

Urban Design: An Underutilized Tool for Disaster Risk Reduction?

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Abstract

In the global context of rising numbers and impacts of nature-originated catastrophes affecting cities, the potential for built environment disciplines to deliver disaster risk reduction outcomes is increasingly being recognised as central to achieving sustainability. This potential, however, remains significantly focused on two levels of analysis: the macro-scale of settlement patterns managed by land use planning; and the micro-scale of single built structures and their construction standards, assessed on a case by case basis. While the macro and micro scales of activity are clearly important, it is also clear that many of the factors that are linked with disaster risks are also linked to the mid range, such as the relationships between buildings as fires spread; or the ways that people evacuate from buildings onto streets and parks. Urban design, a discipline located beyond the single lot of land but at a more specific and functionally grounded level than urban and regional planning, has not been rigorously examined as a tool for mitigating the risk of disasters. To contribute to this gap, this paper provides a framework for integration of urban design, based on core principles from both the urban design and disaster risk reduction fields of theory and practice, identified from relevant literature in these areas. These principles are then examined in terms of their convergences and divergences, leading to the identification of the benefits and key challenges for integration. Finally, the applicability of the integrated framework is demonstrated in the ways that urban design-related characteristics such as street arrangements, density of dwellings and site ratio contributed to emerging patterns of fire-spreading and house loss during the 2009 Black Saturday bushfires in Maiden Gully, Bendigo, Victoria.

1 Introduction

Increasing numbers of disasters are occurring in urban areas, a function of urbanisation becoming the predominate form of settlement, the varied nature and location of urban growth, the vulnerability of those living in these areas, and factors such as climate change, economic disparity and land shortages. In parallel, efforts to cope with these catastrophes are now shifting, albeit mainly in the developed world, from response-and-relief *after* disasters to risk-reduction approaches *prior* to events. In this new framework, integrated and considered management of the built environment has been widely accepted as being fundamental to delivering disaster risk reduction (DRR). For instance, built environment risk reduction actions are often undertaken at the macro-scale of physical spatial planning, mainly through land-use zoning imposing building restrictions and general ordinances. At the other end of the spectrum, the micro-scale of building codes aimed at ensuring proper design and construction of structures to improve their interactions with natural hazards are increasingly used.

Planning and building approaches are clearly important (Burby 1998; March and Henry 2007; Wamsler 2014), but it is argued here that there is also another scale and mode of action that has been significantly underutilized in DRR practices in the built environment. This is the mid-scale of urban design, including actions encompassing the spatial arrangements of buildings and the public space comprised by them, and the integrative potential inherent to this. Integration is essential to achieving effective action in DRR, since buildings' attributes have direct impacts on the geophysical characteristics of a disaster (by either mitigating or aggravating them). Moreover, their characteristics as part of wider spatial arrangements and interaction with public places directly impact upon the manner in which emergency-response activities such as evacuation, sheltering and rescue occur, and where dangerous phenomena such as panic, riots, or stampedes might take place (He and Xu 2012).

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This paper examines the underutilized potential of urban design in DRR through critical examination of an instructive case: wildfire (or bushfire) risk in the state of Victoria, Australia. This analysis includes a review of relevant planning scheme controls for risk reduction and their relevance for different disaster-management activities. It also comprises lessons learnt from the last significant disaster in the state: the Black Saturday wildfires of February 2009.

The paper has five parts. The first provides a theoretical background of the risk reduction and built environment disciplines. The second part analyses the current state of integration of urban design into planning schemes for wildfire risk reduction in Victoria. The third part of the paper examines the opportunities provided by urban design as a wildfire risk-reduction tool, and underlines four main challenges for its practical real-world implementation. The fourth and final part delivers the conclusions of the paper.

2 Background

2.1 From emergency management to disaster risk reduction

Since the 1960s, the annual incidence of disasters 'delivered' via natural systems (e.g. floods, tsunamis, wildfires, earthquakes) has quadrupled to more than 400 events and 200,000 affected people per year in the early 2010s (International Disaster Database 2011). This growth is partially explained by the impact of global warming and poor management of natural resources (Joerin and Shaw 2010). However, it is also a result of the increasing exposure of human populations to natural hazards. This vulnerability is the result of development patterns such as rapid urban growth and rising social inequalities, especially in the developing world. Rapid urbanisation has been a strong factor in refocussing the predominance of disasters from rural areas to cities; these are increasingly becoming 'hot-spots' of disasters (Brown 2012; Joerin and Shaw 2010; Wamsler 2014). A number of risk factors may combine to result in vulnerable settlements: agglomeration of population and assets, social inequalities, informal occupation of vulnerable areas, increased exposure to biological, chemical and physical hazards, and local climate phenomena such as 'heat island' effects (Alexander 1993; Pelling 2003; Twigg 2004; Wamsler 2014).

