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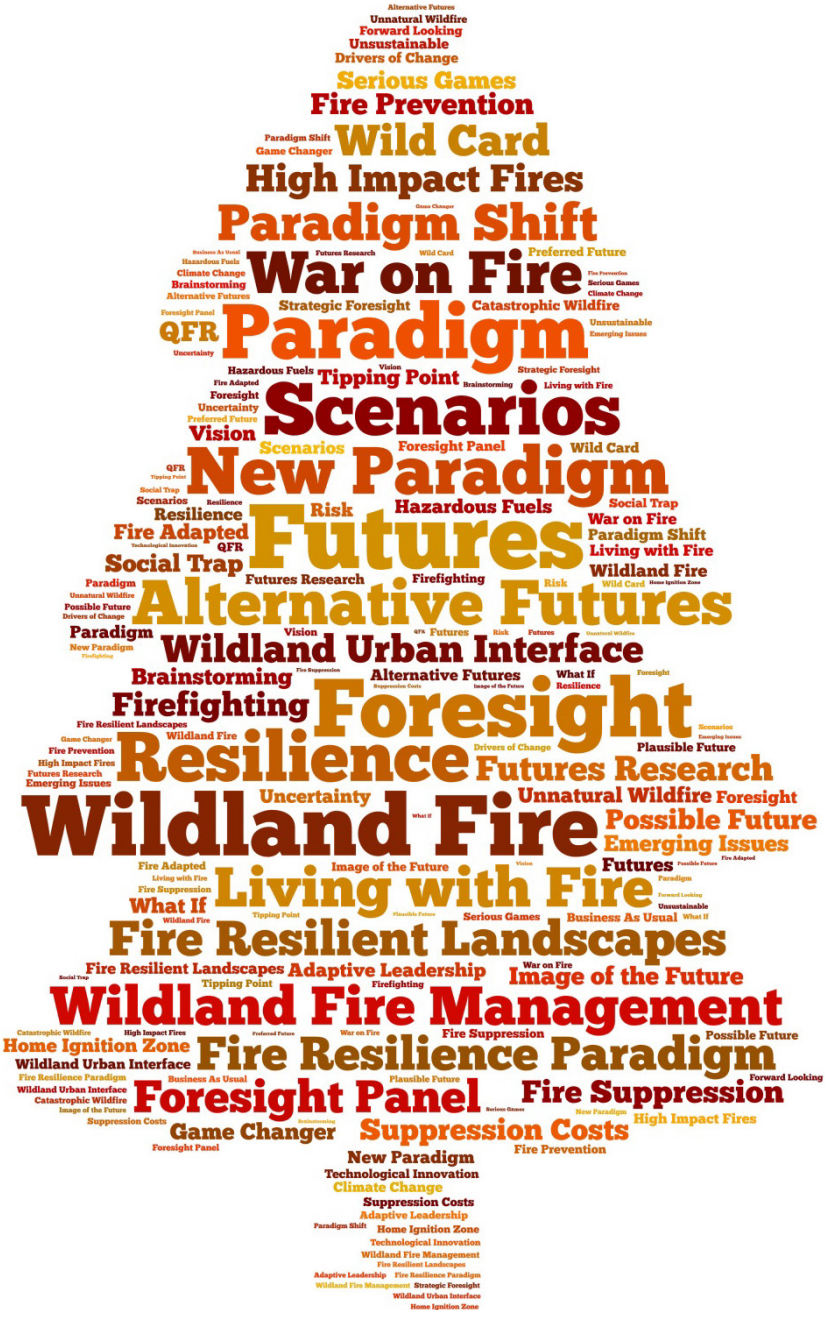
Wildland Fire Management Futures: Insights from a Foresight Panel



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Abstract

Wildland fire management faces unprecedented challenges in the 21st century: the increasingly apparent effects of climate change, more people and structures in the wildland-urban interface, growing costs associated with wildfire management, and the rise of high-impact fires, to name a few. Given these significant and growing challenges, conventional fire management approaches are unlikely to be effective in the future. Innovative and forward-looking approaches are needed.

This study explored wildland fire management futures by using methods and diverse perspectives from futures research. To gain foresight for wildland fire management, we convened a foresight panel consisting of seven leading academic and professional futurists outside of the wildfire community and two wildfire professionals. We engaged the panelists in a series of structured online discussions to elicit their insights and perspectives on the future of wildland fire management.

There are five broad areas where the foresight panel members were in full agreement. (1) The level of uncertainty about external developments and future conditions that will set the context for wildland fire management is significantly greater than is recognized in current planning. (2) As conditions change, the traditional fire prevention and suppression approach to wildfire management will prove unsustainable. (3) A new fire resilience approach is emerging as an alternative to traditional viewpoints and practices. (4) All the major strategies needed to implement this approach are already familiar to wildfire managers. (5) There are strong short-term barriers to adopting the fire resilience approach, but the panelists believe its adoption is nearly inevitable between now and mid-century.

Quality Assurance

This publication conforms to the Northern Research Station's Quality Assurance Implementation Plan which requires technical and policy review for all scientific publications produced or funded by the Station. The process included a blind technical review by at least two reviewers, who were selected by the Assistant Director for Research and unknown to the author. This review policy promotes the Forest Service guiding principles of using the best scientific knowledge, striving for quality and excellence, maintaining high ethical and professional standards, and being responsible and accountable for what we do.

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Wildland Fire Management Futures: Insights from a Foresight Panel

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EXECUTIVE SUMMARY

Wildland fire management faces unprecedented challenges in the 21st century: the increasingly apparent effects of climate change, more people and structures in the wildland-urban interface (WUI), soaring costs associated with wildland fire management, and the rise of high-impact fires, to name a few. Given these significant and growing challenges, conventional fire management approaches are unlikely to be effective in the future. Innovative and forward-looking approaches are needed.

This study explored wildland fire management futures by using methods and diverse perspectives from futures research. To gain foresight for wildland fire management, we convened an expert foresight panel and engaged the panelists in a series of structured online discussions. Most panelists in this study were outside of the wildland fire community. The seven academic and professional futurists and two wildfire professionals provided their insights and perspectives on the future of wildland fire management.

Key Areas of Agreement

There are five broad areas where the foresight panel members were in full agreement.

1. The level of uncertainty about the external developments and future conditions that will set the context for wildland fire management is significantly greater than is recognized in past Quadrennial Fire Reviews (QFRs) and current planning.

For example, the latest report by the United Nations Intergovernmental Panel on Climate Change (IPCC 2014) estimates that if the world continues down its current carbon-emitting course, average global temperatures could rise by anywhere from 2.6 °C (4.7 °F) to a staggering 4.8 °C (8.6 °F) by the end of the century. On anything near this course, wildland fire management would soon become much more difficult, expensive, and dangerous to firefighters than managers are anticipating today. Changes in the economy, energy prices and availability, technology, and other factors make very different conditions possible over the decades ahead.

Given such large uncertainties, the foresight panel members organized their conversations around a set of three scenarios that embrace the span of future conditions they believe are plausible. They range from an image of economic decline and political dysfunction (scenario 1) to a business-as-usual image (scenario 2) and an image of rapid technical and social innovation, more efficient government, and an unprecedented mobilization to deal with climate change (scenario 3).

2. As conditions change, the traditional fire prevention and suppression approach to wildland fire management will prove unsustainable.

Larger and more damaging fires are becoming more common, and panel members see this situation worsening with no end in sight under the current approach to wildland fire management. Constant fire suppression causes the buildup of fuels, so we are self-selecting for fires that we cannot control and that do the greatest damage.

3. A new fire resilience approach is emerging as an alternative to traditional viewpoints and practices.

The emerging approach is based on an appreciation of the self-regulating processes in nature and an aspiration to "go with the flow" of those processes. It accepts fire as a natural part of the landscape with important ecological functions and emphasizes learning to live with fire rather than waging war against it. The central goal of this approach is to create fire-resilient communities, both ecological and human. The new fire resilience paradigm is based on the notion of comanagement of risk, with individuals, communities, governments, and other organizations learning together what they can each do to create a sustainable approach to wildland fire management.

4. The major strategies needed to implement this fire resilience approach are already familiar to wildland fire managers.

Becoming fire-resilient requires well-known strategies such as communities protecting structures with building codes and buffer zones, requiring ignition-resistant landscaping, and designating evacuation routes and safe zones in the community. As communities move toward fire resilience, adjacent areas and back-country lands would be thinned and treated with fire to make them fire-resilient as well. These measures and related strategies are familiar to wildland fire managers and there are programs to encourage them, but not on the needed scale. Fire resilience strategies would apply not just to places where people already live, but also to new development in the 84 percent of the WUI across the western United States that has not yet been developed. Once communities, adjacent lands, and back-country areas have been made fire-resilient, sustainable wildland fire management would then involve maintaining this pattern over time.

5. There are strong short-term barriers to adopting the fire resilience approach, but panel members believe its adoption is nearly inevitable between now and mid-century.

If the future unfolds along the lines of scenario 1, with government budgets cut to the bone, the war on fire would end by force of necessity. Communities that become fire-resilient would survive fires without much harm; others would suffer more damage. If future conditions evolve to be more like scenario 3, with ample resources, a commitment to sustainability, and openness to innovation, panelists believe the fire resilience approach would be readily adopted. Resistance to the fire resilience approach would persist the longest in the business-as-usual conditions of scenario 2, but would eventually crumble as landscapes are devastated by more and more catastrophic fires.

Facilitating the Shift Toward Fire Resilience

Panel members used the scenarios to focus discussion on measures for facilitating the shift toward fire resilience likely to be workable across a broad range of future conditions. This put the focus on low-cost, easy-to-manage measures that might be possible even in the conditions of scenario 1. Many of these ideas are already being implemented and need only to be strengthened or continued. Recommended efforts are:

- Cultivate an adaptive leadership stance where the leader does not have all the answers and where a central leadership task is to span organizational boundaries and facilitate people learning together, experimenting, and cooperating to solve problems.
- Use awards, certifications, and fire resilience design competitions to reward and encourage innovation, such as with a certification program for fire-resistant homes similar to the Leadership in Energy and Environmental Design (LEED) program.
- Create an ongoing and innovative public relations effort highlighting the fire resilience approach.
- Connect wildland fire management to larger global concerns for sustainability and security with low-cost steps such as encouraging studies by organizations like the Worldwatch Institute.
- Conduct additional social science research to more fully understand the human dimensions of a fire resilience approach.
- Provide additional "how to do it" information on becoming fire-resilient in many forms and through many different channels.
- Use "serious games" and playable simulations to train first responders and engage communities, homeowners, and children.
- Help educate the political community about the true nature of wildland fire problems.
- Support the development of a new fire economics that incorporates long-term thinking and the value of life-supporting ecosystem services.
- Start an ongoing dialogue between the wildland fire management community and the insurance industry to discuss strategies for encouraging

communities to become more fire-resilient, such as supporting efforts to develop more fire-resistant structures and helping policy holders understand what they can do to mitigate fire risk.

If more resources are available, many of these actions could be strengthened and many additional actions could be possible, such as rapid expansion of fuel treatment programs or a program to finance fire-resistant home improvements modeled after existing weatherization programs.

If conditions evolve so that strong federal leadership is possible, the federal government could pursue a comprehensive approach, helping to create a new system of firesheds across the country. Each fireshed would have a council responsible for all aspects of wildland fire including fuels treatment, preparedness planning, suppression response, fire rehabilitation and recovery, and promotion of fire-resilient land use building codes and zoning. The federal government could provide incentives to these councils, prioritizing investment based on risk ranking and community performance.

Institutionalizing Foresight in Wildland Fire Management

Our panelists agreed that the development of foresight must be ongoing and institutionalized into routine planning and policy-making to have a lasting effect. A single foresight exercise like this one, or even periodic efforts like the QFRs, quickly loses its value no matter how skillfully done and widely embraced. Institutionalizing foresight capacity in wildland fire management would help identify emerging issues, driving forces of change, potential wild cards (events with low probability and high impact), and a range of plausible scenarios that can help provide the broad context for fire management planning.

Panel members identified two main strategies for institutionalizing foresight into wildland fire management. An in-house strategy would involve creating an interagency fire futures unit that would be staffed with several trained futurists, with enough budget and personnel to do high-quality and continuing foresight. This unit would be responsible for regular horizon scanning and high-priority projects exploring possible, plausible, and preferable fire futures using a range of foresight methods.

An alternative strategy is to have one high-level person assigned specifically to contract with futures research organizations and think tanks, purchasing scans and futures surveys on a regular basis, and working closely with fire planners, managers, and policy makers to incorporate the findings into decisionmaking and strategies. Outsourcing foresight activities is a common approach in corporations, but it is important for decisionmakers to ensure that foresight developed by outside consultants is relevant and incorporated into strategic planning and decisions.

Conclusions

The key areas of agreement among the panelists point toward a new direction for wildland fire management: a paradigm shift from the "war on fire" approach emphasizing fire suppression and exclusion, to a fire resilience approach emphasizing learning to live with fire in resilient communities on fire adapted landscapes. These are certainly not new ideas in the fire management community—they have deep roots in holistic thinking about social-ecological systems. But as with all paradigm shifts, the new fire management paradigm faces many barriers and obstacles. Our hope is that this study will stimulate further forward-looking debate and discussion about the future of wildland fire management.

INTRODUCTION

Wildland fire management faces unprecedented challenges in the 21st century. The list of major challenges is well known in the wildfire community, and includes the following:

- The number, size, and intensity of wildland fires have increased significantly in many parts of the world in recent decades, and they are expected to continue to increase in the decades ahead due to projected climate change (Moritz et al. 2012, Stephens et al. 2013). Factors driving increased frequency and size of fires include rising temperatures, longer fire seasons, earlier spring snowmelts, and an accumulation of forest fuels in many areas due to decades of fire suppression.
- The presence of more people and structures in the path of wildland fires has increased the social and economic impacts of fire activity. Related trends include population growth, sprawling development patterns, growing multiple and seasonal homeownership, amenity migration, and interregional population shifts to the West and Southeast (Hammer et al. 2009). Retirement by the baby boom generation over the next 20 years is expected to intensify most of these trends.
- The cost of wildfire suppression has grown alarmingly and suppression costs are only a small fraction of the full direct, indirect, and postfire costs associated with wildfire. According to Zybach et al. (2009), suppression costs represent no more than 10 percent of actual wildfire costs to society. Studies have estimated that total economic costs can be at least 10 to 50 times suppression costs.
- The frequency of "fire events that cause catastrophic damages in terms of human casualties, economic losses, or both" (San-Miguel-Ayanz et al. 2013: 11) has increased. These large wildfires are distinguished by the extraordinary scope and scale of their impacts. According to Williams (2013), 0.1 percent of wildland fires account for about 95 percent of total area burned and 85 percent of the total costs of suppression. Carbon emissions associated with high-impact fires are positive feedbacks to climate change (Adams 2013).

