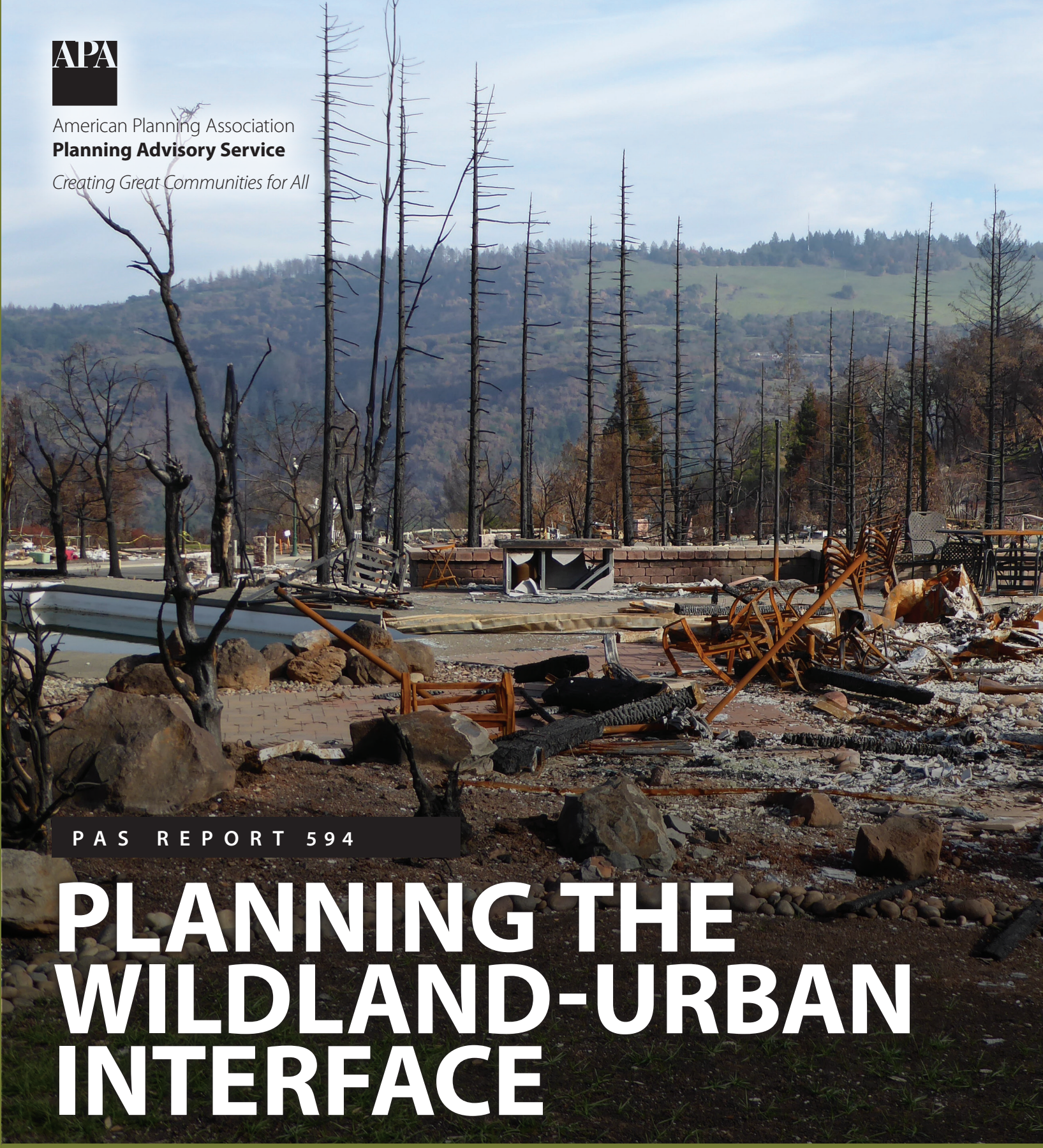

American Planning Association
**Planning Advisory Service**
*Creating Great Communities for All*

PAS REPORT 594

# PLANNING THE WILDLAND-URBAN INTERFACE

Molly Mowery, AICP, Anna Read, AICP, Kelly Johnston, RPF, and Tareq Wafaie, AICP

The American Planning Association provides leadership in the development of vital communities for all by advocating excellence in planning, promoting education and resident empowerment, and providing our members with the tools and support necessary to ethically meet the challenges of growth and change.

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## ABOUT THE AUTHORS

**Molly Mowery,** AICP, has dedicated her professional planning career to helping communities adapt to the new realities of wildfire. She is founder of Wildfire Planning International, a consulting practice that provides services throughout North America. Mowery codeveloped the national Community Planning Assistance for Wildfire program and designed FEMA's Land Use Planning for Wildfire course. She currently serves as a director for the nonprofit Community Wildfire Planning Center and is a member of the Sustainable Development Code Advisory Board. She holds a Bachelor of Arts degree from Naropa University and a master's degree in city planning from the Massachusetts Institute of Technology.

**Anna Read,** AICP, is a planner and researcher. She was previously a senior program development and research associate at the American Planning Association. Prior to joining APA, she worked on regional broadband planning efforts for the state of Missouri and as a project manager for the International City/County Management Association's Center for Sustainable Communities. She has a master's degree in city and regional planning from Cornell University.

**Kelly Johnston,** RPF, FBAN, has worked in wildland fire management since 1991 as a registered professional forester and wildland fire behavior analyst. His primary expertise is in community wildfire risk, fire behavior, and prescribed fire. Johnston is president of Wildland Professional Solutions, Inc., and provides expertise and leadership on a spectrum of innovative local to international projects, including the Community Planning Assistance for Wildfire program, the first FEMA WUI Regulations training course, and the REALFire and My Wildfire Risk Structure Ignition Zone programs. He currently serves as a director for the Community Wildfire Planning Center and is an appointed member of the NFPA Committee on Wildland and Rural Fire Protection.

**Tareq Wafaie,** AICP, is a principal in Clarion Associates' Denver office. He focuses primarily on land use and zoning code revisions and natural hazard mitigation planning and implementation. His recent code updates include Sedona, Arizona; Aurora, Buena Vista, Carbondale, Glenwood Springs, Longmont, and Northglenn, Colorado; Indianapolis; Albuquerque, New Mexico; Syracuse, New York; and Denton, Texas. He also served as the technical lead for developing the *Planning for Hazards: Land Use Solutions for Colorado* guidebook. Before joining Clarion, Wafaie worked in both private and public sectors working with communities large and small. He is a frequent conference speaker on ethics, hazards, and other planning topics.

## ON THE COVER

Post-fire damage in Santa Rosa, California, following the Tubbs Fire in 2017 (Scott Story)

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## PREFACE

The Camp Fire in Butte County, California—which in November 2018 burned more than 150,000 acres, caused an estimated $16.5 billion in property damages, and resulted in at least 85 deaths—was the latest in a long list of deadly and destructive wildfires in U.S. history. The Peshtigo Fire of 1871 ranks as the deadliest, burning 1.2 million acres and killing approximately 1,200 people in Wisconsin. The Great Fire of 1910 burned more than three million acres in Idaho, Montana, and Washington; caused 87 fatalities; and led to the USDA Forest Service policy of rapid suppression of all wildfires. More recently, the 2016 Chimney Tops 2 Fire in the Great Smoky Mountains of Tennessee destroyed more than 2,400 structures and claimed at least 14 lives, illustrating that wildfire risk is not confined to the western United States.

Fire is a natural part of wildland ecosystems, helping to maintain forest health, control invasive species, and provide wildlife habitat. But past fire management practices designed to exclude wildfire from such landscapes have led to the accumulation of understory vegetation and debris that provide fuel for larger, faster-moving, and more destructive wildfires. Rapid growth in the wildland-urban interface, or WUI (areas where human development intermingles with natural vegetation), combined with warmer, drier conditions and ecosystem stresses associated with climate change, are increasing the risks to lives and property from wildfires.

Planners across the country have important roles to play in helping communities reduce their vulnerability to the destructive and tragic consequences of wildfires such as the Camp Fire. Nearly 15 years ago, the American Planning Association published PAS Report 529/530, *Planning for Wildfires* (Schwab and Meck 2005) with the support of the National Wildland/Urban Interface Fire Program, an interagency program operated by the National Fire Protection Association. That report described why wildfire should be a planning priority, provided an overview of wildfire science and the history of wildfires in the United States, and demonstrated how planning can be used to promote effective and realistic solutions to reduce wildfire risk.

Made possible by the support of the USDA Forest Service, this new PAS Report presents a holistic approach to planning the WUI. It is divided into two sections. The first section provides in-depth coverage of WUI concepts and issues, including recent development and wildfire trends and evolving federal policy, fire science and factors affecting fire behavior and structure vulnerabilities, and wildfire hazard and risk assessment. In the second section the authors present a framework designed to mitigate wildfire risk in the WUI through coordinated planning and implementation. Key points include engaging the multiple parties who have a stake in WUI issues; working with experts in fire science and policy; and leveraging co-benefits such as improved environmental quality, reduced costs of public infrastructure and services, and economic returns and better health outcomes from tourism and recreation. The report provides detailed information and links to resources on addressing wildfire risk and other WUI issues through plans, regulations, codes, and public investments.

Dating back to the 1998 publication of PAS Report 483/484, *Planning for Post-Disaster Recovery and Reconstruction* (Schwab 1998), the American Planning Association has prioritized developing resources for planners to help communities prepare for, reduce the impacts of, and recover from natural disasters. *Planning the Wildland-Urban Interface* is the latest report in that series. I can think of no more important topic for planners to address to fulfill their fundamental mission of promoting the public health, safety, and welfare.

David Rouse, FAICP
Managing Director of Research and Advisory Services
American Planning Association

# Where communities meet nature

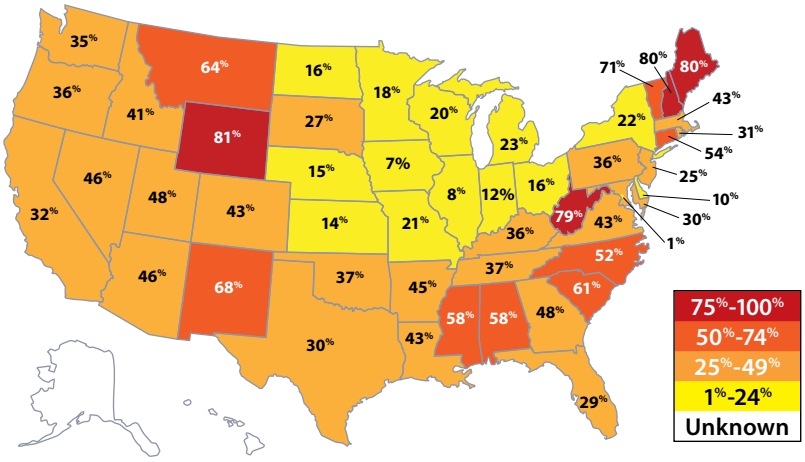
One-third of all U.S. homes are in the wildland-urban interface (WUI), where development and wildlands mix and devastating fires pose a growing danger. **Read PAS Report 594**, ***Planning the Wildland-Urban Interface***, to help build communities that are more resilient to wildfire.

## Wildfire is a growing hazard

| | 1995 | 2005 | 2010 | 2017 |
|---|---|---|---|---|
| **Acres Burned** | 1,840,546 | 8,689,389 | 3,422,724 | 10,026,086 |
| **Federal Firefighting Suppression Cost** | $477,126,000 | $818,954,000 | $809,499,000 | $2,918,165,000 |

## Every state has a WUI

Percent of total homes in the WUI




## Planning solutions for the WUI

- Comprehensive Plan
- Hazard Mitigation Plan
- Community Wildfire Protection Plan
- Subdivision and Zoning Regulations
- Wildland-Urban Interface Regulations

**Source for "Wildfire is a growing hazard"**
"Federal Firefighting Costs (Suppression Only)," National Interagency Fire Center, 2017
https://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf

**Source for "Every state has a WUI"**
"New Analyses Reveal WUI Growth in the U.S.," U.S. Department of Agriculture, 2010
https://www.nrs.fs.fed.us/data/wui/state_summary/#wui-houses

## EXECUTIVE SUMMARY

During the summer and fall of 2018, wildfires were burning in multiple areas across the United States. In many ways, this was not unusual. Whether large or small, wildfires are a natural and frequent occurrence in many landscapes.

What made these wildfires unique, however, was the record-breaking statistics associated with many of them, most notably the devastating Camp Fire that began in November near Paradise, California, and ended as the deadliest and most destructive wildfire in California history. Headlines dominating major news outlets asked what more could be done to safely plan communities with wildfire in mind, and in some cases questioned whether we should be living in wildfire-prone areas at all.

PAS Report 594, *Planning the Wildland-Urban Interface*, seeks to address these timely questions by providing a comprehensive approach for planners to respond to the growing challenges posed by wildfires in our communities. This report is not only for western-based planning audiences that may commonly identify with the challenges of wildfire hazard, but for any planner confronting the increasing threat of wildfires in communities across the United States.

## THE WILDLAND-URBAN INTERFACE

This PAS Report focuses on providing tools and strategies for planners working in the *wildland-urban interface*, or WUI (WOO-EE). The WUI refers to any developed area where conditions affecting the combustibility of natural and cultivated vegetation (*wildland fuels)* and structures or infrastructure (*built fuels*) allow for the ignition and spread of fire through these combined fuels. This combination of human development and vegetation is where wildfires have the greatest potential to result in negative impacts to communities, such as injuries and deaths, damage to structures and infrastructure, and loss of ecosystem services.

WUIs vary based on a number of factors at multiple scales, including the type and quantity of vegetation, topography, fire history, development patterns, and proximity to wildlands. Together, these factors collectively influence how a wildfire will affect an area. In other words, the WUI is not a fixed geographic location, but rather is based on a dynamic set of conditions—and planners have the ability to influence it.

The concept of the WUI emerged in the 1970s to denote the growing trends of more people moving into wildfire-prone areas and more wildfires burning into communities. Wildfires in the WUI were initially viewed as a regionally specific problem. But a confluence of factors—including previous forest management and suppression policies, an increasing number of homes being built in wildland areas across the country, and a changing climate—have resulted in a WUI challenge that is now national in scope.

At least one-third of the current U.S. population lives in the WUI, and counties from coast to coast are continuing to experience WUI growth. Over the past two decades alone, WUI fires have significantly affected communities in states across the country, including Arizona, California, Colorado, Florida, Idaho, Kansas, Minnesota, New Mexico, Oklahoma, Oregon, South Carolina, Tennessee, and Washington. Economic, social, and environmental impacts vary locally, but often bring a host of short- and long-term consequences, costing millions of dollars and taking years to fully recover.

## OPPORTUNITIES TO ADDRESS THE WUI THROUGH LAND-USE PLANNING

Tackling the challenges associated with wildfire impacts on communities has traditionally been within the purview of land management agencies and fire rescue and emergency services. Community preparedness efforts have primarily focused on improving response tactics to protect structures and residents, reducing hazardous fuels (i.e., vegetation) near a community, and educating residents through voluntary programs.

These are all essential activities to reduce wildfire risk in the WUI. But with structure losses continuing to increase and wildfire suppression costs skyrocketing—primarily attributed to WUI fires—it is critical for communities to expand their portfolio of solutions to include land-use planning.

Land-use planning decisions determine where communities are built and influence how vulnerable they are to wildfire. Planners are well positioned to address wildfire concerns during all phases of community planning and development—from creating community visions that incorporate safety and resilience goals to implementing finely crafted regulations that specify construction materials and plant selections on a site.

This PAS Report is designed to help planners understand where and how they fit into addressing the WUI through land-use planning strategies. It represents the evolution of 2005's PAS Report 529/530, *Planning for Wildfires*. This report includes new national policies and planning frameworks that have since emerged and influence the WUI, and it recognizes the latest science, best practices, and data that is driving a better understanding of the WUI and appropriate land-use solutions.

The report is divided into two sections. Following an introductory chapter that introduces the WUI and outlines the scope of the report, Chapters 2 through 4 reflect the scope of the WUI as a widespread wildfire planning challenge and provide planners with an essential technical primer on wildfire basics. The second section, Chapters 5 through 7, focuses on planning solutions by providing a holistic framework and set of policy and regulatory strategies. A concluding chapter summarizes WUI trends and planners' roles in shaping better outcomes, while also acknowledging that more research can further enhance our understanding of this complex topic.

## UNDERSTANDING THE WUI AND WILDFIRE BASICS

The WUI as a national issue has been decades in the making. It is often viewed as a product of two primary drivers, as explained in Chapter 2. First, previous development decisions have allowed or encouraged rapid growth into suburban, exurban, and rural areas without regard for the potential consequences of wildfire hazard. Second, land management policies at the beginning of this century were focused on excluding wildfires from the landscape, which led to an unnatural buildup of forest fuels in close proximity to development.

The latter driver has since evolved, with governmental and other agencies now taking a more balanced approach to ecosystem management and fire's natural role in the landscape. However, in many areas, the first driver—development in wildfire-prone areas—remains unchecked. This can be attributed to factors that continue to attract people to these areas, including privacy, a closer connection to nature, affordable or desirable housing locations, an increase in second home ownership, and access to recreational opportunities.

As a result of WUI growth trends, many undesirable environmental problems occur, such as habitat fragmentation and an increase in nonnative species. The most prominent and devastating effect, however, is the increased number of WUI fires that has been steadily on the rise across the country. To complicate matters, communities now face more uncertainties related to future planning scenarios for wildfire. Climate change is expected to bring hotter temperatures and increasing drought conditions to more areas of the United States in future decades, creating additional planning and response challenges for fire managers. Adding urgency to the situation are other market-based responses, such as insurance carriers that are no longer willing to provide home insurance in some wildfire-prone areas.

The encouraging news is that the specific risk factors that lead to WUI fire disasters are well understood based on scientific research and analysis. Once planners understand the factors that influence fire behavior (fuel, weather, and topography), they can determine which factors they can influence. For example, planners can influence fuel sources by modifying the number of structures permitted in a subdivision or by requiring ignition-resistant construction materials. Chapter 3 outlines key wildfire science basics to provide planners with essential information to make appropriate mitigation decisions for vegetation, structures, and infrastructure.

Making informed decisions that target the WUI requires planners to understand where the WUI is. WUI spatial assessments are typically based on the distribution of housing units and vegetation within an area and can also include other development features such as critical infrastructure and facilities. The other key piece of information is the assessment of the level of wildfire risk or hazard that the community faces, addressed in Chapter 4. Wildfire *hazard* assessments identify local conditions related to vegetation, topography, and other factors, and display the potential likelihood and intensity of wildfires occurring within a defined area. Wildfire *risk* assessments are based on wildfire hazard and include the susceptibility of structures or other values within a defined area. Such assessments are typically displayed spatially using GIS layers or as static maps, and can identify conditions at the landscape, local, and parcel-level scales.

While the development of spatial assessments is undertaken by technical specialists, planners can use these different tools to communicate with elected officials, residents, and other stakeholders about their communities' relationships with wildfire and an acceptable level of risk. These tools also guide the development and implementation of effective WUI policies and regulations.

## A WUI PLANNING FRAMEWORK

Identifying, developing, and implementing appropriate policies and regulations for the WUI may seem daunting—espe-

cially when trying to reverse trends that have occurred over decades. In addition, the multifaceted WUI topic engages a variety of stakeholders across local, state, and federal levels, including land managers, fire and emergency services, planners, developers, residents, elected officials, and industry professionals. This can add complexity to technical and community-based discussions when trying to find appropriate solutions while balancing different perspectives, ownership patterns, and interests. As a result, planners must take a comprehensive and collaborative approach to address challenges in the current WUI and ensure future development does not place more lives and property at risk.

Chapter 5 explains how planners can use a holistic WUI planning framework to create consistency between locally and regionally applicable plans and the regulations, policies, and public investment programs that are used to implement them. This framework also considers relevant state and federal policies that shape WUI planning efforts, such as national wildfire policies that emphasize a cohesive approach to wildfire management in communities, including land-use planning as a mitigation strategy.

The comprehensive plan is one of the most fundamental planning tools that planners can leverage for addressing the WUI. This plan should include policies that address existing development and future growth in the WUI, community safety, accessibility and circulation patterns, natural systems, and post-disaster recovery. However, it may be easy to overlook other plans that also link land-use planning with wildfire risk reduction. Hazard mitigation plans, community wildfire protection plans, open space management plans, watershed plans, and capital improvement plans are all examples of functional plans that also support WUI planning by incorporating land-use strategies into short- and long-term local activities. In addition, neighborhood, district, and other subarea plans can advance the goals of the comprehensive plan by offering additional detail at a more granular scale. Chapter 6 examines how comprehensive plans, functional plans, and subarea plans taken together provide an opportunity to reinforce wildfire risk reduction objectives and ensure that WUI hazard mitigation strategies do not conflict with other community priorities.

While myriad plans serve as the policy foundation for addressing the WUI, regulations provide communities with the legal means to implement these policies—the focus of Chapter 7. WUI regulations can address both existing and future development in the WUI—including structures and attachments, roads and other infrastructure, landscaping, current and future land uses, and additional development features.

While a variety of regulatory options exist, this report focuses on five fundamental tools that are commonly used to regulate land development within the WUI: subdivision, zoning, fire, building, and WUI regulations. Collectively, these tools can be implemented at a full range of scales: from the larger community-level scale, through the neighborhood or subdivision scale, down to the individual building or lot scale. They provide planners with a menu of options for reducing risk through different interventions, such as locating specific uses away from wildfire hazard areas, creating effective landscaping ordinances that are compatible with multiple objectives, and ensuring communities have safe evacuation routes. Understanding this range of options is also helpful if there are local constraints on amending state codes, or when communities have a preferred method of organization within their municipal codes.

Strategies drawn from other community successes and research can support planners in their pursuit of developing, adopting, and implementing plans and regulations for the WUI. Taking incremental steps, tapping into existing resources, and working with other professionals are a few of the examples highlighted throughout this report. In addition, case study examples provide lessons on how different communities are tackling WUI planning, offering guidance and information to help planners roll up their sleeves and get started.

## CONCLUSION

According to the National Interagency Coordination Center's annual wildfire statistics report (2019), in 2018, a total of 25,790 structures were destroyed by wildfire. This included more than 18,000 residences, many of them lost during the Camp, Woolsey, and Carr Fires in California.

In some respects, this was seen as an anomaly year—from 1999 to the present, an average of 2,701 residential structures have been lost annually to wildfire. But fire experts are increasingly questioning whether recent fire years are a sign of what's to come. Expanding development patterns that fail to include mitigation for wildfire, combined with a higher number of human ignitions and rising global temperatures, are calling for a serious reevaluation of development and public safety in the WUI.

Planning, preparing, and adapting communities to wildfire is an ongoing and collaborative process. Fire adaptation in the WUI involves engaging community members and stakeholders in understanding and implementing strategies to mitigate wildfire risk in order to safely coexist with

wildland fire. Pursuing fire adaptation helps communities understand their wildfire risk and collectively take actions to mitigate this risk.

Although not all wildfire risk can be eliminated, it is based on a set of well-understood factors. Land-use planning interventions, such as changes to the location and type of development, can address many risk factors during and after the development process, helping communities avoid devastating outcomes and accepting fire as part of the landscape.

To help achieve fire adaptation, planners need to familiarize themselves with the WUI. Wildfires in the WUI result in devastating impacts to people, places, landscapes, and other areas that residents cherish—and some of these impacts can last for decades. This PAS Report not only argues for a greater need to rethink the WUI, but it offers tangible planning solutions that range from details at the building scale to community-wide changes. It primes planners to meaningfully engage with fire departments, federal and state agencies, elected officials, land managers, residents, and other stakeholders to identify and implement land-use solutions that complement other efforts.

In many ways, the existence of the WUI may be inevitable. Humans will always seek a relationship with nature and will want to live near forests, grasslands, and other wildlands. But intentional actions by planners to mitigate negative consequences in the built environment, including the effects of destructive wildfires on our communities, are an essential responsibility to ensure a safe and resilient future.

CHAPTER 1

# WHY PLANNING THE WUI MATTERS

> Still, one factor stands out above all others—more people are choosing to live in fire-prone wildlands than ever before, yet many, perhaps most, are only minimally aware of the requirements for successful coexistence with nature in such a hazardous context . . . there is often not enough debate within the larger community about the wisdom of permitting such development in the first place and under what circumstances it would be acceptable. (Schwab and Meck 2005, 2)

This quotation—from the introduction of the 2005 PAS Report *Planning for Wildfires*—captures a central challenge of planning the wildland-urban interface (WUI; pronounced WOO-EE). The WUI refers to any developed area where conditions affecting the combustibility of natural and cultivated vegetation (*wildland fuels*) and structures or infrastructure (*built fuels*) allow for the ignition and spread of fire through these combined fuels. This combination of development and vegetation is where wildfires have the greatest potential to result in negative impacts on a community, such as property damage, injuries, or deaths. However, there is also an opportunity for planners to make decisions that positively influence the set of conditions that result in the WUI.

Over the last several decades, the footprint of the WUI has expanded both in total area and in the number of homes located in the WUI. Between 1990 and 2010, new houses in the WUI increased from 30.8 to 43.4 million (41 percent growth) and land area of the WUI increased from 581,000 to 770,000 square kilometers (3 percent growth), making it the fastest-growing land-use type in the conterminous United States (Radeloff et al. 2018). The vast majority (97 percent) of these new WUI areas were the result of new housing development, not increases in wildland vegetation. Nevada, Arizona, Florida, Utah, and Colorado all saw large increases in the number of homes in the WUI during this time (Radeloff et al. 2018).

As growth and development in the WUI is anticipated to continue on this trajectory, the need to look at planning interventions and strategies for community safety is essential. How can people coexist with nature when wildfires, which can be large and destructive, are a natural part of that landscape? How can communities effectively mitigate the risk that these wildfires pose, while also recognizing that wildfire plays an important ecological role in many landscapes? And what role can planners and elected officials play in helping communities in the WUI develop in ways that reduce risk?

These questions are more pressing than ever, as wildfires are increasing in frequency, intensity, and size, and more people are living in or near wildland (Figure 1.1). This PAS Report addresses these questions by analyzing the WUI in terms of its historical roots and today's challenges. It advances the conversation that was started with the 2005 PAS Report and offers necessary knowledge for planners about evolving federal policy, new data and spatial analysis of the WUI, and the growing urgency of issues such as climate change.

This report includes technical information to help planners understand the dynamics of fire behavior and its effects on structure ignitions. It offers guidance on plans, policies, and regulations drawn from best practices, examples, and

*Figure 1.1. Continuing growth and development in the WUI will put more homes and communities at risk of wildfire disasters (Tennessee Division of Forestry)*

*Figure 1.2. The Lake Christine Fire of July 2018 near Basalt, Colorado, started at a shooting range and burned quickly through wildland vegetation, as seen in the left portion of the image. The fire threatened the entire town, prompting mass evacuations and resulting in several structure losses, shown in the center foreground. (Wildfire Planning International)*

models from across the country. It complements other planning efforts, such as planning for post-disaster recovery, and refers to other relevant resources where applicable.

## CHALLENGES IN THE WUI

More people in proximity to wildlands increases the risk of and challenges posed by wildfire. Unlike floods or hurricanes, wildfires are often started by humans or human activities, including campfires, burning waste, downed power lines, equipment malfunctions, smoking, structural fires that spread from homes to surrounding wildlands, and shooting ranges (Figure 1.2).

These human-ignited fires account for 84 percent of all wildfires. They have tripled the length of the fire season and expanded the geography of wildfire to areas where lightning-started wildfires are rare (Balch et al. 2017). On average, there are more than 61,000 human-caused wildfires every year and these fires result in 2.7 million burned acres (NIFC 2013).

As development in the WUI has increased, the cost of fire suppression has also been rising. In 1995, wildland fire accounted for 16 percent of the USDA Forest Service budget. By 2015, it had grown to 52 percent of the budget. It has been projected that by 2025, wildland fire could account for 67 percent of the agency budget (U.S. Department of Agriculture 2015).

WUI development has contributed significantly to the increased costs of fire suppression as the focus shifts to protecting life and property (Rasker 2015; Scofield et al. 2015). Rising costs associated with wildfire suppression constrain public budgets for other activities, such as forest restoration and fuel treatment projects that can reduce wildfire risk to landscapes and WUI communities. At the federal level, Congress has taken steps to end the practice of "fire borrowing," or shifting costs from other programs to fire suppression activities, through the Consolidated Appropriations Act of 2018. Passed in March 2018, this act creates a new funding mechanism under the joint authority of the U.S. Department of Agriculture and the U.S. Department of the Interior, beginning in fiscal year 2020 with $2.25 million and increasing annually by $100 million through fiscal year 2027 (U.S. Department of Agriculture 2018).

Wildfires are also getting bigger. According to the National Interagency Fire Center, the 10 largest wildfires in the conterminous United States have taken place since 2002, with half of those occurring after 2010. California had its largest wildfire on record in December 2017, only to have it surpassed in July 2018, early in the state's fire season. And then in November 2018, the Camp Fire became the most destructive fire in California's history, burning nearly 19,000 structures and claiming 86 lives. The previous most destructive fire had taken place only a year earlier, in October 2017. All five of the state's largest wildfires and 15 of the top 20 have taken place since the year 2000, and seven of the state's 10 most destructive fires have taken place since 2015 (CAL FIRE 2019a; CAL FIRE 2019b).

## KEY WILDFIRE TERMINOLOGY

Wildfire terms are used throughout this PAS Report. Where relevant, terms are defined in the text, and the glossary (see p. 134) contains a more comprehensive list of definitions.

A short list of key wildfire terms is provided below to help introduce readers to the most frequently used terms. It should be noted that terms can vary among different agencies and stakeholders, and there is no single resource that defines wildfire terms for planning practitioners.

**Fire-adapted community:** A human community consisting of informed and prepared citizens collaboratively planning and taking action to safely coexist with wildland fire.

**Fuel:** Any substance that will ignite and combust. Related to wildfire, fuels are defined as wildland fuels (e.g., vegetation) and built fuels (e.g., structures).

**Mitigation:** The act of modifying the environment or human behavior to reduce potential adverse impacts from a natural hazard. Mitigation actions are implemented to reduce or eliminate risks to persons, property, or natural resources, and can include mechanical and physical tasks, specific fire applications, and limited suppression actions.

**Structure ignition zone:** The area around a specific structure and associated accessory structures, including all vegetation that contains potential ignition sources and fuels.

**Wildfire:** An unplanned wildland fire, including unauthorized human-caused fires and escaped prescribed fire projects.

**Wildfire hazard:** The combination of the likelihood of a fire occurring and the intensity of the fire. Also refers to the wildland or built fuels present in a given area, or the combustibility of a given fuel type or fuel complex in general.

**Wildfire risk:** The wildfire hazard plus the addition of the factors that contribute to susceptibility, or the impact of a wildfire on highly valued resources and assets.

**Wildland-urban interface (WUI):** Any developed area where conditions affecting the combustibility of both natural and cultivated vegetation (wildland fuels) and structures or infrastructure (built fuels) allow for the ignition and spread of fire through the combined fuels.

The cost of wildfires goes beyond fire suppression. Communities also experience significant economic impacts, which include costs associated with property damage or loss, reduction in tourism and recreation revenue, health care costs from smoke inhalation, and costs of restoring burned areas. Estimates from Colorado's Hayman Fire, which burned 138,000 acres in 2002, put the total costs at nearly $230 million, including insured private property and timber losses (Mackes 2015).

While planners are not expected to solve the WUI's complexities on their own, these challenges have brought more attention to the role that land-use decisions can play in reducing wildfire risk. Planners bring a comprehensive perspective on community issues and priorities, and they are well positioned to convene community members, elected officials, and other stakeholders around planning the WUI.

Local, state, and federal stakeholders include land management agencies, emergency management agencies, fire agencies, code officials, fire councils, and industry professionals. These stakeholders bring significant technical expertise related to wildfire mitigation practices, which should inform plans as well as land-use and development regulations.

## ENVIRONMENTAL CONCERNS

While wildfire is the primary concern as more development expands into the WUI, there are also other challenges related to development in the WUI. These challenges, which are interconnected and may increase the risk of or be compounded by wildfire, include forest structure, water quality, air quality and public health, and impacts on land management practices.

- **Forest structure.** Development in the WUI can lead to habitat fragmentation and changes in forest succession. Forests and other wildlands provide habitat for a wide array of plant and animal species. Development that fragments landscapes or divides them into smaller, disconnected patches can disrupt and degrade habitats and negatively affect species diversity. It can also alter forest successional patterns, resulting in changes to species composition that can make forests more vulnerable to invasive species and wildfire (Stein et al. 2012). Changes to forest structure can also impact the ecosystem services provided, including water and air quality.
- **Water quality.** Both land-use and development patterns in the WUI and wildfire can have significant impacts on water resources. USDA Forest Service lands are the largest source of municipal drinking water in the country, supplying water to more than 66 million people in 33 states (USDA Forest Service 2018). Forest health affects water quality; degraded water quality reduces ecosystem health and increases water treatment costs. Several large cities, including Seattle, Boston, and New York, have invested in conservation and watershed protection to maintain water quality and reduce the need for water treatment infrastructure (Mockrin et al. 2014). For example, Denver Water, together with the USDA Forest Service, has spent $33 million on more than 70,000 acres in wildfire-specific efforts, including forest restoration and wildfire mitigation, to protect water quality (Krake 2018). Wildfire can make watersheds more susceptible to flooding and erosion, and post-fire watersheds may see increased sediment and nutrient loading. Fires in the WUI can result in elevated levels of additional contaminants in water supplies from ash and debris (U.S. Geological Survey 2018).
- **Air quality and public health.** Forests play an important role in regulating air quality. Trees remove air pollution from the atmosphere, absorbing pollutants through their leaf stomata. These air quality improvements translate into health outcomes. One study estimated that in 2010, trees in the United States removed 17.4 million tonnes of air pollution, resulting in the avoidance of more than 850 deaths and representing a total economic value of $6.8 billion (Nowak et al. 2014). While forests can have positive effects on air quality and public health, wildfires have the opposite. Smoke from wildfires includes gases and particulate matter and can spread beyond the immediate area of the wildfire. It can have negative health impacts, ranging from burning eyes to exacerbating existing heart and lung conditions (AirNow 2017). Studies have found that in areas that are affected by wildfire smoke, emergency rooms see increased visits from patients with respiratory symptoms, including asthma, bronchitis, and cardio-obstructive pulmonary disease (Black et al. 2017). Estimates place hospital admissions for respiratory symptoms stemming from wildland fire at between 5,200 and 8,500 per year, while cardiovascular hospital admissions are estimated at between 1,500 and 2,500 per year (Fann et al. 2018).
- **Land management practices.** Increased development in the WUI can present challenges for land management agencies implementing forest or other vegetation management practices adjacent to private property. These treatments can be more costly to perform based on the additional time and resources required to manage risks near development. For example, home owners may require ed-

ucation to understand the value and importance of thinning of vegetation and prescribed burning that may otherwise be viewed as dangerous or disruptive. Home owners may also object to changes intended to make a landscape more resilient—for example, fuel breaks between forestland and a subdivision—which may be viewed as environmentally unfriendly or aesthetically unappealing.

As planners consider development in the WUI, it is important to understand how this may affect the surrounding wildlands and environment, as well as impacts that it may have on wildland management practices. These challenges may also connect to other community issues and priorities on which planners work, such as green infrastructure, parks and open space planning, and watershed management. Planners are in a position to consider this full range of challenges as they work on plans and regulations for the WUI.

## OPPORTUNITIES FOR PLANNING THE WUI

Planners make decisions every day that affect the WUI at multiple scales, from landscaping requirements to the location of new communities. Planning for the WUI should consider wildfire hazards at all scales and phases of development.

To illustrate the potential roles for planners and importance of land-use planning in reducing wildfire hazard in the WUI, the sections below provide an overview of the wide range of land-use and community development solutions at different scales that can help address the WUI through planning processes. Together, they comprise a holistic approach.

### Community Scale

This scale includes activities or development that occur across a community. It is not necessarily restricted to a group of structures, but rather addresses the analysis of land uses themselves and their appropriateness within or near areas with wildfire hazard.

- **Areas of refuge** within a community (versus areas of refuge within buildings) can be pre-identified by planning and fire departments to designate locations safer from fire and smoke for evacuees to go until they can be rescued by emergency responders.
- **Hazardous land uses** that could potentially cause or exacerbate risk—such as the storage of combustible or hazardous materials (bulk storage, propane tanks, chemical or explosives storage), fueling stations, heavy manufacturing or processing, and temporary fireworks stands—can be restricted or require mitigation in areas with a wildfire hazard.
- **Land uses with dense population or mass gatherings** that occur indoors or outdoors and would place many people at risk if a wildfire were to occur—including permanent uses such as large multifamily housing, hotels, hospitals, and religious institutions, and temporary mass gatherings such as festivals, weddings, concerts, or other events—can be required to show fire mitigation or fire protection as part of their permit approvals.
- **Sensitive area protection** can be required within master planned developments, planned unit developments, or larger subdivisions. These areas can be protected by conservation easements, development agreements, dedications, or set-asides with the intent of keeping development off lands with sensitive environmental conditions such as wildfire hazard areas, wetlands, or migration corridors.
- **Public open space, trails, and parks** can be required to undergo fire mitigation during development and as part of long-term maintenance. If properly managed, these features may serve as buffers between high wildfire hazard areas and neighborhoods or other uses. They may also support fire response efforts, for example by improving access to wildland areas.

### Neighborhood/ Subdivision Scale

This scale encompasses groups of structures, such as a neighborhood or subdivision (Figure 1.3, p. 16), and associated infrastructure, including transportation routes, parks and waterways, and other features within an area.

- **Buffering or screening** standards, such as those for fences or privacy hedges, can provide for noncombustible and low-flammability options to ensure neighborhoods are not increasing their vulnerability through the planting of hazardous fuels.
- **Roads and bridges** can be required to meet specific standards for minimum widths, maximum grades, and numbers of turnarounds or turnouts (depending on other factors) to ensure adequate access by fire apparatus and heavy equipment. Road signs can also be required to meet uniform standards to ensure visibility.
- **Secondary or emergency access** can be required for neighborhoods to provide additional evacuation routes and facilitate increased circulation during a wildfire response.
- **Setbacks** from significant features such as forested areas, steep slopes, ravines, or other large-scale site conditions that affect fire behavior can be required.

*Figure 1.3. Planners can use several approaches to address wildfire hazards for neighborhoods, such as this development near Lake Chelan, Washington (Wildfire Planning International)*

- **Vegetation management** of hazardous fuels can be required for neighborhoods or subdivisions, including the implementation of larger-scale treatments near homes and other neighborhood features (parks and open space management) during the development phase.
- **Water supply** for neighborhoods, such as hydrants, are often required where fire flow (a minimum flow rates of water supply) and pressure allows.

## Building/Lot Scale

This scale focuses on individual structures and their immediate surroundings, such as vegetation or other features on the lot. This scale is often referred to as the *structure ignition zone*.

- **Building materials and construction** standards, including roofing materials, vents, siding, gutters, and windows, should require ignition-resistant materials and construction techniques to reduce exposure to radiant heat, embers, and direct flame contact. Building standards may also apply to accessory dwelling units, sheds, or other structures that pose a vulnerability to primary structures.
- **Building numbering (addressing)** can be required to meet specific, uniform standards to ensure that first responders can easily identify properties.
- **Building siting** standards can ensure that new structures maintain minimum setbacks from slopes and other structures to minimize the increased risk of ignition from radiant or convective heat.
- **Decks and attachments**, such as fences, can also be required to use ignition-resistant or noncombustible materials to reduce the likelihood of ignition, particularly the spread of fire from the attachment to the home.
- **Driveway** requirements can include minimum widths, maximum grades, turnarounds or turnouts on long driveways, and vegetation clearance requirements. This enables easier access for firefighting equipment and safe evacuation routes for residents.
- **Landscaping** standards for individual sites can require the use of fire-resistant plants based on acceptable plant lists. Ongoing vegetation management, such as thinning, spacing, or removal of trees and shrubs (often referred to as *defensible space*), can be required so that landscaping

complies with local fire mitigation standards. Landscaping requirements can also prohibit mulch and other combustible materials within the first five feet of a structure.
- **Water storage** can be required on-site (such as in cisterns) if no other local water supply is available.

## ABOUT THIS REPORT

This PAS Report is designed for readers with different levels of knowledge of the WUI and familiarity with issues related to planning for the WUI.

For planners who are not yet familiar with the WUI, the report provides an in-depth introduction to the WUI, wildfire science, and how planners should consider and address the WUI at different phases of the planning process. For planners who already have a solid understanding of the WUI and its attendant challenges, this report provides a deeper analysis of the challenges, trends, and historical context that will increase their knowledge of factors shaping today's challenges.

For all readers, this report provides practical guidance on how to address the WUI and wildfire challenges in plans, policies, and regulations, and it highlights opportunities for collaboration.

The report is divided into two sections. The first section (Chapters 2–4) describes essential concepts related to the WUI, wildfire management, and understanding hazard and risk. The second section (Chapters 5–7) focuses on what planners can do to address WUI challenges in policies and regulations.

Chapter 2, Understanding the WUI, provides a detailed definition of the WUI. It looks at the history and evolution of the term and trends that have driven growth and development in the WUI. It examines WUI fires across the United States and their impacts, including environmental damage and economic losses. Finally, it looks at the role that planners can play in addressing WUI challenges.

Chapter 3, Breaking the WUI Fire Disaster Sequence, provides an overview of fire science for planners. This chapter addresses the basics of fire science and discusses the natural ecological functions of wildfire. It examines the difference between wildfires and WUI fires and discusses the influence of other factors, including drought and invasive species, on WUI fires.

Chapter 4, Identifying and Assessing Wildfire Hazard and Risk, addresses the difference between wildfire hazard and wildfire risk. It then looks at scales for hazard and risk assessments and the necessary skills and tools for conducting these assessments.

Chapter 5, A Holistic WUI Planning Framework, introduces the second section of the report. It provides an overall planning framework, focused on a holistic planning approach, and addresses challenges that WUI communities may have to consider or balance in their plans and regulations. It also explores how planners can actively engage with other WUI stakeholders.

Chapter 6, WUI Planning Tools, focuses on how planners can address the WUI and wildfire in plans. It discusses the community visioning and engagement processes and includes specific recommendations and practices for incorporating wildfire and WUI considerations into comprehensive, functional, and subarea plans.

Chapter 7, WUI Regulations, discusses regulatory tools that can be used in the WUI. It examines subdivision and zoning regulations, building and fire codes, and WUI regulations—all tools that planners can employ or should have awareness of to address WUI challenges—and shares successful strategies for implementation.

Chapter 8, What Does the Future Hold? provides an overall summary of the report. It also looks at future trends in WUI growth and development and what this means for planners. Finally, it addresses areas for future research.

An appendix to the report offers a glossary of terms that planners should know related to the WUI and wildfire.

CHAPTER 2

# UNDERSTANDING THE WUI

As planners familiarize themselves with the concept of the wildland-urban interface (WUI), it quickly becomes apparent that the WUI is a result of many factors in the natural and built environments. This dynamic nature of the WUI presents many challenges and requires a fundamental shift in views on development and wildfire hazard.

As defined in Chapter 1, the WUI refers to any developed area where conditions affecting the combustibility of natural and cultivated vegetation (*wildland fuels*) and structures or infrastructure (*built fuels*) allow for the ignition and spread of fire through these combined fuels. The WUI is widespread across a diverse range of geographies and landscapes. Planners need not look far to recognize that many developed areas across the country are part of the WUI (Figure 2.1).

Communities often identify specific parameters based on housing and vegetation to spatially define their local WUI. Different conditions, such as vegetation type, topography, and density of structures, will also influence the susceptibility of development and how quickly a wildfire spreads. These conditions can extend into highly urbanized areas and are not necessarily limited to the edge of a community. In addition, there are many undeveloped wildland areas that can

*Figure 2.1. Wildland-urban interfaces exist across the United States, including within the states of (clockwise from top left) California, New Jersey, Colorado, Oregon, Washington, and Tennessee (Wildfire Planning International (top left, top middle, bottom center, bottom right); National Interagency Fire Center (top right); Wildland Professional Solutions (bottom left))*

*Figure 2.2. An intermix WUI (top) and an interface WUI (bottom) have different characteristics related to development patterns and vegetation (NIFC (top), Wildfire Planning International (bottom))*

become a WUI in the future, posing new risks to its residents if development is not located, designed, and maintained with wildfire in mind.

