Information on this website was compiled by a number of people at University of California, Berkeley, and is based on input from fire tests, observations of wildfire damage, and input from those who are involved in firefighting. It is very important to realize that no (livable!) house is fire proof, but you can make it more fire-safe!

The website is organized to give you an opportunity to make changes to your home and the surroundings to reduce the possibility of damage from wildfires. Some of the changes can be done very quickly and relatively inexpensively. Others may require more effort, expense, and, in some cases, professional help.

The main part of the website begins with a list of features or parts that are of concern. If you click on any of these parts, you will go through a series of visual and text information on the specific item (say the roof or siding) that includes a definition of the possible problems and a discussion of potential solutions.

Advanced Housing Research Center
Forest Products Laboratory Madison, Wisconsin

This project was completed in cooperation with the Advanced Housing Research Center of the USDA Forest Service, Forest Products Laboratory in Madison, Wisconsin.

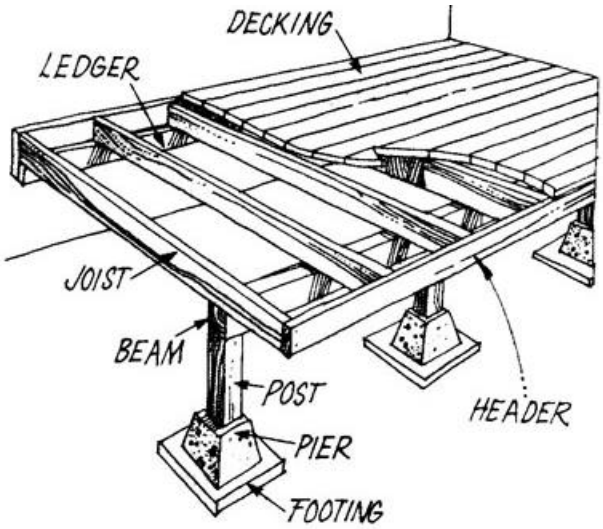
Decks

By decks, we are including all types of horizontal walkways, including landings, porches, and patios that are directly connected or very close to a house. Decks are described by the surface that you walk on (called the deck covering). There are two basic kinds of decks – those that use deck boards as the deck covering, and those that have a solid surface deck covering. The deck boards are almost always made from combustible

materials (wood or one of the wood fiber – plastic composite or 100% plastic deck board products). Solid surface deck coverings are usually made from noncombustible materials, and include light-weight concrete or stone. They are built over occupied (living) space. Occasionally an open frame deck will be installed over a water-proof membrane, again built over occupied space. As with normal decks, this open-frame deck will also be vulnerable to accumulation of debris, and ignition by burning embers.

The figure above shows wood deck, built on wood 2x6 ‘sleepers’ on a solid surface deck (above a garage).

The most important features of decks are deck boards, ledgers, access to the underside, under-deck drainage systems (for raised decks to shelter the lower level), and adjacent doors and windows. This drawing shows some of the important deck elements:



Decks: Potential Problems

There are two major problems that decks present. First, they are a great source of fuel and an ignited deck will also certainly endanger many portions of a structure. Second, nearly all decks are adjacent to large windows or glass sliders. The heat from the deck fire can cause the glass to fail and permit the fire to enter the house, where entry means certain destruction.

In general, the thicker the deck boards (about 1.5 inches thick), the better. Thin boards (about 1 inch or less thick) release heat much faster and are a higher hazard. You may have noticed how much easier it is for thin materials to burn in a fireplace.

One of the greatest risks to structures is a "thin-board" wooden deck (about 1 inch thick). In general, the thicker the deck boards, the better. You may have noticed how much easier it is for thin materials to burn in a fireplace. Thicker materials tend to release heat much more slowly and are a lower hazard.

Deck board gaps (which are there for drainage and ventilation) can permit embers to lodge and cause ignition. In this ground-level deck (or patio), you can see literally tens

of char marks from embers. Although this deck survived, a very similar one next door did not and the townhouse was lost:

The deck above also suffered from having debris in the deck board gaps, and possibly decay at some of the joints, such as where the stairs met the deck.

Raised decks offer another problem - storage of combustibles underneath. This photo may be an extreme case, but consider what would happen if even a single ember got in the stack of wood!

Also, some raised decks have drain systems to permit rainwater to drain away from the deck area. While this can offer a nice dry area, it also encourages storage of combustibles. The drain system can accumulate debris, such as tree needles or leaves that can go through the deck board openings:

Looking at the last two photos, consider the consequences of the next deck that ignited from below, permitting fire entry through the windows (even though the siding was non-combustible).

Quite often, decks that are raised, including those not being used for storage are open to flames or embers, especially those on slopes:

The deck above illustrates another problem — the growth of vegetation under the deck, that when dry, can be a fire hazard.

Ledger boards, used to attach the deck to the house, are often recommended to be installed with a gap for drainage of rain from the siding so that it doesn't pour onto the deck. However, this is a very good trap for burning embers. The ledger board attachment detail is an example of a conflict between moisture and fire regarding 'good' design. In order to maintain adequate performance, this joint must be inspected and maintained. Debris must be cleared. Durable materials should be used to minimize the potential for fungal decay.

