2014 QUADRENNIAL FIRE REVIEW

FINAL REPORT

DEVELOPED BY
BOOZ ALLEN HAMILTON
ON BEHALF OF:

USDA FOREST SERVICE FIRE & AVIATION MANAGEMENT

201 14TH STREET, SW
WASHINGTON, DC 20227

DEPARTMENT OF THE INTERIOR OFFICE OF WILDLAND FIRE

1849 C STREET, NW
WASHINGTON, DC 20024

MAY 2015

Las Conchas Fire, New Mexico, 2011
(Kari Greer Photo)

TABLE OF CONTENTS

Cover: Las Conchas Fire, New Mexico, 2011
(Kari Greer Photo)

McCall Smokejumper
(Kari Greer Photo)

FOREWORD

The Quadrennial Fire Review (QFR) is a strategic assessment process conducted every four years to evaluate current wildland fire management community strategies and capabilities against best estimates of the future environment. This report is the third iteration of the QFR, which began in 2005. It is not a formal policy or decision document, but rather a strategic evaluation of the long-range direction of wildland fire management. It looks far into the future to explore potential risks, challenges, and opportunities that may affect our ability to meet our mission. Moreover, it will inform our strategic planning, investments, operational capabilities, and positioning.

The objective of the QFR is to create an integrated, long-range strategic vision document for the community and to use it as the foundation for policy discussions within federal agencies and, more importantly, among federal agencies and state, local, tribal, and other partners. The summary findings will also inform key stakeholders in Congress, the White House, the Office of Management and Budget, and the Government Accountability Office about the challenges, risks, and opportunities that lay before us in managing wildland fire on federal lands.

The 2014 QFR was conducted in concert with the implementation of the first National Cohesive Wildland Fire Management Strategy (Cohesive Strategy), a collaborative process that includes active involvement from all levels of government and nongovernmental organizations and from the public to seek national, all-lands solutions to wildland fire management issues.

The strategic outlook for this QFR is 10 to 20 years. Looking that far ahead into the future will help us to identify risks and opportunities that may not be readily apparent with the continuous, more immediate challenges that managing wildland fire presents on a daily basis. In contrast, the Cohesive Strategy focuses on driving new and improved approaches to fire management now on the ground and in communities across the country. As we have conducted the QFR, we have been mindful of the extensive efforts made over the past four years in developing the Cohesive Strategy, including the regional assessments and the national analysis of challenges, opportunities, and priorities that have captured the perspectives of traditional stakeholder groups.

The QFR articulates a vision that looks toward the horizon and provides a multidecade view of risks and threats to achieving Cohesive Strategy goals. Over the next half decade, the QFR will help us update the goals of the Cohesive Strategy. We cannot be complacent about the new challenges the future will surely bring. A primary interest of this effort has been to consider multiple plausible futures and to challenge current orthodoxies within our organizations.

We are grateful to Booz Allen Hamilton for developing this report and to all the organizations and individuals who contributed their time and focus to the process. We look forward to continuing the dialogue that we initiated during the development of this report and to using the information contained within it to make better decisions. Our initial managers' assessment, in which we outline the role we see for this QFR, is available at http://www.forestsandrangelands.gov/QFR/.

Tom Harbour
Director, Fire & Aviation Management
USDA Forest Service

Jim Douglas
Director, Office of Wildland Fire
Department of the Interior

Pagami Creek Fire, Minnesota, 2011
(Kari Greer Photo)

EXECUTIVE SUMMARY

The 2014 Quadrennial Fire Review (QFR) is the third iteration of a strategic risk assessment process initiated by the United States Department of Agriculture (USDA) and the Department of the Interior (DOI). It is a joint effort of the USDA Forest Service Fire & Aviation Management (FS-FAM) and the DOI Office of Wildland Fire (OWF), which coordinates the wildland fire management efforts of four DOI bureaus: the Bureau of Land Management (BLM), the National Park Service (NPS), the US Fish and Wildlife Service (FWS), and the Bureau of Indian Affairs (BIA). The first QFR occurred in 2005 and the second in 2009.

As an enterprise-level review, the 2014 QFR sought to identify and explore key wildland fire management issues in the United States; assess the efficacy of current policy, strategy, and programs in expected future environments; and present a set of related actions for consideration by federal wildland fire leaders at the FS and the DOI. A future-oriented mindset was integral to the process; a central aim of the QFR was to offer wildland fire leaders the opportunity to methodically analyze a set of alternative futures that could emerge over the next 10 to 20 years, particularly by asking, *"What are we are not currently seeing?"*

The QFR links closely with the National Cohesive Wildland Fire Management Strategy Cohesive Strategy (Cohesive Strategy) process, yet the QFR and the Cohesive Strategy exist for different, complementary purposes. The 2005 and 2009 QFRs helped set the stage for the three goals outlined in the first Cohesive Strategy; the 2014 QFR will do the same for future Cohesive Strategy iterations. Whereas the Cohesive Strategy assesses the current situation and outlines actions to improve near-term effectiveness, the QFR looks 10 to 20 years forward to explore a range of plausible alternative futures, offers an analytical underpinning for the next Cohesive Strategy, and encourages present-day preparation for emerging change. To that end, the QFR/Cohesive Strategy process is iterative, resulting in complementary documents that leverage and build on each other.

The 2014 QFR process included a "baseline assessment" focused on four key issue areas (changing climatic conditions, risk management, workforce, and operational capabilities), development of four plausible alternative futures set in 2034 and related insights, and distillation of eight strategic-level conclusions and actions for consideration by fire leaders. The paragraphs that follow offer a high-level overview of each primary QFR component.

BASELINE ASSESSMENT

Changing Climatic Conditions. Driven largely by rising greenhouse gas emissions, climatic change across regions of the United States is driving increased temperatures—particularly in regions where fire has not been historically prominent. Such change is causing variation and unpredictability in precipitation and is amplifying the effects of wildfire. Related impacts are likely to continue (or emerge) in several key areas: limited water availability for fire suppression, accumulation—at unprecedented levels—of vegetative fuels that enable and sustain fires, changes in vegetation community composition that make them more fire prone, and an extension of the fire season to as many as 300 days in many parts of the country. These factors are not only driving an increasing prevalence of fire, but also are resulting in fires that increasingly exhibit extreme behavior.

Risk Management. The community has been successful in limiting the presence and impact of unwanted fire, but a variety of emerging trends increasingly put responders, the public, and other values at risk. Fuel levels are also at unprecedented levels due to climatic change, decades of suppression that have limited fire from prewar levels of 25 to 40 million acres burned per year to 5 million or fewer since the 1960s, and a decline in active forest management. Combined with these factors, rapid expansion of the wildland–urban interface (WUI), which has largely been unaccompanied by parallel increases in local community resiliency, is also creating new risks. Apparent declines in prescribed burning and fire use only exacerbate the problem and limit fire managers' best tools to combat fire-related smoke and air quality issues. These issues are expected to become more acute as climatic change exposes new areas of the country, particularly those with high concentrations of organic biomass, to wildfire.

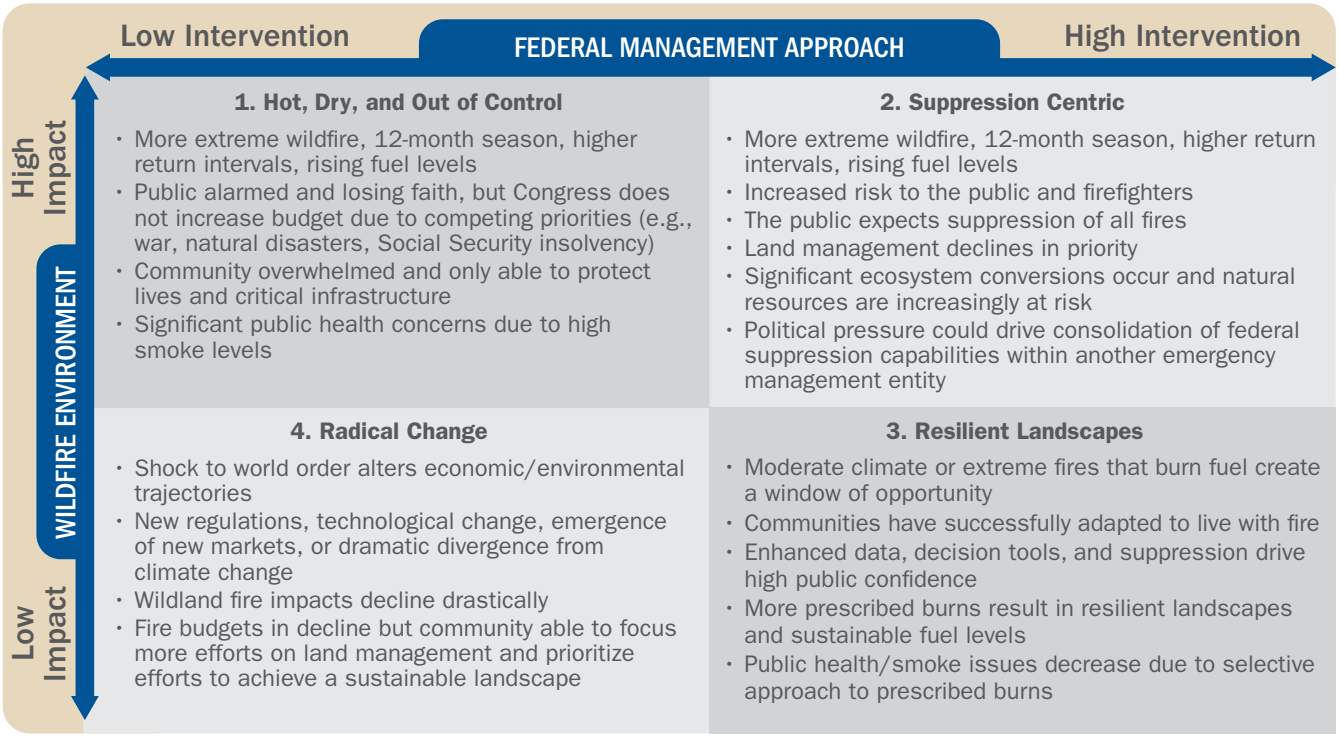
Workforce. Like many elements of the federal government, the FS and the DOI will contend in the coming decades with large numbers of retirements, the need to preserve institutional knowledge, broader shifts in market demand for labor, and changes in the way Americans prefer to learn and work. Furthermore, the declining availability of individuals who are fire-qualified as a secondary duty at both agencies is driving an increasing reliance on retired veteran firefighters, contractors, and capable, but in some cases more costly, state and local firefighter augmentees to fill gaps. This reliance may be unsustainable due to budget pressures at all levels of government and economic challenges

facing individual citizens. Both are driving a decline in the numbers of available, qualified volunteers across the country. Finally, extreme fire behavior is exposing signs of misalignment between the community's suppression needs and available resources (i.e., highly trained Type 1 crews). These factors, when considered together, are increasing firefighter stress levels.

Operational Capabilities. The 2014 QFR defines "operational capability" as the ability to achieve mission goals and realize a guiding vision by effectively and efficiently applying processes, resources, and technologies. The existence of significant gaps in data availability and/or fidelity is one of the weightiest findings in this category. These gaps hinder the assessment of program effectiveness and return on investment (ROI) in areas ranging from fuels management and aviation to facilities and information technology (IT). While the QFR revealed a lack of organic capacity at the federal level to conduct long-range strategic planning, it also identified numerous opportunities. In the area of public engagement and awareness, research indicates that the public increasingly accepts fire, but sustaining, expanding, and leveraging the public's acceptance may require new strategies and messages as new populations experience wildland fire for the first time. These messages should complement Smokey's longstanding message about fire prevention, communicate fire's positive ecological effects, and explain the benefits of fire use and prescribed burning. The QFR's exploration of ongoing technology and innovation (e.g., fire behavior modeling, unmanned aerial systems) revealed significant potential for promising technological breakthroughs, although the community could benefit from more central coordination to maximize ROI and ensure the migration of research efforts to operational employment.

ALTERNATIVE FUTURES

The 2014 QFR includes an extensive alternative futures analysis designed to challenge long-held assumptions in the wildland fire management community and produce a multidimensional planning framework to enable fire leaders' evaluation of strategies and programmatic investments against plausible future environments. That analysis, which included six facilitated workshops attended by 100-plus subject matter experts and a crowdsourcing phase that engaged nearly 2,000 individuals across the United States, resulted in the four alternative futures described below and a set of related insights.



Alternative Futures Key Insights: This effort produced the following set of insights (see page 54 for further detail) that resulted from workshop participant discussion about the four futures above:

- The futures explored during this QFR are not exclusive of each other, and the United States as a whole, or specific regions, could transition through several of them leading up to 2034.
- There is a strong possibility that today's regional wildland fire management dynamics will shift as a result of climate and environmental factors.
- It will be impossible to address the high fuel levels present on the landscape through the fuels reduction program alone during the timeframe of this review (2024–2034).
- The potential exists for a shock-type wildfire event (or series of events) that could cause a significant loss of lives and property equivalent to a major hurricane.
- Smoke and air quality issues associated with wildfire will be a larger concern than ever before.
- The community may face a wildland fire shock-type event while it attempts to reframe public attitudes toward wildland fire management.
- The possibility of a wildland fire shock could result in calls for a restructuring of the federal wildland fire agencies in some way.
- Long-term planning anchored in a new public engagement campaign is critical to preparing to manage a shock and avoiding being forced into an even more unsustainable model.

CONCLUSIONS AND ACTIONS FOR CONSIDERATION

Based on extensive research and engagement with subject matter experts and the public, the 2014 QFR team distilled the following set of conclusions and possible actions for consideration by wildland fire leaders:

#1. PERFORMANCE MEASURES, DATA ANALYTICS, AND OPERATIONAL CAPABILITY ASSESSMENT

CONCLUSION	*ACTION FOR CONSIDERATION*
The FS and the DOI lack sufficient data, with sufficient fidelity and reliability, to inform strategic and programmatic decision making.	**Promote continuous data collection and analysis to increase understanding of broad-based outcomes, explore new performance metrics to assess effectiveness, and conduct an operational capability assessment.**
The FS and the DOI often rely on historical approaches without validating their continued effectiveness or exploring new paths. Data gaps are also prevalent across program areas (e.g., aviation, fuels management, infrastructure, workforce). Where data is available, limited analytic capability presents challenges in terms of fully understanding effectiveness, ROI, and the full impacts of wildland fire.	The FS and the DOI need to develop key performance indicators for all core programs and begin targeted data collection to support evaluation of the effectiveness of those programs. Both agencies noted a lack of shared effectiveness measures for a variety of capabilities. This lack of effectiveness measures limits their ability to engage in joint strategic and investment planning to ensure compatible and complementary approaches to the development of tactical capabilities and to allow course correction. A bottom-up review of operational capabilities will enable the FS and the DOI to establish an optimal mix of workforce, facilities, programmatic infrastructure, and tactical capabilities.

#2. FUELS MANAGEMENT

CONCLUSION	ACTION FOR CONSIDERATION
Funding levels and capabilities for fuels management have been inadequate to mitigate fire risk.	**Create a fuels management optimization framework to enable effective and efficient application of funding and treatments.**
Fire risk and fuel levels are climbing in many areas of the United States. Current performance measures do not sufficiently evaluate and account for risk, risk mitigation effectiveness, or cost-effectiveness outcomes; instead, there has been a focus on output measures, such as acres treated or unit costs of treatment.	Fuels management is critical to achieving Cohesive Strategy goals, but doing so necessitates development of a framework, based on objective assessments of risk and potential ROI, to aid in the application of limited resources. Allocation should favor regions with strong cost-benefit propositions. For example, some regions (e.g., the Southeast) have a long history of prescribed burning and an inherent capability to execute it effectively. In other regions, conversely, fuels treatments by the federal government may offer less ROI than other program areas.

#3. ACTIVE FOREST MANAGEMENT

CONCLUSION	ACTION FOR CONSIDERATION
There is widespread sentiment that elements of active forest management, particularly commercial harvesting of timber and other vegetative fuels, is in decline across the United States.	**The FS and the DOI should conduct research on various elements of active forest management and their ability to begin addressing high fuel levels.**
Factors, ranging from public sentiment and endangered species concerns to economics, are driving this decline. Some experts, however, assert that active forest management has historically been a significant factor in curbing hazardous fuels. While commercial harvesting is controversial, an increase could be one element of a comprehensive approach to fuels reduction and is worthy of examination in a thorough and dispassionate manner.	This research should examine the long-term viability of the forest products industry to identify whether it has the potential to reemerge as a major contributor to managing fuel levels. It should also explore the level of effort required to pursue and approve policies for promoting active forest management. The community would need to assess the cost-benefit proposition for pursuing active forest management as opposed to other tools that may be easier to implement. A parallel research effort should also examine the use of carbon sequestration credit trading as a means to generate revenue and manage fuel levels, while minimizing negative ecological impacts. Depending on this research, the FS and the DOI should consider initiating a dialogue about whether the federal government should develop or implement policies that promote active forest management to help manage fuel levels.

#4. PUBLIC ENGAGEMENT

CONCLUSION	*ACTION FOR CONSIDERATION*
The wildland fire management community needs an evolved communications approach.	**Explore opportunities to enhance awareness about the benefits of fire and public acceptance of prescribed fire and fire use through a set of multifaceted messages.**
The wildland fire management community's outreach needs to engage a new generation. Its narrative should complement Smokey's message and that of the Fire Adapted Communities Campaign and seek to further enhance awareness about the positive ecological effects of fire and its ability, if managed effectively, to reduce risk to the public and other values. Many populations already support proactive fire management, but sustained, grassroots engagement is needed to capture and build on this buy-in.	Historical messaging about preventing unwanted ignitions should continue, but a set of tailored, comprehensive messages, aligned with the Cohesive Strategy, is also needed. Such an approach would require grassroots communications, to reach diverse stakeholders across the country, and the sharing of success stories about prescribed fire with communities and the news media, both in the WUI and in major media markets. Core messaging would emphasize that fire is a natural, necessary, and productive occurrence (with side effects, such as smoke, that are a necessary tradeoff when exposure can be managed at low levels), that planned use of natural ignitions and prescribed burns can achieve positive ends, that there is a shared responsibility for local community resilience, and that the ROI associated with Firewise and Community Wildfire Protection Plans is positive.

#5. TECHNOLOGY AND INNOVATION

CONCLUSION	*ACTION FOR CONSIDERATION*
The wildland fire management community currently lacks an innovation and technology adoption agenda or list of priorities.	**Empower a "Chief Innovation Officer" (CINO) to establish innovation priorities and technology implementation plans, build partnerships, foster innovation at all levels, and inform fire leaders' decisions about investment in "winners."**
The Joint Fire Science Program (JFSP) provides an avenue to advance innovative science and technology, but according to experts consulted during this effort, the community's investment in research initiatives through the JFSP lacks focus. Furthermore, as evidenced by its use of 400-plus IT systems, and its experience with the Fire Program Analysis system, the community sometimes struggles to define common technology priorities and implement integrated, enterprise-level solutions.	Designating an enterprise-level CINO would establish a central coordinating point for innovation and technology investment. The CINO would work with the JFSP and federal fire leaders to set innovation priorities, identify technologies with the potential to advance the Cohesive Strategy goals over 10 to 20 years, inform decisions about "winners" among those technologies, and develop plans to integrate them.[1] The CINO would also communicate FS and DOI innovation priorities. Critical to the CINO's efforts would be developing and sustaining bonds with industry partners and federal technology research organizations (e.g., Defense Advanced Research Projects Agency). An essential role of the CINO for the next 5 to 20 years would be coordinating investments in unmanned aerial systems, data analytics, and mobile technologies.

[1] The CINO would work in close concert with already ongoing activities and governance processes related to the Wildland Fire Information Technology program.

#6. WORKFORCE

CONCLUSION	ACTION FOR CONSIDERATION
A wave of challenges is looming on the horizon for the federal wildland fire management community.	**Conduct a strategic workforce review and develop a strategic plan for the federal wildland fire workforce that addresses pressing emergent challenges.**
Workforce challenges range from declining fire-qualified personnel (militia) to succession planning and institutional knowledge preservation amidst baby boomer retirements to adapting culture and practices to recruit and retain millennials. Furthermore, a reliance on retired firefighters, state and local augmentees, and contractors to replace the militia may be unsustainable because of the aging of retirees, the costs associated with some augmentees, and the experience levels and capabilities of contractors. The community also faces challenges related to firefighter stress and their psychological health resulting from lengthening fire seasons and extreme fire. These challenges will likely persist.	The FS and the DOI should conduct an in-depth workforce analysis and formulate a strategy reflecting current and future workforce issues, not historical norms or ingrained culture. This strategy should address new challenges stemming from a rapidly changing natural environment, with a consideration of technological opportunities to meet them. It should also preserve critical skills and identify new ones, while working to adjust FS and DOI culture and address persistent issues related to fire qualifications. In particular, the FS and the DOI need to shape younger staff as leaders earlier in their careers, even if doing so necessitates establishment of a more creative and flexible qualifications process and alterations to existing experience requirements. Both are critical to facilitating faster promotion of younger staff to meet urgent needs, even if their experience stems from fields outside wildland fire management or from geographic regions different from those in which they currently work. The strategy must also enhance mental and physical health support.

#7. STRATEGIC PLANNING

CONCLUSION	ACTION FOR CONSIDERATION
The wildland fire management community's existing processes and capability for long-range, enterprise-level planning are lacking.	**Develop a capability to undertake ongoing, futures-oriented analysis and planning to identify, plan for, and empower action to address emerging issues.**
As identified during this review and by a nearly simultaneous study the FS Northern Research Station led, the wildland fire management community lacks existing processes or indigenous capability to conduct ongoing environmental scanning, scenario-based planning, and alternative futures analysis. This limitation impedes the community's ability to identify emerging challenges and communicate to key stakeholders about resulting gaps.	The community should augment the QFR by establishing ongoing environmental scanning, alternative futures analysis, and scenario-based planning processes to occur in between QFRs at the enterprise level. Such processes must regularly engage senior staff at the FS and the DOI. Doing so would help institutionalize a long-term perspective, explore uncertainties and potential surprises, decrease reaction time to rapid change, help anticipate unintended consequences, and test the limits of the community's capabilities to respond to catastrophic events. The community could establish a joint, enterprise-level "think tank" unencumbered by political constraints and including trained futurists and subject matter experts from across the FS and the DOI; outsource such activity; or leverage a combination of both.

#8. FEDERAL WILDLAND FIRE AGENCY ORGANIZATION

CONCLUSION	*ACTION FOR CONSIDERATION*
One of the QFR futures, titled "Suppression Centric," postulates that a shock-type fire event (or events) could lead to consolidation of suppression functions housed in the federal land management agencies and their realignment under an emergency management-oriented entity.	**Over the next five years, assess potential organizational schemes and identify associated benefits and drawbacks.**
This hypothetical scenario, which would separate fire suppression from land management, is just one possible outcome based on the interaction of current and emerging trends over the next 10 to 20 years. Experts participating in the QFR considered such a realignment highly undesirable, but agreed that it is conceivable. Many cited the transfer of the Colorado State Forest Service's Fire Division to the State's Department of Public Safety following the 2012 fire season as an example of a mandated realignment that separated land management from fire management.	Given input from experts about the drawbacks of a separation of fire suppression from land management, neither the FS nor the DOI expressed a desire for organizational changes along those lines. Nonetheless, both agencies should reflect on how they can continue to be recognized as world class in wildland fire management, irrespective of their structure. Doing so is vital to ensuring that the FS and the DOI can be agile and proactive in explaining the benefits and drawbacks associated with a range of possible organizational changes—in terms of effectiveness, operational impacts, and costs to the taxpayer—if interest in a change does emerge.

San Juan National Forest
(Forest Service Photo)

INTRODUCTION

Fire is an integral aspect of most ecosystems in the United States and always will be. Fire is a force of nature. In many circumstances, fire is desirable, like rain, wind, and ocean currents. In other circumstances, it is highly undesirable, as are earthquakes, hurricanes, and tornadoes. For most of history, humans have had little ability to control wildfire. As recently as the 19th and early 20th centuries, there were repeated instances across North America of wildfires burning millions of acres of land, causing tremendous damage to property, and claiming large numbers of lives. The infamous fire of 1871 in Peshtigo, Wisconsin, burned 1.2 million acres and killed an estimated 1,700 residents in Peshtigo and nearby communities. The Great Hinckley Fire in Minnesota in 1891 killed more than 400 people and razed four towns.

Since the formation of the United States Forest Service (FS) in 1905, the subsequent establishment of other fire agencies elsewhere in the federal government and at the state, local, and tribal levels, and the development of modern fire preparedness and suppression techniques in the postwar era, megafires like the Peshtigo, the Thumb Fire of 1881 (1 million acres, 200-plus deaths), and the Great Fire of 1910 (3 million acres, 86 deaths) have largely been avoided. In contrast, the Oakland Hills firestorm of 1991 consumed 1,520 acres and claimed 25 lives. While that fire terrorized thousands and vividly demonstrated the vulnerability of the wildland–urban interface (WUI), the fire was also a measure of progress in terms of containing what is considered one of the very worst fires of the postwar era. Since 1949, the average number of acres burned in the United States has dropped precipitously, and no fire has been deadlier than the Oakland Hills disaster.

The irony in this progress is that wildland fire, in comparison to pre-1960s norms, has largely been removed from the landscape—so much so that its beneficial role in maintaining ecosystem equilibriums has been effectively limited in many areas and significantly disrupted in others. The end result of this disruption of natural fire cycles, in combination with a decline in active forest management,[2] has been the accumulation of an unnaturally large backlog of vegetative fuels in many areas of the United States. The continued accumulation of fuels and nearby population growth is forcing an examination of whether great fires like those of the past may occur again.

The 2014 Quadrennial Fire Review (QFR) is the third iteration of a strategic risk assessment process the United States Department of Agriculture (USDA) and the Department of the Interior (DOI) initiated in 2005. It is a joint effort of the USDA Forest Service Fire & Aviation Management (FS-FAM) and the DOI Office of Wildland Fire (OWF), which coordinates the wildland fire management efforts of four DOI bureaus: the Bureau of Land Management (BLM), the National Park Service (NPS), the US Fish and Wildlife Service (FWS), and the Bureau of Indian Affairs (BIA). The first QFR occurred in 2005 and the second in 2009.

As an enterprise-level review, the 2014 QFR sought to identify and explore key wildland fire management issues in the United States; assess the efficacy of current policy, strategy, and programs in expected future environments; and present a set of possible actions for consideration by wildland fire leaders. A future-oriented mindset was integral to the process; a central aim of the QFR was to offer federal wildland fire leaders the opportunity to methodically analyze a set of alternative futures that could emerge over the next 10 to 20 years, particularly by asking, *"What are we are not currently seeing?"*

Little Queens Fire, Idaho, 2013
(Kari Greer Photo)

[2] ***Active forest management:*** Attainment of desired forest objectives and future conditions using practices that include timber harvesting, tree planting, thinning, fertilization, grazing, weed control, and other activities for improving wildlife habitat and watersheds, such as erosion control, and also fire suppression, restoration-based fuel treatment, and prescribed fire. Active management also involves road and trail maintenance, including construction, reconstruction, or deconstruction, as well as activities and practices for improving recreation areas and trails, such as road closures to manage access. In "Sustainable Forest Management Requires Active Forest Management," *Joint Position Statement of the Inland Empire Society of American Foresters and the Montana Society of American Foresters,* accessed December 7, 2014, http://www.cfc.umt.edu/hosting/saf/PositionStatements/Active%20Forest%20Management.pdf. Note: The 2014 QFR also considers biomass harvesting and carbon sequestration credit trading to be integral to active forest management.

The practice of a quadrennial review, which originated in the Department of Defense (DoD) in the 1990s, has been adopted by at least seven cabinet-level agencies.[3] Congress mandated the conduct of Quadrennial Defense Reviews (QDRs) in the 1997 National Defense Authorization Act and subsequently in Title 10 of the US Code. While the QFR was not similarly mandated by Congress, its objectives and the methods employed throughout the review are similar to those of the QDR. Like other quadrennial reviews, the yearlong process that underlies the QFR is as important, or more important, than the final report; the process includes extensive stakeholder engagement, debate among senior fire leaders, structured strategic thinking designed to challenge traditional assumptions, and in-depth analysis. All three iterations of the QFR have facilitated opportunities for face-to-face and virtual interaction on critical issues between a wide cross-section of stakeholders representing the interests of federal, state, local, and tribal governments, as well as nongovernmental organizations (NGOs) and the public.

The QFR process directly supports various federal priorities, including the 2009 Federal Land Assistance, Management, and Enhancement (FLAME) Act. The FLAME Act directed the USDA and the DOI to develop a national cohesive wildland fire management strategy to comprehensively address wildland fire management across the United States. The intergovernmental Wildland Fire Leadership Council (WFLC) initiated the National Cohesive Wildland Fire Management Strategy (hereafter the Cohesive Strategy) in 2010 to meet the requirements of the FLAME Act. The third and final phase of the first Cohesive Strategy process concluded in the spring of 2014. This QFR may serve as the analytic underpinning for updates to the Cohesive Strategy in the late 2010s.

Looking back to 2005, the inaugural QFR[4] identified new approaches for integrated planning, decision making, fuels management, monitoring, local community education and relationships, training, and technical assistance. The review also highlighted a need to incorporate new skills into the wildland fire workforce and explore new methods to meet increasing workloads and future demands. The initiative helped to produce a unified vision for what the future of wildland fire management might hold for federal natural resource management agencies.

The 2009 QFR built on its predecessor to further advance a collective vision for fire management for the natural resource management agencies and the broader wildland fire management community defined in this report as the wildland fire components of the FS and the DOI and their state, local, tribal, and nongovernmental partners. That review revealed that the most significant driving forces to wildland fire management were climate change, drought and fuel conditions, demographic shifts and public expectations in the WUI, emergency response resulting from an increase in natural disasters, and funding shortages. The review provided recommendations for policy action, suggested new strategies, included analyses of workforce and operational capabilities, and set the stage for strategic conversations about the future of wildland fire management.

The 2014 QFR employed new tools and methodologies to engage wildland fire stakeholders more effectively while minimizing agency costs. This review focused on identifying emerging issues (challenges, risks, and opportunities) that the wildland fire management community may face between 2024 and 2034, with the intent to inform changes to policy, strategy, operations, or investments and to ensure that the community has the flexibility and agility to respond to a dynamic environment.

[3] In addition to the DOI and the USDA, the departments of Defense, Homeland Security, State, Veterans Affairs, and Energy also conduct quadrennial reviews of various types.

[4] The official title of the first QFR was the Quadrennial Fire and Fuel Review (QFFR).

Pagami Creek Fire, Superior National Forest, Minnesota, September, 2011 (Kari Greer Photo)

Whitewater-Baldy Complex, Gila National Forest, New Mexico, May, 2012 (Kari Greer Photo)

SECTION I:
BACKGROUND AND OVERVIEW

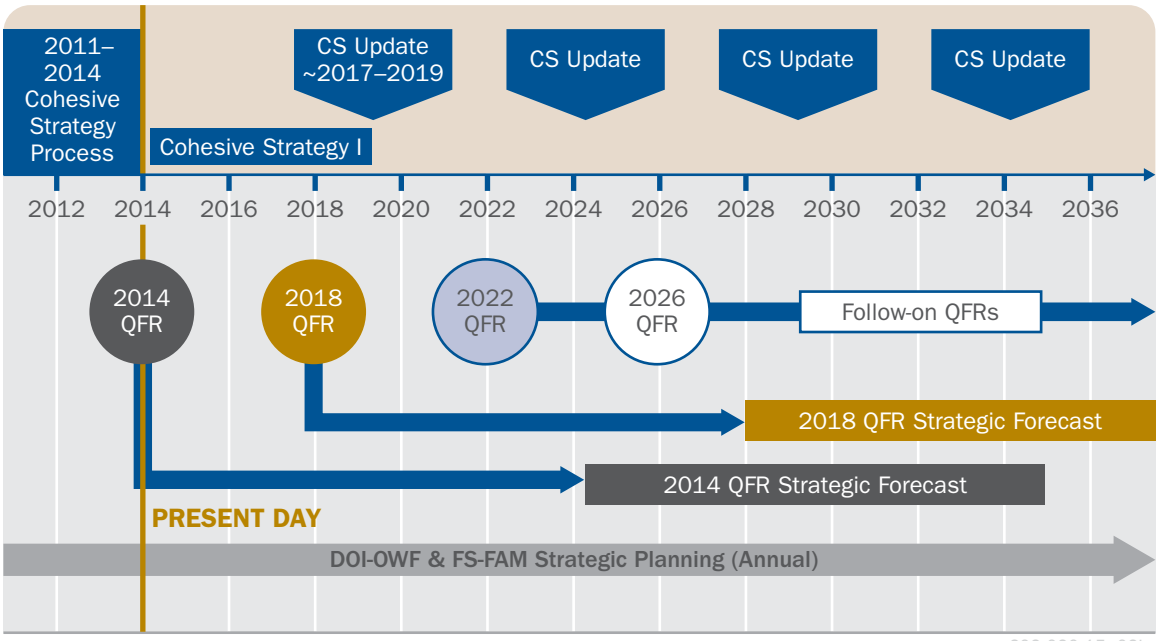
Like its predecessors, the 2014 QFR is a long-range risk assessment that identifies and explores key wildland fire management issues in the United States. It assesses the efficacy of current policy, strategy, and programs in expected future environments and presents a set of related conclusions and possible actions for consideration by federal wildland fire leaders at the FS and the DOI. The QFR links closely with the multiphase, enterprise-level Cohesive Strategy process, yet the QFR and the Cohesive Strategy exist for different, complementary purposes.

As the 2005 and 2009 QFRs helped set the stage for the three goals outlined in the first Cohesive Strategy, which represents a snapshot in time, this QFR may do the same for future Cohesive Strategy iterations. Whereas the Cohesive Strategy assesses the current situation and outlines actions to improve near-term effectiveness, the QFR looks to 2034 by exploring a range of plausible alternative futures for wildland fire management in that timeframe, offers an analytical underpinning for the next Cohesive Strategy, and encourages present-day preparation for emerging change. As depicted in Figure 1, the QFR/Cohesive Strategy process is iterative and results in complementary documents that leverage and build on each other.


Low-intensity prescribed fire burning in the Idaho Panhandle national forests (Forest Service Photo)

As asserted in the Cohesive Strategy, fire plays an important, necessary, and natural role on the landscape. Nonetheless, decades of fire exclusion have impeded the positive ecological impacts that result from "good" fire in many areas. Fire exclusion has allowed the accumulation of unnaturally high levels of fuels on the landscape, which manifests itself through similarly unnatural "bad" fire that scorches landscapes. While "good" fire should be allowed where practicable to support land management objectives, "bad" fire can negatively affect natural processes and create increased risk for firefighters, the public, and other values,[5] particularly when fire occurs near communities that are not fire adapted. The categorization of wildland fires as "good" or "bad" may imply absolutes, but this review acknowledges that the desirability of any fire depends on the conditions at the time of its occurrence and that the entirety of a fire, or parts of it, may transition from "good" to "bad" or vice versa throughout its existence.

Figure 1 QFR and Cohesive Strategy Outlook



[5] The 2014 QFR uses the term "values" in reference to natural resources (e.g., timber, grass, watersheds, recreational areas, wildlife habitat), sacred landscapes, and public and private infrastructure and property.

The wildland fire management community has been extremely successful over the past several decades in suppressing approximately 95 percent to 98 percent[6] of unwanted fires in the initial attack[7] phase (i.e., before they expand beyond 100 acres of forest or 300 acres of grass and bush). However, many of the remaining fires that escape initial attack and become large fires are increasingly demonstrating extreme behavior. These large fires have not only resulted in increased risk to human values, but also they are driving massive increases in suppression costs that often outstrip annual budget allocations and require the transfer of funding from other program areas to the suppression program. The increasing severity of large fires may augur a future where the small percentage of fires (2 to 5 percent) not addressed by initial attack become dramatically more destructive and costly, potentially on a scale equivalent to other natural disasters, such as major hurricanes and earthquakes. As noted in the 2005 and 2009 QFR reports, the following primary risk factors are driving the prospects of more severe fire in the future:

- Continued accumulation of fuels in forests and rangelands
- Continued growth of the WUI unaccompanied by proper planning and zoning to ensure safety in a fire-adapted landscape
- Continued drought in the American West, which is expanding to other areas of the country
- A general increase in temperatures across the United States.

