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Urban–wildland fires: how California and other regions of the US can learn from Australia

Scott L Stephens[1], Mark A Adams[2], John Handmer[3], Faith R Kearns[4], Bob Leicester[5], Justin Leonard[5] and Max A Moritz[1]

[1] Division of Ecosystem Science, Department of Environmental Science, Policy, and Management, 137 Mulford Hall, University of California, Berkeley, CA 94720-3114, USA
[2] Faculty of Agriculture, Food, and Natural Resources, University of Sydney, McMillan Building, Sydney, NSW, 2006, Australia
[3] Center for Risk Community Management, RMIT University, Melbourne, VIC, 3001, Australia
[4] University of California Center for Fire Research and Outreach, College of Natural Resources, University of California, Berkeley, CA 94720-3114, USA
[5] CSIRO and Bushfire Co-operative Research Centre, Highett, VIC, 3190, Australia

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Abstract
Most urban–wildland interface (UWI) fires in California and the other regions of the US are managed in a similar fashion: fire agencies anticipate the spread of fire, mandatory evacuations are ordered, and professional fire services move in and attempt to suppress the fires. This approach has not reduced building losses in California. Conversely, losses and the associated suite of environmental impacts, including reduced air quality, have dramatically increased over the last three decades. In contrast to California, Australia has developed a more effective 'Prepare, stay and defend, or leave early' policy. Using this approach, trained residents decide whether they will stay and actively defend their well-prepared property or leave early before a fire threatens them. Australian strategies have the distinct advantage of engaging and preparing those most affected by such fires: homeowners. Investing more in fire suppression alone, the common response after large UWI fires in California, will not reduce losses. US society has attempted to accommodate many of the natural hazards inherent to the landscapes that we inhabit; by examining the Australian model, we may approach a more sustainable coexistence with fire as well. However, it should be noted that some California communities are so vulnerable that a 'Prepare and leave early' strategy may be the only option.

Keywords: fire policy, fire management, wildland urban interface, wildfire, land use planning

1. Introduction

Wildfires in the urban–wildland interface (UWI) continue to devastate communities in California (figure 1) and across the US. Despite known risks, people continue to move into wildfire-prone areas at high rates. The issue is particularly acute in California where a recent analysis indicated that over five million homes are located in the UWI (Radeloff *et al* 2005, Theobald and Romme 2007). This number is the highest in the US, and is expected to increase further as urban dwellers seek the 'natural amenities'—e.g., open space and recreational opportunities—provided by wildland areas. Similar trends elsewhere in the world are exacerbated by long-term economic conditions, such as the declining value of rural commodities, which result in land being of greater value for housing than for other uses.

Responses after large UWI fires in California have been consistent and largely focused on the procurement of additional

Figure 1. Santiago Canyon Fire in Foothill Ranch, Orange County, California (October 2007). Courtesy of Alex Miroshnichenko (Miro-Foto).

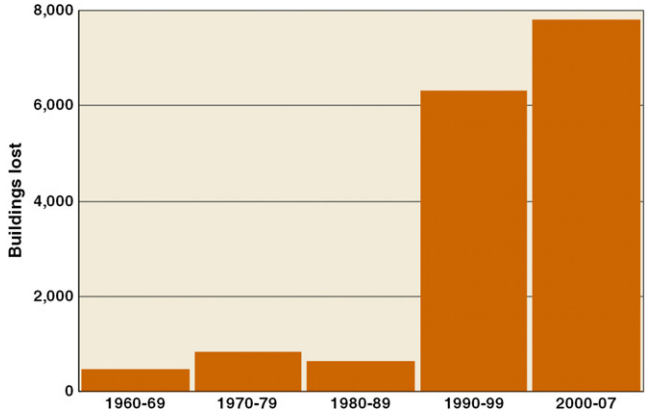

Figure 2. Number of buildings lost from the 25 most destructive UWI fires in California history from 1960–2007.

fire suppression resources, particularly at the state level. The common argument presented is: 'if we had more fire engines, aircraft, and fire fighters then we could have prevented this catastrophic loss of homes'. While fire suppression is a critical component of fire management in the UWI, it alone will not reduce the losses of life and property. A new approach is needed, and that is the goal of our joint examination of the problem by both American and Australian scientists. In a novel collaboration, we present ideas that could be used to fundamentally change fire management in the UWI across the US. Such a new approach must also be examined critically, since it should neither encourage further fragmentation of natural landscapes nor give a false sense of safety to those in the most vulnerable situations.

