Marshall Fire Mitigation Assessment Team: Best Practices for Wildfire-Resilient Subdivision Planning

Revised April 2025

FEMA

DR-4634

This page intentionally left blank.

Table of Contents

1. Introduction

On December 30, 2021, a wind-driven wildfire impacted residential and commercial structures in the City of Louisville, the Town of Superior, and unincorporated Boulder County, Colorado. Evidence gathered after the fire highlighted several vulnerabilities in subdivision planning and in the management of proximate or intermixed communal open spaces, greenbelts, and wildland spaces that likely played a significant role in the spread of fire. This document provides builders/contractors, planning professionals, homeowner associations (HOAs), and local land resource managers with information about subdivision/community planning and open space management to reduce the risk of loss or damage to residential and commercial structures in future wildfire incidents.

Because of the unique nature of the incident, where extreme winds coupled with long term drought, high temperatures, and limited wildfire regulatory adoption, a fast-moving low-intensity grass fire became a highly destructive urban conflagration directly and indirectly impacting several communities and the greater Boulder County area. The Federal Emergency Management Agency (FEMA) deployed its first-ever wildfire Mitigation Assessment Team (MAT) to evaluate building performance during the fire. The MAT was deployed to Louisville, Superior, and unincorporated areas in Boulder County, Colorado, to evaluate damaged homes and commercial structures. MAT members evaluated components and systems of primarily residential structures to determine the effectiveness of various building materials, design, and construction practices for wildfire resiliency. The MAT used the information gathered to evaluate how wildfire-urban interface (WUI) building codes and standards, as well as design, construction, and defensible space practices can be improved to increase community wildfire resilience, particularly as the risk to landscape due to changing weather patterns is continuously evolving and putting more communities at risk.

1.1. Purpose

This document provides builders/contractors, planning professionals, HOAs, and local land resource managers with information about wildfire resiliency planning and open-space management policies, best practices, and procedures at subdivision- and neighborhood-scales. The intent is to prevent or limit the risk of wildfire exposures and impacts through various regulatory and policy approaches during planning and entitlement phases (e.g., fire risk assessments, wildfire impact studies, zoning, wildfire-protection planning), such that wildfire hazards and risks are appropriately considered early in the planning-design-construction life cycle of future developments. Also included are approaches for holistic, ongoing management of communal open spaces, greenbelts, and proximate wildland spaces as integrated features of neighborhood-, subdivision- and community-scale wildfire resiliency of new and existing residential and commercial developments.

Note: This document should also be read in conjunction with the *Marshall Fire Mitigation Assessment Team: Mitigation Strategies to Address Multi-Hazard Events*.

1.2. Key Issues

In the U.S., the resistance of structures to wildfires in the built environment is typically addressed through the application of building and fire codes at the individual building or parcel level, and not usually at the neighborhood-or community-scale. The level, degree, and even presence of building-level wildfire safety requirements depends on the adoption and enforcement of these regulations at state and/or local levels. In some locations, wildfire safety requirements for buildings are based on where a structure or development is located relative to fire hazards, which can be defined in fire hazard maps (e.g., Fire Hazard Severity Zone (FHSZ) maps produced by the state in California[1], Colorado Springs Fire Department's Wildfire Risk Map)[2]. In locations where state and/or local building and fire code regulations are triggered by the fire-hazard classification, design features to improve wildfire/fire resiliency may be required and can include specific building materials, forms of construction, fire-rated or fire-resistive elements, components or assemblies (e.g., vents, exterior walls, windows, roofs, decks), defensible space requirements, minimum levels of access/egress, and water supplies. However, most states and local jurisdictions across the U.S. have limited or no wildfire-safety building codes, standards, guidance documents, programs, tools, and/or resources (FEMA, 2021)[3] to assist designers, engineers, planners, contractors/builders, and other professionals in wildfire resiliency. Even if a state or local jurisdiction has adopted a model WUI building code or local ordinances such as International Wildland-Urban Interface Code (IWUIC) and National Fire Protection Association (NFPA) 1140, these requirements are often limited to individual buildings and mostly residential occupancies, and there is often no information available for the neighborhood, community, city, or regional scales (FEMA, 2021) particularly during the planning phase of a development. Some best practice guidance is detailed throughout the rest of this document.

The following is a list of key issues for neighborhood- and community-scale wildfire resiliency planning and development (see also Figure 6 later in this document):

- **Wildfire Hazard and Risk Mapping –** A range of 'official' and 'unofficial' wildfire hazard and risk maps exist at local, state, and national levels (e.g., West Wide Wildfire Risk Assessment, CALFIRE's Fire Hazard Severity Zone maps, wildfirerisk.org) (FEMA, 2021). However, most available wildfire hazard and risk maps are not explicitly designed to inform land-use planning, zoning, building design codes and standards, or other wildfire resiliency construction practices at the local, neighborhood, or individual home scale, or during a development's life cycle (e.g., planning/entitlement phase to design/construction to long-term management and operations). California is one example where state-extent FHSZ maps are referenced in the California Building

[1] California Department of Forestry and Fire Protection (CAL FIRE). Forestry and Fire Protection's Fire and Resource Assessment Program (FRAP). https://frap.fire.ca.gov/mapping/pdf-maps/

[2] Colorado Springs Fire Department. Wildfire Risk Map. https://gis.coloradosprings.gov/Html5Viewer/?viewer=wildfiremitigation

[3] Rini, D et al. (2021). *Community Wildfire Resilience: Landscape Analysis* (Volume 1) White Paper. FEMA.

and Fire Codes (CBC, 2021)[4], and ultimately all buildings constructed in specific FHSZs (since 2008) are required to have wildfire-specific risk mitigation provisions. However, most states and local jurisdictions have limited or no available wildfire hazard and risk maps to trigger planning and building safety provisions. This means that numerous buildings and developments are potentially being planned, designed, and constructed in high fire risk areas without appropriate building fire safety provisions. Additionally, there are countless existing building stock and developments that may not currently be in a high wildfire prone area but could be at risk in the future due to ongoing changes in the wildfire risk landscape and other factors. Understanding this potential change in the risk landscape is a major challenge that is not currently considered in land use planning.

- Siting of Structure or Development – The location of a development or subdivision on the general landscape is a major driver of its wildfire risk. Wildfire severity and rate-of-spread of fire increase at specific topographic features such as saddles, ridge lines, drainages, canyons, and steep slopes (Figure 1). This can present a significant threat to homes or developments in those locations, such as for a property located mid-slope, which cannot be more easily mitigated using standard defensible space, setback, and structural hardening provisions (described in other Marshall Fire MAT products). Some jurisdictions provide additional siting requirements (e.g., minimum setbacks, additional defensible space requirements, additional structural hardening measures, development of a fire protection plan) for buildings and developments located in higher hazard topographies. However, this is not consistently provided in most local jurisdictions. In addition, most jurisdictions do not have neighborhood-, community- or regional-level planning, or wildfire zoning requirements that introduce limitations on new developments in very high-risk landscapes.

[4] California Building Standards Code. (2022, July 1). Chapter 7A *California Building Code (CBC)*. https://www.osha.gov/coronavirus/safework

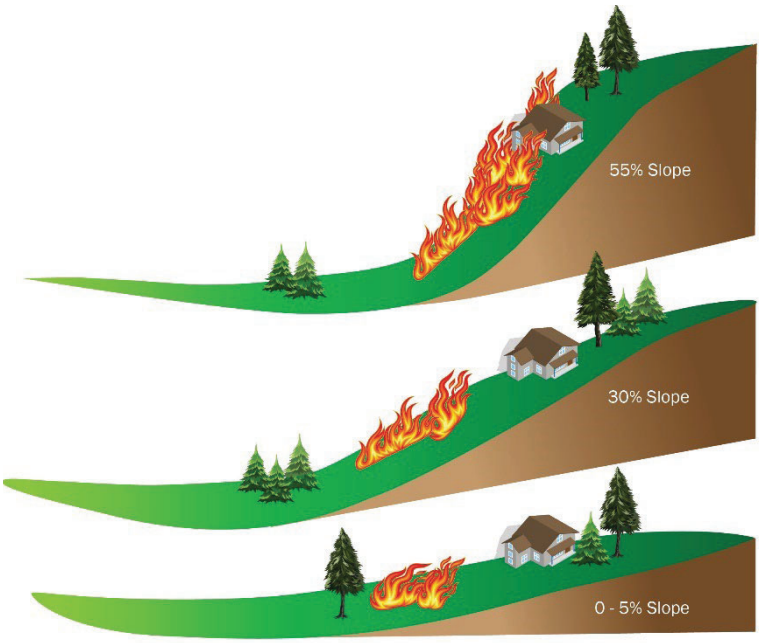

Figure 1. Wildfire intensity and rate-of-spread increases as slope increases.

- **Structure Density** – Current building fire safety regulations typically do not require structure-to-structure fire separations for single family residences (e.g., Type VB, R-3 buildings) unless the home is within 5 feet of the property line. In some cases, where automatic sprinkler protection is provided per NFPA 13D (NFPA 13D, 2016), fire-separation distances for residential homes can decrease to 3 feet or even 0 feet to the property line (IRC Table R302.1(2)). For most other occupancies and construction types, exterior fire-rated walls are typically required where buildings are within 10 feet of a property line in addition to limits on the presence of, or protection required for openings (e.g., windows). Existing fire separation requirements were designed to limit urban conflagration, originating from a single interior building fire (not wildfires or multiple structure fires occurring simultaneously). Under these assumed conditions, firefighters typically have sufficient resources to control and suppress a single-family home fire.

  However, under extreme wildfire conditions, where fires are simultaneously occurring in both the wildland and the built environment, firefighting resources are often overwhelmed and unable to limit structure-to-structure fire spread (particularly under severe fire weather). For typical parcel sizes and residential structure separations (e.g., 5–10 feet), the effects of radiation, direct flaming, and ember exposures from a home on fire are likely sufficient to ignite an adjacent structure, particularly under high-wind conditions (Figure 2). The parcel centric nature of existing codes, in which parcels are considered independently despite the impact they have on one another, leads to minimal structure separation distances (National Institute of Standards and Technology (NIST) Technical Note 2205). Additional wildfire zoning, planning, structural hardening, and other fire-safety features are likely needed to reduce structure-to-structure fire spread.

Figure 2. Typical residential building separations (10–20 feet) are vulnerable to structure-to-structure fire spread under extreme wildfire conditions, as most single-family residences have non-fire rated exterior walls.

