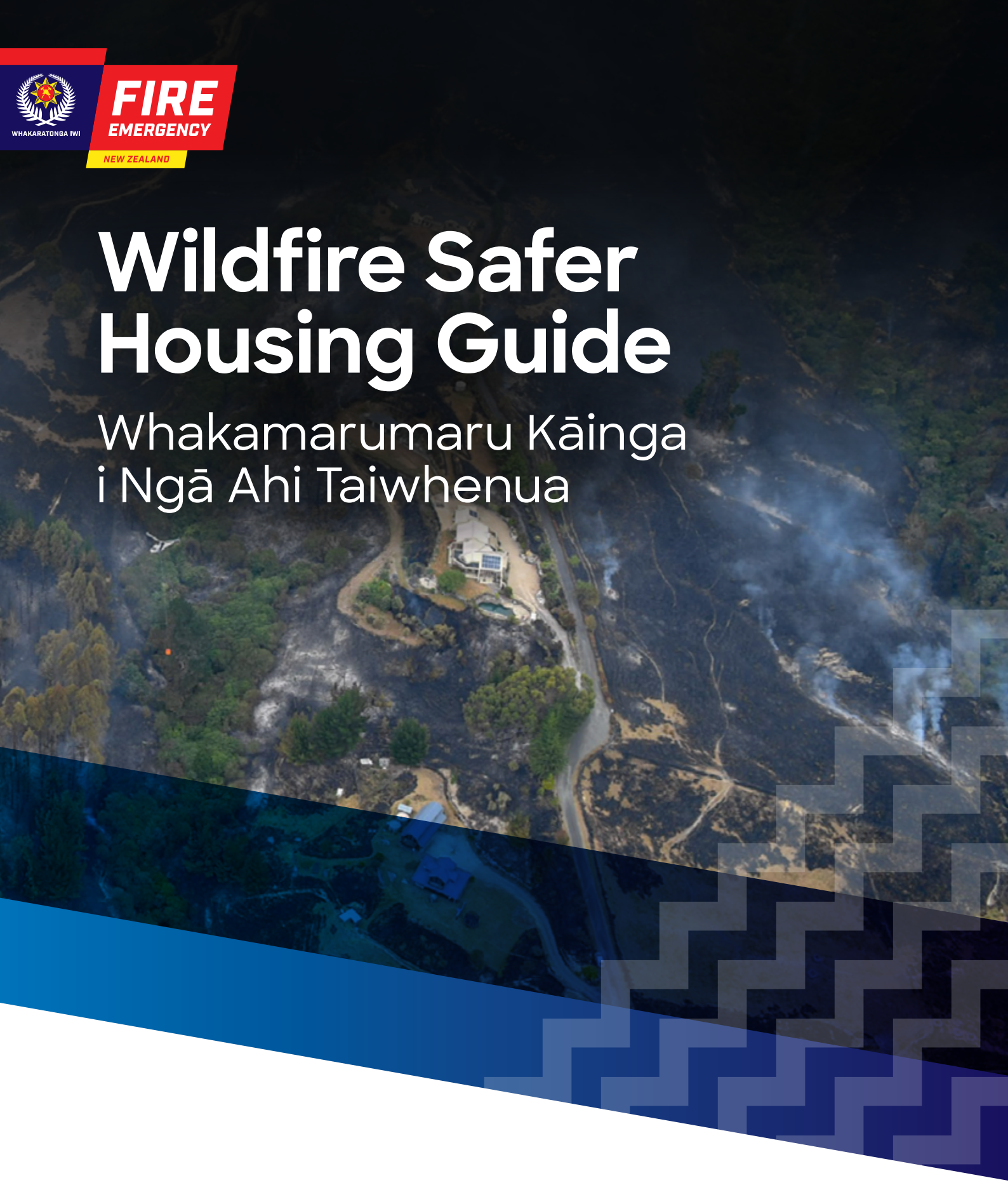

Wildfire Safer Housing Guide

Whakamarumaru Kāinga i Ngā Ahi Taiwhenua

SAFER BUILDING DESIGN

Homeowner's Guide to Wildfire Protection

August 2022

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Status of this document

This document is issued by Fire and Emergency New Zealand.

Recommendations for change

The document, its content and specific processes are not to be altered except through Fire and Emergency New Zealand document management processes.

Requests or recommendations for changes to this material should be sent to the National Manager Risk Reduction.

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Introduction
Whakatakinga

The Lake Ōhau fire of 2020 destroyed 48 homes and over 5000 hectares of land – the largest structure loss due to a single fire in recent New Zealand history[1]. Why some structures were lost while others survived was largely due to the specific fire conditions and how each house presented to the ever-changing fire front.

The risk of wildfire threat to housing is increasing. Many factors – climate change, modern building methods (the trend to open plan design means houses are less compartmentalised), lightweight and composite building materials (often with a synthetic mix) and denser populations living nearer to the natural environment – have significantly changed the risk profile. Homeowners living in areas at risk to wildfire need advice on how to better protect their houses from wildfire.

This Wildfire Safer Housing Guide recommends ways to harden standalone houses to improve their resilience to wildfire. Compliance with this guide is voluntary – the recommendations are additional to the other applicable legislative requirements.

The general recommendations and observations from the Ōhau incident were to:

- avoid or minimise using flat roofs, those with junctions, etc. Houses with simple sloping roofs and building layouts without extra corners/junctions perform better
- minimise openings in the direction of fire approach
- avoid flammable attachments such as decks, etc.
- avoid or minimise using flammable construction materials, especially on the house exterior
- avoid single glazing for windows. Double glazing and triple glazing has performed much better in wildfires, with the inner glass remaining intact despite the outer layer breaking and falling out.

1 Largest house loss in a single wildfire event since the 1918 Raetihi fire

Scope
Hōkaitanga

This guide recommends ways to improve how a house performs when it is attacked by wildfire. The success of a house's protection depends largely on how severe the wildfire is and how complete the protection measures contained in this guidance document are applied. But even small measures can still yield significant benefits; almost all fires start small and if the fire is unable to grow, then the house may be saved.

Wildfire threat is multifaceted and needs more attention the larger it grows. This guide focuses on construction features to increase a house's resilience to this growing threat. It doesn't consider the effects of a house's location on site, the house's proximity to other structures or houses or the size of the wider neighbourhood or community.

The recommendations are based on international reference documents, including codes, standards and guidelines. Each recommendation stands on its own but works better if implemented with the other recommendations. They provide guidance for homeowners on how to develop more resilient housing in areas at risk to wildfire, which may be more than what is required by the Building Code.

The recommendations in this guide do not replace existing regulations, legislation or expert advice on whether and/or how to build a house in areas at risk to wildfire. You must comply with existing building and urban planning regulations and follow the advice and guidance of local authorities/agencies.

