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USDA
United States Department of Agriculture
Forest Service

2010 Photo Contest

Deadline for submission is 6 p.m. eastern time, Wednesday, December 1, 2010

Fire Management Today (FMT) invites you to submit your best fire-related images to be judged in our photo competition. Entries must be received by close of business at 6 p.m. eastern time on Wednesday, December 1, 2010.

Awards

Winning images will appear in a future issue of *FMT* and may be publicly displayed at the Forest Service's national office in Washington, DC.

Winners in each category will receive the following awards:

- 1st place: One 20- by 24-inch framed copy of your image.
- 2nd place: One 16- by 20-inch framed copy of your image.
- 3rd place: One 11- by 14-inch framed copy of your image.
- Honorable mention: One 8- by 10- inch framed copy of your image.

Categories

- Wildland fire
- Aerial resources
- Wildland-urban interface fire
- Prescribed fire
- Ground resources
- Miscellaneous (fire effects, fire weather, fire-dependent communities or species, etc.)

Rules

- The contest is open to everyone. You may submit an unlimited number of entries taken at any time, but you must submit each image with a separate release/application form. You may not enter images that were judged in previous *FMT* contests.
- You must have the authority to grant the Forest Service unlimited use of the image, and you must agree that the image will become public domain. Moreover, the image must not have been previously published in any publication.
- *FMT* accepts only digital images at the highest resolution using a setting with at least 3.2 mega pixels. Digital image files should be TIFFs or highest quality JPGs. Note: *FMT* will eliminate date-stamped images. Submitted images will not be returned to the contestant.
- You must indicate only one category per image. To ensure fair evaluation, *FMT* reserves the right to change the competition category for your image.
- You must provide a detailed caption for each image. For example: *A Sikorsky S-64 Skycrane delivers retardant on the 1996 Clark Peak Fire, Coronado National Forest, AZ.*
- You must submit with each digital image a completed and signed Release Statement and Photo Contest Application granting the Forest Service rights to use your image. For a copy of the release, see http://www.fs.fed.us/fire/fmt/release.pdf.

Disclaimer

- A panel of judges with significant photography and publishing experience will determine the winners. Their decision is final.
- Images depicting safety violations, as determined by the panel of judges, will be disqualified.
- Life or property cannot be jeopardized to obtain images.
- The Forest Service does not encourage or support deviation from firefighting responsibilities to capture images.
- Images will be eliminated from the competition if they are obtained by illegal or unauthorized access to restricted areas, show unsafe firefighting practices (unless that is their expressed purpose), or are of low technical quality (for example, have soft focus or camera movement).

To help ensure that all files are kept together, e-mail your completed release form/contest application and digital image file at the same time.

E-mail entries to:
fmtphoto@me.com

Postmark Deadline is 6 p.m., Wednesday, December 1, 2010

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On the Cover:

On the Cover:

America's wildland firefighters are among the best in the world. Here, the Columbia River Division Initial Attack Crew prepares for action, August 2009. Photo: Aaron Black-Schmidt, Ardenvoir, WA

The USDA Forest Service's Fire and Aviation Management Staff has adopted a logo reflecting three central principles of wildland fire management:

- *Innovation:* We will respect and value thinking minds, voices, and thoughts of those that challenge the status quo while focusing on the greater good.
- *Execution:* We will do what we say we will do. Achieving program objectives, improving diversity, and accomplishing targets are essential to our credibility.
- *Discipline:* What we do, we will do well. Fiscal, managerial, and operational discipline are at the core of our ability to fulfill our mission.

Firefighter and public safety is our first priority.

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by Tom Harbour
Director, Fire and Aviation Management
Forest Service, Washington, DC

Together, Everyone Achieves More

There are few things more important in wildland fire management than partnerships. In our fire prevention work, in our fuels management work, in our aviation work, in our fire suppression work, partnerships make things happen! Some of our long-established partnerships were developed in response to the rapid growth of communities in or close to our public lands. As a result, we have established cooperative agreements with States and many local entities and outlined how each will respond and provide mutual aid and cost-effective fire protection for public lands and their surrounding communities. Additional partnerships include other Federal firefighting agencies, State and local governments, and several nongovernmental partners—like the National Association of State Foresters, the International Association of Fire Chiefs, The Nature Conservancy, the National Volunteer Fire Council, and local volunteer fire departments, just to name a few. We help them, and they help us.

Many of our long-time and well-known partners have contributed stories to this issue of *Fire Management Today*. The National Association of State Foresters and agencies within the U.S. Department of the Interior, for example, share their view of fire management roles in the past, their current challenges, and their vision for the future of partnerships in managing wildland fire. These partnerships are very important to the work we do day-to-day and are highly valued. Many other partners are less visible, though, and we are proud to build on those relationships, described below, and to form new relationships in order to best serve the Nation.

National Aeronautics and Space Administration

In 2003, when the Columbia Shuttle exploded and broke apart over the State of Texas, incident management teams from the U.S. Department of Agriculture, Forest Service, responded to support the National Aeronautics and Space Administration (NASA) and the U.S. Environmental Protection Agency (EPA) to help with the recovery process. As a result, a lasting partnership was formed. Now, NASA assists the Forest Service in meeting National Transportation Safety Board (NTSB) mandates by providing airworthiness opinions—whether aircraft are safe to fly—for the contracted aircraft used during wildland fire operations. NASA also assists the Forest Service with exploration into use of unmanned aerial systems to gain information during wildland fire incidents. Through the agencies' collaboration, the Fire and Aviation Management (FAM) office benefits from NASA's expertise, while NASA has the opportunity to collect data and test new technologies in a unique environment.

International Fire Assistance

Many nations request FAM assistance in all aspects of wildland fire management. In such situations, FAM represents not only the individual agency, but the United States of America. The Forest Service has mutual assistance agreements with Mexico, Canada, Australia, and New Zealand and border agreements with Mexico and Canada. FAM has continuing long-term cooperative programs with Mexico, Russia, Australia, Portugal, South Korea, the Republic of China, and—most recently—with Greece. FAM supports a continuing effort to assist international programs with incident command system (ICS) training across the globe—such as in India and ASEAN (a 10-country, Asian compact) nations.

In 2007, FAM coordinated the development of a collaborative fire management effort with Greece following that year's wildfire season. This program is ongoing. In 2008, Greece sent five employees to work with the Little Tujunga Hotshot crew from the Angeles National Forest and four others to attend S-378 Aerial Supervision training.

FAM continues to provide cooperation and support to the North American Forest Commission's Fire Management Working Group, comprised of Canada, Mexico, and the United States of America, and FAM hosted the group's 2009 meeting in Sacramento, California.

In 2008, FAM provided ICS training to a South Korean delegation at the Wildland Fire Training and Conference Center in Sacramento, California, and traveled to China, where they conducted ICS training at the Nanjing Forest Police College.

U.S. Department of Defense

When an active fire season results in reduced resources available for fighting wildland fires and national coordination centers are unable to meet the resource demands of multiple concurrent fires, the Forest Service turns to the U.S. Department of Defense (DOD) for help. Over the years, our partnership with DOD has strengthened: the Forest Service provides wildland fire training to DOD personnel, and DOD provides us with much-needed groundforces and aviation assets when resource demands exceed our own capabilities.

U.S. Department of Homeland Security

Federal Emergency Management Agency

The all-hazard role of the Forest Service under the National Response Framework (NRF) is complementary to the agency's overall land management mission. In recent years, the number and complexity of all-hazard incidents has increased, resulting in unprecedented demands on Forest Service employees and partners for emergency response—such as the Hurricane Katrina response. FAM's unique combination of people, skills, and resources add significant value to our national all-hazard response capability.

The NRF pursues a comprehensive all-hazards approach to assist in managing domestic incidents. The NRF coordinates Federal, State, local, and tribal government and private sector involvement during incidents. FAM works at the headquarters level with the U.S. Department of Homeland Security, Federal Emergency Management Agency (DHS, FEMA) on issues related to the NRF and disaster preparedness and response.

The Forest Service is the primary agency and coordinator for Emergency Support Function 4–Firefighting (ESF4*) under the NRF. The function of ESF4 is to enable the detection and suppression of wildland, rural, and urban fires resulting from or occurring coincidentally with an incident of national significance. ESF4 coordinates and manages firefighting activities—including the detection and suppression of fires on Federal lands—and provides personnel, equipment, and supplies in support of State, tribal, and local agencies involved in rural and urban firefighting operations.

To successfully accomplish this function, the Forest Service has close working relationships with cooperating departments and agencies. The U.S. Department of the Interior provides staffing support for ESF4 and wildland fire resource support for mission assignments during all-hazard incident response. The U.S. Fire Administration (USFA) provides subject-matter experts and expertise regarding structural/urban/suburban fire and fire-related activities. The Forest Service, in conjunction with USFA, developed a standardized training program for ESF4 personnel.

U.S. Fire Administration

The USFA is an entity within DHS, FEMA, whose mission is to foster disaster preparedness and response tactics by providing national leadership to local fire and emergency services agencies. Historically, USFA's focus was on structural firefighting, but over the years, the group has grown to include all-hazard incident response. USFA has partnered with the Forest Service, is a member of the National Wildland Fire Coordination Group and National Multi-Agency Coordinating Group, and represents local government concerns (including those of volunteer and career fire departments) regarding wildland fire management. USFA provides expertise to local firefighting agencies regarding staffing standards, equipment standards, and training qualifications required for effective firefighting. This partnership fosters better coordinated response at the local level and assists the Forest Service in its response to wildland fire incidents. These partnerships make sense: *Together, everyone achieves more.* ■

*For more information on the Forest Service ESF4 role, see "Response Partnerships During Disasters: Emergency Support Function 4" by Gordon Sachs in *Fire Management Today* 69(3).

A Fire Protection Triangle for the Wildland–Urban Interface

Note: this article is based on a speech by the Chief at the 8th Annual Conference on the Wildland–Urban Interface, sponsored by the International Association of Fire Chiefs, in Reno, NV, on March 29, 2010

Tom Tidwell and Hutch Brown

Wildland fire is all about triangles—the familiar fire triangle of fuel, heat, and oxygen; the triangle that drives fire severity (fuels, weather, and topography); and the triangle of Federal, State, and local resources that provide fire protection in the wildland–urban interface (WUI).

Now there is a new triangle for fire protection in the WUI. Congress, through the Federal Land Assistance and Management Enhancement Act of 2009, has called on the U.S. Departments of Agriculture and the Interior to develop a joint cohesive wildfire management strategy. In response, the Federal agencies are preparing a strategy that focuses on:

1. Restoring ecosystems on a landscape scale,
2. Building fire-adapted human communities, and
3. Responding appropriately to wildfire.

Each side of the triangle contributes to fire protection in the WUI. To succeed, each pillar in the strategy depends on the other two pillars.

Tom Tidwell is the Chief of the Forest Service and Hutch Brown is a policy analyst for the Forest Service in Washington, DC.

When a wildfire starts in or burns into an area where fuels were previously reduced, whether by fire or by mechanical means, the Forest Service consistently found reduced fire severity, less damage, and lower suppression costs.

