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Reducing the Vulnerability of Buildings to Wildfire: Vegetation and Landscaping Guidance

Introduction

What can Californians do to improve the chances that their homes will survive a wildfire? The good news is that research demonstrates that a home's odds of surviving a wildfire can be substantially improved through careful attention to three principles: (1) thoughtful landscape design aimed at reducing and separating combustibles (vegetation, lawn furniture, and other landscape assets) within the defensible space on a property, (2) retrofitting homes to resist wildfire, and (3) implementing ongoing maintenance of the

home and landscaping to reduce combustible materials (for example, leaves and needles) and to address the wear and tear that homes incur over time.

This publication acknowledges the importance of a coupled approach to improving the odds of home survival—an approach that encompasses the home as well as the vegetation and other combustible materials on the property. However, this publication focuses primarily on landscaping issues on a property; more detail about home hardening can be found in publications listed in the reference section (IBHS 2019; Quarles et al. 2010).

Preparing for wildfire does not have to be costly. The first step is to understand the three types of exposures that can threaten a home during a wildfire so that actions specific to the context of an individual's home and landscape can be prioritized.

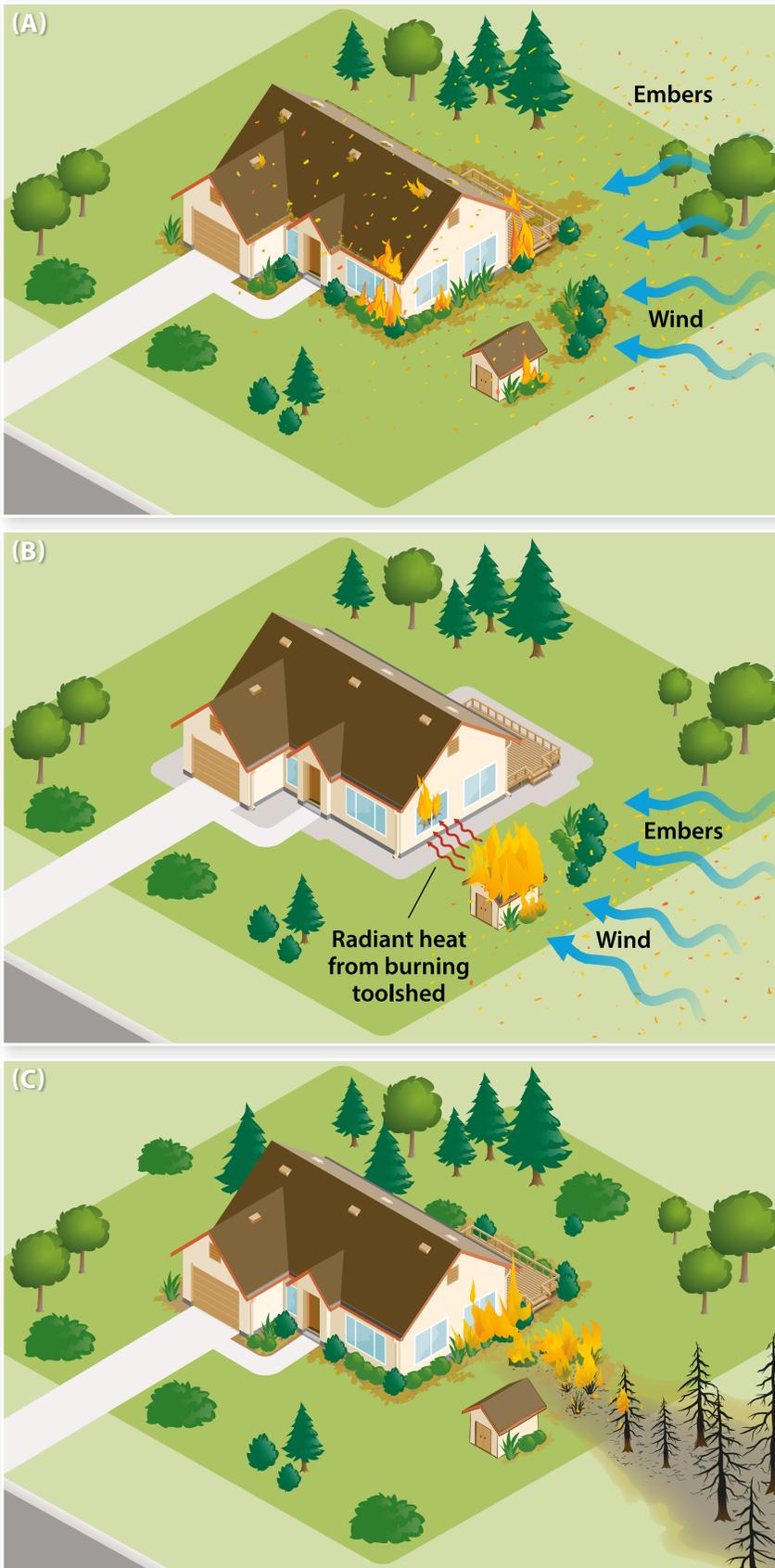


Figure 1. Incorporating fire safe concepts requires preparing for three different types of fire exposures—embers (A), radiant heat (B), and direct flame contact (C).