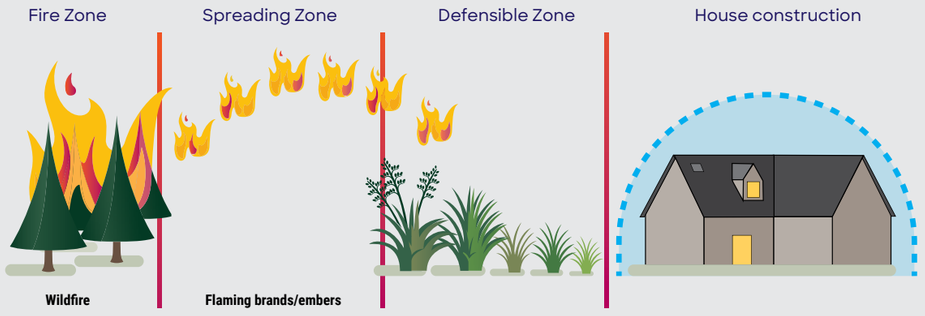


Figure 1: Defining the zones of threat in a wildfire

Exclusions

Figure 1 uses zones to illustrate the generalised understanding of an approaching wildfire and the threat it poses to igniting a house. Each of the zones have potential mitigation strategies. This guide focuses solely on the house construction zone – the building elements of the house itself.

The scope of this guide specifically excludes the following:

- housing construction requirements covered by building regulations
- a measure of a wildfire's potential severity, eg. bushfire attack level (BAL) in Australian documents
- district planning and subdivision
- multi-unit residential development, e.g. apartment blocks
- design advice for community infrastructure and buildings other than residential that may have additional requirements or needs, e.g. commercial buildings, public assembly buildings, buildings for tourism uses, buildings for community refuge/shelter, etc.
- provision of firefighting water, firefighting access and consideration of firefighting operations
- emergency management planning and evacuation plans
- advice on fencing and screen walls
- advice on site selection and planning, e.g. slope
- advice on landscaping, including vegetation types
- maintenance and housekeeping rules (except where provides context)
- outbuildings (except to state that these should ideally be separated from the house by either fire rated construction or a distance of not less than 6 m).

It's worth to note that this guide only focuses on the fire safety aspect of the design. The homeowner will need to ensure they comply with all building regulations when doing any building work. Some of the guidance within this document with other building priorities, such as weather tightness and amenities.

Background
Tāhuhu Kōrero

Areas at risk to wildfire in New Zealand

Identifying areas at risk to wildfire in New Zealand was outside the scope of this project. However, we would encourage any homeowner who is wanting to improve the resilience of their home from wildfire to follow the advice and guidance contained in this document.

Note: The level of risk a house may be exposed to from a wildfire will vary for a range of factors. Those living in areas which are regularly hot and dry should also consider the wildfire risk and recommendations in this guide. Noting many of the recommendations are relatively simple and low cost to do during the building process or retrospectively.

How wildfires ignite a house

Understanding how wildfires can ignite a house will help you to take steps to reduce this risk. Direct flames can ignite anything flammable in their path so having breaks in the path will reduce this threat. Embers can travel more than 2 km from a fire (and sometimes considerably further when there are strong upper winds). The greatest risk is that these embers reach the house and find ready fuels to ignite a fire.

Direct attacks
- Ember attack
- Radiant heat attack
- Flame front contact
- Smouldering fire attack

Indirect attacks
- Tree strike

Research shows there are eight ways that wildfires can damage or destroy houses.

The different attacks rarely occur by themselves; they tend to work together and all contribute to potentially igniting a house in the wildfire's path. Most house fires start with small ignitions. Under ideal fire conditions, these ignitions will accelerate and progressively involve the rest of the house.

For example, if a small ignition against or on a timber deck or a veranda is left unattended, it can grow large enough to break into the house by spreading to a combustible facade or eaves or via a window. Once inside the house, a fire can rapidly spread. Embers landing on external combustible elements or entering the house through gaps can also ignite the house. If you can prevent small ignitions, you can reduce the risk of larger, more destructive fires.

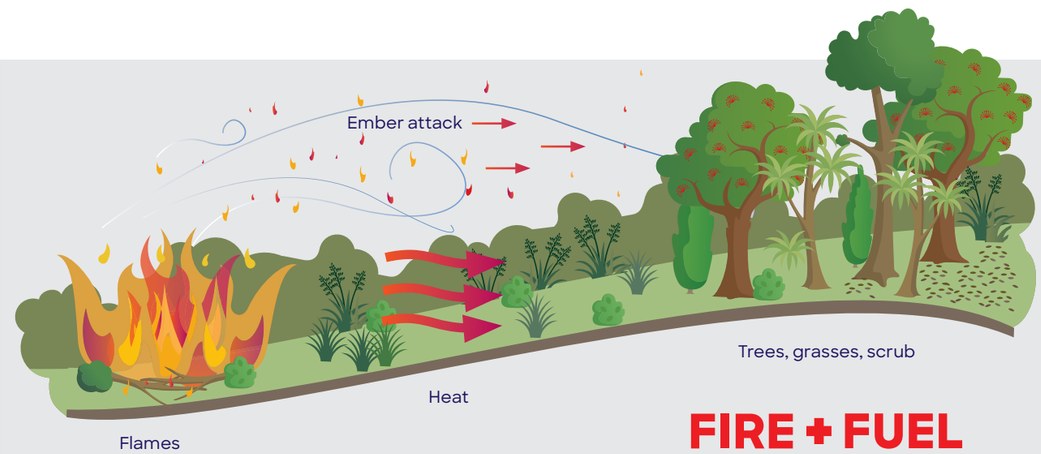


Figure 2: How wildfire spreads

Property vulnerabilities and hazards

This diagram illustrates several ways a building can ignite during a wildfire, such as by ember attack, radiant heat, direct flame[2].

Garden beds

Garden beds can present a wildfire hazard if they contain an abundance of overgrown plants (particularly dry or woody vegetation), are covered with a combustible mulch, lined with combustible timber edging, or contained within a raised timber or plastic garden bed. Each of these elements can ignite and spread flames, radiant heat and embers.

Overhanging tree debris

Overhanging trees and branches can contribute to the build-up of combustible debris. This debris can accumulate in re-entrant corners, on roof tops and access ways, and around doors, vents and windows.

Trees

Trees provide fuel for wildfires, and when burning they produce flames, radiant heat and embers. However, many tree species can be used strategically as screening plants to protect people and buildings from wind and radiant heat exposure, and to filter out embers and other flying debris.

Fences and retaining walls

Fences (and garden walls) can be used as a barrier to block embers, flame and radiant heat, and to help control the spread of debris. They are also effective at ensuring the safe evacuation of occupants during a wildfire by shielding access ways, but if ignited they can produce flames and radiant heat that can impact the surrounding elements. They are also likely to trap debris which can ignite and spread fire.

Combustible ground cover

Ground cover such as dry leaves, bark, twig and combustible garden mulches can spread surface fire to the house.

Outbuildings

Burning outbuildings (e.g. sheds, garages, cubby houses) are a source of radiant heat and flame that can impact surrounding elements.

