



American Forest Foundation



Western Water Threatened by Wildfire:

IT'S NOT JUST A PUBLIC LANDS ISSUE

Message from

TOM MARTIN, PRESIDENT AND CEO OF THE AMERICAN FOREST FOUNDATION



2015 was another extremely dry year for the West. Temperatures were higher, snow packs across the West hit an all-time low, reservoirs were depleted and unprecedented water restrictions were enforced.

These dry conditions combined with our changing climate and the often overly dense conditions of many Western forests, produced a catastrophic wildfire season that saw more than 9 million acres burned

across the West, a level reached only four times on record.

Recent fire seasons like this year's season are now lasting 78 days longer than they did in 1970 and are burning hotter. Fire suppression costs have multiplied and the problem is getting worse.

The consequences are tragic: hundreds of homes destroyed, thousands of residents forced to evacuate and both firefighter and civilian lives lost.

But fire also poses another risk: it threatens the clean drinking water supply for millions of Westerners; drinking water that in dry years like 2015, becomes even more crucial.

Most don't realize our Western forests are a natural water filter and storage system, keeping water clear and replenishing streams and rivers with clean water that ultimately finds its way to the faucets of at least 64 million people who live in the West. A fire that burns with catastrophic severity can wipe out entire stands of forests, and the streams and rivers that run through the scorched land can become fouled with erosion and debris, compromising already scarce clean water supplies, including drinking water for many of the West's major metropolitan areas.

While we cannot do much about drought that leads to increased wildfires and water scarcity, we can do more to solve the problem of too much fuel in the forests that increases the likelihood of catastrophic wildfire and threatens clean water.

Revealing results from a first-of-its-kind assessment, *Western Water Threatened by Wildfire: It's Not Just a Public Lands Issue*, from the American Forest Foundation, examines which lands in 11 Western states are at high risk of wildfire and where these high-risk forests threaten clean drinking water.

The results are both surprising and significant. The report shows that contrary to conventional wisdom,

wildfires are not exclusively a public lands issue. In fact, more than one-third of the high fire risk is on private and family lands, which is land owned by individuals, families, trusts, partnerships and conservation and natural resource organizations. In some states, like California, it's 51 percent. Moreover, nearly 40 percent of the lands that keep the water clean in important watersheds and are at a high risk of fire are private and family owned.

With this new finding, and knowing that wildfires and streamflows don't stop at property lines, cross-boundary approaches for reducing wildfire risk that involve public, tribal, private and family lands are essential. Our forests are only as resilient as their weakest link. Restoration work needs to occur on public and tribal lands, but as this report highlights, if we are to protect clean water, we must address wildfire risk on private and family lands as well.

What's more, the report highlights that among these private and family lands, individual and family forest owners (hereafter referred to as family forest owners) hold one of the largest segments of this land. They are mothers and fathers, children and grandparents who own 10 or 40, or maybe 100, acres of forest. They own their land for many reasons: simple enjoyment of the outdoors, a place to hunt or fish on weekends, income or as a legacy and investment. Regardless of the reason they own woods, they all care deeply for their land and want to be good forest stewards.

Our first-of-its kind survey of nearly 1,800 family forest owners in the West reveals these owners are concerned about the threat of catastrophic wildfire to their land, and they are eager to become part of the solution now by restoring their own forests to more healthy conditions, which in turn will help protect clean water. However, family forest owners need support—financial and technical—to carry out this stewardship. Included in this assessment are a series of significant recommendations that together can provide family forest owners with needed support and engage private and family landowners in restoration work that will help protect the drinking water for millions of Americans.

We have an opportunity to take action now to address this severe threat. We need to engage and help the owners of private and family lands, who are eager to become part of the solution, to ensure wildfires are not costing us our precious water supply. As the drought continues and the inevitable next fire season arrives, we cannot miss the time now to protect this scarce resource in the West: clean water.

Executive Summary



Water is the arid West's most precious and most vulnerable resource.

Western water allows metropolises to bloom in the desert, it fuels America's largest agricultural economy and it supports a ski industry worth more than \$6 billion to state and local economies (Burakowski and Magnusson, 2012). The delivery of clean and abundant water is extremely sensitive to disaster, whether natural or man-made. As years-long drought conditions across the region reinforce, the water quantity and quality in the West is never certain.



What is certain, however, is that in order to protect clean water it is vital to protect the forested ecosystems that play a critical role in capturing, filtering and storing this resource. What is also certain is that every year some portion of the West's forests will burn. While fire is as natural to a stand of trees as sunshine or rain, today's severe wildfires pose a threat to public safety, including our drinking water, as never before.

The impact catastrophic wildfires have on water quality is well understood. When forest fires burn abnormally hot they destroy the forest and soil capacity to absorb and filter rainfall. The consequence can be runoff from denuded and barren soils that foul streams and rivers with mud, soil and debris. What are less well-documented are the ownership

patterns across high fire risk landscapes. While the West is a checkerboard of different landownerships, public lands dominate the landscape. Yet, fire does not respect the jurisdictional lines we draw on a map.

In a first-of-its-kind spatial assessment conducted across 11 Western states, the American Forest Foundation brings new light and answers to these key questions: Who owns the forests at greatest risk of wildfire? How much of these forests at high risk of fire overlap with important water supply watersheds? How much of this risk is borne by private non-industrial landowners? For the purposes of this report, private non-industrial landowners include individuals, families, trusts, partnerships and conservation and natural resource organizations,



while excluding corporate and tribal ownerships. The report refers throughout to private non-industrial landowners and land as private and family landowners and lands. Also, for purposes of this report, Native American tribal lands, while distinct from public lands, are accounted for in tables and maps as part of the public land acreage. This ensures that their acreages are accounted for but not confused with the focus of this report, which is private and family lands.

The assessment, based on data from the Council of Western State Foresters (2015) and the U.S. Forest Service, analyzed fire risk across all burnable wildland

vegetation and important water supply watersheds across all ownership types. The analysis shows more than 52 million acres of high fire risk across the 11 conterminous Western states are on private and family forestland, an area nearly the size of Kansas. Of this ownership category, more than 9 million acres are owned by thousands of individual and family landowners, typically called family forest owners.

When looking at individual states, the report shows the proportion of fire risk on private and family lands is even higher. In New Mexico, for example, almost half of all high fire risk acres are on private

and family lands with more than 7 million acres at risk.

Of the 34 million acres across the West both at high fire risk and in watersheds of important water supplies, more than 13.5 million acres fall on private and family lands, 3.5 million of which are owned by family forest owners. In some states, most notably California and Oregon, these private and family landowners own more lands at risk in key watersheds than the federal government.

The clear conclusion is fire in the West is not exclusively a public lands problem. Understanding the distribution of risk can and should inform the strategies and approaches to mitigating that risk, particularly in areas where a critical public good such as water is implicated. But recognizing that private and family landowners have an outsized role to play in safeguarding Western water by itself is not enough. Understanding how best to empower these landowners to be more active stewards of their lands and of a public good like water is critical.

The second part to this report looks more closely at the behaviors, motivations and barriers to action of Western family forest owners. Nearly 1,800 family forest owners across the West were

More than
40%
of the lands that support the Western clean water supply
that are at a high risk to wildfire,
are private and family-owned.

surveyed to gauge their level of activity in reducing fire risk, the barriers most significant to them, and their motivations to action. While the analysis showed three in five landowners place fire as a primary concern and are, in fact, more concerned with fire today than they were five years ago, relatively few had taken action to reduce that risk. Barely half, 54 percent, have created defensible space around their primary residence. And only 25 percent have already attempted to restore forest health by thinning or removing underbrush. Only one in four landowners say they will “definitely” undertake these actions in the next 12 months.