Given these significant and growing challenges, conventional fire management approaches are unlikely to be effective in the future. Innovative and forward-looking approaches are needed.

Several recent reports have identified challenges, opportunities, and risks to help wildland fire policy makers and managers plan for an uncertain and changing future. Most prominent among these are the Quadrennial Fire Reviews (QFRs), a strategic assessment process carried out by the five federal fire management agencies and their partners in the wildland fire community every 4 years to help guide budgeting and strategic planning. The 2005 Quadrennial Fire and Fuel Review (QFFR) was developed by more than 200 personnel from the fire community, including fire experts from federal, state, local, and tribal partners, with input from the fire and natural resource research community and nongovernmental organizations (U.S. Department of Agriculture [USDA] and U.S. Department of the Interior [USDI] 2005). A series of meetings were held around the country to gather input, followed by more formal "working panels" organized around specific topics of interest. The 2009 QFR broadened the process used in the 2005 QFFR in several respects, such as greater involvement of nonfire and nonfederal participants, an expanded domain of the working panels to explore a wider range of future options, and a greater role for research in the process (USDA and USDI 2009). The next QFR is being conducted by the strategic management and technology consulting firm Booz Allen Hamilton. See Appendix 1 for a brief review of the QFRs and other fire futures studies.

This study offers a supplemental and alternative approach to the QFRs, exploring wildland fire management futures via methods and diverse perspectives from futures research. Futures research is a transdisciplinary social science that uses an array

of methods and perspectives to examine alternative possible, plausible, and preferable futures (Bengston et al. 2012, Cook et al. 2014). The goal of futures research is to produce strategic foresight, defined as "the ability to create and maintain a high-quality, coherent, and functional forward view and to use the insights arising in organizationally useful ways; for example, to detect adverse conditions, guide policy, shape strategy" (Slaughter 2002: 104). To gain foresight for wildland fire management, we convened an expert foresight panel consisting of professional futurists and wildfire professionals, and engaged the panelists in a series of online discussions.

This project does not attempt to "predict the future" of wildland fire management. Successfully predicting the future of complex social-ecological systems is rarely possible because of the prevalence of surprise (Gunderson and Longstaff 2010) and irreducible uncertainties (Carpenter 2002). But wildland fire managers and policy makers must still anticipate and prepare for a rapidly changing world. Futures research offers a productive set of approaches to this challenge. Enhanced foresight resulting from our project may be helpful in preparing for and shaping the future of fire management.

The next section describes the methods used in our study of the future of wildland fire management. This is followed by a discussion of the key areas where our panel members agreed about potential future developments, contexts, and directions for wildland fire management. Recommended actions are then summarized, and guidelines for institutionalizing foresight in wildland fire management follow.

METHODS

This study involved recruiting futurists and wildfire professionals for an expert foresight panel and engaging the panelists in a series of structured, text-based, asynchronous online discussions to explore wildland fire management futures. The use of foresight panels generally entails identifying a diverse set of creative thinkers and querying them about (1) potential high-impact future developments that may affect the topic of interest, (2) the likelihood and impacts of these developments, and (3) policies to encourage positive developments or to deal with negative impacts (Environmental Futures Committee 1995, Gordon and Glenn 2009). Foresight panels are often conducted in multiple, interactive rounds. This section describes the main steps in our three-round, online panel method. See Bengston and Olson (2015) for additional detail.

Selecting Panel Members

Most of the panelists in this study were outside of the wildfire community. Seven leading academic and professional futurists plus two wildfire professionals were recruited to provide their insights and perspectives on emerging issues and trends that will likely affect fire management in the future. The box on page 6 presents a list of our foresight panel members. A biographical sketch for each participant is given in Appendix 2.

A panel consisting mostly of wildfire outsiders was chosen because specialists within a field are often unaware of external developments that may have significant effects in the future. Specialists tend to focus within their field and see what they are trained to see. This phenomenon has been termed the "educated incapacity" of experts with respect to perceiving the future: experts generally "know so much about what they know that they are the last to see that future differently" (Weiner and Brown 2005: 2). People with a broad array of outside perspectives and knowledge spanning diverse fields are more likely to see a wider range of possible and plausible futures.

Our panel of futurists included individuals with diverse perspectives and disciplinary roots. Futurists are generalists by nature and practice. Bell (1997: 182) observed that because futurists examine a wide range of topics and draw on many different fields of knowledge, "the futurist tends to become a polymath, a generalist, and a universalist." Futurists strive to see the big picture and how the parts interrelate to produce the whole.

In addition to the seven top-of-the-profession futurists, two highly regarded wildfire professionals were included on the panel: a social scientist known for her work

Foresight Panel Participants

Futurists

Peter C. Bishop: Retired associate professor of strategic foresight and director of the graduate program in futures studies at the University of Houston; founding board member of the Association of Professional Futurists; president of Strategic Foresight and Development.

Jamais Cascio: Professional futurist at OpentheFuture.com; Distinguished Fellow at the Institute for the Future; Senior Fellow at the Institute for Ethics and Emerging Technologies; cofounder of WorldChanging.com.

James A. Dator: Professor and director of the Hawaii Research Center for Futures Studies, Department of Political Science; former president of the World Futures Studies Federation; cofounder of the Institute for Alternative Futures.

Elizabeth Hand: Award-winning visionary scenario writer; author of 15 novels and 4 collections of short stories; faculty member at the Stonecoast MFA Program in Creative Writing at the University of Southern Maine.

Michael Marien: Former editor of Future Survey, a scanning service published monthly by the World Future Society from 1979-2008; director of GlobalForesightBooks.org; has published a large number of articles in leading futures research journals and other scholarly journals.

Jonathan Peck: President and senior futurist at the Institute for Alternative Futures; futures work spans scientific, economic, political, and social changes that can be addressed with an understanding of complex systems dynamics.

David Rejeski: Director of the Science and Technology Innovation Program at the Woodrow Wilson International Center for Scholars; former head of the Future Studies Unit at the U.S. Environmental Protection Agency.

Wildland fire professionals

Sarah McCaffrey: Social scientist with the U.S. Forest Service, Northern Research Station's "People and Their Environments" research unit; internationally recognized expert on the social dynamics of fire management.

John Phipps: Director of the Rocky Mountain Research Station; former senior advisor in the Deputy Chief's Office, U.S. Forest Service, State & Private Forestry; develops policy analysis and options for national fire issues.

on the human dimensions of wildland fire, and a fire policy expert. These wildfire professionals provided invaluable perspectives and knowledge, and served as a resource for the other panelists when questions about fire management and policy arose during the online discussions. The principal investigators (Olson and Bengston) and research assistants (DeVaney and Thompson) also participated in the online discussions.

Asynchronous Computer Conferencing

Panelists interacted in three separate week-long rounds of discussion (each about 2 months apart) using text-based asynchronous computer conferencing, a form of computer-mediated communication in which there is a delay in interaction between contributors. This approach is in contrast to synchronous computer conferencing, in which participants communicate simultaneously in "real time." Asynchronous computer conferencing has several advantages over face-to-face meetings and synchronous computer conferencing. Travel expenses are avoided, participants can join in and contribute at any time of the day or night, messages are stored and can be searched and analyzed later, and participants have time to reflect before posting a message. This last point may be the most compelling advantage of asynchronous computer conferencing: its capacity to support reflective interaction, independent of the pressures of time (Wu and Hiltz 2004). This feature is especially important in the context of developing high-quality and coherent strategic foresight.

To be effective, computer conferencing requires skilled moderation (Collison et al. 2000, Heuer and King 2004). The moderator needs to actively manage the discussion, including providing instructions to set the discussion parameters, posing questions to clarify points made by participants, adding new topics and questions to a discussion thread, keeping the conversation on track, summarizing the discussion at appropriate points, and identifying emerging themes and common points of agreement and disagreement—a process called weaving (McGugan 2002). One of the principal investigators in this study (Olson) has moderated asynchronous computer conferences over several years involving hundreds of participants. The Web-based conferencing platform used in this study was InVision Power Services, Inc. (IPS Inc., Forest, VA).

Panel Groundwork

After identifying our panel members and securing their participation, we asked them to read a set of nine short background papers intended to quickly familiarize them with U.S. wildfire issues. The background readings covered the following topics: the history of wildfire policy in the United States (Dombeck et al. 2004, Harbour 2009), the Incident Command System (Idaho Firewise 2015, Wikipedia 2013), the wildland-urban interface or WUI (McKinley and Johnson 2007), climate change and wildfire (ScienceDaily 2012a), the phenomenon of mega-fires (Maron and ClimateWire 2011), and perspectives on the future of wildfire (ScienceDaily 2012b, USDA and USDI 2009). The futurists on the panel proved to be quick learners with a big appetite for more information about the wildfire situation and wildland fire management, and they frequently exchanged relevant articles and other information via email throughout the panel process.

Participants were then asked to prepare a short paper or bullet-pointed list stating their initial thoughts about the most significant emerging developments and trends that have potential implications for wildland fire management in the future, drawing broadly from their knowledge and imagination. We encouraged panelists to think broadly about technical innovations, social developments, environmental changes, economic disruptions, changes in government and in the role of the fire management agencies, U.S. developments, global developments, converging developments in different areas, unlikely developments that could blindside the wildfire community, and so on. A spirit of wide-open brainstorming was encouraged, with no idea too wild to hold back. Although they were asked to provide only one or two pages, most of the panelists provided considerably more.

Round 1

We analyzed the initial-thought papers and identified the following 12 major themes, each of which became a separate discussion thread in the first round of online discussion: climate change, monitoring, serious games, bioengineering, new firefighting technologies, insurance, risk assessment, economic and political context, value change, fire-resistant designs and materials, public education and engagement, and policy tools. Within the online conferencing platform, each topic in round 1 began with a "conversation starter" which summarized the ideas brought up in participants' initial-thought

papers, posed broad questions related to the topic, and invited participants to jump into the discussion. Panel members elaborated on their initial thoughts, contributed new ideas, and reacted to and built on each other's ideas.

Two additional topics were added (by the moderator) during the first round: Can the Forest Service escape its "social trap"? and preferred and likely futures.[1]

Round 2

The last topic in round 1 (preferred and likely futures) helped lead into the second round of discussion, in which panel members provided reactions to three mini-scenarios developed by the principal investigators to serve as a framework for strategic conversations. This approach is similar to futurist Jim Dator's alternative futures method, in which multiple generic or archetypal images of the future are used to stimulate broad thinking about the future of an organization, community, or subject area (Dator 2009). The three scenarios described a wide range of plausible social, economic, and technological contexts for fire management in the future: "collapse" (or slow unraveling), "continue" (or business as usual), and "transformation" (a surprisingly positive future). The complete mini-scenarios are given in Appendix 3, but the following outlines give a sense of their character:

Scenario 1: Collapse

- Slow economic growth and then decline stretching into the foreseeable future
- An increasingly polarized, dysfunctional, ineffective federal government
- A sharp decline in government spending
- Progress in science and technology slowed or derailed in most areas
- Peak oil; the natural gas revolution proves shorter lived than expected; soaring energy prices; limited financial ability to invest in renewables or nuclear power
- Stressed ecosystems, severe water scarcities, some environmental impacts eased by economic decline
- Carbon emissions stay high for a time with growing reliance on tar sands and coal, then decline as growth falters
- Growing social unrest at first; growing local self-sufficiency over time

Scenario 2: Continue

- Economic recovery with continuing moderate growth in U.S. and global economies
- Easing of political polarization, some improvement in government functioning
- Cuts to entitlements and other government programs, but increased spending in highest-priority areas
- Continuing technological advances, but few major breakthroughs
- Boom in shale gas and oil, significant growth in renewables but not as a proportion of total energy used
- Increasing pollution, environmental damage, resource depletion; more sprawl in the WUI
- Accelerating climate change; major increase in wildfires in the United States and globally
- Slight easing of economic disparities and social tensions

Scenario 3: Transformation

- Rapid technological progress accelerates growth, but there is less emphasis on consumption, more on investment in energy and resource efficiency, renewable energy, advanced manufacturing, sustainable agriculture
- Revitalized, smaller, and more efficient government; budget cuts in some areas but heavy spending in highest-priority areas
- Major breakthroughs in several areas of technology

[1] A "social trap" is a situation in which the short-term, local incentives and reinforcements guiding behavior are at odds with the long-term, global best interest of society (Costanza 1987, Platt 1973).

- Energy system transformation with large investments in energy efficiency, renewable energy, smart grids, and energy storage
- Reduced environmental impacts and resource depletion despite growth, but global impacts are still high
- Unprecedented mobilization to deal with climate change
- High receptivity to innovation; adaptive leadership; sense of common purpose (creating a sustainable future, shifting to clean energy, minimizing climate change, achieving a higher quality of life) animates society

This wide range of plausible future contexts for wildland fire management, going well outside of the business-as-usual assumptions typically used in planning, provides a more robust way of thinking about wildland fire management futures.

For each scenario, participants were instructed to consider the following questions: What significant changes in wildland fire management could result from (or would be required by) this scenario? How would wildland fire management need to adapt to make the best of this possible future?

In addition to brainstorming about the three scenarios, round 2 included a wild card discussion forum. Wild cards are unlikely but possible developments that would be total "game changers" (for better or worse) if they should occur. Examples of possible wild cards are abrupt or runaway climate change and the development of biotechnology- or nanotechnology-based "virtual fire" that creates the ecological benefits of wildfire without the dangers. The inclusion of wild cards is an important aspect of futures thinking because they are the most disruptive type of discontinuous change yet they are almost always neglected in traditional planning (Petersen and Steinmueller 2009).