Movable objects

Movable objects stored under or near the house (e.g. cars, boats, wood heaps, wheelie bins) are vulnerable to ignition and can form a consequential fire that may ignite, damage or destroy vulnerable elements of the house.

Adjacent buildings

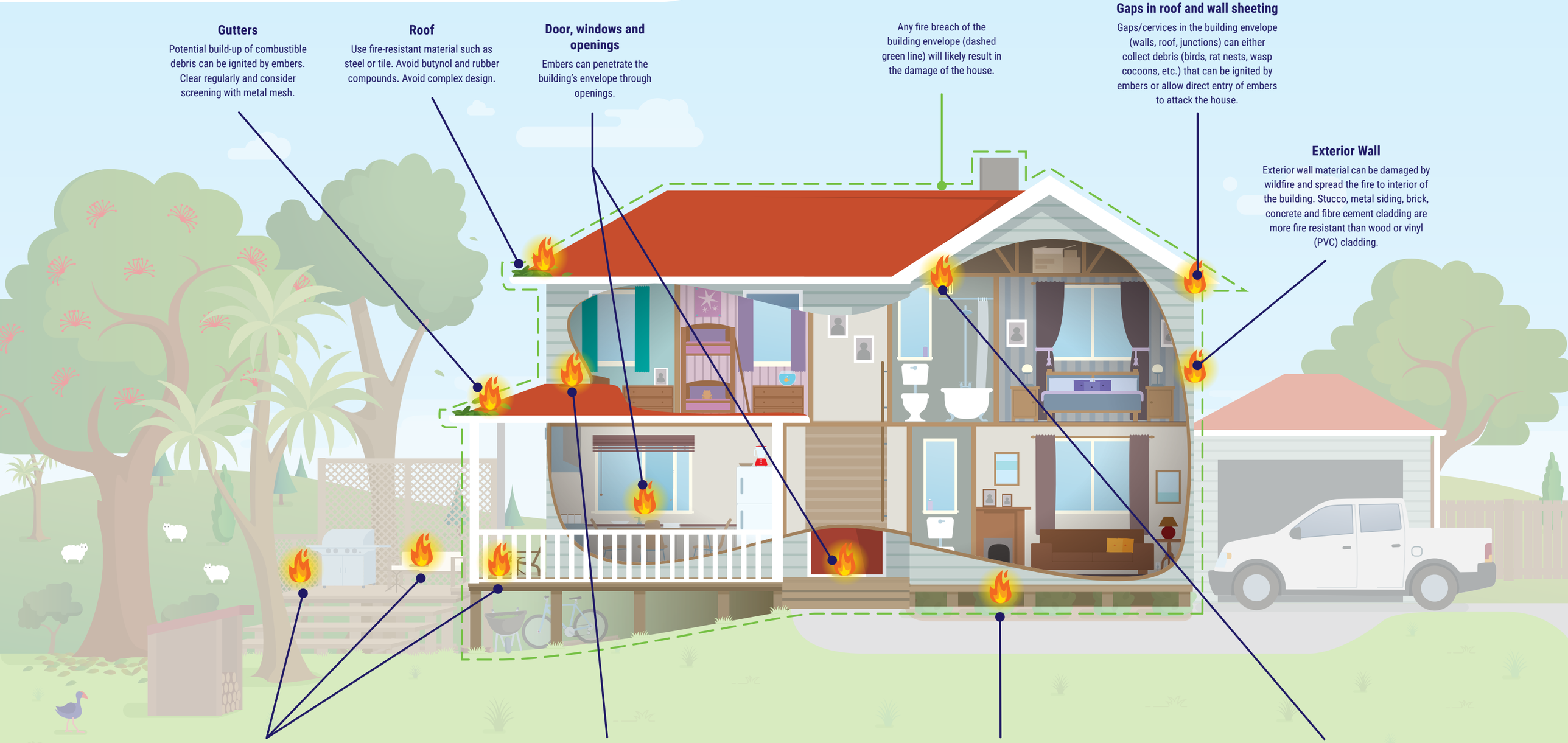
Adjacent house fires can burn for a long time and produce a significant amount of radiant heat and flame. These hazards can ignite, damage or destroy vulnerable elements of the neighbouring buildings.

This guide focuses on improvement to design elements

2 Text adapted from Bushfire Resilient Building Guidance for Queensland Homes

Vulnerability of the house

This diagram illustrates the vulnerabilities creating a breach in the building envelope (dashed green) that can let fire into the house.



Gutters

Potential build-up of combustible debris can be ignited by embers. Clear regularly and consider screening with metal mesh.

Roof

Use fire-resistant material such as steel or tile. Avoid butynol and rubber compounds. Avoid complex design.

Door, windows and openings

Embers can penetrate the building's envelope through openings.

Any fire breach of the building envelope (dashed green line) will likely result in the damage of the house.

Gaps in roof and wall sheeting

Gaps/cervices in the building envelope (walls, roof, junctions) can either collect debris (birds, rat nests, wasp cocoons, etc.) that can be ignited by embers or allow direct entry of embers to attack the house.

Exterior Wall

Exterior wall material can be damaged by wildfire and spread the fire to interior of the building. Stucco, metal siding, brick, concrete and fibre cement cladding are more fire resistant than wood or vinyl (PVC) cladding.

Objects attached/adjacent to the house

Objects attached/adjacent to the house (e.g. pergolas, lean-tos, stairs, decks, trellis, bbq areas, gas cylinders and firewood stacks) are a ready fuel source for consequential fires. These consequential fires produce radiant heat and flame that can damage vulnerable elements of the house envelope, such as window frames and screens, combustible cladding, air-conditioning units, door frames, posts and poles. Radiant heat, flame and embers can then breach the building's envelope through gaps in damaged surfaces.

Re-entrant corners

Re-entrant corners increase the risk of debris build-up and/or embers potentially lodging against the building surface for longer and where possible should be avoided.

Deck/subfloors

Enclose the base of the house, decks etc with fire resistant material or fire mesh to reduce the risk of embers getting in.

Vents

Any gaps are vulnerable to ember attack and the build-up of debris which can ignite and spread fire to internal wall cavities.

Recommendations: House construction elements
Ngā Tūtohunga

The recommended products in this guide are available internationally. As the current NZ regulations do not address wildfire well, some products may not be available locally. Check with your local Building Consent Authorities and/or Territorial Authorities for compliance when using any imported products.

Roof material, eaves, gutters and roof openings

The roof is the most vulnerable component of a house because of its size and orientation. Sparks and burning embers from a wildfire can travel long distances and quickly ignite combustible roofing material, eaves, fascia, roof framing, roof battens and debris matter that has accumulated in gutters, along ridge lines, in roof valleys, against roof penetrations and inside the roof cavity. This debris is vulnerable to ignition and the subsequent fire can ignite surrounding elements if they are combustible. Ember and potential flame entering the roof cavity is often difficult to spot and is almost certain to result in total building destruction if the roof contains combustible framing or other combustible elements.

