PROCEEDINGS OF THE ROYAL SOCIETY OF QUEENSLAND

BUSHFIRE 2006 CONFERENCE SPECIAL EDITION

APRIL 2009 VOLUME 115

FIRE, SCIENCE AND SOCIETY AT THE URBAN-RURAL INTERFACE

A.MALCOLM GILL

Gill A.M. 2009 04 30: Fire, Science And Society At The Urban-rural Interface. *Proceedings of the Royal Society of Queensland*, 115: 153-160. Brisbane. ISSN 0080-469X.

The drama of urban-rural interface fire is a feature of summer newscasts in south-eastern Australia. Fire-suppression agencies report on their activities and on threats to homes. At another level, scientists grapple with the problems of predicting fire spread, recommending house-construction methods, advocating human-safety measures and anticipating environmental effects. The householder can be largely unaware of a fire threat or have expectations of total protection from suppression agencies. Houses can burn down and fatalities can occur. This paper considers a number of the issues surrounding this 'bushfire problem'. Using examples based on the fire event experienced under extreme weather in Canberra, Australia, in 2003, simple models and calculations are presented for: the fire-awareness of householders; the proportion of 'knowledgeable' householders; the capacity of the brigade suppression system; demands for water from the mains; stay-or-go recommendations; and, house loss in relation to householder occupancy during fire. A set of testable hypotheses is suggested. The general socio-political problem is how to meet a rare, extreme, short-term demand for resources that far exceeds normal supply. The conclusion that householders need to be self reliant is apparent. The general scientific problem is one of too many variables and too few data for statistical analysis.

❐ WUI, householder responsiveness, water, house occupancy, stay or go, suppression.

A.Malcolm Gill, CSIRO Plant Industry, GPO Box 1600, Canberra, ACT 2601, Australia, and Fenner School of Environment and Society, The Australian National University, Canberra, 0200, ACT, Australia and Bushfire Cooperative Research Centre, Albert St, East Melbourne, Victoria, Australia

'It is 3.30 on a long hot summer afternoon but it has turned dark from smoke and the street lights have come on automatically. The roar of the approaching fire is intimidating. The gloomy air becomes permeated by a storm of red-hot embers blown into the urban interface by a strong dry wind. People are hosing their houses but gardens are catching alight and many houses seem doomed. There is no fire-suppression appliance to be seen.'

This graphic description depicts the scene of a major bushfire arriving at an urban edge. When houses and lives are lost it is the beginning of a major social problem that can last for years. This is an international problem and one with many facets and complications (Gill, 2005).

Fire, science and society meet at the urban-rural interface and too often in circumstances of death and destruction. What can householders – and society in general - expect? Can science provide any insight into this situation? Can testable hypotheses be formulated, data collected intelligently and better practices put into place?

In this contribution, a limited set of issues is addressed. Here, the house is considered to be the major asset at the interface (see also Gill, 2005). Two 'responsiveness groups' of householders are created and their proportions in the community estimated. Whether or not to stay with the home during a major fire event is considered along with the chances of saving a house using an urban water supply; the situation faced by fire-suppression authorities in such extraordinary circumstances is also considered. This paper is necessarily somewhat speculative but attempts to be constructive and stimulative.

HOUSEHOLDER RESPONSIVENESS TO FIRE

Consider a fire that starts within a hundred metres or so of the urban edge, runs up a slope before a strong dry wind and destroys a house or two (e.g. in the manner of the fire at the edge of the Canberra suburb of Yarralumla, Australian Capital Territory – ACT – in December 2005). In this situation there is very little time for residents to become aware of the threat they face or for agencies to warn anyone of the approach of the fire, let alone respond in time to prevent house loss. The proportion of fire-responding residents in such cases may follow a curve such as that in Figure 1.