2. The need for a new approach

As a society we have attempted to accommodate some of the natural hazards inherent to the landscapes that we inhabit. For example, buildings in earthquake-prone areas are designed to withstand events of a given magnitude. Building on floodplains is typically restricted, and land-use planners are familiar with the concept of the 100- or 250-year flood event. In California and the rest of the US we have yet to adopt this line of thinking for fires—instead we focus much more on *fighting* fire than on coexisting with it.

Fuels, topography, and weather determine the level of fire hazard in any given area (Agee and Skinner 2005). Most of California experiences annual summer drought, and there are many different local patterns of fire weather. Some of the most extreme fire weather conditions, however, are generated by 'Santa Ana' winds in southern California (Schroeder *et al* 1964). These foehn winds—generated as air moves downward from a higher elevation—cause hot, dry, and very strong winds for days at a time. When these episodes coincide with dry fuels in autumn, fires can become very large and are unconstrained by the age and spatial patterns of shrubland fuels (Moritz *et al* 2004), pushing fires into the UWI (figure 1). Extreme fire weather can also occur in south east Australia as demonstrated by the 1983, 2003, and 2009 bushfires.

There is a strong link between fire activity and population patterns throughout California and humans are the dominant source of ignitions for UWI fires (Syphard *et al* 2007). Because substantial population increases are projected in coming decades, the problem of human ignitions will only get worse. In addition, some of the largest fires in California and Australia are often those intentionally set by arsonists, who target the worst conditions and most vulnerable locations. The majority of Californian and Australian ecosystems are fire adapted and altered fire regimes have been a negative influence on their sustainability (Pyne 1991, Sugihara *et al* 2006, Stephens *et al* 2007) further confounding management of the UWI and surrounding wildlands (Dombeck *et al* 2004, Donovan and Brown 2007).

Collaborative research between Australia and California on the performance of construction materials and landscaping during wildfires, quantification of fire hazard and risk in changing climates, effectiveness of fuels treatments, and policy development would enable both countries to advance more quickly in developing sustainable UWI areas.

3. Current UWI fire management in California

Most UWI fires in California and other regions in the US are managed in a similar fashion. Fire agencies first attempt to anticipate the spread of the fire, and mandatory evacuations are ordered. With the public evacuated, professional fire services move in and attempt to suppress the fires. This approach has not reduced building losses from UWI fires in California. Instead, losses have dramatically increased over the last three decades (figure 2). Mandatory evacuations may save lives if implemented well before the time a wildfire arrives to a particular location. However, evacuations at the last minute, when people may be overrun by fast-moving fires, create the most deadly periods in UWI fires (Gill 2005, Handmer and Tibbits 2005). Some people pack their cars with possessions and then procrastinate or wait until the wildfire is in close proximity before leaving, this can be very dangerous.

UWI fire policy in California and other regions of the US has developed piecemeal. Historically, large-scale urban conflagrations were the result of structure-to-structure fires, fueled by wood buildings. These types of urban fires, where hundreds of buildings are lost, are uncommon now because urban areas contain fewer wood buildings and most buildings include a multitude of features such as fire alarms, fire-resistant walls, and sprinklers.

As the recent 2007 and 2008 fires in southern California have demonstrated, we still have a long way to go in reducing similar losses in UWI fires (Mutch 2007, Paveglio *et al* 2008). As homes continue to be built in flammable wildland areas, the Californian approach to building has yet to catch up to the types of hazards faced by homeowners (CFRO 2005). For example, it is evident that most homes ignite in UWI fires (figure 1) due to embers that can travel over 1–2 km. At a minimum, therefore, vents that resist ember entry into attics and fire-resistant roofing and other building materials are key. While there is good evidence as to the efficacy of this type of 'fire safe' approach to building and maintaining homes (Cohen 2000, Blanchi and Leonard 2008), it has remained largely unregulated in the US.

4. What California can do reduces losses in the UWI

4.1. UWI building codes

In California, enforcement of new building codes that include ignition-resistant construction standards only began in early 2008 (CBC 2007). These codes will apply only to new buildings in very high hazard UWI areas and areas where the state has financial responsibility for fire protection. Local jurisdictions will have the ability to accept or reject their zoning designation, thereby influencing where stricter building codes apply. While we believe that this new policy is a step forward, much more needs to be done.

Out of necessity, revised building codes are a compromise between science, policy, and economic interests. Even so, a more rigorous and objective approach to assessing structure vulnerabilities is needed, so that each revision to UWI standards and policies is based on the best scientific analysis possible. All UWI policies should be reviewed and updated as new information becomes available.