Today's WUI challenges are a result of a complex relationship between previous policies and decisions that influenced settlement patterns, wildland vegetation, and fire suppression and management. Planning for safe and resilient outcomes in the WUI therefore requires a combination of policy and regulatory solutions. Planning solutions must also balance myriad social and ecological objectives, such as the desire for people to connect with and live in natural settings, conservation and restoration of habitats and landscapes, and emerging challenges such as regional droughts and increasing global temperatures.

This chapter provides a more detailed look at the WUI's historical context and helps planners understand how it has become such a challenge. It also makes the connection between the WUI and wildfires and describes the range of impacts that communities can experience from WUI fires. Finally, this chapter helps planners understand that land-use strategies as a solution to the WUI are becoming more important and essential than ever before.

## DEFINING THE WUI

How do planners best make sense of such a conceptually expansive area that is found across the country? The sidebar on p. 22 describes the approach taken by scientists and researchers from the USDA Forest Service and the University of Wisconsin–Madison's SILVIS Lab in defining and identifying the WUI at a national scale. Similarly, local communities typically define the WUI area from a spatial or geographical perspective (Hermansen-Baez, Seitz, and Monroe 2009, 3). This helps local planners, fire officials, and other stakeholders identify what types of community assets are located within the WUI and what activities are necessary to address the threat of wildfire occurring in the WUI.

Two primary classifications are used to spatially define the WUI: intermix and interface (Figure 2.2).

- An *intermix WUI* is where development, such as structures, is interspersed or scattered throughout wildland vegetation. An intermix WUI is often found in rural, exurban, or large-lot suburban developments.
- An *interface WUI* is where development, such as structures, is grouped near areas with wildland fuels. There is a clear line of demarcation between development and vegetation, which may appear as an abrupt edge between a highly urbanized or suburban neighborhood and a wildland area—for example, when development borders public lands or when urban growth boundaries are in place.

Planners may also encounter references to an *occluded WUI*, which describes a situation within an urban environment where structures abut an island of wildland fuels, such as a community park, open space, greenbelt, or other natural area. These isolated areas of vegetation within an urban environment raise challenges similar to those found in an interface WUI.


*Figure 2.3. This community adjacent to New Jersey's Pine Barrens exhibits a combination of WUI areas in close proximity to one another (Wildfire Planning International)*

Communities can have a combination of WUI areas within close proximity. Figure 2.3 illustrates this scenario in a planned unit development in New Jersey that abuts the Pine Barrens, a heavily forested area that stretches across multiple counties. The forested edge creates an interface WUI, while low-density development scattered throughout the Pine Barrens results in an intermix WUI. In addition, pockets of vegetation within the community act as buffers between the golf course and homes, creating occluded WUI areas.

Any type of WUI poses a challenge when local conditions—such as flammable vegetation, combustible housing materials, weather patterns, or topography—allow for wildfire to spread through development. Analyzing the spatial patterns of the WUI helps planners understand different ways in which wildfire may threaten a community, how to mitigate wildfire conditions to reduce their potential impacts, and how land-use planning decisions affect wildfire response and public safety. For example, vegetation management requirements can be easier to implement on larger lot sizes because homes are set back from property lines. Large lot sizes are typically found in a rural intermix WUI compared to an urban interface WUI, which will more often have standard lots. However, intermix WUIs with this development pattern require more costly fire response and suppression resources because homes are scattered across a broader geographic area (Clark et al. 2016). Compact urban areas are more prone to "urban conflagrations"—once fire spreads from neighboring wildlands to a single structure, it can quickly affect multiple structures. These and other structure ignition concepts are discussed in greater detail in Chapter 3.

A WUI spatial assessment (i.e., map) is typically based on the distribution of housing units and wildland vegetation within an area (Figure 2.5, p. 23). However, there are many other local assets that can be threatened by wildfire, including the following:

- critical infrastructure: highways, bridges, railroads, utilities, water supplies, communication sites
- critical facilities: hospitals, schools, government buildings, emergency response stations
- commercial and economic activities: tourism, businesses, agricultural lands, ranches
- parks and natural areas: watersheds, forests, recreational areas, historic and cultural resources

## WHERE IS THE WUI?

A national team of scientists and researchers from the USDA Forest Service and the University of Wisconsin–Madison's SILVIS Lab quantified the country's WUI (Figure 2.4). Based on their calculations, the land area of the entire WUI in the conterminous United States is 770,000 square kilometers (297,299 square miles). This equates to 9.5 percent of the total land area within the lower 48 states (Radeloff et al. 2018, 1).

As of 2010, the estimated population living in the WUI was 99 million, approximately one-third of the total U.S. population, and the number of housing units in the WUI was 43.4 million (Martinuzzi et al. 2015, 12). The states with the highest number of houses in the WUI were California (4.46 million) and Texas (3.22 million). Other states with high numbers of houses in the WUI include Florida, North Carolina, and Pennsylvania.

The SILVIS Lab's approach spatially defines the WUI based on the criteria of housing unit density and landcover (Radeloff et al. 2005, Stewart et al. 2007). The following definitions can be used or modified by communities as the basis for developing a local WUI assessment.

- **WUI Intermix**: Areas with 6.18 houses or more per square kilometer and 50 percent or greater cover of wildland vegetation
- **WUI Interface:** Areas with greater than or equal to 6.18 houses per square kilometer and less than 50 percent cover of vegetation located less than 2.4 square kilometers of an area greater than or equal to five square kilometers in size that is greater than or equal to 75 percent vegetated
- **Non-WUI Vegetated (no housing)**: Areas with greater than or equal to 50 percent cover of wildland vegetation and no houses (e.g., protected areas, steep slopes, mountaintops)
- **Non-WUI (very low housing density)**: Areas with greater than or equal to 50 percent cover of wildland vegetation and less than 6.18 houses per square kilometer (e.g., dispersed rural housing outside neighborhoods)
- **Non-Vegetated or Agriculture (low and very low housing density)**: Areas with less than 50 percent cover of wildland vegetation and less than 49.42 houses per square kilometer (e.g., agricultural lands and pasturelands)
- **Non-Vegetated or Agriculture (medium and high housing density)**: Areas with less than 50 percent cover of wildland vegetation and greater than or equal to 49.42 houses density per square kilometer (e.g., urban and suburban areas, which may have vegetation, but not dense vegetation).

Areas classified above as "non-WUI" may still be considered as part of the WUI at the local level when there are structures present. Areas classified as "non-vegetated or agriculture" should still be considered as part of the WUI if ember exposure is expected.

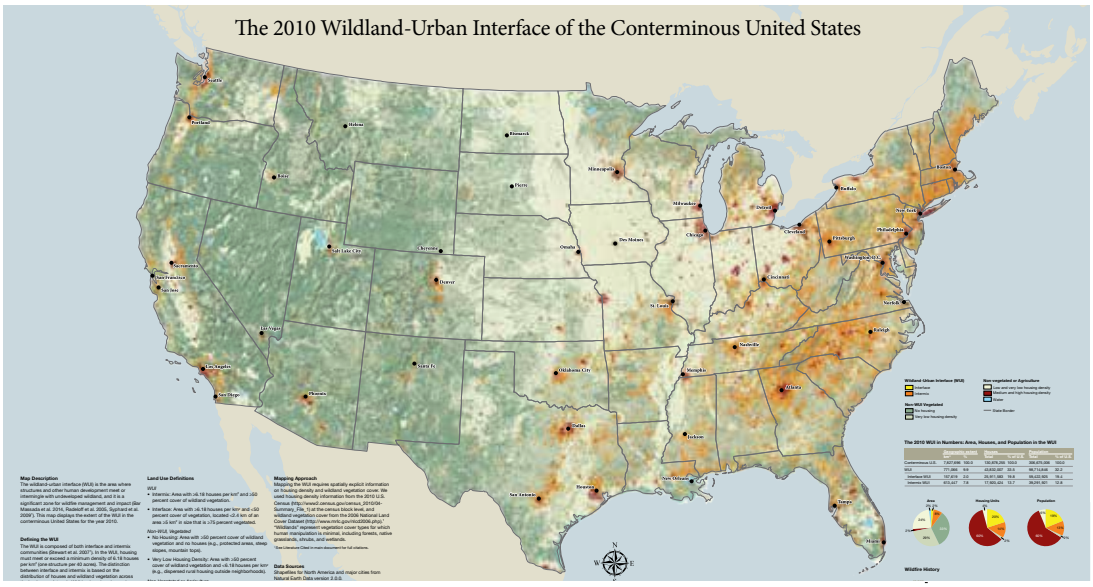



*Figure 2.4. The 2010 wildland-urban interface of the conterminous United States (USDA Forest Service)*

It's important to keep in mind that many of these other assets are often located in close proximity to residential development, even if not included in a WUI map.

A WUI map is different from a wildfire hazard and risk assessment. WUI maps show "values" in proximity to vegetation. Values are identified by a community as having measurable or intrinsic worth that could be negatively impacted by a wildfire. Common community values that are included in WUI maps are housing and other development features (e.g., roads, critical infrastructure, and parks). Planners use a WUI map to define geographic areas within a jurisdiction that should be subject to specific WUI policies or regulations.

Wildfire hazard maps identify local conditions related to vegetation, topography, and other factors, and display the potential likelihood and intensity of wildfires occurring within a defined area. Wildfire risk maps are based on wildfire hazard maps and include the susceptibility of structures or other values within a defined area. Wildfire hazard and risk maps help inform planners in making decisions that relate to current and future WUI areas, such as where there may be geographic areas that are inappropriate to develop based on their level of hazard or risk, or where more mitigation may be required to minimize impacts to developed areas. Chapter 4 discusses in more detail how local conditions contribute to wildfire hazard or risk and explores the relationship between these different spatial tools.

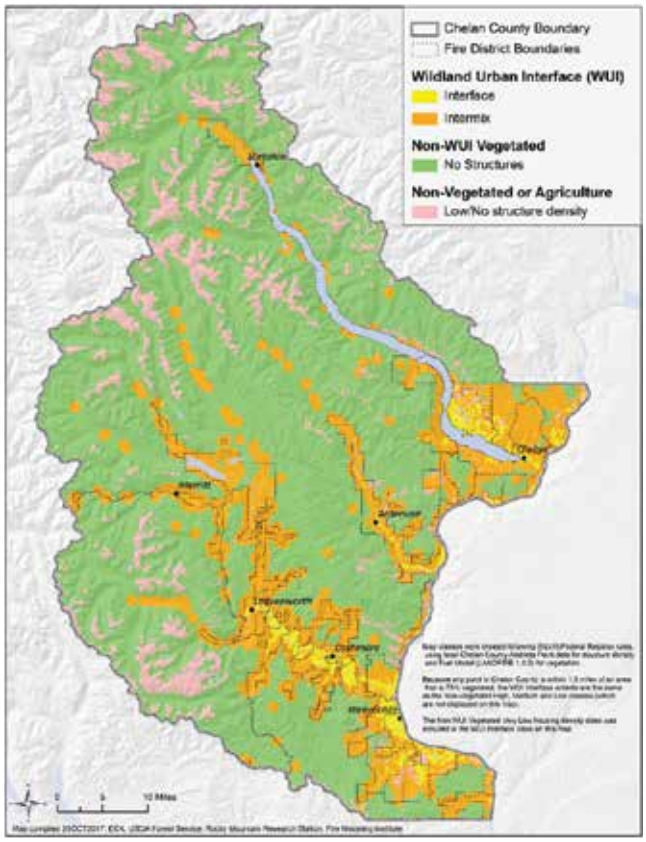



*Figure 2.5. WUI maps, such as this example from Chelan County, Washington, identify where development and vegetation meet specific parameters for intermix or interface WUIs (Community Planning Assistance for Wildfire)*

## HISTORY OF THE WUI

Today's WUI challenges did not occur overnight. The "urban-wildland interface" concept was first introduced in the 1970s by C.P. Butler, a senior physicist at the Stanford Research Institute. The term (which later became "wildland-urban interface") was used to describe a situation related to urban development and wildfires that was gaining recognition:

> In its simplest terms, the fire interface is any point where the fuel feeding a wildfire changes from natural (wildland) fuel to man-made (urban) fuel. . . . For this to happen, wildland fire must be close enough for its flying brands or flames to contact the flammable parts of the structure. (Cohen 1999, 189)

However, the history of the country's extensive WUI began long before the 1970s. Many of today's WUI challenges can be traced back to policy and development decisions that unfolded over the last century, primarily related to two factors:

- rapid expansion of development into wildfire-prone areas, including homes and road networks that increased access to previously remote areas
- national fire policy that excluded wildfires from our natural environments, leading to increased vegetation and more extreme fire conditions

In addition, influences such as climate change have emerged and are now also shaping the social and physical landscape related to the WUI.

### Rapid Expansion into Wildfire-Prone Areas

Beginning in the mid-19th century, increasingly efficient and cost-effective transportation methods enabled faster and easier access into previously undeveloped areas. The first major land-based transportation method that moved large groups of people and goods was the railroad. With the first transcon-

## RECENT GROWTH IN THE WUI

The WUI is now a sizeable land-use type due to its recent growth. Between 1990 and 2010, the number of houses located in the WUI grew from 30.8 to 43.4 million units (Radeloff et al. 2018). These 12.6 million new housing units were added across all 48 conterminous states. Many western counties experienced the highest WUI growth rates, as illustrated in Figure 2.6. Despite known risks that wildfires pose to lives and property, over 100,000 houses were added to areas that corresponded with previous fire perimeters.

Social and economic changes have also resulted in the number of new housing units outpacing population growth over the past 70 years, including smaller households, more single-parent households, fewer multigenerational households, and increasing purchases of second and even third or fourth homes for vacation, seasonal, or investment opportunities (Martinuzzi et al. 2015, 14).

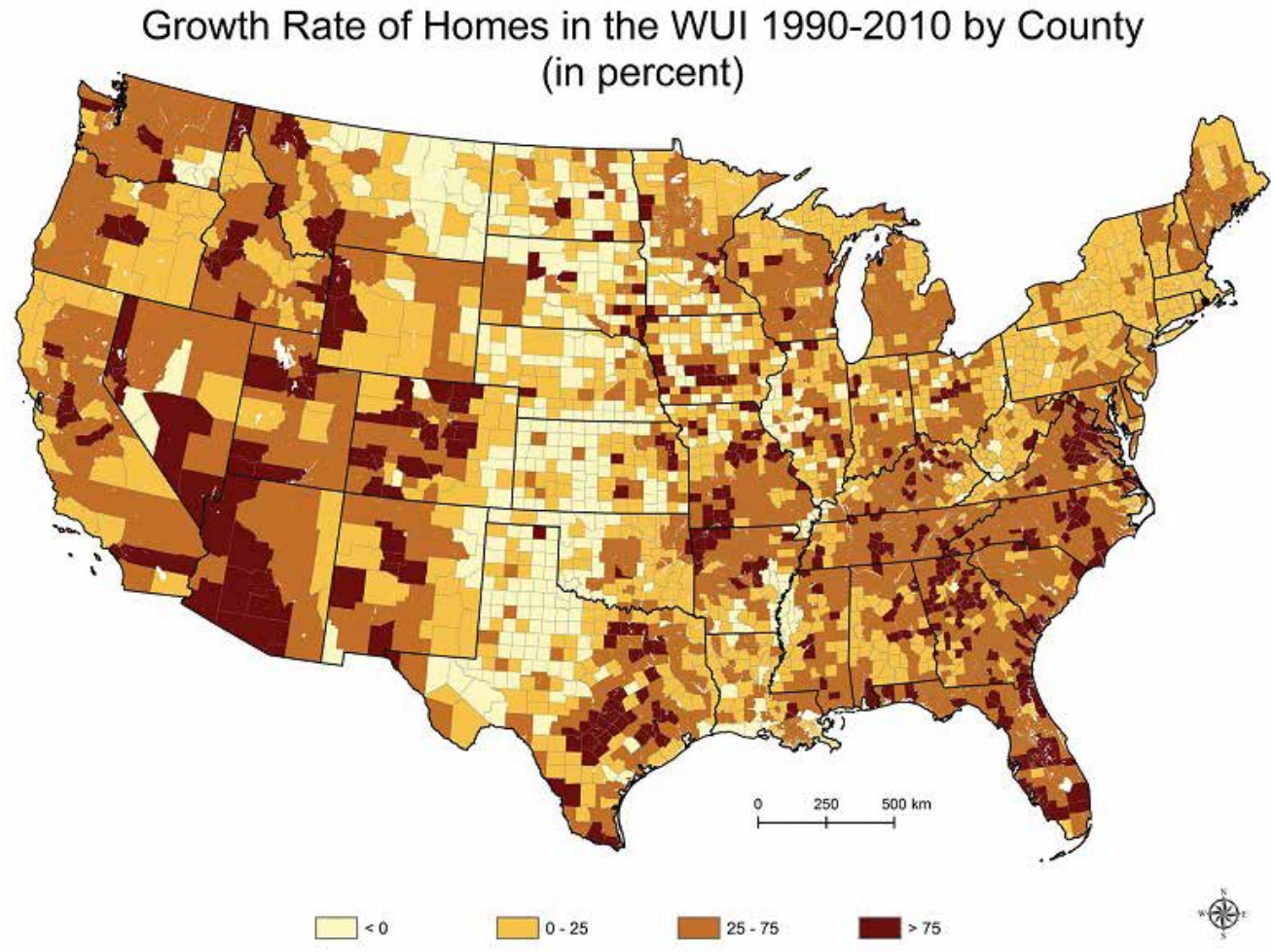



*Figure 2.6. Growth rate of homes in the WUI 1990–2010 by county (in percent) (USDA Forest Service)*

tinental railroad, the Pacific Railroad, completed in 1869, rail systems connected states and territories across the country and enabled settlements to push further west, resulting in new towns and communities (Wheaton 2011, 1–2).

The advent of automobiles in the early 1900s—most notably Henry Ford's invention of the Model T and moving-assembly-line technology—further increased individual mobility and independence (Brooke 2008, 13). Cars quickly became affordable for families and allowed them to move further away from bus lines or rail-dependent urban environments. Increases in automobile traffic also led to pressure for local, state, and federal governments to make road improvements and construct new highways that further accelerated the spatial expansion of transportation networks away from urban centers.

Linked closely to the automobile industry's growth was the steady upward trend of population growth and development. Although rural settlement and land purchase programs that encouraged expansion and home ownership date back to the 1800s, more recent influences on the WUI emerged during the suburban housing boom in the second half of the 21st century. This boom resulted from several factors: a pent-up demand for new homes that had been mounting since the end of the 1920s; national programs that encouraged housing for veterans returning from World War II; new families seeking a change from downtown environments that were beginning to experience neglect and decay; suburban flight in an era of desegregation; and policies that favored suburbanization over urban revival (Schilling and Mallach 2007, 8). Over time, first-ring suburbs grew into second-, third-, and fourth-ring suburbs—many of which expanded into wildfire-prone areas.

As some cities and towns have grown at their suburban edges, other regions, particularly in the South and West, are witnessing a rapid conversion of undeveloped or agricultural land into new communities. These patterns have been driven by different factors, including housing affordability, economic opportunities, or preferences for living in more favorable climates (Schilling and Mallach 2007, 8). Collectively over the past century, many U.S. inhabitants have migrated from older, compact cities in pursuit of other lifestyles and environments—suburban, rural, exurban, forested, and wildland areas. These factors continue to influence WUI growth rates across the United States, as discussed in the sidebar on p. 24.

## Fire Exclusion Policy

While development was expanding across the United States and into wildland areas (now known as the WUI), another set of land management decisions occurred that would later affect the size and intensity of wildfires.

Prior to European settlement, fire was used by Native Americans as a tool to manage agricultural lands and hunting habitat. Some early European settlers continued this practice and also used fire to reduce the amount of vegetation to decrease fuel for future fires (Stein et al. 2013, 8). By the early 20th century, however, a rapidly growing United States relied heavily on raw timber for industrial products, including railroad tracks, housing, and commercial buildings. Large, intense fires that destroyed forests were seen as an economic threat to industrial growth and economic development, and using fire was no longer deemed a desirable land management practice.

The wildfire threat caught national attention in 1910 when multiple fires occurred across the western United States during a drought year. The largest was the Big Blowup (also called the Big Burn), a complex of wildfires that charred more than three million acres of private and federal forest land, totaling 7.5 billion board feet of timber. At least 78 firefighters were killed and 85 total fatalities were recorded (Leuschen and Davis 2010; Miller and Cohen 1978, 47). Multiple towns in Idaho and Montana were significantly damaged or destroyed.

Although the Big Blowup was preceded by a number of destructive fires, it proved to be a tipping point in policy changes for fire response and suppression. The 1910 fire season contributed to the passage of the Weeks Act in 1911, which allowed the use of federal funding to purchase private land for conservation in the eastern United States. The act also called for fire protection efforts through federal, state, and private cooperation. The resulting effect was to centralize fire protection under the guardianship of the USDA Forest Service (Pyne 1982, 250).

Following the Weeks Act, the Forest Service sought to bring uniformity and expertise to protecting national natural resources from fire and demonstrate how professional forestry methods could manage fire (Pyne 1982, 264). As the Forest Service evaluated fire policy, some experts within the agency argued for letting wildland fires burn under certain circumstances to allow for the benefits of fire (Cohen 2008, 21).

Ultimately, however, in 1935 the Forest Service adopted the "10 a.m. policy," which required that all wildland fires be suppressed by 10 a.m. the following day. This policy was intended to eliminate the threat of large, out-of-control wildfires that threatened towns and, even more importantly at the time, timber resources. As a result, annual acreage consumed by wildfires in the lower 48 states dropped significantly beginning in the 1930s (Cohen 2008, 21).

*Figure 2.7. The impacts of climate change, including drought-stricken forests and increases in invasive species, affect the severity and size of wildfires and may further limit the capacity of fire agencies to suppress wildfires (National Interagency Fire Center)*

The significance of this policy history is that over time wildfire suppression dramatically changed ecosystems and the public's perception of wildfire. Without fire, wildland areas experienced an unnatural build-up of fuel, such as shrubs and smaller trees, which competed for water and sunshine. Tree species and habitats that once thrived from low-intensity fires were now threatened or weakened with the ongoing exclusion of fire and fuel accumulation (Cohen 2008, 21–22). Society grew accustomed to a natural world without fire, including the general misconception that all fires resulted in negative outcomes. Whereas previous generations carried knowledge or understanding of fire in the landscape, a new culture of inhabitants in wildfire-prone areas largely did not identify fire as part of the natural environment.

## Other Influences on the WUI

As described above, rapid urbanization and fire exclusion policies have dramatically shaped today's WUI, putting more people in wildfire-prone areas with the increased likelihood for high-intensity wildfires. Other human-caused actions have created unique challenges for some areas. For example, mining activities that occurred across the West dating back to the 1800s have resulted in a number of claims in rugged, wildfire-prone terrain. This patchwork of parcels can be difficult for communities to cohesively manage through land-use planning mechanisms, and this can lead to WUI growth in less-than-ideal locations.

Another influence that is adding urgency to the WUI situation is climate change. Over the past century, human activities such as the burning of fossil fuels have contributed to an increase in global emissions of carbon dioxide, methane, and other heat-trapping greenhouse gases (NASA 2018). Increased emissions are now causing measurable changes to the earth's land, atmosphere, and oceans. Broad consequences of climate change include warmer temperatures, rising sea levels, changes to plant and animal species, and an increase in extreme weather events, including wildfires (Figure 2.7).

Climate change is impacting the intensity, frequency, and pattern of wildfires, and the effects of climate change related to wildfires are inextricably linked to previous land-use decisions. This complex relationship has resulted in increased wildfire activity in the western United States, where

## *DESIGN FOR DISASTER*—THE STORY OF THE BEL AIR CONFLAGRATION

A year after the 1961 Bel Air Fire, members of the Los Angeles Fire Department produced the informational film *Design for Disaster*. The 26-minute film highlighted the confluence of factors that contributed to the disaster and discussed California's growing fire problem in terms of a rapid migration of people into the Los Angeles area, a climate warmed by Santa Ana winds, and residential areas perched on hillsides surrounded by flammable vegetation. As narrated by William Conrad:

*This climate plays an important part in attracting over 3,000 people a month to the city of Los Angeles to become permanent residents. . . . And some move up to the scenic secluded hill areas, where lush California vegetation softens the ridges and valleys for miles in every direction. And breezes blow clean through native growth, and increasingly strong during the late fall months of the Santa Ana and dangerously dry when there has been no rain. It is during this unstable period that firefighters most fear the potential of 134 square miles of thick, dry chaparral and oak, all within the city boundaries of Los Angeles, classed by experts as the fastest-burning ground cover in the western hemisphere. And nestled in that cover, one of the greatest concentrations of high-value homes in America, a serious problem in fire protection in even under the best conditions.*

The video contains rare footage from the Bel Air and Brentwood neighborhoods, including scenes of burning homes, fire response and suppression, and the aftermath of the fire's destruction. Importantly, it poses a central question: How can a brush fire get so out of control within a well-protected city?

*Design for Disaster* analyzes how fire behavior in canyons may change and identifies factors that may enhance fire extinguishment or contribute to home destruction, including:

- Amount of clearance around a home
- Location of homes on top of canyon ridges
- Construction of homes, including combustible wooden roofs; big picture windows; and wide, low eaves

Also acknowledged are challenges posed by traveling embers, primarily in the form of burning wood shingles, that were carried ahead of the fire to ignite new spot fires, overwhelming resources and creating a unique conflagration fire problem. "No one has ever faced this problem before. No definite line of defense could be found, and when a chain reaction of this type occurs, a fire department can do nothing more than pick out individual houses and try to save them."

*Figure 2.9. A scene from* Design for Disaster *showing destruction of a neighborhood following the Bel Air Fire (screenshot of video by Wildfire Planning International)*

The film closes by revealing that in 1959, two years before the fire, experts from the National Fire Protection Association surveyed portions of Los Angeles. They found a "mountain range within the city, combustible-roofed houses closely spaced on brush-covered ridges and canyons, serviced by narrow roads. They called it a design for disaster. They predicted the Bel Air Fire, plus others which are sure to come . . ."

The full video (CC BY) is available at www.youtube.com/watch?v=yj0rfeF5GbA.


*Figure 2.8. Screen shots from the* Design for Disaster *video (compiled by Wildfire Planning International)*

between 1986 and 2003 wildfires occurred nearly four times as often and burned more than six times the land area when compared to the period between 1970 and 1986 (Union of Concerned Scientists 2013).

Specific regions in the United States can expect to see these or other trends continue. Research indicates that increased temperatures and less frequent and predictable precipitation will result in an overall increase in the number and size of wildfires due to hotter and drier fuel conditions as well as increased incidence of drought and tree mortality. Significant increases in lightning-ignited wildfires are projected in the Southeast due to climate change's interaction with moisture and atmospheric conditions (USGCRP 2017). Climate change will also extend the length of the fire season by adding more days above a specific temperature at the start and end of the prior fire season cycles (De Groot et al. 2013).

Under a warmer and drier future climate, fire management agencies will be challenged by these fire weather conditions. This could push current suppression capacity beyond a tipping point, resulting in a substantial increase in large fires (De Groot et al. 2013). With limits to firefighters' ability to control wildfires, the need for addressing the WUI through land-use planning at the local level and other mitigation activities becomes greater than ever.

## WILDFIRES IN THE WUI

A wildfire involving the combined fuels of natural vegetation with structures or infrastructure is referred to as a *wildland-urban interface (WUI) fire*.

There is no official consensus on the first WUI fire. In fact, communities have experienced the devastating impacts of wildfires since the early days of European settlement—most strikingly in areas that were logged or where other industrial activities and development occurred. One of the most deadly examples is the fire that occurred in Peshtigo, Wisconsin, in 1871, which killed at least 1,500 people and scorched more than 2,400 square miles (Schwab and Meck 2005, 23). Other significant wildfires during that time happened in Michigan (1881), Minnesota (1894), and New York (1903) (Cohen 2008, 1).

This troubling trend of wildfire disasters in urbanized or developed areas continued during the 20th century. In 1923, 584 structures in Berkeley, California, were destroyed when a fire began in chaparral and grasslands and entered nearby neighborhoods (Schwab and Meck 2005, 28). Several decades later, on the opposite coast, the historic 1947 Maine Fires left 2,500 people homeless when fires destroyed 851 homes and 397 seasonal cottages (New England Historical Society 2017).

A similar disaster occurred on November 6th, 1961, when a brush fire began in the Bel Air neighborhood in Los Angeles. The fire, driven by Santa Ana winds, spread quickly into the nearby Brentwood neighborhood. Within a two-day period, the fire destroyed 484 homes (Borden 2015). No lives were lost, but the Bel Air Fire caught national attention after many Hollywood celebrities' homes were burned. *Life Magazine* dubbed it "a tragedy trimmed in mink" (Harrison 2017). The sidebar on p. 27 highlights the informational film produced by the Los Angeles Fire Department following the disaster.

The Bel Air Fire elevated discussions on where we live and how we build in wildland areas. The Los Angeles Fire Department and other experts looked at the contributing factors that led to home destruction, such as flammable roofs and the location of homes on vegetated hillsides. As a result, the Bel Air Fire prompted changes to local wildfire safety policies and laws, including the initiation of a brush clearance program and a ban on wood shake or shingle roofs (Borden 2015). The dynamics of what leads to a WUI fire and appropriate mitigation strategies are discussed in detail in Chapter 3.

Wildfires continue to affect WUI communities across the country. Table 2.1 (p. 29) provides a wide sampling of wildfires that have occurred since the 1961 Bel Air Fire and their associated structure losses, which may include homes, commercial properties, apartment buildings, and outbuildings (barns, garages, sheds), where data is available. This list is not comprehensive—many other WUI fires resulting in structure losses have occurred in states not listed, including Georgia, New York, Minnesota, and Oregon. Many wildfires occurring during this period resulted in fatalities. However, Table 2.1 highlights the widespread nature of structure losses that have occurred from WUI fires in recent decades.

### WUI Fire Impacts

The list of WUI fires in Table 2.1 focuses on one outcome from WUI fires: structure losses. The effects of structure losses are significant and cause sizeable ripple effects on the community, including the long-term displacement of residents, economic setbacks, emotional distress, and disruptions to daily life.

There are many other tragic and wide-ranging social, economic, and environmental impacts that can occur from wildfire events. A publication from the National Institute of Standards and Technology (Thomas et al. 2017) comprehensively captures the scope of these potential impacts, which include the following:

## TABLE 2.1. SIGNIFICANT STRUCTURE LOSSES FROM WUI FIRES IN THE UNITED STATES, 1980–2018

| Year | Fire | Location | Structures Destroyed | Source |
|---|---|---|---|---|
| 1980 | Mack Lake | Michigan | 44 | NWCG 2009 |
| | Panorama | California | 325 | NIFC 2013 |
| 1985 | Palm Coast | Florida | 250 | St. Johns County 2018 |
| 1990 | Painted Cave | California | 641 | CAL FIRE 2019b |
| | Dude | Arizona | 63 | NIFC 2013 |
| 1991 | Spokane "Firestorm" | Washington | 108 | Cohen 2008 |
| | Tunnel/East Bay Hills | California | 2900 | CAL FIRE 2019b |
| 1992 | Fountain | California | 636 | CAL FIRE 2019b |
| 1996 | Millers Reach (Big Lake) | Alaska | 344 | NIFC 2013 |
| 1998 | Florida Fires | Florida | 150 | USFA 1998 |
| 2000 | Cerro Grande | New Mexico | 235 | NIFC 2013 |
| 2002 | Hayman | Colorado | 600 | NIFC 2013 |
| | Rodeo-Chediski | Arizona | 426 | NIFC 2013 |
| 2003 | Aspen | Arizona | 340 | Cohen 2008 |
| | Cedar | California | 2820 | CAL FIRE 2019b |
| | Old | California | 1003 | CAL FIRE 2019b |
| 2006 | Texas-Oklahoma Fires | Texas and Oklahoma | 723 | Cohen 2008 |
| 2007 | Witch | California | 1650 | CAL FIRE 2019b |
| | Harris | California | 548 | CAL FIRE 2019b |
| 2009 | Highway 31 | South Carolina | 76 | South Carolina Forestry Commission 2018 |
| | Little Bear | New Mexico | 242 | McCaffrey et al. 2013 |
| 2011 | Bastrop | Texas | 1400 | NIFC 2013 |
| 2012 | Waldo Canyon | Colorado | 346 | NIFC 2013 |
| 2013 | Black Forest | Colorado | 489 | CO DHSEM 2015 |
| | Germann Road | Wisconsin | 104 | WI DNR 2018 |
| 2014 | Carlton Complex | Washington | 343 | Kershner 2014 |
| 2015 | Butte | California | 921 | CAL FIRE 2019b |
| | Valley | California | 1955 | CAL FIRE 2019b |
| 2016 | Anderson Creek | Kansas and Oklahoma | 40 | Engholm 2016 |
| | Chimney Tops 2 | Tennessee | 2460 | Badger 2017 |
| 2017 | Nuns | California | 1355 | CAL FIRE 2019b |
| | Thomas | California | 1063 | CAL FIRE 2019b |
| | Atlas | California | 783 | CAL FIRE 2019b |
| 2018 | Carr | California | 1604 | CAL FIRE 2019b |
| | Camp | California | 18,804 | CAL FIRE 2019b |

*Note: Reported structure losses in Table 2.1 are based on a number of different sources; there is no single database that tracks this information comprehensively across the United States.*

## EARLY WUI GUIDANCE

The idea of taking proactive steps to reduce wildfire risk in the WUI is not new. In 1935, the Forest Committee of the National Fire Protection Association (NFPA), in cooperation with the USDA Forest Service and other organizations, published a technical guide entitled "Fire Protection and Prevention for Summer Homes in Forested Areas" (NFPA Forest Committee 1935). The purpose of the guide was to provide fire prevention measures for summer homes in response to the growing threat of wildfire and structure loss in forested areas across the United States and Canada.

The guide recommended prevention measures such as locating buildings between streams and roads, and away from other buildings; using fire-resistant roofing; keeping needles and leaves away from roofs; and trimming tree branches close to buildings. Recommendations came at a reasonable price: 10 cents.

Although knowledge and understanding of effective WUI measures has expanded since then, this guide helped lay the groundwork for many topics that planning departments and fire agencies still consider when seeking to reduce wildfire risk in the WUI.

- **Deaths.** Many wildfires, including several of those fires listed in Table 2.1, result in resident and firefighter fatalities, primarily from fire exposure, vehicle-related accidents, and heart attacks during a wildfire event. In addition, the effects of chronic smoke exposure from medium and large wildfires have been shown to contribute to respiratory- and cardiovascular-related deaths.
- **Physical and psychological impacts.** Wildfires can have a traumatizing effect on both civilians and firefighters, who may sustain physical injuries or mental and emotional trauma such as depression, anxiety, and post-traumatic stress disorder. Other adverse health impacts include chronic respiratory symptoms, such as increased instances of asthma attacks, coughing, and wheezing.
- **Economic losses.** WUI fires are costly both to suppress and recover from. Economic impacts can stem from lost tourism dollars, interruption to businesses and governmental services, failed infrastructure, evacuation and emergency shelter needs, and lost tax revenues when an area fails to fully rebound.
- **Environmental damage.** In severely burned areas, it can take decades to rehabilitate soils and vegetation, leading to other hazard concerns such as post-fire flooding. Runoff from wildfire-affected areas also has negative effects on aquatic ecosystems and water treatment plants, requiring expensive mitigation measures.
- **Timber and agriculture loss**. Loss of timber resources, agricultural lands, livestock, and outbuildings due to fire significantly affect the livelihoods of land managers, including farmers and ranchers.

Wildfire-related impacts can be particularly detrimental to socially vulnerable populations. A recent study found that more than 29 million Americans live with significant potential for extreme wildfires, a majority of whom are white and socioeconomically secure. However, the study also identified 12 million socially vulnerable Americans (communities with a high percentage of low-income or nonwhite demographics) for whom a wildfire event could be devastating (Davies et al. 2018). The study highlights how wildfire vulnerability is spread unequally across race and ethnicity—census tracts that are majority African American, Hispanic, or Native American are more likely to experience outsized impacts from wildfire events compared to other populations that have more socioeconomic advantages to prepare for and respond to wildfires.

For example, many economically disadvantaged residents—including those in rural areas, low-income neighbor-

hoods, and immigrant communities—who owned or rented homes destroyed during the 2017 California wildfires faced significant challenges finding affordable housing in the area during the recovery phase (Gudell 2017), or they lacked access to the resources necessary to pay for insurance, rebuilding, and continuing investments in fire safety (Davies et al. 2018). Research has also shown that elderly populations have increased risks of hospital admissions for respiratory diseases during severe wildfire episodes (Liu et al. 2017). Elderly and other vulnerable populations may also face increased risk during wildfire evacuations due to limited mobility.

Finally, wildfire losses and associated impacts bring new levels of uncertainty to communities and residents. For example, private insurance companies in hard-hit areas are increasing premium rates or pulling out of the market based on property losses, damages, or increased wildfire hazard (Newberry 2018). This raises concerns of market instability and questions about future affordability. Vegetation losses during a wildfire also lead to a release of sequestered carbon into the atmosphere, further exacerbating the effects of climate change and its future impacts.

## PLANNING IN THE WUI

With so many troubling trends and devastating outcomes, why does the WUI keep growing, and why aren't more communities engaged in strategies to minimize the negative impacts of wildfire and increase local resiliency through land-use planning in the WUI? The answers vary.

Despite the risks related to wildfire, living in the WUI remains an appealing option for many. Reasons for living in the WUI include the desire for privacy or a closer connection to nature, proximity to outdoor and recreational opportunities, or more affordable housing options (Martinuzzi et al. 2015, 12). While there may be growing uncertainty in some geographic-based markets, incentives such as response aid and wildfire insurance continue to facilitate settlement into other fire-prone landscapes (Davies et al. 2018).

In addition, the WUI fire problem has largely been framed as a responsibility of either wildland or structural fire organizations to quickly "put out the fire," but the question of who pays for these resources may be contributing to the growth problem. Protecting WUI areas is different than protecting urban areas from structural fires. An urban fire protection model is typically based on a large pool of residents who pay a nominal fee and receive fairly distributed resources across a designated geographic area.

By comparison, wildfire risk is based on a variety of local factors that can lead to high-, medium-, and low-risk areas across the WUI. Because the federal government bears a large share of the costs to fight wildfires, firefighting in the WUI is paid for by all taxpayers. However, only a small proportion of recipients based on wildfire risk will benefit from this cost. This represents a transfer of wealth to a relatively small group of home owners in locations with high wildfire risk (Baylis and Boomhower 2018, 2). This guarantee of federal protection also generates moral hazard, as home owners are not internalizing the expected costs of future fire protection when choosing where or how to live, nor are local governments internalizing firefighting costs during land-use planning and other development decisions (Baylis and Boomhower 2018, 3).

Meanwhile, governmental and nongovernmental agencies at the local, state, and federal levels, combined with nonprofit community groups, home owners associations, and other interested parties, have been tackling the WUI challenge as awareness of wildfire disasters is growing. However, these efforts have largely focused on activities such as voluntary neighborhood-based programs to help residents learn mitigation techniques and evacuation safety tips, landscape-scale fuel management projects, and collaborative planning efforts to coordinate risk reduction activities. These are essential efforts, but they do not address WUI development outcomes that result from land-use planning decisions.

On a broader level, community development and planning departments and elected officials are often balancing multiple goals when planning for growth, including economic opportunities, affordable housing, and private property rights. These decisions can conflict with redirecting development away from wildfire-prone areas. Planners may also have limited technical capacity for identifying appropriate WUI planning strategies, while elected officials may be unaware of the additional risks when approving final development decisions. In addition, there is typically no one-size-fits all approach to WUI planning solutions (Rasker, Mowery, and Wafaie 2015), making it more challenging to find quick and effective fixes.

However, understanding how to mitigate wildfire risk to structures is not a new concept. More importantly, the essential role of land-use planning to address the WUI has been growing steadily:

- The National Cohesive Wildland Fire Management Strategy—a national strategy borne out of the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009, discussed in Chapter 5—lists creating fire-adapt-

ed communities as one of three primary efforts to address national wildfire challenges. Strategies to become fire adapted include land-use planning, zoning, and regulatory options to increase fire resilience across communities.
- Recent publications focused on WUI risk management from federal agencies and national associations, including the USDA Forest Service, NFPA, and APA, cite land-use planning and zoning in the list of solutions to reduce the risk of home losses in the WUI (e.g., Calkin et al. 2013; Mowery and Anthony 2012; NFPA 2013).
- Technical assistance programs, including the national Community Planning Assistance for Wildfire (CPAW) program and California's statewide Land Use Planning Program, are further promoting awareness of wildfire issues and helping local planners learn about and better plan the WUI.

As awareness of the WUI and planning's role in shaping the WUI has grown, so too has the understanding of what exactly planners can do to address community wildfire risk. Opportunities for improving outcomes in the WUI occur at multiple scales and junctures in the planning process, as discussed in the second section of this report.

## CONCLUSION

The WUI is any area where human development meets or intermixes with wildland vegetation. The combination of this development and vegetation has the potential to result in negative impacts from wildfire on these communities, including fatalities, psychological impacts, economic losses, and long-term environmental damage. The WUI varies based on local conditions such as the amount and type of vegetation, topographical features, and the density and pattern of development. Communities typically conduct a spatial assessment based on the number of housing units and distribution of vegetation to define the local WUI.

Several early influences contributed to the extent of today's WUI and the ways in which wildfire can increase the threat to communities. These influences include rapid development during the last century that has led to sprawling suburbs in wildland areas, a history of fire exclusion that has resulted in more extreme fire conditions, and the emerging effects of human-caused climate change. All of these factors—climate/weather, wildland and built fuels, and decisions made by people—are affecting the pattern, frequency, and intensity of wildfires, and are leading to devastating WUI fires across the United States. Community impacts extend well beyond fire perimeters and require years of long-term recovery activities.

However, growing awareness of the WUI and wildfires has led to interest in how the land-use planning toolkit can be leveraged to address these concerns. Planners can proactively change where and how development occurs in wildfire-prone areas, advance mechanisms for addressing current development in the WUI, and support long-term recovery in communities affected by wildfire. Planning can both minimize damage to an existing WUI and limit the extent of at-risk WUI communities in the future. Solutions include developing sound planning policies for wildfire within community plans, establishing linkages between wildfire mitigation and land-use planning activities, implementing and enforcing regulatory requirements, and exploring innovative standards for land uses. A further analysis of wildfire and WUI conditions that lead to disasters is discussed in Chapters 3 and 4; specific land-use solutions are detailed in Chapters 5 through 7 of this report.

CHAPTER 3

# BREAKING THE WUI FIRE DISASTER SEQUENCE

Understanding the dynamic elements of wildfire and the wildland-urban interface (WUI) disaster sequence can help planners understand their role in breaking it. Specifically, planners and elected officials must have a basic understanding of wildland fire as a natural process, how fire ignites and spreads, how wildfires manifest into a WUI disaster, and how implementing the basic science of WUI mitigation can change these outcomes.

This chapter introduces planners to the basic science, concepts, and terminology important in understanding WUI fire disasters. This information, along with the basics of wildfire hazard, risk, and susceptibility discussed in Chapter 4, provides the building blocks in connecting land-use planning to WUI mitigation.

## DEFINING WILDFIRE

*Wildland fires* are defined as any nonstructure fire that occurs in vegetation or natural fuels (NWCG 2018). These include planned prescribed fires and wildfires. *Wildfires* are unplanned wildland fires that result in a negative impact to human values (e.g., human life, economic drivers, structures, infrastructure). A fire involving the combined fuels of vegetation with structures or infrastructure (i.e., built fuels) is referred to as a *wildland-urban interface (WUI) fire*.