Despite this relative lack of activity, Western family forest owners are motivated. Across acreage size, income level, age and duration of ownership, 70 percent are motivated to reduce risk on their lands by a sense of duty to be a responsible landowner. Fifty-eight percent valued improving the overall health of the forest. Yet, a large majority of 77 percent cite the high cost of management as a serious barrier to carrying out the actions needed to restore forest health. This pattern held across income levels, from the poor to the wealthy.

Finally, the report includes three recommendations to address the challenge of protecting clean water supplies from wildfire risks, given the newly understood and significant role of private and family landowners. The recommendations focus on solutions that can be implemented immediately, recognizing that there is a range of

additional solutions, some of which will take years to pursue. The report recommends strategies that:

- Increase on-the-ground cross-boundary efforts to engage private and family landowners focused on delivering measurable risk reduction and forest restoration at scale;
- Improve policy and public funding to support on-the-ground action, including private and family lands; and
- Catalyze markets that lower the costs of wildfire risk reduction and forest restoration and make ongoing healthy forest management economical.

There is no such thing as a fire-proof forest. Indeed, resource professionals such as foresters and ecologists will be the first to tell you that *forests need fire to remain healthy and productive*. At the same time, today’s hotter more frequent fires pose a threat to Western forests and the water they protect like never before. The future of the forests and the people of the West depends on restoring a resiliency in those forests to survive the inevitable fire. Safeguarding water quality and the many other public benefits provided by forests—such as clean air and habitat for fish and wildlife—requires empowering private and family landowners generally and family forest owners particularly, to manage their land in a way that contributes to the health of their forests and to the collective good of the nation.

TOP LINE FINDINGS

Private and Family Landowners Have a Significant Role to Play in Safeguarding Water

-  Of the 34 million acres at high risk from fire and important water supply watersheds across the West, more than 13.5 million acres fall on private and family lands.
-  In some states, like drought-stricken California and Oregon, private and family landowners own more lands at risk from fire in key watersheds than the federal government.
-  Individuals and families alone own more than 3.5 million acres at high fire risk in important water supply watersheds.

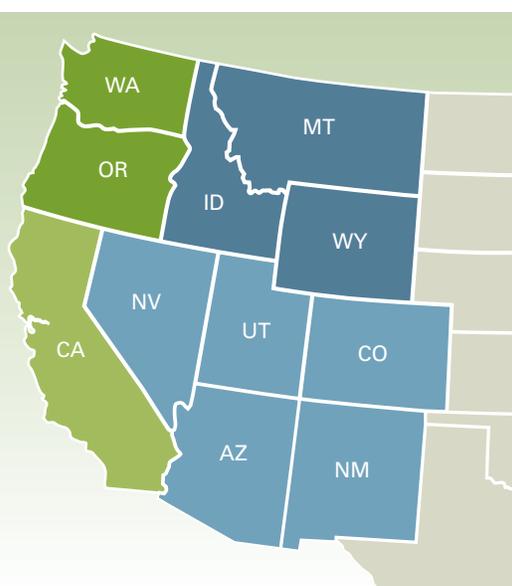
Family Forest Owners in the West Want to Help Protect Clean Water

-  Three in five landowners see fire as a primary concern.
-  Nearly six in 10 want to improve forest health.
-  Yet at most, only 26 percent have cited they will definitely take action in the coming year.
-  Seventy-seven percent cite the high cost of forest management as the most significant barrier to restoration.

Introduction

CONNECTING PEOPLE, WATER, FORESTS AND FIRE

The importance of water quality and supply to the past and future of the West cannot be understated. Ground water stored in vast underground aquifers and surface water flowing from forested headwaters enabled the West to flourish over time. Forests filter and capture snow and rainwater, allowing it to seep into the ground and flow to streams and rivers in a steady and clean condition. Today, roughly 64 million people across 11 Western states collectively depend on Western surface water for their daily needs. Altogether these Westerners consumed 6.7 billion gallons per day; with an additional 57 billion gallons of surface water used daily to irrigate crops in those states in 2010 alone (Maupin et al., 2014), supporting an agricultural industry worth tens of billions of dollars.



For the purposes of this report, we define the Western US to include these eleven states

However, in the arid West, delivery of clean water is never a certain proposition. In fact, concern over water quality and quantity is now viewed by Western voters as an extremely or very serious problem, even more so than unemployment (Colorado College Report and Conservation in the West Annual

Survey, Colorado College, 2015).

Decades of research demonstrates how forests help to recharge groundwater, regulate stream flow, filter water and mitigate flooding. Although only about 31 percent of the West is forested (Forest Resources of the United States, 2007), 65 percent of the water supply in the Western United States comes from forests (Furniss et al., 2010).

As certain as the connection is between the Western water supply and forests, so too is the certainty that some portion of the West's forests will burn every year. According to the National Interagency Fire Center, more than 5.7 million fires have burned some 162 million acres nationwide since 1960, an average of more than 3 million acres annually, an area nearly the size of New Hampshire.

Along with elevation and moisture gradients, wildfire is the dominant ecological force shaping

the growth, health and renewal of Western forests. For thousands of years, Ponderosa pine was the dominant forest type at lower elevations. These forests were characterized by relatively few trees per acre and abundant grassland between the few individual trees and clumps of trees. Fires historically tended to burn gently every few years, clearing underbrush and helping to keep the forests healthy and regenerating. In the higher elevations, spruce and fir forests were dominant. These forests naturally burned hot and violently, but only every 700 to 1,000 years. These fires would cause the entire forest to begin anew. Fire frequency and severity played an essential role in creating the diversity and maintaining the health of Western forests.

However, for the past 100 years, humans have disrupted fire's natural role in an effort to essentially eliminate all fire from

Across 11 Western states more than

a third of the high wildfire risk falls on private and family-owned land, not public land.

the forest. The result is a classic example of unintended consequences. While the intention was to safeguard lives and protect forest goods and services, the consequence was an unprecedented build-up of fuels in many forests. For example, Ponderosa pine forests were transformed from generally open savannahs with relatively few large, fire-resistant trees to stand thick with small trees that were allowed to grow in the absence of naturally occurring wildfires. This unhealthy build-up of trees and other plants unchecked by periodic fire is now fueling many of the catastrophically large and devastating fires Western forests are experiencing on a regular basis.

Fire, simply put, is the dominant force shaping Western forests. The connections between water and forests, and forests and fire are relatively well understood. What is lacking, however, is an accounting of fire risk across public and tribal, and private and family landownerships and the importance of that ownership for the delivery of water and other benefits that come from Western forests.

For the first time, this report, *Western Water Threatened by Wildfire: It's Not Just a Public Lands Issue*, answers these key questions across the West: Where are high fire risk acres located? Who owns them? How do these acres overlap with the water supply on which the West depends? The findings are an essential first step in identifying management solutions and developing cross-boundary, public-private partnerships to safeguard the Western water supply from potential catastrophic fire across jurisdictions.



