Playbook for the Pyrocene

Design Strategies for Fire-Prone Communities

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Aerial view of a wildfire in Los Angeles
Photo: Bethany via Adobe Stock

A helicopter drops water on an advancing wildfire
Photo: Thomas Weinholzner via Adobe Stock

Foreword

Sean O'Malley
Principal, SWA

When I was growing up in San Bernardino, wildfires were a typical, seasonal occurrence — a fall event that provided important ecosystem impacts: clearing dead vegetation, destroying invasive species, stimulating new growth, and improving habitat for wildlife. I can vividly recall sitting on a wall outside my childhood home with my brothers, taking in panoramic views of the San Bernardino National Forest and being mesmerized by the flames dancing up and down the ridgeline, illuminating the night sky. By day, old surplus B-17 bombers would lumber overhead before dropping down into the foothills to release fire retardant onto the forests below. It was a distinct part of my childhood, as natural as rain, snow, or summer heat, and I gained great respect for the power and importance of seasonal wildfires.

As I made my way into the world of landscape architecture while attending Cal Poly Pomona, I was privileged to study under Bob Perry, one of the foremost experts on California native plants. During this time, I learned about how various plant communities need periodic fire to survive and thrive — particularly chaparral biomes. Of course, the seasonal wildfires that benefitted the growth and evolution of these plant communities for millennia occurred at a much lower intensity than what we witness in contemporary times. Early in my professional career, when I joined SWA in 1988, my very first project was a residential community in coastal Orange County known as Newport Coast located in an area prone to seasonal wildfires. It was essential that we planned and designed that community to withstand wildfire events through a process known as fuel modification. At that time, our understanding of fuel modification techniques was less nuanced than our current knowledge of best practices, but we knew we could use landscape to diminish fire's intensity and help ensure that firefighters had sufficient access to structures and critical infrastructure.

Working with the Orange County Fire Department, we went out to the site with blow torches, which we used to flame-test chaparral. Though these experiments were somewhat primitive, they represented a first-of-its-kind approach to applied research in the field of landscape architecture. We learned certain species like sagebrush and buckwheat would burn hot and fast, while native plants with a high turgidity index (plants that hold ample water) would burn at a much slower rate and lower intensity. The beavertail cactus performed especially well, acting almost like a natural fire break, and we learned that even though low grass fuel groups do catch fire, they burn low and slow so they are easier to extinguish. Through this research we eliminated plants with abundant flammable resins and, rather than using two- to three-foot-tall shrubs that easily burst into flames in a chaparral environment, we utilized grasses, which we found could lower the fire's overall intensity and slow its burn rate.

In addition to establishing landscapes with high-turgidity plants and fuel modification zones with native vegetation, we gained other pertinent insights into planning and design decisions that can help save homes and other structures. We realized it was essential to consider fire access roads, wind direction, and

Laguna Beach Fire, 1993
Photo: Tom Lamb, SWA

topography: the locations of slopes as well as their aspects (which direction they face) and their relative incline, as fire climbs more quickly up a steeper slope. Architectural features can play a similarly invaluable role in withstanding wildfire impacts. The use of double-paned glass and tile roofs provided greater safety, in addition to setting homes back a minimum of 30 to 40 feet from the graded pad and establishing cinder block walls to deflect fire from the home.

Our research and the fuel modification techniques we employed at Newport Coast were soon put to the test. On October 27, 1993, a brush fire started in the canyons of Laguna Beach — a few miles south of Newport Beach and the Newport Coast development — and quickly surged into a raging firestorm that ultimately destroyed 441 homes. A headline in the *Los Angeles Times* the following day read “Laguna is left in ashes.” As the fire spread to the Newport Coast development, the fuel modification zones and other techniques that we utilized worked as planned, and no homes were impacted by the fire.

Over the following years, we’ve gained greater understanding of fuel modification zones and related techniques for reducing exposure to wildfire. And we continue to implement these approaches on projects like the Rancho Mission Viejo (RMV) community in southern Orange County. The overall master plan for RMV preserves more than 17,000 acres of the 23,000-acre site, which was established as a working ranch and agricultural area more than 130 years ago. Planning efforts included extensive collaboration with local biologists as well as in-depth scientific and ecological studies. A village framework and clustering of development help preserve the majority of the land, and an on-site farm and community gardens are complemented by large-scale orchards that are designed to act as a fire break in addition to providing local food production. In 2021, RMV became one of the first master-planned communities to receive a Firewise USA Designation from the National Fire Protection Association (NFPA).

With wildfires becoming increasingly prevalent and more destructive due to climate change, the importance of improving upon best practices like fuel modification zones has never been more urgent. SWA has conducted extensive research aimed at supporting landscape architects working in wildfire-prone communities. The techniques and strategies highlighted in the following pages showcase ways for design professionals to mitigate risk associated with wildfire while simultaneously accepting its presence as a powerful and necessary ecological force.

The Rancho Mission Viejo Esencia community is surrounded by an irrigated buffer of citrus trees to reduce potential wildfire exposure. Photo: David Lloyd, SWA

Introduction

Beyond Tidy Solutions: Expanded Professional Responsibility for a Changing Climate

by Alison Ecker, SWA

As wildfires become more frequent and destructive, we must rethink how communities are planned and designed. Fire is as complex as it is elemental, and there will never be a singular, tidy solution. With this in mind, the following collection of strategies aims to support practitioners working in wildfire-prone communities by offering many things all at once: a novel set of scaled approaches, a call to embrace redundancy and layering, and an invitation to begin a long-term and challenging conversation on professional agency and responsibility.

SITES & SCALE

As landscape architects, urban designers, and urban planners, we engage with an expansive variety of communities, clients, and project types. Yet the vast majority of wildfire planning and design resources are geared toward two distinct spatial scales. On one end of the spectrum, many agencies and organizations have released practical guidelines on how to harden houses and yards from wildfire risk. Ranging from cleaning gutters to selecting appropriate plants, these documents offer homeowners the nuts-and-bolts steps to protect their homes. On the other end, scientists and researchers are increasingly studying the large-scale, macro shifts in fire regimes across entire regions and territories as climate change intensifies. This leaves a significant gap in the middle for innovative wildfire mitigation approaches at the scale of subdivisions, neighborhoods, campuses, resorts, and parks. In response, the following pages are intended to inspire and equip developers, planners, and designers to better address wildfire risks at this scale by offering targeted information and a playbook of applied strategies.

REDUNDANCY & LAYERING

These strategies are also intended to be understood as a comprehensive suite of ideas that support layering and redundancy of fire mitigation interventions. As with so many wicked problems, there is no single “silver bullet” strategy for addressing wildfire because there is no single type of wildfire. The way a fire moves through a landscape or community differs based on vegetation cover, building proximity, and topography, among other factors. A fire may behave in radically different ways depending on weather conditions such as heat, humidity, moisture, and wind. Thus, there’s a need to embed multiple protective measures and systems in any fire-prone community in order to holistically reduce the risk of catastrophic loss. A low and slow-moving fire can be maintained and constrained through thoughtful design of open space and management of adjacent wildland areas, whereas the effects of a fast-moving inferno jumping structure to structure may only be mitigated through strategic building material selection and design. In both cases, substantial consideration must be given to the configuration and capacity of emergency evacuation systems. No matter how fire presents itself, it cannot be neatly and uniformly responded to with a simple answer. Rather, an array of various systems and solutions must be embedded to create a mesh of protection that continuously chips away at the risk.

RESPONSIBILITY & AGENCY

In many ways, the task of developing this suite of scaled, embedded wildfire solutions prompts even larger questions. Namely, should designers and planners even be developing projects in high fire risk zones in the first place? Of course, this is a question that not only applies to fire-prone communities, but also to places confronting increased climate change risks such as drought, extreme heat, flooding, and sea level rise.

Part of finding a way to answer this question is finding a way to frame it. One approach is to identify the entire "food chain" of decision-making and action that results in a given development project. At one end, public planning agencies acting on behalf of and with guidance from the community determine which kinds of development are most suitable for a given site. Next, owners and developers invest capital to develop land within those identified areas. Finally, private design and planning firms such as SWA arrive to design within those predetermined limits and with developer direction and intention.

In many ways, the chain ends with us. If these projects are going to happen with or without us, there might be an argument for saying "better us." Let's make sure that it's us at the table pushing for the best design and most resilient strategies.

But on the other hand, by creating these design strategies, are we explicitly or implicitly giving support to those higher up in the chain to justify risky development? Are we not only mitigating but also enabling risk? What is the agency and responsibility of the planner and designer within this chain of decision-making? These will likely to continue to be relatively open questions, not just in the context of wildfire, but also across a wide array of climate change-related design and planning efforts.

Once again, adding nuance and an expanded set of criteria to our answer can help us responsibly consider what roles to play and what sorts of projects to take on. We're entering an era where every site we work on and every community we work with will be increasingly affected by climate change. Despite these challenges, the need for places and environments where people can live and thrive is greater than ever. So, perhaps one way to frame our response to the growing wildfire crisis is to emphasize rebuilding and retaining existing communities, rather than expanding further into high-risk wildlands. Beyond that, designers and planners have an ethical responsibility to seek out and prioritize partners and clients that fully accept the constraints posed by wildfire and completely embrace evidence-based strategies for preserving the health and safety of people and the environment.

Use this publication to explore wildfire planning and design strategies, and also to keep probing at the many challenging questions that remain unanswered.

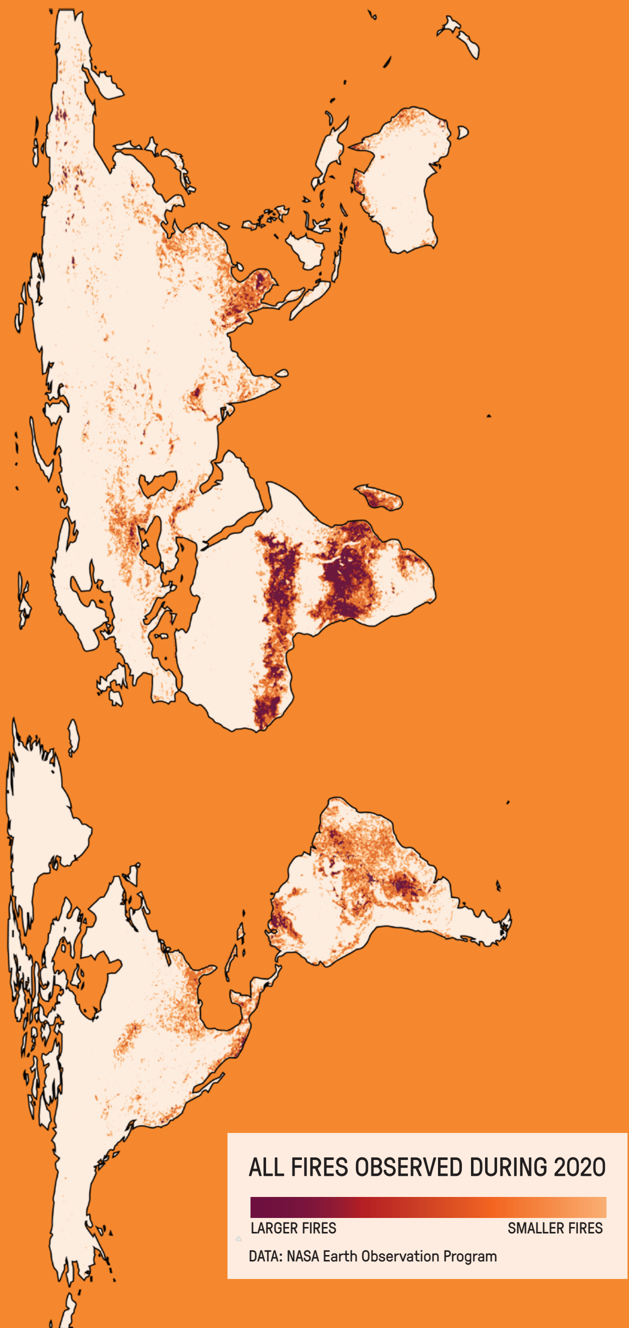
Essay

Fire at the Doorstep: Designing for a New Era of Environmental Risk

by Jonah Susskind, XL research and innovation lab

Earth is a fire-prone planet. For millions of years, fire has shaped and reshaped ecosystems – driving cycles of vegetation growth, soil decomposition, and habitat availability. Today, fire-dependent biomes cover between 30 and 40 percent of our planet's surface, and since 1999, NASA's earth observing satellite program has detected an average of 10,000 active daily blazes.[1,2] Though we often perceive fire as an aberration or a disruption of natural conditions, it is in fact a predictable and regular, if episodic, ecological process. Regional fire regimes have characteristic patterns related to size, seasonality, spatial complexity, intensity, and return interval. These characteristics vary widely across geographic regions and over time.

During the past century, there has been a dramatic increase in catastrophic fires that are larger, hotter, and harder to extinguish than ever before. In the US, the number of properties that stand a significant chance of exposure to fire has surged to nearly 80 million with an estimated 16 percent of the country's population now living in fire hazard areas.[3] In Europe, increases in fire frequency, intensity, and scale may be outstripping the capacity for ecosystems to recover.[4] This year, smoke from Canadian wildfires has put more than 70 million people under air quality alerts. Around the world, the root causes of these supercharged fires are threefold: 1) misguided policies, 2) global warming, and 3) an explosion of development in fire-prone landscapes.



POLICY & FIRE

Since our earliest ancestors began using fire as an agricultural agent, humans have intricately remapped the earth's surface by artificially extending fire's influence in some regions while suppressing it in others.[5] Before European colonization in North America, the intentional setting of regular, periodic, low-intensity fires represented a vital part of indigenous landscape stewardship practices. However, beginning in the mid-19th century, government agencies started implementing policies aimed at restricting the use of cultural fire practices and eventually excluding fire from the landscape altogether. From this point on, it was really human controlled fire suppression, and not naturally occurring wildfires, that became the prime shaper of our modern forest ecosystems.

