ORDINARY VERSUS DYNAMIC BUSHFIRE BEHAVIOUR

Bushfires are commonly accepted as a natural hazard but, according to the ACT Strategic Bushfire Management Plan[i], Australia has experienced a growing number of extreme bushfires since 2001.

Common bushfire behaviour

Some 95% of bushfires burn along the ground in a **long, thin front** which passes quickly at a relatively constant rate of spread. Property tends to catch fire by radiant heat from one burning item igniting another; a 100-metre setback from vegetation is generally adequate protection for property in this situation.[ii] This type of fire occurs on slopes under 20 degrees and the current Australian Standard was designed for this situation using the **McArthur Forest Fire Danger Index** (FFDI) developed in the 1960s. This index combines drought level with wind speed, temperature and humidity.

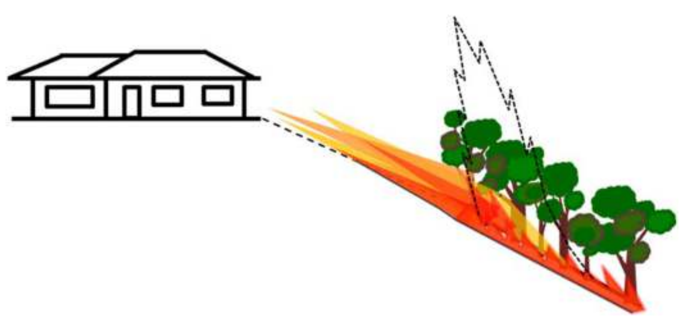
Australian Standard 3959 covers the bushfire safety requirements of building in a bushfire prone area, along with the methodology for calculating the relevant bushfire attack level (BAL). There are six bushfire attack levels based on the severity of the building's potential exposure to ember attack, radiant heat and direct flame contact. These are determined by the regional location, the vegetation type and its distance from the building, and the slope on which the vegetation is located.

Bushfire damage in this scenario can generally be reduced by creating an **asset protection zone (APZ),** free from flammable material, around a property. The minimum distance recommended is 20 metres but, in a highly forested area, a greater distance is needed, generally up to 100 metres.[iii] Nevertheless, according to the AS 3959 2009 Edition, Scope section, there can be no guarantee that a building complying with the standard will survive any particular bushfire.[iv] In 2003, 50% of the 500 houses lost in Duffy were more than 100m away from the forest edge.

Extreme bushfire behaviour

The greatest amount of damage comes from the 5% of fires whose behaviour is dramatically different from the norm, as was the one that devastated Duffy. Records from Canberra Airport show that the majority of high FFDI days come from the north and west, i.e. largely from the Brindabella Range which attracts a lot of lightning strikes. How a bushfire behaves in these higher slope conditions is not fully described by the four FFDI factors listed above.[v]

Recent research has shown that dynamic fire behaviour occurs with steep slopes of over 24-26 degrees. Areas downwind of these slopes are exposed to a much greater risk of damage than normal, associated with dynamic fire propagation and the development of catastrophic '**firestorms**'. This is because, on shallow slopes, a fire's plume will rise into the air but, when slopes are sufficiently steep, a localised loss of air pressure can occur immediately upslope, ahead of the fire, which can cause the flames and plume to attach to the land surface.

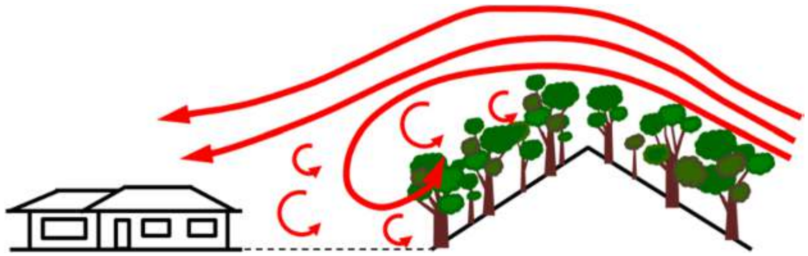


Schematic diagram of a fire burning up a positive slope towards a house. The orange and yellow flames represent the case of eruptive fire spread, in which the flames have attached to the surface. The black outlined flames represent the case of a separated plume, which is the situation depicted in AS 3959.[vi]

If a plume attaches to a surface, then fire spread will be dominated by convective heat transfer (by strong air movement) rather than radiant heat transfer. In addition, such eruptive fires produce a larger area of active flame than the standard fire front, which makes containment of a bushfire more difficult and has implications for determining the appropriate size of APZs.

Whirlwind-driven sideways spread

The 2003 Canberra fires revealed the existence of another unusual mode of fire spread in which the interaction of winds, terrain and fire causes the generation of significant fire eddies on lee-facing slopes, which carry the fire sideways instead of straight ahead. This results in extreme wildfires, with a **large area of land being alight** at any one time, in contrast to the relatively thin line of a normal fire.



Mass spotting

Under most burning conditions, spot fires, largely caused by airborne embers, can be easily put out and do not contribute much to propagation of the fire; however, under extreme conditions, spot fires are so numerous that they become the dominant propagation mechanism and the fire spreads as a cascade of spot fires forming a 'pseudo' front. Fire intensities increase greatly when spot fires join together. Dynamic interactions between different parts of the fire and the atmosphere cause the individual fire fronts to accelerate, with a consequent increase in fire line intensity. **AS 3959 is fundamentally flawed** because these increases in intensity are not currently considered.

Fire thunderstorms

Under conditions of extreme and dynamic fire behaviour, the very large amounts of heat and moisture released from a fire can cause its plume to rise high into the atmosphere – up to several kilometres. In such a situation, the fire's plume can transition into a towering cumulus cloud or a *pyrocumulonimbus*, a fire thunderstorm which can cause more damage than the fire itself. The combination of strong winds and such dynamic fire behaviour drives embers vast distances that make 20-100 metre APZs totally ineffective.

Pyrocumulonimbus cloud over the ACT, Jan 2003
Credit: NSW Rural Fire Service

Current science can identify those areas at greatest risk of catastrophic damage from such extreme fires, which should assist **decision-making on protection versus avoidance** in vulnerable areas. The next step is to determine how close to areas with potential dynamic fire characteristics it is reasonable to establish urban settlements.

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[i] http://esa.act.gov.au/wp-content/uploads/The-ACT-Strategic-Bushfire-Management-Plan.pdf

[ii] ACTPLA, Planning for Bushfire Risk Mitigation General Code: March 2008.

[iii] http://www.as3959.com.au/bushfire-attack-level/

[iv] https://infostore.saiglobal.com/en-au/Standards/preview-122340_SAIG_AS_AS_275109/

[v] Ibid.

[vi] Sharples, J.J. *Risk implications of Dynamic Fire Propagation – A case study of the Ginninderra region*, 2017. http://ginninderra.org.au/Sharples-Fire-Report Most of the section on extreme bushfires is from this work.