In the United States, there are two primary ignition sources for wildfires: humans and lightning (Figure 3.1). Based on data from a 17-year period (2001–2017), the National Interagency Fire Center (2018) reports that humans cause an average of 61,952 (86 percent) of fires per year and are responsible for 2.7 million acres burned each year. Conversely, lightning is responsible for an average of 10,143 (14 percent) of wildfires each year and an average of 1.5 million acres burned each year. This ratio can vary regionally and locally. Human causes of wildfire include:

- Arson
- All-terrain vehicles
- Campfires
- Debris burning/agricultural burning
- Discarded cigarettes
- Industrial activity
- Power lines
- Railroads
- Structure fires
- Target shooting
- Vehicle fires

WUI fire disasters occur when a fire escapes the initial attempts to suppress it (*initial attack*) and progresses to structure involvement, multiple structure involvement, and finally an urban conflagration where multiple structures burn unchecked. Jack Cohen, PHD, a scientist now retired from the USDA Forest

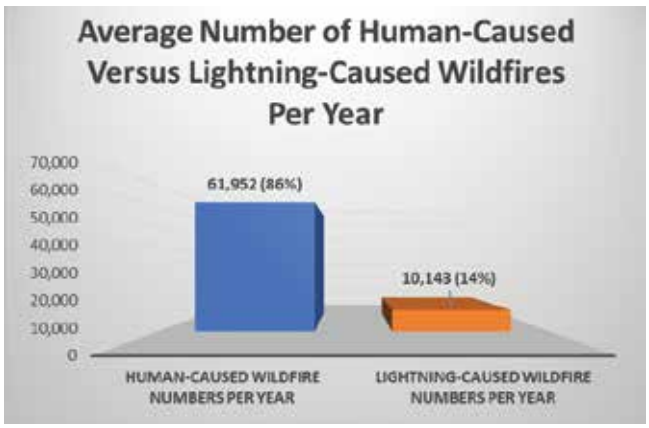



*Figure 3.1. Comparison between the average number of human-caused versus lightning-caused wildfires per year, based on a 17-year average (2001–2017) (Wildland Professional Solutions (adapted from NIFC 2017a, 2017b))*


*Figure 3.2. The WUI disaster sequence concept (from Cohen 2008; Wildland Professional Solutions)*

Service, pioneered WUI disaster research that describes this "WUI fire disaster sequence" concept (Figure 3.2, p. 36).

Cohen (2008) notes that between 97 to 99 percent of wildfires are suppressed at the initial attack stage; it is the two to three percent of fires that escape initial attack that are responsible for these large-scale losses. He further explains that these incidents typically occur when multiple structures are simultaneously exposed to fast-spreading, aggressive wildfires during extreme fire conditions. These multiple exposed structures are simultaneously ignited and immediately overwhelm the ability of fire suppression resources to protect structures. This scenario depends on exposure of multiple vulnerable structures to a wildfire that has escaped control attempts.

Almost all structural fire suppression agencies and their supporting infrastructure (for example, fire water supply) reach their suppression capacity with one to two burning structures at any given time. In a WUI disaster scenario, it is common for hundreds of structures to be simultaneously burning. This can also happen when individual structure fires or wildfires burning within the WUI grow so quickly that initial attack suppression is not possible and adjacent structures are immediately impacted by fire.

Cohen's research has shown that the design and construction material of a building, along with the condition of the immediate area surrounding the home (typically within 100 feet), play significant roles in the vulnerability of a structure to ignition from a wildfire. Cohen called the area that includes the structure and its immediate surroundings the *home ignition zone*. Over time the concept has been expanded to encompass all structures by calling it the *structure ignition zone* (NFPA 2018b). This report will use the latter term.

## FIRE ECOLOGY BASICS

Wildland fire occurs as a natural disturbance process to varying degrees of frequency and intensity in almost all the vegetated terrestrial ecosystems across North America. These are some key concepts that are used in forest ecology:

- **Fire dependence.** Some flora (e.g., pitch pine) and fauna (e.g., Karner blue butterfly) are *fire dependent,* relying on fire as an important component in their natural life cycles.

- **Fire adapted.** Other flora (e.g., interior or Rocky Mountain Douglas-fir) and fauna (Lewis's woodpecker) have become *fire adapted*, evolving to either develop an increased resistance to the negative effects of fire or take advantage of fire effects.
- **Fire frequency.** The *frequency*, or occurrence, of fire varies based on vegetation characteristics, climate (weather), and topography. Fire frequency can range from very frequent in grass vegetation ecosystems, to moderately frequent in shrub or open forest vegetation ecosystems, to very infrequent in coastal rain forests or high alpine forests.
- **Fire intensity.** The *fire intensity* is a factor based on the available amount of fuel available to burn (*fuel loading*), which is influenced by weather, topography, and site-specific growing conditions, as well as the frequency of fire occurrence. Generally, ecosystems with higher fuel loadings and less frequent fires will burn more intensely when they do burn. Due to human influence and fire exclusion policies (see Chapter 2), many ecosystems that would have historically burned more frequently at lower intensities have been artificially altered to a lower fire frequency and a higher fire intensity potential.
- **Fire severity.** The *fire severity* refers to the "depth of burn," or amount of organic material that the fire consumes. The fire severity can be largely correlated with fire intensity; however, the low-intensity smoldering phase that prevails in some fuel types can significantly contribute to the fire severity. This component has also been artificially modified by humans in many ecosystems, resulting in greater fire intensities that cause soil nutrient sterilization, soil stability, and peak water flow issues, as well as increased mortality in otherwise fire-adapted species (e.g., ponderosa pine).
- **Fire regime.** The *fire regime* is the result of the frequency of fire occurrence, fire intensity, and the amount of vegetation (fuel) consumed. This is influenced by the varying differences in fuel characteristics, climate (weather), and topography over space and time. The variation in vegetation cover that results is often referred to a "mosaic" and conributes to the creation of ecological diversity.

As a natural disturbance process, wildland fires are generally considered beneficial to most of the terrestrial ecosystems in which they occur (Agee 1993). Some general positive fire effects from wildland fire include the ability of fire to:

- reduce fuel build-up, lowering the intensity of subsequent fires;

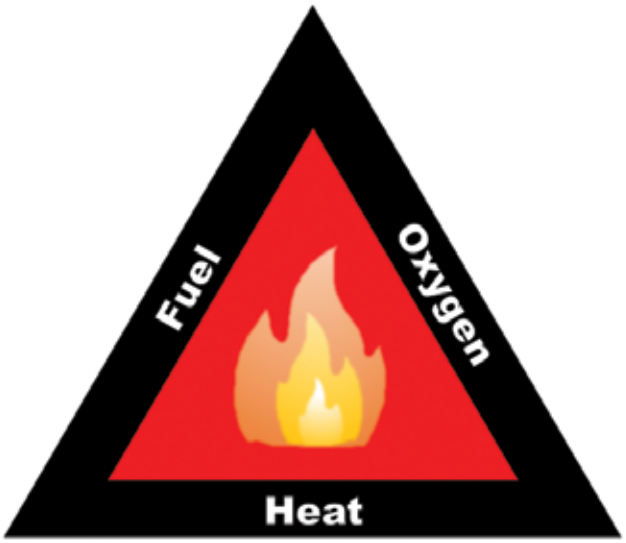



*Figure 3.3. The fire triangle (Wildfire Planning International and Wildland Professional Solutions)*

- remove undergrowth and increase sunlight availability for plants;
- provide a "nutrient boost" to plants;
- control insects or diseases;
- provide critical habitats for wildlife species;
- influence reproductive cycle of some plant species; and
- create an ecologically diverse landscape.

Wildland fires can also result in negative effects. Many of these negative effects are due to the influence of long-term fire management policies (fire exclusion) or other human activities, or they are direct effects on human development. Some of these negative effects include the following:

- High-severity fires can result in the soils becoming "sterilized" of organic material.
- High-severity fires can result in increased slope instability, runoff, water sediment, and peak-flow flooding issues.
- Fires can provide advantageous conditions for invasive or noxious plant species.
- Fires can have negative effects on critical habitat for wildlife.
- Fires can damage or destroy human development and human landscape values and can impact human health and safety (see Chapter 2).

*Prescribed fire* (sometimes called *controlled burning*) is the planned, deliberate application of fire to the landscape to


*Figure 3.4. Removing any element in the fire triangle will stop the combustion process (Wildfire Planning International and Wildland Professional Solutions)*

meet specific objectives. Prescribed fire is most often used for ecosystem restoration through the introduction of fire back into ecosystems where it has been excluded, or as a tool to manage vegetative fuel buildup as part of an overall mitigation strategy. In order to meet the specific objectives, prescribed fire planning involves the detailed analysis of fuels, weather, and topography and the development of a prescription that dictates a specific range of weather and fuel conditions, as well as specific tactics required to meet these objectives.

## WUI FIRE SCIENCE BASICS

To successfully apply planning tools which mitigate wildfires and WUI fires, planners must understand how fire ignites and spreads and the factors that influence fire behavior.

### The Conditions of Combustion

The first concept to understand is the conditions required for combustion (fire) to occur. At the very basic level, three elements are required to sustain combustion: fuel, oxygen, and heat. These three elements can be represented as a triangle, where each side is one element (Figure 3.3, p. 37).

In a WUI fire, vegetation or built fuels (e.g., houses, fences) provide the fuel; oxygen is in the air; and heat is either generated naturally (lightning strike) or is introduced by people (e.g., campfire, discarded cigarette, sparks from an off-road vehicle). Once a fire begins burning, the heat generated propagates the spread of fire to the next available source of fuel.

If any one of these three elements is altered, the fire will behave differently. If one side of the triangle is removed, the combustion process stops (Figure 3.4).

### Heat and the Heat Transfer Processes

In a wildland or WUI fire scenario, heat is initially generated from the ignition source when the heat from the source is transferred directly to a combustible fuel. Typically this occurs through conduction (direct contact). The fire then spreads to other receptive fuels (nearby or adjacent vegeta-


*Figure 3.5. The radiation heat transfer process from vegetation to a structure during a WUI fire (Partners in Protection Association)*

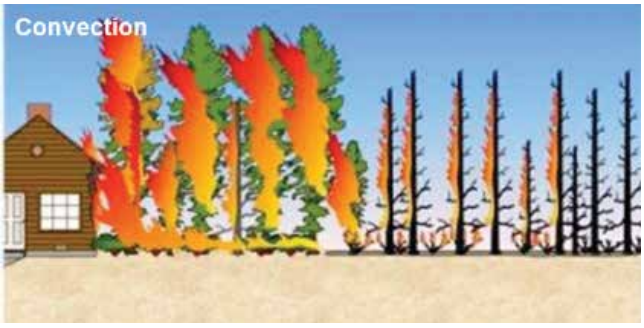



*Figure 3.6. The convection heat transfer process from vegetation to a structure during a WUI fire (Partners in Protection Association)*

tion, structures, or infrastructure) through one or a combination of the following three heat transfer processes.

- **Radiation**. *Radiation* is the transfer of heat through the air from the burning fuel to nearby combustible objects (Figure 3.5, p. 38). A good example is the heat felt when sitting next to a campfire. Radiant heat from a crown fire or other individual significant heat sources (e.g., outbuildings, wood piles, single conifer trees, shrubs) burning at distances less than 30 feet from a structure with combustible walls can ignite the structure walls and break single-pane windows, allowing ember entry to the interior of the structure. Even small plants, shrubs, or other combustible materials burning within five feet of a structure can ignite combustible walls and break window glass through the radiant heat transfer process.
- **Convection.** *Convection* is the transfer of heat by the movement of a hot air mass (usually upwards) that a burning fuel produces (Figure 3.6, p. 38). Rising convection heat can be "tilted" by the wind and slope and therefore can transfer heat to receptive vegetation or structures both adjacent to the fire, or upslope and beyond the influence of radiant heat. The direction that flames and smoke from extend from a fire is a reasonable visual estimation of the direction that the convective heat is travelling. A large, aggressive wildfire will typically also create its own winds that can cause convective heat to extend horizontally and ignite combustible structures or vegetation that are within 100 feet of the fire.
- **Conduction.** *Conduction* is the transfer of heat through solid matter (i.e., objects touching each other) (Figure 3.7). A good example is when embers, generated from burning vegetation or structures, are carried through the air by convection and wind for distances ranging from a few feet to several miles, land on vegetation or vulnerable components of a structure, and subsequently ignite the new fuel source.

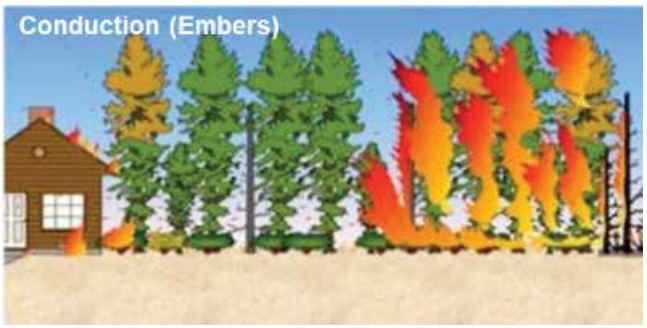



*Figure 3.7. The conduction heat transfer process from vegetation to a structure during a WUI fire (Partners in Protection Association)*

Conduction is an especially significant process: Embers are responsible for more than 50 percent of structure ignitions in WUI fires through conduction heat transfer.

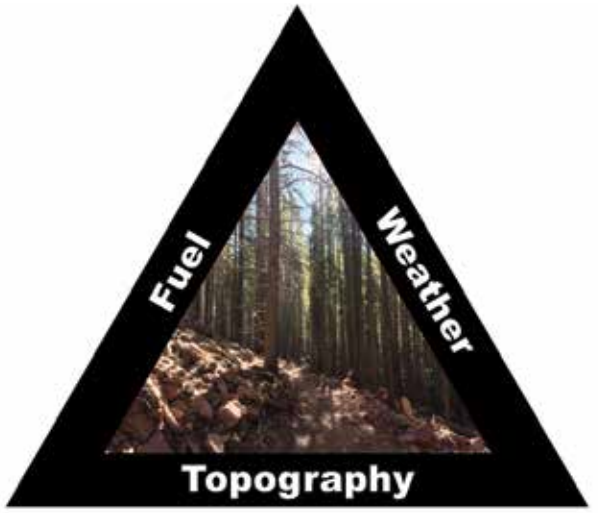



*Figure 3.8. The fire behavior triangle (Wildfire Planning International and Wildland Professional Solutions)*

## 3.1. KEY FACTORS INFLUENCING WILDLAND FIRE BEHAVIOR

| Key Factors | | |
|---|---|---|
| **Fuel** | **Weather** | **Topography** |
| Moisture | Wind | Slope |
| Size | Precipitation | Aspect |
| Spacing (continuity) | Relative humidity | Terrain |
| Fuel loading | Temperature | Elevation |
| Chemical properties | | |

*Source: Kelly Johnston*

## FACTORS INFLUENCING WILDLAND FIRE BEHAVIOR

The three key factors that influence wildland fire behavior are fuel, weather, and topography. These are often displayed


*Figure 3.9. A surface, ladder, and aerial fuel profile as well as horizontal and vertical fuel continuity (Wildland Professional Solutions)*

in the form of a fire behavior triangle (Figure 3.8, p. 39). Of the three factors, planners can only expect to influence the fuel component by modifying, reducing, or removing it to change the heat component. However, weather and topography influence the condition of fuels, and the location of fuels in relation to topography can influence the potential wildfire exposure the fuel is subject to. Further, there are several influencing subfactors within the three primary factors (Table 3.1, p. 39). A basic understanding of how fuel, weather, and topography influence fire behavior will provide planners with valuable knowledge that can be used in planning for the wildfire mitigation of vegetation, structures, and infrastructure fuels.

## Fuel

Any substance that will ignite and combust (burn) is fuel. In a wildfire situation, the two main fuels are *wildland fuels* and *built fuels*. A general understanding of how fire ignites, spreads, and behaves in its interactions with these fuels is important to understand the concepts used to assess and mitigate the WUI.

*Built fuels* include all structures and infrastructure that are capable of igniting, sustaining, and propagating the spread of fire. Generally, residential structures are the primary focus when describing the susceptibility of built fuels in human development; however, any other development, including commercial buildings, bridges, utility poles, and water treatment facilities, can be vulnerable to wildfire if the conditions for combustion are met. The specific vulnerabilities of built fuels in relation to fuel, weather, and topography will be discussed further below.

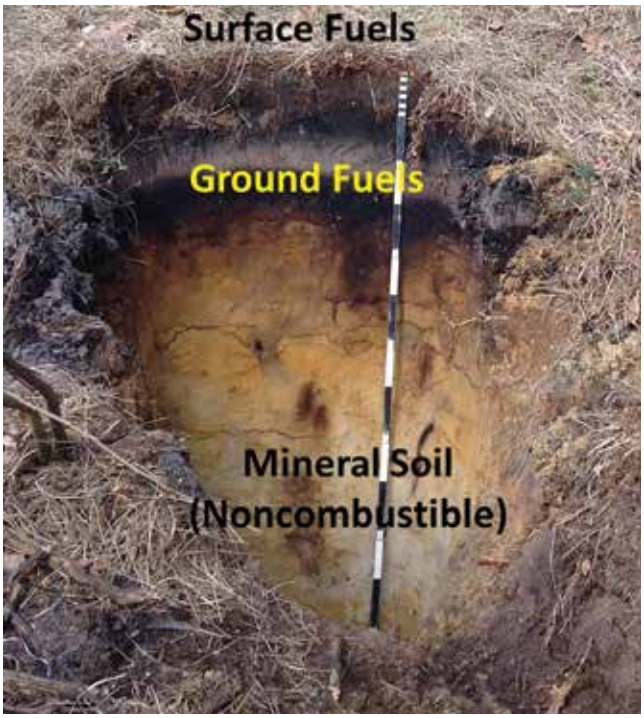



*Figure 3.10. A surface and ground fuel profile (Wildland Professional Solutions)*

For simplicity, *wildland fuels* can be defined to include natural vegetation (forests, grasslands, shrublands) and cultivated vegetation (landscaping). Wildland fuels are typically described in three basic groups (Figures 3.9 and 3.10):

- **Ground fuel**. This includes all combustible substances below the surface litter (e.g., leaves, needles) of the organic soils. This is the fuel layer involved in ground fires.
- **Surface fuel**. This includes all combustibles less than 39 inches above ground level and one year's litter accumulation. This layer can include *lower ladder fuels*, which is a term used to describe the fuels present between surface fuel and aerial fuel. This (along with the ground fuel layer) is the fuel layer involved in surface fires.
- **Aerial (crown) fuel.** This includes all combustible material higher than 39 inches above ground level. This layer can include *upper ladder fuels*. This (along with the ground fuel layer and surface fuel layer) is the fuel layer involved in contributing to crown fires.

Depending on the influencing fire behavior factors, these fuels can produce two basic types of fire in wildland fuels:

- *Surface fires* involve the surface fuels and low-growing vegetation. They can burn without involving the ground fuel layer, though this typically only occurs in the early spring and winter. Fire suppression of surface fires is generally successful at low to moderate rates (speed) of fire spread; however, suppression success significantly decreases when surface fires are aggressive and fast spreading.
- *Crown fires* involve the surface fuels, ladder fuels, and aerial fuels. A combination of a threshold surface fire intensity (how hot the surface fire burns) and ladder fuels are required to develop and sustain a crown fire; the exception are those crown fires driven by very strong wind events combined with steep slope or extremely dry conditions. Fire suppression has limited success with sustained, aggressive crown fires.

There are several important subfactors planners should be aware of regarding fuels.

**Fuel Moisture**. Fuel moisture content is the single most important fuel-related factor affecting fire behavior. Fire will ignite more easily and spread faster in fuels with lower fuel moisture. Fuel moisture in wildland fuels is determined by:

- Weather-related factors affecting the amount of moisture absorbed by the fuel; for example, the amount and type of precipitation (e.g., rain, snow).
- Percentage of live or dead (cured) fuel. For example, green grass will not burn as well as brown (dead) grass; live trees will not burn as readily as dead trees, unless they are suffering from severe drought; plants that retain dead material will burn more readily than plants that do not.

**Fuel Size.** For simplicity, fuel size is divided into *heavy fuel*s and *light fuels*:

- Heavy, slow-burning fuels include logs, stumps, large branch wood, trees, and deep duff (the layer of organic material between the surface litter layer and the uppermost soil mineral layer). These fuels take longer to ignite due to their moisture content, and these fires spread slowly but burn longer with greater intensity. The moisture content change is slower due to a low surface area-to-volume ratio.
- Light, fast-burning fuels include grass, dead leaves, tree needles, brush, and small trees. They catch fire quickly, result in fast-spreading fires, and act as kindling to ignite heavier fuels. The moisture content change is faster due to a high surface area-to-volume ratio**.**

**Fuel Spacing (Continuity).** *Fuel spacing* or *continuity* refers to the arrangement of fuel on the landscape. It can be considered as the fuel distribution in the horizontal and vertical directions (Figure 3.9, p. 40). Fuel that is closer together increases the ability of fire to spread from one fuel source to another, while fuel that is spaced further apart decreases that ability. Horizontal fuel spacing is usually described as "continuous" or "patchy." Vertical fuel spacing refers to the distance between surface fuels and aerial fuels.

**Fuel Loading**. *Fuel loading* refers to the weight or mass of fuels in a given area, usually measured in tons per acre. Fuel loads may vary across the landscape. Higher-density fuel loads will burn at higher intensities (producing more heat) if fuel moisture conditions make all the fuel available for combustion.

**Chemical Properties.** Different plants contain different chemical properties, including waxes, terpenes, or oils that aid the plant in adapting to environmental moisture conditions and the effects of ultraviolet rays from the sun. Plants with a high composition of these volatile chemicals (such as conifer trees, eucalypts, manzanita, junipers, and arborvitae)

### 3.2. COMPARISON BETWEEN FIRE-RESISTANT (LOW-FLAMMABILITY) PLANTS AND FLAMMABLE PLANTS

| Characteristics of Fire-Resistant Plants | Characteristics of Flammable Plants |
|---|---|
| Little fine (light fuels) or dead wood, and tendency not to accumulate heavy dead material fuel loads | Contains continuous fine, dry, dead material (light fuels) within the plant (small branches, needles, bark) |
| Moist, supple leaves | Plant stems, branches, and leaves contain volatile waxes, terpenes, or oils |
| Water-like sap with little or no odor | Leaves are aromatic |
| Low amount of sap or resin material | Gummy, resinous sap with a strong odor |
| | Loose, papery bark |

*Source: Kelly Johnston*

are typically highly flammable in comparison to plants with low volatility chemical composition but high water content.

**Individual Plant Flammability Characteristics.** Each individual plant has a combination of characteristics relating to moisture content, size, spacing, fuel loading, and chemical composition that determines its relative flammability. Table 3.2 (p. 41) summarizes some of the main differences between fire-resistant (low-flammability) and flammable plants.

Planners can use this basic knowledge of wildland fuels to develop land-use policies and regulations that will facilitate reducing wildfire hazard through changing the structure of wildland fuels. For example, providing a required low-flammability plant list for landscaping features within the first 30 feet of a home will alter the behavior of a wildland fire that approaches the structure. See Chapter 7 for more details on specific regulations.

## Weather

Weather factors that influence fire behavior cannot be directly mitigated, but it is important to understand the general weather patterns of a given area to plan for the likely resulting fire behavior.

The interpretation of *fire weather* (weather conditions that influence fire ignition, behavior, and suppression) and its effects requires expert knowledge. Planners can consult with local experts in fire weather meteorology and wildland fire behavior to forecast potential wildfire risk or transmission. These individuals are typically on staff with local, state, or federal wildfire management agencies or wildfire consulting firms. For planning purposes, longer-term weather trend effects on fuel conditions and fire behavior are typically analyzed and provided as an input to an overall wildfire hazard or risk assessment. Still, planners should be aware of the following important subfactors that comprise weather's influence on fire behavior.

**Wind**. Wind is the single most important weather factor affecting fire behavior. It influences fire behavior in the following ways:

- Increasing or decreasing fuel moisture
- Bending the flames and convective heat ahead, which heats, dries, and ignites new fuels
- Carrying embers into new fuel sources ("spotting")
- Feeding more oxygen to a fire
- Driving the direction of a fire

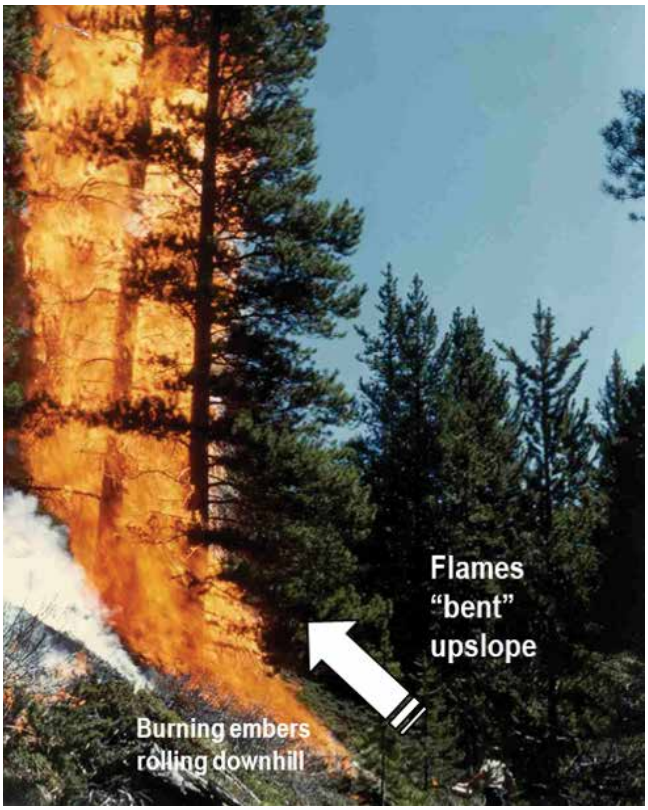



*Figure 3.11. Slope influence on wildfire (Wildland Professional Solutions)*

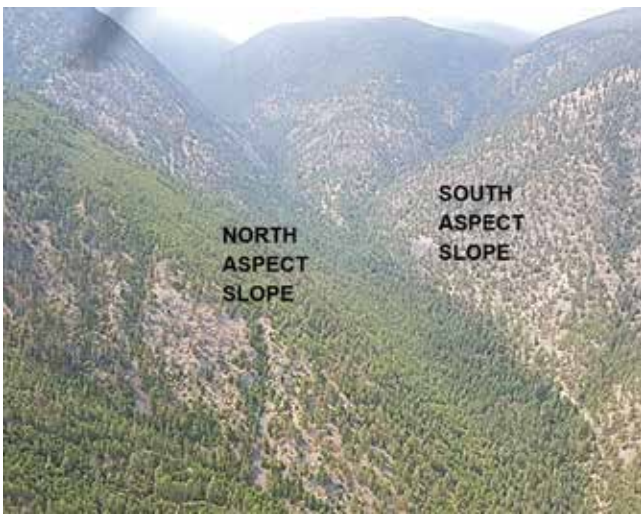



*Figure 3.12. Slope aspect change effect on fuel load: increased moisture on north slope results in a heavier fuel load in comparison to the south slope (Wildland Professional Solutions)*


*Figure 3.13. An example of the "chimney effect" terrain influence in increasing aggressive fire behavior (Wildland Professional Solutions)*

**Precipitation**. Precipitation influences fire behavior by affecting fuel moisture. The effect of precipitation on fuel moisture is mostly dependent on fuel size. Less precipitation is required to raise the fuel moisture content in fine fuels than in heavy fuels, and fine fuels will dry out faster than heavy fuels. Precipitation may not wet ground fuels if they are located under a dense canopy. Perhaps surprisingly, duration of precipitation, not quantity, is the most important factor in determining the effect of precipitation on fuel moisture. This is mainly due to the time it takes for fuels to absorb moisture. Large volumes of precipitation that fall in a short period of time will mostly run off the fuel before the moisture can be absorbed, while the same volume of precipitation distributed over a longer time will result in increased moisture absorption with less "wasted" runoff.

**Relative Humidity**. *Relative humidity* is the percentage of water vapor present in a given parcel of air. It also influences fire behavior by affecting fuel moisture. When the air is dry (low relative humidity), fuels are likely to dry out; when the air is damp (high relative humidity), fuels are likely to absorb moisture, resulting in increased fuel moisture content. Typically, the relative humidity increases overnight and decreases during the day.

**Temperature**. Temperature fluctuations affect relative humidity, thereby affecting fuel moisture. To a lesser degree, temperatures also influence the amount of preheating required to bring fuel to its ignition temperature.

## Topography

There are four topographical factors that influence fire behavior: slope, aspect, terrain, and elevation. Although topography cannot typically be changed, the incorporation of topography's influence on fire behavior as part of land-use planning and development decisions can mitigate the effects of unfavorable topography with respect to fire behavior.

**Slope**. Slope is the single most important topographical factor affecting fire behavior (Figure 3.11, p. 42). Slope affects fire behavior in the following ways:

- Flames are closer to fuels on the uphill side, heating and igniting these new fuels
- Convective heat (rising heat) from the fire travels up the slope, heating and drying new fuels
- The convective air may carry embers, which can ignite spot fires above the main fire
- Embers and large burning material may roll downhill, igniting new, unburned materials below the fire
- Firefighting efforts are hampered and slowed on slopes
- Cooling at night and weather changes can cause winds to blow downslope

**Aspect**. *Aspect* refers to the direction the slope faces (e.g., a southwest aspect is a slope that faces southwest). Several aspect factors affect fire behavior directly. In the northern hemisphere, southern slopes receive the most direct heat from the sun and therefore have higher temperatures, and fuels on south-facing slopes typically have the lowest fuel moisture and fuel loading (Figure 3.12, p. 42).

**Terrain**. *Terrain* is the variation in land features. This primarily affects fire behavior by altering wind direction and speed at a local level. It is useful to think of the wind patterns over terrain as water flowing in a river. Terrain affects wind patterns in the following ways:

- Turbulence or "eddies" can be generated on the leeward side (facing away from prevailing winds) when wind blows across ridges
- Terrain restrictions, such as narrow portions of valleys or knolls, can increase wind speed as the wind passes through or around these restrictions
- Steep-sided gullies or canyons can create a "chimney effect," dramatically increasing uphill fire spread rate and intensity (Figure 3.13)

Often these terrain features will also have heavy fuel loadings, increasing fire intensity, fire severity, and rate of spread.

**Elevation.** Typically, air temperatures follow an elevation gradient, with temperatures being warmer at lower elevations and cooler at higher elevations. Quite often, atmospheric conditions will cause a band of warm air to be trapped at mid-elevation between cool air at lower elevations and cool air above. In mountainous terrain this is a temperature inversion known as a *thermal belt*. Within the thermal belt, temperature will be higher and relative humidity will be lower than the elevations above and below, possibly creating unexpected extreme fire conditions. Over time, a persistent thermal belt condition can result in localized vegetation conditions that support more aggressive fire behavior.

## FIRE BEHAVIOR AND STRUCTURE VULNERABILITIES

A community's vulnerability to the ignition and spread of fire into and throughout the built fuel environment (e.g., structures) is dependent upon the ignition vulnerability conditions of those structures and the influence that weather and topography have on these conditions. The focus of these concepts is typically residential structures. However, commercial and industrial building and infrastructure losses can be significant during a WUI fire, and many of the same fire behavior and ignition concepts can be applied to them as well.

### Wildfire Exposure

The heat transfer process (radiation, convection, conduction) that built fuels are exposed to on a macro scale are determined by the fuel conditions and topography that are present within the larger area that surrounds the built fuel environment and the influence of weather on the area. However, it is the condition of a structure itself and the potential exposure to these heat transfer processes from the area immediately surrounding the structure that determine the survivability of that structure (Cohen 1991; Cohen and Saveland 1997).

Beyond the susceptibility of built fuels, the wildfire exposure conditions presented by the larger surrounding area provides useful guidance for mitigating wildfire impacts to other community values through land-use planning. In other words, planners need to consider conditions both at the parcel scale and the larger WUI environment when planning for wildfire. The details of assessing wildfire risk, hazard, and exposure will be discussed in Chapter 4.

### Structure Ignition Zone Concept

As noted earlier in this chapter, the home ignition zone concept, now known as the *structure ignition zone*, was developed through significant fire behavior and structure vulnerability research (Cohen 1991; Cohen and Butler 1998; Cohen 2000; Cohen 2008). The structure ignition zone concept (Figure 3.14) focuses on the ignition vulnerability of the building materials and design of the structure (to address the effects of radiant

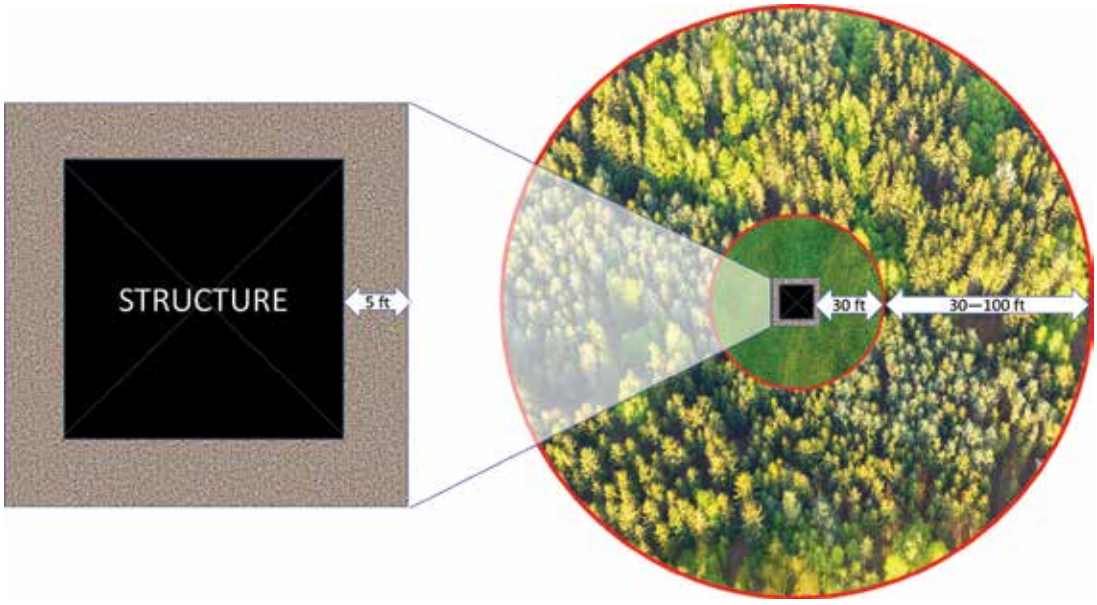



*Figure 3.14. The structure ignition zone concept, which includes the structure, an initial 30-foot zone (including a five-foot noncombustible zone adjacent to the structure), and a second zone extending to 100 feet (Wildland Professional Solutions)*

## TESTING BUILDING MATERIALS AND CONSTRUCTION TECHNIQUES FOR WILDFIRE SAFETY

Research and testing are integral to understanding how wildfires result in structure ignitions and the effectiveness of mitigation techniques for building construction and materials. Different organizations play a key role in wildfire research and testing activities, including the Insurance Institute for Business and Home Safety (IBHS), the National Institute for Standards and Technology (NIST), and the Missoula Fire Sciences Laboratory within the USDA Forest Service Rocky Mountain Research Station.

One of the most exciting applications for the planning community comes from recent studies performed by IBHS in its large research facility in South Carolina. The testing facility has allowed researchers to replicate hazard scenarios, such as the effects of burning embers on a full-sized home. The results from these tests are available in a fact sheet series developed by the National Fire Protection Association's (NFPA) Firewise USA program and IBHS. Some of their recent findings (IBHS 2011; IBHS and NFPA 2017a, 2017b, 2018) show that:

- **Roofs** are highly vulnerable during a wildfire due to their large surface areas and the types of exposure that may occur from embers, radiant heat, or direct flame contact. Roof covering fire ratings are Class A, B, C, or unrated; Class A roof coverings provide the best performance (examples include fiberglass composition shingles, metal roofs, and concrete or clay tiles). To obtain a Class A fire rating, a roof assembly must include additional materials between the roof covering and sheathing. In addition, roofs and gutters should be regularly cleaned to remove vegetative debris.
- **Combustible deck boards** (such as solid wood and wood-plastic composites) that are attached to a house can potentially spread fire to the house when ignited during a wildfire. Recommendations for increasing home survivability are to replace deck boards near the home with noncombustible types, such as metal and fiber cement. Wood joists should be covered on the top and part of the sides with a foil-faced bitumen tape product. No combustible materials should be stored under the deck, and vegetation should routinely be removed from deck board gaps and where the deck meets the house.
- **Exterior sprinkler systems** can be effective in helping a home survive a wildfire, but potential issues exist, including requirements for an adequate water supply over a period of up to eight hours, performance of sprinklers during high-wind events, and questionable activation under ember exposure scenarios. As a result, exterior sprinklers should be used as a supplement to, and not a replacement for, already proven mitigation strategies.

More wildfire fact sheets, educational videos, and resources are available at disastersafety.org.

*Figure 3.15. An example of a complex roof design in which combustible siding extending above the roof line is protected with two inches of noncombustible flashing (Wildland Professional Solutions)*

*Figure 3.16. These gable attic vents have openings that are smaller than one-eighth inch and are therefore effective at mitigating ember entry into the attic space (Wildland Professional Solutions)*

heat, convective heat, and embers) and the condition of the area immediately surrounding the structure. This is the "set of conditions," prioritized in two zones. The first zone extends out to 30 feet (approximately 10 meters) to address the effects of radiant heat produced by a typical crown fire. The second zone extends out to 100 feet (approximately 30 meters) to address the effects of convective heat produced by a typical crown fire.

Cohen conducted the original studies on the overall vulnerabilities of building construction to radiant and convective heat (Cohen 2004). Further research conducted by Steve Quarles, PHD, at the Insurance Institute for Business and Home Safety (IBHS) focused on the vulnerabilities of structure design and construction materials to embers and radiant heat (Quarles 2017; Quarles and Standohar-Alfano 2017; IBHS n.d.). This research furthered the understanding of structure vulnerability and the implementation of best practices that provided an enhanced perspective on specific building components, as well as the importance of the conditions within the first five feet of a building (Figure 3.14, p. 44). The sidebar on p. 45 shares some key findings resulting from wildfire safety research and testing.

## Specific Structure Vulnerabilities and Mitigations

Based on structure vulnerability research and testing, industry best practices for protecting structures against wildfires have been developed. The sidebar on p. 48 offering lessons learned from an assessment of Colorado's Waldo Canyon Fire reinforces this research and testing. The following best practices can provide guidance for voluntary and regulatory mitigation implementation on new and existing structures.

*Figure 3.17. Though this noncombustible gutter will not melt, the combustible debris within it could lead to ignition of any unprotected roof sheeting under the fire-rated roof covering (Wildland Professional Solutions)*

*Figure 3.18. The bottom six inches of this exterior wall is constructed of noncombustible concrete, which in this case is part of the structure's foundation (Wildland Professional Solutions)*

*Figure 3.19. A heavy timber deck over a noncombustible surface that extends five feet from the perimeter of the deck (Wildland Professional Solutions)*

**Roof Assembly**. During a wildfire or urban structure fire event, the roofs of structures can collect airborne embers and combustible debris. If the roof is constructed of combustible material, such as wood shakes, it is highly susceptible to ignition from these embers. A large percentage of homes burned in wildfires are a result of these roof ignitions. The appropriate mitigation is to install a fire-rated roof assembly. For any building component to be considered "fire rated," it must meet the standards of a recognized testing methodology. The Underwriters Laboratory (UL) or American Society for Testing and Materials (ASTM) are two of the most common testing standards used to determine fire ratings of building products and components.

**Dormers and Walls Above Lower Roofs.** Airborne embers and combustible debris can collect in the wall and roof junctions at the base of walls extending above roofs. The "piling up" of these embers in this junction can ignite combustible siding or the combustible wall assembly behind noncombustible siding on any exposure of the building, thereby igniting the walls or combustible material behind the walls of a structure. The appropriate mitigation is to ensure that at minimum, the bottom two inches of siding that extends above the roof surface is noncombustible. This can be accomplished by installing metal flashing, which is already typically required for the roof installation (Figure 3.15, p. 46).

**Roof, Soffit, and Foundation Vents.** Roof, soffit, and foundation vents required to ventilate attics and crawlspaces can provide openings for airborne embers to enter those spaces and ignite combustible material that may be present (e.g., newspapers, cardboard storage boxes). The appropriate mitigation is to install vents that include one-eighth inch noncombustible screening, or to use fire-rated vents (Figure 3.16, p. 46).

**Gutter and Downspout Assembly.** During a wildfire, airborne embers can collect in gutters and downspouts, in which combustible material, such as pine needles, can accumulate (Figure 3.17, p. 46). The combination of embers and burning debris can melt gutters and downspouts and drop burning material to the base of the structure walls, combustible surface vegetation, and materials below the gutter assembly. The appropriate mitigation is to install noncombustible gutters and downspouts and to keep the gutters free of debris.

**Structure Walls.** Radiant heat from adjacent burning wildland fuels or structures can ignite combustible exterior structure walls. In addition, airborne embers piling against the base of structure walls at the junction of structure walls and the surrounding finished grade can ignite exterior combustible siding or the combustible wall assembly behind noncombustible siding. The appropriate mitigation is to install a fire-resistant or noncombustible wall assembly, including a noncombustible bottom six inches of the wall above grade and any decks and attachments (Figure 3.18).

**Windows.** Windows can crack and become displaced from window frames when exposed to the radiant heat generated from adjacent burning vegetation or structures or the convective heat generated from fires burning downslope of a structure. This can create an opening for airborne embers to

## LESSONS LEARNED FROM WALDO CANYON, COLORADO

The following is an excerpt from the Fire Adapted Communities Mitigation Assessment Team report on Colorado's Waldo Canyon Fire (Quarles et al. 2013, 4).