Round 2 also included a "water cooler" forum for discussing any other topic that occurred to the panelists and a discussion labeled "Reactions to Michael Marien's Paper." Panelist Michael Marien contributed a thoughtful and broad-ranging paper on wildfire futures after the first round. The moderator created a separate forum for participants to discuss the paper, which generated significant dialogue, including discussion of the need for a new paradigm of wildland fire management.

Round 3

The third and final round consisted of four discussion threads:

- Actions and strategies appropriate in all three scenarios
- Does the new paradigm, developed in round 2, "work" in all three scenarios?
- Institutionalizing foresight in the wildfire management community
- Another "water cooler" forum for open discussion of any topic

The first of these discussion threads was motivated by the need to identify robust actions that would be appropriate and effective across a wide range of potential future conditions. Participants were asked to look again at the three scenarios used in round 2 and discuss wildland fire management ideas that would be suitable given the circumstances of at least two of the scenarios.

The second discussion thread, "Does the new paradigm 'work' in all three scenarios?", focused on a paradigm shift in wildland fire management that first emerged in the initial-thought papers and grew throughout the first and second rounds. The essence of this paradigm shift is that the current prevailing "war on fire" paradigm (focusing heavily on suppression) will increasingly fail and that we need to embrace a new paradigm of wildland fire management that focuses on learning to live with fire and creating fire-resilient communities. Panelist John Phipps proposed a "2050 Vision" in round 2 that was a good articulation of this perspective and was used as an example of the new paradigm in this discussion forum. Participants were asked to be specific about how and why a new wildland fire management paradigm similar to this vision would or would not be viable across all three of the scenarios.

See Appendix 4 for the full statement of this version of the new paradigm.

Finally, the discussion thread on "institutionalizing foresight in the wildfire management community" focused on specific recommendations to the wildland fire management community about how to improve foresight capability, institutionalize foresight as a continuous process, and effectively integrate it with decisionmaking and planning.

Analysis

After the last round, the transcripts of all three rounds of online discussion were analyzed and summarized for the final report. The open coding method was used to identify major themes in the text, an approach that is well suited to capture rich themes and uncover unanticipated issues. This method involves a process of repeated and careful reading of the text, developing an outline of recurring themes, and cross-referencing each theme back to the original text. See Strauss and Corbin (1998) for details on the open coding method.

KEY AREAS OF AGREEMENT

The foresight panel members disagreed about the likelihood of various future developments and the feasibility of specific actions, but there were five broad areas where all the panelists were in full agreement.

1. The level of uncertainty about external developments and future conditions that will set the context for wildland fire management is significantly greater than is recognized in past Quadrennial Fire Reviews (QFRs) and current planning.

The 2009 QFR identified the following forces for change in wildland fire management (USDA and USDI 2009):

- Effects of climate change
- Cumulative drought effects and fuel accumulation
- Increasing WUI growth as better economic conditions resume
- Escalating emergency response demands
- Stress on agency budgets and fire budget resources

Panel members agreed that these are among the key driving forces. However, they were unanimous in their belief that the plausible range of change in these forces is much greater than assumed in the QFR.

For example, the wildland fire community may be greatly underestimating what is probably the most important long-term driving force: climate change. A 2012 U.S. Forest Service report, *Effects of Climate Variability and Change on Forest Ecosystems* (Vose et al. 2012), estimates that U.S. wildfires could be twice as destructive by 2050, and up to five times more destructive in some regions, such as western Colorado. This estimate is based on the assumption that the temperature will increase by an average of roughly 0.5 °C (0.9 °F) by 2050. This projection is in line with another 2012 study, *The Age of Western Wildfires* (Climate Central 2012), which estimates that for every 1.0 °C (1.8 °F) of temperature increase the area burned in the western United States could quadruple.

There is considerable uncertainty, however, about how much temperatures will actually increase. We cannot predict how much carbon dioxide human activities will emit, because this depends on factors such as how the global economy performs, how society's production and consumption of energy changes, and how responsible and effective governments are in addressing the climate challenge. Beyond that, our limited understanding of how climate feedbacks operate means there is still some degree of uncertainty about how much climate change will occur as a result of a given amount of greenhouse gas emissions. Over timescales of a few decades, natural climate variability, aerosols released from volcanoes, and other factors can mask or modulate the effects of an underlying warming trend. Finally, there is uncertainty about what effect different levels of warming would have on rainfall patterns and other conditions in specific regions.

Despite these uncertainties, all current climate modeling efforts agree that the Earth will experience substantial

warming over the next several generations. The latest report by the IPCC, *Climate Change 2014: Mitigation of Climate Change*, projects that if the world continues down its current carbon-emitting course, average global temperatures will rise by anywhere from 2.6 °C (4.6 °F) to a staggering 4.8 °C (8.6 °F) by the end of the century (IPCC 2014). Projections by the International Energy Agency, accounting for the reality that many of the carbon reduction pledges nations have made are not being met, indicate it is conceivable that business-as-usual might lead to an average warming of 6 °C (10.8 °F) by the century's end. Moving into these higher temperature ranges increases the chance of passing critical tipping points, such as melting large areas of arctic permafrost and releasing vast amounts of methane into the atmosphere, triggering abrupt or runaway climate change.

The foresight panel members conducted a thought experiment imagining the consequences of a temperature increase of 4 °C (7 °F) in the western United States by the end of the century. If the burn area quadruples for every increase in temperature of 1 °C, that might mean up to a sixteenfold increase in the area of wildfires by 2100, and certainly far more than a doubling by 2050. In reality there may not be a continuous increase in area burned for every degree increase in warmth, and burn area is not necessarily equal to destructiveness or bad outcomes. But given that our current wildland fire management system is already struggling with recent increases in the extent of wildfire, any increase in acreage burned would tax the system further. The demand for emergency response and the stress on fire budgets could far surpass current expectations or capabilities, and wildland fire management could become much more dangerous for firefighters than most managers are anticipating today.

Panelists believe many other external conditions that will shape wildland fire management in the future are also more uncertain than usually assumed. For example, the QFR explicitly or implicitly assumes future conditions such as the continued existence of abundant energy supplies (even if somewhat more expensive), an economic system that will recover from its recent problems, and a federal government that can make laws and assure they are effectively carried out. One panelist expressed a very different image of the future:

> My conclusions now are that the era of cheap and abundant energy will soon be over and that expensive, erratic, and eventually very inadequate supplies will be normal; water will be increasingly expensive and scarce; climate change will be increasingly severe and unpredictable; our economy will not function in any way similar to the rather fair and effective way it functioned from the end of WWII to 1980 while the gaps and dysfunctions brought on by fiscal policies and practices from the 1980s onward will increasingly inhibit rather than support our plans and preferences; and that while formal governments at all levels will be increasingly unable to govern effectively, they, along with corporations, will increasingly surveil and strive to control.

Panelists found this image of the future disturbingly plausible, a reasonable extrapolation of many developments currently underway. But panelists' views of "what could be" also included far more positive possibilities. Discussion highlighted changes and potential developments like the rise of sustainability and resilience as guiding concepts, the growing influence of the pragmatic millennial generation, and dramatic progress in energy and other areas of technology that could make it possible to live better while reducing environmental impacts.

Panelists believe that uncertainties about the pace and character of technological progress, including progress in technologies directly useful for wildland fire management, make very different outcomes possible over the decades ahead. On one hand, the kind of economic decline and political dysfunction described above could severely limit technological progress. On the other hand, some participants believe there is a real possibility that progress in areas like artificial intelligence, synthetic biology, and nanotechnology will have revolutionary impacts. They imagined, for instance, the use of "Big Dog"-style all-terrain robots able to follow voice commands, carry heavy loads, go

places where human firefighters cannot go, and assist in complex tasks like fuel treatment.[2] Such all-terrain robots are currently being tested by the military. Looking further into the future, they considered the possibility of developing biotechnology- or nanotechnology-based "virtual fire" able to produce the ecological benefits of fire without the dangers.

In between these extremes, panelists discussed a wide range of technologies that could be implemented soon, or in some cases are already being used but will be substantially improved in the years ahead. Several examples are listed below.

- Real-time mapping and traffic systems (like the Waze© community-based traffic and navigation app) to support safer access and egress during fires
- Serious games and playable simulations to train first responders and engage citizens
- Targeted biological controls for insects that weaken or kill trees
- Genetically modified trees to re-establish species devastated by diseases and insect pests
- Innovations in fire-resistant construction materials and wood treatments
- More advanced precision logging technology for more effective fuel treatment
- Satellites, drones, sensor networks, and possibly even sensors placed on captured and released animals to monitor forest conditions, detect and track fire, and supply data to models

Most of these technologies would be useful in supporting the current approach to wildland fire management. However, panelists emphasize the need for fundamental changes in the current approach and predict that organizational and behavioral changes will be more important to the future of the field than will technological developments.

[2] The U.S. Department of Defense, Defense Advanced Research Projects Agency (DARPA) has funded the development of prototype Big Dog robots in the hope that they will serve as robotic pack mules to accompany soldiers in extremely rough terrain.

Thus, panel members saw a wide range of developments and future circumstances as plausible. Given such large uncertainties about the future, panel members agreed that their own conversations should not be based on any single image of the future but should be organized around a set of alternative futures or scenarios designed to embrace the range of potential future conditions they believe are plausible, i.e., the three scenarios that were the focus of discussions in round 2.

2. As conditions change, the traditional fire prevention and suppression approach to wildland fire management will prove unsustainable.

Congress currently funds the federal wildland fire agencies to extinguish 98 percent of fires on initial attack, and therefore the vast majority of fires are put out and kept small. Despite these efforts, high-impact fires are becoming more common.

Panel members see this situation worsening with no end in sight as long as the current approach to wildland fire management continues. Climate change will increasingly stress forests, especially in the West, making them more vulnerable to fires. The traditional fire season already lasts 2 months longer than in decades past and we may be headed toward a situation where the fire season will extend through much of the year. With constant fire suppression and the resulting buildup of fuels, we are creating conditions for fires that we cannot control and that do the greatest damage. By aggressively suppressing fires now, we are transferring worsening fire risks to the future. As more frequent high-impact fires spread to larger and larger areas, wildland fire management will become increasingly difficult, expensive, and dangerous. Risk will continue to escalate until fuel-filled landscapes eventually reset catastrophically, or until a fundamentally different approach to wildland fire management is implemented.

One participant summed up the discussion with a quotation from the late Nobel laureate economist Herbert Stein: "If something cannot go on forever, it will stop" (Stein 1997).

3. A new fire resilience paradigm is emerging as an alternative to traditional viewpoints and practices.

After extensive discussion, panel members concluded that this increasingly dangerous situation can be resolved only by a shift to a "new paradigm" of wildland fire management. The idea of a new paradigm for wildland fire management is not new. Elements of this approach can be seen in many places, including the QFRs and the recently completed National Strategy (USDA and USDI 2014). Forest ecologists and others have called for a new paradigm in recent years (e.g., Ingalsbee et al. 2007, Jensen and McPherson 2008).

Physicist, historian, and philosopher of science Thomas Kuhn introduced the term "paradigm shift" in his book *The Structure of Scientific Revolutions* (Kuhn 1962). As Kuhn defined it, a paradigm in science is larger than a theory; it embraces the worldview and basic assumptions upon which theories in a given area of science are built. In the 1970s, people working in the fields of sociology and futures studies began using the term to describe a similar pattern of social change where anomalies force fundamental changes in worldviews, assumptions, and values, leading to new ways of looking at things and to more adaptive behaviors (Barker 1992, Barnes 1982).

In Kuhn's view, anomalies—deviations from expectations—are always present to some extent in all areas of science, but small anomalies are typically ignored or set aside as something that will be explained before long. However, when extremely large or numerous anomalies build up in a scientific field and ignoring them becomes impossible, the field is thrown into a state of crisis. During this crisis, new ideas and ideas previously discarded are tried. Eventually basic assumptions are challenged, and a whole new way of looking at things emerges and resolves the anomalies. In Kuhn's terminology, when a scientific discipline goes through this kind of change—as physics did in moving from Newtonian mechanics to Einstein's theory of relativity—that is a paradigm shift.

Panel members believe this pattern fits well with what is happening now in wildland fire management. As they see it, the paradigm that continues to dominate the field is based on a worldview that assumes humans are in some sense above or outside of nature and have the ability to "conquer" nature. The aspiration to prevent and stop forest fires is a manifestation of that outlook, as is the imagery of "firefighters" engaged in a war against fire. From this standpoint, the problem today is that more fires are escaping from our control and the solution is to reassert control over nature.

Panel members recognize that this approach has served society well for a long time. Improvements in technology and management made the "10 a.m." and "extinguish 98 percent on initial attack" goals achievable.[3] Lives were saved and property protected when fires did occur.

Now, however, wildland fire managers are confronted with the anomaly that for all the efforts and past successes, highly damaging fires are burning larger and larger areas and it is virtually certain that this trend will accelerate. Panel members believe that at some point, not too far into the future, the growing costs (ecological, social, and economic) of fires, combined with probable limits on the resources to deal with them, will provoke a crisis in wildland fire management. There will be an increasingly active search for new ideas and a willingness to look at ideas previously discarded or only weakly acted upon.

The panelists believe some aspects of the new paradigm that will eventually prevail can be anticipated. The worldview within this paradigm will be based on a deeper understanding and appreciation of the complex self-regulating processes within natural systems. This will lead to an aspiration to act in ways that "go with the flow" of natural processes rather than disrupting them. Efforts to influence natural processes will not be abandoned but rather will be undertaken with more humility and respect for the self-balancing processes of nature.

[3] Beginning in 1935, the U.S. Forest Service had a "10 a.m." policy which required fires to be controlled as quickly as possible after being reported, preferably the same day they were detected. If same-day control was not possible, fires were to be controlled by 10 a.m. the next day (U.S. Forest Service, n.d.).

The deeper understanding that has begun developing is leading to a fuller appreciation of wildland fire as an inevitable and natural process (Moritz et al. 2014). Across the country many ecosystems evolved in the presence of frequent wildfire and are "fire adapted." These landscapes require wildfire to maintain their balance. Wildfire increases plant and animal diversity by releasing nutrients into the soil, thereby causing a flush of new plant growth, which provides food for forest animals. Some vegetation, like lodgepole pines (*Pinus contorta*), need fire to germinate their seeds and stimulate growth. Without occasional visits by fire, these landscapes become unhealthy and choked with trees and brush.

