demonstrates consistent patterns in general wildfire risk awareness across hazard categorisation. However, significant variation emerged in participants' detailed comprehension of specific hazard factors. This variation was particularly pronounced among participants from HG properties, who identified distinct challenges for wildfire mitigation activities.

Perceptions of landscape fire risk

All respondents across all of the hazard categories considered the likelihood of a wildfire impacting their suburb higher than the probability of their garden or house being affected by a wildfire. People explained that their perception on the likelihood of a wildfire impacting their garden was largely influenced by external environmental factors, i.e. landscape wildfire risk (exemplary quotes in Supplementary Appendix S7).

Proactive garden hazard management

Participants from most categories (LG-LL, HG-LL and HG-HL) had undertaken some wildfire mitigation actions in their garden. When asked: 'Have you made any changes to your house or garden to reduce the risk of bushfire?' the participants noted vegetation management such as removing flammable plants, reducing shrub abundance or increasing the spacing of shrubs. When responding to the question: 'What are the key things you do to prepare your garden for bushfire season?' the participants added additional preparedness measures, such as tidying up, cutting back new growth, removing dead plants and litter and cutting their lawn. The latter question was seen as short term interventions. Only five participants reported they had not done any work in their garden to reduce the risk of wildfire; these participants were all in the HG category. Interestingly, however, when asked about the key things they did in their garden to prepare for wildfire season, four of these five participants noted that they had indeed removed litter in their garden.

Garden wildfire safety satisfaction in relation to biophysical models

There was no consistency of level of satisfaction according to the hazard categories. During the interview people expressed satisfaction ($N = 11$), dissatisfaction ($N = 7$), or uncertainty ($N = 5$) about their garden's wildfire safety (exemplary quotes in Supplementary Appendix S7). Across the sample there was a tendency for participants that were unsure about their garden safety satisfaction to focus on the risk of neighbouring properties, especially in the LG hazard categories.

Identified hazard aspects in the garden in relation to biophysical models

Participants generally presented a level of uncertainty about the hazard level of their garden, and many times the risk perception did not match the biophysical modelling (exemplary quotes in Supplementary Appendix S7). A consistent theme during the interview was a focus on the assumed flammability of plants affecting overall garden wildfire safety, with less appreciation of the importance of plant cover, planting arrangements and spatial zonation (Table 1 and Supplementary Table S1 (in Supplementary Appendix S3)) that drives estimates of garden fire hazard such as those highlighted in the biophysical report. As well as individual hazards in the garden, respondents often talked about garden wildfire safety by considering the overall wildfire garden hazard.

The participants from most categories (LG-LL, HG-LL and HG-HL) highlighted vegetation management and structural adjustments as essential action steps for future increasing of wildfire resilience in their garden. When asked about possible mitigation activities that the participants could undertake in their garden, residents in locations assessed as LG-HL hazard often consider landscape-scale hazard as an important factor for their properties likelihood of surviving a wildfire, rather than mitigation within their own garden (exemplary quotes in Supplementary Appendix S7).

Garden wildfire hazard awareness elicited through the mapping exercise

Nearly all ($N = 18$) participants believed their garden contributed to the wildfire risk to the house. Nevertheless, the mapping exercise demonstrated that the wildfire mitigation awareness held by the participants did not consistently match the biophysical modelling. Biophysical assessments identified at least one hazard in each zone of each garden, however, the analysis of the maps drawn by participants showed that they tended to overlook hazards located in the FFZ, with less than half of participants able to point to hazards in that zone, irrespective of landscape or garden hazard score (Table 2). Moreover, of the people that expressed satisfaction about their garden safety, very few identified any hazard located in the FFZ during the mapping exercise. Conversely, the majority of participants across all hazard categories identified at least one hazard in the OZ (Table 2). We found the most variability in the TZ, with the majority of residents in HG were able to indicate hazards in that zone (Table 2). Another notable point is that people with smaller gardens (i.e. gardens without TZ) tended to be more satisfied with their garden wildfire safety.

