Topic 3 Bushfire Behavior Embers

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Chair

I'm particularly interested in embers because it was it was embers that got our house. I wanted to ask you about is whether much is known about the way people think about embers, because I must admit I tended to think of embers as a single thing that might get in and start a fire. But in fact, the idea of embers that come like a sandstorm and they build up against things and so, in the end, you've got this red-hot stuff that's actually what's going to ignite your window frame, or your mulch, or whatever it happens to be. Has there been much research on how people think about embers.

Justin Leonard

I guess the ember work and investigations is more like a disconnected technical deep-dive into what embers can and can't do, but you do raise a very important question around the difference between human perception of embers and what's technically possible that embers can do, and how you work with them. And I think there's probably something in there to investigate people's diversity of attitudes and assumptions around ember attack.

In reality, ember attack is everything fine that's become airborne that's essentially combustible. So leaves, twigs that are either not burnt yet or are burning and flaming while they fly, or they're glowing while they fly. And they turn up and lodge in and get through gaps and build up in corners and crevices and are continually fanned by the wind, and just create prolific combustible debris build up and localized flame sources on everything external, particularly where there's a complex corner, like everywhere where leaves blow and accumulate in a normal windy day is where these embers and small flame sources build up.

And of course, what can an ember do and how small does it have to be before it's not a problem anymore, and the magic number is certainly down around 2mm. So an ember less than 2mm if it gets into something, let's say a rat's nest in your roof. A 2mm glowing ember is not quite enough to get a rat's nest going if it lands on something perfect as an ignitable source. Larger embers certainly are and the larger they are the more likely. And of course the larger the gaps the more large embers get through, and the more large embers get through the probability of ignition happening increases.

So it is a highly probability driven question. The only absolute certainty is there'll be embers there when there's a bushfire. It's just how many and how big the flame sources are and how many simultaneous things are happening all at once.

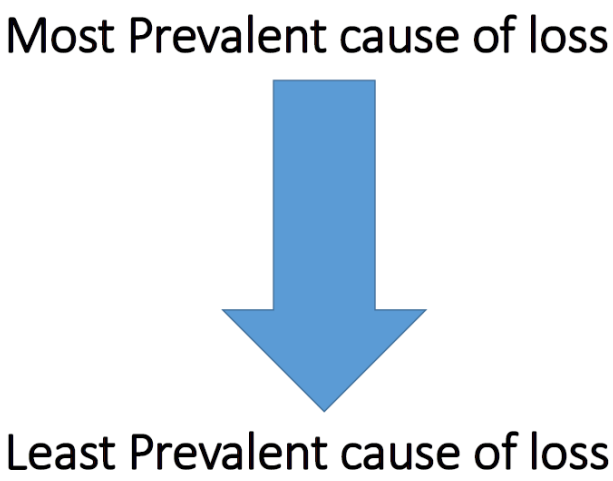
Justin Leonard

I've spent roughly 26 years delving into the nooks and crannies of how to improve our houses in the wake of bushfires.

In terms of a bushfire itself, we do a unique thing and actually study bushfires from the perspective of the house. So, what is it like to experience a bushfire from the house's perspective? And, I guess once you put that lens on, you start to imagine what experiential processes this house will experience, and what are the mechanisms and processes of how it might respond to those things.

And, I guess, as you look into it, it's a far more complex set of actions and processes than simply a fire front turning up and spraying some embers around. There's so many extra nuances around the specific location of the house, and its proximity to other what typically are non-bushfire elements that either play roles as barriers or as additional fuel sources in those environments. I'm going to focus on all those processes, and how to harden a house and prepare its surroundings to eliminate the potential negative impacts of those other processes.

Ember Attack
Debris Accumulation
Surface Fire
Consequential fire
Radiant Heat
Flame Front contact
Wind
Tree strike



Now, if we list these processes out, this is a fairly good profile of what we're up against.

Ember attack.

Debris accumulation, which happens over the months and years building up to a bushfire.