The 2005 and 2009 QFR reports cite these risk factors in detail, and as evidenced in this review, all four have continued to worsen since 2009. While little if anything about the future is certain, it is reasonable to conclude, based on current trajectories, that these risk factors will continue to worsen over the next 20 years and may lead to wildland fires far more destructive than the American public is prepared for.

Paradoxically, a key finding of the 2014 QFR is that the most likely pathway to avoiding the worst possible impacts of wildland fire is for governments and the general public to become more accepting of both wildfire and prescribed fire. This report acknowledges, however, that land management agencies in the federal government and at the state, local, and tribal levels sometimes operate with different objectives in mind. Of particular note is the fact that laws and regulations at the state and local levels typically mandate full suppression of all fires, whereas federal policy allows for fire use when practicable. It also recognizes that while policy allows fire use at the federal level, federal wildland fire leaders face pressure to conduct aggressive fire suppression operations when lives, property, and critical infrastructure may be at risk, even if these operations do not necessarily support the land management objectives of their agencies.

The wildland fire management community faces other critical risk factors, including the impact of smoke on the public and on commerce, dwindling water resources in many parts of the country, and potential pyroterrorism threats. Wildland fire may also emerge over the next 10 to 20 years as an issue of rising concern in areas where it has not been for decades, for example, in the upper Midwest due to climate change. In other areas, such as the South, where fire is a recurring hazard, prescribed burning has been an effective tool in mitigating risk. However, climatic change or changes in the policy or socioeconomic landscape over the next 10 to 20 years that limit agencies' ability to execute prescribed burns in the South could dramatically increase risk to populations and other values.

Addressing these issues will require the FS and the DOI to adjust their messages to stakeholders and their means of reaching them, develop new approaches to measure risk and gauge the impact of their actions, and continue to adopt innovative technology. The FS and the DOI must at the same time invest to sustain and enhance core programs at levels that enable continued initial attack success at historical levels. All these actions will be crucial to executing the key goals of the Cohesive Strategy, while operating under fiscal constraints and amidst pressure to tie future funding to measurable return on investment (ROI).

The Cohesive Strategy, which represents participation from state, local, tribal, and nongovernmental stakeholders, as well as the five federal land management agencies that lead wildland fire management efforts within the federal government, articulates a vision and lists core goals that establish central lines of effort. The vision of the Cohesive Strategy is as follows: *Safely and effectively extinguish fire, when needed; use fire where allowable; manage our natural resources; and as a nation, live with wildland fire.* The key areas and goals of the strategy are as follows:

Restore and Maintain Landscapes: Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives.

[6] The FS and the DOI strive to achieve a 98 percent and 95 percent initial attack success rate, respectively.

[7] ***Initial attack:*** A preplanned response to a wildfire given the wildfire's potential. Initial attack may include size-up, patrolling, monitoring, holding action, or suppression.

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, and efficient risk-based wildfire management decisions.

A. FIRE POLICY AND PROGRAM (PAST AND PRESENT)

FIRE POLICY AND PROGRAM, 1800s TO 1990s

The history of wildland fire management policy and operations in the United States since the late 19th century features an ongoing tension between land management and fire suppression. The US Army, which administered national parks in the West until the creation of the NPS in 1916, directed the suppression of all fires to the extent possible given available resources, with prioritization given to those that threatened developed areas.[8] The federal government continued this approach after the formation of the FS in 1905, and following the passage of the Weeks Act in 1911, began offering federal grants and other assistance to the states to help them establish their own forestry bureaus.[9] The 1924 Clark–McNary Act increased federal funding grants, extended them to private forestry agencies, and sought to foster collaboration across federal, state, and private entities with the intent to protect timber resources.

Informed by the impacts of the devastating Peshtigo Fire of 1871, which killed more than 1,700, and the Great Fire of 1910, which remained the deadliest single event for firefighters in the United States until September 11, 2001, the FS established a new fire management policy in 1935. That policy, known as the "10 am" policy, directed the suppression of all wildfires by 10 am on the day following their discovery. The 10 am policy, which originated in the FS and expanded to encompass other federal lands, endured for nearly three decades and helped instill a "war on fire" mindset that became deeply entrenched during the war years. The Smokey Bear campaign, launched by the FS and the Ad Council during World War II amid fears of Japanese fire balloon attacks in the West, became one of the most successful advertisement campaigns in history.[10] After the war, the establishment of cadres of parachute-trained firefighters known as smokejumpers and the acquisition of surplus military aircraft and ground vehicles used in suppression efforts further ingrained the militarization of wildland fire management.[11]

Beginning with the 1964 passage of the Wilderness Act, however, ecology began to play a more influential role in wildland fire management.[12] The adjustment of the NPS policy in 1968 to recognize fire as an ecological process reflected broader changes underway and signaled the beginning of an era in which federal land management agencies and their state, local, and tribal partners conducted prescribed burns (the intentional ignition of fire) and used naturally ignited fires to achieve positive ecological effects. This approach persisted until the late 1980s, when major fires, most notably the 1988 fires in Yellowstone National Park, prompted another reevaluation of policy and a shift toward a risk-informed approach that allowed fire use and prescribed burns, while also increasing suppression.

Wildland fire managers today have significantly more resources and a deeper understanding of ecology than their 19th century predecessors did. Nonetheless, the decisions they face are similar, and the range of options available to them span a similar spectrum.

Lodgepole Pines in Yellowstone National Park 10 Years After the 1988 Fire (NPS Photo)

[8] Jan W. van Wagtendonk, "The History and Evolution of Wildland Fire Use," *Fire Ecology*, (2007): Special Issue, Vol. 3, No. 2, http://fireecologyjournal.org/docs/Journal/pdf/Volume03/Issue02/003.pdf, p. 4.

[9] Richard C. Davis (ed.), "Weeks Act, 1911," *The Encyclopedia of American Forest and Conservation History* (1983): Vol. 2, http://www.foresthistory.org/Publications/weeks%20act.pdf, p. 685.

[10] The FS and the Ad Council, along with the National Association of State Foresters (NASF), continue to manage the Smokey Bear campaign today.

[11] Stephen J. Pyne, "Flame and Fortune," *Forest History Today* (1996), http://foresthistory.org/Publications/FHT/FHT1996/Pyne.pdf, p. 8–10.

[12] USDA and DOI, Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy, June 30, 2003, accessed September 8, 2014, http://www.sierraforestlegacy.org/Resources/Community/SmokeManagement/AirQualityPolicy/FedWldFireMgmtPolicy.pdf.

Figure 2 DOI 2014 Wildland Fire Management Budget Request

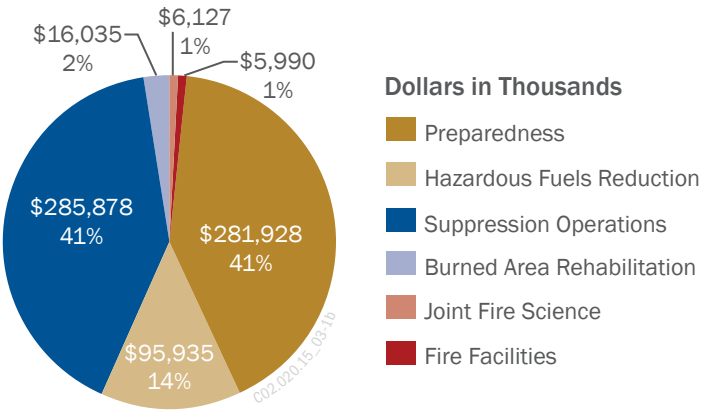
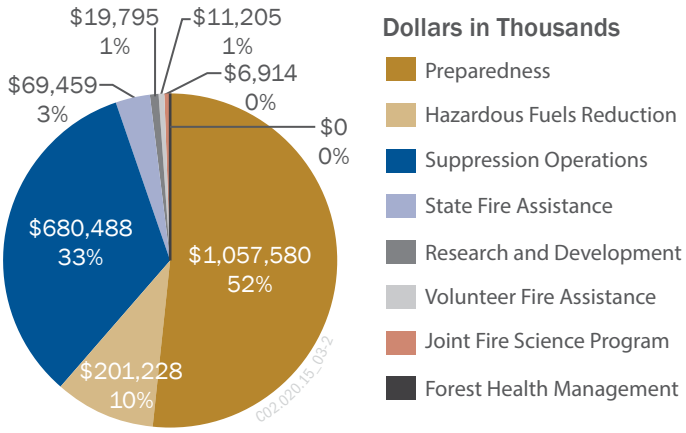


Figure 3 FS FY 2014 Wildland Fire Management Budget Request



THE MODERN FIRE PROGRAM, 1990s TO PRESENT DAY

The paragraphs that follow summarize the largest components of the modern federal wildland fire program. They describe the array of options available to fire managers as they prepare for wildland fire, mitigate the risk it presents, and suppress it as needed when it occurs. Figure 2 and Figure 3 depict the three largest elements of the DOI and FS wildland fire management budgets as of fiscal year (FY) 2014: preparedness, suppression, and hazardous fuels reduction (hereafter fuels management to reflect a change in terminology in FY 2015). These elements made up more than 95 percent of the DOI and FS FY 2014 wildland fire budget submissions.[13]

PREPAREDNESS

Preparedness, which makes up approximately 51 percent and 42 percent of the president's budget submission for the FS and the DOI wildland fire programs, respectively, in FY 2014, ensures the capability to protect life, property, and natural resources while assuring an appropriate, risk-informed, and effective response to wildfires that is consistent with land and resource management objectives.[14] The preparedness program provides funding to staff, train, equip, and deploy fire resources that reduce threats posed by wildfire to lives and values at risk, including national parks and national forests, wildlife refuges and preserves, Indian reservations, and other public lands (i.e., historic and cultural sites, commercial forests, rangelands, valuable wildlife habitat, lands managed by other federal and state agencies).

The preparedness program prepositions resources as needed to ensure an appropriate, risk-informed, effective, and efficient response to wildfire. The FS and the DOI also coordinate wildfire response actions across jurisdictions and fund training to bolster the operational capability and increase the effectiveness of state, local, and tribal assets. The preparedness program funds several highly recognizable areas related to personnel and materials, as outlined in Table 1.

[13] USDA FS, Fiscal Year 2014 Forest Service Budget Justification, April 2013, http://www.fs.fed.us/aboutus/budget/2014/FY2014ForestServiceBudgetJustificationFinal041613.pdf, p. 9-1 and DOI, Budget Justifications and Performance Information (Wildland Fire Management), Fiscal Year 2014, http://www.doi.gov/budget/appropriations/2014/upload/FY2014_WFM_Greenbook.pdf, p. 11.

[14] USDA FS, Fiscal Year 2014 Forest Service Budget Justification, April 2013, p. 9–3.

Table 1 Preparedness Program Funded Areas—Personnel and Materials

PERSONNEL	
Firefighters	Firefighters are personnel trained, qualified, and equipped to conduct wildland fire operations. Firefighters are classified based on their level of training and experience into Type 2 (lowest experience and qualifications level), Type 2 Initial Attack (IA), and Type 1, the most experienced and qualified. Squads of four to five Type 2s and one Type 1 are often combined into groups of three or four to form 20-person hand crews under the direction of a crew boss. Firefighters can support operations as single resources or form into specialized engine, helitack, and smokejumper crews.
Smokejumpers	Smokejumpers are highly trained and experienced wildland firefighters, many with more than 10 years of experience, qualified to parachute into and suppress fires. Smokejumpers deploy to fight remote fires, along with their equipment and supplies, via fixed-wing aircraft. Smokejumpers are a versatile national resource commonly used as surge capability for upper management operational positions in times of resource shortages. Their training, experience, and qualifications enable them to provide leadership as Type 3 incident commanders, division supervisors, strike team leaders, and Air Tactical Group supervisors on fire assignments and incident management teams. The FS and the BLM employ some 400 smokejumpers.
Type 1 Crews	Type 1 crews are hand crews of 20 firefighters (including those known as "Hotshot" crews) specially trained in suppression tactics who are considered elite from their extensive training, high physical fitness standards, and ability to undertake difficult, dangerous, and stressful assignments. Type 1 crews are able to work in remote areas for extended periods with little logistical support. There are approximately 105 Type 1 crews available across the country.
Fire Program and Support Staff	Fire program and support staff represent a varied group of more than 130 positions within the wildland fire incident command systems (ICSs) and dozens of bureau-level functional positions that support all aspects of wildfire suppression, prescribed burning, emergency stabilization and rehabilitation projects, and other aspects of planning, supporting, and managing wildland fire operations.
AVIATION	
Air Tankers	Air tankers are large and small fixed-wing aircraft that drop suppressants (water or chemical fire retardant) to extinguish fire or assist ground resources in fire control and to protect communities and other values at risk.
Helicopters	Helicopters are rotary-wing aircraft that deliver suppressants, move cargo, deliver firefighters to fires in remote localities, and employ sensors to collect data to support ground operations.
Other Aircraft	Other aircraft may consist of a variety of manned and unmanned fixed wing aircraft that deploy smokejumpers via parachute, move cargo, serve as lead planes for air tanker drops, provide aerial platforms to supervise fire operations, and employ sensors to collect data to inform decisions and actions by firefighters on the ground.
HEAVY EQUIPMENT	
Engines	Engines are vehicles with a water tank, hose, and pump configuration used to bring water to a fire to assist in suppression operations. Engines are classified into seven types based on tank size, pumping capability, amount of hose carried, and crew configuration. Type 1s and 2s are large engines used primarily in structure protection. Wildland engines range from Type 3 (highest capability) to Type 7 (lowest capability). Engine crews include a qualified engine boss and a number of firefighters depending on engine size and configuration.
Other Heavy Equipment	Other heavy equipment may include equipment, such as dozers, motor-graders and water tenders (large vehicles with substantial water tanks used to refill wildland engines and provide water to areas without natural sources), and other specialized equipment used in support of wildland fire operations.

The program also supports the national fire caches of standardized equipment and supplies (for wildland fire and other forms of all-hazard, all-use incident support), a range of nonfire personnel support costs, and deployment and maintenance of information technology (IT) systems. Funding also supports planning, prevention, detection, information and education, training, facilities, equipment, advancement of technology, program analysis and reviews, and other fire program management activities that enable mitigation of fire risk, response when and where fire occurs, and assistance with recovery operations after it subsides.

FUELS MANAGEMENT

The FS and DOI fuels management programs[15] mitigate risk through the modification, reduction, and removal of vegetative fuels (thereby reducing fire intensity and rate of spread). State, local, and tribal entities across the United States also execute fuels treatments using a variety of methods. Fuels management methods may include prescribed burns (see Figure 4; also known as controlled or Rx burns), which involve the intentional ignition of fuels in low-risk, controlled conditions to remove fuels and achieve positive ecological effects) and mechanical treatments (see Figure 5), which involve physical removal of biomass material by FS and DOI personnel and through contracts. The fuels management program focuses on the following:

- Strategically protecting communities and associated lives, property, and public infrastructure, particularly in the WUI, which faces the highest risk from wildfire
- Providing a safer environment for firefighters and offering an array of strategic options to fire managers
- Supporting communities working to achieve Firewise standards that have identified areas to be treated in Community Wildfire Protection Plans (CWPPs) or their equivalent and have invested in local solutions to protect against wildland fire.

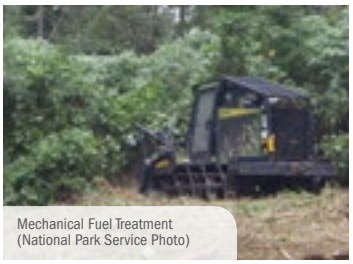
SUPPRESSION

The suppression program funds activities to suppress wildland fires on federal lands and on 20 million acres of nonfederal lands under reciprocal fire protection agreements.[16] Suppression funding enables FS and DOI fire resources to respond to unplanned wildland fire incidents that threaten lives, property, and resources. Response actions range from intensive suppression when wildfires threaten communities, high-value resources, or critical ecosystems to monitoring wildfires in areas where burning accomplishes resource benefits or where it is too dangerous for firefighters to work.

Figure 4

Firefighter Ignites Prescribed Burn (Forest Service Photo)

Figure 5



Mechanical Fuel Treatment (National Park Service Photo)

In instances where unplanned fire constitutes a threat, suppression funding covers expenses incurred by fireline, command, and support personnel beyond those costs covered by the preparedness program. It also funds temporary emergency firefighters, aircraft flight operations and support, logistical services, supplies, equipment (including replacement of lost or damaged capital and expendable equipment), contracts for goods and services, administrative support directly associated with incidents, and immediate measures to repair damage as a result of wildfire response activities.

Suppression also supports emergency stabilization of stream banks and soils during and immediately following wildfire (up to one year) to reduce the risks to life, property, and critical natural and cultural resources. Emergency stabilization treatments reduce the risk associated with damage caused by floods, landslides, debris flows, and erosion.

OTHER PROGRAM AREAS

Beyond preparedness, fuels management, and suppression, the FS and the DOI also expend significant funds each year to support communities and state, local, and tribal fire organizations (e.g., through volunteer or state assistance programs) to enable the recovery and rehabilitation of fire-affected areas and to enable research and development through the Joint Fire Science Program (JFSP).

[15] The FY 2015 DOI and FS budget justifications replace the term Hazardous Fuels Reduction with the term Fuels Management (Hazardous Fuels Management for the FS); this report will use the term fuels management.

[16] USDA FS, Ibid, p. 9–8.

B. QFR METHODOLOGY

The 2014 QFR followed a systematic methodology that built on the processes employed in the two previous reviews but included new steps, analytical approaches, and technologies. The flow chart in Figure 6 depicts the five major phases of the 2014 QFR process. The paragraphs that follow detail key activities associated with each phase.

PHASES I/II: INITIAL ANALYSIS AND REPORT CARD

Phase I of the 2014 QFR focused on the development of a library of the latest literature, science data, and other research materials that address changes in wildland fire management since the 2009 review. Based on a desire by FS and the DOI leadership to assess the efficacy and effects of the QFR process to date, Phase II assessed progress toward the recommendations and the accuracy of the predictions contained in the two previous QFR reports. This effort began by distilling more than 140 recommendations and 30 predictions in those documents into a condensed list. The project team then leveraged the library developed in Phase I, along with selective engagement of wildland fire subject matter experts (SMEs), to assess those recommendations and predictions in a "report card" format that may become an integral component of future QFRs (see Appendix A).

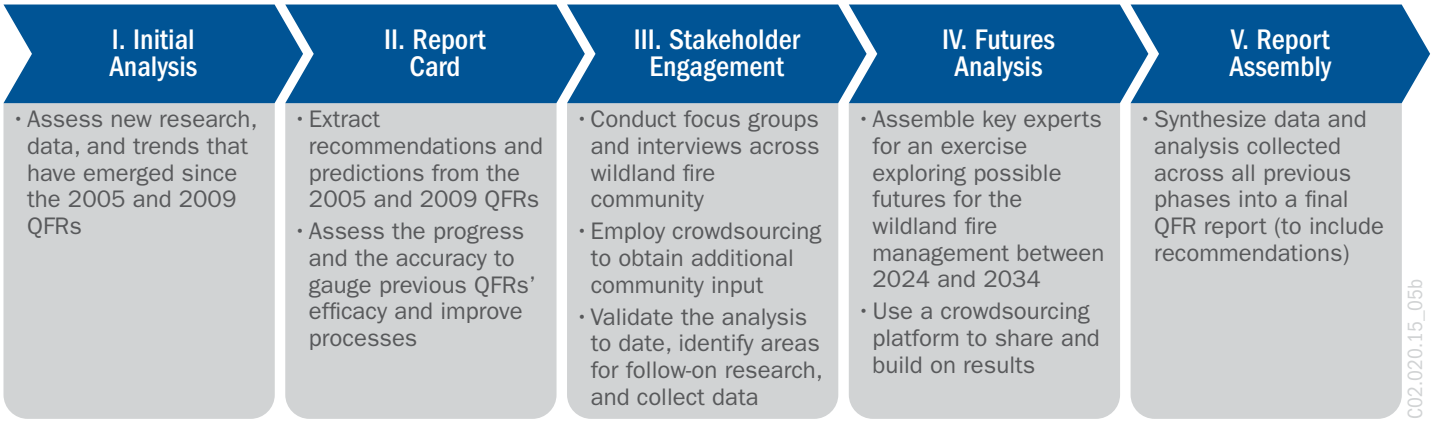
PHASE III: STAKEHOLDER ENGAGEMENT

Wildland Fire Training (National Park Service Photo)

Phase III of the QFR process included extensive yet targeted stakeholder engagement over eight months. QFR team members attended the WUI conference in Reno, Nevada, and the Large Wildland Fire Conference in Missoula, Montana, to conduct focus groups and interviews. Altogether, the team conducted more than 60 virtual or in-person interviews with stakeholders from across the United States and abroad during the review. Throughout this process, the QFR team engaged individuals with expertise ranging from fire ecology and climate change to environmental conservation and data science. Figure 7 depicts levels of direct stakeholder engagement (i.e., participation in an interview, focus group, or workshop [in Phase IV]) across seven categories:

- ***Federal (Land Management):*** FS, DOI bureaus, National Wildfire Coordinating Group (NWCG), National Interagency Coordination Center (NICC), the National Interagency Fire Center (NIFC), etc.

Figure 6 2014 QFR Process Overview



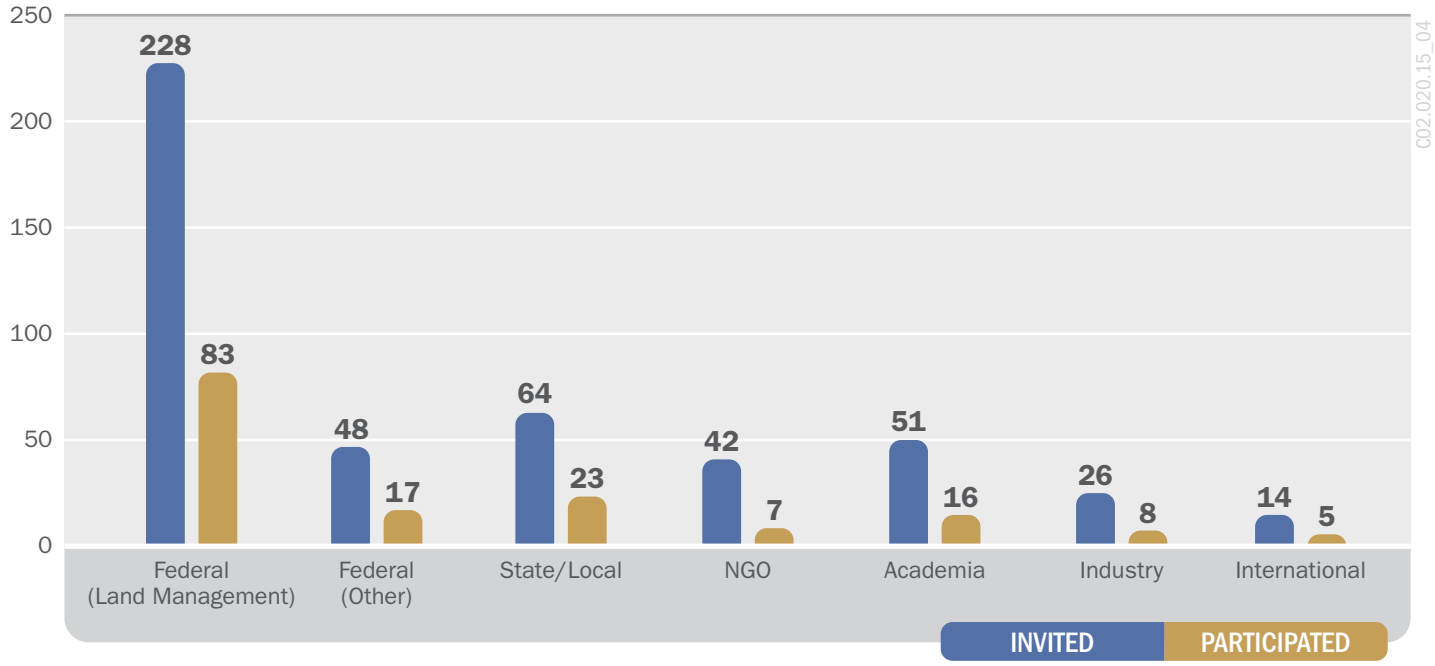
- ***Federal (Other):*** National Oceanic and Atmospheric Administration, US Environmental Protection Agency (EPA), DoD, Department of Homeland Security (DHS) (including Federal Emergency Management Agency [FEMA]), etc.
- ***State/Local:*** State forestry organizations (e.g., National Association of State Foresters [NASF]), state and local fire organizations/departments, municipalities, etc.
- ***International:*** Australian, Canadian, and European partners
- ***Academia:*** Universities and research institutions across the United States
- ***NGOs:*** Environmental groups, associations (e.g., Intertribal Timber Council), etc.
- ***Industry:*** Technology/engineering organizations, contractors, and independent consultants.

In parallel with these efforts, the 2014 QFR also incorporated crowdsourcing, a web-based approach for gleaning broad input from both the traditional wildland fire management community and the public. Crowdsourcing facilitated the sharing of ideas in a virtual manner such that stakeholders were able to post ideas about new and existing challenges facing wildland fire management and possible solutions, and others were able to review and comment on those ideas remotely. The 2014 QFR crowdsourcing site received 3,063 visits from locations ranging from Oregon to Florida, with 1,994 unique users posting 64 original ideas and hundreds of follow-up comments.

PHASE IV: FUTURES ANALYSIS

In Phase IV, the QFR team hosted six one-day workshops with diverse groups of wildland fire stakeholders, as well as two condensed executive sessions with leaders from FS-FAM and DOI-OWF. These workshops employed a methodology called Strategic Foresight to explore a range of plausible alternative future environments for wildland fire management. These sessions occurred in Missoula, Montana; Boise, Idaho; Denver, Colorado; and in the Washington, DC, metro area. Each workshop assembled diverse groups of between 16 and 24 expert participants from federal, state, local, tribal, and international government organizations, as well as NGOs, academia, and industry, to assess the range of challenges, risks, and opportunities that may emerge between 2024 and 2034. Section III: Futures Assessment (10–20 Year Outlook) provides a detailed explanation of the methodology employed during these workshops and executive sessions.

Figure 7 QFR Stakeholder Engagement Response Rate



PHASE V: REPORT ASSEMBLY

The final phase involved the development of a framework for the 2014 QFR final report (described below) and synthesis of research data, stakeholder input, and insights about emerging trends to arrive at a list of conclusions and possible actions for consideration by federal wildland fire leaders. The conclusions and possible actions for consideration in this QFR aim to help the community become more flexible and agile as it moves forward into a setting that promises to be even more dynamic and complex than that of 2014.

C. REPORT STRUCTURE

The 2014 QFR contains four primary sections that follow this background and overview (Section I):

- ***Section II: Baseline Assessment*** explores historical data and trends in the four key areas of changing climatic conditions, risk management, workforce, and operational capabilities and sets the stage for an exploration of the future. The review's authors acknowledge that several areas of concern overlap, and several issues, in particular climate and the WUI, cut across more than one key area. Furthermore, there is also an acknowledgement that these areas of concern are not all inclusive.
- ***Section III: Futures Assessment*** (10–20 Year Outlook) portrays four plausible alternative futures for wildland fire management from 2024 to 2034 that resulted from interaction between experts at the six workshops and two executive sessions described above.
- ***Section IV: Conclusions and Possible Actions for Consideration*** distills the data and findings of Sections II and III to present fire leaders with a set of high-level key conclusions relevant to the path ahead for wildland fire issues, management, and policy. It also offers fire leaders a set of possible actions for consideration to help ensure the successful management of wildland fire over the long term.

Tongass National Forest, Alaska
(Forest Service Photo)

SECTION II:
BASELINE ASSESSMENT

As with any future-oriented strategic review, a critical first step is to identify recent historical trend lines and establish a baseline from which to consider the future. This section examines recent historical data (back to approximately 2000) and trends in four key areas: changing climatic conditions, risk management, workforce, and operational capabilities. This baseline assessment sets the stage for an exploration of plausible alternative futures for wildland fire management in the 2024 to 2034 timeframe.

Pagami Creek Fire, Minnesota, 2011
(Kari Greer Photo)

A. CHANGING CLIMATIC CONDITIONS

OVERVIEW

Climatic changes across various regions of the United States and across the globe are amplifying the effects of wildfire. These changes are contributing to drier seasons in much of the West and Southeast; wetter conditions in the Northeast, Midwest, and Southern Great Plains; and general warming in all regions of the country. Climatic changes are likely increasing the impacts of insects and disease on forests and are contributing to the spread of invasive species. In the Mountain West, Pacific West, and even Alaska, changing climatic conditions are contributing to the accumulation of flammable vegetative fuels on the landscape. Paradoxically, the unprecedented level of fuels accumulation is primarily an unintended consequence of years of successful fire suppression.

This section provides a history of recent climate-related trends, establishes a climate "baseline" for the 2014 QFR, and describes several climate-related issues with the potential to affect current strategies and approaches.

KEY ISSUES

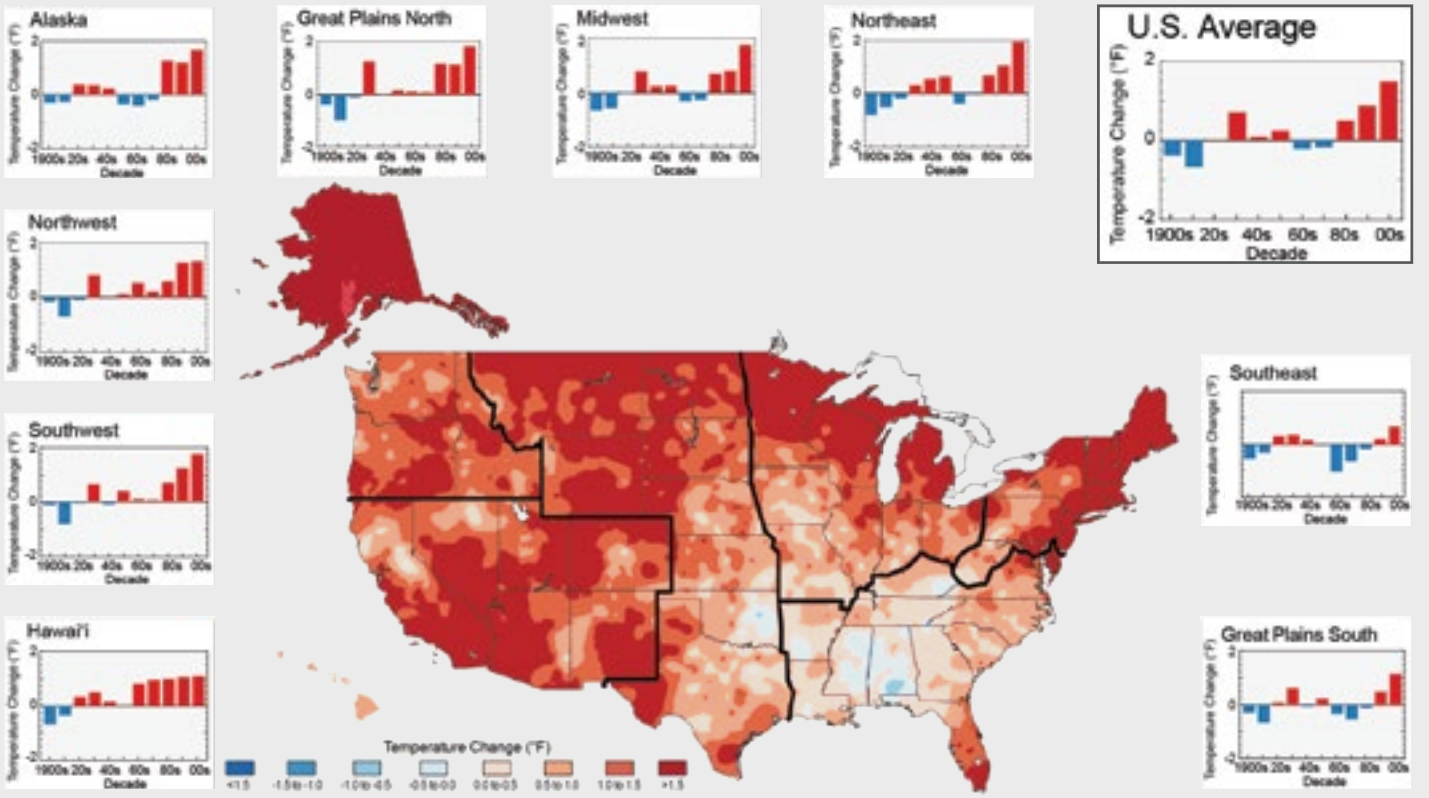
Emissions. Greenhouse gases (GHGs) occur naturally as part of Earth's regular processes and are vital to the planet's natural temperature regulation. Increased GHG levels are a primary driver of climate change, including temperature increases and precipitation fluctuations. A major concern about GHG emissions is the speed with which increases of atmospheric concentrations of GHGs are occurring. The *Fifth Assessment Report* by the Intergovernmental Panel on Climate Change (IPCC) asserts that human-emitted GHGs—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—now substantially exceed the highest concentrations recorded in ice cores over the past 800,000 years.[17] Furthermore, the report concludes that atmospheric concentrations of CO_2, CH_4, and N_2O have increased by 40 percent, 150 percent, and 20 percent, respectively, as a result of human activity since preindustrial years.[18]

Las Conchas Fire, New Mexico, 2011
(Kari Greer Photo)

[17] Intergovernmental Panel on Climate Change, Summary for Policymakers in: *Climate Change 2013: The Physical Science Basis*, September 2013, accessed July 25, 2014, http://www.climatechange2013.org/report/, p. 11.

[18] IPCC, Ibid.

Figure 8 Observed US Temperature Change[21]



The colors on the map show temperature changes for 1991–2012 compared to the 1901–1960 average, and compared to the 1951–1980 average for Alaska and Hawai'i. The bars on the graphs show the average temperature changes by decade for 1901–2012 (relative to the 1901–1960 average) for each region. The far right bar in each graph (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region.
(Figure source: NOAA NCDC/CICS-NC)

Temperature. Increased levels of GHGs interrupt the natural release of heat from Earth's atmosphere and contribute to rising global temperatures. The 2014 United States National Climate Assessment (NCA) report states that the United States has experienced a temperature increase of 1.3 to 1.9 degrees Fahrenheit since 1895, mostly occurring after 1970, as illustrated in Figure 8.[19] Projections suggest that this warming trend will continue, resulting in a 2 to 4 degree Fahrenheit increase over the next few decades.[20] The NCA report projects that northern regions of the United States will experience more rapid temperature increases than the Southeast. It also projects variations of temperature to intensify distinct conditions in different regions of the country.