*The Waldo Canyon Fire started the afternoon of June 23, 2012, near Colorado Springs, Colorado. The fire threatened the Cedar Heights community in the early hours of June 24; however, no homes were lost. Two days later, the fire entered the Mountain Shadows neighborhood, where 346 homes were eventually destroyed on June 26.*

*Considered the worst fire in Colorado state history, Waldo Canyon forced more than 30,000 people to evacuate, scorched 18,247 acres, killed two residents, and took firefighters 18 days to fully contain. The fire burned through brush, mountain shrub, grass, and trees including oak, Pinyon-juniper, ponderosa pine, Douglas-fir, spruce and limber pine. In addition to disrupting thousands of lives and destroying hundreds of properties, the wildfire left the landscape vulnerable to flooding and/or debris slides that will pose long-term problems.*

*The Waldo Canyon Fire presented the first opportunity for partners in the national Fire Adapted Communities (FAC) Coalition to collectively assess the performance of mitigation practices in Colorado Springs in a post-fire environment and to compare the results to the mitigation strategy recommended by the Fire Adapted Communities program. The assessment was conducted July 18–20, 2012, by a FAC Wildfire Mitigation Assessment Team, which included two sets of researchers: structural assessment and forestry experts and social science and public education experts, accompanied by staff from the Colorado Springs Division of the Fire Marshal and the State of Colorado. The structural assessment team surveyed 40 homes that were damaged, undamaged and destroyed during the fire, toured fuels management projects, and examined a variety of mitigation initiatives including creation of defensible space, Wildland Urban Interface (WUI) Codes and Ordinances, wildfire preparedness information and awareness efforts. The team of social science and public education experts talked with local officials, homeowners and community leaders and also toured the above-mentioned areas. The FAC Mitigation Assessment Team included representatives from the USDA Forest Service, Insurance Institute for Business & Home Safety (IBHS), International Association of Fire Chiefs, National Fire Protection Association (NFPA) and The Nature Conservancy.*

The team summarized its key findings as follows (Quarles et al. 2018, 24–25):

### *BUILDING DESIGN AND MATERIALS IMPROVEMENTS AND MAINTENANCE COULD HAVE REDUCED LOSSES*

*Ember ignition via ignition of combustible materials on, in, or near the home was confirmed by the surveys. This reaffirms the serious risk posed by ember ignitions to properties during wildfires. This reinforces the importance of maintaining an effective defensible space and regularly removing debris from areas on and near the home.*

*Home-to-home fire spread was again a major issue, as with prior post-fire field investigations. When it occurred, it was dependent on at least one wildland fire-to-home ignition and then home spacing and slope/terrain.*

*Home-to-home fire spread was attributed to a relatively large number of home losses. Wildland fire-to-home ignition was influenced by location of home on slope and fuels treatment(s) or lack thereof on the slope leading to the home.*

*A building can be hardened with noncombustible materials, for example, but it is also necessary to incorporate appropriate construction details, which will help ensure that the protections offered by those materials is not bypassed. Individual homeowners must take responsibility for fortifying their property against wildfire.*

*Damage by taking appropriate measures to incorporate noncombustible building materials and construction details.*

### *A COMMUNITY-WIDE APPROACH IS BEST*

*Community leaders must recognize the value of community-wide collaboration, an essential component to home survival and creation of fire-adapted communities.*

*While ember resistance, defensible space, and ignition-resistant construction are key wildfire mitigation features, equally important are mitigation efforts conducted neighborhood by neighborhood and community by community. A small dedicated and motivated organization or group can have a big impact.*

*Homes located closer than 15 feet apart can be vulnerable if a neighboring home has not been well prepared and ignites.*

*The community tax base is significantly impacted by the widespread damage and destruction of homes and businesses during wildfires. This has economic consequences for all residents.*

### *FUELS REDUCTION IS IMPORTANT*

*Hazardous fuels reduction should continue both around neighborhoods and in more remote areas containing flammable vegetation. Treatments should have explicit, specific objectives.*

*While the Waldo Canyon Fire caused widespread damage, it also left behind a healthier landscape by reducing the amount of fuel for future fires. The FAC site visit underscored the importance of prescribed fire as a fuels reduction tool.*

*PARTNERS IN PREPAREDNESS CAN EQUAL SUCCESS*

*The preparedness message is most effective when carried by a variety of partners. Public policymakers, officials, and local community and business leaders should echo best practices provided by the Fire Adapted Communities Coalition to reinforce the need for wildfire mitigation efforts at every level.*

*Partnerships are critical in building support and extending the area of influence for wildfire preparedness efforts.*

*The Colorado Springs Mitigation Section integrated a variety of methods that mirrored, to a large extent, the Fire Adapted Communities effort and was able to accomplish significant mitigation, even with a relatively small staff and budget. This was the result of collaborative efforts with important partners.*

*There is a need to create WUI messages that work for different neighborhoods, different audiences, and different contexts. This is particularly true for rural and urban communities.*

*People may not identify with their risk if they don't see their neighborhood as being in the traditional WUI.*

*Contractors and design professionals, along with code/ordinance development bodies, have an important role to play in wildfire preparedness. By incorporating best practices to reduce wildfire vulnerabilities into building design and construction techniques and ordinances, the risks to properties can be reduced.*

Access the full report here: https://fireadapted.org/wp-content/uploads/2018/06/waldo-canyon-report.pdf

enter the structure and ignite interior combustible materials. Although all windows are susceptible to failing, single-pane windows have been documented to fail sooner than thermal-pane windows and tempered glass windows have the highest resistance to failure. The appropriate mitigation is to install double-pane or tempered glass windows.

**Attachments and Outbuildings.** Attached and detached decks and porches within 30 feet of the main structure can spread fire to the main structure. Deck and porch surface junctions with combustible siding walls can collect embers and combustible debris, igniting structure walls. Combustible surfaces, vegetation, or other combustible materials beneath decks and carports can ignite these structures from below, which in turn can spread fire to the main structure. Deck and porch surfaces with gaps provide the opportunity for embers to accumulate on top of deck joists (supporting structures) and ignite the deck, while combustible deck structures are susceptible to ignition from radiant heat.

The appropriate mitigation for decks and porches is to:

- establish and maintain a noncombustible zone below and extending five feet beyond the extent of the deck;
- construct decks with noncombustible, fire-rated, or heavy timber materials (Figure 3.19, p. 47); and
- install a deck surface that does not have gaps or cracks, or if gaps exist, install a noncombustible cap on deck joists and horizontal surfaces of supporting structures.

Attached or detached outbuildings and other adjacent structures are susceptible to the same wildfire exposures as the main structure. Radiant heat generated from ancillary structures within 50 feet of the main structure can generate enough sustained radiant heat to ignite combustible siding and break windows, allowing ember interior entry and ignition of the main structure. To mitigate this, outbuildings within 50 feet of the main structure should meet the same standards as the main building.

**Wood Fences.** Wood fences attached to structures can act as a "wick," allowing fire to spread along the fence to the structure and ignite the structure (Figure 3.20, p. 50). Ensuring that any fence sections within five feet of a structure are ignition resistant or noncombustible will mitigate this.

**Propane Tanks.** Above-ground propane tanks used to supply heating and cooking appliances can present a significant hazard to both structures and fire responders if they explode in a wildfire. It is common practice to locate a propane tank as close to the structure it services as possible to reduce costs and complications. In addition, propane tanks are often

*Figure 3.20. Fire could spread directly from this combustible wood fence to the structure; within five feet of structures, fence sections should be noncombustible (Wildland Professional Solutions)*

screened with either fencing or vegetation, both of which are typically combustible (Figure 3.21).

To prevent explosion, propane tanks are designed to release gas if the internal pressure reaches a critical threshold. If the tank is within 30 feet of radiant or convective heat generated by a crown fire or other significant heat sources, the increased heat exposure may cause the tank to release gas. This gas may ignite in the presence of open flame or embers, resulting in what can be compared to a "flame thrower"-type release, which can in turn ignite structures within 30 feet. If propane tanks are exposed to a sudden and intense amount of heat that causes the gases within the tank to expand faster than the tank can vent, the tank may explode, though this is very rare in a wildfire scenario. The appropriate mitigation is to install the propane tank a minimum of 30 feet from the habitable structure on a noncombustible surface, with 10 feet of clearance from other combustibles.

*Figure 3.21. A large residential propane tank with nearby combustible vegetation (Wildland Professional Solutions)*

**Structure Location on Slope or Near Adverse Terrain Features.** A structure situated mid-slope, at the crest of a slope, or above adverse terrain features (a "chimney," for example) can be impacted by convective heat, extreme fire behavior, and embers generated by a wildfire or other structures burning below the structure. This will significantly increase the risk of the structure igniting. The appropriate mitigation is to ensure the structure is set back from the crest of a slope for a minimum of 30 feet for each story and not located within or above an adverse terrain feature (Figure 3.22, p. 51).

**Structure Density.** Structures should be considered as fuel themselves. They can contribute to the ignition and spread of fire to vegetation and other structures. Communities with dense structure layouts can facilitate a WUI fire transitioning to an urban conflagration in which fire spreads from structure to structure within the community, or vice versa. The appropriate mitigation for existing development is to ensure that all overlapping structure ignition zones (Figure 3.23, p. 51) are appropriately mitigated through building and vegetation management techniques, as described in this chapter. Decisions related to the allowable density are further discussed in Chapter 7.

## INFLUENCE OF OTHER FACTORS ON WUI DISASTERS

Wildfires and their impacts can be influenced by other natural hazards and climate conditions, and they can also influence or exacerbate these hazards. These include the following:

*Figure 3.22. Homes on a slope with no slope setback; the foundations in the foreground remain from homes that were not rebuilt after a wildfire that destroyed this community (Wildland Professional Solutions)*

- **Drought.** Prolonged drought can significantly affect the moisture content of vegetation, often completely depleting the typical moisture reserves of live vegetation to levels similar to those of dead, dry vegetation, and even causing plants that are typically considered low flammability to burn aggressively.
- **Flooding and landslides.** Higher-intensity wildfires result in higher-severity fire effects, including increased consumption of organic materials (depth of burn), hydrophobic (water-resistant) soils, significant reduction in precipitation interception by vegetation, increased peak flows of streams and rivers, decreased soil stability, and increased debris flows. Post-fire flooding and landslides are typical results of precipitation or spring run-off events in areas that have been subject to intense wildfires (Figure 3.24, p. 52).


*Figure 3.23. Overlapping structure ignition zones in a large-lot community (Wildland Professional Solutions)*

*Figure 3.24. Post-fire flooding and erosion are common occurrences in burn areas, leading to significant long-term challenges (Wildfire Planning International)*

- **Climate change.** As discussed in Chapter 2, climatologists are linking extended seasons of fire-conducive weather and fuel conditions and prolonged periods of drought to longer fire seasons and increased incidents of aggressive fire behavior. Climate change is also increasing tree mortality rates due to the spread of insects and disease, resulting in higher fuel loading.

Planners should keep the interrelatedness of and uncertainties associated with these various factors in mind when working to address wildfire challenges in the WUI.

## CONCLUSION

Without mitigation intervention in the structure ignition zone, WUI fires will continue to overwhelm suppression resources, threaten public safety, and destroy homes and other structures in increasing numbers every year. Planners and elected officials need to understand the basics of fire science, the set of conditions that make structures vulnerable to wildfire, and the appropriate mitigation concepts in order to break the WUI disaster sequence. This information helps planners better understand the reasoning behind mitigation and why best practices work, and it helps them better integrate WUI mitigation into their planning practice.

CHAPTER 4

# IDENTIFYING AND ASSESSING WILDFIRE HAZARD AND RISK

To appropriately facilitate informed decision making and plan for and implement mitigation strategies targeted at reducing the impacts of wildfire on the wildland-urban interface (WUI), planners must first identify where the WUI is in their community (as discussed in Chapter 2). They must also understand the levels of wildfire risk or hazard that their communities face.

This information is provided through the assessment of either the wildfire hazard or the wildfire risk, and is best displayed spatially using GIS layers, or as static maps. To accurately interpret these maps, it is also important to understand whether the assessment is a hazard assessment or a complete risk assessment (as defined below).

It is unlikely that planners will undertake the development of wildfire assessments themselves; however, understanding this process will help them acquire and engage with the advanced knowledge and specialized resources required, as highlighted below.

This chapter is intended to help planners gain a deeper understanding of how these tools fit within WUI planning. Specifically, it discusses assessment concepts in further detail to help planners understand the differences between wildfire hazard and risk and the different scales at which assessments are performed. The chapter also covers which types of assessments, and at which scales, are appropriate to inform planning decisions. Finally, it provides a summary of the agencies or other specialists who should be consulted in this process.

## WILDFIRE HAZARD AND WILDFIRE RISK

All too often, the terms *wildfire hazard* and *wildfire risk* are used interchangeably, or even combined to create the term "wildfire hazard risk." It is important to understand the difference between these two terms and use them appropriately in the community wildfire planning context (Scott et al. 2013; Thompson et al. 2016).

*Wildfire hazard* describes the likelihood of a wildland fire occurring and the potential intensity at which it will occur, while the broader concept of *wildfire risk* also includes the potential impacts a wildfire will have on a community. Thus, the main distinction between the two terms is whether the impacts are being included in the description (wildfire risk), as opposed to just the wildfire likelihood and intensity (wildfire hazard).

### Wildfire Hazard

The term *wildfire hazard* is appropriately used in the context of describing the combination of the likelihood of a fire occurring and the intensity of the fire, wildland, or built fuels present in a given area, or the combustibility of a given fuel type or fuel complex in general.


*Figure 4.1. The wildfire risk triangle shows the three components of wildfire risk and their general links to land-use planning (Wildfire Planning International and Wildland Professional Solutions)*

Factors influencing a wildfire hazard assessment may include the following:

- Wildland fuel models or fuel structure (e.g., distribution, size, loading)
- Built fuel vulnerability assessment (e.g., roof, walls, windows, fences)
- Historical fire cause and location (human versus lightning)
- Historical fire size
- Historical weather and fire season
- Historical wildland fire suppression success

## Wildfire Risk

The term *wildfire risk* describes the wildfire hazard along with the factors that contribute to the susceptibility of a community, or the impact wildfire will have on highly valued resources and assets. The concept of wildfire risk is best described using the wildfire risk triangle, which combines the likelihood of ignitions and the intensity of the fire (the components of wildfire hazard) with the susceptibility of the built environment (Figure 4.1, p. 55).

Factors that contribute to the susceptibility component of the wildfire risk assessment may include the following:

- Population demographics
- Public safety
- Ember transport modeling
- Structure and infrastructure susceptibility
- Natural resource values and susceptibility
- Watershed vulnerability
- Socioeconomic values

Figure 4.2 shows the relationship of the wildfire risk compared to the wildfire hazard and some of the susceptibility factors considered when evaluating the wildfire risk and hazard.

Typically, both hazard and risk are described on a relative scale, using terms such as "low," "moderate," "high," or "extreme." In some cases, numerical ratings are used to provide a range in the relative scale.

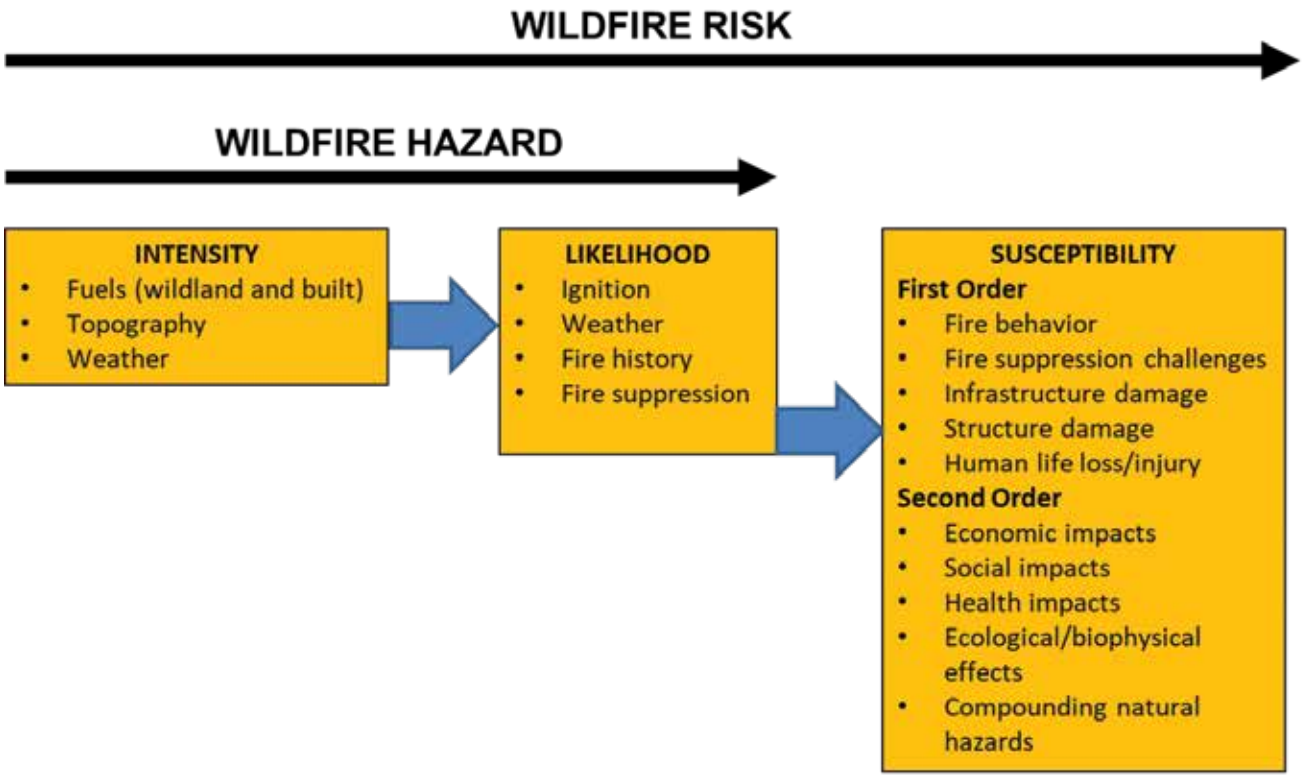



*Figure 4.2. The relationship between wildfire risk and wildfire hazard and the factors that influence the components of each (Wildland Professional Solutions)*

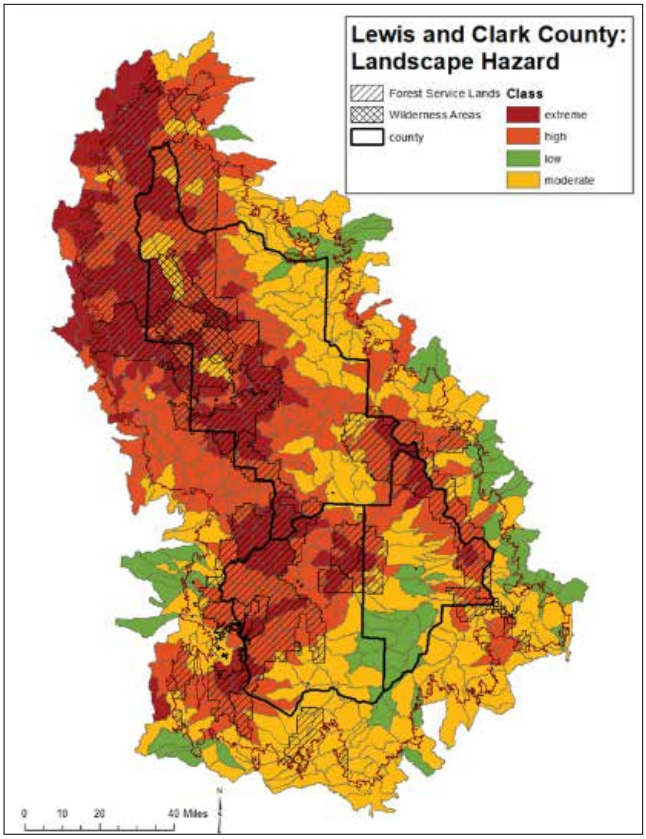



*Figure 4.3. A landscape-level hazard assessment map delineating low- to extreme-hazard classes for Lewis and Clark County, Montana, using 180-meter pixel resolution and summarized to the U.S. Geological Survey National Hydrography Dataset watershed level (Community Planning Assistance for Wildfire)*

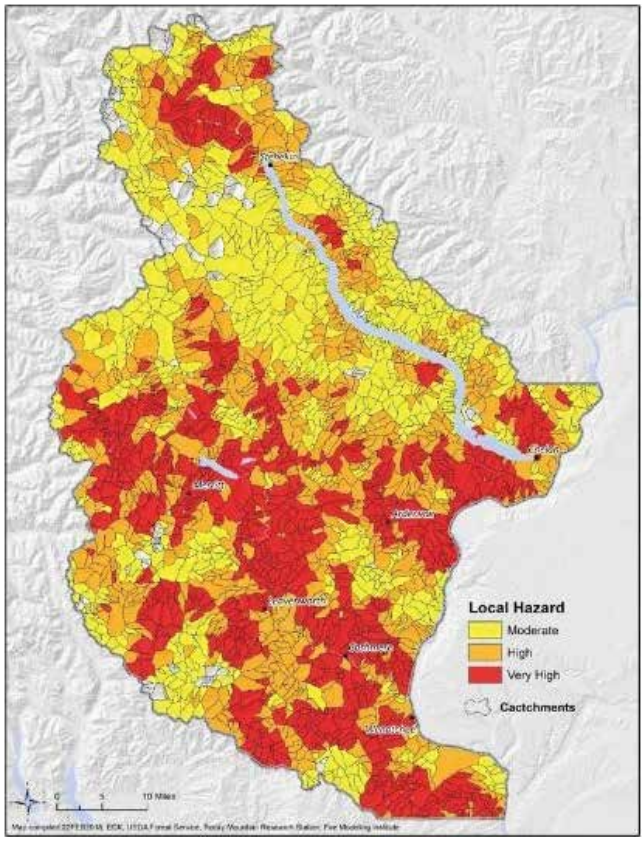



*Figure 4.4. An example of a county-wide local- or community-level hazard assessment map for Chelan County, Washington, delineating moderate- to very high-hazard classes using 30-meter pixel resolution and summarized to the U.S. Geological Survey National Hydrography Dataset catchment level (Community Planning Assistance for Wildfire)*

## WILDFIRE HAZARD AND RISK ASSESSMENTS

It is important to know that wildfire assessments are developed for different purposes and scales of reference. The scale and purpose of a landscape-level assessment should provide context for a community-level assessment, and a community-level assessment must be at a scale to support structure ignition zone-level assessments. This results in a large to small "spatially nested" assessment approach.

### Scale

As noted above, wildfire assessments may be conducted at several different scales: the landscape or regional level, the community level, and the structure ignition zone level. These assessment scales are described below.

#### Landscape or Regional Scale

The landscape-scale wildfire assessment provides the relative spatial delineation of hazard or risk on a large county, multicounty, or even state or regional scale (Figure 4.3). The fire intensity and likelihood components of the risk triangle are most commonly addressed at either this or the community level in an analysis of susceptibility.

This scale of assessment is useful in comparing risk or hazard between communities or across large-scale land management jurisdictions. It may be relevant to county-wide community wildfire protection plans, watershed plans, and other plans that span the landscape scale, as discussed in Chapter 6. However, change at this scale can typically only be influenced by large fire activity, other large-scale forest disturbance (i.e., thousands of acres), or change over

longer time scales (i.e., multiple decades). The scale that these changes occur on will involve multiple land management agencies.

Forestry and fire agencies in several states and regions conduct wildfire assessments and maintain online tools or maps with the resulting information. The sidebar on p. 59 provides more information on how planners may be able to use these resources to help inform local wildfire planning efforts.

### Local or Community Scale

The local or community scale of a wildfire assessment describes the relative spatial delineation of hazard or risk within a community setting (Figure 4.4, p. 57). The fire intensity and likelihood components of the risk triangle are the most commonly addressed analyses at this scale, as well as a more refined level (e.g., subdivision level) of susceptibility.

This information is useful when trying to understand the hazard or risk relative to a subdivision or large tract of private land. This scale of assessment can also be useful in supporting the implementation of a WUI regulation (as discussed in Chapter 7), particularly one that includes a varying degree of stringency based on wildfire hazard. Change at this scale of assessment can typically be influenced by community fuel treatments or subdivision-level hazard or risk reduction.

### Structure Ignition Zone or Parcel Scale

The property or parcel scale of a wildfire assessment provides the individual susceptibility of built fuels for a complete assessment of the wildfire risk triangle (Figure 4.5). Assessment of this scale currently requires a "boots on the ground" approach in which an on-site, visual assessment is conducted to assess all the factors that influence the susceptibility of a structure to wildfire. The data collected at this scale can be spatially related to the local-scale assessment for a complete built fuels risk assessment.


*Figure 4.5. An example of a parcel-level hazard assessment map for the city of Kamloops, British Columbia, delineating low- to high-hazard parcels using on-site "boots on the ground" visual assessment information (Wildland Professional Solutions)*

As noted in previous chapters, structure ignition zone assessments require significant capacity and are often conducted by professional foresters, fire mitigation specialists, or other trained and qualified professionals. The local government authority or fire service sometimes offers this service for free, or it may charge a fee to be paid by the property owner if this service is required for a development application.

In some cases, land-use planners who visit sites to perform an analysis of local conditions may also incorporate wildfire hazard considerations into their assessments. For example, when planners undertake a viewshed analysis for new development, they may also determine whether the site must undergo a professional wildfire assessment. This is further described in Chapter 7.

## Capabilities and Resource Needs

As with any analysis, wildfire risk and wildfire hazard analysis model outputs are only as good as the data that is used and the expertise of those collecting and inputting the data and interpreting the results.

### Required Capabilities

Undertaking and maintaining an effective landscape- or local-scale assessment requires a reasonably high level of expertise and proficiency. Trained professionals, such as contractors or expert analysts from state and federal government fire agencies, will likely undertake these tasks. Required capabilities include the following:

- Significant experience with GIS/spatial analysis
- Significant experience with fire modeling software
- A significant understanding of the relationship between vegetation types and fuel models
- A significant understanding of fire weather influence on model outputs
- A significant understanding of the relationship between the fuel model influence on model outputs
- A strong understanding of the modeling software limitations
- A strong understanding of the interpretation of modeling outputs

## REGIONAL AND STATE WILDFIRE ASSESSMENTS

Many regions and states across the United States have conducted wildfire assessments. These resources are typically developed and managed by forestry and fire agencies and are made available as web-based tools or online downloadable maps (Figure 4.6). Some tools may provide advanced features, such as detailed reports.

It is important for planners to work with state or local fire and forestry agencies to determine if these resources are available and whether they should be used to help inform community- and local-scale assessments. Often the data can help local agencies develop more fine-grained approaches that can be adopted by the community. However, the scale of these assessments does not include parcel-level information, such as the types of structure fuels and surrounding vegetation. As discussed in this chapter, this may limit the accuracy of these assessments for community planners making site-level decisions.

The following are examples of state and regional wildfire assessments, accessible at these websites:

- Southern Wildfire Risk Assessment Portal (SouthWRAP): www.southernwildfirerisk.com
- Oregon Wildfire Risk Explorer: https://oregonexplorer.info/topics/wildfire-risk
- California Fire Hazard Severity Zone Maps: www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones

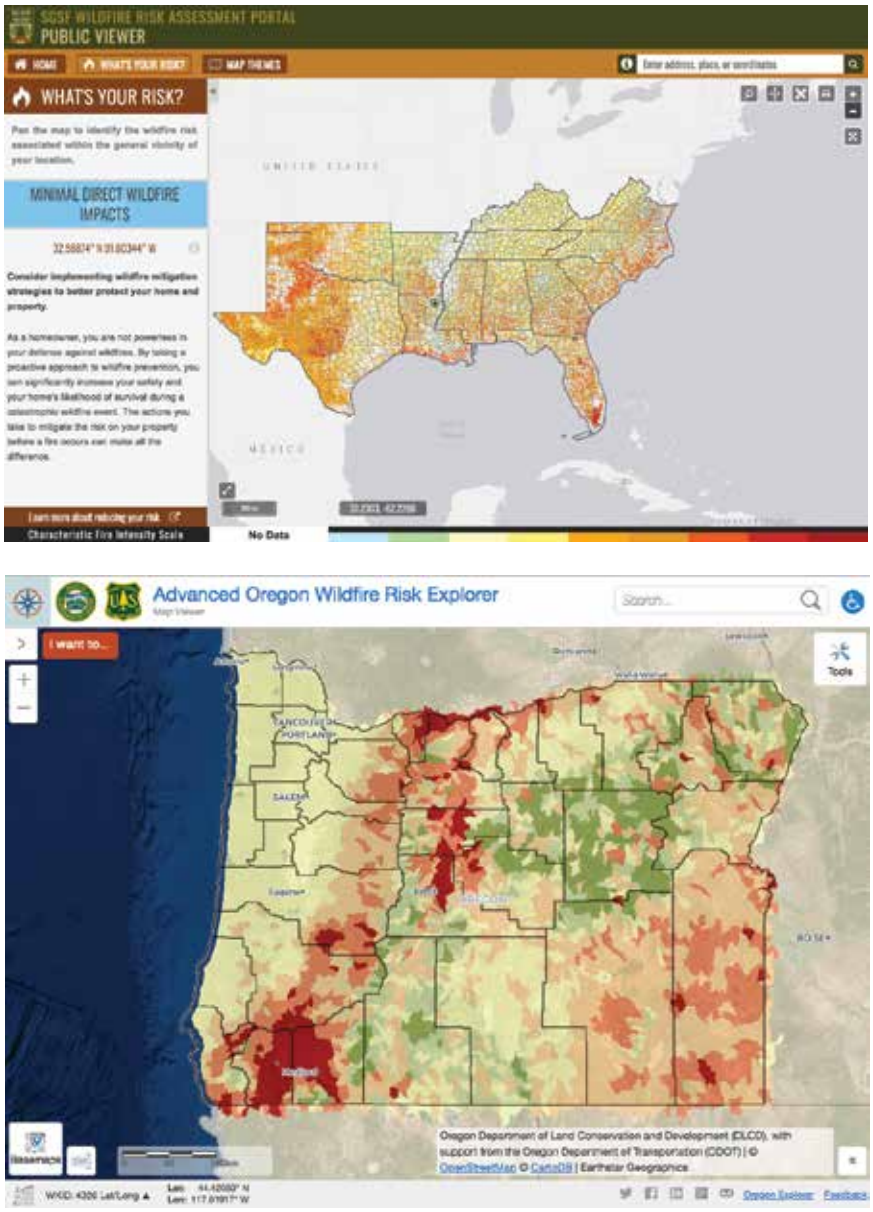



*Figure 4.6. The Southern Wildfire Risk Assessment Portal (top) and the Advanced Oregon Wildfire Risk Explorer (bottom) (southernwildfirerisk.com, tools.oregonexplorer.info)*

Undertaking an effective structure ignition zone assessment also requires a reasonably high level of expertise and understanding of the following:

- Wildland and structural fire behavior
- Building construction
- Forest ecology and forest dynamics
- Structural vulnerabilities
- Fire suppression and structure protection tactics
- Proficient use of the data collection method or tools

Because the built fuels susceptibility component of the risk triangle requires a significant investment in capacity to perform the on-site, detailed assessments of individual structure ignition zones, hazard assessments are typically the easiest and first step for a community. However, a comprehensive risk assessment that includes the susceptibility component of the structure ignition zone will allow the planner to gain a complete risk metric that can allow for tracking measurable risk reduction as mitigation measures are implemented at all scales. Conversely, a hazard assessment will only allow for the tracking of intensity reduction (through vegetation management) and possibly the reduction of likelihood through education and fire ignition restrictions (area closures and hazardous land-use regulations, for example).

#### Hardware, Software, and Data Sources

Specialized hardware and software, as well as access to the appropriate data sources, is necessary to undertake a local- or landscape-level wildfire assessment, and more commonly, a useful structure ignition zone assessment.

Depending on the size of the land base that is being assessed and the resolution and complexity of the assessment, the modeling software can require some significant hardware capabilities. Users can also expect that processing time can take up to two weeks for each modeling run.

As stated earlier, undertaking landscape- or local-level assessments analysis is not typically in the realm of a land-use planner's scope of practice. Users undertaking landscape- or local-level assessments will typically require extensive expertise and access to the ESRI suite of spatial analysis products, as well as specialized fire modeling software, such as the FlamMap, FSim, LANDFIRE, and WindNinja (for wind) software and associated databases; the sidebar on p. 61 provides a brief overview of these tools. These products and data sources will provide the information needed for wildfire assessments, as listed in Figure 4.2 (p. 56). Mobile device-based applications for iOS and Android associated with database transfers and web-based applications are becoming the new standard for file-based structure ignition zone assessments.

As noted above, the individuals responsible for these tasks are typically fire agency, local government, or land management agency spatial data management staff. Considerations related to who collects the data and how data is managed are vitally important. These include controls on who inputs data, edits data, and maintains the data.

Finally, natural ecosystems, the built environment, and the climate are dynamic and constantly changing. Trees grow and die, structures and infrastructure are built and changed. A wildfire assessment is a snapshot in time and space and will require updates appropriate to the changes on the landscape. The time frame for updates varies with the rate and type of change; however, reassessment should occur at least every five years, or sooner if there are significant changes to the community (e.g., large fires, insect outbreaks, rapid development).

## Relationship to Other Types of Assessments

In addition to the final hazard or risk assessment outputs, planners can use the metadata used to derive the final outputs to assess fire effects associated with other objectives, such as the impacts of fire on sensitive lands, ecological values, and watersheds. The intensity or burn severity outcomes that are often included in wildfire hazard assessments can also be used to predict fire occurrence influence on flooding, slope stability, water supply, sediment, and wildlife habitat.

Many of the organizations that specialize in wildfire modeling are also working on solutions to incorporate climate change prediction into the current models; however, an industry-recognized approach is not currently available.

## Other Considerations

Wildfire hazard and risk assessments can be a powerful decision-support tool for land-use planners. However, certain outcomes or concerns associated with collecting and displaying the data should be taken into account as part of the entire process.

For example, when developing wildfire assessments, some jurisdictions include the influence of fire response inputs, such as proximity to fire stations. In many cases a WUI fire typically overwhelms fire response capabilities very quickly, however, to the point that response may no longer have an influence on the risk outcome. This should be carefully considered when undertaking an assessment to ensure fire response inputs are appropriately identified but do not contribute to the underestimation of a community's risk.

## EXAMPLES OF WIDFIRE HAZARD AND RISK ASSESSMENT SOFTWARE TOOLS

The following are examples of wildfire hazard and risk assessment software and modeling platforms used by government agency analysts and other providers.

**FlamMap.** The FlamMap fire mapping and analysis system is a PC-based program that describes potential fire behavior for the constant environmental conditions of a single fire weather scenario, typically referred to as a "problem fire scenario." The FlamMap software was developed by the USDA Forest Service Rocky Mountain Research Station. This software is readily available online at www.firelab.org/project/flammap.

**FSim.** The FSim software is also a fire mapping and analysis system that describes potential fire behavior. However, FSim provides an annualized scenario using multiple weather inputs and historical large fire ignitions. The FSim software was also developed by the USDA Forest Service Rocky Mountain Research Station. This software is available by request and with limited support.

**LANDFIRE.** LANDFIRE is a suite of landscape fire and resource management planning tools. It is a shared program between the wildland fire management programs of the USDA Forest Service and U.S. Department of the Interior. The program provides landscape scale geospatial products to support cross-boundary planning, management, and operations. This tool is readily available online at www.landfire.gov/datatool.php.

**WindNinja.** WindNinja is a computer program that computes spatially varying wind fields for wildland fire and other applications requiring high-resolution wind prediction in complex terrain. It was developed by the USDA Forest Service Rocky Mountain Research Station to be used by emergency responders within their typical operational constraints of fast simulation times (seconds), low CPU requirements (single processor laptops), and low technical expertise. This software is readily available online at www.firelab.org/project/windninja.

Displaying and sharing spatial delineations for wildfire risk or hazard can also result in real or perceived insurance, real estate, or other economic impacts. Residents may become concerned if they see their wildfire hazard or risk publicly displayed on a map, and they may question whether this information will affect their insurance premiums or their ability to resell their homes. They may also disagree with a rating if they do not understand how it was determined. Concerns can often be addressed through public education, but planners should carefully consider these impacts when using these tools.

## CONCLUSION

Spatially delineating the WUI and assessing wildfire risk or hazard are essential decision-support tools for land-use planning policies and regulatory implementation. Assessing wildfire risk down to the parcel level is a comprehensive approach, but it often takes more time and resources than local governments or fire agencies have available for this level of effort. It is therefore more common for jurisdictions to develop higher-level wildfire hazard assessments.

Assessments can be undertaken at multiple scales, including the landscape, local (or community), and parcel scales. Any type or scale of assessment must be performed by an experienced and skilled individual and is often managed by local or state fire or forestry agencies, or local contractors. Undertaking an assessment requires careful consideration of many factors to ensure the application meets the expectations of the outputs for all involved stakeholders. Planners should coordinate with these local, state, or federal stakeholders to understand which scale or type of assessment has already been completed, and whether there is an opportunity to develop a local (community-scale) assessment to inform land-use planning decisions.

Chapters 2 through 4 have provided an introduction to what planners need to know about the WUI, wildfire science, and wildfire hazard and risk assessments. The remaining chapters of the report will provide guidance on how planners can holistically incorporate WUI considerations into local plans and regulations.

CHAPTER 5

# A HOLISTIC WUI PLANNING FRAMEWORK

The first section of this report built an understanding of the wildland-urban interface (WUI), wildfire ignition basics, and issues of wildfire risk and management in the WUI. The next three chapters of the report provide guidance on planning tools and incentives that communities in the WUI can apply.

Planners can play an active role in conversations about where and how development takes place in the WUI. They have broad perspectives on community goals and priorities and can help identify conflicts between other community goals and priorities and those related to reducing wildfire hazard in the WUI—for example, where a goal related to increasing the urban tree canopy for aesthetic or carbon reduction purposes may conflict with goals related to reducing wildfire hazard. Planners can also play convening roles, bringing together multiple stakeholders who have been working on WUI issues and taking a holistic approach toward the range of plans and policies that address WUI challenges.

This chapter provides an overall framework for planning for the WUI and examines some of the core issues that communities need to consider and balance when addressing the WUI in their planning tools and incentives. Chapters 6 and 7 share practical guidance on addressing the WUI in plans and regulations.

## A HOLISTIC PLANNING APPROACH

This framework and the planning tools presented in the chapters that follow focus on a holistic planning approach. This approach is designed around building consistency between locally and regionally applicable plans and the policies and public investment programs that are used to implement them.

A holistic planning approach helps jurisdictions achieve the following with their plans and policies:

- Take into account the cumulative effects of locally adopted and applicable plans
- Establish alignment of goals and policy recommendations across relevant plans
- Create consistency between local plans and their associated implementation mechanisms
- Ensure plans and regulations adhere to applicable federal, state, and local laws

Developing a holistic planning approach is important because it establishes a clear policy direction for the local jurisdiction, which in turn facilitates successful implementation of plans and policies (Figure 5.1). The sidebar on p.

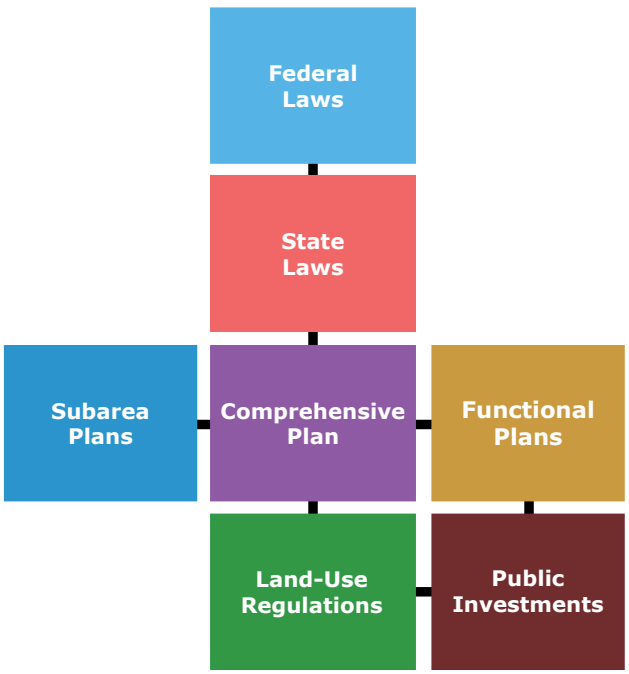



*Figure 5.1. A holistic planning approach (American Planning Association)*

## MULTIHAZARD PLANNING FRAMEWORK FOR COMMUNITIES IN THE WILDLAND-URBAN INTERFACE

The holistic planning approach described in this chapter is adapted from *Multihazard Planning Framework for Communities in the Wildland-Urban Interface* (APA 2018), a tool that APA developed for planners working in the WUI.

The framework examines the range of natural hazards that communities in the WUI may face and includes strategies for how communities can proactively address hazard risk through plans, land-use and development regulations, and public investments. The tool also includes a planning systems audit, which can help communities assess how their plans, policies, and public investments address hazard risk, as well as the alignment between and across these different planning tools.

This tool is available on the APA website at https://planning.org/publications/document/9155699.

66 points planners to a useful tool for applying this holistic planning approach to WUI-related natural hazards planning within their communities.

By looking at the cumulative effects of locally adopted and applicable plans and policies and by building consistency between these plans and their associated implementation mechanisms, communities can work with their elected officials to ensure that they are effectively addressing challenges in the WUI while balancing these considerations with other community priorities and minimizing conflict between them. For example, looking holistically across plans and policies may help a community create better alignment between goals related to mitigating wildfire risk and those related to expanding green infrastructure.

Building consistency and alignment between plans and their implementation mechanisms is important to the process of becoming a fire-adapted community and living more effectively with wildfire. See the sidebar on pp. 68–69 for more information on fire-adapted communities.

### Consistency with Federal and State Regulations

Local plans and regulations should be consistent with relevant federal and state regulations. Relevant federal laws may include the Healthy Forests Restoration Act of 2003 and the Disaster Mitigation Act of 2000, among others (see the sidebars on pp. 68–69 and 70 for descriptions of these laws).

Relevant state regulations begin with comprehensive planning and zoning enabling legislation. All states allow local comprehensive planning and many states mandate it to some degree, though this varies widely across states. State law and court decisions may also require that zoning ordinances and other development regulations be consistent with the goals and policy statements in the comprehensive plan. Additionally, state laws may require or recommend that comprehensive plans include a natural hazards or sensitive areas element, and they may include specific provisions related to the WUI.

For example, California's general plan statutes specifically address wildfire. California Government Code §65302 requires general plans to have a safety element that addresses "the protection of the community from any unreasonable risks," including those associated with wildland fire. Safety elements must address the risk of fire in state responsibility areas (where the state has the primary financial responsibility for fire prevention and suppression) and very high fire hazard severity zones. They must also include fire hazard severity zone maps and historical data on wildfires, as well as the distribution of current and future land uses in very high fire-hazard severity zones and in state responsibility areas. The

Governor's Office of Planning and Research has produced a technical guide focused on fire hazard planning to help communities incorporate wildfire hazard considerations into their general plans (Rubin, Calfee, and Glover 2014).

Outside of planning and zoning enabling laws, states may have other relevant laws or regulations with specific considerations related to the WUI. These laws create requirements and provide incentives for communities to adopt WUI regulations. For example, in Montana, the state code requires that local subdivision regulations reasonably avoid development that would cause negative impacts on the environment or public health, safety, and welfare due to natural hazards, including wildland fire (Montana Code Ann. §76-3-501-9). The state further provides guidelines on development in the WUI, created by the Department of Natural Resources and Conservation (Montana Code Ann. §76-13-104), which can be incorporated into local subdivision regulations if approved by elected officials. These address a range of considerations for subdivision development, including siting, defensible space and vegetation management, fuel breaks, and water supply (Montana DNRC 2009).

And in Utah, counties, municipalities, and special service districts are only eligible to receive financial assistance for wildfire suppression after entering into an approved cooperative agreement with the Utah Division of Forestry, Fire, and State Lands (Utah Code §65A-8-203). Cooperative agreements require that participating jurisdictions adopt a WUI code that meets or exceeds the standards of the state code and invest in fire preparedness and mitigation practices. Counties are also required to have a designated fire warden.

Local plans and regulations must be based on strong legal foundations. Because states vary in terms of their enabling legislation for planning activities and other relevant regulations, this creates different regulatory frameworks and requirements for local plans and regulations. In addition to alignment with enabling legislation and other relevant state regulations, local regulations with a defensible legal foundation have several common elements: a clear purpose statement, consistency in application, and, in the case of regulation in the WUI, a basis in the best available data. WUI regulations can be drafted by planners and other subject matter experts; however, these provisions should be reviewed by the local government's attorney for accuracy and compliance with federal, state, and local laws prior to adoption by the local governing body.

## Consistency Among Plans

A holistic planning approach looks across relevant locally adopted plans to ensure that goals and policy recommendations are coordinated and not conflicting. Communities adopt and implement multiple plans that may address the WUI.

The three basic types of local plans are:

- **Comprehensive plans.** The *comprehensive plan*, also called the general plan or master plan, defines a vision for the community over a 20- to 30-year planning horizon and includes goals, objectives, and policy statements to address future growth and change toward that vision. It serves as the foundational local policy document.
- **Functional plans.** *Functional plans* address specific topics or functional areas. These include community wildfire protection plans (CWPPs), hazard mitigation plans, and parks and open space plans.
- **Subarea plans.** *Subarea plans* address specific geographic areas or jurisdictions. These include neighborhood, district, and corridor plans.

Goals and policy statements defined in the comprehensive plan should be advanced in the community's functional and subarea plans. The comprehensive plan should reference relevant functional and subarea plans in support of its goals and policy recommendations. Building alignment and consistency between comprehensive, functional, and subarea plans strengthens and works to advance plan goals and policy recommendations. It can also be important in identifying and addressing conflicts between plans that hinder successful implementation.

Different departments or agencies often have responsibility for different plans. For example, the local planning department oversees the preparation and adoption of the comprehensive plan, while the local fire agency may oversee the CWPP. As a result, it is important to engage with relevant stakeholders across local agencies to ensure that plans are consistent and that all relevant local agencies have knowledge of all relevant local plans.

## Consistency Between Plans and Implementation Mechanisms

A holistic planning approach goes beyond the plans themselves to address implementation mechanisms. For communities in the WUI, these include land-use and development regulations, as well as building and fire codes. They also include public investments. Plans should address both regulations and public investments in their implementation sections.