So the problem, as the panelists see it, is not that we need to exert stronger control over natural wildfires. In fact, it is hardly an exaggeration to say that there are few areas where natural wildfire still exists in the United States because the wildland fire community has been so successful in removing wildfire from the nation's fire adapted landscapes. And this is the fundamental problem. By eliminating natural wildfire, we have created a worsening situation of high-intensity *unnatural wildfire* fed by the enormous buildup of fuel that natural wildfires would have eliminated. From this very different point of view, what we need to do is to end the war on fire, return natural wildfire to our fire adapted landscapes, and learn to live with it. Panelists believe that moving in that direction is both a preferable and an inevitable future. Characteristics of the current and new wildland fire paradigms are compared below.

4. All the major steps needed to implement this new fire resilience approach are already familiar to wildland fire managers.

Adopting this approach would be relatively easy if fire adapted landscapes were unpopulated, but widespread development in the WUI creates a much more difficult challenge of returning fire to the land with minimal damage to human life and property. This challenge is made even more difficult because many of those landscapes are also loaded with unsustainable levels of hazardous fuels.

An approach that panelists think would be feasible in all three of the scenarios is what one called an "inside-out" protection strategy, where communities, with or without outside assistance, take responsibility for becoming fire-resilient. This approach is in sharp contrast to the current "outside-in" approach, where many people expect to be protected by fire suppression efforts from the outside, largely because fire agencies lead them to have that expectation.

Becoming fire-resilient requires communities to protect structures with building codes and protection zones. At minimum, building codes need to make buildings more fire-resistant by limiting places where embers can enter and ignite the structure. Stronger codes would require the use of more fire-resistant building materials. Protection zones require standards for flammable vegetation adjacent to structures to limit ember sources and direct flame contact. Local governments need to set

Dominant paradigm	New paradigm
• "War on fire"	• "Work with the flow" of natural processes
• Wildland fire is destructive	• Wildland fire is a necessary natural process
• Control wildfire on the landscape	• Learn to live with fire on fire adapted landscapes
• Prevent and suppress wildfires	• Create fire-resilient human and natural communities
• The problem is that wildfires are escaping our control	• The problem is that suppressing natural wildfire is creating an unsustainable buildup of fuels, which results in dangerous "unnatural fire"
• The solution is to apply existing procedures and technologies more strongly to bring wildland fires under control	• The solution is to develop a more holistic approach to wildland fire management where stakeholders work together to comanage their fire risk

protection zone requirements for subdivision design and some minimal land use restrictions to prevent building in very specific, highly dangerous locations such as at the top of steep ridges. A full application of these measures would not apply just to places where people already live, but also to new development in the 84 percent of the WUI across the western United States that has not yet been developed (Headwaters Economics 2015). Several characteristics of fire adapted communities are highlighted in the box below (Fire Adapted Communities Coalition, n.d.).

All these measures are familiar to wildland fire managers. There are many locations where several of them have been applied. Programs and organizations already exist to support these efforts, like community wildfire protection plans that encourage thinning trees and removing understory around homes, the National Fire Protection Association's Firewise Communities program (http://www.firewise.org/), and the Fire Adapted Communities Program (http://www.fireadapted.org/).

Research and direct experience have demonstrated that residential fire disasters do not have to occur even during extreme wildfire conditions (Calkin et al. 2014, Cohen 2010). There is no reason that any homes or structures need to be lost to fire if the right protective measures are in place. The potential for home ignition is principally determined by a home's characteristics in relation to the home ignition zone, its surroundings within 100-200 feet. This means we can effectively increase resistance to home ignition within a relatively small area to prevent residential destruction even without doing extensive fuel treatment and controlling wildfire. A fire resilience approach to home ignition gives us an effective alternative to such impractical approaches as banning residential development in the WUI and total wildfire control.

As a community is moving toward fire resilience, adjacent and back-country areas can be more safely treated with fire to make them fire-resilient as well. Communities do not have to take all possible steps before adjacent land is treated. Thinning can be done at any time and with proper care fire can be used at little risk, as is often done today. Though it is essential for communities to take responsibility, this approach calls for shared responsibility between communities and adjacent public or private landowners.

As communities and their adjacent areas become more fire-resilient, surrounding public lands can be managed to limit potential fire severity so that fires burn in a

How does a community become fire adapted?

Becoming a fire adapted community is a process and includes the following characteristics:

- It is in or near a fire adapted ecosystem.
- It has adequate local fire suppression capacity to meet most community protection needs.
- Its structures and landscaping are designed, constructed, retrofitted, and maintained in an ignition-resistant manner.
- It has local codes (building, planning, zoning, and fire prevention codes) that require ignition-resistant home design and building materials.
- Fuels on land near and inside the community are treated and maintained for safety.
- It has and uses a community wildfire protection plan.
- It has built other safety features such as buffers between fuels and the community, safe designated evacuation routes, and safe zones in the community when evacuation is not advisable.

patchy, low-intensity way. Again, these are familiar measures. Federal fuel treatment programs have been in place for many years but have never approached the needed scale. Once communities, adjacent land, and back-country areas have been made fire-resilient, sustainable wildland fire management would then involve maintaining this pattern over time. Loss of life and property would drop sharply, firefighter safety would increase dramatically, and the cost of wildland fire management would fall well below what it is today.

5. There are strong short-term barriers to the fire resilience approach, but panel members believe its adoption is nearly inevitable between now and mid-century.

Even though land managers understand that continuing the fire suppression approach allows fuel to build up and creates future risks, many have not yet concluded that the risks and costs involved are unsustainable. Even managers who are most concerned about the growing risks find it hard to move away from conventional practices because there are barriers to the fire resilience approach at every level.

At the national level, political leaders have historically exerted pressure to put fires out quickly and have poorly understood the importance of fuels treatment. Within federal agencies, there is little risk to fire managers' careers if they throw everything at a fire and it costs a great deal. On the other hand, if they allow a fire to be monitored instead of quickly suppressing it and if there are adverse consequences, it could end their careers or even lead to civil or criminal charges. Fighting fires is what people have been trained to do and been rewarded for, so getting outside that thinking is difficult.

A complex of businesses including airplane contractors, firefighting equipment vendors, mobile catering services, and companies that supply showers and washing facilities have an incentive to keep policy focused on firefighting. The federal-private "fire industrial complex" is financially and politically vested in continuing the war on wildfire (Keiter 2006, Snider et al. 2006).

At the state level, most state-owned lands are managed with a requirement to produce the best economic value, which means they are actively managed for timber and have to suppress fires to protect the timber. Local governments have limited incentives to support land use planning and building codes because the costs of suppression and recovery are primarily handled at the federal and state level. Local fire departments often view firefighting as their only legitimate function.

Despite these strong barriers, panel members believe that the fire resilience approach is highly likely to be adopted over the decades ahead. The change will happen in different ways depending on future conditions.

If the future evolves along the lines of scenario 1, with a collapsing economy, a dysfunctional federal government, energy shortages, and other serious problems, the war on fire would end by force of necessity. With government budgets at all levels cut to the bone, the kind of herculean efforts made today to prevent fires from advancing toward communities would be unaffordable. Fire would roam on the landscape and fire response would be limited to protecting life and property.

With government unable to shoulder much of the fire protection burden, communities would be forced to assume the primary role themselves through comanagement of risk by citizens and adjacent landowners. Communities that fail to accept this role would burn if fire passes through them. But if communities are proactive and create defensible space and fire-resilient structures and landscapes, they will survive any fires that occur. If they facilitate creation of fire-resilient landscapes adjacent to their communities, the lands they depend on for their quality of life will survive fire without much harm. Allowing fire to roam on the landscape the way it did in the pre-settlement era will help create landscape-scale fire resilience. The wildland fire community could facilitate and speed this adaptive process by various low-cost strategies, but it would happen even if the federal government plays no role.

If future conditions evolve to be more like those in scenario 3, panel members believe the fire resilience approach would be readily adopted. The approach fits the scenario's culture, which is open to innovation, supports adaptive leadership, and promotes commitment

to moving toward a sustainable future. With the ample resources and efficient government in scenario 3, the U.S. Forest Service and other government agencies could play a large role in facilitating the paradigm shift. The scenario's high technological capabilities would provide better tools for learning, communicating, and organizing for change. But the scenario's "cultural fit" with the new paradigm is more important than its technical advances.

In conditions similar to scenario 2, which is the business-as-usual scenario most like the present, panelists expect that resistance to the fire resilience approach would stay strong for a long time. Government is not ineffective as in scenario 1, but it is not innovative and adaptive, either. The scenario has enough resources to keep escalating what we are already doing—for a time. Fire risk is growing rapidly in the scenario, and dealing with immediate fire dangers would tend to use up the time needed for reconsidering the whole approach to the problem.

Panelists see two ways by which the shift to a fire resilience approach is most likely to happen under scenario 2's conditions. The preferable way hinges on the influence of a science-based approach to managing risk. Panelists believe, for example, that continuing research may be able to demonstrate that spending a given amount of money on fuel treatment across the western national forests will reduce expected suppression costs by even more, not even factoring in avoidance of loss to fire. If this proves possible, then the pressure to adopt a new approach might become strong enough to overcome the barriers.

The undesirable way the shift could occur is that current practices would continue for another generation or more. Landscapes would undergo more and more catastrophic fire events, many more firefighters would lose their lives, and fire suppression costs would continue to escalate, until finally the failure of the fire suppression approach could no longer be denied.

The bottom line of the panelists' thinking is that as conditions change over time the existing fire suppression approach will fail across the whole range of plausible future conditions. The emerging fire resilience approach works in all those conditions.

FACILITATING THE SHIFT TO FIRE RESILIENCE

The foresight panel members discussed a wide range of ideas about how the wildland fire community could facilitate the shift to a fire resilience approach. The scenarios mentioned in the preceding section (and given in full in Appendix 3) were used as a tool to focus much of the discussion on measures likely to be workable across a broad range of future conditions. Identifying such "robust" measures is one of the best ways to deal with the future's inherent uncertainty.

In practice, this meant a focus on low-cost/low-resource initiatives that are disproportionately effective compared to other potential actions and are relatively easy to manage. These efforts might still be possible to undertake in conditions approaching those in scenario 1, where the economy is depressed and the federal government is considerably weakened. Most of these initiatives would be in support of locally led action.

Panel members also discussed initiatives that could become possible if more resources are available and the federal government is capable of playing a stronger leadership role, as in scenario 3 and, to a lesser extent, in scenario 2.

A selection of the ideas that panel members discussed is set out below for consideration within fire management agencies and the larger wildland fire community. Many of these actions are already taking place or being implemented and need only to be continued or strengthened.

Actions Appropriate Across a Wide Range of Future Conditions

1. Cultivate a new leadership stance

The new paradigm of wildland fire management fundamentally assumes a different leadership stance, a stance that in itself is a paradigm shift. One panel participant highlighted the need to develop what he called "net-centric leaders" able to provide facilitative leadership across organizations and bureaucratic silos. He argued that the roles, methods, and skills

needed for this kind of boundary-spanning leadership are quite different from those required for effective leadership within hierarchical organizations. Indeed, virtually every idea presented here involves leading and coordinating across organizational boundaries—with local communities, organizations concerned with sustainability and security, other organizations promoting the fire resilience approach, universities, and others.

Another participant stressed the related need for a shift from technical to adaptive leadership (Heifetz et al. 2009). Technical leadership is appropriate for "technical problems," where existing expertise and established procedures and technologies can provide an adequate response. Although good technical leadership is always important, it can "go wrong" when the nature of problems changes, as in today's situation where technical leadership is failing to deal with the changing nature of the wildfire problem. Established procedures and technologies, such as putting fires out and acquiring air tankers, remain the priority. But this technical approach is making matters worse by changing the problem from "natural" wildfire to more dangerous and destructive "unnatural" wildfire.

Today wildland fire managers confront an adaptive problem, where adequate responses are still being developed and clear-cut technical fixes are unavailable. It calls for adaptive leadership, where leaders do not have all the answers and one of their central tasks is to facilitate people learning together, experimenting, and cooperating to develop and apply successful approaches. The new fire resilience paradigm is based on the notion of comanagement of risk, with individuals, communities, governments, and other organizations learning together what they can each do to back away from today's increasingly fuel-filled landscapes and create a sustainable approach to wildland fire management.

The skills of boundary-spanning and adaptive leadership can be learned. Making more training programs in these skills available to fire management agency employees could contribute substantially to their capability to facilitate the shift to a fire resilience approach and deal with other challenging future conditions. Organizations like the National Conservation Leadership Institute can assist in making this kind of training available.

2. Use awards, certifications, and fire resilience design competitions to reward and encourage innovation

Awards and certifications for individuals, communities, and organizations that promote fire resilience can be used as low-cost incentives even in the depressed conditions of scenario 1. For example, federal fire management agencies could work with the U.S. Green Building Council to develop a certification program for fire-resistant homes similar to the Leadership in Energy and Environmental Design (LEED) program.

Fire resilience design competitions could be sponsored or organized with architecture schools, landscape architecture programs, and materials science programs at engineering schools. Design competitions at leading architecture and planning schools could be used to create and popularize ideas for fire-resistant designs for buildings and communities. An architecture challenge could be done with the American Institute of Architects or a group of architecture schools. Dedicated fire resilience design studios would be easy to build into architecture curricula and might be readily accepted if the fire community encouraged them and helped supply educational materials. Similar activities could be sponsored for landscape architects, focusing on combining the provision of defensible space with other landscape goals such as aesthetics, storm water management, and green infrastructure planning and provision. The American Society of Landscape Architects could cosponsor such activities. Competitions for the development of a new generation of fire-resistant building materials and coatings could be sponsored at materials science programs at engineering schools. In all these areas, fire management agencies and organizations could be the catalyst and play a supporting role, but could let other organizations take the lead, provide most of the funding and other resources, and get most of the credit.