In the short-term, these fire suppression policies resulted in far fewer acres burned, but over time, they inadvertently created an immense stockpile of unburnt fuels. As a result, today's fires have become much larger and tend to burn much hotter than they would have naturally.[6] Throughout North America, this restructuring of terrestrial fire ecology has come with far-reaching consequences, both subtle and profound, that we are only now beginning to understand. Eminent fire historian Stephen Pyne has dubbed our current epoch the Pyrocene because of the degree to which human manipulation of natural fire regimes have permanently altered earth systems.[7] Now, experts caution that due to climate change, we have entered a new era of perennial megafires that will only become more destructive and costly in the coming decades.

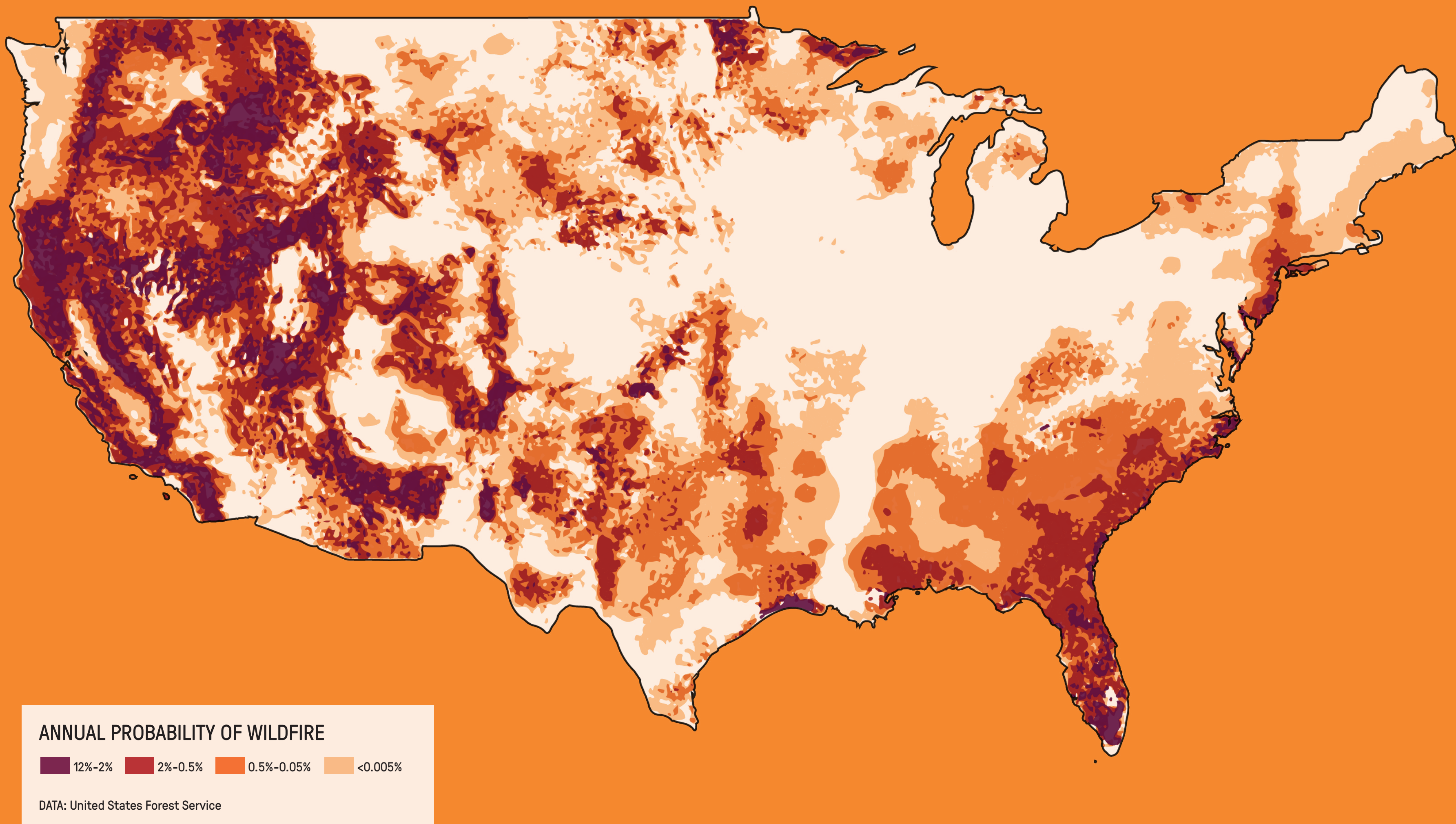
CLIMATE CHANGE & FIRE

Throughout the American West, prolonged periods of record-breaking heat and drought have impacted fire-prone ecosystems by desiccating forests and grasslands and significantly increasing the length of annual fire seasons. In California, where the average wildfire season has nearly doubled in duration over the past half-century, more than 147 million trees have died due to extreme droughts since 2010.[8] In many places, these impacts have been compounded by increased exposure to pests and pathogens, which further weaken ecosystems and add significant amounts of dead plant material to existing surplus fuel loads.

As the resulting fires have exploded in recent years, massive plumes of smoke have drifted across the continent, impacting communities thousands of miles away from the blazes, and undermining decades of air quality reforms. Aside from the health risks associated with smoke inhalation, larger fires emit greater amounts of CO_2 and other greenhouse gasses into the atmosphere, further contributing to climate change through this pernicious feedback loop. In California for instance, a single wildfire season (2020) contributed 200% more carbon emissions than had been saved by all of the state's decarbonization policies over the previous 16 years.[9]

URBANIZATION & FIRE

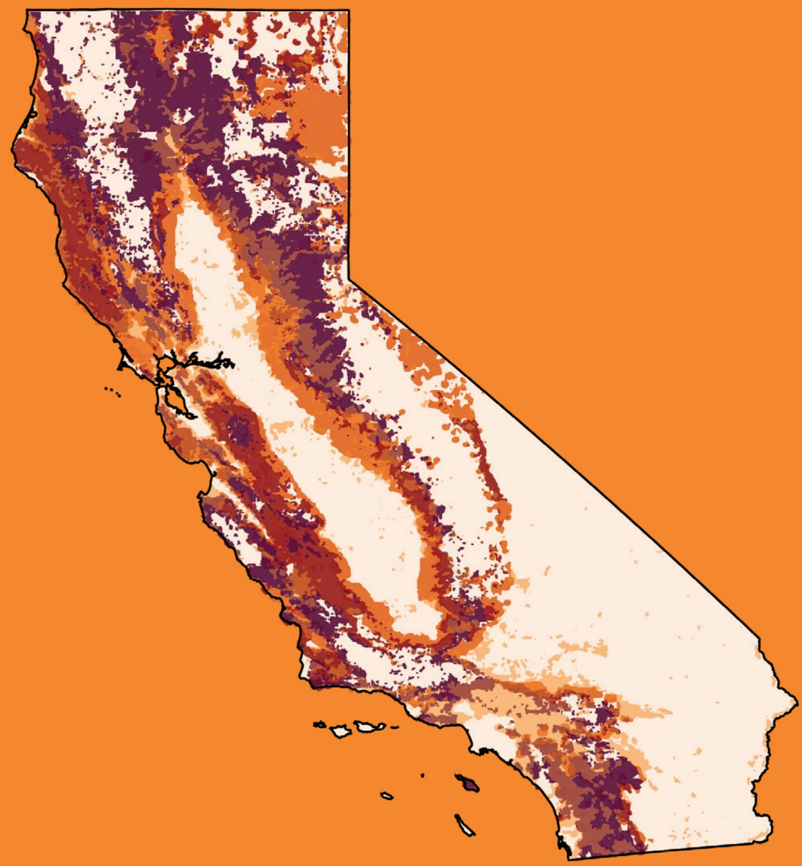
The third major driver behind today's accelerating wildfire crisis is the rapid encroachment of human settlement into areas where risk of wildfire exposure is the highest. Known as the Wildland Urban Interface (WUI), these zones where the built environment comes into direct contact with undeveloped landscapes, are the


ANNUAL PROBABILITY OF WILDFIRE
12%–2%
2%–0.5%
0.5%–0.05%
<0.005%
DATA: United States Forest Service

most vulnerable to the impacts of wildfire. In spite of these risks, WUI areas have attracted residents for generations because of their proximity to natural landscapes and large recreation areas. In recent decades, due to the housing-affordability crisis, NIMBYism, and local zoning restrictions, more affordable development has been pushed further away from city centers to comply with state mandates, and the WUI has become the fastest growing land use category in the US. Today, nearly 100 million people (about a third of the US population) live in the WUI, and in California alone, it is projected that as many as 20 million people will call these fire-prone landscapes home by mid-century.[10,11] During the past three decades, more than 80 percent of California's fire-related structure loss has occurred in these high-risk zones, and as development in the WUI continues to balloon, communities across the country will be increasingly impacted by fire.[12]

THE FUTURE OF FIRE

Perhaps even more complex than the causes of today's wildfire crisis are the debates about how to mitigate risk moving forward. Some point to the need for new approaches to forest management while others have called for a moratorium on future development in fire-hazard zones, and there are constant demands for more investment in technologies like remote wildfire detection and emergency alert systems. From California to the Mediterranean Basin, frontline communities are coming together to expand wildfire education, develop protection plans, and adopt tougher building codes. Government agencies have announced new approaches to fuel management and fire suppression that may help protect communities while making forests more resilient.



FIRE HAZARD SEVERITY ZONES

VERY HIGH | HIGH | MODERATE | WUI AREA

DATA: California Department of Forestry and Fire Protection (CAL FIRE)

Indigenous leaders are asserting their cultural rights to fire as a tool for repairing ecosystems, and legislation aimed at reducing barriers to prescribed burning by land owners is being adopted.

As our approaches to wildfire continue to evolve, two things remain clear. The first is that there will be no silver bullet solution. Fire is a structural force that is increasingly entangled with other fundamental issues like climate change, housing, environmental justice, and indigenous sovereignty. The second is that those working to shape the built environment have an outsized responsibility to address these challenges through informed decision-making.

For practitioners across the building industry, this is a critical moment for increasing wildfire literacy. Landscape architects, urban designers, planners, and developers all have work to do to fill critical knowledge gaps. Best practices will need to be expanded and codified through processes of professional licensure and institutional accreditation. Practitioners will need to have a firm grasp of the basic principles of fire behavior, vegetation management, and defensible space. We will need to build and maintain professional partnerships with firefighting agencies, fire-safe councils, prescribed burn associations, and other key organizations. We will also need to advocate for more robust and ecologically informed wildfire policies that boost accountability for those making development decisions in high-risk areas.

For many, these things will entail realigning our basic instincts in order to plan and design *for* fire – not against it. Fortunately, this is not unprecedented. For decades, landscape architects have shown that even in the face of climate change, an applied understanding of both social and ecological systems can help boost community resilience through design. The discipline has played an important role in helping frontline communities adapt to major challenges like sea level rise, flooding, and extreme heat. As the profession works together to provide support for wildfire-prone communities, we must expand and refine these approaches to meet the increasingly complex socio-ecological challenges of the Pyrocene.

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The aftermath of the 2021 Marshall Fire in Boulder Colorado
Photo: Kent via Adobe Stock

Calwood Fire - Boulder County, Colorado. October, 2020
Photo: Malachi Brooks via unsplash

About this Guide

A Resource for Designers

This collection of site planning and design strategies is intended to support practicing landscape architects, urban designers, and planners by synthesizing key concepts from an array of disciplines including ecology, fire science, forestry, land use planning, emergency management, and indigenous stewardship. It is intended for an audience broadly familiar with ecological principles and landscape systems, but without any advanced background in fire science, policy, or other specialized knowledge per se.

The illustrations and descriptions that follow are intended to highlight high-level rules-of-thumb, and provide key reference points for practitioners through concise language and simple illustrations. An appendix serves as a more comprehensive repository of additional resources, guidelines, best practices, and empirical research related to each strategy.

Site Analysis

Identifying Risks and Hazards

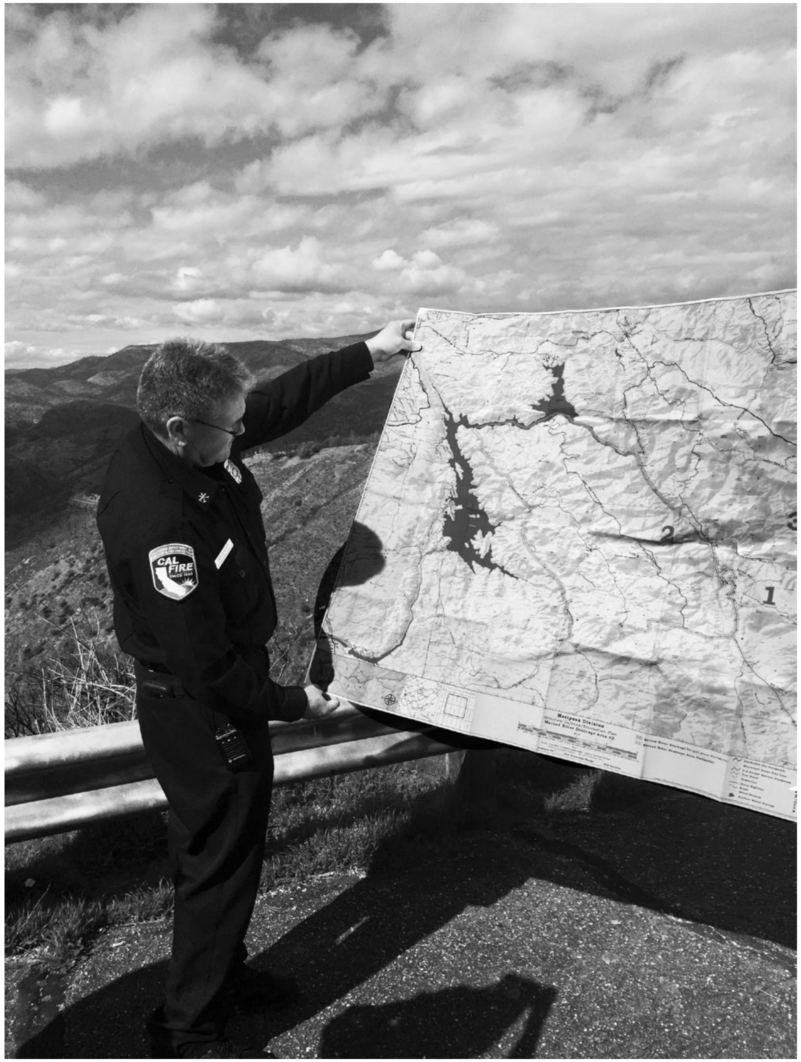
Site Analysis

Identifying Risks and Hazards

For planners, designers, and developers, 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) is critical - especially in the early planning or entitlement phases of new developments. 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 evaluate all relevant state and local wildfire hazard and risk maps as well as local-level community planning documents, plans, and maps. These may include community comprehensive plans, general plans, master plans, form-based plans, zoning requirements, community wildfire protection plans (CWPPs), hazard mitigation plans, emergency operational plans and procedures, or other fire department planning documents. Practitioners should also consult local fire departments for additional guidance during the earliest phases of a project.