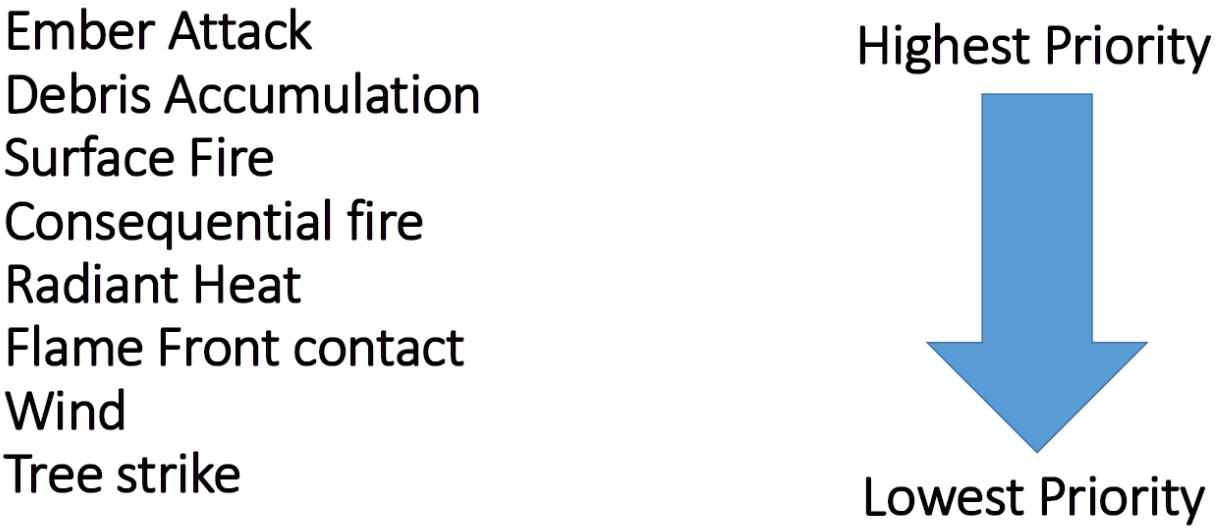
Surface fire, which is the low-level surface fuels that are burnt out when fire fronts arrive, and it helps, and ignited and reignited by embers.

Consequential fire might be a new term you haven't heard before, but it's the term we use to describe heavy fuel elements that burn near houses and present an additional heat load might be radiant heat or flame contact or it might challenge someone's ability to leave a burning house. But a consequential fire is all what we call heavy fuels, and that might be a vehicle or a fence, or a retaining wall, or even a wheelie bin. So, consequential fire is a very important aspect of preparing a home, or having a home adequately built to resist.

Radiant heat is what we all come to know and understand. Radiant heat from a fire front some distance away. The flame front and its ability to contact the house.

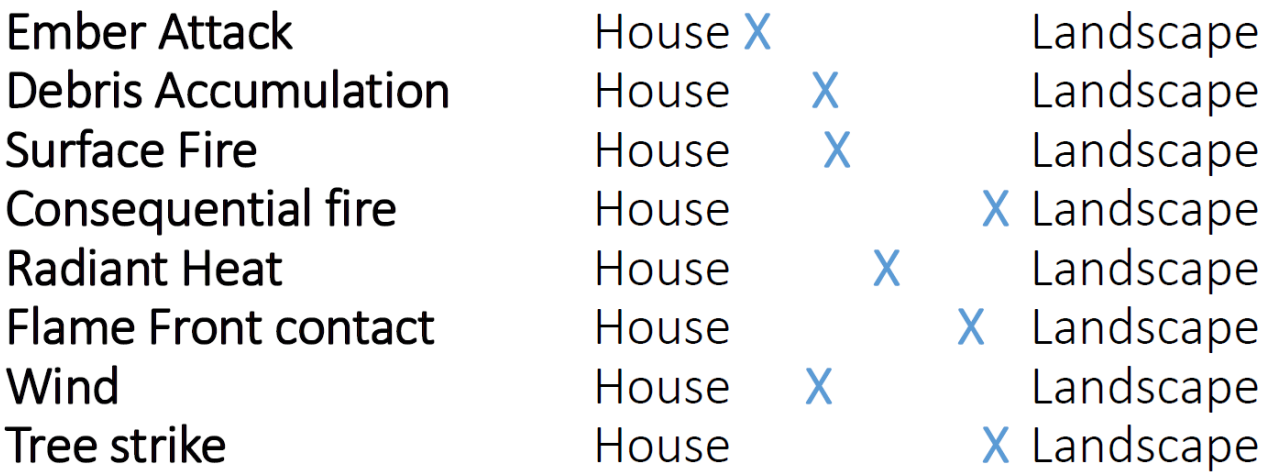
Wind action, which is a very important process that's almost ubiquitous in bushfires, where these winds can directly act on the house and weaken them.

And, of course, tree strike.