'Responsive' behaviour, here, is considered to occur when a threat has been recognised and action considered, or possibly taken, by the resident in response to it. Action may be limited to mental plans or involve fuel modification, suppression action or a decision to stay and defend the property, or stay and shelter, or move away. The time scale at which awareness is graphed depends on the situation. 'Hours' or 'days' may be appropriate in some situations (see below) as opposed to the 'minutes' of Figure 1: the Canberra, ACT, fires of January 2003 (McLeod, 2003) burned for 10 days before reaching the urban edge of Canberra thereby providing a considerable period for reflection and preparation in response to that event – compared with the general preparedness that is a seasonal routine of some households even in the absence of fire. It was observed by the author from a small sample that most people were completely unprepared in Canberra even close to the time of the fire's arrival, and published narratives or people's experience support this (e.g. see Matthews, 2003).

RESPONSIVENESS CATEGORIES

Two contrasting categories of households are recognised here in relation to their 'responsiveness' to an impending fire. The first consists of those people who are seasonally unprepared, apathetic, unconcerned or vague; they might believe that 'the authorities have everything in hand' or that they are covered by insurance so perceive that they 'need not think about it' or that 'it won't happen to me' or that 'it can't happen here'. This group is called the 'naïve' group. Their counterparts are those who are seasonally prepared, fire-experienced or well informed, watchful, concerned and alert (after Cunningham & Kelly, 1994). This group is called the 'knowledgeable' group. The responsiveness of the two groups in relation to an actual fire starting well away from the interface is speculatively depicted in Figure 2.

According to the hypothetical relationships depicted in Figure 2, all households in which people are present become aware of the fire when it arrives but the proportion of the 'knowledgeable' group aware of the possibility of the impending fire rises many days before that of the 'naïve' group. The 'naïve household' would appear to be more likely to make a decision to stay or leave at the last minute while members of the former category have time to consider their position, make final preparations for the arrival of the fire and their responses to it, and seem more likely to stay and defend their property. It is the impression of the author that in the unprecedented Canberra fires of 2003, the 'naïve' group was the larger of the two but there is no definitive evidence to support or refute this.

Note that according to the hypothetical graph depicting the 'knowledgeable' group in Figure 2 some households are responsive well in advance of any possible fire: this may be seen as being responsive to the chance of ignition, the nature of the fuel array, weather forecasts, and fuel moisture.

Only two categories of responsiveness have been discerned here for convenience. It may be sensible in the future to more rigorously define more groups than the two used for illustration here.

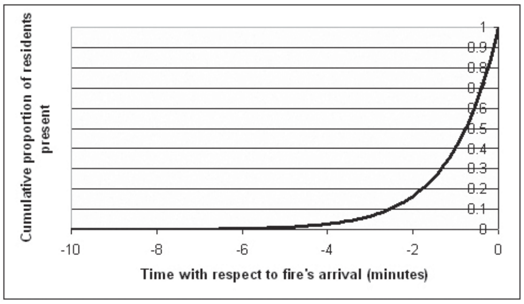

FIG. 1. Hypothetical cumulative proportion of the awareness of fire by a resident urban-edge population. The fire is considered to have started relatively close to the interface.

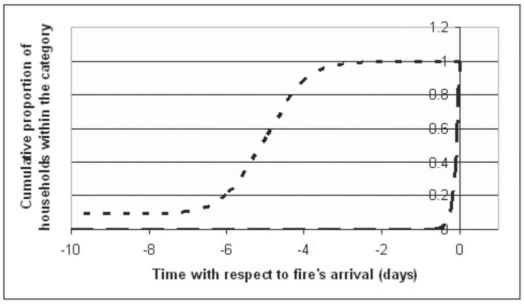

FIG. 2. Hypothetical cumulative proportion of responsive households within the 'naïve' (lower, dashed curve) and 'knowledgeable' (upper, dotted curve) categories in relation to the number days left for the fire to travel before it reaches the interface.