How buildings burn during a wildfire

Home loss during wildfire occurs when some part of the building ignites due to one or more of the three types of wildfire exposure: embers, radiant heat, and direct flame contact (fig. 1).

Embers

Wildland fires spread through a combination of a moving flame front and wind distribution of burning embers (also called firebrands). Embers are small pieces of vegetation or trees, or parts of buildings and other structures, that are light enough to be blown through the air. Embers rapidly spread wildfire when, blown ahead of the main body of the fire, they start new fires, known as spot fires. Embers have been reported to travel over a mile from the main fire front.

Embers can cause home and building ignitions by directly igniting materials on, in, or attached to the building. Additionally, embers can ignite vegetation or combustible materials near the building—which can result in flames touching the building or in a radiant heat exposure that can break window glass or directly ignite some portion of the building. Building ignitions caused by these types of extended exposures are referred to as indirect ember ignitions. It is important to understand that indirect ember ignitions ultimately cause the home or building to be exposed to radiant heat or direct flame contact.

Embers often pile up on the roof of or around the corners of a house. Once embers land, they can ignite combustible mulch, plants, and other combustible materials (for example, vegetative debris, a woodpile, outdoor furniture, cushions, or storage sheds). Once combustible materials have ignited, fire can travel to or penetrate into the house. Mulch in a garden bed, for example, can easily ignite, with the fire burning to the home. Embers that accumulate on the roof or deck may also ignite these parts of the house and find a path to enter the home. Embers can also directly enter the home or attic through a vent or an unscreened, open window. When embers enter the home or attic, they can ignite combustible contents, causing the home to burn from the inside out. When this occurs, there is often

little damage to the surrounding vegetation, making it difficult to understand how the home ignited.

Radiant heat

When heat produced by burning materials is transferred through the air to heat a nearby surface, it is known as radiant heat. If the radiant exposure is hot enough or lasts long enough, exposed materials can ignite even without direct flame contact. A home can be exposed to radiant heat due to the burning of nearby buildings such as sheds, garages, or a neighbor's home, as well as vehicles, firewood piles, uncovered recycling bins, and surrounding vegetation. A good rule of thumb is to locate these larger combustible items as far as possible from a home (or other building of concern) to reduce the threat of radiant heat exposure. Another approach would be to modify, or harden, the home and other buildings of concern, but the most certain approach would be to address the near-home combustible items.

Direct flame contact

When fire burns directly to the house, what determines whether the house will ignite is the duration of direct flame contact and the combustibility of the building component that is exposed. Combustible siding, the underside of an attached deck, wood steps, and nontempered (annealed) glass are particularly vulnerable to direct flame contact exposures.

It is important to take actions that minimize the chances of flame touching the home. Once flames reach the home, combustible siding can ignite, as can decks and combustible materials in the under-eave area, and window glass can break, increasing the likelihood that the home will be destroyed or will experience major damage. For homes with decks and siding made of wood or wood-based products, or other combustible products, it is critical to create and maintain an effective defensible space that minimizes the chance that combustibles close to the home will ignite.

What you can do

The odds of home survival increase when a coupled approach, which encompasses the home as well as the maintenance of the vegetation and other combustible materials on the property, is implemented. Such an approach combines

- careful selection, placement, and maintenance of landscaping vegetation and application of a three-zone defensible space strategy
- awareness and management of other combustible materials on the property (for example, leaf litter or outside furniture and furniture cushions)
- incorporation of fire- and ember-resistant construction materials, with particular attention given to installation details and maintenance

Defensible space zones: What to implement

Defensible space is a term used to describe actions to take in zones around a home that involve the careful selection, location, and maintenance of vegetation and other combustible materials on a property. The goal of defensible space is to

- eliminate pathways for a wildfire to burn directly to the home
- reduce radiant heat exposures
- reduce the potential for embers to ignite vegetation and other combustible materials adjacent to the home
- provide a safe place for fire personnel to defend the home and allow safe routes for evacuation

Implementing an effective defensible space strategy requires awareness that overgrown, dense, or unmaintained vegetation creates significant vulnerabilities (fig. 2)—and that it can enable fire to burn to the home through several fire-spread scenarios, including ember ignition of vegetative debris on the ground and ember ignition of vegetative debris on roofs. Ignition of outbuildings can also occur due to ember ignition of nearby combustibles. These fire-spread scenarios can also result in radiant heat

