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Wildfire Adaptation and Historic Buildings

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Wildfires damage and destroy thousands of buildings each year, and when wildfire spreads from building to building, entire neighborhoods can be lost in the ensuing conflagration. Because the effects can be so catastrophic, owners of historic buildings in areas at risk for wildfire should take preemptive action to adapt them to be more resilient well before one occurs. Resilience, as used in this Preservation Brief, refers to a historic property's ability to withstand and recover from a wildfire event.

The complexity of wildfire necessitates a comprehensive approach that responds to the specific fire hazards presented by a building's geographic location and surroundings. Wildfire resilience requires adaptive treatments to both the site and the building—to the site to provide **defensible space** around the building and help protect it against high-intensity fire, and to the building itself (**building hardening**) to help prevent it from catching fire. It also relies on continuous maintenance of the building and site and periodic reevaluations of the wildfire risks to ensure that the adaptive treatments remain sufficient.

Adopted wildfire code requirements and checklists produced by government entities, trade, and industry groups can be helpful, but they can also conflict with preserving the historic character and features of a historic building if applied without careful planning. Some adaptive treatments can result in unnecessary loss of character-defining features and materials or changes to the historic site and setting or, even more importantly, may not sufficiently address the historic property's specific wildfire vulnerabilities. Effective planning should result in a **wildfire protection plan** that balances preservation objectives with wildfire resilience and is tailored to both the historic significance and the vulnerabilities of the specific building, site, and setting.

This Brief provides a framework for property owners of historic buildings and others to help plan and implement a wildfire risk-mitigation strategy while preserving the character of the historic property consistent with the *Secretary of the Interior's Standards for Rehabilitation*.

The Brief delineates a methodical and iterative four-part planning and implementation process to develop a comprehensive wildfire protection plan:

- **Identify** priorities for preserving the property's historic character, including its distinctive features and attributes;
- **Assess and rank** wildfire vulnerabilities specific to the historic building, site, and setting;
- **Develop** a wildfire protection plan tailored to reducing the property's wildfire risks while preserving its historic character; and
- **Implement** the wildfire protection plan, periodically reevaluating it as necessary to ensure it remains adequate.

Developing appropriate adaptive treatments requires a good understanding of wildfire behavior and the objectives of typical treatments. Therefore, the Brief begins with background information on wildfire behavior and the benchmark "wildfire defense system" layered approach to creating a more wildfire-resilient site and building.

This information provides the technical foundation for the **assessment and planning framework** that follows to develop a property-specific wildfire protection plan, which forms the core of the Brief. Three detailed tables on defensible space, building hardening, and property maintenance identify feature-specific risks of the site and building, common adaptive site and building treatments, and preservation considerations for each. The final section discusses other wildfire risk-mitigation measures that are generally outside regular code-accepted practices but may be useful in special circumstances.

As wildfires often result in total loss, at-risk historic buildings and their sites and settings may require greater adaptive treatments than would normally

be acceptable in other contexts. Such treatments should be carefully selected to work together as part of a comprehensive risk-mitigation plan, minimizing impacts to the property's historic character as much as possible, and be developed in consultation with qualified design, preservation, and wildfire-resilience professionals. Wildfire risk cannot be eliminated entirely, but coordinated adaptation treatments can help significantly increase the resilience of historic buildings and reduce the risk of irreplaceable loss.

While principally focused on adapting historic buildings and their sites to be more resilient to wildfire hazards, the concepts and treatments presented here can be applied to non-historic buildings. Similarly, the treatment of character-defining site and landscape features is discussed throughout, and the concepts herein can be equally applied to other historic property types such as districts, cultural landscapes, sites, and man-made and natural objects. Lastly, for specific code requirements and installation details, the Brief should be secondary to adopted state and local ordinances and guided by appropriate professional expertise.

Wildfire Behavior

Wildfire risk to a historic building is directly related to the individual historic features and materials of the building and site most likely to ignite from fire exposure and potential compounding effects such as structural failure. To understand an individual property's risk and develop compatible adaptive treatments requires understanding how wildfire behaves and how historic buildings can ignite, sustain burning, and spread fire.

Fire is a chemical reaction that occurs when a combustible material and oxygen combine in the presence of heat. Wildfire ignition and spread follow the laws of thermodynamics that describe energy conservation and heat transfer, as well as the principles of fluid dynamics. Heat energy moves from hot to cold through **convection** (heat carried by moving hot gases and heated air currents), **conduction** (direct contact, including embers or flames), and **radiation** (heat transfer through electromagnetic waves, e.g., from the sun or fire). Wildfire defense systems aim to reduce the heat energy produced by a fire as it approaches a building and to interrupt or prevent conductive or radiant heat transfer to a building.

Most materials have a temperature at which they will burst into flames or autoignite without an external source, called the **ignition point** for solid materials and the **flash point** for flammable liquids and vapors. Other materials, such as vinyl, have a critical temperature when they melt, called the **melting point**. **Sustained combustion** occurs when sufficient fuel and oxygen are present for continued burning. These foundational concepts help identify which building materials and construction assembly components are most vulnerable and inform appropriate defense strategies.

Wildfire occurs when wildland fires burn out of control. Wildfire behaviors are characterized by their **movement** (rate of spread), **intensity** (heat energy produced, often signified by flame height), and indicators of rapid combustion such as **spotting**, **crowning**, and **fire whirls**. Spotting occurs when embers are carried by wind or convection to ignite new fires ahead of the main fire front. Crowning is a particularly dangerous type of wildfire where fire spreads through the canopy of trees. A fire whirl is a spinning column of fire, smoke, and hot gases that creates a tornado-like vortex; they are extremely dangerous because they can move quickly and unpredictably. These conditions undermine adaptive treatments and firefighting strategies.

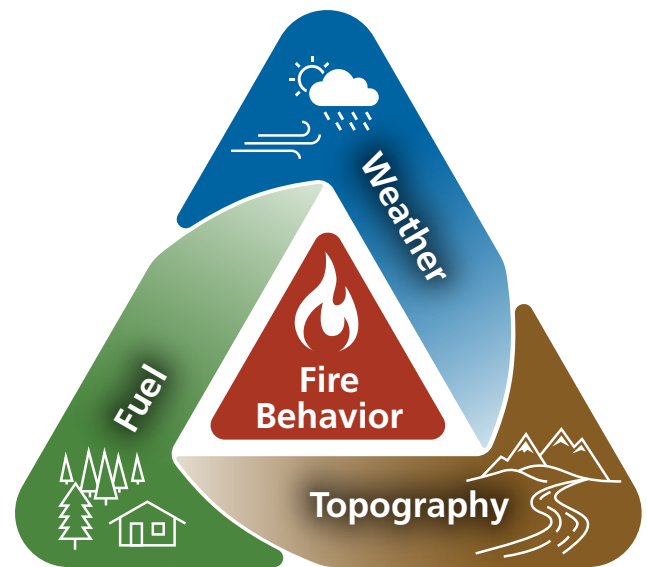


Figure 1: Wildfire behavior is shaped by three interacting variables: fuel, weather, and topography. Fuel is the only variable a historic property owner can directly manage or affect.

Graphic: Blank Space LLC for NPS

The behavior of a wildfire is shaped by **fuel**, **weather**, and **topography**, with fuel being the only factor a property owner can meaningfully influence (see Figure 1). Fuel includes vegetation, structures, vehicles, stored materials, and any other combustible element. The types, amount, and continuity of fuel determine how hot a fire burns, how long it lingers, and how quickly a fire spreads. Reducing fuel loads and breaking up fuel pathways can help reduce ignition risk and intensity, helping to control a fire by slowing its movement.

Weather conditions—especially wind, temperature, and humidity—directly influence fire ignition and spread. Wind can preheat and dry fuels ahead of the fire front and transport embers long distances. Hot, dry conditions are often associated with “fire season” because they make wood materials and vegetation substantially more flammable while cycles of plant growth followed by drought increase available fuel. Although lightning can start wildfires, human activity accounts for most ignitions near developed areas, making wildfire a year-round concern.

Topography influences the movement of air and fire. Fires typically accelerate upslope, increasing flame lengths and heat exposure to buildings uphill. Fires cresting hills can move unpredictably, and saddles and canyons can create high velocity wind funnels. Conditions for rapid fire spread can also occur when topography and weather intersect to create extreme downslope windstorms.

How Historic Buildings Ignite

For building materials and vegetation in a wildfire, the critical concern is whether the fire exposures of embers, radiant heat, or direct flame contact can raise surface temperature to the autoignition threshold (see Figure 2). Moreover, these fire exposures often act together, compounding risks. By far, embers are the most common cause of ignition and subsequent loss of historic buildings during wildfires, while flames are the most aggressive type of fire spread. Extreme or prolonged heat, alone or in combination with moisture, can also irreversibly damage historic noncombustible materials such as glass, masonry, and stucco. Understanding each type of fire exposure helps inform how a historic building can be made more resilient in response.

Embers, or firebrands, are small burning particles that can ignite combustible materials such as building materials and vegetation, directly or indirectly. They often accumulate in corners, roof valleys, gutters, at the base of walls and fences, and beneath decks—places where dry vegetative debris naturally collects. Historic buildings are especially vulnerable because traditional materials and details such as wood shingles, log ends, checks, and joints, as well as complex building geometries and decorative detailing, can trap embers or allow them into concealed spaces like attics and crawlspaces. Indirect ignition occurs when embers ignite nearby fuels such as mulch, dead leaves or pine needles, or firewood, which then ignite the building. Burning debris can roll down a sloped site toward the building and even across containment measures.

Wildfire generates large quantities of embers. High winds and convection can carry embers and burning debris at high velocity against trees, building walls and roofs, and

can deposit embers on leeward walls (walls on the side of the building protected from the wind) and in corners. In extreme intensity fires, embers can create new fires over a mile away. High wind and temperature conditions can lead to pressure differentials between the inside and outside of a building, resulting in embers being drawn into highly combustible and unmonitored spaces such as attics.

Radiant heat can ignite combustible materials without physical contact. High-intensity flames adjacent to vegetation or buildings may raise the surface temperature of a material to reach its ignition or melting point. Metal can quickly conduct enough heat to ignite covered or adjacent wood elements, and glass can transmit enough heat to ignite interior curtains or furnishings. Walls are generally more exposed to radiant heat than roofs because heat energy travels linearly. Radiant heat decreases with distance from the heat source, which is an underlying principle behind the dimensions used to create defensible space zones or rings discussed later in this Brief.

Direct flame contact is the fastest method of fire ignition. The flame provides immediate, concentrated heat to a material's surface. Once something is burning, combustion continues as long as fuel, heat, and oxygen are available. Suppression methods work by reducing temperature and oxygen levels. Fuel reduction can help slow wildfires and reduce their intensity, thereby allowing fire-suppression activities, if available, a better chance of succeeding.

Adaptive treatments to block ignition and lower heat exposure are fundamental to helping protect historic properties during a wildfire incident. Once a building ignites, it becomes a **structure fire** that can burn for hours, increase radiant heat in its vicinity, and spread to adjacent buildings. Firefighters combating structure fires require separate training and different resources than for wildland fires. During large or rapid wildfire events, the suppression of structure fires is frequently deprioritized entirely or unavailable, since the firefighting resources are committed to wildland fire containment and community evacuation.

The primary strategy for property owners must be preventing ignition of a building through the pre-event creation of defensible space surrounding the building and

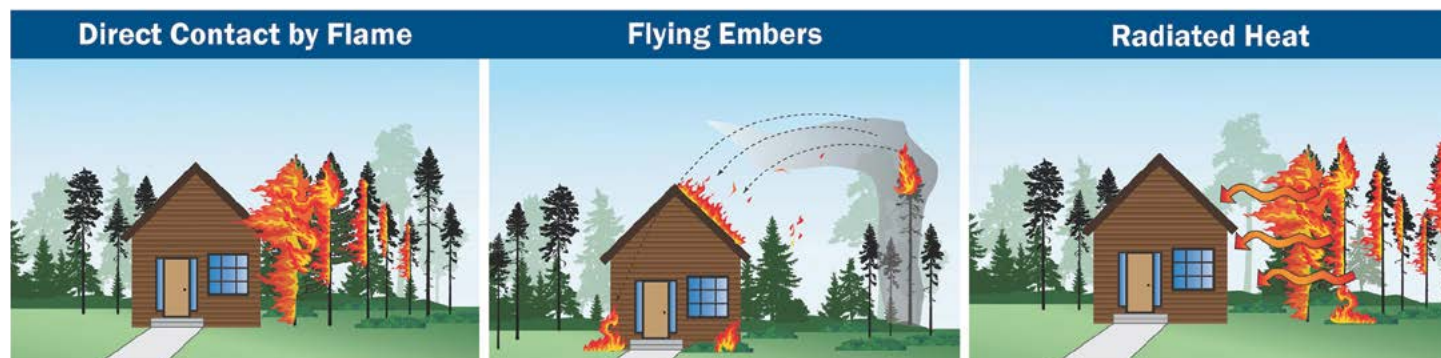


Figure 2: Wildfires ignite buildings through three mechanisms: direct flame contact, flying embers, and radiant heat. Embers cause an estimated 90 percent of structure ignitions, though these exposures often act together, requiring adaptive treatments that consider all three. Graphic: FEMA

hardening its exterior, rather than relying on a suppression response. The discussion of wildfire adaptive treatments later in this Brief is organized in part around the specific fire exposures that might put the building at risk.

The Wildfire Defense System Approach to Protecting Historic Buildings

Because of the high potential for fast, unpredictable wildfire behavior and compounding fire exposures, the most effective protection approach is a comprehensive, layered defense, or wildfire defense system, responsive to the specific fire hazards of the historic property and its surroundings. For each property, a tailored system integrating alterations to the building exterior and its site works best to help slow fire movement, reduce fire heat and growth, and prevent new fire ignitions. For a historic property, this should be accomplished while also preserving and retaining its historic character and features.

- **Setting:** The larger surroundings or context of the property influences fire behavior and approach pathways. Utilities and infrastructure (power, water, access) also impact wildfire risk and possible defense strategies. While many variables are outside an individual owner's control, collaborating with neighbors and the broader community can help reduce parcel-level risk.
- **Site:** The site itself provides a first line of defense to an approaching wildfire. The site should be configured and maintained as concentric defensive zones or rings around the historic building to slow fire, reduce intensity, and support safe firefighting. These design goals are achieved by creating and maintaining what is referred to as defensible space around buildings for a radius of 100 feet minimum from the building perimeter, that is, the outermost edge of the building including its projecting or attached features.
- **Building Enclosure:** The building exterior should be hardened to be as noncombustible and impenetrable as possible to intrusion by embers, flames, and radiant heat commensurate with the wildfire hazard. Building hardening is the final line of defense against approaching fire and its ignition mechanisms.

Wildfire vulnerabilities can be increased by deferred maintenance. **Continuous repair and maintenance activities** of both the defensible space and the building exterior are integral to the wildfire defense system. Vegetative fuel management activities, detailed in the **Property Maintenance Table**, can help provide consistent, measurable risk-reduction. Resilience planning must include monitoring, inspection, clean-up, and repair activities on a routine basis.

Risk and the Historic Building's Setting

The topography, vegetation, and the density of land development of the surrounding area will establish the type of wildfire, how quickly it may spread, and how intense the flame front may be. Controlling wildfire depends on the fuel involved, available utility supplies, and responder access. While these could be considered external factors, they should be understood as part of the planning process for an individual property.

Fire in areas dominated by grasses or low vegetation can be intense, but the fire generally moves fast and does not linger unless it engulfs other fuels. Conversely, heavy fuels, such as dense vegetation or heavily forested surroundings, can result in long linger times that generate higher temperatures, increased exposure duration, and a greater chance of an ember or flame entering a building. More densely developed settings can have high concentrations of diverse fuels including grass, trees, buildings, and vehicles that can lead to more complex fire behavior. Understanding the topography and fuel in the area surrounding the building, both offsite and onsite, helps identify vulnerabilities along the property boundaries.

Street trees, for example, can present substantial risk, depending on species, age, spacing, proximity to the building, and maintenance. At the same time, a continuous canopy of more flame-resistant tree species, an orchard, or solid, noncombustible walls can create windbreaks, potentially helpful at reducing ember spread. Cemeteries and golf courses that are mostly manicured turf with specimen or accent trees may help slow or stop a fire's spread. In densely populated areas, cooperation and communication among neighbors may become essential to wildfire resilience.



Figure 3: Wildland fires can quickly become urban conflagrations in densely developed communities. Photo: ©Ringo Chiu

Utilities should be evaluated for whether there is sufficient power and water in the event of a fire; whether gas, power, and water systems are aging and need upgrades; whether electrical transformers need upgrading; and whether power lines should be undergrounded. Infrastructure considerations include proximity to the nearest fire station, as well as how easily firefighters can locate and access the property considering signage and road clearances.

Defensible Space and the Historic Building's Site

Wildfire risk is managed on the site of the historic building by creating and maintaining a **defensible space**, sometimes called the home or structure ignition zone, consisting of concentric treatment zones (also referred to in the Brief as rings or bands) around the building. Each zone has a different objective intended to progressively slow the movement and help reduce the intensity of a fire as it approaches the building and to avoid the ignition of new fires immediately around the building. A proper defensible space gives the building some chance of surviving a wildfire because the likelihood of any building surviving a high-intensity fire is low.

To create a proper defensible space, fuel around a building is selectively reduced for a total distance of 100 feet minimum from the primary building. The defensible space may need to be enlarged, its shape altered, or both, to help adequately protect the resource in response to the specific facts and circumstances of the building, its contents, site, and setting; some situations may require a total distance of 200 to 500 feet.

The size, shape, number, function, and nomenclature of the individual zones will vary by jurisdiction. This Brief follows a defensible space approach established by three zones radiating outward from the building (see Figure 4).

- **Zone Zero** (also known as the Immediate Zone, Noncombustible Zone, or Ember-Resistant Buffer Zone) is the area immediately surrounding the building where all combustible materials should be eliminated to help protect the building against the threat of localized fires caused by embers and creeping fire. Zone Zero is established by measuring a minimum of 5 feet from the building perimeter, defined as the outermost edge of the building including its eaves, projections, and other attached features. Zone Zero consists of this band, plus the area between the building perimeter line and the building exterior wall (see Figure 12).

The 5-foot minimum dimension directly relates to the anticipated flame length from nearby combustible materials and the objective of preventing flames from reaching the building or any attached features. Regulations or higher performance objectives may increase that dimension; for example, above

Defensible Space Zones

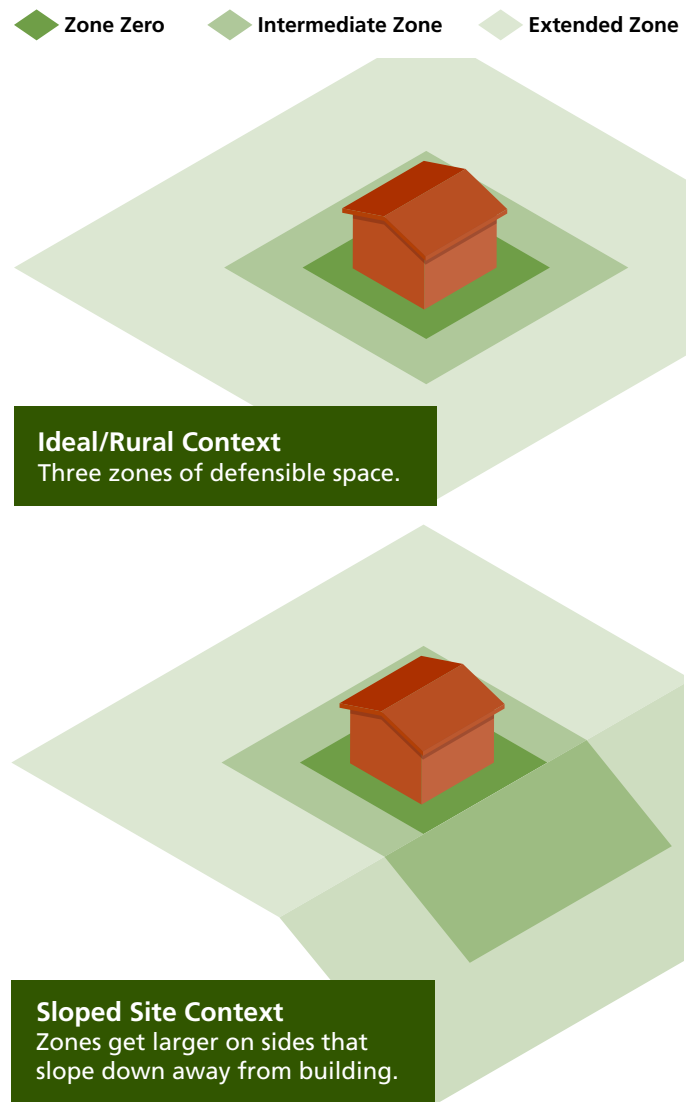


Figure 4: Defensible space aims to interrupt fire approaching a building by keeping flames low in the Extended Zone, decreasing fire behavior in the Intermediate Zone, and eliminating combustibles in Zone Zero. Sloped terrain is one factor requiring enlarged base zone dimensions and shape. Graphic: Blank Space LLC for NPS

downslope areas where flame lengths are longer or to better protect reentrant corners, which are among the most vulnerable points on any building. Driveways and other pathways should also have a Zone Zero setback to facilitate safe egress from the site and enable firefighter access.

- **Intermediate Zone** (in the middle, also known as Zone 1 or “Lean, Clean and Green” zone) is the next 25 feet (min.) beyond Zone Zero. This zone is sized about five times wider than Zone Zero because its purpose is to help reduce the fire intensity from moderate to low when it reaches Zone Zero and to create discontinuity (or fuel breaks), both horizontally (e.g., fences and hedges) and vertically (e.g., shrubs below trees). Low intensity fires move slowly, have small flame heights and low heat output, and are, therefore, easier to defend against.

Flame lengths increase proportionally with terrain slope, often necessitating increases to zone dimensions by 50 to 100 percent on downslope portions of the site. Increasing distances also helps manage radiant heat from the flame front. In more urban and other densely developed situations, the entire property may be within, or mostly within, the first two zones. These circumstances typically require further reducing vegetative and other combustible materials up to the property lines and possibly increasing some building hardening requirements.

- **Extended Zone** (farthest out, also known as Zone 2) is the next 70 feet (min.) beyond the Intermediate Zone. This dimension is almost three times the width of the intermediate zone and is designed to help reduce fire to moderate intensity when it reaches the Intermediate Zone. Moderate intensity fires are more predictable and produce less spotting, in contrast to high or extreme intensity fires.

The required width of the extended zone may be enlarged when terrain and fuel conditions make longer flame lengths or more intense fires more likely, or when the property contains irreplaceable resources or presents life safety concerns.

One of the most important aspects of creating a proper defensible space around a building is to ensure it is adequately sized and that the shape takes into account the level of wildfire hazard and vulnerabilities posed by the building's geometry and the site terrain, among other factors. Determining the size and shape of the defensible space begins at the **building perimeter**, which regulations typically define *not as the building's exterior wall surface*, but as the outermost edge of the roof, any projections, and any attached features such as decks or porches. This definition for what constitutes the building perimeter for the purposes of wildfire risk-mitigation arises from the need to help protect the outer edges of the building, its projections, and any attached features against flames.

Additionally, to help protect against embers, the Zone Zero treatments must also include the site area between the building's exterior wall surface and the building perimeter line. For example, if a building has an eave that projects two feet from the exterior building wall, the 5-foot-minimum dimension would be measured from the outermost edge of

the eave (the building perimeter), and the actual Zone Zero would extend seven feet as measured from the exterior building wall (see Figure 12).

Because wildfires cross property boundaries indiscriminately, coordination with neighbors or the larger community may be most effective to fully manage the risk of deficient defensible space between buildings such as in urban and suburban situations. Accessory structures, outbuildings, or small-scale landscape and site features may also require their own defensible space and hardening measures. When buildings or features are grouped such that their zones overlap, defensible space should be measured from the building perimeter of the overall grouping rather than each structure individually (see Figure 5). The **Defensible Space Table** elaborates on these and other considerations.