A growing understanding of disasters having their origins in social, political and economic conditions instead of in nature (Mileti 1999; Oliver-Smith 2002; Wisner et al. 2004) has led to a change in coping tactics with them. The strategies have shifted from civil-defence-based response and relief approaches to disaster risk reduction (DRR) actions, which have become a core part of governance and also a central concept in society (Pearce 2003; Tarrant 2006; UNISDR 2004). Risk-reduction strategies usually have the form of a 'disaster management cycle' comprising four inter-related groups of activities. Two of them occur before the catastrophe, and two of them afterwards (Alexander 2002; Coppola 2011; Emergency Management Australia 2004; Topping 2011; Twigg 2004). These activities are (1) prevention or mitigation (i.e. reducing or eliminating the likelihood, extent or impact of future disasters); (2) preparation (measures taken to reduce the impact of an imminent disaster, under unaltered risk and vulnerability circumstances); (3) response (emergency actions taken during the impact or short-term aftermath of a disaster, to reduce or eliminate its consequences); and (4) recovery (repairing damage and restoring essential community services, returning victims' lives back to a normal condition). Risk reduction activities comprise a wide range of tools, from civil-engineered defences to education policies, including insurance. In recent years, a proper management of the natural and built environment has been increasingly accepted as an essential tool for delivering DRR, as underlined by the recent Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations 2015). These processes include activities such as land use and urban planning, building codes, and environmental and resource management.

2.2 Designing the built environment for DRR

Erickson and Lloyd-Jones (2001, p. 3) contend that the activity of design “attempts to make the future better than the present (...) this involves planned change in the material world”. In particular, Lawson (2006, p. 5) argues that three-dimensional and environmental design “generate objects or places which may have a major impact on the quality of life of many people”. Disciplines in this area include product design, architecture, urban design and physical spatial (e.g. urban or regional) planning (see Figure 1). This specialization is the outcome of the increasing complexity of the design processes, which has led to different scales of work, materials, technologies and requirements (Erickson and Lloyd-Jones 2001; Lawson 2006).

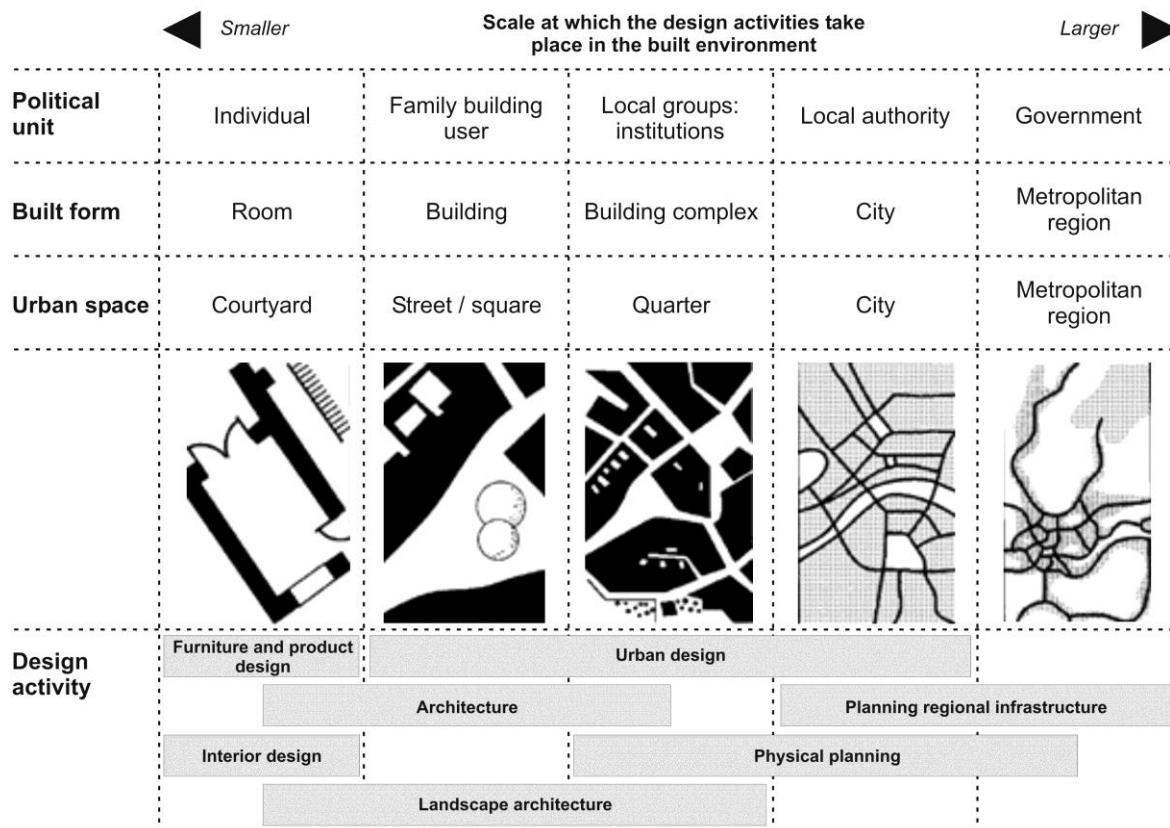


Figure 1: Scale of design activity in the built environment. Source: adapted from Erickson and Lloyd-Jones (2001).