In June 2002, Ken and Lois Carpenter, owners of the 180-acre Pine Song Tree Farm in La Plata County, Colorado, were hit by the devastating Missionary Ridge Fire. The fire burned some 72,000 acres of San Juan National Forest and destroyed 58 neighboring homes. Almost half of the Carpenters' forest burned, nearly one-quarter of which was a total loss. The Los Piños River, which runs through their property lost 100 percent of its fishery, with few signs of

other wildlife after the fire. "It was the worst thing you could imagine," recalled Ken Carpenter, "I watched the fire most of the night. The flames were over 200 feet high."

After the fire, erosion across the burn scar became a severe problem as homes were flooded and inundated with mud; falling trees and potential mudslides posed threats to nearby neighborhoods.

Motivated by the love of their land, the Carpenters were resolved to restore Pine Song Tree Farm and mitigate future risk of catastrophic fires. They started by cleaning out the dead trees and planting new ones—600 seedlings and small trees to jumpstart the recovery of their forest. They then turned their attention to the water.

The Carpenters used a \$12,000 grant and \$6,000 of their own money to clean up Pine River. It took one year to remove the debris from the landslide and recreate the riverbed. "By cleaning up the creek and

ravine, we had good water coming through the property again," said Ken Carpenter. With help from state officials they were able to restock the river with trout.

Today, Pine Song Tree Farm is well on the road to recovery. "It's wonderful to have Pine Song and to be able to share it with others," said Ken Carpenter.



Fire and Water



Healthy forests are key to a healthy water supply. Under normal conditions, forests act as a complex and dynamic water filter. They are a multi-layered strata of tree canopies, understory grasses, forbs, shrubs and decaying organic matter and roots that efficiently and sustainably manage the pace of rain as it falls to Earth and either cycles it back into the atmosphere or sends it downslope carrying this vital resource to our springs, rivers, lakes, cities and farms. Fire can profoundly alter this elemental dynamic.



In low severity fires, like those that naturally burned in many forests prior to the West's rapid development in the 19th century, changes to watershed function are minimal. But a high severity fire that burns in a forest type that hasn't evolved to accommodate it can damage a healthy and functioning watershed for decades. In these cases all vegetation, from tree canopy to forest floor, is burned in large continuous blocks, allowing rainwater to fall unimpeded to the exposed soil. In addition, surface soil temperatures, which can reach a sustained 1,500 degrees

Fahrenheit or greater, can sterilize and essentially destroy the living soil structure, creating an impenetrable layer through which water cannot seep (Ice et al., 2004). This type of fire creates a "parking lot" effect where soils become hydrophobic, causing rainfall to sheet off the forest floor, flooding streams, eroding stream banks and riverbeds and on steep terrain unleashing mudslides.

After the Fourmile Canyon Fire in 2010 near Boulder, Colorado, water quality plummeted when summer thunderstorms washed the burned landscape into waterways. Turbidity (a measure of water clarity) skyrocketed, as did dissolved organic carbon and nitrates; some heavy metal concentrations increased up to four times their normal levels while the streams themselves carried 8,000 times their normal water volume (U.S. Geological Survey, 2013).

Water users downstream of severely burned forests face dramatic declines in water quality, increased costs associated with water treatment and water supply complications that can persist for years (Brunskill, 2013). Providing safe drinking water for urban centers can require costly clean up after severe fires, and impacts can be long term and widespread, effecting communities as far as

100 miles away from the actual burn site (Meixner, 2004).

With changes in climate and intense drought, compounded by uncharacteristically dense low to mid-elevation forests, the potential impact of severe fire on water quality is significant. Climate scientists predicted the West will see a 3.6 to 9 degree increase in summer temperatures by 2050 (Climate Central, 2012). Already, fire seasons average 78 days longer than they did in the 1970s (U.S. Forest Service, 2015). The future of this region is likely to be defined by overall drier conditions, which will exacerbate the threat to water resources that are vulnerable to severe fire.

Reducing fire risk through ecology-based restoration treatments in many low and mid-elevation forest types, however, can restore forest resiliency and watershed function in the face of the inevitable fire. Studies show that the degree to which wildfire degrades water quality and supply depends on wildfire intensity and the health of a watershed prior to a burn (New Mexico Environment Department, 2015).

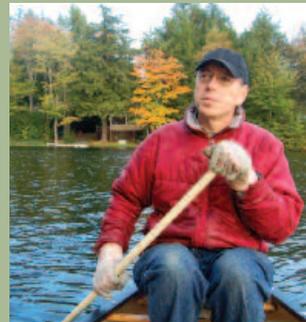
The benefits of such restoration investments tend to be greatest in watersheds where the probability of a severe fire occurring and where the consequences of such a burn are highest.

Fire Resilience Through Partnership

As an ecological force of nature like hurricanes or floods, fire does not respect the jurisdictional boundaries we place on the land. Where fuel, topography, and climate align, fire will burn public and private lands alike. And because of the sheer size of and intensity in which many Western wildfires burn today, isolated efforts to restore forest resilience or protect water and communities are often not sufficient.

Looking ahead, greater attention must be given to action not only on private and family lands as this report suggests, but also to partnerships that work across public and private land boundaries. There are thousands of family forest owners eager to become part of the solution by restoring Western forests to more healthy conditions, which reduces the risk of catastrophic wildfire, which in turn helps protect clean drinking water. There is need and opportunity for federal and state agencies, universities, national and local non-profit organizations to invest and work in partnerships to engage private and family landowners to complement the forest resilience work of their neighbors, whether public or private. Coordination and collaboration across jurisdictions has never been as important.

The scale of the challenge demands nothing less.



Risk and Value:

A SPATIAL ANALYSIS

Meeting the 21st-century fire and water resource challenges in the West requires a landscape-scale and cross-jurisdictional look at where the risk of fire is greatest and where that risk is relative to forests that protect clean drinking water. In 2015, the American Forest Foundation conducted a spatial analysis of wildfire risk across 11 Western states (AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY) based on land ownership.



This risk ownership profile was then overlaid with data depicting watersheds important for water supply, as defined by the U.S. Forest Service (USFS) and the Environmental Protection Agency (EPA). The results of this analysis describe not only the relative fire risk among public and tribal and private and family lands throughout the West, but also the degree to

which that fire risk poses a threat to public water supply. The findings highlight significant Western fire risk on these private and family lands overall and in particular in watersheds important to the water supply needs of communities across the West.

DATA, DEFINITIONS AND METHODS IN BRIEF

This assessment was based on state-specific data for the 11 Western states from the Western Wildfire Risk Assessment (WWA), a 30-meter resolution, tiled-by-state data set and a product of the Council of Western State Foresters and the Western Forestry Leadership Coalition.

- The regionally leveled Fire Threat Index (FTI) integrates the probability of an acre igniting and the expected final fire size based on the rate of spread in

four weather percentile categories into a single measure of wildland fire susceptibility.

- The Drinking Water Importance Areas (DWIA) layer identifies an index of surface drinking water importance, reflecting a measure of water quality and quantity, characterized by Hydrologic Unit Code 12 (HUC 12) watersheds. The USFS Forests to Faucets (F2F) project is the primary source of the drinking water data set.

In addition to the ownership data contained in the WWA data set, the assessment utilized a geospatial data set published by the USFS, titled *Public and Private Forest Ownership in the Conterminous United States: Distribution of Six Ownership Types* to quantify private forests across the West.