Ecological Restoration

One way to protect the WUI is to restore surrounding landscapes to a healthy, resilient condition. Healthy, resilient forest ecosystems are less likely to see uncharacteristically severe wildfires that turn into human and ecological disasters. The USDA Forest Service is restoring healthy ecosystems and protecting the WUI partly through the use of fire. As Stephen Pyne (2001) has noted, "Fire protection might be better grounded in fire's calculated use than in fire's unwitting suppression."

Forest Service specialists are testing that hypothesis. When a wildfire starts in or burns into an area where fuels were previously reduced, whether by fire or by mechanical means, the Forest Service systematically assesses the results. In 2009, about a hundred such assessments consistently found reduced fire severity, less damage, and lower suppression costs.

For example, the Los Padres National Forest in California conducted prescribed burns on more than 13,000 acres (5,260 ha) from 2005 to 2009. In 2009, when the La Brea Fire burned into the treated areas, suppression forces were able to contain that portion of the fire perimeter. Hundreds of nearby homes would otherwise have been threatened and many likely would have burned.

The Forest Service and other Federal land managers have taken such lessons to heart. From fiscal year 2001 (when the National Fire Plan was launched) to fiscal year 2008, Federal land managers jointly treated 29.1 million acres (11.8 million ha), about 3.6 million acres (1.6 million ha) per year on average (Healthy Forests and Rangelands 2009). More than half of the area treated was in the WUI.

But more is needed. Schmidt and others (2002) found that 127 million acres (51 million ha) of Federal land were at moderate to severe risk from uncharacteristically severe fires. At a treatment rate of 3.6 million acres (1.6 million ha) per year, it would take 35 years to treat the entire Federal area at risk, not to mention the much greater area—270 million acres (109 million ha)—at risk in non-Federal ownership. Meanwhile, millions of additional acres are likely to need treatment. Is the Nation even holding its own?

Restoration requires an all-lands approach, working across borders and boundaries to get the job done and marshalling resources across jurisdictions. The National Forest System contains only 20 percent of the Nation's forests. Fifty-seven percent are in private landownership, and another 23 percent are in State, tribal, county, municipal,

Jim Bailey, fuels assistant fire management officer for the Naches Ranger District, monitors the behavior of the Kaboom prescribed burn. Wenatchee–Okanogan National Forest, WA, August 2009. Photo: Aaron Black-Schmidt, Ardenvoir, WA.

and other Federal ownerships. Forest ecosystems typically form mosaics—mosaics of plant and animal communities and mosaics of landownerships. This is true not only in the East, but also in the West, where the critical issues are the same: forest health, invasive species, fire and fuels, water quantity and quality, and wildlife habitat connectivity. Such issues neither begin nor end at national forest boundaries.

The Forest Service has therefore adopted the all-lands approach to conservation through cross-boundary partnerships. The Federal cohesive wildfire management strategy

At a treatment rate of 3.6 million acres (1.6 million ha) per year, it would take 35 years to treat the entire Federal area at risk.

is a start. Under the new strategy, Federal land managers will:

- analyze the ecological components of landscapes that shape wildland fire conditions;
- examine the impacts of wildfires, insects and diseases, invasive species, and vegetation management programs on the fire environment, especially in the WUI; and
- identify strategies and priorities for fuels treatments and compare alternative programs for fuels management and restoration.

Based on the results, the Forest Service will work with partners across borders and boundaries to get more done on the ground—to build the fire-adapted natural communities needed to protect the WUI.

Fire-adapted Communities

Ecological restoration is key, but it alone will not be enough. To protect the WUI, the Nation also needs to build fire-adapted human communities. About 70,000 communities in the WUI are now at risk from wildfire, and only about 6,000—less than 10 percent—have community wildfire protection plans. Since 2000, nearly 28,000 homes, businesses, and outbuildings have burned in wildfires. To make people, homes, and communities safe from fire, more work is needed, not only in the woods, but also where people live.

No single entity can succeed alone. Federal, State, and local authorities have found effective ways of working together in the past. The Big Burn of 1910 set the stage for the Weeks Act of 1911 and the cooperative fire management partnerships that followed. The jurisdictional triangle of local, State, and Federal partners needs to become even stronger. The first step is to clearly define roles in order to build on each other's strengths.

The Forest Service's role is clear. The agency trains and equips firefighters to keep wildfires away from homes and communities—or at least to reduce fire severity to acceptable levels. However, Forest Service firefighters are not trained and equipped for structure protection outside Federal lands. The agency will do anything to save lives, but Forest Service fire managers will not put pilots and firefighters at risk—*lives* at risk—to protect someone's poorly prepared private property in the WUI. Structure protection in the WUI is the role and responsibility of individual property owners and State and local agencies. It is up to State and local agencies—not the Forest Service—to actually protect

The Forest Service works to keep wildfires away from homes and communities, but individual property owners have the primary responsibility for protecting their homes. The Forest Service works with State and local agencies to help build fire-adapted human communities. Photo: Ryan Ludlow, Boulder County Land Use forestry education and outreach coordinator, Boulder, CO.

structures in the WUI. Individual homeowner responsibility is key. Americans have a long and proud tradition of individual freedom and private property rights, but with those rights and freedoms comes responsibility. The main responsibility for fire protection in the WUI lies with individual homeowners and communities.

Still, the Forest Service does have a role to play. Tens of thousands of Forest Service employees live in communities all over the country, many in the WUI. They have a vested personal interest in building fire-adapted communities. The Forest Service's strategy is to work through cross-jurisdictional partnerships *before* a fire starts rather than relying solely on suppression efforts *after* it starts.

The partners have an array of tools at their disposal. A good example is the national Firewise program, which encourages individual homeowners to take responsibility for

The Forest Service aggressively fights fire in the wildland–urban interface. Fire managers use experience and professional judgment to allocate the appropriate ground and air resources. Photo: Aaron Black-Schmidt, Ardenvoir, WA.

Lightning caused fires are often the most appropriate means—often the only means, given limited resources—to achieve restoration goals on a landscape scale.

making their properties firesafe. With funding from the U.S. Department of the Interior, the Forest Service administers a grant with the National Fire Protection Association to provide support and educational materials for the Firewise program. The program has been growing by leaps and bounds. From 2008 to 2009, the number of designated Firewise communities—communities able to survive wildfire without intervention—grew from 400 to almost 600.

Building fire-adapted human communities is the second pillar of the Federal cohesive wildfire management strategy, encompassing a series of tools, partnerships, and processes needed to help communities reduce the risk of wildfire. Federal agencies will:

- analyze the components of effective community wildfire mitigation;
- assess the roles and responsibilities of Federal, State, and local governments;
- examine land use and zoning;
- study the use of community wildfire protection plans;
- evaluate the effectiveness of fire prevention; and
- explore the potential for engineered solutions, such as fire-resistant structures

Response to Wildfire

Nevertheless, even the best efforts to restore landscapes and build fire-adapted communities will not be enough. Suppression will be needed, and fire protection in the WUI will always be predicated on a response to wildfire. The question is: What is the appropriate response?

The question has two parts:

1. What should the Nation's general strategy be in responding to wildfires?
2. What tactics should be used to implement our strategy?

The Big Burn of 1910 gave the Forest Service a rallying cry that resonated with Americans across the Nation: Put 'em out, put 'em all out, and put 'em all out fast! Fire exclusion, in the form of the 10 A.M. policy and various other policies, was for decades the national strategic response to wildfire.

It took decades to see how futile and misguided that policy was. Fire can be postponed, but in most landscapes it cannot be excluded. Today, we are seeing the results: overgrown forests, in a drought, are fueling megafires. From 2000 to 2008, at least nine States had record-breaking fires; if not for the Big Burn of 1910, the list would also include Idaho and Montana.[1]

Accordingly, Federal wildland fire management policy has changed. The Forest Service still suppresses human caused wildfires; but when lightning is the cause, if conditions are right, fire managers take the opportunity to allow fire to play its natural role. Lightning caused fires are often the most appropriate

[1]Alaska (Taylor Complex, 2004—1.3 million acres [526,100 ha]); Arizona (Rodeo-Chediski, 2002—468,600 acres [189,600 ha]); California (Cedar, 2003—279,200 acres [113,000 ha]); Colorado (Hayman, 2002—137,800 acres [55,700 ha]); Idaho (Murphy Complex, 2007—652,000 acres [263,900 ha]); Georgia (Big Turnaround Complex, 2007—388,000 acres [157,000 ha]); Montana (Valley Complex, 2000—292,000 acres [118,200 ha]); New Mexico (Ponil Complex, 2002—92,500 acres [37,400 ha]); Oregon (Biscuit, 2002—499,600 acres [202,200 ha]); Texas (East Amarillo Complex, 2006—907,200 acres [367,100 ha]); and Utah (Milford Flat, 2007—363,100 acres [146,900 ha]) (NIFC 2009).

The Forest Service will aggressively fight fire in the WUI, using every resource at its disposal. But fire managers will *not* put lives and resources at needless risk

means—often the only means, given limited resources—to achieve restoration goals on a landscape scale.

In summer 2009, the Federal land managers went a step further. Federal fire managers now have the flexibility to manage a lightning-caused wildfire to achieve multiple objectives. They also have the flexibility to change their objectives in response to the way a fire spreads across the landscape. Nevertheless, they remain as aggressive as ever in putting out wildfires that threaten lives, homes, and critical natural resources.

But the most carefully crafted strategic response to wildfire isn't worth anything if not executed well. Forest Service fire managers have the expertise and experience to make sound decisions—to use the right resources in the right places at the right times.

The Forest Service will aggressively fight fire in the WUI, using every resource at its disposal. But fire managers will *not* put lives and resources at needless risk. They will not put pilots in the air when it will make no difference in the suppression effort, and they will not put firefighters in harm's way when a fire will likely simply jump over a fireline. To do so would be unconscionable, unprofessional, and irresponsible to the American people. Appropriate fire response in the WUI is predicated on partnerships, and the Forest Service is strongly committed to supporting its State and local partners. In 2009, the agency provided:

- more than $35 million in grants to State forestry agencies for preparedness, suppression, equipment, and other support, including training for more than 42,000 personnel;
- more than $10 million in grants to volunteer fire departments for equipment and other support, including training for more than 24,000 personnel; and
- through the Federal Excess Personal Property program, more than 800 pieces of equipment, including more than 400 trucks and trailers equipped with tanks, generators, and pumps.

A huge barrier to cooperative fire protection in the WUI is the inability of Federal, State, and local fire organizations to communicate with each other by radio. To solve the problem, the Forest Service is launching the Central Oregon Interagency Radio Integration Pilot Project. The goal is to have a single interagency radio system in place by 2013.

Appropriate fire response is the third pillar in the Federal cohesive wildfire management strategy. As part of the strategy, the Federal agencies will:

- conduct a comprehensive analysis of wildfire response and suppression capabilities, and
- provide a comparative analysis of suppression program alternatives.

Relationships Are Key

To summarize, the new cohesive wildfire management strategy rests on three pillars:

1. Restoring fire-adapted natural communities;
2. Building fire-adapted human communities; and
3. Responding appropriately to wildfire.