Consistency between plans and local regulations helps ensure that a community is effectively implementing its stated policy goals and that results are not in conflict with these

## EVOLVING FEDERAL POLICY

Over the last 30 years, there has been a significant shift in federal policy regarding wildfire. For much of the 20th century, federal policy focused on rapid response and suppression of wildfire (see Chapter 2). While this policy was focused on preventing economic losses to timber resources and towns, it had the unintended consequence of interrupting natural fire regimes.

Toward the end of the century, policies began to focus on the natural role that wildfire plays and the consequences of previous policies that excluded all fires on the landscape. The 1995 *Federal Wildland Fire Management Policy and Program Review*, an interdepartmental review focused on improving wildfire risk management, recognized that fire suppression and land-use practices have altered landscapes in ways that increase the risk of high-intensity wildfires and that fire agencies are becoming overextended in their ability to respond to these fires (U.S. Department of Interior and U.S. Department of Agriculture 1995). It called for fire to be reintroduced to ecosystems to maintain and restore ecosystem health.

This policy shift has been continued by the Healthy Forests Restoration Act of 2003 (see the sidebar on p. 70) and the National Cohesive Wildland Fire Management Strategy.

## NATIONAL COHESIVE WILDLAND FIRE MANAGEMENT STRATEGY

The National Cohesive Wildland Fire Management Strategy was created as the result of a directive in the Federal Land Assistance, Management, and Enhancement (FLAME) Act of 2009, which mandated the development of a cohesive wildland fire management strategy. It was developed by the Wildland Fire Leadership Council (WFLC), an intergovernmental council with representatives from federal, state, tribal, and local governments, through a three-phase process.

The Cohesive Strategy presents the following vision for the next century:

> *to safely and effectively extinguish fire, when needed; use fire where allowable; manage our natural resources; and as a Nation, live with wildland fire.*

This vision represents a significant shift from the prior century's policies of fire exclusion and rapid fire suppression.

The Cohesive Strategy focuses on three central goals toward achieving its vision (WFLC 2014, 3):

- **Restore and maintain landscapes:** Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.
- **Fire-adapted communities**: Human populations and infrastructure can withstand a wildfire without loss of life and property.
- **Wildfire response:** All jurisdictions participate in making and implementing safe, effective, efficient risk-based wildfire management decisions.

It further identifies four central challenges that need to be addressed to attain these goals. These are: (1) vegetation and fuels management; (2) protection of homes, communities, and other values; (3) human-caused ignitions; and (4) effective wildfire response.

Two elements of the Cohesive Strategy are of particular relevance to planners. The first is collaborative management—or the All Hands, All Lands approach—and the second is the idea of living with wildfire through community fire adaptation.

### All Hands, All Lands

The All Hands, All Lands approach focuses on aligning goals and priorities across multiple stakeholders. It allows for collaborative management practices toward these goals across stakeholder groups, including federal, state, and local agencies and private landowners. It depends on ongoing communication, collaborative engagement, and shared decision making. This approach has been applied to conservation, landscape restoration, and community wildfire protection plans.

Because the All Hands, All Lands approach focuses on collaboration across stakeholder groups and land management boundaries, planners can play important roles as coordinators and conveners within the process. Additionally, planners can help stakeholders understand how local regulations may impact different properties and help stakeholders prioritize long-term projects through planning processes.

### Living with Wildfire in WUI Communities

Living with wildfire—also known as *fire adaptation*—focuses on a community's ability to both accept fire as a natural part of the landscape and to take actions to mitigate the risk. "Fire-adapted" communities understand wildfire risk and the importance of taking both individual and collective action to mitigate this risk.

Community members in fire-adapted communities understand the ecological function of wildland fire. They also know that mitigation measures may

not guarantee structures are not lost during extreme wildfire events, but they recognize that adaptation can reduce dependence on fire suppression; reduce risk to the public, fire personnel, and property; and improve a community's preparedness for and ability to recover from a wildfire event (Leschak 2014). Fire adaptation is an ongoing process—one that involves multiple tools and strategies, ongoing education, and continued adaptation.

Fire-adapted community concepts target WUI communities. Strategies include fuel treatments, plans, voluntary neighborhood programs, and codes and ordinances. Many states and local governments are now embracing this concept. Coordinated programs or learning networks have been developed in Washington, New Mexico, Colorado, Arizona, Minnesota, Montana, Georgia, and other areas.

goals. For example, if a community has a goal in its comprehensive plan to limit development in environmentally sensitive areas, including wildfire hazard areas, incorporating provisions in the local zoning code or subdivision regulations that place conditions on or limit development in these areas will help achieve this goal. As noted above, state law may require that zoning ordinances and other regulations related to development be consistent with the goals and policy statements in the comprehensive plan.

In addition to creating consistency between plans and regulations, communities should also create consistency between goals and policy objectives defined in local plans and public investments. Public investments include capital investments (including land acquisition), financial incentives and direct financial assistance to home owners and businesses, technical assistance, and education and outreach programs.

### Planning Applications Across Scales

Different planning tools address different scales. To address WUI challenges in their plans and regulations, it is important that communities consider the appropriate scale for an intervention and the resulting depth of that intervention, as well as coordination across scales. For example, the comprehensive plan may include goals related to mitigating wildfire risk in the WUI. A neighborhood plan could further advance those goals by identifying an appropriate area for a fuel break between a neighborhood and the surrounding forestland. Planners also need to understand building and site-scale considerations in the WUI (see Chapters 1, 2, and 7).

## BALANCING COMMUNITY PRIORITIES

Building alignment among plans, regulations, and public investments as part of a holistic planning approach can be both time consuming and resource intensive for communities. Working to do so, however, can help a community balance competing or conflicting priorities and ensure that WUI challenges are addressed uniformly across plans and their implementation mechanisms.

All communities and their elected officials must address questions of where and how to develop—where should growth occur and what form should that growth take? Answering this question inherently involves balancing different priorities. For communities in the WUI, these can include weighing proximity to scenic amenities and open spaces against the risk that development in the WUI poses, different challenges related to existing and new development, and

## FEDERAL REGULATIONS THAT ADDRESS WILDFIRE

While multiple federal laws impact communities in the WUI, there are three that have particular relevance to planning: the Healthy Forests Restoration Act of 2003, the Disaster Mitigation Act of 2000, and the Disaster Recovery Reform Act of 2018. Planners should be aware of these laws and how community wildfire protection plans and multihazard mitigation plans impact federal land management and disaster mitigation funding decisions, respectively.

### HEALTHY FORESTS RESTORATION ACT OF 2003

The Healthy Forests Restoration Act (HFRA) was signed into law by President George W. Bush in December 2003. Following severe fire seasons in 2000 and 2002, the Bush administration launched the Healthy Forests Initiative to improve forest health and wildfire response. HFRA was the central legislative component of this initiative.

HFRA provides funding and guidance for forest management activities, with the goal of protecting communities from catastrophic wildfire. Activities addressed include implementing hazardous fuel reduction projects on federal lands, working with private landowners and tribal governments to protect and restore watersheds, and promoting conservation activities to protect endangered species habitat and enhance biodiversity (Forests and Rangelands 2004).

As part of its focus on hazardous fuel reduction, HFRA defines community wildfire protection plans (CWPPs). CWPPs are voluntary, but federal land management agencies (e.g., the Bureau of Land Management and USDA Forest Service) are required to use CWPPs to prioritize funding for fuel-reduction projects on both federal and nonfederal lands. As a result, preparing a CWPP provides communities with significant opportunities for input into the implementation of hazardous fuel management on surrounding federal lands, such as national forests.

CWPPs are required to be developed through a collaborative process and must address treatments for structural ignitability. Communities can also use the CWPP to locally define the boundaries of the WUI. The final CWPP must be approved by the city or county government, the local fire department, and the state forest management agency. For more information on CWPPs, see Chapter 6.

### THE DISASTER MITIGATION ACT OF 2000

The Disaster Mitigation Act of 2000 (DMA2K) amended the 1998 Robert T. Stafford Disaster Relief and Emergency Assistance Act. The goal of the DMA2K is to reduce disaster losses—particularly repetitive losses from local development in high-risk areas—and improve the effectiveness of federally funded mitigation projects through planning (Schwab 2010).

The DMA2K requires Federal Emergency Management Agency (FEMA)-approved state, local, and tribal government multihazard mitigation plans as a condition for receiving certain types of nonemergency disaster assistance, including funding for mitigation projects. DMA2K creates incentives for better coordination in mitigation planning and implementation. It also establishes the Pre-Disaster Mitigation program, a funding and technical assistance program for pre-disaster mitigation activities.

State, local, and tribal mitigation plans undergo a plan approval process whereby the plan is reviewed by the state and FEMA for adherence to federal regulations. For more information on hazard mitigation plans, see Chapter 6.

### DISASTER RECOVERY REFORM ACT OF 2018

The Disaster Recovery Reform Act of 2018 (DRRA) was adopted as part of the Federal Aviation Administration Reauthorization and amends the 1998 Robert T. Stafford Disaster Relief and Emergency Assistance Act. The DRRA is designed to address the rising cost of disasters (including wildfires) by helping communities better prepare for and recover from disasters. It supports pre-disaster planning and mitigation by allocating a portion of post-disaster funding to mitigation planning for future disasters (House Transportation and Infrastructure Committee 2018).

considerations related to hazard mitigation. These potential conflicts are explored in more detail below.

### Scenic and Amenity Value

As noted in Chapter 2, a desire to live in proximity to nature is one of the drivers of WUI growth. People move to the WUI to be closer to natural areas and wildlands for the scenic and recreational amenities they provide, as well as for the privacy afforded by these landscapes.

As communities look to address WUI issues in their plans and regulations, they must balance what people value about living in the community with the risks that certain forms of development or development in certain areas may pose. For example, development on slopes and ridgelines may offer scenic vistas, but it also results in increased risk to the development during a wildfire event.

### Existing and New Development

Existing development can also pose a challenge for WUI communities. Many communities have a large share of development that existed prior to the adoption of WUI codes, WUI standards in building codes, or other WUI regulations. As a result, a significant portion of existing development in areas of wildfire risk may be nonconforming.

Nonconformities may include inadequate access to water supplies on site, construction with combustible building materials, or hazardous land uses, among other challenges. While communities can work to phase out code nonconformities that threaten public health or safety, doing so can be politically challenging, resource intensive, and costly.

New development presents a trade-off. It is more likely to be built in accordance with the most recent WUI standards, including fire breaks, adequate water supply, secondary access for emergency responders, and street numbering on properties that is visible and uniform. New developments are also more likely than older developments to have home owners associations that take on the responsibility for management of community open spaces and have requirements for vegetation or landscape management on private lots (Duerksen, Elliot, and Anthony 2011). However, new development—even development that conforms to the latest WUI standards—also means the continued expansion of the WUI and more homes in wildfire hazard areas.

### Hazard Mitigation

Mitigating wildfire hazard and risk in the WUI requires that communities know where their WUIs are and understand their current levels of wildfire hazard and risk (see Chapters 2 and 4). Developing this understanding can help planners devise mitigation strategies that are most appropriate to different areas of the WUI, as well as decide how to weigh competing community priorities or values that may impact these mitigation activities.

Mitigating wildfire hazard and risk in the WUI presents several challenges. These include land management techniques, the need for ongoing enforcement, and the dedication of community resources. Land management in wildland areas often includes fuel treatments, such as thinning of vegetation, prescribed fire, and other techniques to reduce fuel accumulation. However, development in the WUI can make it difficult for land managers to use these techniques, as property owners may be concerned about health and safety.

Hazard mitigation efforts require the dedication of community resources, including both staff and volunteer time and financial resources. Regulations designed to mitigate wildfire hazard and risk in the WUI require ongoing funding, enforcement, and maintenance. For example, fuel breaks need continued maintenance to ensure that they remain clear of vegetation. This requires resources for maintenance of fuel breaks on public lands and staff time and resources for enforcement for those that are privately maintained by entities such as home owners associations. Mitigation efforts also require resources for ongoing education and outreach efforts for home owners and other community stakeholders.

Finally, these efforts require political will and public support to address. It can be difficult to change long-standing patterns or devote significant resources to enacting and enforcing regulations. Communities must balance the available resources with the political will and feasibility of addressing the challenges in prioritizing the planning tools that will most effectively achieve their hazard mitigation goals.

## ENGAGING STAKEHOLDERS

Planners are playing increasingly active roles in addressing WUI challenges and awareness is growing of the importance and benefits of addressing WUI issues in plans and land-use regulations. It is also important to recognize that in many communities, other departments and agencies have been leading local efforts to address these challenges. Whether planners are just beginning to address wildfire issues in their jurisdictions or are seeking to further expand on existing efforts, they should proactively engage the following agencies and stakeholders in developing plans and shaping implementation mechanisms for the WUI.

*Figure 5.2. Planners and fire officials participate in a scenario-building exercise for wildfire planning during a training at the Western Planner conference in Spearfish, South Dakota (Wildfire Planning International)*

- **Federal land management agencies.** Numerous land management agencies are involved in forest and wildland management and wildfire response. The four major federal land management agencies—the USDA Forest Service, the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the National Park Service—administer more than 610 million acres of land, primarily in western states. Because wildfire impacts the health of federal lands, the Forest Service and Bureau of Land Management actively engage in wildfire protection (Vincent, Hansen, and Argueta 2017). The Bureau of Indian Affairs and Department of Defense also play major roles in fire management in some regions. Federal agencies often work with communities through planning processes, such as hazard mitigation plans or CWPPs. Planners can further work to actively engage federal stakeholders in community visioning and local comprehensive planning processes.
- **State land management agencies.** State land management agencies, including state forestry departments, state parks agencies, and state conservation agencies, also play active roles in managing land in and surrounding the WUI. Planners can work to engage state land management agencies in local visioning and planning processes. Often state agencies are an intermediary for communities to access federal grant money for planning, mitigation, or equipment.
- **Emergency management agencies.** Emergency management agencies are often responsible for the hazard mitigation plan (see Chapter 6) and may coordinate or take the lead on local mitigation efforts. Planners can work with emergency management agencies on the development of hazard mitigation plans and should also engage with emergency managers when incorporating mitigation-related provisions into other local plans, such as the local comprehensive plan.
- **Fire agencies.** Fire agencies are often responsible for CWPPs (see Chapter 6), as well as community outreach and education programs focused on steps community members can take to mitigate wildfire risk. Planners should engage with fire agencies through the CWPP process and should also work to align messaging around mitigation used in community visioning or planning processes with the outreach and educational materials produced by the fire agency.
- **Code officials.** WUI regulations are frequently contained in the building, fire, or WUI codes (see Chapter 7). As a result, code officials will often have knowledge of and responsibility for existing WUI regulations. Planners should work closely with code officials to identify existing regulations that may align or conflict with goals and actions identified in local plans and when developing new regulations.

- **Community groups.** Local residents across the country have formed community-based groups to represent the needs of home owners associations, neighborhoods, and other community members in planning for wildfires, coordinating mitigation activities, and identifying funding opportunities. Some of these groups may participate in established structures or formal programs, such as Fire Safe Councils (https://cafiresafecouncil.org) or the Firewise USA program (www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA). Planners should conduct outreach to these groups through the planning process. Because they are community based and are actively involved in coordinating mitigation and identifying funding, they can be key partners for building public support for WUI plans and working on implementation measures.

While where and how we develop has important implications for the WUI and for managing wildfire risk, resulting in a clear role for planners, it is important for planners to recognize that other departments and agencies at multiple levels of government have long been engaged in these issues and have significant expertise related to addressing challenges in the WUI. As planners engage more actively around the WUI and wildfire, it is important to align efforts and work collaboratively with these stakeholders (Figure 5.2, p. 72).

## CONCLUSION

Communities in the WUI can benefit from a holistic approach that works to create alignment between plans, policies, and public investments. While such an approach can be time and resource intensive, it can help communities balance competing priorities and address conflicts and inconsistencies between plans and regulations. This can help facilitate successful implementation of plans and policies, which is important to mitigating wildfire risk and working toward fire adaptation at the community level.

The following chapters provide specific guidance on applying planning tools and incentives. Chapter 6 focuses on plans. It discusses community engagement and visioning when addressing WUI issues in local plans. It then looks at how WUI issues can be addressed in comprehensive, functional, and subarea plans. Chapter 7 focuses on WUI regulations. It provides an overview of WUI issues, their scales, and relevant regulations; profiles specific tools; and discusses strategies for successful implementation.

CHAPTER 6

# WUI PLANNING TOOLS

Communities adopt a wide variety of plans, focused on different topics and at various scales. These plans range from "big-picture" plans such as the comprehensive plan, which addresses a broad spectrum of community planning priorities, to detailed topic- or area-specific plans, including community wildfire protection plans (CWPPs), hazard mitigation plans, parks and open space plans, watershed plans, and neighborhood or district plans.

Some plans provide obvious linkages to the wildland-urban interface (WUI). For example, climate adaptation plans can analyze how future wildfire activity may increase due to climate change and what the relevant impacts will be on a community's WUI. Other linkages, however, may be less intuitive—such as finding connections between open space plans and wildfire mitigation policies.

This chapter helps planners understand how land use, the WUI, and wildfire topics fit together during the planning process and in the plans themselves. It starts with an overview on community visioning and community engagement as opportunities to incorporate WUI discussions into the plan-making process. It then takes an in-depth look at the comprehensive plan as a primary tool for addressing the WUI, including detailed guidance on policy development. Additional sections focus on hazard mitigation and community wildfire protection plans to help planners understand how land use can be inserted into these plans and how to best leverage them for WUI planning. Finally, this chapter discusses other functional plans and subarea plans to identify topics relevant to the WUI.

## COMMUNITY VISIONING AND COMMUNITY ENGAGEMENT

Community visioning is a participatory planning process that creates a consensus around a shared idea of the community's future—it provides a method of engaging the community around a future vision. A visioning process can help address rapid change or contentious issues and should seek to engage a broad array of community stakeholders, including locally elected officials. It often takes place as the first phase of a comprehensive planning process, in which case the visioning process will address a wide spectrum of community issues and priorities.

Community visioning can also be a stand-alone process. In this case, it may be more narrowly scoped on an issue or several issues that are of high priority to the community. For example, a community visioning process could focus on fire adaptation or living with wildfire.

Community and stakeholder engagement is important to ensuring that the resulting plan reflects community needs and values and has the buy-in required for successful implementation. It also provides an opportunity for community outreach and education around WUI issues.

While federal regulations for some planning processes—including both hazard mitigation and community wildfire protection planning—require the engagement of community stakeholders (see the sidebars on federal wildfire-relevant policies and programs in Chapter 5 and the sections on hazard mitigation and CWPPs below), this should be much more than a perfunctory activity. Local governments can engage a broad range of community members and stakeholders in the planning process using multiple methods of engagement.

When undertaking community engagement processes that address the WUI or wildfire, it is important for planners to recognize that other departments, such as the local fire department, land management agency, or emergency management agency, may have well-established community engagement, outreach, or education programs in place, as described in the previous chapter. Planners should learn about these programs and collaborate to ensure that community vision-

## ARCHETYPES OF WUI COMMUNITIES

Research conducted by a team with the USDA Forest Service Rocky Mountain Research Station examined case studies of 18 WUI communities and developed four community archetypes (Cooke 2016; Paveglio et al. 2015). The team then analyzed adaptive capacity characteristics across these archetypes.

Although communities will have unique local considerations, these archetypes can be helpful to planners in thinking about community motivations, preferences, and stresses when designing community visioning and engagement processes and incorporating WUI considerations into local plans and policies.

The four archetypes are:

- Formalized, suburban WUI communities
- High-amenity, high-resource WUI communities
- Rural lifestyle WUI communities
- Working landscape/resource-dependent WUI communities

These community archetypes fall on different continuums related to density, amenities, and adaptive capacity. High-amenity, high-resource WUI communities and rural lifestyle WUI communities have the highest degree of outdoor and recreational amenities. As a result, they experience higher degrees of people moving to these communities for access to scenic and recreational amenities and have higher proportions of second-home owners; high-recreation, high-amenity WUI communities see the largest share of residents attracted to local amenities and second-home ownership. Formalized, suburban WUI communities and working landscape/resource-dependent WUI communities both comprise primary residences, though formalized suburban WUI communities tend to be subdivisions or planned developments, while working landscape/resource-dependent WUI communities are generally rural, low density, and located in working landscapes.

Formalized, suburban WUI communities and high-amenity, high-resource WUI communities are generally more comfortable with regulations and have higher degrees of expectation that government services (including firefighting) will be provided. Rural lifestyle WUI communities and working landscape/resource-dependent WUI communities are less comfortable with regulations and have fewer expectations of government services. They also generally have more knowledge of wildfire risk reduction practices and are more likely to view wildfire preparedness as a personal responsibility.

ing and engagement processes amplify the messages of existing programs. This also avoids potential confusion or conflict.

Engaging community stakeholders and the public in the planning process can also build knowledge around actions that residents can take to reduce wildfire risk on their own properties, including creating defensible space and using fire-resistant building materials. It offers an opportunity for community outreach and education around WUI issues, which can help build support for practices that reduce overall community wildfire risk, such as fuel treatments (e.g., prescribed burning). In addition to educating local officials, home owners, and other community stakeholders about what they can do to reduce wildfire risk on their properties and in the community, community outreach and engagement that focuses on wildfire prevention can help reduce human-caused ignitions (Stein et al. 2013).

The sidebar on p. 76, which describes the four archetypes of WUI communities, presents a helpful framework for planners when engaging with local stakeholders. Additional examples of community engagement are included throughout this chapter.

## THE COMPREHENSIVE PLAN

The local comprehensive plan, also called the general plan, master plan, or growth policy, is the foundational policy document for local governments. Communities use this plan to establish a long-term planning framework that guides public and private decisions about future growth, preservation, and change over a 20- to 30-year horizon.

The comprehensive plan has traditionally focused on physical development, but many contemporary comprehensive plans also discuss a wide range of economic, environmental, and social topics (Morley 2014). Issues related to sustainability, resiliency, and natural hazards are increasingly becoming more relevant to help communities prepare for uncertainties associated with climate change, raise awareness about pre- and post-disaster planning needs, and create forward-thinking plans that reflect citizen concerns. The American Planning Association (APA) has developed the Comprehensive Plan Standards for Sustaining Places to help communities integrate sustainability principles and practices into their comprehensive plans (Godschalk and Rouse 2015).

### Addressing the WUI in the Comprehensive Plan

Communities that are interested in addressing the local WUI and associated wildfire concerns within their comprehensive plan can do so in various ways. In some cases, such as in California, state planning laws require communities with wildfire hazard to consider wildfire goals and policies as part of their general plan (i.e., comprehensive plan) update process. Other jurisdictions may have fewer legal requirements or guidance for WUI planning in the comprehensive plan but recognize the benefits associated with incorporating wildfire hazard-related policies into the long-range planning process. In addition, growing public concern about wildfire is prompting communities to rethink how hazards are included.

Recognizing the individuality of comprehensive plans, there is a lot of room to consider why and how to address the WUI in the plan development process.

**Do some homework.** First, gather information from multiple sources to inform the plan development process. Communities need to know where the starting point is in terms of what information has already been identified (e.g., a WUI assessment or wildfire hazard map), whether any WUI-related goals and policies exist in the current plan and may require revision, or if they are starting from scratch and no previous planning has yet occurred related to the WUI and wildfire.

In some cases, existing content may be readily available. Good information sources include hazard mitigation plans, CWPPs (discussed later in this chapter), and state or regional data available through forestry and fire agencies. As noted in Chapter 5, communities must also determine if their state has specific guidance or requirements related to the WUI or wildfire hazard to ensure that their comprehensive plans comply with state laws.

Finally, talk with local fire departments, emergency services, state forestry agencies, and local land management organizations. These groups will often have quick access to resources that planners may not be as familiar with, such as wildfire hazard maps and other spatial tools or data. They may also have valuable perspectives on local development, land management, or resource concerns that will be helpful to learn about early in the plan update process.

**Engage the public.** Incorporate conversations about natural hazards into the public outreach process. These discussions may be centered around general resilience or environmental themes, but they should include dialogue related to wildfire and other pertinent hazards. Surveys or other public outreach tools should include specific questions on local hazard concerns. This enables planners and other policy makers to understand the nature of public concerns and provide educational opportunities on the importance of addressing hazards as part of the planning process.

## DEADWOOD, SOUTH DAKOTA: COMMUNITY ENGAGEMENT FOR WUI PLANNING

During the start of Deadwood, South Dakota's comprehensive plan update in 2017, the city developed a community survey to help identify local planning challenges and priorities related to housing, city services, community facilities, special events, parks and recreation, transportation, and growth. Natural hazards, including wildfire, were not included in survey questions, nor were they added in public comments.

However, city planners were interested in this topic due to Deadwood's past history with wildfire and awareness of the hazard that the community faces. The city applied for technical assistance from the Community Planning Assistance for Wildfire (CPAW) program, a national program funded by the USDA Forest Service and private foundations that offers voluntary guidance to communities interested in WUI planning. CPAW consultants worked closely with the city's comprehensive plan committee, which included citizen and business representatives, to develop principles and strategies related to wildfire. This content was integrated into the plan draft and the public had the opportunity to comment on this section during two open houses (Figure 6.1). Residents prioritized strategies to attract and retain volunteer firefighters and develop a community evacuation plan (Zeller 2018).

The approach taken by the Deadwood shows that opportunities to educate and engage the public on the WUI topic can still occur even if they initially did not come to the forefront during the comprehensive plan development process.

*Figure 6.1. Community members from Deadwood, South Dakota, meet with planning experts (top) and during a public open house (bottom) to discuss wildfire planning priorities for the city (Wildfire Planning International (top), Deadwood History, Inc. (bottom))*

In communities where wildfire is a recent or regular occurrence, public engagement often naturally focuses on the WUI. However, other communities may not readily identify themselves as being in the WUI or prioritize local wildfire hazard actions. This latter circumstance can require different engagement strategies when seeking public input into the comprehensive plan, as is illustrated in the sidebar on p. 78 about the approach taken in the city of Deadwood, South Dakota.

**Draft background information.** Draft content related to the WUI and wildfire hazard to help the community understand the relevance of this topic for planning. In other words, identify what is helpful for the reader to know in order to appreciate why this topic is part of community planning, not just emergency management planning.

General content to include should focus on:

- **WUI and hazard identification**. Include or link to a WUI or wildfire hazard map (see Chapters 2 and 4) to help the community identify the extent of existing conditions as well as the potential for future WUI growth. For example, a WUI map would show where current and future policies apply; a wildfire hazard map can be referenced to ensure land-use and future growth decisions account for this hazard as part of comprehensive planning goals. If communities do not yet have this information but are aware that wildfires are a general threat to the community, they can acknowledge the importance of understanding the WUI and its potential implications.
- **An overview of historical local wildfires and significant community impacts**. Many of this detailed information may appear in other hazard plans (described below), but providing a summary adds local context. As illustrated in Chapter 2, the range of social, economic, and other community impacts from wildfires are often felt far beyond fire perimeters. Acknowledging these impacts lends relevance and importance to the topic.
- **Fire's ecological role in the landscape.** Community wildfire planning is frequently framed as negative based on the range of devastating consequences. However, it is also important to recognize that fire can bring benefits to local habitats and species and plays a critical role in shaping the environment. For example, in its comprehensive plan *Imagine 2040*, Horry County, South Carolina, describes how development alongside forested tracts of land hinders the ability for land managers to conduct prescribed burns—a land management tool that uses fire to both decrease the likelihood of larger, more intense wildfire and to preserve wildfire-dependent habitats (Horry County 2018).

Including this information heightens awareness of local planning factors and sets the stage for goals, objectives, and policies. As previously mentioned, content should also account for any state requirements related to WUI, wildfire, and other natural hazard planning information.

**Develop goals, objectives, and policies.** Based on fact-finding and community input, develop goals, objectives, and policies to address the WUI and wildfire.

Consider the range of potential topics that may currently exist within the community or require future attention:

- **Existing development:** The type of uses that are currently in the WUI, such as housing, critical infrastructure, parks, cultural or heritage sites, and other community assets
- **Future growth and land uses:** Potential development in the current WUI or in areas with identified wildfire hazard
- **Community safety:** Planning needs to ensure public and first responder safety, such as adequate water supply and other infrastructure requirements
- **Transportation:** Accessibility of neighborhoods and other areas to enable timely response and efficient evacuations
- **Economic impacts**: Commercial activities that could be disrupted by a wildfire event, such as businesses, agricultural production, and tourism
- **Natural systems and resources**: Forests, watersheds, grasslands, environmentally sensitive areas, habitats, and other natural systems that could be affected by a wildfire
- **Air and water quality**: Direct and indirect effects from wildfire on air and water quality, such as sediment, runoff, or smoke
- **Post-disaster recovery**: Likelihood of short and long-term needs and effects, such as debris removal and damaged infrastructure, and the rebuilding and reinvestment process
- **Relationship to other hazards**: The potential for post-fire flooding, drought, or other hazards and how that may affect wildfire planning activities
- **Sustainability and climate change**: How wildfire may be exacerbated by climate change, or implications of local wildfires on sustainability goals (such as zero emissions)
- **Partnerships, stakeholders, capacity, and collaboration**: Roles, responsibilities, and ability to plan for actions related to the WUI and wildfire mitigation

Some of these topics can become captured as high-level goals—for instance, "the community seeks to ensure

## PALM COAST, FLORIDA: PLANNING FOR THE WUI

The Palm Coast, Florida *2035 Comprehensive Plan* was adopted in 2004 and last updated in 2018. Chapter 6, the Coastal and Conservation Management Element, includes a detailed set of policies to address a range of wildfire risk reduction activities for the WUI through various architectural, site planning, and landscaping and material decisions. Policies also promote voluntary neighborhood programs, such as Firewise USA.

Below are some examples of wildfire-related objectives and policies from the plan; a full listing is available at www.palmcoastgov.com/about/comp-plan.

*Objective 6.2.6—Firewise Planning. Protect life, property, and the economy by eliminating or minimizing the present and future vulnerability to wildfire hazards.*

*Policy 6.2.6.1—The City shall carefully consider all land uses in areas at risk from wildfire and restrict or prohibit certain land uses as necessary to assure public health, safety, and welfare and the protection of property. Land uses and specific development plans for which adequate wildfire mitigation cannot be provided, or that would preclude or severely limit the use of wildfire mitigation or natural resource management options such as prescribed fire, shall not be authorized in severe wildfire hazard areas.*

*Policy 6.2.6.2—The City shall continue to identify areas with high wildfire risk and enforce LDC regulations implementing mitigation strategies.*
*A. Require that developers provide for a minimum of two emergency ingress/egress access ways,*
*B. Require streets, roads, driveways, bridges, culverts, and cul-de-sacs shall be designed to assure access by firefighting equipment, providing for weight class, cornering, turn around and overhead clearance, and*
*C. Provide a defensible space on land between the wildland urban interface areas and adjacent development.*

*Policy 6.2.6.3—All new developments in wildfire hazard areas shall complete and implement a wildfire mitigation plan specific to that development, subject to review and approval by the City, which shall be incorporated as part of the development plan approved for that development. The mitigation plan shall include:*
*A. Project and parcel design features, such as defensible project perimeters, interior project fuel breaks, individual site defensible space, landscaping guidelines and plant material suggestions, and the placement of structures.*
*B. Provisions for periodic inspections by the City to verify construction, implementation, and maintenance of the wildfire mitigation features in accordance with the plan. The inspection period may range from once a year to once every three years depending on site conditions.*
*C. Implementation of the wildfire mitigation plan for the entire life cycle of all developments requiring plans.*
*D. Water storage facilities, accessible by standard fire-fighting equipment, shall be provided, dedicated, or identified for fighting wildfires. Where public supply is available, fire hydrants of sufficient pressure shall be required.*

*Policy 6.2.6.4—The City shall coordinate with the Florida Division of Forestry to manage the wildland urban interface areas within the City and in surrounding areas and wildfire management practices shall include, but not be limited to, controlled burns, mechanical mowing of vegetation, herbicide treatment, or other means deemed appropriate. The City shall amend the LDC, if necessary, to implement this Policy.*

*Policy 6.2.6.5—The City shall promote the expansion of the Firewise Communities Program into other high-risk subdivisions and areas of the City and implement and enhance educational programs promoting Firewise principles.*

*Policy 6.2.6.6—The City shall seek funding from public and private agencies to assist in the development and enhancement of wildfire mitigation programs and practices.*

*Figure 6.2. Palm Coast, Florida, leverages its comprehensive plan to address local wildfire concerns, including requirements for mitigating hazardous vegetation near development (City of Palm Coast)*

public safety and resilience." Objectives and policies, however, will require customization and increased specificity to describe and address local concerns, as the example from Palm Coast, Florida, described in the sidebar on p. 80, demonstrates.

Communities have many helpful resources to turn to for support in developing effective plans. Goals, objectives, and policies can be organized in a single chapter or integrated throughout the plan. For example, some communities add WUI and wildfire information in a single chapter, such as the environment, natural resources, or natural hazards element, as in the Palm Coast plan.

Alternatively, communities can take an integrated approach that includes wildfire policies in connection to other planning topics. The Greater Bemidji Area in Minnesota took this latter approach in its recent comprehensive plan update; wildfire planning topics are included in separate chapters that address land use, the economic regional center, community facilities and services, and natural resources. The full plan is available on the Greater Bemidji Area Joint Planning Board website (www.jpbgba.org).

**Create alignment.** Goals, objectives, and policies should be reviewed for compatibility and alignment with other planning priorities. Common policies that require reconciliation are urban forestry practices that promote tree planting and reforestation in the WUI, community design standards that encourage aesthetics that may be at odds with wildfire-resistant features, or planned growth adjacent to wildland areas that requires different management objectives for maintaining natural areas and ensuring public safety. This is not to suggest that WUI policies take precedence over other policies, but planners should consider how to meet multiple objectives without inadvertently increasing wildfire hazard in the WUI.

Other topics may strengthen WUI planning objectives. For example, prioritizing sustainable areas of growth by identifying areas that have limited water supplies also reinforces WUI policies that ensure water availability is a requirement for future residential or commercial development.

**Identify next steps.** Where applicable, identify leads, partners, priorities, and time frames for policy implementation. Keep in mind that implementation is also addressed in other detailed plans, such as hazard mitigation plans, community wildfire protection plans, and subarea plans, as discussed below, as well as in regulations, as discussed in Chapter 7.

The sidebar on p. 82 offers additional resources from several states that will help planners address wildfire and the WUI in comprehensive plans.

## FUNCTIONAL PLANS

Communities adopt functional plans to address specific topics, or *functional areas*. Locally adopted functional plans can add further detail and nuance to the goals and actions outlined in the comprehensive plan.

Some functional plans—such as hazard mitigation plans and CWPPs—provide obvious vehicles for defining strategies to address wildfire risk in the WUI. Other functional plans, including watershed plans, parks and open space plans, and sustainability or climate adaptation plans, can also incorporate WUI- and wildfire-specific considerations.

### Hazard Mitigation Plans

The Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act of 2000, provides the legal basis for state, tribal, and local governments to undertake risk-based approaches to reducing natural hazards through mitigation planning (FEMA n.d.). As a condition for receiving certain types of nonemergency disaster assistance, including funding for mitigation projects, the Federal Emergency Management Agency (FEMA) requires that state, tribal, and local governments develop and adopt hazard mitigation plans.

Hazard mitigation plans, also referred to as local mitigation strategies or other variations, enable communities to plan for and take action to reduce the impacts of disasters. Communities use hazard mitigation plans to profile natural and human-caused hazards, including wildfire, drought, and flood, that are applicable to the planning area.

Hazard mitigation plans are developed at different scales. States develop hazard mitigation plans to identify statewide hazards, compile demographic data such as social vulnerabilities and land-use trends, plan for capabilities, and implement mitigation activities. Statewide plans also facilitate a coordinated approach, as many hazards span jurisdictional boundaries.

At the local level, hazard mitigation plans are adopted by counties, local jurisdictions, and in some cases larger regions that include multiple counties and local jurisdictions. When adopted at the county scale, plans typically represent communities within the county.

Although there is no required format for plan organization, there are specific requirements to keep in mind for plans to be approved by FEMA for mitigation project funding. These include documenting a collaborative planning process, developing a mitigation strategy with specific hazard mitigation actions based on a risk assessment, and reflecting current needs and values of the community. In

## ADDITIONAL WUI RESOURCES FOR COMPREHENSIVE PLANS

Several states have produced guides to support communities interested in addressing the WUI and wildfire through the planning process. Although these guides provide state-specific examples, many of the concepts are relevant and transferable for WUI communities in other states interested in wildfire planning.

**California.** The California Governor's Office of Planning and Research provides a technical guide for planners and land-use officials on fire hazard planning as part of its General Plan Technical Advice Series. The guide provides information on federal and state requirements related to fire hazard planning and mitigation—including general plan policy requirements for the safety element, an overview of policies related to fire safety, issues that local governments should consider when developing fire hazard policies, and additional resources and planning examples from across California.

http://opr.ca.gov/docs/Final_6.26.15.pdf

**Colorado.** Following a series of devastating fires and floods across the state in 2013, the Colorado Department of Local Affairs launched *Planning for Hazards: Land Use Solutions for Colorado*. This resource is available as both a downloadable guide and an interactive, searchable website. The guide covers multiple hazards and includes a detailed section on wildfires. Geared specifically to planners, it provides an array of planning tools and strategies on how to address hazards in plans and policies. Best practice examples from across Colorado illustrate how communities address the WUI.

www.planningforhazards.com/addressing-hazards-plans-and-policies

**Florida.** In 2010, the Florida Division of Forestry released *Wildfire Risk Reduction in Florida—Home, Neighborhood, and Community Best Practices*. This 186-page guide provides information for readers including planners, elected officials, business leaders, code enforcement officials, fire managers, developers, and community educators. Topics for planners include a description of state planning enabling legislation, sample wildfire policies from Alachua County, a discussion on using the future land-use element to address the WUI, and advice on plan implementation and overcoming potential barriers.

Main website: www.freshfromflorida.com/Divisions-Offices/Florida-Forest-Service/Forests-Wildfire-Publications

Specific document link: https://freshfromflorida.s3.amazonaws.com/Wildfire_Risk_Reduction_in_FL.pdf

**Idaho.** The USDA Forest Service and the Idaho Department of Lands provided a grant to scholars at the University of Idaho and Boise State University to address WUI planning throughout Idaho's varied terrain and communities. The resulting guide, published in 2015, provides an in-depth look at how Idaho communities can plan and regulate for wildfire. The appendix includes a detailed list of potential comprehensive plan policies excerpted from communities across the west.

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2845046

addition, plans must be updated every five years to maintain their eligibility.

Relevant resources available to help planners include APA's PAS Report 560, *Hazard Mitigation: Integrating Best Practices into Planning* (Schwab 2010), FEMA's *Local Mitigation Planning Handbook* (FEMA 2013b), and FEMA's *Integrating Hazard Mitigation into Local Planning (Case Studies and Tools for Community Officials)* (FEMA 2013a).

#### Linking Hazard Mitigation Plans with Land-Use Planning

Planners have an opportunity to both include WUI and wildfire topics in community plans and ensure that pertinent land-use planning concepts are integrated into hazard plans. This ensures that plans "speak" to one another and information flows in both directions. Some tips for linking hazard mitigation plans with land-use planning include the following:

- **Get engaged.** Planners who participate in the hazard mitigation plan development process provide a valuable skill set that will help inform the plan's outcomes (Schwab 2010). Planners will also get the benefit of learning more about their communities through the lens of hazard planning. In addition, the collaborative process builds and strengthens partnerships with other departments and agencies, promoting cross-pollination of knowledge and experience.
- **Share key community plans.** A current comprehensive plan and other local community plans provide important data and trends for the hazard mitigation plan. For example, if a community expects future population growth, then both plans should consider where safe growth is most appropriate to reduce loss of life and property within identified planning areas. This process will align the future land-use map with the risk assessment contained within the hazard mitigation plan. Other key linkages include capital budgeting, including capital improvement programs, to ensure that public funds are invested in mitigation (Schwab 2010).
- **Inform mitigation actions.** What other actions can be taken to lessen the impacts of wildfire disasters on a community? Land-use regulations and codes are often appropriate responses to hazard concerns because they standardize a mitigation process, as discussed in Chapter 7. This may include a disaster recovery ordinance, regulations for new and existing structures in high-hazard areas, or complementary programs such as incentives for retrofits. It's important to be at the table when these actions are discussed to inform how regulations can be effective and where they fit into the mitigation process.
- **Utilize the plan**. Once the hazard mitigation plan is finalized, planners can in turn use this information to inform development processes in their jurisdictions. For example, the risk assessment can guide future discussions on where land-use decisions should account for wildfire during development application reviews.
- **Track updates**. Hazard mitigation plans are required to be updated every five years to stay in compliance with FEMA project funding. Some communities will issue interim updates to their hazard mitigation action plan. Stay connected with the project committee to learn about plan updates and implementation progress.
- **Coordinate plan updates.** Communities can also take advantage of the timing of plan updates to address the WUI and wildfire in a coordinated approach, as highlighted in the sidebar on Wasco County, Oregon, on p. 84.

## Community Wildfire Protection Plans

CWPPs focus on a community's WUI and wildfire concerns. CWPPs have been developed across the country since 2003, when the Healthy Forests Restoration Act (HFRA) was signed into law (see the sidebar in Chapter 5, p. 70).

Like other plans, CWPPs are not legally binding documents. However, HFRA gave statutory incentives for the USDA Forest Service and the Bureau of Land Management to consider the priorities of local communities who develop and implement forest management and hazardous fuel reduction projects (i.e., CWPPs). As a result, CWPPs can be powerful tools to help communities work across jurisdictional boundaries with land management agencies to collaborate on challenges that affect the WUI, such as adjacent national forests or other areas with high wildfire hazard.

HFRA requires that CWPPs meet three minimum requirements:

1. Be collaboratively developed by local and state government agency representatives, in consultation with federal agencies and other interested parties
2. Identify and prioritize areas for hazardous fuel reduction treatments and recommend the types and methods of treatment that will protect one or more at-risk communities and essential infrastructure
3. Recommend measures that homeowners and communities can take to reduce the ignitability of structures in areas addressed by the plan

HFRA also requires that the applicable local government, local fire department(s), and the state entity respon-

## WASCO COUNTY, OREGON: INTEGRATING COMPREHENSIVE AND HAZARD MITIGATION PLANNING

Wasco County, Oregon (Figure 6.3), a largely agricultural county home to just over 25,000 residents, lies in northern Oregon, east of Portland. The county began its *Wasco County 2040* comprehensive plan update in 2015; final adoption will occur by 2020.

Meanwhile, the county is also updating its natural hazards mitigation plan (NHMP), which was completed and submitted to FEMA for review and approval in in 2018. This is a joint effort led by Wasco County Emergency Management and the Wasco County Planning Department, in partnership with local agencies such as school districts, fire districts, public works, and the soil and water conservation district; small cities within the county; state agencies such as the Oregon Department of Forestry and the Department of Land Conservation and Development; and others (Wasco County 2018).

Both planning efforts address wildfire, but they vary in the level of detail and specificity of actions. *Wasco County 2040* will include a section on natural hazards. This complies with Oregon's statewide Land Use Planning Goals and Guidelines (Goal 7, Areas Subject to Natural Hazards) and acknowledges the importance of local hazards, including wildfires, and their impacts on the county. However, more detailed information and actions will be included in the NHMP to direct future resources to wildfire mitigation activities. These actions include creating a wildfire coordinator position and increasing fire protection coverage across the county. Both the NHMP and *Wasco County 2040* will also support a future update to the county's community wildfire protection plan (CWPP), which will examine in even finer detail how to implement the larger strategies in each region of the county.

Public outreach has been an important part of each update. *Wasco County 2040* included mobile workshops across the county, online surveys, and a dedicated website to keep the public informed of new plan content and other updates. Planners also hosted a community open house—"Disasters and Donuts"—focused specifically on the NHMP update. This workshop was designed to both educate the public on how wildfire is being addressed in county plan updates and seek input on NHMP priority actions.