The following pages offer supplemental information related to common hazards and risks for practitioners working in fire-prone landscapes.



CAL Fire officer overlooking a recent burn scar. Mariposa County, CA
Photo: Jonah Susskind

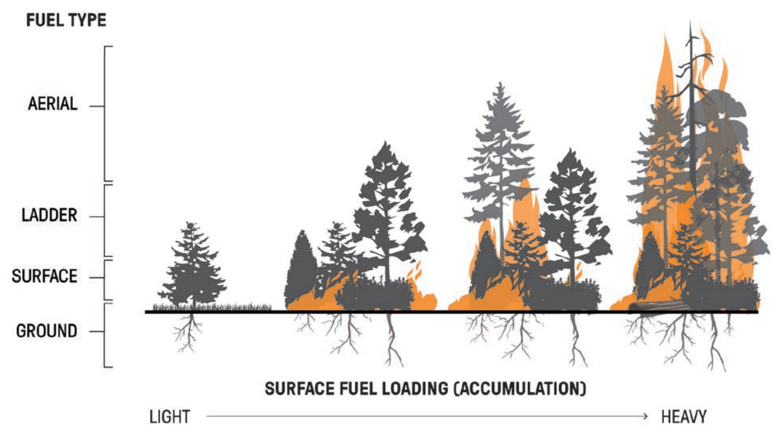
I

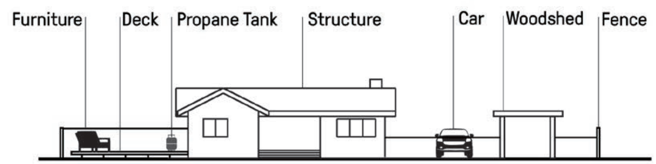
Fuels

Anything that can burn can act as potential fuel for a fire. This includes all kinds of plant material, including grasses, shrubs, trees, dead leaves, and fallen pine needles. As these combustible materials pile up, they allow fires to burn hotter, larger, longer, and faster. Fire behavior is dependent on particular fuel characteristics such as type, amount, availability, and arrangement.

Ladder fuels are those that carry a surface fire up into the canopy, making it more difficult and dangerous to manage. These typically include low-lying branches or shrubs located under the canopy of larger trees.

Developed sites typically contain other combustible materials (fuels) as well, including structures, gas tanks, woodpiles, and even cars.





OTHER COMBUSTIBLE MATERIALS

Fuel Groups

At the landscape scale, different fuel groups have specific associations with fire behavior. In forest fuel groups, which include closed-canopy, open-canopy, and woodland savanna types, fire behavior depends primarily on how close together trees are, and how much slash is on the ground. In shrub fuel groups (which include chaparral landscapes) as well as grass fuel groups, fire behavior depends largely on the concentration, size, accumulation, and continuity of vegetation.

Each of the three major fuel groups can be broken down into subcategories based on the concentration and accumulation of surface fuels. Each fuel group includes its own primary carriers of surface fire. In forest fuel groups, for instance, surface fire is typically carried by fallen leaves, branches, and logs, while in both shrub and grass fuel groups, it tends to be carried by leaf litter, flower heads, seeds, grasses, or duff.

COMMON FIRE-CARRYING FUEL GROUPS


A


B


C


D


E


F


G


H


I

A. Closed-Canopy Forests
B. Open-Canopy Forests
C. Woodland Savanna
D. Large Brush/Chaparral
E. Shrub/Sage Brush
F. Patchy & Sparse Shrub
G. Tall Grass
H. Short Grass
I. Patchy & Sparse Grass

Photos via Adobe Stock:
A. **Ruslan,** B. **Kathryn,** C. **Bill,** D. **Unwind,** E. **Stephen,** F. **Bill Lawson,** G. **jdoms,** H. **Wichit S,** I. **vadim_orlov**

III

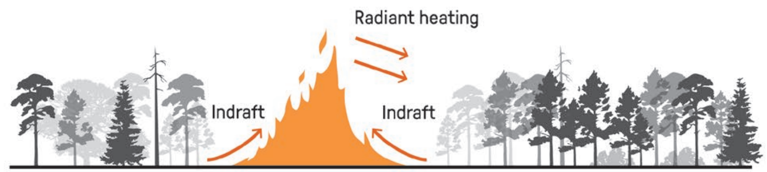
Terrain

Variations in topographic features such as valleys, drainages, canyons, saddles, steep slopes, and ridges present hazards that can attract or intensify fires.

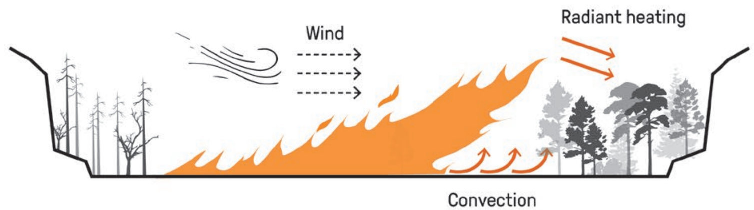
Valleys and other concave landforms tend to channel and concentrate winds. This increases a wildfire's intensity and its rate of spread (ROS). As fire moves through canyons and saddles, this effect is even more pronounced.

When fire moves up a slope, it “preheats” the fuels in front of it. This helps the fire gather speed and intensity. The effects of slope on ROS become greater as the slope becomes steeper. Studies have shown that a 20 percent slope can double a fire's ROS. Steep slopes also increase the risk of rolling debris that can be carried downhill, igniting new areas below.

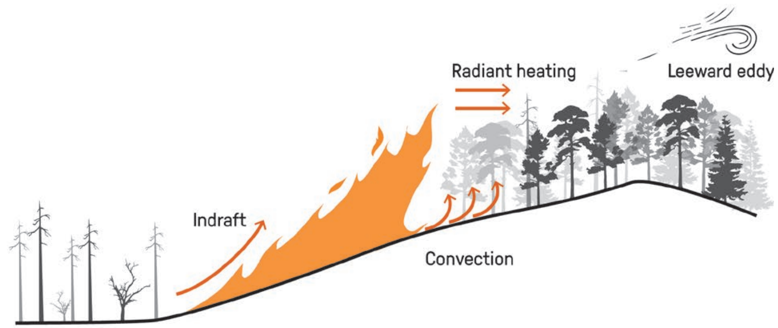
Ridges and other elevated areas typically experience more wind than their surrounding landscapes. As wind crosses a ridge, a leeward eddy can occur, exposing both sides of a ridge to wind and fire and making it particularly hazardous.



FLAT GROUND



VALLEYS, SADDLES, & CANYONS



STEEP SLOPES & RIDGES

IV

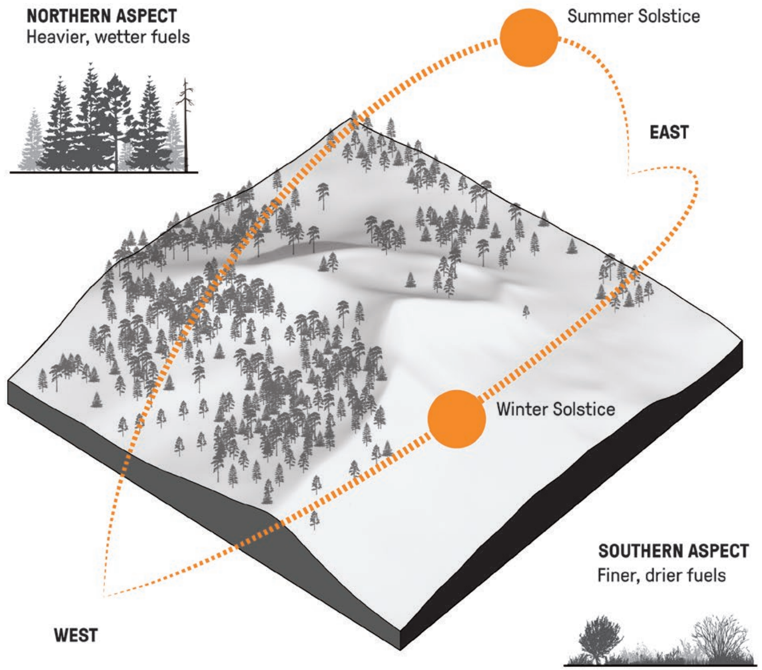
Orientation

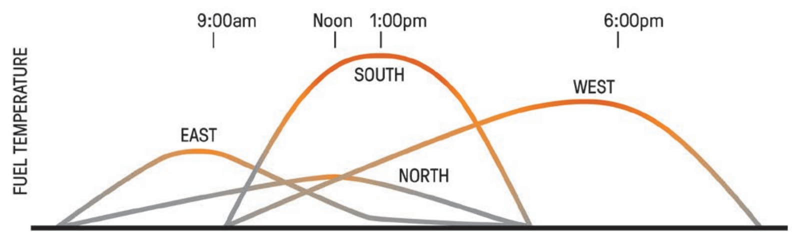
A site's orientation influences the amount of daily solar radiation it receives along with its moisture availability, which, in turn, contribute to its vegetation composition and overall fire risk. Slopes over 30 percent are significantly influenced by a site's orientation.

In the northern hemisphere, south-facing slopes receive the most direct sun and become hotter than slopes facing any other direction. This results in lower humidity, rapid loss of fuel and soil moisture, and drier, lighter, flashier fuels such as grasses and shrubs.

North-facing slopes, on the other hand, generally have lower daily average temperatures, more shade, and higher ground moisture levels. As a result, north-facing slopes tend to have heavier fuels and less fire activity.

East- and west-facing slopes experience similar amounts of solar heating as the sun moves across the sky. East-facing slopes heat up and cool down earlier than west-facing slopes.





FUEL FLAMMABILITY BY TIME AND ASPECT

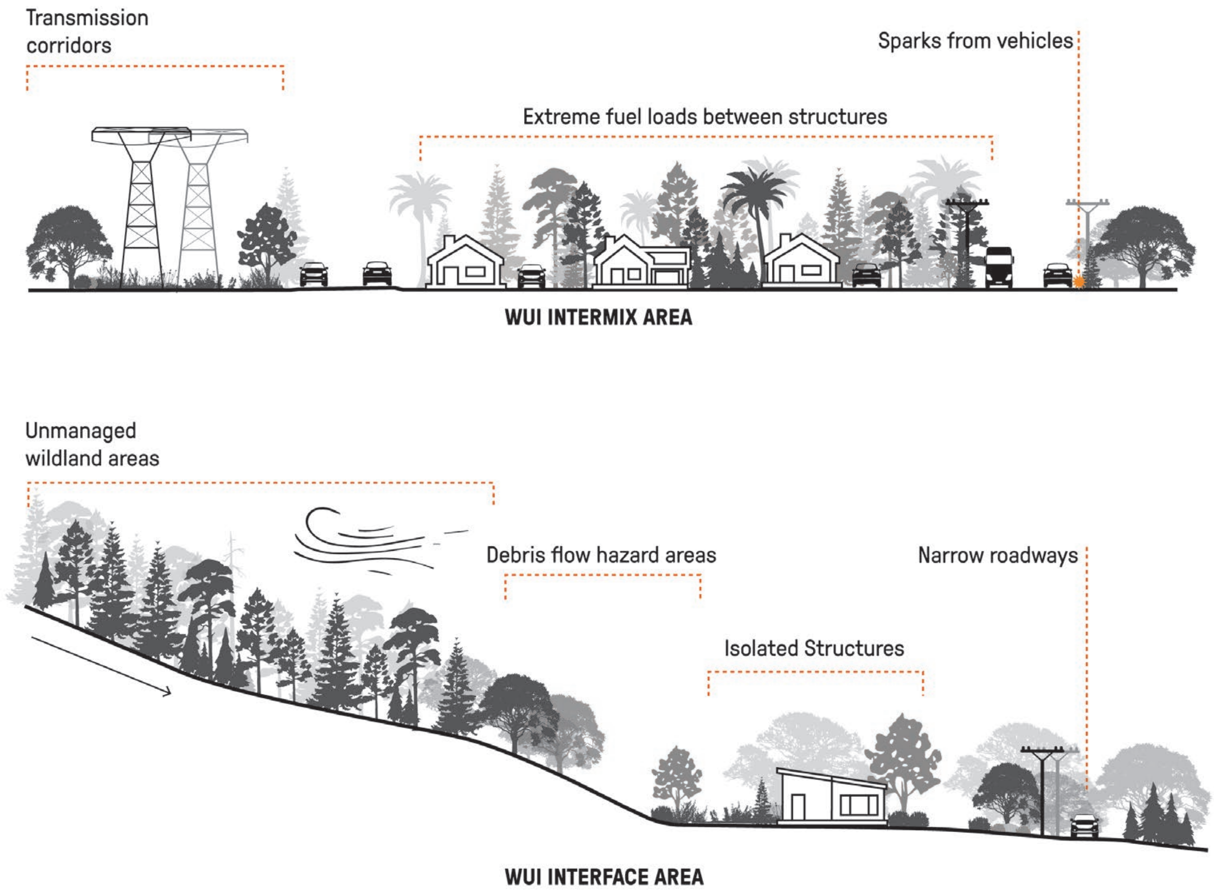
V

WUI Areas

The Wildland-Urban Interface (WUI) is a term that refers to the transition zone between human settlements and undeveloped landscapes, where communities experience an elevated risk of exposure to wildfire. WUI areas can be divided into two main categories: 1) intermix and 2) interface.