Roof design

- Use non-combustible construction material where possible, including roof covering, roof frame, fascia, eaves, gutters and gutter guards. Ideal material includes clay tile, concrete tile, metal and fire-retardant-treated[3] asphalt shingles for roofing and galvanised steel, copper and aluminium for gutters (see figure 3).
- Metal shingles and panels are non-combustible, but they readily transfer heat. If they are installed over wood battens, specify and install fire-retardant-treated battens and roof sheathing. Avoid butynol or rubber compounds, untreated wood or asphalt shingles or other flammable materials.
- Some roofing materials have a gap between the roof covering and the roof sheathing. These gaps typically occur at the ridge and edge of the roof. A mortar mix or birdstop would be the best option to plug openings at the ridge and hips of the roof. The goal is to keep fuel sources, such as nesting materials and windblown debris, from getting under the roof covering (see figure 4).
- A simple roof design will reduce the number of locations on the roof where combustible debris and embers can accumulate[4].
- Avoid complex roof designs with lots of valleys, roof/wall intersections and ridges where combustible debris can accumulate. These designs will need complex roof protection details to stop embers from entering (see figure 5).

Metal roof

Tile shingles

Figure 3: Example of non-combustible roofing material

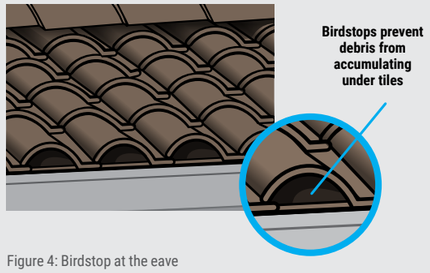


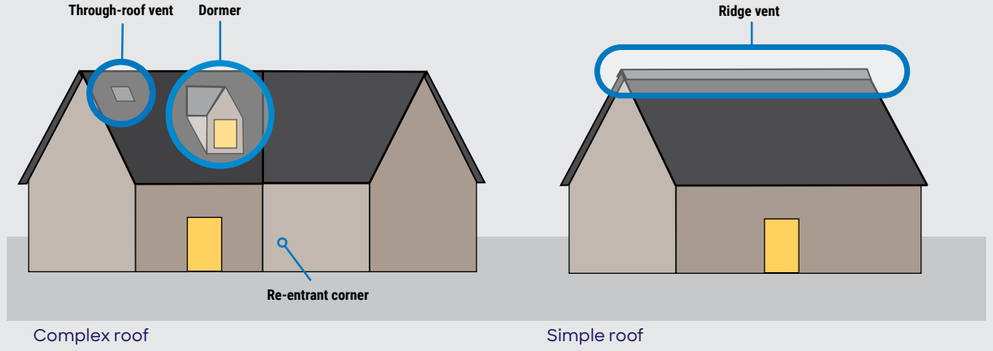
Figure 4: Birdstop at the eave

If you are doing further research, please note:

3 In the United States, roofs are classified as class A, B or C depending on their resistance to external fire exposure. To achieve a class A rating , shingle-type roofs can be treated with a fire retardant, but must be maintained regularly to remain effective.

4 FireSmart™ Canada (n.d.)

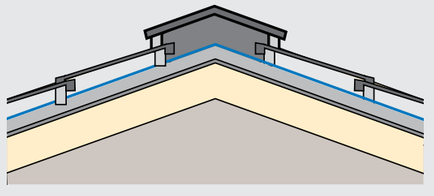
- Specify flat and plain tiles to be tightly butted to form a closed valley, and install pieces of metal flashing under each tile course along the valley centreline (see figure 6).
- House materials usually change at edge-of-roof locations. The adjacent materials should provide comparable protection to the roofing material. Install a non-combustible and corrosion-resistant metal drip edge to provide protection for the combustible components at the edge of the roof, i.e. sheathing and fascia.
- At a roof-to-siding location, using metal step flashing that extends up the cladding/siding at least 150 mm could also reduce the vulnerability of a combustible external wall material. Install flashing so that water cannot get between the flashing and external wall.
- You should also treat junctions such as roof/wall and roof/roof. Seal these connections with fascia and eaves linings or by sealing between the top of the wall and the underside of the roof and between the rafters at the line of the wall.
- It is possible to build fire-resistant roofing systems, but these systems are not available locally and would need to be researched if interested (see AS3959).



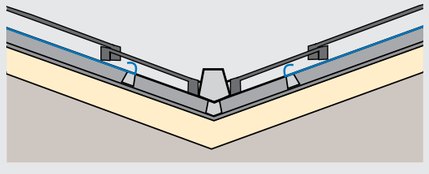
Complex roof

Simple roof

Figure 5: Complex versus Simple roof design



Ridge



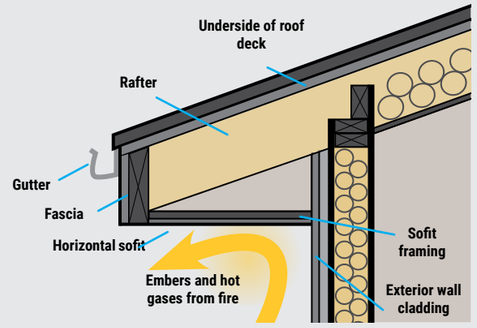
Valley

Figure 6: Roof ridge and roof valley

Open eaves

Soffited eaves

Figure 7: Open-eave versus closed-eave (soffited-eave)



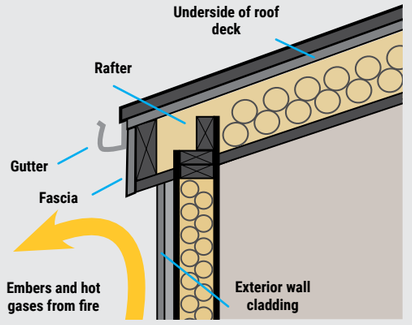


Figure 8: An eave with essentially no overhang versus an enclosed overhang with horizontal soffit

Eave design

- There are two basic designs for under-eave construction: open-eave and soffited-eave (i.e. one that is boxed in or 'closed'). Select a soffited-eave (boxed in or 'closed'). design for the house. Exposed or open eaves create an entry point for sparks and embers. The vents that are in the blocking between rafters in open-eave construction are more vulnerable to embers than vents in a soffited-eave (see figure 7).
- Avoid sloping soffits because they create pockets that can trap hot gasses. Eaves with short overhangs and flat soffits are the recommended option (see figure 8).

Gutter design

- Use gutters and downspouts made of non-combustible materials such as galvanised steel, copper and aluminium. Use metal hood leaf guards to reduce the amount of debris accumulating in the gutter. Some leaf guards result in debris accumulating on the roof behind the gutter, so these types of guards will still require routine maintenance.
- Be aware that the roofing membrane/paper often protrudes past the edge of the roof line into the gutter and can be flammable. You can protect any protruding material by using mesh guards that also prevent leaf litter build-up.