Challenges for wildfire prevention reported before reading the report

Participants identified multiple challenges in implementing wildfire mitigation activities in their gardens. A primary concern was acquiring sufficient knowledge to effectively balance fire risk reduction with other garden values. Additionally, participants reported various practical constraints, including green waste management, temporal and financial resource constraints, regulatory compliance requirements and topographical challenges such as steep gradients. Analysis revealed distinct patterns in perceived challenges and support needs across garden hazard categories.

LG-LL participants demonstrated heterogeneous responses regarding challenges and required support mechanisms. LG participants generally perceived garden hazard mitigation as manageable within their properties. Nevertheless, they identified external factors, particularly neighbouring property hazards, as significant challenges to comprehensive wildfire mitigation. HG-LL participants predominantly focused on emergency response support, emphasising needs for improved warning systems (comparable to Victoria State Government n.d.), and water access during emergencies. HL participants

Table 2. Identified hazards in each garden zone.

		Landscape and garden risk			
		LG-LL	HG-LL	LG-HL	HG-HL
N gardens		4	7	3	7
N gardens with a TZ		3	4	2	3
Gardens with hazards identified	FFZ	2 (50%)	3 (43%)	1 (33%)	2 (29%)
	OZ	3 (75%)	5 (71%)	3 (100%)	7 (100%)
	TZ	0 (0%)	4 (100%)	1 (50%)	2 (67%)

Summary results of the mapping exercise. For each zone (Fuel-Free Zone (FFZ), Open Zone (OZ) and Tree Zone (TZ)), the number of gardens in which residents identified hazards is presented for each of the four categories (low landscape risk (LL), high landscape risk (HL), low garden risk (LG) and high garden risk (HG)).

frequently advocated for community-based support structures, specifically emphasising the establishment of community groups to enhance collective risk ownership, risk awareness and coordinated mitigation activities through working groups. Participants in the HG categories consistently reported insufficient understanding of appropriate mitigation strategies, expressing desire for enhanced access to garden-specific wildfire mitigation information. Moreover, HG-HL participants frequently identified emotional attachment to garden elements as a primary barrier to implementing mitigation measures (see Supplementary Appendix S7).

Personal connection to the garden illustrated through photo elicitation

Analysis of photographs from the 'personal connection snapshot' exercise (Table 3) revealed consistent patterns of emotional attachment across all garden categories. Participants predominantly captured images relating to garden functionality, particularly food production. Aesthetic values, including views and ornamental plantings, emerged as another significant theme. This pattern persisted among HG-HL category participants, where both functionality and aesthetic elements dominated the photographic narratives. Within this category, two participants additionally highlighted natural elements, such as moss formations and wildlife habitat (specifically native marsupial presence), while two others documented recreational spaces enjoyed by their family members, such as children and grandchildren. Notably, participants who demonstrated hesitation to implementing biophysical garden hazard report recommendations often selected aesthetically significant elements during the photo elicitation exercise, whereas other participants exhibited more diverse emotional attachments to garden elements.

Garden report and impact on the participants motivation

All of the participants across all of the hazard categories found the assessment of the landscape and garden helpful,

Table 3. Photo elicitation of participants personal connection to their garden.

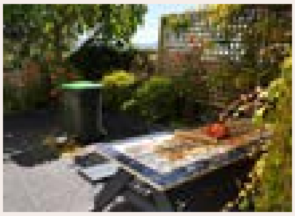
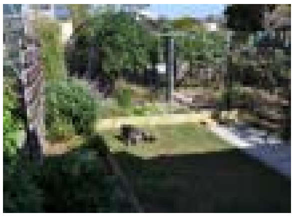
Category	Photograph	Description	Emotional meaning
LG-LL		Patio	An area of enjoyment and for spending time with family.
HG-LL		Brick-wall	An appreciated aesthetic feature of the garden. A unique brick wall that also works as a terraced plant-bed.
LG-HL		Pond	The pond is a memory of past loved ones, and a symbolic beacon of hope in case of a bushfire. Connection to fish and birds.
HG-HL		Vegetable and fruit garden	Area for growing food and enjoying time. A loved pet.