A series of locally severe fire seasons has heightened interest in exploring better protections for development and critical facilities in the WUI (Smith 2018). In 2018, more than 230,000 acres burned in the county, destroying agricultural crops and structures, causing one death, and severely affecting the local economy (NWCG n.d.; Hamway 2018). This came on the heels of the nearby Eagle Creek fire the previous year. Resulting state and federal disaster declarations from several fires have also opened up new funding sources for NHMP actions.

One key element that has improved local coordination is the primary role of Wasco County's planning department in both updates. This has enhanced synergies, reduced the chance of duplication, and enabled a logical method for placement of information and actions.

*Figure 6.3. Wasco County, Oregon, has a variety of land uses to consider during its planning process—many of which can be affected by wildfire (Wildfire Planning International)*

sible for forest management mutually agree to the final contents of the CWPP.

Typical information contained in a CWPP includes a clear methodology for identifying and spatially delineating the extent of the WUI, historical information on regional wildfires, a community wildfire hazard or risk assessment, potential funding sources, data related to response capabilities, required actions to address minimum requirements, and other factors or strategies that require consideration for the community. In other words, CWPPs become the "one-stop shop" for information related to a community's wildfire planning needs and are the glue that helps bind wildfire mitigation activities together.

CWPPs are also effective at different scales, some of which may overlap:

- Counties may adopt a countywide CWPP to address overarching concerns across the county.
- Towns or cities can also pursue their own CWPPs to address a local approach to their WUI. This can be done with or without a county CWPP in place.
- CWPPs can be adopted by fire districts and align with district boundaries.
- Subdivisions or home owners associations may also develop a CWPP to address neighborhood-level challenges specific to their communities.

Collaboration frequently occurs between counties and other jurisdictions to ensure a coordinated approach. A notable difference between the CWPP and the hazard mitigation plan is that hazard mitigation plans address multiple hazards. CWPPs, therefore, provide the highest level of detail related to the WUI and related wildfire information. This positions the CWPP as the primary go-to document on wildfire hazards for communities when adopted at the relevant scale.

### Linking Community Wildfire Protection Plans with Land-Use Planning

CWPPs are often spearheaded by fire and emergency management agencies. However, there is a tremendous opportunity for planners to participate in the development and implementation process. Planners can lend their facilitation and project management skills to a CWPP process. Planners can also share their expertise on current and future development patterns and land uses while discussing potential constraints associated with wildfire hazard in the WUI. Participation establishes a long-term relationship between fire and planning departments to collaborate on local wildfire and growth issues.

Recommended practices for integrating CWPPs into community planning processes include the following.

- **Investigate existing plans and resources.** Because several CWPPs may be adopted within the same jurisdiction at multiple scales, it's helpful to know what exists. A quick inquiry to the local fire department or state forestry agency will typically yield these results.
- **Check with state agencies.** State forestry or natural resource departments may issue their own sets of guidelines or templates for CWPPs. It's important to know what your state requires as part of its approval process. In addition, state agencies typically offer resources and plan examples online.
- **Adopt with the hazard mitigation plan.** CWPPs can be adopted as addendums to hazard mitigation plans. This creates a formal connection between these two plans. It can also increase funding opportunities for CWPP actions and help ensure that regular updates and plan maintenance occur in conjunction with the five-year hazard mitigation plan approval process. Securing funding is critical for implementation. Funding opportunities are often based on a combination of state, federal, and local sources. Missoula County, Montana, recently completed coordinated updates of its CWPP, hazard mitigation plan, and growth policy (the state's term for the comprehensive plan); the sidebar on pp. 86–87 describes how the county was able to leverage synergies among the plans during this process.

Additional CWPP insights are available in the guide *Best Management Practices for Creating a Community Wildfire Protection Plan* (Jakes et al. 2011).

## Watershed Plans

Communities may have other functional plans that intersect or overlap with planning for the WUI. Watershed plans are intended to help restore and protect water resources and address current and future threats to water quality. They focus on point and nonpoint sources of pollution within the watershed boundary and include measurable goals and defined actions to address water quality challenges.

Watershed plans may be developed by a watershed organization, a flood control district, a local government, or a state or tribal environmental agency. They are often built on partnerships between multiple jurisdictions that span the watershed and multiple partners that work on watershed-related issues, providing opportunities to engage WUI stakeholders.

## MISSOULA COUNTY, MONTANA: PUTTING ALL THE PIECES TOGETHER

Comprehensive plans, hazard mitigation plans, and community wildfire protection plans should align to provide a coordinated approach to the WUI. This concept is well illustrated in Missoula County, Montana, where updates to all three of these plans have occurred within the last several years.

### Missoula County Growth Policy

In Montana, state law requires that a community's growth policy (i.e., comprehensive plan) include an evaluation of the potential for fire and wildland fire in the jurisdictional area. This evaluation determines whether there is a need to delineate the WUI and adopt applicable regulations in the WUI for defensible space around structures, adequate ingress and egress to and from structures and developments to facilitate fire suppression activities, and adequate water supply for fire protection (Montana Code Annotated 2015, §76-1-601).

To meet state planning requirements, Missoula County's growth policy (adopted in June 2016) contains background information on the WUI and goals, objectives, and actions on wildfire hazard, including:

- Goal #11: Reduce the safety risks and costs associated with wildland fire, flooding, and other hazards.
- Objective 11.1: Discourage development in hazardous areas and areas where public and emergency responder safety is compromised.
- Objective 11.2 When development in hazardous areas does occur, take appropriate measures to limit safety risks and ensure emergency personnel have sufficient resources to respond safely and effectively.

The county's actions to support these objectives include the following:

- identifying hazardous areas for wildfire
- providing mapping and other information to the public about local hazards in an easily accessible format
- exploring zoning regulations to guide growth to appropriate locations
- working with public safety and resource agencies
- adopting development regulations that require the best possible hazardous mitigation techniques
- providing information to landowners regarding development in hazardous areas
- supporting efforts to help landowners reduce fuels and take measures to make their properties more resilient to hazards

Other information related to wildfire is incorporated throughout the growth policy. Chapter 6, Infrastructure Strategy, addresses how the county plans to assist with fire protection infrastructure. Chapter 9, Conditions, Trends & Projections, includes wildfire as part of its list of climate-related changes that will affect landscapes. This chapter also links WUI information to the CWPP and subdivision regulations to support implementation of wildfire risk reduction actions. Finally, wildfire smoke is discussed as part of air quality concerns.

Each relevant action has an identified time frame and lead partners. Implementation will also occur through updating the county's land-use designation map to achieve goals such as providing for community growth while protecting rural character and reducing safety risks and costs associated with wildfire and other hazards. The updated map will help evaluate future development proposals to ensure compliance with the map. Other wildfire implementation tools include the county's pre-disaster mitigation plan and CWPP.

### Pre-Disaster Mitigation Plan

Following its growth policy update, the county updated its pre-disaster mitigation plan (PDM), which was adopted in March 2017. The PDM was spearheaded by the Missoula County Office of Emergency Management and engaged other county departments, including the Community and Planning Services Department.

The updated PDM has multiple connections to the planning process, including a section on how the county's growth policy and other regional plans relate to and support hazard planning objectives. The PDM also discusses how regulatory tools such as zoning ordinances, subdivision regulations, and building codes can address local hazards. In addition, the plan provides a hazard analysis of proposed future development projects in Missoula County. Finally, wildfire mitigation projects reinforce actions listed in the Missoula County Growth Policy.

### Community Wildfire Protection Plan

Following adoptions of the growth policy and PDM, Missoula County began updating its CWPP. The county's first CWPP was written in 2005. Many changes had occurred since that time that affected wildfire risk and the WUI, such as new development, multiple wildfires, and landscape fuel treatments. The CWPP update was led by a core group of stakeholders, including the Office of Emergency Management, Community and

Planning Services Department, local fire protection districts, the Montana Department of Natural Resources, and the USDA Forest Service.

A key part of the CWPP update was the development of new WUI maps and a wildfire risk assessment (Figure 6.4). These outputs achieved the growth policy and PDM actions that called for updated maps to inform future planning decisions. Building from these outputs, the CWPP also included short-, mid-, and long-term actions to address the WUI and wildfire risk. Stakeholders view the plan as a living document that will continue to get monitored and updated as different actions are implemented.

The CWPP was adopted in May 2018. As part of the adoption process, stakeholders developed an interactive story map to help the public learn more about local wildfire risk and key outcomes from the CWPP. The Office of Emergency Management plans to amend the PDM to include the updated CWPP as an appendix.

Missoula County illustrates an effective approach to wildfire planning. Successful ingredients of the process included engaging local elected officials early in discussions and regularly briefing them during each planning project. Presentations to county commissioners by local, state, and federal staff outlined the issues, challenges, and effective approaches to dealing with wildfire through each plan and implementation measure. Stakeholders leveraged the timing of plan updates to build on one another and mutually reinforce goals and implementation strategies. Aligning these plans also strengthened opportunities for stakeholder engagement. As each plan was developed, additional details and tangible outcomes were explored.

The development process of each plan was also an essential opportunity for stakeholder collaboration and discussion. This resulted in improved relationships and increased communication—aiding long-term implementation success. The culminating action plan in the CWPP provides a set of strategies that stakeholders buy into and understand.

Links to Missoula County plans:

Growth Policy: www.missoulacounty.us/government/community-development/community-planning-services/plans

PDM: www.missoulacounty.us/home/showdocument?id=25947

CWPP: www.missoulacounty.us/government/public-safety/office-of-emergency-management/community-wildfire-protection-plan

Story Map: http://mcgis.maps.arcgis.com/apps/MapSeries/index.html?appid=29b21eb849db408c8b36960fff3cb3e6

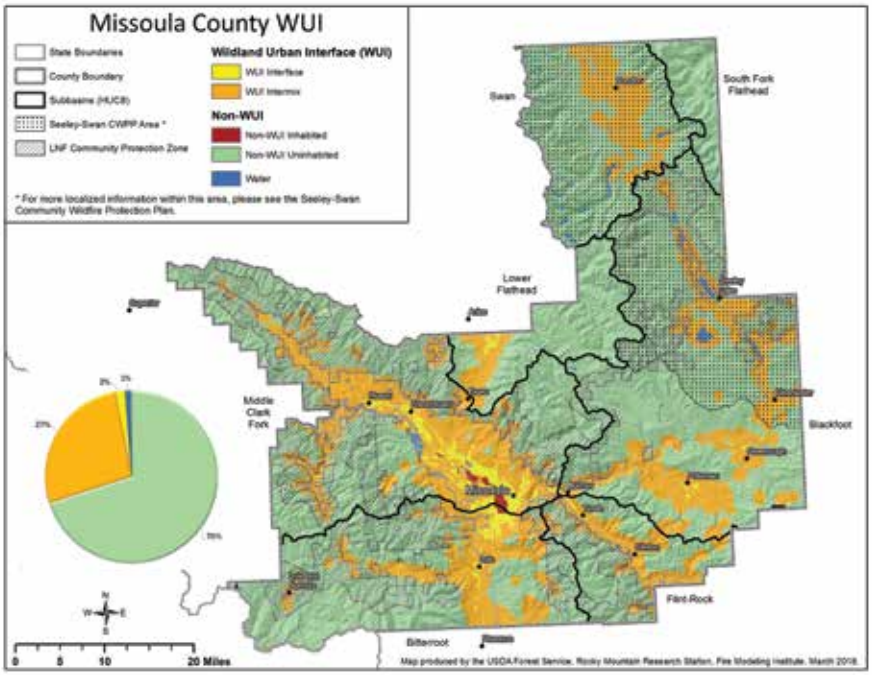



*Figure 6.4. Missoula County staff and fire officials worked with the USDA Forest Service to develop an updated WUI map during the development of the county's CWPP (USDA Forest Service)*

Watershed plans address immediate threats, but also identify and address sources of pollution that pose long-term challenges to the watershed. These considerations could include post-wildfire impacts, such as nutrient and sediment loading and post-wildfire watershed restoration.

The Clean Water Act is an important driver for watershed plans. It requires that states designate the primary use of water bodies within their borders and adopt water quality standards. Section 303(d) requires that states compile a list of impaired waters (those that do not meet water quality standards) and threatened waters (those that currently meet water quality standards but are at risk of not meeting them).

Funding for watershed plans is available under section 319 of the Clean Water Act, which addresses the need for greater federal leadership to coordinate state and local efforts to combat nonpoint source pollution through technical assistance, grants, education, and demonstration projects, among other efforts.

Watershed plans can identify and address the impacts of both WUI development and wildfire on watersheds. Communities may also identify overlap between goals and actions focused on improving water quality and reducing nonpoint source pollution and those focused on mitigating wildfire risk.

### Addressing the WUI in Watershed Plans

Both development in the WUI and wildfire can have significant impacts on watersheds. Planners can work to incorporate land-use impacts into watershed plans, which also provide opportunities to consider wildfire impacts and post-wildfire restoration needs. Recommendations include the following:

- **Address land-use impacts.** Land uses and land-use change have significant impacts on watershed characteristics. Watershed plans should address current land uses and forecast land-use change. For example, a plan for a watershed that is primarily forested but seeing rapid development in the WUI should address the impacts of increased development, which may include overexploitation of groundwater resources. It should also address how increased WUI development may change wildfire impacts to the watershed.
- **Include data on wildfire impacts**. Wildfire can have significant impacts on watersheds. It can result in increased sedimentation and nutrient loading, changes to water quality, flooding, erosion, and impacts on species habitat. Development patterns can further these effects. Watershed plans should include data on how wildfire has historically impacted these aspects of the watershed, as well as projected future impacts.
- **Consider post-wildfire watershed restoration.** In watersheds that have a history of wildfire or are located in areas of wildfire risk, watershed plans can address post-wildfire restoration or rehabilitation needs, including soil stabilization and erosion barriers.

*Figure 6.5. Community parks, such as this one in Coeur d'Alene, Idaho, can serve as buffers between forests and other community features (Wildfire Planning International)*

- **Identify alignment with hazard mitigation strategies**. Watershed priorities may overlap with hazard mitigation goals, priorities, and strategies. Watershed plans should reference hazard mitigation plans and CWPPs where goals and strategies align.
- **Identify partnerships for implementation**. Watershed planning is a collaborative process. Actively engaging with stakeholders in the wildfire and hazard mitigation fields can help ensure successful implementation of shared goals.

## Parks and Open Space Plans

Communities adopt parks and open space plans to address the provision and management of parks and open spaces. Parks and open space plans may be focused at the state, regional, or local scales. These plans allow communities to define parks, address the broad range of benefits parks and open spaces provide, and define level-of-service standards for the quantity of open space within a jurisdiction and the proximity and accessibility of parks for residents.

Within a community, parks and open spaces provide places for recreation and community gatherings. They may also protect important cultural resources and can provide necessary environmental or ecological functions (Figure 6.5, p. 88). As a result, plans often treat them as multifunctional and address the different purposes they serve for the community.

Due to their focus on the multiple cobenefits provided by parks and open spaces, these plans can be useful tools for advancing hazard mitigation and WUI management goals. For example, prioritizing land conservation in high wildfire risk areas can increase access to open space and recreational amenities while also reducing development in higher-risk areas. However, communities may also identify conflicts between goals and priorities for addressing WUI challenges and those for managing parks and recreational spaces.

### Addressing the WUI in Parks and Open Space Plans

Recommended practices for integrating WUI and parks and open space planning include the following:

- **Focus on multifunctionality**. Parks and open spaces can provide recreational value while reducing wildfire risk. For example, trail corridors can aid suppression activities during a wildfire response. Similarly, parks and open space land uses that reduce amounts of hazardous vegetation, such as ball parks, golf courses, and soccer fields, can act as buffers between other development and wildland areas.
- **Ensure resources for ongoing maintenance**. Resources for ongoing management of landscaping and vegetation are important for parks and open spaces in the WUI. This ensures parks do not become overgrown with hazardous wildland fuels and pose a threat to neighboring uses.
- **Incorporate fire-resistant design practices**. In programmed parks and recreational areas, use native and fire-resistant plants for landscaping and incorporate fire-safe practices, such as the use of defensible space around park structures and facilities. Consider making these areas public demonstration gardens to educate the public on low-flammability plants and landscaping techniques.
- **Collaborate with stakeholders to align activities.** Work with land management agencies to align planning activities with other land management objectives. For instance, park managers and planners can codevelop educational signage for parks that includes messages about the role of prescribed fire in ecosystem management, risk reduction, and habitat protection.

## Climate Adaptation and Mitigation Plans

Communities adopt climate adaptation plans, also referred to as climate action plans, to assess local impacts and address climate change-related challenges. Climate adaptation plans focus on strategies to adapt to the local risks and adverse impacts associated with climate change.

These plans are distinct from climate change mitigation plans, which are generally focused on strategies to lessen or mitigate the impacts of climate change. In this case, mitigation is often accomplished through goals and policies that seek to lower greenhouse gas emissions, such as reducing vehicle miles traveled or increasing the energy efficiency of municipal buildings. Both plans provide opportunities to address wildfire through future adaptation and mitigation planning.

### Addressing the WUI in Climate Adaptation and Climate Mitigation Plans

Recommended practices for addressing WUI challenges in climate adaptation and mitigation planning include the following:

- **Address climate impacts on wildfire**. Changing climate conditions will impact the frequency and severity of fire. Regional climate variations include changes to precipitation patterns, which can affect fuel moisture content and the health of tree and plant species, as well as create water scarcity for wildfire suppression. Climate adaptation plans should specifically address wildfire hazard in relation to the anticipated changes that will affect the local commu-

nity, in addition to other hazards. They should also reference other local plans that address wildfire, such as the CWPP and the hazard mitigation plan.

- **Identify areas of alignment between climate and wildfire risk reduction goals.** Measures focused on increasing energy efficiency or using sustainably sourced or "green" construction materials can achieve goals related to climate mitigation while also being consistent with or reinforcing structural requirements for homes in the WUI.
- **Identify conflicts with WUI management and wildfire risk reduction goals**. Goals and strategies focused on reducing a community's carbon footprint may inadvertently contribute to wildfire risk. For example, WUI communities should ensure that activities associated with increasing vegetation as a means of reducing or offsetting their carbon footprint (e.g., planting more street trees) are compatible with wildfire risk reduction goals. By working with local foresters or similar specialists, planners can make appropriate decisions that meet multiple objectives in the WUI, such as selecting fire-resistant plant species.

*Figure 6.6. Proactive policies can facilitate post-fire rebuilding and recovery; this Tennessee home burned in a 2016 wildfire and has not been rebuilt (Wildfire Planning International)*

## Resiliency and Post-Disaster Recovery Plans

Resiliency plans can encompass a number of elements discussed in other functional plans, including climate adaptation or mitigation plans, hazard mitigation plans, and CWPPs. Concepts tied to resiliency planning typically include disaster preparedness, capacity building, and post-disaster recovery. Some communities may also develop a discrete plan for post-disaster recovery as opposed to integrating it within a larger resiliency plan.

Local communities and state agencies pursue resiliency plans or frameworks. More than 20 U.S. cities participate in the global 100 Resilient Cities initiative (www.100resilientcities.org) supported by the Rockefeller Foundation. Recognizing that there are many variations in resiliency and post-disaster recovery plans, recommended practices for incorporating wildfire include the following:

- **Consider scenarios.** Where applicable, consider worst-case scenarios for where and how wildfire can affect the WUI and resulting implications. For some communities, this means it may be necessary to consider a scenario similar to the 2017 Tubbs Fire in Santa Rosa, California, in which multiple neighborhoods were destroyed in a single disaster event. This enables communities to plan for topics such as clean up and debris removal, government roles and responsibilities, and priority areas for rebuilding.
- **Be proactive.** Many resources exist to help communities increase their resilience in advance of a wildfire event and establish protocols for a long-term recovery process. Planners can familiarize themselves with this information now to avoid having to make decisions under the stressful conditions following a wildfire disaster. Establishing systems in advance may also help expedite the recovery process, reducing the number of lots that remain vacant after a fire (Figure 6.6). Helpful resources include APA's Hazards Planning Center, which features PAS Report 576, *Planning for Post-Disaster Recovery: Next Generation* (Schwab 2014), along with projects, case studies, and webinars focused on resiliency, recovery, and climate adaptation.
- **Track progress.** Resilience can be a ubiquitous term that spans diverse topics such as social equity, economic resil-

ience, extreme weather events, and ecosystem management. Scorecards, indicators, audits, or similar tools provide useful ways to capture resiliency topics and measure progress in achieving local goals. Ensure that any scorecard template used locally includes a metric for wildfire hazard planning to ensure this topic is part of resiliency efforts.

## SUBAREA PLANS

Subarea plans, such as neighborhood and district plans, focus on specific geographic districts or subcomponents of a jurisdiction. Smaller geographic scales allow for a focus on more specific issues, such as WUI conditions in certain areas, than in the comprehensive plan.

While these plans often further advance goals and policies established in the comprehensive plan, they may also be stand-alone plans. Their scale—a focus on a single neighborhood or district (such as a downtown area) within a community—allows for a greater degree of granularity and a shorter planning horizon than the comprehensive plan.

Because neighborhood plans are centered on the specific needs or problems of defined neighborhood planning areas, they can either focus on a broad set of topics or they can be more narrowly defined around specific challenges or needs of that planning area, including specific hazard mitigation strategies. For neighborhood planning areas in the WUI—or those in areas of higher wildfire risk in WUI communities—neighborhood and district plans can promote goals, policies, and actions related to reducing wildfire risk.

### Addressing the WUI in Subarea Plans

Recommended practices for integrating WUI planning into neighborhood and district plans include the following:

- **Engage home owners associations.** Home owners associations are responsible for maintaining community spaces and may have landscaping or design requirements that are at odds with community wildfire protection or hazard mitigation strategies. Engaging these groups in the planning process can help identify and address these conflicts. Home owners associations can also be effective partners for educating home owners about actions they can take on their properties, and as mentioned in Chapter 7, they can incorporate vegetation management and other structure ignition zone standards into their policies.
- **Include wildfire hazard maps.** Neighborhood and district plans can include wildfire hazard maps at the neighborhood scale. These maps often connect to local CWPPs and may also reflect parcel-level information.
- **Address mitigation activities at the neighborhood scale.** Neighborhood and district plans can identify areas that require mitigation, including fuel treatments or vegetation management within the neighborhood planning area, referencing the hazard mitigation plan and CWPP and defining who is responsible for implementation.

## PLANS AND PUBLIC INVESTMENTS

Successful implementation of plans requires the commitment of resources, which can take the form of capital investments or programmatic investments. *Programmatic investments* include programs that provide education and outreach or technical assistance. They also include direct financial assistance, including grants, rebates, and loans—for example, grants to home owners to help with the creation or maintenance of defensible space on their properties.

*Capital investments* are major nonrecurring expenditures on physical assets. This can include fee-simple land acquisition for conservation or hazard mitigation and purchase of development rights. Capital investments are laid out in the jurisdiction's capital improvements program (CIP), a three- to six-year itemized schedule of capital projects. The CIP may be required by state law and should be prepared by a team that involves staff from multiple departments, including planning, finance, and public works or engineering.

The CIP can be used to coordinate actions and investments across multiple adopted plans, departments, and agencies, making it a powerful tool for implementing locally adopted or relevant plans. Local and county governments may use bonds, such as open space bonds, to support capital investments, including land acquisition. For example, Summit County, Utah, has been using recreation and open space bonds to support acquisition of open space for conservation, as well as scenic and recreational amenities, since 2004 (Summit County n.d.).

Finally, consider critical infrastructure as part of wildfire mitigation planning. Critical infrastructure such as roads, reservoirs, utilities, and facilities (e.g., hospitals, schools, and police and fire stations), should be inventoried and assessed to determine vulnerability to wildfire. Mitigation strategies, such as the removal of hazardous vegetation, can be part of a CWPP or hazard mitigation plan; however, if a critical infrastructure plan exists separately planners should seek connections between these plans.

## CONCLUSION

Planners have multiple avenues by which to incorporate WUI considerations into plans. This starts with community visioning and engagement processes, which are essential for building the community buy-in necessary for successful implementation. Planners can incorporate WUI considerations into multiple plans at different scales, including the local comprehensive plan, hazard mitigation plans, CWPPs, and neighborhood plans. It is important to ensure that WUI-related goals and strategies are aligned across the full range of locally applicable plans.

Communities should also ensure that necessary resources are dedicated to implementing plans. Chapter 7 addresses the regulatory tools, if adopted by local officials, that planners can use to advance the goals and policies defined in local plans.

CHAPTER 7

# WUI REGULATIONS

Regulations provide communities with the legal means to implement policies defined in locally applicable plans. Regulations aimed at existing and future development in the wildland-urban interface (WUI)—including structures and attachments, roads and other infrastructure, landscaping, current and future land uses, and additional development features—serve the critical purpose of protecting life and property from harm by using proven methodologies and standards for wildfire risk reduction in the built and natural environments.

Communities have many options to regulate land development within the WUI. This chapter focuses on five primary tools: subdivision, zoning, fire, building, and WUI regulations. It also at times calls out specific standards (such as water supply standards, vegetation management regulations, or fire protection standards) within these bodies of regulations.

This chapter begins by recognizing that communities have different starting points when considering WUI regulations, which may influence the type, scale, and administration of the regulations. Some communities may have existing WUI regulations that require revisions or tweaks, while others may be starting from scratch. Communities may also have vast or limited toolkits, depending on existing state and local legislation. To assist planners in these differences, this chapter provides an overview on the scope of what can be regulated, followed by key considerations, including determining the applicability of WUI regulations at different scales, understanding the legal basis for developing defensible regulations, and ensuring compliance. For those communities who already have WUI regulations in place, the sidebar on p. 100 offers suggestions on how planners can evaluate and improve existing WUI regulations.

Following the first section, each regulatory tool is discussed in detail within its own section. It is important to keep in mind that although these tools are discussed individually, WUI regulations are complementary and often intertwined. For example, a community may regulate the structure ignition zone—the structure and immediate surroundings—through the building code, while hazardous land uses (e.g., fireworks stands, propane and gas facilities) are regulated by the zoning and fire codes.

Finally, adopting WUI regulations can come with hurdles, including public resistance and limited capacity for implementation. The final section of this chapter includes successful strategies for adoption to help address common challenges associated with regulating the WUI.

## KEY CONSIDERATIONS WHEN SELECTING WUI REGULATIONS

A crucial first step in the WUI regulation process is to understand the scope of what can be regulated. Table 7.1 (p. 96) provides an overview of land-use and community development features in the WUI that can be regulated by subdivision regulations, zoning or land development codes, building codes, fire codes, and WUI codes. Features can be regulated at different scales: the community scale, the neighborhood/subdivision scale, and the building/lot scale. It should be noted that due to the array of local amendments available to communities, it is likely that there are many exceptions.

As the table shows, communities have multiple codes at their disposal for regulating a given WUI concern. For example, vegetation management requirements for landscaping or defensible space can be addressed through subdivision regulations, a zoning code, or a WUI code. If a community currently has fewer options—e.g., it only uses subdivision regulations—it will want to focus on how to maximize this particular tool, or it may look to adopt new codes in the future that can address the WUI. Understanding the range of options is also helpful if there are local constraints on amend-

ing state codes, or when communities have a preferred method of organization within a municipal code.

## Legal Basis for Regulation

A strong legal foundation is essential for WUI regulations, given that such regulations dictate development parameters and are typically adopted by ordinance. Planners should work closely with their elected officials and local government's attorneys to ensure alignment with local, state, and federal laws. General guidelines when drafting new regulations include the following:

- Work with the local government attorney to determine if the proposed regulations are within the community's legal authority.

### TABLE 7.1. LAND-USE AND COMMUNITY DEVELOPMENT FEATURES ADDRESSED BY WUI REGULATIONS

| **WUI Regulatory Tools (by type)** | | | | | |
|---|---|---|---|---|---|
| Land-Use or Community Development Feature | Subdivision Regulations | Zoning/Land Development Code | Building Code | Fire Code | WUI Code |
| **Community Scale** | | | | | |
| Areas of refuge (external) | X | X | | X | X |
| Hazardous land uses or development activities | | X | | X | X |
| Land uses with dense population/mass gatherings | | X | | X | X |
| Safe growth (directing growth towards low-hazard areas) | X | X | | | |
| Sensitive area protection | X | X | | | |
| Public open space, parks, and trails | X | X | | X | X |
| **Neighborhood/Subdivision Scale** | | | | | |
| Buffering/screening | X | X | | | X |
| Roads and bridges | X | | | X | X |
| Secondary access | X | | | X | X |
| Setbacks | X | X | | | X |
| Vegetation management | X | X | | | X |
| Water supply (neighborhood scale) | X | | | X | X |
| **Building/Lot Scale** | | | | | |
| Building materials and construction | | X | X | X | X |
| Building numbering (addressing) | X | | X | | X |
| Building siting | X | X | | X | X |
| Decks and attachments | | X | X | | X |
| Driveways | X | X | | X | X |
| Landscaping | | X | | | X |
| Water storage (on-site) | X | | | X | X |

*Source: Molly Mowery and Tareq Wafaie*

- Establish a clear purpose for the regulations.
- Determine whether the proposed regulations are the most appropriate and rational tool to achieve the stated purpose.
- Determine whether additional data is necessary to provide defensible justification for the regulations.

## Applicability

Although some communities may apply WUI regulatory tools broadly, others may choose to develop a more nuanced approach that allows some types of development and redevelopment to occur without imposing additional regulations. This is an important discussion for planners to facilitate early, ideally while establishing long-range planning policy, because community officials must often balance competing interests such as affordable housing, economic development, and sustainability.

Factors to consider include whether the regulations will apply to existing development or retrofits of existing development, and whether they will apply broadly throughout the jurisdiction or vary based on size, context, geography, or type of development activity.

### New Versus Existing Development

Planners must determine whether WUI regulations will apply to existing development and redevelopment, or only to new development. For new development, the discussion is usually simple—new development must comply with the regulations in effect at the time of application.

For existing development, the discussion is far more complex. The answer to questions such as "Is my property grandfathered?" or "Do the regulations apply to my existing building?" is typically, "It depends." Although the International Code Council's International Wildland-Urban Interface Code (IWUIC) includes model language for a retroactivity clause, most communities opt not to apply new regulations retroactively as this can raise questions about the fairness of imposing new regulations on existing and otherwise compliant properties. Such application of new standards to existing properties (or some feature of those properties) may result in the creation of nonconformities.

To ensure long-term compliance with the new regulations, many communities develop an approach to applying the regulations to existing properties as property owners make improvements to those sites. Examples include the expansion of structures, major repairs to structures, new site features (such as parking areas, decks, or fencing), a change of use on the property, or permits for accessory structures. For example, Summit County, Colorado, recently adopted new defensible space standards that apply to existing single-family development for any exterior improvements that require a building permit, unless the requirement is waived by the review authority. That applicability standard recognizes the importance of mandating compliance to reduce risk over the long term, while still allowing flexibility when warranted. Communities must weigh the costs and benefits of applying standards to existing properties, which also depends on local capacity to administer and enforce.

*Figure 7.1. Rebuilding, especially following a disaster event such as the Sleepy Hollow fire in Wenatchee, Washington, may prompt discussions on the administration of existing WUI regulations or the need for revisions (Wildfire Planning International)*

### Rebuilding

Sometimes the line between existing and new construction may be blurred by a recent hazard event (Figure 7.1). For example, how should the local government apply WUI standards to a property that was recently destroyed, or partially destroyed, by wildfire?

Communities should discuss policy related to the rebuilding process and the extent to which flexibility is established within the rebuilding process. Some communities may offer an expedited review process or waive building permit fees; others may allow improvements to the site that did not exist prior to the wildfire. Policies on rebuilding should be included within a community's pre-disaster recovery planning process prior to a wildfire event to streamline rebuilding during an already tumultuous time. Maui County, Hawaii, for example, has developed guidelines for post-disaster reconstruction to establish protocols and avoid having to make on-the-fly policy-level decisions (Maui County 2014).

Additional planning resources for post-disaster recovery and redevelopment planning are available through APA's Hazards Planning Center (www.planning.org/nationalcenters/hazards). Resources include information on disaster recovery programs and a model pre-event recovery ordinance (Topping 2014) that provides a template to assist communities in preparing before a hazardous event to better manage the process of recovery after a disaster.

#### Location

Another consideration is the locations in which the standards should apply. Planners and their communities may decide to apply WUI standards in a number of ways:

- broadly throughout the jurisdictional boundaries
- only to areas within the identified WUI
- only within certain zoning districts
- only to properties or uses within another specified and mapped hazard area

Additionally, a community may opt to apply standards based on specific parcel conditions obtained from a site visit and assessment. For communities opting to apply standards to mapped areas, it is important to maintain those maps as conditions change over time (e.g., as the WUI expands, or as properties are mitigated).

#### Development Activities

Prior to making recommendations to elected officials, planners should evaluate which types of development applications would be subject to the standards of a particular tool. For example, vegetation management standards would ideally be enforced at both the site plan review stage and during review of applications for building permits with previous development approvals. WUI regulations should also apply when a property owner applies for a variance, if such variance would impact activities or vegetation within the structure ignition zone. Other types of permits that may trigger compliance with WUI regulations include fence permits, deck replacements, and construction of accessory structures.

#### Size and Scale

Another key consideration is whether WUI regulations should be applied to development based on the size or scale of the development. Size thresholds for applicability could be based on square footage of an expansion, the number of dwelling units, the acreage of a new subdivision, or any combination of size-related conditions.

Establishing expansion thresholds is an excellent way to engage the community in a meaningful discussion about planning for the WUI. Planners should suggest a starting point for discussion and supplement with local project examples as a reference point. For example, it is common not to require a building permit for sheds and other accessory structure less than 200 square feet in size. However, these accessory structures can pose a threat when they are located within a certain distance from the primary structure and are not mitigated for wildfire. Although development may not be subject to WUI requirements because it falls below a certain size threshold, such development may increase structural vulnerabilities to wildfire unless it is properly mitigated.

## Compliance and Administration

For each regulation, planners should consider how they expect to ensure compliance. WUI regulations often require applicants to consult a local WUI map, or wildfire hazard or risk map when available, to determine whether they are subject to regulations. Applicants may also be required to submit additional hazard-related information, such as a site-specific analysis of local conditions that affect fire behavior (e.g., topography, vegetation) as described in Chapter 3.

This should be addressed early in the drafting process. Planners should consider how much of the demonstration of compliance with the standards should be the burden of the applicant, and how much the jurisdiction is willing to provide internally. For example, a community with a robust wildfire mitigation staff team may provide site-specific analysis of a site for a nominal fee, whereas another community might require the applicant to hire a contractor for such services and to submit the analysis to the planning department.

During the development of WUI regulations, any changes to submittal requirements should become part of a work plan to update application submittal checklists, which may include changes to forms, online checklists, or codified procedures.

Planners should also consider whether existing internal processes require updates to effectively administer and enforce the new WUI regulations. For example, will development review times take longer? Are additional staff or trained subject matter experts required? Answering these questions will inform an overall assessment of the resources required to administer the tool.

## Single Versus Integrated Approaches

When planning for the WUI, planners may find it intuitive to search for a single regulatory approach to reduce wildfire risk. For example, a community could adopt one of the

model WUI codes (discussed later in this chapter) with local amendments. That single model covers many aspects of land-use regulations for the WUI including, but not limited to, vegetation management, building construction standards, and maintenance standards.

A single approach is beneficial in that one document can be adopted as a stand-alone ordinance or resolution, without requiring substantive amendments throughout a large body of regulations. However, a stand-alone approach still requires a comprehensive evaluation of other local codes and standards to avoid potential inconsistencies. For example, a stand-alone WUI code may require a vegetation management plan that refers to fire-resistant vegetation, while the landscaping ordinance may require building foundation plantings and a certain number of trees. These two regulations could be in direct conflict with each other and should be reconciled.

Alternatively, a suite of regulatory approaches may be more comprehensive and effective. An integrated approach incorporates aspects of a model WUI code into several articles or chapters of the existing land-use regulations. For example, vegetation management for wildfire hazard reduction can be a section within the landscaping regulations; water supply and emergency access can be addressed in subdivision regulations; decks and attachments can be addressed in development standards; and additional approval criteria and fire management plans can be addressed in the code's administrative and procedural requirements. Although more complex and potentially more difficult to draft, an integrated approach emphasizes the importance of risk reduction to the community and can lead to a holistic outcome for land-use regulation and risk reduction.

## Home Owners Associations and CCRs

Often complicating the administration and enforcement of land-use regulations are home owners associations and their respective covenants, conditions, and restrictions (CCRs), which are private regulations applicable to the property owners within the established association boundaries.

CCRs can be stricter than the jurisdiction's adopted land-use regulations, in which case each property owner within the controls of the association is subject to the higher standard. For example, a condition or restriction may impose WUI regulations within the structure ignition zone even when the local government has no similar regulations in place.

Concepts and regulations that are embraced by one neighborhood may be a good source of standards for other neighborhoods with similar conditions. Although local governments do not enforce private CCRs (unless they are made legal party to the CCRs), planners should become familiar with local home owners associations and their respective CCRs to the extent possible and look for opportunities to turn neighborhood-scale protections into broader applications where appropriate.

## Unintended Consequences and Conflicts

For any regulation, planners should consider the unintended consequences. For example, does a provision place an undue burden on an applicant that could potentially hinder desired growth and development? If so, those policy-level issues should be discussed in greater detail with the community's key decision makers prior to drafting.

In some instances, vegetation management standards conflict with other provisions in the zoning or land-use code (such as minimum landscaping requirements). In those instances, planners should consider including a clause clarifying that the vegetation management provisions shall govern when there are inconsistencies among other provisions in the zoning or land-use code.

## Model Codes and Standards

Communities will often use model codes or standards when drafting local WUI regulations. As discussed in Chapter 3, scientific research and testing by multiple organizations provides the basis for codes and standards. This makes them both reliable and defensible, and it provides administrators with the assurance that wildfire destruction can be minimized through regulation.

Using model codes or standards also alleviates upfront drafting time and provides an efficient process for addressing updates when future versions are released. Primary resources for codes or standards related to the WUI are the International Code Council (ICC) (www.iccsafe.org) and National Fire Protection Association (NFPA) (www.nfpa.org). The following list highlights WUI-relevant codes and standards:

- ICC International Building Code
- ICC international Residential Code
- ICC International Fire Code
- ICC International Wildland-Urban Interface Code
- NFPA 1: *Fire Code*
- NFPA 1141: *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas*
- NFPA 1142: *Standard on Water Supplies for Suburban and Rural Fire Fighting*
- NFPA 1144: *Standard for Reducing Structure Ignition Hazards from Wildland Fire*

## IMPROVING EXISTING WUI REGULATIONS

Though many of the tools and strategies outlined in this chapter apply to developing new WUI regulations, there are a few specific considerations that can help communities strengthen existing regulations. Planners can evaluate current WUI regulations in terms of the following questions:

- ***When were WUI regulations last updated?*** Model codes and standards are regularly updated to reflect the latest science and industry standards. Adopting the latest editions of these codes can help ensure that a community is administering the most effective and up-to-date regulations. Even if local WUI regulations are not based on a model code, it can be helpful to check guidelines and standards against these national models or the current science and best practices to maintain currency and defensibility.
- ***Is the WUI hazard or risk map still accurate?*** Significant events such as wildfires, land annexations, or other community-scale development can change the relevance of spatial assessment tools. Frequent updates maintain ongoing defensibility of the maps. Reevaluation of maps should occur in conjunction with other efforts, such as the update of the community wildfire protection plan (see Chapter 6).
- ***Have other plans changed that may affect regulatory implementation?*** The comprehensive plan, hazard mitigation plan, or other hazard and community plans, as discussed in Chapter 6, may get updated at different times. Policies and actions may affect WUI regulations, such as revegetation policies for flood-prone areas. These policies should be implemented in collaboration with wildfire risk reduction goals to ensure mutual compatibility.
- ***Have development codes been recently reviewed for conflicts or barriers?*** Similarly, major updates to the zoning or land-use development code should trigger a review of WUI regulations. This will ensure that no inadvertent conflicts were created in the process, such as new requirements for landscaping or combustible screening features in wildfire-prone areas.
- ***Is enforcement working?*** In some cases, planners may administer WUI regulations but not enforce them. It's necessary to check with code enforcement staff on what's working, what's not working, and what could be improved.
- ***Where are there gaps?*** Check with other departments and staff, such as building officials, fire inspectors, community foresters, or landscape architects, to explore if any gaps exist in WUI regulations. For example, are all WUI scales being effectively mitigated? Is there a large demographic, such as second-home owners, that requires a different approach to regulations?
- ***Are there other opportunities to increase compliance?*** Exploration of the issues may also lead to nonregulatory options to improve compliance. This may include educational trainings for stakeholders (e.g., developers, contractors, gardeners, architects), public outreach, or incentives to encourage voluntary implementation. Finally, having a pulse on issues that may affect home ownership affordability, such as rising insurance premiums, may also help renew interest in WUI discussions.

These will be described in more detail throughout this chapter. The full text of each code or standard is available to view online at no charge—consult each organization's website for more information.

### Fire Department Coordination

As emphasized throughout this report, it is essential to work with the local fire department on the adoption of WUI regulations. The fire department has in-depth knowledge of technical specifications that will help determine appropriate standards. In some cases, such as administration of the building and fire code, the fire department takes the lead and planners play a supportive role. In all cases, coordination between planners and the fire department is necessary to determine effective and compatible land-use planning and public safety outcomes.

## SUBDIVISION REGULATIONS

Subdivision regulations prescribe the rules for dividing parcels into developable lots and the design of those developable lots. When establishing regulations for the WUI, subdivision regulations are an effective tool because subdivision typically occurs early in the development process. Development decisions made at the time of subdivision have long-term impacts on the built environment and can affect subsequent development applications and permits.

### Wildfire Hazard Mitigation Provisions

Common approaches to addressing wildfire hazard or risk in subdivision regulations include provision of adequate access and circulation, adequate water supply, fire protection and vegetation management plan requirements, and evaluation and approval procedures (Figure 7.2). These approaches are incorporated in a number of different subdivision regulation elements.

**Access and circulation.** A key consideration for new subdivisions is establishing adequate ingress and egress into the subdivision, as well as circulation in and around the subdivision. For example, although cul-de-sacs provide a private oasis from pass-through traffic, they inherently do not provide adequate connectivity within a neighborhood and can contribute to bottlenecks during a wildfire event. This is particularly important within the WUI, where emergency operations and evacuation are critical to life safety.

Fire departments often review and comment on proposed subdivisions as they relate to access and circulation.


*Figure 7.2. Subdivision regulations can address a range of WUI topics, including road and driveway access, water supply, and circulation (Wildfire Planning International)*

Planners should coordinate with fire departments to ensure integration of the following design features:

- Multiple access points into and out of a subdivision
- Multiple driveways for large developments and multifamily developments
- Driveway widths, lengths, pullouts, and slopes adequate for firefighting apparatus
- Street signage and addresses on individual properties visible from the roadway and constructed of durable materials

Depending on local conditions, additional access and circulation standards may be appropriate to avoid challenges with fire suppression or evacuation.

**Lot and block design.** A fundamental element of subdivision regulations is the design of lots and blocks. Most subdivision regulations require lots to be designed in a way that complies with applicable zoning district requirements, such as lot width, lot area, and overall density.

When considering the WUI, planners can establish additional lot and block design standards to ensure compliance with vegetation management provisions and to avoid particularly hazardous wildfire areas in terms of vegetation type, topography, and other features that increase fire behavior. One way to implement these requirements is to require applicants to show building envelopes on the associated plat to ensure that future development within a subdivision maintains required building setbacks and to indicate applicable fuel management requirements within the structure ignition zone.

One alternative approach to traditional lot and block designs is *cluster subdivisions*. This procedure allows reduced lot sizes or greater densities in exchange for clustering individual lots in suitable areas away from the most hazardous or sensitive areas within a development site. This approach should only be taken in cases where adequate structural mitigation will occur to reduce the threat of home-to-home ignitions in higher-density areas.

**Open space.** Another key consideration during the subdivision process is ensuring that adequate open space is provided and maintained over time. Preserving areas as open space can play an important role in protecting sensitive areas from the impacts of development.