In particular, ‘physical’, ‘spatial’, ‘town’, or ‘urban’ planning comprises an orderly sequence of actions aimed “to provide for a spatial structure of activities (or of land uses) which in some way is better than the pattern existing without planning” (Hall and Tewdwr-Jones 2011, p. 3). As was discussed above, this ‘macro-scale’ activity has been increasingly accepted as an essential tool for implementing DRR in cities. This is due to its capacity to manage and modify the spatial arrangements, functions and ongoing growth or decline of settlements and regions (Burby et al. 1999; Wamsler 2014). Planning “provides a medium for the reduction of uncertainty in dealing with hazards, allowing mitigation of their worst effects, and even the remediation of past mistakes” (March and Henry 2007, p. 19). Land-use planning for risk reduction “offers communities a rational means for understanding and managing the inevitable change” (Johnson, Dwelley-Samant, and Frew 2005, p. 48). Planning activities can combine a series of tools to achieve risk reduction: public participation, systemic and comprehensive studies, political linkages, land-use regulations, and strategic interventions (Schwab and Topping 2010). For instance, planning can manage cities or regions via zoning ordinances seeking to avoid development altogether in, or to establish generic or specific occupation guidelines for, hazardous areas within spatially defined locations.

Another common focus for delivering DRR is the 'micro-scale' of the single building and its construction standards. These requirements (e.g. seismic building codes or fire-resistance standards) are typically examined on a case by case basis, with the purpose of ensuring proper responses in front of a hazard. DRR measures can be included in the design during the project stage, but also delivered as retrofitting actions on built structures.

2.3 An underutilized tool? Urban design for DRR

Between the 'macro-scale' of physical spatial planning and the 'micro-scale' of architecture, there is the 'mid-scale' of urban design. This has been defined as a field of study located beyond the single site but at a more specific level than the structure plans and growth models of urban and regional planning, aimed to shape the human settlements' physical features (Madanipour 2006; Sternberg 2000) (see Figure 1). Batty et al. (2000, p. 2) argue that urban design "relates physical arrangements of buildings and streets to functional organization which in turn reflects the social and economic structure which makes the built environment function or dysfunction". At the same time, Gunder (2011, p. 185) points out that, while urban planning is a more empirical and social-science based policy approach, urban design is focused on "the city's physical form, appearance and function". Moreover, Sternberg (2000, p. 268) underlines that urban design's greater concern is the buildings' broader interrelationships, including "street walls, roads and avenues, neighbourhood, land gradient, views, and other landscape features".

Unlike the cases of physical spatial planning and building standards, DRR efforts have not been widely developed at the mid-scale of urban design. Murao (2008, p. 1) points out that "although spatial design (architecture, urban design, and landscape design) is an essential component of disaster management, the relationships between spatial design and disaster management have rarely been discussed in the literature". For instance, in the case of disaster-response activities Allan and Roberts (2009) and Allan et al. (2013) underline that there is little research on the role of urban form to influence a community's ability to respond rapidly and effectively to a disturbance. This paper examines this gap in the context of an ongoing process of mainstreaming urban design into DRR policies: the case of wildfire risk reduction in the state of Victoria, Australia. This paper introduces the relevant policies and planning schemes involved in the four phases of the the disaster management cycle (mitigation, preparation, response and recovery). At the same time, the effectiveness of these measures is critically examined against lessons learnt from previous research of past disasters (the most notorious one, the Black Saturday wildfires of February 2009).

3 Examining the integration of urban design into the disaster management cycle: the case of wildfire risk reduction in Victoria, Australia

3.1 Victoria, one of the most wildfire-prone regions in the world.

The state of Victoria, Australia, is one of the most wildfire-prone areas in the world, as the result of its combined location, vegetation and climate characteristics (Hughes and Mercer 2009; O'Neill and Handmer 2012). This is a condition that is expected to increase due to growth pressures in urban fringe areas (which continue to attract new dwellers with their promise of contact with wildlife and bushland, larger lots, and apparently lower costs) and climate change (O'Neill and Handmer 2012; Teague, Mc Leod, and Pascoe 2010). Proof of this long-term vulnerability are disasters such as the Black Friday (1939), Ash Wednesday (1983) and Black Saturday (2009) wildfires, which provoked hundreds of deaths, extensive material damage and the loss of hundreds of thousands of hectares of forest (Collins 2009; Teague, Mc Leod, and Pascoe 2010).