Membership of Response Categories

While responsiveness within a category of responsiveness varies with time, the numbers of households falling into one or the other of the two identified categories varies. Thus, the proportion of 'knowledgeable' households will vary from place to place and at any one place with the passage of time; contributing affects may be the year the resident arrived in the area, the time since the last fire, the effectiveness of official and unofficial warnings, the quality of the information stream from fire authorities, and the extent of personal observation and learning. Residents who have been through a Community Fireguard program in Victoria (Boura, 1999) or are members of a Community Fire Unit (New South Wales and ACT) are more likely – perhaps much more likely – to be in the 'knowledgeable' category than others.

Starting at the end of a socially-disastrous fire, rather than leading up to it as in Figures 1 and 2, we may assume that all affected residents at the interface are part of the 'knowledgeable' group even if they were absent from their homes at the time of the fire because, on return, they would experience the devastation of the neighbourhood, hear the stories of those who stayed and read an extended media coverage of the event. Thus, the major fire event provides us with a starting point for an exploration of year-year changes in the proportion of 'knowledgeable' and 'naïve' households in a community.

In Cunningham & Kelly's (1994) survey in the Blue Mountains, there were 27% "experienced" households (here called 'knowledgeable') 16 years post fire. The model shown in Figure 3 suggests an attrition rate of about 4.67% per year in the proportion of 'knowledgeable' households to 1985 (upper, dashed, line) but then Cunningham & Kelly (1994) identified an additional loss of awareness within the 'knowledgeable' group after 1985 (lower, dotted line); we can call this a 'backsliding' effect. Apathy may follow.

One reason for the decline within the 'knowledgeable' group could be the incorrect perception of residents that the longer it has been since the last fire, the less likely there will be another fire; further perceptions, perhaps misleading, may be that 'these fires only occur cyclically' (Edgell & Brown, 1975); e.g., 'it's not that long since the last one' and 'fire management must have improved since last time' so 'there is nothing to worry about at the moment'.

In suburbs where house numbers are largely static, the sale of houses at the interface after a major fire may be taken to represent the loss of 'knowledgeable' households from the area because 'knowledgeable' residents are more likely to be replaced by 'naïve' ones when a house is sold; new residents would appear to be more likely to be from a city core or from interstate rather than from another interface. Figures for house sales and other housing data in those parts of Canberra directly affected by the 2003 bush fires were obtained from ACTPLA, the Australian Capital Territory Land and Planning Authority. Numbers of sales were able to be expressed as proportions when data for the number of houses per suburb from the 2001 census were obtained from the Australian Bureau of Statistics web site. The ten-year average sales figure – for the period 1996-2005 – was 6.6% per year for the Canberra suburbs of Chapman, Duffy and Holder.

When proportional sales in 2003 were graphed against proportional house losses for the 2003 fires for seven affected suburbs (loss data from the ACT Department of Urban Services), there was a positive correlation (not shown here), supporting the idea of greater turnover of ownership soon after fire. This could be modelled by using a lower value for the 'knowledgeable' group at the outset in Figure 3 rather than assuming a starting value of one, although it is possible that people who sell up in one part of the burnt area then buy up in another.

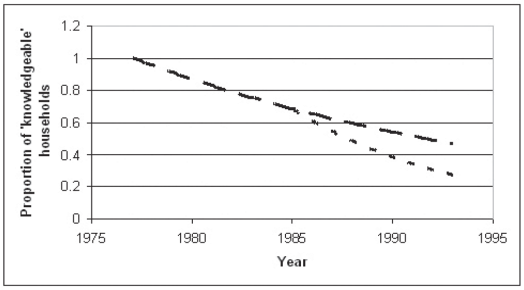

FIG. 3. A model of the proportion of 'knowledgeable' households in the Blue Mountains from the time of the 1977 fire (after Cunningham & Kelly, 1994). The modelled attrition of 'knowledgeable' households, apparently due to a net departure from the survey area of about 4.67% per year, is shown by the dashed line (upper) while the dotted line after 1985 shows the added effect of an apparent loss of 'knowledge' by some households of about 10.9% per year.