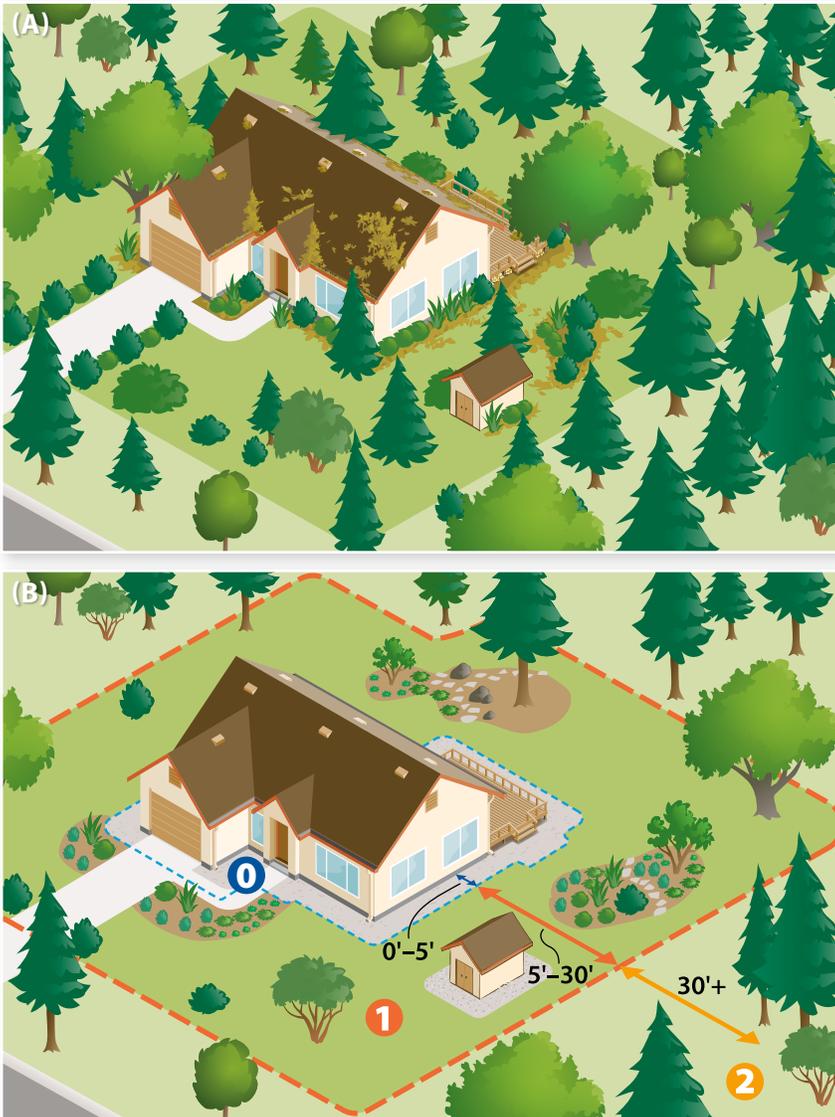


Figure 2. Before (A) and after (B) implementation of the three-zone defensible space strategy. While this figure shows a forested setting, the same concepts apply to other vegetation types or more residential settings.

or flame contact exposures to the home. Additional fuel reduction strategies, such as reducing vegetation along access routes or limbing trees to allow for easier passage of fire equipment, should be implemented to create safe routes for evacuation.

Zone Zero: Ember-resistant zone (0–5 ft from home)

Zone Zero (see fig. 2) is the area within 5 feet of the house and any outbuildings, as well as the area under the footprint of all attached decks and stair landings. For some, removing combustibles in Zone Zero may be a radical change, but both postfire assessments and research (Hedayati et al. 2018) have

demonstrated the importance of this area in reducing the threat from wildfire-caused exposures. The most critical part of an effective defensible space strategy includes Zone Zero because eliminating combustible materials and vegetation in this region reduces the potential for direct flame contact and elevated radiant heat exposures that would result from near-building ember ignitions. Because embers can accumulate at the base of an exterior wall, it is essential that Zone Zero features be coupled with a 6-inch noncombustible zone between the ground and the start of the building's exterior siding.

What can be kept

In this zone, removing combustible plants, planter boxes, combustible mulches, wood piles, and wooden fences is highly recommended. In some cases, this may mean placing walkways closer to the home and placing garden beds 5 feet or more from the home. Zone Zero is an excellent location for walkways or hardscaping with pavers, rock mulch, or pea gravel. In some cases, it may not be possible to remove all vegetation. In such situations, develop and maintain

- a well-maintained and irrigated lawn (for example, mowed dry grass less than 1 inch in height would be an acceptable alternative)
- sparsely planted, widely separated, low-growing, nonwoody, herbaceous plants without surrounding combustible mulch

In addition, some low-growing ground cover (such as *Fragaria*, *Ajuga*, *Alyssum*, succulents, moss, and so on) may be acceptable alternatives. Keep in mind that a decision to keep vegetation in this zone creates several challenges because the plants shed dead foliage and may develop a dead thatch layer. In addition, their presence may serve as a net that accumulates dead leaves and debris blown in the wind, which can collect at the base of the building's exterior walls and can be difficult to remove. As a rule of thumb, the more vegetation present in Zone Zero, the more likely the horizontal and vertical protection functions of the zone will be compromised, resulting in ignition of this vegetation and flames that can impinge on the building's siding.

Actions to take in Zone Zero

Creating Zone Zero requires removing combustibles near the home and under attached decks, as well as developing a maintenance program to rake, sweep, or dispose of leaves and other debris that accumulate throughout the year. Suggested actions include

- removal of accumulated leaves or needles
- removal of combustible mulches
- removal of woody vegetation of any type, including foundation plantings and climbing plants
- relocation of planters made from combustible materials or that contain woody plants
- relocation of all stored firewood, lumber, storage containers, and propane tanks
- removal of tree limbs overhanging the building (these limbs will lead to greater accumulation of vegetative debris on and near the home)
- replacement of wooden gates and arbors that attach to the house (replace with metal or other noncombustible alternatives)
- replacement of natural fiber doormats, or locating them inside when a wildfire threatens
- relocation of plastic garbage and recycling containers when fire threatens; alternatively, storing them in a noncombustible enclosure—for example, a metal structure or one clad with a fiber cement product

Firewood, lumber, storage containers, and propane tanks should be placed more than 30 feet from the home. If a neighboring property lies closer than 30 feet away, move these items as far away as possible. Firewood can be stored in a noncombustible enclosure. Larger propane tanks can also be enclosed, or undergrounded.