3.2 Managing the built environment for wildfire risk reduction

In the state of Victoria, wildfire risk management has been increasingly mainstreamed at the macro-scale of physical planning frameworks. In 1997 the Wildfire Management Overlay (WMO) was introduced into the Victorian Planning Provisions. Its aim was to provide a shelter for the people, by ensuring the survival of their houses (Hughes and Mercer 2009). These provisions were dramatically tested by a sequence of tragic Victorian events (2003 Alpine Fire, 2006 Grampians Fire, 2006/2007 Great Divide Fire) that peaked on the Black Saturday catastrophe in 2009. This was one of Australia's worst natural disasters. Particularly dangerous weather conditions (a decade-long drought, a record-breaking heatwave, and hot gusty winds) combined with human activity and the failure of electricity assets to trigger multiple bushfires across Victoria. As a result of this, 173 people died, more than 400,000 hectares of public and private land were affected, and over 2,000 homes were destroyed (Holland et al. 2013; Teague, McLeod, and Pascoe 2010). This disaster led to the introduction in 2011 of the Bushfire Management Overlay (BMO), focused on protecting human life (Victorian Government 2014). The BMO introduced a more accurate mapping of bushfire risk in Victoria, based on criteria including vegetation, weather characteristics and slope. Three levels of risk were defined: (1) low risk areas (outside the BMO); (2) bushfire prone areas, where construction standards are required according to an on-site bushfire attack level (BAL) examination; and (3) high-risk areas, where building and planning measures are required. The latter include defensible space, vegetation management, water supplies and access requirements (Groenhart, March, and Holland 2012). Defensible space is "an area of land around a building where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with a bushfire" (CFA 2012, p. 4).

On the other hand, bushfire risk management has also been mainstreamed at the micro-scale of building standards. The BAL levels above mentioned (from ember attack to direct exposure to fires) lead to six construction levels. Each of these implies requirements for the materials and design of buildings, according to the Australian Standard AS 3959-2009 (Standards Australia 2009).

3.3 Urban design for wildfire risk reduction: the current approach

At the mid-scale of urban design, the Victorian framework for wildfire risk reduction includes some measures that are undertaken across the four phases of the disaster management cycle (mitigation, preparation, response and recovery). In the *prevention* or *mitigation* phase, the most important tool for DRR is the Clause 52.47 of the Victorian Planning Provisions, 'Bushfire protection: planning requirements' (Victorian Government 2014). This document aims to promote appropriate location, siting and layouts of new land subdivisions, with the objective of mitigating the risk of wildfires. Moreover, the design components of subdivisions (including roads, public open space, lots, services and facilities) should be used to reduce the impact and intensity of the fires (CFA 2012). This can be achieved, for instance, by providing each lot with an appropriate amount of defensible space, and by using elements such as roads and open spaces as barriers between the hazard and the dwellings.

In the *preparation* phase, DRR is carried out, for instance, via state-funded programs for the maintenance of fire access roads for response (CFA 2015). In parallel, the Victorian State Department of Environment and Primary Industries (DEPI) regularly carries out planned burns in public-owned land, while the Country Fire Authority (CFA) supervises private burn-offs (under the regulations established by each council).

For the *response* phase, the Clause 52.47 establishes access and water supply objectives aimed to facilitate fire-fighting and property protection (CFA 2012). In particular, long access and egress routes should be avoided; development has to be located close to each property's entrance; and roads' design (e.g. widths, curve radius, slopes, and clear vertical space) must be appropriate for the transit of emergency vehicles.

Lastly, efforts developed after the 2009 Black Saturday catastrophe provide examples of *recovery* actions in Victoria. While a large part of these have been focused on restoring communities' pre-

catastrophe conditions, other activities have contributed to reduce the risk of future disasters, like new masterplans promoting a better location of critical infrastructure and management of vegetation (see for instance the urban design framework developed for the town of Marysville, available in http://robertsday.com.au/greatplaces_renew/marysville-triangle-towns).

3.4 The unexplored dimension? Urban design for understanding and managing interactions

It was argued above that urban design is particularly focused on understanding the interrelationships between buildings and their larger surroundings (Sternberg 2000). This paper argues that this potential has not been fully mainstreamed into DRR policies for wildfire risk reduction in Victoria, including planning frameworks that guide urban design (particularly in the case of new subdivisions). This occurs despite the fact that, during a developing wildfire, the spatial interactions among the elements of the built and natural environments have a significant impact on the characteristics of fire-spreading patterns (e.g. speed, intensity and direction). For instance, Honey and Rollo (2011) demonstrated that factors such as built form, site, orientation and proximity to natural and artificial shapes can significantly affect the ember attack on a structure during a wildfire in the urban-rural interface.

