

How bushfires set houses alight — lessons from Ash Wednesday

For many people the memory of February 16, 1983 ('Ash Wednesday') will take a long time to fade. For Dr Caird Ramsay of the CSIRO Division of Building Research, the terrible destructiveness of that day has never been far from his thoughts, but for a scientific reason.

Within a day of the disaster, he and his fellow fire researchers began a new (and unexpected) project: a detailed study of the fires and the effects they had on buildings. Why did one house burn while an apparently similar one, perhaps on an adjacent block, survived?

He and his colleagues surveyed some 1150 houses (ones that burnt and ones that survived) in the Otway Ranges, by far the most significant area in terms of house loss. A close assessment of practically every house in the fire zone (covering 85 factors) was undertaken, and now, with data collection complete, some results have become available.

Why did one house burn while an apparently similar one, perhaps on an adjacent block, survived?

The researchers believe that houses are most often set alight by burning debris (embers of bark, twigs, and leaves) borne on the fierce wind accompanying the fire. The rain of burning embers can lodge in roof spaces, on decks and window sills, or against doors, walls, steps, stumps, or poles. The researchers have found evidence for a build-up of this smouldering material under the floor, and between joists and bearers.

Another likely entry route for burning debris is through windows broken by radiant heat or flying debris. Unless sturdy metal fly-wire screens or shutters are installed, the intense radiation can crack windows. Missiles conveyed on the wind can also open up a house to entry of embers.

As in an ordinary house fire — started, perhaps, by a cigarette lodged in a chair — a steady build-up in intensity occurs as the fire gradually takes hold. Only after many



minutes, if not hours, will it build up sufficiently to consume a house.

The important point is that people (if not the fire brigade) stand a good chance of extinguishing the fire if they are around in the early stages. You will find a few buckets of water and wet mops are enough if you can attack the fire then.

Some newspaper reports at the time maintained that houses will 'explode into flames' when the fire front hits. The CSIRO team has found no evidence to substantiate such claims. Provided you are able-bodied, it is highly likely that you can shelter from a bushfire in your home, and save your life and, quite possibly, your home.

A house may be considered as a refuge against bushfire in the same way as against

storms, Dr Ramsay believes. Of course, you would be safest if you were right out of the fire zone, but fleeing your home on smoky fire-lashed roads can be more dangerous than staying in your house and putting out spot fires. Staying or fleeing must remain an individual decision, but in the light of Ash Wednesday the Country Fire Authority now recommends that, unless elderly or disabled, you are better off staying.

The survey

The survey would not have been possible without the assistance of the Geelong Regional Commission, which initially requested that it be done. Mr Ross McBride of the State Emergency Services was also involved



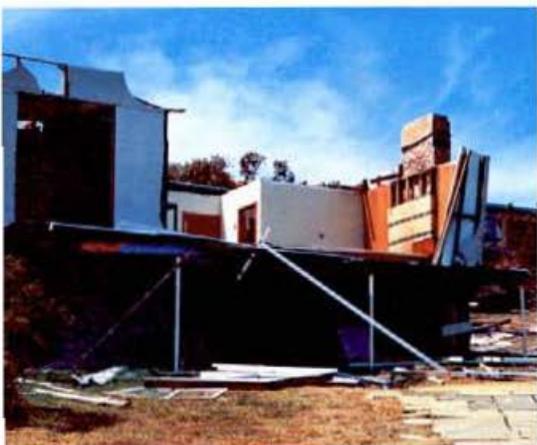
The ferocity of Ash Wednesday.

in the genesis of the survey, and volunteers from the planning and architecture faculties of Deakin University and the Royal Melbourne Institute of Technology formed the core of the several dozen surveyors. The CSIRO team included Mr Neville McArthur, Mr Vince Dowling, and Mr Tony Cerra.

After completing the survey of the destroyed sites — the trick was to stay ahead of the bulldozers — the team assessed all the standing houses in the survey area, which covered North Lorne, Eastern View, Mogg's Creek, Fairhaven, Airey's Inlet, and Anglesea.