At least **64 million** Westerners depend on surface water for their clean water supply that comes from or is filtered by **forested watersheds.**

HIGH FIRE RISK LANDS



- High fire risk areas on private and family land
- High fire risk areas on public and tribal land
- Large urban areas
- Water bodies
- ★ State capitals
- Freeways

Data source: Spatial Informatics Group

For the purposes of this report, private non-industrial lands includes ownerships by individuals, families, trusts, estates, family and unincorporated partnerships and associations, as well as conservation and natural resource organizations across all burnable wildland vegetation (referred to throughout this report as private and family lands). It excludes tribal lands as depicted in the WWA data set and corporate forest ownership as depicted in the USFS data set.

The analysis identified areas where high fire threat overlay areas of high water supply importance. The analysis ran a set of pixel-level queries on the data layers. High fire threat areas were determined by querying for pixels

above a minimum threshold value from the WWA's FTI layer. Water supply importance was based on querying for pixels above a minimum threshold value from the DWIA layer. All watersheds with value greater than an established threshold were also included in the importance map after rasterizing those watersheds.

The result depicts areas of no fire threat, fire threat and no relevant values, and fire threat and water importance value. This was done for each state separately. Within each state, this analysis was done for all lands and for all private lands.

Complete data sources and methodologies are presented in Appendix 1.





Photo courtesy of Sierra Nevada Conservancy

and New Mexico. In Washington state, there are one million more acres at risk on private lands than on public and tribal lands.

Because there is so much private and family lands at risk, private and family landowners must play a key role in the solution. How they manage their land determines how well clean water is protected. Assessing the fire situation in the West demands a broad landscape view, one that looks at all lands under all ownership, and works to address fire threats wherever they occur. Forest restoration priorities that focus on only federal lands will fail to safeguard the clean water provided by more than one-third of the West’s high-risk acreage.

WHO OWNS FIRE RISK?

The relative risk of wildfire on more than 750 million acres of burnable wildland vegetation across 11 states was analyzed. The findings show that fire threat looms large over the arid West, with one in five acres in these states at “high fire risk” (145 million acres) across all ownerships. Of these high-risk lands, the analysis also shows 52 million acres fall on private lands—an area nearly the size of Kansas.

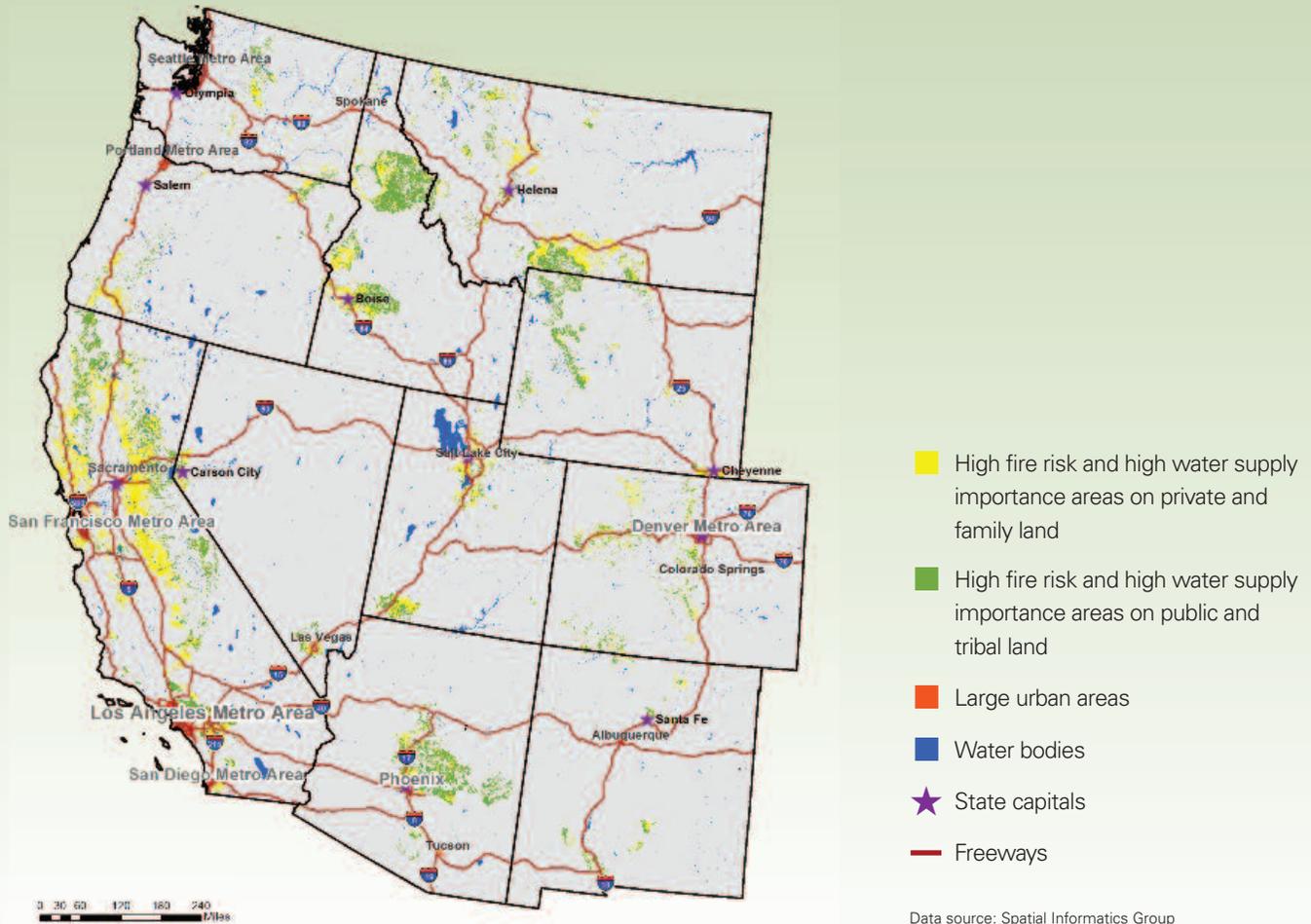
None of the 11 states has fewer than 2,161 square miles at high fire risk on private land. But the ownership patterns of high fire risk vary considerably by state. In fact, over half of the overall footprint of high fire risk on private and family land occurs in just three states- California, Montana,

State	Acres of High Fire Risk on Family Forestlands**	Acres of High Fire Risk on Private and Family Lands*	Acres of High Fire Risk on Public (and Tribal) Lands
All	9,076,342	52,279,015	93,061,841
AZ	263,884	1,938,321	9,721,307
CA	2,964,146	12,268,458	11,920,472
CO	519,289	1,383,250	4,273,011
ID	354,964	3,926,654	12,735,679
MT	844,439	7,909,662	10,087,543
NM	1,768,151	7,023,820	7,272,749
NV	186,058	4,312,284	16,793,314
OR	647,548	3,626,351	5,145,250
UT	925,013	3,551,260	8,426,872
WA	360,519	2,676,277	1,621,728
WY	242,331	3,662,678	5,063,918

*Private and family land refers to land owned by individuals, families, trusts, estates, family and unincorporated partnerships and associations, as well as conservation and natural resource organizations across all burnable wildland vegetation.