An intermix WUI area is where structures and infrastructure are interspersed with wildland areas or other pockets of unmanaged vegetation. Intermix WUI areas are often found in rural, exurban, or large-lot suburban developments. The combination of fuels from both wildlands and human structures can lead to more intense and challenging fire behavior. Understanding the unique fire behavior in intermix areas is crucial for implementing effective risk reduction measures.

An interface WUI area is where clusters of structures are grouped near larger, contiguous swaths of wildland fuels or occluded vegetation. Interface areas can usually be identified by a clear line of demarcation between development and wildland vegetation such as the boundary between a residential neighborhood and an adjacent state forest. Fire behavior can vary dramatically in these areas depending on things like fuel loading (amount) and residential density.



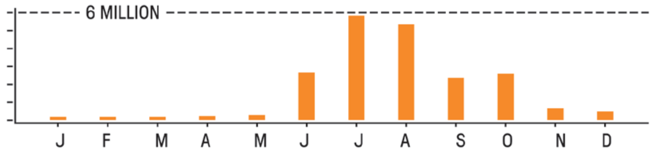
VI

Fire Seasons

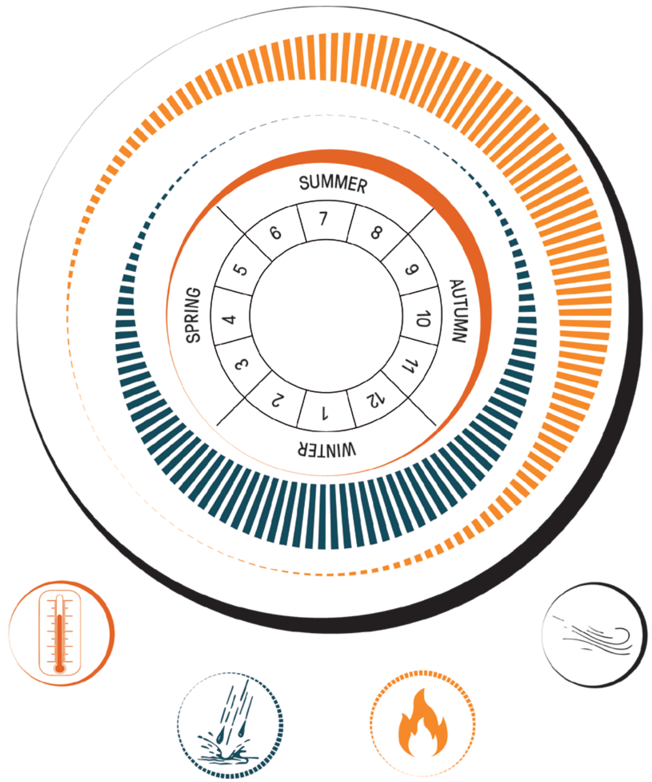
“Fire season” refers to an annual period of time when the risk of wildfire is significantly elevated. Fire seasons vary globally due to factors such as climate, vegetation type, and human activity.

Fire seasons are not uniform worldwide and vary significantly from region to region. In temperate zones like California or the Mediterranean Basin, fire seasons typically occur in the summer and early autumn, whereas in tropical regions, they are generally linked to the timing of the dry season, which differs by hemisphere. Due to the impacts of climate change on seasonal patterns like the timing of snowmelt, vapor pressure changes, and the arrival of spring rains, fire seasons are becoming longer in many parts of the world.

In some of California’s most fire-prone landscapes, fire season often coincides with the formation of high-pressure systems that produce a combination of low humidity and dry, gusty winds. These wind events can dramatically increase a fire’s rate of spread, making it harder for fire-fighting resources to control.



ACRES BURNED BY MONTH IN CALIFORNIA (1979 - 2018)



CALIFORNIA’S ANNUAL FIRE CYCLE

Risk Reduction Strategies

Planning and Designing for Fire

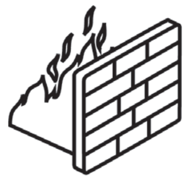
Risk Reduction Strategies
Planning and Designing for Fire

Fire is complex, and so are the landscapes and communities that are shaped by it. For planners, designers, and developers, the key to mitigating risks associated with wildfire is to respond to this complexity with redundancy. By layering multiple strategies on top of one another, practitioners can substantially reduce the likelihood of catastrophic losses.

These include preemptive strategies that allow communities to anticipate and prepare for potential wildfire events, as well as defensive strategies that reduce a community's ignition potential through the use of non-combustible materials, or the provision of space between a structures and potential fire sources.

This set of 20 strategies is compiled as a representative summation of key trends found across the literature. When used in combination with one another, they become especially powerful tools for practitioners working in fire-prone communities.

Prepare
Anticipate and prepare for wildfire through education, analysis, and planning.



Harden
Reduce ignition potential through non-combustible materials and configurations.

Buffer
Maximize defensible space between the built environment and wildland areas.

01

Create and Maintain Defensible Space

Defensible space is created through a series of tiered buffers between structures and their surrounding fire-prone landscape. Adequate defensible space is intended to act as a barrier to slow or halt the progress of a fire advancing toward a home or a community. A structure located on a brushy site above a south or west facing slope will typically require more extensive defensible space planning than a structure situated on a flat lot with sparse vegetation.

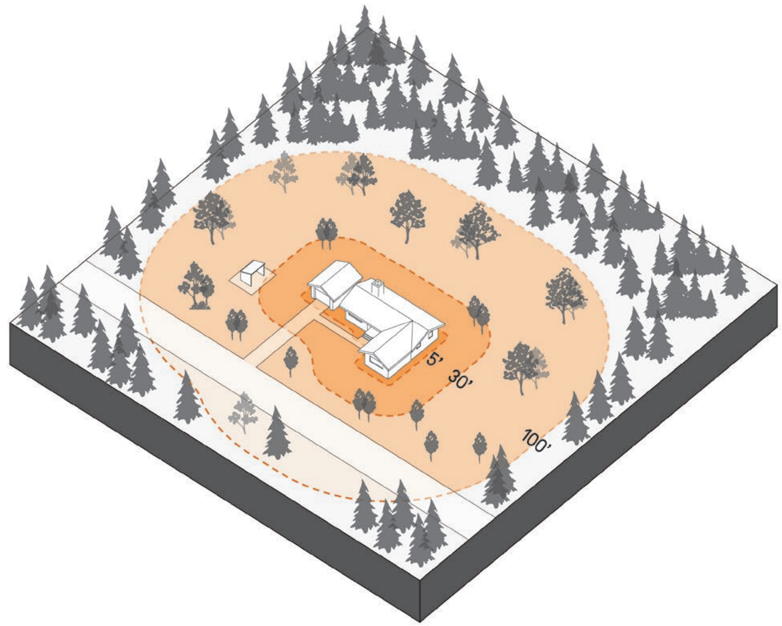
A defensible space buffer is divided into three zones. Zone 0 includes everything within five feet of a structure. Fire protection strategies here typically include structure hardening, replacing combustible materials like mulch with hardscape materials like gravel or pavers, limiting combustible items like outdoor furniture, and relocating hazards like propane tanks, woodsheds, or RVs.

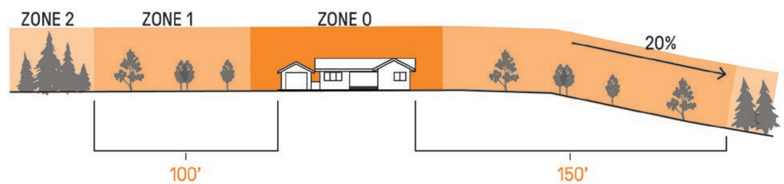
Zone 1 includes everything from five to thirty feet away from a structure, and zone 2 extends the defensible space area out to 100 feet or more. For both of these zones, there are extensive guidelines and best practices for maintaining vegetation and reducing potential fuel (see following pages).

Account for Slope

Fire moves faster and burns hotter as it travels up slopes. When possible, the defensible space buffer should be extended further in the down-slope direction of structures.

TYPICAL DEFENSIBLE SPACE ZONES (FLAT SITE)





EXTENDED DEFENSIBLE SPACE ZONES (SLOPED SITE)

DEFENSIBLE SPACE - ZONE 0

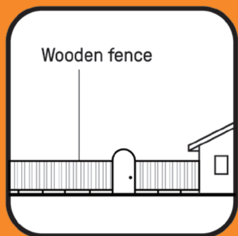
Use hardscape materials like gravel or pavers

Limit combustible items on top of decks

Remove all branches within 10 feet of chimneys

Screen or wall-in stilt foundations and decks

Relocate firewood and lumber to Zone 2



Use non-combustible fences and gates

DEFENSIBLE SPACE - ZONE 1

Select plants with fewer fire hazard traits

Create gaps between hedges and shrubs

Remove dead plant material

DEFENSIBLE SPACE - ZONE 2

Create vertical clearance below lower branches

Cut or mow annual grasses to a max height of 4 inches

Keep at least 10 feet of clearance from wood piles

02

Thin Excess Vegetation

While well-maintained defensible space buffers may be adequate for addressing fuel removal close to individual structures, larger-scale vegetation management practices may be necessary for reducing risk at the community scale.

One common approach to vegetation management at this scale is the creation of shaded fuel breaks, which are areas where dense forest canopies are thinned and most of the underlying brush is removed.

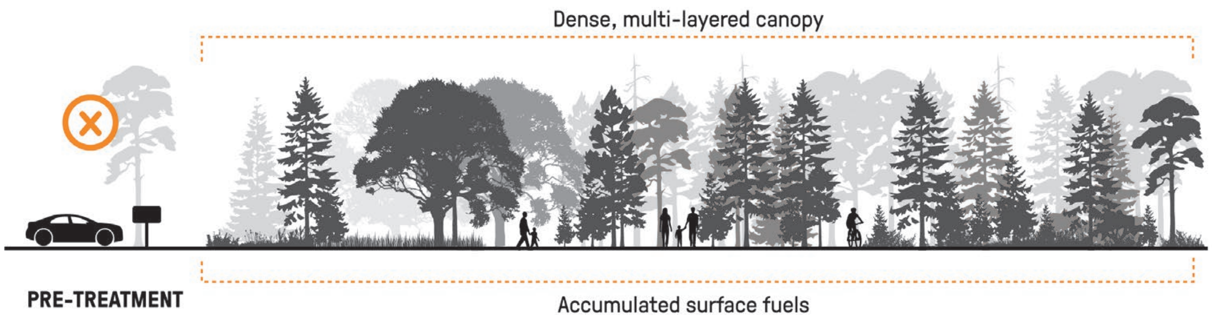
The objective of a shaded fuel break is to reduce, modify, and manage fuels within designated areas in order to slow down or stop an advancing fire without jeopardizing the health of forest ecosystems. They are often created along ridges and access roads, or surrounding subdivisions and other development areas.

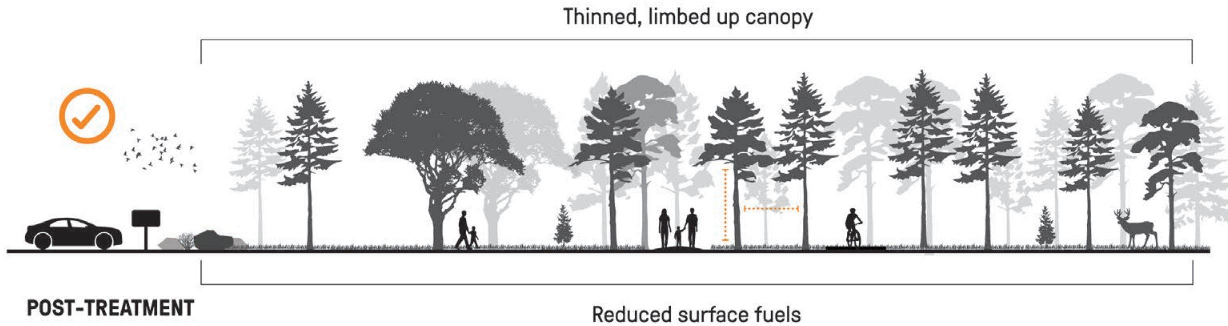
Include Roadways

Consider integrating existing roadways into fuel breaks in order to reduce the cost of implementation and provide potential vehicular access for fire suppression resources in the event of an emergency.

Maintain to Sustain

Shaded fuel breaks must be regularly maintained every few years to prevent new growth from creating a new fire hazard.





03

Keep Fuel Loads Low

There are several methods for maintaining a shaded fuel break in forested landscapes. Likewise, in other fire-prone landscapes (i.e. woodland savannas, grasslands, or areas dominated by chaparral), approaches to fuel reduction and maintenance can vary depending on budget, site conditions, anticipated uses, and ecological priorities.

In some cases, regular grazing of sheep, goats, or cattle can work as a low-cost method for reducing grasses, shrubs, and other surface fuels. For trees and larger vegetation, mechanical thinning, pruning, chipping, and mastication are often combined to reduce the overall amount and continuity of combustible vegetation.

Prescribed burning refers to the controlled application of fire by a team of experts under specified conditions to reduce hazardous fuels while simultaneously restoring healthy fire-adapted ecosystems. Prescribed burns and other fuel management projects are typically coordinated and implemented by local, state, or federal agencies according to regional goals.

Good Fire

In addition to hazardous fuel abatement, prescribed fire can be used to help meet a variety of environmental management objectives, including minimizing the spread of pests and disease, improving habitat, recycling nutrients back into the soil, and increasing groundwater availability.