All the houses were more or less equally threatened. Unlike fires elsewhere that fateful day, the Otways fire was uniformly intense, burning out huge tracts of forest and coastal scrub.

The wind on Ash Wednesday was very strong, as this wind-damaged house testifies.



The survey team collected 85 data elements, including:

- ▷ degree of damage
- ▷ design of house
- ▷ roof type
- ▷ wall type
- ▷ window construction
- ▷ floor material
- ▷ layout of steps and decking
- ▷ openings
- ▷ colour
- ▷ out-buildings
- ▷ combustibles (wood heaps, fuel containers, etc.)
- ▷ slope of site
- ▷ surrounding vegetation
- ▷ action of occupants during or immediately after the fire

As well as obtaining data from inspection of the sites, they gathered information from building plans and interviews with the owners.

A total of 720 of the surveyed houses were damaged or destroyed, while 433 were

not significantly affected. The surveyors rated the fire's effects on the houses on a six-category scale ranging from untouched through superficial, light, medium, and heavy damage to destroyed.

Only 8% of houses were classed as 'damaged, but repairable', and this is consistent with the team's impression that houses were generally at one or other end of the scale. However, these partly burnt houses provided important information on the way the fire took hold.

Many of them were saved by human effort, and there is no reason to believe that the fire attacked the saved houses any differently from those it destroyed.

Three modes of attack

A bushfire can attack a house in three ways: by direct flame, by radiation, and by flying embers. The team found little evidence of the first two playing a major role. Radiation kills people, but in the short periods during which it peaks — perhaps 60–90 seconds — it did not appear to have much effect on buildings. Very few of the surviving houses showed signs of scorching, such as blistered paint or charred wood.

However, the team did see windows apparently cracked and broken by radiation. Metal fly wire can cut down the intensity of this form of heat. On one house

assessed, all the unprotected windows, on all four sides of the house, were cracked or broken, whereas the screened ones remained intact.

Many modern houses incorporate quantities of plastics — such as PVC cladding, gutters, and piping. Radiation did soften, distort, or char these materials, but didn't ignite them.

Although fire in the trees surrounding a house usually persists for many minutes, the team's observations also don't support direct flame from the bushfire as a major cause of ignition. Even the cases of charred wood fascias that they saw could have arisen from burning debris in the gutters, rather than from impinging flame.

A number of partly built timber-frame houses lay in fire zones. Most survived, yet many were surrounded by burnt-out homes. If direct flame contact was a major cause of ignition, these exposed frames should have been the first to go. Their survival supports the view that ember attack rather than attack by flame is the main danger. Embers are likely to blow straight through the frame, with few nooks and crannies to trap burning material.

The team found no evidence to back up eyewitness accounts of houses 'exploding' due to the impact of the fire front, which came out at the time. While in some areas the fire spread rapidly and with astounding violence, many houses burnt down after the fire front passed — sometimes 2, 3, or 4 hours after.

And, whereas some reports talked of fires travelling like express trains, the fastest speed documented by the Forests Commission, Victoria, was 9–10 km per hour.

The amount of heat given out was enormous. One metre of the hottest fire front gave

Left: A coir doormat caught fire and the fire spread to the decking. Spot fires like this are easy to extinguish in the early stages.

Centre: Looking for clues among the remains.

Right: Burning embers lodge in nooks and crannies: the corner of a window frame is a likely spot.

out about 100 megawatts, so 60 metres emitted energy equivalent to Victoria's peak electrical power consumption, 6000 megawatts. People caught in the open were likely to die. But in some fire areas nearly half the houses survived.

Some houses did look as if they had exploded. The team saw houses where not even much ash remained, and others with portions (windows, for example) many metres away. However, the point to be made is that a more conventional explanation is probable.