Fascia boards are often used as decorative edges on decks, but often cause decay to develop between the fascia and deck. This deck corner ignited in a decayed area at the deck corner:

deck8

Deck surface materials must be carefully considered. In tests conducted at the UC Forest Products Laboratory starting in the late 1990s, many wood-plastic and plastic decks were found deficient in behavior. This information is posted on the following web page: http://nature.berkeley.edu/~fbeall/WDDeckIntro.htm

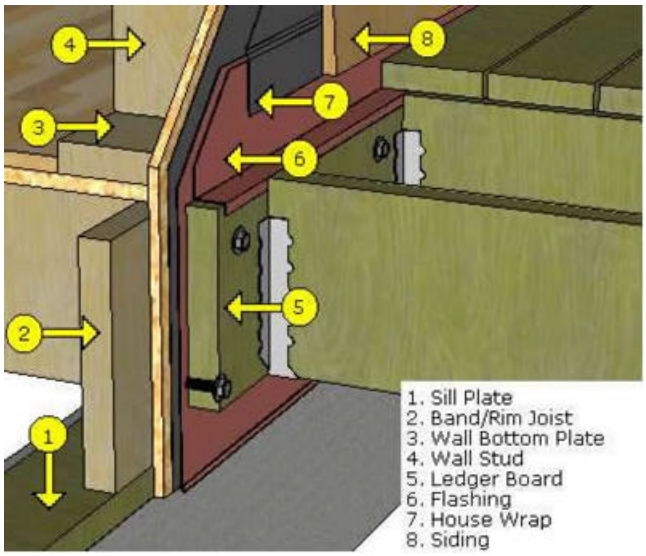
As a rule of thumb, the thicker the wooden decking material, the better the fire performance. That does not mean that such decks will survive a wildfire, but they will not contribute enough heat release to endanger the house.

Decks that are just above ground level should be screened to prevent combustible debris from entering. This also keeps out animals, such as skunks! Also, note the stones being used to minimize growth of vegetation.

deck9

The gaps between deck boards (about 3/16 in.) are there for drainage and ventilation. Keeping the gaps clean also protects the deck boards and joists from decay. The best advice is to keep these clean of debris, especially before and during the fire season.

The problem with gaps between the deck and the house (such as offset ledger board construction) are probably best handled by covering the gaps with screening having about 1/8 in. openings to prevent lodging of debris and embers. Ledger boards that are attached without gaps should be flashed (see below)--this not only provides protection against water penetration, but also acts as a fire barrier to embers.

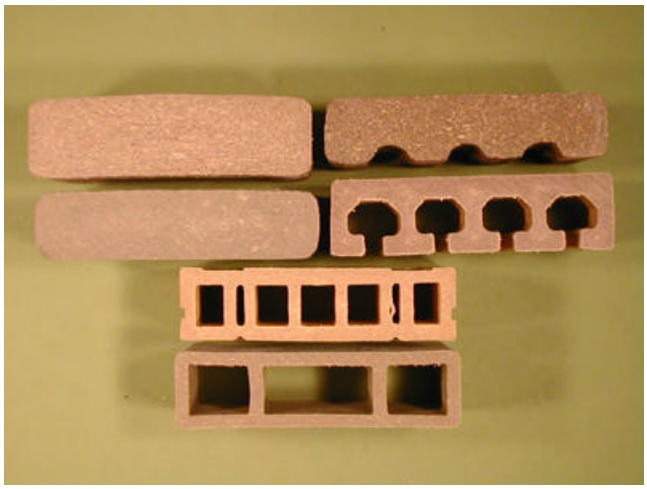


Replacement of deck boards is obviously expensive, but could be one of the best investments you can make. For replacements, consider any material (plastic, plastic lumber, fire-retardant treated lumber for exterior use, or lumber) that passes the standard posted on the web page of the Office of the State Fire Marshal:

http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_codes.php#testingstandards

Then click on 'Testing Standards CA SFM12.7A-4 Decking'

This and other testing procedures listed on this site have been approved for use by the Office of the State Fire Marshal, and have been incorporated into the new California Building Code for new construction in designated wildland urban interface areas. You should check with your local building and fire officials to find out what products are acceptable in your area. In the tests done by the UC Forest Products Laboratory, all-heart 1 1/2 inch thick redwood (2 x 6s), a widely used decking, and some (but not all) plastic-fiber composite decking products, performed acceptably. Note the information in bold; redwood sapwood was not tested in that study, so its performance was not determined. Also, because any sapwood will readily decay, it wouldn't be the most appropriate choice. Thinner material could be risky (for mechanical failure as well as fire). They found that certain types of wood-plastic board profiles (hollow and channeled) did not perform well:



Fences

Fences (and walls) are both decorative and functional (for security and privacy) and come in many materials and configurations. While we have no laboratory fire test data on fences,there are a number of observations that indicate fences--like plants--are a much greater hazard close to a house. Fences and gates can also be an access problem for fire crews trying to enter your yard, so it is advisable to get an inspection from your local fire department.

Fences: Potential Problems

The fence shown below was responsible for substantial damage to both adjacent houses that were saved only through quick intervention by firefighters.

The house on the right had a gate attached to the front corner of the garage. The gate was totally consumed as were most of two 8-foot sections of fence. The geometry and combustibility of this arrangement was an invitation to burn in this type of "zero-lot-line" construction. There are several reasons for fences to be of concern. For one, a combustible fence or gate attached to a structure is an obvious threat if it catches on fire. The fire can arise in a number of ways. One is that debris (leaves, trash, etc) often collect at the bottom.

Another problem is that many wooden fence boards are in contact with soil at the bottom and will eventually decay at that point (see the Appendix for more information on decay).

Combined with combustible debris, fences can be an excellent fuel source. Also, fence boards usually have small vertical openings where brands can lodge and even cause the fence boards to ignite directly. In all cases, the thinner the fence boards, the greater the risk!

A number of homeowners have found their fences to be convenient places to store firewood, not realizing that what burns well in the fireplace can also spread embers throughout the neighborhood. The photo below is an example of an accident waiting to happen!

Fences: Possible Solutions

1. Any fences or gates that are attached to houses should be designed to reduce the fire hazard. Metal gates and heavy wooden fence sections can minimize this problem. Below is a combination of wooden framing with wire mesh, which minimizes the amount of combustible material in the fence.

2. For fences in "zero-lot-line" situations, consider using a non-combustible material, fire-resistant lumber (fire retardant treated for exterior exposure), or thicker dimension lumber (1 1/2 inch). Another option is to use a chain-link fence with climbing vines to provide privacy. Of course, the vines must be maintained so that they do not become a fire hazard!