- Access, Egress, and Evacuation Planning – Recent wildfires have highlighted the critical need for properly planning and designing safe paths of egress and access during a major wildfire incident. Many residents and first responders have been placed in dangerous situations, often at night and with limited time to either safely evacuate or respond to an approaching wildfire.

  Current building codes and standards are primarily focused on mitigating interior building fires for single parcels or buildings. However, access and egress requirements to safely manage people (e.g., number, separation of, and capacity of exits) are aimed at getting people out of buildings. There currently is not an equivalent fire safety code, standard, or consensus document that requires provisions for people management during wildfire events at neighborhood-, community- or regional-scales. This means that most existing and new developments may not have a sufficient number, arrangement, or capacity of egress routes to evacuate all residents to a relative place of safety during a major wildfire incident or allow for sufficient access for first responders (Figure 3).

Figure 3. Wildfire evacuations place considerable stress on residents, first responders, resources, and transportation infrastructure. Few neighborhoods, communities- or cities- have properly planned for timely and safe egress from a fire.

Both infrastructure and evacuation planning are key components at the neighborhood- and community-scales in high wildfire-prone settings, such that people are able to safely and quickly evacuate before being endangered by fire, smoke, or hot gases, and first responders can safely and effectively conduct emergency operations.

- Subdivision Landscaping and Vegetation Management – The location and vegetative make-up of open spaces within and adjacent to a development can increase risk of wildfire intensity and spread at the WUI and provide pathways for wildfire to enter a community like a wick. Common spaces, greenbelts, and other types of open spaces can lead to high-risk vegetative conditions (e.g., non-fire adaptive plants, high fuel load due to presence of creek bed or other water features, no fuel management, more flammable vegetation types, proximity to structures) which, in combination with high fire hazard topographic features (e.g., slopes, drainages), can further exacerbate intermix/interface wildfire hazards and risks (Figure 4 and Figure 10).

Figure 4. Unmaintained open space adjacent to the Sagamore neighborhood in Superior CO pre- and post-Marshall Fire. This unmanaged open space likely played a role in the rapid spread and subsequent ignition of the proximate neighborhood.

- Protecting Critical Infrastructure - Though there are some regulations and guidance on mitigating wildfire risks for electrical infrastructure (e.g., vegetative management around poles and lines), other types of critical infrastructure (e.g., communication systems, road networks, power supplies, water supplies) at various scales have few codes, standards and/or guidance documents for wildfire resiliency, or post-wildfire hazards particularly at the subdivision planning scale. As most critical infrastructure is designed and managed at city and regional scales, most developers, contractors, engineers, and planners have little influence over the wildfire safety provisions for those large-scale systems. Recent and past wildfires have resulted in significant short- and long-term impacts to critical infrastructure (e.g., loss and/or damage of water tanks and associated pumps, post-fire debris flows and landslides washing out transit networks) that have resulted in greater financial losses, increased downtime, extended recovery and rebuilding periods, and general disruption to social capital in communities (Figure 5). Understanding what risks wildfire threats present to critical infrastructure (during and post-incident) in a subdivision, and what types of measures are necessary to protect these assets (pre-, during and post-incident) is critical, particularly where a developer, contractor or designer has control over the protection of those lifeline services (Figure 6).

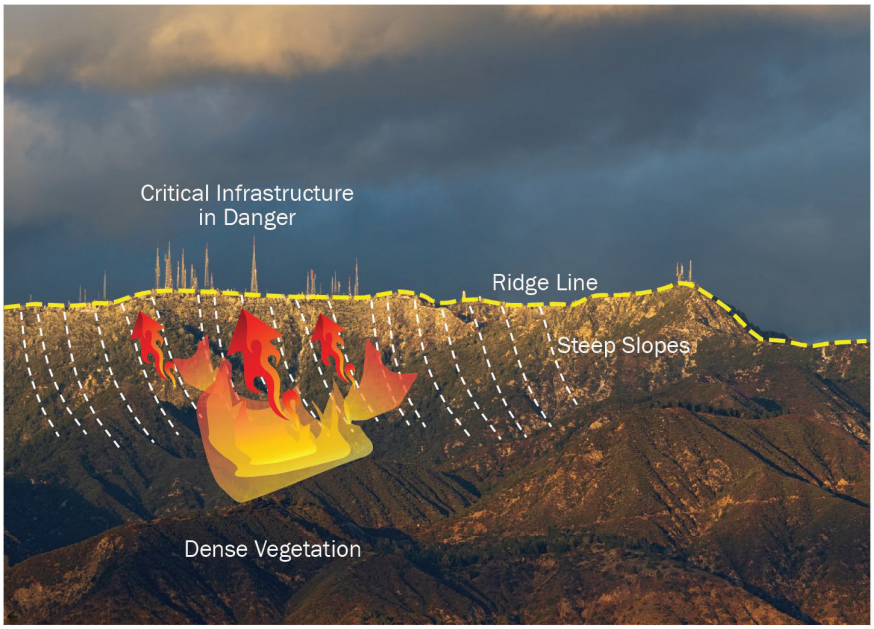

Figure 5. Critical infrastructure is often located in settings with severe wildfire risk (e.g., along ridge lines, on steep slopes, in remote settings with dense vegetation).

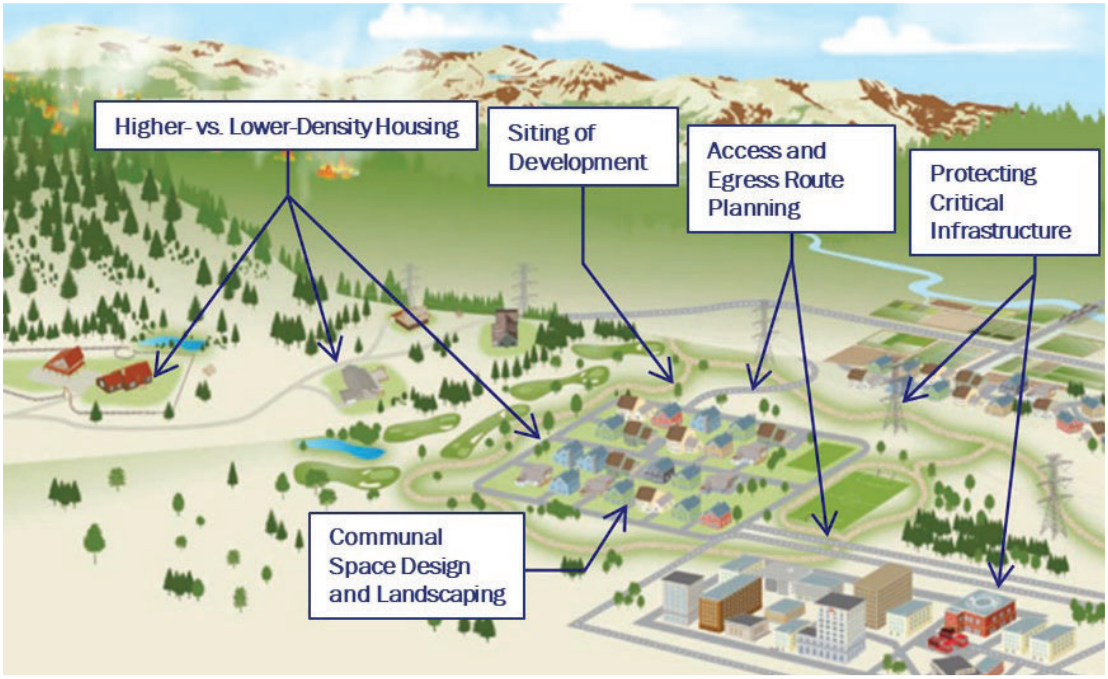

Figure 6. Multiple key issues at the subdivision, neighborhood, and community scales all influence the overall wildfire risk of structures (adapted from Wildfire Planning International, 2016).

1.3. Definitions

Approved or recommended plants – "Approved" or "recommended" plants are generally based on characteristics that allow for a more fire-resistant landscape. Common characteristics include

drought-resistance, high moisture content, low levels of volatile oils and other readily flammable chemicals, pest-resistance, noninvasive, slow, and low growing, low litter production and bark shedding, and will grow without supplemental fertilization.

Communal defensible space – The area or space around a collection of properties where the minimum defensible space distances (30–100 feet) is achieved by the sharing of vegetation management and fuel treatments across neighbor property lines. This is in lieu of individual property owner's ability to achieve the requisite defensible distances for setbacks and defensible space within their own parcel. This is related to the concept of "overlapping ignition zones."

Communal or common space – Land or space that is intended for common ownership or use by the residents of surrounding dwelling units.

Community scale –A large area within a community or, in some cases, the whole community (i.e., an entire town or county) (adapted from NFPA, 2013).

Defensible space – The area or space around homes and buildings where vegetation and other features (e.g., trash, firewood piles) are managed to reduce the structure's risk of ignition due to radiation (heat), direct flame impingement, or exposure to firebrands from a wildfire (adapted from Bell et al. 2007). Defensible space also provides firefighters a place of relative safety to conduct firefighting operations (e.g., control or suppression fire, search-and-rescue) during a wildfire or urban conflagration.

Greenbelt – A belt of parkways, parks, or farmlands that encircles a community (Merriam-Webster, 2022).

Interface WUI – The area where developed/settled areas abut wildland vegetation (Radeloff et al., 2018).

Intermix WUI – The area where houses and wildland vegetation directly intermingle (APA, 2018a).

Neighborhood or subdivision – An area composed of a collection of residential structures (APA, 2018a) that are typically part of a defined subdivision or large Planned Unit Developments (PUDs), particularly when applications for major new developments are submitted for planning or permitting. These are smaller areal units of residential or commercial use that do not cover an entire community, city, or county (Adapted from APA, 2018a and NFPA, 2013).

Vegetation management – Tree thinning, spacing, limbing, and trimming; removal of any vegetation growing under tree canopies (typically referred to as "ladder fuels"), surface vegetation removal, and brush clearance; vegetation conversion, fuel modifications, and landscaping (NFPA, 2013).

Wildfire hazard assessment – Hazard assessment identifies areas based on natural factors such as fuel/vegetation, slope, and weather patterns that increase the likelihood of wildfire occurring (NFPA, 2013).