In the case of the interactions between built structures, urban design has the potential for delivering a range of desired spatial outcomes, such as density of occupation (i.e. number of units per area), amount of site coverage, and location of buildings in lots. These characteristics can have a significant impact on a wildfire's characteristics, by affecting the pattern of fire-spread and transfer. Evidence from the 2003 Canberra disasters shows, for instance, that around a 30% of house loss was caused by radiant heat coming from burning surrounding vegetation or built elements (Blanchi, Leonard, and Leicester 2006). The incidence of these losses could be diminished by an increased distance between dwellings (see Figure 2). It has to pointed out, however, that recent research shows that the opposite approach, i.e. increased urban densities, might also diminish the likelihood of house loss during a wildfire (Opie et al. 2014). This is the case, for instance, when dwellings located closer to the fire front act as a protective barrier to farther houses (see Figure 3). Currently, the Victorian planning provisions for wildfire risk reduction do not include measures for controlling or guiding the spatial relationships between buildings.

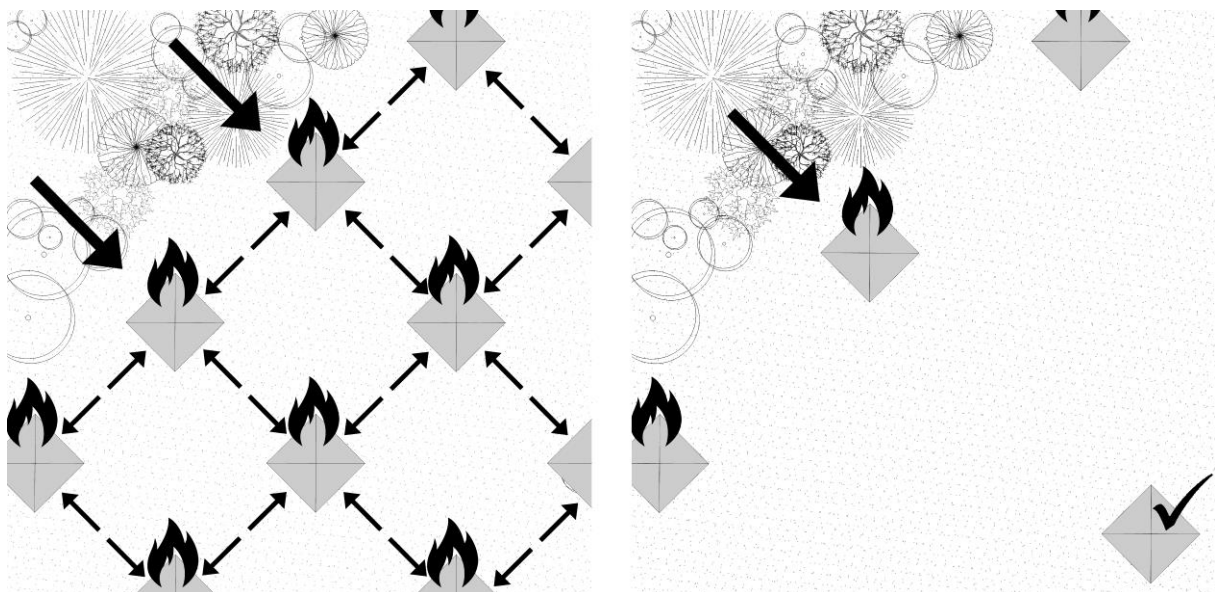


Figure 2: Impact on fire transmission from increased distance between dwellings (indicative image). Larger arrows show direction of fire front approach. Source: the authors.