Defensible Space Zones

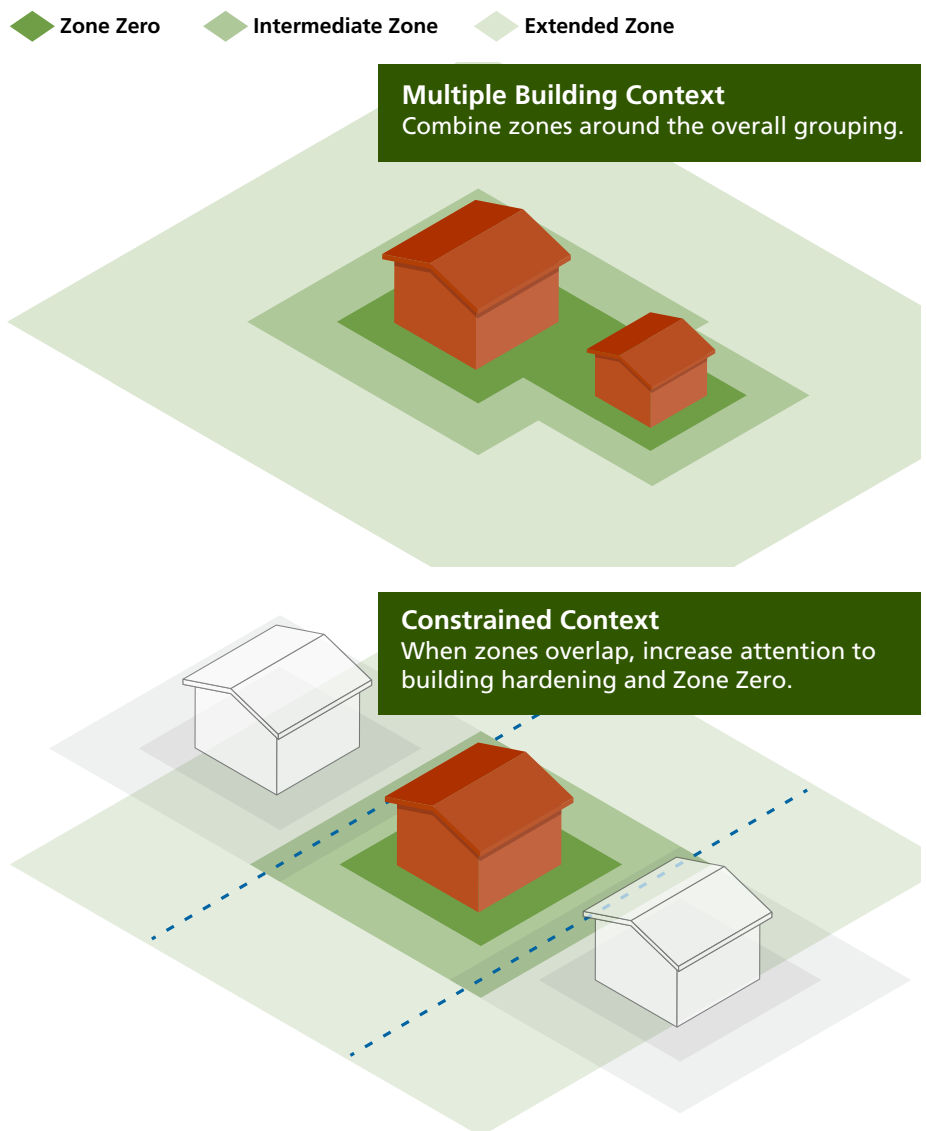


Figure 5: Once ignited, a building can burn for hours, radiating intense heat and spreading fire to adjacent structures. Treatments that help prevent this building-to-building spread are especially critical in densely developed areas. Graphic: Blank Space LLC for NPS

Building Hardening and the Historic Building Enclosure

The historic building's enclosure physically separates exterior and interior environments and defines the historic character of the building through its features and materials. In the context of wildfire, the building's exterior must resist ignition, be impenetrable to embers and flames, and limit heat transfer. Direct exposure to the fire front typically lasts only a brief period (less than six minutes on average). Equally if not more importantly, the building must be able to withstand longer periods of exposure to firebrands and ember storms ahead of the front, radiant heat from the fire front, neighboring and localized fires, as well as exposure to residual fires and embers.

The extreme complexity of wildfire challenges the ability to develop adequate adaptive treatments for any building. Proper building hardening should address all exterior building elements—roofs, eaves, gutters and downspouts, exterior walls, flashing, underfloor enclosures, projections, windows, exterior doors, and vents, as well as any detached accessory buildings or structures. Joints, fasteners, and coatings can also create weak points.

Highly vulnerable building features commonly include complex massing and roof geometries, combustible cladding and trim, viga/log ends and other decorative wood features, single-glazed windows and doors, covered porches and carports, and projecting or cantilevered architectural features—all character-defining features and materials typical of many historic buildings. The wildfire vulnerabilities of such often distinctive historic features as open eaves with decorative brackets or expressed rafter tails are not fully understood. Character-defining features of mid-century modern buildings can present a different set of vulnerabilities, such as expansive plate glass windows, deep overhangs, and an intimate spatial relationship with landscape in courtyards or integrated planters.

Wildfire Hazard Areas and Wildland-Urban Interface (WUI) Codes

The guidance in this Brief should generally be applied to properties in areas formally designated by state or local government as a wildfire hazard area (see Step 2 of the Framework for Developing a Wildfire Protection Plan). Designated wildfire hazard areas are commonly in what is called the **wildland-urban interface (WUI)**. The WUI is where human development meets or intermingles with undeveloped wildland or vegetative fuels, resulting in increased potential for wildland-fire mechanisms to ignite structures. However, at-risk historic properties may also be directly adjacent to such areas or situated where wildfire threats are increasing due to changing conditions.

Construction requirements for buildings in designated wildfire hazard areas typically must comply with adopted building and fire codes, plus special building construction codes for WUI areas. WUI codes seek to specify a minimum level of protection to safeguard life and property against burning wildlands and adjacent buildings and to keep building fires from spreading to wildland fuels, even in the absence of fire department interventions. The WUI provisions are generally not designed for sheltering-in-place.

The wildfire defense system approach described in this Brief originates with WUI building codes intended for new construction and alterations within WUI areas. WUI building codes are developed based on statistical probabilities, post-incident reports, and other scientific research from around the world, and they seek to be as broadly applicable as possible. To this end, WUI code provisions are generally enumerated by building feature and by individual fire protection standards for establishing and creating defensible space, controls for combustible materials storage in relation to the building, and for interior automatic sprinkler systems. Many provisions are prescriptive-based; performance-based ones generally require compliance of a feature with specified testing standards.

Construction Materials and Assemblies

Although this Brief focuses on special WUI code requirements, regular adopted building codes still apply and must be met when stipulated by local governments. While building codes establish fire-resistant ratings for building elements based first on the type of construction, wildfire codes establish ignition-resistant construction requirements *based on the severity of the wildfire hazard*. Because building codes and special WUI codes are designed for distinct purposes and based on different criteria, the differences should be understood, and construction materials and assemblies will need to meet both sets of requirements (i.e., for both fire and ignition resistance).

Fire resistance refers to the ability of specific construction materials and assemblies to withstand fire for a certain period of time (e.g., one hour) without losing structural capacity. Fire-resistant-rated construction aims to confine a fire within a specific area of a building for a rated period to allow time for occupant evacuation and for fire crews to suppress the fire at the source, isolating damage to that area.

Ignition resistance refers to the ability of the construction to resist ignition or sustained burning when exposed to a source of heat or flame and preventing it from becoming involved in a fire. Ignition-resistant materials and assemblies are generally required only for the outermost layer of the building's exterior. Appropriate detailing is essential to help protect vulnerable substrates and avoid penetration of embers, heat, or flame.

State/local jurisdictions and WUI codes commonly establish different tiers of ignition-resistant construction requirements commensurate with hazard level. Higher tiers may require more robust treatments depending on the amount of defensible space around a building that can be achieved, available water supply, or other site-specific conditions.

Ignition-resistant materials generally fall into three categories: **noncombustible materials** that do not ignite or burn when subjected to fire; **ignition-resistant materials** that hinder ignition or sustained flaming; and **fire-retardant-treated (FRT) wood**, that is wood that has been factory-impregnated with chemicals through an approved process and appropriately labeled. In general, paints, coatings, stains, or other surface treatments are not considered “FRT wood” for code purposes.

Some finishes and coatings can be applied to ignition-resistant materials without compromising their fire resistance, depending on their flammability. Suitability is typically

based on flame-spread index, with lower ratings indicating slower surface fire spread.

Code and technical definitions for fire or ignition resistance can vary, so it is important to confirm the specific technical requirements for the applicable code or standard when assessing wildfire vulnerabilities and developing adaptive treatments. Historic buildings frequently contain materials that satisfy neither classification as-built. The vulnerabilities assessment should evaluate each building assembly against both criteria to identify the full range of needed treatments.

A comparison of autoignition thresholds for common building materials can also help prioritize wildfire-risk vulnerabilities and inform mitigation treatments. Wildfire flames burn at temperatures that far exceed the ignition or failure points of most building materials (see Figure 6). Vinyl and plastics are most vulnerable, melting at roughly a third of typical wildfire flame temperatures. Untreated dry softwood can ignite at around half of such temperatures, while hardwoods and masonry can be more resilient due to their substantially higher ignition thresholds. Wood and cellulose material ignition characteristics vary by species and density, and their autoignition thresholds vary significantly based on moisture content and exposure duration.

How construction materials and assemblies each react to heat, moisture, and rapid temperature changes helps explain the justification behind different code requirements. This information can also help in developing appropriate adaptive treatments for the building’s materials or assemblies. Material-specific considerations for common noncombustible, combustible, and heat-vulnerable materials that apply across all building and site features are further explained in the Historic Building Materials: Performance Under Wildfire Conditions section at the end of the **Building Hardening Table**.

“Passive” Versus “Active” Fire-Protection Treatments

In the building construction industry, every type of fire-protection measure is considered to be either a “passive” or an “active” system. Passive fire-protection measures, by definition, do not rely on electricity, water, or human interaction to function during a wildfire. Passive treatments require no preparation prior to evacuation, and they can be implemented and already in place well before there is an immediate wildfire threat. Building codes generally require passive fire-protection treatments in the form of fire-resistant-rated construction of structural and non-structural building elements. WUI provisions require passive fire-protection treatments in the form of defensible space and building hardening treatments.

Both building codes and WUI provisions also require active fire-protection treatments that, by definition, rely on immediate human action, electric grid or battery power,



Figure 6: Heat-vulnerable materials like vinyl soften and deform under low heat (top); combustible materials like wood ignite and burn even more quickly when dry (middle); noncombustible materials like masonry resist ignition but can still fail under prolonged extreme heat (bottom). Photos: (top) Fred Greaves / Reuters; (others) Shutterstock

or sufficient water supply to function properly. Interior automatic sprinkler systems, automatic fire shutters, and self-closing fire doors are all examples of “active” fire-protection measures, also called “self-defense” mechanisms. During a wildfire event, active fire protection measures carry increased risk of failure commonly caused by loss of utility power or water supply, mechanical failures, or inadequate maintenance leading to degraded performance. The degree of risk depends on the system and its purpose. For example, model WUI codes require interior automatic fire sprinkler systems for new construction in high hazard areas because they significantly decrease the chance that an interior building fire will ignite a wildfire.

Other examples of active fire-protection measures that may be beneficial during a wildfire event include protective covers and wraps, exterior sprinkler or deluge sprinkler systems, water spray or irrigation systems, and field-applied fire retardants (see **Other Wildfire Risk-Mitigation Measures**). These systems alone are generally not accepted as code-compliant alternatives to passive measures due to a lack of national standards and mixed performance histories, and they may require special approval by local code offices and insurance companies. When considering active systems, local fire officials may require documented justification developed in collaboration with qualified design and engineering professionals.

Framework for Developing a Wildfire Protection Plan

The purpose of a wildfire protection plan is to guide the design and implementation of the physical treatments and operational changes required to help increase the wildfire resilience of a property. Developing a wildfire protection plan for a historic property requires balancing the urgency of wildfire risk against the imperative to preserve its historic character. The assessment and planning process is most effective when undertaken proactively and methodically. This Brief presents the following four-step process for developing a wildfire protection plan, summarized on the opposite page before a more detailed discussion.

- **Step 1:** Identify priorities for preserving the property’s historic character, including its distinctive features and attributes.
- **Step 2:** Assess and rank the wildfire vulnerabilities specific to the historic building, site, and setting.
- **Step 3:** Develop a wildfire protection plan tailored to reducing the property’s wildfire risks while preserving its historic character.
- **Step 4:** Implement the wildfire protection plan, regularly reevaluating it to ensure it remains adequate.

Each historic property presents a unique combination of wildfire exposures, architectural features, landscape conditions, and preservation objectives, and the planning process should be iterative, with information gathered at any stage informing refinement of earlier decisions. Adaptive treatments should aim to help reduce wildfire vulnerabilities among all features and materials of the historic building and site by addressing weak points that increase the chance of ignition during a wildfire. When new adaptive treatments are needed, they should be designed and implemented in a manner that has the least impact on character-defining features and the property’s overall historic character.

A one-size-fits-all or piecemeal approach to risk assessment and developing treatments can leave significant gaps in a historic property’s wildfire vulnerabilities and create a false sense of risk reduction. For all properties, adequate wildfire protection requires a comprehensive assessment of the specific building, site, and setting, followed by coordinated treatments of the building exterior and the site immediately around the building, extending out to the property lines.

A wildfire protection plan need not be elaborate; a concise, well-organized list of actions with estimated costs and implementation dates can be sufficient. When treatments require approval from code officials or local historic commissions, a clear and well-structured plan can also assist in those reviews and demonstrate how proposed actions can help provide adequate protection while balancing wildfire risk and historic preservation considerations.

A complete wildfire protection plan should generally include:

- **Preservation Considerations:** Specifies the character-defining features and materials that must be retained and explains how adaptations will be designed to help minimize visual and physical impacts.
- **Treatment Selection and Rationale:** Summarizes how treatments were evaluated and chosen based on wildfire hazard, code requirements, feasibility, and preservation priorities.
- **Defensible Space Strategy:** Defines defensible space zones based on site conditions and identifies treatments for features that commonly require attention, including vegetation within Zone Zero, fuel pathways, and adjacent combustible items.
- **Building Hardening Strategy:** Identifies exterior features most vulnerable to ignition, such as roof systems, eaves and soffits, gutters, vents, exterior wall materials, windows, and decks, and outlines how the building will be adapted to help reduce ignition risk while retaining historic character.

Developing a Wildfire Protection Plan for a Historic Property

Step 1: Identify priorities for preserving the property's historic character and character-defining features

- Determine the historic significance of the property and identify character-defining features of the building, its site and setting, and their relative importance to conveying its historic significance.
- Establish preservation objectives and priorities for the historic features and materials important to preserving the historic character of the building, its site and setting, as part of an adaptive treatment plan.
- Document the historic property for treatment planning and as a record in case of future damage or loss.

Step 2: Assess and rank the wildfire vulnerabilities specific to the historic building, site, and setting

- Prioritize life safety, including establishing and practicing a site-specific emergency plan for occupants and identifying pre-evacuation actions that can help protect the building if time allows.
- Determine the severity of the historic property's wildfire hazard and identify any additional factors or objectives, such as hazardous materials, preventing smoke infiltration, or operational continuity. Consider potential multi-hazard and secondary hazard events, such as earthquakes, high winds, flooding, soil erosion, or landslides.
- Review and understand the compliance requirements of relevant WUI and building code provisions, insurance underwriters, and other applicable wildfire risk-mitigation standards and guidance. Engage local code officials and property insurers early in the planning process, particularly in high-hazard areas where insurance availability may depend on demonstrated protection measures.
- Establish the size and shape of minimum defensible space zones; refine the zones through the planning process.
- Assess the building exterior, site, and surrounding area to determine how individual building and site components and systems influence wildfire risk in the context of the property's wildfire hazard severity. Identify hazardous materials for potential abatement, as well as areas or features with a high probability of ignition and loss or with high importance to life safety.

Step 3: Develop a Wildfire Protection Plan tailored to address the property's wildfire risks while preserving its historic character

- Begin removing accumulated vegetative debris from the building and site and undertake property maintenance immediately while developing the wildfire protection plan.
- Identify and evaluate feasible treatment options for each wildfire vulnerability, individually and collectively, weighing their relative effectiveness against anticipated wildfire exposures, their impact on historic character and features, and their relative risk-reduction priority, reversibility, and maintenance needs.
- When wildfire risks cannot be adequately addressed without substantial changes to distinctive character-defining features of the historic property, some compromises will likely be necessary; document the rationale and any residual risk accepted.
- Consider how neighbors and local communities have decided to adapt to the risk of wildfire hazards and to treat historic properties impacted by these risks. Draw on available code flexibilities and solutions adopted elsewhere. Consult with qualified professionals and officials to help identify effective, compatible adaptive treatment options.
- Anticipate an iterative planning process to arrive at a comprehensive, layered wildfire defense system of adaptive treatments that optimizes risk mitigation while minimizing impacts to historic character and appearance of an individual property (and any district) as much as possible, consistent with the Standards for Rehabilitation.

Step 4: Implement the wildfire protection plan, regularly reevaluating it to ensure it remains adequate

- Phase implementation of the plan to focus first on items with a high probability of ignition and loss and consequence to life safety or irreplaceable features; additional prioritization criteria may include construction dependencies and cost-effectiveness.
- Document completed resilience measures (photographs, receipts, permits, certifications) for insurance underwriting at renewal and potential claims post-event.
- Monitor and maintain the condition of the property.
- Treat the wildfire risk-mitigation plan as a living document and update it as conditions change.

- **Implementation Priorities and Schedule:** Summarizes the general order of work and an implementation schedule, considering workforce, estimated costs, and possible contracting and permitting processes.
- **Property Maintenance Strategy:** Establishes an ongoing program of vegetation management, debris removal, exterior inspection, and system upkeep to ensure resilience measures remain effective over time.

The wildfire protection plan should be treated as a living document that is reviewed and updated at regular intervals to reflect changes in the environment, weather patterns, and research on wildfire resilience. Regular updates help ensure that chosen adaptive treatments remain effective and adequate as site conditions and wildfire risk-mitigation best practices evolve.

Step 1: Identify Priorities for Preserving the Property's Historic Character

Before altering a historic property, it is crucial to understand its historic significance and to identify the physical features, materials, interior spaces, and spatial relationships important in conveying its historic character, historical associations, and appearance. The historic character of the building exterior is typically defined by its size, shape/massing, roof form, openings, materials, and other features. Depending on the building and why it is significant, all sides of the building may be important in establishing its historic character or just the ones more visible from primary rights-of-way. The building site and setting are also important in defining the historic character of the property, distinguished by such features and characteristics as spatial organization and land-use patterns, topography, vegetation, circulation pathways, decorative and functional site features, and materials.

Publications that can assist in the identification and prioritization of character-defining features include [*Preservation Brief 17: Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character*](#) in addition to local historic resource inventories or survey forms, National Register of Historic Places nominations, or local designation reports. The State Historic Preservation Office or Tribal Historic Preservation Office is also a good resource to locate these documents or for understanding the potential historic status of the property.

The assessment process should evaluate the historic integrity and physical condition of historic features and materials. Documenting the dates of original construction and later changes through historic and physical research is an

effective way of identifying original building elements as well as later changes that may or may not be historically significant. The physical condition should also be evaluated for any deterioration, distress, or needed repairs.

Important character-defining features and materials of high integrity and in good physical condition should generally be prioritized for retention and preservation. Important features and materials in more deteriorated condition are potential candidates for repair, augmentation, or replacement with more fire-resistant substitute materials to improve the property's wildfire resilience. Features and materials that are less important to the historic character, or not character-defining, can often accommodate more change without having as great an impact on the historic character of the property.

Applying the Secretary of the Interior's Standards When Reducing Wildfire Risks to Historic Buildings

[*The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*](#) should be consulted when considering adaptations to improve wildfire resilience. The Standards offer four treatment philosophies to help protect and maintain the historic character of buildings and sites when undertaking repairs and alterations. Each project should be guided by the appropriate set of Standards, applied in a reasonable manner that takes into consideration economic and technical feasibility, as well as the property's significance, existing physical condition, and available documentation.

Rehabilitation is the most common treatment used when adapting historic buildings to wildfire risk. It emphasizes maintaining and preserving the historic character and features of the property while allowing for changes that accommodate evolving uses and needs. However, the other three treatments also anticipate, and can accommodate, changes within the treatment approach, and the need to help protect historic properties from wildfire risk is not limited to rehabilitation projects.

While the Brief is intended to guide adaptive treatments in the context of the Rehabilitation Standards, its guidance can also be applied to the Preservation, Restoration, and Reconstruction Standards. Under the Preservation Standards, most risk-reduction actions such as vegetation management, sealing gaps, and maintaining roof and wall assemblies are routine, noninvasive activities that help safeguard existing materials. Other physical changes necessary to prevent loss may still need to be undertaken depending on the scope of the hazard. Under the Restoration Standards, resilience measures should generally avoid altering features from the chosen restoration period as much as possible; adaptive treatments that are concealed or visually compatible such as ember-resistant underlayments

Cultural Landscapes

Historic sites and districts identified as cultural landscapes should also be considered when developing a wildfire protection plan and identifying preservation priorities for the historic property. Features of a site or landscape can contribute to the significance of a historic property as integral components of the historic site and setting, or as individually significant resources, or both. Significant features may include historic buildings and other structures, but also the broader historic patterns of land use, spatial organization, viewsheds, topography, and vegetation. Circulation features such as roads, paths, and steps and small-scale site features such as fences, benches, trellises, lights, and fountains can also be important historic features. Landscape features, like the historic features of a building, can be character-defining and evoke the distinctive historic qualities of a place; therefore, they should be considered when developing preservation priorities.

Although this Brief focuses primarily on historic buildings, its overall approach to wildfire vulnerability assessment, establishing preservation and wildfire-resilience priorities, and developing a wildfire protection plan can also be applied to cultural landscapes and their character-defining features. The concepts and treatments concerning defensible space, building hardening, and property maintenance for historic buildings can likewise be planned and implemented with consideration for associated cultural landscapes, whose historic character and features should be integrated into the development of the wildfire protection plan for the historic property.

Cultural landscapes may be formally designed or have evolved organically through vernacular use. Some may appear as relatively undeveloped, natural places, despite their historic significance and use, which can make them easy to overlook in a wildfire risk assessment. Regardless of landscape type, vegetation and other site features can be easily ignited and highly combustible, posing additional challenges for wildfire risk-mitigation, and vulnerable landscapes can increase the wildfire vulnerability of historic buildings. Ethnographic landscapes are used or valued by traditionally associated or descendant communities, whose cultural values should be considered, and the protection of archaeological resources should also be carefully integrated. The preservation of cultural and ethnographic landscapes requires thoughtful planning to support long-term wildfire resilience of the whole historic property.



Figure 7: Routine mowing and pruning may help reduce the potential impacts of wildfire on this historic, working apple orchard. Photo: NPS

Maintaining adequate defensible space while retaining character-defining features is essential to adapting cultural landscapes to be more resilient. Vegetation management such as pruning deadwood, providing adequate water, nutrients and healthy soil, removing ground debris, and managing plant size should be prioritized. In higher-risk areas, tree and shrub thinning, reduction pruning, and crown management are needed to reduce the potential for ladder fuels. Removing and replanting vegetation away from buildings may be necessary to increase spacing between features and meet defensible space requirements. Creating larger buffer zones or substituting vegetation with similar but more fire-resistant species may also be appropriate strategies. Other combustible features such as fences, benches, and trellises may need to be interrupted to break up continuous fire paths, rebuilt with noncombustible materials, or redesigned to reduce debris-catching elements.

As with historic buildings, cultural landscapes and their associated site features require adaptive treatments to help improve their wildfire resilience, but in a manner that preserves their character-defining features as much as possible. Cultural landscapes and their features may need to be modified to protect other nearby resources, such as to achieve adequate defensible space around historic buildings. Conversely, historic buildings and structures may need to be more robustly hardened in other instances to lessen the amount of change required to the site. For additional guidance, see [Preservation Brief 36: Protecting Cultural Landscapes: Planning, Treatment, and Management of Historic Landscapes](#).

or vent detailing may still be undertaken when required for protection of the building. Under the Reconstruction Standards, new construction that replicates a documented historic form can still address contemporary hazard conditions. Just as in the Rehabilitation Standards, substitute materials may also be used under the other three sets of Standards in the context of wildfire resilience when they appropriately match the historic appearance. The guidance in this Brief can assist in selecting fire-resistant materials and assemblies that match the documented historic appearance while improving resilience.

The Standards for Rehabilitation

The Standards for Rehabilitation require that character-defining features, spaces, and materials generally be retained and preserved. Some character-defining features and materials may not meet WUI code requirements or may substantially increase a building's vulnerability to wildfire ignition and loss. Conversely, some adaptive treatments may threaten a historic building's features, appearance, or integrity; for example, covering or replacing combustible materials with incompatible non-matching ones or enclosing character-defining open eaves. When conventional adaptive treatments conflict with preservation priorities, alternatives should be carefully evaluated, including possible combinations of site and building adaptations that achieve a comparable level of wildfire resilience. Some compromise will likely be necessary to balance competing priorities.