Wildfire risk assessment – Risk assessment identifies where wildfire is most likely to threaten something of community value, such as human life, property, natural/historic resources, or other features or resources of local value. Risk assessment often includes other risk factors, such as existing roof types, road access, water supply, location and density of structures, and likelihood of post-fire flood damage. A high hazard rating in an area with a low-risk rating (i.e., a wildfire in an undeveloped area) may therefore result in low risk (NFPA, 2013).

2. Subdivision Wildfire Planning

Neighborhood-level codes, standards, and guidelines for planning and design of subdivisions do not currently exist or are very limited. However, because subdivision regulations address a range of conditions on parcels, there are elements of subdivision planning that are critical for reducing wildfire risk (Figure 7). Planning at the subdivision scale can also be an effective tool for addressing several issues of concern for communities in the WUI. Important areas of consideration include:

- Wildfire hazard and risk assessment
- Siting of development
- Housing density considerations
- Access, egress, and evacuation planning
- Water sources for fire fighting
- Subdivision landscaping and vegetation management
- Protecting critical infrastructure & lifeline services

Note: Structural hardening and defensible space provisions at the building/parcel level are the subject of separate Marshall Fire Mitigation Assessment Team products including Marshall Fire MAT document *Homeowner's Guide to Reducing Risk of Structure Ignition from Wildfire* and Marshall Fire MAT document *Guide to Reducing Wildfire Risk Through Defensible Space*.

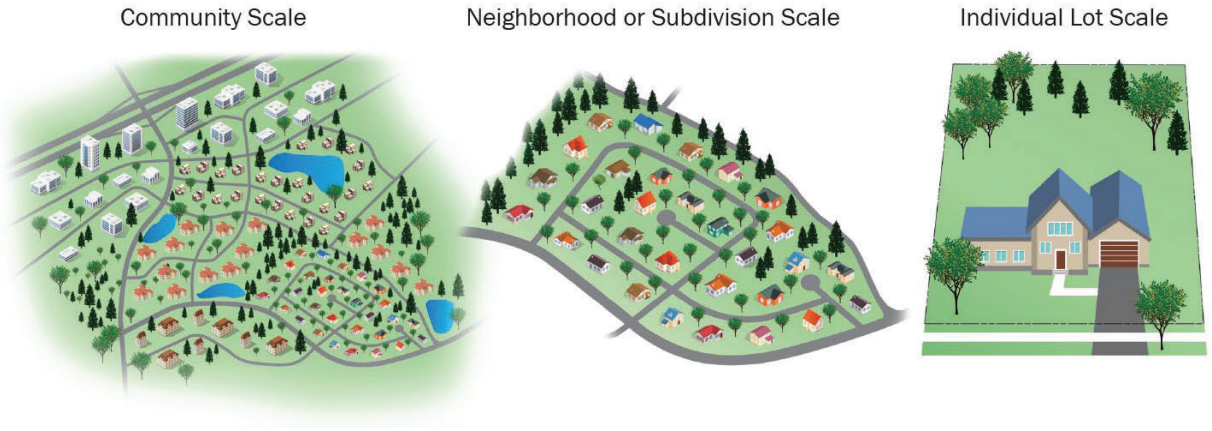

Figure 7. Schematic illustrating scale differences critical for holistic wildfire resiliency planning (adapted from UCANR 2020).

2.1. Wildfire Hazard Assessment

The effective use of wildfire hazard information (e.g., wildfire hazard and risk maps, local wildfire/fire safety ordinances, zoning restrictions, wildfire safety elements in general plans) in the early planning or entitlement phases of new developments including subdivisions is critical. Such information can help to avoid the placement of new developments in very high fire-hazard areas as well as understand site- and neighborhood-specific wildfire vulnerabilities and risks, allowing communities to more comprehensively plan for and design against potential loss of life, property, or other assets. It is fundamental that the evaluation of wildfire hazard conditions is not only conducted at the parcel-level, but also at the subdivision and community-scales. Contractors, developers, design professionals, and planners should undertake the following tasks to understand wildfire hazards during the planning process:

- Evaluate all relevant state and local wildfire hazard and risk maps. Wildfire hazard and risk maps at the state level are typically provided by the State Fire Marshall's office, State Forestry Department, or equivalent state fire agency (e.g., Colorado Forest Atlas, CALFIRE FRAP resources, Texas Wildfire Risk Explorer). At the local level, wildfire hazard and/or risk maps are typically provided by County or Local fire agencies, office of emergency services (OES), or other local government agencies. Local level fire maps (e.g., Colorado Springs wildfire risk maps, Boulder County Fire Zone maps, Local Responsibility Area maps in California) may supersede state level information. The availability and recency of wildfire hazard and/or risks maps will vary depending on the state and local jurisdiction.

- Most available wildfire hazard and "risk" maps only capture the potential severity of a wildfire due to local environmental settings (e.g., topography, vegetation, and weather). Although sometimes called "risk" maps, these maps often do not encompass the risk a wildfire may pose to community values or assets (e.g., life safety, property protection, environmental protection) or any existing or planned vulnerabilities in the neighborhood and community (Figure 8), such as:

    - Occupant characteristics (e.g., age, income, limited English proficiency, limited mobility)
    - High-risk land uses or occupancies (e.g., large assembly, hazardous facilities, schools, hospitals)
    - Availability of fire safety resources (e.g., access/egress, water supplies, power distribution, communications)
    - Construction practices (e.g., pre-WUI code building practices, combustible construction)

- As "risk" is a function of hazard, exposure, and vulnerability; a high-density housing development without WUI code construction and transit-dependent senior care facilities in a medium wildfire hazard zone may experience greater overall risk than a high-end construction, residential subdivision with golf courses and manicured greenbelts in a very high-fire-hazard zone. Given this, the contractor, designer, and/or planning professional will need to evaluate not only site-specific hazards, but also potential risks to the proposed development (see next bullet point).

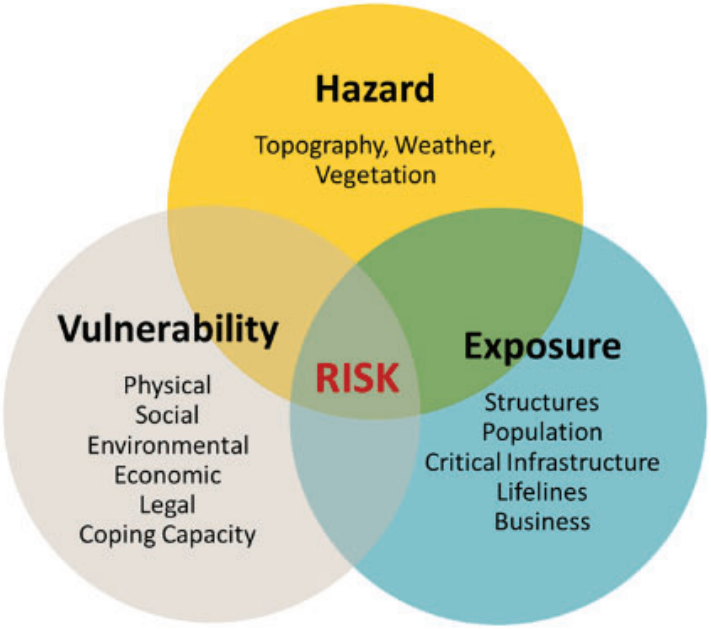

Figure 8. Wildfire risk identifies where wildfire is most likely to threaten a community value (e.g., human life, property) and is defined by the combination of hazard, exposure, and vulnerability.

- Determine if an environmental review (e.g., National Environmental Policy Act or California Environmental Quality Act) is required as part of the planning phase. The objectives of environmental reviews may conflict with the objectives of wildfire hazard and risk-reduction measures, so consultation with both a wildfire/fire safety specialist and an environmental protection specialist should be undertaken to appropriately address and balance public safety and environmental concerns.

- Evaluate all relevant local level community planning documents, plans, and maps. This may include, but is not limited to the following:

    - Community Comprehensive Plans at county, city, and local levels
    - General plans, master plans, form-based plans, zoning requirements, and land-use planning
    - Community Wildfire Protection Plans (CWPPs)
    - Hazard Mitigation Plans (HMPs) (e.g., All-Hazard Mitigation Plans, Multi-Jurisdictional HMPs). Reference *Marshall Fire Mitigation Assessment Team: Mitigation Strategies to Address Multi-Hazard Events* for additional guidance
    - Emergency operational plans and procedures
    - Unit Strategic plans or other fire department planning documents

    The existence of and detail in these documents varies widely between jurisdictions. In best-case scenarios, these plans should provide hazard mapping for the area, indicate overlap between

natural hazards and vulnerable community assets, detail structural vulnerabilities, and list concerns about post-wildfire impacts (APA, 2018).

- Consult state and locally adopted wildfire safety building and fire codes, ordinances, and other relevant regulatory documents. Where the state or local jurisdiction have not adopted any wildfire-specific safety regulations, refer to the 2021 International WUI Code (Table 502.1 and/or Appendix C: Fire Hazard Severity Form) for general guidance around analyzing the fire hazard of a specific site.

- Consult with the local fire department to understand any local requirements, additional guidance documents, wildfire planning processes and reviews, and existence of any mutual aid agreements and/or alternative mitigation initiatives appropriate to the area.

2.2. Siting of Development

The location of a development or subdivision on the landscape is a major driver of its wildfire risk. Local site conditions (e.g., topography, vegetative characteristics, vegetative maintenance, proximity of fuels and other developments, weather, and orientation of a site) can markedly influence site-specific wildfire hazards and exposures not typically captured by the federal, state, and local level wildfire hazard and risk maps discussed in the previous section. The following paragraphs include recommended best practices to consider during planning for siting a development in the WUI:

Consult existing state and local wildfire hazard and risks maps, as well as other wildfire related planning documents described in the previous section for a general understanding of “landscape” level fire hazards. Where state or local hazard maps are nonexistent, out-of-date, or of low spatial resolution, consider contracting a specialist to complete a project-specific wildfire hazard and risk assessment. A project-specific assessment will provide a higher level of granularity of anticipated wildfire behavior, will highlight any vulnerabilities due to the presence of local topographic conditions (e.g., hilltops, ridges, steep slopes), and will show potential fire flow paths from neighborhood- or community-level features such as greenbelts, open spaces, or drainages (Figure 9). In recent fires, such as the Marshall fire in Colorado, drainages and other communal open spaces provided an avenue for wildfire to spread into the more developed urban/suburban environments. This type of detailed analysis may be particularly prudent if your development will be in an interface or intermix WUI or in an occlusion zone (Figure 10).