3. Keep the bottom of fence boards clear of debris (leaves, trash, etc) and make sure that they are not in or touching soil. A good rule of thumb is to create about a one-inch gap at the bottom.

4. Do not store combustibles (such as firewood) against fences.

Garages

When houses are surveyed for wildfire vulnerabilities, quite often the garage is not considered even though it could be the most hazardous aspect of the house.

Attached Garages: Potential Problems

Garages are typically not well sealed since they are generally not heated or cooled. Gaps at the top, bottom and edges of doors can let glowing embers enter, and we all know that garages are full of flammable materials. Garages usually have vents at various locations, especially if they contain gas furnaces or hot water heaters. These vents are easy entry points for embers.

These photos show a full-size roll-up garage door that has not been properly adjusted, creating a gap at the right bottom where embers could easily enter.

Small embers can easily enter through the door gaps. Sliding doors (that are hung at the top edge) have a special problem in that one side is offset, leaving a large gap at the top edge. In addition, many garage doors have glass in the top sections plus personnel entry doors that have single pane glass that (although it is tempered in newer construction) can easily be broken from heat or flying debris. For more information on glass, see the section on Windows.

This garage car door has glass panels that could break during wildfire exposure, including vertical flamespread up the combustible door. Some current door manufacturers advertise that their glass panels are tempered.

The window in this particular door is tempered glass, but is also single pane which does not offer a great amount of wildfire protection.

An even greater concern is attached carports or any type of garage that does not have doors. These types of garages would typically have an extreme number of combustibles and many nooks and crannies for embers to lodge.

Attached Garages: Possible Solutions

For garages with roll-up doors, the top and bottom can be weatherstripped (quite often the bottom is sealed to prevent water entry). The roll-up mechanism should be adjusted to obtain a good seal at the top. Tilt-type doors have similar solutions, although sealing at all edges is easier.

The vertical edges on roll-up doors are also a problem in that weatherstripping is not usually an option, however, non-contacting materials can be added that baffle the direct movement of air through the edges, as shown in the first picture. In this photo, a small piece of 2x4 has been tacked on to show how the upper

opening in the framing could be blocked if it were extended the full width. The next photo shows the door closed and how the upper opening is blocked. Of course, most of these doors are not installed with that upper trim.

For attached carports, as a first step, combustibles should be minimized. However, this would still present the greatest hazard to your home, and some serious thought should be given to have the garage properly enclosed.

Car-entry garage doors with glass panels can either have the panels replaced with fire-rated glass or simply filled in.

Personal entry doors with windows can also have the windows replaced with fire-rated material or the window could be replaced with paneling. Another solution is to consider a stell-clad door as shown below, which provides both fire resistance and security from break-ins.

Parcels

The general surroundings of your home and any detached buildings can have a major impact on vulnerability to wildfire. The first step to take is to contact your local fire station get their help in identifying problems in both your neighborhood and on your parcel. See other parts of this Guide for issues related to your structure as well as the "home zone," the area within 6 feet of the building.

Vegetation management

As a rule of thumb, you need to make sure that a fire moving toward your home cannot follow a continuous path through vegetation. In other words, make sure that the plants are small and are in broken clusters (a mosaic arrangement). The closer to the home, the smaller the plants and clusters should be. Also, make sure that ignition of brush will not cause trees to burn. In general, trees are less of a hazard than brush in moving the fire. The main concern with trees is any within a 30-foot area that might release a great amount of heat toward a vulnerable part of your home. Also, certain types of trees (such as pines and eucalypts) generate many burning embers that could threaten your (or your neighbors' homes). The distances recommended for vegetation management under "slopes" provides a general guidance, but homeowners in a neighborhood should seek the advice of a professional on how to both implement and manage the vegetation over time.

General parcel characteristics

Slope. The critical slope of concern is about 10 to 20 degrees; less than 10 degrees can be thought of as flat. Using a simple protractor, you can determine your slope. Grades over 20 degrees are considered very hazardous. The amount of recommended vegetation management depends largely on the slope:

0 to 10 degrees: 30 feet
10 to 20 degrees: 30 to 60 feet (3 feet per degree)
Over 20 degrees: multiply the number of degrees by 3 to get the distance in feet.

Position of home. If your home is at the top of or somewhere on a slope greater than 10 degrees, you need to double the recommended vegetation management distance. However, if the home is set back from the slope by about 30 feet, then most of the vegetation management can be concentrated in that 30-foot area and about 30 feet down the slope.

Another factor to consider is the most likely direction of winds during fire weather and the aspect of the slope. The worse case scenario is a south-facing slope with winds that would come from that direction. For recommendations of additional vegetation management to account for winds and slope, seek the advice of your local fire authorities.

Distance to closest wooden structure (including fences). If another major structure is within 10 feet of your home, it poses a severe threat from heat released or even burning embers. The implications of this are that you should not have combustible materials on or near that side of your home. This includes siding on the home, fences, firewood, etc. See the section on Fences for guidance on construction and materials. Over about 50 feet of separation, the nearest structure is largely a threat from burning embers. For example, a gazebo with wooden shakes or shingles, or other lightweight wood construction should be modified to eliminate this problem. The 10 to 30 foot spacing is a gray area. Wind-aided flames could easily span this distance with the right wind direction.

Fire-fighting effectiveness

Access for equipment. There are two parts to this. One is that you must have enough space for firefighting equipment to move onto your lot, as close as possible to your home (check with fire authorities about this), and to be able to turn around. Next, what is the access to your parcel? The recommended conditions for access are the following:

Two or more roads in and out. Dead-end should have a turnaround as approved by the local fire authority.

An "all-weather" road at least 20 feet wide.

Road grade of less than 5% (5 foot rise for each 100-foot distance).