3. Create ongoing public relations efforts highlighting the fire resilience approach

Most panelists felt the effort should use Smokey Bear as an effective wildfire messenger, as Smokey is still so well known, beloved, and trusted that no one can really replace him. Most participants recommended that he appear in traditional formats such as posters and public service announcements but also that he have his own strong and vibrant presence on social media, going well beyond his current Twitter account and Facebook page. A person or a small group of social media professionals who are savvy, smart, and funny could oversee this "Smokey Avatar" and keep him active.

Panelists agreed that Smokey should carry a new simple central message, replacing the outdated "Only you can prevent forest fires." A suggestion that arose in the discussion was "Only you can make your home fire-safe," but there was no intention to recommend that or any other message. Rather, panelists thought a major effort involving wildfire personnel and public relations professionals should go into distilling the new message.

A suggestion was also made that Smokey may need a few animal friends to join him, each with a crisp message, that taken together sets out the "new story" of how fire-resilient communities can live safely in harmony with nature. The story should not be backward looking (such as "ending the war on fire") but rather forward looking and positive (for example, "We can save money, reduce property damage, save lives, and create healthy forest ecosystems by doing A, B, and C"). Another suggestion for presenting the "new story" is to make more extensive use of information displays that describe the recovery process at sites of previous fires in highly visible areas, with photographs and information about plant species that propagate or benefit by wildfire and how fire-dependent plants support animal life and healthy ecosystems.

Some public relations efforts already underway support the new fire management paradigm. For example, the messages in the Ad Council's Fire Adapted Communities™ campaign (http://fireadapted.adcouncil.org/TV-and-Radio/) are excellent examples of wildfire messages supporting the new paradigm. Describing public service announcements about wildfire preparedness, the Ad Council (Advertising Council 2014) states: "In many communities across the country, wildfires are an inevitable fact of life; it's not a matter of 'if', but 'when.' A Fire Adapted Community is one where its members understand and accept their wildfire risk and have taken pro-active steps to improve the safety and resilience of their homes, landscapes, and community assets to withstand a wildfire." Campaigns such as this need to become a major focus of an expanded and ongoing effort.

4. Connect wildland fire management to larger global concerns for sustainability and security

Panel participants were surprised by the lack of connection they found between the field of wildland fire management and networks and organizations concerned with sustainability. One panelist has devoted his career to scanning and reviewing futures and sustainability-oriented literature—books and articles in journals, magazines, and newspapers—and reported that "from what I have seen, the growing incidence and destruction of wildfire and its threat to sustainable development … is not in the literature." He continued: "What I have found remarkable is that wildfire is not only virtually absent from the vast literature on sustainability … but the focus is notably nationalistic. Surely there is much to be learned by assembling information on the growing incidence of wildfire in Canada, Australia, Russia, China, Indonesia and elsewhere, and especially on how the problem is perceived and what policies are most effective."

Panel members recommended that the wildfire community take a number of low-cost steps to "go global" and connect to organizations concerned with sustainability. For example, the U.S. Forest Service could encourage the Worldwatch Institute in Washington, DC, to write a paper on the global threat of wildfires and emerging approaches to sustainable wildland fire management. Similar initiatives could involve international organizations, such as the International Union for Conservation of Nature (IUCN). The world's oldest and largest environmental

organization, IUCN publishes more than 150 books and reports each year. Many of these publications are about forests, but none, so far, has dealt with wildfire. Outreach to undergraduate programs in sustainability and environmental science could help attract a new generation of people to wildland fire management.

Another suggestion is to work with *National Geographic* magazine, which does in-depth future-oriented articles on environmental issues. An example of its extensive treatment of such topics is the cover feature on "Rising Seas" in the September 2013 issue (pp. 30-57), which included a five-page fold-out map of what the world would look like if all the ice melted, raising seas by 216 feet. Fire management agencies and organizations could encourage *National Geographic* reporters to do an overview of "World on Fire," highlighting vulnerable areas worldwide and illustrating the success of fire adapted communities in living with fire.

The notion of "security" has been broadening in recent years to include food security, energy security, climate change, and other concerns. Panel members believe that the growing threat of large and destructive wildfires should become part of this expanding conception. The fact that the Federal Emergency Management Administration's (FEMA's) National Incident Management System has its roots in the U.S. Forest Service Incident Management System (U.S. Department of Homeland Security 2004) suggests that the wildland fire community has much to contribute to the design and implementation of national and international disaster response and mitigation protocols.

Panelists believe an important result over time of these kinds of outreach efforts would be to raise the profile of the field of wildland fire management within the domains of sustainability and security, draw new people into the field, and perhaps give it a higher priority within the federal budget.

5. Conduct additional social science research to more fully understand the human dimensions of a fire resilience approach

Much has been learned from fire social science research. For example, past research shows that most people in the WUI already understand the risk posed by fire and feel responsible for their property (McCaffrey and Olsen 2012), so the focus of research should be on barriers to action besides risk perception. Research is needed on how people feel about more fire on the land, how individuals interpret the concept of fire adaptation, whether the response of fire agencies needs to change during fires involving fire adapted communities, and many other topics. McCaffrey et al. (2013) review key social science research lessons related to wildland fire management and identify future research needs.

6. Provide additional "how to do it" information in many forms through many channels

Many educational materials that support the shift to fire resilience have been developed and disseminated. But providing additional clear and practical information is an inexpensive, cost-effective approach that can be strengthened. Some possibilities are as follows:

Continue to disseminate model codes (building, protection zone, subdivision planning, fire resilience) widely to state and local governments. In addition, provide more information on the types of policy instruments, such as incentives, disincentives, regulations, and information campaigns that communities can use to help implement these codes.

Develop additional educational materials for individuals and local communities on well-known topics such as:

- How to assess homes for vulnerability to fire
- What specific steps people can take to retrofit existing structures to make them more ignition-resistant
- How to design fire adapted structures and use fire-resistant construction materials
- How to create adequate defensible space
- How to create and use a community wildfire protection plan

New educational materials are especially needed on the critical and neglected issue of how to cooperate with adjacent landowners to comanage fire risks.

Make this information available in a variety of forms from checklists for homeowners and videos available on YouTube to material for construction professionals. Engage real estate agents, insurance companies, local governments, fire departments, libraries, civic groups, and other organizations in making these materials widely available. Encourage their distribution at local activities like festivals, home and garden shows, health fairs, and other events that involve the whole community.

Keep newsworthy reports and video messages ready to maximize their impact in "teachable moments" when large wildfires are in the news. The volume of news media coverage spikes dramatically during large wildfires (Fingerman Johnson et al. 2009). All of the above ideas about information dissemination ideas are already being followed, but devoting additional resources to these and similar approaches could be a cost-effective strategy.

Provide greater support for other organizations' educational efforts promoting elements of a fire resilience approach. Federal fire management agencies currently provide support for a wide range of such efforts. For example, the Fire Adapted Communities Web site (www.fireadapted.org) provides access to information targeted to homeowners, fire and emergency responders, forest and land managers, and civic and community leaders. The Ready, Set, GO! (RSG) program managed by the International Association of Fire Chiefs (IAFC) helps train fire departments to teach individuals who live in high-risk wildfire areas how to best prepare themselves and their properties for fire threats. California's Fire Safe Council provides a model that could be promoted to other states. The Nature Conservancy is at the forefront of environmental organizations promoting new fire approaches. Additional support for efforts such as these may be an effective strategy to promote change. In addition, federal fire management agencies and their partners could broker support for these outreach efforts from other organizations like the Westinghouse Foundation, the MacArthur Foundation, and regional film councils.

7. Use serious games

Serious games are simulations of real-world events or processes. Although serious games can be entertaining, their main purpose is to train or educate users. They can also be used to engage communities, inform national planning, and solve problems. One panel member identified the following advantages of a game platform:

- A game can provide a whole systems view that very few citizens (or policy makers) ever have. Some call this "topsight," and it is critical in addressing complex systems issues.
- Games built on dynamic simulation models are one of the few ways to teach people about system dynamics, nonlinearity, non-intuitive feedback loops, rebound effects, time lags, etc.
- Games can generate significant amounts of data about player strategies.
- Games scale in a way that other public participation techniques cannot. They shift the economics of engagement to a "software model," where it is very expensive for the first person engaged (the price of developing the game) but each successive player drives the cost down a rapidly descending curve.

Serious games and playable simulations can be used in training first responders and others. See, as an example, the Incident Commander game at http://www.incidentcommander.net/.

The wildland fire community could also help develop interactive games to engage communities, homeowners, and children, giving players a sense for the key parameters that result in high-impact wildfires, actions to take if a fire threat looms near, policy options for dealing with the growing wildfire problem, and long-term consequences of different policy choices. Games can be designed to work with tablets and smart phones and their use should be encouraged in schools in fire-prone areas. Materials to structure discussions in

classrooms and online about what people are learning from wildfire management games should be developed.

Serious games can also be used to solve real-world problems. One panelist commented, "If gamers on Foldit can find the structure of a protein key to AIDS development in 3 weeks, while scientists had not been able to solve the puzzle for years, who's to say that they won't come up with creative solutions to sustainability problems, such as wildfire management?" (See Horn 2011.)

The fire community could work through the Serious Games Association (http://www.seriousgamesassociation.com/) and attend the association's Serious Play Conferences to team with experienced game developers and organizations that have used serious games. One panel member suggested setting up an internship program specifically targeted toward those with backgrounds in game development and computer simulation with the goal of creating user-friendly games or platforms related to wildfire. The Woodrow Wilson International Center for Scholars has a Serious Games Initiative that has developed games such as Budget Hero in which players balance the federal budget (http://www.wilsoncenter.org/budget-hero). Budget Hero has generated a database of more than one million game runs.

Serious games are not a panacea, but with 215 million gamers in the U.S. population (average age is 34 and 40 percent are female), they deserve consideration for education, community engagement, and problem-solving related to wildland fire management.

8. Help educate the political community

Because much of the pressure for immediate fire suppression comes from politicians (Donovan et al. 2011), it will be important to find ways to educate the political community about the true nature of wildland fire problems, the limitations of the current approach, and the feasibility of a fire resilience approach. Educating political leaders will be a significant challenge considering the political community's short-term focus and always-imminent elections. Nevertheless, long-term educational efforts need to begin soon, with a realistic expectation that the wildfire problem may have to get worse before most politicians will be open to re-thinking how to deal with it. Panel members urged that the wildland fire community make the development of an effective, ongoing informing and engagement process a high priority.

9. Support development of a new fire economics

Several panel members made the point that a new paradigm of wildland fire management requires a new fire economics that incorporates long-term ecological thinking and the value of life-supporting ecosystem services. A great deal of relevant activity is occurring in economics that is not visible in the mass media. The work of the environmentally focused International Society for Ecological Economics and its journal *Ecological Economics* is especially relevant (http://www.isecoeco.org). A new U.S. Forest Service Research and Development work unit that would apply the concepts and methods of ecological economics to fire economics could develop a new fire economics.

10. Initiate an ongoing dialogue between the wildland fire management community and the insurance industry

As a highly regulated and competitive industry, the insurance industry has a limited ability to provide discounts to policy holders for engaging in mitigation or raising rates for lack thereof. But the exposure of the insurance industry to wildfire risk is growing and will continue to grow, and insurers might be able to play a useful role in facilitating the shift to fire resilience. We suggest convening a conference and keeping a dialogue going between the wildland fire management community and the insurance industry to discuss strategies for moving communities to become more fire-resilient. Topics of discussion could include supporting efforts to develop more fire-resistant structures and helping policy holders understand what they can do to mitigate fire risk.

Actions Requiring More Resources

If future conditions are more like those described in scenario 2, where there is moderate continuing growth and the government's functioning is somewhat improved, or like the still-better conditions in scenario 3, then fire management agencies could play a stronger role in facilitating the shift to a fire resilience approach.

All of the actions previously described would still be worth consideration, but many could be strengthened. For example, significant financial awards could be given to design competition winners. More expensive ways of communicating the "new story" could be pursued, such as producing a high-quality documentary film or helping to finance the production of a PBS NOVA episode.

At an even higher resource level, funding could be made available for fire-resilient home and property improvements, administered by state-run agencies or private organizations, modeled after existing weatherization programs. Subsidies could be provided for construction using fire-resistant materials, similar to subsidies provided for solar energy. Fuel treatment programs could be expanded rapidly so that as communities become fire-resilient, adjacent lands and back-country areas could be treated simultaneously.

Under the conditions described by scenario 2 or 3, a "Forest Preservation Corps" could be created to clear understory brush, conduct prescribed burns, and perform other tasks to promote fire resilience, with volunteers receiving funds for college or forgiveness of student loans. Adding an educational component to these activities could make it attractive to people interested in forestry, environmental science, and related fields. Something along this line may even be possible in ongoing depressed conditions more like those in scenario 1 because, as with the Civilian Conservation Corps during the Great Depression, it would help provide employment and social stability.

Panel members discussed at length a vision presented by one participant for how strong federal leadership could accelerate the shift to a fire resilience approach (see Appendix 4). This vision would be feasible in conditions resembling those in scenario 3, with adequate resources, efficient and respected government, and high receptivity to innovation. It might even be feasible in the more constrained conditions of scenario 2 if using a science-based approach for managing risk convinces leaders of the urgency of adopting a new approach.

In this vision, the federal government helps create a new system of firesheds across the country. A fireshed is defined as an area surrounding a community that can potentially support a wildfire that could affect the community. In the West, firesheds would typically be large because fires can move great distances from point of origin and several communities may share the same fireshed.

Each fireshed would have a fireshed council with the responsibility of managing wildfire risk within its area. For firesheds that contain federally owned land, councils would have the responsibility of comanaging risk with the federal government by statute under a Wildland Fire Resilience Act of Congress. As required by this act, councils would consider all aspects of wildland fire, including landscape fuels treatment, preparedness planning, suppression response, fire rehabilitation and recovery, and land use zoning and building codes.

Federal investment in firesheds would be prioritized based on risk management models. For any community in a fireshed, federal government investment would require the community to protect its structures with building codes and protection zones. As this is done, funding would become available for fire managers to treat adjacent areas with fire. Once the communities and adjacent areas were fire-resilient, back-country areas of the fireshed could withstand more natural fire patterns without significant fire protection.