**Family forestland refers to land owned by families and individuals and is a subset of private and family land.

HIGH FIRE RISK AND IMPORTANT WATER SUPPLY LANDS



- High fire risk and high water supply importance areas on private and family land
- High fire risk and high water supply importance areas on public and tribal land
- Large urban areas
- Water bodies
- ★ State capitals
- Freeways

Data source: Spatial Informatics Group

WESTERN WATER SUPPLY AND FIRE RISK

The 2011 Las Conchas Fire in New Mexico started on a June afternoon when a tree fell on a power line. By the time the fire was 100 percent contained in early August, it had burned more than 150,000 acres. Three weeks later, heavy rains in the Jemez Mountains led to widespread area flooding. The National Weather Service estimated that three to six inches of rain fell over the burn scar (Matlock, 2011) that stretched more than 22 miles from the southern edge of Bandelier National Monument to Santa Clara

Pueblo lands where roughly 80 percent of the pueblo's watershed burned severely (Wright, 2015). As a result of the fire, hydrologists estimate that certain storm conditions could now send up to 21,000 cubic feet of water per second (cfs) down the Santa Clara Canyon where a channel that diverts creek water through the residential areas of the pueblo can handle only 8,000 cfs.

Just as fire is an inevitability in the West, so too are significant storm events. Where the two follow in sequence, the impacts to communities can be severe.

Of the 145 million acres of high



HIGH FIRE RISK AND IMPORTANT WATER SUPPLY LANDS IN CALIFORNIA



fire risk land across the West, one in four acres, or 34 million acres in total, are located in watersheds USFS and EPA scientists have identified as important to meeting the needs of urban and rural populations alike. More than 13.5 million acres of this risk is owned by private and family landowners, making significant portions of the public water supply dependent on the health of land in the hands of private and family owners.

In fact, in some states, acres of private and family lands at high fire risk in important water supply watersheds outnumber acres on public and tribal land. In drought-ravaged California, where Sierra Nevada snowpack is at a 500-year low (Morin, 2015), private and family landowners own 7 million acres of the land in important watersheds that carry high fire risk compared to 5.9 million acres on public lands. In Oregon, a state also experiencing extreme drought conditions, 684,000 acres of high risk acres in important watersheds are located on private and family lands compared to 645,000 on public lands.

Landowners want to do the right thing on their land, and

are motivated to take action to reduce the help protect clean water

State	Acres of Family Forestlands* with High Fire Threat and High Water Supply Importance	Acres of Private and Family Lands** with High Fire Threat and High Water Supply Importance	Acres of Public (and Tribal) Lands with High Fire Risk and High Water Supply Importance
All	3,537,675	13,578,999	20,796,509
AZ	16,391	277,201	2,715,310
CA	2,134,746	7,039,686	5,971,320
CO	251,692	636,047	1,397,849
ID	151,819	1,008,027	3,856,784
MT	240,505	1,761,969	2,308,757
NM	138,574	280,778	522,659
NV	12,764	191,845	372,534
OR	204,036	683,999	645,237
UT	294,029	808,134	909,603
WA	57,149	293,635	452,419
WY	35,970	377,835	1,644,038

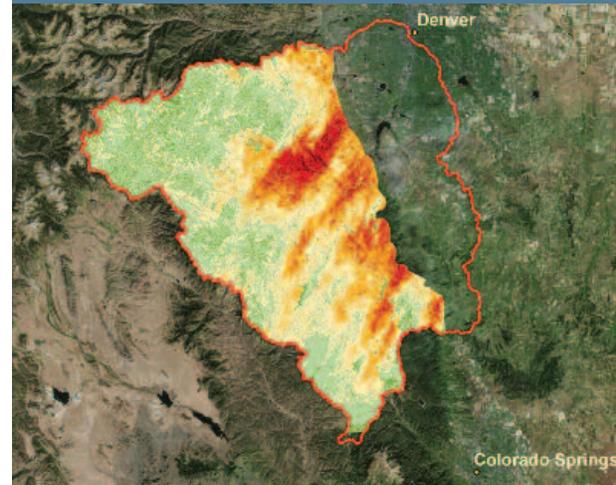
*Private and family land refers to land owned by individuals, families, trusts, estates, family and unincorporated partnerships and associations, as well as conservation and natural resource organizations across all burnable wildland vegetation.

**Family forestland refers to land owned by families and individuals and is a subset of private and family land.

Six states—California, Colorado, Idaho, Montana, Oregon, and Utah—account for roughly 88 percent of all high fire risk in important watersheds on private and family lands across the West. And while Arizona, Nevada, New Mexico, Washington, and Wyoming together account for the remainder of the total acres at risk on private and family lands and in important watersheds, each of these states has seen single fire events in recent years that burned an area larger than

their entire private and family lands footprint.

This spatial analysis highlights a crucial point in the national discussion of the West’s fire challenge: public water supplies cannot be protected without the engagement of private and family landowners. Only by looking at the landscape as a whole, and prioritizing an all-lands approach to fire management, can the considerable threat severe fire poses to water quality on public, tribal, private and family lands be addressed.



The Upper South Platte watershed

is a 2,600 square-mile watershed located to the south and west of Denver, Colorado. The five major municipal supply reservoirs in the watershed supply drinking water to nearly one-third of Colorado’s residents (1.3 million residents). The watershed has also been the site of five significant fires in the past 20 years. Denver Water, the state’s largest water utility, has spent more than \$27 million repairing damage to water supply infrastructure caused by these fires.

While about 60 percent of the watershed is publicly owned, there are more than 80,000 acres owned by private forest landowners, many of which are in high fire risk portions of the watershed.

A new collaboration—the Upper South Platte Partnership—has brought together federal, state and local agencies and research institutions, water providers and national and local non-profits, including the American Forest Foundation, to coordinate forest restoration work and investments to help protect this vital water supply.

“All hands, all lands” efforts like this are focused on increasing forest resiliency before the next fire strikes and in doing so help protect the drinking water supply on which so many depend.

risk of wildfire and in their forests.

Private Land Stewards:

A SURVEY OF FAMILY FOREST OWNERS

As the report demonstrates, fire risk reduction through active forest restoration on private and family lands needs to play a role in protecting water. Defining the scope and nature of the West's fire challenge across ownership patterns is a necessary first step to creating sustainable solutions. But by itself, it is not enough. Understanding the perspectives, values and needs of private and family landowners in meeting this challenge is also fundamental to protecting clean water.

One of the largest groups of private landowners is family forest owners. These families and individuals own their land for many reasons: simple enjoyment of the outdoors, a place to hunt or fish on weekends, income or as a legacy and investment for their children and grandchildren. Regardless of why they own their land, they are united in caring deeply for their land. Yet, many family forest owners face obstacles to active stewardship to restore forests, reduce fuel loads and reduce the risk of catastrophic

wildfire.

In order to better understand how best to reach and support family forest owners in the stewardship of their land with respect to wildfire, the American Forest Foundation undertook a first-of-its-kind West-wide survey of these family forest owners. Family and individual landowners with 10 acres or more of forest cover were surveyed to (1) understand the level of risk reduction and forest restoration activity happening on family forestlands in the West, (2)

learn landowner motivations in taking these actions, and (3) identify the most significant barriers to action. The mail survey was conducted by Public Opinion Strategies among 1,767 landowners throughout the 11-state region. The interviews were completed June 22 to July 27, 2015. The margin of sampling error for this survey is ± 2.33 percent at the 95 percent confidence interval for the total sample.