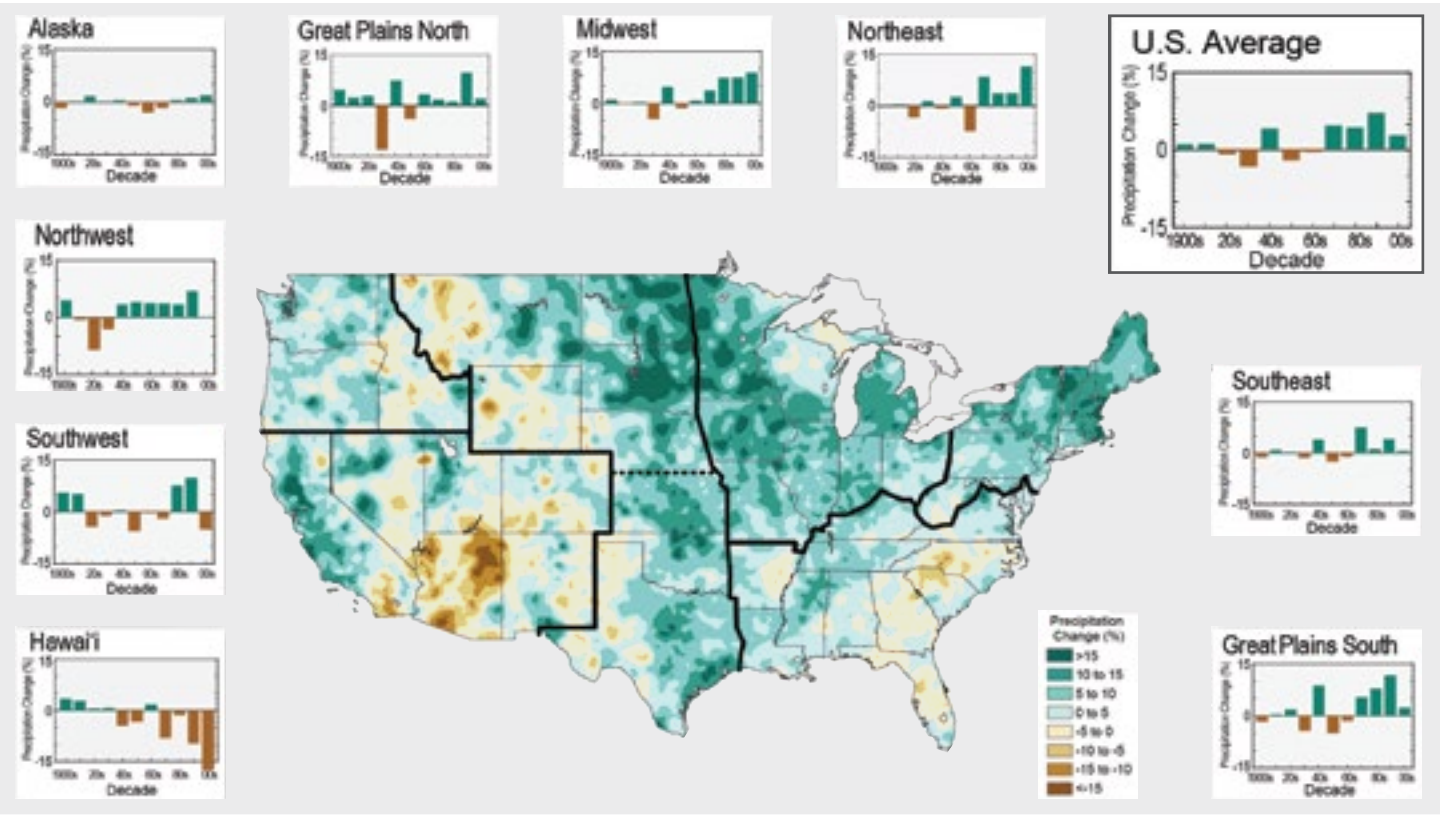
Precipitation. Climatic changes—and rising temperatures, in particular—affect the types and patterns of precipitation within the hydrologic cycle. Impacts can differ greatly between regions. For example, most of the Northeast, Midwest, and Southern Great Plains have experienced at least an 8 percent increase in precipitation between 1991 and 2012 relative to the 1901 to 1960 baseline average

[19] Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., *Climate Change Impacts in the United States: The Third National Climate Assessment*, US Global Change Research Program, May 2014, accessed July 25, 2014, http://nca2014.globalchange.gov/downloads, p. 28–29.

[20] Climate scientists view a temperature increase of 3.6 degrees Fahrenheit (2 degrees Celsius) above preindustrial levels as the threshold signifying where dangerous and catastrophic changes may occur in the global environment. The changes past this threshold could harm all sectors of society—water and food supply, health and security, energy, ecosystem balance, economic prosperity, etc. Both the IPCC and NCA reports indicate the threshold will be surpassed within the next few decades if future trends continue at the recent historic pace.

[21] Melillo, Ibid, p. 29.

Figure 9 Observed US Precipitation Changes[22]



The colors on the map show annual total precipitation changes for 1991–2012 compared to the 1901–1960 average, and reveal wetter conditions in most areas. The bars on the graphs show average precipitation differences by decade for 1901–2012 (relative to the 1901–1960 average) for each region. The far right bar in each graph is for 2001–2012.
(Figure source: adapted from Peterson et al. 2013)

(see Figure 9). Although precipitation variability is a natural occurrence, most projections suggest that the impacts of climate change will either magnify or alter natural precipitation types and patterns (e.g., wet areas will be wetter and dry areas will be drier).[23]

While climatic change as it is now understood assumes significant unpredictability in weather patterns, there is broad scientific consensus that long-range temperature increases and variations in precipitation patterns can be expected to increase. The vast majority of experts that provided input to the QFR expect these changes to directly impact several key factors that shape wildland fire management, including water availability, fuel levels, accumulation and condition, vegetation community composition, and fire season length.

Water. Climatic change affects water quantity and water quality. Regarding quantity, precipitation inhibits fire ignition and spread by influencing fuel moisture and replenishes natural and artificial reservoirs used in fire suppression. The types and patterns of precipitation of a region affect its hydrologic cycle, which influences the water quantity avail-

[22] Melillo, Ibid, p. 32.

[23] Melillo, Ibid, p. 33.

able throughout the year. The Northeast, Midwest, and upper Great Plains, for example, are experiencing increases in the frequency and intensity of extreme precipitation events (e.g., heavy downpours) because of warmer temperatures that allow the atmosphere to hold more water vapor.[24] In the Southwest, conversely, precipitation is declining from a northward expansion of the high-pressure belt of the subtropics, which results from changes in large-scale weather patterns.[25] Increased temperatures are also affecting snowpack-reliant regions by causing earlier snowmelt, which in turn drives peak river flows earlier in the season and increases precipitation that arrives as rain rather than snow.[26] Winter snowpack in these areas provides a natural water reservoir that historically has prolonged the period of moisture availability to ecosystems as snow melts during the dry summer months. With more of this moisture falling as rain, this reservoir capacity is diminished, amplifying summer drought, minimizing moisture availability for vegetation during the summer, and placing further stress on fuels. All these events are contributing to increased occurrence of fire events.

While drought may limit vegetation growth over the long term, thus reducing fuels accumulation, in the short term, the combination of drought with existing high fuel loads is likely to cause significant fire impacts. California is in the midst of an exceptionally severe drought affecting 82 percent of its land area.[27] There is precedent and ample geologic evidence to suggest that this drought could continue for many years, if not decades,[28] leaving the San Joaquin Valley and the populated foothills of southern and central California prone to damaging fire events. As an example, experts noted that the recent 2014 King Fire, which scorched some 97,000 acres of the Sierra Nevada, will likely result in significant runoff-related silting of watersheds that supply Northern California. When combined with aforementioned declines in snowpack, this silting could exacerbate the impacts of California's ongoing drought on regional populations.

Dust Storm Near Winslow, Arizona, April 2011
(US Geological Survey [USGS] Photo)

This situation is not, however, limited to California. While experts expect climatic change to drive wetter, warmer overall conditions in the Northeast, rising temperatures and low levels of rainfall in the summer months may contribute to intermittent drought conditions and exacerbated fire risk.[29] Data from the IPCC *4th Assessment Report* suggests that even with rising precipitation, some regions may be drier than today as rising temperatures will cause an expansion of transpirational and evaporational water loss equal or greater than the increase in precipitation.[30]

In addition to its impact on reservoirs that support human populations, fire's effects on water quality also limit available fire suppression resources. Rising temperatures are causing thermal stratification of lakes and reservoirs for longer periods of time. Stratification hampers or eliminates seasonal patterns of overturn and causes excess accumulation of nutrients, heavy metals, and other toxins. Precipitation changes are diminishing water quality resulting from sediment, nutrient, and contaminant transportation after heavy downpours, including transporting mineral weathering[31] products and fertilizers. As a result, water sources can experience low water levels and can contain high toxin levels that make them unsuitable for suppression, especially if the toxins are harmful to vegetation, wildlife, and humans.

24 Melillo, Ibid, p. various.

25 Melillo, Ibid, p. various.

26 Melillo, Ibid, p. various.

27 US Drought Monitor, accessed September 9, 2014, http://droughtmonitor.unl.edu/.

28 B. Lynn Ingram and Frances Malamud-Roam, *The West Without Water: What Past Floods, Droughts, and Other Climatic Clues Tell Us about Tomorrow* (Oakland: University of California Press, 2013).

29 *The National Cohesive Wildland Fire Strategy: Northeast Regional Risk Analysis Report*, November 1, 2012, accessed September 22, 2014, http://www.forestsandrangelands.gov/strategy/documents/reports/phase3/NortheastRegionalRiskAnalysisReport11012012.pdf.

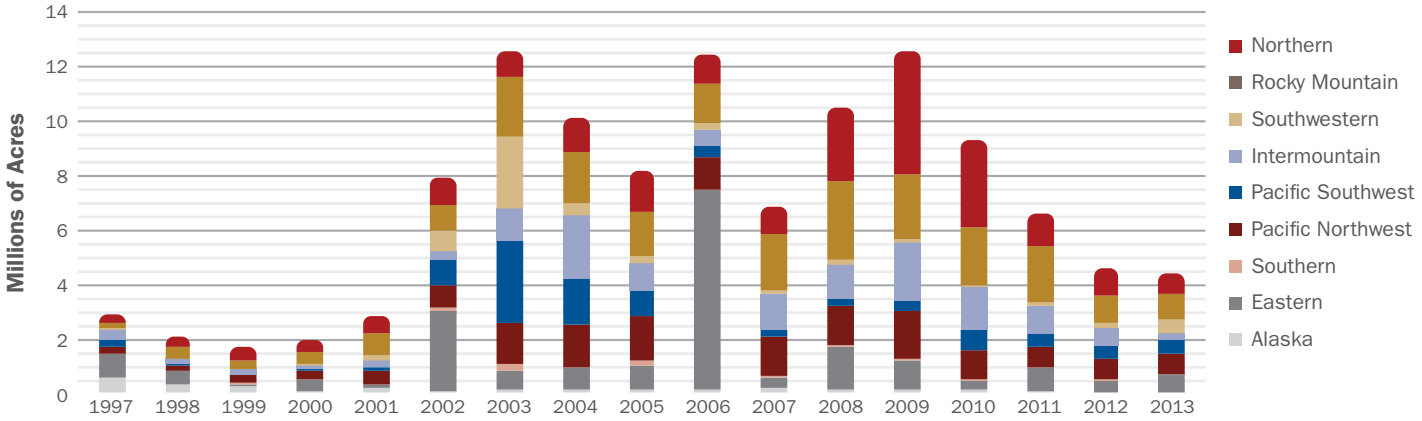
30 Intergovernmental Panel on Climate Change, *4th Assessment Report*, 2007, accessed September 26, 2014, http://www.ipcc.ch/report/ar4/.

31 Mineral weathering products include calcium, magnesium, sodium, and silicon and nitrogen loads.

Fuels. To burn, fire must have access to fuels, which include organic ground fuels (e.g., duff,[32] rotting branches, peat), surface fuels (e.g., coarse woody debris, leaf litter, grass, shrubs), and aerial fuels (e.g., branches, bark, leaves). Rising GHG emissions and temperatures have contributed to increased fuel loads. For example, the combination of increased CO_2 in the atmosphere and increased temperatures enables vegetation to be more productive during longer growing seasons. This trend is especially true for regions projected to experience increases in precipitation, such as the Northeast, Midwest, and upper Great Plains. Increased vegetation provides ample fuel for fire, especially if those regions experience short-term periods of dry weather or the precipitation pattern is disrupted by a drought. Recent studies in the Northeast found several observable effects of climate change in the form of wildflowers and woody perennials blooming earlier, upslope shift of approximately 300 to 390 feet in the boundary between the northern hardwoods and boreal forest of the Green Mountains, and uncertainty about what forms of vegetation will replace disappearing spruce-fir forests in the Adirondack Mountains.[33,34] Alternatively, increasing temperatures and lack of precipitation will lead to dry or drought conditions for some regions. Decreasing soil and vegetation moisture through evapotranspiration quickly creates an abundance of dry and dead vegetation that provide fuel for fires. Radiant heat through direct sunlight and warmer air temperatures provides optimal conditions for a quickly spreading wildland fire.

Invasive species, insects, and diseases that were previously controlled through natural controls (e.g., predators, pathogens), environmental factors (e.g., cold winters, precipitation), and the self-defense mechanism of vegetation (e.g., tree sap production) will likely thrive both in areas where they exist currently and in new ones. Figure 10 illustrates how rapidly changes in tree mortality can occur in different regions of the country. Over the past decade, bark beetles, spruce beetles, pine beetles, and budworms have overwhelmed nearly 11 million acres of western forest.[35] As the planet warms, the spread of these pests is projected to increase.[36] For example, as depicted in Figure 10, tree mortality in the Northeast experienced severe spikes in 2002 and 2006 and may again in the future. According to experts, the Northeast is also facing an influx of phragmites, a nonnative species of weed increasingly found in marshy and coastal areas that is particularly fire-prone and has led to several notable fires in Massachusetts in recent years, including a brushfire that occurred in Boston in 2010. Both factors suggest that the Northeast could be prone to severe fire events that have not been experienced in recent decades.

Figure 10 Tree Mortality Caused by Insects and Diseases[37]



Data Source: Insect and Disease Survey Database, US Forest Service Forest Health Protection

C02.020.15_08b

32 Duff: The layer of decomposing organic materials lying below the litter layer of freshly fallen twigs, needles, and leaves and immediately above the mineral soil.

33 Increased productivity from some Northern hardwood trees are projected due to longer growing seasons and assuming significant benefit from higher atmospheric carbon dioxide; however, summer drought and other extreme events may offset productivity.

34 Melillo, Ibid, p. 380–381.

35 Climate Central, *The Age of Western Wildfires*, September 2012, accessed July 25, 2014, http://www.climatecentral.org/wgts/wildfires/Wildfires2012.pdf, p. 8.

36 Climate Central, Ibid, p. 8.

37 FS, *All damage types acres for all pests by state (2009-2013)*: accessed September 3, 2014, http://foresthealth.fs.usda.gov/portal/PestSummary/DamageSummary.

Vegetation Communities. Experts generally expect increased emissions, rising temperatures, and variable precipitation to lead to increases in invasive vegetation growth, insect and disease activity, and habitat-type conversions. These increases may accelerate the transition of many vegetation communities, including from native to nonnative, or accelerate transitions to entirely new communities. Experts do not, however, expect these changes to occur in a uniform manner across the United States, with some regions transitioning to become less fire-prone. In other cases, regions that are expected to experience increases in regular precipitation, such as the Northeast, may have long, high-growth seasons that result in abundant vegetation but inhibit fire.[38] Short periods of dry weather could also occur that allow large, intense fire events to occur as a result of ample fuel loads. Alternatively, areas experiencing decreases in precipitation may have severe drought conditions, and the habitat may shift to shrubland, grassland, or desert.

Although these examples offer contrasting fuel types, the abundance of fuel in some scenarios may result in the expansion of extreme fire to areas of United States that have not experienced fire events in recent history. For example, Midwest states have histories of fire and contain large areas of red pine, jack pine, and white pine forests that have evolved as fire-tolerant species or that require fire to regenerate. These areas of the country also feature extensive areas of WUI and may be increasingly at risk from expected climatic change. Changes in temperature and precipitation allow or encourage geographic shifts of some species, while causing others to die out. With hotter, drier environments, some forest habitats are experiencing habitat-type conversions to brushlands, grasslands,[39] or desert, especially following fire events in drought-stricken areas. The Southwest, for example, has experienced extensive tree death across the region from increased temperatures and drought, as well as winter warming, which exacerbates bark beetle outbreaks. These conditions combined with the recent fire events contribute to upslope shifting of vegetation, spread of invasive plants, and conversion of forests to brushlands or grasslands. Alternatively, areas experiencing increased precipitation and increased productivity from longer growing seasons could experience increases in nonnative species, significantly altering the vegetation community composition, and thus, fire regime.[40] The replacement of native grasses, shrubs, and trees with species that are flammable are expected to render many land and fire management strategies outdated in the near future as ecosystems change.

Fire Season. Figure 11, Figure 12, and Figure 13 compile wildland fire data on fire season length from six federal organizations. These charts, which isolate 11 western states, as well as Texas, Oklahoma, and Alaska, show an overall trend that the length of fire seasons is increasing on federal lands.[41] The length of the fire season is calculated by comparing the first and last fire start date of fires 1,000 acres or larger for each year. Despite variation between years, western states are gradually evolving toward a typical fire season of more than 300 days per year.

Comparing the past decade to the 1980s, there were 2.5 times more fires of 1,000 acres or more, 3.5 times more fires of 10,000 acres or more, and 3.6 times more fires of 25,000 acres or more on FS land in the 12 western states. Using the same comparison, there were 1.7 times more fires of 1,000 acres or more, 2.6 times more fires of 10,000 acres or more, and 3.5 times more fires of 25,000 acres or more on DOI land in the 12 western states. Changing climatic conditions have created drier conditions and increased vegetation available to burn and have supported expansion of invasive species, insects, and diseases. In combination, these changes are allowing forests to become fire-ready earlier in the year than in the past, and remain that way longer, thus enabling an increased number of fire events. Projections suggest that continued climate change will further exacerbate these issues, for example, by potentially quadrupling the areas burned in the western United States with every 1.8 degrees Fahrenheit of temperature increase above preindustrial levels.[42] In Alaska, recent modeling conducted by the Alaska Fire Science Consortium projects an increase in fire seasons' length by 3 to 20 days per year by the 2040 to 2050 timeframe.[43]

38 *The National Cohesive Wildland Fire Strategy: Northeast Regional Risk Analysis Report*, Ibid.

39 Melillo, Ibid, p. 469.

40 Fire Regime: A description of the patterns of fire occurrences, frequency, size, severity, and sometimes vegetation and fire effects as well in a given area or ecosystem. A fire regime is a generalization based on fire histories at individual sites. Fire regimes can often be described as cycles because some parts of their histories are often repeated, and the repetitions can be counted and measured, such as fire return interval.

41 Bureaus and agencies included FS, BIA, BLM, USGS, Bureau of Reclamation, NPS, and FWS; states included Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

42 Climate Central, Ibid, p. 9.

43 Mike Flannigan et. al, "Global wildland fire season severity in the 21st century." *Forest Ecology and Management* (2013), accessed September 25, 2014, http://dx.doi.org/10.1016/j.foreco.2012.10.022.

Figure 11 Number of Days in Fire Seasons in 11 Western States

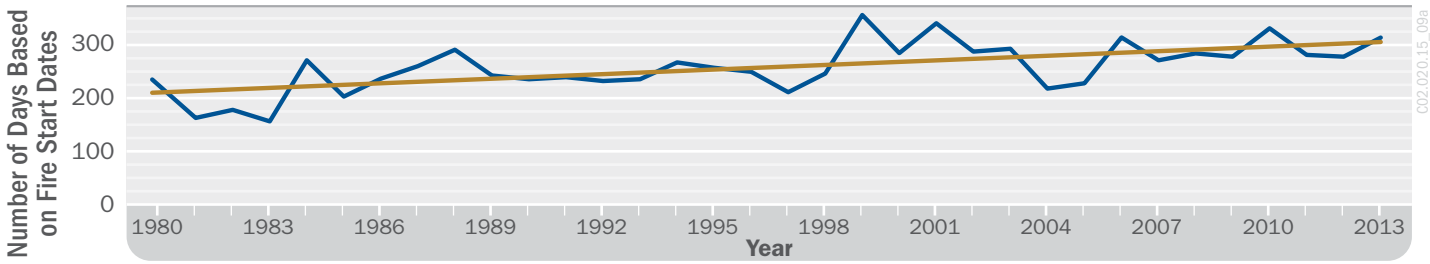


Figure 12 Number of Days in Texas and Oklahoma Fire Seasons

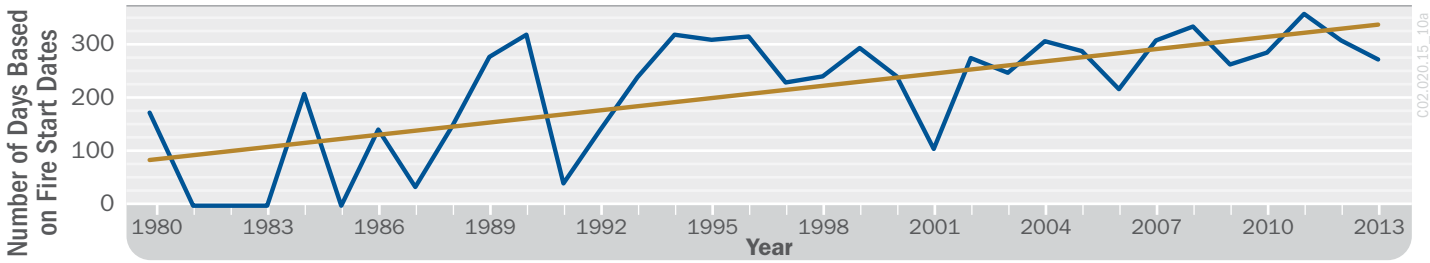
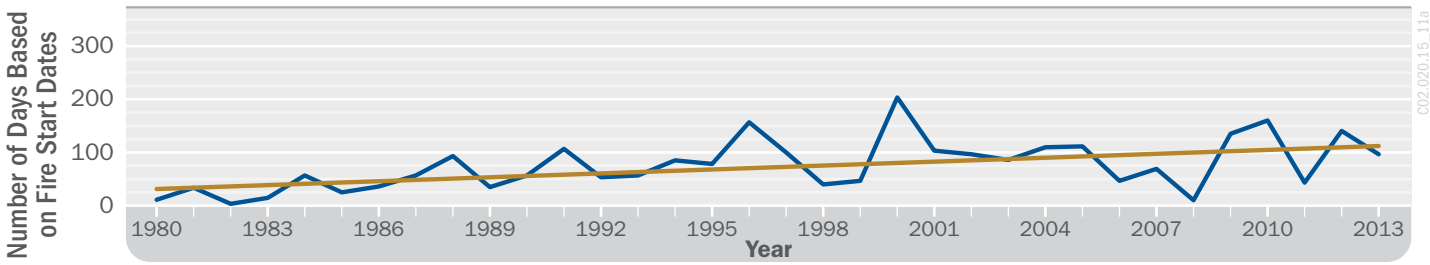


Figure 13 Number of Days in Alaskan Fire Seasons



B. RISK MANAGEMENT

OVERVIEW

The wildland fire management community's approach to mitigating risk to human populations, property, and other selected values through fire suppression has been extraordinarily successful in limiting the presence and impact of unwanted fire since the emergence of the 10 am policy and the subsequent emergence of current wildland fire management policies. Likewise, fuels treatments and other treatments (e.g., directed at invasive species, which make areas more fire prone), although only able to address a small percentage of federal lands, have in many cases been effective in areas where they have been applied and maintained over time. The community has also expended significant effort since the 1970s to promote the positive effects of fire on the landscape and the use of naturally ignited and prescribed fire to achieve those effects.

Nevertheless, wildland fire risk management is continuing to evolve and will likely become even more complex in the next 10 to 20 years. Years of successful mitigation and suppression operations have minimized the impact of fire on citizens and structure loss trends, but risks to the public and firefighters are on the rise due to a variety of factors. Natural factors driving this increase are due, in some cases, to uncontrollable changes in the natural environment that include longer fire seasons; an expansion of areas prone to fire, invasive species, insects, and disease; and more frequent extreme climate events. Human-caused factors driving increased risk include the following:

- Choices at the state and local levels to allow unregulated expansion of the WUI (i.e., without building code regulations on new construction)
- Choices by citizens not to make modifications to increase the fire resiliency of their properties
- Rising fuel levels that are unintended consequences of highly effective fire suppression and a simultaneous decline in active forest management.

One additional human-caused factor, and one that is noteworthy given this QFR's focus on identifying *"what aren't we seeing?,"* is the specter of pyroterrorism. The validity of pyroterrorism as a legitimate risk has been the subject of considerable debate. Nonetheless, experts consulted during this review did acknowledge that if executed under the right weather and fuel conditions and in the right locations, multiple simultaneous fires could overwhelm wildland fire resources and create significant risk for responders, the public, critical infrastructure, commerce, and other values. One recent analysis pointed to alleged plots by Al Qaeda to use "fire bombing" against woodland areas in the United States, and another pointed to actions by serial arsonists as case studies for pyroterrorism. Further assessment through scenario-based analyses may be warranted to fully comprehend both immediate and cascading events of such a shock-type event, as well as the ability of the fire and law enforcement communities to accurately recognize such an event and direct multiple types of response for comprehensive threat mitigation.[44]

Ultimately, while the Cohesive Strategy advances critical messages about the need for communities and individuals to accept greater responsibility for fire mitigation, the wildland fire management community has limited leverage to mandate change on its own. The fire management community's ability to protect lives, critical infrastructure, natural resources, and other values to date represents success against obstacles that are largely out of its direct control, but WUI expansion, more frequent extreme fire events, and fiscal pressure on its programs may jeopardize the community's ability to sustain that success. The community must adequately analyze trends and indicators associated with these issues so that it can accurately estimate potential effects and adjust its management direction, as necessary, to prepare for or mitigate them.

KEY ISSUES

CHANGING FIRE ENVIRONMENT

Existing trends, statistics, and indicators point to a future featuring more wildfire—and more severe wildfire—on the landscape. This changing fire environment will pose new challenges to mitigating risk to the critical natural resources that the federal land management agencies oversee (e.g., watersheds, timber, recreational areas, sacred landscapes, endangered species) and also to lives, property, and critical infrastructure. The number of wildfires exceeding 50,000 acres has increased dramatically over the past 30 years, with most of that change occurring over the past decade.[45] The length of the western fire season has also increased by 2.5 months since the 1970s and major climate-related shifts occurring in the hydrologic cycles of landscapes (particularly in snowmelt-dominated regions) could exacerbate risk to firefighters and the public.[46] While many of the aforementioned large fires have occurred in the West, it is worth noting that other parts of the country, particularly the Southeast, experience huge numbers of small fires annually. Given population density, small, high-intensity fires can also present significant risk to populations and other values.

New climate projections indicate that the number of acres burned by wildfire in the United States could quadruple from approximately 5 million to some 20 million acres by 2050.[47] The United States has a long history of wildfire of significant magnitude on its landscapes. During a period of extreme drought in the 1930s, wildfires burned between 20 million and 50 million acres each year, averaging nearly 39 million acres burned per year.[48] By the 1960s, aggressive

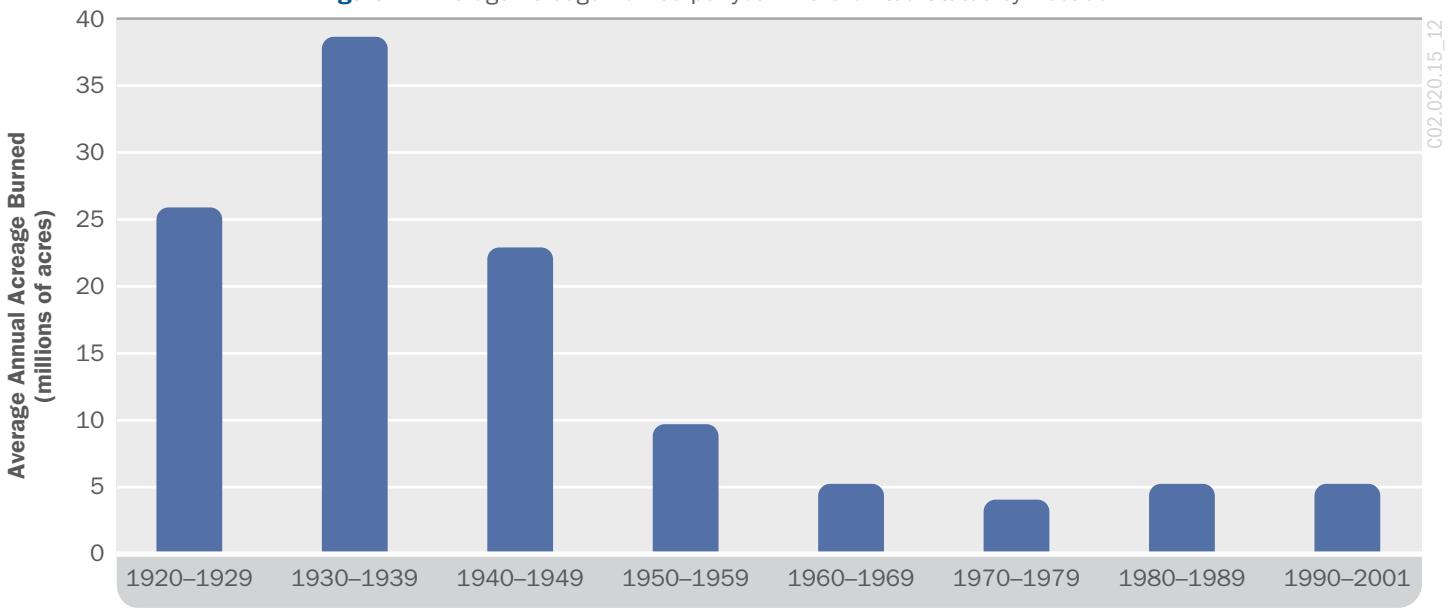
[44] Ed Ballam, "Forest Service: Pyroterorrism a Threat in the US," *Firehouse.com News*, February 21, 2013, accessed December 9, 2014, http://www.firehouse.com/news/10882251/forest-service-pyroterrorism-a-threat-in-the-us and Robert Baird, "Profiles in pyroterrorism," *The Counter Terrorist*, March 2, 2011, accessed December 9, 2014. http://www.homeland1.com/disaster-preparedness/articles/985110-Profiles-inpyroterrorism/

[45] FS, Wildfire, *Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland-Urban Interface*, January 2013, accessed 2014, http://www.fs.fed.us/openspace/fote/wildfire-report.html, p. 1.

[46] Climate Central, Ibid, summary.

[47] Climate Central, Ibid, p. 9.

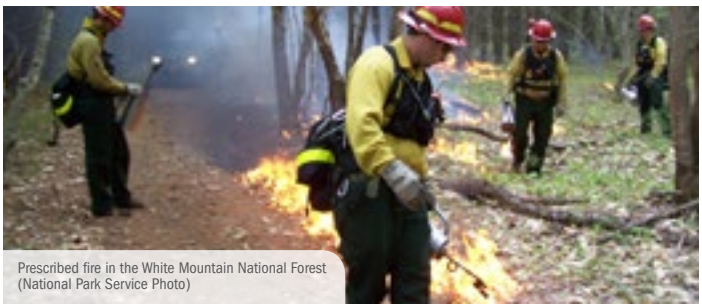
Figure 14 Average Acreage Burned per year in the United States by Decade[50]



fire suppression, interagency coordination, fire prevention, and public education efforts, such as the Smokey Bear fire prevention campaign, resulted in a reduction in annual wildfire acres burned by 90 percent.[49] Despite this dramatic decrease (depicted in Figure 14), fire exclusion policies and current climate trends suggest that a return to pre-1950s levels is a realistic possibility.

FUEL LOADING, FIRE SUPPRESSION, AND PRESCRIBED FIRE

There is consensus within the community that decades of successful fire suppression and a decline in active forest management have exacerbated fuel loading across the United States, and, as a result, annual fuel accumulations are now significantly greater than the amounts removed by wildfire, prescribed burning, and mechanical and other treatments combined. The widespread sentiment within the community is that active forest management has declined on a variety of fronts, particularly in terms of the forest products industries that have historically been a major contributor to managing vegetative fuels. Furthermore, social and political opposition to fire, based on, for example, its smoke impacts and potential danger to endangered species, have also contributed to high fuel levels in many areas of the country. Other factors include wildfire exclusion laws that require full suppression of all fires, typically to protect WUI areas and state and private land with economic value (e.g., timber, grazing), and limited legal protections for state managers looking to put more fire on the landscape. These fuel levels create a lingering liability that will eventually find resolution, planned or unplanned, that could have significant negative implications. Until the wildland fire management community is able to evolve to a fundamentally different, tailored approach that balances the unique land management requirements in states across the country—or fire resets the landscape catastrophically—this risk will continue to escalate.[51]



Prescribed fire in the White Mountain National Forest (National Park Service Photo)

[48] Congressional Research Service (CRS), *Forest Fire/Wildfire Protection*, March 7, 2012, accessed September 24, 2014, http://fas.org/sgp/crs/misc/RL30755.pdf.

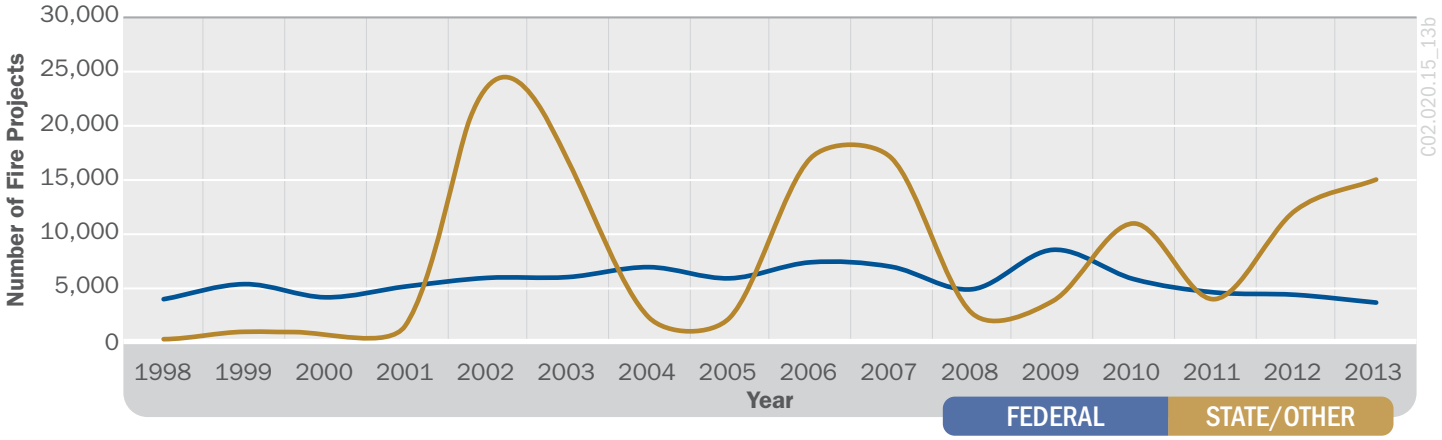
[49] MacCleery, D. W., *American Forests: A History of Resilience and Recovery* (Durham, NC: The Forest History Society, 2011), accessed 2014, http://www.foresthistory.org/publications/issues/amforests.html, p. 36.

[50] CRS, *Forest Fire/Wildfire Protection*, Ibid.

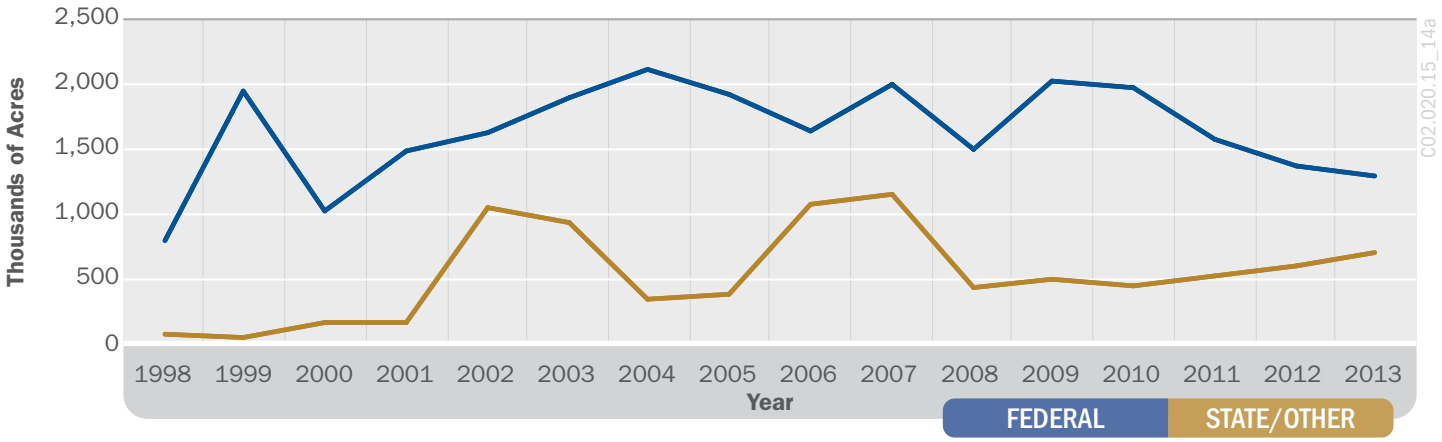
[51] FS, *Final Report: Wildland Fire Management Futures: Insights from a Foresight Panel.* July 2, 2014, not available online.