House fires usually progress from the inside out, with the contents carrying the fire through the house, and the structure joining in later. Many small fires within a house, started by flying embers, can, after burning steadily for some time, build up to reach 'flashover', causing windows to break outwards and giving the impression of a house exploding. (This phenomenon is well documented in city fires.) Alternatively, a burning house can become structurally weakened, allowing the force of the wind to 'blow it apart'.

Indeed, Dr Ramsay emphasizes that high winds played an important role in the destruction of houses. During the Otways fires, winds in excess of 120 km per hour were reported. Some houses were damaged by wind, whereas with others it was hard to tell whether they had been blown open and burnt down, or burnt down and blown away. You can get some idea of the force of the wind from the accompanying picture of a wind-damaged house. Windows can easily be broken by flying debris from destroyed houses, allowing embers to enter easily. For example, one surveyed house had all the windows in its upper storey broken, and the marks left by embers were found on the beds. Luckily, the house survived.

In another house, shutters saved the windows from breakage: these were damaged by impact of flying debris, but the house still stands.

A rain of embers

The prime agent of attack appears to be a prolonged shower of burning brands and embers, the researchers conclude. Incen-

The toll of Ash Wednesday

The terrible Ash Wednesday fires claimed 76 lives — 48 in Victoria and 28 in South Australia. Hundreds of others were burnt or otherwise injured.

The Victorian fires burnt an area twice the size of metropolitan Melbourne (200 000 ha). They occurred at Cudjee and Branxholme (near Warrnambool), around Macedon, in the Dandenongs, and along the Otways. In South Australia fire consumed 159 000 ha, including areas in the Adelaide hills and in farming country in the south-east.

Destroyed houses totalled 2463 — 2080 in Victoria and 383 in South Australia. The number of insurance claims on houses destroyed or damaged ran to 5300.

About 290 000 head of stock were lost, and 1.5 million bales of hay, 20 000 km of fencing, and at least 1000 barns and other farm buildings were destroyed.

The Insurance Council of Australia put the insurance payout at \$186 million, and the total financial cost of the fires was many times more. The Victorian government estimates the fires in that State cost at least \$236 million: \$138 million from insurance and \$23 million from the public bushfire appeals, plus amounts from State government assistance and what the victims themselves spent.