When replacing character-defining features and materials is necessary, the Standards allow for the use of substitute materials. [*Preservation Brief 16: The Use of Substitute Materials on Historic Building Exteriors*](#) addresses the use of substitute materials for enhanced resilience to natural hazards and provides a framework for evaluating possible substitute replacement materials. In the context of fire risk, considerations when selecting substitute materials include how closely the substitute material matches the appearance of the historic material, as well as such considerations as fire or ignition resistance, flame and smoke spread, durability, potential impact on human health during or after a wildfire, cost and installation factors, and the potential need for structural augmentation.

A project meets the Rehabilitation Standards (or any of the sets of Standards) when the overall, or cumulative, effect of all work remains consistent with the property's historic character. Treatments that might not be considered in other rehabilitation contexts may be acceptable when adapting historic buildings to wildfire hazards, provided they minimize changes to the historic character and features as much as possible while addressing the risk. Adaptation treatments should prioritize resilience without destroying significant historic materials, features, or spaces.

Document the Property Adequately

Planning for wildfire risk-mitigation should include assembling available records and documentation of the historic property for assessment purposes, treatment planning, and use in the event of loss or damage. It is important to document the visual character and appearance of buildings and structures, including interior features, equipment, and site features, both before and after any work.

The types and level of documentation necessary will vary depending on the property's significance and intended use. There is little risk in over-documenting a property, particularly if the site has not previously been documented or documentation has not been updated in some time, and many types of documentation can be produced easily and cheaply. Digital photographs and narrated videos are easy to produce and store. For insurance purposes, it is also important to inventory and document the building's contents to establish their monetary value. A variety of user-friendly, readily available, and often free inventory software apps are available to support the documentation and inventory process before a disaster occurs.

For highly significant properties in high-hazard areas, more technical methods of documentation may be particularly valuable. Photogrammetry from consumer-grade cameras and drones can produce accurate 3D models of complex facades and features at modest cost. Tools like 3D laser scanning can be invaluable for carved stone, decorative plaster, stained glass, and other complex features where more technical documentation strategies are needed to facilitate potential reconstruction or replacement. In special cases, pre-event identification of qualified preservation contractors who could undertake post-event reconstruction may be desirable.

Written notes or inventories, maps, sketch plans, historic and current photographs, videos, laser scans, virtual photo tours, ownership records, and any available construction drawings (whether original or later) can all be helpful records to have. It is essential that critical documentation is stored offsite (or digitized and backed up in multiple locations) where it will be accessible and not at risk of being destroyed by the same incident.

Step 2: Assess and Rank Wildfire Vulnerabilities

Assessing wildfire vulnerabilities requires understanding the degree of wildfire hazard the property faces, building code and land-use regulations, triggers for code compliance, insurance requirements, and any other desired goals or objectives for property improvements and protections. The minimum performance requirements that any wildfire protection plan must satisfy are typically adjusted by code and insurance requirements based on the property's

relative wildfire hazard severity. Understanding regulatory and insurance requirements, plus any other objectives, at the outset can prevent costly missteps and ensure that preservation-appropriate solutions can be evaluated against the full range of applicable constraints from the beginning of the planning process.

Identify Wildfire Hazard Severity

Local or state governments classify and map wildfire hazard areas to establish where compliance with adopted WUI codes is then required. The federal government also encourages wildfire-resistant design and construction in areas at risk of wildfires, whether through FEMA or in its own management of public lands.

Many state or local building and fire departments maintain WUI classification and mapping records, and some jurisdictions provide GIS-based wildfire hazard maps online. While most wildfire hazard areas are within the WUI, the WUI designation may not capture all at-risk locations, including some remote or densely developed areas where fire can spread rapidly. If a fire reaches the edge of a designated hazard area, the fire may readily spread outside the zone when conditions are conducive. In denser neighborhoods, adjacency to a hazard area may warrant mitigation measures regardless of designation.

Where wildfire hazard area designations do not exist, the USDA Forest Service's "Wildfire Risk to Communities" web-site offers nationwide risk data, and some model codes

include a fire hazard severity form that can be used to analyze a specific property. Insurance companies may also maintain proprietary wildfire hazard maps, which can differ from government designations, often considering how many properties in the vicinity have been adapted to help reduce risk.

Property owners should consider the potential for future changes to local wildfire hazard area designations and threats. In recent decades, more properties have experienced wildfire activity, extreme fire behavior, and increased property loss. New development, fuel buildup, and climate-driven weather patterns (such as drought, high temperatures, and high winds) have made wildfire a year-round risk in many regions. Communities may lag in designating WUI areas as risk expands; once a community has established WUI areas, updates generally occur every few years.

Identify Applicable Code and Insurance Requirements

In wildfire hazard areas, life safety planning is the first priority. Owners and occupants should develop and regularly practice a site-specific emergency plan focused on occupant safety and pre-evacuation checklists, for which detailed guidance is commonly available from state or local governments and fire departments, among other sources. Life safety should also be integral to developing any treatment plan, including a wildfire protection plan otherwise oriented around reducing the wildfire risks to the historic building.

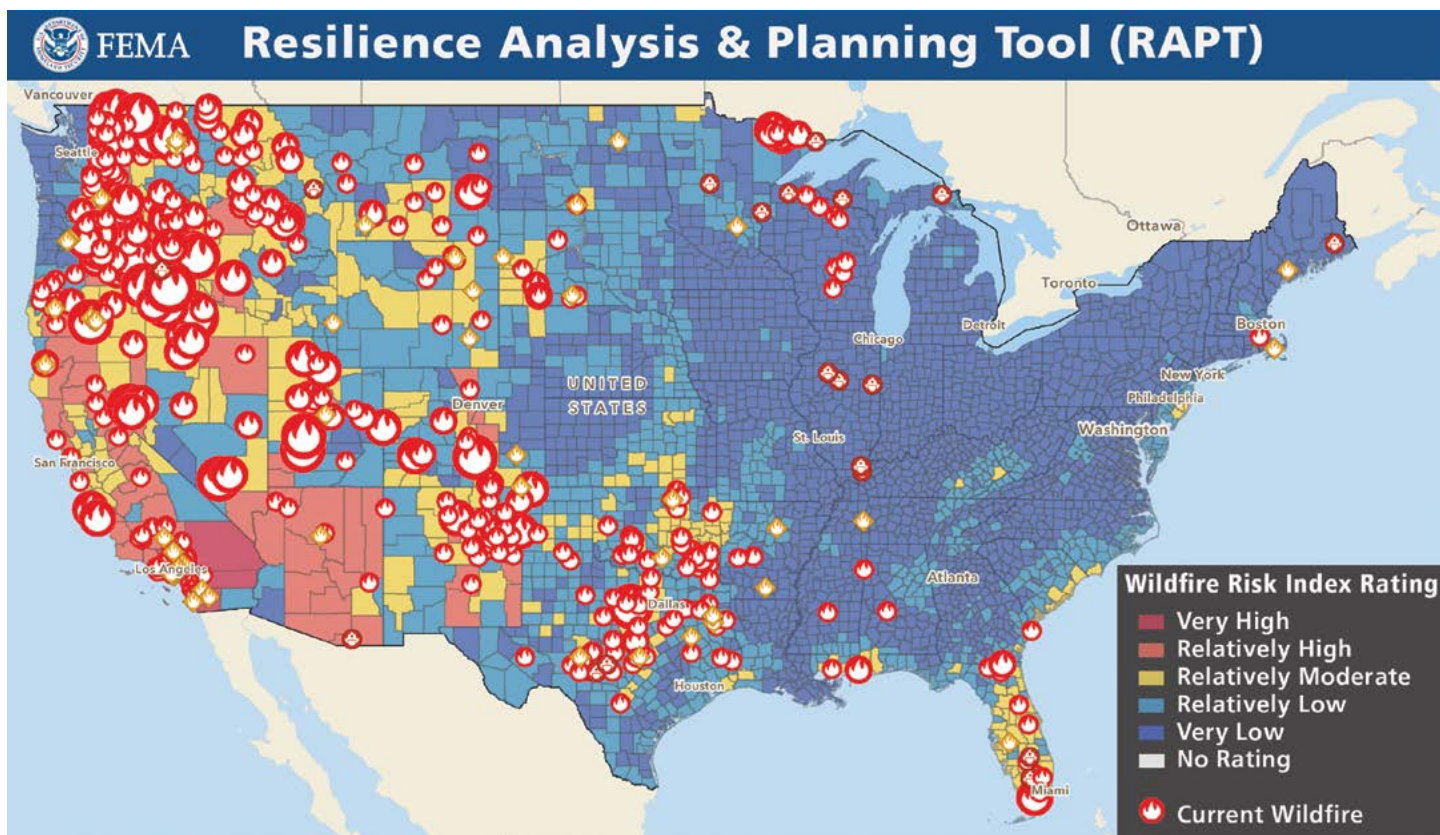


Figure 8. FEMA's RAPT map draws on the National Risk Index for natural hazards, including wildfires, and measures relative risk based on the hazard, expected losses, social vulnerability, and community resilience. Source: FEMA

At an early planning stage, property owners should determine the adopted building construction codes applicable to their property, as well as project thresholds that require compliance with WUI and any other adopted codes. Additive to building and fire codes, the two main model special building codes for construction in designated wildfire hazard or WUI areas are the National Fire Protection Association's *NFPA 1140 Standard for Wildland Fire Protection* and the *International Wildland-Urban Interface Code (IWUIC)*, published by the International Code Council (ICC). When adopting a WUI code or standard, governments generally amend these codes to address local fire hazard and fire-fighting conditions. Many regulations have evolved from a focus on residential development due to historically higher loss rates, but the requirements apply to any building type in the WUI.

Certain types of exterior construction and repair activities will trigger compliance with the WUI code requirements, depending on local or state regulations. Common project thresholds include full or partial re-roofing, gutter or vent replacement, and new additions. In some localities, changes to exterior cladding, window or exterior door repairs, or work to accessory structures may also trigger compliance with code provisions pertaining to those features.

Property owners should also understand which adopted WUI code provisions, if any, apply retroactively to existing conditions and whether local codes include performance-based alternative compliance paths for qualified historic buildings that may provide additional flexibility to achieve a comparable level of protection. Exemptions or reduced requirements for historic buildings may make compliance with the codes easier, but they can also put the historic building at greater risk and are therefore not recommended. [*Preservation Brief 51: Building Codes for Historic and Existing Buildings: Planning and Maximizing Their Application*](#) provides additional guidance on understanding the different codes, code requirements, and possible compliance paths for historic buildings.

Insurance companies increasingly drive wildfire protection decisions by property owners, particularly in high-hazard states where coverage availability itself may depend on specified adaptive treatments distinct from what may otherwise be required to meet local codes. Insurance company requirements typically take the form of inspection checklists, and they may not have been developed with historic buildings in mind. Owners, especially in high-hazard areas, should engage authorized insurance representatives early in the assessment and planning process.

Additional assessment and planning resources, such as online tools, may be available at the state or community level. Local-level planning documents such as a Hazard Mitigation Plan or Community Wildfire Protection Plan (CWPP) guide local infrastructure priorities, hazardous fuel reduction, and recommended measures to help reduce the ignitability of the area.

CWPPs can be particularly valuable for historic neighborhoods and districts because they can drive fuel reduction on adjacent federal, state, or private lands that a single property owner cannot otherwise influence. For historic districts at the WUI edge or when historic buildings are particularly closely spaced, a district-scoped CWPP may be the most effective and practical pathway to create defensible space that extends beyond an individual property parcel. In densely developed environments, it is important to build resilience as a community.

Analysis of code and insurance requirements should also identify whether specific provisions appear to conflict with preservation standards or risk damaging character-defining features, as discussed below. Understanding the parcel-level hazard variables and adaptive treatment interdependencies may enable alternatives that better preserve a historic building's features and materials. For example, some code provisions reduce ignition-resistance construction requirements when an above-minimum defensible space system is created or when an approved vegetation management plan is enacted. In all cases, the proposed treatments must be adequate to the risk.

Local fire officials and programs such as NFPA's Firewise USA can offer guidance specific to the community and each property at the parcel level. In more complex situations, a project team with more extensive expertise may be necessary to inventory, evaluate, and develop a comprehensive wildfire risk-mitigation strategy for the property. Grants and funding may be available to support increased resiliency and fire-hardening efforts for historic properties in some instances.

Other Possible Considerations

Additional factors may also warrant consideration when developing the wildfire protection plan. Areas at risk for wildfires may also be at risk for other natural hazards such as high winds, earthquakes, and flooding, either at the same time or sequentially. Potential secondary, or post-fire hazards can include severe soil erosion, debris flows, or landslides. Planning for these conditions should be incorporated into planning for increased wildfire resilience.

Hazardous materials pose a substantial health risk to evacuees and responders during a fire, as well as individuals exposed to the post-fire environment. If not remediated before a fire, these hazards will be present in smoke, ash, and other wildfire by-products. Older buildings may have hazards such as lead, asbestos, and mercury, while modern electronics, solar panels, and batteries may contain trace toxic elements. On-site hazardous materials should be identified and disclosed. Remediation of hazardous materials is best undertaken in a pre-fire setting.

Smoke, soot, and ash infiltration may jeopardize historic interior features and finishes of buildings that survive or are near wildfire events. Treatments to seal against air

infiltration and to increase interior air filtration can help limit costly post-fire damage or remediation. At minimum, pre-evacuation checklists should include steps to take if time allows, such as closing windows and turning off heating, cooling, and ventilation systems so they do not draw smoke or soot into the building.

Hospitals and schools are often required to meet higher code requirements because of their use and the health and safety of occupants. Museums may choose, or be required by their specialty insurance underwriters, to exceed minimum code requirements for programmatic reasons like preserving irreplaceable collections. More robust risk-mitigation treatments may include expanded defensible space requirements, higher levels of ignition-resistant construction, blocking smoke, soot, and ash infiltration, increased interior air filtration, or suppression systems supported by on-site water reservoirs.

When property owners need to maintain operations during or after a wildfire, continuity of water and energy supplies is paramount. Both regular and backup energy sources, like batteries, generators, fuel tanks, solar panels, and charging stations, increase the types of flammable materials on site that may need to be protected during a wildfire.

Assess the Property's Vulnerabilities to Wildfire Exposures

Existing building and site features and materials should be evaluated against current WUI requirements before identifying treatments. The assessment should consider the potential movement and intensity of the wildfire across the site to the historic building, the potential fire exposures (embers, radiant heat, and flames, individually and acting concurrently or sequentially), and in worst-case weather scenarios.

Site Vulnerabilities to Wildfire Exposures

The **Defensible Space Table** that follows this Framework discussion suggests an outline for the assessment and planning process to help ensure all existing site features are considered. The following overarching questions can help guide the evaluation of each defensible space zone and each site feature:

- Will occupants be able to evacuate safely and will first responders be able to safely find, access, and protect the property?
- What is the appropriate size and shape of each defensible space zone, starting with Zone Zero, for the building? Where

the necessary defensible space extends across property lines, what are the adjacent combustible hazards for the building and site?

- What combustible features and elements exist in each defensible space zone, and which are highly flammable and pose the greatest risk?
- What are the horizontal and vertical fuel pathways, including trees and plantings, fences, vegetative debris, and combustible storage, that would enable a fire to spread across the site to the building and other structures and site features? What fuel breaks already exist?

Once the entire site has been assessed, wildfire vulnerabilities should be prioritized by the degree of risk each represents:

- Which ignition pathways are most likely given local conditions (embers are statistically dominant)?
- Which vulnerabilities affect irreplaceable historic building or site features or life safety?

To identify and prioritize site vulnerabilities:

- **Establish the minimum size and shape** of the defensible space zones, beginning with Zone Zero.
- **Evaluate individual features** in the context of the risk-mitigation objectives and specific code requirements for each zone.
- **Prioritize the identified vulnerabilities of the building's site to wildfire exposures** by the degree of risk for spreading fire and flag potential conflicts with preservation priorities.

Use the Defensible Space Table that follows this Framework discussion for more detailed, zone-specific preservation considerations and feature-level treatments to help manage wildfire as it approaches the historic building.

Building Vulnerabilities to Wildfire Exposures

The **Building Hardening Table** that follows this Framework discussion suggests an outline for the assessment and planning process to help ensure all existing building features are considered. The following overarching questions can help guide the evaluation of the building enclosure or envelope as a whole, in addition to specific individual features and materials:

- Where will debris and embers accumulate, and are the enclosure materials, joints, and substrates in those locations combustible?
- Where are building enclosure gaps large enough for embers and flames to enter, including areas with negative pressure differentials? Note that to block embers, openings should typically be no greater than 1/8" diameter.
- What enclosure components and surfaces are most likely to ignite or melt in the presence of direct flames or high heat, and will substrates ignite? Where are non-combustible materials deteriorated or otherwise vulnerable to high heat or rapid temperature changes (see **Building Hardening Table** Building Materials: Performance Under Wildfire Conditions)?
- If flames reach the building, what features and elements (including attached features such as fences or decks) or enclosure materials will most likely ignite?

Once the entire building enclosure or envelope has been assessed, building vulnerabilities should be prioritized by the degree of risk each represents:

- Which are most likely to allow ignition, and how likely is this new fire to spread?
- Where, if embers, flames, or high heat gain access to the building interior, could compounded effects such as structural failure result?

To identify and prioritize building vulnerabilities:

- **Assess the building enclosure** feature-by-feature, from roof to grade (or, if applicable, below grade) on all sides of the building, as well as any attached features.
- **Evaluate the exterior building materials, details, and physical condition**, including temporary conditions (e.g., stabilization shoring or scaffolding) that may introduce additional wildfire vulnerabilities.
- **Prioritize the identified vulnerabilities of the building enclosure to wildfire exposures** by the degree of risk for catching and spreading fire; flag potential conflicts with preservation priorities.

Use the Building Hardening Table that follows this Framework discussion for feature-specific resilience and preservation considerations.

Compile and Rank the Property's Vulnerabilities to Wildfire Exposures

A final step in the wildfire-risk assessment process is to list the wildfire vulnerabilities and rank them by their relative degree of risk, taking into consideration such factors as life safety, preservation priorities, and site and building features and materials most likely to ignite (embers being statistically dominant) and spread fire. After identifying the property's most consequential vulnerabilities, the "weakest links" that put the historic building at greatest risk should rise to the top as priority focus areas in developing the wildfire protection plan.

Common 'weak-link' patterns include dense or highly flammable vegetation, deferred maintenance leading to ember entry or ignition, or external factors such as limited firefighting resources. Many properties will have multiple or interrelated 'weak-link' vulnerabilities that should be addressed first. Vulnerabilities related to character-defining historic features and materials should be specifically flagged for careful planning.

Step 3: Develop the Wildfire Protection Plan

To develop a wildfire protection plan that addresses the identified preservation and wildfire-resilience objectives, ranked wildfire vulnerabilities must be translated into a list of possible adaptive treatments for evaluation and selection, and, lastly, prioritized implementation. No single treatment fully resolves a property's wildfire risk, and few historic properties will have one obvious set of treatments; selecting the right combination depends on the specific building, site, and setting. An iterative process should be anticipated to arrive at a comprehensive, layered wildfire defense system that retains the property's historic character and important physical features as much as possible, balanced against the need to reduce wildfire risk. At times, effective solutions may not be reflected in standard code checklists or industry guidance and will require a more creative approach. Good stewardship will require making choices and taking timely action up front, particularly for properties in high fire-hazard risk areas.

Identify and Evaluate Treatment Options

Removing accumulated vegetative debris from the building and site and implementing regular property maintenance treatments should begin immediately, while potential defensible space and building hardening treatments are evaluated and the wildfire protection plan and implementation schedule are under development.

A range of potential risk-mitigation treatment options is available for most building and site features, as presented in the **Defensible Space**, **Building Hardening**, and **Property Maintenance** tables that follow this Framework discussion. For each identified wildfire vulnerability, all feasible treatment options should be identified, individually and in combination, and evaluated taking into account the following considerations:

- **Existing resilient conditions.** Before identifying new treatments, existing building and site features and materials should be evaluated for inherent characteristics that already help resist wildfire. Even non-historic modifications that reduce risk may warrant retention.
- **Effectiveness against the anticipated exposures.** How each adaptive treatment option performs against embers, radiant heat, and direct flame (individually and as part of a larger wildfire defense system, as well as under both anticipated and potential worst-case weather conditions) should be understood and evaluated in comparison to the risk. For example, adding ember-blocking mesh does not stop flames, whereas wildfire-rated vents block both embers and flames. Treatments should address construction joints, connections, and assemblies, not just surface materials,

since the former are common points of weakness. Where relevant to the property, such factors as hazardous materials, smoke, soot, and ash infiltration, multi-hazard scenarios, or operational continuity should also be considered.

- **Impact to historic character.** Each option's impact on character-defining features and materials should be evaluated, both individually and cumulatively as part of all the adaptive treatments planned for the property. Features on primary or highly visible elevations generally warrant more preservation-sensitive treatments; less visible or non-character-defining features can typically accommodate greater change.
- **Relative risk and priority.** The likelihood and the relative consequence of the specific wildfire vulnerability should be weighed against the adaptive treatment's impact on the character of the impacted features. A particularly distinctive feature with comparatively low wildfire risk may need only a 'light-touch' adaptive treatment or none at all, while a less important feature that poses a high risk may warrant more substantial change. Embers are statistically the most dominant risk to a historic building, and selecting treatments that protect life safety or irreplaceable features should be prioritized.

Wood Roofs

Wood roofing can be an important character-defining feature of a historic building, but *untreated* wood shingles are among the most ignition-prone building materials and are therefore generally discouraged or prohibited in wildfire contexts. Some WUI codes may allow listed and labeled fire retardant-treated (FRT) wood shingles as part of a Class-A roof assembly, while other jurisdictions may prohibit their use entirely based on wildfire hazard conditions or adopted WUI provisions.

When wood roofing is prohibited or a noncombustible roofing material is otherwise preferable, available substitute roofing materials can generally be used without significantly diminishing the overall historic character of the building, consistent with the Rehabilitation (and other Treatment) Standards. Substitute materials should be evaluated on a case-by-case basis, selecting the material that best matches the visual and physical characteristics of the historic material while also meeting the other project requirements and conditions. See **Building Hardening Table**, Roof Materials, for additional context.

Where wood roofing is integral to a building's historic character and is highly visible, or the building is in a lower wildfire-risk area where wood-based roofing might be permitted, replacement with FRT wood roofing

as part of a rated roof assembly may provide a compatible treatment approach while improving fire-ignition resistance. All wood shingle installations are vulnerable due to the significant presence of points where embers may enter or become trapped. The performance of the material can also be augmented in some instances by active fire-protection systems (see **Other Wildfire Risk-Mitigation Measures** discussion later in this Brief).



Figure 9: Untreated wood roofs are highly vulnerable to ignition, as flying embers easily lodge in the rough texture and joints. Adaptive treatment options for wood roofing should be carefully considered. Photo: University of Nevada, Reno Extension

Implementing the adaptive treatments necessary to address high risks to life safety and important character-defining features is also critical.

- **Interdependencies between site and building adaptive treatments.** Wildfire codes may allow or require a more robust treatment to offset a less robust treatment elsewhere. For example, an enlarged defensible space (where it can be achieved) or an approved vegetation-management plan may reduce a property's fire hazard severity enough to lower the level of ignition-resistant construction otherwise required for the building exterior. Conversely, where property boundaries limit the ability to create required defensible space distances, Zone Zero treatments may need to extend to the property line, or a higher level of ignition-resistant construction may be required on elevations facing the increased exposure. Identifying such trade-offs can reduce the need for a more invasive treatment to a character-defining feature. Code exemptions or reduced requirements for historic buildings, discussed in Step 2, should generally not be treated as an alternative to adequate wildfire risk-mitigation, since they can put the building at greater risk.
- **Reversibility and degree of intervention.** Where multiple options achieve comparable risk-reduction, the option that is more reversible, retains more of the character-defining features and materials, or can be upgraded later is generally preferable to one that requires irreversible loss of historic features and materials in good condition. A partial treatment, such as protecting only the most vulnerable portion of a feature, may adequately address the risk without requiring wholesale replacement. For example, replacing combustible cladding with compatible, noncombustible substitute material only where required, rather than on the entire building, may be adequate to address the potential site-specific exposure to embers, flames, and radiant heat.
- **Passive fire-protection treatments first, active measures as a supplement.** Passive fire-protection treatments, including defensible space and building hardening, should remain the primary strategy since they require no preparation or resources during a fire event. Active fire-protection measures such as temporary covers, exterior sprinklers, or field-applied retardants may be of value where defensible space is constrained or building hardening would substantially diminish historic character, but they carry a higher risk of failure and should supplement, not replace, passive adaptive treatments. See **Other Wildfire Risk-Mitigation Measures** for active treatment-specific considerations.