ANIMAL GRAZING

MECHANICAL THINNING AND HERBICIDE APPLICATION

PRESCRIBED BURNING

04

Select Plants with Fewer Fire Hazard Traits

Fire-resistant plants are those that do not readily ignite when exposed to fire. These plants can be damaged or even killed by fire, but their foliage and stems do not significantly contribute to the fire’s intensity. There are dozens of key factors that influence the fire hazard characteristics of plants, including moisture content, age, total volume, amount of dead material, and resin content.

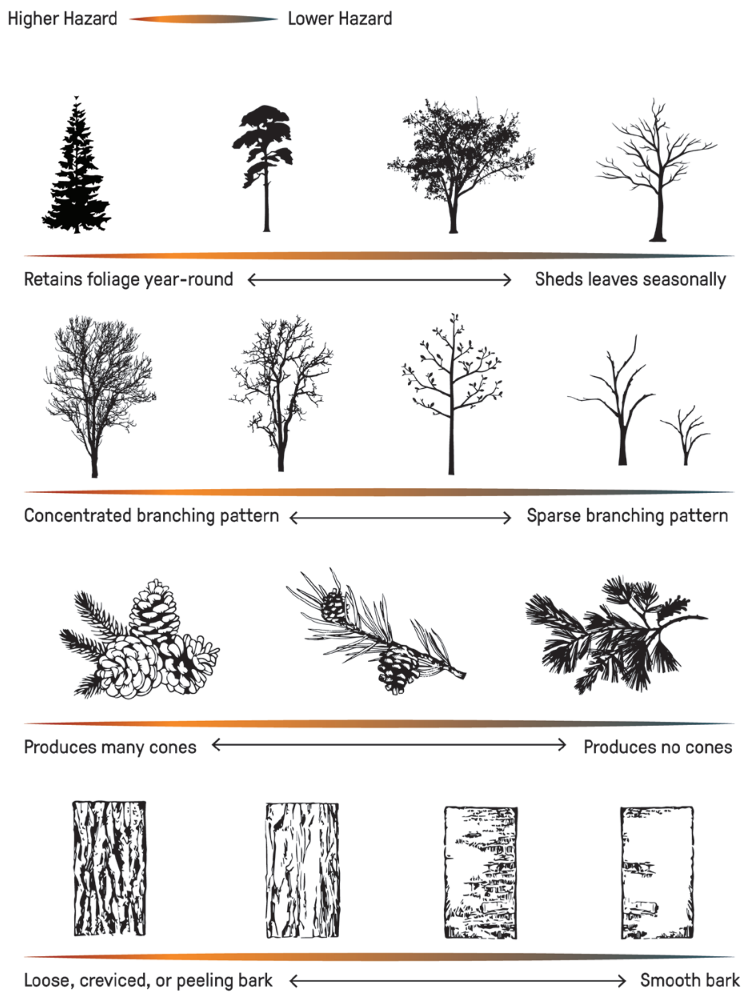
While all vegetation can burn under the right conditions, there are some key traits and underlying principles to be aware of when selecting plants. Fire-hazardous plant charac-teristics include:

- Plants that are summer-dormant
- Plants that produce dry leaf-litter
- Trees and shrubs with dry, peeling bark
- Trees and shrubs with oily or waxy leaves
- Tall, dry grasses

Conditions Over Species

The condition of a plant is often as important as its species. Many fire-hazardous plants can be relatively ignition-resistant if properly maintained and irrigated, especially natives. Depending on its growth, form, and access to water, the same species may be ignition-resistant in one environment and flammable in another. For instance, water-stressed plants in poor condition are more likely to burn.

FIRE HAZARD PLANT TRAITS (trees & shrubs)



FIRE HAZARD PLANT TRAITS (trees & shrubs)

Higher Hazard ⟷ Lower Hazard

Oily or waxy leaves ⟷ Moist and supple leaves

Large, curling fallen leaves ⟷ Small, flat fallen leaves

Generates lots of debris (leaves, needles, bark) ⟷ Generates very little debris

FIRE HAZARD PLANT TRAITS (ground covers & grasses)

Higher Hazard ⟷ Lower Hazard

Tall growing ⟷ Short growing

Full and feathery seed heads ⟷ Small and simple seed heads

Generates lots of debris (leaves, thatch, seeds) ⟷ Generates very little debris

05

Create Clearance

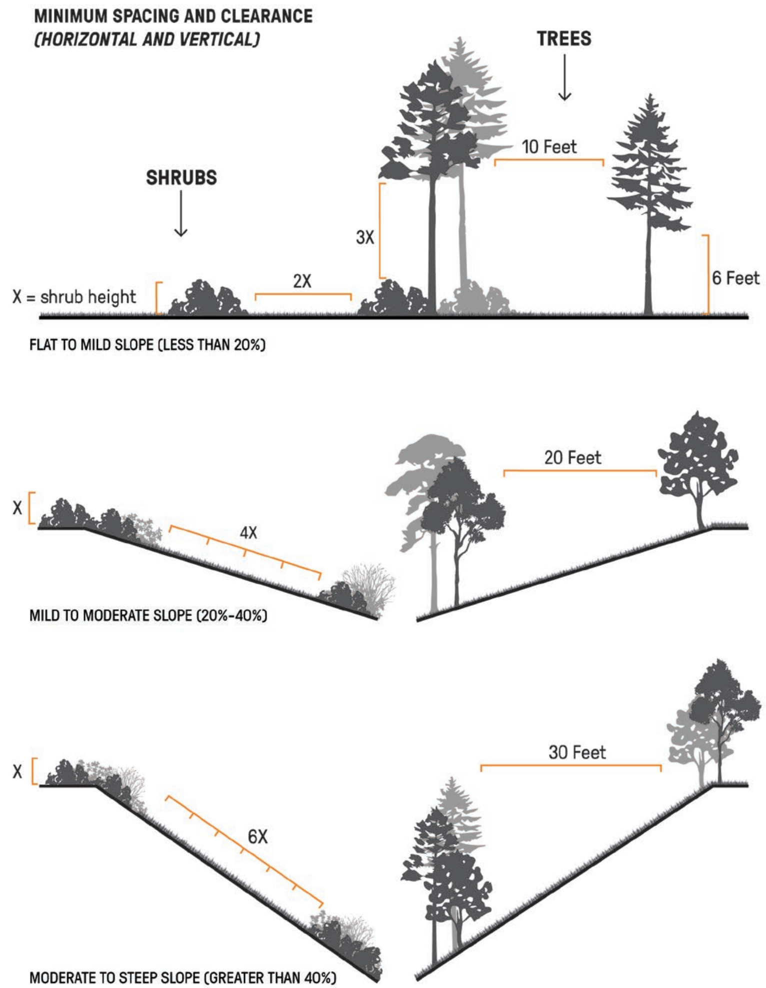
The spacing between trees, shrubs, and grasses can significantly influence the spread of fire. In most cases, recommendations for plant spacing are determined by the type and size of vegetation at mature height, as well as the site's topography. For example, a property on a steep slope with larger vegetation may require more space between trees and shrubs as compared to a level property with small, sparse vegetation.

Horizontal Spacing

Adequate horizontal spacing between aerial fuels, such as the outside edges of tree crowns or high brush, can help limit the spread of fire from plant to plant by creating gaps.

Vertical Spacing

Adequate vertical spacing between shrubs and trees can reduce the likelihood that a surface fire will climb up into the canopy, where it typically becomes more intense and harder to extinguish.



06

Site Structures away from Slopes and Ridges

Wildfire severity and rate of spread can be significantly increased by specific topographic features such as saddles, ridges, drainages, canyons, and steep slopes. Structures located on steep slopes or other hazardous topography typically require more ignition-resistance measures and/or larger defensible space buffers than those on flat terrain.

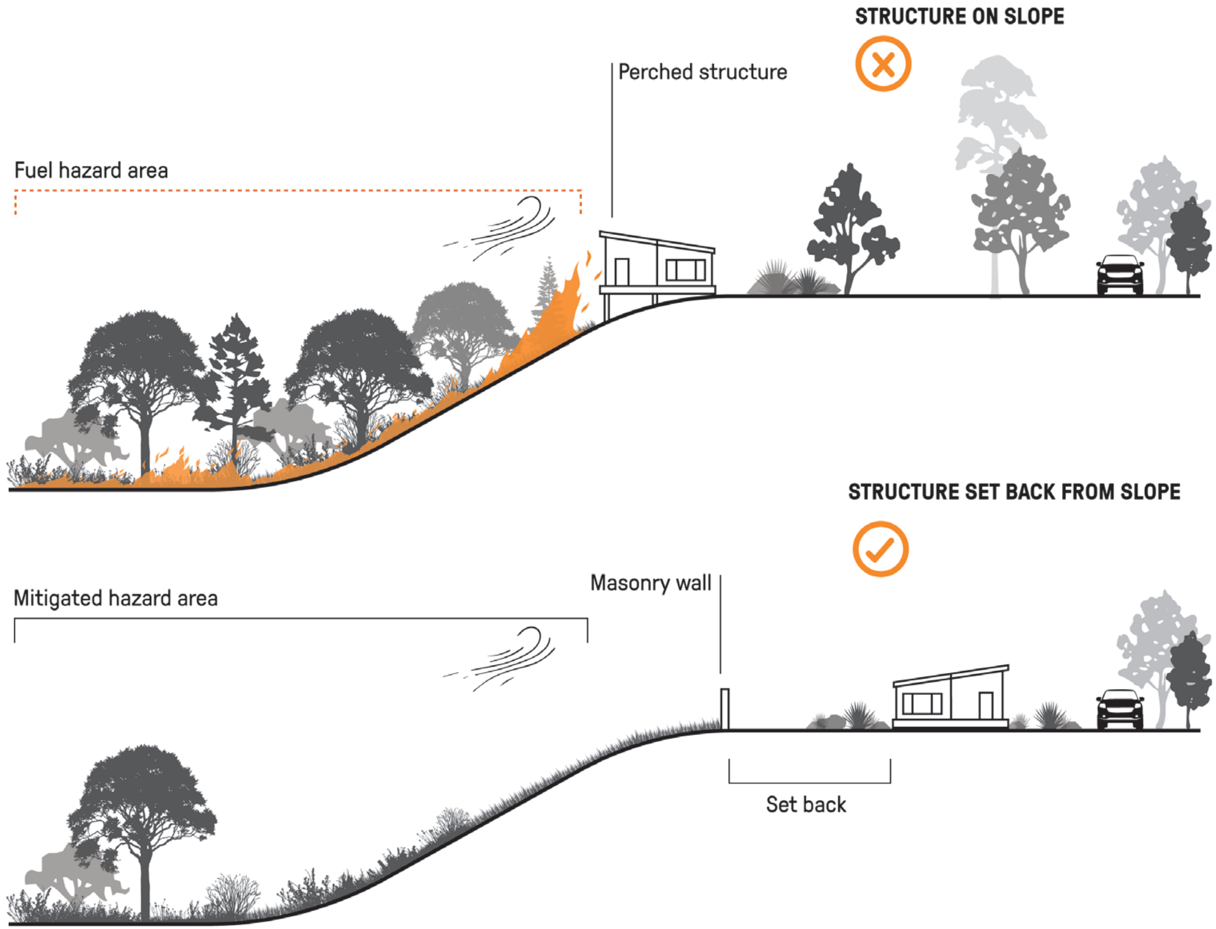
Harden the Hilltop

If a structure is situated on top of a slope, consider constructing a stone or masonry wall between the structure and the most likely path of approaching fire to help repel flames, heat, and burning embers. This may also be a good place to install a lawn, pool, or hardscape patio area.

Stabilize the Slope

Vegetation on slopes should be minimal in both height and volume, but should not be completely eliminated; bare slopes may be subject to higher risk of erosion and instability. Consider removing dead trees and shrubs – leaving the roots in place, if practical.

On slopes, consider planting widely-spaced, deep-rooted shrubs to help control erosion. In most cases, these plants can be interspersed with mulch or low-growing ground covers without substantially increasing risk.



07

Armor the Edges

In fire-prone regions, special consideration should be given to the areas that immediately surround a development or an individual parcel. These areas often represent the last line of defense against an advancing fire front – and because they are typically sites of substantial human activity, they are also prone to human-caused ignitions.

One way to limit potential ignitions and overall exposure to wildfire in these areas is to turn them into firebreaks, which are contiguous areas with little or no combustible materials.

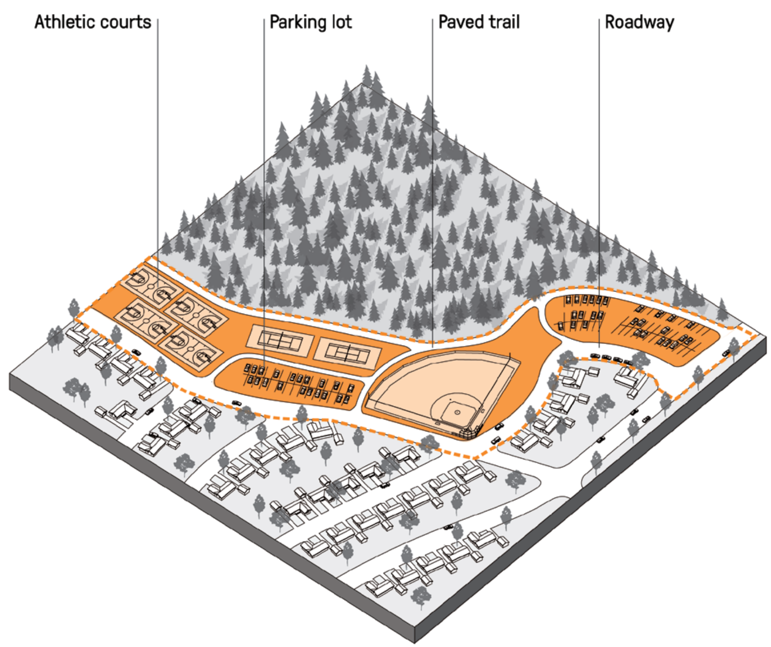
At the community scale, firebreaks may include an array of fire-safe elements like paved surfaces for parking or recreation. Ideally, these areas can be configured to double as anchor points and staging areas for fire suppression resources in the event of an emergency.