So, I've actually listed them in a deliberate order, from the ones that are most prevalent in causing structural loss through to the ones that are least prevalent. So, this gives us a bit of a guide to move through a list, from the most crucial things to begin and address first, and move further and further down the list to the lesser important ones. But, of course, for all circumstances I'd strongly encourage you to work through the entire list.

So, in terms of the process of trying to unpack, how do we solve each of these actions? It's important to recognize that they're not all created equal in terms of the best way to approach them.



And, what I've put up here is a profile of whether a particular attack mechanism is easier to resolve through house design and upgrade, or modification, or it's more easily addressed through landscaping and removal of it as an action on the house.

Justin Leonard

Now, if we move through these, it becomes fairly clear ember attack, which is quite a prolific process in the landscape, and embers are spraying everywhere in a bushfire context, it's almost impossible to imagine that we could eliminate ember attack by clearing enough vegetation and enough sources of embers. It's just simply not a practical process to go for elimination from a landscape approach. However, solving it from a house design perspective is relatively straightforward. So, that's why we have an 'X' leaning well over against the house side of the process.

Now, let's start by also considering that these attack processes are obviously very important for house survival, but they are actually absolutely critical for occupant survival. So, not only is a house potentially experiencing all of these processes, but an occupant, if they're forced to leave their house during a fire event because the house may actually ignite and start to burn down will be faced with these very same actions. So, we have to think that we're doing these mitigation processes both for the house's benefit but also to make an improvement in the potential for occupant survival.

And, this graph is one of my favorite graphs to display how, as we move through the categories of fire weather severity, how the potential for life and house loss escalates. So, one of these profiles is life loss and the other one is house loss, ranging from zero to a hundred percent of all the loss that we've studied across the history of Australian fires.

So, we can see that the context of actually planning and preparing our houses for the pointy end of this process, up around the Extreme in Code Red, is particularly important. Therefore, having those types of fire-weather severity in mind when we're planning and upgrading our house and modifying our landscape, it really needs to be able to perform and be effective under those categories- when the winds are very severe, the landscapes are very dry and the fires are very aggressive.

Justin Leonard

So, back to the mechanisms and we're going to address ember attack and debris accumulation first. So, these two processes are predominantly focused around “House”: what we can do with the house. So, we can do a little bit with debris accumulation by removing overhanging trees, but most of our work is trying to prepare a house to be adequate to withstand ember attack, and to be tolerant to some amount of debris accumulation.

So, photos like this show the obvious implications of adjacent and overhanging trees. And, even if they're plants that are well considered, if they are overhanging and can deposit their debris on the structure, the structure accumulates that debris load in obvious places like the gutter lines and in the subfloor areas. But, it also builds up in places that you can't see, which is under roof capping, and under tiles, and in roof cavities.

Now, to design against this kind of approach, you would think something like sarking might be might be a possible approach. However, all of our conventional sarking, even the ones specified in our building standards, actually perform similarly to this, where the debris that might accumulate on top of that sarking, and below your ridge line, will simply burn away and allow that debris to drop further into your roof cavity during a fire event. So, sarking isn't really a solution, and the most appropriate way to go is actually to think about removing in this case, you could remove the capping and place a thin strip of fiberglass insulation batt, and then screw down the ridge capping, which actually seals off while allowing some airflow it, seals off ember access and debris access to that ridge line.

Justin Leonard

Of course, a house is made up of many gaps, and we need to be really diligent in reviewing where all those gaps may be that embers could enter, including the ones that are quite large, and in some cases are often overlooked, like the overhead gap over a roller door. But, in terms of finding gaps and understanding where they go, it's really a detective process of looking and looking and looking at your house to understand where they are and resolve them through whatever means you can. But, it's really an attitude and an approach that you just have to come to terms with and observe very carefully, and look at deliberate vents that may not have small enough apertures. The 2mm rule is absolutely relevant to every gap around your entire house.

Justin Leonard

The second part of my presentation is focused around the house, and what the house actually experienced within that broader context. So, the house, obviously, is presented as a bunch of possibly vulnerable elements, and any detail on the house, such as a re-entrant corner we're looking at two re-entrant corners here in this inset is a place where debris and embers can lodge and build up, and cause small ignitions that may develop into structural fires and loss. So, we can actually see here where two ember scorch marks have begun to burn. Now, the owner or a neighbor has actually put them out, but even since they were put out and suppressed, further leaf debris has actually fallen into these re-entrant corners. So, any detail like a roof valley, a gutter, a sub-floor space, a re-entrant corner, are all the places where leaf debris and embers can exploit and develop into small flame attacks.
If those re-entrant corners are actually rotted or decayed, it simply makes it significantly worse with an elevated chance of ignition and transition to flame. Any gaps and voids, be it a deliberate vent in a structure, is a place where embers can enter. The magic dimension that you need to protect from ember entry is 2mm. So, if the aperture or opening in a fine mesh is 2mm or smaller, the embers that get through that mesh have little to no chance of igniting anything behind it, even if it's fine debris behind that vent. That's why the standards and a lot of advice points to using metal fly screen meshes with apertures smaller than 2mm.