When wildfire threatens, and if there is sufficient time, take a series of steps in Zone Zero before evacuating. These actions include moving combustible cushions and natural-fiber doormats inside and relocating wicker furniture away from the house. Also, propane tanks for gas grills located on patios or decks should be moved as far from the home as possible. Propane tanks' valves should be turned off and the tanks should be left standing up so that,

if they vent, they vent upward. If no suitable outside location for a tank exists, it should be moved indoors. In addition, close all windows, pet doors, and operable skylights.

Zone One: The lean, clean, and green zone (5–30 ft from home)

Zone One adds a defensible zone that extends outward from Zone Zero to 30 feet from the house. In this area, the goal is to reduce the connectivity between garden beds, shrubs, and trees so that if a wildfire enters this zone, the vegetation will not burn to the house or into the crowns of trees. If fire personnel are available, Zone One can also provide a safe place where they can work to defend the home.

What can be kept

Short-statured trees, irrigated lawns, and garden beds, along with other landscaping elements—which provide shade and beauty for a home—are appropriate in Zone One. From a fire-prevention perspective, the goal in this zone is to reduce the connectivity between islands of vegetation by increasing spacing between trees, by removing lower branches of trees and shrubs to reduce ladder fuels, and by creating areas of irrigated and mowed grass or hardscape between lush vegetation islands. Key strategies include

- maintaining the moisture content in the vegetation located in this zone by selecting plants that retain moisture and use water efficiently
- pruning and thinning plants to reduce fuel densities
- creating separation between plantings, trees, and the home to achieve fuel and vegetation discontinuity

Actions to take in Zone One

Working outward from the house, continue to manage accumulations of leaves and other vegetative debris, limb and prune trees, and mow or trim grass to reduce pathways along which fire can reach the house. Key concepts include

- removing all dead and dying grasses, weeds, shrubs, plants, and trees
- disposing of all fallen leaves, needles, twigs, bark, cones, and small branches surrounding the vegetation

- incorporating organic soil amendments to increase water holding capacity before planting and using noncombustible rock mulches and avoiding shredded bark mulch (gorilla hair)
- allowing space between shrubs measuring at least two times the height of mature plants, increasing spacing on steeper slopes (fig. 3)
- trimming tall trees to remove limbs from 6 feet to 10 feet off the ground (see fig. 2); for younger and smaller trees, limbing lower branches over time but maintaining at least two-thirds of the total height in foliage (that is, only removing branches in the lower one-third of the tree)
- removing branches that overhang the roof of the home or come within 10 feet of chimneys; overhanging tree limbs lead to greater accumulation of vegetative debris on and near the home

- moving firewood and lumber out of Zone One—or storing in a noncombustible enclosure
- removing combustibles from around and under detached decks and overhead structures (pergolas, gazebos, and arbors, for example); avoiding incorporation of climbing vegetation on these structures
- reducing ignition sources for wooden structures by removing vegetation and other combustibles around and at the bases of wooden fences, outdoor furniture, and sheds and other outbuildings
- if Zone One extends into a neighbor’s yard, coordinating actions with the neighbor to enhance the value of your collective efforts

Zone Two: The extended, or reduced-fuel, zone (30–100 ft from home)

Zone Two extends from 30 feet to at least 100 feet from the home (or more, if manageable). This zone may need to be extended when the home is located on a steep slope. In this zone, the goal is to reduce the flame heights of an approaching wildfire or spot fire. Due to modifications of tree or shrub spacing and reductions in the connectivity between tree limbs and shrubs, a fire burning under moderate conditions may drop out of the tree or shrub canopy to the ground. Also, if fire personnel are available, they may find a safe place to defend the home. These actions will increase the effectiveness of Zone One efforts.

What can be kept

In this zone, the goal is to moderate potential fire behavior by reducing the density of trees, shrubs, and herbaceous plants or grasses to slow fire spread and reduce flame height. Vegetation does not need to be eliminated, but should be managed.