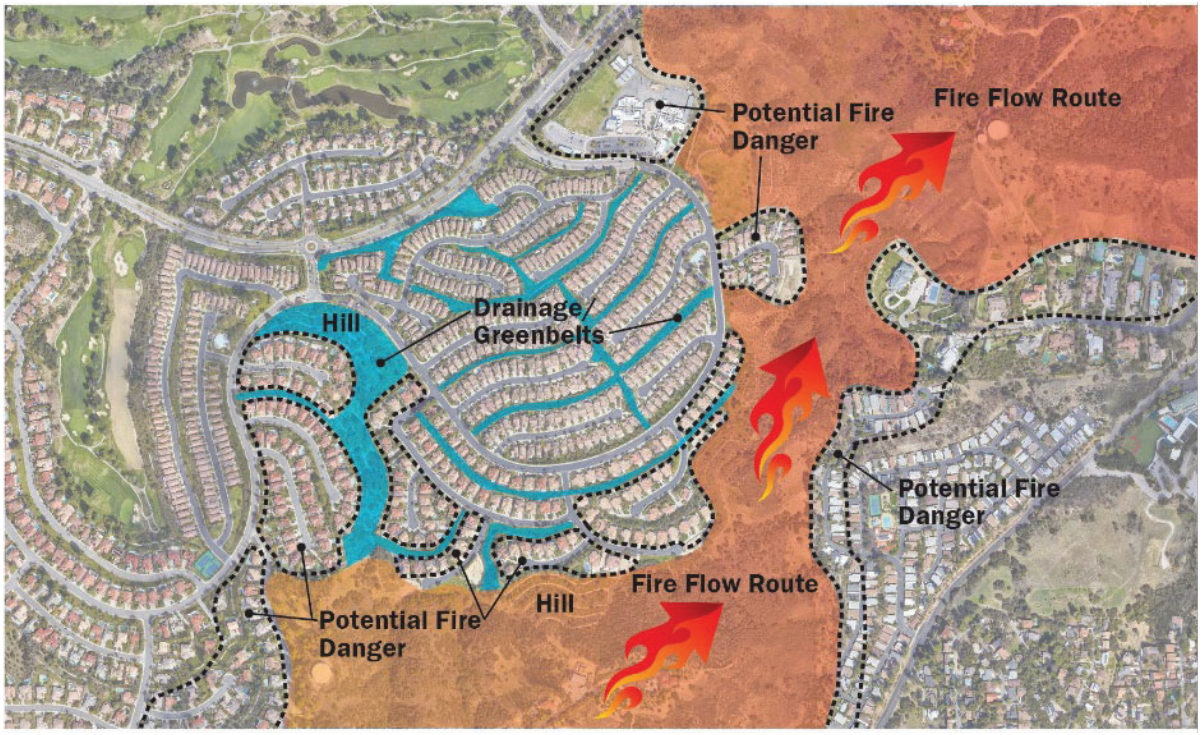

Figure 9. Drainages and greenbelts in or adjacent to communities can provide access for fire to flow into the urban/built environment.

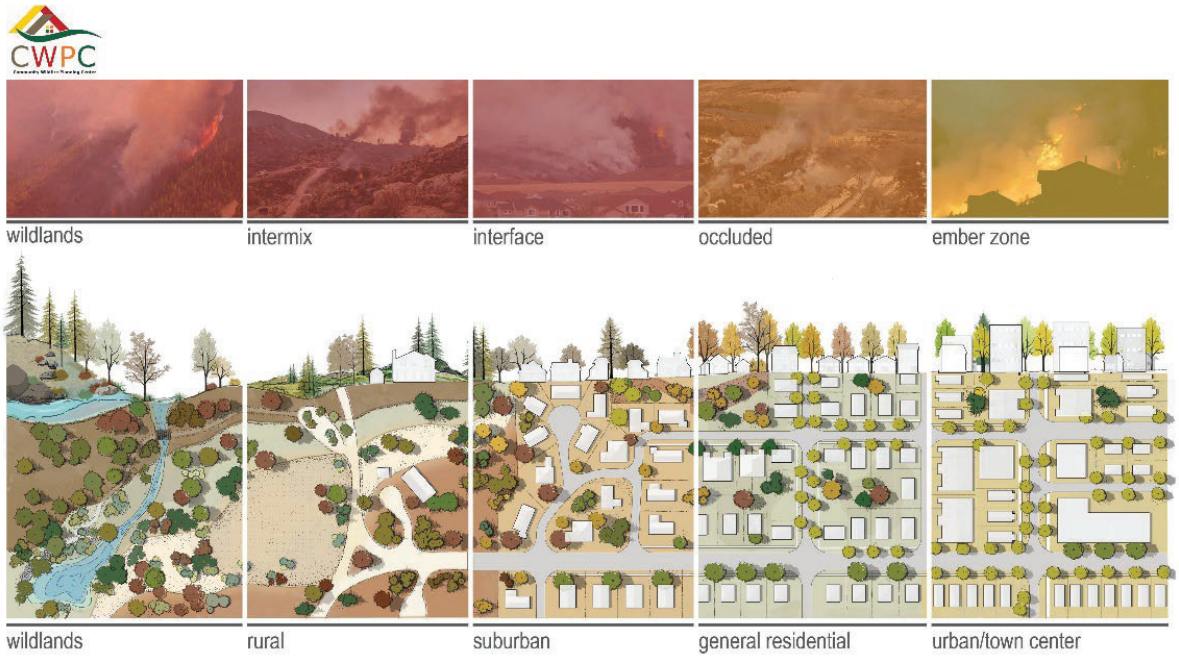

Figure 10. The spatial relationship between vegetation and development changes along a continuum from wildland to urban. Intermix, interface, and occluded/urban forest WUI often have the highest wildfire hazard (Image courtesy of Community Wildfire Planning Center).

If a detailed wildfire hazard assessment is not available or feasible, the following general guidance for siting a subdivision or development can help reduce wildfire risk:

- Avoid selecting a construction site along a gully or in a narrow canyon
- Avoid selecting a construction site in or adjacent to a saddle or narrow mountain pass
- Avoid constructing a new development adjacent to or on a steep slope. If a ridgetop site is selected, consider the following:
    - Choose an area that allows for a minimum 30–100-foot setback from wildland vegetation on the downslope side (see Figure 11). Increase the setback at sites with heavier fuels such as in a forested environment. Implement the measures in Marshall Fire MAT document *Homeowner's Guide to Reducing Risk of Structure Ignition from Wildfire* and Marshall Fire MAT document *Homeowner's Guide to Reducing Wildfire Risk Through Defensible Space*.

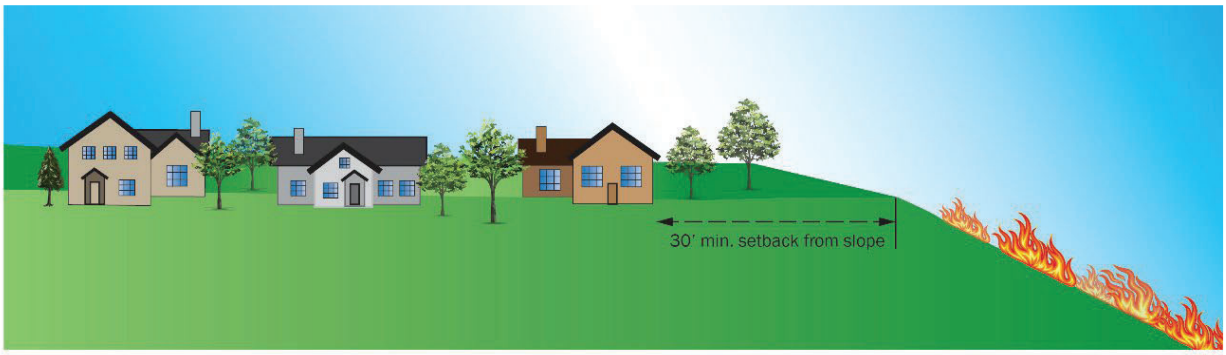

Figure 11. Topographic features, such as slopes, may increase wildfire risk. Appropriate mitigation actions, such as slope setbacks, should be undertaken.

    - Develop a fuel modification and long-term vegetation management plan for the steep slopes proximate to the development site (if within your control) (Figure 12). Given the specific topographic and vegetative conditions more than 100 feet of defensible space will likely be needed. Consult with the local fire department or other authority having jurisdiction for site-specific guidance and/or local ordinance requirements. In some jurisdictions, this can be as much as 200+ feet (e.g., Los Angeles County, Orange County in California). See vegetation management section below. Refer to the *Marshall Fire Mitigation Assessment Team: Homeowner's Guide to Reducing Wildfire Risk Through Defensible Space* as well as additional guidance documents in the references section.

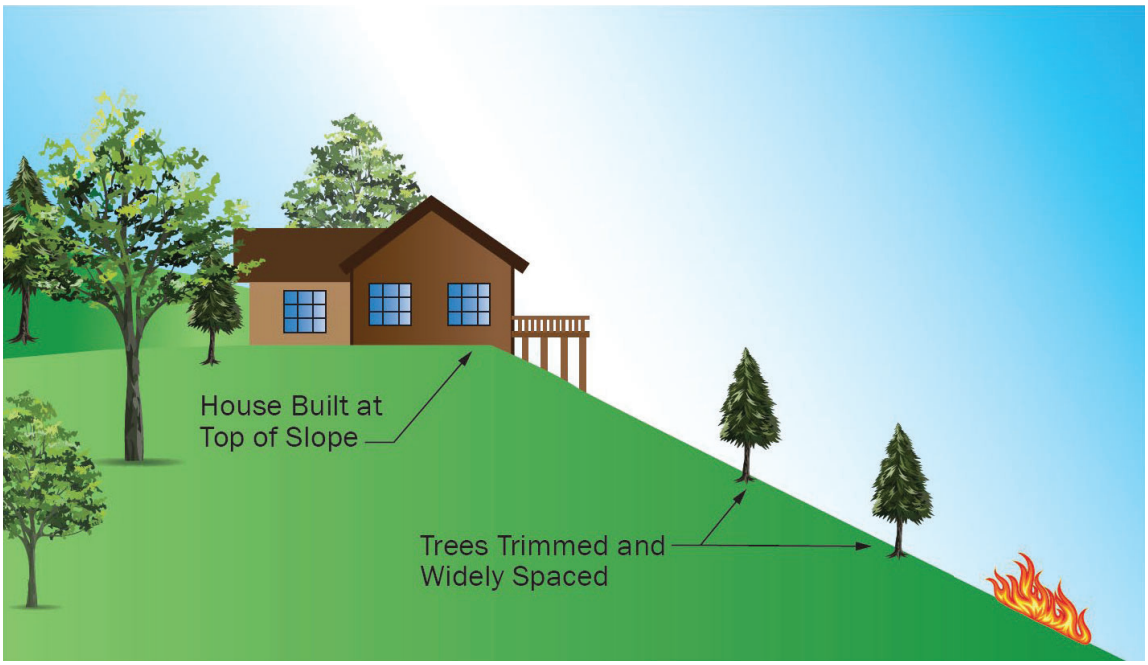

Figure 12. Topography and vegetation influence wildfire risk. Where 50-foot setback to steep slopes is not feasible, provide a minimum of 100–200 feet of fuel modifications along the proximate slope.