The models used above provide us with some indication of what is likely but they cannot be perfect reflections of what actually is the proportion of 'knowledgeable' residents. In particular, the turnover of people in rental accommodation is not known. Residents in such circumstances may be long or short term. The proportion of rented houses in seven affected Canberra suburbs was estimated to be between 8 and 25%. Another complication is the partial sale of houses between joint owners and what effects this might have; partial sales – between multiple owners – were not considered above.

Target audiences for fire-safety messages are likely to be continually changing (Coleman, 1995) as people move into and out of potentially fire-affected suburbs.

EXPECTATIONS OF FIRE BRIGADE PRESENCE: LIMITS TO AGENCY SUPPRESSION CAPACITY

Both 'knowledgeable' and 'naïve' groups may be expecting protection from the urban fire brigade in the event of an urban-interface fire. In 2006 the main categories of people involved in fire suppression in the ACT were the ACT Fire Brigade (urban predominantly), the ACT Rural Fire Service (rural, consisting of Park's units, and volunteers from urban and rural locations, augmented by 'seasonal fire fighters'), the post-2003 Community Fire Units (specially-trained local householders with access to local fire hydrants but under the command of the ACT Fire Brigade), general householders (using mains water from taps - no access to hydrants), and 'farmers' (individual rural lessees). The ACT Fire Brigade and the ACT Rural Fire Service are part of the ACT Emergency Services Agency. The vehicle fleet for house-fire suppression in the ACT Fire Brigade (personal communication, 2006) consisted of 14 pumpers, 5 tankers and, for the first time, 4 compressed-air-foam tankers - a total of 23 possible urban-interface fire-suppression vehicles. Two helicopters were available during the fire season of 2006-07.

On January 18th, 2003, over 500 houses were burnt in Canberra (Leonard & Blanchi, 2005). Assuming one tanker or pumper to each threatened house, then the entire ACT urban capacity is mopped up by just 23 threatened or burning houses at any one time. Given that several thousand houses were threatened and hundreds burnt over a period of several hours in the Canberra fires of 2003 (ACT Government, 2003; Leonard & Blanchi, 2005), the maximum demand for suppression services can greatly exceed supply even if rural fire service vehicles are also used for house-fire protection.

When property protection is paramount, all fire appliances could be fully engaged at rural and urban house sites, so no suppression of the moving fire perimeter by agency fire-fighters is possible. Equipment breakdown and further outbreaks of fire can exacerbate the situation but the timely arrival of crews and appliances from other jurisdictions can offset this. The capacity of rural (Gill, 2005) and urban fire-suppression services can be quickly overcome when many structures are threatened, or already alight.

Would society ever allow governments to spend the money necessary to establish a full-time, fully-equipped, professional fire-suppression force with adequate training for dealing with large, rare, high intensity fires burning into the urban-interface under the worst possible weather and, possibly, fuel conditions? If it did, such supply would be excessive for the vast majority of the time. This problem is at a different time scale to that of normal seasonal variations - which is addressed by having trained volunteers and by employing, apparently increasingly, paid seasonal fire fighters. If an adequate number of volunteers offered their services for the most extreme situation, and they were fully equipped with vehicles, there would be no 'action' for most of them year after year; as a result, many could be expected to lose their enthusiasm and skills and drift away.

Householders can expect that they will be without agency support in the event of a large fire at the urban edge or in the few minutes it takes a fire starting near the edge to reach houses and ignite them; there is an operating domain in which agencies can best assist the public through fire suppression. Defining what this range is in detail remains a challenge. If the time for the fire to reach an urban house from a rural ignition is short, the response time of an urban brigade may be too long to prevent house loss; if the capacity of the fire suppression agency is exceeded because there are too many houses threatened or alight, the response time for many houses may be too long also, albeit for a different reason. Between these limits, however, the response time might be regarded as sufficient.