Actions to take in Zone Two

In this zone, focus on managing the space between tree and shrub canopies to create islands of vegetation. Prune lower branches or remove understory shrubs to eliminate the risk of fuel ladders. Key strategies include

- thinning trees so the branches that extend between trees, or groupings of trees, are separated by at least 10 feet; removing dead

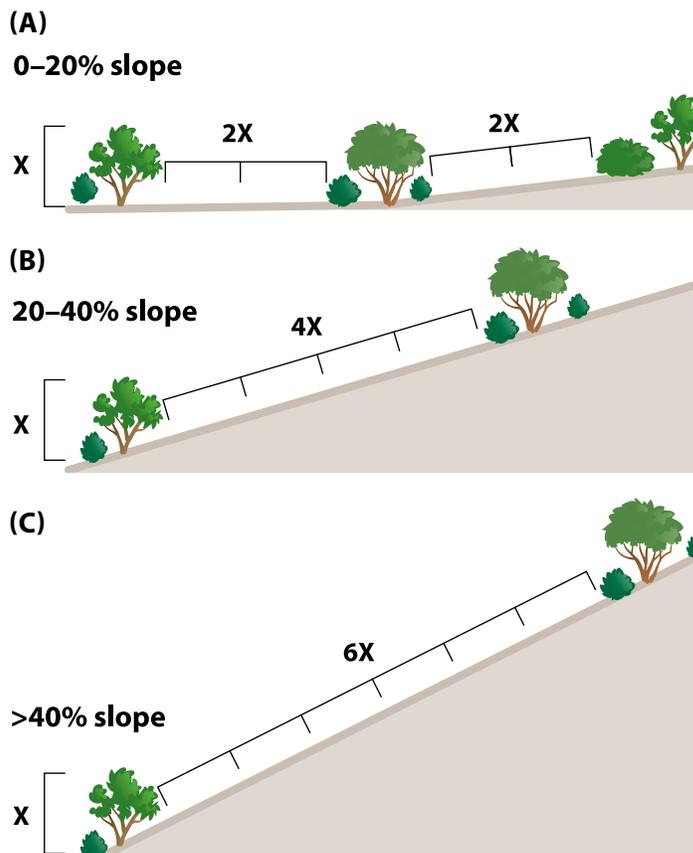


Figure 3. Distance between islands of vegetation increases as slope increases—in the figure, from 0 to 20% (A), 20 to 40% (B), and greater than 40% (C). The distance between islands will also vary with the height of the tallest plant in each island grouping. Spacing distance, shown as “x,” is a function of the slope and the height of the vegetation.