The wildland fire management community's suppression orientation and decisions at the federal and state levels to borrow from prevention and fuels treatment funds to do so, coupled with air quality and fiscal pressures, and an inconsistent understanding of fire as a natural change agent across the country have led to reductions in the use of prescribed fire. This decline has resulted in a similar decline in the capability to execute prescribed burning, particularly due to challenges in justifying projects given competing priorities, particularly those related to suppression.[52] As reflected in Figure 15 and according to NICC data, use of prescribed fire by federal agencies peaked in 2009 (numbers of fires and acres burned) and has been in decline since that time, with numbers of projects declining by approximately 55 percent and acres burned declining by approximately 35 percent.[53, 54] Conversely, at the state level, NICC's data depicts an approximately 200 percent increase in prescribed fire projects and an approximately 50 percent increase in acres burned over the same period.

Figure 15 Annual Prescribed Fire Projects and Acres Burned Annually Using Prescribed Fire



Data Source: National Interagency Coordination Center Wildland Fire Summary and Statistics Annual Reports



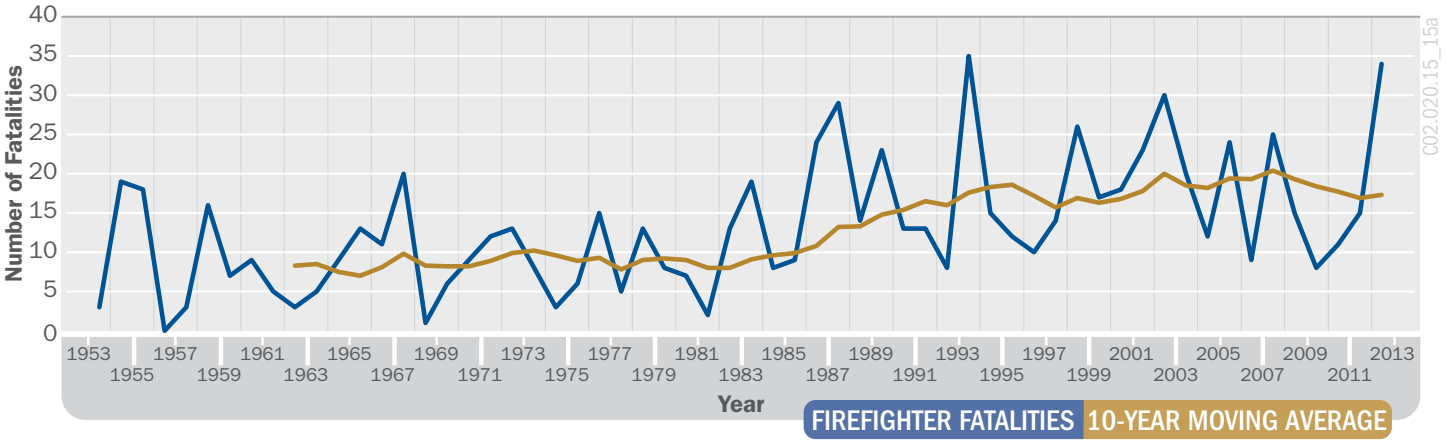
Data Source: National Interagency Coordination Center Wildland Fire Summary and Statistics Annual Reports

[52] According to FS and DOI budget justifications from 2006 to 2015, hazardous fuels reduction full-time equivalents peaked in 2009 and had declined by 34 and 33 percent, respectively, as of 2013. Hazardous fuels reduction funding peaked in the FS and the DOI in 2010 and has declined by 12 percent and 33 percent, respectively, as of 2013.

[53] NICC, *Wildland Fire Summary and Statistics Annual Report* (2000–2013), accessed September 23, 2014, http://www.nifc.gov/fireInfo/fireInfo_statistics.html.

[54] The NICC maintains the only historical database on prescribed fire trends in the United States, but a recent survey conducted by the Coalition of Prescribed Fire Councils, Inc. (CPFC) and NASF suggests that NICC's data may be incomplete. While the CFPC/NASF survey represents a snapshot in time (2011), it indicates that federal, state, local, tribal, and private stakeholders burned 7.8M acres in forestry-related prescribed burns in 2011, representing a more than 200 percent increase over the 2.5M acres captured in NICC's data for the same year. Mark A. Melvin, *2012 National Prescribed Fire Use Survey Report,* Coalition of Prescribed Fire Councils, Inc. and the National Association of State Foresters (NASF), 2012, accessed December 5, 2014, http://www.stateforesters.org/2012-national-prescribed-fire-use-survey-report.

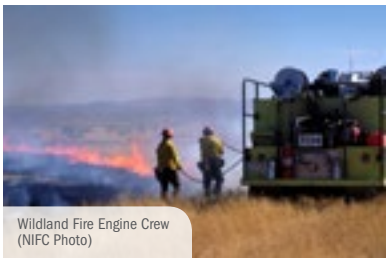
Figure 16 Wildland Firefighter Fatalities in the United States (1954–2013)[59]

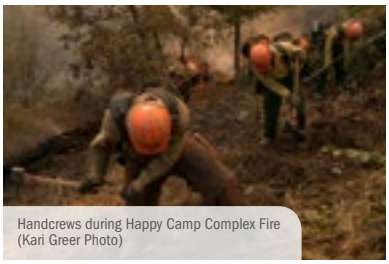


Many states, particularly in the South, Midwest, and Great Plains, have a longstanding tradition of prescribed burning (including by private entities on private land) and a strong capability to use it for fuels reduction and ecosystem maintenance. If social and political pressure result in a decreased ability to execute prescribed burning over the next 10 to 20 years, devastating fires in WUI areas could result.[55]

Given high fuel levels on the landscape, it is noteworthy that fuels management full-time equivalents (FTEs) at the FS and the DOI declined by a combined 745 FTEs between 2008 and 2013, representing a 22 percent reduction.[56] As depicted in the Cohesive Strategy, prioritizing these resources is more critical than ever. Employees funded through the fuels management program plan and execute prescribed burns and mechanical treatments to reduce fuel loads and enhance local community and ecosystem resiliency. These employees are also highly trained in suppression operations, and reduction in fuels management-funded employees significantly reduces the pool of available fire resources to support suppression actions both at the local initial attack level and at the national level supporting large and complex fire suppression actions.

FIREFIGHTER SAFETY


Wildland Fire Engine Crew (NIFC Photo)


Handcrews during Happy Camp Complex Fire (Kari Greer Photo)

Firefighter fatalities and serious injuries are a key metric in wildland fire safety. There is ongoing debate within the wildland fire management community as to whether fatalities among wildland firefighters are on an upward trendline, but NICC data does indicate that approximately 30 percent of wildland firefighter deaths since 1900 have occurred within the last 20 years.[57] This information, viewed in combination with aforementioned changes in the fire environment, may be a leading indicator of increased risk to firefighters, and it warrants further consideration by fire leaders as they look to align policy, strategy, and capabilities in the coming years.

Over the past decade, the average annual fatality count for wildland firefighters at the federal, state, local, and tribal levels was 17 (see Figure 16).[58] In 2013, however, the

[55] Interviews at Large Wildland Fire Conference (Missoula, Montana: University of Montana), May 19–22, 2014.

[56] USDA FS and DOI Budget Justifications 2011–2015, Ibid.

[57] NIFC, *Wildland Fire Fatalities by Year* (1910–2012), 2012, accessed September 11, 2014, http://www.nifc.gov/safety/safety_HistFatality_report.html.

[58] DOI, *Wildland Fire Management Annual Report* (FY2013)—DRAFT—v1.0, February 25, 2014, accessed 2014, not available online.

[59] NIFC, Ibid.

wildland fire management community suffered more than twice the annual average for the decade, with 34 fatalities, including 19 firefighters who perished tragically during the 2013 Yarnell Hill fire in Arizona. Yarnell Hill represents the third largest wildland firefighter death toll in history, after the 1910 Devil's Broom fire in Idaho (86 fatalities) and the 1933 Griffith Park blaze in Los Angeles (29 fatalities).[60] Such statistics represent red flags. Rising temperatures, lengthening fire seasons, increases in acres burned, and the rising prevalence of extreme fire events may exacerbate existing issues and will require close attention by fire leaders in the coming years.

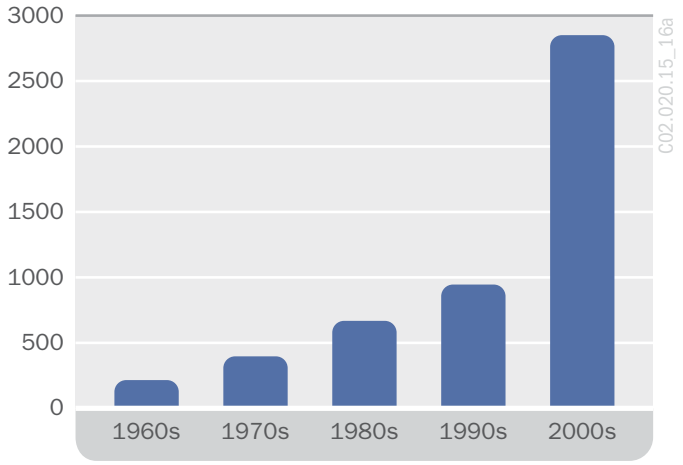
The increased psychological toll on firefighters associated with lengthened fire seasons, more severe fires, and limited available resources creates significant health and safety challenges. Although there is little data available on the specific impact to wildland firefighters, it may be valuable to consider data available for structural firefighters. For example, the rate of posttraumatic stress disorder (PTSD) for structural firefighters is 37 percent, which is 10 times greater than the rate in the total United States population (3.6 percent).[61] As such, many local and state structural fire stations employ chaplains or counselors to monitor firefighters and support their well-being.[62] According to experts consulted during this review, wildland firefighters often lack the resources that their structural fire counterparts have when it comes to addressing trauma-related stress reactions, such as depression, domestic abuse, workplace conduct issues, suicides, and alcohol and drug abuse. It is reasonable to assume that wildland firefighter health and safety will become increasingly challenging as wildland fire becomes more extreme.

PUBLIC HEALTH AND SAFETY

Wildland fire-related public health and safety issues are on the rise. Presently, no comprehensive nationwide system tracks these issues, and wide variability exists in the quality and completeness of data available at the state level; as a result, the wildland fire community's understanding of specific trends is currently limited.[63] Nevertheless, future risk to the public from wildfire will increase as the fire environment becomes more extreme.

Structure loss is an important metric that can quantify wildland fire impacts on communities. Annual structure loss counts from wildfires have steadily increased for more than six decades and are the result of increasingly extreme fire, growing WUI populations, and associated increases in the exposure of built environments. Since 1990, the average number of structures lost to wildfire annually has grown by more than 300 percent. In the 1970s, wildfire destroyed an average of approximately 400 structures annually. That annual average jumped to 670 in the 1980s, 930 in the 1990s, and 2,970 in the 2000s, as depicted in Figure 17. Given multiple factors, including climatic changes and continued WUI expansion, it is reasonable to expect that these numbers will continue to increase.[64]

Figure 17 Average Annual Structure Loss in the United States Due to Wildland Fire[65]



SMOKE AND AIR QUALITY

Wildland fire smoke emissions continue to be a major concern for fire managers and planners. Decades worth of aggressive fire suppression have resulted in an unprecedented accumulation of fuels across the country and, as a result, a similarly unprecedented absence of smoke. These fuels will burn sometime in the future whether or not society is prepared for it.

Numerous studies have explored the effects of wildland fire smoke and revealed significant impacts to public and firefighter health and safety, as well as economies and transportation. Excess carbon monoxide and particulates from smoke can cause impaired physical and mental capability,

[60] Ahrens, M., National Fire Protection Association: Fire Analysis and Research Division, *Brush, Grass, and Forest Fires*, November 2013, accessed 2014, http://www.nfpa.org/research/reports-and-statistics/outdoor-fires/brush-grass-and-forest-fires, p. 57.

[61] "Facts About PTSD in Firefighters," Mental Health Answers, accessed September 2, 2014, http://mentalhealth.answers.com/ptsd/facts-about-ptsd-in-firefighters.

[62] "Facts About PTSD in Firefighters," Ibid.

[63] Turner, C., "A wildfire forum takes radical approach to protecting wildland-urban interface," *High Country News* (February 6, 2014), accessed 2014, https://www.hcn.org/blogs/goat/behind-closed-doors-wildfire-solutions-forum-takes-radical-approach-to-protecting-wui-from-wildfire.

[64] Headwaters Economics (2014), Ibid, slide 13.

[65] Headwaters Economics (2014), Ibid, slide 13.

Smoke from Las Conchas Fire, New Mexico, 2011 (NIFC Photo)

decreased oxygen in the body, and depressed immune system functionality, as well as damage to the layer of cells in the lungs that protect and cleanse airways. Individuals who are exercising or participating in arduous activity, such as firefighting, are at a higher risk for such health issues. Children, the elderly, and others with preexisting health conditions, such as asthma, chronic bronchitis, and emphysema, are also at a higher risk because they are more susceptible to the harmful effects of smoke inhalation. Long-term exposure of particulates from wildfire smoke has been associated with increased risks of cancer, lung disease, cardiovascular disease, and ischemic stroke.[66]

Russia's long and extreme 2010 and 2012 fire seasons exemplify the risks associated with smoke impacts on air quality. During the 2010 season, Russia's western regions experienced some 20,000 fires that burned nearly 700,000 acres, many in areas with deep organic soils. Wildland fires that burn organic soil tend to burn cooler and longer and produce more smoke than similarly sized fires in forested areas, due to less complete combustion, and they result in significant GHG production and enhanced public safety concerns.[67] Studies following the 2010 Russian fires concluded that high levels of smoke and its impacts on air quality resulted in 54,000 more deaths in the affected area between June and August compared to the same period the previous year.[68] The wildfires that occurred in San Diego County, California, in 2003 and 2007, which resulted in a 50 percent increase for respiratory health issues during times of peak particulate concentrations compared to days without fires, are additional examples.[69] Emissions resulting from organic soil fires can be staggering. As global temperatures increase, vast new stretches of organic soils in the United States, particularly in Alaska, the upper Midwest, and the Southeast, may become ripe for combustion, potentially resulting in daunting smoke, air quality, and carbon management issues.

Economic costs associated with smoke and air quality are also significant. Experts contributing to the 2014 QFR estimated health and safety costs associated with smoke from wildfires at 8 dollars to 80 dollars per person per day for those impacted. In many cases, the costs and ramifications to health and safety are likely much higher than the costs to suppress the fire. Smoke can also impede commerce and cause serious transportation safety concerns, particularly when smoke combines with water vapor during the nighttime hours to create "super fog" that causes whiteout conditions and affects ground and air transportation. Smoke can travel hundreds of miles from a fire to cause issues several states away from its origin.

Wildfire experts consulted during this review also expressed concern that new federal regulations could limit suppression and prescribed burning options in the future. According to experts on the NWCG Smoke Committee, wildfires currently produce about 17 percent of the total GHGs gas released in the United States. Existing EPA regulations and agency policies do not require wildfire managers to address reduction of smoke impacts on air quality in their suppression planning activities, but an increase in wildfire in the next 10 to 20 years that drives fire-caused GHGs well above 17 percent could result in the emergence of new parameters. Experts consulted during this review suggested that major fires in regions with high levels of peat-based biomass (e.g., the Southeast, upper Midwest, Alaska) could exacerbate this challenge. Unlike aboveground fires, which can be suppressed or put out naturally by rain or the onset of winter, peat can burn, or smolder, for extremely long periods of time and has been known to burn beneath Alaskan snow coverage in winter and emerge in the spring. Peat also contains highly concentrated particulate matter accumulated over hundreds or thousands of years (e.g., CO_2,

[66] Jane Beitler "Tracking Natures Contribution to Pollution," *Earth System Science Data and Service* (October 17, 2006), accessed 2014 from National Aeronautics and Space Administration Earth Observatory website, http://earthobservatory.nasa.gov/Features/ContributionPollution/.

[67] Natural Resources Canada, *Peatland fires and carbon emissions*, March 14, 2014, accessed September 22, 2014, http://www.nrcan.gc.ca/forests/climate-change/13103.

[68] Sarah Elise Finlay, Andrew Moffat, Rob Gazzard, David Baker, and Virginia Murray, "Health Impacts of Wildfires," *PLOS Currents – Disasters* (November 2, 2012): accessed September 11, 2014, http://currents.plos.org/disasters/article/health-impacts-of-wildfires/.

[69] Nancy French and Mike Billmire, "Respiratory Health Impacts of Wildfire Particulate Emissions Under Climate Change Scenarios," *Michigan Tech Research Institute—Michigan Technological University*, (December 19, 2013), accessed September 11, 2014, http://www.mtri.org/fire_health.html.

methane gas, metals [particularly mercury]) that presents emissions concerns. The 1997 peat fires in Indonesia, for example, released between 0.81 and 2.57 gigatons of carbon over more than 12 months, equivalent to 13 percent to 40 percent of global carbon emissions from fossil fuels.[70] As a point of comparison, a recent study revealed that the 6,500 acre Lateral West Wildfire, which occurred in the Great Dismal Swamp National Wildlife Refuge, a peatland area that straddles the North Carolina/Virginia border in 2011, released 1.1 gigatons of carbon.[71]

Prescribed burning offers a significant mechanism for fire and land managers to manage smoke emissions that is not similarly available during suppression operations. As air quality management and mitigation policies evolve, opportunities may emerge to promote the use of prescribed burning, at ideal times and locations under the right weather conditions, as a method to mitigate air quality impacts associated with wildfire and better integrate smoke into risk management planning.

If the future does indeed present longer fire seasons, more fire on the landscape, and more extreme fire, the quantity and duration of smoke and related human health issues will increase. The latter will be particularly true for firefighters, given their close proximity to fire during suppression operations. To develop mitigation strategies for wildland fire emissions, fire leaders must have a better understanding of the relationships between climate change, population growth, and development patterns and how smoke and air quality impact human health and safety.[72]

WILDLAND-URBAN INTERFACE

According to the FS, wildland fire plays an important ecological role in 94 percent of wildlands[73] across the contiguous United States.[74] According to the 2012 US Census, there are an estimated 220 million acres of WUI overlaid with 46 million single-family homes, several hundred thousand businesses, and a population estimated to be more than 120 million.[75] Based on factors such as overall population growth, interregional migration to areas on the periphery of urban centers in the West and Southeast, and an aging baby boomer generation that is relocating, projections suggest an expansion of the WUI by 12.3 million homes in the West (111 percent growth) and 4.6 million in the Southeast (93 percent growth) by 2030.[76]

Home that survived wildfire, after nearby trees were thinned (NIFC Photo)

In the West, in particular, only 16 percent of available wildlands are developed (i.e., have experienced residential construction within 500 meters of wildlands: forests, brushlands, and grasslands).[77, 78] Sixty percent of new homes built in the United States since 1990 have been constructed in the WUI, converting wildlands to WUI at a rate of approximately 4,000 acres per day and nearly 2 million acres per year.[79, 80] Without new zoning regulations and building codes, experts suggest continued development in the WUI will result in many new subdivision housing areas with only a single entrance and exit, limited or no water sources, and inadequate mitigation efforts to address wildfire risks, creating grave safety risk to residents and to the firefighters assigned to protect them.[81]

[70] "Sumatra: Going Up In Smoke," *Greenpeace Southeast Asia* (May 28, 2014); accessed September 11, 2014, http://www.greenpeace.org/international/Global/international/briefings/forests/2013/Peat-Forest%20Fires_Briefer_May28-2014.pdf.

[71] US Geological Service, *Quantifying Soil Carbon Change from Wildfires in Peatland Ecosystems of the Eastern United States Using Repeat LiDAR*, not available online.

[72] Matthew D. Hurteau, Anthony L. Westerling, Christine Wiedinmyer, and Benjamin P. Bryant, "Projected Effects of Climate and Development on California Wildfire Emissions through 2100," *Environmental Science & Technology (2014)*, http://pubs.acs.org/doi/abs/10.1021/es4050133.

[73] Wildland: An area in which development is essentially nonexistent, except for roads, railroads, powerlines, or similar transportation facilities. Structures, if any, are widely scattered.

[74] FS, *Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland-Urban Interface,* Ibid.

[75] International Association of Wildland Fire (IAWF), IAWF WUI Statistics and Fact Sheet, August 1, 2013, accessed 2014, http://www.iawfonline.org/pdf/WUI_Fact_Sheet_08012013.pdf, p. 2.

[76] Hammer, R. B., Stewart, S. I., Radeloff, V. C., "Demographic Trends, the Wildland-Urban Interface, and Wildfire Management (Oregon State University Rural Studies Program, Working Paper Number RSP 08-01, February 2008), accessed 2014, https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/9260/RSP-08-01.pdf?sequence=1, p. 11.

[77] Headwaters Economics, "The Rising Cost of Wildfire Protection," June 2013, accessed 2014, http://headwaterseconomics.org/wildfire/fire-cost-background.

[78] Headwaters Economics, "Summary: Wildfire Costs, New Development, and Rising Temperatures," Spring 2013, accessed 2014, http://headwaterseconomics.org/wildfire/fire-research-summary.

[79] Headwaters Economics (2014), Ibid, slide 12.

[80] IAWF, Ibid., p. 1.

[81] Turner, Ibid.

Federal, state, and local governments and nongovernmental partners have undertaken several major efforts to implement protection programs for WUI communities. Nonetheless, after nearly 15 years of effort, only 2 percent of some 70,000 high-risk communities are certified as "Firewise."[82, 83,84] Furthermore, insurance companies have inspected less than 3 percent of the 46 million homes in at-risk communities for wildfire survivability. Only 10 percent (7,000) of communities have adopted a WUI code, and between 5 and 8 percent (11 to 18 million acres) of the estimated 220 million acres of WUI in the United States have received fuels treatments since 1999.[85] With 84 percent of wildlands still undeveloped and expansion continuing, the resilience of WUI communities will need to improve at a faster pace to adequately mitigate risk over the 10- to 20-year time horizon of this review.

C. WORKFORCE

OVERVIEW

Like many elements of the federal government, the FS and the DOI face a looming wave of workforce challenges and will contend in the coming decades with large numbers of impending retirements, the need to preserve institutional knowledge, broader shifts in market demand for labor, and changes in the way Americans prefer to learn and work. At the same time, it is likely that the wildland fire community will face fire-specific challenges resulting from increasingly extreme fire conditions and increased levels of stress—both physical and mental (e.g., PTSD, see Section II: Sub-Section B)—that will affect the firefighters who represent large components of their workforces.[86]

The work conducted by fire personnel in the 110 wildland fire positions used within the ICS—which include incident commanders, prescribed burn bosses, firefighters, engine bosses, and fire behavior analysts—is grueling and dangerous. The system of qualifications and certifications necessary to obtain these positions is complex and requires years of experience. In the realm of land management,

Fire Planning, Boise National Forest, 2012 (NIFC Photo)

the FS and the DOI incorporate another series of positions staffed at local units and state, regional, and national offices.

Assessing the state of the workforce, determining future needs, and planning to meet those needs are major tasks. There are strong indications that the capability of the workforce has been shrinking over the past decade and gaps are appearing in succession planning both within incident management teams (IMTs) and among agency personnel at the local level. These issues are not new. The 2005 and 2009 QFRs both noted impending workforce concerns and the 2005 report recommended "maintain[ing] the core fire management force structure, especially at the local (initial response) level and… [maintaining] high levels of initial attack success." Issues affecting agencies' ability to meet workforce needs include fiscal challenges, alignment of personnel levels and capabilities with needs, management of generational change, and data collection and analysis.

KEY ISSUES

PERSONNEL

The FS and the DOI are both experiencing a contraction in numbers of qualified responders. For example, fire-funded FTEs, which peaked at 18,094 in 2005, declined by 14 percent to 15,580 by 2013.[87] The USDA recognized in a 2012 report that its current workforce and employee development practices "have not kept pace with the changing role and nature of wildland fire management."[88]

[82] Firewise is a program that encourages local solutions for safety by involving homeowners in taking individual responsibility for preparing their homes from the risk of wildfire. Firewise, "About Firewise," 2014, accessed September 10, 2014, http://www.firewise.org/about.aspx?sso=0.

[83] IAWF, Ibid, p. 6.

[84] Findings suggest that many other communities have taken Firewise-like actions to increase their resilience, but have not sought formal certification; additional research may be truly measure progress.

[85] IAWF, Ibid, p. 6.

[86] Gregg Zoroya, "Wildfire crews battle PTSD, much like soldiers at war," USA Today (September 6, 2014), accessed September 22, 2014, http://www.usatoday.com/story/news/nation/2014/09/06/climate-fires-firefighters-ptsd-strain/14061659/.

[87] USDA FS, Fiscal Year 2014 Forest Service Budget Justification, April 2013, Ibid, and DOI, Budget Justifications and Performance Information (Wildland Fire Management), Fiscal Year 2014, Ibid.

[88] FS, *USDA Forest Service Fire and Aviation Management Workforce and Development Strategic Framework*, Ibid, http://www.fs.fed.us/fire/people/workforce_succession_planning/documents/fam_workforce_development_strategic_framework.pdf, p. 4.

The NWCG concluded in 2010 that "our current workforce management and succession planning for wildfire response is not sustainable in the future."[89] The NWCG explained that increasing fire season length is stressing the "militia" model as personnel qualified to serve on IMTs face challenges in reconciling assignments with regular job demands.[90] According to workforce experts at the FS, declining overall numbers of fire-qualified individuals, as compared with historical norms prior to the late 1980s, is exacerbating the problem. These concerns spurred the creation of the Evolving Incident Management (EIM) program, which was designed to transform policies and processes used to develop and staff national Type 1 and Type 2 incident management teams. The EIM is still in the developmental stage, and significant work remains before this effort will provide positive changes to address ongoing and future needs.

Beyond those individuals that the fire program directly funds, many individuals possessing wildfire qualifications are federal employees not currently assigned to fire management positions. Referred to as militia, these individuals have provided surge capacity for decades. Although fire has historically been funded to meet 90 percent of suppression requirements, when extreme events occur, militia, state, local, tribal, and contracted resources, the DoD, and other cooperators (including international partners like Canada, Australia, and New Zealand) have provided the remaining 10 percent. Furthermore, the National Forest System and forest management staff, which historically provided personnel for the militia, declined in number by 35 percent and 49 percent, respectively, between 1998 and 2012.[91] According to experts consulted during this review, similar reductions in nonfire bureau personnel who historically constituted militia are also occurring across the DOI. Furthermore, stakeholders suggested that a decline in numbers of privately contracted resources, which have historically played a significant role in protecting economic resources (e.g., timber industry assets) and have often been the first to respond, is also putting pressure on suppression capacity at all levels of government.

Many experts consulted during this review believe that suppression demands will soon overwhelm the viability of the militia approach. According to experts, driving factors include declining numbers of qualified individuals stemming from retirements, cultural barriers between the fire and nonfire communities that prevent nonfire employees from gaining requisite fire experience, and declining interest among nonfire employees in serving on IMTs during increasingly lengthy fire seasons. Conversely, in some parts of the country, such as the Northeast, the long intervals between major fires and declining budgets have also made it difficult to justify full-time firefighter positions for those firefighters to maintain their qualifications and for state and local organizations to justify expenditures on wildland firefighting equipment. Interviews and engagement during the QFR crowdsourcing effort revealed an overall decline in the emphasis on qualifying all new personnel to support fire activities since the early 1990s. The DOI and the FS used to include fire as a secondary duty in many nonfire position descriptions, which greatly enhanced the ability to train, develop, and maintain a large militia workforce. This requirement has been fading since the advent of the National Fire Plan in 2001, and the problem is expanding from an overall loss of bureau employees and a general decline in budgets. Fire managers are now required to do more with less, and fewer incentives remain to provide nonfire-funded resources to assist in suppression activities when managers see increasing difficulty in fulfilling their own land and resource management responsibilities.

This loss of militia capability is driving an increased use of Administratively Determined (AD)[92] and casual hires of retired veteran firefighters, contractors, and capable, but in some cases, more costly state and local firefighter augmentees to fill gaps in militia numbers. Currently, many of the national Type 1 and Type 2 IMTs rely heavily on retired firefighters to fill critical command and general staff positions. Most of these retirees were forced to retire due to federal policy that mandates retirement at age 57 for individuals eligible for firefighter retirement citing the mental and physical stress of these positions over time (similar to the military). Today, many retired firefighters in their 60s and 70s are filling positions on these teams, which raises not only significant workforce concerns, but also may create safety issues. While the use of AD and casual hires masks existing workforce gaps, it is not sustainable over the long term.

A 2010 USDA Office of Inspector General (OIG) report evaluating FS firefighting succession planning assessed that retirements occurring between 2015 and 2020 will present major challenges because of the time required for individuals to gain the knowledge, training, and experience to

[89] NWCG, National Incident Management Team Succession Planning—Key Messages, January 15, 2010, accessed September 11, 2014, http://www.nwcg.gov/general/memos/nwcg-002-2010.html.

[90] NWCG, National Incident Management Team Succession Planning—Key Messages, Ibid.

[91] US Senate, Committee on Energy and Natural Resources, Statement—*Thomas Tidwell, Chief, USDA, Wildland Fire Management*. USDA Forest Service, June 4, 2013, http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=e59df65c-09c6-4ffd-9a83-f61f2822a075, p. 3.

[92] Administratively Determined: A person hired and compensated under the Pay Plan for Emergency Workers.

qualify for critical fire management positions.[93] It also concluded that the FS had not taken necessary steps to ensure it has sufficient numbers of qualified staff to meet future requirements. Approximately 24,000 FS employees hold firefighter qualifications and 4,300 occupy one of 54 critical wildland fire position types involving essential fire command (e.g., incident commanders) and support activities (e.g., logistics section chiefs). Of those 4,300, 86 percent will be eligible to retire by 2019. The OIG also found that of approximately 11,000 critical firefighter employees at the FS, only 50 percent were in training to fill positions expected to be vacant. The OIG noted that FS needs a national workforce plan to ensure that personnel with critical firefighting qualifications will continue to be available to meet the firefighting needs of the FS. The FS had not made it a priority to develop such a plan because it believed the agency's general workforce planning process was sufficient to cover any firefighter shortages. The OIG concluded that this is not the case.[94]

Regarding national assets such as IMTs, smokejumpers, and Type 1 Hotshot crews, the National Multi-Agency Coordinating Group (NMAC) concluded in 2013 that current resource levels might not sustain recent levels of firefighting support in the future. For example, between 2007 and 2013, the DOI experienced a decline in available interagency Type 1 crews from 23 to 16 (a 30 percent reduction).[95] The NMAC suggested that the 2013 fire season could represent a "new normal" in which "overall resources decreased, even as fire seasons, in general, became more severe and managing fires grew more complex."[96] During recent severe fire years (years with high levels of acres burned and numerous days at Preparedness Level 4 and 5), the community was only able to fill an average of 34 percent of requests for Type 1 crews.

The 2014 QFR also found that requests for Type 2 crews dropped by approximately 80 percent from the period between 2000 and 2007 (1,179 requests per year) to the period between 2008 and 2013 (213 requests per year).[97] Experts asserted that most IMTs seek out Type 1 crews because of the increased complexity of fire, the limited experience of Type 2 crews, and the resulting safety issues. When Type 1 crews are unavailable, IMTs typically request Type 2 (IA) crews. While Type 2 (IA) crew numbers are increasing, their numbers have not increased sufficiently to meet demand. As a result, when requests for Type 2

Sacramento Lodgepole Fire, 2013 (Kari Greer/mphoto)

[93] USDA-OIG, Forest Service's Firefighting Succession Planning Process (Audit Report 08601-54-SF), March 2010, accessed September 8, 2014, http://www.usda.gov/oig/webdocs/08601-54-SF.pdf.

[94] USDA-OIG, Ibid.

[95] DOI, Budget Justifications and Performance Information (Wildland Fire Management), Fiscal Year 2014, Ibid.

[96] NMAC, Key Issues 2013, 2013, accessed September 11, 2014, http://gacc.nifc.gov/wgbc/GBCG/Memos/nmackeyissues.pdf.

[97] NICC, *Resource Order Requests* (2000-2013), accessed September 12, 2014, http://www.predictiveservices.nifc.gov/intelligence/intelligence.htm.

(IA) crews go unfilled, available data suggests that IMTs are choosing not to order Type 2 crews because of safety and capability concerns. A lack of data on numbers of Type 2 and Type 2 (IA) crews precludes thorough analysis of this issue.

Another significant and ongoing workforce concern relates to partner organizations. According to the National Volunteer Fire Council, 69 percent of firefighters in the United States were volunteers as of 2012, and nearly 67 percent of some 30,000 fire departments across the country were completely reliant on volunteers.[98] Since 1984, there has been a steady decline (approximately 13 percent overall) in the number of volunteer firefighters in the United States.[99] Factors driving this trend include increased call time, expanded training requirements, less available time due to the proliferation of two-income families and long commutes, and declining employer flexibility to support responses to calls.[100] This finding suggests that the current use of local augmentees by the FS and the DOI may become increasingly challenging, or at minimum, more expensive, over the timeframe of this review.

Engagement with stakeholders during this review revealed a commonly held belief that the decline in the federal workforce is resulting in a greater reliance on contracted firefighters. Recent analysis, which included interviews with 48 fire incident commanders and staff, concluded that contractors often lack required training and experience, require more oversight, and in some instances cost more than government personnel to recruit, train, and transport.[101, 102] Achieving a full understanding of the cost-effectiveness of contracted fire personnel is critical. While studies have attempted to achieve a deeper understanding, they have largely been inconclusive, and experts consulted during this review attributed their limited knowledge on the subject to a lack of data.[103]

GENERATIONAL CHANGE

According to data collected by the Office of Personnel Management (OPM) in 2010, the DOI and USDA[104] workforces (at the department level)[105] were both out of sync with the broader US workforce in terms of generational demographics. For example, baby boomers (those born between 1946 and 1965) made up 38 percent of the US workforce in 2010, but made up more than 55 percent of both the DOI and USDA workforces.[106] Conversely, millennials (those born between 1981 and 2000), who made up 25 percent of the US workforce, made up 18.6 percent and 17.3 percent of the DOI and USDA workforces, respectively. While numbers of millennials at the DOI and the USDA lag the overall American workforce, it is noteworthy that the USDA and the DOI place second and third, respectively, among cabinet agencies in their inclusion of millennials.[107] The QFR team was unable to obtain additional data from the OPM or from the DOI or the USDA to ascertain whether these numbers have come into balance since 2010. Nonetheless, as evidenced by retirement eligibility within the DOI and FS workforces, both organizations will need to formulate workforce strategies designed to entice millennials and following generations into their workforces in higher numbers to judiciously ensure an adequate succession pipeline.

Such a strategy will require consideration to ensure that FS and DOI culture and practices accommodate millennials' preferences to work in organizations that offer flexibility in schedule and location, open communication, mentoring, and cutting-edge technology.[108] The FS and the DOI will need to do so while managing generational differences between millennials and their baby boomer and Generation X predecessors. For example, the NWCG maintains and coordinates delivery of approximately 130 different training courses to support the qualification and certification of wildland fire positions across agencies. According to inter-

[98] National Volunteer Fire Council, Key Fire Service Facts, accessed September 10, 2014, http://www.nvfc.org/hot-topics/key-fire-service-facts.

[99] National Volunteer Fire Council, Ibid.

[100] Jason Ferguson, "Where have all the firefighters gone?" *Custer County Chronicle*, (February 7th, 2013), accessed September 11, 2014, http://www.custercountynews.com/cms/news/story-673642.html.