- **Durability and maintenance needs.** The maintenance requirements and the responsible parties for each adaptive treatment option under consideration should be identified and evaluated. A treatment that will not be properly maintained may provide a false sense of reduced risk.
- **Less studied historic features.** Where a character-defining feature's fire risk and possible treatments are not well understood, less-proven alternatives may carry uncertain code or insurance acceptance in addition to unverified performance.
- **Economic and technical feasibility.** Not every effective treatment will be realistic for a given property owner to complete, given its cost, the specialized skill or trades it may require, or the time available before the property may next be at risk. Treatments should be evaluated for whether they can realistically be completed as planned and on the implementation schedule as adopted, not just for their theoretical effectiveness, since a treatment that stalls before completion provides no protection in the interim.

When wildfire risk-reduction and preservation priorities conflict, alternative adaptive treatment options and treatment combinations should be explored before concluding that a character-defining feature must be significantly altered or removed. Where a significant wildfire vulnerability cannot be adequately addressed without changes to character-defining features and materials that would not typically meet the Standards, some compromise to historic character will likely be necessary. The rationale for such decisions, including any residual wildfire risk being accepted, should be documented for discussion with code officials and insurance underwriters and for future reference. In all cases, proposed adaptive treatments must be responsive to the anticipated wildfire risk while preserving the historic character of the property as much as possible.

Best Practices for Finding Effective, Compatible Solutions

The following practices can help identify potential adaptive treatment options to help reduce wildfire risks while limiting impacts to historic character.

- Identify flexibilities offered in the locally adopted WUI code, such as reduced ignition-resistant building construction requirements achieved through an enlarged defensible space or approved vegetation-management plan (see Interdependencies, above).
- Explore treatment approaches allowed by model WUI codes or code provisions adopted in other jurisdictions; local code officials may more readily approve adaptive treatments that have been successfully implemented and documented elsewhere.

- Consider how comparable historic properties, neighbors, and the local community have approached wild-fire adaptation; compatible solutions already tailored to the local natural and built environments may exist and can be adapted to the property.
- In densely developed areas, wildfire risk-mitigation treatments should be coordinated with adjacent property owners to the greatest extent feasible, and community-level programs or agreements that can achieve shared defensible space beyond what a single parcel could establish alone should be supported.
- Supplemental active fire-protection measures may also be considered when passive treatments alone cannot adequately address the risk without unacceptable impact to historic character.
- Prioritize meaningful property maintenance treatments such as debris removal or vegetation thinning that can be undertaken immediately by the property owner; consider whether community programs, grants, or other financial assistance may be available to help offset the costs of more specialized adaptive treatment work.
- Adaptive treatment options should be developed and weighed in consultation with qualified design, preservation, and wildfire-resilience professionals, as well as local code, fire, and preservation officials, particularly when a proposed treatment departs from standard code-prescribed solutions.

Once individual adaptive treatment options have been selected, they should be reviewed together to confirm that the full set of chosen treatments addresses the property's highest-priority wildfire vulnerabilities and collectively retains its historic character, rather than evaluating each just in isolation. This resulting set of selected treatments becomes the basis for the wildfire protection plan. **Step 4: Implement the Wildfire Protection Plan** addresses sequencing the implementation of these treatments, organizing them into a written document, and reevaluating the plan over time.

The Critical Role of Fuel Management and Property Maintenance

Maintaining wildfire resilience requires ongoing attention to both the site and the building enclosure. WUI codes specify that continued maintenance of the building envelope and defensible space is required. This is because the efficacy of the wildfire defense system directly relates to the fuel load on the property and the related potential for embers, radiant heat, and direct flames to ignite the fuel or spread the fire.

Live vegetation and the accumulation of dead plants, branches, and debris can rapidly increase the fuel load

on a property. Vegetation needs adequate maintenance to control growth by mowing grasses, trimming branches, and removing volunteer plants. Dead plants, branches, and fallen pine needles and leaves must be removed and disposed of or composted properly to avoid creating large fire hazards.

Small gaps will also develop as materials and assemblies age, particularly at joints and connections, and the continuity of surfaces must be maintained. Protective mesh over openings can detach and these gaps can allow embers into buildings. Routine inspections and repairs are critical to keeping the wildfire defense system in place. Because newly implemented adaptive treatments are only effective if maintained, continued maintenance should be built into the wildfire protection plan as an ongoing commitment. The **Property Maintenance Table** provides more specific treatment and preservation considerations.

Identify Actions that Can Be Taken Immediately: Fuel Management and Building Maintenance

Steps toward meaningful risk reduction can begin immediately, before a vulnerability assessment is complete and before other adaptations are underway. Systematic fuel management, relocation of combustible debris and storage away from the building, and routine preventative maintenance can significantly help reduce near-term wildfire hazards with minimal cost or preservation impact.

These actions are not a one-time task; maintaining resilience requires ongoing monitoring, inspection, and upkeep.

Use the Property Maintenance Table that follows this Framework discussion for sustaining resilience and preservation considerations.

Step 4: Implement the Wildfire Protection Plan

Once the list of selected treatments has been developed, a clear prioritization and sequencing strategy for implementation must be established as part of the wildfire protection plan. This process differs from simply ranking preservation or wildfire vulnerabilities—the primary objective is to translate assessed risks and selected treatments into a practical and preservation-minded action plan that guides the systematic execution of the risk-mitigation measures.

Prioritization in this context is not a numerical ranking or a rigid scoring system. Rather, it should be developed in a structured way to address the most critical vulnerabilities

first, establish foundational improvements early, and be followed later with more complex or cost- or resource-intensive adaptations when possible. This approach keeps preservation and wildfire risk-mitigation goals central throughout planning and execution.

The implementation timeline and sequencing of treatment should be informed by the following criteria:

- **Probability:** Treatments addressing the most likely ignition pathways should be implemented first. Embers are statistically dominant for causing building fires and should anchor early implementation decisions.
- **Consequence:** Treatments that can help protect irreplaceable features or directly support life safety warrant priority regardless of complexity or cost.
- **Dependencies:** Certain treatments must precede others, e.g., determine whether defensible space or building hardening should be optimized first; generally roof and gutter treatments precede wall treatments.
- **Cost-effectiveness:** Many high-impact treatments, such as debris removal, gutter guards, and vent screening, are low in cost and preservation impact and should be undertaken without delay.

The implementation timeline should reflect a practical progression, from treatments that address the highest wildfire vulnerabilities and preservation risks to longer-term adaptations that are best undertaken within broader rehabilitation or restoration projects.

- **Immediate Priorities:** Address the conditions most likely to lead to rapid ignition or ember entry. These actions strengthen the property's baseline resilience and can help meaningfully reduce near-term risk. Immediate fuel management and maintenance tasks fall into this category.
- **Short-Term Priorities:** Focus on mid-level vulnerabilities that influence how heat, embers, or flames interact with the building and site. These measures typically require modest planning and help form a more complete defensive system.
- **Longer-Term Priorities:** Plan for more complex, cost- or resource-intensive adaptations best integrated with broader rehabilitation efforts. These measures address greater vulnerabilities while balancing preservation needs.
- **Continuous Maintenance:** Sustain resilience over time by monitoring and maintaining vegetation, managing fuels, and maintaining exterior materials.
- **Regularly Reevaluate the Plan:** The Wildfire Protection Plan should be a living document, regularly revisited and adapted to any changed conditions.

Steps for Developing a Wildfire Protection Plan

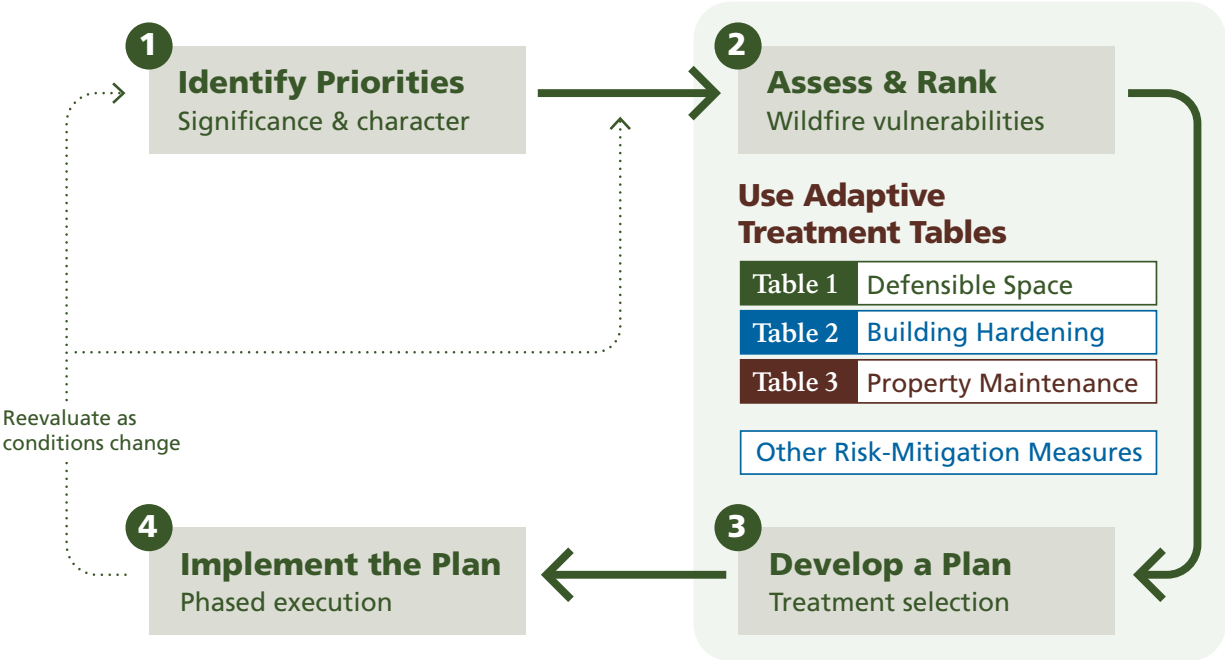


Figure 10: Developing a wildfire protection plan for a historic property requires balancing the urgency of wildfire risk against the imperative to preserve its historic character. This Brief presents a four-step process for developing a property-specific wildfire protection plan, using adaptive treatment tables that help to integrate preservation considerations when identifying and prioritizing wildfire vulnerabilities, treatment options, and implementation strategies. Graphic: Blank Space LLC for NPS

Using the Adaptive Treatment Tables

The following tables support the assessment and planning framework to identify and prioritize adaptive treatments when developing an effective wildfire protection plan for historic buildings. These tables identify the risks, treatment options, and considerations to help reduce wildfire risks to the building, its site, and setting while preserving its historic character. Each adaptive treatment table corresponds to a major component of the wildfire defense system:

- **Table 1 – Defensible Space** outlines wildfire vulnerabilities and adaptive treatments for vegetation, site features, and fuel pathways within the defensible space zones of the historic site.
- **Table 2 – Building Hardening** identifies vulnerabilities and treatments for exterior materials and features of the historic building to help reduce ignition caused by embers, radiant-heat exposure, and direct flame contact.
- **Table 3 – Property Maintenance** summarizes recurring tasks required to sustain long-term resilience of the historic building and its site.

The tables are organized by landscape or architectural feature important to the wildfire vulnerability of the historic property and provide:

- A brief explanation of the wildfire exposure or vulnerability of the feature,
- Adaptive treatments to help reduce the vulnerability to the anticipated fire exposures, and
- Preservation considerations to help evaluate or reduce the impact of potential adaptive treatments to the historic character of the building, its site and setting, and, in particular, its character-defining features and materials.

An additional section following the tables outlines **Other Wildfire Risk-Mitigation Measures**, potential active fire protection treatments, either temporary or permanent, that are sometimes used to help supplement or augment the passive defensible space and building-hardening treatments in certain circumstances.

This Brief provides general guidance intended to help create more wildfire-resilient historic buildings. Specific requirements, installation details, etc., should be obtained from appropriate code and other sources. Comprehensive and balanced risk-mitigation strategies should be developed in consultation with wildfire specialists, historic preservation and design professionals, and code officials.

Use the **Defensible Space**, **Building Hardening**, and **Property Maintenance** tables, along with the section on **Other Wildfire Risk-Mitigation Measures**, to develop a holistic wildfire protection plan for the historic property that:

- (1) Identifies and prioritizes the wildfire vulnerabilities of the historic property,
- (2) Develops a comprehensive list of coordinated adaptive treatments adequate to the wildfire risk and compatible with the historic character of the property as much as possible, and
- (3) Prioritizes the implementation and phasing of work (i.e., immediate, short-term, or longer-term, as well as continuous maintenance).

Not every treatment will apply to every building and property, and each should be evaluated in relation to the property's preservation priorities, wildfire-hazard classification, specific wildfire risks, code requirements, programmatic objectives, and other factors.



Figure 11: To create defensible space around this Florida home at risk for wildfires, vegetation was removed while still retaining the historic character of the site and setting. Photos: USDA Forest Service

Table 1. Defensible Space and the Historic Site

Use this table along with the **Building Hardening** and **Property Maintenance** tables as part of developing a wildfire protection plan to create defensible space tailored to help safeguard the historic building, its site, and setting from wildfire exposure while preserving the property's historic character.

The site should provide a first line of defense to an approaching wildfire. It should be configured as concentric defensible space zones or rings around the historic building, each designed to help progressively slow fire movement, reduce its intensity, break continuous horizontal and vertical fuel pathways, prevent ignition around the building, and support safe firefighting. These objectives are achieved by altering vegetation and site features for a distance of 100 feet or more from a building (or group of buildings). Some situations may require a defensible space extending to a distance of 200 to 500 feet.

The table begins with general information about planning the size and shape of adequate defensible space and its concentric zones, as well as general considerations for vegetation in the defensible space. The discussion is predicated on a three-zone defensible space, starting immediately around the building with the innermost Zone Zero, the middle Intermediate Zone, and the outermost Extended Zone. The rest of the table provides a zone-by-zone discussion of common wildfire exposures to specific site features, typical treatments, and preservation considerations as follows:

Features within Zone Zero*

- Fences, Retaining Walls, and Other Features Attached to the Building
- Trees and Foundation Plantings
- Mulch and Hardscaping
- Equipment and Utilities
- Vehicles, Furniture, Storage Areas, and Other Movable Combustible Items

Features within Intermediate/Extended Zones**

- Garages, Sheds, Barns, Stables, Gazebos, and Other Detached Accessory Structures or Outbuildings
- Fences, Trellises, and Other Combustible Site Features
- Vegetation in Intermediate Zone
- Trees
- Shrubs
- Ground Cover Plantings
- Flower and Vegetable Gardens
- Mulch

*See **Building Hardening Table** for the discussion of decks and porches, as well as the partial hardening of exterior walls to create a noncombustible vertical clearance above a horizontal surface.

See **Other Wildfire Risk-Mitigation Measures for discussion of protecting pools and water features.

Establishing Defensible Space

For the purposes of this Brief, the three-zone defensible space (see Figures 4 and 5) consists of:

- **Zone Zero** (the innermost band, also known as Immediate Zone, Noncombustible Zone, or Ember-Resistant Buffer Zone) is a zone ringing a building where all combustible materials must be eliminated to help protect the building against localized fires caused by embers (statistically dominant) and creeping fire. Zone Zero is established by measuring a minimum of 5 feet outward from the building perimeter, that is, the outermost edge of the building including its eaves, projections, and other attached features. Zone Zero consists of this band, plus the area between the building perimeter line and the building exterior wall (see Figure 12).
- **Intermediate Zone** (the middle band, also known as Zone 1 or "Lean, Clean and Green" zone) is a fuel management zone where vegetative and man-made fuel is altered and maintained to help reduce fire intensity (flame length and heat energy) from moderate to low and to create discontinuity (fuel breaks), both horizontally and vertically. The Intermediate Zone comprises the next 25 feet (min.) beyond Zone Zero, or from 5 to 30 feet (min.) as measured from the building perimeter.
- **Extended Zone** (the outermost band, also known as Zone 2) is a fuel management zone where vegetative and

Establishing Defensible Space

man-made fuel is altered and maintained to help reduce fire intensity (e.g., worst-case, from an extreme or high intensity fire, to moderate intensity), reducing flame lengths, slowing the rate of spread, and lowering the heat output as it approaches the Intermediate Zone. The Extended Zone comprises the next 70 feet (min.) beyond the Intermediate Zone, or from 30 to 100 feet (min.) as measured from the building perimeter.

The minimum size, shape, function, nomenclature, and sometimes number of zones may vary by jurisdiction, but the preservation considerations outlined in this table can be adapted to other defensible space zone strategies.

Planning the Size and Shape of Defensible Space

Fuel, topography, and weather determine how hot a fire burns and how quickly it spreads. The types, amount, and continuity of fuel are the only variables a property owner can meaningfully influence. Buildings are more easily protected against wildfire by creating and maintaining adequate defensible space.

CREATING THE ZONE BOUNDARIES

- Calculate the size and shape of the base defensible space zones around the historic building (or grouped buildings), based on local code and insurance requirements, starting with the building perimeter (defined not as the exterior building walls, but as the outermost projections of overhanging eaves and attached features such as decks and porches), and working outward (see Figure 12). Note that the entire Zone Zero begins at the building's exterior wall surface.
- Increase the base zone dimensions to establish the minimum width for each concentric zone as required by code to adjust for the actual wildfire hazard threshold for the property (e.g., moderate, high, extreme), vegetative fuel density and types, the slope of the site, and local fire department capabilities (see Considerations below).
- Enlarge and refine the size and shape of the zones as necessary to address more vulnerable building geometry (including reentrant corners) or construction materials (such as glass walls), preservation priorities, and other objectives. Prioritize a larger defensible space with a simplified perimeter shape to maximize protection. Note that increasing the size of one of the inner zones does not reduce the dimension of another zone but may affect where it starts and ends.
- Establish Zone Zero noncombustible clearances around first responder access/egress routes as well as power lines, transformers, and gas meters to prevent embers from igniting materials near utilities. Protect fire department connections and hydrants, as well as electrically powered water supplies.
- Adjust the size and refine the shape of the defensible space and each zone as appropriate when considering different building hardening or site treatment options as part of efforts to better balance preservation and wildfire resilience priorities, such as expanded defensible space zones that might preempt needing more robust hardening treatments that might negatively impact the historic character of the building.

Defensible Space - Zone Zero

- Calculate minimum size and shape per local jurisdiction
- Optimize for risk and performance objectives

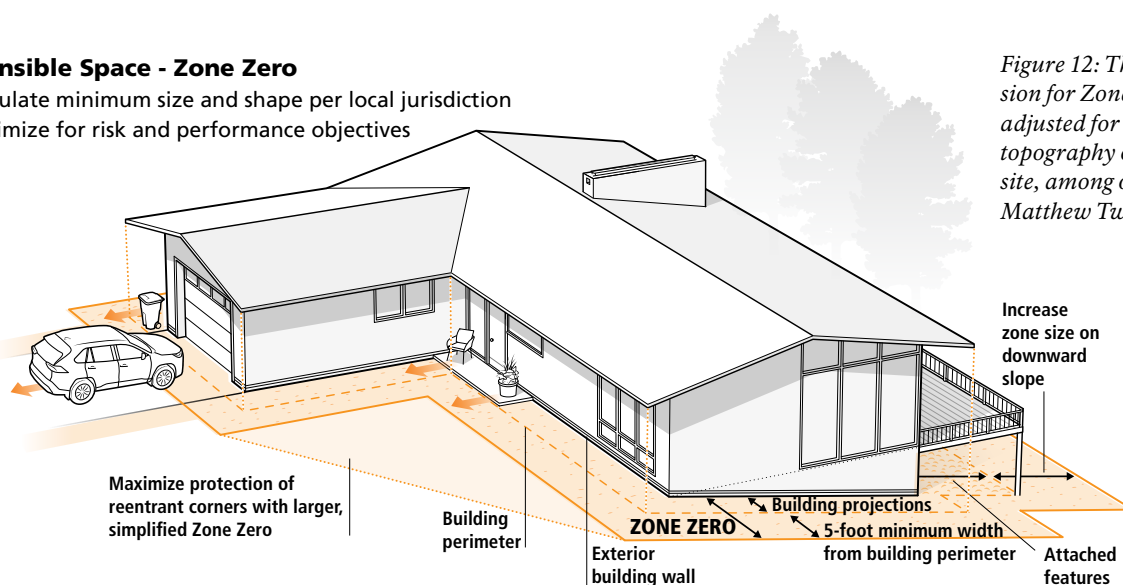


Figure 12: The 5-foot base dimension for Zone Zero should be adjusted for the geometry and topography of each building and site, among other factors. Graphic: Matthew Twombly for NPS

Planning the Size and Shape of the Defensible Space, continued

MULTIPLE BUILDINGS

- Establish defensible space zones for each accessory structure, outbuilding, and, where warranted, small-scale character-defining site features and elements and historic vegetation.
- When buildings or features are grouped on a property such that the inner zone(s) of each overlap, treat the entire grouping as a single unit for defensible space-planning purposes.

DENSELY DEVELOPED AREAS

- When buildings on neighboring properties are within the historic building's defensible space, such as in a main-street or suburban location, enlarge the zones as required. Zone Zero may need to be enlarged (including up to the shared property line), fuel may need to be further reduced in any remaining Intermediate Zone, and building hardening may need to be increased or prioritized, depending on the site conditions and the extent of zone overlap.
- When adequate building hardening and defensible space cannot be achieved on the site itself, coordinate defensible space treatments with adjacent property owners and support community-level planning or programs that propagate shared defensible space.

CONSIDERATIONS

The site features and views that contribute to the property's historic character and appearance should be identified and their relative importance evaluated and ranked early in the planning process to inform defensible space zoning and treatment decisions. Site and setting often play major roles in defining historic character; aspects may include spatial organization, topography, design, planting patterns, vegetation, circulation pathways, and other site and landscape features. Depending on the property's significance, the entire site may contribute to its historic character or only the areas visible from public rights-of-way or associated with the primary elevation.

Historic districts often include landscape and site features that contribute to the historic significance, appearance, and integrity of the property and the district or can be part of a cultural landscape. The development of defensible space zones and adaptive treatments should consider how to protect these character-defining features, particularly small-scale site features and historic vegetation, when balancing wildfire risk-mitigation priorities. Protective zones for each character-defining feature can be established, and appropriate adaptive landscape and site treatments can be undertaken (see sidebar on **Cultural Landscapes**).

When establishing the size and shape of defensible space zones, WUI code provisions typically assume a single building on flat land, and dimensions are measured perpendicular to the building perimeter and extended vertically to the sky. By design, this affords wider zones on sloped terrain and for roof overhangs, as well as Zone Zero protection for decks and porches, bay windows, and other projections.

Reentrant corners are among the most vulnerable points on any building because they can accumulate debris and embers, receive radiant heat from two directions simultaneously, and are difficult to maintain. A reentrant corner is better protected when the initial zone, Zone Zero, is measured from a straight line connecting the two outside corners.

WUI regulations may enlarge the base zone dimensions for properties with higher likelihood or intensity of wildfire exposure, such as those situated in high local hazard severity or with dense, highly flammable vegetation. As slope increases, flame lengths and heat exposure increase proportionally, often justifying dimensions enlarged by 50 or 100 percent on downslope portions.

In special circumstances, such as to protect valuable collections, insurance carriers may recommend a defensible space outward to 500 feet.

When neighborhoods are densely developed, or when firefighting resources and water supply are limited, community-level approaches may be one of the best paths to achieving meaningful defensible space. Examples of community-level risk-mitigation measures can include mutual vegetation management agreements, neighborhood defensible space programs like Firewise USA, and establishing a Community Wildfire Protection Plan.

Vegetation in Defensible Space (All Zones)

Vegetation ignites easily and is generally highly combustible. In addition, it constantly changes as a result of growth, spread, seasonal debris, and shifting environmental factors such as water, light, heat, and soil conditions.

TREATMENTS

- Determine where and how vegetative debris and removed limbs, plants, or organic mulches will be composted on site without increasing wildfire risk or taken off-site (see **Property Maintenance Table**).
- Identify highly flammable vegetation and prioritize its removal or replacement with fire-resistant vegetation.
- Evaluate vegetation, particularly on sloped sites, for its soil-stabilizing function and its anticipated response to drought and heavy rain, conditions that can increase fuel. Debris flows, severe erosion, and landslides commonly follow wildfire.
- Identify existing hardscape and ground cover planting areas that can be used as fuel breaks.
- Use irrigation as needed to help ground-cover plantings and other vegetation retain moisture and improve fire resistance. Any plantings in Zone Zero must be watered and kept alive during the fire season.

CONSIDERATIONS

Assess how landscape patterns and plantings contribute to the historic character of the building, site, and setting (and, when applicable, the historic district) before modifying vegetation. Research the size of plantings during the period of significance and implement succession planting to maintain the historic appearance. Consult preservationists with expertise in historic landscapes and plantings when the building site and setting have more historical significance.