Photo Elicitation Exercise: Garden and landscape hazard score (Category) indicated relevant to personal connection snapshots (photographs and description) and their elicited meaning in text (emotional meaning); photos taken by participants and used with permission. Hazards are presented for each of the four categories: low landscape risk (LL), high landscape risk (HL), low garden risk (LG), and high garden risk (HG).

generally appreciating its flexible, scientific approach and clear categorisation that makes garden wildfire mitigation a less overwhelming task, reducing cognitive load and providing answers to complicated questions. Although participants noted that the report did not substantially alter their perception of wildfire hazard, the report helped provide a way to manage gardens to reduce wildfire hazards by providing an alternative way of participants to consider their wildfire hazard, think through options and identify clear steps to mitigate hazards whilst providing habitat for wildlife. For instance, participants acknowledged and valued that the report identified flammable plants and highlighted options for replacing them with less flammable alternatives, especially native plants. The reported emphasis on the importance of managing the spatial and structural arrangement of plants provided a means for people to reduce the hazard of their garden without losing the floral diversity and aesthetics that they value. The cognitive interviewing during reading of the report highlighted persistent limitations experienced by the participants to undertake wildfire mitigation activities in their garden, such as lack of time, and unwillingness to cut down trees were reported as barriers to reducing hazards among the garden owners. Hesitation was predominantly associated with participants' values of gardening, lifestyle choices, or to balance fire risk with wildlife habitat. HG owners mentioned resistance to some recommended changes, particularly removing certain plants (such as beloved trees), reducing the abundance of native plants, removing flammable objects and, more generally, changing the character of the garden.

The majority of respondents ($N = 14$) expressed that they were motivated to integrate advice from the report. The remaining respondents ($N = 9$) were tentative, meaning they would consider the advice. Although all of the participants would be willing to act on, or to consider the advice from the report, the participants in HL areas were more motivated to act on the advice from the report. People with HG gardens (and especially in HL areas) highlighted the value of understanding zoning of the garden, and especially the space closest to the house (the FFZ).

Discussion

Our study combined biophysical wildfire risk assessment of gardens and landscape, quantitative surveys, qualitative interviews, mapping exercises and photo elicitation to understand barriers and opportunities for implementing practical and effective wildfire prevention strategies in residential gardens in Greater Hobart, Tasmania. We found significant discrepancies between residents' perception of garden hazard and empirically assessed risk levels. Participants universally perceived higher risk at the suburb level compared to their individual properties, with external environmental factors heavily influencing personal risk perception. Within their garden, participants consistently underestimated hazards in the zone immediately surrounding their homes (FFZ), while showing greater awareness of risks in the surrounding garden (OZ). Furthermore, their awareness of fire risk was focused on plant flammability rather than crucial factors like plant cover, arrangement and spatial zonation that drive actual fire hazard levels. While most participants had undertaken some form of mitigation actions in their garden, particularly vegetation management, people were unsure of which measures were needed for effective wildfire mitigation. The hazard assessment report proved effective in motivating change; the majority of participants, and particularly residents in fire prone areas (HL), expressed willingness to implement recommendations. However, multiple challenges emerged in implementing fire prevention strategies. These included knowledge gaps in balancing fire risk reduction with other garden values, practical constraints such as waste management and resource limitations, and emotional barriers, particularly attachment to garden elements and biodiversity values. Social factors, including concern about neighbouring properties' hazards, also played a crucial role. Below we explore the findings of this study by comparing and contrasting them to previous research, consider possible further research including how to improve the veracity of socio-ecological inquiry, and consider the implication for wildfire management policy.

Wildfire perceptions and garden hazard management

Participants generally showed awareness of wildfire threats. Indeed, they volunteered to be interviewed because they were motivated to learn more about wildfire hazard mitigation in their gardens. A wider sample may be required to confirm whether this awareness of the landscape level wildfire hazard is reflected across the general population in Greater Hobart (similar to Campbell et al. 2024). Given the qualitative methodology, this study focused on understanding perceptions rather than measuring their prevalence (see Lucas et al. 2022 for a mixed-method study on garden fire risk perspectives).