[101] Timothy Ingalsbee, "Getting burned: a taxpayer's guide to wildfire suppression costs: a report for Firefighters United for Safety, Ethics, and Ecology (FUSEE)" (August 2010), accessed September 24, 2014, http://www.iawfonline.org/A%20TAXPAYERS%20GUIDE%20TO%20WILDFIRES.pdf

[102] DOI, *Wildland Fire Management Program Benefit-Cost Analysis, A Review of Relevant Literature*. p. 7.

[103] For additional information, see Geoffrey H. Donovan, "Comparing the Costs of Agency and Contract Fire Crews" *Fire Management Today*, (Volume 67, No. 1, Winter 2007), accessed October 9, 2014, http://www.fs.fed.us/pnw/pubs/journals/pnw_2007_donovan003.pdf

[104] Data collected at the cabinet-department level. OPM, *Federal Civilian Employment Distribution Within Selected Age Groups*, September 30, 2010, accessed September 12, 2014, http://www.opm.gov/policy-data-oversight/data-analysis-documentation/federal-employment-reports/demographics/2010/table9mw.pdf.

[105] Specific data related to the age demographics of the wildland fire management workforce were unavailable, but according to interviews with experts in the community, it can be assumed that its workforce is younger than that of the USDA and the DOI at large.

[106] Catalyst – Generations in the Workplace in the United States and Canada, accessed September 12, 2014, http://www.catalyst.org/knowledge/generations-workplace-united-states-canada.

[107] Millennials, on average, made up 13.3 percent of the federal workforce in 2010.

[108] Jessica Brack, "Maximizing Millennials in the Workplace," *University of North Carolina, Kenan-Flagler Business School*, 2012, accessed September 12, 2014, p.3.

views conducted during the QFR, the NWCG has achieved significant progress in converting some training components to a virtual format to meet the demand from younger staff. Nonetheless, fully altering historical training regimes and processes to meet the learning needs of a new generation—while ensuring older generations remain qualified—will require substantial, sustained effort and investment.

While the FS and the DOI are already grappling with large numbers of baby boomer retirements, a generation that includes approximately 80 million individuals, Generation X (those individuals born between 1966 and 1980), which is smaller and includes only some 60 million individuals, is expected to fill many of the leadership roles currently occupied by baby boomers.[109] With Generation X insufficient in size to fill resulting gaps, the FS and the DOI will need to ensure that their workforce strategies establishes the structures necessary to shape a new cadre of millennial-aged staff as leaders and managers earlier in their careers than did their predecessors. According to experts consulted during this review, the FS and the DOI should not undervalue experience, qualifications, and merit (and the time required to obtain them), but some existing policies and cultural factors can be an unnecessary impediment. For example, the current system often forces new hires with transferrable skills acquired outside the wildland fire management community to "relearn" those skills in a wildland fire-specific context. Similarly, it often demands that existing employees who have fireline experience and qualifications in one region complete additional training and exhaustive trainee assignments after transferring to a new region before they are considered qualified in that region.

WORKFORCE DATA

During a 2012 review that explored organizational restructuring, DOI fire leaders agreed that further analysis was necessary before moving forward because there is a lack of reliable data.[110] The assessment also concluded that inconsistent nomenclature and coding in personnel records negatively affect the ability of DOI bureaus to determine nationwide staffing figures for the wildland fire programs. Representations of staffing typically rely on FTE numbers, which represent the person-hours charged to wildland fire program appropriations, as it is difficult to track personnel consistently.[111] Numerous shifts of FTEs between the preparedness and suppression accounts over the past decade in the FS have exacerbated the challenge of tracking the workforce. Whereas most federal agencies can conduct detailed workforce assessments and develop well-informed workforce plans, the FS and the DOI lack the foundational data necessary to execute much-needed strategic workforce planning.

D. OPERATIONAL CAPABILITIES

OVERVIEW

This review defines operational capability as the ability to achieve mission goals and realize a guiding vision by effectively and efficiently applying processes, resources, and technologies. To assess the current and potential future state of wildland fire operational capability, the 2014 QFR assessed the operational functions and structures that exist to enable achievement of the vision outlined in the Cohesive Strategy. Key operational resources and functions include public awareness and education, integrated resource planning, strategic planning, infrastructure and facilities, the Interagency Fire Cache System, capital equipment (e.g., fire engines, water tenders), aviation assets, and IT (e.g., dispatch and mobilization systems, communication systems, weather forecasting and recording, computing, data analytics).

KEY ISSUES

AWARENESS, EDUCATION, AND PUBLIC ENGAGEMENT

The wildland fire management community uses several programs to engage the public about wildland fire-related issues. These communications programs fit into three broad categories:

1) Public affairs: Provision of information on wildland fire and fire events to news media

2) Public awareness: Messaging conducted at the local level by NGOs or by local, state, or federal agencies to notify the public about wildland fire risks in specific geographic areas (also known as disaster or hazard communications)

3) Public outreach: A variety of different forms of engagement—from national advertising campaigns to classroom lectures—on a wide array of issues concerning fire management and ranging from prevention of unplanned ignitions to the benefits of sustainable fire ecology on natural ecosystems.

[109] Catalyst, Ibid.

[110] DOI, *Interior Fire Program Assessment – Implementation Plan*, October 17, 2012, http://www.doi.gov/pmb/owf/upload/IFPA_Implementation-Plan-2.pdf, p. 4

[111] DOI, *Interior Fire Program Assessment – Implementation Plan*, p. 12.

Ranger Talk, Boise National Forest, 2012 (National Park Service Photo)

The community has recently undertaken a number of public education initiatives that advance or complement the Cohesive Strategy. Some of these initiatives include efforts such as the "Firewise Communities/USA" and "Ready, Set, Go!" campaigns and programs coordinated by the Fire Adapted Communities Coalition to improve local community and homeowner preparedness, situational awareness, and evacuation planning. Appropriately, the majority of these education efforts target communities at risk from fire events, primarily in the WUI.

One notable exception to the education efforts targeted at WUI communities is the "Wildfire Prevention" campaign epitomized by Smokey Bear. This long-running and extraordinarily well-recognized campaign, jointly supported by the FS, the Ad Council, and NASF, is nationwide in scope and is encapsulated by the motto, "Only you can prevent wildfires." The campaign has been important to furthering public safety and is much needed, as underscored by the fact that 90 percent of unplanned fire events are still caused by human ignitions.

Nonetheless, a critical finding of this review is that the wildland fire management community is lacking a complementary public engagement campaign to capitalize on public awareness about the benefits of fire ecology.[112,113] Such a campaign could raise public support for prescribed burns and the benefits of fire use in appropriate locations. Just as importantly, it could reassure the members of the community that its stated policies on the responsible and proactive use of prescribed fire are supported by the public. Social science research on public attitudes toward wildland fire indicates that:

- The public has a fairly sophisticated understanding of fire's ecological role and the environmental factors that can increase fire risk.[114]
- Active land management generally has greater citizen support than no-action alternatives for improving ecosystem health and reducing fire risk.[115]
- The public accepts the practice of prescribed fire for active forest management and tolerates the accompanying smoke.[116]
- The public expects and is supportive of the involvement of government land agencies in such educational efforts.[117]

Such a campaign could build on this existing public support for prescribed burns to highlight the benefits of wildland fire use in appropriate locations. Just as importantly, it could reassure the members of the wildland fire community that its stated policies on the responsible and proactive use of fire (prescribed and naturally ignited) are supported by the public. Such a campaign would require careful planning. It would likely require a new strategic education coordination body that could develop messages, informed by research, that would most effectively expand public understanding of the benefits of fire and ways to mitigate existing fire risk (e.g., defensible space, building codes) while not undercutting existing fire prevention awareness efforts. The initiative would build on the Ad Council's existing "Fire Adapted Communities"[118] campaign and would require development of a

112 "…fire policy decisions must have a strong public information component to address ignorance about the ecological role and benefits and risks of fire in ecosystems." Susan K. Jacobson, Martha C. Monroe, Susan Maryknowksi, "Fire at the wildland interface: the influence of experience and mass media on public knowledge, attitudes, and behavioral intentions," *Wildlife Society Bulletin* (Autumn, 2001), Volume 29, No. 3.

113 "Public education leads to greater understanding and acceptance of prescribed fire and to more meaningful public participation in fire policy debates." G.H. Stankey and S.F. McCool, "Visitor attitudes toward wilderness fire management policy: 1971-1984," *US Department of Agriculture, Forest Service* (1986), T.C. Daniel and J.G. Taylor, "Prescribed fire: public education and perception," *Journal of Forestry* (1984), p. 361–365, and M.J. Manfredo et al., "Attitudes toward prescribed fire policies: The public is widely divided in its support," *Journal of Forestry* (1990), p. 19–23, and Susan K. Jacobson and Susan Maryknowksi, "Ecosystem management education for public lands," *Wildlife Society Bulletin* (Spring 1999): Vol. 27, Number 1.

114 "Research Perspectives on the Public and Fire Management: A Synthesis of Current Social Science on Eight Essential Questions," Sarah M. McCaffrey and Christine S. Olsen, USDA Forest Service, Northern Research Station, General Technical Report NRS-104, September 2012, Accessed July 7, 2014. http://www.nrs.fs.fed.us/.

115 Ibid, McCaffrey and Olsen.

116 Ibid, McCaffrey and Olsen.

117 Riley Dunlap, et. al, "Health of the planet: results of a 1992 international environmental opinion survey of citizens in 24 nations," Gallup International Institute (1993); accessed October 3, 2014, not available online.

118 The Fire Adapted Communities campaign seeks to build understanding and acceptance within communities across the country of wildfire risk and encourage proactive steps to improve the safety and resilience of individual homes, landscapes, and community assets to withstand a wildfire. United States Forest Service and the Ad Council, *Fire Adapted Communities Campaign Fact Sheet*, http://fireadapted.adcouncil.org/campaign-background/.

long-running, national campaign using multiple channels for engagement—from mass media and social media to classroom education and direct engagement with communities.[119]

According to input gleaned from the 2014 QFR crowdsourcing participants, public engagement efforts should make use of clear terminology geared toward lay persons: many terms commonly used in the fire community, such as "WUI" and "defensible space," may be outdated or not intuitively understood and may hinder the intended message. Participants also offered that explaining the science of fire behavior could be useful in helping to debunk myths about how wildfires cause property damage. Finally, participants suggested that engagement efforts should be more collaborative, with members of the fire community also receiving education about the latest social research on public knowledge of and attitudes toward fire.

This review also found that the wildland fire management community is not taking systematic advantage of yet another opportunity to build public support for the beneficial uses of fire and fuels reductions, especially prescribed fire—publicizing its prescribed fire success stories. By contrast, anecdotes abound about the lasting risk aversion to the use of prescribed fire in the wake of the Cerro Grande (Los Alamos, New Mexico) fire of 2000, which began with a prescribed burn in Bandelier National Monument, New Mexico. Like the Oakland Hills fire, Cerro Grande was a signal fire event for the postwar era, as it spawned national news coverage and multiple investigative reports.[120] Despite the unintended consequences of the Cerro Grande fire, the reality—largely unknown to the public—is that federal land managers typically conduct hundreds of successful prescribed fires every year. Indeed, the community has a largely unrealized strategic opportunity to publicize prescribed fires for the benefits they yield, particularly the mitigation of damage that likely would otherwise be caused by unplanned ignitions in the same areas.

For example, on August 17, 2004, the Deep Fire in the Sequoia National Forest was contained at 3,143 acres. Concerns were extremely high about this fire from the time it started on August 12. It threatened a number of communities in Tulare County and had the potential to burn through groves of Giant Sequoia located in the Giant Sequoia National Monument. While the fire was costly to contain, estimated at $6.3 million, potential damage caused by the fire was substantially reduced thanks to several strategic fuel treatments Sequoia National Forest conducted in 1999, 2000, and 2001, with just this situation in mind. The Coffee prescribed burn project of 1999 and 2000 and the Slick Rock thinning/prescribed burn project of 2000 and 2001 provided essential strategic points from which firefighters were able to widen the containment lines, which eventually contained the fire. These fires are an excellent example of the value of strategically placed fuels reduction projects and are the kind of success story that could be publicized to further enhance the public's general support for prescribed fire.

A finding of interest in this area is that the wildland fire management community is saddled by risk aversion and overly steeped in traditional modes of fire and forestry management that prevent it from leveraging the public's general receptivity to the beneficial use of fire. Some researchers and thought leaders assert that the community is wedded to aggressive suppression because:

- Suppression is the most effective way to reduce short-term risk (while extending some long-term risk, particularly continued accumulation of fuels).
- There is a fire-industrial complex that encourages a suppression-first approach to fire management.
- The community finds it easier to demonstrate the effectiveness of suppression.
- The fire community is swayed by the most vocal members of the public, who are typically those whose health is most threatened by smoke or whose property is most threatened by fire destruction.
- Laws at the state and local levels in many areas across the United States mandate fire exclusion.
- For most of the 20th century, federal land managers operated under the assumption that wildland fires should be prevented or suppressed as soon as possible when they occur. The pride that the community takes in its initial attack suppression rate appears to be a symbol of the deepest values of the culture.

These assertions are difficult to prove, but could be substantiated through survey research on the opinions and the risk tolerance of federal, state, and local fire managers. A comparison of attitudes between the general public and

[119] According to F.J. Singer and P. Schullery, "Yellowstone wildlife: populations in process," *Western Wildlands*, (1989), "The negative media coverage of wildfires in Yellowstone National Park may have led the public to believe that fire annihilated life rather than created and enhanced habitats." Conversely, Cortner et al., "Public support for fire-management policies, *Journal of Forestry* (1984), p. 359–361, suggested that positive media coverage probably improved public opinion toward fire management in an Arizona study.

[120] Lessons Learned From the Cerro Grande (Los Alamos) Fire, testimony to the Committee on Energy and Natural Resources, US Senate, July 20, 2000, GAO/T-RCED-00-257 Cerro Grande Fire; Los Alamos Prescribed Fire: Investigative Report, Secretary of the Interior, May 18, 2000; Los Alamos Prescribed Fire, Independent Review Board Report, May 26, 2000.

members of the community could be useful in illuminating where there is alignment and where there are disconnects between it and the public and in identifying strategic opportunities for engagement, and also in mutual education. Indeed, some participants in this QFR suggested that the community has much to learn about and from the public.

STRATEGIC PLANNING

Unlike the DoD and the DHS, the wildland fire management community currently does little in the way of scenario development and analysis as part of its strategic planning function. This lack of scenario development and analysis is unsurprising, given declining budgets for planning and preparedness, differing organizational structures and processes across the community, and competing demands resulting from a need to send fire-qualified headquarters personnel into operational roles in response to hundreds of wildland fires every year. Nonetheless, this review found that the establishment of an enterprise-level process to engage in scenario planning for more extreme fire seasons and catastrophic events (e.g., a fire at the edge of a major city that causes a large loss of life and property in a short period) could be beneficial. Scenarios that test the limits of suppression capabilities would help key stakeholders better understand the upper threshold of the response capability for catastrophic events and spur development of contingency plans. Currently, the community lacks the ability to tell key stakeholders when and why the accumulation of stressors would leave it unable to respond effectively to protect public safety, property, and natural resources. Until very recently, the DoD's force planning construct has required the US military to maintain capabilities to fight two—but not three—major regional conflicts simultaneously. This mandate has informed the formulation of defense and foreign policy. By contrast, the wildland fire management community does not have a set of parameters for describing the number and types of major fire events it can manage simultaneously (i.e., a true definition of what "success" looks like).

The crowdsourcing effort conducted during this review yielded a noteworthy suggestion on "Organizational Border Theory," which was endorsed by multiple crowdsourcing participants. One commenter asserted, "The geographical interface between different fire management jurisdictions can prove to be complex places for initial attack. Cultural and technical differences[121] between fire organizations often lead to delays and conflicts until truly common operations are established. Studying human behavior with regard to these interface areas and developing proactive means to ensure seamless response (in addition to ICS) could help mitigate cultural dissonance."

This suggestion is consistent with other findings that the wildland fire management community lacks a forum for observing and improving the quality of human interactions in fire events, such as through interagency and interjurisdictional disaster simulations or games. These approaches to optimizing the human element of disaster response, used widely by the DoD and other disaster management agencies within the US government (e.g., DHS, FEMA), could prove beneficial to the fire management community.[122]

Structures for training and mentoring fire planners at various functional levels are also lacking. In findings presented to the NWCG executive committee in May 2011, the Interagency Fire Planning Committee stated that, "Fire planners find few or scattered applicable training opportunities. They rely heavily on informal networks, mentoring and self-teaching for professional development and the information they need."[123] The suggestion of the report to the NWCG, which holds long-range significance, is that the deliberate cultivation of a cadre of professional fire planners, trained in the same planning methodologies, could be an important contributing factor to the community's ability to transform itself from a reactive to a proactive institution.

An additional gap identified during this review is a structure for senior fire management executives and their key personnel to engage in long-range strategic planning that leverages alternative futures analysis to inform planning. The introduction of the strategic foresight methodology to the community during the 2014 QFR proved useful to helping participants identify a wide range of plausible alternative futures, which in turn promotes a more comprehensive and unbiased approach to strategic planning.

While the execution of the QFR represents buy-in from senior FS and the DOI fire leaders into the concept of futures-oriented planning, the wildland fire management community lacks existing processes or indigenous capabil-

[121] It is important to note that legal factors also play a role.

[122] "Response work best when it is tightly linked to preparedness. It is hard for responders to plan a response without closely coordinating their work with the officials analyzing the threats. It is even harder to develop critical close partnerships among all the participants if there are artificial dividing lines between preparedness and response. It vastly complicates the job of first responders if they need to establish separate relationships with officials charged with preparedness and response. Trying to switch team in the middle of a major event–or starting from scratch to build new teams in the middle of an event–would be even harder. Indeed, part of what complicated and delayed the response to [Hurricane] Katrina was the great difficulty of putting together new partnerships, from scratch and on the run." Donald F. Kettl, System Under Stress–Homeland Security and American Politics, (Washington, DC: CQ Press, 2007), p. 78–79.

[123] Interagency Fire Planning Committee presentation to the NWCG executive committee, May 24, 2011.

ity, at an enterprise level, to engage in ongoing (i.e., more frequently than every four years) environmental scanning, alternative futures analysis, and scenario-based planning. A nearly simultaneous 2014 study the FS Northern Research Station conducted uncovered essentially the same finding.[124] This limitation impedes identification of emerging strategic issues, planning for resulting gaps and opportunities, and effective communication to key stakeholders about actions that need to occur to address them.

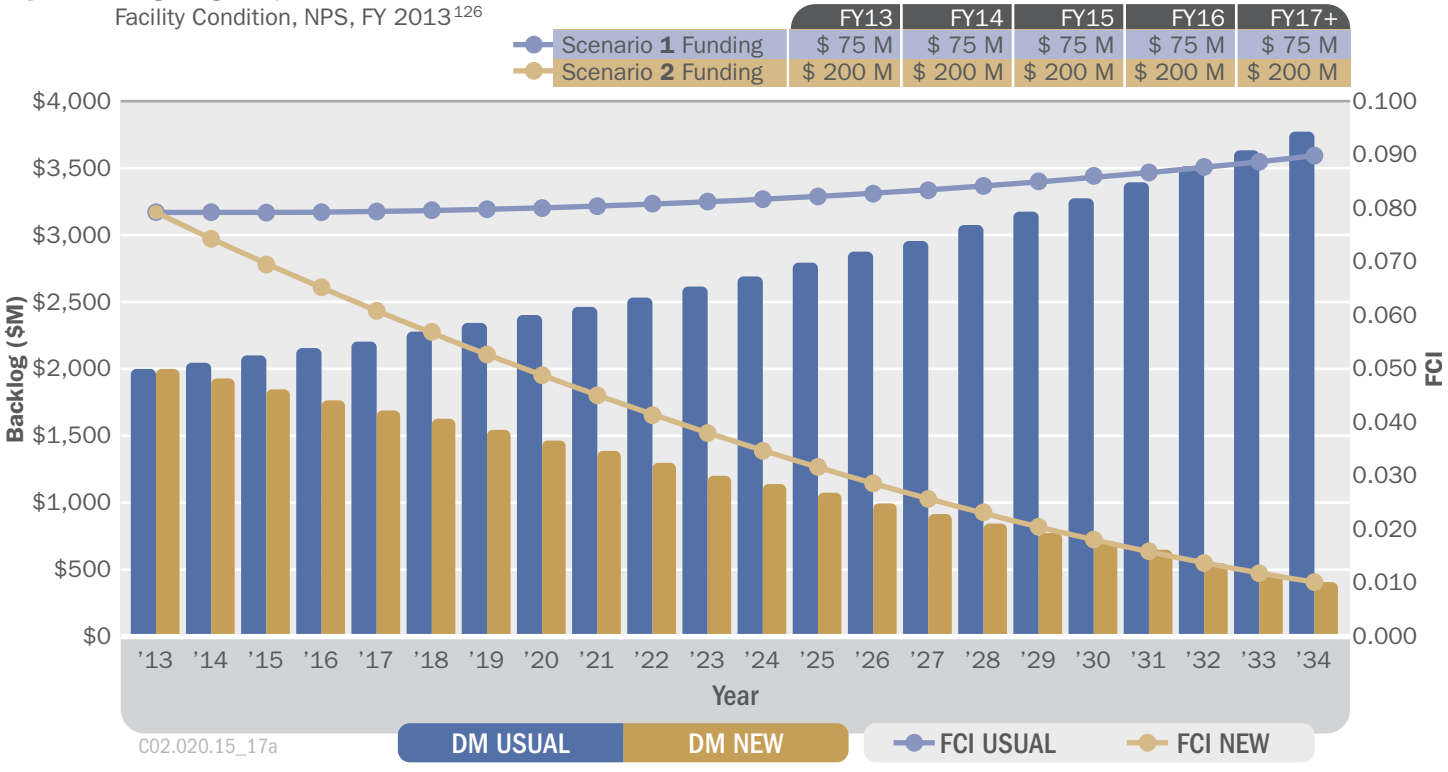
INFRASTRUCTURE, FACILITIES, CAPITAL EQUIPMENT, AND INTEGRATED RESOURCE PLANNING

Research conducted during the 2014 QFR identified significant shortcomings in wildland fire management community long-term planning capabilities for infrastructure, facilities, and capital equipment. There is no national-level interagency database for tracking the portfolio of infrastructure (e.g., roads, utilities) and constructed assets (e.g., barracks, engine bays, fire caches, hangars) that support operations. As a result, it can be extremely challenging to engage in fully informed, long-range, nationwide planning for infrastructure and facilities.

For example, each DOI bureau engaged in wildland fire management (the NPS, BIA, FWS, and BLM) uses the IBM Maximo® enterprise data management system, but there is no reliable way to determine systematically which constructed assets specifically support wildland fire management as Maximo lacks a dedicated field to do so.[125] Ideally, each federal fire management agency should be able to identify which constructed assets support wildland fire management, as well as the age, current replacement value, status of use, key components, deferred maintenance (DM) and other deficiencies, component renewal requirements, and condition as measured by the Facility Condition Index (FCI).

With this information, the wildland fire management community could develop 20-year projections of the facility condition and recapitalization requirements of its collective asset portfolio. Figure 18, using a tool developed by the NPS Facility Management Program for analyzing the entire NPS asset portfolio, demonstrates how such an analysis could inform facility planning.

Figure 18 Long-Range Projections of Deferred Maintenance and Facility Condition, NPS, FY 2013[126]



[124] FS, Final Report: Wildland Fire Management Futures: Insights from a Foresight Panel, July 2, 2014, not available online, p. 45.

[125] A keyword search of asset title fields is the only way to identify whether an asset supports wildland fire management; this method is highly unreliable.

[126] This data is provided for illustrative purposes and is not intended to represent comprehensive NPS facility needs.

Figure 19 DM Distribution by Region, NPS, FY 2013

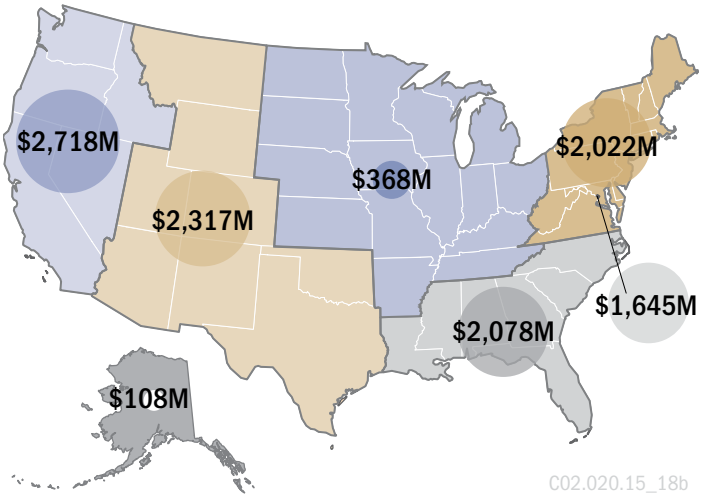


Figure 18 shows projected levels of DM for a subset of the NPS portfolio on the left y-axis and FCI on the right y-axis. The gray line shows DM increasing and FCI significantly worsening if the NPS can only invest 75 million dollars per year in recapitalization of its building portfolio. The green line depicts that the condition of the building portfolio would improve dramatically if the NPS could increase its recapitalization budget to 200 million dollars per year. This analysis is a standard exhibit in NPS's annual budget submission.

The ability to conduct an analysis similar to the NPS's would enable the wildland fire management community to identify its long-term facility investment needs and parse the analysis by geographic region, as shown in Figure 19. This type of analysis could become a more pressing requirement if wildland fire becomes more prevalent in new regions, thus requiring new facility investments.

Lacking precise data, DOI experts estimate the backlog of fire facility requirements to be approximately 100 million dollars. To maintain current capability, experts assert that 10 million to 12 million dollars annually will be necessary to replace existing facilities or to build new ones. Experts consulted during this review asserted that fire facility replacement cycles would project a much higher level of work than the current program supports and that the DOI and the FS must jointly develop a 10-year construction plan and a 20-year needs assessment before moving forward.

Many of the challenges associated with fire facilities management are also prevalent with fire equipment. Stemming from funding limitations, many bureaus use nonfire funding to assist with the purchase or replacement of fire vehicles. Furthermore, there is no national database for wildland fire equipment other than incomplete data captured by the Fire Program Analysis (FPA) system, a planning and budgeting tool originally established in 2002 in response to congressional direction that is now being decommissioned. As such, it is difficult to determine current equipment inventories or identify future equipment needs.

The FPA was intended to provide managers across the five land management bureaus with a common interagency process for strategic fire management planning and budgeting. The system required bureaus to compile data identifying suppression resources (e.g., staffing, engines, aircraft, others) and assigned those resources to an owner (management unit) and location. The FPA created significant workload at the field level, but resulted in the first-ever comprehensive mapping of the overall field-level wildfire suppression resource capability.[127]

A 2008 review by the Government Accountability Office determined that the FPA could identify when a particular mix of assets was more or less cost-effective than another, but it could not determine the most cost-effective mix and location of federal firefighting assets for a given budget. Furthermore, while the FPA could consider assets stationed at individual management units, it lacked the capability to examine centrally located assets or those under regional or national control (e.g., Type 1 interagency Hotshot crews and air tankers).[128] Although the FPA included many of the critical operational resources and provided a baseline for a national-level analysis, it did not include every facility that supports fire management operations, it did not capture data on replacement cycles and costs or infrastructure backlogs, and it did not provide a process for planning to meet future challenges in a rapidly changing environment.

The strategic planning limitations of the FPA are expected to be substantially addressed by the Wildland Fire Investment Planning System (WFIPS) currently under development. The WFIPS will likely serve as a system of record for national fire assets (such as engines, aircraft, and remote weather monitors), or at least contain comprehensive asset records, but the WFIPS will not serve as a system of record for real property, including buildings, hangars, and roads. Like the DOI, the FS is unable to use its infrastructure database system, the INFRA, to systematically identify constructed assets (real property) that support fire operations. No plans exist to improve INFRA capabilities in this respect. In fact, the INFRA is a far more limited tool than

[127] FS and DOI, *Fire Program Analysis Charter,* October 2010, http://www.forestsandrangelands.gov/WFIT/applications/FPA/documents/overview/FPA_Charter_20101014.pdf.

[128] GAO, *Wildland fire management: interagency budget tool needs further development to fully meet key objectives* (GAO-09-68), November 24, 2008, http://www.gao.gov/products/GAO-09-68.

Maximo, the facility management system the DOI uses. The INFRA does not have a work order management module, meaning that real property management is done less systematically within the FS than within the DOI, with fewer and less current data inputs and no searchable record of work performed. As a result, the FS can expect its facility portfolio to deteriorate faster than DOI's, and it will have less ability to strategically prioritize mission-critical facilities, including those that support fire management.

OPERATIONAL CAPABILITIES ASSESSMENT

A key finding of the QFR is that the wildland fire management community's ability to compare and articulate the relative value of each individual capability within its overall portfolio or describe the cost-benefit proposition for maintaining those capabilities is limited. Limitations in the ability to compare and articulate the relative value is due in part to the lack of data and well-substantiated key performance indicators (KPIs) for programs such as fuels management, fire support facilities, the fire workforce, and the community's various forms of fire suppression capability. For example, the lack of KPIs for measuring the marginal benefit of fire program capabilities and investments is demonstrated by the lack of consistency between the FS and the DOI in measuring the effectiveness of different kinds of aviation assets.

This review examined progress toward several of the 2009 QFR's aviation-related recommendations (see Appendix A) and found progress to be limited. Progress-limiting factors include a need for a more rigorous understanding of aircraft effectiveness and its relationship to fleet mix planning. The need for a better understanding of aircraft effectiveness and desired fleet mix is underscored by disagreement between the DOI and the FS on the appropriate types and mix of aircraft for wildland fire suppression and whether aviation capability is best obtained through a wholly owned or contracted fleet. In response to identified gaps in aviation capability and to significantly reduce safety hazards, the FS has embarked on a long-range initiative to acquire a significant number of air tankers and supporting aircraft. Consistent with the performance goals described in the USDA Forest Service Aviation Strategic Plan 2014–2018, the FS is preparing to acquire seven C-130Hs and as many as 15 C-23s and is considering acquiring C-130Js. While the FS expects a wholly owned fleet to improve operator safety and address the need for a more robust and reliable core capability,[129] there is a lack of consensus within the community that this is the optimal approach.

BaE-146 airtanker supporting the Carlton Complex fire in 2014 (Kari Greer Photo)

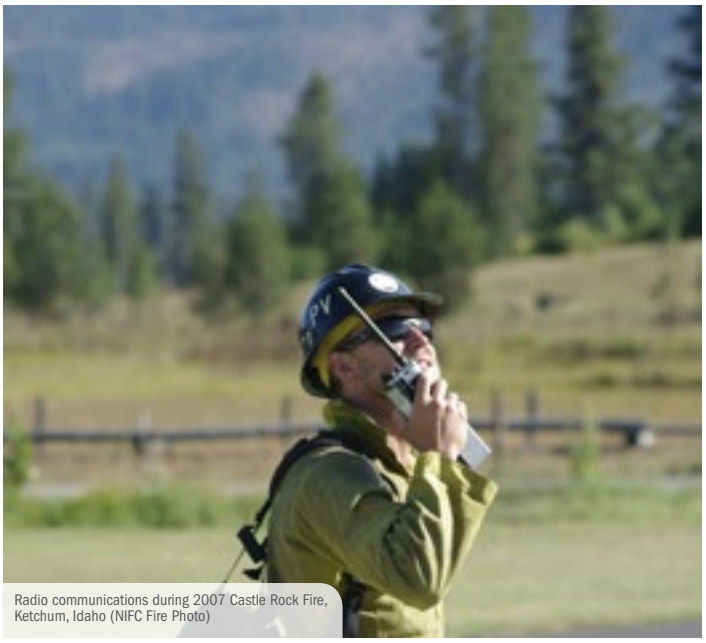
Differences of opinion exist across the community in part because neither the DOI nor the FS has a common set of metrics for evaluating the effectiveness of existing or planned aircraft in performing various operations—from monitoring to suppression—that are needed to demonstrate the costs and benefits of any given fleet mix.

But the need to develop data requirements, protocols, and KPIs to establish a common set of performance metrics is not limited to aviation and also includes, for example, fuels management, facilities, and workforce. During this review, both agencies noted that the wildland fire management community lacks a shared set of effectiveness measures for a variety of capabilities, which limits the ability of the agencies to engage in joint strategic and investment planning to ensure compatible and complementary approaches to the development of tactical capabilities and to provide for course correction when necessary. It is worth noting that the previously mentioned WFIPS, when launched, is expected to provide a robust planning capability for assessing operational requirements and the allocation of resources. Nonetheless, the WFIPS is not expected to be a substitute for a comprehensive operational capabilities assessment, including cost-benefit analyses of the relative value of various operational capabilities.

TECHNOLOGY—INFORMATION TECHNOLOGY SYSTEMS, DATA ANALYTICS, MOBILE DEVICES, UNMANNED AERIAL SYSTEMS, AND RESEARCH AND DEVELOPMENT

The interagency management of IT in the wildland fire management community is complex, like many other operational capabilities, but it is compounded by the technical complexity of IT itself, the terminology used to describe it, and

[129] An additional consideration for aviation management, although generally more tactical in nature than the long-range strategic focus of the QFR, is the emerging need for the establishment of an internal capability at FS-FAM to manage the sizeable administrative and programmatic requirements of aviation fleet ownership, i.e., an Aviation Program Management Office.



Radio communications during 2007 Castle Rock Fire, Ketchum, Idaho (NIFC Fire Photo)

incessant technological change that can undermine five-year strategic planning efforts that do not move rapidly. By design, the analysis for the QFR takes a longer range, a 10- to 20-year view. Technologies that will exist in 20 years are not necessarily predictable, but the QFR can offer perspectives on strategic approaches that will enable the community to take advantage of new technologies as they emerge.

The wildland fire management community's dispatch and mobilization system, along with associated common standards for wildland fire resource typing, have enabled it to provide comprehensive ordering, tracking, and mobilization of fire resources across diverse geographic areas and multiple layers of government. The system has greatly increased the capability and effectiveness of wildland fire operations over the past 50-plus years.

Both the 2005 and 2009 QFRs recommended seeking efficiencies in fire dispatch, mobilization, and the Resource Ordering and Status System (ROSS) through new technologies to support incident mobilization and resource coordination. Progress since 2009, however, has been limited. The NWCG assessed the ROSS in 2013 and recommended improving its usability and functionality.[130] Wildland fire experts consulted during this review believe a valuable upgrade to the ROSS would involve leveraging geospatial tracking capabilities through an enterprise geospatial portal and existing dispatching information data systems such as the Wildland Fire Computer Aided Dispatch System or the Selkirk Dispatch Situational Awareness Application through use of the Integrated Reporting of Wildland Fire Information System. Expanding the capabilities of the current system could provide enhanced operational capability in the future while improving firefighter safety.[131] Interviews conducted for the QFR revealed that the FS plans a comprehensive redesign of the ROSS in the near future, with enterprise architecture beginning as soon as 2015. It is unclear what enterprise-level integration may occur between the ROSS and other systems.

More broadly, this review found that an estimated 400-plus IT systems are currently in use across the community. At least 10 mobile applications for wildland fire now exist and dozens more can be expected in the near future. The interagency governance of IT systems in the federal wildland fire management community is difficult to untangle, with more than a dozen working groups, committees, and subcommittees and a thicket of reporting lines across agencies and departments.

The long-term, strategic direction for wildland fire IT has been a work in progress, though the emergence of the Wildland Fire Information and Technology (WFIT) initiative now offers a way ahead. In 2012, the WFIT Executive Board published a report, *Wildland Fire Information and Technology (WFIT)—Strategy, Governance, and Investments*, which outlined an approach to governance and management of the interagency wildland fire information and technology program that:

> *Creates an integrated and cohesive structure while maintaining the integrity of the reporting relationships of personnel within the USDA Forest Service and Department of the Interior wildland fire management programs. The structure is intended to provide a clear, single interface point between the wildland fire "line of business" and the investment decision-making structures of the two agencies, thereby creating a single, unified capability to identify requirements and priorities, to efficiently make investment decisions, and to manage all of those investments as a single portfolio.*[132]

A project plan, published in 2013, followed the report and initiated a four-phase plan for integrating governance and investment decisions. The plan is expected to run through 2015, at which time the community will be better able to assess the effectiveness of the plan.