Justin Leonard

If we go to ember attack, the challenges around where embers act is really ubiquitous. There's just so many details and elements on houses that play out as a way ember attack can reach houses. The way it builds up in gutters and gets into roof cavities and causes ignitions that are in many cases completely unaware to an occupant until that building cavity is well alight and starts to threaten the integrity of the house. Brick buildings, even double brick buildings, are susceptible, given the way that those wall cavities are ventilated. So screening all of the entry points down to gaps smaller than 2mm, which is quite a formidable task when you think about house and building tolerances and the way window frames are fitted to building facades. It's quite rare to actually find such attention to detail that a genuine 2mm tolerance is met.

It's also worth noting that things like timber features on houses, or timber facades on houses, shrink in, whereas their moisture content varies and shrink and expand. So, actually maintaining dimensional tolerance 2mm or less is impossible with some building designs as well. Every once in a while, I do find an incredible effort to achieve ember mitigation and tolerance, and probably the picture on that bottom right is an example of a very well-considered and structured enclosure of what was otherwise previously an open carport. So, it's actually very fine punctured steel that's been very very precisely cut in and fitted to enclose, and this tilt panel door is one of the few types of roller doors that is actually quite tight-fitting when it closes. You notice there's not a gap across the top like a traditional roller door that the gap grows as the spool unwinds in the roller door.

And this particular tilt panel door actually has those high temperature nylon brushes along the base and along the track edges and along the top edge, so that as it closes those brushes are pulled up and act as an ember screen. So, it is achievable, but it is a real question of detail and understanding about "can a 2mm object get through and into either a building cavity or into the occupiable space of your home," is really the only way to unpack it and spend a lot of time understanding where all these features are.

Chair

Blocking of a roof ridge capping caused by corrugated roofing. Can you confirm that you suggested a fiberglass batt to block the openings? This person had read, and I must admit, I believed that rockwool was recommended for those sorts of things. Because again, not all insulation is created equal.

Justin Leonard

Yes, it's certainly true that rockwool and glass wool are two quite different batt materials, and that the rockwool, by name, means that it's actually made from a rock silica material which has a much higher melting point than glass wool. But in that application, under a roof ridgeline for ember attack, both will perform adequately because there simply isn't the heat locally to actually melt out the glass batt. So, it's easy to go with the more compliant, cheaper glass batt. If you were trying to prepare a roof for flame attack and direct flame-zone impingement, then the rockwool option would be a preferred upgrade.

Chair

I was looking at the slide of the garage roller door, and I'm listening to you but I'm trying to work out now: how would I deal with that? What would I do? How am I going to protect that opening? What's the best you've seen? Are there proprietary things you can buy? How can you go about improving that situation?

Justin Leonard

So, a roller door has a couple of challenging points. The first one's the contact point where the roller door touches the ground. And the ideal thing there is to have a reasonably-good high-temperature silicon seal that runs along the bottom so it comes down and contacts the ground firmly, and with a flexible material that is going to stay in place even when debris burns up against it.

The second place the roller door is susceptible to is up both sides where the roller door runs in a track. And, unfortunately, the tolerances in those tracks are so broad that a bit of air pressure against it will allow embers to blow around that track and allow embers to get into your garage. And the third one is the one shown in that photo, which is the massive gaps that can be at the top of your roller door, when the roller door unspools and it's lowered.

And the way to address that is either to have a flashing that comes down, and a nylon fire-retardant brush seal that rubs against your roller door as it goes up and down, but you end up losing a certain amount of overhead height to allow that brush seal to come in contact with the roller door that is already remaining in the track. So, it doesn't go in and out. There is a better way than that to do it, and that is to work from inside your garage, and you actually box out the entire spool of roller door and put the nylon seal on the back face of your roller door, at the bottom of the box. So that the box actually forms a whole ember-tight helmet for your roller door.