- Avoid constructing a new development adjacent to an unmanaged open or wildland space where 50 to 100 feet of defensible space cannot be provided on the proposed site. If a site is selected that is proximate to an unmanaged open or wildland space, consider the following design features:
  - Integrate inherent fuel breaks such as fruit orchards, irrigated landscaping/greenbelts, golf course or other similar low-wildfire hazard features (Figure 13).
  - In addition, or where achieving perimeter defensible space is infeasible, consider providing increased structural hardening measures for structures proximate to the open or wildland space such as 6-foot non-combustible perimeter walls or 1-hour fire-resistant exterior walls and protected openings (Figure 13).
  - Refer to Marshall Fire MAT document *Decreasing Risk of Structure-to-Structure Fire Spread in a Wildfire* and Marshall Fire MAT document *Homeowner's Guide to Reducing Wildfire Risk Through Defensible Space*.
  - Refer to Marshall Fire MAT document *Decreasing Risk of Structure-to-Structure Fire Spread in a Wildfire* for additional siting recommendations at the building-scale (e.g., building orientation relative to fire flow paths, debris and ember accumulation, window number, and orientation.

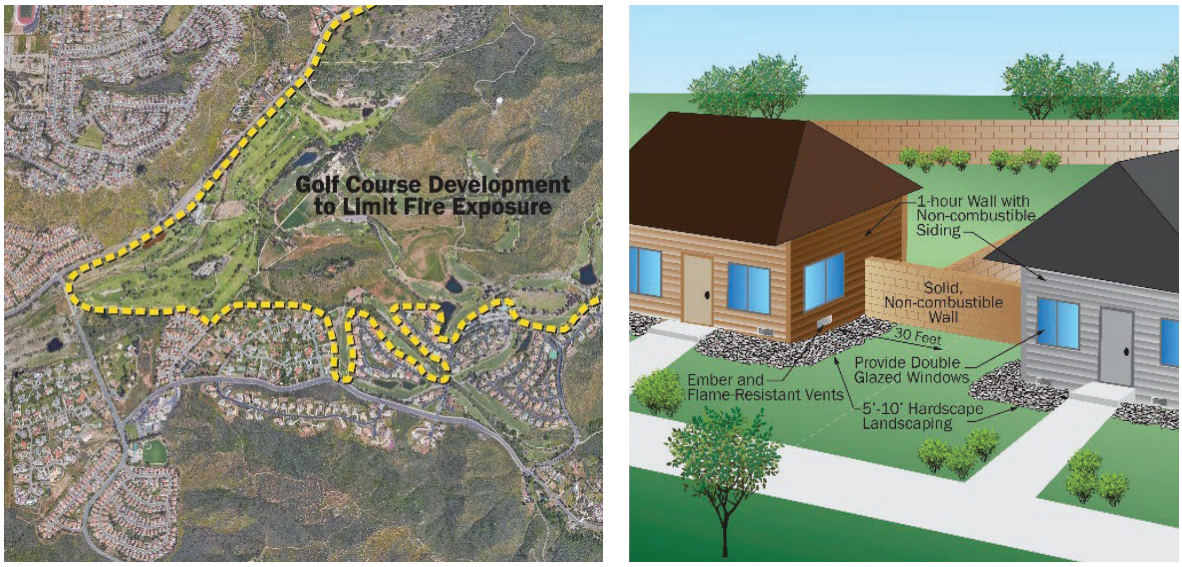

Figure 13. Example of golf course placement around a development to limit wildfire exposure (left) and fire-resistant construction techniques (right).

In recent catastrophic wildfire incidents (e.g., 2017 Camp Fire, 2021 Marshall Fire), fire spread rapidly not only via wildlands and other open spaces, but also from structure to structure (via direct flame contact, hot gases, radiation, and embers). Given the devastating influence nearby subdivisions can have during a wind-driven fire incident, developers and planners should consider the extent and proximity of surrounding developments and their influence on fire behavior. The following provides general guidance for siting a subdivision or development relative to other existing or future developments:

- Avoid construction sites proximate to an existing or future development in a high or very high fire hazard severity zone, where a minimum 30-foot setback to the property line cannot be provided. Where this cannot be avoided, consider integrating design features, such as fuel breaks and increased structural hardening measures, like those described for sites proximate to unmanaged open or wildland space (see section above).

- If there will be any hazardous land uses on the site that could potentially exacerbate risk (e.g., storage of combustible materials, fuel storage facilities) and which cannot be restricted, consider providing additional mitigation measures (APA, 2019), such as larger setbacks and defensible space areas, secondary emergency water supplies and associated emergency power, increasing exterior wall fire resistance rating (e.g., 1-hour to 2-hour). Consult with a fire-safety engineer, design professional, or local fire department for guidance, as needed.

2.3. Housing Density Considerations

When planning a new housing development, there are various options and considerations in selecting the density of houses and structures, both across multiple lots and on a single lot. These decisions are generally guided by local regulations and zoning, economic and financial needs of the developer, and preferences of homeowners/buyers. In WUI areas, an additional consideration must

be reducing wildfire risk. There may be conflict between guidance and best practices for wildfire risk mitigation with residential development needs and preferences.

Currently, there is limited formal guidance to assist developers, design professionals and planners in providing appropriate wildfire safety provisions given the range of housing density and layout considerations in practice (see NIST Technical Note 2205 and UCANR 8680 for additional detail). Development planning provides a unique opportunity to mitigate wildfire risk at a neighborhood scale, rather than at the individual lot scale, which forms the basis of current building and fire code requirements. This document provides general guidance given two different housing density designs: (A) "Clustered" or High-Density and (B) "Traditional" or Low-Density, as shown in Figure 14.

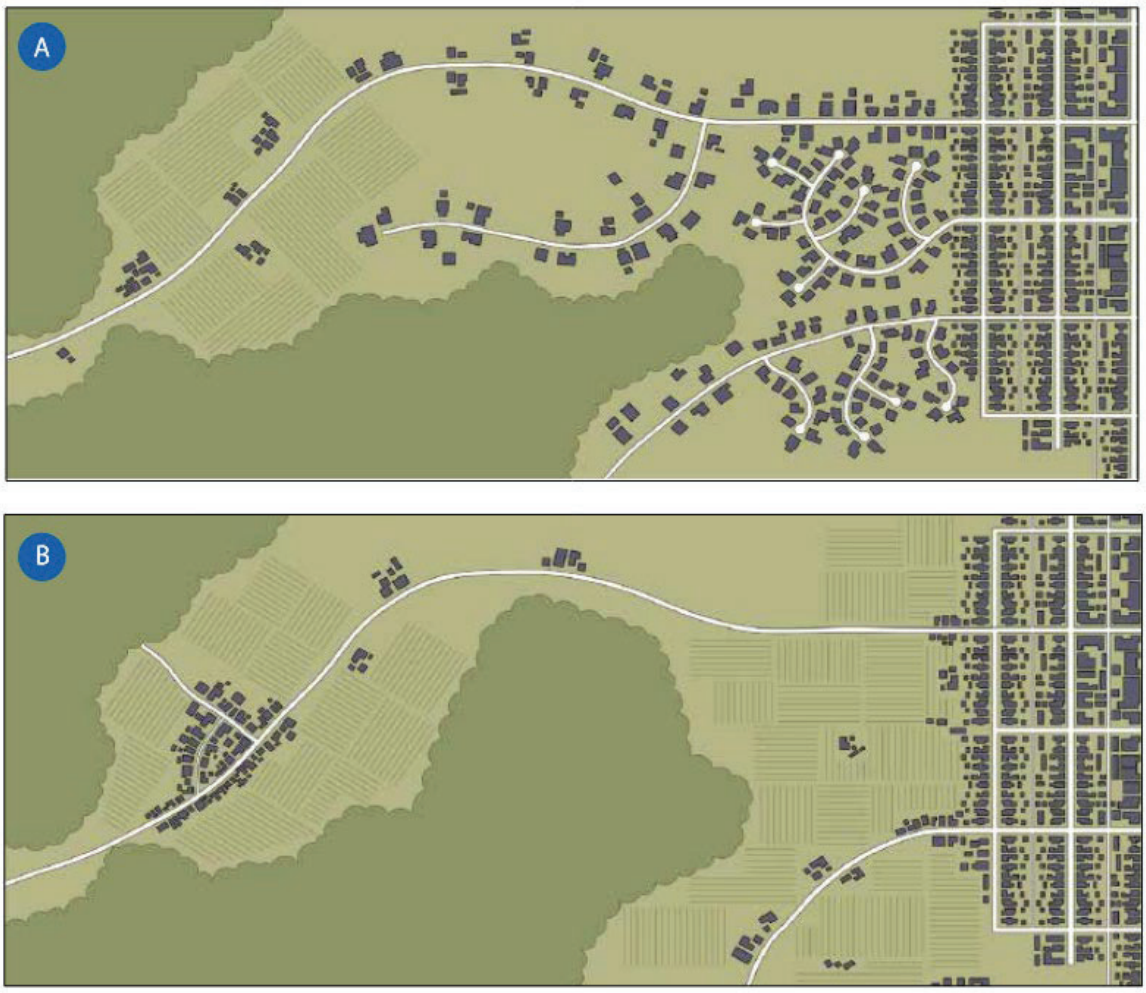

Figure 14. Conventional, or traditional, development with low-density houses (A) versus clustered development with several high-density clusters of structures (B) (UCANR, 2020).