[130] FS and DOI, *2014 QFR Report Card*, April 18, 2014, p. 18, http://www.forestsandrangelands.gov/QFR/documents/QFR_Report_Card_04182014.pdf.

[131] FS and DOI, Ibid, p. 19.

[132] Wildland Fire Information and Technology Project Plan, Wildland Fire Information and Technology Executive Board, March 22, 2013. Accessed August 6, 2014. www.forestsandrangelands.gov/WFIT/.../WFIT_ProjectPlan3-22-13.pdf.

Another specific area identified for exploration in this review is unmanned aerial systems (UASs). There is considerable and lively divergence within the FS and the DOI about the utility of UASs, the desirability of integrating them within its asset mix, and the prospect of UASs replacing manned aircraft. Some senior leaders interviewed for this report expressed skepticism about the cost and utility of UASs, asserting that any aviation function that can be accomplished with UASs can be accomplished more economically with the traditional aircraft already in use.

To the contrary, emerging evidence indicates that over the next 5 to 10 years, UASs may provide greater operational capacity and flexibility and reduce risk to personnel, at lower cost than traditional manned aircraft. One key role envisioned for UASs is to support persistent nighttime monitoring of fires, or even suppression operations, a capability that is currently lacking. Such a capability would empower fire planners with data to inform allocation of ground-based firefighting resources to attack fires in ideal conditions in the early morning, rather than having to wait until manned aviation resources arrive in the daylight hours. A November 2014 test at the New York State UAS test site explored the use of an optionally manned K-Max helicopter to conduct precise water and retardant drops. Such a capability, once operational, could potentially triple the amount of active aerial firefighting time over traditional methods and enable aerial suppression in ideal conditions (i.e., at night) or at times when other resources are grounded (i.e., periods of limited visibility resulting from weather or smoke).

Another high-potential application for UASs is their use singly or in groups as an integrated mobile system charged with collecting, analyzing, and transmitting data on fire conditions to personnel in hazardous situations. Such a system could consist of multiple types and sizes of UASs, deployed together to support IMTs by:

- Collecting current data on fire conditions (e.g., wind speed, wind direction)
- Transmitting fire condition data to national fire modeling systems that integrate a wide array of available inputs for real-time processing
- Distributing actionable information to firefighters via mobile devices
- Enabling real-time communications relay between disparate fire resources.

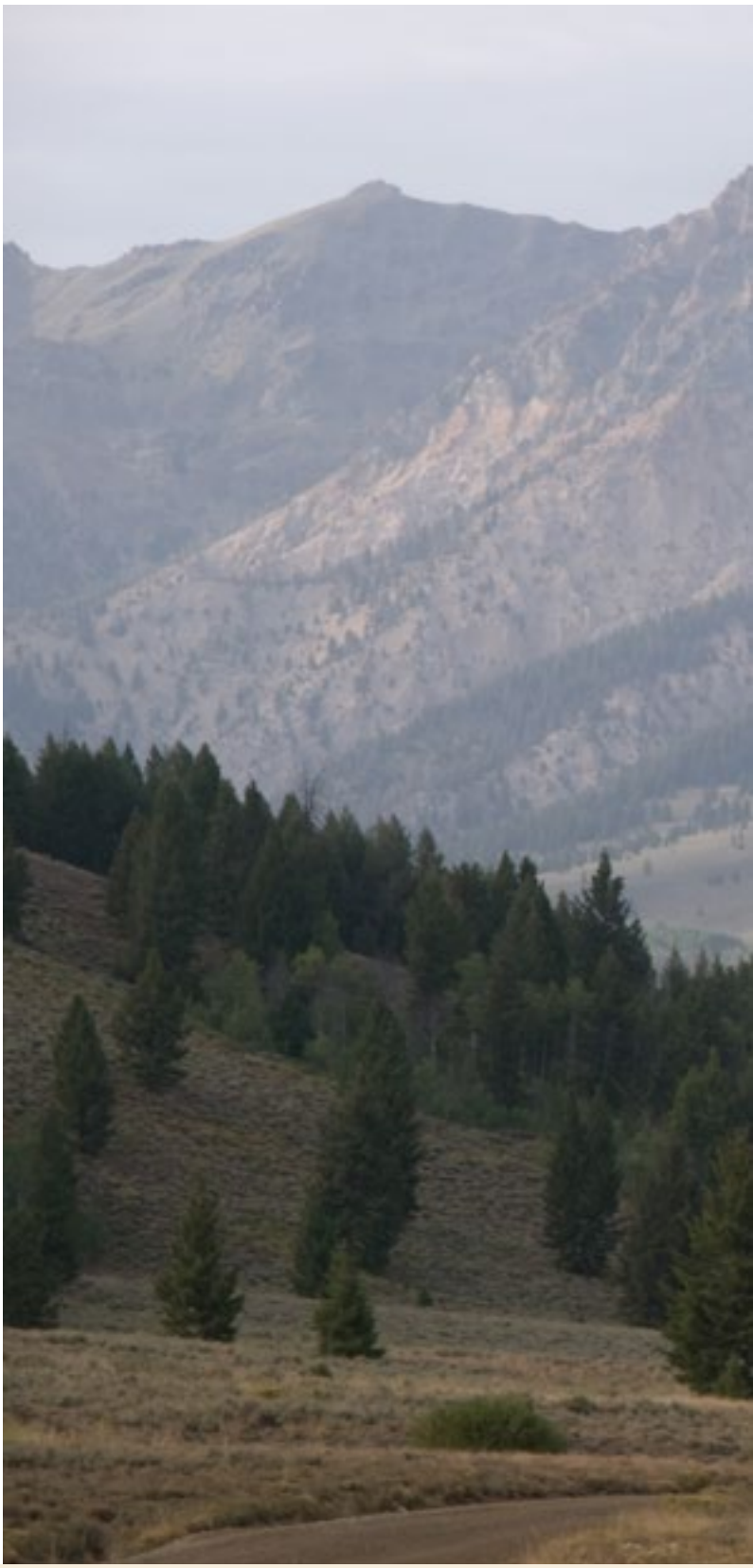
Wildland fire aviation personnel note a strong relationship with the Federal Aviation Administration's (FAA) unmanned aircraft office as a key enabler of progress toward the use of small, runway-independent UASs to collect data within temporary flight restricted (TFR) areas around fires. Nonetheless, obstacles remain in terms of the use of larger UASs (or optionally manned aircraft) to support suppression operations. These obstacles include FAA policy, which curtails the use of larger UASs that must transit to TFRs from distant runways, cultural barriers in a community that has relied on manned aircraft—and the pilots that fly them—for decades, and potential data bandwidth challenges[133] resulting from the simultaneous use of many UASs. Despite these challenges, when combined with advanced sensors, data analytics, and mobile applications, UASs can offer a broad array of potential benefits over the next 10 to 20 years.


Missoula Fire Sciences Laboratory, Rocky Mountain Research Station (Mark Finney Photo)

Research related to fire characteristics and behavior represents another area of opportunity. While numerous models are available today to forecast the expected spread of wildland fire, these models represent fire's physical processes using dozens of different interpretations. Differing interpretations about the basic principles of fire spread impede advancements in modeling, firefighter training, and strategic and operational planning. Recent work at the Fire Science Laboratory in Missoula, Montana, however, suggests a possible breakthrough. This research has shown that convection, not radiation, is the heat transfer mechanism by which wildland fire ignites fine fuels, such as pine needles, and that flame structure is a well-organized wave (not chaotic, as previously thought) that can be re-created in laboratory experiments. While this research is in its early stages, it is expected to inform adjustments to current fire models within three to five years that will allow more accurate predictions of fire spread and enhance training for firefighters. Ensuring the transition of this discovery from theory to practical application will require continued funding and attention from fire leaders at the FS and the DOI.

[133] Spencer Ackerman and Noah Schactman, "Almost 1 in 3 US Warplanes Is a Robot," *Wired* (January 1, 2012), accessed October 3, 2014, http://www.wired.com/2012/01/drone-report/.

A final strategic finding identified during this review is that the wildland fire management community lacks a well-defined innovation and technology agenda or list of priority areas warranting investment. Although the JFSP provides an avenue and significant funding to advance innovative science and technology, according to experts consulted during this effort, the community's approach to prioritizing JFSP initiatives could benefit from greater focus. A current best practice that is gaining prevalence in industry and in state and local governments across the United States is the Chief Innovation Officer (CINO).[134, 135] CINOs are typically multiskilled and although they often have a technical bent, they are distinguishable from Chief Information Officers (CIOs) in that they focus on establishing enterprise-level policies and procedures to maximize progress versus managing IT programs.[136] CINOs set innovation priorities for their organizations, help identify emerging concepts or technologies to address those priorities—either by fostering internal innovation or by building and sustaining bonds with external partners—and provide insight to inform leadership decisions about investment in specific areas.



[134] David Raths, "Will the Chief Information Officer Transform Government?" *Government Technology*, January 31, 2013, accessed September 29, 2014, http://www.govtech.com/e-government/Will-the-Chief-Innovation-Officer-Transform-Government.html.

[135] William Miller and Langdon Morris, Fourth Generation R&D–Managing Knowledge, Technology, and Innovation (Hoboken, NJ: Wiley, 1998).

[136] Chloe Green, "Rise of the Chief Innovation Officer – leading the way to transformational innovation," *Information Age* (April 9, 2014), accessed October 14, 2014, http://www.information-age.com/it-management/strategy-and-innovation/123457889/rise-chief-innovation-officer-leading-way-transformational-innovation.

Beaver Creek Fire, Idaho, 2013
(Kari Greer Photo)

Carlton Complex, Methow Valley, Washington, 2014 (Kari Greer Photo)

SECTION III:
FUTURES ASSESSMENT (10–20 YEAR OUTLOOK)

A. BACKGROUND

Weather and forces of nature have often changed the course of history in ways entirely unexpected. The Great Flood of 1862 in the Pacific West inundated 300 square miles of the Sacramento and San Joaquin valleys. Parts of Sacramento were covered in 10 feet of water. The flood destroyed an estimated one-quarter of the taxable real estate in California, driving the state into bankruptcy. With 200,000 cattle drowned, the state's economy shifted from ranching to farming, and grazing competition spawned the Owens Valley Indian War.

The Russian wildfires of 2010 were driven by the hottest recorded summer in Russian history. The Centre for Research on the Epidemiology of Disasters estimated that smoke from the fires and the accompanying heat wave resulted in a staggering 56,000 deaths, and Munich RE (a reinsurance company) estimated that damages from that fire cost 15 billion dollars. For a period, smoke blanketing Moscow doubled the daily mortality rate from 350 to 700.[137] The wildfires and the heat wave destroyed one-third of Russia's 2010 wheat harvest, and the Russian government set a grain export ban to fight inflation. The International Food Policy Research Institute has suggested that the resulting spike in world food prices contributed to the Arab Spring in late 2010.

In hindsight, the future often seems to have been preordained. Once an outcome is known, individuals are often deluded into thinking that that outcome was an inevitable consequence of the factors leading to it. This heuristic for making meaning of events, dubbed "creeping determinism" by psychologist Baruch Fischhoff, is commonly referred to as hindsight bias, and it has profound implications for how we understand the past, which we often interpret to be a single path to the present.

Similarly, individuals are often overconfident in their ability to determine future outcomes and insufficiently appreciative of the other factors beyond human control, especially weather and natural forces. The overconfidence effect, another form of pervasive human bias, imparts "unwarranted confidence in people's judgments of their abilities and the occurrence of positive events" and insufficient estimates "of the likelihood of negative events."[138]

With hindsight bias and the overconfidence effect in mind, the recognition of the following two basic facts can vastly improve strategic planning:

1) No one future is predetermined. Unpredictable forces of nature and unpredictable human actions can combine to create an endless number of possible alternative futures. Some futures can be expected to be more likely than others, with careful examination of current trends and conditions, but none are certain.

2) Planners in the fields of defense, security, and disaster management cannot afford the luxury of planning for just a desired future state; multiple future states must be contemplated and prepared for.

In an evolution from the 2005 and 2009 QFRs, the 2014 QFR deliberately explored a range of futures that could plausibly result from interactions among a number of trends, drivers, and shocks. This approach addresses a larger portion of the "realm of the possible" for the future of wildland fire management during the 2014 to 2034 timeframe. The resulting discussion and debate better equips the wildland fire management community for whatever future ultimately manifests. According to a 2008 study of managerial behavior conducted by researchers at Harvard Business School and Carnegie Mellon University's Tepper School of Business:

> *Interventions that force people to think about alternative perspectives, interpretations, or hypotheses are often effective at shaking people's overconfidence and inducing more accurate levels of confidence…In other words, thinking about why you might be wrong can help correct for the influence of [overconfidence].*[139]

The 2014 QFR intentionally questioned conventional wisdom in the wildland fire management community and sought to stretch stakeholders' imaginations. The authors of the 9/11 Commission Report[140] asserted that the US government's "failure in imagination" was one of the factors that allowed Al Qaeda to deliver a strategic surprise on 9/11.[141] Given the significant risk to firefighters, the public, and other values posed by a similar strategic surprise (natural or manmade), the QFR employed a variety of methodologies and tools to help stakeholders avoid tunnel vision. This study looked beyond the generally accepted future and postulates possible futures (before they occur) so that fire leaders might develop mitigation strategies to avert potential wildland fire-related crises or respond in a more agile manner if those crises do unfold.

[137] Munich RE (Group), Severe weather in North America, 2012, accessed July 2014, http://www.munichre.com/en/media-relations/publications/press-releases/2012/2012-10-17-press-release/index.html

[138] Leigh Thompson, *The Mind and Heart of the Negotiator*, 2nd ed. (Upper Saddle River: Prentice Hall, 2001).

[139] Max. H. Bazerman and Don A. Moore, *Judgment in Managerial Decision Making*, 6th ed. (Hoboken: John Wiley & Sons, 2009).

[140] A study conducted to examine the events leading to September 11, 2001.

[141] The National Commission on Terrorist Attacks Upon the United States, *The 9/11 Commission Report*, July 27, 2004, accessed August 15, 2014, http://www.9-11commission.gov/report/911Report_Ch11.pdf, p. 339.

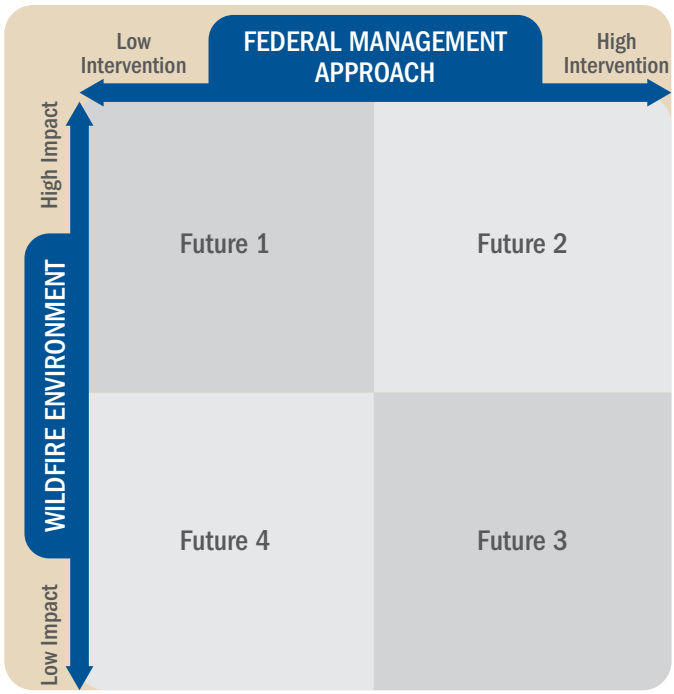
History proves that although historical trend data may indicate a single trajectory for the future represented via a linear extrapolation, shocks or brief divergences from trend lines can result in dramatic overcorrections and impacts. As one example, ecology experts broadly agreed that climate change is an inexorable force reshaping the wildland fire environment. At the same time, they also acknowledged that a period of above average precipitation or cooling, however brief, could occur within the next 20 years, creating significant opportunities. If not planned for, these situations could result in missed opportunities and exaggerated risks.

B. QFR STRATEGIC FORESIGHT APPROACH

Wildland fire experts and futurists who contributed to this QFR pointed out that the only assumption we can make about the future is that it is uncertain. This review is not intended to serve as a "crystal ball" for fire leaders, but rather, it is intended to provide a multidimensional planning framework for leaders to evaluate strategies and programmatic investments and gain important insights to inform decision making. This QFR identified the basic assumptions held within the community and then posed a question, *"What are we not currently seeing?"*

To help stakeholders look beyond the conventional wisdom in their communities, the 2014 QFR employed *Strategic Foresight* methodology. Strategic Foresight is a planning methodology that has been employed in industry and government since the 1970s to help leaders question preexisting assumptions, assess emerging challenges, and act to mitigate risk or capitalize on opportunity.[142] Within and beyond Strategic Foresight, the 2014 QFR team used a variety of tools, such as alternative futures and scenario-based analysis, to incorporate diverse perspectives, vet input, and play "devil's advocate" to challenge and refine strategic possible actions for consideration by federal wildland fire leaders. The Strategic Foresight approach for the 2014 QFR team included five major phases, as depicted in Figure 20.

Figure 21 Alternative Futures Matrix (Notional)



In Phase I, the QFR team worked with the FS-FAM and DOI-OWF to develop an alternative futures matrix to serve as the foundation for a series of workshops exploring alternative futures for wildland fire management. The resulting matrix has two axes, "Wildfire Environment" (ranging from low to high wildfire impact) and "Federal Management Approach" (ranging from low to high levels of federal intervention), as shown in Figure 21. This framework allowed workshop participants to explore four plausible and distinct outcomes, representing crosscutting trends and drivers shaping the future between 2024 and 2034.

Figure 20 2014 QFR Strategic Foresight Approach

[142] Royal Dutch Shell (RDS) was the first organization to integrate future-oriented scenario analysis in to its business planning. RDS's Director of Group Planning, Pierre Wack, presented RDS leadership with a set of scenarios in the early-1970s in an attempt to alter their perception that oil prices would remain low. Wack's exercises did not drive immediate changes, but RDS leadership was much better prepared to "think on its feet" when the 1973 oil crisis inflated oil prices. In response to the crisis, quick actions by RDS leadership transformed the company from a mid-sized player into a global powerhouse. Peter Schwartz, *The Art of the Long View* (New York, NY: Currency Doubleday, 1996), Chapter 1.

Phases II, III, and IV included 6 one-day alternative futures workshops; each workshop gathered 16 to 24 participants from across the United States. In these workshops, participants identified the trends driving each potential future and outlined the characteristics of each future in the year 2034.[143] In Phase V, the QFR team presented the output of those workshops to the broader array of wildland fire stakeholders using a web-based crowdsourcing forum to gather additional input.

C. QFR ALTERNATIVE FUTURES

The QFR process resulted in the following four plausible and distinct alternative futures for wildland fire management in 2034:

1) High impact, low intervention: "Hot, Dry, and Out of Control"

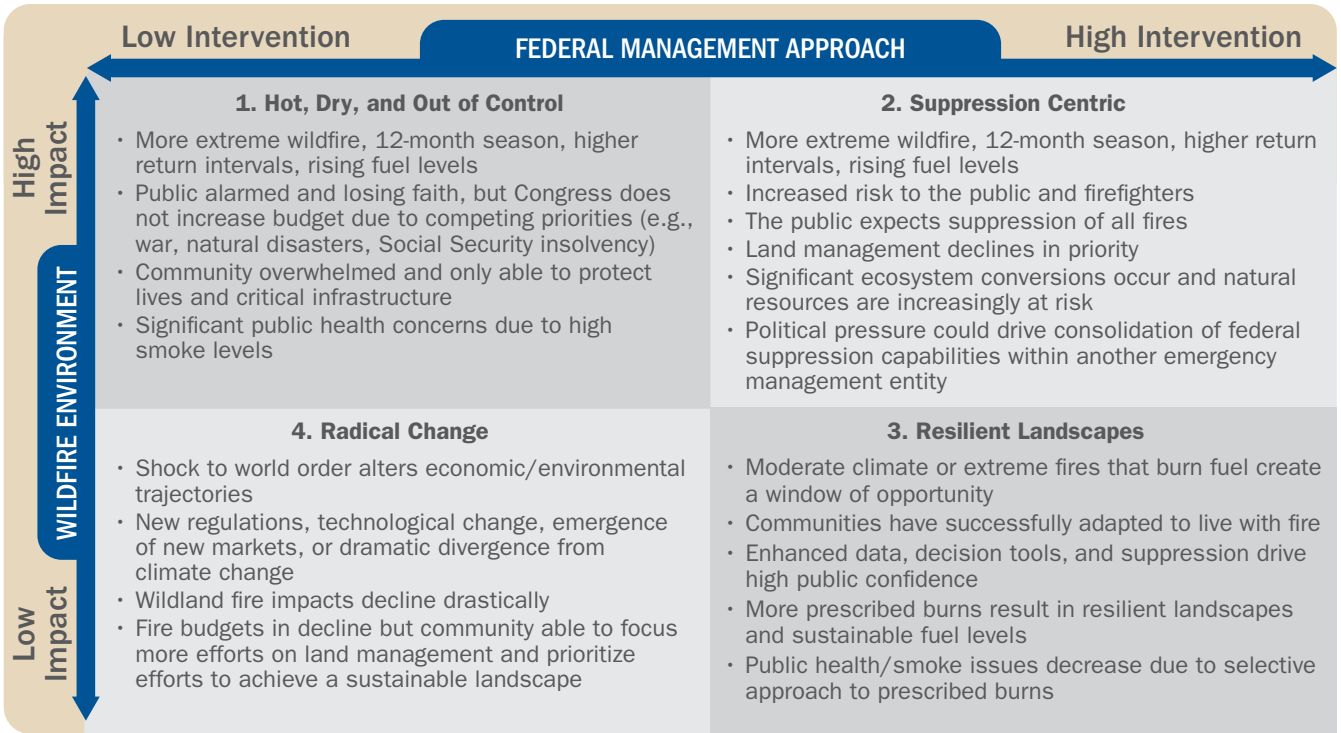
2) High impact, high intervention: "Suppression Centric"

3) Low impact, high intervention: "Resilient Landscapes"

4) Low impact, low intervention: "Radical Change"

The matrix in Figure 22 details the characteristics of those four futures, developed based on input gathered during the alternative futures workshops with wildland fire stakeholders, as well as in subsequent engagement using crowdsourcing. Each future reveals challenges and opportunities, some obvious and others more subtle. While some futures may appear preferable to or more likely than others, all present important considerations for federal fire leaders about the future of wildland fire management. The four sections that follow describe each alternative future in detail.

Figure 22 Alternatives Futures Matrix (Completed)



[143] The QFR team conducted workshops in Missoula, Montana; Boise, Idaho; Denver, Colorado; and Washington, DC. It also facilitated two condensed sessions with FS-FAM and DOI-OWF fire leaders.

FUTURE #1 : HOT, DRY, AND OUT OF CONTROL

HIGH-LEVEL CHARACTERISTICS			
Fire Management Budget	**Public Understanding & Acceptance of Fire**	**Values at Risk**	**Environmental Factors**
Declining	Low	High	Increasingly Difficult

Extreme wildfire is occurring over a 12-month fire season across much of the country. Firefighter casualties are mounting, fires are resulting in increased damage to property and significant smoke concerns, and a smaller federal government (relative to 2014) is facing a plethora of other challenges, both foreign and domestic, that have relegated wildland fire concerns to a lower priority level. With federal wildland fire management budgets on the decline due to reallocation by Congress to other priorities, and the states challenged to fill the resulting gaps, agencies at all levels are overwhelmed and under-resourced.

TRENDS LEADING TO FUTURE #1 (2014 TO 2034)

1 To arrive at this future, the wildland fire management community would have contended with a plethora of challenges in the previous 10 to 20 years. These challenges would include rising temperatures and decreased snowpack across the United States, continued lengthening of the fire season, drought-related water shortages in the West and Southwest, extreme weather (i.e., wind, dry lightning events), continued fuels accumulations combined with a decline in prescribed burning and other fuels treatments, habitat-type conversions, and exposure of new areas of the country to wildland fire risk. This future would feature a nation distracted by nonfire events (e.g., Social Security insolvency, sea level rise and related natural disasters, overseas conflict), as well as a constrained federal budget resulting from a fiscally conservative Congress and negative public sentiment about the role of the federal government. The community would face a decline in funding relative to a rapid expansion of demand for its capabilities. A concurrent rise in firefighter casualties could also lead to a loss of public confidence about the status quo approach to wildland fire management, and the public could begin to look for solutions outside government.

***Note:** A significant number of alternative futures workshop and crowdsourcing participants agreed that indicators suggest the community is driving toward this future already, and barring changes to current policy or implementation, it is very likely to become a reality.*

The combination of these factors could lead federal wildland fire management agencies to transfer funding at even higher levels from other program areas (e.g., fuels reduction, resource management programs) to suppression and result in extremely harsh prioritization of that funding to focus only on protecting lives and the most critical infrastructure. With shrinking federal assistance available to states and municipalities struggling to meet increased suppression demands, fuel treatments and all other management efforts, except for aggressive suppression, would be in decline. Recognizing a void in available resources at all levels of government, communities would slowly adjust building codes at the local level, adopt Firewise, create CWPPs, and sometimes hire contracted fire firefighters.

DETAILED CHARACTERISTICS OF FUTURE #1 (IN 2034)

Environmental and Fire Conditions. Stemming from accelerating environmental change from 2014 to 2034, the community faces extreme wildfire conditions. These conditions feature 12-month fire seasons in many parts of the country, higher fire intensity and destructiveness, and fires in other areas of the country that have not experienced wildfire in more than 100 years. Furthermore, due to an increase in biomass loads, expansion of exotic or nonnative species, and substantial increases in insect and disease impacts from changes in average temperatures, forest flammability is at an all-time high. Fire behavior is now so extreme that, because of safety concerns, the community is limited in terms of what fires it can suppress with ground forces alone. With fire agencies prioritizing suppression to protect an expanding WUI and associated infrastructure, other values (e.g., timber and mineral industry, at-risk species, national forests and parks) are increasingly at risk. While fuel levels are expected to decline over the long term due to burnt landscapes, fire is in the meantime driving an increased prevalence of smoke-related health issues, particularly in the West, Southwest, and Southeast.

Public Policy and Economics. Insurance companies have backed away from offering insurance to WUI residents because of a perceived increase in risk and a decreased willingness of Congress to "bail out" residents affected by fires. Only those households able to undertake mitiga-

tion-oriented improvements to their homes can maintain insurance coverage. Sea level rise, population increase, and baby boomer retirement is driving a continued expansion of the WUI, even in the face of stricter insurance standards and expanding risk, further exacerbating the problem. The use of privatized fire protection is on the rise, largely based on demand from wealthy citizens, insurance companies, and communities.

Fire Workforce and Technology. With budgets stretched, the FS and the DOI can no longer afford to operate large air tankers, and these agencies have largely moved away from aviation because of funding limitations. With the exception of tankers contracted by the few states that can afford them, the Air National Guard provides the majority of large air tanker support across the country. These aircraft are only available for deployment on fires that pose great risk to lives and critical infrastructure. While the federal government still employs wildland firefighters and land managers, they employ both in smaller numbers. Budget cuts have also forced a consolidation of the community's built infrastructure. Despite progress in the 2000s toward alleviating the burden of all-hazards response on the wildland fire agencies, a plethora of new sea level-related natural disasters are again stretching the community's resources. To allow for risk-informed allocation of limited resources, fire agencies have—out of necessity—invested significant funds to develop new joint fire modeling tools to predict and avoid or prepare for ignitions and fire spread.

Happy Camp Fire, Klamath National Forest, California, 2014 (Kari Greer Photo)

POSSIBLE RISKS AND OPPORTUNITIES IN FUTURE #1

POSSIBLE RISKS	POSSIBLE OPPORTUNITIES
• Decline in roles, responsibilities, budget, personnel numbers, and influence of federal wildland fire management community • Increased smoke and an aging society elevating health risks to large groups of the public for an extended period of time • Loss of access to recreational opportunities and natural resources (e.g., timber, minerals) and increased risk to endangered species due to limitations on management capability and a need to prioritize protection of lives and critical infrastructure	• Communities might lack resources to undertake suppression efforts at 2014 levels, but fiscal realities could engender a greater degree of risk acceptance and more "opportunistic" use of fire (natural and prescribed) to manage fuels • This future could over time, result in public more adapted to and accepting of fire, healthier ecosystems, and more sustainable landscape • A realization that fire suppression as we know it is unsustainable, forcing difficult transitions at all levels of government and society

FUTURE #2 : SUPPRESSION CENTRIC

HIGH-LEVEL CHARACTERISTICS			
Fire Management Budget	**Public Understanding & Acceptance of Fire**	**Values at Risk**	**Environmental Factors**
Rising; Suppression Prioritized	Low	Very High	Increasingly Difficult

Like in Future #1, extreme wildfire is occurring over a 12-month fire season in many regions. Fuel loads are at an all-time high and the WUI is continuing to expand; however, efforts to achieve fire-adapted communities have been ineffectual. Significant public and firefighter casualties, structure loss, and impacts to other values have resulted in immediate and drastic action by Congress aimed at a "quick fix." The result is a transfer of fire suppression capabilities from the FS and the DOI and their consolidation under another federal emergency management entity charged with suppressing all fires at almost any cost. The resulting organization lacks land management responsibility, which the FS and the DOI retain, albeit with lower budgets.

TRENDS LEADING TO FUTURE #2 (2014 TO 2034)

2 To arrive at this future, the wildland fire management community would have contended with a plethora of challenges during the previous 10 to 20 years. These challenges could have included rising temperatures and decreased snowpack across the United States, continued lengthening of the fire season, drought-related water shortages in the West and Southwest, extreme weather (i.e., wind, dry lightning events), continued fuels accumulations combined with a decline in prescribed burning and other fuels treatments, habitat-type conversions, and exposure of new areas of the country to wildland fire. Because of public opposition to the use of prescribed burns, new EPA standards that regulate smoke to limit health impacts, a decline in the wood products industry, and decreased grazing on public lands, this future would also include a significantly accelerated fuels buildup. Concurrent rapid expansion of the WUI resulting from a strong economy and the limited success of efforts to achieve fire-adapted communities would result in increased numbers of ignitions and an increasing convergence of fire with a public neither conditioned to nor tolerant of wildfire.

Facing these extreme conditions, the community would have inevitably encountered a series of massive wildfires (resulting from natural and human ignitions, the latter potentially including pyroterrorism) that overwhelmed its capabilities, resulting in hundreds or even thousands of casualties and thousands of homes lost. Such fires could occur across multiple states and in major suburban or urban areas that are not well conditioned or adapted to fire. This type of occurrence would shake public confidence and place enormous scrutiny from the public, the media, and Congress on the historical approach to wildland fire management. Facing pressure to take immediate action, Congress could initiate a consolidation and/or reorganization of the wildland fire management community in the late 2020s (akin to the post-9/11 creation of the DHS), accompanied by an increase in funding for suppression-related programs.

DETAILED CHARACTERISTICS OF FUTURE #2 (IN 2034)

Environmental and Fire Conditions. Because of accelerating environmental change between 2014 and 2034, the community faces extreme wildfire conditions. These conditions feature 12-month fire seasons, higher fire intensity and destructiveness, and fires in areas of the country where they have not occurred in more than 100 years. Due to an increase in biomass loads, the expansion of invasive species, and insect and disease infestations resulting from changes in average temperatures (warmer weather and shorter winters), forest flammability is at an all-time high. Stemming from the volume and intensity of fires, smoke is affecting 30 percent of the population of the United States annually and is driving considerable disillusionment from air quality concerns and lifestyle disruptions. Aggressive suppression is limiting negative societal impacts of fire, but an inability to achieve positive ecological effects through prescribed burns, other fuels treatments, and opportunistic use of fire means that much of the country is a tinderbox and conditions are continuing to deteriorate.

Public Policy and Economics. Wildland fire management components and programs historically focused on suppression now align under another federal emergency management entity that leads fire suppression across the country, whereas the FS and the DOI continue to lead land management efforts, albeit at decreased budget levels. Part of the DHS and/or FEMA, this entity has a disaster management mentality, and Congress has been appropriating significant funds to enhance suppression operations. Stemming from rising fear, a perception that all fire is "bad," the increas-

ing prevalence of catastrophic megafires, and the illusion that the federal government will be able to fully protect the public's interests, most communities have still not become fire adapted. Wildland fire policy now overwhelmingly emphasizes full suppression of every fire with the potential to impact lives, resources, or public infrastructure. The entity charged with leading suppression on federal lands is extremely risk averse and constrained by policy that prevents it from opportunistically leveraging fire to achieve positive ecological effects.

Fire Workforce and Technology. The suppression budget is at an all-time high and is enabling the acquisition of new types of high-technology firefighting equipment (including a wholly owned, modern, large air tanker fleet). Nevertheless, firefighting remains dangerous and labor intensive. Facing increasingly stressful conditions, firefighters are exhibiting conditions similar to PTSD and are demanding and receiving better access to psychological health resources. The land management agencies are suffering attrition among nonfire-funded incident management experts recruited to staff suppression roles, resulting in significant knowledge gaps. In addition to firefighters, highly trained data analysts capable of accessing fire-modeling data, projections, and imagery are also deploying to the fire line. Small, low-cost satellites, ground-based remote sensors, and small, long-endurance UASs are operational and providing real-time, wide-aperture imagery that can quickly identify

Two-Day Burn Operation during 2013 Elk Complex Fire in Idaho (Kari Greeer Photo)

the outbreak of fires across the country. The program is exploiting new aviation capabilities to directly pinpoint retardant drops, strategically deploy firefighting resources, and mitigate risk to personnel. At the same time, new aerial deployed robotic mules are increasingly deploying with firefighting teams to carry more equipment and enhance their ability to access difficult terrain.

POSSIBLE RISKS AND OPPORTUNITIES IN FUTURE #2

POSSIBLE RISKS	POSSIBLE OPPORTUNITIES
• Separation of land management from fire suppression could result in declining budgets and influence for land managers (given the emphasis on suppression) • Continued aggressive suppression could further exacerbate already unsustainable trends in biomass loads and set the stage for potentially more catastrophic future fires • Continued expansion of a nonresilient WUI • A rising perception among the public that fire is not a natural component of the ecosystem; resistance to building local community resilience • Large-scale suppression, including the use of new mechanized ground equipment to access difficult terrain, could result in increasing damage to watersheds and critical habitat • Overarching issues of smoke and fuels deficits will continue to increase • Decimation of fire-related intellectual capital at land management agencies resulting from their recruitment to another federal entity charged with suppression	• Wildland fire management community elevated to national prominence • Able to make significant investments to replace obsolete infrastructure, acquire new equipment, and provide higher levels of training and other benefits to the workforce • Improved firefighter safety through acquisition of new technology • Possibility of cost savings and efficiencies over time (e.g., from new commonalities in equipment, combined IT systems, streamlined business processes)

FUTURE #3 : RESILIENT LANDSCAPES

HIGH-LEVEL CHARACTERISTICS			
Fire Management Budget	**Public Understanding & Acceptance of Fire**	**Values at Risk**	**Environmental Factors**
Status Quo	High	Steady Decrease	Moderating

Fuel loads and fire severity are on the decline as a result of favorable environmental conditions, greater public tolerance of unplanned ignitions and prescribed burning, and a greater preparedness and resilience of communities due to Cohesive Strategy efforts. Risks to firefighters and the public are also declining due to significant acceptance of the fire-adapted community concept. The wildland fire workforce is evolving toward a model that includes larger numbers of ecologists and land managers and fewer firefighting resources.