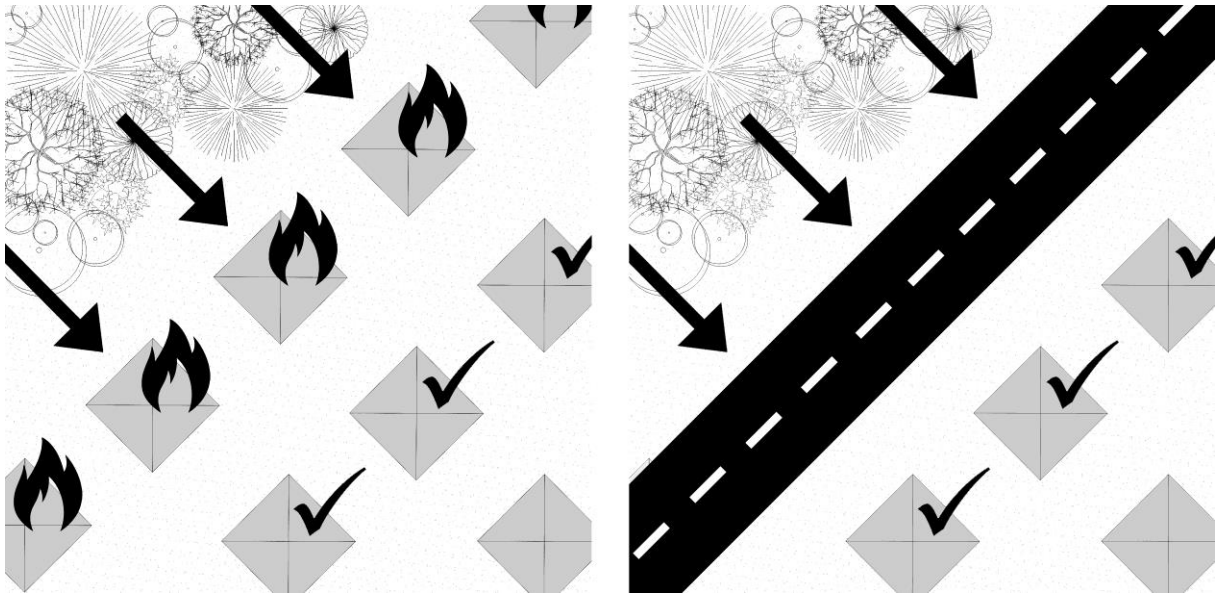


Figure 3: Existing dwellings or roads can serve as protective barriers for houses (indicative image). Larger arrows show direction of fire front approach. Source: the authors.

More problems emerge in the examination of another type of interaction: that between each building in a subdivision and its surrounding open space, where the main source of hazard (i.e. vegetation) is located. Currently, the planning provisions are focused on the requirement (for each dwelling in a lot) of a *defendable space* “where vegetation is modified and managed to reduce the effects of flame contact and radiant heat associated with a bushfire” (CFA 2012, p. 10). An appropriate defendable space can increase the possibility of house survival. Moreover, if a dwelling is destroyed by fire, defendable space provides a non-flammable zone where occupants can find refuge after the passage of the main fire front (see Figure 4).

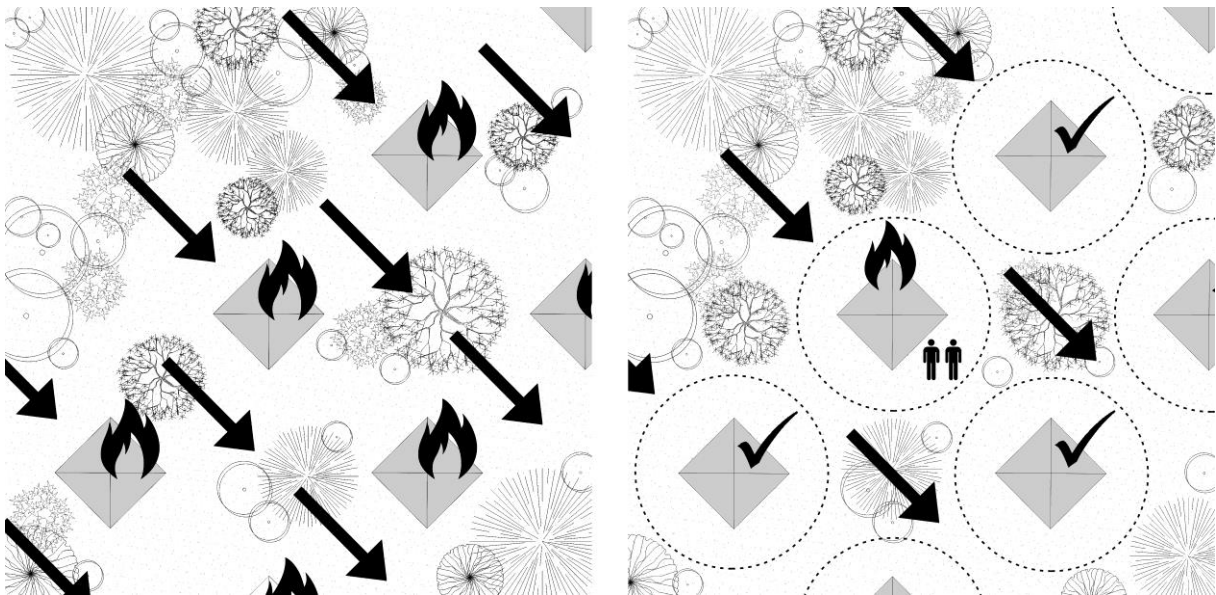


Figure 4: Defendable spaces prevent house loss and provide a refuge zone for occupants (indicative image). Larger arrows show direction of fire front approach and passage. Source: the authors.