These three elements form a triangle for fire protection in the WUI. Each is necessary for success; and all three sides of the triangle rest, in turn, on the jurisdictional triangle of cooperation and collaboration among local, State, and Federal authorities. With this relationship in mind, citizens in and around Federal lands will be better able to live with fire than simply be subjected to it.

Acknowledgment

The authors thank Jennifer Jones, a public affairs specialist for the National Interagency Fire Center, Boise, ID, for writing the first draft of the speech on which this article is based.

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Bureau of Land Management Fire and Aviation: Unique Contributions From a Unique Agency

Ken Frederick

As the manager of the 258 million acre (104 million ha) National System of Public Lands (NSPL)—the largest single block of public lands under Federal management—the Bureau of Land Management (BLM) plays a critical role in managing wildland fire. The agency manages fire on more than 370 million acres (150 million ha) across the United States, including military and native lands in northern Alaska for which the BLM has suppression responsibility. It is a huge job for a relatively small agency. To do the job, the BLM relies on a particular set of skills and capabilities and a culture steeped in self-reliance and hard work.

Rapid and Safe Initial Attack

Because of the volatility of typical fuels on BLM lands, rapid and safe initial attack on new fires is often the best management response available. The typical kinds of fuel found on BLM lands explain a lot about BLM firefighting. Although the NSPL does include timber stands (especially in southwestern Oregon), the vegetation on BLM lands tends toward grass- and brush-dominated rangelands, arid forests of piñon pine and juniper, and millions of square miles of black spruce and brush in Alaska.

Ken Frederick is a public affairs specialist with BLM External Affairs at the National Interagency Fire Center in Boise, ID.

"Given our fuels and topography, we rely a lot on engines, helicopters, and bulldozers to fight fire in the BLM"

Besides being stocked with highly flammable fuels, BLM lands also tend to be isolated, and this fact exerts a significant influence on how the agency responds to and manages fires.

"Our land base is often rural," said Mike Benefield, fire management officer for the BLM's Moab District in southeastern Utah. "The BLM manages land that has always been remote and isolated—socially and geographically. This isolation has historically attracted self-reliant and adaptive people. You can't just run back to the office for something when the office is 80 miles [129 km] away."

The combination of volatile fuels, flat topography, and vast landscapes creates ideal conditions for what some have termed the BLM's "mechanized infantry" approach to firefighting.

"Given our fuels and topography, we rely a lot on engines, helicopters, and bulldozers to fight fire in the BLM," added Benefield. "We rely less on hand crews compared to other Federal, State, and tribal firefighting organizations." BLM fires tend to have high rates of spread, which makes the use of mechanized technology and tactics preferable.

Wildland engines are the backbone of the BLM's fire program. The BLM manages the acquisition and development of engines centrally out of the Equipment Development Unit headquartered at the National Interagency Fire Center (NIFC) in Boise, ID.

"We centralize engine fleet management for a couple of significant reasons," said Carl Dorsey, who recently retired as supervisor of the Equipment Development Unit. "First, we gain a lot of efficiency and value by purchasing components in large quantities. Second, a standardized engine fleet reduces crew training costs and allows our engine crews to be interchangeable. They can go pretty much anywhere in the country, hop on a BLM engine, and fight fire."

Typical BLM fuels—brush and grasses—create volatile fires. Photo: Kari Greer, NIFC, August 2007, near Ketchum, ID.

BLM engines doing what they do best—fighting a fast-moving fire in western range country. Photo: Courtesy of BLM, Arizona Strip District.

Approximately 150 BLM smokejumpers provide initial attack on new fires and on-scene coordination and leadership for emerging large fires primarily in Alaska, Colorado, Idaho, Nevada, and Utah.

The kinds of engines in the BLM fleet are designed to fight fire specifically in BLM fuels and topography. For example, the largest BLM engine, the Model 668 Wildland Ultra "Tatra," has advanced features that make it a formidable firefighting machine. The Wildland Ultra's six-wheel-drive, high ground clearance, and in-motion/in-cab tire inflation enables it to get to fires unreachable by traditional wildland engines. The Ultras also have a front-mounted monitor nozzle, which is operated from inside the cab with a joystick. And the Ultras carry a huge payload of water—2,250 gallons (8,500 L)—which is nice to have when the fire is miles from the nearest refill source.

BLM single engine airtankers are a welcome sight on wildfires. Photo: Kari Greer, NIFC, August 2007, near Ketchum, ID.

The BLM, however, is not just about engines. The agency fields 11 interagency hotshot crews, located in Alaska, California, Colorado, Idaho, Mississippi, Nevada, Oregon, and Utah. The BLM has wide latitude to pre-position its interagency hotshot crews in response to changes in conditions and priorities. Like other hotshot crews, the BLM hotshot crews meet all national standards for training, experience, and capability.

Specialists in Fire Aviation

Ground attack is not the only tool the BLM uses as an appropriate response to wildfire on the NSPL. The agency also has a significant role in aerial firefighting.

The BLM pioneered development of single engine airtankers (SEATs) in the mid-1980s, and SEATs have gained an important role in fire aviation. "SEATs have grown up," said Brad Gibbs, the operations officer for the BLM's National Aviation Office. "Over the last 10 years, SEATs have become faster and have developed a higher payload capacity, and this development has helped fill the gap in the national interagency airtanker fleet."

Advances in SEATs have come at the right time. With the dramatic reduction in the federally contracted fleet of heavy airtankers in the early 2000s, SEATs have picked up a good portion of the fire aviation workload. The BLM typically contracts between 40 and 50 SEATs each year for aerial firefighting work, and it has contracted up to 90 SEATs during busy fire seasons. The BLM has changed more than just the kinds of SEAT aircraft it uses over the past decade. What used to be a regional resource has now grown into an important national resource.

"SEATs are now known for their ability to move proximal to fires," added Kevin Hamilton, chief of the BLM's National Aviation Office. "They are highly mobile, and they don't need a fixed retardant base for support."

The BLM is also capable of delivering several hundred firefighters aerially to meet its initial attack mission. Helitack crews travel to fires by helicopter and specialize in rapid size-up, initial attack, and support of wildfires. Nearly 200 BLM helitack personnel are strategically positioned at 20 bases across 9 Western States.

The BLM helitack program has some distinctive attributes. For example, the BLM developed a software application called Automated Helicopter Performance Planning. This system enables pilots, helicopter managers, and crew supervisors to calculate allowable helicopter payloads accurately and quickly, given the critical mission variables involved with each mission. This tool is especially useful for in-flight mission changes, which usually require recalibrations for flight duration, elevation, fuel consumption, weather conditions, and payload.

Smokejumpers are another component of the BLM's aerially delivered firefighter force. Nominally divided between two smokejumper bases in Boise, ID, and Fairbanks, AK, about 150 BLM smokejumpers provide initial attack on new fires and on-scene coordination and leadership for emerging large fires primarily in Alaska, Colorado, Idaho, Nevada, and Utah. BLM smokejumpers spend little time at their primary base during the busy parts of the fire seasons; they work out of multiple satellite bases in the Great Basin and Alaska, depending on fire activity.

The Ram-Air parachute system used by BLM smokejumpers is unique to the agency. It enables BLM smokejumpers to perform effectively in the high-elevation, high-wind conditions that typify BLM terrain. The BLM's aerially delivered firefighters comprise a highly mobile, highly skilled, and flexible

The BLM builds on the effectiveness of traditional prevention and education programs by adding an element it calls mitigation.

A BLM helitack crewmember marshals a helicopter into a mountain helispot. Photo: Courtesy of California BLM State Office, September 2008.

A BLM smokejumper approaches a timbered jump spot. Photo: Nicole Hallisey, NIFC, April 2008, near Idaho City, ID.

resource, positioned for wildland firefighting in Alaska and the Western United States.

In the late 1990s, BLM aviation managers implemented an aerial supervision method pioneered by Canadian fire aviation managers. In past years, two support aircraft served coordination roles over a

The BLM trains incident commanders in rapid and critical decisionmaking because BLM fires tend to be hot and fast moving.

fire: a lead plane to coordinate retardant drops and an air tactical group supervisor (ATGS) in another plane to provide overall aircraft coordination over a fire.

Several years ago, National Aviation Office specialists decided to fill two roles by including the ATGS in the lead plane. Officials reasoned that both roles could still be filled using this approach, but consolidating two roles into one aircraft would make operations over a fire safer while reducing costs. "This approach has worked really well," said Hamilton. "It is starting to catch on with other agencies and States," he added.

Prevention and Mitigation

Suppression isn't the BLM's only distinctive response to wildland fire. The BLM also focuses on fire prevention, mitigation, and education.

Traditional fire prevention is a proven success. Programs like public education, outreach to schools, signage, and public service announcements clearly help prevent accidental fire starts. The BLM builds on the effectiveness of traditional prevention and education programs by adding an element it calls "mitigation." Fire mitigation recognizes that we simply cannot prevent every fire—that in some parts of the United States it's not a question of if wildfire is coming, but when.

"Mitigation activities are designed to reduce or eliminate risks to persons or property," said Terina

BLM fire mitigation and education specialists in Elk City, ID, teach school children about defensible space. Photo: BLM, June 2007.

Mullen, a fire mitigation and education specialist at the BLM's Butte Field Office in western Montana. "We work with communities through the Community Wildfire Protection Plan process to do [fuel reduction] projects that achieve the biggest bang for the buck for both parties." Mitigation works through planning, fuels treatment, preparation, and project design. Fire mitigation is one way the philosophy of coexisting with wildland fire finds its footing.

BLM Leadership Development in Fire and Aviation

Leadership in fire and aviation is important to the BLM. "The BLM is committed to developing leaders," said Jim Douglas, the BLM's assistant director for Fire and Aviation. "Developing good leadership doesn't happen by chance. It's something we work at continuously."

The BLM trains incident commanders in rapid and critical decision-making because BLM fires tend to be hot and fast-moving. The agency trains fireline leaders to develop the thinking skills required for effective supervision and incident command. These skills include the ability to simultaneously consider the meaning and importance of multiple influencing factors, including weather, fuels, topography, resources, values at risk, and obstacles to progress. These skills also include understanding human factors, like communication and motivation.

One fertile training ground for leadership development is in the BLM smokejumper program. Due to the nature of smokejumping, it forms an exceptional "school" for leadership development. Smokejumpers often work under conditions that both teach and demand clear thinking, decisiveness, and a finely tuned knowledge of fire behavior.

This intentionality in leadership development works. Although smokejumpers comprise only 7 percent of BLM firefighters, the two BLM smokejumper bases provide about 20 percent of all type 3 incident commanders in the BLM.[1] Numerous BLM smokejumpers have progressed in their careers to assume greater roles of leadership and responsibility—not because they are smokejumpers, but because they are capable and competent leaders in wildland fire.