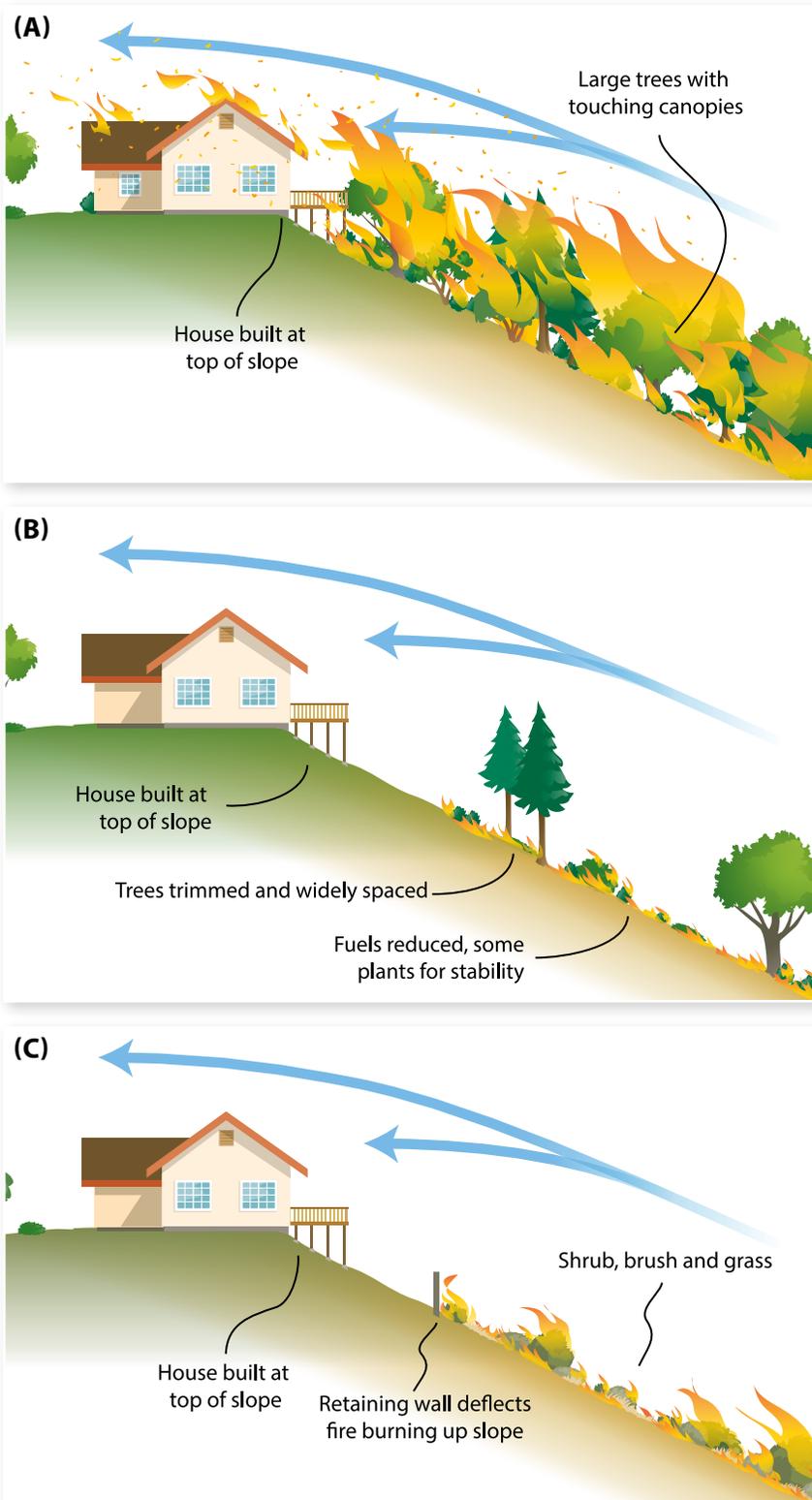


Figure 4. When an attached deck overhangs a slope, take additional precautions to reduce the chance that flames from burning vegetation can impinge on the underside of the deck (A). When downslope vegetation is composed of trees (B), thinning, limbing, and removing ladder fuels are recommended because flame heights from trees can easily exceed the height of a noncombustible wall. When downslope vegetation is low-growing (that is, shrubs, brush, and grass), clearance can be supplemented with the addition of a noncombustible wall (C).

or dying trees and branches; planning for the growth of retained trees

- for taller trees, limbing the lower branches up to a height of at least 10 feet to reduce connectivity between fuels on the ground and the tree canopies
- mowing grasses to a maximum height of 4 inches
- disposing of fallen leaves, needles, twigs, bark, cones, and small branches
- removing all piles of dead vegetation
- storing exposed woodpiles on bare mineral soil or other noncombustible surfaces, such as rock or concrete, and providing as much separation as possible from other combustibles (for example, 5–10 feet); covering woodpiles with a tarp treated with fire retardant or enclosing them in a noncombustible structure (to avoid accumulation of vegetative debris inside woodpiles, which is easily ignited by embers)
- if Zone Two extends into a neighbor’s yard, working with neighboring property owners so that the actions of each owner provide mutual benefits

Steep slopes

If a home is located on a steeper slope (see fig. 3), in a drainage, in a windy area, or in an area surrounded by unusually dense, tall vegetation, the need for thinning increases. Additionally, if the home’s surroundings include a vegetation type that is especially prone to ignition, or if the area has an active fire history, greater clearance and separation between plants and plant groupings will be needed. How much space is needed between trees, shrubs, or groupings is a function of slope (see fig. 3). If a home is at the top of a slope, keep in mind that fire and heat rise, allowing for preheating of upslope fuels, which results in the potential for more intense fire behavior (fig. 4). In these cases, greater effort should be directed toward the area downhill or upwind from the home. When an attached deck overhangs the slope, higher levels of fuel treatment should be used to minimize the chance that flames will contact the underside of the deck (see fig. 4). For shrub, brush, and grass vegetation types, installing a noncombustible retaining wall downslope

from the deck could reduce the threat of a fire burning upslope (see fig. 4).

Space limitations

If your property doesn't extend 100 feet or more around your house, prioritize the actions recommended for Zones Zero and One (fig. 5). After completing these actions, work with neighbors so that each side supports the other's

efforts. Additional resources may be available from CAL FIRE or your local fire department, Fire Safe Council, or Firewise Community.

Defense of larger properties

As property size increases, so do the opportunities for strategic fuel treatments (fig. 6). Along any road system it is good practice to thin and prune trees, mow grass, and cut back shrubs to allow for safe emergency access and evacuation from the property. Strategic fuel breaks may be an option, especially along ridgelines or other critical control points that the local fire department can help identify. Ladder fuel reduction on a broad scale will be beneficial for tree survival during wildfires. Water storage and installation of easily accessible pipe fittings for fire personnel are also recommended.

"Fire safe" plants and landscaping

Is there such a thing as a "fire safe" plant? While some plants are marketed and described as "fire safe" or "fire resistant," all plants will burn under the right conditions, regardless of their classification. A plant's environment and maintenance generally have more influence on the combustibility of the plant than does its characterization as fire safe or not fire safe. For example, a plant with a good water supply could have a greater growth form (that is, grow taller and wider) and hold leaves longer, whereas a plant in a stressed or drought condition may have stunted growth and accumulate dead materials. Therefore, a certain species may be relatively fire resistant in one environment and less so in another. Some plants, such as lavender, may initially have lush supple growth—but several years later, the growth may be woody and choked with dead materials. Other plants, under a green surface, may develop a highly combustible dead thatch layer.

Plant lists

Be cautious about "fire safe" plant lists and labels. In general, there is little evidence to support fire safe claims. In a recent review of 20 years of plant flammability studies, Bethke et al. (2016) determined that fire safe labels often relied on inconsistent types of testing or no testing at all—in part because, according to