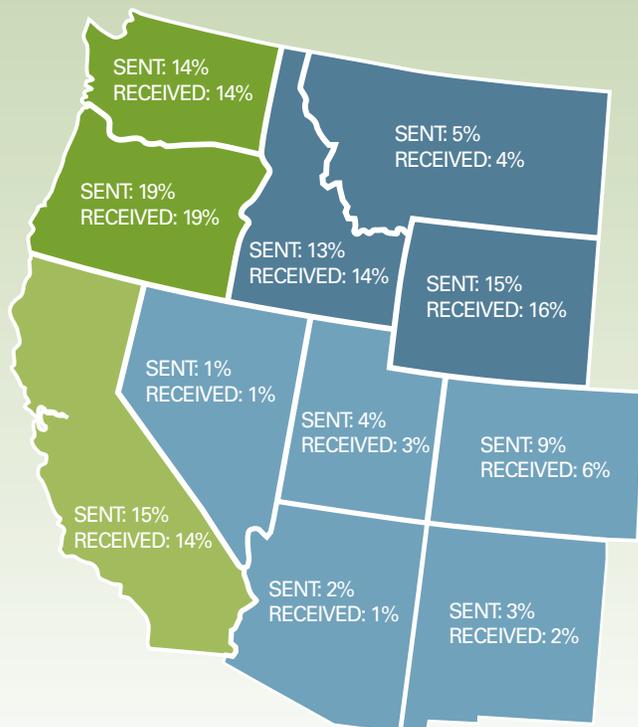
PERCEPTIONS OF WILDFIRE RISK

Most family forest owners in the West see fire as a serious concern. Three in five landowners surveyed place fire as a primary concern and 67 percent have witnessed a wildfire firsthand on their land or on neighboring land. More than half, 55 percent, said they worry more about fire now than five years ago. Looking forward, half of these landowners think it is almost certain or at least very likely that a catastrophic fire will occur on either neighboring public lands or on their neighbors' property.

MITIGATING RISK ON FAMILY FORESTS

Whereas most family forest owners understand the risk they face, most have not taken any action to address the risk. This despite the fact that 80

SURVEY DISTRIBUTION AND RESPONSE BY STATE



Percentages of family forest owners who have or are willing to take management actions on their land.	“Definitely” Will	Already Have Done
Tend to stands (thin, limb up, prune, or remove underbrush)	26%	25%
Create defensible space around structures	23%	47%
Create or maintain fire breaks	14%	25%
Install a pond, water tank or other water source	8%	38%
Conduct a controlled burn	6%	5%

percent say they know what to do to address that risk. Family forest owners were asked to rank, on a scale from zero to 10, how much more they felt they could do to reduce fire risk on their lands. Only 8 percent responded with a zero—everything possible has been done to reduce risk. Similarly, only 5 percent responded with a 10, meaning significantly more could be done. With a mean response of 4.6, Western family forest owners appear to have an uneasy sense that they have things under control on their land.

When asked about specific actions they have taken, only one-quarter have taken steps to restore forest health by thinning stands or removing underbrush. Less than half (47 percent) said they have created defensible space around structures on their property. Only one in four landowners said they will “definitely” tend to their stands or create defensible space around structures in the next 12 months.

BARRIERS DESPITE MOTIVATION

Across acreage size, income level, age and duration of ownership, 70 percent of family forest owners were motivated to reduce risk on their lands because of a sense of

responsibility as a landowner. In addition, 58 percent valued improving the overall health of the forest through their own management actions. Landowners who had more recently purchased their land identified firefighter safety and benefiting wildlife habitat as prime motivators to reduce fire risk.

More than half (54 percent) cite the high cost of management as an extremely or very serious barrier to taking action to restore forests and reduce the risk of fire; nearly 60 percent of owners who have owned

their land 10 or fewer years, identified this a top concern. This pattern is reflected across income levels, from lower to upper income brackets. While financial assistance alone will not motivate all family forest owners to engage, it is still important. Only 14 percent of family forest landowners said that other barriers were too pressing.

In sum, family forest owners are leading stewards of the private and family land estate in the West. They understand the risk that they face and they believe they have the knowledge to act. Most critically, they are motivated in large part by a sense of duty for the management of their lands and overall forest health. These insights are essential to understanding the necessary changes in not only policy but also outreach efforts to connect family forest owners to the support and assistance they need.

Percentage of landowners identifying barriers to taking actions to reduce the risk of wildfire on their land.	Extremely/ Very Serious	Total Serious
High cost/cost of hiring additional workers or contractors	54%	77%
Neighboring/ nearby land not managing their own land, therefore my actions would not necessarily reduce risks to my property	23%	47%
Too much work/time	29%	63%
Amount of red tape or paper work	26%	48%
Inability to access portions of the property to take action	24%	52%
Disposing of trimmings and brush	20%	48%
Unsure of actions to take	13%	20%
Appearance of the property would be less appealing	5%	20%

Recommendations

Given the nature of the challenge before us, if we are to protect critical clean water supplies in the West by overcoming the barriers preventing forest restoration and fire risk reduction activities on private and family lands, a comprehensive set of actions, both public and private, are needed. The following strategies can help drive landscape scale efforts across ownership boundaries:

- Increase on-the-ground cross-boundary efforts to engage private and family landowners focused on delivering measurable risk reduction and forest restoration at scale.
- Improve policy and public funding to support on-the-ground action, including private and family lands.
- Catalyze markets that reduce the costs of wildfire risk reduction and forest restoration and make ongoing healthy forest management economical.

While there are a range of ways to achieve these strategies, we focus below on the opportunities we think offer the most near-term potential for progress on the ground.

Increase On-the-Ground Cross-Boundary Efforts to Engage Private and Family Landowners Focused on Delivering Measurable Risk Reduction and Forest Restoration at Scale

While there are a range of collaborative efforts under way across the West to address wildfire risk, most collaborative efforts are focused on public lands that, while necessary, are not by themselves sufficient as this report demonstrates. More on-the-ground efforts must incorporate private and family lands and include outreach to these landowners at a scale commiserate to the challenge. As this report's landowner survey notes, family forest owners, the largest segment of this private and family landownership, are ready to do the right thing and can act

expeditiously, whereas public lands treatments often take significant time to plan and execute.

In addition to the need for increased cross-boundary work, there is also a need for increased effective and coordinated landowner outreach efforts that tie to cross-boundary efforts. There are a host of federal and state agencies, university extension services and national to local non-governmental organizations that are conducting outreach to private and family landowners. However, these efforts are often not coordinated and sometimes duplicative. The American Forest Foundation has tested a number of strategies in collaboration with multiple agencies and organizations for effectively engaging private and family landowners to deliver landscape-scale outcomes. Based on our

77%
of landowners cite
high cost of management
as a barrier to action.

learning, grounded in 12 landscapes nationwide, we recommend an increased focus on the following:

- Identify shared landscape outcome(s) early to not only define meaningful and measurable results but also to stay focused.
- Leverage local collaborative capacity to coordinate and focus resources and avoid duplication.
- Develop initial marketing outreach that meets landowners where they are and on their terms.
- Follow up with landowners. Most forest management actions are not a simple, one-time activity but will require continuous and multiple steps, so follow up is essential to achieving the outcome.
- Develop and implement a tracking system for both outreach and landowner action in order to track progress towards outcome and enable timely follow up.
- Adapt strategies deliberately to enhance learning.

Improve Policy and Public Funding to Support On-the-Ground Action, Including Private and Family Lands

Public policy and public funding can have a tremendous impact on private lands. However, most wildfire related funding and policy has been directed at public lands.

As noted in this report’s family forest owner survey, most owners cite cost as the primary barrier to



risk reduction and forest restoration efforts. These landowners aren’t looking for a handout, most are willing to invest their own time and resources in managing their land, but often their time and money alone is not sufficient to reduce shared fire risk and to safeguard a public good like water supply.