Roof vents

- All vents and vent flashing should be made of non-combustible and corrosive-resistant material, ideally metal products.
- Vents should be a minimum of 3 m from property lines and other buildings.
- With roof ventilation openings like gable and roof vents, fit them out with ember guards made of non-combustible material or a mesh or perforated sheet that is made of corrosion-resistant steel or bronze, or is fire rated. Mesh screens should have a maximum opening of 6 mm at all vent openings and vent openings should have a maximum net free area of 0.1 m^2 (see figure 9, over the page).
- Avoid using dormer-type through-roof vents, gable-end vents and whirlybirds (turbine vents) as these types are vulnerable to ember entry.
- If you do use gable-end vents, you should fit them with specially designed metal shutters. Use a hinged shutter that can be latched in an open or closed position. Shutters should have a gasket that provides a tight seal between the shutter and gable-end vent. For a more conservative shutter, use a shutter with an insulated core encapsulated by metal (similar to a refrigerator door).
- Avoid using through-roof vents for attic ventilation because there is no known effective strategy for preventing embers and hot gases from entering, other than blocking the vent.
- Ridge vents that are rated to resist the entry of wind-driven rain will also resist the entry of embers – ones with an external metal baffle and 3 mm wire mesh are effective against ember entry.
- Soffit vents interact with roof vents as part of required roof ventilation and will actually pull embers in during a wildfire. You should fit roof vents with screens or shutters, or they should be fire rated.
- Seal roof penetrations (including aerials, vent pipes and supports for solar collectors or the like) at the roof with non-combustible material such as mineral fibre/mineral wool insulation to prevent gaps.

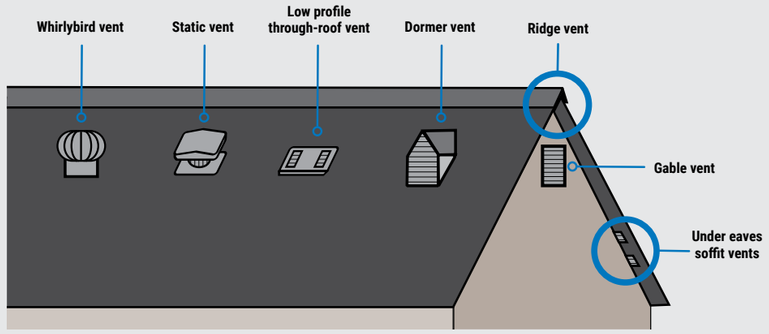


Figure 9: Common types of roof venting

Skylights

- There are two basic kinds of skylights: domed-style made of plastic and flat-style made of glass. Flat-style, glass skylights have less risk than domed-style, plastic skylights that may melt and burn when exposed to heat from a wildfire. This risk is greater on sloped roofs, because of the increased likelihood that the skylights will be exposed to radiant heat.
- If the skylight can open, close it when wildfire is threatening to prevent embers from entering the house. Consider adding a 1.5 mm non-combustible, corrosion-resistant metal mesh screening to reduce the likelihood of embers entering the house, in case you can't close the skylight before you evacuate.

Chimney

- Cover chimney and stovepipe outlets with a non-combustible screen. Use metal screen material with openings no larger than 12 mm to minimise embers leaving the chimney. Install an approved spark arrester that has a 12 mm mesh size on chimneys. Close the fireplace flue during fire season when you are not using the chimney.

Maintenance

- The roof is a large surface where combustible debris can accumulate. A wildfire can be some distance away but still produce embers which can land on the roof and ignite debris, potentially putting the building at risk. You should regularly clean combustible debris off the roof, especially the areas around roof features such as skylights and solar panels that could be an entry or accumulation point for windblown embers. Remove tree branches that overhang the roof and remove any dead vegetation, including branches, within the defensible space (see figure 1).
- Regularly inspect roof locations that are potential 'weak links' – areas with an exposed wall junction, open entry points under the roof covering, exposed combustible surfaces above gutters, or missing drip edges[5] (see figure 10).

Figure 10: Example of debris accumulation in gutter

5 FireSmart™ Canada (n.d.)

Exterior wall

After the roof, an exterior wall that is combustible or has glazing components is the structural component next most vulnerable to wildfire. Embers can ignite a combustible wall (sidings or cladding[6]) either by attaching directly to certain materials like rough-sawn timber, or by accumulating against the wall, causing localised flame contact. Wind can help this process by depositing more debris onto the same locations where embers are likely to land. Radiation can promote ignition by drying out and heating the exterior wall, increasing the likelihood and severity of the flames spreading from ember ignition. Direct flame contact from surrounding burning objects can damage the exterior wall. Flame contact is especially prevalent in re-entrant corners (internal corners that form an angle of 180° or less). Localised flames can burn the exterior wall or enter through small gaps and then burn the internal face of the wall and adjacent framing.

Design

- Use non-combustible material for the exterior wall covering. Stucco, brick, fibre cement boards panels, concrete block, poured concrete or rock all offer a good level of fire resistance. Metal is non-combustible but readily transmits heat, so install exterior walls with a fire-resistant sheathing (see figure 11).
- You should avoid using construction materials that can melt when exposed to high temperatures, such as vinyl. This material will let the fire reach the combustible underlying wall components and penetrate the interior of the building. Also avoid using an exterior insulation finish system.
- Take caution when using fire-retardant coatings to provide fire protection for combustible wall material, such as fire-retardant paint or intumescent coating. Recent research shows that their performance may be degraded by exposure to weathering, e.g. snow, moisture, sun.

6 A cladding is typically applied 'indirectly' to a building exterior, i.e. it is separated from the exterior sheathing by furring strips, creating a ventilated drainage plane and water-resistant barrier. A siding is applied 'directly' to the exterior wall sheathing or insulation foam boarding.

Stucco/cement board

Metal siding

Brick wall

Concrete wall

Rock wall

Figure 11: Example of non-combustible exterior wall material

Figure 12: Example of how vulnerable timber cladding is to ember attack, radiant heat or direct flame. Fire has broken through and set bathroom inside alight. Ōhau 2021 (Fire 3088958)

- Consider a robust approach that uses both non-combustible wall and framing materials. Where the framing is combustible, you should use multiple layers of non-combustible wall material and take great care around wall perforations and edge details to prevent flame contact.
- Ensure a ground clearance of no less than 15 cm before any combustible wall cladding starts to minimize the risk of embers attacking or ground level debris or vegetation fire penetrating the wall cladding from the ground.
- Eliminate or reduce the use of wall junctions with other building elements that create re-entrant corners where embers can accumulate, e.g. a carport roof.
- Where drainage cavities exist in the exterior wall, be aware of plants that may grow against the wall that could burn up into this space (through the vermin strip barrier).
- All joints in the external surface material of walls should be covered, sealed, overlapped, backed or butt-jointed.
- Fill gaps in wall and trim materials with a good quality caulk and replace building materials in poor condition.