The BLM helitack program has also taken a strategic approach to leadership development. Recognizing that the BLM and other agencies are going to need skilled leaders in fire aviation in the future, in 2009 the BLM created the Aviation Leadership Development Initiative. This program has two primary focuses: 1) to help defray tuition costs and other expenses related to obtaining formal training for emerging leaders in fire aviation and 2) to provide critical experience by steering these employees toward formative aviation projects and activities at all levels of the bureau. The BLM fills a unique and important niche in wildland fire management's multi-agency effort. The BLM looks forward to continuing to hone and adapt its skills, its workforce, and its mission. ■

BLM smokejumper Deb Yoder smiles after completing a practice jump. Photo: Nicole Hallisey, NIFC, April 2008, near Idaho City, ID.

1 According to data in the Resource Ordering and Status System, April 2009.

State Forestry's Role in Wildland Fire: Suppression, Community Protection, Cooperation, and More

Dan Smith

Successful prevention, mitigation, and restoration response to wildland fire requires coordination at all levels, among all stakeholders, and across all landscapes. State forestry agency leaders are unique in their ability to build partnerships among different stakeholders, including land management agencies, landowners, local governments, nonprofit organizations, tribal groups, conservation organizations, and businesses. State foresters provide leadership in building community capacity to manage forest resources, promoting accountability and efficiency, addressing threats to forests, and promoting the role of forests in the environmental and economic health of our Nation.

Mandates, Missions, and Jurisdictions

State general statutes across the United States mandate that State forestry agencies manage, develop, and protect forest resources on State and private lands, which make up two-thirds of the Nation's forests. Forestry agencies address these mandates by managing existing natural resources, creating and developing new and better forests, and protecting these valuable resources. The statutory mission of State agencies with forestry and wildfire protection responsibilities varies significantly from State to State. In general, all have a statutory responsibility to provide services in protecting State and private lands from wildfire.

Dan Smith is the fire director of the National Association of State Foresters. He is stationed at the National Interagency Fire Center in Boise, ID.

> State foresters provide leadership in building community capacity to manage forest resources, promoting accountability and efficiency, addressing threats to forests, and promoting the role of forests in the environmental and economic health of our Nation.

State forestry agencies are required to protect private forest lands and may provide resource management assistance to private landowners. The agencies, however, do not own or have direct resource management control over private forest lands. This is in contrast to Federal natural resource agencies in mission and public customer service expectations. Although landownership patterns and individual objectives vary across landscapes within a State, it is rare for a landowner to use natural ignition for resource benefits on private land; as a result—with rare exceptions—State agencies support and provide fire suppression programs for rapid and aggressive initial response to wildfire with the intent of limiting fire spread.

In 2009, 80 percent of the wildfires reported by all agencies to the National Interagency Coordination Center (NICC) via daily situation reports and incident status summaries (ICS-209 reports) occurred within areas of State jurisdiction. The 63,307 fires reported by States burned 3 million acres (1.3 million ha), or 51 percent of the total area burned last year. The 10-year averages reported to NICC for the number of fires and area burned (77 percent of the total number of fires reported by all agencies and 39 percent of area burned) also reflect a very significant workload for the States.

Local and State taxes and protection assessments often fund wildland fire protection, yet State suppression actions must be commensurate with the natural resource values at risk. Many private forest landowners—individuals and businesses—manage their forest lands for economic return and long-term investment, and these landowners are deeply concerned about adequate wildland fire protection for their property. In many States, the forest products industry is economically important, providing thousands of jobs and major contributions to States' economies.

Many State forestry agencies carry out an aggressive initial attack response for wildfire suppression.

For example, the North Carolina Division of Forest Resources strives to contain the average size fire to less than 3.5 acres (1.4 ha), while Montana's Forestry Division goal is to contain 95 percent of direct protection fires to 10 acres (4 ha) or less. Most wildfires in State jurisdictions—estimated at 90 percent—threaten structures, increasing the need for aggressive initial attack and coordination of attacking forces. The Texas Forest Service recently determined that 80 percent of the wildland fires in Texas started within 2 miles (3.2 km) of communities.

Local fire departments play a pivotal role across the United States in providing initial attack and structure protection on wildland fires. In most areas, the local fire department is first on the scene regardless of jurisdiction responsibilities. State foresters are very appreciative of the contributions of these fire services and work cooperatively with local fire departments to train personnel and build capacity at the local level. Various State-administered programs for rural fire departments (including grants, administration of Federal excess property programs, and specialized wildland fire training for structure fire departments that meet National Wildfire Coordinating Group standards) provide support for rural fire departments at local, State, regional, and national levels.

Communities At Risk and Community Wildfire Protection Programs

One of the greatest challenges that faces State agencies with wildland fire protection responsibilities is the ongoing threat within the wildland-urban interface (WUI), where entire communities and their associated infrastructure are at risk from the destructive force of wildfire. To address this ever-increasing problem on a national scale, the National Association of State Foresters (NASF) produced and maintains the document *Field Guidance for Identifying and Prioritizing Communities at Risk* as specified in *A Collaborative Approach for Reducing Wildfire Risks to Communities and the Environment: 10-Year Strategy and Implementation Plans* (2002 and 2006). This document provides general guidance and a process for assessing and communicating wildfire risks to communities. It was accepted by and distributed to agency field organizations with the endorsement of the NASF, the Chief of the Forest Service, and the Assistant Secretary of the Department of the Interior in December 2003. Subsequently, Congress passed the Healthy Forests Restoration Act (HFRA), which identified community wildfire protection plans (CWPPs) as the means to reduce wildfire risk to communities and municipal watersheds through a collaborative process of planning, prioritizing, and implementing hazardous fuels reduction projects.

The HFRA gives State foresters an important role in the process for developing CWPPs. It identifies the State agency responsible for forest management (along with local governments and fire departments) as one of the three entities responsible for agreeing on the contents of the locally developed CWPPs. The HFRA further requires that Federal agencies give priority to projects that provide protection to communities at risk. It is important to note that CWPPs are also in place and currently under development in communities not associated with the HFRA or near Federal lands. These CWPPs, addressing private and State lands, are positive examples of how the process of collaboratively protecting communities has expanded across the United States.

A local wildfire protection plan can take on a variety of forms, based on the needs of those involved in its development. The complexity of a CWPP should reflect the needs of the individual community and should be as simple and straightforward as possible. Minimum requirements for CWPPs, as described in the HFRA, include:

1. Collaboration: A CWPP must be collaboratively developed by local and State government representatives in consultation with Federal agencies and other interested parties.
2. Prioritized fuel reduction: A CWPP must identify and prioritize areas for hazardous fuel

About NASF

The National Association of State Foresters (NASF) is a nonprofit organization that represents the directors of forestry agencies from the 50 States, 8 U.S. territories, and the District of Columbia. Through public-private partnerships, NASF seeks to discuss, develop, sponsor, and promote programs and activities that will advance the practice of sustainable forestry, the conservation and protection of forest lands and associated resources, and the establishment and protection of forests in the urban environment.

treatments and recommend the types and methods of treatment on Federal and non-Federal land that will protect one or more at-risk communities and their essential infrastructure.
3. Treatment of structural ignitability: A CWPP must recommend measures that homeowners and communities can take to reduce the ignitability of structures throughout the area addressed by the plan.

In partnership with the National Association of Counties, Western Governors Association, Society of American Foresters, and Communities Committee, NASF produced *Preparing A Community Wildfire Protection Plan: A Handbook for Wildland Urban Interface Communities*, which has been utilized as the national guide for developing CWPPs. An electronic version of this handbook is located at <http://www.stateforesters.org/files/cwpphandbook.pdf>.

CWPPs are a proven, successful tool to address the challenges of the WUI in a way that brings about comprehensive and locally supported solutions. The continued success of CWPPs requires dedicated and focused leadership along with meaningful collaboration by all partners. The plans by themselves do not reduce wildfire risk. It is important that agency and organizational leaders understand and demonstrate commitment to the unique roles they play in producing and implementing effective CWPPs. Long-term financial commitment along with implementation and monitoring of CWPPs are critical to their continued success.

The August 2008 follow-up document, *Community Guide to Preparing and Implementing a Community Wildfire Protection Plan*, provides a framework for a comprehensive and consistent CWPP monitoring and evaluation process. This handbook was developed collaboratively to address performance measures for reducing hazardous fuels and promoting community assistance in the *10-Year Strategy Implementation Plan*. Sponsors include NASF, Western Governors Association, and Society of American Foresters. Links to this and other documents are located at <http://www.forestsandrangelands.gov/communities/>.

In 2009, 80 percent of the wildfires reported by all agencies to the National Interagency Coordination Center via daily situation reports and incident status summaries occurred within areas of State jurisdiction.

States have taken a leadership role in identifying local communities at risk from wildfire and maintain that information in the form of a document or map. States are using the NASF *Field Guidance* and regional risk assessments to assess, categorize, and maintain the wildfire risk to communities in the State. To do so, NASF has encouraged States to identify at least three levels of relative risk (e.g., high, medium, or low). NASF continues to support the following points regarding communities at risk:

- Maintain lists or maps of communities at risk at the individual State level and not in the Federal Register or the National Fire Plan Operating Reporting System (NFPORS).
- Compare relative risk to communities from wildfire within each State according to the risk assessment process—but not between or among States.

NASF prepares an annual report on the progress made in identifying communities at risk and the number of CWPPs completed.

The FY 2009 report identified 69,930 communities at risk, and, of those, only 5,567 were covered by a CWPP. The 17 Western States have produced 3,920 CWPPs. Survey results also indicate a significant increase in the number of communities at risk that have been identified by State foresters as being at "reduced risk." The number of communities that are now at reduced risk has increased dramatically to 10,293. A community is at reduced risk from wildfire if it has satisfied at least one of the following requirements:

- The community is recognized as a "Firewise community" or equivalent;
- The community has enacted a mitigation/fire prevention ordinance; or
- The community has reduced high-priority hazardous fuels identified in a CWPP to appropriate fuel levels in accordance with the plan schedule.

The number of communities deemed "at risk" will likely increase for some time due to improved risk assessments currently planned or in progress.

Of the at-risk communities, 13,836 reported increased local suppression capacity, defined by the increasing number of trained or certified firefighters and crews, upgraded or new fire suppression equipment, or formation of a new volunteer fire department or expansion of an existing one. While progress has been steady, the numbers released in the 2008 NASF report reflect the magnitude of the work that remains to be done to reduce risk to communities and build response capacity in those communities.

Wildfire Risk Assessments

Each of the three NASF regions (South, West, and Northeast–Midwest) have produced or are in the process of completing region-wide geographic information system-based wildfire risk assessments that can be utilized at the local, State, and regional levels. Numerous States—including Colorado, California, Florida, and Texas—have also completed wildfire risk assessments at the State level. The risk models used in the South and West integrate historic weather, fire ignition data, surface and canopy fuels, fire behavior analysis, fire effects, and suppression effectiveness. The models describe the probability of fires using methods that are quantifiable, repeatable, and comparable across time and space.