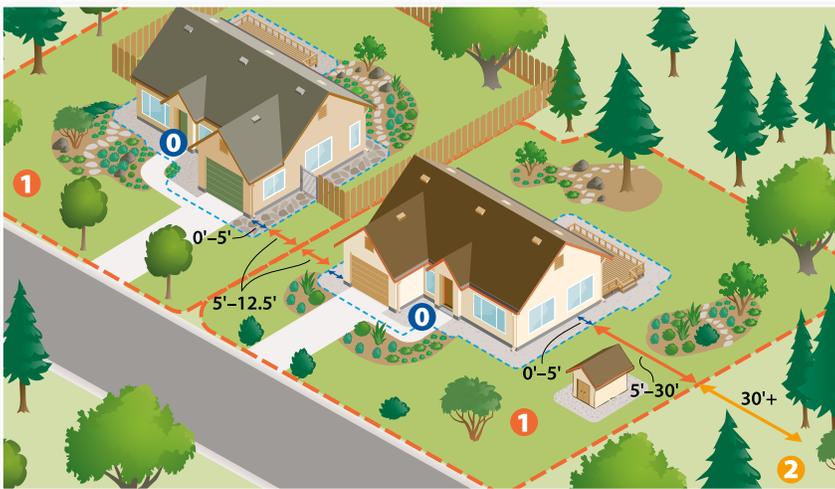


Figure 5. When spacing between homes is less than 30 feet, home-to-home fire spread is likely. By working together, neighbors can minimize the chance of individual home ignitions and can increase the impact and reach of each other's defensible space efforts. A critical step is neighborhood development and maintenance of effective defensible space, including Zones Zero and One. Incorporation of a metal gate, as shown outside the house on the left, is part of an effective Zone Zero.



Figure 6. Before (A) and after (B) a fuel reduction treatment in which smaller trees are thinned and lower limbs are pruned from larger trees.

the researchers, “no consistent, standardized plant flammability testing or criteria for rating” exists to assess flammability. Furthermore, across regions and climate areas, the researchers found that labels confused common and species names, relied on problematic definitions, and gave inconsistent recommendations for plant care.

Plant characteristics and basic properties

Given these difficulties in ratings and labels, what can be done? When selecting plants, apply an ignition-resistant framework to the decision-making process by asking a few key questions.

Are the plant’s leaves high in moisture, and therefore less likely to ignite? The leaves of plants that grow in vegetable gardens, for example, are high in moisture.

Does the plant contain a lot of waxes, oils, and resins? The leaves of waxy and oily plants have a protective shine or film that will likely be more flammable and release more energy when they burn. Resinous plants include many conifers.

Does the plant have an open-growth structure (fig. 7)? A more densely structured plant, like a juniper or cypress, can capture embers and may be more likely to ignite, especially if the densely structured areas of the plant consist

of dead and fine fuels. A densely structured plant is also more likely to readily ignite from a surface fire.

Does the plant accumulate dead branches, needles, or leaves? A plant with a big leaf or needle drop creates a greater need for cleanup around the property, on the roof, and in rain gutters.

Does the plant shed bark? A plant that sheds bark or branches is likely to need more regular cleanup to reduce fuel accumulations on the ground.

How fast does the plant grow? How tall will the plant grow? A plant that grows quickly may exceed growth expectations and require greater maintenance.

Native plants and pollinator-friendly or drought-tolerant plants can be good choices for people who value these plant characteristics, but such features don’t directly translate to fire resistance.

Plant placement and maintenance

Where plants are placed and how they are maintained are more important than the type of plant selected. When vegetation touches the siding located in front of windows, under eaves and vents, or under or near a deck, the likelihood increases that a home will be ignited and destroyed during a wildfire. Incorporating

(A)



(B)



Figure 7. Over time, a dense manzanita bush can become a plant with lots of dead branches (A). With regular pruning, it is possible to create a more open-growth structure that eliminates ladder fuels, resulting in a plant that is less susceptible to wildfire (B).

Zone Zero practices, whereby combustible vegetation and other combustible materials are minimized or eliminated in the area immediately adjacent to the home, reduces the potential that near-home ember ignitions will result in flame contact exposures to the house. Following Zone One recommendations—which include separation of landscaping into islands of vegetation, resulting in fuel discontinuity—can minimize the chances of direct flame and radiant heat exposures to the home and increase the odds of home survival.

From a fire-resilience perspective, essential vegetation management involves good water management practices, appropriate fertilization, and regular plant pruning and cleanup (fig. 8). With regular watering, plant health increases, and plants that are green and lush (or nonwoody) are more resistant to ignition. Drip irrigation and mulching can be beneficial for water conservation (Downer and Faber 2019). Unfortunately, combustible mulches near the home create an additional fire risk (Quarles and Smith 2008). In Zone Zero, eliminate combustible mulches; in Zone One, recognize that combustible mulch can burn or smolder. Rock mulches are noncombustible and are a better choice for Zone Zero. As such, it may be a better alternative when working near the perimeter of Zone Zero.

As plants age, overhead branches receive the majority of the light and older branches are shed. To decrease the potential that fire will climb from the ground into the upper portion of the plant, remove lower branches and prune to create a more open structure. Clean up dead leaves, branches, and flower heads on the ground. Monitor plant height and prune to reduce continuity to taller vegetation.

Other considerations

Additional elements are important to evaluate in a landscaped yard. Do the trees on the property provide protection from the sun, or do they contribute to increased fire risk? What about other wooden structures that support climbing vines or provide shade?