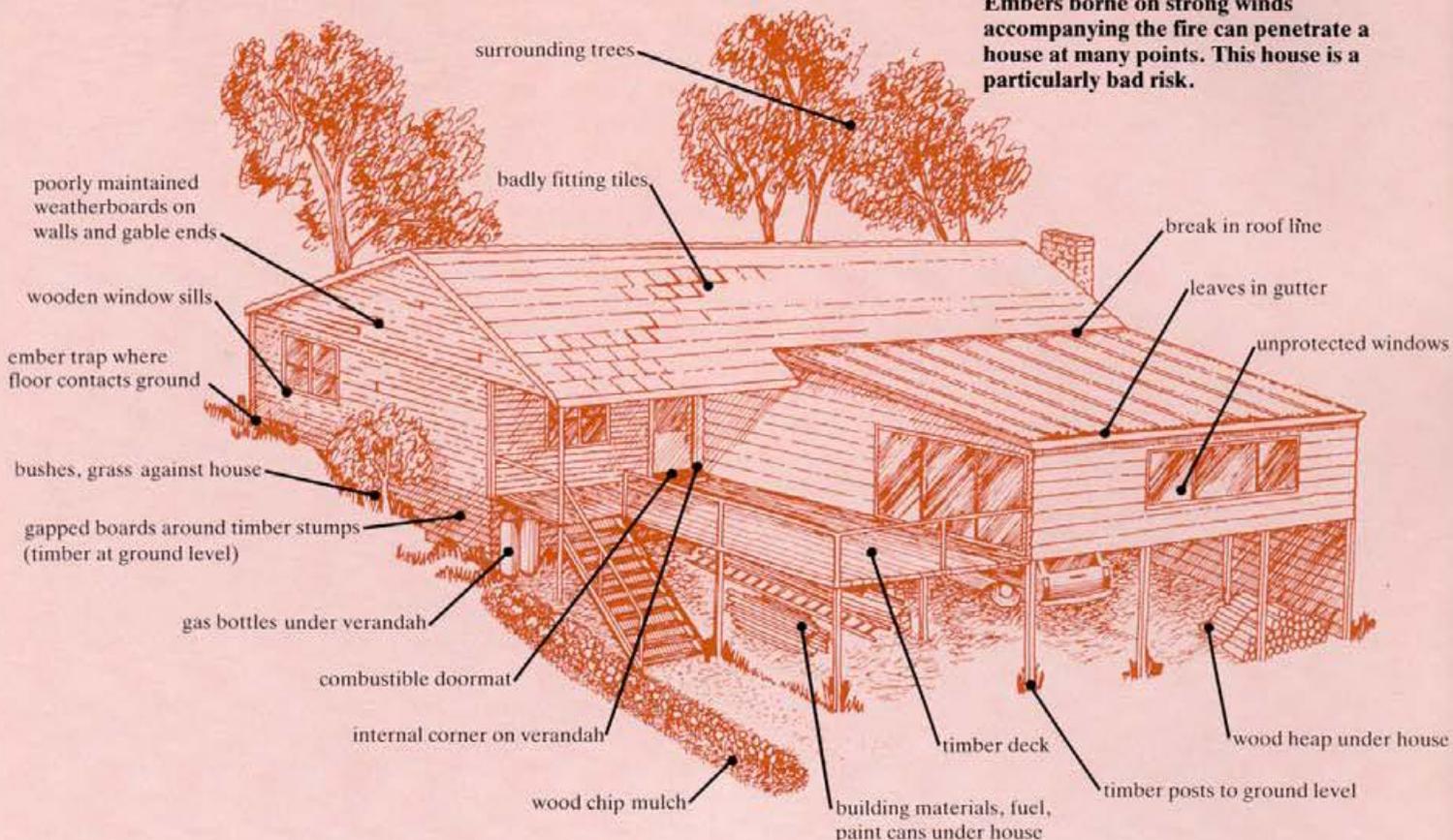
The report in August 1984 by the Commonwealth House of Representatives Standing Committee on Environment and Conservation — 'Bushfires and the Australian Environment' — sets the total loss at 'probably in excess of \$500 million'.

diary pieces of bark and leaves can start falling on a house half an hour or more before the fire front arrives, and continue for hours afterwards. From the houses examined, and from interviews with owners and witnesses, it appears that most buildings caught fire this way.

Embers were found to have lodged in gaps or crannies, such as window sills. Evidently, the embers can build up into drifts, like snow or hail, and even sturdy



A bad candidate for survival



Embers borne on strong winds accompanying the fire can penetrate a house at many points. This house is a particularly bad risk.

stumps, posts, and poles can then catch fire. A coir doormat is easy prey, and its burning may ignite combustible parts of a house. (Luckily, in the case pictured, the fire was extinguished before it could spread.)

Evidence suggests that having bricks or other non-combustible materials at ground level confers a definite advantage. A brick-walled house survived even though a wood heap against the wall was consumed.

Embers can also gain access to the house through unscreened vents or windows that are open or broken; and gaps — in tiles, under ridge caps, and at the gutter — can allow entry into the roof space. Partially enclosed spaces under a house, especially where used as storage areas, also pose a significant threat.

A brick house survives bushfires best, according to the statistics. Other factors studied by the CSIRO team included action of the occupants, surrounding vegetation, and roof material and slope.

Statistics

What factors does the survey indicate are important in warding off ignition? The researchers' analysis of the data so far has revealed factors that are likely to be important, but more statistical work is required to determine their significance and relative importance. And so the results presented here could be modified somewhat later on. Nevertheless, some good pointers have emerged.