Dedication of public open space or payment of a fee-in-lieu (for acquiring future open spaces) can be required for subdivisions of a specified type and scale (for example, subdivisions with more than 10 dwelling units or subdivisions that include multifamily residential). Open spaces may include natural areas, trails, and playgrounds or other developed recreation areas. Open space requirements vary by community and are often tied to development patterns and local site characteristics.

Creating open space also has implications within the WUI. Open space should be located and designed thoughtfully rather than simply dedicating remainder parcels or tracts to satisfy a requirement, which can leave unmanaged hazardous fuels close to development. Dedicated open space can be beneficial when used to reduce hazard by modifying or reducing fuels, but that benefit is only realized with adequate vegetation management and long-term maintenance.

**Water supply.** The amount of water available to support new subdivisions is an important consideration, especially in water-scarce regions. Water supply is equally important from a fire protection standpoint.

When establishing WUI regulations, communities should require applicants to demonstrate adequate water supply for fire response and suppression, including minimum water levels and flow rates dependent on the use type (with stricter standards for multifamily or nonresidential development than for single- or two-family dwellings). In establishing such regulations, planners may refer to the IWUIC for guidance or NFPA 1142: *Standard on Water Supplies for Suburban and Rural Fire Fighting* for the technical aspects of water supply regulations. Planners should also consider whether some types of structures and uses, such as garages, sheds, agricultural buildings, or structures under a specified size threshold, should be exempt from water supply standards.

**Additional application requirements**. With proposed subdivision applications, communities may opt to require submittal of fire protection and vegetation management plans. These provisions should describe and demonstrate compliance with the regulations, and they should require applicants to obtain sign-off from the local fire protection agency or the state forestry agency for such plans prior to subdivision application approval.

## Applicability and Administration

Recommended approaches for integrating wildfire risk reduction into application approval procedures are similar for both subdivision regulations and zoning codes, which are discussed in the next section.

Because the act of subdivision most frequently occurs prior to physical development of the site, the approval process for subdivisions is an excellent opportunity to con-

sider appropriate safeguards related to wildfire hazard and risk. But applicability of the standards is an important consideration—requiring robust wildfire mitigation standards for a simple lot split or lot consolidation may not be appropriate. It is worth noting that some states authorize exemptions from the subdivision review process for certain subdivision activities (such as boundary line adjustments, court-ordered lot splits, or lot transfers) and therefore those activities may not be subject to the additional wildfire safeguards.

### Additional Considerations

Developing subdivision regulations to facilitate change in the WUI can be challenging. New regulations are not always met with open arms, even when they make sense for reducing risk. Planners may consider the following recommendations for establishing clear and defensible subdivision standards.

- **Establish a strong politically supported and legal foundation.** A community's ability to establish subdivision and zoning regulations that address WUI concerns depends on its legal authority to do so. Not all states are created equal when it comes to the specifics of what can be regulated through zoning and subdivision controls at the local government level. A strong legal foundation is achieved by establishing a clear purpose and defensible provisions based on best available data.
- **Coordinate with service providers.** A concept that may be considered a planning best practice could be met with resistance from local service providers (such as fire, police, water, and other utilities). Involve the service providers in the development of draft regulations so that the adoption and ultimate administration and enforcement of the regulations are clearly understood by all affected parties.
- **Create a unified development ordinance.** A unified development ordinance (UDO) integrates the zoning code with the subdivision regulations (and often other standards such as floodplain regulations) to create a single document. The benefits of the UDO include the consistent and transparent application of approval procedures, a single set of definitions, the ability to reconcile any potential conflicts between zoning and subdivision regulations, and a one-stop-shop development code for the community. For example, Summit County, Colorado's land-use and development code allowed the county to comprehensively address wildfire hazard in both its zoning and subdivision regulations, as described in the sidebar on p. 104.

## ZONING CODE

A zoning code or zoning ordinance, sometimes referred to as the land-use code or development regulations, provides the regulatory basis for site improvements within a community. Zoning codes are collections of local laws enacted by ordinance that control and regulate land use and development. They carry out the intended land-use and development policies that were set forth in the comprehensive plan by establishing the types of uses allowed in geographic areas, the quality and quantity of site characteristics (such as landscaping, parking, and signage), and the procedures for evaluating various development applications.

Early zoning codes in the United States, such as New York City's zoning plan of 1916, were adopted in response to the prevalence of incompatible land uses and an increasing belief that cities and towns should be divided into areas for household living and areas for commercial or industrial activities (Elliott 2008). Modern zoning codes are more nuanced, recognizing that quality, form, and character of development is as important as the types of land uses allowed.

As development issues evolve, so must the regulatory framework. For reasons already identified in this report, zoning code administrators more clearly recognize their roles in shaping development efficiently, sustainably, and safely in and around the WUI. Unlike most long-range planning mechanisms, the zoning code is the law. Although the zoning code may integrate some level of flexibility into standards and procedures, it prescribes the minimum bar that development must meet.

Zoning codes are an effective tool for limiting damages caused by hazards because they can both restrict development in hazard areas and direct growth to safe locations (Schwab 2010). Planners with a deeper understanding of conditions in the WUI are better equipped to update local zoning codes as primary wildfire mitigation tools. Examples and details on both restricting development and directing growth to safe locations are included in this section.

### Addressing WUI Issues in the Zoning Code

Zoning codes offer numerous opportunities to minimize development in WUI areas with high wildfire hazard or risk and guide development to safer areas of the community. Al-

## SUMMIT COUNTY, COLORADO: LAND USE AND DEVELOPMENT CODE

In Colorado, the Summit County Wildfire Council and members of the county's Community Development Division worked with a consultant team to assess the current planning and regulatory framework and its ability to effectively address wildfire hazard. The team prepared a set of recommendations, many of which were adopted in early 2018 through a major amendment to the county's land-use and development code.

The updates included revisions to both zoning and subdivision regulations. Some of the highlights are as follows:

- ***Rezoning Policies*** (§3200). The county adopted a new set of wildfire hazard area standards to be considered during the rezoning process. These standards include submittal of a forest management plan and a fuels reduction or defensible space plan that includes proposed mitigation. The requirements also provide a direct linkage to the Summit County Community Wildfire Protection Plan (CWPP).
- ***Walls and Fences*** (§3515.06.D). Although chain-link fencing is generally prohibited, the county added an allowance for properties needing to comply with noncombustible fencing provisions within 10 feet of a structure (Figure 7.4).
- ***Landscaping Requirements*** (§3600). Defensible space provisions were integrated throughout the landscaping regulations, including adjustments to the minimum planting requirements and tree preservation standards to comply with defensible space fuel-reduction zones. Additionally, a new allowed plant materials list was included in the code that includes a column for whether the species is firewise or fire resistant.
- ***Residential Outdoor Storage*** (§3815.02). A new prohibition was added on the storage of firewood during peak fire season (May 1 to November 1) within 30 feet of a structure unless stored within a certified flame-retardant covering. Limitations for commercial firewood storage were also included (§3815.04).
- ***Subdivision Requirements*** (§8100). The county requires a fuel reduction/forest management plan that includes considerations of the CWPP. It must be developed in consultation with the Colorado State Forest Service, USDA Forest Service, or local fire protection district. Such plans are required to include maps showing property boundaries, existing and proposed roads, existing and proposed building envelopes, defensible space zones, and prescription burn areas; an inventory of current fuels; secondary fire apparatus access and emergency water supply; and other existing features or prescriptions. If the subdivision is planned to be platted in phases, the plan needs to show subdivision-wide improvements that will be carried out prior to the sale of any lots or completion of road improvements. A long-term maintenance plan or covenants, conditions, and restrictions with assignment of the party responsible for implementation (e.g., the homeowners association) is also required.
- ***Lots and Blocks Design Criteria*** (§8154). The county added a condition that all proposed lots must accommodate fire mitigation for zones one and two (for defensible space) as set forth in the building code, but this can be adjusted if circumstances warrant such an adjustment.
- ***Rural Land Use Subdivisions*** (§8420). Although the rural land-use subdivision tool (the county's version of cluster subdivisions) already existed in Summit County, the updates added a new purpose statement to include the reduction of "exposure of new development to wildfire hazards."

The Summit County Land Use and Development Code may be accessed at www.co.summit.co.us/255/Land-Use-Development-Code.

*Figure 7.3. Summit County, Colorado, where WUI issues are prevalent (Clarion Associates)*

though zoning codes vary in terms of their organization, they typically share several standard elements:

- Zoning districts
- Use regulations
- Site development standards
- Administrative and procedural requirements

The following sections describe possible approaches for addressing the WUI for each of these elements.

### Zoning Districts

A fundamental application of land-use regulation is achieved through establishing zoning districts. Combined with use regulations, they allow communities to direct growth away from the highest wildfire hazard or risk areas and otherwise limit the intensity and density of development within an area already identified as the WUI (Figure 7.4).

Traditionally, zoning districts are applied to an official zoning map as a base zoning district (with standards and conditions that apply to that district, regardless of geographic location), as an overlay zoning district (with standards that apply to a particular geography, regardless of base zoning district), or as a planned development (with negotiated standards that apply to a particular site).

**Base zoning districts.** When addressing the WUI, planners should consider which zoning districts are appropriate based on resulting density and whether additional district-specific standards should apply. For example, a low-density, large-lot residential zoning district may be appropriate in an area of moderate wildfire hazard or risk, whereas a higher-density multifamily zoning district may not. Or, that same multifamily zoning district may be appropriate with adequate safeguards such as limitations on outdoor storage of firewood or propane and additional building code provisions.

Applying a base zoning district occurs either during the annexation process or through rezoning property. It can be challenging to apply stronger wildfire standards retroactively to existing properties by means of base zoning districts and applicable district-specific standards.

**Overlay zoning.** In *overlay zoning*, additional or stricter standards are introduced within designated areas to address underlying conditions, regardless of the base zoning district boundaries. Depending on state and local laws, overlay zoning can occur as a legislative act because it applies standards across larger areas throughout the jurisdiction (versus quasi-judicial rezonings applied to a selection of individual properties).

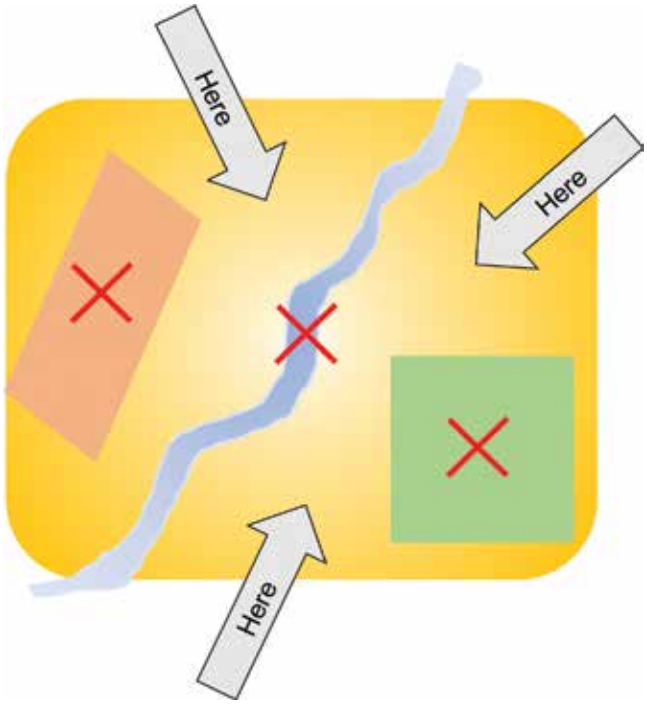



*Figure 7.4. Directing growth to appropriate and safe areas while avoiding wildfire or other hazards requires first analyzing the location of prevalent hazards (red Xs) and then identifying opportunity areas (arrows) for new development or redevelopment (Wildfire Planning International and Clarion Associates)*

An overlay district may be applied to a specific geographic location (such as mapped high-hazard areas) or to properties with certain site conditions (such as steep slopes or specific vegetation types). The application depends largely on existing data and mapping capabilities. A community with in-depth parcel-level analysis of WUI conditions may assign the overlay to properties within a certain level of risk based on that map, whereas a community with less granular data may rely more heavily on applicants to provide a site analysis to determine whether the overlay standards would apply.

Within the overlay district, standards to reduce risk may include prevention or mitigation of certain risk-prone uses, specific construction design (roofing, vents, and eaves), or requirements for vegetation management that otherwise would not apply in a base zoning district.

**Floating zones**. *Floating zones* are zoning districts that are applied to a site when a certain set of site conditions are met. Similar to an overlay district, these districts are flexible regardless of the base zoning district boundaries and rely on

## DAYTONA BEACH, FLORIDA: WILDFIRE PROTECTION ZONE

The City of Daytona Beach, Florida, adopted its Wildfire Protection Zone as part of amendments to its land development code in 2016. The ordinance requires developments adjacent to heavily wooded or vegetated areas posing a threat to wildfire impacts to designate a "low-fuel zone" along the perimeters of such areas. This requirement is limited to properties within the city that are west of Interstate 95.

To administer this regulation, the city's fire chief provides a wildfire hazard assessment for any development west of I-95 to determine if the standard shall apply. If the chief determines that there is a heightened hazard of wildfire, he or she may designate all or a portion of the site as a Wildfire Protection Zone.

Within a Wildfire Protection Zone, the city may adjust development standards that are otherwise applicable in the land development code as provided in the Wildfire Protection Zone (§6.5), including the following:

- Standards ranging from fuel-reduction perimeters and defensible space to prescribed burns
- Tree and landscaping standards, including the ability to waive tree replacement standards and reduce landscaping requirements
- Maintenance plan requirements, including provisions for vegetation management

The Fire Department has successfully implemented the Wildfire Protection Zones for years, and enjoys having the ability to work with prospective developers and home owners on wildfire protection approaches. Daytona Beach Fire Marshal Brian Sievertson says that the city is flexible when it comes to working with the community and noted that most people are supportive of the Wildfire Protection Zones. According to Sievertson, the city wants to educate property owners on the importance of the regulations—most importantly defensible space and maintaining a 14-foot clear path for fire apparatus suppression services.

The regulations have allowed the city to adapt to increasingly drier conditions. Sievertson also credits a good working relationship with the planning department in being able to successfully implement the standards—especially on long-term maintenance. "We have weekly meetings with the planning department. When we have questions about landscaping, we can simply run those questions by the landscape architect." He also points out that developers may have an initial learning curve until they determine how best to implement the additional requirements that apply within the Wildfire Protection Zones, an issue compounded by the fact that no two development projects have the same site conditions.

As for the need for such standards in Daytona Beach, Sievertson said, "If we didn't have them, we would be in real trouble. We can get complacent in Florida because we have hurricanes, and a lot of time between bad fire seasons."

certain site characteristics to determine the applicability of the floating zone.

In the case of the WUI, a floating zone may be applied that triggers compliance with vegetation management requirements when a site is in close proximity to an area of high wildfire risk, contains steep slopes or particularly dangerous vegetation, or is located in an area in which it is difficult to provide suppression services. In Daytona Beach, Florida, properties within a certain area of the city that have a high wildfire risk may be designated as a Wildfire Protection Zone, as described in the sidebar on p. 106.

**Transect zones.** *Transects* divide communities based on the level of development intensity, character, or urbanization. Transects are widely known as a function of form-based codes, which regulate development more by the physical form of the site and the building than the types of land uses. Transects range from urban environments, such as downtowns and central business areas, to rural environments, such as agricultural and forested land.

For communities facing high risk to wildfire, a transect zone could be established for the WUI, with stronger sensitive area protection standards and regulations for physical development. An ideal WUI transect would leave the natural environment relatively untouched, with little to no development in areas with the highest hazard.

**Planned development.** For planned developments (PDs) or planned unit developments (PUDs), some of the development parameters of the site may be negotiated on a case-by-case basis. For wildfire risk reduction, planners may determine that due to particular site conditions additional mitigation techniques are warranted, such as additional access points, vegetation management, water sources to supplement firefighting apparatus, or even prohibitions on or requirements for certain building materials.

**Transfer of development rights.** Some communities establish *transfer of development rights* (TDR) programs to allow additional density in preferred growth areas in exchange for protecting hazardous areas, or other environmentally sensitive areas, from development. Those sensitive areas—in this case, areas in the WUI—become "sending areas," from which the rights to develop those areas are "sent" or transferred to preferred growth areas ("receiving areas"). Those wanting to develop in receiving areas can purchase the development rights to expand the development potential of that site—such as additional density, increased height, or more intense land uses. Property owners in sending areas gain value from protecting those areas through the sale of development rights either to a developer in a receiving area or to a TDR bank managed by the local government.

Although effective, the complexity of TDRs should not be underestimated. TDR programs can require more staff resources and administrative attention than other growth management or hazard mitigation tools. Communities with successful TDR programs include Pima County, Arizona; Pinelands, New Jersey; and King County, Washington.

### Use Regulations

Along with establishing appropriate zoning districts and the standards within them, the zoning code establishes the appropriate uses allowed within each district. This fundamental aspect of zoning is especially important when planning for the WUI.

**Allowed uses.** Establishing which uses are allowed, and to what degree or intensity, is often illustrated through an allowed use table. An effective use table (or, within many older zoning codes, a list of allowed uses) clearly communicates the types of uses allowed in a district and whether those uses are allowed by right or require an additional procedural step such as a conditional use permit or special use review.

When considering the WUI, planners should revisit the allowed uses list or table and determine whether updates are necessary for particular zoning districts that may contain areas of wildfire hazard or risk. If potentially hazardous land uses are allowed, such as those listed in the next subsection below, communities may wish to require a conditional use permit or other type of special use review for those uses to ensure adequate mitigation is provided.

**Use-specific standards.** Once a use has been established as either prohibited, allowed by right, or allowed with a special review process, planners should consider whether mitigation requirements or other conditions should apply to a specific use. For example, bulk fuel storage may be allowed only if the applicant submits an adequate fire management plan that meets outlined mitigation criteria with the application. Alternatively, bulk fuel storage could be allowed in a particular zoning district, but not within a designated hazard or risk area pursuant to an official wildfire hazard, risk, or WUI map.

Other uses to which planners should consider applying additional standards to reduce wildfire risk include the following:

- Residential outdoor storage (e.g., firewood, propane, hazardous materials)
- Lumber yards or building materials storage

- Automobile service stations/gas stations
- Special events with large congregations, such as festivals or weddings
- Health care facilities
- Shooting ranges and target practice areas
- Other critical facilities and public facilities (e.g., recreation centers, community centers, religious institutions, schools, emergency response facilities)

Such use-specific standards could require a conditional use permit, minimum distances from hazardous vegetation, evacuation plans, evidence of adequate fire protection, or additional plans to ensure adequate mitigation is provided (Figure 7.5, p. 108).

**Temporary uses.** When establishing allowable use types and the conditions placed on such uses, planners should also consider temporary uses. For example, a temporary fireworks stand—a seasonal use in most jurisdictions—presents a particular risk to the WUI that other seasonal sales uses (such as a pumpkin patch) would not.

Other potentially problematic temporary uses include outdoor mass gatherings such as music festivals, wedding venues, and other special events. These typically involve large congregations of people and activities that could result in human ignition sources (e.g., campfires, cigarettes). Establishing standards for access, circulation, water supply, required fire protection, and emergency services for those temporary uses can help alleviate concerns related to both ignition and response.

### Site Development Standards

The site development standards of a zoning code regulate the physical layout, design, and quality of development. Development standards often address grading and drainage, access and connectivity, parking and loading, landscaping, building design, signs, and exterior lighting.

The level to which a community regulates site development varies by jurisdiction—some have robust and lengthy standards and others have only minimal requirements. Sometimes the types of regulations applied to subdivisions and the regulations applied to site development on previously subdivided property overlap. In those cases, development codes should clarify when those standards apply. For example, standards addressing driveway lengths may apply both during the subdivision process (when lots are established) and during the site planning review process prior to issuing a building permit. The same may also be true for grading and drainage standards.

When regulating the WUI, planners should consider the following approaches within the development standards if not addressed by other codes.

**Site-specific sensitive area protection standards**. Establishing sensitive area protection standards allows a community to holistically evaluate multiple natural site features prior to approving any foundation or building improvements. Features may include floodplains or riparian areas, hillsides or steep slopes, heavily forested areas, natural resources, historical features, mature tree stands, or wildlife habitat or migration paths. Sensitive area protection standards should be tailored to local ecology and existing conditions.

*Figure 7.5. Potentially hazardous land uses such as lumberyards (left) may require regular management of vegetation surrounding the use; vulnerable critical facilities may need fire protection, such as this paved road that acts as a fuel break for a medical center in Summit County, Colorado (right) (Wildfire Planning International (left), Clarion Associates (right))*

Sensitive area protection standards can be implemented by requiring applicants to establish "limits of disturbance" on a site—meaning the applicant is required to indicate the specific areas on the site where development activities are expected to take place. This approach allows the planning staff and the developer to be thoughtful and deliberate about the best locations within a site to contain development activities. The limits of disturbance concept also benefits the applicant in that the application of the standards is reduced to the development activity area, thus not rendering an entire property undevelopable.

Communities may also encourage improved site design by offering density bonuses (either by lot size reduction or an increase in the allowable base density) for development that avoids particularly sensitive areas, including identified wildfire hazard areas. As with dedicated open space, preserved wildfire hazard areas can be used for community risk reduction by reducing fuels—but that is only effective with adequate vegetation management and long-term maintenance, not just by preserving those areas from development.

**Lot and building dimensional standards.** Zoning regulations typically establish lot and building standards—the minimum and maximum development parameters that affect the built environment within each zoning district. These range from building setbacks and building height to lot area requirements and impervious coverage maximums. The lot and building dimensional standards are essential to maintaining appropriate densities and the desired character of each zoning district.

When planning for the WUI, lot and building dimensional standards are important factors for risk reduction. For example, the size of lots influences the amount of vegetation management within the structure ignition zone that property owners can feasibly maintain. When buildings are tightly spaced together, such as in a high-density neighborhood or a cluster subdivision, structure ignition zones will overlap. Planners must consider mitigating home-to-home ignitions through stricter building code and vegetation management requirements. If larger lots are allowed, planners may wish to require minimum setbacks from lot lines that ensure structure ignition zones do not overlap.

**Landscaping standards**. Landscaping standards address both the amount and the type of landscaping required. One of the most common landscaping topics related to the WUI is vegetation management requirements in the structure ignition zone, with particular attention to species selection, spacing, thinning, removal, and other techniques that reduce the likelihood that burning vegetation would affect a structure, as described in Chapter 3. Structure ignition zone provisions may also be located in a stand-alone section of the zoning code, or within a larger body of wildfire mitigation standards, such as an adopted WUI code.

Many other important landscaping standards should be evaluated for opportunities to reduce wildfire hazard and ensure they don't conflict with WUI management objectives, such as requirements for buffers and screening.

- **Type and amount of landscaping.** Many older zoning codes (and even some modern ones) require landscaping materials in amounts that are appropriate for aesthetic purposes but may be inappropriate in terms of water conservation and wildfire hazard reduction. Competing interests must be further evaluated. For example, development of hillsides is often heavily regulated for different purposes than WUI mitigation, such as protecting view corridors or preventing hillside erosion. This often results in dense forestation around hillside development, but it can also make hazardous-fuel reduction projects (such as vegetation management between structures) difficult to implement. Some zoning codes also require a certain amount of vegetation to be planted near building foundations, which unfortunately can create dangerous conditions that may result in ground-to-structure transfer of wildfire. Vegetation species or plant lists should also be reviewed to determine whether landscaping requirements are encouraging more flammable types of vegetation (such as arborvitae).
- **Landscape buffers.** Planners should review existing regulations for landscape buffers and common open space and evaluate whether they align with local policies for wildfire risk reduction. As with minimum vegetation requirements, buffers are often required to create aesthetic transitions. However, buffers can help reduce wildfire threat to adjacent development if they are wide enough and include the types of vegetation and landscaping that may slow the progress of a fire. For example, grassy swales or rock mulch may slow the progress of a surface fire better than buffers containing a lot of shrubs and evergreen trees. It is also important to consider availability of water—irrigated grassy swales may not be appropriate in areas with prevalent drought conditions.
- **Tree preservation.** Many codes have stringent protections in place to prevent deforestation and to protect heritage trees. Although tree preservation offers many benefits, planners should establish flexible standards that allow property owners to practice vegetation management (i.e., remove certain trees) to reduce wildfire risk.

- **Landscape maintenance and vegetation management.** Effective vegetation management also requires that the landscape is maintained over time. Most zoning codes include some level of landscape maintenance and installation requirements to ensure that vegetation is managed consistently. Those maintenance provisions are most commonly intended to achieve a desired long-term aesthetic, but they can also serve a wildfire risk reduction purpose. Poorly maintained landscaped areas can also be considered nuisances when overgrowth and weeds begin affecting surrounding properties and the general health, safety, and welfare of the community. Nuisance issues are most commonly addressed by a separate ordinance outside the zoning or subdivision regulations that may have stronger enforcement and abatement provisions.

**Fencing.** Fencing materials should also be considered when planning for the WUI. As discussed in Chapter 3, combustible features such as wood or vinyl fencing can act as a wick by carrying fire from the lot to attached structures. Although fences are commonly used for other purposes (such as privacy), planners and building officials should require that any fencing within the first five feet of the structure be made of noncombustible material.

### Administration and Procedures

The procedures established to evaluate proposed development applications are as important as the technical zoning code standards themselves. There are several mechanisms for reducing wildfire risk within the administration and procedures of the zoning code, including requiring hazard-related information to be submitted with an application and establishing a clear process and criteria related to risk reduction when evaluating proposed developments.

**Application submittal requirements.** Most planning departments clearly specify what information must be submitted with various application types, and this generally increases with the scale and complexity of the application type.

Integrating wildfire risk reduction into development application submittal requirements is an effective way to understand localized risk and mitigate accordingly. For example, if a development application is proposed within an identified wildfire hazard zone, the planning department may require a fire protection and vegetation management plan, whereas a proposal outside of the wildfire hazard zone would not be subject to such requirement. The requirements for submittals can be clearly communicated on standard forms and through presubmittal meetings. Providing visuals and wildfire mitigation tip sheets are also helpful resources for applicants.

**Site-specific assessments**. A community may establish a site-specific assessment procedure by which the local government either facilitates a site visit or requires an applicant to contract an assessment of the development parcel and its localized wildfire risk. Such assessments can be applied to all types of developments community-wide or only within certain geographic areas (such as a high wildfire risk area). Site-specific assessments are a flexible approach to mitigation because planners and other subject matter experts consider unique features of a site, such as topography and existing vegetation, rather than just reviewing a proposed development based on the information submitted in the application.

Santa Fe, New Mexico, conducts site assessments in the Escarpment Overlay District, a 500-acre area containing some of the highest wildfire risk in the city (Figure 7.6, p. 111). The city's planning manager spends significant staff resources managing development in the Escarpment Overlay, balancing competing community priorities of protecting historic hillside views while also ensuring the provision of adequate defensible space.

Development applications in the Escarpment Overlay District are subject to stricter standards than other applications. For example, landscaping in the Escarpment Overlay District is treated differently than other areas within the city—vegetation with a lower burn risk is required. Additionally, siting of all structures must be approved by city staff prior to issuance of any grading or building permit.

The city's success of working with property owners to reduce wildfire risk is in part due to the overall culture of collaboration. City planners, alongside the fire department's WUI specialist, work together on site assessments to effectively manage development from multiple perspectives.

**Approval criteria.** Another effective tool to elevate the importance of wildfire mitigation is through approval criteria for development applications. Planners are familiar with standard approval criteria for various applications, such as "protecting the public health, safety, and welfare," "general conformance with the comprehensive plan," and "does not result in adverse impacts." However, additional hazard-specific criteria can be added for certain application types. For example, consider adding approval criteria for rezoning applications, when key decisions are made related to intensity and density of development. The criteria may require consideration of wildfire hazard and demonstration of adequate mitigation.

Similar criteria can also be applied to other application types where conditions may be necessary, such as condi-

tional use permits, major site plans, subdivision applications, changes of use, and variances.

**Development agreements**. Development agreements, which are legally binding contracts between the local government and the developer, can ensure that a proposed development meets a set of standards that are otherwise not required by the zoning code.

Both the local government and the developer can benefit. The local government can establish more stringent standards than otherwise allowed under the zoning code (for example, it can require vegetation management and fire protection plans when such plans are not otherwise required by the development review procedures). The developer may in turn gain flexible alternatives through the agreement ranging from reduced fees or expedited review times to density bonuses or waivers from certain code requirements. The terms are individually negotiated but can result in a meaningful approach to wildfire risk reduction in the absence of codified standards.

For example, an annexation agreement between the Town of New Castle, Colorado, and the developer of the Lakota Canyon Ranch included the following requirement:

> Wildfire Hazard and Mitigation Response Plan. Developer has prepared and the Town has approved a Wildfire Hazard and Mitigation Response Plan dated October 15, 2002 which sets forth certain techniques, strategies, and mitigation measures designed to reduce the risk of injury to persons and damage to property from wildfire. Developer shall comply with the provisions of the Wildfire Mitigation Plan in designing and constructing Lakota Canyon Ranch … (New Castle 2002)

## BUILDING CODE

Although the planning department may not always act as the administrator of the building code, understanding this code as part of a comprehensive approach to WUI regulation is fundamental for reducing structure loss. In fact, building codes originated in response to highly destructive urban fires in the late 1800s, as noted in the sidebar on p. 112.

As discussed in Chapter 3, even the best fire protection resources may not prevent all wildfires. When resources are overwhelmed during a wildfire it becomes critical that structures in the WUI can survive on their own, without reliance on suppression. Structure survivability is accomplished through interventions on the lot and building in the structure ignition zone. It is therefore essential that planners familiarize themselves with the building code to understand its effectiveness and how it complements other WUI regulations.

*Figure 7.6. Santa Fe planning and fire department staff speak with author Molly Mowery about their WUI planning efforts in the Escarpment Overlay District (Clarion Associates)*

## THE EVOLUTION OF BUILDING CODES

The regulation of buildings in the United States began in the late 1800s when major cities began to adopt and enforce building codes in response to fires that affected urbanized areas (FEMA Building Sciences Branch n.d.). The most notable example was the Great Chicago Fire, which occurred October 8–10, 1871, leaving at least 250 dead and 18,000 buildings destroyed. Following the tragedy, the Chicago city council mandated the use of fire-resistant materials in the construction of future buildings in the downtown (Kamin 1992). Pressure from insurance underwriters following the fire also led to advances from the iron industry to strengthen buildings through improved construction techniques (Kamin 1992).

The primary intent of early building codes was to reduce fire risk. The scope of today's building codes has broadened to govern the design, construction, alteration, and maintenance of structures to ensure structural integrity, safe exits, lighting, adequate ventilation, and more. These standards are meant to safeguard the health, safety, and general welfare of building occupants. Codes also ensure uniformity across the building and fire industries.

*Figure 7.7. Ignition-resistant siding (such as stucco), multipaned or tempered glass windows, noncombustible gutters, enclosed eaves, and other features are typical requirements in building codes that address the WUI (Wildfire Planning International)*

Building codes that incorporate WUI mitigation focus on a range of topics, including the selection of proper materials, construction techniques, and landscaping requirements in the structure ignition zone (Figure 7.7, p. 112). Table 7.2 (p. 113) shows typical requirements that apply to structures in the WUI. These are generalized requirements; in many cases, exceptions apply to requirements and model codes or standards should be consulted for more details. Building requirements not listed include other fire and smoke protection features, such as exterior sprinklers, spark arrestors, fences, retaining walls, and other appendages or projections.

California has adopted an especially robust set of building and related codes to address wildfire hazard. The state's approach is described in the sidebar on p. 114.

### Adoption Process

The adoption of building codes is generally undertaken by the state or local jurisdictions through a legislative and public policy process. Many states and local jurisdictions that regulate structures in the WUI through the building code refer to the IWUIC or NFPA 1144: *Standard for Reducing Structure*

## TABLE 7.2. TYPICAL BUILDING COMPONENTS AND CODE REQUIREMENTS FOR THE WUI

| Building Component | Typical Code Requirements |
|---|---|
| Roofs | Require Class A fire-rated roof assemblies on any structure in a wildfire hazard area. |
| Eaves, overhangs, soffits | Use noncombustible material, ignition-resistant materials, application of gypsum sheathing, or one-hour fire resistance rating on exterior wall assembly applied to the underside of rafter tail, soffit, or roof deck in areas exposed to radiant or convective heat. |
| Gutters and downspouts | Install noncombustible or fire-resistant roof gutters and downspouts.<br>Install leaf guards or other protective means to prevent the accumulation of leaves, needles, and debris in the gutter. |
| Exterior walls and siding | Construct wall covering or wall assembly with noncombustible, ignition-resistant materials or heavy timber exterior wall assembly, log wall construction assembly, or other assemblies that meet established performance criteria.<br>Protect exposed underside of exterior porch ceilings, underfloor projections, and other appendages with noncombustible, ignition-resistant, or other acceptable material. |
| Vents | Specified vents must be noncombustible and have opening dimensions of a minimum of 1/16 inch and a maximum of 1/8 inch, or rated vents must be installed.<br>Attic ventilation openings, foundation or underfloor vents, or other ventilation openings in vertical exterior walls and vents through roofs must not exceed a maximum opening size as established by the code. |
| Windows and skylights | All exterior windows and exterior glazed door assemblies must be constructed of multipane glazing or tempered glass meeting established safety glazing requirements, glass block units, or materials with established fire-resistance ratings or other performance requirements. |
| Exterior doors | Where radiant or convective heat exposure is likely, exterior surfaces must be of noncombustible or ignition-resistant material, be constructed of solid core wood that complies with thickness requirements, or meet established fire-resistance rating or performance requirements. |
| Decks and attachments | Decking surfaces must be constructed with noncombustible, exterior fire-retardant-treated wood, approved wood thermoplastic composite lumber, ignition-resistant materials, or other material that complies with established performance requirements.<br>Deck framing must meet one-hour fire-resistance construction standard, use noncombustible materials, or be constructed with other approved materials. |
| Detached accessory structures | Accessory structures within 50 feet of primary structures are subject to the same minimum requirements of the code for exterior walls, windows, and roofs, and other applicable standards. |

*Source: Molly Mowery and Kelly Johnston*

*Ignition Hazards from Wildland Fire* to integrate model code language or standards.

During the adoption process, states and jurisdictions frequently make amendments to ensure that codes reflect local needs. In some cases, local jurisdictions can adopt more stringent requirements than those set forth in the state building code; this is the case in California, as discussed in the sidebar on p. 114. In other cases, states adopt a "mini/maxi" code, meaning that no local jurisdiction can enforce a code more or less restrictive than the state-approved model code (ICC 2017).

Other states may have a statewide building code but do not require its adoption at the local level. One such state is Montana; however, if a city, county, or town within the state chooses to adopt a building code, it may only include codes adopted by the state's Building Codes Bureau (Montana Department of Labor and Industry n.d.).

Adoption of building codes is uneven across and within states, even in areas with high levels of hazard, such as wildfire, earthquake, flooding, hurricanes, or tornados (FEMA Building Sciences Branch n.d.). This may be due to a variety of reasons, including lack of political will for regulating structures in areas with strong property-rights interests, limited capacity to administer and enforce additional requirements for hazard mitigation standards, unknown increased costs associated with more stringent requirements, or lack of tech-

## CALIFORNIA BUILDING STANDARDS CODE

California's fire-prone lands make wildfires an inevitable reality for many communities across the state. To minimize the potential impacts of wildfires, the state relies on a vast toolkit of fire-safety education programs, regulations, policies, plans, and initiatives, as well as a state-of-the-art fire protection system. These activities are administered by local, state, and federal agencies and organizations dedicated to public safety, resilience, and wildfire risk reduction.

One of the state's fundamental WUI regulatory tools is the California Building Standards Code (CBSC) (California Code of Regulations (CCR) Title 24). The CBSC is developed by state agencies as the statewide minimum building design and construction regulations for California. Cities and counties may also adopt local ordinances and code amendments that are more restrictive than CBSC regulations. The CBSC is typically enforced by local city and county agencies during the local building permit and construction management process (California Building Standards Commission n.d.).

Minimum wildfire protection requirements and referenced performance-based test standards for building construction are contained in different parts of the CBSC:

- California Building Code, CCR Title 24, Part 2
- California Residential Code, Part 2.5
- California Fire Code, Part 9
- California Referenced Standards Code, Part 12

Similar requirements for mobile homes and other types of manufactured buildings are regulated by the California Department of Housing and Community Development (CCR Title 25). All parts of the CBSC pertaining to wildfire protection building construction are published by the International Code Council.

These codes seek to achieve two primary objectives: removing flammable materials from around a structure and constructing the building of fire-resistant material. California's Office of the State Fire Marshal maintains a list of approved WUI products that comply with the requirements of applicable codes. Users (contractors, developers, and other applicants) can search the database for applicable WUI categories under the building materials listings, such as decking, under eave, exterior doors, exterior windows, and exterior wall siding and sheathing.

More information on WUI building requirements is available from the CAL FIRE Office of the State Fire Marshal: http://osfm.fire.ca.gov.

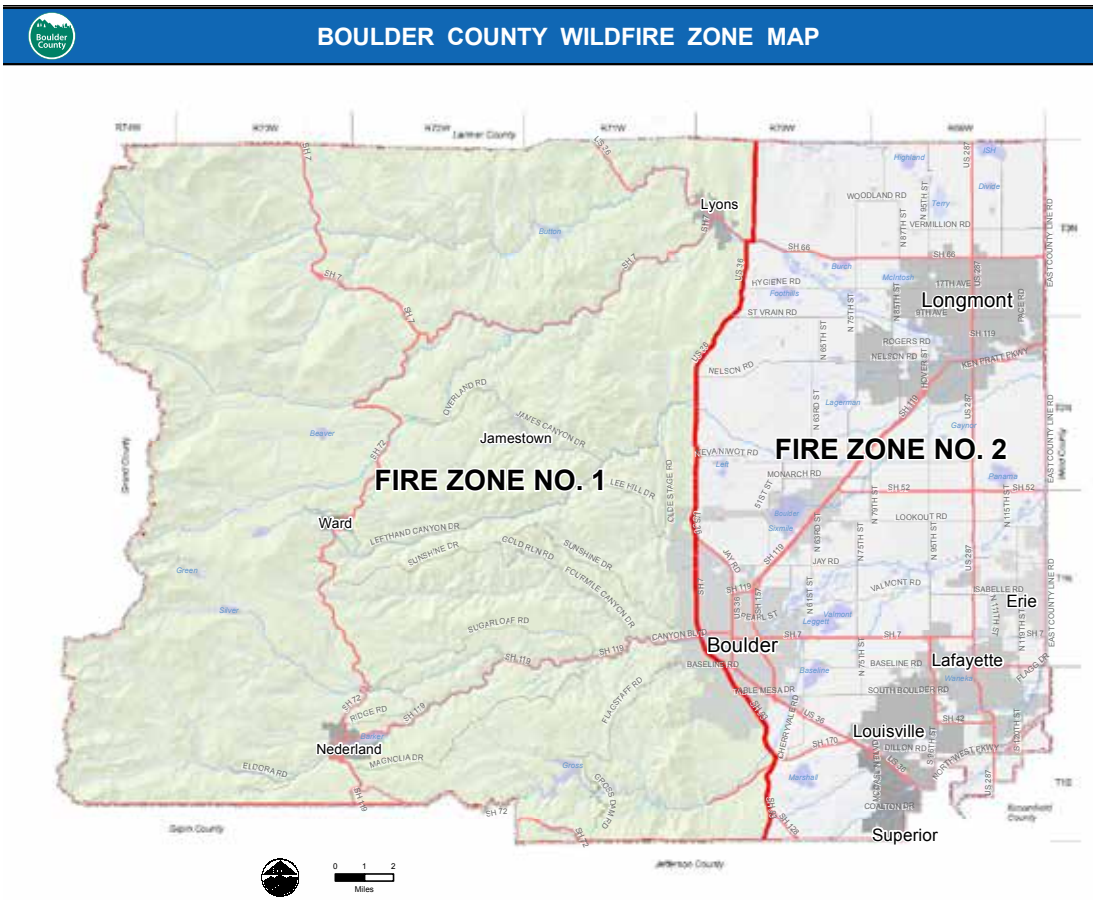



*Figure 7.8. Boulder County, Colorado's Wildfire Zone Map is used to determine where corresponding wildfire regulations apply (Boulder County 2016, Figure R327.2)*

nical knowledge or understanding of the need to require hazard-specific regulation of buildings.

## Applicability and Administration

Building codes are often adopted in conjunction with other codes, including residential, fire, and WUI codes, and therefore the WUI is sometimes addressed in several areas.

When regulating the WUI through building codes, states and local jurisdictions must apply requirements within an applicable area, such as a wildfire hazard map or identified WUI area. This is determined by either the state or the local authority having jurisdiction to establish and administer such requirements (often by the code official, fire chief, or other designated department). For example, Boulder County, Colorado, amended its 2015 building code to include requirements for structures in wildfire hazard areas (§R327.2). These areas are designated as Fire Zone 1 and Fire Zone 2 on the county's Wildfire Zone Map (Figure 7.8). For buildings located in more than one wildfire zone, the requirements of the more restrictive zone apply.

Building codes are administered by building officials, who may be required to have certified training by the Council of American Building Officials or ICC on applicable local codes. Depending on the size and capacity of the community, functions of the building official may be performed by other staff members or departments, including examination of plans, field inspections, permitting, and enforcement. Some jurisdictions may also designate a different code official, such as the fire marshal or fire inspector, to administer fire-related building requirements contained within the code.

Even if planners do not administer building codes, they will interact closely with building departments and reference building code contents. For example, building officials may participate in land-use review and decision making as part of development review committees. Planners will refer to the building code on a number of policy and development mat-

ters, including green and energy efficiency goals; safe and resilient housing requirements; and sustainability, climate, or disaster risk reduction objectives.

### Additional Considerations

Jurisdictions will use different terms to define acceptable building materials and construction in the WUI, such as fire-resistance-rated construction, ignition-resistant building materials, fire-retardant treated materials, and noncombustible materials. The ICC and NFPA provide definitions in their model codes or standards, and states or local jurisdictions may amend these definitions. Planners should note any differences in key definitions to ensure terms are applied appropriately.

### Potential Challenges

Potential challenges that jurisdictions face regarding building codes include administration and inspection, which require technical knowledge by trained building professionals. Enforcement requires additional capacity to ensure that buildings comply with the regulations. In addition, maintenance can be difficult to enforce on an ongoing basis. Finally, communities will encounter the fairness issue as it relates to any economic burden imposed on structures subject to the code, for example, whether a building permit for a new deck should trigger additional mitigation requirements for an entire home to bring it into compliance with the code.

## FIRE CODE

Fire codes were originally developed to regulate the hazardous materials or processes that may be present in an inhabited structure. Like building codes, they have evolved significantly over the past 150 years to reflect the complexities of the built environment and emerging technology (Havel 2017).

Both building and fire codes are now comprehensive in their scopes and are often intertwined when it comes to regulating the safety of buildings and their occupants, minimizing the risk of fires and explosion hazards, protecting first responders, and addressing the WUI. For example, some jurisdictions adopt fire codes that are embedded within a building code and others may designate a WUI chapter within the fire code, though still other fire codes may remain independent from the building code and WUI code.

Similar to some counties' subdivision regulations, topics typically regulated by fire codes include access roads, emergency exits, water supplies, emergency planning and preparedness, active and passive fire protection systems (e.g., automatic sprinkler systems and fire alarm systems), accumulation of trash and debris, the storage and use of hazardous materials, and special uses or hazard considerations. Many of these topics are directly or indirectly related to WUI planning, including requirements for:

- Access for fire response, such as road and driveway widths, grades, and turnarounds
- Water supply, such as hydrants and minimum fire flow
- Life safety, such as refuge areas and escape routes (usually within buildings)
- Prevention of fire spread between buildings
- Regulation of hazardous operations and storage (e.g., chemical warehouses)
- Public nuisances, such as weeds or other materials that pose a fire hazard

In Boise, Idaho, the city's WUI regulations are housed within its Fire Prevention Code (§7-01-69) as a separate chapter (Chapter 49). The WUI is designated by the code official (the chief of the Boise fire department or designee) and is delineated into two zones. Buildings and structures in both WUI zones must be constructed in accordance with the International Fire Code, International Building Code, International Residential Code, Boise City Code, and the Fire Prevention Code. Requirements address a range of structural features and other WUI vulnerabilities, including roof coverings, eaves, exterior walls, unenclosed underfloor protection, decks, exterior doors and windows, vents, fire sprinkler systems, emergency vehicle access, and defensible space landscaping. In addition, a fire safety plan must be filed with any subdivision or planned unit development for identified areas in the WUI. The fire code official works with the city's planning department to coordinate reviews of development applications during the initial application review stage. This allows important input and feedback to be incorporated into any mitigation requirements prior to final site layout.