The interdisciplinary approach of this study revealed that the participants' understanding of specific hazards, particularly in the FFZ (0–1.5 m from the house), often fell short of expert assessments. This discrepancy supports the notion that awareness alone does not necessarily translate into accurate and detailed risk perception or effective action (Brenkert–Smith et al. 2006; Eriksen and Gill 2010). Fuels close to the house (e.g. plants near the wall or window, branches overhanging the roof) are one of the few garden characteristics consistently identified by post-fire studies as likely to increase the chances of house loss (e.g. Syphard et al. 2014; Penman et al. 2019; Samora-Arvela et al. 2023; Vermina Plathner et al. 2023; Ondei et al. 2024). However, Australian guidelines for the creation of defensible space do not currently include a FFZ, but rather they incorporate it in the OZ in an 'inner zone', albeit with specific suggestions regarding the presence of plants near windows or overhanging the roof (Ondei *et al.* 2024). Adding a FFZ to Australian defensible space guidelines might help people to focus on hazards located in close proximity to the house and would align with guidelines from the US and Canada, which already include this zone and emphasise its importance.

Analysis of risk perception patterns revealed distinct differences between hazard categories. Respondents in LG-LL and LG-HL categories predominantly conceptualised wildfire as an external threat with potential impacts on their gardens. This perception may be attributed to their prior implementation of substantial garden modifications, suggesting the necessity for scaling mitigation strategies to encompass broader landscape-level (community-wide) interventions. In contrast, participants categorised as HG-LL and HG-HL exhibited notably lower perceived likelihood of wildfire impact on their properties within a 10-year timeframe. This discrepancy between objective risk assessments and self-perceived vulnerability aligns with established literature on cognitive biases in risk assessment (Kruger and Dunning 1999; Sawdon and Finn 2014). However, this perception gap may also reflect competing priorities and psychological barriers (Crocker and Robeyns 2010; Hamilton 2019), particularly evident in the HG-HL cohort where emotional attachment to vegetation emerged as a significant factor. Qualitative data from interviews revealed that participants reporting low perceived wildfire likelihood often acknowledged basing these assessments on affect (feelings), including hope and wishful thinking. Some explicitly stated that residential choices were predicated on a denial of fire risk, suggesting they would not maintain residence in areas they consciously perceived as high-risk. These findings underscore the complex interplay between cognitive, emotional and social factors in risk perception, highlighting the methodological challenges inherent in risk perception research (Prior and Eriksen 2012; Vandeventer 2012; Slovic *et al.* 2013; Traczyk *et al.* 2015; Williams *et al.* 2018).

The analysis revealed notable variations in risk perception across hazard score categories. Significantly, property owners with low hazard gardens in LG-HL demonstrated elevated risk awareness levels (Fig. 4). This correlation suggests that heightened risk perception may serve as a catalyst for proactive mitigation behaviours, specifically in the context of garden maintenance and modification, indeed all the participants in the LG category had undertaken risk mitigation in their garden. This finding aligns with established risk perception frameworks that posit a relationship between perceived risk magnitude and individual preparedness actions, supporting further advancement in risk communication with specific focus on 'bushfire-wise' gardening (Lucas *et al.* 2022).

Interestingly, participants with smaller gardens tended to be more satisfied with their garden wildfire safety. This finding suggests that property size might be an important factor in risk perception and management. Advice on zoning provides a clearer framework and less overwhelming approach to mitigation, allowing people with large gardens to prioritise the closest zones or work with one zone at a time, this approach increases self-efficacy and confidence in implementing mitigation measures (Deci and Ryan 2008; Hu and Gill 2016). This staged approach helps overcome the overwhelming nature of comprehensive garden modifications while maintaining residents' sense of agency in protecting their properties. Potentially people can still maintain their garden values while taking heed of research based advice to reduce fire hazards (Gibbons *et al.* 2018; Ondei *et al.* 2024).

Response to garden report

Our results strongly support the value of providing residents with detailed, property-specific wildfire hazard assessments (Lucas *et al.* 2022; Ondei *et al.* 2024). All participants found the assessment reports helpful, with many indicating increased willingness to implement changes, especially among those with HL scores. This positive response aligns with Lucas *et al.* (2022) recommendations for integrating biophysical data with community input to enhance fire adaptability. The reports contributed to reducing the cognitive load of the participants. Which is helpful in cases where people struggle to balance wildfire mitigation initiatives with every-day pressing issues (Eriksen and Gill 2010). While the reports increased motivation, they also highlighted barriers to implementation which echoes the findings of Eriksen and Ballard (2020) and Bradstock *et al.* (2014). This underscores the importance of providing a flexible, non-judgmental framework to create space for participants to increase their garden's wildfire safety.