Shade trees

Trees have many beneficial qualities, including their ability to absorb solar radiation and provide shade. Unfortunately, a tree that overhangs a home can cause physical damage to the house when branches rub on the roof or walls. More importantly, from a fire perspective, leaf and needle drop result in the accumulation of debris on the roof and decks, in gutters, and on the surrounding landscape. For this reason, remove trees or branches that overhang any roof or deck. A healthy and lush green tree canopy itself is not necessarily receptive to

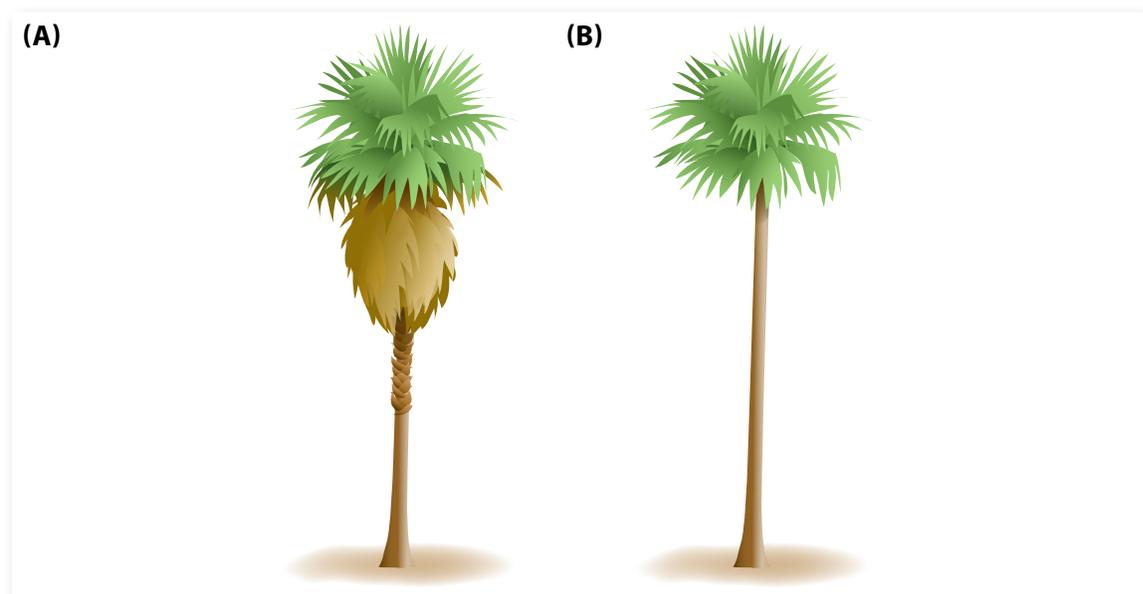


Figure 8. Vegetation maintenance is critical to reducing ember receptivity and continuity of fuels from the ground to the crown. When working with a poorly maintained palm (A), prune dead fronds until the branches grow in a horizontal position (B). Be careful not to overprune and stress the plant.

embers or immediately flammable. To maintain the benefits of a shade tree while simultaneously increasing fire safety, remove trees in Zone Zero and favor the retention of trees in Zone One—as long as the lower limbs are pruned and vegetation, vines, and other dead fuels that could allow fire to move from the ground to the upper portion of the tree (that is, the tree crown) are eliminated. If a tree in a Zone One location is diseased or showing signs of decline, consider removal and replacement. If trees in Zone Zero cannot be removed, it is important to understand the ongoing maintenance needed to remove leaves and debris from gutters, decks, skylights, and other vulnerable locations. Even with regular maintenance, the wind associated with an approaching wildfire will bring more debris down upon the house at the same time as distributing embers.

Trellises and arbors

Generally, decorative structures that support climbing vegetation are made of wood products and are therefore ignitable. If a home has an attached trellis, it is recommended that the structure and the vegetation be removed to implement the standards of Zone Zero. If the structure is farther from the home, work to reduce fuel continuity by removing combustible grasses, mulch, and leaf material that may accumulate at the base of the structure and provide continuity to other combustible vegetation. Keep in mind that the structure is likely to ignite during a wildfire, so the goal is to make sure that, if structure ignition does occur, it does not connect directly to other vegetation or the home.

Conclusions

Wildfire will always be a part of the California landscape. The challenge is to design and maintain homes and adjacent property in ways that reduce their vulnerability to wildfire. A key component of such protection is the proper placement and maintenance of plants on the property and around the home. Many people seek plants whose labels assure some level of fire resistance, but it is important to recognize that any plant will burn under the right conditions and regular plant maintenance

is therefore critical. To reduce a home's exposure—whether from embers, radiant heat, or direct flame contact—develop and implement a three-zone strategy whereby the highest priorities and most restrictive measures are incorporated in the area closest to the home or other building of interest. Incorporating these strategies requires adjusting the ways of the past, but with a change in approach it is possible to have both a beautiful landscape and a home that is more resilient to wildfire.

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Figure 6 appears courtesy of Humboldt County Fire Safe Council.

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Inquiries regarding the University's equal employment opportunity policies may be directed to: Affirmative Action Compliance and Title IX Officer, University of California, Agriculture and Natural Resources, 2801 Second Street, Davis, CA 95618, (530) 750-1343. Email: titleixdiscrimination@ucanr.edu. Website: https://ucanr.edu/sites/anrstaff/Diversity/Affirmative_Action/

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