If you lack any of these, there could be little that you can do as an individual homeowner, but it might be possible to get the neighborhood together to lobby for changes as recommended by your local fire authority.

Water supply. This is another item that you need to discuss with your local fire authority. They can determine the availability of pressurized and non-pressurized water within the distance.

Plants

While plants close to a building can be a major fire hazard, those farther away can also serve as buffers against radiation and convective heat, and fire brands. Trees, in particular, can block many of these hazards by diverting wind flow away from the house. These townhouses in a rim location were protected by the trees at the rim edge.

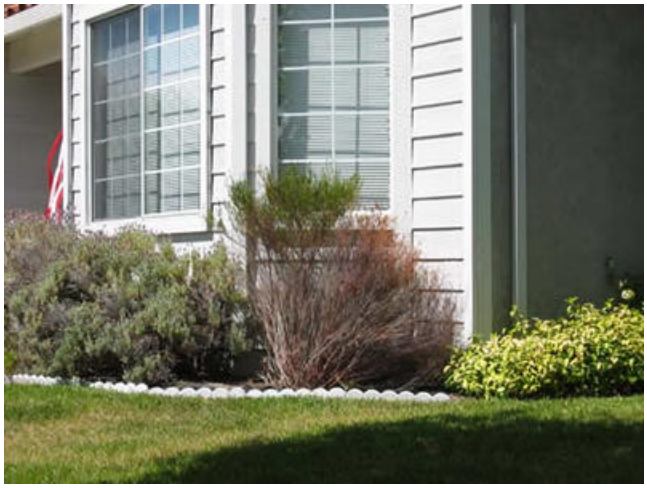
Plants: Potential Problems

Plants against combustible siding present the greatest hazard since their flames make direct contact with the siding and can cause vertical flamespread.

As the separation from plants to building increases, then we are concerned about the radiant energy from combustion (like the heat generated from a fireplace). There is a very large difference in the amount of radiant energy felt by the siding as the distance increases, for example, the same plant 4 feet away as compared to 1 foot would only have about 10% of the radiant effect on the siding.

All plants within the "home zone" should be assessed using the four key criteria: size, location, structure, and condition.

Size and location: These effects go together. A small plant (about 2-feet high) against combustible siding under a window or at an inside corner is a real threat. A plant just under or next to a window is a primary concern. A typical window will last about 1 to 3 minutes when exposed to fire.



Another bad place is an inside corner of a building, which can be ignited much more easily than simply the side of a house.

Structure: Plants with a lot of fine materials, such as junipers or cedars ignite easily and can release a lot of heat in a short period of time. For example, the 1-foot juniper below generated 10-foot flames, which in many cases can reach up to the eaves.

Condition: Dead material in or under plants can add substantially to the dry fuel, which in the fire season can be a formula for disaster.

Plants: Possible Solutions

Size and location: The smaller the better, especially close to combustible siding, under a window, or at a inside corner. Better still, consider using ground cover wherever possible next to combustible siding or near windows for any type of siding.

Structure: Look for "leggy" plants with succulent leaves. For example, plants similar to oleander are a good choice, as are roses.

Condition: Any plants near a house should be pruned, regularly watered (preferably dripped) and any dead material removed, including at the soil level. Along with these precautions, don't use bark or other combustible natural materials as plant bedding. Embers can land in this, smolder, and later go into flaming combustion.

The burned cedars in these photos had all of the wrong characteristics!

The picture shows one green cedar (far right) and one scorched (center).

This picture is over to the right of the same side of the house where the scorching of the area around the window is evident from a cedar just below the window. A fire crew arrived just in time!

Roofs and Gutters

In this section, we discuss the flat or sloped covering over your home. This would include the living space, garage (if covered), and deck (if covered).

Your roof and edge components (such as your gutters) are arguably the most important part of your home in terms of making it safer from wildfires. While your home may only be subjected to the flaming front of the wildfire for a few minutes, your roof (and the rest of your house) could be subjected to airborne glowing or burning embers for a few hours as the wildfire approaches and burns through the area where you live.

Roofs: Potential Problems

How well your roof performs during a wildfire will depend on a number of factors, including:

1. The roofing material used.
2. The age and condition of your roof.
3. The 'complexity' of your roof (that is, how many levels and wall/roof intersections you have, and how much debris can collect there).
4. Gutters and other 'edge of roof' factors.
5. Vents and other penetrations in your roof.

As you can tell from this list, how your roof performs will depend not only on the roof covering, but also on intersections where your roof connects to other materials. These connections are often at a horizontal to vertical intersection.

The fire rating of roof coverings is determined for all materials used in code-compliant housing, and will be classified as Class A, B, C, or 'unrated'. Class A provides the best fire resistance, so for the best

protection for your home, you should have a 'Class A' fire-rated roof covering. Information regarding Class A roofs is given in an Appendix H: Roof.

Every thirty years or so, you will have the opportunity to select a new roof covering. In the meantime, one of the most important jobs you have is inspecting your home and near-home vegetation, and performing needed maintenance. The standard tests to determine fire performance are conducted on new covering materials (the exception being fire retardant treated shakes that must also be evaluated after natural weathering). An older roof may not perform as well as a fire-resistance membrane. It will be up to you to make sure your roof covering is inspected and maintained, and replaced when needed.

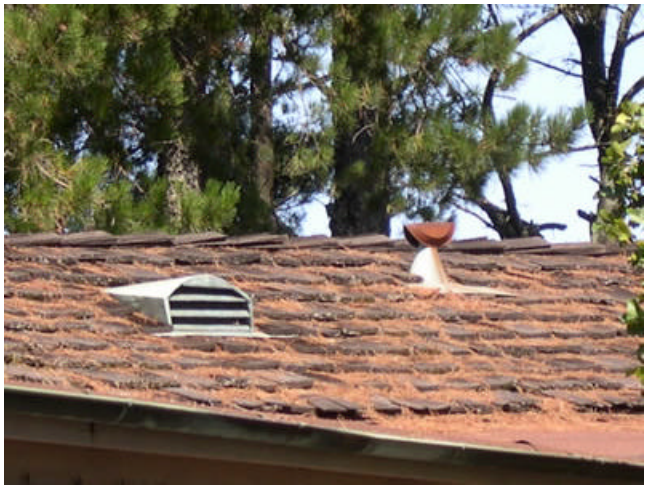
When new, this asphalt composition roof covering has a Class A rating. The older and weathered roof may not provide the same protection from wildfire, and may also be more vulnerable to water leaks.