Chair

There were a few things there that resonated with me. I think you had a slide of a rotted window, and certainly when our home burned down, I saw our rotted window frame catch fire. The flames went straight up the window frame and caught on the old roller blind that was above the window, and it went from there straight into the roof. And so, the ignition of the roof space was all over in about a minute. Maybe less than a minute. So that rang true to me.

Chair

There's silicon sealants and things like that. Are there preferences there for ones that are better than others?

Justin Leonard

Yes, silicon is a pretty good go-to gap filler. And, I guess, when you move on to other approaches to fill gaps, any joining strips between AC sheets and things like that that are typically things like PVC joining-strips you should actually think about all of those polymer systems that attempt to join boards together as being quite likely that they may melt and fall away during those events too.

Not only think about gaps that are there that you need to fill or seal, but actually gaps that can develop when a modest amount of heat is applied to your house. And, I guess, embers don't have a predominant direction they come at. So, look at the gaps from all angles, look up underneath the seals of windows, look along the bases of doors, and I guess your active openings are going to be one of your biggest issues to address. And there's actually quite a good range of weather seals that work on, obviously, around door jambs and along the bases of doors, and those active weather seals are really handy. And you can get high temperature versions of those in almost any type of seal.

Chair

If you're working with an older home, is it viable to use fire resistant silicon to address those small gaps and openings?

Justin Leonard

Yes, silicon is quite a useful go-to material. Go for the higher temperature ones or the fire-rated ones. They're better than the typical ones, although all silicon products are reasonably good. A useful thing for you to try is actually, when you get a dag of silicon hanging off your silicon gun and it's cured, you can actually light it and it actually burns. So it's not completely innocuous to burn, but what you'll actually find is when it's beaded into a crevice, the silicon doesn't burn into the crevice. It's not that flammable. And if it's beaded into a re-entrant corner as a corked bead, it doesn't tend to burn into that corner. So while it's being cooled by the surfaces it's bonded to, it can oxidize and burn a little bit on its surface but it actually acts like a like a barrier even when there's significant flame and radiant heat applied to it.

Chair

if someone's surrounded by unmanaged bush and they've got slopes down to the north and the northwest, how effective is that 50m scrub removal when you've got that much bush and it's downhill to the north and the northwest?

Justin Leonard

So the particular issue there is what is the slope under the vegetation beyond 50m or 30m - beyond the clearance point. The slope under the vegetation beyond that point is going to be the slope that supports or enhances the fire spread up to your property.
And, as a general rule, the fire will move with twice the speed and therefore twice the severity up a slope for every 10 degree increase in slope up towards your property, and conversely slower and less severe with a 10 degree downslope.
it's not so much the slope between the edge of the bush and you but what's beyond. And that's a nuance where the 10/50 and the 10/30 rule isn't sensitive to slope, and I would be very careful and cautious about other measures and being particularly focused on house design and other measures when you're facing a significant upslope fire approach.

Chair

And is the greatest threat there the radiant heat or is it from embers being directed by that slope and the ferocity towards the house?

Justin Leonard

Invariably, the greatest risk by fire is the ember attack and the surface fire that ignites the houses. That’s the predominant way houses are ignited. And I guess that doesn’t rule out, or under-emphasize, the importance of dealing with radiant heat and flame attack on particularly high-risk properties. What it does highlight is that even though you might be facing a significant upslope run through some heavy fuels, many things have to also align, like the wind direction and a formal fire-front that's lined up along that slope for it to come out and express at its worst-case potential. So, what you find is some houses in those worse scenarios are impacted by the flame contact and the radiant heat. But, it's relatively rare in the broader scheme of things. And if you haven't addressed all the ember attack and surface-fire issues first, then you're not really doing it justice before you move on to the radiant heat and flame issues.

Justin Leonard

I would say that roofs, and the weaknesses around roofs and roof access, is probably really the one to emphasize in that there is quite a high degree of loss implication around those roofs, and as a priority getting your roof sorted out is a really good approach, so good to see that one second. And, I guess, yeah, the broader issue, I guess, addressing gaps in structures is also a key approach. In a sense, the roofs are a real one I would keep coming back to in that if you happen to be in a house and trying to use it for survival, the last thing you want is it to fail via a roof failure. Because one of the main challenges is that the first thing you know about your roof actually failing is when the ceiling lining starts to fall in. And at that point, you have fractions of minutes to safely get out of that house.

Conversely, if you do have a vulnerable roof, you really need to think about ways of managing it actively during a fire, like having a really good water source near the manhole and a safe way of accessing and constantly scanning that roof cavity.