The following sections provide potential fire safety design considerations given "clustered" or high-density designs vs. "traditional" or low-density design options.

2.3.1. "CLUSTERED" OR HIGHER DENSITY HOUSING

Clustering homes together within a subdivision can reduce the expansion of development in high-wildfire hazard areas while also minimizing the overall number of houses on a site. This design strategy can also help limit impacts to environmental services, ecological needs, and recreational goals for open spaces, while also reducing the distribution of firefighting resources during a major wildfire incident (APA Multihazard Planning Framework for Communities in the WUI, 2018; UCANR, 2020).

However, higher-density designs may increase structure-to-structure ignitions due to the closer arrangement of buildings, and therefore require additional fire safety mitigations to offset reduced fire separations (e.g., fire-rated exterior walls, non-combustible construction materials, ember resistant vent protection). These include:

- Provide vent covers with 1/16-inch wire mesh or an approved ember and flame-resistant vent. Some jurisdictions have "pre-approved" products such as CALFIRE's Building Materials Listing Program[5] . Local building and/or fire officials have discretion to approve products.
- Provide combustible siding with non-combustible or ignition resistant materials (e.g., fiber cement, stucco).
- Provide combustible decking with non-combustible decking.
- Provide noncombustible materials for non-vegetative features (e.g., ornamental grass, sheds, pergolas, gazebos) or design any combustible elements in surrounding landscape (e.g., trash bins, wood piles, vehicles) to be more than 30 feet away from homes or structures or to be enclosed in non-combustible construction.
- Provide double-paned or tempered-laminated glazing. Recommend reducing the number of openings (i.e., windows, glazed doors, vents) on the aspect where exterior walls are in close proximity to other buildings.
- Use noncombustible materials (e.g., concrete, masonry, metal), particularly for fences that attach to adjacent homes or structures.
- Provide structural hardening measures for the entire home (e.g., upgrading to a Class A roof). Refer to Marshall Fire FS-2 "*Homeowner's Guide to Reducing Risk of Structure Ignition from Wildfire*".

Given the increased structural hardening measures and other fire safety features, higher-density designs, can be viewed as one large "building" or development, where prescriptive requirements for

[5] https://osfm.fire.ca.gov/divisions/fire-engineering-and-investigations/building-materials-listing/bml-search-building-materials-listing/

achieving 100 feet of defensible space is provided around the perimeter of the entire development site, while also considering the following integrated design features:

- Provide a minimum 100-foot inherent fuel breaks around the entire development such as fruit orchards, irrigated landscaping/greenbelts, golf courses, roads, or other similar low-wildfire hazard features. See vegetation management section below for further discussion of this topic.
- Concentrate housing on inner side of roadways and away from vegetation (UCANR, 2020).

Although high-density development can efficiently create vegetative buffers (e.g., green belts, golf courses, orchards) and allow for fire department response, additional risks are involved when structures are closely spaced. See Marshall Fire MAT document *Decreasing Risk of Structure-to-Structure Fire Spread in a Wildfire* for information on mitigating risk for high-density neighborhoods and subdivisions. Additionally, reference Marshall Fire MAT document *Homeowner's Guide to Reducing Wildfire Risk Through Defensible Space*. Marshall Fire MAT document *Homeowner's Guide to Reducing Risk of Structure Ignition from Wildfire* for information on protecting structures within high-density developments. and "Traditional" or lower-density housing.

2.3.2. "TRADITIONAL" OR LOWER DENSITY HOUSING

Traditional housing developments, with lower density designs, allow each individual home/structure to directly integrate wildfire safety provisions (e.g., structural hardening measures and defensible space) prescribed in wildfire codes and standards for each individual building or home. However, as shown in Figure 15, lower-density housing, collectively, requires a higher amount of land area dedicated to defensible space compared to higher-density designs, which can have negative impacts to environmental services and other ecological goals of the community. Lower density developments can also result in the need to disperse firefighting resources and suppression activities in the event of a major wildfire incident, given the larger spread of development. (UCANR, 2020).

Be aware that unplanned subdivisions or structures on adjacent lots may not have been designed to meet an equivalent level of safety as described in this document, therefore, the fire risk they can present to surrounding properties is uncertain. Thus, the guidance in this document is intended to mitigate this uncertainty by recommending fire safety measures at the neighborhood level during planning and development specific to subdivisions, such as communal defensible space or high-density vs low-density design options.

In the event that the low-density housing development still is unable to meet 100 feet of defensible space on all sides of an individual structure, contractors should ensure that communal defensible space considerations and structural hardening measures on all affected properties are implemented as described in the *Marshall Fire Mitigation Assessment Team: Homeowner's Guide to Reducing Wildfire Risk Through Defensible Space*. Refer also to this fact sheet, where 30 feet of setback from property lines is not feasible.

2.4. Access, Egress and Evacuation Route Planning

Both road infrastructure and evacuation planning are key components at the neighborhood- and community-scales in high wildfire prone settings, such that people are able to evacuate during a major wildfire safely and quickly along primary and secondary routes, and first responders can effectively gain access to conduct emergency operations. This includes providing sufficient number, arrangement, and capacity of road networks, as well as meeting specific roadway standards, and understanding the impact of new development on the regional road network. The following guidance provides recommendations for planning appropriate wildfire access/egress for new subdivisions:

Figure 15. Access roads should have sufficient separation.

- **Separation of Access/Egress Routes** (Remoteness of exits) – Emergency access/egress to or from a neighborhood is necessary to protect life safety in the case of evacuation and fire responder activities. Access/egress routes should be spaced sufficiently so that both routes are not blocked during a wildfire emergency event. Where two access/egress roads are required (e.g., developments of one- or two-family dwellings where the number of dwelling units exceeds 30), they should be separated by a distance not less than one-half the length of the maximum overall diagonal dimension of the area to be served (IFC Appendix D) (Figure 15). The ease of separating access will depend on site setting and surrounding terrain and may require consultation with the local fire authority. (Planning for Wildfires; APA Zoning Practice 9, 2018).

- **Subdivision or Neighborhood Wildfire Access/Egress Capacity and Dead-End Conditions**

    - All roads should provide a minimum of two 10-foot traffic lanes, not including shoulder and striping. These traffic lanes should provide for two-way traffic flow to support emergency

vehicle and civilian egress unless other standards or additional requirements are mandated by Local Jurisdictions or local subdivision requirements.

- Where one-way roads are provided, they should provide a minimum of one 12-foot traffic lane, plus shoulders. One-way roads should connect to a road with two traffic lanes providing for travel in different directions and provide access to an area currently zoned for no more than 10 Residential Units. Avoid providing one-way roads in excess of 2,640 feet in length. Where one-way roads are provided, turnouts should be placed and constructed at approximately the midpoint of each one-way road.

- All lengths should be measured from the edge of the road surface at the intersection that begins the road to the end of the road surface at its farthest point. Where a dead-end road crosses areas of differing zoned parcel sizes requiring different length limits, the shortest allowable length should apply.

- Fire Apparatus Access – Fire codes, local ordinances, and standards for roads, driveways, and bridges to ensure access by fire department apparatus and emergency services equipment should be followed and may be more restrictive than the following suggestions. These include minimum road width, maximum grade, number of turnarounds/turnouts, and load limits. Note: The following guidance provides minimum suggestions. Consult with local fire and other authorities having jurisdiction where requirements may be more restrictive.

  - Fire apparatus access roads should have a minimum width of 20 feet, and a minimum clear height of 13 feet 6 inches. Dead-end roads more than 150 feet in length should have turnarounds. A driveway which does not meet the requirements of a fire access road should not serve more than five residences (IWUIC 2021). Consult the local fire department for jurisdiction-specific requirements.

  - Grades for all roadways and driveways should not exceed 16% or as limited by the local fire department. Consult the local fire department for confirmation.

  - Driveways in excess of 150 feet in length should be provided with turnarounds. These turnarounds should have an inside turning radius of not less than 30 feet and an outside turning radius of not less than 45 feet (IWUIC 2021). Road intersections should accommodate similar turn requirements.

  - Driveways in excess of 200 feet in length and less than 20 feet in width should be provided with both turnarounds and turnouts. Turnouts should be an all-weather road surface and not less than 10 feet wide and 30 feet long (IWUIC 2021).

  - Roads should be designed and maintained to support the imposed load of fire apparatus weighing 75,000 pounds and provide an aggregate base. Consult the local fire department for jurisdiction-specific requirements.

- Road signs should be uniform and meet visibility requirements. Any locked gates should have a Knox box installed for emergency responder access (APA Zoning Practice 9, 2018; PAS 594).

- **Protection of Primary and Secondary routes –** Planning for fire-adapted landscaping and/or fuel treatments such that a minimum of 10 feet on either side of all major access/egress routes within the subdivision should be considered (Figure 16). Consult with a wildfire specialist, landscape architect or other design professional for detailed guidance and best management practices.

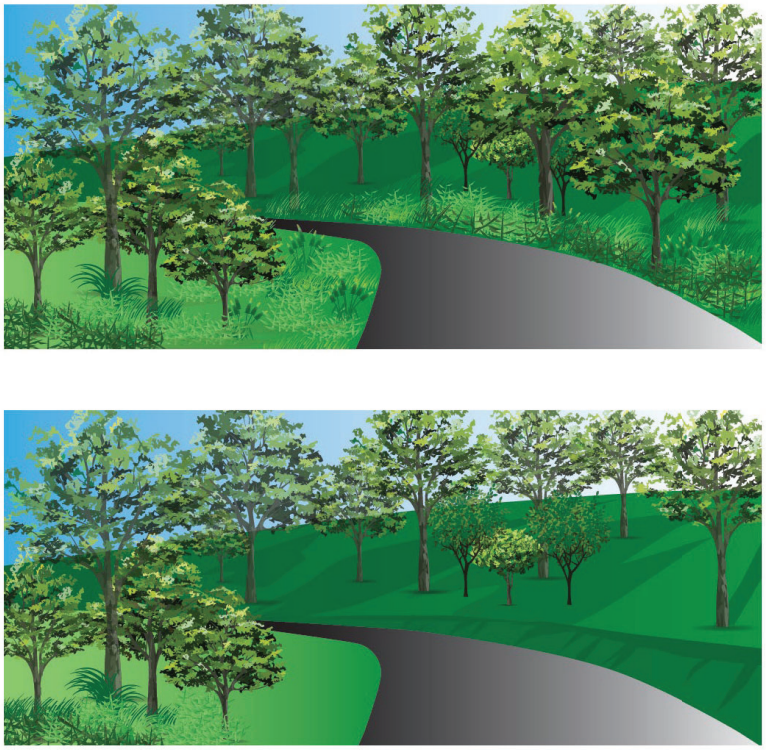

Figure 16. A minimum of 10-feet of fuel modification should be maintained around primary and secondary egress routes. This distance may increase where an access road is in high hazard topography (e.g., steep slopes, ridgelines, drainages, canyons).