The Southern Wildfire Risk Assessment (SWRA), sponsored by the Southern Group of State Foresters, was the first regional wildfire risk assessment completed and has been utilized to identify more than 57,000 communities at risk in the South. The results of the SWRA help States coordinate with local communities and the Federal Government in addressing ways to mitigate these risks. In addition, the assessment offers the States a valuable tool for evaluating fuel mitigation scenarios prior to funding specific projects and can be used as a tool to model the effectiveness of these scenarios and monitor them over time. The identification of wildfire risks provides the South with the capacity to prepare and respond to wildfires as they occur and to plan for mitigation afterward.

The primary output layer of the Southern Wildfire Risk Assessment and the West-Wide Wildfire Risk Assessment (under development) is the "Level of Concern Index." This index provides an overall measure of wildfire risk by analyzing the likelihood of an area burning and the expected effects if a fire were to occur. The higher the Level of Concern values, the higher the concern for suffering loss from a wildland fire. The risk assessments have proven to be valuable tools, and ongoing improvements in methodology are expected, which will likely increase the number of communities identified as being at risk.

Firewise

In addition to the preparation of CWPPs, State forestry agencies are heavily engaged in the development and delivery of the Firewise Communities/USA program across the Nation to mitigate risk to communities. Firewise has proven to be a great interagency effort to reach homeowners, community leaders, planners, developers, and others in efforts to protect people, property, and natural resources from the risk of wildland fire. Recent accomplishments reported by the Firewise program include:

- More than 500 communities in 38 States actively participate in the program.
- In 2009, 87 new Firewise communities joined the program.
- More than 500,000 people live in areas participating in Firewise Communities/USA recognition.
- Forty-five States participate, with formal State Firewise liaisons assigned to the program.

It is important to note that Firewise programs have been delivered to hundreds of communities across the Nation, and that many of those communities are now recognized as Firewise Communities/USA or are working toward that goal. In New Jersey, 12 communities have been recognized as Firewise Communities, while another 16 communities are working on achieving that recognition. There is also value in educating communities that may never meet the criteria for such recognition if at least some of the homeowners implement the program standards for creation of defensible space.

Complex Incident Management Course

Since 2000, State foresters have built considerable incident management team (IMT) capacity with the development and presentation of the Complex Incident Management Course (CIMC). States initiated the CIMC to build capacity for State IMTs to manage complex wildland fires and all-hazard incidents.

Type 2 IMT qualification has been a prerequisite for CIMC. In May 2008, NWCG recognized CIMC certification as equivalent to advanced incident management (S-520) training completion. While CIMC focuses on building State IMT capacity for managing complex wildland fires and all-hazard incidents, the recognition of the course as equivalent to S-520 can help build capacity for geographic area and national IMTs as well.

The demand for CIMC continues to grow within State forestry organizations and other incident responders. To date, 55 IMTs have received the training. There are currently 35 State IMTs that meet or exceed Type 2 IMT standards, and so can be made available for national mobilization. States coordinate with their geographic coordination center and NICC when their teams are available for national mobilization. It is not unusual for several of the State teams to be mobilized in support of the western fire season and for all hazard response—especially for hurricanes.

Suppression Capabilities

While States invest considerable resources into mitigation and wildfire prevention, most also maintain or support strong wildfire suppression organizations. State wildfire suppression capabilities vary from State to State commensurate with protection mandates and areas to be protected.

Types of State resources vary by geographic location in the United States. The use of mechanized equipment—especially bulldozers and tractor plow units—is extensive in the Midwest, Northeast, and Southern areas. It is not unusual for State forestry agencies to own, operate, and staff 50 to 100 of these suppression units; some Southern States with high fire occurrence staff 200 to 300 units. States also staff various engines and provide hand crews, aviation assets, overhead, and other wildland fire resources to firefighting efforts.

Mobilizing Resources

There are three mechanisms currently available to States for sharing wildland fire resources with other States and interagency partners. First, the National Wildland Fire Resources Mobilization System provides a mechanism to mobilize resources from other States and Federal partners using the resource order and status system (ROSS). The Master Cooperative Wildfire and Stafford Act Agreement provides the authority and guidance for mobilizing interagency resources for out-of-state assignments and covers mutual aid response and annual operating plans at the local and State levels.

The second mechanism is region-based. There are eight regional interstate forest fire compacts across the United States involving 42 State participants. The compacts (Southeast, South Central, Mid-Atlantic, Northeast, Great Lakes, Big Rivers, Northwest, and Great Plains) allow States to mobilize resources out of State and help one another with prevention and suppression operations. In 2008, the Southern States processed 2,000 compact resource orders that provided over 18,000 personnel days of fire assistance to Texas and North Carolina. Three of the compacts are international in scope and include specific Canadian provinces; in 2009, the Northeast Forest Fire Protection Compact provided fire crews to Quebec. Multistate training is also a large component of a number of the State-to-State compacts.

The third mechanism for mobilizing State wildland fire resources is the Emergency Assistance Compact (EMAC), which promotes assistance and sharing of resources between individual States to address any emergency. The Governor of a State activates EMAC through a declaration of emergency. This level of assistance is typically the last option exercised: when dealing with wildland fire, State forestry agencies ordinarily use the national mobilization system or go to regional compact arrangements first.

A Shared Vision

Interagency cooperation and collaboration is essential for all of us in the wildland fire business. Some of the current issues that can strain interagency relations are:

- decreasing budgets,
- longer and more severe fire seasons,
- resource shortages,
- more people in the WUI,
- wildfires that cross jurisdictional boundaries,
- sharing of suppression costs,
- revisions in the implementation of fire management policy, and
- the different missions of various agencies.

Wildland fire is a complex land management and societal issue that goes beyond suppression alone.

A group of wildland fire agency leaders have been working on developing a framework of principles, strategic direction, and selected roles and responsibilities for Federal, State, tribal, and local agencies that will help us manage and live with wildland fire as a Nation. The vision is that effective partnerships, with shared responsibility held by all stakeholders of the wildland fire problem, will create well-prepared, fire-adapted communities and healthy, resilient landscapes at the most efficient cost. While this effort continues, the strong interagency relationships in place at local, State, regional, and national levels must serve us well in today's complex world of wildland fire management. I am confident that, collectively, we are up for the challenge. ■

Supporting Cultural Uniqueness: The Bureau of Indian Affairs Branch of Wildland Fire Management

Protecting human life…Restoring cultural landscapes…Supporting Indian self-determination.

Robyn Broyles

Whenever a fire crew leaves the Zuni Reservation in New Mexico, the tribe makes an offering of cornmeal and says a prayer to pay respect to the spirit of fire. Firefighters then carry cornmeal pouches to the fireline as a source of protection. Upon their safe return, the tribe makes another offering and says a prayer of thanks.

Native Americans are no strangers to fire management. From time immemorial, tribes have been living on and managing landscapes for cultural and natural resource benefits through fire. People in Indian Country know and respect fire as an important land management tool and honor it spiritually in ceremony (Kimmer and Kanawha 2001; Dejong 2004; White 2005). As the agency that supports tribal interests, the U.S. Department of the Interior, Bureau of Indian Affairs' (BIA) role in wildland fire management is as diverse as the 352 federally recognized tribal populations and Alaskan villages it serves.

Mission

The cultural, spiritual, and historical ties tribes have to the land give rise to the unique contributions the Branch of Wildland Fire Management (the Branch) brings to the interagency wildland fire community. The roots that ground the Branch are found in the larger BIA mission—which, as a tribal partner, is to fulfill its fiduciary responsibility of enhancing the tribal quality of life, promoting economic opportunity, and carrying out the obligation to protect and improve the trust assets of American Indians, Indian tribes, and Alaska Natives. This mission has influenced the Branch's history and organizational structure, which cross many natural resource fields within Indian Country. This historical perspective provides a better understanding of the economic and cultural role of forestry and fire protection in Indian Country.

> The cultural, spiritual, and historical ties tribes have to the land give rise to the unique contributions the Branch of Wildland Fire Management brings to the interagency wildland fire community.

The Branch is a component of the Division of Forestry and Wildland Fire Management, which reports to the Deputy Bureau Director, Office of Trust Services, in Washington, DC. The most unique aspect of Indian Country fire management is its mission to provide services consistent with each tribe's goals and objectives. With about 65 permanent, full-time employees, the Branch executes its fiduciary trust responsibility by protecting lives, property, and resources while restoring and maintaining healthy ecosystems. Using cost-effective and creative fire management programs, the Branch also promotes Indian self-determination.

History

The Forest Service was formed in 1905 to protect America's timber lands. The BIA soon followed suit and developed its Division of Forestry in 1910 with the goal that forests should be used to help tribes become self-supporting (Newell and others 1986). Today, forests on Indian lands cover nearly 18 million acres (7.3 million ha) on 275 reservations and form the largest private commercial timber holding in the United States.

In order to protect the timber holdings of the tribes, the Indian Division of the Citizen Conservation Corps (ID-CCC)

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was created in 1933 as part of President's Roosevelt's plan to put people back to work during the Great Depression. Throughout the 9 years the program was funded, 80,000 Native American and Alaskan Native workers helped build forest protection infrastructure, including roads, trails, telephone lines, lookout towers, and fire cabins. They also became trained experts in preventing, detecting, and fighting wildfires (Newell and others 1986; Kimmer and Kanawha 2001; Dejong 2004; Shaw 2005).

When veterans returned home from the Second World War, forest protection continued to be a valuable source of income for tribes and provided veterans a natural niche in which to apply their skills and energy. In the postwar era, Native American fire suppression crews sprang up across the Western States and Alaska. In Arizona and New Mexico, 2,000 Southwest Indian forest firefighters became available. In 1955, several reservations in Montana and Idaho formed the Montana Indian Firefighters, and in 1957, the Bureau of Land Management formed crews using Native Americans and Alaskan Natives.

In 1977, the BIA Office of Trust Responsibilities (now Trust Services) appointed George Smith as the first permanent representative to what was then the Boise Interagency Center, the predecessor to today's National Interagency Fire Center in Boise, ID. Since then, the reputation and stature of the BIA fire organization has continued to grow in the national fire community.

The reputation and stature of the BIA fire organization also benefitted from the cultural view that being a firefighter brought honor and recognition to one's tribe. That tradition still holds true today.

> The organization within the branch is tribally driven and operates from a bottom-up approach rather than being driven by centralized agency oversight.

Organization

Indian Country encompasses approximately 66 million acres (26.7 million ha) across 34 States and a population of nearly 1.9 million American Indian and Alaskan Natives. The history of BIA fire protection and the development of the Branch are intrinsically connected, not only to the land, but to the other natural resource and forest management programs in Indian Country as well. From the time the BIA program was established at NIFC, the overlap between agency and tribal natural resource management concerns has yielded a successful and progressive collaborative relationship.

Overall, the Branch consists of eight major sections: fire operations, aviation, preparedness (fuels management and prevention), fire planning, training, administration, budget and fiscal management, and communication and education. Each program is responsible for providing guidance to BIA central offices in Washington DC, and regional directors regarding the integration of wildland fire procedures into natural resource management.

The organization within the Branch is tribally driven and operates from a bottom-up approach rather than being driven by centralized agency oversight. Lyle Carlile, BIA fire director, states that the Branch is an organizational structure that works and one he appreciates: "We have the freedom to be creative to help the field as the need arises."