FIRE SUPPRESSION AND URBAN WATER RETICULATION

The most common resource for all the participants engaged in fire suppression at the urban interface is water. From the urban perspective, this is supplied by a network of catchment storages, local reservoirs and mains by a government, or semi-government, agency. Farm dams, water tanks and streams supply rural brigades but once near the urban edge, hydrants can be tapped.

Canberra's water is piped from open storages in the mountains to enclosed concrete reservoirs in the hills surrounding the suburbs - from whence it is distributed by gravity to householders through a network of pipes sectored according to reservoir location. A fire may impinge on a long or short edge of a network sector and so affect the demand by householders for water differentially. Neighbours on opposite sides of a street may be in different network sectors and so may experience different water pressures.

While water is the common resource, the tools for its application and the ways in which it is used vary considerably. Urban Brigades have pumpers and tankers of varying capacity and apply water with or without foams (with or without compressed-air enhancement); rural brigades apply water with or without flame retardants (including foams); farmers, householders and Community Fire Units use water without special treatment.

In the urban environment, there can be inadvertent competition for the water from the mains in the event of a major urban interface fire. However, people with independent sources and application techniques – such as swimming pools with pumps and hoses – are free of this.

In the major Canberra fires of 2003, there were two sources of inadequacy in the supply of water for fire fighting and there is a need to distinguish these:

1. The first source was highly localised and apparently characterised by a sudden loss of pressure in the hoses of householders that was not necessarily experienced by neighbours. There were many informal reports of this type. The failure of water pressure in garden hoses was due, perhaps, to the burning through of plastic pipes in garden-sprinkler systems (McFeat, 2004).
2. The second type was experienced as water-supply failure by the urban fire brigade drawing on the mains water supply and this can be regarded as neighbourhood-wide. Demand exceeded supply.

The water pressure at any pipe outlet in the suburbs is influenced positively by the 'head of water' (the difference in elevation between the water level in the reservoir and that at the outlet); water supply is increased by higher pressure and decreased by friction in the pipes and demand on the network. The total frictional losses are dependent on many physical properties of the mains network including the diameter and length of the pipes and, for the householder, the plumbing system of the property. A householder who has joined garden hoses to gain access to a wider area of the property will find a reduced flow due to greater friction.

Having an adequate and alternate water supply to that from the mains – temporary or permanent – is ideal for a householder faced with a major fire event. This may be a swimming pool or a tank, for example. Alternatively, a 'knowledgeable' resident will fill the bath, bins and other containers as a backup in case mains pressure fails. Turning off vulnerable, pressurised, garden-sprinkler systems not in use is advisable.

Modelling pipe network performance under different water-demands, and testing the predictions, is possible for water-supply agencies. If done, weak points in the system could be found and strategies designed for the best use of water in such places.

MITIGATION OF RISK TO LIFE AND PROPERTY

Residents have two basic and obvious options when fire threatens their house: they may stay or they may leave at a time of their choosing. However, there are variations on this theme as some people may be ordered to leave rather than leave voluntarily and some may 'stay and defend' their property or 'stay and shelter' only. Those who leave may do so at various times during the event. Those who stay may try to protect neighbour's houses as well as their own. 'Knowledgeable' residents will, by definition, have a different view of the event than 'naïve' residents, and be better prepared.

LEAVE EARLY

The prevailing paradigm of Australasian fire authorities is one of 'leave the potential fire scene early' if one considers it unwise to stay for various reasons, or 'prepare, stay and defend the home', the rationale being that it is safer to stay with the protection of a building – temporarily, if it catches alight – than to flee from the fire at the last moment (see McLeod, 2003; Handmer & Tibbits, 2005).

'Prepare, stay and defend' or 'leave early' both imply a necessary minimum time to get ready for appropriate action. In the first instance, time is needed to prepare water sources, don suitable clothing and make last-minute preparations to the house and garden while, in the second, time is needed to exit the potential fire-affected area before the fire arrives and before egress is affected. For the purposes of illustration let us assume that one hour is the absolute minimum time necessary in both cases. Where will the fire be one hour before the fire arrives? If I can see the flames nearby, have I left it too late? Cheney *et al.* (2001) used this approach in the context of fire-fighter safety in a forest fire; here it is applied to the urban-interface dweller.