When vegetation is character-defining, consider options that will have a more minimal impact and focus on plant health and managing plant size. In higher fire-risk conditions, treatments may involve pruning, spacing adjustments, selective thinning, or selective relocation to reduce fuel quantity and continuity while still retaining the overall design intent as much as possible.

Highly flammable species, even if distinctive, may need to be replaced with compatible less-flammable alternatives that maintain the landscape's general visual appearance and design. Non-native or invasive plants are often pyrophytes and flammable.

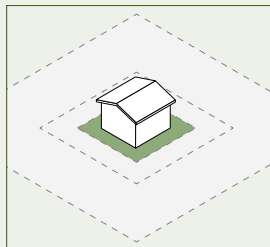
Non-historic plantings less important to the historic character of the site may be removed or modified as necessary. For small parcels where vegetation forms direct fire pathways, the relative importance of the vegetation to the property's historic character and its retention should be balanced against the fire risk it poses to the building.

Site vegetation choices should consider the local climate, topography, ecological systems, and native plants. Characteristics of flammable vegetation commonly include high oil content, low moisture, or producing excessive debris that increases fire intensity and spread. Selecting dense, slow-growing plants over resinous or invasive species helps reduce fuel loads and improves ignition resistance of the site. Professional landscapers or the local fire department can often provide recommendations for more fire-resistant vegetation appropriate to the locality.

Irrigation should be positioned so it does not saturate building materials or lead to rising damp conditions.

Creating and maintaining defensible space is a labor-intensive practice that requires regular attention, especially during the fire season (see **Property Maintenance Table**).

Zone Zero (immediately around the building)



Creating Zone Zero, also known as the Immediate Zone or Noncombustible Zone

Embers and creeping fire can create localized fires close to the building or up against its foundation that can ignite combustible building envelope materials or crawl spaces and introduce radiant heat levels that can break glass, allowing flames into the building interior.

TREATMENTS

- Establish a noncombustible zone encircling the perimeter of the building and any attached features to create a fuel break between site and building and to prevent ember-driven spot fires proximate to the building.
- Move flammable materials, both vegetative and man-made, to outside Zone Zero or replace them with noncombustible materials. Materials can also be removed completely or stored inside the building. A limited number of easily moved items, such as potted plants or furniture, can remain in Zone Zero, as long as they can be removed or stored inside prior to a wildfire event. Note that in a fire event, there may not be adequate time to relocate anything.
- Clear vegetation, combustible mulch, and storage from under elevated features of the building like decks and porches, as well as under highly explosive fixed-fuel items like large propane tanks and from around power lines, transformers, and gas meters.
- See **Building Hardening Table** for treatments of decks and covered porches.

CONSIDERATIONS

Zone Zero is one of the most critical components of the overall wildfire defensive system, and this area immediately around the building will typically require modifications to enhance the fire resilience of the overall site and the historic building.

Zone Zero is functionally interdependent with hardening the lower part of the building's exterior walls to create a noncombustible vertical clearance above a horizontal surface (see **Building Hardening Table**, Vertical Clearance/Foundation Walls).

The changes necessary to landscape plantings, features, and materials within Zone Zero may be some of the most impactful changes required to protect the historic building from wildfire exposures. For many properties, these changes will have minimal impact on the property's historic character. For other properties, the historic character may be adequately retained by shifting landscape features and elements away from the building, moving them entirely to outside Zone Zero, or through creative use of substitute materials. Note, also, that many buildings historically had vegetation-free perimeters and that existing foundation plantings may not be the historic condition.

Any alterations to the site must maintain positive (above- and below-grade) drainage away from the building foundation to prevent water intrusion year-round and to manage runoff from firefighting efforts. A positive slope also helps avoid build-up of flammable debris along the building perimeter and helps prevent firebrands from rolling toward the building.

Fences, Retaining Walls, and Other Features Attached to the Building

Combustible features attached to a historic building, such as fencing, trash enclosures, gates, posts, and wood retaining walls, can create continuous pathways for fire to spread to the building.

TREATMENTS

- Remove flammable fencing, gates, posts, trash enclosures, trellises, arbors, and retaining walls within Zone Zero, at minimum, or replace them with noncombustible materials.
- Maintain and trim vegetation near or on fences; alternatively use rock mulch or gravel to reduce fuel loads and plant maintenance needs.
- Relocate any smaller outbuildings outside Zone Zero or remove them completely. In some localities, relocation to double the distance of Zone Zero may be required.

CONSIDERATIONS

Fences or other attached features may not always be available in similar-looking noncombustible materials. In those cases, any replacement fencing should be as compatible as possible with the historic character of the property and the design of the feature being replaced.

For considerations when exploring building relocation, see Intermediate Zone and Garages, Sheds, Barns, Stables, Gazebos and Other Detached Accessory Structures or Outbuildings.

Zone Zero (immediately around the building)

Figure 13: Noncombustible fencing within Zone Zero breaks continuous fuel paths such as those created by a traditional wood fence attached to a building or under roof overhangs. In this example, metal fencing evokes the appearance of the wood fencing beyond. Photo: Boulder County Wildfire Partners



Trees and Foundation Plantings

Vegetation close to a building increases ignition risk, as all vegetation can ignite under wildfire conditions. Even well-watered plantings may rapidly dry and preheat during intense or upslope fires.

TREATMENTS

- Remove or relocate plantings from Zone Zero and replace with noncombustible materials and surfaces (see Mulch and Hardscaping below).
- When tree crowns are in or near Zone Zero, create and maintain at least 10 feet of horizontal separation (or double the Zone Zero distance) between tree crowns and the building exterior (roof edges, decks, chimneys, plus overhead utilities); adjust separation distance per jurisdiction requirements.
- Remove climbing plants and any supporting trellises.
- Excavate any root balls to eliminate a fuel that can burn below grade for a long time and to prevent regrowth. If not removed, burning root balls adjacent to a building can lead to displaced foundation walls or cause other damage.
- When the jurisdiction allows vegetation within Zone Zero, ensure it does not form a connective path for fire to spread to any building, structure, or other combustible site feature. Allow no vegetation to contact the building or its overhangs and increase vegetation and building separation to account for plant growth and realistic maintenance cycles. Adjust groupings, reduce plant height, widen spacing, and use fire-resistant species to limit the potential exposure of high heat and flames to the building.

CONSIDERATIONS

When historic foundation planting areas are present within Zone Zero, explore treatment options that retain the historic character; for example, consider the impacts of reducing the size of the planting area, shifting it away from the building, or moving it entirely outside Zone Zero.

When historic trees are present within Zone Zero, or when it is not feasible to thin or reduce the crown size of a large adjacent tree, note the tree as a possible significant source of fire risk and consider its removal balanced against its importance to the historic building and its site.

Removal of vegetation should be carefully done to avoid scarring historic building features such as structural foundations or piers and tree roots. Following removal of climbing plants, the building's exterior surfaces should be inspected for damage and any necessary repairs undertaken.

Grinding tree stumps in Zone Zero is not recommended because the process leaves wood mulch. Treating stumps with herbicide may help prevent new growth, but the hazard of the stump itself would effectively remain.

Another benefit of limbing trees back and up from roofs is reduced debris accumulation. Keeping vegetation away from walls also improves air circulation, allowing wall surfaces to dry and reducing moisture-related deterioration.

Zone Zero (immediately around the building)

Mulch and Hardscaping

Combustible mulches can ignite quickly or smolder and cause delayed ignition. Deep mulch layers can generate enough heat through decomposition to self-ignite. Rubber or vinyl mulches present similar hazards. Once ignited, mulch can form a pathway for fire to reach the building.

TREATMENTS

- Remove combustible mulches and edging to bare soil.
- Use noncombustible materials for mulch, landscape edging, and hardscaping. Examples include decomposed granite, brick chips, gravel, lava stone, rock mulch, river rocks, sand, concrete, stone, or brick pavers. For landscape edging, consider masonry, concrete, or metal.
- Low hardscape features and landscape edging may also be used to help obstruct ground-driven embers and burning debris. On slopes, evaluate efficacy against burning debris rolling downhill. Always maintain positive drainage away from the building.

CONSIDERATIONS

New noncombustible mulch, landscape edging, and hardscaping should be compatible with the historic character of the site, setting, and landscape in design, size, shape, texture, and color. More flexibility is possible in less visible or secondary areas.

Traditional hardscape materials using oyster shells or materials that include consolidants to create an accessible surface may require evaluation for combustibility, off-gassing, and resilience to wildfire exposures.

Rubber mulch, sometimes used for accessibility, is highly flammable and should be treated the same as combustible mulch in Zone Zero.

Additional benefits to removing combustible mulches include deterring termite infestation, avoiding moisture retention against foundations, or maintaining positive drainage.



Figure 14: The character of defensible space can vary widely and still meet local resilience requirements (e.g., some codes may allow limited planting within Zone Zero). The defensible space should be compatible with the historic character of the building and its site and setting. Photos: (top) go360listing.com, realtor Ed Ortiz; (bottom) Saxon Holt / PhotoBotanic, design by April Owens Design, LLC

Zone Zero (immediately around the building)

Equipment and Utilities

Utilities or screening can be ignition sources or pathways for fire to spread to buildings. Some equipment contains highly flammable liquids that may ignite or explode. Natural gas poses immediate explosion, fire, and toxic exposure risks to responders, occupants, and buildings. Water service capacity impacts firefighting capabilities, and melted water piping can lead to contaminated potable water.

TREATMENTS

- Establish and maintain recommended vegetation clearances around power lines, utility equipment, and fire hydrants on the property.
- Protect fixed flammable fuel storage, such as propane tanks, fuel oil tanks, or natural gas meters, with noncombustible barriers or relocate them outside Zone Zero where feasible.
- Follow local utility guidance regarding emergency preparedness and wildfire mitigation planning; know the location of gas, electric, and water main shut-off controls and how to turn them off safely.
- Ensure any aesthetic screening does not transfer fire to the building. Avoid screening with combustible materials or plants as they may offer a fire ladder pathway to the building.
- Mark sub-grade tanks and vaults to promote firefighter and equipment safety.
- When electrical service is overhead, coordinate with local utility providers to convert to underground service (where feasible).

CONSIDERATIONS

Exterior equipment can include HVAC units, pumps, water heaters, and on-site fuel or power systems. The potential for ignition, spread, and explosion should be considered in addition to protection of the equipment itself.

Flammable, fixed fuel storage presents both fire hazard and explosion risk during wildfire exposure. Consult applicable fuel-storage codes, which may differ from wildfire-related requirements.

Adding enclosures should generally be avoided on primary elevations, and their design should be compatible, yet secondary and as unobtrusive as possible.

Overhead electrical connections and transformers can be highly dangerous during wildfire. When burying conduit, consider the historic site features, finishes, and plantings when selecting a location.

Vehicles, Furniture, Storage Areas, and Other Movable Combustible Items

Loose combustible items or vehicles near a historic building can ignite and expose the structure to radiant heat or flames. Vehicles and other fuel-containing movable objects can be highly explosive. Electric vehicles and batteries also pose a risk.

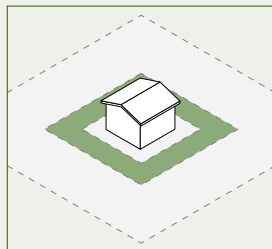
TREATMENTS

- Plan for the storage or removal of firewood, trash containers, and other movable combustible items so they are not left outside or unprotected in Zone Zero. Note that in a fire event, there may not be adequate time to relocate anything.
- Lightweight combustible furniture and a minimal number of noncombustible plant containers may remain within Zone Zero if they can reliably be moved indoors or to the extended zone during high wildfire-risk days or extended absences.
- Park vehicles, motorcycles, and gas grills outside Zone Zero if they cannot be moved beyond 30 feet from the building during high wildfire-risk days or extended absences. Alternatively, store them in a fire-hardened garage or use fire-resistant covers to protect against heat, embers, and ash.

CONSIDERATIONS

Any new garage or permanent outbuilding or structure should be carefully sited relative to the defensible space zones and designed to minimize impacts on the historic character of the building, its site, and setting. (See **Building Hardening Table**, New Additions to Historic Buildings and Related New Construction.)

Intermediate Zone (the transition between zones)



Creating the Intermediate Zone, also known as Zone 1 or “Lean, Clean and Green” Zone

Wildfires can move rapidly through a site, following continuous fuel pathways, driven by winds, and advanced by spotting, radiant heat, and direct flame contact.

TREATMENTS

- Alter and manage landscaping through thinning, spacing, removing, or adequately sheltering vegetative and man-made fuels to help slow the rate and intensity of an advancing wildfire and to create a safe area for fire suppression operations to occur.
- Utilize existing driveways, walkways, and noncombustible patios or decks as fuel breaks or create new ones to help disrupt fire behavior.

CONSIDERATIONS

The Intermediate Zone typically has the biggest impact on defining the historic character of the building site and setting. Primary views to and from the building should be understood and treatments designed to preserve character-defining spatial relationships as much as possible.

Garages, Sheds, Barns, Stables, Gazebos, and Other Detached Accessory Structures or Outbuildings

Once ignited, accessory structures and outbuildings generally burn at higher temperatures and for longer times, and generate bigger flames than most vegetation, and can therefore put the primary building at greater risk of ignition. Burning construction materials can also generate additional flying embers.

TREATMENTS

- Relocate larger outbuildings, generally those larger than 25-square-feet in size, to or outside the Extended Zone.
- When an accessory building is in the Intermediate or Extended Zone, assess it for wildfire risk and mitigate by hardening its exterior envelope and establishing individual defensible space.
- When the defensible space of an accessory building overlaps the inner zone(s) of another building, treat the entire grouping as a single unit for defensible space-planning purposes or increase building hardening measures for the secondary building(s).

CONSIDERATIONS

Accessory buildings and structures include pergolas, gazebos, garages, and sheds. Appropriate mitigation measures will depend on their significance, size, design, materials, and proximity to the historic building.

Because historic accessory buildings and structures are generally secondary in importance to the primary building, greater adaptive change may be acceptable. Relocation or complete removal may need to be considered as options, depending on their level of significance and the wildfire risk they pose to the overall property.

When relocating historic accessory buildings and structures, the original orientation, setting, and relationship to the main building should be maintained as much as is reasonably possible, considering the building, structure, and site conditions. Note that contributing buildings and structures to a property or district listed in the National Register of Historic Places may require pre-approval by the National Park Service to maintain listing.

Non-historic accessory buildings and structures can be removed without adversely impacting the historic character of the property. Modifying or relocating non-historic features should be undertaken in such a manner to avoid impacting the property's historic character.

Intermediate Zone (the transition between zones)

Fences, Trellises, and Other Combustible Site Features

Fences can trap accumulated vegetative debris and embers and, once ignited, provide continuous pathways for flames to reach a building where they may threaten combustible cladding, eaves, and nearby windows or find small gaps in building exteriors or other vulnerabilities.

TREATMENTS

- Remove back-to-back (parallel) combustible fences spaced less than 5 feet apart (or spaced less than the Zone Zero width, if it is greater than 5 feet, and depending on the fence height, design, or material).
- Replace combustible site features in locations that could contribute to fire spread with noncombustible materials. Wholesale removal may sometimes be the most prudent mitigation action.
- Keep combustible vegetation and materials away from combustible fences and other site features and prune back any tree branches touching them; alternatively use rock mulch or gravel to reduce fuel loads and plant maintenance needs.

CONSIDERATIONS

Combustible site features, such as fences, wood trellises, arbors, play-systems, and railings, can be important character-defining features of a historic site. If matching noncombustible options of the features are not available, replacement features should be compatible with the historic character of the property and the historic feature as much as possible (see sidebar on **Cultural Landscapes**).

When parallel fences occur at property boundaries, coordinate mitigation efforts with neighboring properties. Options may include removing one fence or replacing one with a noncombustible one.

Solid noncombustible fencing with Zone Zero treatment can serve as a fire break. On sloped sites, hardscape designed to contain embers may not be effective against burning debris rolling downhill.

Vegetation in the Intermediate Zone

The wildfire risks posed by vegetation depend on its type, density, grouping, horizontal and vertical connectivity, and proximity to the historic building, especially under windy and sloping conditions.

TREATMENTS

- Thin and space vegetative fuels, both horizontally and vertically, to reduce fire spread and intensity.
- Rigorously maintain vegetation to remove dead plant material and to perpetuate the minimum-required spacing distances (see **Property Maintenance Table**).

CONSIDERATIONS

Replacing large-scale areas of vegetation with hardscape is generally not needed or recommended. Denuded landscapes can exacerbate the movement of embers and large burning debris toward buildings and can significantly alter the historic character of the site and setting of the historic property.

As further discussed below, vegetation outside of Zone Zero may generally include trees, shrubs, ground cover, and ornamental plants. As in Zone Zero, mulch choices can result in fire spread.

Intermediate Zone (the transition between zones)

Trees

Fire can readily spread to a building or intensify into a dangerous crown fire when tree spacing or proximate vegetation create continuous horizontal or vertical fuel paths. Vegetation beneath or climbing on trees can enable surface fires to become ladder and crown fires. Attached dead vegetation, such as dead palm fronds or low branches, can exacerbate the ladder effect.

TREATMENTS

- Create a vertical fuel break by removing ladder fuels, such as vines, trimming or removing shrubs within the tree's dripline, and pruning lower tree branches as needed.
- Maintain horizontal spacing between tree crowns as well as between trees and building edges, chimneys, utilities, and driveways. Adjust spacing based on slope, species flammability and anticipated flame length, wind exposure, and mature canopy size.
- Limit trees to small clusters to prevent continuous fuel paths and break up vegetation continuity.

CONSIDERATIONS

The preservation of an individual tree may depend on its relative significance to the historic property and such things as whether it is an individual specimen or part of a historic grouping, such as a windbreak, orchard, woodlot, or formal planting. Flame-resistant trees in a windbreak can help reduce fire spread.

Decisions on limbing or removing trees should be based on the tree's character-defining qualities, proximity to buildings and property access/egress, whether nearby fuels can be removed instead, the tree's age and health, and its flammability characteristics (e.g., its density, volatile oils, debris production, etc.). Consider engaging an arborist to identify sick or diseased trees.

Review and integrate local heritage tree ordinances when developing treatments.

Shrubs

Shrubs can spread fire horizontally or be ladder fuels that spread fire to trees, buildings, and other parts of the property, often resulting in difficult-to-control fires.

TREATMENTS

- Limit shrubs to small clusters of a few each to break up vegetation continuity across the landscape.
- Thin or remove large, dense groupings of shrubs. Separate individual shrubs or small clusters. Surround with areas of noncombustible material where appropriate.
- Remove shrubs located within 10 feet of the tree canopy, within five feet of a building, or near building-access pathways, driveways, and roads.

CONSIDERATIONS

Decisions for pruning or removal should be based on their character-defining qualities to the site and property as well as their relative fire risk, proximity to buildings and property access/egress, and their flammability characteristics (e.g., density, volatile oils, debris production, etc.).

In a shrub-dominant landscape design, rehabilitation will be required to achieve compatible alterations to the landscape that meet defensive space requirements.

Ground Cover Plantings

Tall ground cover can rapidly ignite and generate surface or creeping fires that can move quickly and spread widely.

TREATMENTS

- Maintain low ground cover height (e.g., lawns and native grasses at approximately 4 inches) to reduce surface fuels.
- Remove highly flammable species of ground cover or replace them with a more fire-resistant species.
- Strategically alter large continuous areas of ground covers by adding hardscape or noncombustible mulch to create fire breaks.

CONSIDERATIONS

When the ground cover is character-defining within the landscape, replacement plantings should have a similar form, height, and appearance.

Efforts to create fire breaks within ground-cover plantings may involve hardscaping or noncombustible mulch and should be designed to minimize visual impacts on the landscape. Ground-cover plantings can also be used to create fire breaks between larger vegetation.

Intermediate Zone (the transition between zones)

Flower and Vegetable Gardens

Flower and vegetable gardens often include a wide variety of plantings, each with different combustibility characteristics.

TREATMENTS

- Adequately distance gardens from other vegetation, other combustible items such as compost piles, and buildings and structures.

CONSIDERATIONS

Consult fire officials and historic landscape experts for historic large, complex, or designed gardens in the defensible space and how best to address them in protecting the historic building, other historic site and landscape features, and the feature itself.

Mulch

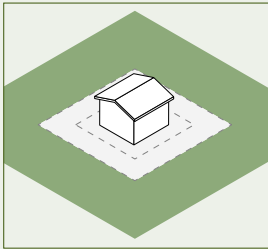
The dangers of combustible mulches are described in Zone Zero, Mulch.

CONSIDERATIONS

Certain organic mulches, such as weathered/composted hardwood chips, may be acceptable in the Intermediate Zone, but each should still be evaluated for burn behavior and used only in limited quantities. Mulches that burn slower and with shorter flame lengths are less hazardous to wildfire spread.

Around combustible significant features within the Intermediate Zone, follow Zone Zero mulch treatments and considerations.

Extended Zone (the zone farthest from the building)



Extended Zone, also known as Zone 2

Wildfires can move rapidly through a site, fed by fuel types, following continuous fuel pathways, driven by winds, and advanced by spotting, radiant heat, and direct flame contact.

TREATMENTS

- Manage the site to interrupt the fire's path and keep flames smaller and on the ground, adjusting for the slope of the property's terrain per local guidance or insurance requirements.
- Remove dead vegetation, including heavy accumulations of ground litter/debris, dead plants and trees or tree limbs.
- Remove select live vegetation, specifically small conifers growing between mature trees and vegetation adjacent to storage sheds or other outbuildings.
- Trim and limb trees to establish appropriate horizontal spacing between canopy tops.
- Limit trees to small clusters to prevent continuous fuel paths and break up vegetation continuity.

CONSIDERATIONS

Some types of combustible mulch such as pine needles, shredded redwood, or cedar bark may be acceptable in the Extended Zone if at least 30 feet away from any building (including on adjacent parcels) or combustible site features.

Large sites with commercial operations, working landscapes, or large-scale designed planting features (such as ranches, orchards, allées, hedgerows, etc.), whether historic or non-historic features, may have to balance additional considerations in developing a wildfire risk-mitigation plan.

Table 2. Building Hardening and the Historic Building Exterior

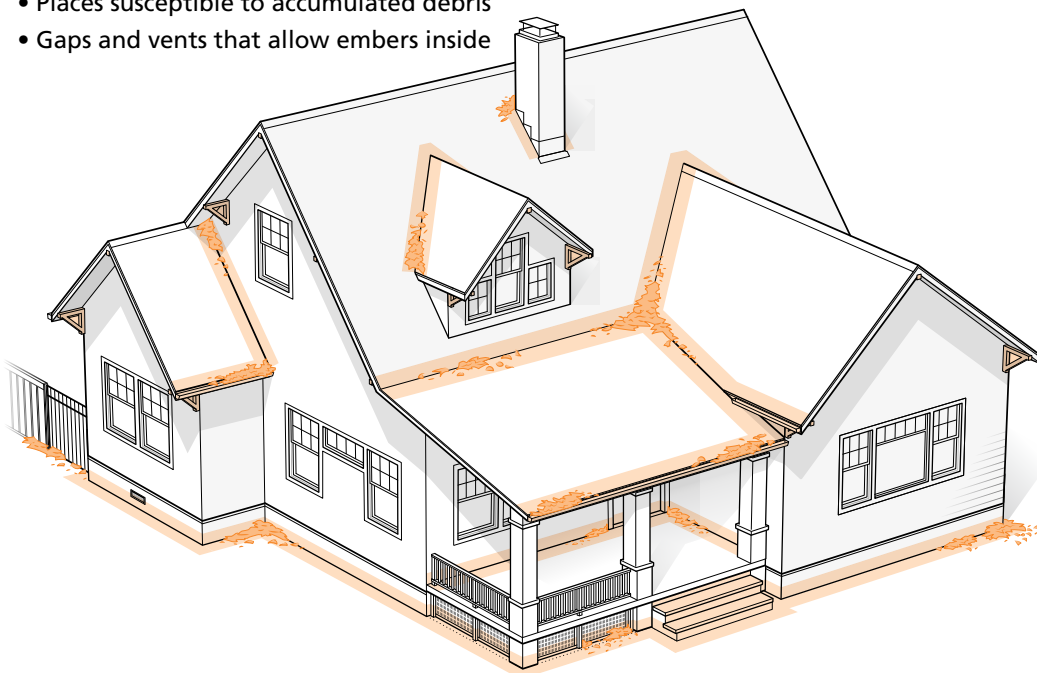
Use this table together with the **Defensible Space** and **Property Maintenance** tables as part of developing a wildfire protection plan to help reduce the ignition potential of the historic building while preserving its historic character. This **Building Hardening Table** identifies common wildfire vulnerabilities and adaptive treatments for exterior building features and materials, grouped into two tiers based on their statistical probability relative to potential structural loss. Criteria to help prioritize the second tier of building features based on their specific characteristics and the property conditions are also included. Additional considerations are identified on designing new additions and new construction on historic properties in wildfire-prone areas and the performance of building materials under wildfire conditions.