- **Community Scale Wildfire Evacuation Capacity –** The planning process for new developments (particularly large developments) in very high fire hazard areas should consider undertaking a wildfire evacuation analysis to consider various likely wildfire scenarios, assess how a new development will impact the broader community road network during an evacuation, and undertake comprehensive evacuation modeling and planning that considers the specific needs of the local population. Standard roadway designs do not explicitly consider large scale emergency evacuations. A wildfire evacuation often results in larger egress flows which exceed typical roadway design flow assumptions, whether employing phased or total evacuation strategies. Wildfire-specific analysis and consideration is crucial to prepare for sufficient evacuation capacity or alternative people management strategies. Consult with the local planning and fire department for local guidance and requirements.

2.5. Subdivision Landscaping and Vegetation Management

Most subdivisions will include various common open spaces (e.g., parks, play areas, undeveloped lots, road medians, trails). Careful consideration needs to be given to planning these areas with fire-adaptive landscape design features. In addition to initial design and planning, long-term maintenance plans must be developed and implemented. The placement of open spaces within a development, specific types of plants to use and avoid, and ongoing maintenance are all important planning elements. Specific topics to consider and recommendations include:

- Place open spaces within the development site with consideration to underlying wildfire hazard and risk. This may include designating areas of high wildfire hazard as permanently conserved open spaces (with ongoing fuel reduction treatments), thereby reducing the introduction of people and property in higher-hazard areas. An added benefit of this technique may be conserving useful habitat for native plants and animals (UCANR, 2020; APA, 2018a).

- Consider the different types of open space which may exist or be built within the development. Small, landscaped, and manicured open spaces have a lower risk profile than large spaces with non-native, and possibly more flammable, vegetation. Surround larger spaces with defensible space and plan for them to burn periodically (UCANR, 2020). The outside perimeter of a development is a good place to locate walkways and trails, to reduce fuel loading adjacent to structures.

- Design vegetated open spaces so that relatively high-water content is maintained in leaves, which makes plants less likely to ignite. This requires consideration of both plant selection, irrigation systems, and a regular maintenance schedule (UCANR, 2020).

- Consider placement of vegetation within each open space. Recommended separation distances will vary by community and vegetation type (Figure 17). Reference recommendations and requirements for tree spacing based on the slope and location of the property.

    - Select specific plant types based on fire-resistance. There may be an approved or recommended plant list for your location. Also be aware of plants to avoid specific to your local area. Be aware that native plants may not be fire resistant and some may be extremely flammable.

    - In addition to initial vegetation and landscape planning, ongoing vegetation management and maintenance is crucial (Figure 18). This includes all areas with vegetation in the development—both heavily landscaped open spaces and those dominated by native vegetation. Regular fire mitigation over the long-term should be required or performed (APA, 2019).

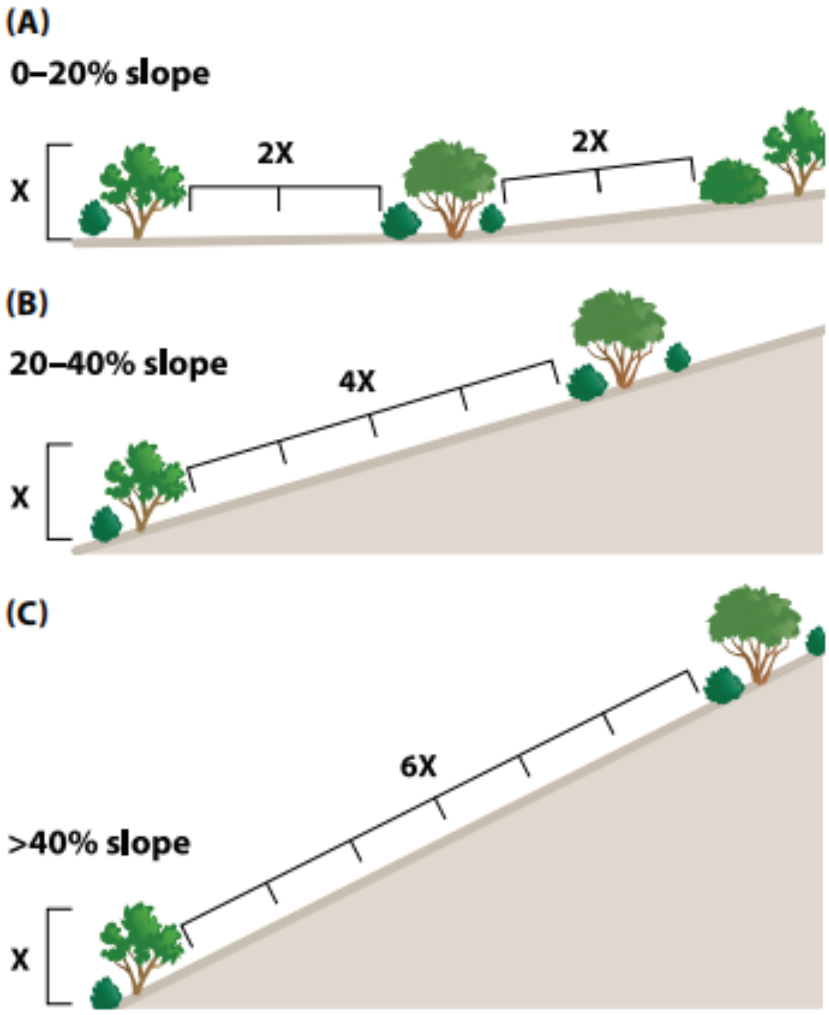

Figure 17. As slope increases, recommended distance between vegetation also increases. Steeper slopes should have widely spaced vegetation (UCANR 8695).

Figure 18. Before (left) and after (right) fuel reduction thinning treatment (California Climate Investments, 2022).

2.6. Protecting Critical Infrastructure

The protection of critical infrastructure (e.g., access/egress routes, communication systems, water supplies/infrastructure, electrical power infrastructure) from wildfire hazards, as well as limiting the potential source of wildfire ignitions due to some of these features, is an important planning consideration where relevant to a new development or subdivision. Currently, there are limited codes, standards, and guidance documents for protecting certain types of critical infrastructure from wildfire, but also ensuring that certain types are not sources of wildfire ignitions themselves at the subdivision or development scale.

The following guidance and best practices should be considered where a new development requires the design and installation of critical infrastructure. Refer also to FEMA's *Home Builder's Guide to Construction in Wildfire Zones Technical Fact Sheet No. 16* for additional details.

2.6.1. GENERAL GUIDANCE

- Critical infrastructure may span across multiple jurisdictions and may have multiple responsible entities (e.g., public utilities, city, county). Coordinate with all responsible parties. Infrastructure should be inventoried and assessed to determine vulnerability. Mitigation strategies, such as the removal of hazardous vegetation, may be part of an existing CWPP or HMP. If a critical infrastructure plan exists separately, planners should seek connections between these plans (APA, 2019).

- Consider hiring a fire protection engineer or wildfire safety specialist to evaluate and recommend wildfire safety provisions, protection measures, etc.

2.6.2. ELECTRICAL UTILITIES AND EXTERIOR EQUIPMENT

- Where possible, place all electrical distribution equipment in conduit underground.

- Where underground distribution equipment is infeasible, consult any relevant state and local fire safety ordinances for adequately designing overhead electrical distribution lines and associated equipment (e.g., transformers) to reduce the likelihood of this equipment providing a source for wildfire ignitions. Consideration should be given not only to the hardening of the equipment, but also in providing adequate vegetation clearance, appropriate plant selection such that fall-in, grown-in and lean-in of vegetation is minimized, and long-term management.

- Where state or local guidance is not available, Chapter 17 of NFPA 1 provides some limited and general guidance on clearance of brush and vegetation growth around electrical lines. This includes a combustible free zone around poles and towers of not less than 10 feet in each direction (Figure 19). For distribution lines, vegetation clearances are defined as a function of line voltage and time of trimming (e.g., a 4160V line requires a minimum of 4 feet clearance, so trimming requirements are triggered when vegetation is 4 feet from the line and must be trimmed to 6 feet clearance, to allow for growth in between trimming cycles).

Figure 19. A minimum of 10 feet of clearance should be maintained around utility equipment.

- Regular vegetation maintenance should be planned to maintain appropriate clearances, and should take into consideration species' growth rates, trim cycle, and line sway (NFPA 1, Chapter 17).

2.6.3. ACCESS/EGRESS ROUTES

Refer to the "Access, Egress and Evacuation Planning" section above for details.

2.6.4. FUEL-RELATED UTILITIES

- Fuel tanks (e.g., propane) can present a significant hazard to both structures and first responders if they start off-gassing or explode during a wildfire. Exposed, fuel lines can also be vulnerable to wildfire damage (see NFPA 58).
- Bury or shield fuel lines to protect them from the effects of radiation, direct flaming, and ember exposure.
- Bury pressurized fuel-storage vessels underground, where possible.
- Where fuel storage tanks are stored or installed above ground, the following guidance should be considered:
    - Install tanks a minimum of 30 feet from habitable structures
    - For cylindrical tanks, use vertical tanks (e.g., Figure 20) or orient horizontal tanks so that the circular ends are pointed away from residences or structures since the ends are weaker than the tank body
    - Install tanks on and surrounded by noncombustible surfaces
    - Provide a non-combustible masonry wall enclosure, where possible

- Avoid installing tanks near high-risk topographic features (e.g., steep slopes, drainages)
- Maintain at least 10 feet of clearance from other combustibles
- Avoid installing tanks in proximity to primary or secondary egress routes (APA, 2019)
- Ensure pressurized storage tanks have a pressure-relief valve and that the valve/vent is directed away from residences and structures

- Provide signage or other form of notification of type and location of fuel-related utilities, where concealed or inconspicuous.