Public funding invested in reducing wildfire threats will reduce wildfire fighting costs—a smart investment that will ultimately save money on the continuously growing cost of fighting wildfires. Private and family lands treatments are a smart investment that can be implemented immediately.

While there are a range of policy and funding solutions, both federal and state, that could be put in place, three near-term actions are needed:

- **Fix How Wildfire Fighting Is Funded in the Federal Government:** Currently, because of poor budgeting practices complicated by the increasing cost of wildfire fighting, public and private land risk reduction and restoration programs have seen shrinking budgets and funds “borrowed” to cover emergency wildfire fighting when funds have run out. This creates disruption and inefficiency in program implementation, delaying the urgent restoration action needed on the ground. Congressional action is needed to treat wildfire fighting, especially those costs that are truly catastrophic in



nature, like other federal disaster emergency funding.

■ **Create and Enhance Authorities and Funding to Stimulate Cross-Boundary Action on Private and Family Lands:**

While there are a number of authorities and funding sources at both the federal and state level aimed at collaborative efforts to reduce wildfire risk, few include a strong emphasis on cross-boundary action involving private and family landowners. Additionally, there are several landscape programs in the U.S. Forest Service and the U.S. Department of Agriculture's (USDA's) Natural Resource Conservation Service directed at state and private lands that could be strengthened to encourage cross-boundary efforts. We recommend a review of these authorities to strengthen the funding and policy support for action on private and family lands and cross-boundary action on wildfire mitigation, especially

in important watersheds. We also encourage, where feasible, that these policies and funding sources support market-based utilization of materials.

In addition to these federal actions, a number of Western states in recent years have prioritized funding for private and family lands risk reduction and restoration that can be leveraged with federal funding. Local municipalities, water authorities and others have also begun to direct funds to mitigation efforts, as a means to reduce water treatment costs. We commend these efforts and encourage continued investment in this effective, immediate solution on private and family lands.

■ **Prioritize Cross-Boundary Activities in State Forest Action Plans:** Catalyzed by the 2008 Farm Bill, states have produced Forest Action Plans to guide each state's forest priorities and funding from both federal and state sources.

Many Western state forest action plans include emphasis on wildfire risk reduction and forest restoration on private and family lands. We encourage states to use their regular review processes to look for opportunities to prioritize efforts in landscapes where there is a threat to water supplies and there is potential for cross-boundary, collaborative, landscape efforts.

Catalyze Markets That Reduce the Costs of Wildfire Risk Reduction and Forest Restoration and Make Ongoing Healthy Forest Management Economical

While public funding is crucial to addressing the cross-boundary wildfire risks in the West, it will be insufficient to address the problem in the long term and at the scale necessary to address the challenge. Given the largest barrier to family forest owner action is cost, markets that utilize the byproducts of treatments and defray the costs for private and family landowners are crucial to a scaled impact.

There are a number of ways to catalyze markets for the use of the byproducts of wildfire risk reduction and restoration treatments. Our review of the barriers to market development points to two high-priority approaches that can be implemented immediately, among a whole range of needed strategies:

■ **Social Capital Investment Solutions:** Upfront investment cost is one of the largest barriers to developing

infrastructure not only to successfully conduct on-the-ground treatments but also to utilize those projects' byproducts. Technologies that utilize wildfire mitigation and restoration byproducts and make a whole range of products from energy to nanotechnology exist, but returns often take longer than traditional loan programs are willing to allow. Given the scale of the problem and the fact that there is a ready supply of raw material on private and family lands, private-sector investors looking for economic return while providing a societal good—reducing risk and safeguarding

Western clean water supply—could establish social capital funds with low interest loans or other strategies to invest in businesses that build this infrastructure. If combined with other strategies, such as the private and family landowner engagement activities outlined above, access to raw material will not be an issue and expeditious implementation will be possible.

- **Focus Market Investment Where Private and Family Lands Can Supply Raw Material:** There are significant public-sector loan and grant programs in existence—from the USDA Rural Development

programs to state programs—to invest in market infrastructure that will utilize wildfire risk reduction and restoration byproducts. However, many of these programs have focused investments in businesses that source their raw materials from public lands. We recommend focusing these programs on infrastructure investments where there is a mix of raw material from both public and private and family lands and where there is effective private and family landowner engagement to help deliver immediate, secure raw material.



Conclusion

In 1913, Forest Service Chief Henry Graves stated, “The necessity of preventing forest fires requires no discussion” (Cohen, 2008). More than a century later America is still dealing with the effects of this mindset, watching as a century of built-up fuels in many Western forests are now causing severe fires during prolonged droughts. Western water is now one of the most vulnerable resources to these severe fires. What will the future hold if this pattern of drought continues and watershed systems that protect clean water are fundamentally disrupted by repeated and severe fires?



This report reveals that public lands are only a part of the West’s fire and water challenge: substantial wildfire risk to essential forested watersheds exists on public, private and family lands. In order to restore fire resiliency and watershed health in the West, restoration is needed across boundary lines and a full accounting of the scope and nature of fire risk in the West is essential. The National Cohesive Wildland Fire Management Strategy is predicated on an all-lands approach to fire management. But in practice, the focus and resources have gone overwhelmingly to public forest action. To be sure, these resources for public land activities are critical and must continue. But until the nation comes to terms with the risk borne by private and family landowners and clearly understands and addresses their needs in contributing to the solution, evolution in national fire management will remain conceptual.

The spatial analysis presented in this report has shown that private and family land is a critical component of forest and watershed resiliency. Results from the family forest owner survey provide insight on the financial and technical needs of family forest owners to participate in management for the public good.

Fire is inevitable in the West. Catastrophically severe fire that compromises already tenuous water quality need not be. Simply put, the future of the West depends on fire resilient forests. Private and family landowners have a critical role to play. Protecting the public goods and services provided by forests—most critically water—will require a focus on empowering private and family landowners to steward their land in a manner that contributes to the health of their woods and to the collective good.



Appendices

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Spatial Data and Methods

GENERAL METHODOLOGY

The analysis identified areas where high fire threat overlay areas of high importance value in terms of water supply. The analysis ran a set of pixel-level queries on the data layers, all of which are described in the section below. High fire threat areas were determined by querying for pixels above a minimum threshold value from the Western Wildfire Risk Assessment's Fire Threat Index layer, described, along with all other data inputs, under the section "Data Layers Used" below. Water supply importance was based on querying for pixels above a minimum threshold value from the Drinking Water Importance Areas layer. Fire threat and water supply importance required establishment of minimum threshold values. These are described below under the section "Description of Cutoff Values."

Ownership data were then taken from the Council of Western State Foresters' Western Wildfire Risk Assessment database, in turn based on GAP analysis data, to extract only those pixels in private land. The result allowed us to map areas of no fire threat, fire threat and no relevant values and fire threat and water importance value. This was done for each state separately. Within each state, this analysis was done for all lands and for all private and family lands.

DATA LAYERS USED

Regionally-Leveled Fire threat index (FTI)

Source: Western Wildfire Risk Assessment (WWA) data set

Data model: 30-meter pixels, tiled by state

Description from WWA: "The Fire Threat Index (FTI) is a value greater than 0.0 and less than or equal to 1.0. It was developed consistent with the mathematical calculation process for determining the probability of an acre burning. The FTI integrates the probability of an acre igniting and the expected final fire size based on the rate of spread in four weather percentile categories into a single measure of wildland fire susceptibility. Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. But since all areas of the project have this value determined consistently, it allows for comparison and ordination of areas of the state as to the likelihood of an acre burning."