The federal government's investment strategy in this vision would be to: (1) facilitate establishment of firesheds across all fire adapted landscapes, (2) establish fireshed councils, (3) provide correct incentives, (4) prioritize investment based on risk ranking and community performance, (5) focus first on the highest opportunities for risk reduction, and (6) invest sufficiently to reduce risk to acceptable levels. Aspects of this approach, such as establishing firesheds and fireshed councils, could prove valuable even in situations where resources were not available to realize the full vision.

INSTITUTIONALIZING FORESIGHT IN WILDLAND FIRE MANAGEMENT

Strategic foresight (or futures research) is a transdisciplinary field of inquiry that uses a variety of methods to explore alternative possible, plausible, and preferable futures. Bell (1997) further characterizes futures research as an "action science," with an orientation to informing decisionmaking and action. With roots extending back many decades, futures research is now a mature field with a considerable body of literature, many specialized journals, professional organizations, and distinct methods (Bengston et al. 2012). The goal of futures research is to produce strategic foresight, defined as "the ability to create and maintain a high-quality, coherent, and functional forward view and to use the insights arising in organizationally useful ways; for example, to detect adverse conditions, guide policy, shape strategy" (Slaughter 2002: 104). The box below describes a wide range of possible contributions of futures research.

One of the discussion forums in round 3 of our online conferences focused on how to improve foresight capability in the wildland fire management community and institutionalize it as a continuous process that is effectively tied in with decisionmaking and planning. The QFRs are a good periodic effort, but our panel members agreed that foresight work must be ongoing and institutionalized into routine planning and policy-making to have a lasting effect. A single foresight exercise like this one, or even periodic efforts like the QFRs, quickly loses its value no matter how skillfully done and widely embraced. Institutionalizing foresight capacity in wildland fire management would help

Possible Contributions of Futures Research

- **Creating a longer-term perspective**: The temporal scales considered in futures research are beyond the range usually used in planning and decisionmaking. This longer-term perspective may help identify issues of concern as well as opportunities that could be overlooked in the prevailing shorter-term view.
- **Exploring key uncertainties and potential surprises**: Futures research can help identify fundamental uncertainties and potential surprises, especially those arising from other domains, that could affect fire management, thereby facilitating the development of policies to increase adaptive capacity to deal with surprises (Bennett et al. 2003).
- **Decreasing reaction time to rapid change**: Insights about possible and plausible futures can help decrease reaction time as events rapidly unfold. Decisionmakers can explore possible responses in advance and react swiftly to change as it occurs. A classic business example is Royal Dutch Shell's use of scenario planning and its subsequent quick response to the 1973-1974 OPEC oil embargo and price shock (Schwartz 1991).
- **Anticipating unintended consequences**: The methods of futures research can help identify potential unintended consequences of new technologies, proposed policies, and social and cultural trends. A better understanding of potential consequences of change can help in the design of policies and strategies that will minimize negative consequences and enhance resilience.
- **Encouraging thinking big**: Futures research promotes thinking big in terms of multiple disciplinary perspectives, creative problem-solving, and a systems perspective, and can help all stakeholders take a broader and more creative view.
- **Shaping a preferred future**: A preferred future or vision is a compelling statement of the future that a group or organization wants to create based on shared deep values and purpose (Bezold 2009). A clear, shared understanding of the preferred future enhances options and possibilities in the present.

identify emerging issues, driving forces of change, potential wild cards, and a range of plausible scenarios that can help provide the broad context for QFRs and other fire management planning processes.

Panel members identified two main strategies for institutionalizing foresight into wildland fire management. An in-house strategy would involve creating an interagency fire futures unit that would be staffed with several trained futurists, with enough budget and personnel to do high-quality and continuing foresight. This unit would be responsible for regular horizon scanning (Bengston 2013) and high-priority projects exploring possible, plausible, and preferable fire futures using a range of foresight methods. A growing number of federal agencies have in-house foresight units, as shown in Table 1.

An alternative strategy is to have one high-level person assigned specifically to contract with futures research organizations and think tanks, purchasing scans and futures surveys on a regular basis, and working closely with fire planners, managers, and policy makers to incorporate the findings into decisionmaking and strategies. Outsourcing foresight activities is a common approach in corporations, but it is important to ensure that foresight developed by outside consultants is relevant and incorporated into strategic planning and decisionmaking (Day and Schoemaker 2005).

A hybrid approach to institutionalizing foresight, involving both an in-house futures unit and regular use of outside experts, is often most effective. In-house foresight champions know the culture and the ways of the organization or field, and outside experts bring new ideas and perspectives.

CONCLUSIONS

Wildland fire management faces a daunting set of challenges in the coming decades. Traditional approaches to wildland fire management and policy, developed in the last century, will have to change to meet these unprecedented challenges. Foresight is needed to help planners, managers, and policy makers navigate this turbulent and uncertain future.

To gain foresight, this study convened an online foresight panel of professional futurists and fire policy experts to explore broad issues related to wildland fire management futures. The futurists on this panel brought a diversity of fresh and forward-looking perspectives from outside of the fire management community, informed and enhanced by the insider knowledge and insights of the fire policy experts.

Five broad areas of consensus emerged among our panel members in the course of three rounds of discussion:

- The level of uncertainty about external developments and future conditions that will set the context for wildland fire management is significantly greater than is recognized in the Quadrennial Fire Reviews and current planning.
- As conditions change, the traditional fire prevention and suppression approach to wildland fire management will prove unsustainable.
- A new fire resilience paradigm is emerging as an alternative to traditional viewpoints and practices.
- All the major steps needed to implement this new fire resilience approach are already familiar to wildland fire managers.
- There are strong short-term barriers to the fire resilience approach, but panel members believe its adoption is nearly inevitable between now and mid-century.

These key areas of agreement among the panel members point toward a new direction for wildland fire management: a paradigm shift from the "war on fire" approach emphasizing fire suppression and exclusion to a fire resilience approach emphasizing learning to live with fire in resilient communities on fire adapted landscapes. These are certainly not new ideas in the fire management community—they have deep roots in holistic thinking about social-ecological systems. But as with all paradigm shifts, the new fire management paradigm faces many barriers and much resistance. Our hope is that this study will stimulate further forward-looking debate and discussion about the future of wildland fire management.

Table 1.—Examples of current and recent strategic foresight efforts in the U.S. government

Agency	Description	URL
U.S. Army, Army Environmental Policy Institute (AEPI)	Conducts or sponsors monthly horizon scanning on environmental issues with discussion of military implications. The Millennium Project now carries out these horizon scans for the AEPI, although the latest online reports are for June 2011.	http://www.aepi.army.mil/reports/ http://www.millennium-project.org/millennium/env-scanning.html
Department of Homeland Security, Federal Emergency Management Agency, Strategic Foresight Initiative (SFI)	Was launched in 2010 as a broad effort to create an enduring foresight capability. Key SFI reports include *Crisis Response and Disaster Resilience 2030* and *Toward More Resilient Futures: Putting Foresight Into Practice.*	http://www.fema.gov/strategic-planning-analysis-spa-division/strategic-foresight-initiative
U.S. State Department, Project Horizon	Was initiated in 2005 and involved more than 200 senior executives across more than two dozen agencies in an effort to explore ways to develop the interagency capacities that would be crucial to successfully navigating global challenges that may face the nation over the next 20 years.	http://www.osif.us/images/Project_Horizon_Progress_Report.pdf http://www.businessofgovernment.org/brief/getting-our-foreign-affairs-order-project-horizon-06-2007
U.S. Central Intelligence Agency, National Intelligence Council, Global Trends	*Global Trends 2030: A Transformed World* (2012) is the fifth installment in the National Intelligence Council-led effort to identify key trends and drivers likely to shape world events a decade or more in the future. It uses scenarios to illustrate ways in which the drivers may interact to generate challenges and opportunities for future decisionmakers.	http://www.dni.gov/index.php/about/organization/national-intelligence-council-global-trends
Department of Veterans Affairs (VA), Office of Policy and Planning, Strategic Studies Group	Was formed in 2011 and leads the VA's horizon scanning efforts. Helps identify long-term, cross-cutting challenges and opportunities for the department. Its 10- to 15-year assessments of strategic drivers and identification of alternative "future worlds" for veterans help create the context for the VA's quadrennial strategic planning process.	Currently no Web site.
U.S. Coast Guard, Office of Strategic Analysis	Began its foresight efforts in 1998. Its most recent effort, Project Evergreen, relies on the use of alternative futures scenario-planning. Identified scores of drivers and trends that would affect the Coast Guard's mission and distilled them into five scenarios, to determine what capabilities they would need to have in place in years to come.	http://www.uscg.mil/strategy/docs/Evergreen/EG3_BlueBook.pdf
U.S. Marine Corps, Strategic Vision Group	The Marines have historically looked 10 years out and have linked their efforts with the Department of Defense-wide Quadrennial Review and joint operations with their sister military services. The Strategic Vision Group has pushed the vision further out into the future by identifying a range of different world-view scenarios.	http://www.onr.navy.mil/~/media/Files/About-ONR/usmc_vision_strategy_2025_0809.ashx
U.S. Air Force, Future Concepts and Transformation Division	The Air Force has regularly developed 20-year strategic outlooks. Its environmental assessments integrate perspectives on technology, intelligence, environmental resources, demographics, economics, and politics into a series of "megatrends" used to develop its strategic plan.	Currently no Web site.

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APPENDIX 1

Previous Wildfire Futures Efforts

A handful of past reports and workshops have explored the future of wildland fire management. Some of these efforts have used the perspectives and methods of futures research, albeit to a limited extent. An early example was a 1987 symposium titled "Wildland Fire 2000" that brought together scientists, educators, fire professionals, and other stakeholders "to consider the possible, probable, and preferred status of wildland fire management and science in the year 2000 and beyond" (Davis and Martin 1987: iii). Almost all of the participants in Wildland Fire 2000 were from within the wildland fire and natural resource management communities, and the contributed papers focused mainly on the issues and concerns of the 1980s rather than looking forward. But the symposium did include a small-group futuring process to develop visions of the future for nine topic areas and then outline strategies for achieving the visions. [1] The preface to the proceedings of this symposium mentioned previous "futuring sessions" conducted by individual wildfire agencies, but no record of these earlier efforts found their way into the permanent literature.

The 1995 U.S. Forest Service report *Course to the Future: Positioning Fire and Aviation Management* was a revision in federal fire policy rather than a futuring effort, although the report did identify desired future outcomes (U.S. Forest Service 1995). Motivated by the deadly and costly 1994 fire season, *Course to the Future* was part of a shift in fire policy toward recognizing the role of fire as a vital ecosystem process.

Another high-level fire policy effort is the recently completed three-phase Cohesive Strategy effort (U.S. Department of Agriculture [USDA] and U.S. Department of the Interior [USDI] 2014), which identified a national vision and goals for wildland fire management, described challenges and opportunities, and established national priorities for achieving the vision. This 5-year effort was forward looking but did not involve futures research.

In recent years, the five federal natural resource management agencies and their partners in the wildland fire community have carried out a strategic assessment process every 4 years to help guide budgeting and strategic planning of fire management. The inaugural effort was called the 2005 Quadrennial Fire and Fuels Review (QFFR). Modeled roughly after the Department of Defense's Quadrennial Defense Review and facilitated by the Brookings Institution, the 2005 QFFR was developed by more than 200 personnel from the fire community, including fire experts from federal, state, local, and tribal partners, with input from the fire and natural resource research community and nongovernmental organizations (USDA and USDI 2005). A series of meetings were held around the country to gather input, followed by more formal "working panels" organized around specific topics of interest.

The 2009 Quadrennial Fire Review (QFR) broadened the process used in the 2005 QFFR in several respects, such as greater involvement of nonfire and nonfederal participants, an expanded domain for working panels to explore a wider range of future options, and a greater role for research in the process (USDA and USDI 2009). Evidence of the more prominent role for research is provided by an advanced briefing report prepared for the 2009 QFR working panels titled "The Future of Wildland Fire Management" (The Brookings Institution 2008). This briefing report contained "new assumptions" papers prepared by a group of researchers from wildfire and natural resource management backgrounds. A research advisory panel rated the most significant driving forces and

emerging trends identified in the new-assumptions papers. The three broad categories of the most significant driving forces were: (1) climate change, ecosystem dynamics, and the new scale of wildland fire in the United States, (2) managing resource values and sustaining fire-dependent ecosystems, and (3) social dynamics and values for public lands and the wildland-urban interface (WUI). Specific driving forces and trends related to each of these broad categories were highlighted for consideration by the 2009 QFR working panels in preparing future alternatives.

Trends, forecasts, and recommendations for change noted in the 2009 QFR include the following:

- Longer fire seasons will result from climate change, and geographic areas that have commonly been considered low-risk—such as the Northeast and Great Lakes region—will increasingly be affected by fire.
- The current drought cycle will likely continue, resulting in greater stress on vegetation and more fires.
- Growth of housing and communities in the WUI will slow, but these areas will still be at high risk for wildfires.
- The budgets of agencies that deal with fire will be stretched thin by growing demands and rising costs.
- Social networking will become the most effective way to communicate with and educate the public about wildfire issues.
- The focus of educational efforts should shift toward promoting "fire adapted communities" and greater self-reliance.

Solicitation for a contractor to conduct the next QFR was announced in FedBizOpps.gov in July 2013 (U.S. General Services Administration 2013). The synopsis of the solicitation reads as follows:

> The U.S. Department of Agriculture (USDA) Forest Service (FS) and Department of [the] Interior seek to conduct a Quadrennial Fire Review (QFR) that will perform a forward-looking risk assessment of wildland fire management and response on a landscape scale to determine the key challenges that lie ahead and analyze recommended strategic alternative paths for the future of fire management in response to those challenges. The contractor will be responsible for reviewing and understanding previous two QFR's and having knowledge of management and policy changes that have occurred since those reviews. In addition, the contractor must be knowledgeable about the Federal Fire Policy and the National Cohesive Wildland Fire Management Strategy, which guide wildland fire management in the U.S. The contractor will gather information through interviews with a wide variety of people including fire managers, natural resource managers, scientists, academia, the public and other partners. They will also review additional relevant documents including available science and fire reports, laws and policies.