4.2. Land-use planning

Large portions of California's 58 counties are under local land-use planning control, and several jurisdictions have adopted local ordinances to mandate defensible space and fire-resistant materials in home construction in the UWI (e.g. Ventura and Los Angeles counties). Most local jurisdictions, however, have employed a variety of standards over the years, changing requirements as priorities and economic conditions change. The resulting mixture of different aged housing stock—and thus structural vulnerabilities—makes long-term standardized solutions problematic. The continued expansion of the UWI and fragmentation of fire-prone wildlands is also directly related to increases in the number of ignitions. Importantly, the UWI poses a series of additional environmental challenges, including ecosystem fragmentation, increased exposure to invasive species, and water and air pollution (Alavalapati *et al* 2005).

Alternative policies and/or regulatory approaches aimed at reducing the inconsistencies in local land-use planning should be implemented. For example, one approach would be to move some local, land-use planning authority to the state level. This would mean in reference to fire in the UWI, any new development would have to be reviewed by a state level, land-use planning agency. This standardized review would include both materials used in construction, construction methods, and land-use planning objectives, based on a strategic plan to protect the many public assets that fire affects. This type of comprehensive planning may be especially important in the face of climate change (Moritz and Stephens 2008), an issue that links fire, development patterns, and ecosystem services in broader context.

As a model, in the state of New South Wales in Australia, the Rural Fire Service performs a similar service (albeit at a sub-division level rather than the level of individual houses). In 1997 the Rural Fire Act was passed in New South Wales and this consolidated 142 separate fire municipalities into one organization with similar standards; in 2002 this act was amended to incorporate the review of new housing construction in all wildlands. Such a strategy has advantages because one set of UWI standards is applied to the whole state, and each review includes a mandatory fire perspective. This approach has the best chance of success if planning and building provisions are combined into a holistic process.

4.3. Fire suppression

The costs of fire suppression continue to rise at both federal and state levels in the US (Stephens and Ruth 2005). A large proportion of 'fire' budgets are focused solely on fire suppression with more limited funds for the reduction of hazardous fuels and public education (Steelman and Burke 2007). However, a recent study by the Natural Resources Defense Council reported an average cost of only $2510/home to make the needed improvements (e.g., vent screening and enclosing open eaves to prevent ember intrusion) to create more fire-resistant homes in a community in the Sierra Nevada foothills (Mall and Matzner 2007). Even if subsidized by state or local governments, or insurance companies, these costs are substantively lower than the losses incurred in massive UWI fires.

4.4. Insurance issues

With the numbers of structures lost in California wildfires, many homeowners now risk losing, or never being able to obtain, fire insurance. Although the State of California has developed a program to offer insurance to those homeowners unable to obtain private insurance, the price is higher, and it is not available everywhere it is needed. Regardless, insurers could play a much larger role in providing incentives to homeowners to reduce structure-based wildfire hazards, and therefore losses. However, an insurance-based approach

cannot fully solve the UWI fire challenge because a home-based policy disregards non-monetary goods and services (uninsured personal property, recreation, aesthetics) (Talberth *et al* 2006).

In New South Wales and Victoria, Australia, significant components (approximately 17%) of private fire insurance premiums paid by individuals are used in fire mitigation practices. These resources are used to fund rural fire services, neighborhood community groups regarding fire, and public outreach and education (Henri 2003). Connecting fire insurance companies to UWI homeowners can increase incentives to reduce the vulnerability of homes through the marketplace (i.e. lower premiums for houses that resist ember attack, have access to water supplies, include multiple access/egress opportunities).

5. The Australian policy

The 'Stay or Go'—or more accurately 'Prepare, stay and defend, or leave early'—approach has recently been endorsed by all Australian fire services, as well as by most police forces (AFAC 2005); there is a similar approach in southern France although this is not based on a national policy.

The Australian position is that all residents should prepare their property against fire and decide whether to stay and actively defend their property or leave early before a fire threatens the area and road travel becomes dangerous. If they decide to stay, they are advised to prepare their property through vegetation (fuel) management, undertaking house protection measures, and ensuring they have the resources, both physical and psychological, to actively defend their property. The approach does not entail or encourage people to passively 'shelter in place' which is dangerous (Gill 2005). The common American usage of the phrase 'shelter in place' in the context of fire implies a much more passive response than what the Australian policy requires.