The maximum predicted distance that a line of fire can travel in one hour on level ground under the extreme weather conditions experienced in Canberra in completely cured grass (i.e. no green grass present) or in eucalypt forest is substantial - 15.5 km, 13.2 and 6.6 km in 'natural', 'cut/grazed' or 'eaten-out' grassland categories respectively (Cheney *et al.,* 1998) and 5.1 km in forest (after Cheney *et al.,* 2001). These are extremes and not the usual of course. However, such long distances would be even longer if there was an upward slope or extreme spot fire activity in the direction of the wind, and somewhat shorter for fire travelling against, or at right angles to, the wind or slope.

Given such rapid rates of spread, leaving for a safe haven when the fire is still far distant is wise if one is going to leave. Note that one hour is not necessarily enough time; one hour is used purely for illustration.

STAY AND DEFEND (OR JUST SHELTER)

Experience from major fires indicates that house occupancy is important to house survival. However, if everyone was at home and capable, there is still a chance that some houses would be lost. On the other hand there is a chance that even if all the homes were unoccupied some would survive. In this section we speculate upon the relationship across the spectrum of possibilities for house loss assuming a general lack of professional fire-fighters. The parameters of the situation could be changed to describe the effects of more or less severe conditions, the presence of more fire fighters, loss of a water supply, house type etc. but there is no attempt to do that here. The idea (Fig. 4) provides a background as to what the situation of 'stay-or-go' might mean in different circumstances.

Actual data are rare and do not cover the spectrum of possibilities. The dashed lines in Figure 4 mark out a domain of house loss; these circumstances are somewhat artificial. As noted above, even if there was 100% occupancy, some houses are likely to be lost under the most severe conditions; even if there was no one present, some houses might survive despite being unprotected. The neat relationships in Figure 4 would be modified as to intercepts and slope, and, possibly, shape, in the real world. The few available data are shown in Figure 5.

The linear extrapolation of the trend line for real data in Figure 5 represents the simplest hypothesis for the relationship between occupancy and house loss at the urban-rural interface.

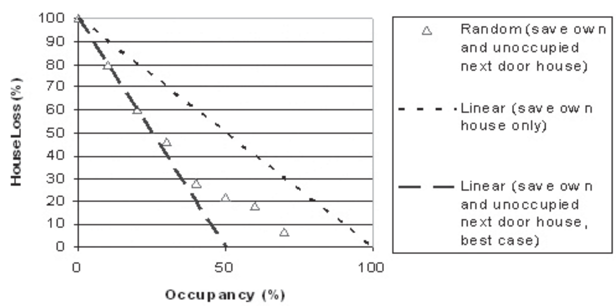

FIG. 4. A model for the loss of houses (n=100) when each household saves its own house and, where indicated, that of a house next door if unoccupied.

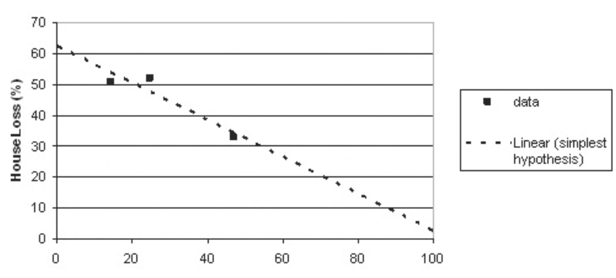

FIG. 5. The dotted line shows the extrapolated trend for data from Wilson and Ferguson (1986) and Leonard and Blanchi (2005, and personal communication for the Otways Fire, Victoria). Note the apparent 62% house loss when no one is present and the apparent 3% loss when everyone is present according to the extrapolation. The real shape of the relationship is unknown.