A new component of the QFR effort in 2014 was a crowdsourcing Web site to gather input from diverse stakeholders on the following four areas plus a wild card topic for any ideas that did not fit within the specified topics:

- Changing climatic conditions and effects on landscape
- Evolving risk in public and fire fighter safety

- Water quality and quantity
- Technology and program infrastructure
- Wild card: What aren't we seeing?

Stakeholders submitted ideas related to these topics and could comment on ideas submitted by others.

Another recent wildfire futures effort was a 2008 workshop on "The Future of Wildland Fire and Fuels Management," sponsored by the Joint Fire Science Program and conducted by Global Business Network (GBN), a prominent futures consulting firm (Gray 2008). The 2-day workshop was part of a broader project investigating the use of software tools and systems in the fire community. The purpose of the workshop was "to identify some of the factors and forces that are likely to shape fire management in the coming decade" and to explore their implications.[1] Workshop participants used GBN's FastForward® scenario methodology to develop brief qualitative scenarios about the future of fire and fuels management based on sets of givens, uncertainties, and potential wild card events. Nine alternative futures were identified and briefly described, including the "business as usual" or "official future" that workshop participants believed the fire community is planning for. The implications of the nine scenarios were then explored, with an emphasis on potential information and research requirements for the future.

An ongoing fire futures project is being carried out by the U.S. Air Force Academy's Center of Innovation and Intel Corporation futurist Brian David Johnson (Roeder 2014, U.S. Air Force Academy Public Affairs 2014). A 2-day workshop was held in Colorado Springs, CO, in February 2014 that included experts from the Federal Emergency Management Agency, the Red Cross, wildfire experts, local wildland firefighters, and government officials. These stakeholders developed a preferable future for wildfire and then used a back-casting method to identify the steps needed to achieve that future.

Another ongoing project related to the future of fire management is the Alternative Fire Management Futures initiative led by the Department of the Interior's National Park Service (Nydick and Sydoriak 2011). Focused on the Southern Sierra Nevada ecoregion, this collaboration among resource managers, fire managers, and scientists is using scenario planning and other tools to achieve the overall goal of developing "the capacity to manage fire under a 'new lens' and to revise fire management objectives, tools, and methods so that valued resources sensitive to climate change can be conserved at an appropriate scale" (Nydick and Sydoriak 2011: 44). A range of future scenarios of climate, fire, and vegetation have been developed to help managers make strategic decisions that will be robust for a range of plausible futures.

Finally, almost no studies about the future of wildfire and fire management have been published in futures research journals. An exception is a paper titled "The future of fire in environmental management" (MacGregor 2006). This think piece examined the relationship between humans and wildfire, exploring the apparent dilemma between the needs of nature (ecosystems that are dependent on fire for their health and sustainability) and the needs and desires of humans and communities.

[1] Global Business Network. 2008. The future of wildland fire and fuels management—workshop report. Unpublished report, p. 1. On file with: Global Business Network, San Francisco, CA. 13 p.

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APPENDIX 2

Biographical Sketches of Panel Members

Peter Bishop is a recently retired associate professor of strategic foresight and coordinator of the graduate program in Futures Studies at the University of Houston. Bishop specializes in techniques for long-term forecasting and planning. He delivers keynote addresses and conducts seminars on the future for business, government, and nonprofit organizations. He also facilitates groups in developing scenarios, visions, and strategic plans. His clients include IBM, the NASA Johnson Space Center, Nestle USA, Tetra Pak, the Shell Pipeline Corporation, the U.S. Department of Defense, the U.S. Central Intelligence Agency, the Lawrence Livermore National Laboratory, the W.K. Kellogg Foundation, the Waitt Family Foundation, the California Environmental Protection Agency, and the Center for Houston's Future. Bishop is also a founding board member of the Association of Professional Futurists, and is president of Strategic Foresight and Development, which offers education and training in futures thinking and techniques to the corporate market. Bishop came to the University of Houston in 2005, having taught Futures Studies at the University of Houston–Clear Lake since 1982. Bishop received his doctoral degree in sociology from Michigan State University in 1974. He has published numerous articles in leading futures journals such as *Foresight, The Futurist, Futures Research Quarterly,* and *Journal of Futures Studies*, and is the coauthor of *Thinking About the Future: Guidelines for Strategic Foresight* (2006), and *Teaching about the Future: The Basics of Foresight Education* (2012, both written with Andy Hines).

Jamais Cascio was selected by *Foreign Policy* magazine as one of its Top 100 Global Thinkers. In 2010 he was named a Distinguished Fellow at the Institute For The Future, where he is a primary contributor to its annual Ten Year Forecast program. Cascio is also a Senior Fellow at the Institute for Ethics and Emerging Technologies. In 2003, he cofounded WorldChanging.com, the award-winning Web site dedicated to finding and calling attention to models, tools, and ideas for building a "bright green" future. In his time at WorldChanging, Cascio wrote much of the site's content, covering topics including urban design, climate science, renewable energy, open-source models, emerging technologies, social networks, and "leapfrog" global development. In March 2006, he started Open the Future as his online home. He writes about the intersection of emerging technologies, environmental dilemmas, and cultural transformation, specializing in the design and creation of plausible scenarios of the future. His work focuses on the importance of long-term, systemic thinking, emphasizing the power of openness, transparency, and flexibility as catalysts for building a more resilient society. Cascio's work appears in a wide range of publications including *Metropolis*, the *Atlantic Monthly*, the *Wall Street Journal*, and *Foreign Policy*. He has been featured in multiple television programs discussing foresight and environmental issues, including National Geographic Television's 2008 documentary on the effects of global warming, "Six Degrees"; the History Channel's 2009 series on emerging technologies, "Science Impossible"; and the 2010 Canadian Broadcasting Company documentary "Surviving the Future." Cascio speaks about future possibilities at a variety of venues around the world. Recent appearances include the Fifth Astana Economic Forum in Astana, Kazakhstan, the 2012 National Geographic Aspen Environmental Forum, and Futuro è Sostenabilità in Rome, Italy. He was a featured speaker at the TED 2006 conference, "The Future We Will Create," in Monterey, CA. Cascio's first book, *Hacking the*

Earth: Understanding the Consequences of Geoengineering, was published in 2009. In 2010, he was invited to present on the subject at the National Academy of Sciences in Washington, DC. Cascio has worked in the field of scenario development for more than a decade, beginning with scenario-planning pioneer Global Business Network.

James A. Dator is a professor and director of the Hawaii Research Center for Futures Studies, Department of Political Science, and an adjunct professor in the Program in Public Administration, the College of Architecture, and the Center for Japanese Studies, of the University of Hawaii at Manoa. He also taught at Rikkyo University (Tokyo, for 6 years), the University of Maryland, Virginia Tech, the University of Toronto, and the InterUniversity Consortium for Postgraduate Studies in Dubrovnik, Yugoslavia. He is a Danforth Fellow, Woodrow Wilson Fellow, and Fulbright Fellow. Dator is the former president of the World Futures Studies Federation, and was a cofounder of the Institute for Alternative Futures (IAF), a leader in the creation of preferred futures. He is the author of *Advancing Futures: Futures Studies in Higher Education* (2002), two other books, and a large number of futures research articles and reports. He is an editorial board member of many futures studies journals, including *Futures*, *Foresight*, *Journal of Futures Studies*, *Futures Research Quarterly*, *On the Horizon*, and *Technological Forecasting and Social Change*. Dator's research includes studying and developing theories and methods appropriate for futures studies, both basic and applied; the design of new governance institutions; the futures of law, education, and technology; and the political-economic futures of North America, East Asia, and the Pacific Islands.

Elizabeth Hand is an award-winning visionary scenario writer. She is one of today's most imaginative and prolific writers of speculative fiction, is the author of 15 novels and 4 collections of short stories, and serves on the faculty at the Stonecoast MFA Program in Creative Writing at the University of Southern Maine. Her carefully researched stories range across topics as varied as climate change, ecological restoration, genetic engineering, and artificial intelligence. Hand is a longtime contributor of book reviews and articles to numerous publications, including the *Washington Post*, *Salon*, *Los Angeles Times*, *Village Voice*, and *Fantasy and Science Fiction* magazine. She has twice received the Nebula Award, the most prestigious award in the field of science fiction; is a four-time winner of the World Fantasy Award; and has received the Shirley Jackson Award and the Tiptree Award, among others. She worked at the Smithsonian's National Air & Space Museum before beginning to write full time in 1988.

Michael Marien plays a unique role in futures research as the leading scanner, summarizer, and reviewer of futures-relevant books and articles published in the English language. He is the former editor of Future Survey, a scanning service published monthly by the World Future Society between 1979 and 2008, and is currently director of GlobalForesightBooks.org. Marien prepared some 21,000 abstracts of futures-oriented books and articles for Future Survey. Global Foresight Books offers online searchable abstracts of more than 4,000 books and reports published since 2009, arranged in 30 categories. He also prepares lengthy and critical Book of the Month reviews that appear on his Web site. His work provides a concise cross-disciplinary overview of an enormous array of trends, emerging issues, and futures thinking. Marien has also published many articles in leading futures research journals such as *Futures*, *Futures Research Quarterly*, *World Future Society Bulletin*, and *The Futurist*, and a wide range of other scholarly journals including *The Information Society*, *Telecommunications Policy*, and the *Journal of*

Humanistic Psychology. Marien is the coauthor (with Land Jennings) of the book *What I Have Learned: Thinking About the Future Then and Now* (1987).

Sarah McCaffrey is a research forester for the U.S. Forest Service, Northern Research Station. Her research focuses on the social aspects of fire management. This work has included National Fire Plan- and Joint Fire Science Program-sponsored projects examining social acceptability of prescribed fire and thinning, characteristics of effective communication programs, wildfire risk perception, and incentives for creating and maintaining defensible space. She has also initiated work examining social issues that occur during and after fires including evacuation decisionmaking, agency-community interaction during fires, and long-term health impacts of experiencing a fire. More recent work has begun looking at the interactions of social dynamics across the time spectrum, from preparedness to response to recovery. Much of her time is focused on identifying, translating, and transmitting relevant research findings to the fire community. This work includes consultation with organizations (e.g., the Insurance Institute for Business and Homes Safety, Orange County Fire Authority); providing scientific findings to policy efforts (e.g., Quadrennial Fire Review, National Wildfire Cohesive Strategy); and invited presentations at conferences, workshops, webinars, and manager training courses. She received her Ph.D. in Wildland Resource Science in 2002 from the University of California at Berkeley, where her research examined Incline Village, NV, homeowner views and actions in relation to defensible space and fuels management.

Jonathan Peck is president and senior futurist at the Institute for Alternative Futures (IAF). This leading nonprofit futures think tank, founded in 1977, works with a wide range of organizations to help them choose and create their preferred futures. Its for-profit subsidiary, Alternative Futures Associates (AFA), works with corporations to apply futures methods to their strategy development. Peck provides a wide range of research, consulting, speaking, meeting design, and facilitation services. A certified Myers-Briggs Type Indicator practitioner, he has integrated psychological patterns and insights into his facilitation of vision, mission, and strategic processes for corporations, organizations, and government agencies. He led IAF's 2019: Health Care That Works for All project, which created a visionary outcome of U.S. healthcare reform. His futures work spans the scientific, economic, political, and social changes that can be addressed with an understanding of complex systems dynamics. Peck has coauthored two books and written numerous articles for *Business and Health*, *Pharmaceutical Executive*, *Food & Drug Law Review*, *Clinical Cancer Research*, *The Monitor*, *Futures Research Quarterly*, and many other publications. He received his master's degree at the Futures Studies Program in the political science department of the University of Hawaii.

John Phipps is currently the director of the Rocky Mountain Research Station, U.S Forest Service. At the time of this project, he was senior advisor, State & Private Forestry, in the U.S. Forest Service. In this role, he provides policy analysis and advice relating primarily to wildland fire. Phipps has worked 38 years in the U.S. Forest Service and previously served as associate deputy chief, State & Private Forestry; deputy regional forester; forest supervisor; and district ranger. Throughout his career, he has been involved in the fire militia, prescribed fire, fire risk management, and the agency's safety program. He has also served in numerous fire agency administrator assignments. Phipps earned B.S. and M.S. degrees in forestry from the University of Washington.

David Rejeski is the director of the Science and Technology Innovation Program (STIP) at the Woodrow Wilson International Center for Scholars in Washington, DC. The mission of STIP is to explore the scientific and technological frontier, stimulating discovery and bringing new tools to bear on public policy challenges that emerge as science advances. This program focuses on emerging technologies and the critical choices innovation presents to public policy. Work includes synthetic biology (www.synbioproject.org), nanotechnology (www.nanotechproject.org), participatory technology assessment, geoengineering, and the application of information technologies, computer games, and social media to public policy challenges. Rejeski has been a Visiting Scholar at the Environmental Law Institute, a Visiting Fellow at Yale University's School of Forestry and Environmental Studies, and an adjunct affiliated staff member at RAND. Between 1994 and 2000, he worked at the White House Council on Environmental Quality and the Office of Science and Technology Policy (OSTP) on a variety of technology, research and development, and policy initiatives, including the development and implementation of the National Environmental Technology Strategy, the Greening of the White House, and the Education for Sustainability Initiative. Before moving to OSTP, he was head of the Future Studies Unit at the U.S. Environmental Protection Agency (EPA). Rejeski sits on the advisory boards of several organizations, including the Board on Global Science and Technology of the National Academy of Sciences; the expert panel advising the Defense Advanced Research Projects Agency's (DARPA's) Living Foundries Program; the National Science Foundation's (NSF's) Advisory Committee on Environmental Research and Education; the NSF-funded Synthetic Biology Engineering Research Center (SynBERC); the external science advisory committee of the Center for Environmental Implications of Nanotechnology; the Committee on Science, Engineering and Public Policy of the American Association for the Advancement of Science; the Center for Environmental Policy at American University; the National Council of Advisors for the Center for the Study of the Presidency; the *Journal of Industrial Ecology*; and Games for Change. Between 2004 and 2009, he was a member of EPA's Science Advisory Board and he has served on the EPA's Board of Scientific Counselors. He has graduate degrees in public administration and environmental design from Harvard University and Yale University, respectively, and a degree in industrial design from the Rhode Island School of Design. He is the coauthor (with Robert Olson) of *Environmentalism and the Technologies of Tomorrow* (2005), and many articles about technological and environmental futures.