There is considerable evidence that well-prepared houses can provide a safe place for people during wildfires, based on the key assumption that a fire front passes quickly and that houses can survive this period and protect occupants from radiant heat, smoke and embers. This is well supported by research on how houses ignite and are destroyed largely through ember attack (Cohen 2000, Blanchi and Leonard 2008). Risk from embers can be reduced by advance preparation, such that when small fires are ignited by embers, they can be extinguished if residents are present and prepared, and actively defending their property.

No option is risk free, but evidence suggests that the most common avoidable cause of death is being caught outside of a structure as the fire front passes with its lethal radiant heat and smoke. Fleeing at the last minute often involves driving or running through flames, ember storms, and intense heat and smoke, with accompanying disorientation and poor visibility. This is the most dangerous option.

Evidence from Australia has come from oral histories, documented practice by fire agencies and those at risk, post-fire public inquiries, scientific publications, and a fatality data-base (Handmer and Tibbits 2005, Gill 2005, Handmer and Haynes 2008, Leicester and Handmer 2008). Most of this material deals with extreme fires—the worst Australian fires in the last 70 years—and their findings indicate:

- *Evidence supports current Australian practice*. The most risky thing to do, and the cause of most fatalities, is to leave at the last moment as the fire front arrives and when roads may be blocked by smoke, electrical power lines, stalled cars, and burning debris.
- Building research confirms that *embers ignite houses* and these fires can be put out by vigilant trained homeowners.
- The critical factor in *building survival is the presence of people.*
- There is *no legal impediment*, but there are some gaps such as some Australian police agencies ordering mandatory evacuations during UWI fires at the same time as fire services want prepared people to stay (Tibbits and Whittaker 2007).
- There are *many implementation issues* to do with information provision, expectations that fire agencies will be at every house, belief that houses explode in fires, confidence, commitment, and high risk decisions. This therefore requires a strong and sustained commitment to public education and outreach.

In Victoria, Australia, the 'Operation Fireguard' program attempts to educate all communities at risk to wildfire attack (CFA 2004, 2007). Training courses are held every year preceding the onset of the fire season, and there are numerous newspaper articles on both preparation and action plans. All residents are exhorted to prepare an 'action plan' prior to the start of the fire season. Within this action plan they select whether they will choose the 'stay and defend' option or the 'leave early' option. The 'Prepare, stay and defend, or leave early' strategy has frequently worked well in Australia, but experience shows that for this to happen all critical components of this strategy must be in place, particularly (a) the effective education of the community, (b) the psychological, infrastructure, landscaping, and equipment preparation of those who plan to stay and (c) an effective early warning system to communicate to those living in the UWI.

6. People living in the UWI: a potential resource regarding wildfire

The Australian approach to UWI fire management has the distinct advantage of engaging those most affected by such fires: homeowners. Homeowners that prepare for inevitable UWI fires can be a positive resource in fire management, instead of simply people to be evacuated, as in the California case. It is recognized that some UWI communities are dominated by vacation homes that are only occupied a few weeks each year. The Australia UWI policy would not directly apply in these areas because of the general absence of people.

In both the US and Australia, most new residents in the UWI have arrived there from cities and have little experience of natural hazards such as fire (Pyne 1991, Moritz and Stephens 2008). This is all the more reason for engagement. By engaging and training those potentially affected by UWI fires,

losses could be reduced in California and other regions of the US. However, it is not clear if factors unique to some California UWI communities might make it impossible to implement a policy similar to that in Australia. There may be some regions where the local climate, topography, and infrastructure may render a 'Prepare, stay and defend or leave early' option to be inadvisable. In these locations, a focus on preparing your property to resist ignitions and leaving early may be the only viable option. UWI areas surrounded by crown fire adapted ecosystems such as chaparral or mountain ash (*Eucalyptus regnans*) forests could be particularly hazardous.

Investing solely in more resources for fire suppression in an attempt to reduce losses from California UWI fires is not justified. There will never be enough suppression resources alone to reduce losses with an ever-expanding UWI. Part of the solution is a more sustainably designed and built UWI, inhabited by informed and prepared homeowners.