At the individual parcel scale, these elements could include masonry walls to deflect flames, heat, and embers, hardscape patios and walk-ways, or water features like pools and ponds.

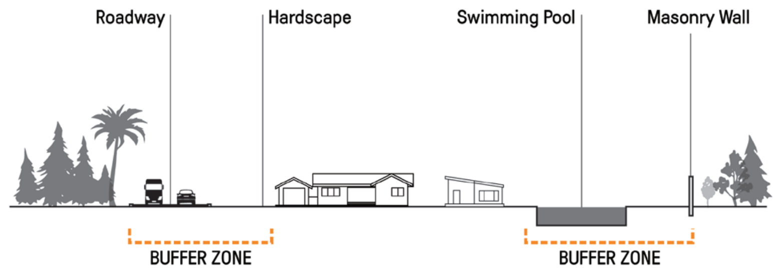
Incorporate Redundancies

As with other fuel treatments, these types of firebreak strategies are most effective when combined together over the largest possible contiguous surface area to create maximum separation between structures and potential fire sources.

COMMUNITY-SCALE BUFFER



PARCEL-SCALE BUFFER



08

Design Double-Duty Trails

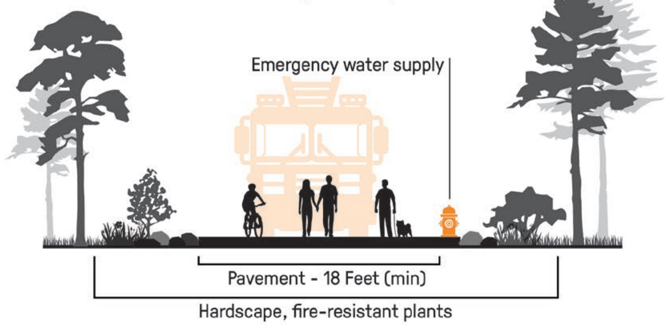
Most concentrated recreational activities in parks and parkland areas occur close to roads and trails. Reducing fuels along these corridors can provide an effective barrier to fire spread, lower the risk of human-caused ignitions, and increase firefighter safety when used as access points for wildfire defense.

Trails, fire roads, and other low-capacity roadways can be designed to function as both fuel breaks and emergency response infra-structure. Larger paved trails and road-ways can double as access routes for fire trucks and other heavy equipment – especially when turn-around areas are incorporated at regular intervals.

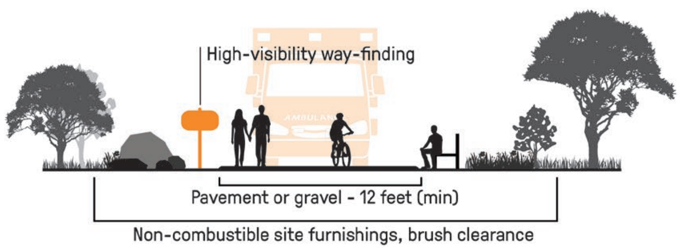
Smaller and mid-sized recreational trails can double as access routes for smaller emergency response vehicles and hand-crews. These corridors can be used as anchor points and control lines for both fire suppression as well as prescribed burning.

Signing for Safety
Consider incorporating high-visibility (i.e. reflective), easy-to-read signage and other way-finding elements constructed from fire-proof materials alongside roadways and trails.

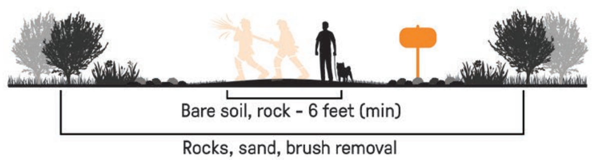
LARGE MULTI-USE PAVED TRAILS
Sufficient width for fire trucks and heavy machinery



MID-SIZED PAVED OR GRAVEL TRAILS
Sufficient width for smaller emergency response vehicles



SMALL UNPAVED TRAILS
Sufficient width for hand-crews and first responders



09

Irrigate the Edges

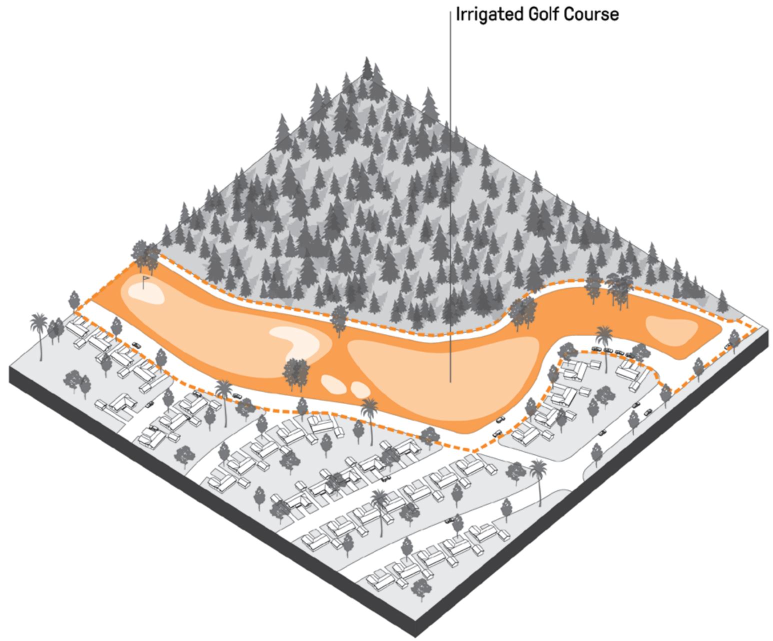
Regularly irrigated landscapes can act as effective fuel breaks, and can sometimes be combined with paved surfaces, roadways, and other non-combustible elements to increase separation from wildlands. These can include working agricultural landscapes like orchards, vineyards, and cropland areas, or recreational landscapes like golf courses and athletic fields.

Aside from establishing regular irrigation regimes during hotter, dryer parts of the year, these areas should be maintained to increase their efficacy as fuel breaks. This typically includes regular mowing or grazing, invasive species management, and the use of non-combustible fencing.

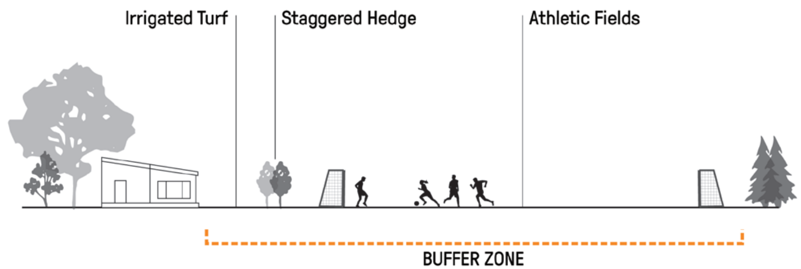
Size Matters

There is no universal standard for the dimensions of a fuel break, but a common "rule of thumb" is that it should be three times wider than the maximum height of the surrounding vegetation. Typically a bare ground line four to ten feet wide is sufficient, but narrow cow trails and even mowed lines can be safely used as anchor points for suppression firefighting or controlled burning. Fuel breaks may need to be wider in areas influenced by other significant factors such as slope or exposure to frequent high winds.

COMMUNITY-SCALE BUFFER



PARCEL-SCALE BUFFER



10

Establish Greenways

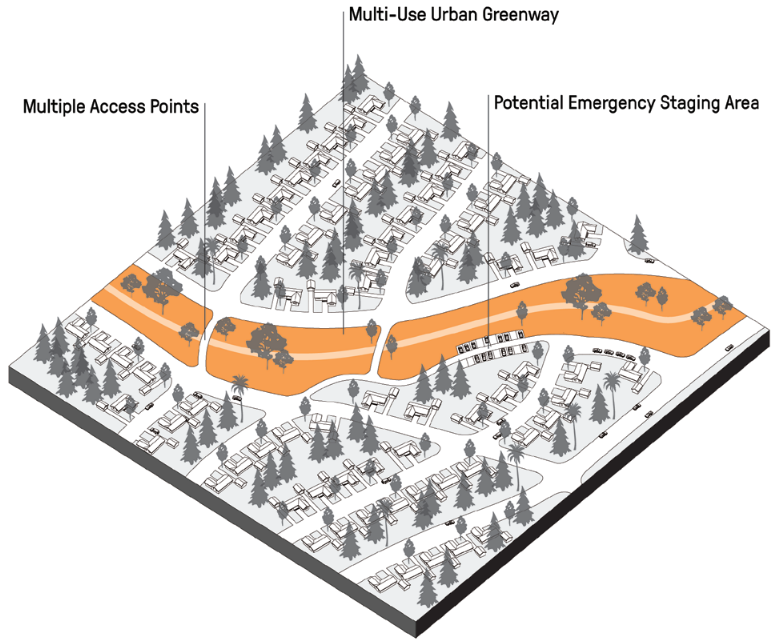
In addition to large irrigated buffers surrounding a community, smaller-scale greenways strategically integrated *within* a community can help reduce the risk of catastrophic loss during an extreme wildfire event, while bringing an array of additional environmental and recreational co-benefits.

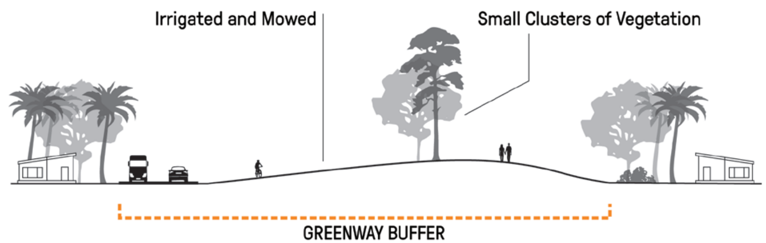
When areas of fire-resistant landscaping are placed in between residential blocks or other clusters of structures, they can contribute to defensible space and reduce the chances that embers from an approaching wildfire will land on homes. They can also reduce home-to-home ignition, which is often the main cause of property loss in neighborhoods during a wildfire event. Such greenbelt features can slow a fire's rate of spread, cause it to change direction, or stop it altogether. In some cases, they can even provide critical refuge for residents during an evacuation scenario.

Layering Protection

Urban greenways are often designed for multiple uses, and may include trails, parking areas, water resources, and other features that can be designed to reduce risks associated with wildfire. Consider managing vegetation to reduce fuel loads in occluded wildland vegetation areas between residential and recreational zones where ecologically appropriate. Designing greenways with multiple entry points can make it significantly easier for firefighting resources to access and use them as defensible space.

COMMUNITY-SCALE BUFFER





11

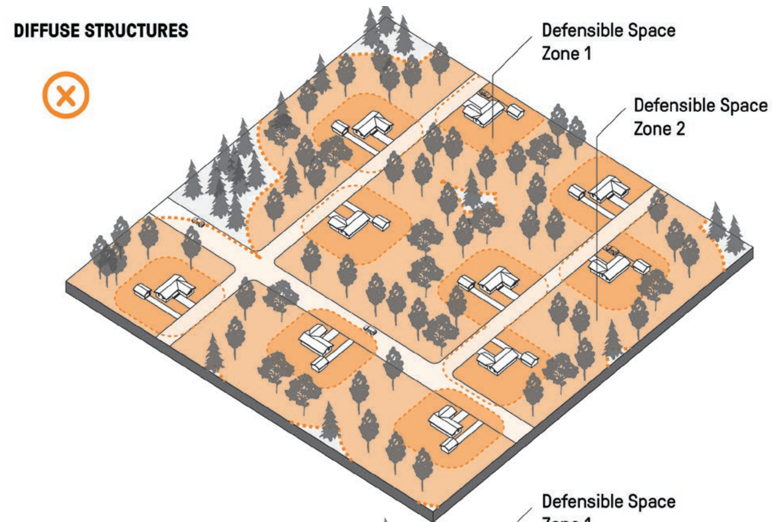
Cluster Structures

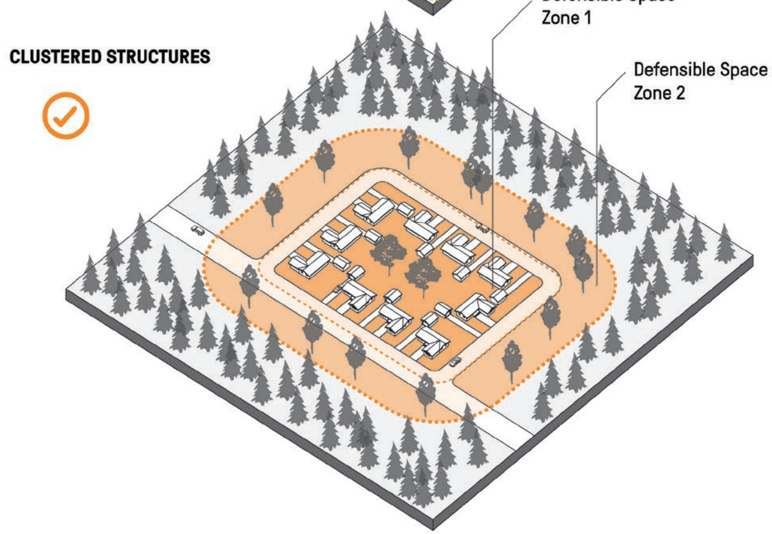
When there is more distance between struc-tures, more effort is required to coordinate and maintain zones of defensible space. Additionally, a diffuse development pattern often requires substantially more fire fighting resources and can make fire suppression more complex during a fire event.

Recent research suggests that clustering structures together may help make communities easier to defend from fire while simultaneously simplifying defensible space planning and substantially reducing the overall impact of development on wildlife habitat. This approach can also help limit negative impacts to the surrounding environment and provide expanded opportunities for recreational and open space planning.

Trade-offs

On the other hand, higher-density developments may increase structure-to-structure ignitions due to the closer arrangement of buildings, and therefore may require additional structure hardening measures such as fire-rated exterior walls, non-combustible construction materials, ember-resistant vent protection, etc.





12

Isolate Islands

On large sites where it is not ecologically appropriate, cost effective, or aesthetically desirable to install and maintain a shaded fuel break, it may be possible to maintain thicker, multi-layered vegetation if isolated in individual clusters with adequate space in between.