While achieving an appropriate amount of defendable space for each lot is clearly important for wildfire risk reduction, its practical application may lead to some undesirable outcomes. For instance, when large individual defendable spaces are required, the result could be a wholesale clearing of vegetation, implying reducing amenity, inefficient land use and ecological impact. On the contrary,

shared defensible space, regulated to also include certain types of trees and vegetation, can help to achieve an enhanced subdivision design, providing safety *and* liveable open spaces (see Figure 5).

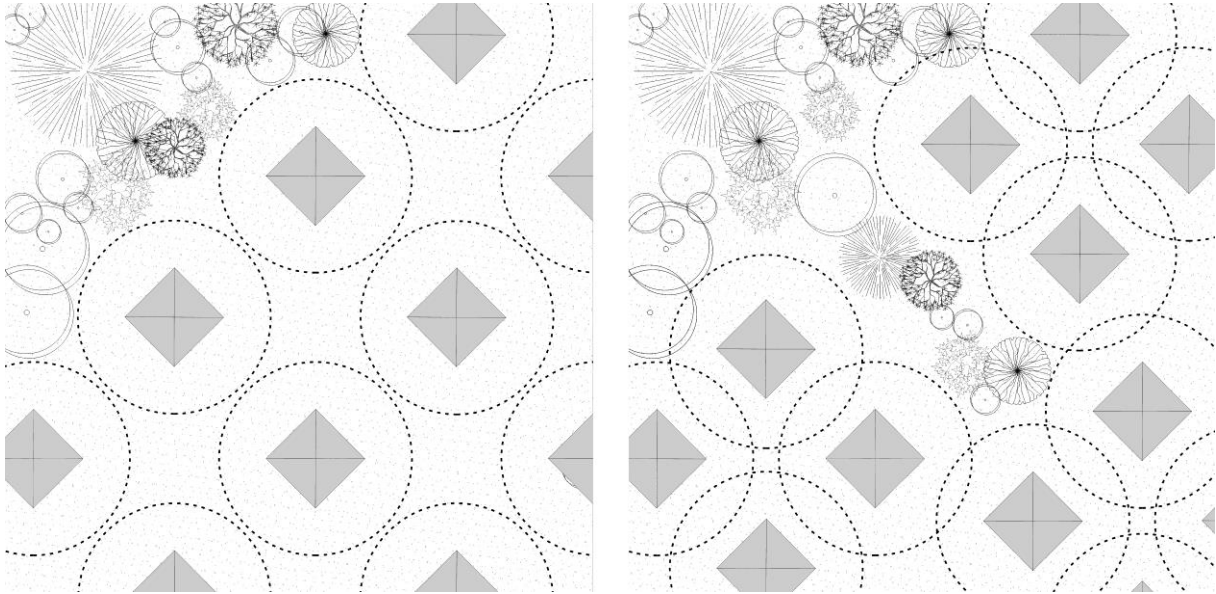


Figure 5: Shared defensible space allows the provision of enhanced open spaces in subdivisions (indicative image). Source: the authors.

Fragmented management of defensible spaces might lead to other undesirable outcomes. For instance, adjacent lots in a subdivision with different sizes or location of dwellings might imply dissimilar management of vegetation, increasing risk of fire-spread during an emergency. Instead of this fragmented approach, urban design has the potential to organize the open space as a three-dimensional spatial continuum, carefully including elements such as vegetation, topography, roads, water bodies, and recreational areas.

Lastly, urban design has the potential to deliver appropriate spatial interactions between a subdivision and its larger surroundings. It has been demonstrated, for instance, that perimeter roads can serve as barriers to fire spread into urban areas (Blanchi, Leonard, and Leicester 2006; CFA 2012) (see Figure 3). While Clause 52.47 currently establishes requirements for location (e.g. according to the existing vegetation), any references to a particularly important type of spatial interaction are provided. This is the case of *connectivity* to surrounding areas, i.e. the group of road connections that enable movement between places (Handy, Paterson, and Butler 2003). Increased street connectivity has a critical importance during a disaster like a wildfire; it provides “greater emergency vehicle access and reduced response time, and, conversely, provide multiple routes of evacuation in the case of disasters” (Handy, Paterson, and Butler 2003, p. 13). In this respect, requirements such as minimum numbers of access/egress routes, or maximum distance between a dwelling and its nearest exit, have not yet been included into Victorian planning schemes. See Figure 6.