Another critical inspection and maintenance item for your roof will be to remove of debris (needles, leaves, and other combustible material) from collection points on your roof (for example, nooks and crannies), and from your gutters. Ignition of debris in these locations can ignite other roof components besides the roof covering - components that don't perform as well as your Class A roof. These components include the underside of the roof , and exterior siding. Debris that accumulates at the inlet to roof Vents can also ignite during a wildfire and enter the attic, potentially igniting other combustible materials in your attic.

If ignited, the debris on this roof would expose the underside of the overhanging roof, or the exterior siding. Both of these components are potentially more vulnerable to flame and ember exposure than a Class A asphalt composition shingle roof covering.

Vertical walls adjacent to the roof can accumulate combustible debris, typically leaves and needles. The ignited debris can expose the exterior siding, in this case wood shingles, and potentially the underside of the roof.

If ignited, debris in this gutter would expose the roof edge, with flame and embers potentially getting under the roof covering.



Pine needles on this non-fire retardant treated wood shake roof can easily be ignited, with flame and embers entering the attic through this 'through-roof' vent.

A through-roof vent can provide a "backstop" that can serve to accumulate wind-blown debris. If ignited, the burning debris can easily enter your attic.

Wind-borne debris can accumulate in the ends of this clay tile barrel roof covering. If accessible, birds can also build nests in the space between the roof sheathing and the bottom of the tiles, also providing combustible debris that is easily ignited if embers are driven into this area (under the tiles).

The ends of this clay tile barrel roof were covered by a cut-to-shape metal strip, but it has become disconnected, or was never properly installed. Embers can easliy enter these openings.

Skylights should be constructed with two layers of glazing. Another likely exposure for a skylight would from an impact of an ember, or other object lofted during the wildfire. For best performance, skylights should consist of two layers, with one of them consisting of tempered glass (for improved resistance to larger embers striking and breaking the glass).

The upper (domed) light in the photograph shown is plastic, and won't be able to withstand an 'A' brand exposure. To prevent entry of burning embers during a wildfire, this operable skylight should be closed.

Valleys

Many homes are constructed with roofs that contain 'valleys', the intersection where two sloping surfaces meet. These intersections can consist of metal flashing material, or in the case of asphalt composition shingles, the shingles themselves can be used. Since metal flashing can be made of aluminum, this region can be more vulnerable to wildfire exposures than the roof covering material.

Metal flashing was used on the valley of this roof. The roof covering consists of Class A asphalt composition shingles. The valley may also be 'Class A' construction, but it will depend on the underlying material(Appendix H: Roof).

Asphalt composition shingles are 'woven' together in this valley. The valley would have the same fire rating as the rest of the roof.

Roofs: Possible Solutions

Roof Covering and Accumulation of Debris

The importance of a Class A roof covering cannot be understated. If you don't have one, you should make an upgrade to a Class A roof covering a priority item. Lack of a Class A roof covering should immediately increase your attention and focus on near home vegetation, and inspection and clearing debris from your roof and gutters. Remove debris from your roof and gutters as often as required - inspect often at first until you determine how frequently debris accumulated. You shouldn't wait for water to overflow your gutters during a heavy rain to realize that your gutters are full of debris. Care should be taken during inspection - some roofs and gutters are easier to inspect than others. Consider hiring this job out if your roof and gutters are at a high elevation, or are otherwise inaccessible.

Birdstops

If you have a clay tile roof with a barrel design, install birdstops at the end at the roof edge, and make it one of the items you look at during your inspections to make sure they are still *in place*.

This is an example of a properly installed bird stop at the end of a barrel-style clay tile roof.

Gutters

Gutters play a very important role on a house in providing a means of collecting and directing rainwater from the roof into downspouts, and then away from the house. This helps reduce the amount of water in

the soil that can enter the crawlspace or basement, and that may lead to problems from mold and decay fungi.

Gutters: Potential Problems

Flammable debris can build up in gutters, especially from nearby or overhanging trees. Second story gutters are even more problematic, since they are seldom cleaned on an annual basis. If ignited, combustible debris in the gutter will expose the underside of the roof covering, and may be able to more easily enter the attic.

Another issue that has been seen in some houses is the use of barrel tiles to channel water from the upper gutter downspouts to the lower-story gutters, as shown below. In this case, there tends to be a buildup of debris at the transition point.

While metal gutters have been recommended over plastic ones in fire hazard areas, there doesn't appear to be any justification for this, other than the possibility that some plastics could burn. It seems advisable to avoid the unknown!

Gutter guards or covers can be installed over or in your gutters. When properly installed (and maintained), these can reduce the amount of vegetation litter and debris that accumulate in your gutter and therefore reduce the need to clean it. Some products can become dislodged over time, and they will have to be reinstalled when that happens. There are a number of commercially available products specifically intended for this purpose - just type 'gutter guard' in a web-browser search engine to get an idea of the options you have.