DISCUSSION AND CONCLUSIONS

There are numerous facets to the problem of landscape fires entering the urban-rural interface (Gill, 2005). Only a small subset of possible topics has been addressed here. Some other topics of importance are: town and landscape planning; building and garden design and construction; disaster recovery; restoration of property and businesses; environmental effects including those on water supply, biodiversity, air and stream quality; warnings; communication of fire information; fire behaviour; and, fuel management. Reports resulting from various official post-fire inquiries canvas many topics which, while not always directed at interface fires, can be relevant there (see, for example, Esplin *et al.,* 2003; Ellis *et al.,* 2004).

'Time scale' emerges as an important variable to consider with respect to fires and the damage they may do at the urban-rural interface during extreme weather conditions. Houses at the urban edge may be affected in a very short time after a fire is ignited nearby; so short can be the time, in fact, that even urban appliances cannot reach the site before damage to property has occurred. On the other hand, the very large fire with long distances to travel may be so large that fire-suppression forces are simply not numerous enough to cope. In both of these cases, the householder who is 'knowledgeable' will be better able to cope. There are limits to effective suppression and a general recognition of these by communities and governments is important if fire problems at the urban-rural interface are to be suitably addressed.

The general problem for society is how to deal with a rare and extreme event like a major unplanned fire burning under extreme weather conditions leading to the loss of homes and human lives – another scale problem. It would appear that the costs of being able to address the most extreme event in a comprehensive way, at least for fire suppression, are prohibitive; the question of the possibility of more comprehensive, but potentially routine, fuel treatments and how they might affect the situation has not been addressed here. How to integrate preparedness and response among the many private and government stakeholders involved when extreme fires reach the urban interface remains an important challenge to all affected, or potentially-affected, societies.

Data issues with respect to the topics of this contribution are substantial. There are too few data and too many variables to consider. This makes conventional scientific analysis impracticable yet policy formulation, even laws, are created or contemplated on the few available data or on perceptions of the circumstances of fires and their impacts on the urban-rural interface. International co-operation in the sharing and analysis of data is recommended. In this contribution, the approach has been to take the scraps of available data and use what appear to be appropriate surrogates, like house-sale information, to develop some testable hypotheses as another step on the way toward greater understanding.

The testable hypotheses arising from this paper follow.

1. Hypotheses related to householder knowledge:
   (a) With respect to their responsiveness to the occurrence of urban-rural interface fires, households can be divided into two groups based on their knowledge, skills and attitude - a 'naive group and a 'knowledgeable' group
   (b) The proportion of households in the 'knowledgeable' category declines predictably in the years after a major fire and is reflected in house-sale data – a surrogate.
2. Hypotheses related to fire suppression:
   (a) Mains water supply at the interface can be accurately modelled. Places less well served than others can be identified.
   (b) Limits to suppression can be accurately modelled. The short response times of urban fire brigades may be demonstrated to be inadequate to save houses under extreme conditions and local ignition while appliance numbers may be too few or inadequate in a large intense fire from a remote ignition point.
3. Hypotheses related to house occupancy:
   (a) 'Occupancy' by able-bodied people is important to house survival. The difficulty here is how to measure 'occupancy'. It could be measured using a score weighted according to 'time-since-fire-arrival' rather than on a simple 'present' or 'absent' basis. For example, based on a negative exponential probability of house loss with time since fire arrival (in the absence of people), the score could be the sum of the probabilities of house loss for each hour, multiplied by a zero or one for the presence of able-bodied people in each time slot. Frequent visits by a neighbour in any time slot would be counted as someone being 'present'.
   (b) House survival is negatively proportional to 'occupancy' by able-bodied people.

(c) The minimum time between safe departure from home and safe arrival at a refuge can be calculated from the fire rate of spread in rural areas and distance of the fire from the house (to give the latest possible departure time for example) and the time to travel to safety during passage from the house to a place of refuge.