Identified challenges for mitigating garden wildfire hazards

The challenges identified by our participants in implementing wildfire mitigation measures largely align with those documented in the literature (Brenkert–Smith *et al.* 2006; Eriksen and Gill 2010; Lucas *et al.* 2022). Financial constraints, time limitations and the physical demands of garden management were common themes, supporting the findings of Penman *et al.* (2016) on the significant costs associated with wildfire preparedness. Our study also highlights the importance of emotional and aesthetic factors in garden management decisions, an aspect that may be underrepresented in purely economic or risk-based analyses (Williams *et al.* 2018). The strong emotional connections to gardens described by our participants (HG-HL) resonate with the work of Francis and Hester (1990) and Freeman *et al.* (2012) on the deep personal significance of garden spaces.

Residents in the LG-LL category were not consistent in the responses about what they found challenging, or which support they needed. These are the people a long way from the WUI, who might not see wildfire prevention as a topmost priority in their daily life (Eriksen and Gill 2010).

Garden wildfire mitigation is a novel point of inquiry and providing advice and studying wildfire risk perceptions is a complicated avenue for research, thus requiring collaborative, community-based approaches to wildfire management (McDonald and McCormack 2022; McLennan 2022). This is corroborated by the interest expressed by participants in HL for community-level support. Collaborative work that enables shared vison for the future amongst multiple stakeholders with different perspectives and skillsets may aid wildfire adapted communities (Lederwasch 2011; Williams 2014; Rodríguez *et al.* 2018; Gjedrem and Log 2020; Heslinga *et al.* 2020).

Integrating garden hazard in wildfire risk mitigation strategies

In Australia, local councils and private landowners have a shared responsibility for managing fire hazards (Page and Thorp 2010), with government bodies authorised to implement penalties, advice and education programs (Richards *et al.* 2014; Opden 2021). Thus, our findings must be considered within Tasmania's broader wildfire management context. The City of Hobart (2022), Australia's second driest capital city, has implemented a Bushfire Management Strategy that aims to protect human life, property and ecosystems while building community resilience. While regulations and compliance measures may accelerate community-wide wildfire adaptation, purely punitive approaches often fail to address underlying implementation challenges (Penman *et al.* 2013; McLennan *et al.* 2014). Instead, addressing root causes requires integrated strategies for fire-adapted communities (Sturzenegger and Hayes 2011; Johnston *et al.* 2024) that encompass socio-economic and environmental considerations (Lindenmayer *et al.* 2008; Kremen and Merenlender 2018; Paveglio *et al.* 2018). Community-scale actions, including wildfire safety programs (McGee 2011; Tasmania Fire Service 2014; Country Fire Authority 2016), Landcare groups (e.g. Friends of Knocklofty n.d.; Friends of Randalls Bay n.d.) and Aboriginal cultural burning practices (e.g. the Tasmanian Aboriginal Centre n.d.), can foster shared responsibility and knowledge exchange grounded in local communities (Owen 2018; McDonald and McCormack 2022; Ascoli *et al.* 2023). Our results support a nuanced approach combining education, community engagement and targeted support (Bowman 2024; Williams 2014), particularly in high-risk areas (Haynes *et al.* 2020; Lucas *et al.* 2022; McLennan 2022).

Study limitations and strengths

The small sample size ($N = 23$) and self-selected nature of participants limit generalisability, likely overrepresenting environmentally conscious or risk-aware residents. While our sample overrepresented high-hazard properties, this aligns with our focus on effective wildfire mitigation (Williams *et al.* 2018). Qualitative data collection during two seasons (Summer–Autumn 2024) and focus on Greater Hobart may not capture seasonal variations or challenges faced by residents in other fire-prone regions. Our reliance on self-reported data also introduces potential bias in reported practices and beliefs. Nonetheless, the study's multi-modal approach, combining quantitative and qualitative techniques (Johnson and Onwuegbuzie 2004), provided several key advantages. Our interdisciplinary methodology bridged the gap between expert knowledge and resident experience (Williams *et al.* 2018; Eriksen and Ballard 2020), revealing important insights, such as the disconnect between perceived and actual hazards in some specific parts of the garden.