The Nebraska Ponca bison herd grazes on restored pasture following a prescribed fire. The fire was ignited as part of a fuels management plan to restore native grasslands and in turn increase the Nebraska Ponca bison herd, the lifeblood of the Ponca culture. Photo: Larry Wright, Ponca tribe of Nebraska Bison Program Manager, 2006.

The intimate connection between the Branch and tribal governing bodies also provides timely feedback that has direct impact on both the tribes and the Branch. It also fosters relationships that enable the Branch to respond to tribal, agency, regional, and national needs.

Firefighting Operations

Tradition and culture are threads that hold families and communities together. Since the dawn of the ID-CCC program, being a member of a fire crew has become a part of a cultural heritage in many communities. Cal Pino, BIA fire management officer for the Southwest Region, explains, "It is not uncommon for two consecutive generations of a family to work on the same hand or camp crew. While a parent is away on fire assignments, children are often left with grandparents who may have been members of the original ID-CCC crews. Also, while traveling, members function as representatives of the interagency fire community; in doing so, they bring honor to their tribes, which hold them in high esteem."

Approximately 98 percent of all fire starts in Indian Country are suppressed before becoming large, costly incidents.

Pino explains that there is also an economic element to this tradition. Seasonal employment provides a significant economic contribution to families in Indian Country. For communities like Santo Domingo, New Mexico, for instance, where many tribal members must otherwise depend almost entirely on income as self-employed artisans, fire assignments help subsidize annual earnings.

In hiring firefighters, the BIA relies heavily on the administratively determined (AD) pay plan, which enables agencies within Indian Country that otherwise lack sufficient funding for full-time fire programs to temporarily hire local individuals as needed. In 2007 and 2008, nearly 7,000 AD firefighters were hired by BIA. This brought in $19.6 million to families in tribal communities. In economically depressed areas, this income is very important (Shaw 2005).

Many firefighters who begin their careers as ADs will choose to move up into more challenging positions such as membership in the elite interagency hotshot crew (IHC) ranks. They are among the most experienced and highly skilled fire crews in the national fire community. Of the 107 nationally certified IHCs, 7 are sponsored by the BIA. "It is a very competitive program, and only the best of the best are admitted," says Dalan Romero, BIA fire operations director, adding that, "in Indian Country, being a member of one of these crews is a badge of honor for the tribes represented."

Another program, the Model 52 program, has also served an important and unique role in fire operations. Through this program, the BIA is the only remaining agency to build and assemble its own uniform fleet of engines. Operating out of three centrally located regional offices, each having specialized mechanics, parts, and mobile support vehicles to keep the fleet running in the field, the Model 52 has proven to be an efficient and cost-effective program.

New standardized BIA Model 52 Engines on display at Dulce, NM. Initially started as a grassroots movement, the design and layout of the fleet comes directly from the experience and feedback of the engine technicians and field operators who build and maintain the fleet throughout the Nation. Photo: Dennis Zentz, BIA Model 52 Program Manager, Dulce, NM, 2009.

Overall, the BIA has over 200 engines that—along with dozers, water tenders, and heavy equipment—contribute to fire suppression efforts in Indian Country. With this equipment, aviation resources totaling 22 fixed and rotor wing aircraft, and highly experienced crews, firefighters suppress approximately 98 percent of all fire starts in Indian Country before they become large, costly incidents.

Fuels Management

The fuels program in Indian Country manages the vegetation across a broad spectrum of landscapes, fuels, and ecosystems from Alaska to Florida. Of the 66 million acres (26.7 million ha) under BIA jurisdiction, close to 30 percent of them are within the wildland-urban interface (WUI) areas. This proportion of WUI area to total jurisdiction is greater than in any other land agency within the U.S. Department of the Interior. While this presents challenges for fuels managers, tribal members agree on the need for and positive outcomes of fuel treatments.

> Traditional ecological knowledge is aggressively being reintroduced by tribal elders and community members to help teach and better understand the historic relationship between fire, the environment, and people.

"Tribes live in a rural environment and understand fuel manipulation. This awareness provides tribal income, reduces the risk of wildfire, and promotes healthier forests," said Gene Lonning, fuels specialist for the BIA's Northwest Region. Lonning is an expert in fuels management and helps manage one of the largest and most progressive fuels program in Indian Country. Each year, this program alone treats more than 40,000 acres (16,000 ha) through prescribed fire, mechanical thinning, and other treatments.

Using Traditional Knowledge

While more modern technology and tools have their place, traditional ecological knowledge is aggressively being reintroduced by tribal elders and community members to help teach and better understand the historic relationship between fire, the environment, and people. Through traditional stories told and performed by tribal elders, fire is being returned to a respected place in land management (Pierrotti and Wildcat 2000; Kimmer and Kanawha 2001; White 2005).

Dennis Dupuis believes this is a critical and necessary approach. "Reintroducing indigenous use of fire is not optional. It brings back a lost art that is relevant and essential to restore cultural landscapes," he said. Dupuis also notes the traditional landscape fosters diversity and sustainability; supports edible and medicinal plants; and creates an environment that encourages spiritual involvement, qualities he recognizes as essential for the Indian way of life. By blending traditional ecological knowledge with a scientific approach, BIA fuels management is working alongside tribes to restore natural resources and culturally familiar landscapes.

Fire Prevention

When an unwanted wildfire occurs, the resources it threatens and everything connected to them can be affected for the next two or three generations. Hence, Native Americans and Alaska Natives, with their strong ties to the environment, sense a deep urgency to protect and nurture the land and natural resources.

Unwanted, human-caused wildfires are the most common wildland fires in Indian Country, and unfortunately, this problem is increasing. Wildfire prevention and education is a function the BIA takes very seriously.

In total, the BIA sponsors 41 fire prevention programs throughout the Nation. Prevention staff work closely with communities to implement juvenile firesetter intervention programs, develop community wildfire protection plans, and support community participation in Firewise workshops. They also conduct fire investigations and collaborate with appropriate law enforcement to provide leadership in fire trespass cases.

A CL-215 drops a load of water on the Westside Fire on the Red Lake Reservation, MN. Highly experienced aviation crews work with 22 fixed and rotor wing aircraft throughout the year to suppress unwanted wildfires. Photo: Greg Peterson, BIA Midwest Aviation Manager, 2009

Unwanted, human-caused wildfires are the most common wildland fires in Indian Country. Wildfire prevention and education is a function the BIA takes very seriously.

Every region, agency, and tribe has unique needs regarding fire prevention and education. As a result, the BIA prevention programs encourage each reservation and jurisdictional area to develop their own strategy and curriculum to meet their specific needs. Most tribes challenged by high numbers of human-caused fires now have approved fire prevention and mitigation plans and appropriate staff to implement them.

Training

Training is a critical element in the success of BIA's fire management program. The Branch training program, in concert with its interagency partners, oversees a comprehensive training program geared toward achieving a highly skilled, safety-conscious, and professional workforce.

Some of the focus areas within this program are the class C chain sawer operator (C-Faller) training program, the Prescribed Fire Mentorship program, Technical Fire Management, the Interagency Qualification Communications System, and Interagency Fire Program Management.

With the help of Walt Lara, a Yurok tribal member, forester, and longtime faller, the C-Faller training program provides a highly professional, hands-on learning experience. Twice a year, experienced and qualified C-Fallers meet, typically on the Hoopa Reservation on Yurok land in California, to learn and hone their skills. This C-Faller program uses instructors with the highest level faller certification, as well as other professional fallers experienced in safe fire operations.

Although the mentorship program is relatively new, it has proven to be extremely successful. Each winter, trainees at all levels of experience, knowledge, and expertise travel to the Seminole Indian Reservation in Florida. There, through networking and sharing, trainees develop and improve their skills in everything from creating burn plans to implementing projects and monitoring fire effects. Designed as an experiential learning opportunity, this program is proving to be a great benefit to trainees, the BIA, and the U.S. Department of the Interior as a whole.

Shaun Willeto conducts C-Faller training on the Hoopa Reservation on Yurok land in California. The C-Faller program provides highly professional, hands-on learning experience to new and experienced fallers. Photo: Dave Koch, BIA National Training Specialist, 2009.

Outreach

Smoke Signals is a quarterly publication that collects and distributes information through all levels of the firefighting community: individual firefighters, tribes, partners, and other land and natural resource management entities. The *Smoke Signals* readership continues to grow, in part, because the publication is a bottom-up effort: its authors are agency and field personnel who encourage the open exchange of ideas and recognize successful individuals and programs across Indian Country.

A Unique Agency and Organization

Fire plays a significant role in Earth's natural cycles, or perhaps none understand and value this more than those living in Indian Country. The BIA's Branch of Wildland Fire Management arose from the determination, dedication, knowledge, and wisdom of the early fire crews. These crews renewed a tradition of service that makes tribes and families proud. Today, the Branch is a unique and multifaceted organization that continues to foster highly trained, skilled, and professional hotshot, engine, and aviation crews on the front lines to protect Indian Country lands.

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General Services Administration's Role in Wildland Firefighting

John Barnicle and William Hicks

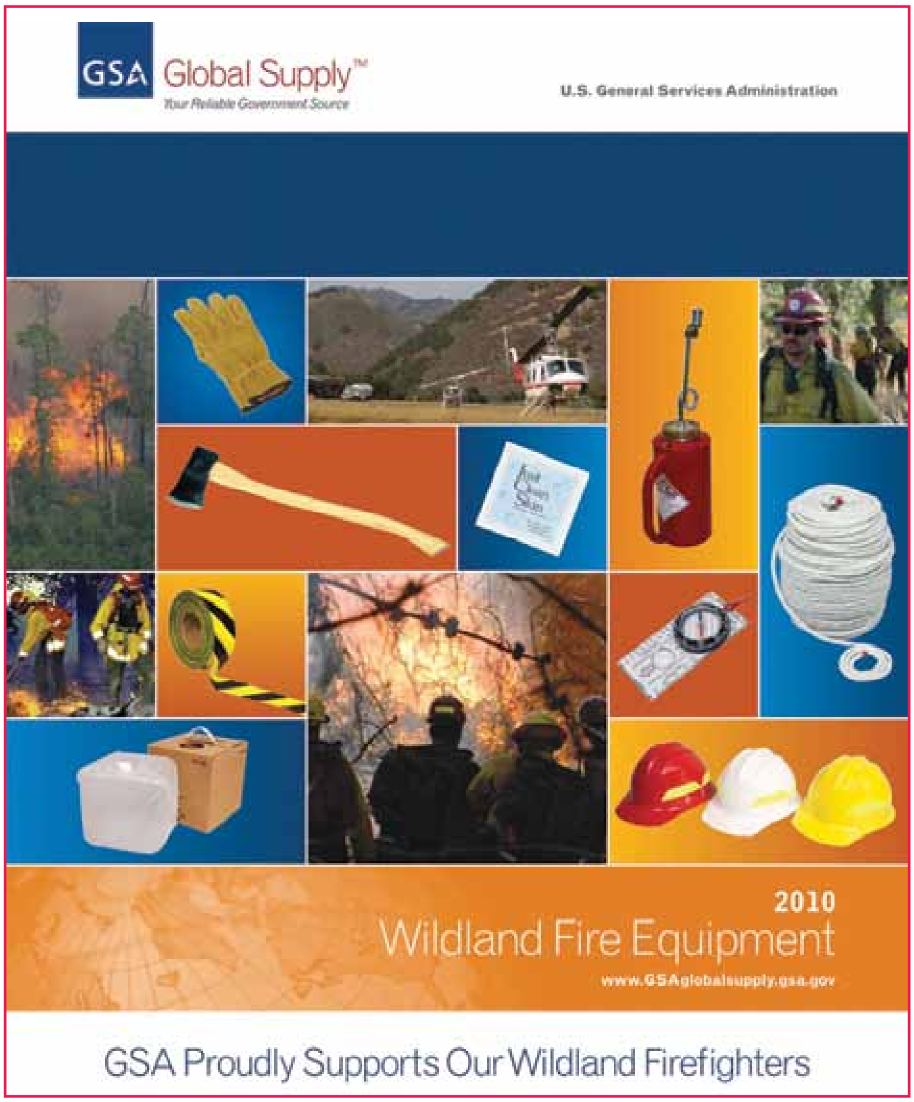
The Federal Government's General Services Administration (GSA) has actively supported the national wildland fire suppression effort since the 1950s. The terms of this support are outlined in interagency agreements between GSA, the USDA Forest Service, and the U.S. Department of the Interior, Bureau of Land Management (BLM). GSA coordinates several functions in support of wildland firefighting, including fire item specifications, purchasing, order processing, stocking, inventory management, and transportation.