Maintenance

- Ensure the exterior wall is free of gaps, holes or other areas where embers could accumulate, lodge or penetrate. If you identify any vulnerable areas on the exterior wall, repair them as soon as possible. These areas are places such as window and door ledges, flashings, edges of wall/window junctions (see figure 12).

Windows, vents, doors and openings

Although combustible window components, such as frames and seals, can ignite when exposed to ember attack, flame contact or radiant heat attack, studies have shown that the glass is the most vulnerable part of the window. Glazing can crack or shatter when exposed to radiant heat or flame, depending on how long and intense the exposure is. Damaged glazing can provide a point of entry for ember attack, which can ignite internal furnishings. Smaller windows are more likely to hold glass in place even if the window breaks, whereas the glass in large windows is more likely to fall away and create openings due to its weight.

Combustible parts of the door can ignite when exposed to ember attack, direct flame contact or radiant heat attack. These attacks may come from the wildfire itself, or consequential fires, e.g. door mats. Similar to windows, the glazing in a door system can break when exposed to radiant heat or flame, depending on how long and intense the exposure is, the type of glass and type of seal.

Window design

- Limit the size and number of windows in the house that face densely vegetated areas or the likely path of a wildfire. When building, consider which direction the wind predominately blows from.
- Use non-combustible materials or metal-clad wood to construct window frames, sills and reveal. Don't use wooden and plastic frames. Vinyl windows may deform if exposed to radiant heat. The horizontal member in a single- or double-hung window, and the vertical member in a horizontal slider window, can be particularly vulnerable to radiant heat. Make vinyl windows less vulnerable by using metal reinforcement in these members.
- Seal any gaps around windows and doors to prevent embers getting inside.
- Install screening or wildfire shutters on windows or fire-rated windows to improve performance against radiant heat exposures and to minimise the size and number of embers that could enter the building.

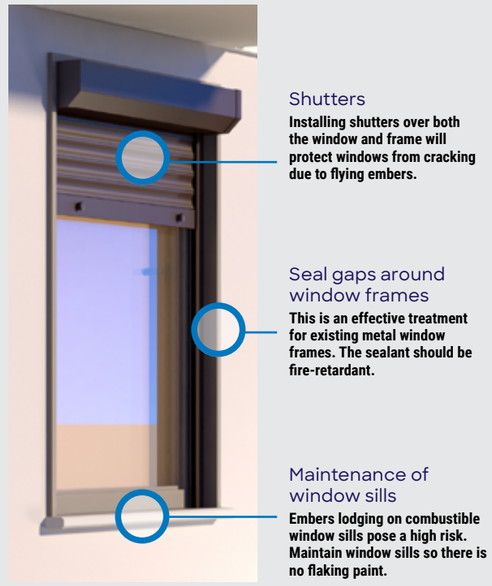


Figure 13: Recommended window protection

- Solid metal shutters are unlikely to ignite or melt, so choose these over wooden or plastic shutters. For enhanced protection, get an insulated metal shutter designed, made and installed.
- Screens fitted to window openings should have a maximum aperture of 2.0 mm and be tightly fitted to the frames. Steel or bronze insect screens can also help to block embers and reflect some radiant heat.
- Exterior window shutters can provide protection for windows and sliding glass doors in a wildfire (see figure 13).
- Consider how shutters may be operated, as there may not be anyone available to close them when a wildfire is imminent.

Glazing

- Recommended glazing products are tempered glass, glass with a low emissivity, fiberglass-reinforced translucent glazing and insulated glazing units (IGUs). Avoid using annealed glass (also known as common float glass), laminated glass, ceramic glass and plastic glazing, unless protected by shutters.
- Tempered glass is a better choice for windows because it is three to four times more resistant to heat exposures than typical annealed glass, and when it breaks, it creates small chunks rather than sharp shards.
- Double and triple glazing has performed much better than single glazing in wildfires, with the inner glass remaining intact despite the outer laying breaking and falling out. It is better to choose multi-pane options containing tempered glass for windows for both wildfire resilience and energy efficiency (see figure 13).

Door design

- All exposed door components should be made of non-combustible materials. Solid-core timber doors offer a degree of fire resistance but are not the ideal material.
- Use fixtures and materials that are durable, heat resistant and rated to withstand extreme wind conditions.
- All doors should be tight fitting, with gaps smaller than 2 mm. If this fitting is not possible, install adjustable weather draft strips and non-combustible or fire-resistant seals/trim around doors on the interior side of the door frame, to ensure there are no gaps greater than 2 mm for ember entry. Also, specify and install an automatic door bottom or threshold weather stripping.
- For exterior trim that covers the opening between the door frame and exterior wall, specify and install non-combustible or fire-resistant material such as fire-retardant-treated wood or fibre cement board.

Seal gaps around door frames

If the door is non-combustible, sealing the gaps around the door will prevent embers from entering the home.

Non-combustible door sill

Replacing combustible door sills with a non-combustible product will reduce the chance of an ember igniting.

Figure 14: Recommended door protection

- Install a non-combustible screened security door that is self-closing, made of corrosion-resistant bronze or steel mesh and has apertures no larger than 2 mm. Protect gaps between doors including jambs, heads or sills (thresholds using draught seals and excluders or the like).
- Doors should be self-closing and easily opened from the inside without needing to use a key or deadlock (see figure 14).

Vents and other openings

- Place all vent openings at least 3 m from other buildings or property lines to avoid them being ignited by embers and hot gases from an adjacent building that is on fire.
- Vents should not be in areas where flame contact is expected, as mesh screens may not prevent flames or flammable gas entering through the vent. For example, place vents at least 500 mm from ground level to prevent surface fire interacting with them.
- All vent components, including vents and vent flashing, should be made of non-combustible, durable, heat and corrosion-resistant materials.
- Vents and weepholes in external walls should be tightly fitted and secured with a screen with maximum aperture of 2 mm, except for weepholes to the sills of windows and doors. The vents and weepholes should be made of stainless steel or galvanised steel frames and mesh, with bronze mesh as a reasonable alternative to steel or aluminium. Galvanised steel requires more frequent replacement and is the best option. Avoid securing the vent and screening materials with plastic, coated glass fibre or rubber beadings or clips.
- Seal any perforation of internal lining (e.g. internal light, pipes and extraction) with non-combustible material to avoid any gaps greater than 2 mm. It is important to seal small gaps with appropriate joining strips. Use silicone for sealing in areas with no direct flame attack, and fire-rated sealants and steel flashings for areas where flames can contact the gap that was sealed (such as the flame front, consequential fire and surface fire). Don't use polymer joining strips unless they are fire rated, i.e. don't use PVC.
- Consider specifying and installing specially designed metal shutters instead of wall louvres. If you do use wall louvres, specify and install ones that have adjustable tight-fitting blades that can be closed when a wildfire threatens.
- For more protection for either shutters or adjustable blades, specify and install fire dampers within the ducts immediately behind the wall louvres. If sufficiently high heat gets beyond the louvre, the fire damper will automatically close and stop it from going farther[7].