There is a need for collaboration between the public, scientists, land managers and governments to learn as much as possible from rare and tragic social circumstances such as devastating fires at the urban-rural interface.

ACKNOWLEDGEMENTS

I would particularly like to thanks the following ACT Government Agencies for their support in this project: ACT Department of Urban Services; ACT Emergency Services Agency through the ACT Fire Brigade and ACT Rural Fire Service; EnvironmentACT; and ACTPLA – the ACT Planning and Land Authority. Scott Byrne of ACTPLA kindly provided data on rentals and house sales and offered interpretive advice. Professor John Handmer kindly commented on the draft manuscript.

LITERATURE CITED

ACT GOVERNMENT 2003. The Report of the Bushfire Recovery Taskforce. (ACT Publishing Services, Canberra).

BOURA, J. 1999. Community Fireguard: Creating Partnerships with the Community. (Country Fire Authority of Victoria Occasional Paper 2).

CHENEY, N.P., GOULD, J. & CATCHPOLE, W.R. 1998. Prediction of fire spread in grasslands. International Journal of Wildland Fire 8: 1-13.

CHENEY, N.P., GOULD, J. & MCCAW, L. 2001. The dead-man zone – a neglected area of firefighter safety. Australian Forestry 64: 45-50.

COLEMAN, R.J. 1995. Structural wildland intermix. USDA Forest Service General Technical Report PSW-GTR-158: 141-145.

CUNNINGHAM, C.J. & KELLY, S.B. 1994. Awareness of bushfire hazards: a case study of the Blue Mountains, New South Wales, Australia. Proceedings, New England-St Lawrence Valley Geographical Society 24: 67-83.

EDGELL, M.C.R. & BROWN, E.H. 1975. The bushfire environment of southeastern Australia. Journal of Environmental Management 3: 329-349.

ELLIS, S., KANOWSKI P. & WHELAN, R. 2004. National Inquiry on Bushfire Mitigation and Management. (Commonwealth of Australia. Canberra).

ESPLIN, B., GILL, A.M., & ENRIGHT, N. 2003. Report of the Inquiry into the 2002-2003 Victorian Bushfires. (State Government of Victoria. Melbourne).

GILL, A.M. 2005. Landscape fires as social disasters: an overview of 'the bushfire problem'. Environmental Hazards 6: 65-80.

HANDMER, J. & TIBBITS, A. 2005. Is staying at home the safest option during bushfires? Historical evidence for an Australian approach. Environmental Hazards 6: 81-91.

LEONARD, J. & BLANCHI, R. 2005. Investigations of Bushfire Attack Mechanisms Resulting in House Loss in the ACT Bushfire 2003. (Report by CSIRO Construction, Mining and Information Technology for the Bushfire CRC).

MATTHEWS, S. 2003. How Did the Fire Know We Lived Here? Canberra's Bushfires January 2003. (Ginninderra Press. Canberra).

MCFEAT, D. 2004. We had to do our bit. Pp. 76-81. In Chapman Residents Action Group (eds), Our Story. (Ginninderra Press. Canberra).

MCLEOD, R. 2003. Inquiry into the Operational Response to the January 2003 Bushfires in the ACT. (Australian Capital Territory. Canberra).

WILSON, A.A.G. & FERGUSON, I.S. 1986. Predicting the probability of house survival during bushfires. Journal of Environmental Management 23: 259-270.

AUTHOR PROFILE

Dr A. Malcolm Gill has been a full-time fire ecologist since 1971 when he joined CSIRO Plant Industry in Canberra. Since retiring in 2000 he has been an Honorary Research Fellow at CSIRO and a Visiting Fellow at what is now the Fenner School of Environment and Society at The Australian National University. He has authored or co-authored many research papers and reports on a range of fire topics. In 2003 he was personally and professionally involved in the 2003 Canberra bushfires and was a member of the Bushfire Inquiry after the 2003 fires in Victoria. He is a member of one of Canberra's Community Fire Units.

CONTENTS