Features predominantly linked to structural losses

- Roof Systems
- Roofing Materials
- Gutters and Downspouts
- Vents/Penetrations
- Eaves and Soffits
- Vertical Clearances/Foundation Walls
- Covered Porches, Decks, Overhead Structures, and Other Projecting Architectural Features

Building Hardening - Ember Risk

- Places susceptible to accumulated debris
- Gaps and vents that allow embers inside



The hardening of exterior walls to create a noncombustible vertical clearance above a horizontal surface is sometimes discussed as part of defensible space but is included in this Brief as part of the **Building Hardening Table**. The effectiveness of vertical clearance treatments at wall bases is interdependent with Zone Zero treatments, discussed in the **Defensible Space Table**, but also applies to other horizontal areas on buildings and building features where embers can accumulate such as at dormer walls.

Other features that might put the property more at risk, depending on the characteristics and features of the specific building

- Exterior Walls
- Window Units, Skylights, and Curtain Walls
- Glass
- Doors
- Other Projecting Features and Cantilevers

The **Other Wildfire Risk-Mitigation Measures** discussion that follows the tables addresses potential temporary and permanent treatment alternatives that may, in certain circumstances, be used to enhance the wildfire resilience of the historic building and property.

Figure 15: Embers cause up to 90 percent of wildfire-related building ignitions. Anywhere debris collects is vulnerable to accumulating embers and, consequently, direct or indirect ignition. High winds and pressure differentials can trap embers in irregular surfaces and drive them into gaps or inside the building. Graphic: Matthew Twombly for NPS

Building Hardening: Features Predominantly Linked to Structural Losses

Embers cause up to 90 percent of wildfire-related building ignitions, and roof and vent pathways are the dominant entry points. The following building features are generally more susceptible to ignition from embers or to allowing embers into unmonitored space, where fire grows undetected (see Figures 15 and 16). Building hardening actions to these features should therefore be prioritized.

Roof Systems

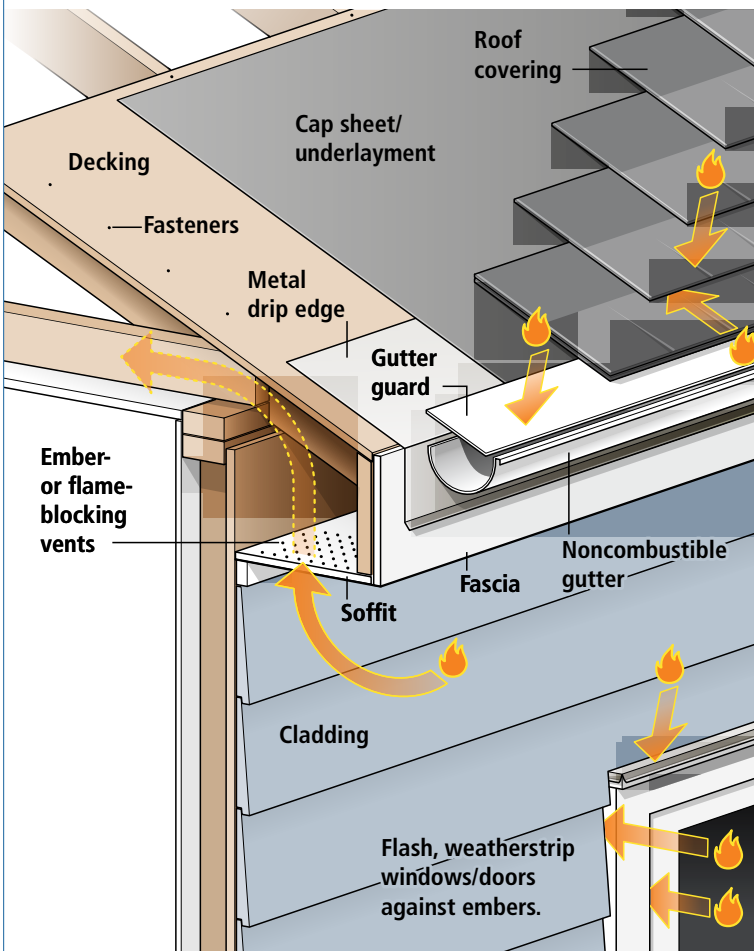
Roofs readily accumulate debris and embers, and vulnerability increases with complex roof shapes, poor maintenance, and combustible coverings. Steeply sloped roofs may also face higher exposure to radiant heat and direct flames.

TREATMENTS

- Verify existing roof assembly (covering material, underlayments, decking, fasteners, insulation, flashing) and assess for combustibility and gaps (see Figure 16).
- Repair or replace components to achieve the required minimum-rated fire-resistant roof assembly (or higher), in addition to sealing gaps to block ember pathways with appropriate fire-rated sealant (see Figure 17). Select sealants compatible with historic substrates. Protect combustible substrates from embers, heat, and flame exposure.
- Augment or replace flashing to be noncombustible, located where debris and embers will accumulate, and appropriately sized.
- Secure sheet goods and fasteners against hurricane-level wind uplift; correct loose or corroded components.
- Coordinate roof edge treatments with gutters, eaves, soffits, exposed rafter tails, and vertical clearance treatments.

CONSIDERATIONS

Roof form, detailing, and materials are often character-defining, so adaptive treatments must balance reducing ignition risk with preserving historic appearance. Wood roofs (discussed further below) may require more in-depth evaluation due to higher vulnerability and potential code conflicts.



Class A (per ASTM E108) is the highest rated fire-resistant roof assembly. Class B or C roof assemblies may be acceptable by code in areas with less wildfire risk, depending on the defensible space or other factors. These ratings measure resistance to exterior fire spread but do not address ember intrusion at ridges, hips, valleys, eaves, or penetrations. Even a Class-A assembly can admit embers if gaps are unsealed, so both fire-rating and ember-resistance requirements must be paired.

The vulnerabilities of dormers, cupolas, skylights, and walls intersecting roof planes must also be addressed as part of the roof system treatment to avoid weak spots (see Vertical Clearances, Walls, Windows, and Glass).

Roofing replacement, partial or complete, may trigger WUI code compliance.

Figure 16: The roof and wall assembly should be evaluated as a coordinated system for ignition resistance and impenetrability. Embers can exploit weaknesses at any single point, from gutters and vents to windows, doors, and roof coverings. Graphic: Matthew Twombly for NPS

Roofing Materials

The roofing material can significantly affect where embers may accumulate or become trapped and how readily the assembly may ignite.

TREATMENTS

- Select roofing materials that allow roof assemblies to meet or exceed the ignition-resistance performance required for the wildfire-risk level.
- Utilize compatible substitute roofing materials when in-kind replacement is not feasible or appropriate to the risk.
- Supplement with additional protective measures when appropriate (see **Other Wildfire Risk-Mitigation Measures**).

CONSIDERATIONS

Each type of common roofing material performs differently when exposed to wildfire. Existing noncombustible or metal roofing assemblies may require minimal adaptations to achieve an ignition-resistant assembly, whereas untreated wood roofing, for example, is highly vulnerable to wildfire and will generally require replacement.

Noncombustible roofing materials: Slate, clay, concrete, masonry, and many asphalt-fiberglass shingles in good condition typically need minimal adaptation to meet wildfire-resistant standards. Preserve visible intersection details (e.g., valleys, dormers) while making minor adjustments needed for vertical clearance and ember-resistance (see Vertical Clearances).

Metal roofs: Metal roofing can warp, conduct heat to combustible substrates, or admit embers through gaps or failed seams. Add nonconductive, noncombustible nailers, improve underlayments, seal gaps, and maintain tight seams. When replacement is necessary, evaluate panel widths, seam profiles, color, and other visual qualities to preserve historic character.

Wood shake/shingle roofs: Untreated wood roofing is highly vulnerable to ignition and can contribute to fire spread. When replacement is needed, assess whether factory-impregnated fire-retardant-treated (FRT) products can meet required assembly performance. Note that FRT initial appearance, durability, and appearance after weathering vary. Evaluate size, profile, texture, lap exposure, and installation pattern to maintain historic character. Inform local fire officials when FRT materials are present to support accurate triage decisions.

SUBSTITUTE MATERIALS

Noncombustible or ignition-resistant **substitute replacement materials** that match the visual and physical properties of historic materials may be appropriate alternatives when historic materials cannot meet required or desired fire performance. (This is true for any of the four Treatment Standards in the context of wildfire adaptation.) Evaluate substitutes for visual compatibility, durability, thermal movement, structural capacity, strength/impact rating, roof slope, lifespan, and maintenance needs. Additional considerations may include material availability, economic and technical feasibility, and other factors.

Untreated wood shake/shingle roof coverings are more likely to be replaced with a substitute material (see **Wood Roofs** sidebar). Replacement material options may include asphalt shingles, cementitious and clay tiles, synthetic polymers/composites, and metal shingles/panels. Visual compatibility can vary widely with these materials. Many simulate the appearance of wood shingles and offer adequate visual matches for use on some historic buildings. Visually dissimilar corrugated or standing-seam metal roofing may be acceptable in certain cases when justified (e.g., backcountry conditions).



Figure 17: Even a Class-A roof assembly can admit embers if gaps are left unsealed, so fire-rating and ember-resistance requirements must be paired. Open ends of clay tile roofing (left) should be plugged. Metal roof assemblies (right) should interrupt rapid heat transfer to combustible substrates, such as by using a fire-resistant, high-temperature underlayment as shown here. Photos: (left) NPS; (right) Local Roofer, Inc.

Gutters and Downspouts

Debris-filled gutters can ignite and spread fire to the roof edge, deck, fascia board, or adjacent cladding. Vinyl and other plastic gutters are highly combustible and can melt or detach under heat, exposing rafter tails and roof-edge components, while combustible downspouts can wick fire upward along exterior walls toward adjacent windows and eaves.

TREATMENTS

- Install noncombustible gutter guards and keep gutters clean of litter and debris as a high-priority action.
- Replace combustible gutters and downspouts with noncombustible metal components (aluminum, copper, or steel), in addition to replacing fascia boards with noncombustible, nonconductive material such as fiber-cement board.
- Install metal flashing or drip edges between the gutter and roof edge to shield combustible substrates from ignition.

CONSIDERATIONS

Gutter and downspout upgrades generally have minimal visual impact on the historic character of a building. When replacing historic gutters and downspouts, match important profiles and dimensions where visible to retain character, especially on primary elevations.

Vents/Penetrations

Embers entering vents or gaps at wall or roof joints can ignite unmonitored spaces, such as crawlspaces, attics, or wall framing cavities, often undetected until the fire breaches the exterior envelope. During fire conditions, pressure differentials between exterior and interior can actively draw embers into the building.

TREATMENTS

- Protect historic noncombustible vents with ember-blocking mesh or replace with compatible wildfire-rated units that block embers and flames. Replace combustible vents with wildfire-rated units.
- Install functional metal louvers or flaps on forced-air vents (e.g., dryer vents) in place of mesh to ensure proper airflow.
- Abandon and close unused vents or penetrations. Seal gaps around wall and roof penetrations with appropriate fire-rated sealant; select sealants to avoid staining or damaging historic substrates.
- Utilize through-wall vents instead of roof vents. When roof vents are unavoidable, install a fire damper in the duct at roof plane.
- Maintain the functionality, such as code-minimum free-area, of the ventilation design or remove the need for a vent (e.g., change from natural to mechanical ventilation systems).
- Avoid storing combustible materials in vented crawl spaces or attics.
- Install noncombustible and corrosion-resistant spark arrestors at chimneys and stovepipes.

CONSIDERATIONS

Most vents are minor visual features; ember-resistant upgrades typically have little effect on historic character while meaningfully reducing risk. Any replacement or new vents should be designed and located to minimize visual impact and avoid harm to the historic building.

Ember-blocking mesh must be noncombustible and corrosion-resistant and have a grid sized to block fine embers. The grid size can be dimension-based or performance-based, as stipulated by local codes or requirements, and typically translates to openings no larger than 1/8-inch diameter (see Figure 18). Install mesh to prevent edge gaps.

Wildfire-rated vents utilize special shapes and intumescent-coated components that close under heat and may require replacement after a fire.

Weepholes should not be filled with caulk or mortar; instead use appropriate noncombustible, heat-resistant inserts (e.g., stainless steel screens, stainless steel wool, or copper mesh) that block embers while allowing moisture to escape.

Vent replacement may trigger compliance under some local WUI codes. See **Other Wildfire Risk-Mitigation Measures** for temporary vent covers or shutters.

Eaves and Soffits

Eaves and soffits can trap heat, hot gases, and embers, particularly open eaves or angled closed eaves.

Exposed joints, decking, and gaps increase the likelihood of ember intrusion and ignition during wildfire events.

Open eaves with exposed rafter tails are especially vulnerable due to a high amount of combustible surfaces and numerous points of ember entry.

TREATMENTS

- Confirm ventilation requirements for closed eaves and soffits before undertaking treatments; ensure these requirements are accommodated to prevent moisture accumulation and material deterioration. See Vents/Penetrations above.
- Construct or retrofit closed eaves and fascias as fire-resistant assemblies or replace with noncombustible substitute materials as required to meet local codes.
- Enclose open eaves with noncombustible angled or boxed soffits where risk warrants. In lower risk areas, heavy-timber open eaves may be acceptable by code.
- When enclosing open eaves would change historic character, explore alternatives for blocking embers, increasing ignition-resistance, reducing heat, and venting hot gases (see Considerations below).
- Verify Zone Zero measurements begin at the outermost roof edge and possibly expand Zone Zero beyond required minimums where eaves are complex or deeply overhanging.

CONSIDERATIONS

Roof edge details are generally important and distinctive features of a roof, including closed or open eaves with exposed rafter tails (see Figure 18), decking, brackets, and other decorative elements.

Open eaves and decorative detailing can be a point of conflict between code requirements and retaining the historic character of a building, as they are an ember-entry risk, yet are also important to many architectural styles. Other risks associated with open eaves include combustible components and geometries that can trap hot gases and wind-blown or convective current-borne embers. Decorative brackets and other features can provide many places for embers to lodge.

Adaptive treatments to retain open eaves and decorative elements that might present ember or other risks have been less studied but potentially could include ember-blocking mesh infill, fire-retardant coatings, introducing fire-resistant underlayments behind soffit decking and top of wall, reconstructing decorative elements and decking with noncombustible materials, and adding exterior fire sprinklers within the eave. Whether such treatments need to be considered may depend on how important these features are to the historic character of the building. The effectiveness of these treatment options may vary significantly, and some, specifically mesh infill and underlayments, have limited field validation in actual wildfire conditions compared to full enclosure of the feature. Property owners should understand that these are less-proven alternatives, and acceptance under code and insurance requirements may vary.

A high priority for buildings with overhanging eaves is meticulous maintenance of Zone Zero, and in densely developed areas, coordinated defensible space with neighboring properties.



Figure 18: Existing vents should be covered with 1/8-inch or smaller corrosion-resistant noncombustible mesh, shown here in comparison to more open mesh designed to block vegetative debris or wildlife (left), or replaced with wildfire-rated vents. When open eaves are important character-defining features, treatment alternatives should be explored to retain their appearance while reducing their wildfire vulnerability (right). Photos: (left) Ethan Turpin / Santa Barbara County Fire Safe Council; (right) NPS

Vertical Clearances/ Foundation Walls

Embers and debris often collect where vertical walls meet the ground or other horizontal surfaces, igniting the debris, adjacent vegetation, or combustible cladding (see Figure 15). These areas are also more susceptible to direct flame contact and radiant heat.

TREATMENTS

- Provide a noncombustible, impenetrable vertical clearance at wall bases (typically 6 inches minimum), measured from the ground or other horizontal surface; increase height (up to 2–5 feet) where debris accumulation, slope, or anticipated flame length elevate risk (see Figure 19).
- Cover or replace combustible cladding with compatible noncombustible substitute materials to meet required vertical clearance.
- Protect joints between clearance and combustible cladding above, substrates behind, and any adjacent materials; augment or replace flashing to be noncombustible and appropriately sized.

Building Hardening - Vertical Clearances and Roof Flashing

- Protect against ember- and flame-driven ignition

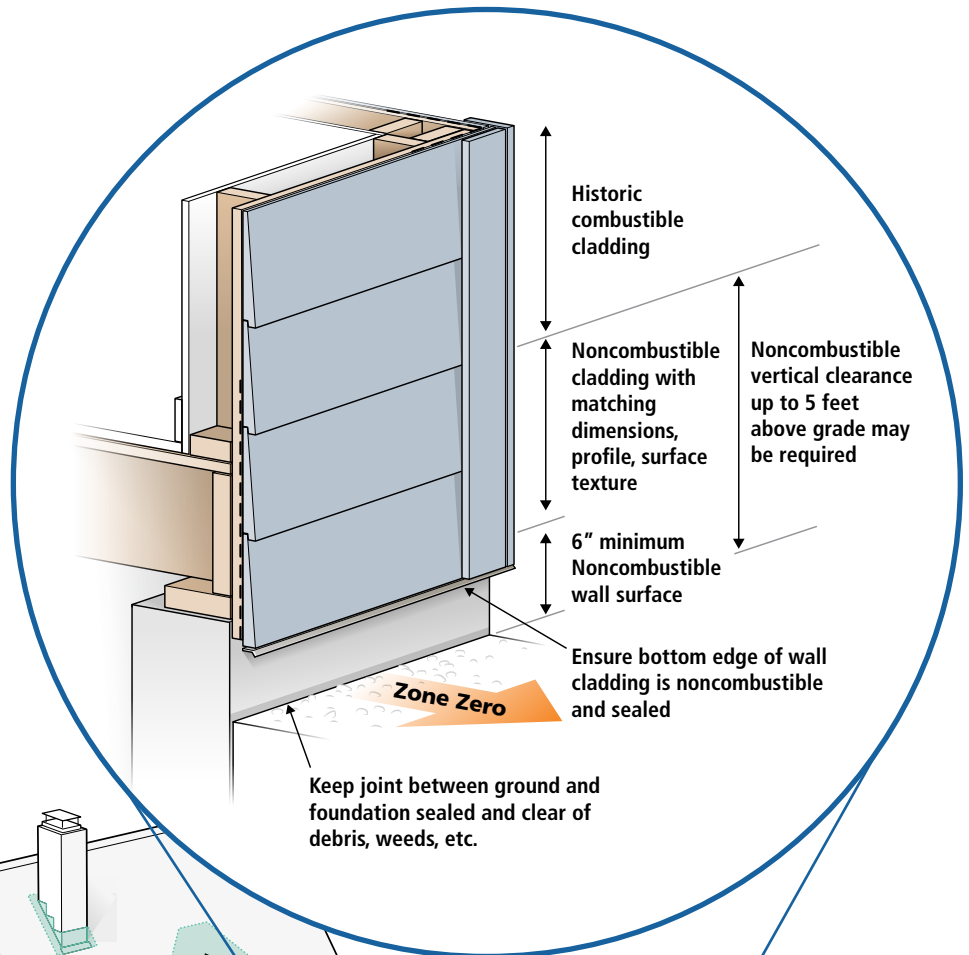
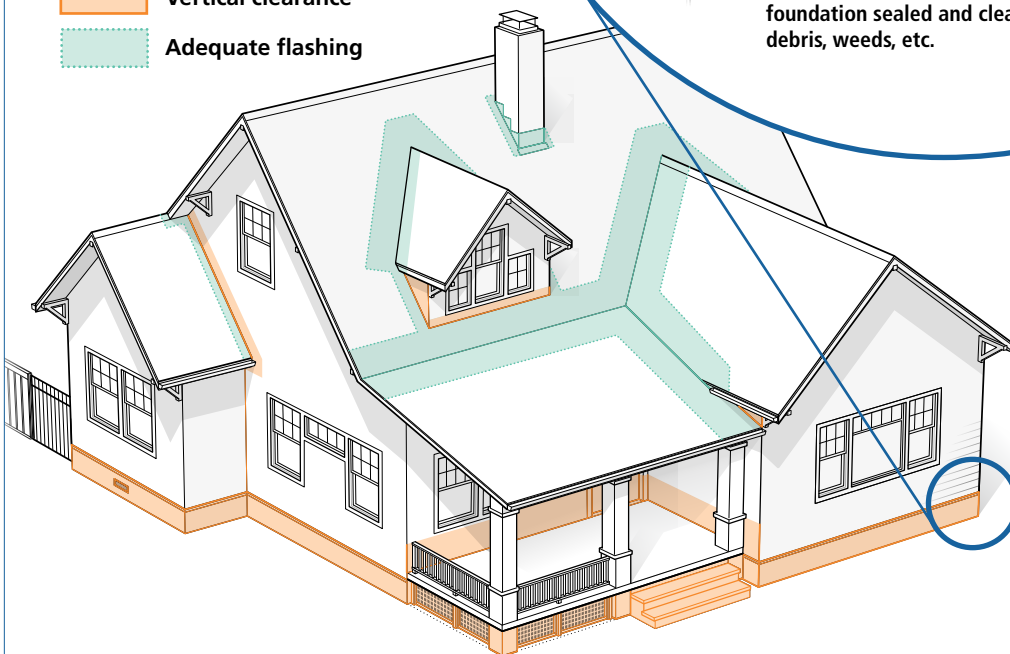
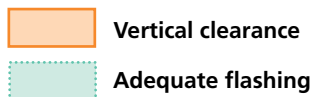


Figure 19: Wherever embers and debris collect, exterior materials such as roofing and cladding should be noncombustible, and adequate flashing should be used to help protect combustible substrates from ignition. To retain historic character, the bottom courses of combustible cladding and trim can be replaced with noncombustible substitute materials matching the historic dimensions and profile. Graphic: Matthew Twombly for NPS

Vertical Clearances/ Foundation Walls, continued

TREATMENTS, CONTINUED

- Address window wells, areaways, and below-grade stairs to reduce debris and ember traps, especially if they are used for egress; consider noncombustible bulkheads or fire-rated doors where appropriate.
- Adapt windows and doors within the vertical clearance as needed (see Windows and Doors).
- For buildings on piers, apply equivalent noncombustible barriers or modify adjacent grade to create and maintain the required vertical clearance (see Covered Porches, etc., and Other Projecting Features and Cantilevers for treatments and considerations of framing and under-surfaces).

CONSIDERATIONS

The intersection of Zone Zero and vertical clearance is a critical point where defensible space and building hardening treatments are interdependent. Vertical clearance must be created at grade, at visible below-grade features, and where horizontal (e.g., the ground or roof plane) and vertical surfaces (e.g., building walls) intersect.

Lower-height vertical clearances can generally be achieved with minimal impact to historic character of the building. When cladding extends to grade, compatible noncombustible substitute materials may be necessary to retain the building's visual appearance.

Covering existing cladding may change the historic character. A more compatible option may be to replace combustible materials with noncombustible cladding that matches the appearance of the historic.

Creating Zone Zero may increase the visibility of foundation walls; consider compatible screening approaches where appropriate (see **Defensible Space Table**, Trees and Foundation Plantings).

The typical clearance height of 6 inches is based partly on historical moisture-management code requirements for wood-frame buildings. Taller clearances (up to 2 to 5 feet) may be required where debris loads are high, ember exposure is significant, or flame lengths increase such as above downhill slopes.

Covered Porches, Decks, Overhead Structures, and Other Projecting Architectural Features

Attached features are commonly constructed of wood, their detailing generally creates places for debris and embers to become trapped, and flammable materials may often be stored above and below walking surfaces. Once ignited, these features can transfer fire to the building itself.

TREATMENTS

- Remove all vegetation and combustible storage beneath elevated features. Do not store combustibles in carports or other attached covered structures.
- Limit combustibles on walking surfaces to a few items that can be quickly removed prior to evacuation. Note that in a fire event, there may not be adequate time to relocate anything.
- Verify the Zone Zero measurements begin at the outside edge of combustible features. Enlarge the radius as needed to meet the risk.
- Protect combustible posts, at minimum, with applied noncombustible materials to the same height as the vertical clearance used for foundation walls. Alternatively, use heavy timber or noncombustible materials for posts, walking surfaces, or the complete assembly (joists, railings, posts, and walking surface).
- Ensure attachments do not compromise fire-rated wall and roof assemblies; introduce fire-blocking and noncombustible vertical clearances (e.g., metal flashing) between combustible materials.
- See Other Projecting Features and Cantilevers for treatments and considerations of under-surfaces of overhead structures and elevated decks and porches.

Covered Porches, Decks, Overhead Structures, and Other Projecting Architectural Features, continued

OVERHEAD STRUCTURES

- Apply the same ignition-resistant roof and roof edge requirements for the building to attached overhead structures, including porches, canopies, window hoods, carports, pergolas, and gazebos.
- Limit combustible overhead slats (e.g., pergolas); to retain the feature, cover top surfaces with metal where code permits or replace with noncombustible materials to match the appearance of historic features.
- Avoid combustible awnings, such as fabric or untreated composite materials.
- See also **Defensible Space Table** for detached overhead structures.