Drinking Water Importance Areas: Lower 15 States

Source: Western Wildfire Risk Assessment (WWA) data set

Data model: 30-meter pixels, tiled by state. It is a rasterized version of a vector watershed layer, with the pixel value representing the importance value on a scale from 1 to 10.

Description from WWA: "This Drinking Water Importance Areas layer identifies an index of surface drinking water importance, reflecting a measure of water quality and quantity, characterized by Hydrologic Unit Code 12 (HUC 12) watersheds. The Hydrologic Unit system is a standardized watershed classification system developed by USGS [U.S. Geological Society]. Areas that are a source of drinking water are of critical importance and adverse effects from fire are a key concern. The U.S. Forest Service Forests to Faucets (F2F) project is the primary source of the drinking water data set. This project used GIS [geographic information system] modeling to develop an index of importance for supplying drinking water using HUC 12 watersheds as the spatial resolution. Watersheds are ranked from 1 to 100 reflecting relative level of importance, with 100 being the most important and 1 the least important. Several criteria were used in the F2F project to derive the importance rating including water supply, flow analysis, and downstream drinking water demand. The final model of surface drinking water importance used in the F2F project combines the drinking water protection model, capturing the flow of water and water demand, with a model of mean annual water supply. The values generated by the drinking water protection model are simply multiplied by the results of the model of mean annual water supply to create the final surface drinking water importance index. Watersheds are ranked from 1 to 10 reflecting relative level of importance, with 10 being the most important and 1 the least important."

Ownership

Source: Western Wildfire Risk Assessment (WWA) data set

Data model: Vector data tiled by staterasterized version of a vector watershed layer, with the pixel value representing the importance value on a scale from 1 to 10.

Description from WWA: “This GIS-based dataset was created to help people integrate protected areas data into their daily work (e.g. mapping, planning, analyses, and problem-solving). For example, this database makes it easy for users to address important conservation and resource questions pertaining to climate change adaptation, green energy development, infrastructure planning, and wildlife connectivity. State and regional planners and managers will appreciate this dataset as it provides critical contextual information for their work. Institutions responsible for national and international reporting will find this database full of reliable, accurate information for their purposes. The scientific and conservation community will also benefit from having this standardized base map to carry out their research and planning objectives.”

Source: Public and private forest ownership in the conterminous United States, U.S. Forest Service data set

Data model: 280m raster data

Description from Developer: “This data product contains raster data depicting the spatial distribution of forest ownership types in the conterminous United States circa 2009. The data are a modeled representation of forest land by ownership type, and include three types of public ownership: federal, state, and local, as well as three types of private: family (includes individuals and families), corporate, and other private (includes conservation and natural resource organizations, unincorporated partnerships and associations.” For purposes of this report, which is focused on private and family land owned lands, Native American tribal lands, while distinct from public lands, are accounted for in tables and maps as part of the public land acreage. This ensures that their acreages are accounted for but not confused with the focus of this report.

DESCRIPTION OF CUTOFF VALUES

FTI

For FTI, we hoped to find a critical threshold value of FTI that would yield the same distribution of pixels designated as “high” or “very high” threat categories as the Wildfire Hazard Potential (WHP) product, which is the only major nationwide fire mapping product that makes such a characterization. An analysis of WHP indicated that 20 percent of its total pixels and 23 percent of its non-water, non-inflammable pixels are listed as “high” or “very high” fire hazard. We decided

to choose a threshold value of FTI that would yield the latter percentage designated as high threat. The latter was used because the FTI layer leaves water and many non-flammable pixels as blank. It was impossible to get an exact cutoff value of FTI that yielded 23 percent of the pixels designated because of the large number of runs of identical values. However, we were able to get close. A cutoff value of 0.004 FTI using the regionally leveled FTI data yielded a designation of 22.7 percent of pixels above the cutoff, which was deemed sufficiently close. An Arc Model was developed that automated the creation of the 1/0 fire threat query raster layers by state using a raster iterator.

Water

It was decided to choose a cutoff that would yield the top 20% of watersheds in terms of their importance value. The WWA water importance product (DWIA) ranks watersheds from 1-10 based on importance to water supply, with 10 being greatest. We compared the WWA product to the Forest to Faucets (F2F) product from which it was derived. As described above, the F2F data set has a score going from 1-100 where each increment represents one percentile (one hundredth) of the population of watersheds. We determined that the WWA product essentially converts the F2F’s 1-100 quantile-based score of watershed importance to a 1-10





decile based scored (although methods of rounding remain unclear). From our analysis of F2F and DWIA data (which was complicated by the fact that F2F is vector and DWIA is raster), it appeared that the WWA defined quantiles based not on a west-wide but on the original nationwide data set of watersheds. That is, if a watershed had a score of 95, it meant that it was in the top decile of all watersheds in the country, in terms of importance, not just the top decile of watersheds from the western states. However, because the distribution of high-importance watersheds is skewed to the eastern US, that means that the decile rankings do not represent the distribution of watershed scores in the west alone and that they tend to be lower than they would otherwise be if the deciles were based only on the western population of watersheds. Therefore, we needed to determine which cutoff value of the DWIA score would correspond approximately to the upper 20th percentile of data only for the eleven western states. Our analysis indicated that for the western states, using a cutoff of 6 would get us the closest to the desired 20% population share, so this was used. An Arc Model was developed that automated the creation of the 1/0 fire water supply importance layers by state using a raster iterator.

Masking by Ownership

Once the 1/0 state-level maps had been created for FTI and water, the next step was to mask out just private lands on a state-by-state basis. The following categories

were used in attribute query to select for private lands: private land, private conservation land, corporate land and tribal land. Once the selection was made for each state, just the selected polygons were exported to a new layer for that state. The two output maps (FTI, fire+water) were then masked out to private and family lands using the “extract by mask” function with an Arc Model Builder batch function.

Summarizing Data by Watershed

All of the main binary outputs (FTI, FTI+water) were then summarized by vector watershed using the mean value of pixels within that watershed. This was done by first using zonal statistics using a raster iterator in Model Builder. The output of this step was a zonal table for each state and for each output (11*3) that gave the HUC code in one column and the mean of the value in question in another. To populate a given mean value field in the HUC layer from the input tables, 11 joins and field calculations had to be done, because the pixel values resided in state-level layers. This was done using a tabular iterator in Model Builder that first added a join, then did a field calculation using a python script to ensure that only rows with null values in the target cells would be calculated, then removed the join, before going on to the next table in the workspace.

This model was run once for each of the three binary raster outputs described above. This was done for the combined private and public coverage layers, because a mean value for just private land in a HUC could be misleading if, for instance, only a tiny percentage of the HUC was occupied by private land. Rather, we decided we would distinguish between private and public land at this coarser scale by identifying which HUCs were predominantly public and which were predominantly private. This was done by adding a field to each private land layer, with all values set to 1, then converting that to raster, then reclassifying the raster to set “no data” to zero and then using zonal statistics to summarize the mean pixel value by HUC. That value could then be interpreted as a percentage. This series of operations was done using a combination of feature class, raster and table iterators in Model Builder. The result was that we could now easily identify which HUCs were greater than 50 percent private. This allowed us to create codes to be used in color coding output maps that would, for instance, differentiate between high FTI/high water importance HUCs with mostly public versus with mostly private land.

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