APPENDIX 3

Three Scenarios for Wildfire Futures

The three scenarios below were used to help structure the project's online conversations. They were developed as a way to capture the range of future circumstances that the foresight panel participants believe are plausible. They were used to stimulate creative thinking and identify "robust" actions to put forward for consideration. Looking through the lens of significantly different yet plausible images of the future is a powerful method for spurring creative thinking about the range of actions that may be appropriate for dealing with challenges ahead. Testing potential actions and strategies against a range of scenarios to identify robust actions that appear feasible and useful across a wide range of potential future circumstances is an effective way to deal with the future's inherent uncertainty.

Scenario 1: Collapse

Clear warning signs of serious cracks in the foundation of the social-ecological system emerged between 2015 and 2020: stagnant or declining economies in the United States and globally, persistently high unemployment, a widening gap and growing tensions between the rich and poor, mounting social unrest, increasing incidents of international terrorism. By 2018, there was a growing consensus that production of conventional oil had peaked and was now declining, and gasoline prices soared to more than $10 per gallon. Global food prices also spiraled due to higher oil prices, China's massive grain imports, and depleting aquifers ("peak water") that limited irrigated agriculture in many places around the world. Arctic sea ice was disappearing, glaciers melting, and sea levels rising faster than scientists had anticipated. Federal resources to help states and local communities deal with the impacts of these challenges were severely limited by budget cuts needed to reduce deficits and the national debt.

Nervousness about all these factors and the long-term lack of economic recovery led many investors to pull out of the market, and in 2021 global stock markets crashed. Crashing stocks set off a chain reaction of protectionist actions and negative economic and social events, which acted to prevent an economic recovery. A persistent worldwide economic depression settled in. Progress in many advanced technologies such as biotechnology and nanotechnology was slowed down or derailed by depression.

The economic collapse made it impossible to invest heavily in a massive switch to renewable energy, especially because the cost of renewable energy technologies increased rapidly with the escalating cost of the fossil fuels needed to build them. As conventional oil production declined and the natural gas boom fizzled, the dirtiest energy sources—oil shales, tar sands, coal—were increasingly used. By 2030, atmospheric carbon dioxide (CO_2) levels have surged above 450 parts per million, even with the depressed level of economic activity. Extreme weather events have increased in frequency and intensity, including mega-fires, hurricanes, tornadoes, drought, flooding, and record-breaking heat waves.

By 2030 it has become clear that the era of cheap and abundant energy is long over and that expensive, erratic, and inadequate supplies are the new normal. Water is increasingly expensive and scarce. Climate change is increasingly severe and unpredictable. Our economy does not

function in any way similar to the rather fair and effective way it functioned from the end of World War II to 2000, and governments at all levels are increasingly unable to govern effectively.

Communities have realized that the capacity of federal and state governments to deal with the unraveling of the social-economic-ecological system is severely limited. Local communities increasingly pick up the pieces. They creatively do what is needed to build resilience and adapt to the substantial changes with whatever resources they have on hand, with limited help from the outside. For example, "collaborative consumption" arrangements have become ubiquitous and mainstream, expanding from personal lending to sharing and bartering networks for everything imaginable. High energy prices have led individuals, families, communities, and businesses to take advantage of all the most affordable technologies for using energy more efficiently. Major energy-saving behavior changes have spread rapidly as everyone has engaged in learning to live at a much lower level of energy intensity. Consumer preferences for locally produced foods and innovations in sustainable agriculture have driven a revival of small farms in both rural and urban areas.

Although the role of the federal government has been sharply curtailed, it still plays a supportive role in promoting local self-reliance and community development through small-scale efforts such as information programs to highlight successful community efforts, small grants for local experiments, and basic support for maintaining the most critical public infrastructure. By 2030, wildfires have grown to nearly twice their extent in 2014 and federal funding for fighting wildfires has been cut to the bone, forcing the development of creative new approaches to wildland fire management.

Questions for Online Panel Discussion: What significant changes in wildland fire management could result from (or are required by) this scenario? How would wildland fire management need to adapt to make the best of this possible future?

Scenario 2: Continue

The modest turnaround in the U.S. economy was fueled largely by the energy revolution in shale gas and oil. Booming oil and gas production and relatively cheap energy provided the stimulus needed to finally shake off the Great Recession, saving the average American household $1,500 to $2,000 annually and tipping the scales in favor of U.S. producers of steel, chemicals, and many other materials and products. Millions of direct and indirect jobs were created in the late 2010s, finally driving unemployment down to 5 percent—considered "full employment" by most economists. Economic growth continued in the United States, most of Europe, and the BRIC countries (Brazil, Russia, India, and China) throughout the 2020s. Although the rate of growth was slower than hoped for, it was steady. Most of Africa, some of South America, and the Middle East did not fare as well.

Full employment and the resumption of economic growth helped generate a modest revival of the middle class, easing but not eliminating the nation's political and social tensions. Congress and the White House relearned the art of compromise, at least on less controversial issues. Deals on federal spending and debt allowed most government programs to continue without draconian cuts.

Advances in biotechnology, nanotechnology, and other areas in the 2020s helped maintain continued growth, creating new industries and revitalizing old ones. Progress was made in renewable energy technologies as well. But cheaper fossil fuels meant that the share of energy use accounted for by renewables increased only very slowly throughout the 2020s.

Continued global growth resulted in significant increases in the consumption of all natural resources, putting more strain on ecological systems. Suburban and exurban sprawl picked up where it had left off during the Great Recession, causing more fragmentation of forests and loss of wetlands. A new wave of large homes was built in the wildland-urban interface (WUI), greatly complicating wildland firefighting.

By 2030, climate change is toward the high end of past projections and is clearly accelerating due to melting permafrost in the Arctic, releasing growing amounts of methane, which is 20 to 80 times more potent as a greenhouse gas than CO_2.

The area burned by wildfires by 2030 in the United States and globally is considerably larger than anticipated at the start of the century and the extent of annual damage continues to escalate. With many competing needs and tight federal budgets, the U.S. Forest Service has to persuade the public and policy makers that wildland fire management is a high priority and that improved approaches are possible.

Questions for Online Panel Discussion: What significant changes in wildland fire management could result from (or are required by) this scenario? How would wildland fire management need to adapt to make the best of this possible future?

Scenario 3: Transformation

The years between 1950 and today in 2030 witnessed what futurist John Platt called "ten Industrial Revolutions … rolled into one" (quoted in Cornish 1977:1). The Great Recession, concerns about oil availability, and other problems contributed to a temporary loss of nerve about technological progress earlier in the 21st century, but it was actually during this period that some of the most important advances affecting our life today were gestating: inexpensive solar panels an order of magnitude more efficient than previous models, artificial photosynthesis, advanced batteries for electric vehicles and grid storage, super-efficient buildings, biomimetic industrial processes (innovative processes that emulate nature's time-tested patterns and strategies), drought-resistant self-fertilizing crops, advanced robotics and artificial intelligence, high-quality voice language translation allowing people everywhere to talk to each other, memory and intelligence enhancement, all kinds of novel organisms and biologically based devices produced by synthetic biology … the list goes on and on.

A listing like this makes it sound like social change is mainly driven by technology, but the dynamics of change have been much more complicated, and forest fires have played an important role. During the 2010s, large fires raged in Australia, Indonesia, China, Russia, and the United States. Then, in 2018, a major wildfire occurred in the spruce (*Picea* spp.) cover near the 100-square-mile tailing ponds of the tar sands mining operation in Alberta. It was never determined if the fire was caused by a lightning strike or arson, but it ignited the "goop," which has petroleum in the mix. Two years later, in 2020, the United States experienced the largest

wildfire in modern history, the so-called "Mother Fire," which caused a major disaster, severing power and water supplies to California's Bay Area.

Wildland fires had never been treated as a major issue in discussions of sustainability, despite the links to climate change, deforestation, water availability, air pollution, soil erosion, and other issues. That now changed: wildfires began to be regularly treated as among the "top 10 sustainability issues" as well as a significant security issue. The greater importance given to wildfires, combined with the recovery from the Great Recession, led to substantially more resources becoming available for wildland fire management.

The really important development was that wildfire replaced large storms as the "face" of climate change. The drama, unpredictability, and fear associated with fire had a powerful effect on public opinion, helping to break through remaining resistance and galvanize all-out efforts to deal with climate change. During the 2020s these efforts reached the scale of mobilizing for a war, which was a key factor stimulating the economy and accelerating technological change. People at every level from local communities to international organizations became involved. Politicians and civil servants, entrepreneurs and corporate leaders, scientists and academics in the social sciences and humanities, environmentalists and other leaders of nongovernmental organizations, journalists, teachers, religious leaders, film producers, musicians, and people involved in all the arts engaged in the effort to help cut greenhouse gas emissions. As successful as these ongoing efforts were proving to be, here in the United States and as a model for other nations, scientists still predicted warming by nearly 2 °C by the end of the century.

The efforts to deal with climate change helped trigger a revitalization of the federal government. An urgent mission, the influx into politics and government agencies of the more cohesive and pragmatic millennial generation, and enormous pressure on government from corporations and other stakeholders to "shape up" led to a smaller, more flexible, and more efficient federal government with clearer priorities and cuts in many areas of inappropriate or wasteful spending, but substantially increased resources for dealing with high-priority issues. In government, as well as in the private sector and community life, the 2020s became one of those rare creative periods when new visions of how to do things emerged or gained legitimacy and people felt empowered to act on their aspirations.

The extent of areas affected by wildfires increased, but by a lesser amount than experts once feared. Damage from wildfires decreased thanks to the comprehensive implementation of a "new paradigm of wildland fire management."

Questions for Online Panel Discussion: What changes in wildland fire management could result from the technical progress, economic growth, improved governance, and spirit of innovation and empowerment described in this scenario? What changes in wildland fire management would make the best of this possible future?

LITERATURE CITED

Cornish, E. 1977. **The study of the future: an introduction to the art and science of understanding and shaping tomorrow's world.** Bethesda, MD: World Future Society. 307 p.

APPENDIX 4

New Paradigm of Wildfire Management 2050

John Phipps

Wildfire plays an important and natural necessary role on fire adapted landscapes. In recognition of this hard truth, humans have adapted to these landscapes. Human settlement and fire adapted vegetation coexist with fire on the landscape. Fire is an occasional natural occurrence and passes without much consequence like a rainstorm. Humans have ended their war with fire on these landscapes. As a result, loss of life and property has dropped considerably, firefighter safety has increased dramatically, and costs of wildland fire management have declined significantly.

How did we arrive at this future? In 2015, the federal government facilitated a new system of fireshed management across the country. A fireshed is defined as the area surrounding a community that can potentially support a wildfire that can impact the community. In the West, firesheds are typically large because fires can move great distances from point of origin and communities may share the same fireshed.

The fireshed system of management was a game changer. Each fireshed had a fireshed council that had the responsibility to manage the wildfire risk of the fireshed. For firesheds that contained federal ownership, the council had the responsibility to comanage risk with the federal government by statute under the Wildland Fire Resilience Act of 2015 (WFRA). All aspects of wildland fire, including landscape fuels treatment, preparedness planning, suppression response, fire rehabilitation and recovery, and land use zoning and building codes, are considered by the councils as required by WFRA.

All the fire adapted areas in the country are now organized into firesheds, each with a council. Federal investment in firesheds is prioritized based on risk management models. For any given community in a fireshed, federal government investment requires the community to adopt an "inside-out" protection philosophy to community protection instead of the current "outside-in" practice. The "inside-out" philosophy requires communities to protect structures with protection zones and building codes. Protection zones require standards for flammable vegetation adjacent to structures.

Once a community is fire-resilient from the inside out, it sets up an opportunity for other areas of the fireshed to become fire-resilient from the community to the backcountry of the fireshed. If the community is fire-resilient, then fire managers can safely treat adjacent areas with fire to make those areas fire-resilient. Once those adjacent areas are fire-resilient, the back-country areas of the fireshed can experience more natural fire patterns without significant fire suppression. Once this pattern is established and maintained via prescribed fire over time, the fireshed is considered fire-resilient and sustainable.

The federal government investment strategy under WFRA was to: (1) facilitate establishment of firesheds across all fire adapted landscapes, (2) establish fireshed councils, (3) provide correct incentives, (4) prioritize investment based on risk ranking and inside-out philosophy adoption, (5) focus first on the highest opportunity for risk reduction, and (6) invest to reduce risk to acceptable levels. Following this strategy created the proper set of incentives for communities and land managers to create a trajectory toward an acceptable level of risk to communities, landscapes, and firefighters.

Olson, Robert L.; Bengston, David N.; DeVaney, Leif A.; Thompson, Trevor A.C. 2015. **Wildland fire management futures: insights from a foresight panel.** Gen. Tech. Rep. NRS-152. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 44 p.

Wildland fire management faces unprecedented challenges in the 21st century: the increasingly apparent effects of climate change, more people and structures in the wildland-urban interface, growing costs associated with wildfire management, and the rise of high-impact fires, to name a few. Given these significant and growing challenges, conventional fire management approaches are unlikely to be effective in the future. Innovative and forward-looking approaches are needed.

This study explored wildland fire management futures by using methods and diverse perspectives from futures research. To gain foresight for wildland fire management, we convened a foresight panel consisting of seven leading academic and professional futurists outside of the wildfire community and two wildfire professionals. We engaged the panelists in a series of structured online discussions to elicit their insights and perspectives on the future of wildland fire management.

There are five broad areas where the foresight panel members were in full agreement. (1) The level of uncertainty about external developments and future conditions that will set the context for wildland fire management is significantly greater than is recognized in current planning. (2) As conditions change, the traditional fire prevention and suppression approach to wildfire management will prove unsustainable. (3) A new fire resilience approach is emerging as an alternative to traditional viewpoints and practices. (4) All the major strategies needed to implement this approach are already familiar to wildfire managers. (5) There are strong short-term barriers to adopting the fire resilience approach, but the panelists believe its adoption is nearly inevitable between now and mid-century.

KEY WORDS: wildland fire management, futures, foresight panel, resilience, scenarios

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