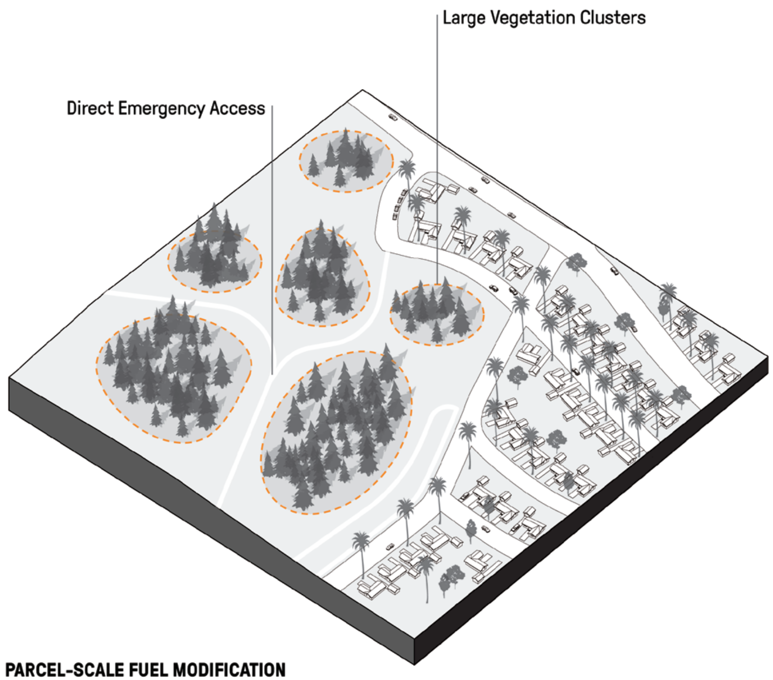
On smaller sites, this clustering strategy can help screen views by increasing the overall volume of vegetation without significantly increasing the risk of fire spread.

At both scales, the appropriate size and space between clusters may need to be modulated based on consultation with local fire agencies and the influence of individual risk factors such as slopes or exposure to frequent high winds.

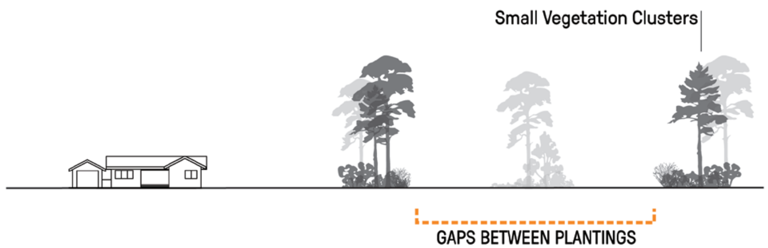
Mind the Gaps

In general, it is a good idea to avoid planting trees and shrubs in rows or hedges that provide an uninterrupted path for fire. Consider staggering multiple rows of gapped plantings with adequate space between clusters as a strategy for achieving similar aesthetic outcomes without significantly increasing risk.

COMMUNITY-SCALE FUEL MODIFICATION



PARCEL-SCALE FUEL MODIFICATION



13

Integrate Windbreaks

Wind-driven fires can be especially dangerous because of their rapid rate of spread, high fire intensity, and unpredictable behavior. Gusty winds increase the risks of embers and firebrands being carried across firebreaks and containment lines, where they can start spot fires, which can overwhelm firefighting resources.

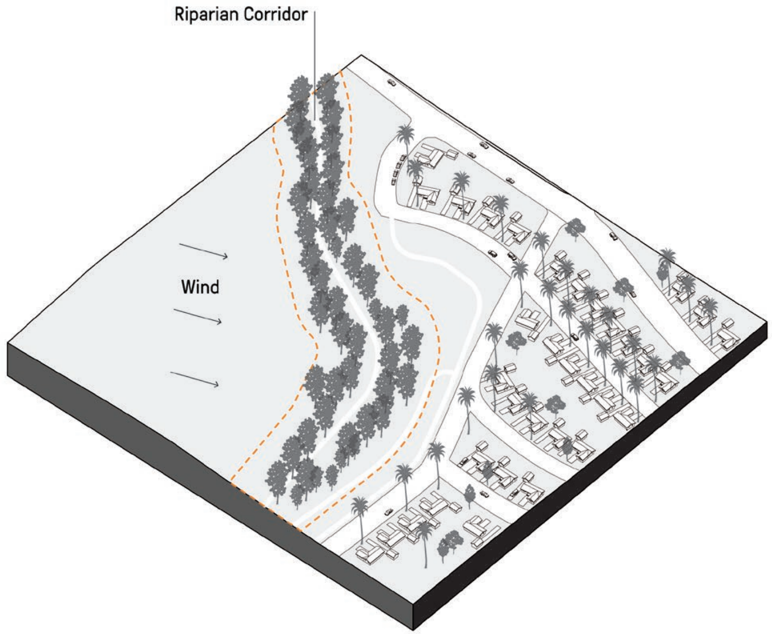
Wildland firefighters – especially those working in grassland or prairie ecosystems – have long shared anecdotal evidence that windbreaks, riparian areas, and other woodland vegetation can slow rapidly spreading wildfires, providing a vital opportunity for evacuation or containment.

Well-designed and installed windbreaks have the ability to reduce wind speeds on both their leeward and windward sides. By working to reduce wind speeds around structures, windbreaks may help limit danger for firefighting resources and reduce the risk of structure loss.

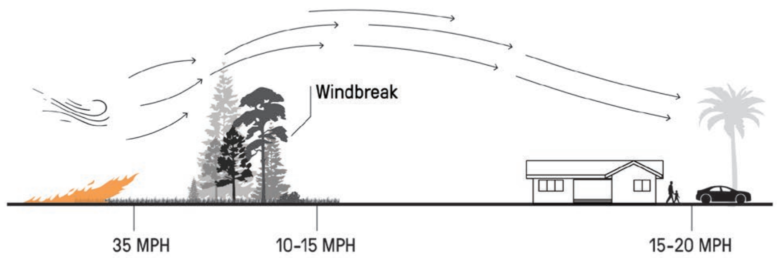
Siting for Safety

When siting a windbreak, it is important to negotiate between trade-offs. While they can help to slow a wind-driven fire front, they can also pose additional risks by providing an uninterrupted fuel path for fire to move along. Generally, windbreaks should not be installed within 30 feet of a structure, and local fire agencies and other experts should be consulted for local ordinances and guidelines.

COMMUNITY-SCALE WINDBREAK



PARCEL-SCALE WINDBREAK



WIND VELOCITY

14

Incorporate Technology

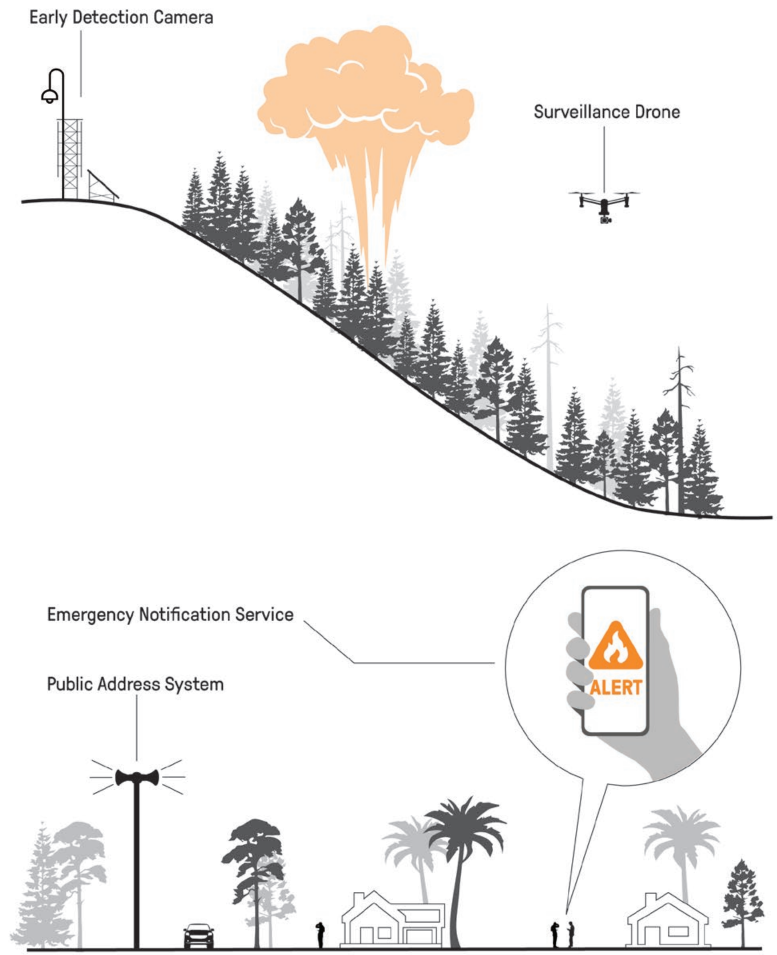
Although wildfires cannot be prevented entirely, their potential devastation can be minimized if they are detected early and precisely geolocated. While fire managers have been using satellite imaging and cameras to spot wildfires for years, that technology has gotten sharper, and is part of a growing toolkit that now also includes artificial intelligence, drones, and sensors.

Networks of sensors can be simple to set up and generally inexpensive to run and maintain – especially compared with other types of wildfire detection technology such as camera towers and drone fleets.

Subscription-based emergency alert systems are increasingly available in fire-prone communities. These systems use mass e-mail or text messages from public agencies that include safety messages and evacuation instructions during emergencies.

A Layered Approach

Reliable early detection of wildfires will likely require a combination of different technologies working together to detect possible fires, monitor active fires, predict potential fire behavior, and send real-time alerts to nearby communities.



15

Embed Emergency Water Systems

Emergency water systems are designed to 1) lower the likelihood of an ignition on and around structures and 2) help extinguish approaching fire fronts. An effective system should be able to work during a power outage and remain effective through dramatic drops in water pressure. This often means that emergency water systems need to operate independently of municipal water and power supplies.

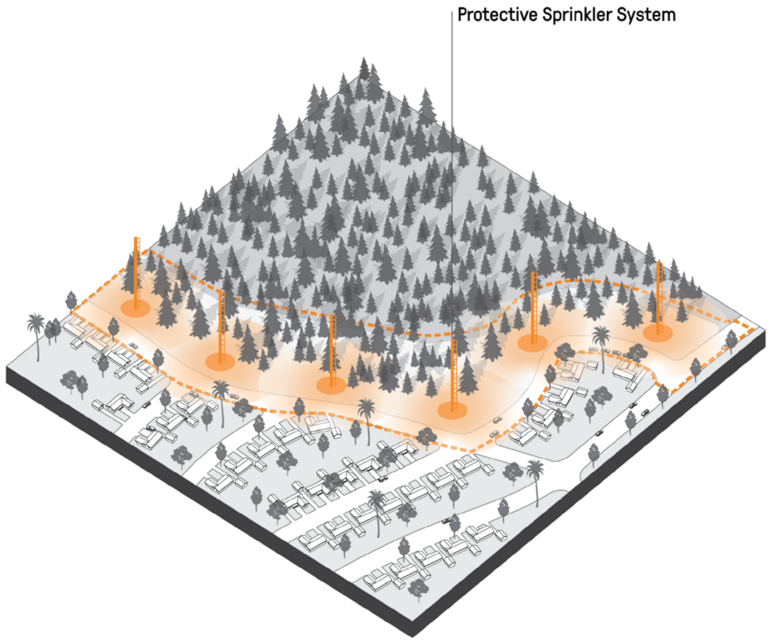
In some cases, it may be appropriate for communities to install networks of sprinkler towers along the edges of wildland areas, designed to stop an advancing fire in its tracks by regularly dousing the surrounding vegetation with recycled water supplied by nearby homes.

At the individual parcel scale, emergency water sources could include pools, ponds, hot tubs, cisterns, and water tanks that can be connected to hoses and emergency sprinkler systems.

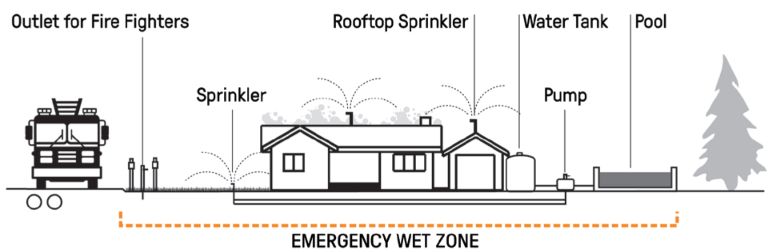
Materials and Maintenance

Valves, pipes, and sprinkler heads should be constructed of corrosion-resistent materials. Valves should be easily accessible and located within sight of the sprinkler heads. Pipes should be buried deep enough to avoid damage from heavy machinery and large vehicles. Pathways that lead to water sources should be well maintained. Cisterns and water tanks should be cleaned out regularly.

COMMUNITY-SCALE SYSTEM



PARCEL-SCALE SYSTEM



16

Introduce Social Infrastructure

Smoke caused by wildfires contains particulate and chemicals that are hazardous to breathe, and is especially dangerous for children and people with respiratory or pulmonary illnesses. Often, these smoke events coincide with high temperatures and other compounding environmental risks, which can pose serious challenges to public health agencies.

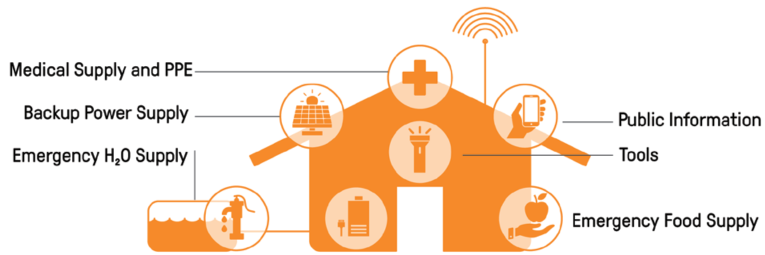
Social infrastructure such as community resilience hubs, cooling centers, and clean air facilities can help provide communities with access to shelter, water, and electricity during wildfires, smoke events, extreme heat events, public safety power shutoffs, or other emergencies.