TRENDS LEADING TO FUTURE #3 (2014–2034)

From an environmental perspective, several parallel trends between 2014 and 2034 could lead to this future. These trends could lessen the need for aggressive fire suppression and offer the "breathing space" to achieve positive changes in wildland fire management. One trend could be a period of extreme fire that consumes large quantities of fuel in parts of the country without significantly affecting lives, property, or infrastructure as a result of increasingly effective suppression techniques and increased local community resilience.[144] Another trend could feature higher precipitation and temperature reductions in other areas of the country, such as the Pacific Northwest, northern California, and the Southeast.

The 10 to 20 years leading up to Future #3 could feature effective implementation of the Cohesive Strategy through highly effective, targeted, and tailored outreach by the wildland fire management community to enhance public understanding of the positive benefits of fire, promote personal responsibility and fire-adapted communities, and offer grants to municipalities to enhance resilience. Public confidence in wildland fire management would be on the rise due to (a) investment in new technology to enhance decision making during suppression and to track impacts of fuels management and (b) improved insurance claim processes for damage reimbursement associated with prescribed burning. Political leaders would be more accepting of moderate risk-taking by fire managers and less apt to rebuke the community for occasional mistakes because they would perceive increasing ROI from fuels management and decreasing risks.

DETAILED CHARACTERISTICS OF FUTURE #3 (IN 2034)

Environmental and Fire Conditions. Fuel loads remain high after decades of aggressive suppression efforts in the 20th century and early 21st century, but because of habitat-type conversions, milder weather in the Pacific Northwest, increased employment of prescribed burning, and more opportunistic use of wildfire, fire risk is declining. Although fires are still occurring regularly, the severity of those fires has lessened and fires are resulting in positive ecological changes in the natural environment and decreased risk for firefighters and the public. The community is achieving higher ROI for its wildfire management practices than it has historically and it is effectively documenting and publicizing its success through outreach (e.g., stories about prescribed burning in the Southeast, fire-adapted communities in the West, effective suppression in California).

Public Policy and Economics. The public increasingly tolerates fire on the landscape as a result of effective and wide-reaching educational engagement that promotes acceptance of wildland fire. Wildland fire management policy is largely unchanged since 2014, and fire agencies are better able to leverage the full range of options offered by the existing policy for various reasons. First, Congress's changing perspective on fire has enabled a cultural shift that allows fire leaders to move away from the "war on fire" model and to make more strategic choices about which fires to suppress and which to manage. The community's budget remains flat since 2014, but it has been able to dedicate larger parts of its budget to strategic land management efforts and robust implementation of the Cohesive Strategy for education and risk mitigation in WUI communities. Other supporting factors included enhanced decision support models, real-time fire and weather assessments, and effective public outreach. With individuals increasingly employing home resilience measures, fire insurance for WUI property is more readily available to residents whose homes pass inspection (along the lines of flood insurance).

Fire Workforce and Technology. The community is less focused on aggressive fire suppression and the wildland fire workforce is increasingly integrated with land management, thus requiring fewer firefighters and other suppression

[144] Workshop participants suggested that a megafire that caused hundreds of casualties could lead to a "kneejerk" reaction (e.g., consolidation of suppression capabilities within another federal emergency management entity). They also noted that a megafire that damaged a national treasure (e.g., a prominent national park or icon) might lead to public pressure for a different approach, perhaps to include better use of prescribed fire as an integral part of land management.

resources. Advances in unmanned air, ground, and stationary monitoring systems dedicated to real-time fire monitoring are resulting in greater firefighter safety. In an effort to sustain the downward trend in fuels, the community is leveraging new robotic technologies for mechanical fuels reduction and employing better modeling to execute prescribed burning safely and measure the positive impacts of both efforts.

Shenandoah National Park (National Park Service Photo)

POSSIBLE RISKS AND OPPORTUNITIES IN FUTURE #3

POSSIBLE RISKS	POSSIBLE OPPORTUNITIES
• If the community is not adequately prepared to identify and act on a window of opportunity to change perceptions about the current path of wildland fire management, more extreme wildfires (akin to those depicted in Futures #1 and #2) become more likely	• Long-term climate trends suggest warming is highly likely, but several years of moderate climatic conditions are not implausible, and natural or human-created conditions could allow the community to begin addressing decades of fuel buildup • A period of cooler, wetter years could offer a window of opportunity to condition the public to unplanned ignitions and prescribed fire, thus evolving current approaches to be more in line with policy in a sustainable manner • Future #3 could allow reallocation of budget away from hugely expensive suppression operations toward land management

FUTURE #4 : RADICAL CHANGE

HIGH-LEVEL CHARACTERISTICS			
Fire Management Budget	**Public Understanding & Acceptance of Fire**	**Values at Risk**	**Environmental Factors**
Decreasing Budget, Stabilizing Economy	Potentially Increased (depending on path)	Rapid Decrease	Significant Moderation

A shock to the world order has altered the path of 21st century economic and environmental trajectories in a drastic manner. The number and severity of wildland fires and the associated risks to the public are in decline due to unpredicted changes in the natural environment, new building codes and regulations imposed on WUI residents, and/or the emergence of new technologies and markets. Congress has exercised cuts to wildland fire management budgets, but the community has been able to achieve extremely high success rates with suppression operations around urban areas.

TRENDS LEADING TO FUTURE #4 (2014 TO 2034)

Future #4 would feature changes between 2014 and 2034 based on drivers that are more unexpected than in any other future and that have impacts that could be more drastic and widespread than any other future. This future might feature climatic conditions, such as rising temperatures, decreased snowpack, and drought, but radical economic, climatic, demographic, or political shifts could mitigate the impact of climate related-changes in the behavior of wildland fire and lessen the need for federal involvement in wildland fire management in many areas of the country. Another event that could create this future would be a "Krakatoa-like" event that spews so much ash, dust, and other particulates into the atmosphere that climate change is reversed for a period of a decade or longer.[145]

The changes leading to this future could range from new and drastic government regulations, radical population shifts, the emergence of new markets, or game-changing technologies. For example, new regulatory measures requiring fire-adapted architecture and materials in combination with vegetation thinning around new properties in WUI and rural areas could drive a migration into cities for those who could not afford such measures. Similarly, a dramatic shock to energy markets from geopolitical strife or a new carbon tax regime could make fuel for personal transportation unaffordable, thus driving a shift toward urbanization.[146] With the resulting depopulation of the WUI, fewer human-caused ignitions would occur and those that did lead to fire would have less impact on populations (and thus less media attention and associated spreading of fear). Furthermore, the emergence of commercially viable nanocellulose products and other new technologies could drive a revitalization of timber and other extractive industries and lead to extremely high levels of biomass consumption, effectively eliminating the "fuels deficit" and resulting in lower fuel loads on the landscape.[147, 148, 149]

DETAILED CHARACTERISTICS OF FUTURE #4 (IN 2034)

Environmental and Fire Characteristics. Fuel loads are declining rapidly as a result of two primary factors. The First is the emergence of new industries that mechanically extract large amounts of biomass and process it to produce consumer items. The second is the increasing ability of the wildland fire management community to let backcountry fires burn naturally due to declines in the WUI and rural populations and an increasingly fire-adapted community for those that remain. While warming trends are extending the fire season and large numbers of fires still occur, fire severity is in steep decline and megafires have disappeared almost entirely from the landscape. In areas where commercial harvesting cannot occur because of regulations or limited access (i.e., NPS or FWS land or Alaska), the community has been able to do increased prescribed burning without major pushback from the public stemming from declining overall smoke levels that have resulted from fuels treatments on huge swaths of FS, BLM, and BIA land.

Public Policy and Economics. The federal wildland fire agencies face challenges to their continued relevance from the declining prevalence of extreme wildfire and the fact that the WUI, an area that presented significant risk in the early 21st century, is increasingly depopulated or fire adapted (in areas that can afford to be). Policy now prioritizes highly effective suppression operations around the

[145] Workshop participants discussed the possibility a dramatic environmental change induced by a global cooling driver (e.g., meteor/asteroid, massive volcanic eruption, nuclear detonation) could also lead to this future, but tabled the discussion because wildland firefighting would not likely be a high priority for the federal government in such a future.

[146] A rapid increase in mortgage interest rates or a repeal of the mortgage interest deduction for second homes could also drive a decline in WUI expansion.

[147] For reference, see: Mitch Jacoby, "Nano From the Forest," *Chemical Engineering News*, June 30, 2014. Participants discussed how rising oil prices could make bioenergy a viable with similar affects.

[148] Participants discussed reforestation with plants and trees genetically modified to be fire adapted.

[149] In an extreme scenario, participants noted that a total economic collapse could lead individuals to rely on wood and plant products for heating, thus arriving at reducing fuel loads.

edges of major urban areas to prevent the spread of fires into major population areas. Because only small numbers of residents live in rural areas outside of expanding WUI rings around urban centers, the community is able to manage wildfires through monitoring and limited resource engagement, letting the majority of fires burn out naturally in wildland areas. As a result, communities that remain in WUI or rural areas rely primarily on the fire-adapted nature of their communities and, when necessary, local or private fire protection resources.

Fire Workforce and Technology. With fuels management largely in the purview of a reemerging wood and plant extractives industries, the community's focus is on coaching those industries to employ environmentally sustainable practices and responsibly managing federal lands. With fire suppression budgets in decline from decreasing demand, the FS and the DOI land management bureaus are refocusing their missions and consolidating fire assets. The firefighting workforce has declined markedly, focusing primarily on monitoring firesheds near major urban areas to identify ignitions and/or whether backcountry fires may burn into urban areas. The workforce is extremely technologically adept and effectively uses advanced analytics tools to process surveillance data and dispatch preestablished strike teams of firefighters aided by robotic "mules" and UASs to extinguish fire that present risk to urban populations.

Lodgepole Fire, Idaho, 2013 (Kari Greer Photo)

POSSIBLE RISKS AND OPPORTUNITIES IN FUTURE #4

POSSIBLE RISKS	POSSIBLE OPPORTUNITIES
• Potential loss of wildland fire intellectual capital and potential for unpreparedness to manage large-scale wildland fires in the future—and the associated increased risk to firefighters—if the changes resulting in this future are not sustained • Negative perceptions of the wildland fire management community by lower income members of the population if the community perceived to be the driver of new regulations that require fire adaptation and impose significant financial costs	• Avoidance of damaging megafires and related impacts on population, infrastructure, and other values • Can achieve healthier ecosystems if federal land management agencies effectively educate and/or regulate extractive industries • Could use fire opportunistically in backcountry with limited impact on major populations and less political blowback if mistakes occur • Could alter the philosophy from the war on fire to living with fire • Could enhance the capability of land management agencies to conduct active management • Potential to shift a significant portion of the fire suppression organization into advanced strategic planning capability and conduct prescribed burning in areas of the country unsuitable for mechanical fuels removal

D. QFR ALTERNATIVE FUTURES PROCESS KEY INSIGHTS

The alternative futures phase of the 2014 QFR resulted in a set of high-level, crosscutting insights worthy of consideration by wildland fire leaders regardless of the future the community faces 10 to 20 years from today. The community lacks a "crystal ball" capable of predicting precisely the future in which it will operate, but it can be better prepared to help shape that future by sustaining internal debate on tough issues and continually scanning for signals that a particular future might be emerging. The results of such efforts will be critical to informing forward-looking, enterprise-level strategic planning initiatives such as the Cohesive Strategy.

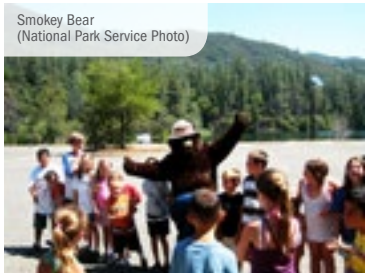
Key insights from this phase are as follows:

- ***The futures explored during this QFR are not exclusive of each other.*** The United States may experience any of the four futures to varying degrees across regions, and the potential exists for these futures to arrive in varying time sequences up to or following 2034. Many QFR process participants found it reasonable to conclude that the community will face more than one of these futures, or elements of several, in the next 10 to 40 years. For example, Future #1 (Hot Dry, and Out of Control) could easily lead to Future #2 (Suppression Centric) or Future #3 (Resilient Landscapes) depending on the trends, events, or shocks that occurred while in Future #1. At the same time, a failure of a suppression-centric approach could also eventually lead to Future #3. As the community conducts its strategic planning, it should consider more than one potential outcome to ensure that it is ready to address the challenges and exploit the opportunities in each future, if or when they may occur. The community should not rely on planning for its desired vision, but rather should make contingency plans for a number of futures, including undesirable ones.
- ***There is a strong possibility that today's regional wildland fire management dynamics will shift as a result of climate and environmental factors.*** Climate change could result in habitat-type conversions (e.g., forests, brushlands, grasslands, deserts, swamps, tundra) closer to the end of the time horizon of this review or in the years following that present significant impacts. Alaska, the Pacific Coast, the Mountain West, the Great Plains, and the Southeast could contend with more unplanned wildfire or more extreme fire events—or both. Other regions, such as the upper Midwest and the Northeast, that have limited recent experience with fire, could begin to experience regular fire events, some potentially extreme, resulting from climatic change and related factors. Such a shift could necessitate a reallocation of workforce, equipment, and facilities for fire prevention and could necessitate new investments for expanded fire suppression capability. The prospect of additional fires in areas where peat is prominent (e.g., southeastern swamps or Alaskan tundra) from climate change is highly problematic because of related smoke concerns, as described in detail below.
- ***It will be impossible to address high fuel levels present on the landscape through the fuels reduction program alone over the next 10 to 20 years.*** There was broad consensus among the experts consulted during this review that the community will not be able address the fuels problem using prescribed burning or mechanical treatments within the next 10 to 20 years. Lacking a dramatic expansion in the opportunistic use of fire, the potential exists for a significant expansion in average acres burned annually nationwide by unplanned/unwanted wildfire by 2034.[150] The reduction or elimination of prescribed burning in areas where it has previously been prominent (e.g., the Southeast) due to new air quality regulations or public concerns about smoke could exacerbate this trend. Such an increase in the number of acres burned would place tremendous demands on the current fire suppression infrastructure and workforce and would necessitate significantly greater financial expenditures on fire management of all kinds at the federal, state, and local levels.
- ***The potential exists for a shock-type wildfire event (or series of events) that could cause a significant loss of lives and property equivalent to a major hurricane.*** Recent fires have not resulted in situations that rival the worst cases of natural disasters in recent history (i.e., Category 5 hurricanes like Andrew and Katrina). Nonetheless, QFR participants asserted that—given changing climate factors, high fuel loads, and continued population growth in the WUI that is unaccompanied by simultaneous adjustments to wildland policy, regulations, and operations—the community could witness a return of devastating megafires like those that killed hundreds and damaged thousands of structures in the late 19th century and early 20th century. Although federal, state, local, and tribal capabilities have been extremely successful in wildfire suppression during the past several decades, such fires could ulti-

[150] FS, Final Report: Wildland Fire Management Futures: Insights from a Foresight Panel. July 2, 2014, not available online, p. 18–19.

mately overwhelm the existing system. The success rates enjoyed by the community in quickly suppressing the majority of wildland fires can create an illusory, and even overconfident, sense of control over this tremendous force of nature.

- ***Smoke and air quality issues associated with wildfire will become a larger concern than ever before.*** With a lengthening of the fire season, increases in acres burned, more extreme fires, and the potential for a reduction in prescribed burns, wildfire smoke will become a greater nuisance to the public and could create public health crises. With the community challenged to address these fuel loads, nature could address them through large, extreme fires and a return to historical burning levels (and associated smoke) like those experienced prior to 1950 (see Figure 12). Pre-1950s burning levels represent a 350 to 600 percent increase over current levels and could dramatically increase the urgency of smoke issues on nearly every path to the year 2034. To illustrate this point, participants postulated a scenario in which smoke enveloped a major city (e.g., Miami, Salt Lake City, Houston) for weeks, and the effects on public health, including psychological health, commerce, recreation, and other values. Resulting political pressures could drive the creation of new air quality regulations that could drastically affect the community's ability to leverage prescribed burning and opportunistic use of unplanned wildfires, which are useful tools in managing smoke effects.
- ***The community may face a wildland fire shock while it attempts to reframe public attitudes toward wildland fire management.*** Today's emphasis on costly, aggressive suppression of fires results from more than 100 years of public expectations, political pressure, state and local laws, and a deeply ingrained culture. Stakeholder engagement conducted during this QFR suggested that, as a result of this, the community faces a high risk of a shock event. A shock, or shocks, could entail a series of extremely stressing fire seasons, the burning of an icon, such as a prominent national park, the complete destruction of a town or village in the WUI, or a wildfire burning into a major metropolitan area (e.g., Denver, Atlanta, San Antonio). Without imaginative, future-oriented advance planning designed to remove organizational blinders, and significant effort to expand public acceptance and understanding of wildland fire, the community might not be able to shape the after effects of a shock to avoid an outcome that places it on an even more unsustainable path.
- ***A wildland fire shock could result in calls for a reorganization of the federal wildland fire agencies, but reorganization is not a panacea.*** The QFR process included repeated discussion by experts and members of the community about the possibility of a consolidation of federal suppression functions under another emergency management-oriented entity. Because such an organization would focus on suppression at the expense of far-sighted, integrated land management practices, most participants agreed that this would be an undesirable outcome and that it could lead to the further accumulation of unsustainably high fuel loads, and therefore even more hazardous fire conditions, particularly if accompanied by forecasted climate trends. The establishment of such an organization would also be complex and expensive due to a need to integrate systems (particularly IT and aviation) and coordinate management of fire facilities with the FS and several DOI bureaus. While reorganization may offer the opportunity to achieve long-term efficiencies and process improvements, experts generally agreed that the community cannot reorganize its way out of the challenges on the horizon.


Smokey Bear
(National Park Service Photo)

- ***Long-term planning anchored in a new public engagement campaign is critical to preparing the community to weather a shock and avoid being forced into an even more unsustainable model.*** Input from QFR participants suggests that the single most effective measure that the community could take to manage the growing threat of catastrophic wildfire in the future is to undertake a strategic public engagement campaign to expand public acceptance of prescribed burns and the opportunistic use of unplanned wildfires. Broader acceptance of a higher frequency of prescribed burns and wildland fire use consistent with natural cycles could help the community begin to address the fuels deficit. To be effective, however, this effort must be accompanied by continued implementation of the Cohesive Strategy and other efforts, such as the Fire Adapted Communities campaign, to increase the resilience and preparedness of WUI communities.

Whitewater-Baldy Complex, Gila National Forest, New Mexico, May, 2012 (Kari Greer Photo)

SECTION IV:
CONCLUSIONS AND ACTIONS FOR CONSIDERATION

Based on in-depth analysis, broad stakeholder engagement, and an assessment of possible alternative futures, the 2014 QFR offers the following set of conclusions and possible actions for consideration by federal wildland fire leaders at the FS and the DOI:

1 ***Performance Measures, Data Analytics, and Operational Capability Assessment:*** The FS and the DOI lack sufficient data, with sufficient fidelity and reliability to inform strategic and programmatic decision making. As such, both organizations often fall back on historical approaches to conducting business rather than validating their continued application and effectiveness or exploring new paths. Data gaps are prevalent across program areas within the wildland fire program, including aviation, fuels management, infrastructure, and workforce. In areas where data is available, limited analytic capability presents challenges in terms of fully understanding program effectiveness and ROI, as well as the full impacts of wildland fire. Data gaps across program areas also create challenges for fire leaders during interactions with Congress, the Office of Management and Budget, and other oversight bodies.

ACTION FOR CONSIDERATION #1

Promote continuous data collection and analysis to increase understanding of broad-based outcomes, explore new performance metrics to assess program effectiveness, and conduct an operational capability assessment. The FS and the DOI need to develop KPIs (aviation, fuels management, infrastructure, workforce) for all core programs and begin targeted data collection to support evaluation of the effectiveness of those programs. During this review, both agencies noted a lack of shared effectiveness measures for a variety of capabilities, which limits their ability to engage in joint strategic and investment planning to ensure compatible and complementary approaches to the development of tactical capabilities and to provide for course correction when necessary. While this need will be met in part by the WFIPS resource planning tool, a bottom-up review of operational capabilities will enable the FS and the DOI to establish an optimal mix of workforce, facilities, programmatic infrastructure, and tactical capabilities. A key part of this review should be the development of KPIs that rate and compare the marginal value of any given element of the fire program and thereby demonstrate the cost-benefit proposition of each element.

2 ***Fuels Management:*** Funding levels and agency capabilities for fuels management have been inadequate to mitigate increased fire risk in many parts of the country, and fuel levels continue to grow. Current performance measures do not sufficiently evaluate and account for risk, risk mitigation effectiveness, or cost-effectiveness outcomes; instead, there has been a focus on output measures, such as acres treated or unit costs of treatment. An additional program-level issue is that current measures disproportionately emphasize fuels while leaving other programs—including much larger ones, such as preparedness and suppression—comparatively unmeasured. Metrics that are associated with overall risk reduction and are inclusive of multiple values, the potential for impact, and ROI (rather than simply acres) will be critical going forward.

ACTION FOR CONSIDERATION #2

Create a fuels management optimization framework to enable effective and efficient application of funding and treatments. The fuels management program is critical to achieving the goals advanced by the Cohesive Strategy, but doing so necessitates development of a framework based on objective assessments of risk and potential ROI to aid in application of limited fuels management resources. Allocation should favor regions with strong cost-benefit propositions. For example, some regions (e.g., the Southeast) have a long history of prescribed burning and an inherent capability to execute it effectively. In other regions, conversely, fuels treatments by the federal government may offer less ROI than, for example, promotion of state and local programs through Firewise campaigns.

3 ***Active Forest Management:*** Research conducted during this QFR revealed widespread sentiment that elements of active forest management, particularly commercial harvesting of timber and other vegetative fuels, is in decline across the United States. A number of factors, which range from perceptions of public sentiment and endangered species concerns to economic drivers, appear to be driving this decline. Some experts, however, assert that active forest management has historically been a significant factor in curbing hazardous fuels and that active management has broader citizen support than no-action alternatives for improving ecosystem health and reducing fire risk. While commercial harvesting of timber and other biomass can be highly controversial, an increase in commercial harvesting of forest products could be one element of a more comprehensive approach to reducing fuel levels and is worthy of reexamination in a thorough and dispassionate manner by federal land management agencies and their state and local partners.

ACTION FOR CONSIDERATION #3

Conduct research to better understand whether (or not) active forest management offers potential to address high fuel levels. The FS and the DOI should conduct research on various elements of active forest management and their ability to begin addressing high fuel levels. First, this research should examine the long-term viability of the forest products industry to identify whether it has the potential to reemerge as a major contributor to managing fuel levels. Second, the level of effort required to pursue and approve policies for promoting active forest management would merit examination. The community would need to assess the cost-benefit proposition for pursuing active forest management as opposed to other tools that may be easier to implement. A parallel research effort should also examine approaches to using carbon sequestration credit trading as a means to generate revenue and manage fuel levels, while also minimizing negative ecological impacts. Depending on the outcomes of this research, the FS and the DOI should considering initiating a dialogue about whether the federal government should develop or implement policies that promote active forest management to help manage fuel levels.

4 ***Public Engagement:*** The Smokey Bear campaign has been enormously successful in raising awareness about unwanted ignitions over more than six decades. Nonetheless, QFR participants repeatedly asserted that an evolved communications approach is integral to reaching a new generation. Such an approach would complement Smokey's message and that of the Fire Adapted Communities campaign and seek to further enhance awareness about the positive ecological effects of fire and its ability, if managed effectively, to reduce risk to human populations and their value. While social science research indicates that many populations are already accepting of proactive fire management, sustained, grassroots engagement can help to capture and build on this buy-in. Such a campaign could enhance much-needed public support for prescribed burns and use of naturally ignited wildfires and support the goals outlined in the Cohesive Strategy.

ACTION FOR CONSIDERATION #4

Explore opportunities to enhance awareness about the benefits of fire and public acceptance of prescribed fire and fire use through a set of multifaceted messages. Historical messaging about prevention of unwanted ignitions should continue, but a set of tailored, comprehensive messages that align with the tenets of the Cohesive Strategy are also needed. Such an approach would require targeted and tailored communications, spearheaded at the grassroots level to reach diverse stakeholders across the country, and sharing of success stories about prescribed fire with communities and the news media, both in the WUI and in major media markets. Core messaging would emphasize that fire is a natural, necessary, and productive occurrence (with side effects such as smoke that are a necessary tradeoff when exposure can be managed at low levels), that planned use of natural ignitions and prescribed burns can achieve positive ends, that there is a shared responsibility for local community resilience, and that the ROI associated with Firewise and CWPPs is positive.

5 ***Technology and Innovation:*** The wildland fire management community currently lacks an innovation and technology adoption agenda or list of priorities. While the JFSP provides an avenue to advance innovative science and technology, according to experts consulted during this effort, the community's investment in research initiatives through JFSP lacks focus. Furthermore, as evidenced by its use of 400-plus IT systems, and its experience with the FPA, the community sometimes struggles to define common technology priorities and implement integrated, enterprise-level solutions.

ACTION FOR CONSIDERATION #5

Empower a "Chief Innovation Officer" to establish innovation priorities and technology implementation plans, build partnerships, foster innovation at all levels, and inform fire leaders' decisions about investment in "winners." Designating a CINO at the enterprise-level would establish a central coordinating point for all innovation and technology investment efforts. The CINO would work closely with the JFSP and senior fire leaders at the FS and the DOI to set innovation priorities, help identify technologies with the potential to advance the community's goals over 10 to 20 years, provide information to help fire leaders choose "winners" among those technologies, and develop plans to integrate them at the enterprise-level over a 5- to 10-year timeframe. The CINO would also communicate the FS and the DOI innovation priorities within the federal community (down to the tactical level) and with external partners. Critical to this effort would be the development and sustainment of bonds with industry partners and with the managers of relevant programs within the various technology research organizations across the federal government (e.g., the Defense Advanced Research Projects Agency).[151] An essential role of the CINO for the next 5 to 20 years would be coordinating investments in UASs, data analytics, and mobile

[151] For example, NASA, Defense Advanced Research Projects Agency, the Advanced Research Projects Agency-Energy (ARPA-E), the Intelligence Advanced Research Projects Agency (IARPA), and the Homeland Security Advanced Research Projects Agency often research and test technological concepts and then pass them off to industry or other government agencies to fully develop.

technologies (e.g., handheld devices, applications). An immediate priority for a CINO could include establishing a program management office to drive high-potential research (e.g., recent discoveries related to fire behavior) through to practical application.

6 ***Workforce:*** The community faces a looming wave of workforce challenges that range from a decline in numbers of fire-qualified personnel to succession planning and institutional knowledge preservation amidst baby boomer generation retirements to adapting training and workplace practices to best suit the differing aptitudes, work styles, and preferences of younger staff. In the realm of fire-qualified personnel, the community's continued reliance on retired AD employees, state and local augmentees ("blueshirts"), and contractors to fill gaps in the regular and militia workforce may be unsustainable because of the aging of those retirees, the costs associated with some augmentees, and the experience levels and capabilities of contractors. The community already faces major challenges related to firefighter stress and psychological health due to lengthening fire seasons and more extreme fire events, and these challenges will likely persist and could potentially increase. Furthermore, the community lacks data in sufficient fidelity to systematically identify and analyze workforce gaps, overlaps, or mismatches, as well as to understand the pros and cons associated with its options.

ACTION FOR CONSIDERATION #6

Conduct a strategic workforce review and develop a strategic plan for the federal wildland fire workforce that addresses pressing emergent challenges. The FS and the DOI should conduct an in-depth workforce analysis and formulate a strategy that reflects current and future workforce issues across all aspects of the program, not just historical norms or ingrained culture. This strategy needs to address new challenges stemming from a rapidly changing natural environment, with consideration of new opportunities in technology to meet those challenges. The strategy must also preserve critical skills and identify new ones, while also working to adjust the FS and the DOI cultures in line with new norms and address persistent issues related to fire qualifications. In particular, the FS and the DOI need to identify opportunities to shape younger staff as leaders earlier in their careers. Doing so may necessitate establishment of a more creative and flexible qualifications process and alterations to existing experience requirements. Both are critical to facilitating faster promotion of younger staff to meet urgent needs, even if their experience stems from fields outside wildland fire management or from geographic regions different from those in which they currently work. Furthermore, the strategy must support firefighters and other personnel who operate in increasingly high-stress environments through mechanisms focused on mental (e.g., PTSD) and physical health.

7 ***Strategic Planning:*** As identified during this review and by a nearly simultaneous study led by the FS Northern Research Station,[152] the wildland fire management community lacks existing processes or indigenous capability to conduct ongoing environmental scanning, scenario-based planning, and alternative futures analysis. This limitation impedes the community's ability to identify emerging challenges and communicate to key stakeholders about resulting gaps.

ACTION FOR CONSIDERATION #7

Develop a capability to undertake ongoing, futures-oriented analysis and planning to identify, plan for, and empower action to address emerging issues. The QFR is an excellent start, but the community should augment it by establishing ongoing environmental scanning, alternative futures analysis, and scenario-based planning processes to occur in between QFRs at the enterprise level. Such processes must regularly engage senior fire management executives at FS and the DOI and their key personnel. Doing so would help institutionalize a long-term perspective, explore uncertainties and potential surprises, decrease reaction time to rapid change, help anticipate unintended consequences, and test the limits of the community's capabilities to respond to catastrophic events. It could also help the community identify issues (challenges and opportunities) emerging within the realm of wildland fire and in adjacent areas, and spur development of contingency plans that address multiple outcomes. The community could develop the capability to execute these processes using multiple approaches, including the establishment of a joint, enterprise-level "think tank" unencumbered by political constraints and including trained futurists and subject matter experts detailed from across the FS and the DOI, by outsourcing such activity, or a combination of the two.

8 ***Federal Wildland Fire Agency Organization.*** One of the QFR futures, titled "Suppression Centric," postulates that a possible outcome of a shock-type fire event (or events) could be a consolidation of suppression functions currently housed within the federal land management agencies and their realignment under an emergency

[152] FS, Final Report: Wildland Fire Management Futures: Insights from a Foresight Panel, Ibid.

management-oriented entity. In this hypothetical future scenario, such an entity would be outside the FS and the DOI and would separate fire suppression from land management. This type of organizational realignment is just one possible outcome based on the interaction of current and emerging trends over the next 10 to 20 years, and it is by no means certain. Most experts consulted during this review considered such a realignment highly undesirable, but agreed that it is conceivable. Many cited the Colorado State Assembly's passage of a bill to transfer the Colorado State Forest Service's Fire Division to the State's Department of Public Safety following the 2012 fire season, the worst in the state's history, as an example of a mandated realignment that separated land management from fire management.[153]

ACTION FOR CONSIDERATION #8

Over the next five years, assess potential organizational schemes and identify associated benefits and drawbacks. Given input from experts throughout this review about the drawbacks of a realignment that separates fire suppression from land management, neither the FS nor the DOI expressed a desire for organizational changes along those lines. Nonetheless, both agencies should reflect on how they can continue to be recognized as world class in wildland fire management, irrespective of their structure. Doing so is vital to ensuring that the FS and the DOI can be agile and proactive in explaining the benefits and drawbacks associated with a range of possible organizational changes—in terms of effectiveness, operational impacts, and costs to the taxpayer—if interest in a change does emerge.

[153] "Colorado State University – Agency Profile," Colorado State Forest Service, accessed December 3, 2014, http://csfs.colostate.edu/our-service/agency-profile/.

Carlton Complex, Methow Valley, Washington, 2014 (Kari Greer Photo)

Gladiator Fire, Crown King, Arizona, Prescott National Forest, May, 2012 (Kari Greer Photo)

SECTION V:
APPENDICES

APPENDIX A.

QFR REPORT CARD SUMMARY

The 2014 QFR process began in early 2014 with development of a "report card" designed to evaluate the recommendations and predictions included in the 2005 and the 2009 QFRs to provide an analytical foundation for this review. It is the intent of the FS and the DOI that future QFR processes begin with the development of similar report cards that will measure the community's performance against the goals included in previous QFRs, help ensure accountability, and glean best practices for the future.

This 2014 report card effort began with a review of the two previous QFRs to extract 143 specific recommendations and 31 predictions related to wildland fire management and the synthesis of that content into 33 high-level recommendations and 24 forward-looking predictions. The team then conducted an extensive literature review of government, academic, and science documents—along with selective engagement of wildland fire subject matter experts—to analyze progress toward each recommendation and to gauge the accuracy of each prediction. The team developed a report card template that depicts the results of that effort using gradient scales and "stoplight" charts. It also included process-oriented recommendations to enhance future QFRs.

Carlton Complex, Methow Valley, Washington, 2014 (Kari Greer Photo)

As a quick reference, the table below lists the 33 high-level recommendations extracted and synthesized from the previous QFRs, along with a simple assessment of each recommendation's status. The team assigned status grades for each recommendation on a linear scale consisting of "No Progress to Date," "Minimal Progress to Date," "In Progress," and "Complete." The team then plotted the status of each recommendation on a gradient scale ranging from red to green, with red representing "No Progress to Date" and green representing "Complete."

To access the full report card, and explore the predictions included in the two previous QFRs, visit forestsandrangelands.gov.

#	QFR	RECOMMENDATION	STATUS
1	09	Modernize Aviation Policy & Capability	
2	09	Establish National Interagency Air Attack & Aerial Supervision Module Programs	
3	05	Enhance Decision Processes & Tools for Managers	
4	05/09	Implement AMR & Refine WFSA & WFIP Processes	
5	05/09	Enhance Predictive Services Capabilities	
6	05/09	Improve Spatial Landscape Data	
7	05	Employ FPA for Prioritizing Interagency Staffing & Facilities	
8	05	Improve Monitoring & Evaluation Processes	
9	05/09	Increase Collaboration in Emergency Response	
10	05/09	Expand Local–Level All Hazard Response Capability	
11	05/09	Upgrade IMT Capability & Structure	
12	05	Enhance Decision Support Tools for Fuels Management	
13	05/09	Create Landscape-Level Fuels Investment Strategy	
14	05/09	Promote Fire Adapted Communities	
15	05/09	Launch Public Outreach & Education Initiatives	
16	05/09	Create New Wildland Fire Governance & Policy Framework	
17	09	Employ Web-Based Forums to Educate the Public	
18	05	Improve Planning Processes to Better Support NEPA	
19	05	Model the Desired Future Vegetative Condition	
20	05	Realign Hazardous Fuels Program Policies & Processes	
21	05/09	Increase Use of AARs in Wildland Fire	
22	05/09	Consider All Factors in Suppression Decisions	
23	09	Strengthen Safety & Risk Management Metrics	
24	09	Implement Strategic Management Response	
25	05/09	Increase Remote Sensing Capability	
26	05/09	Improve Efficiencies in Dispatch and Mobilization	
27	09	Expand Science & Technology Partnerships	
28	05	Maintain Fire Management Force Structure	
29	05	Explore Realigning GACC Boundaries for Efficiency	
30	05/09	Enhance Employee Development Opportunities	
31	05	Implement a Targeted Career Development System	
32	05	Leverage Strategic Sourcing	
33	05	Enhance Succession Planning Processes	

APPENDIX B.