Materials Supply

There are nearly 300 items classified as fire items and contained in the GSA wildland fire equipment catalog. These items include water handling equipment and supplies, fireline tools, fire shelters, protective clothing, canteens, field packs, sleeping bags, batteries, chainsaw chaps, first aid kits, gloves, goggles, and safety glasses. Specifications for these items are developed and maintained by the Forest Service, which employs experts on the latest technology and materials available from the commercial market as well as standards established by the National Fire Protection Association (NFPA). They use the information to improve the quality and safety of available items. Input is provided by wildland firefighting agencies, including State forestry organizations.

GSA can provide the same selection of items and professional support to local agencies that is available to the Forest Service and other Federal agencies.

At the end of the fire season—normally around the end of September—the GSA inventory managers review current demand



GSA's 2010 Wildland Fire Equipment catalog.

John Barnicle is a supply specialist with the General Services Administration's Federal Acquisition Service in St. Paul, MN. William Hicks is the Fire, Disaster, and Mandatory Source Coordinator of the General Services Administration's Federal Acquisition Service in Fort Worth, TX."

GSA Goes International

While GSA's primary focus for wildland fire support is assisting Federal, State, and local partners with U.S. operations, there are situations that require GSA to provide international assistance as well. In recent years, for example, Greece has suffered from terrible fires and received support from American agencies.

In January 2010, GSA assisted the Federal Emergency Management Agency and the U.S. military with emergency response to the tragic earthquake in Haiti. At the same time, widespread wildland fires in Colombia threatened to grow in size and severity. At the request of the U.S. Agency for International Development, Office of U.S. Foreign Disaster Assistance (USAID/OFDA), an official of the USDA Forest Service Disaster Assistance Support Program (DASP) contacted GSA Fire Coordinator Bill Hicks for assistance. Hicks worked with staff at GSA's western distribution center and Tory Henderson of the National Interagency Fire Center to assemble a shipment of approximately 30,000 pounds (13,000 kg) of firefighting equipment from GSA and interagency fire caches around the country. The shipment, which was paid for by USAID/OFDA, was flown to Bogota, Colombia, on January 25 and immediately dispatched to fire brigades around the country. According to Forest Service-DASP records, the shipment was the largest to date for U.S. fire equipment to a foreign country.

data on each fire item and compare it with comparable demand data for the prior 5 years. After the review, GSA presents stock level recommendations for items designated as "critical" to the Forest Service and BLM for review and approval. GSA then schedules purchases so that deliveries will be staggered throughout the following months, with stock level objectives to be met by June 1, when fire activity normally increases substantially. GSA accepts emergency orders around the clock, 365 days a year. (GSA's fire program coordinator is always available via cell phone or email.) These orders can typically be delivered within 26 hours to most destinations in the continental United States. During an average fire season, GSA processes orders for 1,600 tons (1,450 tonnes) of gear to support ongoing fires and replenishment efforts.

Additional Resources

In addition to the items stocked by GSA and highlighted in the annual catalog, there are other resources available through complementary GSA programs. Schedule contracts with commercial suppliers provide access to firefighting vehicles and other heavy equipment. The GSA Personal Property program handles excess property and has transferred equipment, including aircraft, to firefighting agencies for immediate use or, in some cases, modification for firefighting duty. Also, GSA's Schedule 899 (environmental services) offers training programs on specific fire-related topics, including fire preparedness and public safety education.

Federal Partnerships With State and Local Firefighters

GSA and its Federal partners provide assistance to State and local firefighting agencies and coordinate this support to avoid confusion and overlap. State and local agencies are invited to contact their Federal Excess Personal Property (FEPP) coordinator to evaluate the feasibility and practicality of a cooperative agreement with the Forest Service. When such an agreement is reached, partners are eligible to receive an activity address code from GSA to verify eligibility and to facilitate ordering. Then, a State's department of natural resources, for example, can order the same equipment from GSA that Federal agencies can buy. Depending on the State's organization and policies, the relevant State agency can coordinate supply operations for its county and municipal partners or delegate supply orders to the local level. In either scenario, GSA can provide the same selection of items and professional support to local agencies that is available to the Forest Service and other Federal agencies.

To find out more about cooperative agreements, State and local officials can contact a FEPP coordinator at the State level. Information is available at <www.fs.fed.us/fire/partners/fepp/> or through GSA at <www.gsa.gov/fireprogram>. ■

U.S. Fish and Wildlife Service: Keeping Fire on Our Side

Karen Miranda Gleason

The U.S. Department of the Interior's U.S. Fish and Wildlife Service (FWS) is the principal Federal agency responsible for conserving, protecting, and enhancing fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Its mission is to work with partners to achieve these goals. The agency has two separate management tools for accomplishing its mission: a land base of more than 150 million acres (60 million ha) and authority for implementing the Endangered Species Act (ESA).

The FWS fire management program supports the long-term, ecologically based mission through strategic hazardous fuels reduction and wildfire management projects that achieve dual benefits for both people and wildlife: reducing the risk of damage to land and property while maintaining and restoring healthy ecosystems. As the only agency managing lands in all 50 States and every U.S. territory, the FWS manages fire on the greatest number of units with the smallest fire budget of any Federal agency. To date, the FWS has maintained an exemplary record of firefighter and public safety, with only three fire-related fatalities in its history—those occurred in 1979 and 1981, prior to standardized training.

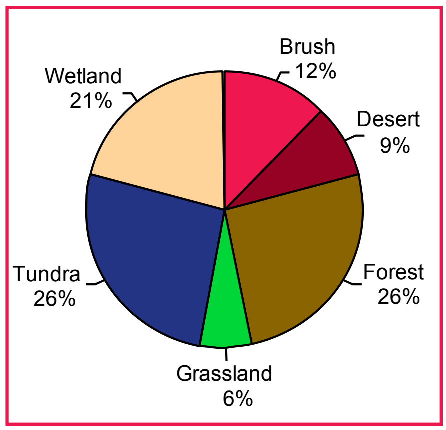
Karen Miranda Gleason is the national fire outreach coordinator for the U.S. Fish and Wildlife Service, National Interagency Fire Center, in Boise, ID.

As the only agency managing lands in all 50 States and every U.S. territory, the FWS manages fire on the greatest number of units with the smallest fire budget of any Federal agency.

A Network of Diverse Lands and Values

Fire is essential to managing FWS lands, which include 551 national wildlife refuges (at least one within an hour's drive of every major city in the United States), 70 national fish hatcheries, and tens of thousands of small tracts spread across rural and urban areas and along every U.S. coastline. These parcels comprise large wetland management districts, small waterfowl production areas, a variety of conservation easements, and other special management units. They are home to 280 of the Nation's 1,200 federally listed threatened or endangered species, as well as more than 700 species of birds, 220 species of mammals, 250 reptile and amphibian species, and more than 200 species of fish. In Alaska, the FWS manages 72.4 million acres (29.2 million ha), more than any other Federal agency. About 20 million acres (8.1 million ha) of FWS lands in 26 States are protected wilderness. Refuge lands also include wild and scenic rivers and marine protected areas.

The FWS's more than 75 million burnable acres (30 million ha) includes 25 million acres (10 million ha) of burnable wetlands, 16 million acres (6.5 million ha) of forest, 8 million acres (3.2 million ha) of brush, and 4 million acres (1.6 million ha) of grassland. The majority of these lands are fire-adapted: more than 80 percent in the lower 48 States and more than 90 percent in Alaska. Without fire, land managers could not restore and maintain the health of these ecosystems.



U.S. Fish and Wildlife Service lands by vegetation type. The U.S. Fish and Wildlife Service manages 150 million acres (61 million ha) of diverse lands in all 50 States and every U.S. territory. Data valid as of 2005.

Fire as a Critical Tool

The FWS has long recognized fire as an effective tool for shaping ecosystem structure and function. Native Americans, pioneer agriculturalists, and wildlife biologists have used prescribed burns to manage wildlife and plants. Without

Without fire to periodically cleanse dead and overgrown vegetation and recycle nutrients back into the soil, there could be no native tallgrass prairie, no duck-laden wetlands, no lodgepole pine or jack pine forests, and no productive fields of medicinal wildflowers.

fire to periodically cleanse dead and overgrown vegetation and recycle nutrients back into the soil, there could be no native tallgrass prairie, no duck-laden wetlands, no lodgepole pine or jack pine forests, and no productive fields of medicinal wildflowers. The populations of many animal species would dwindle as the lush mosaic of feeding, mating, and nesting areas was diminished by lack of fire.

The roots of fire management in the FWS are interwoven with early wildlife management in the Southeast. Wildlife biologist Herbert L. Stoddard first discovered a beneficial relationship between fire and wildlife while studying quail (Stoddard 1925). After biologists became aware of the connection between fire and wildlife, they ignited a prescribed burn in 1927 along the Gulf Coast, on what became St. Marks National Wildlife Refuge. In 1933, naturalist Aldo Leopold reinforced the concept of using fire to manage wildlife habitat when he identified "the axe, the match, the cow, the plow, and the gun" as the five critical tools for game management (Leopold 1933). Thus, fire became recognized as a critical tool for managing national wildlife refuges.

Fire greatly benefits both the endangered Fender's blue butterfly and its host plant, the threatened Kincaide's lupine, in the Willamette valley, OR. Photo: Quentin Cronk, University of British Columbia, 2009.

Even during the era of aggressive Federal fire suppression, starting in the 1930s and 1940s, refuge managers took the long view by continuing to burn. Through this quiet confidence in science and mother nature, trees and brush on many refuge lands were regularly thinned, while vegetation accumulated in areas where fire was excluded. This foresight is carried on today in the agency's continuing use of fire to maintain the desired condition of its lands.