Vent mesh screen size

- Small (1.5 mm) mesh screens can reduce both the size and number of embers that can pass through. Because the embers are smaller, they self-extinguish quickly. While this mesh screen size is ideal for stopping embers getting in, it does require more maintenance because it clogs easily. Accumulated debris on vents can become a source of embers if you don't clean them regularly. The small mesh screen size also reduces air flow.
- Mid-size (3 mm) mesh screens allow more, larger embers to enter, but are still better than 6 mm mesh screens. Mid-size mesh screens are a common choice because they need less maintenance while still being relatively effective.
- Large (6 mm) mesh screens allow many, larger embers to enter.
- Laboratory research has shown that embers that are small enough to pass through 6 mm and even 3 mm mesh screens are large enough to ignite fine fuels, so while screening will help, it isn't the perfect solution. And while a finer mesh screen will offer better protection against the entry of embers, it will also require more maintenance to keep it free of debris.

Maintenance

- Avoid putting combustible objects close to the window.
- Inspect your vents and openings regularly to ensure the vents are in good condition and to remove any accumulated combustible debris.
- Turn off the HVAC system, including exhaust fans, when a wildfire threatens.

7 FEMA (2008)

Verandas, decks, steps, landings, subfloor space and floor

The materials, size and relative location of decking and stair configurations can vary significantly. Factors that affect both the likelihood of a deck or other attached structure igniting and how severely it will burn include:

- decking surface
- bearer and pile materials
- height of the decking above ground level
- where debris accumulates
- separation distance between decking elements and the house.

If these factors are left unattended, small ignitions on timber decks, porches, patios or verandas can grow large enough that they ignite or break building elements such as combustible facades, windows, doors, eaves and subfloors.

Embers and surface fire can ignite unprotected underfloor spaces, underfloor enclosures and combustible supporting posts. It is common for debris to build up in these areas and become a considerable fine fuel source. Also, people often store heavy fuels in their underfloor space, such as firewood, building materials, sporting equipment and gardening equipment. You should avoid storing items in unenclosed floor spaces because these elements are vulnerable to ignition and the subsequent fire can threaten the floor and its support systems.

Non-combustible materials such as masonry, brick, veneer, mud brick or concrete are the best material to use for floors.

Deck design

- Avoid building decks and other attached structures that face heavily vegetated areas or are in the likely path of a wildfire. If you are building a raised deck that faces a down-slope, make sure there is nothing flammable below and consider constructing a non-combustible wall set back to shield the deck from radiant heat and embers.
- Build balconies and decks, supporting posts and bearers with non-combustible materials where possible. Avoid using wood, plastic or fibre-plastic composites. If you do use wood, use thick high-density timber treated with fire retardant and make sure you reapply fire retardant regularly according to the manufacturer's specifications. As mentioned in earlier sections, take care when using fire-retardant treatment. Be aware that wood preservative treatments can make wood burn more easily.
- Isolate the attached structure by surrounding it with non-combustible material such as gravel, brick and concrete pavers, or patio stones. Extend the non-combustible surface for 1.5 m out from the perimeter of deck and put it under the deck as well.
- Enclose the base of the house and any decks with fire-resistant skirting or fire mesh to reduce the risk of embers getting beneath the house and igniting it. Cover required vents with 3 mm metal mesh. Do not use wooden lattice to enclose decks.
- Make sure there is a way to access the spaces under the deck so you can clear fine combustible debris that may fall between decking boards and accumulate (see figure 15).

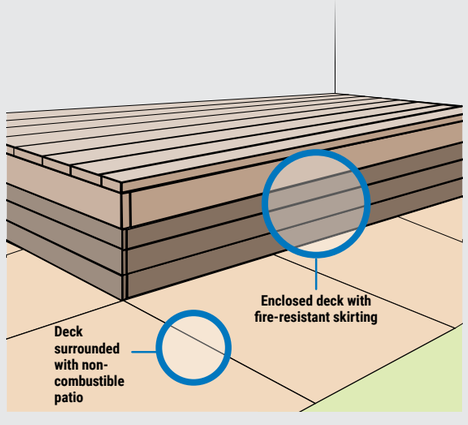


Figure 15: Enclosed deck isolated by patio

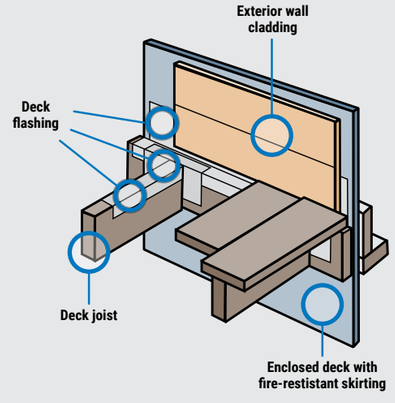


Figure 16: Deck flashing

- Use steel joists and posts to reduce the vulnerability of the deck from both flames and embers.
- If the exterior wall is combustible, ensure there is a corrosion-resistant metal flashing strip or non-combustible material at the deck/house wall junction. The flashing should be at least 20 cm and should be tucked in behind the exterior wall above. It should also be on top of the support joists, as well as a few millimetres down the side (see figure 16).
- For deck railings, use metal or tempered glass and select non-combustible patio furniture and decorations.
- Where possible, use fire-resistant barriers to separate any direct attachments to the house that are combustible, e.g. carport pergolas, patio areas. If subfloors are not enclosed, you should remove all flammable materials from the underside, and seal any gaps using mesh or perforated sheet made of corrosion-resistant bronze or steel (see figure 17).
- Where possible, consider non-combustible decking materials.

Figure 17: Example of how vulnerable wooden decks are to being ignited via direct flame, ember attack or radiant heat exposure

Maintenance

- Removing combustible debris, vegetation, wood piles and other easily ignited materials on, around, in between gaps, and under decks and other attached structures is a key factor in reducing their vulnerability to ignition during a wildfire. Even if the deck is enclosed, it is essential to access and regularly clean underneath it. If there are any combustible wooden deck boards, check their condition and replace or repair boards that are showing signs of rot or have large cracks.
- When you are not using it, move combustible patio furniture (especially those with woven components that can trap embers), cushions, decorative pieces and brooms inside or as far away from the house as possible.

Utilities

Equipment for utilities that is attached to the house often has combustible components. These components increase the risk that the equipment and the house wall it is attached to will ignite. Most utilities have ducting and conduits that need to penetrate the house's envelope (the exterior elements). Install utility connections underground, if possible, and seal gaps and penetrations in exterior walls and roofs with fire-resistant products. Store fuel underground or surround it with a non-combustible barrier.

Water

Please refer to the current New Zealand Firefighting Water Supplies standard for specific information (see bibliography for reference).

Maintain a water supply to the house for both automatic active defense and manual active defense. Make sure there is a static water supply that is big enough for the combination of all possible uses in a wildfire and that it is full to this level through a wildfire season. The tank and pipework should be able to work properly throughout the wildfire event. Pumping systems should be able to continuously provide adequate water pressure for all uses, even if both mains water pressure and power supply are lost. Systems that can automatically switch over are better.