The combination of statistical and biophysical analyses helped maintain research quality by challenging bias and increasing credibility (Johnson and Rasulova 2017). Specifically, our approach of categorising participants by both garden (LG/HG) and landscape (LL/HL) hazard scores revealed important patterns in wildfire mitigation behaviour. A core novelty and strength of this paper only made possible through combining biophysical and social research. This 'Safety-2' (Hollnagel *et al.* 2015) perspective, focusing on what works rather than what fails, showed that participants with LG scores and smaller gardens often expressed higher confidence in implementing wildfire adaptations. However, LG-LL participants sometimes struggled to identify needed support, possibly due to their urban location and lower perceived risk compared to those in HL areas. In contrast, HG participants identified specific barriers to adaptation, including knowledge gaps and emotional attachment to garden elements. These findings suggest that increased confidence and intrinsic motivation (Ryan and Deci 2000; Martin *et al.* 2007), as demonstrated by LG owners, may facilitate better wildfire adaptation outcomes. Another key strength lay in our methodological approach to participant engagement, which prioritised empowering and non-judgmental interactions (Rosenberg and Chopra 2015). This created safe spaces for open discussion through garden walks and photo-elicitation, enabling participants to highlight personally significant aspects of their gardens. The observed positive response to garden assessment reports demonstrated how specific, scientifically-grounded advice can bridge the 'information gap' between awareness and action (Gill and Stephens 2009).

Further research and management implications

While generalisability is not the primary aim of qualitative research, our focus on 'transferability' (Johnson and Rasulova 2017) means our findings provide valuable insights for similar WUI contexts. Studies that aim at investigating garden wildfire mitigation in the future should expand to include broader demographic sampling, longitudinal studies capturing seasonal changes, mixed-method approaches with participatory-observation and investigation of findings' applicability across different socio-economic and regulatory contexts. Follow up studies after expert advice on garden wildfire mitigation is provided would be valuable to investigate, if the expert resources have impact on behavioural change among garden owners. Moreover, other research avenues have been identified in this study. While garden wildfire mitigation guidelines are broadly available (Ondei *et al.* 2024), their limited implementation highlights critical research gaps in three key areas. First, research is needed to understand effective communication strategies for conveying garden wildfire advice to diverse populations, particularly translating technical information into accessible guidance while respecting homeowners' values (Williams *et al.* 2018; Eriksen and Ballard 2020). There is a clear need to emphasise the FFZ in Australian defensible space guidelines and develop education strategies that focus on spatial arrangement and structural aspects, while providing flexible frameworks that respect residents' garden values (Ondei *et al.* 2024). Balancing scientific assessments with residents' lived experiences and address both practical and emotional barriers to implementation. Second, studies should investigate the development of community-based support systems, examining how social networks influence mitigation behaviour (Prior and Eriksen 2013) and how to scale successful local initiatives through longitudinal studies focusing 'success stories' (Hollnagel *et al.* 2015), to inform policy and planning. Third, policy-focused research should identify mechanisms addressing practical, socio-economic and psychological barriers to implementation (Bradstock *et al.* 2014; Log *et al.* 2020), investigating incentive structures and policy frameworks that balance regulation with support, while accommodating diverse homeowner values (Lucas *et al.* 2022). These research directions could enhance understanding of how to bridge the gap between wildfire mitigation knowledge and practice, ultimately contributing to more fire-resilient communities.

Conclusion

Our study provides valuable insights into the complex interplay between garden owners' perceptions, attitudes and behaviours regarding wildfire risk and mitigation. The findings underscore the need for nuanced, community-engaged approaches to wildfire preparedness that consider both the physical aspects of fire risk and the social, emotional and practical factors influencing residents' decisions. Future research and policy development in this area should continue to explore interdisciplinary methods and prioritise empowering, non-judgmental engagement with residents to foster more effective and sustainable wildfire mitigation strategies.

Supplementary material

Supplementary material is available online.

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Data availability. A methodological explanation of the biophysical garden assessment will be available in (Ondei *et al.* 2025). Deidentified biophysical data can be provided on request.

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