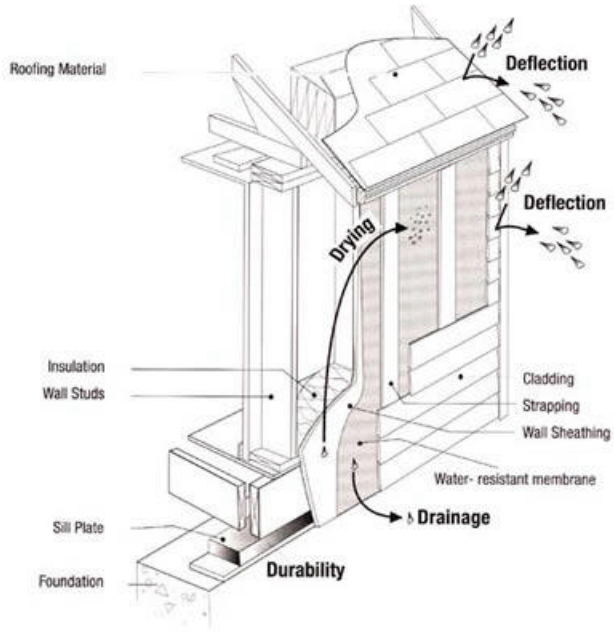
It is possible that your home won't have gutters. Although this will eliminate any 'debris accumulation' issue, it will result with a heavy rain load around your home, and depending on drainage, may contribute to moisture related problems.

Note that some of the covers in the gutters on this roof have dislodged, and therefore no longer keep out debris. Gutter guards should be inspected, and reattached when necessary.

Since second story gutters are difficult to reach, it is advisable to have these cleaned and screens added to minimize the need for subsequent cleaning. One means of doing this more economically is to organize a community-wide effort with professional help.

Siding

Siding (cladding) is an important esthetic attribute for houses, but it also has a key role as part of a protective enclosure to help shed rain, while permitting excessive vapor to move through and out of the house, as shown in the photo below.



Siding: Possible Problems

Combustible siding provides a rapid vertical path for flames to reach vulnerable portions of a house such as the eaves or windows.

In a fire test, burn-through (through siding and sheathing) did not occur for the shingle siding below, but the fire spread vertically and quickly penetrated the soffit, which was 1/4-inch plywood. Even 1-inch solid wood is inadequate as a soffit material because of the edge gaps, unless it is tongue and groove.

Keep in mind that combustible siding needs a source of ignition. In many cases that will be caused by plants near the house, or from other combustibles, such as firewood.

Another potential problem with combustible siding is decay at the bottom edge caused by wetting in contact with soil, concrete, or exposure to lawn sprinklers (See Appendix F: Wood decay for more information on decay).

In the first diagram of the outside wall, note that it has an open "drainage plane" behind the cladding (siding). While this form of construction has been shown to be effective for drainage of water that gets behind the siding, it has been shown to be a problem if fire enters the cavity below or through the siding.

Some plastic siding deforms with heat and can expose the sheathing or the wall cavity to fire.

Tests conducted by the University of California Forest Products Laboratory have shown that siding without sheathing (both combustible and non-combustible) ultimately fails by burning through laps or conduction of heat to the studs. However, the presence of sheathing (plywood or OSB) largely prevents failure. The type of lap is also very important; the plain bevel siding (on the left below) failed in just over one minute, but the rabbet bevel siding (on the right) lasted over 21 minutes.

The relationship observed with horizontal lap siding would also apply to vertically lapped products, such as T1-11-type panel products and board-and-batten siding. A more complicated joint is preferable from a flame entry perspective. Panel products can have a butt-joint covered with a sealant, or with 'batten' cover, or have a more complicated joint. Board-and-batten consist of a number of wood-to-wood joints similar to plain bevel, and so flame penetration into the stud cavity would occur more easily In these cases.

Siding: Potential Solutions

All lapped wood siding should have an interlocking type of lap (such as the rabbet bevel shown above) to prevent flame penetration. If you have combustible siding, carefully inspect it annually for gaps and make sure that they are filled with a high-quality caulk.

A possible solution to the soffit problem (with boxed eaves) is to replace it with cement board that is properly filled with fire-resistant material at all joints.

For buildings that are 2-story, there is a real opportunity to break up the vertical combustion path with a non-combustible first-story:

If you do replace your siding, consider several other options to improve your fire, seismic, and durability performance:

Add structural sheathing (plywood or OSB) to improve both your fire and earthquake resistance. To find the earthquake hazard rating for your area, go to:http://www.consrv.ca.gov/cgs/rghm/ap/index.htm.Have your sill plates (the lumber that is fastened to the foundation) inspected to see if they need upgraded holddowns (again for seismic protection).

If you reinstall your windows, make sure that they are properly flashed to prevent leaking and subsequent decay. Also, think about potential upgrades for more fire-resistant windows (see the section on Windows for more information).

Trees

Trees often get a bad rap because of the potential to spread fire in the crown, but that is seldom a hazard to structures. There are exceptions, however.

Trees: Possible Problems

Major concerns from trees are those that they spread embers around a neighborhood. Pines, in particular, can have cones that ignite and are carried a great distance by the wind. Another problem common to all trees is that the leaves or needles that drop onto roofs or other places become very dry tinder in fire season. Any trees with limbs that are near or above power lines are especially hazardous.

Trees: Potential Solutions

The rule of thumb is that trees should not have branches that come within 6 feet of the vertical plane of a house.

Obviously, there are a number of trees that violate this, so some judgment should be used as to the remedy. A good idea is to evaluate all of your trees and make both short-term and long-term plans, from pruning to replacement. Those with branches that overhang the roof or power lines should be pruned to eliminate or minimize the overhang. In the case of power lines, those crossing your property are your responsibility and not that of the power company. A licensed tree pruner should be used to remove such branches and any others that might later grow into a hazard.

If the tree is deciduous, then it will probably lose its leaves before the fire season, so it may not be a flammability hazard at all. Placing deciduous tree on the southerly side of a building is good energy saving practice. Trees in this location shad the building in the summer and permit passive solar heating in the winter. However, it is still an indirect hazard because of leaves that are dropped (typically just before the fire season).