- Above-ground, exposed water supply pipes and their fittings should be metal. Water tanks and their stands should be made of non-combustible material, such as metal or concrete, or alternatively installed underground as a subterranean tank. Avoid using water tanks comprised of combustible materials.
- Use non-combustible pipework.
- Size the water tank for all possible uses, including firefighting and static water supply.
- Where possible, use gravity water pressure if there is suitable terrain to support this.
- Use non-combustible tank and pipework for all elements that are less than 150 mm below the earth.
- If you have an external water pump, ensure it is designed and protected so it can operate under extreme wildfire conditions. Electric, petrol and diesel pumps are susceptible to radiant heat and flame contact. Petrol and diesel pumps are also susceptible to ember attack and higher air temperatures, which can cause the fuel to vaporise or the air inlet filter to ignite. It is also important to consider the refuelling requirements of these pumps – it is better to have a fuel tank that is big enough to not need refuelling during a wildfire event.

Electricity

Maintain an electricity supply and manage electrical infrastructure appropriately. Protect electrical infrastructure on the property in a way that does not exacerbate wildfire hazards or obstruct firefighting. Think about installing a backup electrical power supply.

- If possible, install electrical infrastructure underground.
- Shield power cables and other wiring with non-combustible or fire-resistant materials to protect the cables and wiring from convection, radiation and conduction heat, and direct flame contact.
- Use non-combustible or fire-resistant materials for mounting systems of roof-mounted equipment[8].
- Use surge protectors to protect sensitive electronic equipment.
- Create a cleared, open space between vegetation and any exposed electrical infrastructure such as poles and wires.
- Remove and replace fire-resistant sealants and non-combustible mortar each time you reinstall a cable or pipe.
- For a backup power supply, consider either a battery backup system linked to a solar power system, or a protected generator. In each case, it is better to have an automatic switch rather than a manual one – electricity supply failure is most common during the peak of the fire event.

Gas

Protect gas lines both outside the house and within the cavities of the house from wildfire actions. Isolate the gas supply before the wildfire arrives. After the event, follow gas safety procedures when reactivating the gas supply.

- Install gas lines below ground to minimise the risk of explosion.
- External gas pipes and fittings above ground should be steel or copper. Their minimum wall thickness should be in accordance with gas regulations or 0.9 mm, whichever is the greater. The metal pipe should extend a minimum of 400 mm within the building and 100 mm below ground.
- Avoid using PEX (cross-linked polyethylene) gas piping above ground and in building cavities. It can lose integrity at 80°C, and building cavities can reach this temperature in a wildfire.

When a gas bottle vents, it can ignite the house or any combustible materials in the path of the flare. Protect people from the hazards associated with gas cylinders. A gas tank that is not secure may fall and if the tank continues to be heated in this position, it may violently explode. This type of explosion is common after the fire front has passed, and poses a significant threat to people and houses.

- Protect gas cylinders from falling by securely attaching them with a metal chain or cable to a solid steel or masonry structure that cannot collapse, even if the adjacent structure burns. Ensure the pressure relief valve points away from the house.
- Ensure that all fixed gas cylinders are kept at least 10 m away from vegetation and all flammable materials and are shielded on the hazard side. Ensure that connections to and from gas cylinders are metal.
- If you need to install gas cylinders close to the building, make sure their safety valves are directed away from the building. Keep the gas cylinders at least 2 m away from any combustible material so that they do not act as a catalyst to combustion.
- Use metal connections, pipes and fittings. Do not use polymer-sheathed flexible gas supply lines to gas meters that are near buildings.
- Direct the over pressure relief valve on the gas cylinder away from structures and exit pathways.

8 FEMA (2008)

Additional recommendations: Fire safety systems
Ngā Tūtohunga Tāpiritanga

This guide is mainly concerned with house construction improvements to address known ways that wildfire can attack and enter a house to burn it down. But there are also additional measures – fire safety systems – that you can use to make a house more resilient and mitigate wildfire threat. This section describes several of these systems.

External spray system

When considering home or external sprinkler systems, engage a sprinkler specialist

External spray systems can wet down combustible external elements such as the roof, eaves, facades, decking and surface fuels that are immediately adjacent to the house.

These systems are not effective in sealing gaps or preventing the spread of fire to parts of the house that are sheltered from the weather, such as the roof cavity, wall cavities, under floor areas and the occupied areas of the house.

Because of these limitations, consider external spray systems as one part of a wider holistic approach to wildfire resilience. Use external spray systems in combination with other design measures to reduce the overall wildfire risk, rather than expecting these systems to provide a complete solution.

- If there are external sprinklers installed in areas where freezing temperatures occur, they need special provisions such as dry sprinklers to prevent the water in the piping from freezing and rupturing it.
- Maintain an adequate water supply with adequate water pressure that can continue to operate if both mains water pressure and power supply are lost.
- Consider using automatic activation using a combination of smoke or heat sensors.
- Landscaping sprinkler systems may also help reduce the likelihood of fire reaching your home. Ensure that the system has sufficient water supply and pressure. Ideally, the system should have independent water and electric supply.

Home sprinkler system

Home sprinkler systems are designed to reduce the impact of a fire that breaks out inside a house. In some cases they can completely extinguish the fire. They are however principally a "life safety" system, buying the occupants an extra ten minutes to enable evacuation to a safe place outside. Although not specifically designed to do so they can be enhanced to include property protection. If desired, consideration of protecting the pipework and location of the sprinkler heads is required. For fire attack that originates outside the house, sprinkler heads located within those areas that can pre-wet or protect these spaces can help, but would need careful design.

- Consider using additional sprinkler heads in unoccupied, enclosed spaces if they contain or are made of combustible materials, such as the roof cavity and subfloor spaces.
- An interior sprinkler system is only effective if it has adequate water pressure and supply. Consider using a pressurised holding tank to ensure that water is available to the system during a wildfire, even if the structure is connected to the reticulated water supply.
- Consider linking the system with an external spray system if there are external combustible facades or adjacent features. External sprinklers mounted on the outside of the house can be configured to use water piping through the attic or roof, or to use piping on the exterior of the structure in conjunction with home sprinklers.

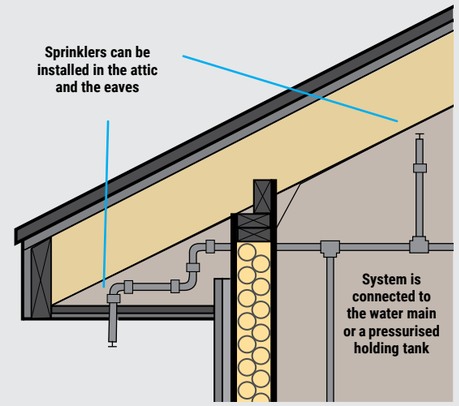


Figure 18: External and home sprinkler can be installed in conjunction with each other

Acknowledgement

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