ELEVATED DECKS & PORCHES

- Enclose under-deck voids with ember-blocking mesh; select darker finishes to minimize visual impact (see Figure 21).
- Replace foundation lattice or slats, where historically appropriate, with noncombustible substitute alternatives and add exterior ember-blocking mesh. Alternatively, remove lattice within the required vertical clearance (see Foundation Walls) or install a noncombustible curb between posts.
- For walking surfaces, reduce or eliminate gaps between replacement deck boards to prevent ember accumulation and pathways to combustible framing. Evaluate the fire performance of any substitute materials; avoid those that off-gas easily especially on egress routes.
- Ensure deck assembly accommodates drainage and ventilation requirements to prevent moisture accumulation and material deterioration.
- For railings and posts, replace combustible elements with noncombustible materials; limit combustible infill where permitted.

CONSIDERATIONS

Attached porches, decks, overhead structures, and projecting architectural features can be an area of potential conflict between code requirements and retaining the historic character of a building; how to adapt these features needs to be carefully considered. Historic attached decks and overhead structures may include covered porches, canopies, window hoods, awnings, carports, pergolas, and gazebos and are typically important character-defining features that should be retained and preserved.

Whether historic or existing non-historic features of a historic building, these features pose a potential hazard to the building. Features located above a downslope face greater underside flame exposure and may warrant higher priority risk-mitigation.

Removing and reconstructing materials and features using flame-resistant or noncombustible materials may reduce historic integrity but is often preferable to simply removing character-defining features.

Fully enclosing the under-deck or under-porch area with solid cladding should be avoided for moisture concerns and potential visual impact.

For walking surfaces, consider tongue-and-groove or overlapping board profiles that shed water while blocking embers.

Some porch floors were historically painted, but paints can spread flames. To achieve the look of a painted surface, alternatives may include opaque stains or integral-color substitute materials that perform better in fire. Material options may include specialty composites, aluminum, or labeled fire-retardant-treated wood.

Building Hardening: Other Features

The building features in this section are generally less vulnerable to ignition from embers. When defensible space measures can sufficiently reduce radiant heat and flame exposure to the building, hardening treatments for these features may be a lower priority. Conversely, these features may be a high priority for adaptive treatments when adequate defensible space cannot be created (e.g., a densely developed neighborhood or a building close to a property line), when buildings are in more vulnerable terrain (e.g., saddles and canyons), or when specific architectural features and materials of the building (e.g., large windows, deep overhangs, complex geometries) increase susceptibility to ignition. Factors for evaluating the relative risk of these features to the historic building are included to help prioritize these treatments as part of the wildfire protection plan.

Exterior Walls

Exterior walls are vulnerable to radiant heat, direct flame contact, and ember entry through joints and gaps. Combustible cladding can rapidly spread fire to adjacent features (windows, doors, eaves) and concealed spaces, where fires are difficult to detect and can extend to roof structures and interior spaces.

PRIORITIZATION FACTORS

- Prioritize mitigation of combustible exterior wall materials when other buildings are within the intermediate zone, or within 30–50 feet of each other; focus on walls and corners directly facing neighboring and accessory buildings.
- Prioritize exterior wall treatments for buildings at the WUI edge and on sites with steeply sloped terrain, canyon conditions, or wind/sun exposure that intensify fire behavior.
- Address most vulnerable walls first as part of a phased implementation.

TREATMENTS

- Verify the existing exterior wall assemblies (solid or cavity wall, and including exterior covering, sheathing, framing, insulation, and fasteners) and assess for combustibility, heat vulnerability, flame-spread characteristics, deterioration, and gaps. Identify and assess susceptible joints, intersecting assemblies, and connections between dissimilar materials. (See Building Materials: Performance Under Wildfire Conditions below for material-specific behavior.)
- Repair or replace components to meet local WUI code and insurance requirements, and seal gaps and joints with fire-rated products that will not damage historic substrates.
- Augment or replace flashing to be noncombustible and appropriately sized.
- When walls are masonry, repoint as needed; repair or replace cracked or spalled units; protect embedded wood elements (e.g., lintels and sills). Protect masonry from becoming saturated or exposed to high heat.
- When the wall does not comply with code requirements, evaluate alternatives that balance wildfire risk and the importance of materials to historic character. Selectively replace combustible cladding with compatible ignition-resistant materials.
- Coordinate wall treatments with Zone Zero, vertical clearance, eaves and soffits, vents and penetrations, windows, doors, and projecting features.

CONSIDERATIONS

Exterior wall materials can be an area of potential conflict between code requirements and retaining the historic character of a building. The exterior walls of a historic building are almost always important character-defining features, especially on primary, public, and highly visible elevations. Any changes to wall materials to reduce fire risk must balance preservation needs with the threat of embers, heat, and flame from the anticipated fire type.

Methods to improve the ignition-resistance of combustible exterior wall coverings include adding ignition-resistant substrates, underlayments, or flashing to protect combustible sheathing or framing, and partial or full replacement of combustible cladding with compatible ignition-resistant substitute materials. Utilize compatible substitute materials when in-kind replacement is not feasible or appropriate to the risk.

Partial cladding replacement may be appropriate on elevations or features with higher fire exposure or lower visibility, as well as areas more vulnerable to debris and ember accumulation and reflected heat such as reentrant corners. Replacement with substitute materials should consider the relative fire hazard, added resilience, visual compatibility, cost, and related factors.

Exterior cladding replacement may trigger compliance under some local WUI codes.

Window Units, Skylights, and Curtain Walls

Exterior glazing is primarily vulnerable to direct flames and radiant heat, which can cause breakage allowing embers and flames to enter the building. Direct flame contact and radiant heat pose the greatest threat to window frame and sash materials, decorative surrounds or shutters, and combustible substrates. Gaps between operable window sash or doors and their frames can allow embers to be drawn into the building due to air pressure differentials.

PRIORITIZATION FACTORS

- Treatments should first protect against embers, then against broken glass that would admit embers, hot gases, heat, and flames, such as single-pane glass.
- High windows may be more prone to wind-driven impact damage from debris.
- Windows near the ground or another horizontal plane and in reentrant corners are vulnerable due to the tendency of embers and debris to collect in these areas.
- Large windows or curtain walls are particularly vulnerable to deflection and breakage caused by thermal variation across the glass surface, high winds, and wind-blown debris and firebrands.
- Jalousie or “Florida” windows have louvered slats and are highly vulnerable due to their configuration.
- Prioritize windows facing nearby buildings or other combustible structures or features within the Intermediate Zone.
- Address the most vulnerable windows and doors first as part of phased implementation.

TREATMENTS

- Explore modifications to retain historic windows before considering replacement. Strategies may include adding exterior metal screens to block embers, metal- or fiberglass-framed exterior storm windows with tempered or laminated glass to also block heat and flames, and adding temporary covers or automatically deployed fire shutters (for the latter, see **Other Wildfire Risk-Mitigation Measures**).
- Upgrade glass or modify thick sashes to accept insulated-glass units (see Glass discussion below).
- When replacement of historic units is necessary, use fire-rated window, door, or skylight assemblies (e.g., 20-minute-rated minimum) that match historic appearance.
- Upgrade or replace non-historic windows with compatible and higher-performing windows.
- Evaluate and adapt curtain-wall components (glass and spandrel panels, framing, anchoring systems, gaskets, and sealants) to achieve higher fire rating and performance.
- Ensure the joints between operable window sashes and their frames have weatherstripping and gaps are sealed to block embers with appropriate fire-rated products that will not damage or stain historic substrates.

CONSIDERATIONS

Windows can be an area of potential conflict between code requirements and retaining the historic character of a building. Fenestration patterns, window designs, and decorative features are typically key character-defining features of any historic building. Single-pane and non-tempered glass are particularly vulnerable to breakage and should be prioritized. Stained or leaded glass also requires special consideration (see Glass).

Consider the combustibility, heat-transfer characteristics, and potential gaps in window assemblies or joints. Frame materials respond differently to heat and can affect adjacent materials (see Eaves and Soffits for treatments and considerations for decorative features).

Interior storm windows may be preferred on primary (character-defining) elevations to avoid altering façade appearance in less wildfire-prone areas. However, exterior storm windows may be preferred in high wildfire-hazard areas to better protect the historic sash against loss. Install storm windows so as to avoid condensation that can lead to deterioration of the historic wood or metal.

Replacing windows may be appropriate when historic windows are deteriorated beyond repair, cannot be adapted for fire performance, or are located on less visible elevations.

Where historic windows are missing, new windows should be compatible with the historic character, property type, period, and architectural style of the historic building.

Window replacement may trigger compliance under some local WUI codes.

Window Units, Skylights, and Curtain Walls,
continued

CONSIDERATIONS, CONTINUED

Similarly, the components of a storefront, window-wall, or curtain-wall system that might be vulnerable to breakage, the vulnerabilities in the assemblies, and how the frame materials might respond to heat must all be taken into consideration.

Glass

Glass type, including annealed, tempered, laminated, or insulated units, significantly influences vulnerability to breakage from radiant heat, direct flame contact, and wind-driven debris.

TREATMENTS

- Ensure all exterior glass features have at least two layers of glass. Specify tempered or laminated glass where exposure is high or high-intensity fires are anticipated (e.g., large panes, close spacing to other buildings).
- When a historic window is in good condition and can handle the additional weight of multiple glass layers, retrofit the window to accept insulated units with at least double-pane glass.
- When single-pane glass is important to the character, explore specialty alternatives such as safety or security films, ceramic films, fire-rated ceramic clear glass, or fire-rated and impact safety-rated glazing with clear intumescent interlayers. Confirm product performance against wildfire exposures with the manufacturer.

CONSIDERATIONS

Replacement glass should retain the appearance of the historic glass as much as possible, whether the historic glass is clear, colored, or tinted. When adding tint or film to clear glass, select options that maximize visible light transmittance and minimize exterior reflectivity to maintain the clear character and appearance of the historic glass.

Multiple layers of glass provide backup against breakage that helps keep embers, hot gases, and flames out (see Figure 20). Tempered glass is about four times more resistant to breakage than annealed glass, but may shatter, spread widely, and fall out when it fails. Laminated safety glass typically holds broken pieces together due to the interlayer and can be necessary in high wind areas. Low-emissivity (Low-e) glass can reduce the transmission of radiant heat.

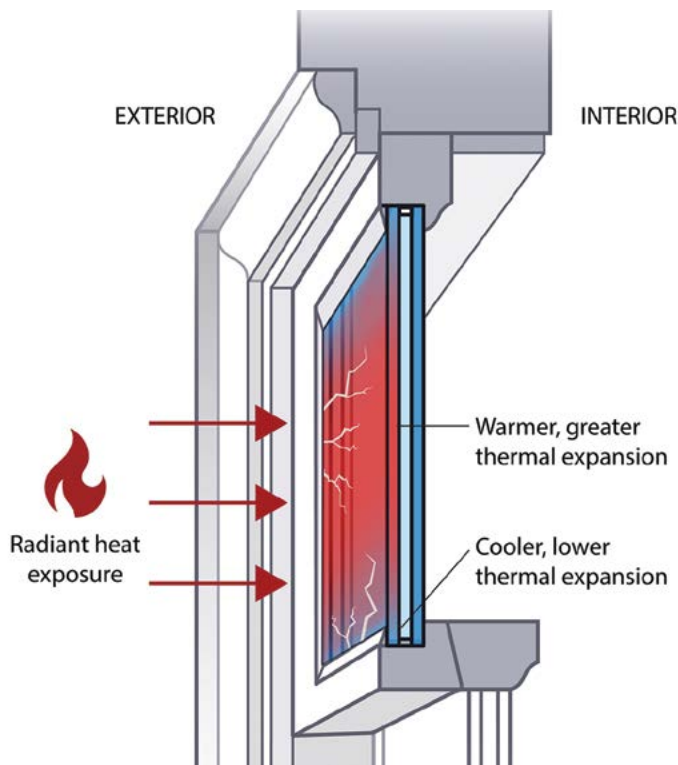
Leaded glass windows are highly vulnerable because lead came softens and deforms at relatively low temperatures, displacing panels and opening pathways for embers and flame entry. Stained glass with organic-based colorants may also have reduced heat tolerance. Increased

protection that limits temperature rise is essential, such as increasing Zone Zero around the buildings (see **Defensible Space Table**). Exterior ember-blocking mesh may help with ember exposure but not heat loads; exterior storm windows with tempered, laminated, or fire-rated safety glass may also help. Sprinkler systems may offer additional protection but rapid cooling can cause hot glass to shatter (see **Other Wildfire Risk-Mitigation Measures**).

In high hazard areas, consider permanently relocating leaded or stained-glass windows to a safer interior or off-site location; infill character-defining openings with compatible replacement windows. Consult a stained-glass specialist with wildfire risk-mitigation expertise.

Glass block units are considered noncombustible and generally require only sealing of gaps to prevent ember entry.

Figure 20: Window glass can break due to thermal differentials between the exposed glass and where it is shielded at its edges, such as by glazing putty or stop. Exterior storm windows can also help protect historic single-glazed windows against glass breakage caused by thermal stresses or wind-blown debris. Graphic: NPS



Doors

Exterior doors and frames are vulnerable when debris or embers accumulate at thresholds or enter gaps between the door, jamb, or weatherstripping.

PRIORITIZATION FACTORS

- Prioritize treatment of large overhead doors, below-grade entries, and doors with extensive glazing.

TREATMENTS

- Maintain defensible space to reduce vulnerability of exterior doors to flames.
- Add metal thresholds, kick plates, and plinths to protect against embers, or replace combustible components with compatible noncombustible substitutes.
- Replace with fire-rated door assemblies (door, frame, trim) when deteriorated beyond repair or unadaptable for fire performance requirements.
- Ensure the joints between doors and their frames have weatherstripping and gaps are sealed to block embers with appropriate fire-rated products that will not damage or stain historic substrates.
- For door glass, see Window Units and Glass above.

CONSIDERATIONS

- Entrances are almost always important in defining the historic character of a building. Prioritize treatments that retain historic doors and trim on primary elevations.

Other Projecting Features and Cantilevers

Other projections and cantilevered elements, particularly those at the first floor above grade, are susceptible to debris, embers, and heat collecting below them. Heat can concentrate below a material with a lower ignition point, and flames can reach slender structural supports and the underside of the overhanging structure.

PRIORITIZATION FACTORS

- Prioritize treatment of large projections or cantilevered elements, especially those close to grade where debris and embers readily accumulate, within a 30-foot horizontal setback from a steep downslope, or at setbacks otherwise mandated by local ordinance requirements or code officials.

TREATMENTS

- Assess large overhangs and smaller features (e.g., bay windows) for underside heat and ember traps, then apply the following measures:
 - Enclose bases to grade with noncombustible materials, where appropriate.
 - Cover, augment or replace structural supports, framing, and under-surfaces with noncombustible or fire-resistant materials.
 - Reconstruct the feature in noncombustible materials to match appearance when risk, feasibility, and significance warrant.

CONSIDERATIONS

Bay windows, balconies, turrets, large soffits, and cantilevered spaces are often character-defining; weigh visual impacts carefully when selecting treatments.

Introducing noncombustible or fire-resistant materials, rather than fully enclosing the spaces below significant building components, often better retains historic character.

New Additions to Historic Buildings and Related New Construction

Additions and new construction on historic sites should meet code requirements for new construction in wildfire areas while following the Standards for Rehabilitation to ensure they are compatible with the historic character of the property (see [Preservation Brief 14: New Exterior Additions to Historic Buildings: Preservation Concerns](#) for additional information on this topic).

Adding onto a historic building or site can introduce substantial new fuel for a wildfire.

TREATMENTS

- Design additions and new construction with simple massing and building forms that minimize areas where embers can accumulate.
- Use noncombustible and fire-resilient materials compatible with the historic property.

CONSIDERATIONS

New additions and new construction should preserve the historic character of the property, consistent with the Standards for Rehabilitation.

Offsets between the historic building and any new additions are often used to differentiate new work from the existing building, pursuant to Standard 9 of the Standards, but in wildfire-prone areas these features can increase ember traps and ignition vulnerabilities. Where continuity of wall and roof planes or simplified junctions reduce risk, differentiation can be achieved through other means such as material selection or trim and edge detailing.

New additions or new construction may trigger WUI code compliance, which may require the addition of interior fire sprinkler systems throughout the building. Changes in occupancy use may trigger similar requirements, which may require specific setback dimensions related to topography or the addition of interior fire sprinkler systems.



Figure 21: Decks and other projecting building features can be partially mitigated with gravel or rock mulch below and surrounding them, plus, depending on the deck height, ember-blocking mesh. Windows near the ground may require additional fortification, such as safety glass and metal screens with ember-blocking mesh. Photo: Fire Ready Exteriors

Building Materials: Performance Under Wildfire Conditions

How historic exterior building materials perform under wildfire conditions varies significantly and can directly influence treatment decisions of building and site features. Historic buildings frequently contain materials that satisfy neither current ignition-resistance nor fire-resistance code requirements as built. Understanding how materials behave under wildfire conditions, including whether they ignite, conduct heat, melt, spall, or create ember pathways, can be important in assessing vulnerabilities and selecting effective treatments.

The combustibility and heat-vulnerability of materials fall into three broad categories: **Combustible**, **Noncombustible**, and **Heat-vulnerable materials**, as follows.

Combustible materials *ignite and burn when exposed to sufficient heat or flame.*

Wood and cellulose (cladding, sheathing, framing, decking, log construction): Vary widely in ignition temperature by species, dimensions, density, and moisture content; higher moisture content raises the effective ignition threshold but does not eliminate risk. Sustained flaming typically requires higher temperatures than initial ignition. Heavy timber and log construction resists rapid combustion after charring due to large cross-sections, although butt joints, checks, and exposed end grain are vulnerable ember traps regardless of overall mass.

- Protect combustible framing with ignition-resistant substrates or replace cladding with compatible substitute materials.

Vinyl and plastics: Melt and deform at relatively low temperatures, exposing underlying substrates and cavities to embers, heat, and flame before igniting.

- Eliminate non-historic vinyl and plastic features; add ignition-resistant substrates below any historic finishes that cannot be removed.

Field-applied coatings and intumescent products: Often fail under flames or intense heat. Exterior intumescent coatings may lose fire-retardant properties in under one year of weathering. Factory-applied products must meet testing standards for use in a fire-rated assembly.

- Confirm performance ratings and service life before specifying.

Noncombustible materials *do not ignite or burn, but can experience cracking, spalling, heat conduction to adjacent combustible substrates, or structural failure under extreme or prolonged heat exposure.*

Brick, stone, terra cotta: Generally meet WUI requirements when in good repair, but all are vulnerable to cracking and spalling from rapid temperature change or thermal shock from suppression water. Saturated porous units form steam when heated, accelerating spalling. Steam formed by moisture trapped in hollow units may explode the units. Heated embedded steel anchors and rebar expand and can cause localized structural failure. Embedded wood elements (lintels, sills) can ignite and cause structural collapse.

- Keep in good repair, protect from saturation, and address embedded wood elements as a priority.

Concrete: May begin losing strength; surface spalling can appear at average fire temperatures; prolonged extreme heat can cause compressive strength loss and chemical changes. Embedded rebar expands and can cause localized failure.

- In high-risk areas, evaluate mix and patches for heat vulnerability.

Mortar: Fails under heat; deteriorated mortar at scale can cause structural instability.

- Keep mortar continuous and in good repair.

Historic stucco (3-coat): Is noncombustible, but intersections and joints remain vulnerable to ember entry, heat, and flames. Thermal shock can cause cracking.

- Maintain joint integrity or sensitively augment.

Fiber cement: Is noncombustible and resists ignition and flame spread. Joints and fasteners remain vulnerable; fasteners can fail under flame.

- Specify high-heat fasteners.

Heat-vulnerable materials do not ignite or burn but melt or deform at relatively low temperatures, which can expose underlying substrates or open pathways for ember entry. Where materials are vulnerable to heat exposure, design treatments to limit the heat reaching the assembly.	Metals (cladding, flashing, structural elements): Do not ignite but conduct heat rapidly to adjacent combustible substrates and warp under high heat. Gaps and failed seams admit embers. Heated steel embedded in masonry and concrete expands and can cause localized failure. • Improve underlayments, seal gaps, and maintain tight seams. • Ensure embedded steel is adequately covered and protected from high heat. Fiberglass: Is noncombustible, but its binding resins can melt or burn; performance varies by manufacturer and flame-retardant chemistry. Fasteners and attachments are often the first component to fail. • Specify high-heat fasteners. Single-pane (annealed) and leaded glass: Are highly vulnerable to breakage from radiant heat, temperature differentials, thermal shock, and wind-driven debris. Lead came softens and deforms at relatively low temperatures, displacing panels and creating openings for embers and flames. • See Window Units and Glass.
Hazardous materials	Older historic buildings may contain lead, asbestos, and mercury; modern building systems may contain arsenic, cadmium, selenium, and beryllium. These are present in smoke, ash, and debris after a wildfire. Post-fire remediation is significantly more costly and poses serious health risks to responders and occupants. • Identify, disclose, and remediate before a fire event where feasible.

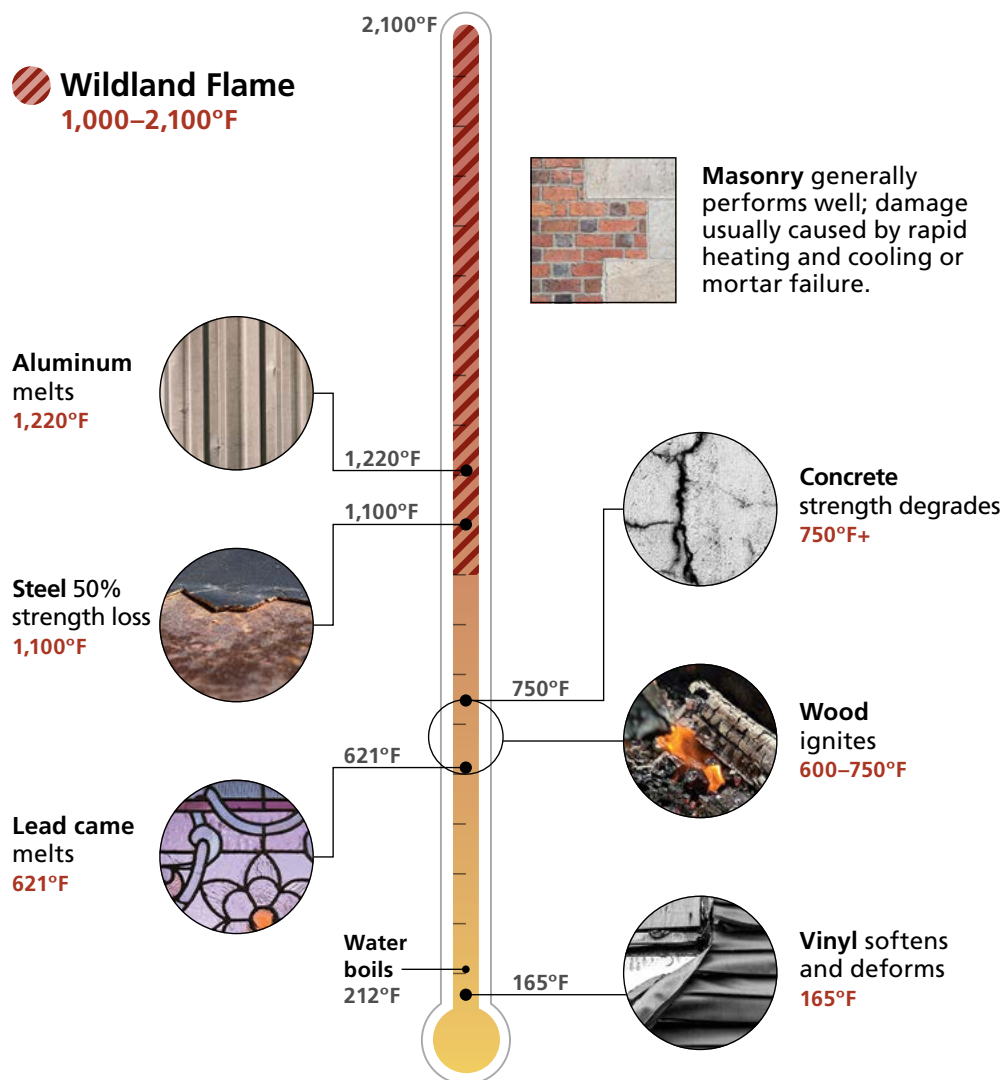


Figure 22: A comparison of autoignition thresholds and heat-impacts to building materials can help prioritize wildfire-risk vulnerabilities and inform adaptation treatments when developing a wildfire protection plan. Graphic: Blank Space LLC for NPS

Table 3. Property Maintenance and Fuel Management

Use this table when developing a wildfire protection plan to identify, organize, and schedule the routine site and building maintenance actions necessary to maintain the wildfire defense system for the historic property. The table should be used along with the **Defensible Space** and **Building Hardening** tables and the **Other Wildfire Risk-Mitigation Measures** discussion.