LIST OF ORGANIZATIONS CONSULTED

TYPE	ORGANIZATION NAME(S)	INTERVIEW OR FOCUS GROUP	FUTURES WORKSHOP
Academia	Arizona State University	●	●
	Colorado State University		
	University of Edinburgh (Scotland)		
	University of Florida		●
	Oregon State University	●	●
	University of Colorado, Denver	●	●
	University of Maryland, College Park		●
	University of Montana		●
	University of Nevada, Reno		●
	New Mexico Highlands University		●
	University of Idaho	●	
Federal Agency	USDA FS	●	●
	Department of Commerce, NOAA		●
	Department of Defense (DoD), DARPA	●	
	DoD, US Northern Command (USNORTHCOM)		●
	DHS		●
	DHS, FEMA		
	DHS, FEMA, US Fire Administration (USFA)		●
	Department of Health and Human Services (HHS), Centers for Disease Control (CDC), National Institute for Occupational Safety and Health (NIOSH)	●	
	DOI, BIA	●	
	DOI, BLM	●	●
	DOI, FWS		●
	DOI, NPS		●
	DOI, USGS		●
	DOI, OWF	●	●
	DOI, Office of Aviation Services (OAS)	●	
	EPA		●
	US Global Change Research Program		●

TYPE	ORGANIZATION NAME(S)	INTERVIEW OR FOCUS GROUP	FUTURES WORKSHOP
NGO	American Lands Alliance	●	
	Center for Climate and Energy Solutions (C2ES)		●
	Clark Fork Coalition	●	
	Firefighters United for Safety, Ethics & Ecology (FUSEE)	●	
	Idaho Conservation League	●	
	International Association of Fire Chiefs (IAFC)	●	
	International Association of Wildland Fire (IAWF)	●	
	Intertribal Timber Council	●	
	National Association of State Foresters (NASF)	●	
	Southern Governors Association	●	
	Watershed Research & Training Center	●	
International Partners	Canadian Interagency Forest Fire Center (CIFFC)		●
	County Fire Authority (Australia)	●	
	Department of Environment & Primary Industries (DEPI), State of Victoria, Australia	●	
	International Association of Wildland Fire (IAWF)	●	
State Partners	California Department of Forestry and Fire Protection (CAL FIRE)		●
	Colorado Department of Natural Resources		●
	Colorado Division of Homeland Security and Emergency Management		●
	Colorado State Forest Service		●
	Colorado Division of Fire Prevention and Control		●
	Florida Forest Service		
	Montana Department of Natural Resources and Conservation		●
	New Hampshire Division of Forests and Lands		●
	Wyoming State Forestry Division		●

TYPE	ORGANIZATION NAME(S)	INTERVIEW OR FOCUS GROUP	FUTURES WORKSHOP
Local Partners	Austin (Texas) Fire Department	●	
	Boulder County Parks & Open Space		●
	Boulder County Policy and Legislative Affairs		●
	Columbus (Montana) Fire Department	●	
	Colorado Springs Fire Department	●	
	Deschutes County Commission	●	
	Fire/EMS, Jackson Hole Wyoming	●	
	Lompoc (California) Fire Department	●	
	North Lake Tahoe Fire Department	●	
	San Diego Fire Department	●	
	San Juan County	●	
	Texas A&M Forest Service	●	
Industry	10Tanker LLC		●
	Booz Allen Hamilton	●	●
	Institute for Business and Home Safety (IBHS)	●	
	METI, Inc.	●	
	Pikes Peak Wildfire Prevention Partners		●
	Renoveling LLC	●	
	Vinson & Elkins LLP		●

APPENDIX C.

LIST OF INDIVIDUALS INTERVIEWED

The 2014 QFR team would like to express our utmost appreciation the individuals listed below (and any we may have neglected to include) for their interest, their willingness to give their time to participate in QFR interviews or focus groups, and their enormously insightful input to this review.

NAME	ORGANIZATION	TITLE
Patricia Alexandre	University of Wisconsin-Madison	Ph.D. Graduate Student
Mark Bathrick	DOI, OAS	Director
David Bengston	USDA FS	Northern Research Station
Marko Bourne	Principal	Booz Allen Hamilton
Lloyd Burton	University of Colorado-Denver	Professor and Concentrations Director
Corey Butler	CDC—National Institute for Occupational Safety and Health (NIOSH), Western States Office	Public Safety Sector Program Co-Coordinator
Chris Campbell	USDA FS	Assistant National Facilities Program Manager
Lyle Carlile	DOI, BIA	Director, Branch of Wildland Fire Management
Kathy Clay	Teton County, Jackson Hole Fire/EMS	Battalion Chief Fire Marshal
David Cleaves	USDA FS	Climate Change Director
Stephen Covell	USDA FS	Program Manager USDA FS Pesticides, and State and Private Forestry Invasive Plants
Bill Crapser	Wyoming State Forestry Division	State Forester
Mike Delurey	Booz Allen Hamilton	Principal/"Big Data" Expert
Judith Downing	USDA FS	Public Information Officer
Jim Erickson	Intertribal Timber Council	Forester
Mark Finney	Rocky Mountain Research Station	Research Forester
Deb Fleming	DOI, BLM-National Wildfire Coordinating Group (NWCG)	Training Branch Manager
Marshall Frith	DARPA	Program Manager, PCAS/FLAME
Alan Goodwin	IAWF	Vice President, Chief Fire Officer
Ed Greutert	Booz Allen Hamilton	Senior Associate/UAS Expert
Frank Guzman	USDA FS	FAM, Assistant Director—Boise
Jaelith Hall-Rivera	USDA FS	Deputy Area Budget Coordinator—State and Private Forestry
Bob Harrington	Montana Department of Natural Resources and Conservation	State Forester
Art Hinaman	USDA FS	FAM, Assistant Director
Anne Hoover	USDA FS	Deputy Director
Timothy Ingalsbee	American Lands Alliance	Co-Director
Melissa Jenkins	USDA FS	Forest Biologist
Jim Karels	Florida Forest Service	Division Director and State Forester

NAME	ORGANIZATION	TITLE
Max Keefer	CDC—National Institute for Occupational Safety and Health (NIOSH), Western States Office	Director
Pete Lahm	USDA FS	Smoke Manager
Karen Lewis	USDA FS	NRM Project Manager
Paul Linse	USDA FS	Branch Chief—Aviation Business Operations
Gary Man	USDA FS	Forest Biologist
Sarah McCaffrey	USDA FS	Social Scientist
Penny Morgan	University of Idaho	Professor
Bob Mutch	USDA FS (Retired)	Former Program Manager
Tessa Nicolet	USDA FS	Fire Ecologist
Christine Olsen	Oregon State University	Research Associate and Instructor—Forest Ecosystems & Society
Jonathan Oppenheimer	Idaho Conservation League	Senior Conservation Associate
Sean Parks	USDA FS	Ecologist
Rock Parrilla	USDA FS	FS Aviation Planner
Travis Paveglio	University of Idaho	Assistant Professor—Department of Conservation, Social Sciences
Roshelle Pederson	DOI-OWF	iRWIn Business Lead (Integrated Reporting of Wildland-Fire Information)
John Phipps	USDA FS	Senior Advisor, Deputy Chief's Office
Ken Pimlott	California Department of Forestry and Fire Protection (CAL FIRE)	Director and State Forester
Elizabeth Reinhardt	USDA FS	FAM, Assistant Director
Bryan Rice	USDA FS	Director of Forest Management
Karin Riley	USDA FS	Missoula Fire Sciences Laboratory
Julie Rogers	FUSEE	Education Director
Robert (Bob) Roth	USDA FS	Aviation Management Specialist
Albert Simeoni	IAWF	Board Member
Brad Simpkins	New Hampshire Division of Forests and Lands	Director and State Forester
Alen Slijepcevic	IAWF	Board Member
Dan Smith	NASF	Fire Director
Eva Strand	University of Idaho	Assistant Professor—Dept. of Forest, Rangeland, and Fire Sciences
Dave Thomas	Renoveling LLC	Contractor
Kim Van Hemelryck	DOI-FWS	Fuels Management Specialist
Willy Watsbaugh	Teton County, Jackson Hole Fire/EMS	Battalion Chief Fire Marshal
Christie Wiley	DOI, OWF	Communications Specialist
Jerry Williams	USDA FS (Retired)	Former National Director, FS FAM
Bill Yohn	DOI, NPS	Fire facilities working group chair

APPENDIX D.

WORKS CITED

Ackerman, Spencer and Noah Schactman, "Almost 1 in 3 US Warplanes Is a Robot," *Wired* (January 1, 2012): accessed October 3, 2014, http://www.wired.com/2012/01/drone-report/.

Ahrens, M., National Fire Protection Association: Fire Analysis and Research Division, *Brush, Grass, and Forest Fires,* November 2013, accessed 2014, http://www.nfpa.org/research/reports-and-statistics/outdoor-fires/brush-grass-and-forest-fires.

Baird, Robert, "Profiles in pyroterrorism," The Counter Terrorist, March 2, 2011, accessed December 9, 2014. http://www.homeland1.com/disaster-preparedness/articles/985110-Profiles-inpyroterrorism/.

Baird, R. A., *Pyroterrorism—The Threat of Arson Induced Forest Fires as a Future Terrorist Weapon of Mass Destruction* (United States Marine Corps University, School of Advanced Warfighting, 2005), accessed 2014, http://www.dtic.mil/dtic/tr/fulltext/u2/a509220.pdf.

Ballam, Ed, "Forest Service: Pyroterorrism a Threat in the US," *Firehouse.com News,* February 21, 2013, accessed December 9, 2014, http://www.firehouse.com/news/10882251/forest-service-pyroterrorism-a-threat-in-the-us.

Barnett, T. P., Adam, J. C., and Lettenmaier, D. P., "Potential impacts of a warming climate on water availability in snow-dominated regions," *Nature* (November 17, 2005): Volume 438, Issue 7066, accessed 2014, http://www.eldis.org/go/home&id=18630&type=Document#.U82N90DyTJF.

Bazerman, Max H. and Don A. Moore, *Judgment in Managerial Decision Making,* 6th ed. (Hoboken: John Wiley & Sons, 2009).

Beitler, J., "Tracking Natures Contribution to Pollution," *Earth System Science Data and Service* (October 17, 2006), accessed 2014 from National Aeronautics and Space Administration Earth Observatory website, http://earthobservatory.nasa.gov/Features/ContributionPollution/.

"Black Saturday bushfires," Wikipedia, accessed 2014, http://en.wikipedia.org/wiki/Black_Saturday_bushfires.

Brack, Jessica, "Maximizing Millennials in the Workplace," University of North Carolina, Kenan-Flagler Business School, 2012, accessed September 12, 2014, http://www.kenan-flagler.unc.edu/executive-development/custom-programs/~/media/DF1C11C056874DDA8097271A1ED48662.ashx.

Bracmort, Kelsi, *Wildfire Management: Federal Funding and Related Statistics* (Congressional Research Service report for Congress, August 30, 2013), accessed 2014, http://fas.org/sgp/crs/misc/R43077.pdf.

Bracmort, Kelsi and Ross Gorte, Congressional Research Service (Congressional Research Service), *Forest Fire/Wildfire Protection,* March 7, 2012, accessed September 24, 2014, http://fas.org/sgp/crs/misc/RL30755.pdf.

Brumback, K., "Wildfire Injuries, Deaths on Rise in Georgia, Other Southern States," *Insurance Journal* (August 17, 2006), accessed 2014, http://www.insurancejournal.com/news/southeast/2006/08/17/71428.htm.

"Budget & Performance," United States Forest Service: *Annual Forest Service Budget Justification* documents, Fiscal Years 2004 – 2015, accessed September 8, 2014, http://www.fs.fed.us/about-agency/budget-performance.

Burton, Lloyd (ed.), "Wildfire Mitigation Law in the Mountain States of the American West: A Comparative Assessment" (University of Colorado, Denver School of Public Affairs, posted July 2013), accessed 2014. http://www.ucdenver.edu/academics/colleges/SPA/Research/EAWG/Research/wildfires/Documents/WhtPprIntrstStdy15jul13.pdf.

Catalyst – Generations in the Workplace in the United States and Canada, accessed September 12, 2014, http://www.catalyst.org/knowledge/generations-workplace-united-states-canada.

Climate Central, *The Age of Western Wildfires,* September 2012, accessed July 25, 2014, http://www.climatecentral.org/wgts/wildfires/Wildfires2012.pdf.

Cohen, J., "The Wildland–Urban Interface Fire Problem - A Consequence of the Fire Exclusion Paradigm," *Forest History Today* (Fall 2008), accessed 2014, http://foresthistory.org/Publications/FHT/FHTFall2008/Cohen.pdf.

Colby, S. L., and Ortman, J. M., *The Baby Boom Cohort in the United States: 2012 to 2060* (United States Census Report Number: P25-1141), May 2014, accessed 2014, http://www.census.gov/library/publications/2014/demo/p25-1141.html.

"Colorado State University – Agency Profile," Colorado State Forest Service, accessed December 3, 2014, http://csfs.colostate.edu/ourservice/agency-profile/.

Conway, M., Increasing temperatures have large effects on the hydrologic cycle, influencing snowmelt, snowpack, stream flow and water runoff (University of Indiana, School of Public and Environmental Affairs, Spring 2012), accessed 2014, http://www.indiana.edu/~spea/pubs/undergrad-honors/volumn-6/Conway,%20Morgan%20-%20Global%20Warming%20Impact%20on%20Snow%20Covered%20Mountain%20Ranges%20and%20the%20Effects%20on%20the%20Surrounding%20Areas%20-%20Faculty%20Todd%20Royer.pdf.

Corripio, J. G., Purves, R. S., & Rivera, A, "Modelling climate-change impacts on mountain glaciers and water resources in the Central Dry Andes," *Darkening Peaks: Glacier Retreat, Science, and Society* (p. 126–135), University of California Press, Berkeley, CA: accessed August 4, 2014, http://www.uibk.ac.at/geographie/personal/corripio/publications/jgc_rsp_ar_07.pdf.

Daniel, T.C. and J.G. Taylor, "Prescribed fire: public education and perception," Journal of Forestry (1984), not available online.

Davis, Richard C. (ed.), "Weeks Act, 1911," The *Encyclopedia of American Forest and Conservation History* (1983): Vol. 2, p. 685, http://www.foresthistory.org/Publications/weeks%20act.pdf.

Department of Interior, Budget Justifications and Performance Information (Wildland Fire Management), Fiscal Year 2014, http://www.doi.gov/budget/appropriations/2014/upload/FY2014_WFM_Greenbook.pdf.

Department of the Interior, Wildland Fire Management Annual Report (FY2013)—DRAFT—v1.0, February 25, 2014, accessed 2014, not available online.

Department of the Interior, *Wildland Fire Management Program Benefit-Cost Analysis, A Review of Relevant Literature,* June 2012, accessed September 9, 2014, http://www.doi.gov/ppa/upload/Wildland_fire_literature_review_060812FINAL.pdf.

Donovan, Geoffrey H. "Comparing the Costs of Agency and Contract Fire Crews" *Fire Management Today,* (Volume 67, No. 1, Winter 2007), accessed October 9, 2014, http://www.fs.fed.us/pnw/pubs/journals/pnw_2007_donovan003.pdf.

Dunlap, Riley et. al, "Health of the planet: results of a 1992 international environmental opinion survey of citizens in 24 nations," Gallup International Institute (1993); accessed October 3, 2014, not available online.

Environmental Protection Agency, "Causes of Climate Change," accessed August 11, 2014, http://www.epa.gov/climatechange/science/causes.html.

Facts About PTSD in Firefighters," Mental Health Answers, accessed September 2, 2014, http://mentalhealth.answers.com/ptsd/facts-about-ptsd-in-firefighters.

Fahy, R. F., *Wildland Firefighter Fatalities, 1999–2008,* (National Fire Protection Association, Fire Analysis and Research Division, July 2009), accessed 2014, http://www.nfpa.org/~/media/Files/Research/NFPA reports/Fire service statistics/oswildlandfff.pdf.

Ferguson, J., "Where have all the firefighters gone? CFD one of many departments struggling to find volunteers," Custer County Chronicle Online (February 7, 2013): accessed 2014, http://www.custercountynews.com/cms/news/story-673642.html.

Forest and Rangelands, *Fire Program Analysis Charter,* October 2010, accessed 2014, http://www.forestsandrangelands.gov/WFIT/applications/FPA/documents/overview/FPA_Charter_20101014.pdf.

Finlay, S. E., Moffat, A., Gazzard, R., Baker, D., Murray, V., "Health Impacts of Wildfires," *PLOS Currents Disasters* (November 2, 2012): Edition 1, accessed 2014, http://currents.plos.org/disasters/article/health-impacts-of-wildfires/http:/currents.plos.org/disasters/article/health-impacts-of-wildfires/.

Flannigan, Mike, et. al, "Global wildland fire season severity in the 21st century." *Forest Ecology and Management* (2013); accessed September 25, 2014, http://dx.doi.org/10.1016/j.foreco.2012.10.022.

French, N., Thelen, B., Ginsberg, M., Loboda, T., Wu, S., Johnson, J., Koziol, B., Owen, R. C., Billmire, M., Huang, Y., Tyner, M., *Respiratory Health Impacts of Wildfire Particulate Emissions Under Climate Change Scenarios* (Michigan Technological University, Michigan Tech Research Institute, December 19, 2013), accessed 2014, http://www.mtri.org/fire_health.html.

Gabbert, Bill., "Almost half of requests for air tankers were not filled in 2012," *Fire Aviation,* February 24, 2013, accessed 2014, http://fireaviation.com/2013/02/24/almost-half-of-requests-for-air-tankers-were-not-filled-in-2012/.

Gabbert, Bill., "Measuring the Severity of a Fire Season," *Wildfire Today,* November 25, 2013, accessed 2014, http://wildfiretoday.com/2013/11/25/measuring-the-severity-of-a-fire-season/.

Gabbert, Bill., "Update on Next-Gen Air Tankers," *Fire Aviation,* May 2, 2014, accessed 2014, http://fireaviation.com/tag/747/.

Green, Chloe, "Rise of the Chief Innovation Officer – leading the way to transformational innovation," *Information Age* (April 9, 2014); accessed October 14, 2014, http://www.information-age.com/it-management/strategy-and-innovation/123457889/rise-chief-innovation-officer-leading-way-transformational-innovation.

Hammer, R. B., Stewart, S. I., Radeloff, V. C., "Demographic Trends, the Wildland–Urban Interface, and Wildfire Management (Oregon State University Rural Studies Program, Working Paper Number RSP 08-01, February 2008), accessed 2014, https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/9260/RSP-08-01.pdf?sequence=1.

Headwaters Economics, "Oregon Home Building, Higher Temperatures Drive Price Tag Ever Higher," January 2012, accessed 2014, http://headwaterseconomics.org/wildfire/oregon-homes-and-cost-of-wildfires.

Headwaters Economics, "The Rising Cost of Wildfire Protection," June 2013, accessed 2014, http://headwaterseconomics.org/wildfire/fire-cost-background.

Headwaters Economics, "Solutions to Home Development in the Wildland Urban Interface," presentation 2014, http://headwaterseconomics.org/wphw/wp-content/uploads/wildfire_homes_solutions_presentation.pdf.

Headwaters Economics, "Summary: Wildfire Costs, New Development, and Rising Temperatures," Spring 2013, accessed 2014, http://headwaterseconomics.org/wildfire/fire-research-summary.

"Holy Smoke!," World Climate Report (July 8, 2002): Volume 7, Number 21, accessed 2014, http://www.worldclimatereport.com/archive/previous_issues/vol7/v7n21/feature.htm.

Hurteau, M. D., Westerling, A. L., Wiedinmyer, C., and Bryant, B. P., "Projected Effects of Climate and Development on California Wildfire Emissions through 2100," *Environmental Science & Technology* (January 20, 2014): Volume 48, Issue 4, accessed 2014, http://pubs.acs.org/doi/abs/10.1021/es4050133.

Ingalsbee, Timothy, "Getting burned: a taxpayer's guide to wildfire suppression costs: a report for Firefighters United for Safety, Ethics, and Ecology (FUSEE)" (August 2010), accessed September 24, 2014. http://www.iawfonline.org/A%20TAXPAYERS%20GUIDE%20TO%20WILDFIRES.pdf.

Ingram, Lynn B. and Frances Malamud-Roam, *The West Without Water: What Past Floods, Droughts, and Other Climatic Clues Tell Us about Tomorrow* (Oakland: University of California Press, 2013)

Intergovernmental Panel on Climate Change, Climate *Change 2014: Mitigation of Climate Change,* April 2014, accessed 2014, http://www.ipcc.ch/report/ar5/wg3/.

Intergovernmental Panel on Climate Change, Summary for Policymakers in: *Climate Change 2013: The Physical Science Basis,* September 2013, accessed July 25, 2014, http://www.climatechange2013.org/report/.

Intergovernmental Panel on Climate Change, Freshwater Resources, in: *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* Part A: Global and Sectoral Aspects, March 2014, accessed July 22, 2014, http://www.ipcc.ch/report/ar5/wg2/.

International Association of Wildland Fire, *IAWF WUI Statistics and Fact Sheet,* August 1, 2013, accessed 2014, http://www.iawfonline.org/pdf/WUI_Fact_Sheet_08012013.pdf.

Insect and Disease Survey (IDS) Database, United States Forest Service Forest Health Protection, accessed September 3, 2014, http://foresthealth.fs.usda.gov/portal/PestSummary/DamageSummary.

"Intelligence," National Interagency Coordination Center: *Wildland Fire Annual Reports,* Fiscal Years 2000 – 2013, accessed September 9, 2014, http://www.predictiveservices.nifc.gov/intelligence/intelligence.htm.

Jacoby, Mitch, "Nano From the Forest," Chemical Engineering News, June 30, 2014. Participants discussed how rising oil prices could make bioenergy a viable with similar affects.

Joint Position Statement: "Sustainable Forest Management Requires Active Forest Management," Inland Empire Society of American Foresters and the Montana Society of American Foresters, accessed December 7, 2014, http://www.cfc.umt.edu/hosting/saf/PositionStatements/Active%20Forest%20Management.pdf.

Kettl, Donald F., System Under Stress–Homeland Security and American Politics, (Washington, DC: CQ Press, 2007).

Lessons Learned From the Cerro Grande (Los Alamos) Fire, testimony to the Committee on Energy and Natural Resources, US Senate, July 20, 2000, GAO/T-RCED-00-257 Cerro Grande Fire; Los Alamos Prescribed Fire: Investigative Report, Secretary of the Interior, May 18, 2000; Los Alamos Prescribed Fire, Independent Review Board Report, May 26, 2000.

MacCleery, D. W., *American Forests: A History of Resilience and Recovery* (Durham, NC: The Forest History Society, 2011), accessed 2014, http://www.foresthistory.org/publications/issues/amforests.html.

Manfredo, M.J., et al., "Attitudes toward prescribed fire policies: The public is widely divided in its support," Journal of Forestry (1990), not available online.

Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., *Climate Change Impacts in the United States: The Third National Climate Assessment.,* US Global Change Research Program, May 2014, accessed July 25, 2014, http://nca2014.globalchange.gov/downloads.

Melvin, Mark A., 2012 *National Prescribed Fire Use Survey Report,* Coalition of Prescribed Fire Councils, Inc. and the National Association of State Foresters (NASF), 2012, accessed December 5, 2014, http://www.stateforesters.org/2012-national-prescribed-fire-use-survey-report

Miller, William and Langdon Morris, Fourth Generation R&D - Managing Knowledge, Technology, and Innovation (Hoboken, NJ: Wiley, 1998).

McCaffrey, Sarah M. and Christine S. Olsen, "Research Perspectives on the Public and Fire Management: A Synthesis of Current Social Science on Eight Essential Questions," USDA Forest Service, Northern Research Station, General Technical Report NRS-104, September 2012. Accessed July 7, 2014, http://www.treesearch.fs.fed.us/pubs/41832http://www.nrs.fs.fed.us/.

Mowery, M., "The Hidden Costs of Wildfire Examined," *NFPA Journal* (January/February 2013), accessed 2014, http://nfpatoday.blog.nfpa.org/2013/01/the-hidden-costs-of-wildfire-examined-in-nfpa-journal.html.

Munich RE (Group), Severe weather in North America, 2012, accessed July 2014, http://www.munichre.com/en/media-relations/publications/press-releases/2012/2012-10-17-press-release/index.html.

National Aeronautics and Space Administration, "NASA's Landsat Revisits Old Flames in Fire Trends," August 29, 2013, accessed 2014, http://www.nasa.gov/content/goddard/nasas-landsat-revisits-old-flames-in-fire-trends/#.U81hxEDyTJF.

National Aeronautics and Space Administration, "Causes," accessed August 11, 2014, http://climate.nasa.gov/causes/.

National Aeronautics and Space Administration, "NASA 'Fire Towers' in Space Watch for Wildfires on the Rise," August 2013, accessed 2014, http://www.nasa.gov/content/goddard/nasa-fire-towers-in-space-watch-for-wildfires-on-the-rise/index.html#.U81fHUDyTJG.

The National Cohesive Wildland Fire Strategy: Northeast Regional Risk Analysis Report, November 1, 2012, accessed September 22, 2014, http://www.forestsandrangelands.gov/strategy/documents/reports/phase3/NortheastRegionalRiskAnalysisReport11012012.pdf.

National Commission on Terrorist Attacks Upon the United States, *The 9/11 Commission Report,* July 27, 2004: accessed August 15, 2014, http://www.9-11commission.gov/report/911Report_Ch11.pdf.

National Interagency Fire Center: National Wildfire Coordinating Group Operations and Workforce Development Committee, *National Incident Management System: Wildland Fire Qualification System Guide* (PMS 310-1), October 2013, accessed 2014, http://www.nwcg.gov/pms/docs/pms310-1.pdf.

National Interagency Fire Center: National Wildfire Coordinating Group, Memo: Current Status on Incident Management Team (IMT) Succession Planning Project (NWCG#038-2010), August 13, 2010, accessed 2014, http://www.nwcg.gov/general/memos/nwcg-038-2010.html.

National Interagency Fire Center: National Wildfire Coordinating Group, Memo: *National Incident Management Team Succession Planning*—Key messages (NWCG#002-2010), January 15, 2010, accessed 2014, http://www.nwcg.gov/general/memos/nwcg-002-2010.html.

National Interagency Fire Center, *Resource Order Requests* (2000-2013), accessed September 12, 2014, http://www.predictiveservices.nifc.gov/intelligence/intelligence.htm.

National Interagency Fire Center, Wildland Fire Summary and Statistics Annual Report (2000-2013), accessed September 23, 2014, http://www.nifc.gov/fireInfo/fireInfo_statistics.html.

National Multi-Agency Coordinating Group, *Key Issues 2013,* accessed 2014, http://gacc.nifc.gov/wgbc/GBCG/Memos/nmackeyissues.pdf.

National Wildfire Coordinating Group, National Incident Management Team Succession Planning—Key Messages, January 15, 2010, accessed September 11, 2014, http://www.nwcg.gov/general/memos/nwcg-002-2010.html.

"Office of Budget," United States Department of the Interior: *Budget Justification and Performance Information for Wildland Fire Management* documents, accessed September 8, 2014, http://www.doi.gov/budget/index.cfm.

Office of Personnel Management, *Federal Civilian Employment Distribution Within Selected Age Groups,* September 30, 2010, accessed September 12, 2014, http://www.opm.gov/policy-data-oversight/data-analysis-documentation/federal-employment-reports/demographics/2010/table9mw.pdf.

Olson, R. L., Bengston, D. N., DeVaney, L. A., Thompson, T., *Final Report: Wildland Fire Management Futures: Insights from a Foresight Panel* (July 2, 2014), not available online.

Postel, S., "Water: Adapting to a New Normal," *The Post Carbon Reader* (p. 77–94), Watershed Media in collaboration with Post Carbon Institute, Healdsburg, CA: accessed July 24, 2014, http://books.google.com/books?id=UHFbK1D3A7AC&pg=PA87&lpg=PA87&dq=With+water+supplies+tightening,+we+will+need+roughly+a+doubling+of+water+productivity+by+2025+to+satisfy+human+needs+while+sustaining+nature%E2%80%99s+life-support+systems.&source=bl&ots=S-.

Pyne, Stephen J. "Flame and Fortune," *Forest History Today* (1996), http://foresthistory.org/Publications/FHT/FHT1996/Pyne.pdf.

Quadrennial Fire Review Report Card, Assessment of work accomplished on recommendations and the accuracy of predictions contained within the 2005 and 2009 QFR's compiled by Booz Allen Hamilton (June 2014), http://www.forestsandrangelands.gov/QFR/documents/QFR_Report_Card_04182014.pdf.

Raths, David, "Will the Chief Information Officer Transform Government?" *Government Technology,* January 31, 2013, accessed September 29, 2014, http://www.govtech.com/e-government/Will-the-Chief-Innovation-Officer-Transform-Government.html.

Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N. W., Clarke, D. B., et al., Multi-model Assessment of Water Scarcity Under Climate Change. *Proceedings of the National Academy of Sciences of the United States of America,* 111(9) (December 16, 2013): accessed July 20, 2014, http://www.pnas.org/content/111/9/3245.full.

Schwartz, Peter, The Art of the Long View (New York, NY: Currency Doubleday, 1996).

Singer, F.J. and P. Schullery, "Yellowstone wildlife: populations in process," Western Wildlands, (1989), not available online.

Stankey, G.H. and S.F. McCool, "Visitor attitudes toward wilderness fire management policy: 1971-1984," US Department of Agriculture, Forest Service (1986), not available online.

"Statistics," National Interagency Fire Center, accessed September 9, 2014, http://www.nifc.gov/fireInfo/fireInfo_statistics.html.

"Sumatra: Going Up In Smoke," *Greenpeace Southeast Asia* (May 28, 2014); accessed September 11, 2014, http://www.greenpeace.org/international/Global/international/briefings/forests/2013/Peat-Forest%20Fires_Briefer_May28-2014.pdf.

Thompson, Leigh, The Mind and Heart of the Negotiator, 2nd ed. (Uppers Saddle River: Prentice Hall, 2001).

Tidwell, Tom, Chief of United States Forest Service, Testimony before the US Senate Committee on Energy and Natural Resources (June 4, 2013), accessed 2014, http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=e59df65c-09c6-4ffd-9a83-f61f2822a075.

Toppo, G., Overberg, P., "US population growth slows to just 0.71%," *USA Today* (December 31, 2013), accessed 2014, http://www.usatoday.com/story/news/nation/2013/12/30/census-state-population-estimates-growth/4248089/.

Turner, C., "A wildfire forum takes radical approach to protecting wildland–urban interface," *High Country News* (February 6, 2014), accessed 2014, https://www.hcn.org/blogs/goat/behind-closed-doors-wildfire-solutions-forum-takes-radical-approach-to-protecting-wui-from-wildfire.

United States Census Bureau, Population Division, *Projections of the Population and Components of Change for the United States: 2015 to 2060* (NP2012-T1), December 2012, accessed September 9, 2014, http://www.census.gov/population/projections/data/national/2012/summarytables.html.

United States Department of Agriculture Office of Inspector General, *Forest Service's Firefighting Succession Planning Process* (Audit Report 08601-54-SF), March 2010, accessed 2014, http://www.usda.gov/oig/webdocs/08601-54-SF.pdf.

United States Department of Agriculture and Department of Interior, *Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy,* June 30, 2003, accessed September 8, 2014, http://www.sierraforestlegacy.org/Resources/Community/SmokeManagement/AirQualityPolicy/FedWldFireMgmtPolicy.pdf.

United States Department of Agriculture, *Forest Service, Fiscal Year 2014 Forest Service Budget Justification,* April 2013, http://www.fs.fed.us/aboutus/budget/2014/FY2014ForestServiceBudgetJustificationFinal041613.pdf.

United States Department of Agriculture, Strategic Plan FY 2014 – 2018, accessed August 5, 2014, http://www.usda.gov/documents/usda-strategic-plan-fy-2014-2018.pdf.

US Drought Monitor, accessed September 9, 2014, http://droughtmonitor.unl.edu/.

United States House Committee on Natural Resources, Forest Health and Wildfires, July 2013, accessed August 12, 2014, http://naturalresources.house.gov/issues/issue/?IssueID=5924.

United States Forest Service, All damage types acres for all pests by state (2009-2013): accessed September 3, 2014, http://foresthealth.fs.usda.gov/portal/PestSummary/DamageSummary.

United States Forest Service and the Ad Council, Fire Adapted Communities Campaign Fact Sheet, http://fireadapted.adcouncil.org/campaign-background/.

United States Forest Service, *Fire and Aviation Management, Workforce and Development Strategic Framework,* 2012, accessed 2014, http://www.fs.fed.us/fire/people/workforce_succession_planning/documents/fam_workforce_development_strategic_framework.pdf.

United States Forest Service: Forest Health Protection Division, Forest Insect and Disease Conditions Reports, accessed August 12, 2014, http://www.fs.fed.us/foresthealth/management/fhm-conditions.shtml.

United States Forest Service, Historical natural fire regimes map, unpublished analysis of LANDFIRE 1.0.5 fire regime groups layer. On file with G. Dillon, US Forest Service, Rocky Mountain Research Station, Fire Modeling Institute, Missoula Fire Sciences Laboratory, 5775 W. Highway 10, Missoula, MT 59808-9361.

United States Forest Service, Internal agency document identifying the numbers of airtankers and Type 1 and Type 2 helicopters 1960-2013, accessed August 7, 2014, not available online.

United States Forest Service, Large Airtanker Modernization Strategy, February 10, 2012, accessed 2014, http://www.fs.fed.us/fire/aviation/airtanker_modernization_strategy.pdf.

United States Forest Service Open Space Conservation, Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland–Urban Interface, January 2013, accessed 2014, http://www.fs.fed.us/openspace/fote/wildfire-report.html.

United States Forest Service Wildland Fire Chemicals Systems, *Wildland Fire Chemical Products: Toxicity and Environmental Concerns General Information,* accessed July 24, 2014, www.fs.fed.us/rm/fire/documents/envissu.pdf.

United States Government Accountability Office, *Wildland Fire Management: Interagency Budget Tool Needs Further Development to Fully Meet Key Objectives* (GAO-09-68 publicly released November 24, 2008), accessed 2014, http://www.gao.gov/products/GAO-09-68.

United States Geological Survey, Historic Federal Wildland Fire Occurrence Data, accessed September 3, 2014, http://wildfire.cr.usgs.gov/firehistory/data.html.

United States Geological Survey, *Quantifying Soil Carbon Change from Wildfires in Peatland Ecosystems of the Eastern United States Using Repeat LiDAR,* not available online.

van Wagtendonk, Jan W. "The History and Evolution of Wildland Fire Use," *Fire Ecology,* (2007): Special Issue, Vol. 3, No. 2, http://fireecologyjournal.org/docs/Journal/pdf/Volume03/Issue02/003.pdf.

Vose, J. M., Peterson, D. L., and Patel-Weynand, T., Eds., *Effects of Climatic Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the US Forest Sector* (United States Forest Service, Pacific Northwest Research Station General Technical Report PNW-GTR-870, December 2012), accessed 2014, http://www.usda.gov/oce/climate_change/effects_2012/FS_Climate1114%20opt.pdf.

Wildland Fire Information and Technology Project Plan, Wildland Fire Information and Technology Executive Board, March 22, 2013. Accessed August 6, 2014. www.forestsandrangelands.gov/WFIT/.../WFIT_ProjectPlan3-22-13.pdf

Zoroya, Gregg "Wildfire crews battle PTSD, much like soldiers at war," USA Today (September 6, 2014), accessed September 22, 2014, http://www.usatoday.com/story/news/nation/2014/09/06/climate-fires-firefighters-ptsd-strain/14061659/.

Zybach, B., Dubrasich, M., Brenner, G. and Marker, J., US Wildfire Cost-Plus-Loss Economics Project: The "One-Pager" Checklist," (published by Wildland Fire Lessons Learned Center, August 1, 2009), accessed 2014, http://www.wildfire-economics.org/Checklist/Zybach_et_al_2009b.html.

ACKNOWLEDGMENTS

The following individuals made significant contributions to the development of this report:

- Janae Bawden, Communications and Facilitation
- Ryan Belote, Business Support Services
- Sarah Burke, Editor
- Andrew Fontana, Analyst
- Will Healy, Program Manager
- Kirk Hornburg, Workshop Facilitator
- Andrew Jesmain, Deputy Project Manager and Analysis Lead
- Jeff Keeton, Analyst
- Troy Kofroth, Executive Advisor
- Brian McManus, Wildland Fire Expert
- Michael Pacheco, Report Design and Graphics Lead
- Eric Pynn, Senior Analyst
- Fred Richardson, Project Manager
- Mary Vogt, Contract Officer
- Marc Weber, Executive Advisor
- Jessica Williams, Editor
- Amy Wilson, Communications Lead

The project team would like to extend its sincere thanks and appreciation to Sandra Burnett of the Forest Service Fire & Aviation Management and Russ Johnson of the Department of the Interior Office of Wildland Fire, for their leadership and support during the execution of the 2014 QFR.

Happy Camp Fire, Klamath National Forest, California, 2014 (Kari Greer Photo)

2014 QUADRENNIAL FIRE REVIEW

FINAL REPORT