WALL MATERIAL

Houses with masonry walls (of clay or cement) were ignited less frequently (57% not ignited) than those with walls of timber (35%) or fibre-reinforced cement (36%). However, only 14% of the surveyed homes had masonry cladding, whereas 63% were clad with fibre-reinforced cement, and 19% with timber. The claybrick houses that did ignite (19% of cases) often suffered damage rather than complete destruction, but the

intervention of people may account for this. Keep in mind, too, that features other than the nature of the cladding (for example, the material used at ground level) could contribute to these results.

WALL COLOUR

People have suggested that the colour of the walls is important, but the survey data do not show this.

ROOF MATERIAL

Steel-deck-roofed houses survived better than those with corrugated steel or fibre-reinforced-cement roofs.

ROOF SLOPE

Two-thirds of the roofs were flat and one-third pitched, and their survival rates proved no different. However, roofs with mixtures of pitches appeared to fare worse.

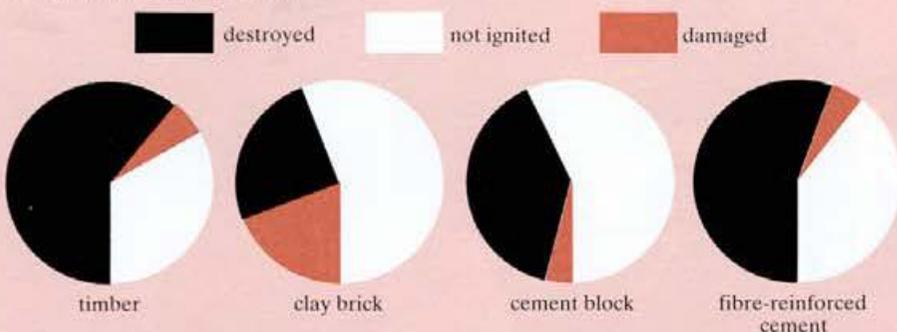
SURROUNDING VEGETATION

The vegetation next to the house varied from only grass to dense trees. The survival rate drops as the vegetation increases.

PEOPLE

Nearly half the houses were not occupied on the day of the fire (many in the Otways are holiday homes). Only 1% of houses remained occupied during the fire. Yet the survey has made clear that intervention by

The effect of wall material



Not the first survey

Two previous surveys concerned with house survival in bushfires are worth noting.

The first was carried out by CSIRO after fire swept through the Melbourne suburb of Beaumaris in January 1944. Some 118 houses were surrounded by fire: 66 ignited and 52 did not. This survey studied 17 of the ignited houses in detail.

In the second, the Experimental Building Station (EBS) of the Commonwealth Department of Housing and Construction surveyed the effects of the 1967 Hobart fires and the New South Wales Blue Mountains fire of 1968, and analysed the data jointly. A total of 555 houses were included, but only 162 (73 ignited, 89 not ignited) were studied in detail. The findings were not published fully until 1983.

The conclusions of these two surveys differed considerably. Only three factors — unprotected eaves, neighbouring wood heaps, and surrounding bush — were identified in both as contributing to the risk of house damage.

While the EBS survey found that houses clad in timber or fibre-reinforced cement were at greater risk than brick ones, the Beaumaris one did not. The Beaumaris survey cited unprotected openings as a risk factor, whereas the EBS one didn't. In fact, two of the EBS conclusions — about the cladding of houses and the lesser vulnerability of elevated houses — are not compatible with current advice.

Discrepancies between these two provided sufficient reason to undertake another survey. Further, much of the current advice is based upon anecdotal evidence and well-meaning 'common sense', and the CSIRO team wanted to verify (or overthrow) it, and perhaps uncover factors that had not yet been recognized.

Although Dr Ramsay hopes there will be no need for another survey of the magnitude of the present one, he and his team will continue to examine houses involved in bushfires. This is necessary to refine conclusions from the present survey, and to keep up with changes in building technology and fashion.