Before and after emergency situations, social infrastructure can provide a centralized resource for information, education, and other everyday services.

Centering Schools

Where possible, retrofitting schools may be a good way to help ensure that resilience hubs are accessible to children, who are especially vulnerable to the impacts of poor air quality and extreme heat.

COMMUNITY RESILIENCE HUB



17

Identify Emergency Refuge Areas

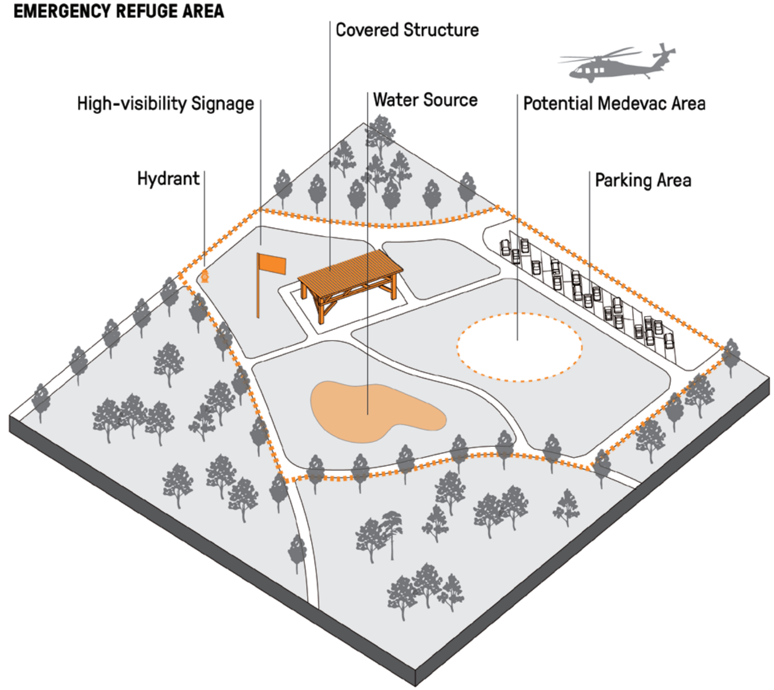
During some of the worst emergency scenarios, when a rapidly spreading fire is advancing toward a community and local evacuation routes are compromised or clogged, area residents may be forced to find refuge where they can. This was the case in 2018, when the Camp Fire raced through the town of Paradise, California. Nearly 80 people rushed to a neighborhood park where they spent hours huddled under a metal-roofed picnic pavilion, protected from falling embers and firebrands.

Emergency refuge areas can be embedded into parks and other public open space areas where large groups can take shelter and access emergency water sources and medical equipment. Emergency refuge areas are most effective when they are easily accessible and separated from any nearby fuels such as dense vegetation, wood piles, or gas tanks.

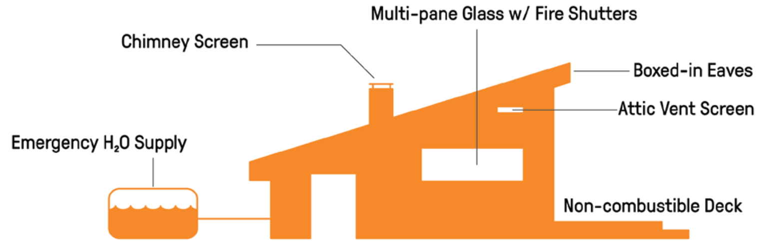
Hardening Structures

Pavilions or other structures identified as potential emergency refuge areas should be constructed or retrofitted with fire-resistent materials. Structures with wood or shingle roofs are at higher risk of being destroyed during a fire. Exposed eaves are vulnerable to flying embers. Single-paned and large windows are particularly vulnerable to breakage, which may allow heat and embers to enter. Consult with local fire agencies for additional structure-hardening guidance.

EMERGENCY REFUGE AREA



KEY STRUCTURE-HARDENING ELEMENTS



18

Ensure Emergency Access and Egress

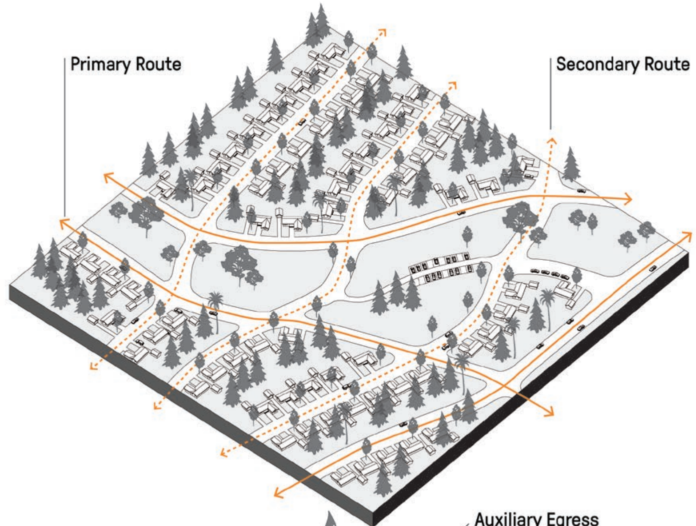
Wildfire evacuations place considerable stress on residents, first responders, and transportation infrastructure. During short-notice evacuation scenarios, the capacity of local roadways can be one of the most significant safety factors for a community. In fire-prone communities, it is especially important to evaluate the capacity of an evacuation network under a range of emergency scenarios.

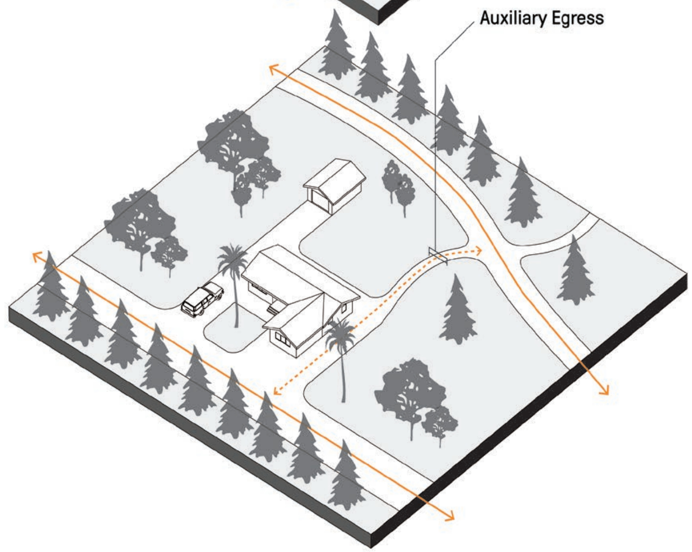
People must be able to safely and quickly evacuate without impeding access for first responders and firefighting resources, which typically travel against the flow of outgoing traffic. At a minimum, communities should have multiple two-way emergency evacuation routes.

Smaller parcels and dense neighborhoods should have as many escape routes as possible. Consider establishing auxiliary routes through neighboring properties. This may mean installing gates that can be opened form both sides.

Unlocking Gates

Look for additional opportunities to 1) improve connectivity throughout the community; 2) increase the number of facilities that can be used during an evacuation; and 3) reduce the number of major mobility barriers. For gated driveways or access roads, consider sharing gate code information with local fire agencies.





19

Keep Roadways Clear

Most fires are caused by humans, and ignition risk is typically highest near roads and other high-use areas. These areas often double as access points for fire responders. Keeping roadways clear of hazards can help minimize the chances of fire starting accidentally (e.g. via sparks from trailer chains, catalytic converters on cars, campfires, etc.)

Safer roads are ones that can safely and swiftly accommodate passage for both evacuating residents and incoming emergency response teams. A road's overall safety is influenced by its width, fuel clearance, and visibility.

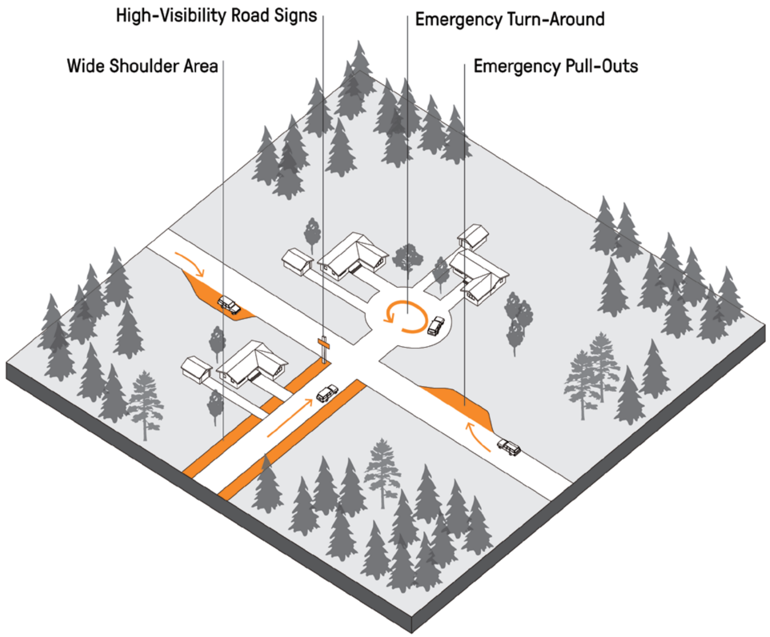
Turn-Arounds

Firefighters may be reluctant to use a driveway if escape routes are not evident. Long driveways and narrow streets with dead ends should have a place for large trucks to turn around. An adequate turn-around provides both a means of escape and a place to stage a defense.

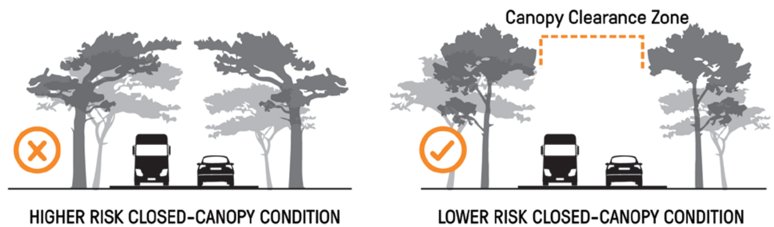
Shoulders & Pullouts

If narrow streets and driveways do not have adequate passing room for emergency vehicles to get around cars, they can create potentially lethal bottlenecks. Ensure that driveways have adequate width, and consider widening roadway shoulders or incorporating pullouts or off-street parking areas at regular intervals.

EMERGENCY VEHICLE ACCESS



VEGETATION CLEARANCE



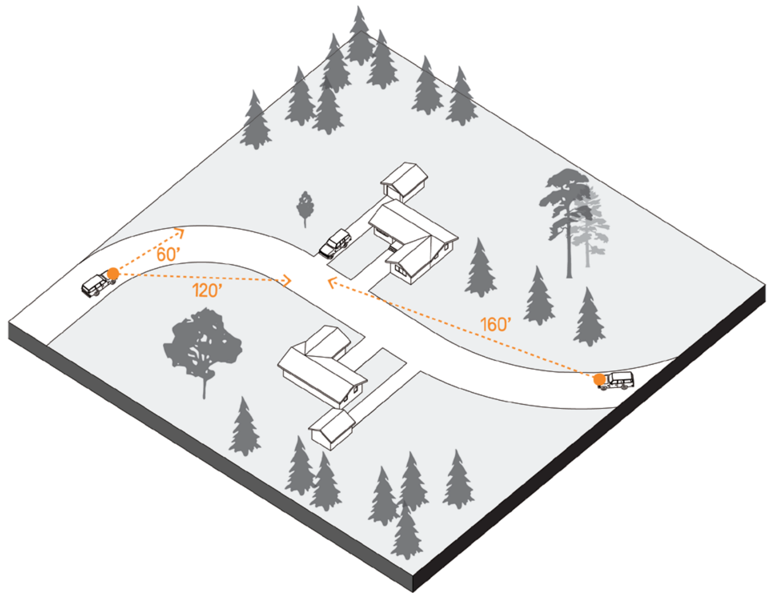
Keep Sight Lines Clear

When visibility is reduced along roadways, a driver's average rate of travel typically decreases. In an emergency evacuation scenario, drivers rely on clear lines of sight. In the US, the national standard is to have no fewer than 155 feet of forward visibility for cars traveling at 25 miles per hour. Maintaining visibility around curves may require trees and large shrubs to be set back from the inside of the curve.

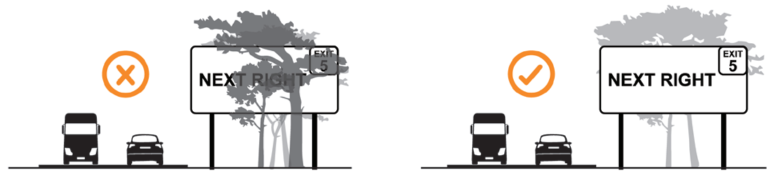
Seeing The Signs

Road signs should be constructed from non-flammable materials and should be clearly visible to accommodate drivers during night-time evacuations and/or moments of heavy smoke.

ROADWAY SIGHT LINES



ROADSIDE VEGETATION CLEARANCE



OBSTRUCTED ROAD SIGN

VISIBLE ROAD SIGN

Appendix
References and Resources

Appendix
References and Resources

The information and strategies outlined in this publication reflect a thorough survey of existing literature from an array of disciplines. In combination with standard literature reviews, the research team conducted interviews with experts from relevant fields, and collected insights and information from design projects, conference proceedings, planning frameworks, and direct fieldwork.

Listed here are ~100 references deemed most relevant to practicing landscape architects and urban designers.

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New development in the Wildland Urban Interface, Southern California.
Photo: Jonah Susskind, Alan Berger

Shaded fuel break outside of Paradise, California.
Photo: Jonah Susskind

Prescribed burn, Northern California
Photo: Jonah Susskind