Vents

Roof and crawlspace vents are required by most building codes, which specify the vent openings. The function of the vents is to remove excess moisture from those spaces. Moisture can enter the crawlspace from the soil or through the foundation wall from the surrounding landscape. It can also enter the attic space from roof leak or through the ceiling in the living space of the house. If too much moisture accumulates, then fungi can grow leading to mold or decay.

In crawlspaces, cross-ventilation is called for (meaning that ideally, vents will be present on all sides of the crawlspace), however, if your house is built on a concrete slab, or over a basement, you won't have crawlspace vents.

Attics will usually have both inlet and outlet vents. Inlet vents, such as in soffits (eaves) are usually located on the lower portion of the roof.

Crawlspace vents are positioned at different locations along the perimeter wall.
Several types of vents are used to ventilate attic spaces, including:

1. Soffit vents (there are different kinds of soffit vents, with the common feature being their location along the eave of the house)
2. Through-roof vents (also known as 'eye-brow' or 'dormer' vents)
3. Gable-end vents
4. Ridge vents

A 'strip vent,' which is commonly found in boxed-in eaves.

A through-roof (or 'eye-brow') vent, usually located near the ridge (or peak) of the roof.

A gable-end vent, usually located just below the ridge of the roof.

A ridge vent (as seen from the side of the roof) that is found along the entire ridge of the roof. Baffles along the front edges of the vent keep rain from entering and provide for a negative pressure region that helps pull air out of the attic.

Vents: Potential Problems

Evidence from recent wildfires in the West has shown that vents are an easy entry point for burning embers and (not surprising) flames. Embers can 'rain' on and around homes for hours before the wildfire flame-front reaches your house. Embers that enter your attic can ignite construction materials and other items you may have stored there. Flames can also enter if embers ignite near-home vegetation or debris that has accumulated on a deck or in a corner.

Entry of burning embers has been problematic for attic vents in general, and soffit vents in particular. Also, locally generated embers and flame can enter vents, as shown below.

This plant immediately under the a vent (and next to a single pane window) could be a problem if it ignites.

Needles (debris) from near-by pine trees that have accumulated on the lower roof section could easily ignite from embers and subsequently exposure the gable-end vent to embers or flames.

This trellis vegetation could also expose the gable-end vent to embers or flames.

Ignited debris at the inlet to this through-roof vent could enter and ignite combustible materials in the attic.

Most vents incorporate a screen at the inlet. Most building codes stipulate a minimum mesh size of 1/4-inch to minimize plugging of vent holes and reduction in air movement. Smaller mesh screen is easier to plug up, whether by air borne debris, or as shown in the photograph below, being painted over during routine painting.

This fine-mesh screen is easily plugged by debris, or as shown in this photograph, by paint

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Vents: Possible Solutions

Your options regarding vents in *existing homes* are

1. Inspect and maintain vegetation in the vicinity of soffit vents. Remove highly combustible Plants.
2. Clean vents on a regular basis to minimize build up of debris in the mesh.
3. Remove debris that accumulates on roofs, and other areas that may expose vents if ignited. This includes grounds near crawlspace vents.
4. Prepare vent covers that can be temporarily installed when a wildfire approaches your home. Vent covers can be manufactured from plywood or other solid substance that would provide short term protection from embers and flame.

Because of code restrictions, 1/4-inch mesh screen is commonly used in vents. This points to conflict for building and fire code officials. While it is clear that 1/4-inch mesh cannot prevent entry of embers and flame during wildfires, if smaller screens become plugged, vents cannot operate as intended to remove excessive moisture. Smaller mesh screens might improve fire performance, but it is hard to say how much.

In some *new construction*, soffit vents are often being eliminated. In those cases, the inlet vent function is being performed by through-roof vents located in the lower region of the roof, or by placing a strip vent on the vertically oriented facia, as shown in the photographs below. If you select these courses of action, make sure the total vent area meets code requirements.

In this case, the soffit vent has been replaced by a through-roof vent located near the eave line of the roof.

In this case, the soffit vent has been replaced by a strip vent, located above the vertical facia board, and immediately below the gutter.

The new California Building Code that will affect new construction in designated wildland urban interface areas specifies that vents should resist the entry of embers. With time, vents that are designed to resist the entry of embers during wildfires, while still maintaining adequate air flow under normal wind conditions, will be commercially available. Standard test procedures are currently being developed that will provide a consistent way to evaluate the performance of these types of vents.

New home that incorporate unvented attic spaces into the design are currently available, and are being built in some locations. This construction option may be more widely available in the future, but shouldn't arbitrarily be implemented in existing homes because of moisture-related durability problems that would develop.

Windows

In this section we will discuss the performance of windows. This would include the framing material and glass.

Windows: Potential Problems

If the glass in a window breaks during a wildfire the fire can easily enter your home. Similarly, if your window frame ignites, it is possible that the fire could burn through the frame material, and ignite other material inside your home. Both of these scenarios could easily result in the loss of your home. Therefore, windows must be able to resist the following wildfire exposures:

1. A radiant exposure severe enough to break the glass in your window or ignite the exterior siding directly below. Burning vegetation could also ignite combustible siding.

2. A flame impingement exposure that would result from embers igniting vegetation and/or exterior cladding that burns up to your window.

3. The impact from burning embers on the glass. Remember that during a wildfire, your home can be subjected to exposure from thousands of embers for hours before and after the relatively short time (minutes) it takes for the wildfire to actually pass by your home. Embers could also land on the window sill and ignite debris that has accumulated.

In this laboratory test, window failure occurred as a result of glass breakage. The exposure was flame impingement from a propane gas burner located 2 feet below the window. The burner simulated a medium-sized plant on fire.

Glass breakage in a window occurred as a result of temperature differences between the edge of the glass protected by the frame, and the glass exposed to the flame (the part of the glass you can see). These temperature differences cause the heated glass to expand at different rates. Minor flaws at the edge of the glass start to grow, and if the temperature differences are large enough, the glass will crack, grow, and potentially break out.