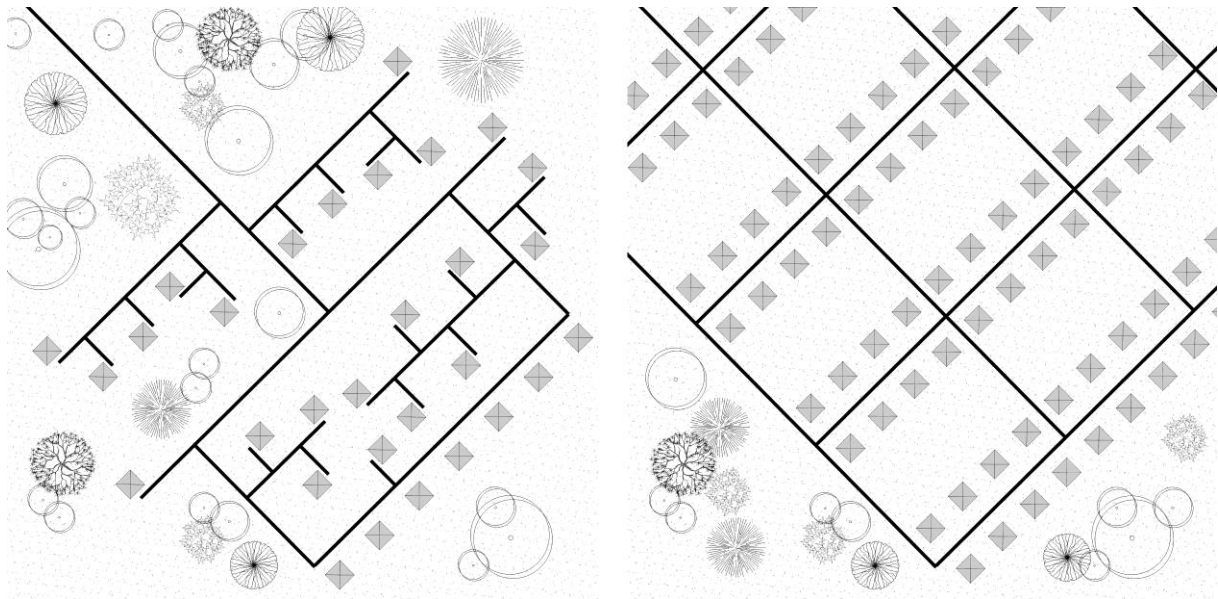


Figure 6: 'Hierarchical' urban grids (left) with limited access increase risk (indicative image). 'Redundant' grids (right) improve evacuation and facilitate fire-fighting. Source: the authors.

4 Opportunities and challenges for improvement

The examples provided above show that, while current planning schemes in Victoria help to deliver wildfire risk reduction, there are significant shortfalls that urban design-focused efforts might help to overcome, which in turn pose important opportunities for improvement. The most prominent deficit of planning schemes is their shortcomings in appropriately encompassing the *complexity* and *unpredictability* of the wildfire phenomenon in multiple settings, where every emergency is different. Currently, the schemes deliver a 'binary' approach where an examined site is either inside or outside a bushfire management zone, which in turn triggers a series of requirements to fulfil. In contrast, urban design has a potential for examining multiple *risk scenarios* within an examined area. This can be achieved by exploring a detailed range of interactions between the built environment's elements (e.g. dwellings, streets, open spaces, water bodies, and vegetation) exposed to different hazard conditions.

At the same time, a wildfire risk-reduction approach based on urban design poses four main *challenges*. The first one is that a detailed, scenario-based urban design involves larger technical and professional resources, in the case of both land developers and council planners. Secondly, these types of design actions require greater levels of detail, a process that might extend in time both design and assessment actions, and that potentially has no natural end (Lawson 2006). Thirdly, urban design by definition must encompass and reconcile diversity, where DRR is only one of several (competing) objectives that need to be accommodated within successful projects. Lastly, this discipline's scope is largely associated with new developments, and significant challenges remain for the mitigation of wildfire risk in already built areas, due to their inherent inertia to change.

5 Conclusions

This paper aimed to examine the integration of a built environment discipline, urban design, into wildfire risk-reduction policies in the state of Victoria, Australia. By an analysis of current policies and planning schemes for disaster mitigation, this paper showed that there are certain design-focused actions included in the provisions (e.g. the promotion of appropriate location, siting and layouts of new subdivisions of land). Nonetheless, it was also shown that there is a significant dimension of the problem that requires further exploration: the progressive interactions of detached buildings with their larger surroundings, including other built structures, the open space and its vegetation, and the neighbouring urban areas.

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This paper argued that the complexity and unpredictability of the interactions between the built environment and the hazard can be better managed by a wildfire risk-reduction approach based on urban design. Specifically, this paper underlined the potential of this discipline for testing multiple disaster scenarios, by purposefully combining the built environment's elements and a range of wildfire conditions.

Lastly, this paper underlined four challenges for a more thorough integration of urban design into wildfire risk reduction policies. These are (1) the larger technical and professional resources required (in comparison to current planning-based schemes); (2) the greater levels of detail involved in the design actions, which in turn might lead to long design and review processes; (3) the multiple competing objectives that urban design needs to accommodate in a proposal; and (4) the difficulties for modifying already built areas.

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