The wildfire protection plan should identify the objectives, actions, timeline, onsite personnel needs and responsibilities, and anticipated costs for budgeting purposes. The plan should be a living document, and the maintenance portion may need updating more frequently than annually.

The table is organized as follows and suggests an outline for developing and implementing a routine fuel management and maintenance action plan.

- Prioritizing Actions and Implementation Timeline
- Site Management: Vegetation and Fuel Maintenance
- Site Management: Site and Landscape Feature Maintenance
- Building Enclosure Maintenance
- Maintenance of Other Risk-Mitigation Systems

Prioritizing Actions and Implementation Timeline

Prioritizing maintenance actions and establishing a clear maintenance schedule are essential for mitigating wildfire vulnerabilities, as timely debris removal, vegetation management, and building repairs directly reduce ignition risks and help protect historic structures in at-risk areas. This approach ensures that critical tasks are completed before wildfire season, maximizing the effectiveness of defensible space and building-hardening strategies.

TREATMENTS

- Focus first on site and building maintenance activities that reduce the greatest wildfire-ignition risks:
 - Debris removal from roofs and foundations (even if Fire-resistant-rated and with noncombustible vertical clearances), gutters (with or without guards), fences (even if noncombustible) and below decks, porches, and cantilevered features.
 - Maintaining clear noncombustible site areas adjacent to walls.
 - Repairing gaps or vulnerabilities that could admit embers.
 - Closing and sealing abandoned vents and small openings.
- Sequence work seasonally based on vegetation growth cycles, local fire season, and weather:
 - Pre-season cleanup, inspection, and repairs.
 - Mid-season debris clearing and quick checks.
 - Post-season repair of wear or storm impacts.
 - Adjust for a year-round wildfire season if necessary.
- Integrate maintenance tasks into annual property management routines.
- Schedule quick, low-impact actions immediately; plan larger repair or compatibility interventions on a longer cycle.
- Assign personnel responsible for each activity to ensure effectiveness.
- Reassess priorities annually and prior to predicted high-wind events, after weather events, drought periods, or significant vegetation changes.

CONSIDERATIONS

Regular fuel management on the site and maintenance of the building can help greatly reduce potential fire-ignition risks with minimal impacts on the historic character and features of the historic building and property. Many communities offer a vegetation thinning and pickup event prior to fire season, often at no cost.

Before modifying site vegetation and features, understand how the landscape design, planting patterns, vegetation, and site features may contribute to the historic character of the property.

Before modifying any building features and materials, understand how they may contribute to the historic character of the building.

Maintenance activities should be careful not to cause deterioration, alteration, or destruction of historic building and site and landscape features or materials.

Site Management

Vegetation and Fuel Maintenance

The growth of live vegetation and the accumulation of dead plants, branches, and debris can rapidly increase the fuel load on a property. Rainy periods can increase the speed and density of vegetation growth and the quantity of vegetative debris generated naturally. Dry conditions increase the speed of fire ignition and spread. Once ignited, vegetation and debris can cause a fire to spread rapidly across a site to a building. Large, compacted compost piles can spontaneously combust due to heat generated by the decomposition process.

TREATMENTS

- Remove ongoing vegetative debris from foundations and perimeter walls, fence lines, corners, site walls, and around accessory structures.
- Conduct routine inspection and thin, prune, remove, or replace vegetation to sustain previously established defensible space conditions around buildings and features and in concert with succession planting designed to maintain the historic character of the landscape. Remove dead or fallen vegetation promptly (branches, limbs, shrubs).
- Maintain grass and other ground cover so that it is no taller than 4 inches.
- Maintain noncombustible mulches and hardscaping (gravel, stone, masonry) near buildings to remain clear and functional without volunteer growth or vegetative debris.
- Properly dispose of all yard waste and debris outside the defensible space or off-site. Small compost piles can be stored like firewood, at least 30 feet away from buildings and tree crowns.
- After storms or wind events, remove new accumulations of debris at predictable catch points; keep under-deck and under-porch spaces free of vegetative debris.

CONSIDERATIONS

Routine pruning, spacing, and selective thinning should retain the overall design intent as much as possible while reducing fuel quantities and continuity.

Use hand tools or soft-impact methods near historic building and site features, structural foundations, and tree roots to avoid mechanical damage.

Avoid altering grade or drainage patterns that could harm historic materials and features.

Site and Landscape Feature Maintenance

Fences, outbuildings, landscape features, paths, and areas underneath decks can accumulate vegetative debris and become ignition points during wildfires, especially if not regularly cleared or maintained. Their proximity to structures and potential for fuel buildup increases the risk of fire spread to primary buildings.

TREATMENTS

- Routinely inspect fences, walls, trellises, small structures, and other site features for:
 - Debris buildup,
 - Plant encroachment, and
 - Deterioration that increases ignition potential.
- Maintain free and unobstructed clearance around HVAC equipment, propane tanks, or mechanical units by removing accumulated vegetation and litter.
- Maintain paths, landscape edging, historic hardscape, and circulation routes for continued function as subtle fuel breaks.
- Store trash and recycling bins outside Zone Zero in noncombustible bins.

CONSIDERATIONS

Maintenance should use gentle cleaning methods and careful repairs on the surfaces of historic site and landscape features.

Maintain outbuildings following guidance for building enclosures.

Routine inspections and maintenance can help prevent the need for extensive repairs later.

Building Enclosure Maintenance

Vegetative debris

can be easily ignited by burning embers or firebrands, and wind-driven embers and vegetative debris tend to accumulate in the same places on buildings such as building foundations, reentrant corners, roofs, gutters, vents, and attached fences or gates. Small gaps in sealant or detached protective mesh over openings can also allow embers into buildings.

TREATMENTS

- Perform regular maintenance to remove debris and biological growth from roofs, roof drains, gutters, and along parapets; vents, screens, and louver blades; along foundation walls; and under decks, porches, and cantilevered features.
- Routinely inspect roof edges, valleys, flashing, guards, saddles, chimneys, dormer walls, skylight curbs, and other intersections and features for clogged debris or deterioration such as loose, missing, or corroded materials.
- Visually inspect exterior cladding, trim, joints, seams, and rafter-tail areas for new cracks, gaps, or separations; seal with compatible fire-resistant caulks or sealants.
- Clean, reattach, or repair ember-blocking screens at vents, crawlspace openings, porch skirts, and under-deck areas.
- Inspect for deterioration in:
 - Exterior wood cladding (checks, rot, failed paint),
 - Masonry (mortar loss, vegetation intrusion), and
 - Vents or soffits (loose mesh, corrosion).
- Ensure downspouts and drainage convey water away from foundations.
- Ensure no flammable materials are stored in attics, on or under decks or porches, in crawlspaces or under carports.
- Do not store combustible items such as gasoline and firewood under buildings with open foundations.

CONSIDERATIONS

Maintenance should use gentle cleaning methods and careful repairs on historic building exterior surfaces. Sealants must be compatible with the historic materials and preserve the existing appearance. Any mesh or guards installed should be discreet and easy to remove. It is important to avoid trapping moisture through improper installation of guards or sealants. Routine inspections and maintenance can help prevent the need for extensive repairs later.



Figure 23: Regularly removing vegetative debris near buildings and trees helps protect the historic property, prevent wildfire spread, and improve fire safety. Photo: Preston Keres / USDA Forest Service

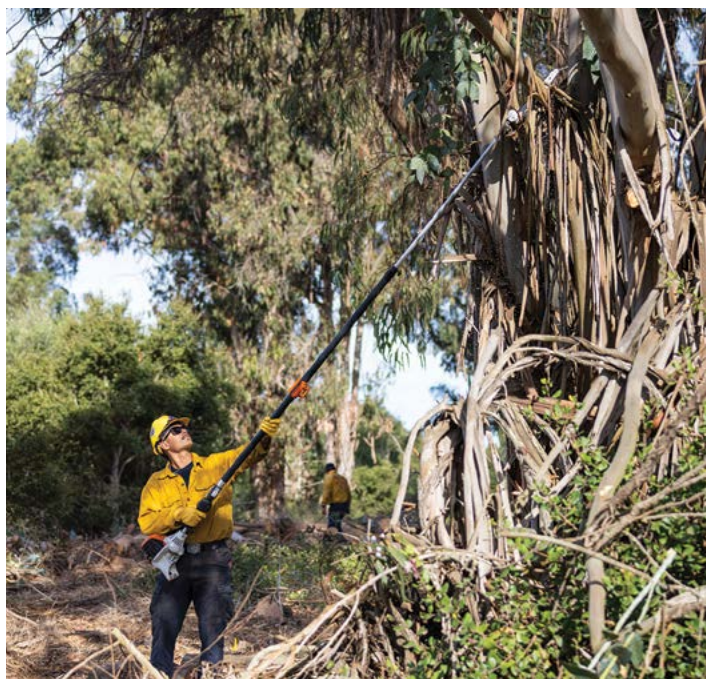


Figure 24: Broader property and landscape maintenance can improve a community's fire resilience and reduce the risk and severity of wildfires. Photo: Ricky Biggs / © 2024 City of Santa Barbara

Maintenance of Other Risk-Mitigation Measures

Active fire protection systems such as fire sprinklers, deluge systems, soaker hoses, and irrigation rely on regular testing to ensure operability. Temporary building wrap requires pre-planning and training ahead of installation.

TREATMENTS

- Test exterior sprinklers, pumps, hoses, and irrigation systems at least seasonally, according to the manufacturer's instructions.
- Confirm the site retains positive drainage sloped down away from building foundations.
- Inspect water tanks, cisterns, or emergency water storage for leaks, sediment, or poor access, and monitor water quality.
- Regularly verify generator or battery systems are operational and fuel is fresh.
- Maintain clear access to system components and remove vegetation around tanks and equipment.
- Seasonally inspect building wraps or protective materials and associated fasteners stored onsite for deterioration; ensure attachment methods will not damage historic surfaces.
- Undertake periodic training to keep current with systems operation or to ensure temporary wraps or covers will be properly installed.
- After using or testing, dry and store temporary wraps and protective coverings to avoid chemical reactions or stains on historic finishes.

CONSIDERATIONS

Active fire protection systems (see **Other Wildfire Risk-Mitigation Measures**) should not cause damage to historic materials through moisture, abrasion, fasteners, or chemical exposure. Verify water delivery systems do not direct water toward building foundations or masonry walls.

All alternative systems should be reversible and compatible with the building's historic character and materials.

Routine inspections and maintenance can help prevent the need for extensive repairs later.



Figure 25: Deferred maintenance such as peeling paint, cracked cladding, failed shutters, and nesting debris increases the risk of ignition and loss from wildfires. Photo: NPS



Figure 26: Routine inspections and maintenance to remove vegetative debris and close gaps in the building exterior are important for wildfire resilience and may help prevent the need for extensive building repairs later. Photo: NPS

Figure 27: This historic rural residence was adapted to be more resilient to wildfire risk by addressing its primary vulnerabilities. A mature tree within Zone Zero was removed, and the non-historic roof was replaced with a Class-A assembly. The building was lifted and placed on an exposed reinforced concrete foundation surrounded by gravel paving, establishing a noncombustible vertical clearance and perimeter at grade. Photos: NPS



Figure 28: This vernacular wood building survived the devastating August 2023 Lahaina wildfires. Prior to the fire, mulched foundation garden beds were replaced with river rock below the roof overhang, and trees and other vegetation were removed. On a very small lot, a wider defensible space was effectively created on three sides of the building by virtue of the paved road in front, an empty lot on one side, and the ocean 15 feet away behind it.



The asphalt-shingle roof was replaced with a corrugated metal one with no gutters, and fiberglass window screens were replaced with bronze metal mesh ones. Otherwise, the building retained its historic wood walls, casement windows, and trim, along with open eaves and rafter tails.

At the time of the fire, the house was closed up, and the irrigation system ran before the power failed. During the fire, 80-mph winds blew in from the sea, blowing ocean water onto the property, and likely helping to keep flames away. The house suffered minor cosmetic damage on one side only. The neighboring house had a heavily vegetated yard and did not survive the fire. Source: NPS files



Other Wildfire Risk-Mitigation Measures

The prior adaptive treatment tables for **Defensible Space** and **Building Hardening** describe “passive” fire-protection treatments because they are implemented well before there is any direct wildfire threat and require no prior preparation or other resources to be effective during a fire event. WUI codes generally require passive treatments as the baseline.

This section addresses potential “active” fire protection treatments that may, in certain circumstances, help supplement or enhance the wildfire resilience of the property, although they may not be accepted by local fire officials or insurance companies as independently fulfilling WUI code requirements. This Brief describes three types of active treatments and outlines preservation considerations for each, as follows.

- Temporary Protective Covers and Wraps
- Water-Based Irrigation and Sprinkler Systems
- Field-Applied Fire Retardants

The following active fire protection treatments are discussed in order of their typical impact on historic character, from temporary measures that avoid permanent alteration to treatments that carry the greatest preservation implications.

Active systems bring a higher risk of failure during a wildfire event because, by definition, they rely on timely human action, electricity, and a dependable on-site water supply during a wildfire to function properly. Common failure modes of active systems observed in major WUI events include the loss of utility power, interrupted water supply due to overtaxed or damaged municipal systems, pump or mechanical failure under sustained operation, and inadequate maintenance leading to degraded performance. Any active system design must account for both single-point and concurrent system failures. Passive measures should remain the primary mitigation strategy even when active systems are installed.

Each active system should be assessed for operational reliability during wildfire events; the ability to time implementation of systems relying on finite resources when a wildfire lasts multiple days or weeks; and compatibility with the historic features and materials of the property. Additional factors include cost, maintenance requirements, environmental impacts, product availability, installation quality, and acceptance by code officials and insurers.

Temporary Protective Covers and Wraps

Temporary or non-permanent protective measures such as covers/wraps or fire shutters provide barriers to embers and radiant heat igniting the building envelope and slow heat transfer to building interiors. The systems are deployed or activated when an immediate wildfire threat is predicted, and the systems are removed or opened afterward. Temporary measures generally are affordable and have low impact on the historic character of the property because they avoid permanent alterations. Such measures include temporary covers or automatically deployed fire shutters for windows, doors, or vents, as well as building wraps or flexible covers for combustible three-dimensional features.

Temporary Covers for Windows, Doors, and Vents

Temporary covers or automatically deployed fire shutters can help protect discrete openings in the building envelope such as windows, doors, and vents. Temporary covers are removed and stored between incidents, whereas automatically deployed shutters remain hinged or rolled-up in housing when not deployed. Solid metal shutters are more fire-resistant than wood or plastic ones, and insulated metal shutters can offer enhanced protection. These systems present additional considerations.

- For any of these systems, there may not be sufficient time or anyone present to deploy them during rapid fire conditions. During wind-driven wildfire events, the window for deployment may be minutes, not hours. Wind speeds in major WUI events frequently exceed 50 mph, and fire arrival can follow a wind shift with little warning. Deployment feasibility should be evaluated against realistic worst-case timelines, not fair-weather assumptions.
- Manual temporary covers must be cut to size, marked/keyed, stored for quick access and installation prior to evacuation by trained, practiced, and available personnel who have not yet evacuated. Seals between the cover and substrate must be tight enough to block embers, hot gases, and flames; otherwise, they will be ineffective. Fasteners and their removal should minimize damage to historic substrates and be minimally visible when covers are not in place, yet they must resist the high winds that commonly accompany a wildfire event. When covering vents, maintain functionality and monitor openings regularly.
- Automatically deployed fire shutters have advantages in rapid-onset wildfire scenarios but require reliable power and mechanical systems. Hinged or roll-up shutters can be quite visually intrusive and impact the appearance of the building exterior or of historically

significant interior spaces, if installed on the interior, and the locations should be evaluated for their visual impact. The housings, guides, and other hardware should minimize damage to the historic features and substrates. When installed on the building interior, the exterior appearance of the window or door can be unimpacted, but the features themselves will be unprotected.

Temporary Wraps for Whole Buildings, Combustible Features, or Vehicles

Aluminumized structure wraps can be used to wrap entire buildings or individual architectural features, such as wood lintels, viga ends, etc. Wraps are aluminum-glass fabrics designed to help keep exterior surfaces below ignition temperatures. As installation requires trained personnel and advance warning, wraps may not be feasible in areas with fast-moving fires, and there may be seasonal shortages if not purchased in advance. These systems present additional considerations.

- Temporary building wraps must be installed and removed per the manufacturer's recommendations to avoid exterior and interior damage. Insufficient overlap or improperly sealed joints can allow fire entry, resulting in catastrophic loss. High radiant heat may still damage materials.
- Installation can require 4 to 8 hours for a simple small-scale building, even for trained multi-person crews, representing a significant resource commitment. Complex geometries and multi-story buildings or structures with numerous projections can require significantly more time. For many historic properties with complex rooflines, porches, and decorative elements, pre-fire deployment may not be feasible.
- Wraps are most practical for small, simple-form wood buildings with limited firefighter access, or for protecting specific vulnerable architectural features (e.g., wood lintels or viga ends) or any openings or penetrations on larger or otherwise noncombustible buildings.
- Wraps should not attach directly to fragile or porous building materials. Partial wraps protecting combustible elements in masonry should be anchored to mortar joints.
- Where defensible space and building-hardening measures are properly executed, wraps should generally not be needed.
- Wraps are not recommended for historic vegetation but can be installed at the base of large-diameter trees with flammable bark or oils.



Figure 29: Temporary protective wrapping (top) requires a substantial amount of material, trained personnel, and sufficient time for safe and proper installation and evacuation from the site, which may not be feasible once a wildfire threat is imminent. Wrapping individual building features or components (middle) requires expertise to avoid damage to historic materials (bottom). Effective protective wrap relies on attachments that will be secure in high winds and create continuous seals. Sacrificial nailers or other more careful alternative attachment methods could possibly reduce installation damage. Photos: Evan Oskierko-Jeznacki / NPS

- Vehicles can also be wrapped when they cannot be moved out of the way of the fire or far enough from the building.
- Standard temporary wrap is not meant to be reused as it wears and tears easily. For repeated installations, consider fabricating sacrificial opening-infill wooden nailers held in place with wedges to minimize staple damage to historic materials and finishes.
- Wrap is costly and does not store well; excessive rubbing or transport can tear or wear off the aluminum coating.

humidity, and help lower the probability of ignition within the defensible space. These systems present additional considerations.

- A continuous water supply and reliable power source are essential; independent on-site water supply and a backup source of electrical power should be considered.
- Independent water sources, including on-site tanks, pools, or natural bodies of water, can be used to feed fire protection systems separate from a community water supply system. Storage systems must be sized for potential fire reignition, be accessible to firefighters, and free of contaminants or debris. Any on-site water tank storage should be sited to minimize its potential impact on the historic site and setting as much as possible.
- System activation can be automatic or manual. Evaluate feasibility, reliability, and maintenance when considering selection.
- Protect sensitive electronics and control systems from heat and ash during an active fire.
- Annual testing, regular maintenance, and clear, well-planned installation are critical to continued effectiveness, especially for modified legacy (upgraded existing) systems.

Water-Based Sprinkler and Irrigation Systems

Water-based fire-protection systems can serve multiple roles in wildfire-prone areas. WUI-building codes commonly mandate interior sprinklers for new construction or when historic buildings are expanded or experience a change in occupancy. Permanent and temporary external sprinkler systems, deluge systems, or soaker hose systems can help extinguish embers and cool combustible roofs, walls, and openings below their ignition points. Exterior irrigation systems, whether temporary or permanent, can be activated ahead of a wildfire to saturate vegetation, raise



Figure 30: A temporary exterior sprinkler system that draws from an independent water source using a portable pump (visible at the end of the dock) has been installed ahead of an approaching wildfire to increase the humidity immediately around the building. Water-based sprinkler systems can help lower the probability of ember-caused ignition or autoignition. However, there are no national standards for such systems, and they rely on maintaining a continuous water supply and reliable power. Photo: Liz Valencia / NPS

- Sustained wetting of organic or porous materials can cause material failure, promote biogrowth and insect damage, and introduce salts depending on water quality. Typically, irrigation systems should be set away from structures and avoid direct contact; their primary use is to raise relative humidity and suppress spot fires within the defensible space, not direct suppression of the building (like deluge systems).
- Hose bibbs or swimming pool pumps and garden hoses should provide full property coverage to extinguish spot fires wherever they may occur, before they can escalate into a wildfire.

Interior Sprinkler Systems

Automatic interior suppression systems protect life safety and property. In the WUI context, their importance also stems from preventing the building from becoming a wild-fire ignition source itself.

- Interior sprinklers should be installed so as to avoid damaging the historic materials or character-defining features. While historic buildings were not built with these systems, there are creative ways to install systems in historic buildings without damaging the historic fabric or character-defining features.
- NFPA standards provide design guidance for interior systems. Property insurance underwriters may have property-specific guidelines for high-value or historic properties.
- Some insurance companies offer premium discounts for sprinkler systems in homes and businesses.

Exterior Sprinkler Systems

- Consideration should be given to exterior building materials when evaluating the appropriateness of an external sprinkler system. Wood-roofed or wood-clad buildings may be good candidates for such systems. However, external sprinkler systems can also cause thermal shock and spalling in masonry buildings, exacerbated when masonry is saturated, and breakage of pre-heated glazing. Careful system design is required for masonry buildings (see Building Materials and Glass).
- No national standards exist for the design, installation, and maintenance of exterior sprinkler systems, although NFPA 1144 provides some design guidance. The absence of standards makes qualified fire protection engineering consultation essential—not optional.
- As a feasibility benchmark: exterior sprinkler systems for structure protection of a residential-scale property typically require 5,000–10,000+ gallons for 1–2 hours of operation.

Pools and Water Features

Pools and water features that are historic features or those to be used as supply for water-based suppression systems must be kept free of contaminants and debris.

- Clear flammable vegetation around the pool or water feature to create a defensible space and reduce debris in its vicinity.
- Cover the pool or water feature to help block airborne ash and angle return jets downward to push clean filtered water to the bottom of the pool and allow ash to be skimmed off the top more quickly.
- During an active fire, pool decking and water feature surrounds should be protected to limit direct flame and radiant heat exposure, such as with a noncombustible or fire-resistant cover.

Field-Applied Fire Retardants

Fire retardants are chemical treatments or coatings designed to delay ignition of a material and slow flame spread across a surface. Most chemical-based fire retardants and suppressants applied in the field are salts dispersed in a liquid form. Field-applied retardants and suppressants can be applied using water bags, tanks, pumps, hoses, and other special equipment. Aerial applications are deployed by firefighting agencies, and historic property owners will have little control over where or how they will be used. In advance of a wildfire event, property owners can treat vegetation and exterior combustible materials with long-term and pre-treatment retardant products, coatings, or stains. These systems present additional considerations.

- Fire retardants should be evaluated as a last-resort measure for historic properties since they present significant preservation risks for historic materials. Most long-term wildland fire retardants are phosphate-ammonium salt formulations that are corrosive to metals, stain stone and wood, and are difficult to remove from porous substrates (brick, stone, unpainted wood). The manufacturer's "2–3 day" removal window assumes site access and water availability that are frequently unavailable post-fire. For sensitive historic materials, retardant exposure may itself constitute a preservation impact comparable to the fire exposure it was intended to prevent.
- Field-applied retardants do not typically meet WUI code requirements and require regular and periodic reapplication to be effective. Consider the effects on the appearance of the building and on building materials over time, the retardant's longevity, frequency of reapplication, and installer qualifications. Test samples are recommended.

- The use of these last-resort options should generally only be undertaken in consultation with qualified fire-protection and preservation professionals and an understanding of how the proposed products will affect the historic building ahead of a wildfire event.
- Some fire departments and building owners may apply Class-A foam to an entire building exterior. Limitations include the potential damage to historic materials, on-site storage of chemicals and deployment equipment, maintenance needs, the shelf life of the product, and post-application product removal.
- Ground-applied retardants may be effective in the defensible space, but the potential impacts on wildlife, vegetation, and waterways should be considered. Because of known environmental impacts, fire retardants are regulated; understand and comply with applicable local, state, and federal regulations.



Figure 31: Aerial fire retardant drops can coat a building during a wildfire response. These chemicals can cause staining, efflorescence, and swelling of fragile, porous historic building materials. Post-fire removal is time-sensitive, but access to the site and the water supply needed may be unavailable in the days following a fire, increasing the risk of permanent damage to the building. Photo: Josh Edelson / Getty Images

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This publication and other sets of NPS guidelines, related guidance, and technical preservation information are available from the Technical Preservation Services website at www.nps.gov/tps.

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