A survey of houses affected in the Beaumaris fire, January 14, 1944. G.J. Barrow. *Journal of the Council for Scientific and Industrial Research*, 1945, **18**, 27-43.

Houses exposed to bushfires; a survey of the effect of the Hobart fire of 1967 and the Blue Mountains fire of 1968. *Experimental Building Station Technical Record* 390(L), August 1983.

people played a very significant role in the survival of houses. People returned to some 17% of them within 12 hours, and many were able to extinguish small spot fires with a minimum amount of water and effort. The statistics show an improved outcome for those houses where the owner returned.

A lesson learnt?

Given the experience that has been gained from Ash Wednesday, often at extreme cost, you may be surprised to know that the houses that are being rebuilt generally do not differ in design from their ill-fated predecessors. Even people who have received advice do not seem to be using it, Dr Ramsay finds.

They give various reasons: 'nothing could have saved my house'; 'it's too expensive'; 'if it's necessary it would be in the building regulations'; 'there's nothing I can do really'. Dr Ramsay interprets this as a real need for community education — a changing of attitudes and behaviour before another fire disaster strikes.

If you are planning to build or renovate a home in bushfire-prone areas, then follow this advice.

- ▷ Keep the design (the plan and roof shape) simple; buildings of complicated design increase wind turbulence, and more easily trap burning particles.
- ▷ Securely attach the roof of the structure; fix every tile well, with fire-retardant aluminium foil underneath.
- ▷ Seal all openings to prevent the entry of sparks (box eaves; seal roofs — particularly at ridges and gutters; weather-proof doors and windows).
- ▷ Use brick cladding if possible, especially at ground level. Wood cladding should be smooth-sawn and well maintained.
- ▷ Protect windows with metal shutters or metal fly-wire screens.
- ▷ Protect doors and vents with metal fly wire.
- ▷ Keep wooden steps, decking, and pergolas to a minimum.
- ▷ Use slab-on-ground construction where possible. If elevation is necessary, use non-combustible supports and totally enclose the under-floor space using non-combustible material at ground level (cover vents with metal fly wire).
- ▷ Site outbuildings and gas bottles some distance from the house.



The map shows the region of the Otway Ranges where fire struck. The area was chosen for study because of the fire's relatively uniform severity throughout.

- ▷ Keep space around the house free of vegetation, firewood, and any other fuels. Mown lawns, paving, and gravel provide a useful 'break'.

In 1983 Boral Ltd conducted a competition for the design of a 'bushfire-resistant' house. The results were published in the February 1984 issue of 'Builder N.S.W.', available from the Master Builders Association of New South Wales, Private Bag 9, Broadway, N.S.W. 2007 (cost: \$2.00).

Other resources you should be aware of include:

'Design and Siting Guidelines: Bushfire Protection for Rural Homes.' (Department of Planning and Country Fire Authority of Victoria: Melbourne 1983.)

'The Homeowner's Bushfire Survival Manual.' (State Government of Victoria and The Herald and Weekly Times Ltd: Melbourne 1983.) \$2.95.

'Bushfires.' (State Government Insurance Commission of South Australia: Adelaide 1983.)

'In Case of Fire.' A free pamphlet published by the CSIRO Division of Building Research, P.O. Box 56, Highett, Vic. 3190.

'Houses Exposed to Bushfires.' Notes on the Science of Building No. 154. (Experimental Building Station, Department of Housing and Construction: Sydney 1979.)

'Design of Buildings in Bushfire-prone Areas.' A report of the Building Science Forum (South Australian Division) working party, March 1984.

Achieving a degree of bushfire immunity for your home demands considerable planning and continued vigilance, but, as Ash Wednesday demonstrated, is well worth the price.

Andrew Bell

More about the topic

'A Survey of Houses Involved in the Otway Ranges Fire, February 16, 1983.' G. Caird Ramsay, N.A. McArthur, and V.P. Dowling. (CSIRO Division of Building Research: Highett 1985, in press.)