In this laboratory test, window failure occurred as a result of the ignition of the frame material, with subsequent burn-through into what would be the living space in the house. Note than in this case, flame penetration occurred at the horizontal separator in a hung window. The exposure was flame impingement from a propane gas burner located 2-feet below the window. The burner simulated a medium-sized plant on fire.

Results from one study showed that for vinyl window frames, the horizontal separator shown in the photos above can be vulnerable to radiant heat exposures. At fairly low radiant exposures, the frame deformed, and the glass fell out. Results from testing done at the University of California Forest Products Laboratory (UCFPL) did not show this effect. All of the double hung windows (i.e., windows where the upper and lower parts of the window can both move) were constructed with an aluminum bar in the separator. This aluminum reinforcement is usually present because it is needed to resist wind loads. The bottom line of the UCFPL research was that by far the important factor in determining the performance of windows under wildfire exposures is the glass, and not the frame material. This finding is also supported by research conducted in Australia.

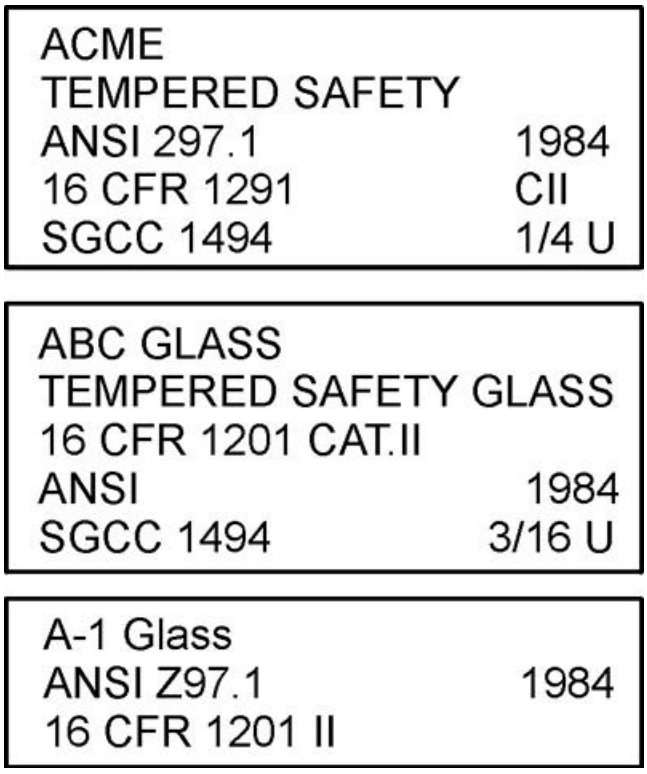
Burning embers could land on a window sill, or as is shown in this photo, the sill at an entry door. The embers could then ignite debris, or ignite the decayed trim. Decayed wood ignites as a lower temperature than that required for sound wood.

Burning embers could ignite this plant, which would then result in a flame impingement exposure of the window.

Windows: Possible Solutions

Because of the importance of glass in the performance of a window in a wildfire, the most important thing you can do is install dual-pane windows. With dual pane windows, the outer pane often serves as a thermal shield and protects the inner pane. The inner pane is allowed to heat up more slowly, and uniformly, and therefore may not fail even though the outer pane does. You can select the frame material that makes the most sense for you, based on cost, aesthetics, energy efficiency, or other issues that are important to you. If you purchase a window from a manufacturer that is a member of either the American Architectural Manufacturers Association (AAMA) or the Window and Door Manufacturing Association (WDMA), other window features that can improve the overall performance of your window will be present.

Above is a cut-away view of two panes of glass in an insulating glass unit (IGU). Because of energy code requirements, most windows in new construction consist of two or more pieces of glass in an IGU. Tempered glass is stronger than 'regular' annealed glass, and will provide additional protection during a wildfire, but we think dual pane is the most important part of the equation. Tempered glass is also more expensive, and will add approximately $1 per square foot to the cost of your window. Building Codes already require tempered glass in some locations, so some of your newer windows may already have tempered glass. For example, in newer construction, windows that come within 18 inches of the floor must have tempered glass. Sliding glass doors, and other doors with windows, and windows immediately adjacent to doors, will also have tempered glass.



A small white etching is often present in the corner of a piece of glass in a window if it is tempered. Since it is small, it may be to read.

Low-E coatings have sometimes been discussed as a means of enhancing the wildfire performance of your windows. Low-E coatings are always on one of the inner surfaces of the IGU, either on the pane closest to the outside, or the one closest to the inside. If it's on the outer pane (i.e., the inner surface of the outside pane), it could reduce the performance of the glass because the exposed glass would heat up more quickly relative to the glass protected by the frame.

Insect Screens

Research has shown that insect screens improved the performance of glass under *radiant* exposures. Bronze, fiberglass (with polyvinyl chloride coating), and aluminum screens all improved glass performance (increased the time needed for edge cracks to develop). Results from this study showed that bronze screens were most effective, and aluminum the least effective. However, research at UCFPL has shown that screens do not provide added protection in a *flame impingement* exposure.

Unfortunately, in a severe firestorm, your windows will still be vulnerable. Both panes are likely to break and fall out. Glass that would perform better (e.g., laminated glass) is currently very expensive, and therefore not affordable for many homeowners.

For additional protection homeowners should consider taking additional precautions to protect your windows. These precautions include fabricating covers (for example, 3/4-inch plywood covers), cut to size and marked so that it can easily be installed over a window prior to evacuation. Shutters or other roll-down devices could also be installed. In this case, you will have to make these items part of your routine

inspection and maintenance program to make sure they operate properly. All of these have the disadvantage of requiring an action to implement.

Some of the gels and foams marketed for structure protection during wildfires indicate they will also protect windows, but verification of these claims by an independent source isn't currently available.