2.6.5. FIRE-PROTECTION EQUIPMENT

- Critical fire-protection equipment (e.g., water tanks, water supply pumps, pump houses) may necessitate fire-hazard reduction measures to protect this infrastructure from being damaged or lost during a wildfire incident.

- As a minimum, 30 feet of brush clearance should be maintained around critical fire protection equipment (Figure 20). This distance may vary pending review and discussion with local fire authorities. Refer to NFPA 1 and local ordinances for detail.

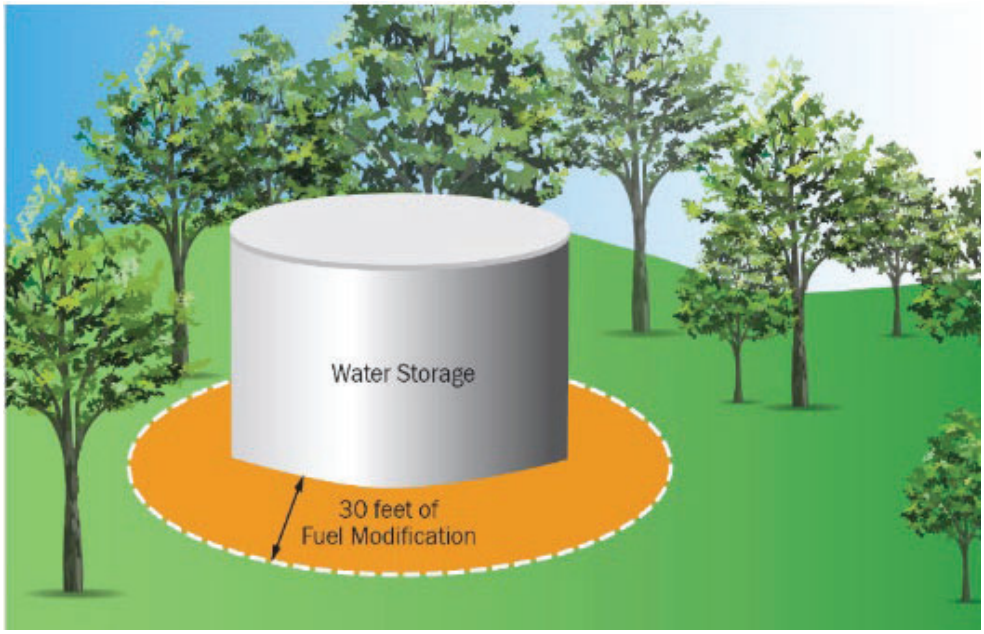

Figure 20. A minimum of 30 feet of fuel modification should be maintained around water storage tanks.

- Water supply and water storage, including on-site storage, are components of critical infrastructure within a development. Minimum water storage requirements should be applied to provide protection for dwellings and other structures where adequate public/private water supply is not available.

- Developers should coordinate with local fire departments to determine water supply requirements and hydrant placement (APA, 2018a). Many fire authorities provide specific requirements for their jurisdiction on water storage requirements and equipment (e.g., hose adapter).

2.6.6. COMMUNICATION TOWERS

- Consider providing 30 feet of hardscaping or brush clearance around communication towers and associated equipment. Consult with local fire authorities for any local requirements, guidance, and best practices. Where no local guidance is provided, consult NFPA 1, NFPA 1140 or IWUIC.

3. Additional Resources and Useful Links

Design Guidance for New Construction

While the recommendations in this Recovery Advisory focus on existing residential structures, several resources are available with design guidance for new homes.

- International Wildland Urban Interface (IWUI) Code, Section 603
- NFPA 1140, 2022 Edition: Standard for Wildland Fire Protection
- SFPE & SFPE Foundation WUI Virtual Handbook for Property Fire Risk Assessment & Mitigation

Guidance for Wildfire Vulnerability Assessments

- NFPA 1140, 2022 Edition: Standard for Wildland Fire Protection
- NFPA “Assessing Structure Ignition Potential from Wildfire" training. https://www.nfpa.org/Training-and-Events/By-topic/Home-Ignition-Zone?gclsrc=aw.ds&?order_src=G076&gclid=Cj0KCQjw1vSZBhDuARIsAKZlijT7pqdYOPLrprSJ0_ZdMy3IYD3yT6Z521MfTaXnFcW8gYI4etDRGPcaAogJEALw_wcB&gclsrc=aw.ds
- Fire Adapted Communities Learning Network. https://fireadaptednetwork.org/

4. References

American Planning Association. (2018). Multihazard Planning Framework for Communities in the Wildland-Urban Interface. Chicago, IL.

American Planning Association. (2018a). Zoning Practice. Chicago, IL.

American Planning Association. (2019). Planning the Wildland-Urban Interface. Chicago, IL.

Boulder County. (2022). Prescribed Burn Projects. https://bouldercounty.gov/open-space/management/prescribed-burns/

Boulder County. (2017). Your Defensible Space Slideshow. https://assets.bouldercounty.gov/wp-content/uploads/2017/02/defensible-space-slideshow.pdf

Boulder County. (2011). Community Wildfire Protection Plan. https://assets.bouldercounty.gov/wp-content/uploads/2017/02/community-widfire-protection-plan-book-low-resolution.pdf

CALFIRE. (2022). Prepare for Wildfire: Defensible Space. https://www.fire.ca.gov/programs/communications/defensible-space-prc-4291/

CALFIRE. (2019). Defensible Space. https://www.readyforwildfire.org/prepare-for-wildfire/get-ready/defensible-space/

California Climate Investments. (2022). A Forested Area at Camp Butano Creek Before (Left) and After (Right) Fuels Reduction Treatment. https://www.caclimateinvestments.ca.gov/2022-profiles-1/2022/forest-health

Colorado State Forest Service. (2022). Home Ignition Zone Checklists. https://csfs.colostate.edu/wildfire-mitigation/home-ignition-zone-checklists/

Colorado State Forest Service. (2021) The Home Ignition Zone: A guide to preparing your home for wildfire and creating defensible space. https://csfs.colostate.edu/wp-content/uploads/2021/04/2021_CSFS_HIZGuide_Web.pdf

Colorado State Forest Service. (2012). Protecting Your Home from Wildfire: Creating wildfire-defensible zones. https://static.colostate.edu/client-files/csfs/pdfs/FIRE2012_1_DspaceQuickGuide.pdf

East Bay Municipal Utility District. (2022). Dangerous materials and conditions for sloped sites. https://www.ebmud.com/water/conservation-and-rebates/watersmart-gardener/firescaping

FEMA: Protect Your Property from Wildfires: https://www.fema.gov/sites/default/files/2020-11/fema_protect-your-property_wildfire.pdf

FEMA: Technical Fact Sheet – Home Builder's Guide to Construction in Wildfire Zones https://wildfiretoday.com/documents/FEMA_home_builders_guide_wildfire_zones.pdf

Fire Adapted Communities (FAC). (2014). Guide to Fire Adapted Communities. https://ucanr.edu/sites/SoCo/files/272862.pdf

Fire Adapted Communities (FAC). (2021). Fire Adapted Communities Graphic and Facilitator's Guide. https://fireadaptednetwork.org/resource/fire-adapted-communities-graphic-and-facilitators-guide/

Humboldt County (2022). Fire Adapted Landscapes and Safe Homes. https://humboldtgov.org/690/Fire-Adapted-Landscapes-Safe-Homes-Progr

IBHS: Home Preparedness Guide https://disastersafety.org/wp-content/uploads/2021/08/WFR-Home-Preparedness-Guide.pdf

International Code Council. (2021). International Fire Code. Country Club Hills, Illinois.

International Wildland Urban Interface (IWUI) Code. (2015): Section 202 (definitions)

Merriam-Webster. (2022). Greenbelt. https://www.merriam-webster.com/dictionary/greenbelt

National Fire Protection Association (2022). How to prepare your home for wildfires. https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Preparing-homes-for-wildfire#:~:text=Space%20trees%20to%20have%20a,the%20edge%20of%20the%20structure

National Fire Protection Association. (2022a). NFPA 1140, 2022 Edition: Standard for Wildland Fire Protection

National Fire Protection Association. (2022b). NFPA – Firewise Factsheets: https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA/Firewise-USA-Resources/Research-Fact-Sheet-Series

National Fire Protection Association. (2022c). NFPA “Assessing Structure Ignition Potential from Wildfire" training.

National Fire Protection Association. (2020). NFPA “WUI-NITY: a platform for the simulation of wildland-urban interface fire evacuation”. https://www.nfpa.org//-/media/Files/News-and-Research/Fire-statistics-and-reports/WUI/RFWUINITY.pdf

National Fire Protection Association. (2013). NFPA “Community Wildfire Safety Through Regulation: A Best Practices Guide for Planners and Regulators”. https://www.nfpa.org/-/media/Files/Public-Education/By-topic/Wildland/WildfireBestPracticesGuide.ashx?la=en

National Institute of Standards and Technology. (2022). NIST Study Finds Wildfire Hazards in Residential Fences and Mulch Beds. https://www.nist.gov/news-events/news/2022/08/nist-study-finds-wildfire-hazards-residential-fences-and-mulch-beds#:~:text=Across%20nearly%20200%20fire%20experiments%2C%20researchers%20at%20the,generally%20disproportionately%20higher%20when%20combustible%20objects%20burned%20together.

National Institute of Standards and Technology. (2022a). NIST WUI Structure/Parcel/Community Fire Hazard Mitigation Methodology. https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2205.pdf

University of California Agriculture and Natural Resources (UCANR). (2022a). Landscape Restoration. https://ucanr.edu/sites/fire/Recovery/Revegetation/

University of California Agriculture and Natural Resources (UCANR). (2022b). Wildland Fire Safety Starts in the Home. https://ucanr.edu/sites/SAFELandscapes/

University of California Agriculture and Natural Resources (UCANR). (2020). Building to Coexist with Fire: Community Risk Reduction Measures for New Development in California. Mountain View, CA.

USDA Forest Service (2022). Urban and Community Forestry Program: Tree Pruning Guide. https://www.arborday.org/trees/tips/

Wildfire Planning International. (2016). A fire adapted community is prepared for the next wildfire.

Valachovic, Y., Quarles, S. L., and Swain, S. V. (2021). Reducing the Vulnerability of Buildings to Wildfire: Vegetation and Landscaping Guidance. University of California Agriculture and Natural Resources. Irvine, CA.