At the state level, Florida's Fire Prevention Code includes a chapter that addresses the WUI. The sidebar on p. 117 describes the Florida Fire Prevention Code in greater detail.

### Adoption Process

Similar to the building code adoption process, many states or local jurisdictions will adopt a model fire code, such as the International Fire Code or NFPA 1: *Fire Code*, and will make amendments to the model code. For example, NFPA 1 is currently adopted statewide in 19 states (NFPA 2018). Adoption of these codes at the state level will often dictate which codes

## FLORIDA FIRE PREVENTION CODE

The Florida Fire Prevention Code provides a comprehensive set of fire code provisions and is enforced by the local fire official within each county, municipality, or special fire district in the state. The sixth edition of the code is based on the 2015 editions of NFPA 1: *Fire Code* and NFPA 101: *Life Safety Code*, with state amendments. It is adopted by the Florida state fire marshal at three-year intervals (Florida Statutes Chapter 633.202). Some local jurisdictions have adopted local amendments to the state code.

NFPA 1 contains a chapter on the WUI (Chapter 17, Wildland Urban Interface), which Florida has adopted without any state amendments. Chapter 17 addresses planning, construction, maintenance, education, and management elements for the protection of life and property from wildfire, and cross-references NFPA 1144: *Standard for Reducing Structure Ignition Hazards from Wildland Fire*. Any community that declares an area within their jurisdiction as a WUI is required to perform a wildland fire hazard assessment of each structure ignition zone in the development to determine relative risk, the extent of wildland fire hazard, and applicable mitigation measures (§17.1.1).

The chapter also provides a comprehensive set of requirements for the structure assessment process, which includes documenting conditions of the surrounding environment; exterior construction of the primary structure, including any projections; and the landscaped area within the structure ignition zone. Based on the findings from the structure assessment, the local jurisdiction may require a wildland fire hazard mitigation plan that includes specific mitigation actions to reduce the ignition potential around and including the structure, along with a hazard mitigation implementation and maintenance schedule (§17.1.10.3).

Other WUI issues addressed by this chapter include prohibitions on smoking materials, tracer bullets, tracer charges, explosives, or fireworks within hazardous fire areas unless permitted by the local jurisdiction; clearance standards for brush and vegetation near electrical transmission and distribution lines; vegetation management requirements near structures; spark arresters for fireplace and woodstove chimneys; and regulations for other exterior exposure hazards such as outdoor fireplaces and grills.

More information about the Florida Fire Prevention Code is available at www.myfloridacfo.com/division/sfm/BFP/FloridaFirePreventionCodePage.htm.

are adopted locally and whether amendments can be made. While each model code covers the same general topics, differences may vary across specific requirements.

### Applicability and Administration

Fire code official duties are typically performed by a fire marshal or fire inspector; in some cases, authority for code administration is granted by the fire chief. Planners are not administrators of the fire code, but they should be aware of its contents as they relate to fire safety, development, and the WUI.

One of the key differences between building and fire codes is that building codes regulate and integrate fire-safe design and fire prevention during the construction and installation phase of a building, while fire codes dictate fire prevention on an ongoing basis beyond the initial design and construction. In other words, fire codes are used to ensure that building owners maintain what the building code requirements were at the time of construction—after the certificate of occupancy is issued and once the building is in use. This is particularly relevant to the WUI, where maintenance can pose a challenge for ensuring that wildfire risk reduction is ongoing.

### Additional Considerations

Fire codes often work in conjunction with other codes, including building codes. When considering WUI regulations, it is important to coordinate with fire and building departments to discuss what type of requirements may already be in effect under existing codes.

In some cases, however, different local authorities may adopt and enforce different model codes. For example, the building official may use the International Building Code, while the fire official may use NFPA 1 as the fire code (Hammerberg 2012). In addition, each may operate on different editions that may not be the latest editions available. Planners should not assume that just because the community has adopted the ICC version of the building code, it uses the ICC version of the fire code, WUI code, or other related codes. It is relatively easy to determine which codes the community uses simply by asking the fire marshal and building official.

### Potential Challenges

Fire codes are lengthy in scope and complex in their levels of technical detail. In addition, these codes may include both prescriptive requirements and performance-based options, requiring the code official to have the expertise to interpret and approve final submission plan requirements.

## WILDLAND-URBAN INTERFACE CODE

A wildland-urban interface code, commonly referred to as a WUI code, provides a minimum set of regulations to protect life and property from wildland fire exposures and to prevent structure fires from spreading to wildland fuels.

WUI codes can regulate a comprehensive scope of features, including structures, vegetation surrounding structures, access requirements such as road widths and turnarounds, water and power supply for fire response, hazardous land uses that may contribute to wildfire risk, and more. When properly administered and enforced, WUI codes can strengthen the likelihood of a structure's survival and reduce reliance on suppression and response resources.

WUI codes are convenient because they offer a central location within a community's set of regulations for addressing the WUI. Their level of depth and breadth can vary significantly, depending on the degree to which the community seeks to regulate development in the WUI or any restrictions posed by state-level requirements.

### Adoption Process

As previously noted, WUI codes can be adopted as a chapter within a fire or building code, an appendix to one of these codes, or as a stand-alone chapter within the jurisdiction's appropriate code.

State and local governments often adopt the IWUIC or NFPA standards and make local amendments that may be more or less restrictive than the model. The sidebar on p. 119 provides a more detailed look at the IWUIC. Local amendments also allow communities the flexibility to accommodate local concerns or issues and ensure that they meet other state requirements. Jurisdictions should be aware that they may be incurring limitations on risk reduction if they do not comprehensively adopt a model code or set of standards, unless local amendments provide appropriate substitute provisions.

Communities can also draft their own WUI codes, independent of a model. This approach is conceptually attractive because it maximizes flexibility of regulations, such as creating performance-based mitigation measures, and enables content to be organized in the most logical manner for the community. A customized code can also draw from multiple sources to be better tailored to local regulations and administrative review processes. However, developing a customized WUI code requires a significant initial effort both in technical expertise and capacity. Customized WUI codes may also be more onerous to update due to the time required to ensure they incorporate recent scientific findings or changes in in-

## A CLOSER LOOK AT THE ICC INTERNATIONAL WILDLAND-URBAN INTERFACE CODE

Using model codes is a common approach for many communities nationwide. When regulating the wildland-urban interface, one model code option is the International Wildland-Urban Interface Code (IWUIC), which establishes minimum requirements for land use and the built environment in designated WUI areas. This model code uses prescriptive and performance-related provisions and is founded on data collected from tests and fire incidents, technical reports, and mitigation strategies.

As of 2018, the IWUIC is in use or adopted at the state or local level in 18 states. The code is compatible with the suite of International Codes published by the International Code Council. The first IWUIC edition was issued in 2003; periodic editions have been released since that time to incorporate updated science and research. The IWUIC 2018 edition is organized into seven chapters and eight appendices, as follows:

- Chapter 1: Scope and Administration
- Chapter 2: Definitions
- Chapter 3: Wildland-Urban Interface Areas
- Chapter 4: Wildland-Urban Interface Area Requirements
- Chapter 5: Special Building Construction Regulations
- Chapter 6: Fire Protection Requirements
- Chapter 7: Referenced Standards
- Appendix A: General Requirements
- Appendix B: Vegetation Management Plan
- Appendix C: Fire Hazard Severity Form
- Appendix D: Fire Danger Rating System
- Appendix E: Findings of Fact
- Appendix F: Characteristics of Fire-Resistive Vegetation
- Appendix G: Self-Defense Mechanism
- Appendix H: International Wildland-Urban Interface Code Flowchart

Communities typically adopt the IWUIC with amendments to better address local needs, such as creating local definitions of the wildland-urban interface and referencing locally appropriate wildfire risk or hazard assessments.

dustry best practices, as opposed to model codes, which are updated on a regular cycle.

In either case, WUI definitions and terminology should be consistently used across the WUI code and within other chapters and titles. As a recommended practice, jurisdictions can eliminate confusion by adding references to the WUI code rather than providing multiple instances of definitions.

## Applicability and Administration

Important considerations when developing and adopting a WUI code include the following:

- Aligning a locally adopted code with any state requirements
- Ensuring that the code requirements implement intended mitigation policies in local plans
- Defining the code's scope and applicability
- Designating a code official

Communities must determine whether state-level requirements influence what type of regulations may be adopted at the local level. This is most often the case when a state adopts a building, fire, or WUI code that controls the degree to which additional requirements can be adopted by local jurisdictions.

For example, the Washington State Building Code comprises several different codes, many of which are model codes adopted by reference and amended at the state level. This includes the International Fire Code, which has an optional appendix for a WUI code (based on the IWUIC with state amendments). Provisions in the appendices do not apply unless specifically adopted by local jurisdictions. The Washington State Building Code Council determined that a local ordinance adopting Appendix N, the state's preapproved and amended WUI code, may be approved by any local government upon notification to the council. However, if local jurisdictions make additional amendments, they may be required to seek approval from the council. The sidebar on pp. 122–23 describes how Wenatchee, Washington, has adopted and is now updating WUI regulations.

When local governments adopt a WUI code, they must determine where the code provisions will apply. This typically requires the adopting authority to define the WUI in terms of a geographic area (i.e., a map) or a narrative description, such as a certain distance from specified wildlands. In Chapter 3, Wildland-Urban Interface Areas, the IWUIC provides a methodology to establish and record WUI area(s) based on findings of fact. Jurisdictions who adopt the IWUIC may choose to use this standard language, while others amend this section with their own WUI definitions to provide a more accurate reflection of the local WUI.

In addition to identifying where the WUI is, jurisdictions must also specify what will be regulated within the WUI. A WUI code may apply to one or more of the following:

- Any structure within the WUI (residential and commercial)
- New construction
- Additions, remodels, renovations, and retrofits
- Structures or units over a certain size
- Accessory dwellings
- Designated land uses that are deemed hazardous (e.g., warehouses, industrial uses)
- Parcels or structures that receive a specific hazard rating

Model WUI codes provide this language to guide jurisdictions in determining which types of development should be considered. As previously stated, however, communities may wish to modify this language as appropriate.

A WUI code can also specify under what conditions additional standards may be required. For example, the IWUIC requires that buildings and structures in the WUI meet specified construction requirements as outlined in an ignition-resistant construction table. Communities may also choose to require on-site parcel evaluations by professionals in certain circumstances. For example, if a hazard rating in the WUI is above a certain threshold (e.g., high, very high, or extreme), the professional site assessor may evaluate the site to determine whether additional vegetation management or a secondary emergency access is required. This must be established within the code to ensure the process is transparent and fair.

Administration of a WUI code is typically performed by the local fire department, planning or land-use department, or building department. Determining the appropriate code official to administer the WUI code depends on the local government's organization; formal relationships between fire, building, and planning departments; and other organizational factors.

## Potential Challenges

As with other WUI regulations discussed in this chapter, communities must anticipate potential challenges that could arise when updating or adopting a new WUI code. Challenges often relate to concerns over the economic impacts associated with wildfire mitigation requirements, aesthetic

preferences for building materials and landscaping features that do not conform with the code, private property rights, and others. Strategies are suggested in the following section to help overcome or address these challenges.

As discussed above, jurisdictions need to be aware of any state code requirements that restrict the type of regulation allowed at the local level. Jurisdictions should contact their state building code council (or equivalent, as applicable) and state fire marshal's office prior to developing a WUI code.

In addition, WUI code provisions can often conflict with other local requirements in a jurisdiction's code. This is particularly true for standards pertaining to landscaping such as tree preservation, privacy screening and buffering between uses, habitat and species protection, maintenance of viewsheds, and risk reduction of other hazards (such as mitigation that requires retention of vegetation). To address these potential conflicts, jurisdictions should perform an analysis prior to adoption of a WUI code and resolve regulatory conflicts. This can also be done by including conflict resolution language that clearly states the relationship between regulations.

Finally, jurisdictions must consider the type of resources that will be required for code updates and enforcement. The next section offers more information on enforcement strategies.

## STRATEGIES FOR ADOPTING WUI REGULATIONS

With all the different options discussed above to choose from, it is tempting to think that planners have an easy path toward implementing WUI regulations. But it is also easy to get overwhelmed when considering updating or adopting new WUI regulations. Public and political resistance can feel intimidating if planners are uncertain about the level of support for regulations. The learning curve for understanding the technical aspect of WUI regulations may seem daunting. Resources and capacity are often limited.

Despite these and other challenges, many communities have successfully found ways to adopt local WUI regulations. This section shares strategies and best practices drawn from community examples and research to support planners in their pursuit of developing, adopting, and implementing WUI regulations.

### Take Incremental Steps

Communities that have no WUI regulations in place may find it helpful to start incrementally. This can be achieved by targeting the most vulnerable aspects of structures or properties. For example, research by the Insurance Institute for Business and Home Safety (IBHS) and NFPA indicates that an untreated wood shake or shingle roof covering is the greatest threat to a home. Creating a roof ordinance that requires Class A roof coverings in the WUI would target this structural vulnerability.

Other incremental approaches include the following:

- regulating the most at-risk areas of the community first (i.e., areas with the highest level of hazard)
- targeting new development only, as opposed to all development
- modifying tree preservation requirements to allow for removal of trees that pose a wildfire hazard

These approaches target vulnerabilities at different scales; however, it is worth noting that select application of WUI regulations will still leave the community susceptible to wildfire. This should be clearly communicated during the adoption process to ensure that stakeholders, including elected officials, are aware of gaps and consider a long-term, comprehensive package of WUI regulations.

### Ensure Plans Support WUI Policies

Local support can also be built by ensuring that plans and policies address a community's WUI. The example of Deadwood, South Dakota, in Chapter 6 illustrates this. Planners and stakeholders were interested in exploring future WUI regulations but recognized there could be resistance to jumping into a regulatory approach. They seized the opportunity to first work with local stakeholders during a comprehensive plan update to discuss how wildfire goals and policies fit into the plan. As part of their process they identified different WUI challenges, such as limited access, evacuation routes, at-risk populations, tourist events during wildfire season, and historic structures vulnerable to wildfire. Policy outcomes included potential future regulations to address some of these concerns.

Gaining community input and buy-in paves the way for planners to pursue development of WUI regulations. At a minimum, planning policies that consider wildfire hazard can support sound development decisions. For example, planners can promote conformance with the comprehensive plan as a rationale for requiring additional mitigation requirements during an application review. This process should be transparent and fair, and it can be an effective way to integrate wildfire concerns into current planning processes if WUI regulations have not yet been adopted.

## WENATCHEE, WASHINGTON: REGULATING THE WUI

Nicknamed the "Apple Capital of the World," the city of Wenatchee, Washington, is situated in a river valley along the Rock Island Reservoir, at the confluence of the Columbia and Wenatchee Rivers, and is bordered by grassy foothills on the west. It serves as the county seat for Chelan County and has a population just over 33,000 (U.S. Census Bureau 2017).

As discussed in the *Wenatchee Urban Area Comprehensive Plan: Planning to Blossom 2037* (last updated in 2017), wildfires are part of the area's natural environment. The region falls in the rain shadow of the Cascade Mountains, contributing to hot, dry summer months that see average temperature highs of 88 degrees Fahrenheit in July and August in Wenatchee (U.S. Climate Data n.d.). Since 1992, the city has been directly affected by four significant wildfire events, including the 1992 Castle Rock Fire and the 2015 Sleepy Hollow Fire. As a result, Wenatchee has been proactive in its approach to planning for and regulating wildfire.

In 2011, the city adopted a set of WUI standards within the Fire title of the city code (Chapter 3.36). These standards currently designate two WUI zones: primary and secondary zones. This determination is based on a property's location and exposure to large tracts of natural vegetation. Property and structures immediately adjacent to undeveloped land with natural vegetation without fuel breaks establish the interface line, or "primary zone"; property and structures located to the east, or developed side, of the primary zone and within 1,500 feet of the interface line are included in the city's "secondary zone." The code official retains final authority in determining which properties are affected by the WUI zone designation.

Within its WUI standards, Wenatchee also provides a definition of defensible space, outlines the responsibilities of the land owner, and references the IWUIC and NFPA 1144: *Standard for Reducing Structure Ignition Hazards from Wildland Fire*. Requirements for all new applicable structures and additions in the primary zone include Class A roof covering or roof assemblies (§3.36.050)—wood shakes and wood shingles are prohibited in both primary and secondary zones—and minimum construction standards for eaves and soffits, exterior walls, attic ventilation and other openings, and detached accessory structures greater than 200 square feet.

In addition, all newly constructed structures in the WUI zone must be protected by a 30-foot defensible space from undeveloped land. Defensible space may be a modified fire-resistive perimeter area within a common lot or roadway outside of individual lot lines, or a fire-resistive landscaped yard area within individual lot lines in accordance with NFPA 1144 (Figure 7.9). The maximum building envelope for development sites must be identified on each parcel to provide adequate access around the structure for fire protection and to provide a fire break (§3.36.160).

In addition to its chapter on WUI standards, the city has also adopted a separate set of regulations for the storage of combustible material (Chapter 3.12) to address the fire hazard associated with empty wooden boxes, bins, pallets, cartons, and trays. This is a local concern associated with the large number of commercial fruit-packing warehouses in the area. Included in the regulations are requirements for distances between combustible storage materials and structures and maximum heights for stacked bins.

As with all codes, the city continues to seek potential improvements in the effectiveness of its WUI standards. In 2016, the city participated in the national Community Planning Assistance for Wildfire (CPAW) program, in which multidisciplinary teams of planning and forestry experts help communities identify and implement better land-use policies and regulations to minimize wildfire impacts in the WUI. The program is funded by the USDA Forest Service and private foundations and provides assistance at no charge to communities.

As part of the program, CPAW team members and local stakeholders analyzed the 2015 Sleepy Hollow fire impacts, which burned 30 homes on the outskirts of town (due to direct flame impingement and embers) and multiple commercial warehouses in the urban downtown core (due to the transportation of embers from the burning structures). The fire exposed some of the limitations of defining the WUI in terms of a primary and secondary zone, which did not fully capture the set of conditions that promotes the ignition and spread of fire through the WUI fuel complex (wildland and built fuels).

Taking previous fire experiences and risk information into account, the CPAW team recommended that that the entire city be identified as the WUI, with a redefined primary and secondary zone. The most stringent WUI standards were recommended to apply to the primary zone, where structures will be potentially exposed to radiant and convective heat transfer, as well as burning airborne embers. Less stringent standards were recommended to apply to the secondary zone, where structures are potentially exposed to localized radiant and convective heat, as well as short-,

*Figure 7.9. Wenatchee Broadview neighborhood immediately after the Sleepy Hollow Fire (top left); improved setbacks following the fire (top right), and new landscaping techniques (bottom) (Wildfire Planning International (top left), City of Wenatchee staff (top right, bottom))*

medium-, and long-range burning embers. The city is currently working with the county and other local jurisdictions to determine how an updated WUI code may align with other regional regulatory efforts—highlighting the dynamic nature of implementing WUI regulations.

Additional information about local mitigation efforts in and around Wenatchee may be found in this *#forestproud* podcast's conversation with fire and mitigation specialists from Chelan County Fire District 1: https://forestproud.org/2018/06/05/10-building-communities-living-with-fire.

## Seek Professional Assistance

When capacity is limited—which it often is—or when technical knowledge may be lacking, planners can outsource the regulatory review process to appropriate agencies or qualified professionals. Referring plans to qualified professionals for on-site reviews ensures that mitigation plans (e.g., structure ignition zone requirements, site layout, setbacks) are being appropriately reviewed for compliance with WUI regulations.

External professionals should be screened for appropriate understanding of the regulations and should have minimum qualifications such as forestry and fire experience. Plan review duties can also be referred to the fire department or state agencies when capacity and expertise is available.

## Get Creative with Enforcement

Ideally, communities have dedicated staff to uniformly review and enforce mitigation requirements and respond to complaints. However, this is not always the case, and communities may express hesitation in adopting WUI regulations because they fear that they cannot enforce them.

To counter this, communities have gotten creative with enforcement approaches. For example, Wasco County, Oregon, developed a robust set of fire safety standards and enforces them through self-certification. Applicants receive information about wildfire regulations and then are required to sign a form that certifies their compliance. Another strategy is to perform a lottery-style enforcement approach, where applicants may be randomly selected for an on-site review of the required mitigation. Finally, other communities may hire part-time or seasonal employees to enforce wildfire regulations primarily during a wildfire "season." These strategies remove the burden from staff but still ensure there is some mechanism in place for enforcement.

## Time it Right

There is no single perfect time to adopt WUI regulations, but there are some considerations to keep in mind. In the aftermath of a fire, stakeholders may be able to galvanize support around adopting new or improving existing WUI regulations. For example, following the Waldo Canyon Fire in 2012 (see sidebar in Chapter 6), the Colorado Springs Fire Department successfully led an effort to strengthen its existing WUI regulations, such as additional requirements for vegetation clearance and structural hardening (Mockrin et al. 2016).

Conversely, communities may find that adopting new or revising existing WUI regulations under a "blue-skies" scenario—when no immediate wildfire disaster is looming—is preferable. That is because recovery from a wildfire can put pressure on planning departments to expedite the review process and encourage rebuilding, rather than allowing for a thoughtful approach to evaluating WUI regulations. Disaster recovery also requires a tremendous amount of resources, and undertaking a regulatory adoption process may be a distraction rather than a welcome opportunity.

Finally, planning departments should consider what other issues may take precedence in the upcoming months. For instance, communities anticipating zoning changes based on other current planning topics may find staff capacity and public attention is focused on different priorities for a limited time. Planners should time discussions on WUI regulations appropriately to avoid competing for agenda space.

## Take the Conversation Outdoors

Field tours are an effective way to learn, discuss, and share WUI concerns that inform potential regulations (Figure 7.10, p. 125). These interactive opportunities can also build communication and trust across different sectors (Evans et al. 2015).

Whether planners want to learn more about wildfire hazard from local fire and mitigation specialists or help the public and elected officials understand WUI concerns, getting outdoors brings some issues to light. For example, taking a tour with first responders to explore access challenges in specific neighborhoods can lead to creative regulatory (or nonregulatory) solutions, such as identifying signage and clearance requirements that should be included in the WUI code, or planning future easements for secondary emergency evacuation routes.

## Collaborate on Public Education and Outreach

Codes and regulations work best when implemented in concert with other voluntary mitigation efforts that encourage resident awareness and education. A report by the Fire Protection Research Foundation that interviewed 12 communities on their use of WUI regulations found that the public was often skeptical of proposed WUI regulations but usually came to support WUI standards if a strong public education effort was made to address concerns and correct misinformation in a transparent and open manner (Duerksen, Elliott, and Anthony 2011, 2). In addition, WUI home owners and elected officials are more likely to accept regulatory practices that are perceived as fair and part of a comprehensive approach (Winter et al. 2009, 573).

Planners need not tackle the public education and outreach process on their own. In fact, research has also found that wildfire information received by the public from local volunteer fire departments and county wildfire specialists

*Figure 7.10. Field assessments and discussions provide on-the-ground opportunities to understand WUI conditions and opportunities for regulations (Wildfire Planning International)*

has been positively associated with higher levels of mitigation (Brenkert-Smith et al. 2012). Planners should enlist the help of knowledgeable and trusted professionals from the local fire department or state and federal forestry agencies when seeking to educate the public on potential adoption of WUI regulations.

And as discussed in Chapter 5, developing a collaborative approach and finding allies to support regulatory efforts is essential—not only with local fire departments and forestry agencies, but with a broader set of industry stakeholders, including developers, home builders, realtors, landscape and gardening professionals, and others. Flagstaff, Arizona, used a broad public engagement process spearheaded by the local fire department to gain support for proposed WUI regulations, resulting in the city's adoption of the IWUIC in 2008, as described in the sidebar on p. 125.

## FLAGSTAFF, ARIZONA: COLLABORATING ON PUBLIC ENGAGEMENT

In 2008 Flagstaff, Arizona, adopted the IWUIC 2006 edition with local amendments. The code applies to most of the city per its locally defined WUI. Local amendments include requiring defensible space on an entire property for applicable structures and subdivisions within the WUI (FFD n.d.).

The adoption followed an 18-month development process that engaged the Homebuilders Association, real estate and insurance agents, community leaders, engineering firms, developers, the general public, and others (Summerfelt and Wheeler n.d.). The adoption effort was led by the Flagstaff Fire Department and drew on previous collaborations with the city's community development department and other efforts. Almost all input from stakeholders was incorporated into local amendments to the codes, resulting in a community-supported set of WUI regulations.

The city adopted the IWUIC in tandem with the International Fire Code. These codes are complemented by the implementation of the *Greater Flagstaff Area Community Wildfire Protection Plan* (GFFP 2018), the citywide *General Forest Stewardship Plan* (FFD 2005), and the city's *Hazard Fuels Mitigation Guidelines* (FFD 2011).

For further information, see the Flagstaff Fire Department's "Community Risk Reduction" webpage at www.flagstaff.az.gov/240/Community-Risk-Reduction.

### Communicate the Benefits

In the face of potential skepticism or resistance, it's important to be equipped with information that communicates the benefits of WUI regulations along myriad themes, including the following:

- **Safety.** WUI regulations advance the safety, welfare, and protection of the public and first responders during life-threatening wildfire events.
- **Savings.** For every $1 of investment in hazard mitigation measures that meet or exceed model building codes, the nation can save $4 in future disaster costs (NIBS 2017).
- **Science.** WUI regulations are based on decades of research, field data, and laboratory tests on home survival methods.
- **Sustainability.** WUI regulations offer co-benefits that can result in increased energy efficiency by improving construction standards for structures, requiring building materials that address gaps and vulnerabilities (e.g., doors, windows), and supporting land-use patterns that encourage smart growth.

### Stay Committed

Adoption of WUI regulations can take months, if not years. Similar to other planning processes, it takes commitment and perseverance. Setbacks are likely and may take a variety of forms, including the need for new relationship building and ongoing education.

Summit County, Colorado (see the sidebar on p. 104), provides an inspiring example of a community that stayed committed to moving its wildfire regulations forward through a multiyear process. Changes in staff, unanticipated concerns from stakeholders, and different planning priorities all occurred. But after several years of research, discussion, and stakeholder collaboration, the county adopted innovative wildfire regulations that met specific wildfire needs within the community.

## CONCLUSION

Planners, working in tandem with their elected officials, fire departments, and other stakeholders, have many options when determining the appropriate path for regulating current WUI conditions and potential development in wildfire-prone areas. Primary WUI tools include subdivision regulations, zoning codes, building codes, fire codes, and WUI codes. Although some of these tools are not directly administered by planners, it is essential for them to understand the full suite of available WUI regulatory approaches. While many of these planning mechanisms have merit as stand-alone mitigation tools, planners should consider multipronged approaches to WUI regulations because many of them work together to achieve comprehensive wildfire risk reduction.

In addition to appropriate tool selection, there are many considerations for administering, adopting, and enforcing regulations. Best practices and research incorporated throughout this chapter provide helpful strategies to support communities in their implementation efforts.

CHAPTER 8

# WHAT DOES THE FUTURE HOLD?

The existence of the wildland-urban interface (WUI) is a direct result of human decisions to build in wildfire-prone areas. Associated wildfire disasters are a result of several influences, including land-use decisions, previous fire suppression and forest management policies, and climate change. Present day WUI challenges have been decades, if not centuries, in the making; consequently, overnight solutions are unlikely.

Current trends affecting the WUI include a projected U.S. population increase of more than 100 million people by 2050 (Passel and Cohn 2008), and hotter, drier, and more severe weather conditions and extreme wildfire events. As recent fire seasons and high-profile wildfires have underscored, these trends are likely to exacerbate the challenges already faced by communities in the WUI.

These trends also emphasize the need for a thoughtful, comprehensive approach to WUI solutions—solutions in which planners can play active roles by guiding outcomes related to where communities are built and what forms they take. This final chapter reflects on planners' roles in shaping the WUI to help mitigate future disasters, and it poses several topics to keep in mind while embracing the uncertainty associated with planning in the WUI.

## PLANNERS' ROLES IN THE WUI

As this PAS Report has shared, planners have numerous opportunities to positively alter wildfire-related outcomes while achieving other important community goals. Planners can:

- Lead community-based conversations about development in the WUI, associated risks from wildfire, and potential social, economic, and environmental impacts from WUI fires
- Advocate for planners' roles in public safety, community resilience, and preparedness through WUI planning
- Work with local officials to develop WUI maps and wildfire hazard and risk assessments to inform current and future land-use planning decisions
- Initiate the integration of wildfire into community policies and actions
- Participate in hazard plan updates and plan maintenance activities to ensure land-use planning is linked to the hazard mitigation plan and community wildfire protection plan
- Coordinate with local, state, or federal mitigation specialists on education campaigns that target the WUI
- Identify regulatory options to reduce wildfire hazard in the WUI at appropriate local scales
- Work with fire departments to identify gaps in administration and enforcement of existing or future WUI regulations
- Prepare for wildfire scenarios by implementing pre-and post-disaster plans that address mitigation and recovery
- Collaborate with local stakeholders, such as builders and developers, on WUI solutions that strengthen structures while factoring in affordable housing concerns
- Look for conflicts with other planning projects that may inadvertently create or exacerbate WUI issues
- Educate elected officials on WUI planning issues and economic tradeoffs of not actively using land-use planning tools to reduce wildfire risk
- Explore synergies with other planning topics, such as sustainability, resiliency, green infrastructure planning, and growth management

## ADDRESSING CHALLENGES

For some communities, implementing new plans and policies in the WUI is likely to be met with challenges. These may include resistance toward new regulations that bring

## PLANNING FOR THE UNEXPECTED


PAS Report 531, *Planning for the Unexpected: Land-Use Development and Risk* (Johnson et al. 2005), provides an in-depth discussion on the risks that planners face during the land-use decision-making process. For example, some risks are straightforward, such as physical risks that accompany development in an area with an identified hazard. However, many other decisions may affect risk in more subtle ways, such as exacerbating or ignoring emerging risks, increasing some types of risks while reducing others, or allowing risks to accumulate over time.

To help planners consider how to establish a local approach to risk-based planning, the report examines four risk management programs from diverse geographic areas. These examples integrate the options for managing risks—avoidance or elimination, reduction or mitigation, sharing or transfer, and retention—and risk management principles. The report also provides a basic framework to manage risks, which includes identification, assessment, decision making, and monitoring. Planners interested in gaining more knowledge on how to plan for risk and uncertainties should consult this resource.

The report is available on the APA website at www.planning.org/publications/report/9026860.

perceived or real economic burdens to property owners, public opinion that wildfire is not a high planning priority, lack of political will from elected officials, and limited technical understanding or internal staff capacity to implement new policies or regulations.

Many communities have overcome challenging situations to successfully address their WUIs through plans, policies, regulations, or other strategies. As outlined in Chapter 7, successful outcomes use a combination of strategies that involves collaboration with other partners, creative solutions, education, outreach, and long-term commitment. Implementation often takes time and is done incrementally. Research and case studies shared throughout this report are meant to inspire readers by providing examples of how communities have successfully implemented plans and policies to address challenges in the WUI.

## IDENTIFYING UNCERTAINTIES

Despite the roadmap that this report provides, our landscapes and built environments are in a constant state of change as a result of both human influences and natural processes. With these changes come uncertainties about the future.

Some of these uncertainties and associated risk factors, such as the relationship between humans and wildfire ignitions, are becoming well known. Other factors are less understood, including how hazards such as wildfires, drought, and severe storms may increase in severity and frequency and alter an individual community's risk. Scientists have modeled precipitation and temperature changes across different regions to provide possible scenarios (USGCRP 2017). Less is also known about how these scenarios relate to environmental changes, such as tree species migration or increases in invasive species, which may also contribute to wildfire hazard. PAS Report 531, *Planning for the Unexpected*, examines how to factor risk into land-use planning (see the sidebar).

Other external factors are also linked to changing wildfire hazard, further disrupting our ability to plan in a linear and predictable fashion. Private insurance markets, for example, are regularly evaluating their exposure to natural hazards. As a result, some insurance premiums in wildfire-prone areas are becoming cost prohibitive. In more extreme cases, home owners are experiencing challenges with maintaining policy coverage altogether (Mehaffey 2017). This can affect the real estate market and put additional urgency on fast-tracking local WUI mitigation requirements.

Planners must embrace change and uncertainty as part of WUI planning—specific outcomes at the local level can never be 100 percent known. Staying current with the science of climate change will help our profession plan for these unknowns and how they may affect the WUI. Uncertainty is also a skill set in which the planning profession excels—planners operate under scenario-based thinking, and they can apply this approach to wildfire planning for future development.

## AREAS FOR FUTURE RESEARCH

The planning profession's responsibility to keep our communities safe and resilient to wildfire is aided by the many effective WUI strategies outlined in this report. However, there is much more planners can learn and fine tune when it comes to understanding wildfire risk reduction through land-use planning.

This list, although not exhaustive, proposes areas of future research that could further inform successful WUI planning:

- **Additional lessons learned from structure survival and loss rates in the WUI as they relate to different land uses and development patterns.** Many studies have been conducted on the effectiveness of fuel treatments and building materials. However, few studies have analyzed the effectiveness of land-use strategies on wildfire risk reduction. For example, fire behavior science informs recommended regulations to place structures away from slopes through establishing minimum setbacks. Showcasing specific examples of where structure survival occurred through a regulatory setback would aid the communication of real-life examples during code adoptions. Such research could further analyze the trade-offs between different development patterns, such as clustered development that increases density of homes but may lead to urban conflagrations (without proper mitigation) versus large-lot subdivisions in which vegetation management can be easily implemented but other effects from sprawl create challenges.
- **Comprehensive compilation of state and local WUI planning approaches for case studies and knowledge exchange.** Many state and local governments are interested in what other communities are doing to implement planning solutions in the WUI. Building a national database of community examples (e.g., case studies, statutes and regulations, best practices, policies, incentive programs) would lend itself to increased professional knowledge and could improve uptake of WUI planning strategies across jurisdictional boundaries.
- **Increasing understanding of sustainable outcomes for wildfire risk reduction and other planning priorities.** Implementing building codes that address WUI requirements can also improve energy efficiency measures. These co-benefits can be helpful when building buy-in and support for WUI regulations. Other WUI planning decisions may be less understood. For example, communities that face challenges with water supply should be considering the impacts on the WUI when approving new growth. How much is "enough water" that meets both short-term minimum fire protection standards and also sustains development for decades or centuries? Having these discussions with the local fire department and natural resource planners can address concerns about long-term sustainability of resources and more immediate needs for fire protection.

## CONCLUSION

Unless action is taken to reverse the current course, WUI disasters will continue to bring social, economic, and environmental harm to communities across the country. These disasters have significant and long-lasting community impacts on public and first responder safety, water and air quality, housing stock and affordability, health and well-being, local industry, recreational opportunities, and more.

The challenge of the WUI may seem daunting. Over the last 10 years, the United States saw an average of 56,000 wildfires per year (NIFC 2018). Climate change is bringing hotter temperatures and drier conditions to many regions, leading to extreme wildfire events (Herring et al. 2015). Increased human activity in wildfire-prone areas has resulted in more wildfire ignitions, extending the length of wildfire seasons (Balch et al. 2017). The WUI now accounts for nearly 10 percent of the conterminous United States. With continued population and housing growth in the WUI expected, how communities manage this growth is critical.

It is both infeasible and undesirable to remove all wildfires from the landscape. They have shaped ecosystems for millennia and, under the right conditions, provide multiple ecological benefits to forests, grasslands, habitats, and plant and tree species. The alternative is to reevaluate the way land-use decisions lead to outcomes and to strive for the creation of fire-adapted communities.

Fire adaptation is an ongoing and collaborative process that involves engaging community members and stakehold-

ers in understanding and implementing strategies to mitigate wildfire risk in order to safely coexist with wildland fire. The process of fire adaptation helps communities understand their wildfire risk and collectively take actions to mitigate this risk.

Although not all wildfire risk can be eliminated, it is based on a set of well-understood factors. Land-use planning interventions, such as changes to the location and type of development, can address some of these factors during and after the development process, helping communities avoid devastating outcomes and accepting fire as part of the landscape.

WUI solutions also require collaboration across multiple professions and agencies. Many communities have been overreliant on fire suppression and response activities as their main tools for managing fire risk, which does little to address the underlying WUI challenge. Conversely, planners make daily decisions about the built and natural environment—many of which have direct consequences for the WUI. As a result, planners can offer valuable input, guidance, and expertise in addressing WUI challenges.

Firefighters, land managers, emergency managers, scientists, community leaders, and residents need the participation of planners in applying land-use planning tools to address WUI challenges. Now is the time for planners to step forward and play a meaningful part to help build communities that are more resilient to wildfire.

## APPENDIX: GLOSSARY OF TERMS

**Adaptive capacity:** The combination of local social characteristics and external forces (including ecological processes or larger social forces) that influence whether and how human communities take action to reduce their exposure or modify the severity of disturbance events.[1]

**Aerial fuels:** Standing and supported live and dead combustible materials not in direct contact with the ground and consisting mainly of foliage, twigs, branches, stems, cones, bark, and vines.[2]

**Built fuels:** Combustible structures, including buildings and infrastructure.

**Conflagration:** A raging, destructive fire. Often used to connote such a fire with a moving front as distinguished from a fire storm.[2]

**Crown fire:** A fire that advances from top to top of trees or shrubs more or less independent of a surface fire. Crown fires are sometimes classed as running or dependent to distinguish the degree of independence from the surface fire.[2]

**Defensible space:** The selection, location, grouping, and maintenance of vegetation on the property in such a manner that the opportunity for fire to burn directly to a structure is minimized. [7]

**Embers:** see *firebrand*.

**Exposure:** The contact of an entity, asset, resource, system, or geographic area with a potential hazard. Note: In incident response, fire responder exposure can be characterized by the type of activity.[3]

**Fire-adapted community:** A human community consisting of informed and prepared citizens collaboratively planning and taking action to safely coexist with wildland fire.[4]

**Firebrand:** Any source of heat, natural or human made, capable of igniting wildland fuels; flaming or glowing fuel particles that can be carried naturally by wind, convection currents, or by gravity into unburned fuels.[2]

**Fire effects:** The physical, biological, and ecological impacts of fire on the environment, or, the physical, safety, health, social, and economic impacts of fire on humans and human development. This is often expressed as first order (immediate effects) and second order (subsequent effects as a result of first order effects).

**Fire intensity:** Commonly referred to as fire line intensity, this is the amount of heat energy that is generated by burning materials.

**Fire weather:** Weather conditions which influence fire ignition, behavior, and suppression.[2]

**Firewise USA:** A voluntary program administered by the National Fire Protection Association that teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action to prevent losses. Some communities have applied the term "firewise" more broadly to refer to wildfire mitigation activities.

**Fuels:** All combustible materials in the wildland-urban interface, including but not limited to vegetation and structures.7
Fuel treatment: Manipulation or removal of fuels to reduce the likelihood of ignition or to lessen potential damage and resistance to control (e.g., lopping, chipping, crushing, piling, and burning).[2]

**Greenfield:** Land, including farmland and open spaces, that has not been previously developed.

**Ground fuel:** All combustible materials below the surface litter, including duff, tree or shrub roots, punky (rotted) wood, peat, and sawdust, that normally support a glowing combustion without flame.[2]

**Hazard:** Any real or potential condition that can cause damage, loss, or harm to people, infrastructure, equipment, natural resources, or property.[3]

**Home ignition zone (HIZ):** Also see *structure ignition zone*. The area where the factors that principally determine home ignition potential during extreme wildfire behavior (high fire intensities and burning embers) are present. The characteristics of a home and its immediate surroundings within 100 feet comprise the HIZ.[2]

**Hydrophobic soils:** Resistance to wetting exhibited by some soils, also called water repellency.

**Infill development:** Development characterized by development or redevelopment of undeveloped or underutilized parcels of land in otherwise built-up areas, which are usually served by or have ready access to existing infrastructure and services.

**Initial attack (IA):** A preplanned response to a wildfire given the wildfire's potential. Initial attack may include sizing up, patrolling, monitoring, holding action, or suppression.[2]

**Ladder fuels:** Fuels which provide vertical continuity between strata, thereby allowing fire to carry from surface fuels into the crowns of trees or shrubs with relative ease. They help initiate and assure the continuation of crowning.[2]

**Landscape scale:** A large spatial scale, which addresses multiple land uses, ecosystem services, and conservation objectives. Landscape-scale approaches focus on achieving multiple environmental, economic, and social objectives across the defined area.

**Mitigation:** The act of modifying the environment or human behavior to reduce potential adverse impacts from a natural hazard. Mitigation actions are implemented to reduce or eliminate risks to persons, property, or natural resources, and can include mechanical and physical tasks, specific fire applications, and limited suppression actions.[2]

**Natural hazard:** Source of harm or difficulty created by a meteorological, environmental, or geological event.

**Preparedness:** Activities that lead to a safe, efficient, and cost-effective fire management program in support of land and resource management objectives through appropriate planning and coordination.[2]

**Prescribed fire:** Any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific objectives.[2]

**Prevention:** Activities directed at reducing the incidence of fires, including public education, law enforcement, personal contact, and reduction of fuel hazards (fuels management); actions to avoid an incident, to intervene for the purpose of stopping an incident from occurring, or to mitigate an incident's effect to protect life and property.[2]

**Resiliency:** The ability to prepare and plan for, absorb, respond, recover from, and more successfully adapt to adverse events.[5]

**Risk:** A measure of the probability and consequence of uncertain future events.[3]

**Risk assessment:** Product or process that collects information and assigns values to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision making.[3]

**Structure fire:** Fire originating in and burning any part or all of any building, shelter, or other structure.[2]

**Structure ignition zone (SIZ):** Also see *home ignition zone*. The area around a specific structure and associated accessory structures, including all vegetation that contains potential ignition sources and fuels.[6]

**Suppression:** A wildfire response strategy to "put the fire out" as efficiently and effectively as possible while providing for firefighter and public safety.[2]

**Surface fire:** A fire that burns loose debris (e.g., dead branches, leaves, and low vegetation) on the surface of the ground.[2]

**Surface fuel:** Fuels lying on or near the surface of the ground, consisting of leaf and needle litter, dead branch material, downed logs, bark, tree cones, and low-stature living plants.[2]

**Urban conflagration:** A large, destructive fire that spreads unimpeded by fire suppression efforts or barriers, destroying large areas of structures and infrastructure.

**Values:** Items identified by a community as having measurable or intrinsic worth that could be negatively impacted by a wildfire. Values include property, structures, physical improvements, natural and cultural resources, community infrastructure, and economic, environmental, and social values.[2]

**Wildland:** An area in which development is essentially nonexistent, except for roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered.[2]

**Wildland fuels:** All vegetation (natural and cultivated).

**Wildfire:** An unplanned wildland fire, including unauthorized human-caused fires and escaped prescribed fire projects. Wildfire management objectives may vary based on site-specific circumstances and conditions.[8]

**Wildfire hazard:** The combination of the likelihood of a fire occurring and the intensity of the fire. Also refers to the wildland or built fuels present in a given area, or the combustibility of a given fuel type or fuel complex in general.

**Wildfire risk:** The wildfire hazard plus the addition of the factors that contribute to susceptibility, or the impact of a wildfire on highly valued resources and assets.

**Wildland fire:** Any nonstructure fire that occurs in vegetation or natural fuels. Wildland fire includes prescribed fire and wildfire.[2]

**Wildland-urban interface (WUI):** Any developed area where conditions affecting the combustibility of natural and cultivated vegetation (wildland fuels) and structures or infrastructure (built fuels) allow for the ignition and spread of fire through these combined fuels.

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American Planning Association
205 N. Michigan Ave., Suite 1200
Chicago, IL 60601-5927

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