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References

Agee J K and Skinner C N 2005 Basic principles of fuel reduction treatments *Forest Ecol. Manag.* **211** 83–96

Alavalapati J R R, Carter D R and Newman D H 2005 Wildland–urban interface: challenges and opportunities *Forest Policy Econ.* **7** 705–8

Australian Fire Authorities Council 2005 *Position Paper on Bushfires and Community Safety* (East Melbourne: AFAC Limited)

Blanchi R and Leonard L 2008 Judging Structure Safety *Community Bushfire Safety* ed J Handmer and K Haynes (Melbourne: CSIRO Publishing)

CBC 2007 *California Build Code* Materials and construction methods for exterior wildfire exposure Title 24, part 2, volume 1 of 2 (Sacramento, CA: California Code of Regulations)

Center for Fire Research and Outreach (CFRO) 2005 Living with fire in chaparral ecosystems project; scientific expertise component U C Berkeley, CA http://firecenter.berkeley.edu/livingwithfire/stayorgo.html

CFA 2004 *Living in the Bush:, Bushfire Plan Survival Workbook* (Melbourne: Country Fire Authority)

CFA 2007 *Building in a Wildfire Management Overlay; Application Kit* (Melbourne: Country Fire Authority)

Cohen J 2000 Preventing disaster: home ignitability in the urban–wildland interface *J. Forestry* **98** 15–21

Dombeck M P, Williams J E and Woods C A 2004 Wildfire policy and public lands: integrating scientific understanding with social concerns across landscapes *Conserv. Biol.* **18** 883–9

Donovan G H and Brown T C 2007 Be careful what you wish for: the legacy of smokey bear *Front. Ecol. Environ.* **5** 73–9

Gill A M 2005 Landscape fires as social disasters: an overview of 'the Bushfire problem' *Environ. Hazards* **6** 65–80

Handmer J and Haynes K (ed) 2008 *Community Bushfire Safety* (Melbourne: CSIRO Publishing)

Handmer J and Tibbits A 2005 Is staying at home the safest option during bushfires? Historical evidence for an Australian approach *Environ. Hazards* **6** 81–91

Henri C 2003 Fire policy: an insurance perspective *Australia Burning. Fire Ecology, Policy and Management Issues* ed G J Cary, D B Lindenmayer and S Dovers (Melbourne: CSIRO Publishing) pp 162–5

Leicester R and Handmer J 2008 Bushfire *Transitions: Pathways Towards Sustainable Development in Australia* (Melbourne: CSIRO Publishing) pp 245–52

Mall A and Matzner F 2007 *Safe at Home: Making the Federal Fire Safety Budget Work for Communities* (New York: Natural Resources Defense Council) http://www.nrdc.org/land/forests/safe/safe.pdf (accessed 8-25-08)

Moritz M A and Stephens S L 2008 Fire and sustainability: considerations for California's altered future climate *Clim. Change* **87** (suppl 1) S265–71

Moritz M A *et al* 2004 Testing a basic assumption of shrubland fire management: How important is fuel age? *Front. Ecol. Environ.* **2** 67–72

Mutch R W 2007 *FACES: The Story of the Victims of Southern California's 2003 Fire Siege* (Tucson, AZ: The Wildland Fire Lessons Learned Center)

Paveglio T, Carroll M S and Jakes P J 2008 Alternatives to evacuation—protecting public safety during wildland fire *J. Forestry* **106** 65–70

Pyne S J 1991 *Burning Bush: A Fire History of Australia* (New York, NY: Henry Holt)

Radeloff V C *et al* 2005 The wildland-urban interface in the United States *Ecol. Appl.* **15** 799–805

Schroeder M J *et al* 1964 *Synoptic Weather Types Associated with Critical Fire Weather AD 449-630* (US Department of Commerce, National Bureau of Standards, Institute for Applied Technology, Washington, DC)

Steelman T A and Burke C A 2007 Is wildfire policy in the United States sustainable? *J. Forestry* **105** 67–72

Stephens S L, Martin R E and Clinton N E 2007 Prehistoric fire area and emissions from California's forests, woodlands, shrublands and grasslands *Forest Ecol. Manag.* **251** 205–16

Stephens S L and Ruth L W 2005 Federal forest fire policy in the United States *Ecol. Appl.* **15** 532–42

Sugihara N G, van Wagtendonk J, Shaffer K E, Fites-Kaufman J and Thode A E (ed) 2006 *Fire in California's Ecosystems* (Berkeley, CA: University of California Press) p 596

Syphard A D *et al* 2007 Human influence on California fire regimes *Ecol. Appl.* **17** 1388–402

Talberth J, Berrens R P, McKee M and Jones M 2006 Averting and insurance decisions in the wildland-urban interface: implications of survey and experimental data for wildfire risk reduction policy *Contemp. Econ. Policy* **24** 203–23

Theobald D M and Romme W H 2007 Expansion of the US wildland–urban interface *Landsc. Urban Plan.* **88** 340–54

Tibbits A and Whittaker J 2007 Stay and defend or leave early: policy problems and experiences during the 2003 Victorian bushfires *Environ. Hazards* **7** 283–90