Maintaining Positive Environmental Conditions

Wildland fire management benefits human communities by lowering the risk of property damage from wildfire and enhancing outdoor recreation. The FWS plans and conducts prescribed burns to realize these benefits while maintaining clean air and clean water. Management objectives during large wildfires remain dynamic, depending upon changing conditions, and are chosen to best protect communities and natural resources.

Clean Air: Through long experience in prescribed burning, the FWS is able to plan and manage burning conditions and smoke dispersion to keep smoke away from major roads and communities and within acceptably safe air quality levels. This avoids potential driving hazards and health risks that often occur during wildfires. During wildfires, incident management teams minimize these impacts whenever possible.

Prescribed fire planning helps to divert smoke away from roads and homes at Ding Darling National Wildlife Refuge, FL. Photo: U.S. Fish and Wildlife Service, 2004.

Clean Water: Whether serving as the local fishing hole or a town's water supply, a water source is best protected by effective management of fire. The FWS's long-term ecological approach to land management minimizes the risk of intense wildfires that severely damage soils, thus avoiding potential mudslides and impairment of water quality. An active program of emergency stabilization after wildfires helps decrease the risk of post-fire erosion and keep lakes, rivers, and streams cleaner.

A Small But Skilled Organization

In 1978, Congress directed the FWS to establish a formal fire program. The first national fire director, Art Belcher, was previously assigned to the Bureau of Land Management fire program. At FWS, he began by building a fire budget and hiring professional regional fire managers. In 1979, Belcher joined the FWS operation to other agencies at the Boise Interagency Fire Center, and FWS became an equal partner in the National Wildfire Coordinating Group (NWCG). In the 1980s, FWS began implementing NWCG training and operational standards and developed a unique field training course that integrated basic fire suppression (S-130), basic fire behavior (S-190), and prescribed fire operations. The course, presented in several regions throughout the country for the next half dozen years, was the first fire training sponsored by FWS.

The FWS's fire management program is now administered as part of the FWS National Wildlife Refuge System (NWRS), with fire management coordinators in each of eight FWS regions. Zone and refuge fire management officers handle fire staff operations on the ground to protect and manage FWS lands and provide assistance to other Federal, State, and local agencies. More than 500 permanent employees and more than 200 seasonal and temporary fire staff members support the fire management program across the United States.

The FWS Fire Management Branch, which includes 20 diverse professionals at the National Interagency Fire Center (NIFC) and a handful in other locations, is responsible for policy,

FWS and Bureau of Land Management fire staff on the Lower Colorado River observe the ignition of a prescribed burn at Imperial National Wildlife Refuge along the Arizona–California border. Photo: U.S. Fish and Wildlife Service, 2004.

U.S. Fish & Wildlife

Fire Staff Locations

REGION 1
911 NE 11th Ave
Portland, OR 97232-4181
http://www.fws.gov/pacific/refuges/fire/index.html

REGION 2
P.O. Box 1306
Albuquerque, NM 87103-1306
http://www/fws.gov/southwest/firemanagement/

REGION 3
Federal Bldg, Fort Snelling
1 Federal Drive
Twin Cities, MN 55111-4056
http://www.fws.gov/midwest/fire

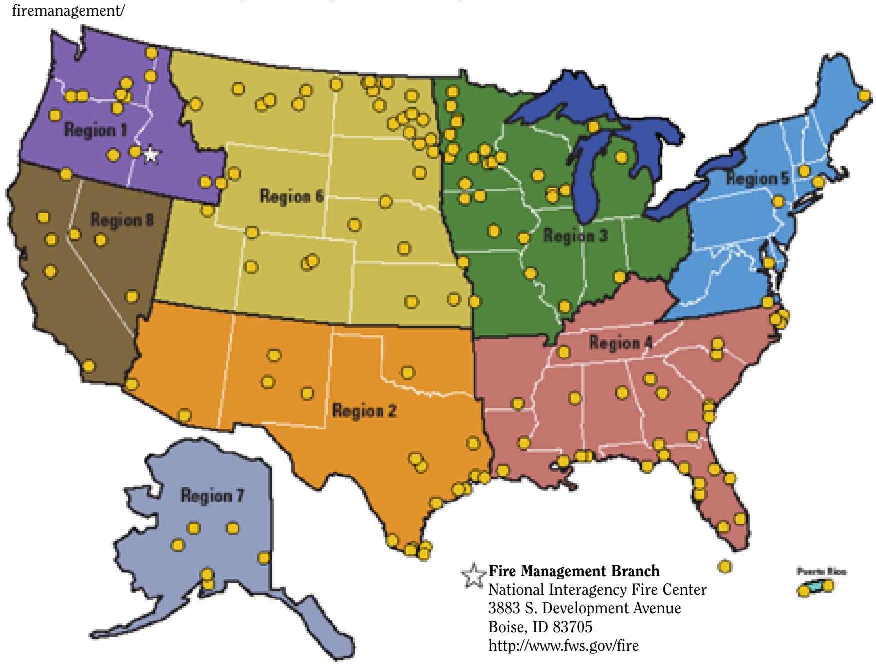
REGION 4
1875 Century Boulevard
Atlanta, GA 30345
http://www.fws.gov/southeast/refuges/fire-management.html

REGION 5
300 Westgate Center Drive
Hadley, MA 01035-9587
http://www.fws.gov/northeast/refuges/fire

REGION 6
134 Union Boulevard
Lakewood, Colorado 80228
http://www.fws.gov/mountain-prairie/fire/

REGION 7
1011 East Tudor Road
Anchorage, AK 99503
http://alaska.fws.gov/fire/default.cfmw

REGION 8
2800 Cottage Way W-2606
Sacramento, CA 95825
http://www.fws.gov/cno/fire/index.cfm



More than 500 permanent employees and 200 seasonal and temporary fire staff members across the United States support the FWS fire management program.

budgeting, and oversight of the FWS's national fire management program. In addition, about 2,000 FWS employees hold one or more qualifications under the Interagency Qualifications and Certification System (IQCS) to support wildland fire operations. FWS fire staff have helped train firefighters from the U.S. military and foreign countries in basic fire suppression, fire behavior, and prescribed burning. As Brian McManus, chief of the NWRS branch of fire management, sees it: "Because we are a small organization, we tend to know each other and operate well together. Managing our network of refuges in small communities has taught us to take a down-to-earth approach when working with our partners."

Active and Versatile Fuels Management

In addition to suppressing an average of 450 unwanted wildfires that burn, on average, more than 954,000 acres (386,000 ha) on its lands each year, FWS maintains an active hazardous fuels reduction program. With its strong history and practice in the use of fire, FWS is able to cost-effectively reduce fuels using prescribed fire on an average of 350,000 acres (142,000 ha) per year. More than 90 percent of its fuels reduction treatments are accomplished using fire, often in combination with mechanical thinning, chemical treatment, and other means—including selective grazing. FWS fuels reduction projects combat the spread of invasive plants and yield wood chips now used to supply paper factories and heat rural schools and homes.

A showcase project at San Diego National Wildlife Refuge directs fuels reduction funds to the local fire department, which purchased two small chippers and contracted a five-person crew to run them. This community-based initiative provides an incentive for residents to clear vegetation from around their homes by offering free chipping and mulch.

> In 1933, naturalist Aldo Leopold reinforced the concept of using fire to manage wildlife habitat when he identified "the axe, the match, the cow, the plow, and the gun" as the five critical tools for game management.

Local Partners Are Essential

With more than 700 at-risk communities located near national wildlife refuges and other FWS-managed lands, local residents are important partners in fire planning, fire protection, and fire management. In recent years, increased housing development around refuges, the acquisition of refuges near urban settings, and a growing need for critical habitat for declining species have increased the complexity of fire management issues. Thinning overgrown vegetation on and around FWS lands has become increasingly important to keep fire from damaging both human and biological communities.

A mother and son watch goats graze as part of a hazardous fuels reduction treatment on a conservation easement at Stone Lakes National Wildlife Refuge, CA. Photo: Kipp Morrill, U.S. Fish and Wildlife Service, 2008.

Every national wildlife refuge is required to have a detailed fire management plan, part of the comprehensive conservation plan process that elicits ongoing public involvement. Fire managers also encourage residents near refuges to take responsibility for mitigating risk by implementing Firewise principles and participating in community wildfire protection plans. Refuge visitors are reminded to be careful while enjoying the outdoors—hot parts of all-terrain vehicles, flames and embers from cooking stoves, and sparks from firearm use could all start wildfires. As Fire Management Branch Chief Brian McManus puts it: "The safety of people and their livelihoods comes first in everything we do."

Protecting Threatened and Endangered Species

Under provisions of the Endangered Species Act of 1973 (ESA), with a priority on human safety, the FWS

Support crews at San Diego National Wildlife Refuge provide free mulch chips to nearby residents in exchange for clearing flammable vegetation around their homes. Photo: U.S. Fish and Wildlife Service, 2002.

provides biological expertise to all fire management organizations. The ESA directs all Federal agencies to conserve threatened and endangered species and, in consultation with the FWS, to ensure that their actions do not unnecessarily jeopardize listed species or destroy or adversely modify critical habitat. FWS wildlife biologists consult with fire managers on hazardous fuels reduction projects and review fire management plans to maximize protection and management of threatened and endangered fish, wildlife, and plants. During many large wildfire incidents, wildlife biologists from FWS or the local jurisdiction will advise incident management teams on wildlife-related values or concerns, noting that the ESA allows for emergency procedures and does not stand in the way of an emergency response.

Adapting to Ongoing Change

A long-term land management approach involves continual adaptation to changes in environmental conditions and sociopolitical priorities. Fire management is no exception. Whether facing loss of habitat and species, climate change, shifting demographics, or fluctuations in budgets and public support, the FWS continues to adjust its operations to meet its goals in service to all Americans. As it looks to the future, the FWS and its fire program managers anticipate further changes in how it manages fuels and wildfire with ongoing flexibility and the collaboration of its partners.

A home remains standing after wildfire at Kenai National Wildlife Refuge, AK, due to advance measures taken by the occupants to apply Firewise principles. Photo: U.S. Fish and Wildlife Service, 2007.

U.S. Fish and Wildlife Service—With an Emphasis on "Service"

By keeping natural areas in a sound condition, FWS can support wildlife populations and offer visitors wildlife-associated recreation opportunities on national wildlife refuges: sustainable hunting, freshwater and saltwater fishing, wildlife observation, photography, and environmental education. These activities attract nearly 40 million visitors a year and generate almost $1.7 billion in sales for regional economies (Carver and Caudill 2006). As this spending flows through communities, it creates jobs for nearly 27,000 people and generates $542.8 million in employment income annually.

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Stoddard, H.L. 1925. Report on cooperative quail investigation, 1924. Washington, DC: U.S. Biological Survey, Committee Representing the Quail Study Fund for Southern Georgia and Northern Florida. 62 p. ■

The National Park Service: A History of Wildland Fire in Resource Management

Roberta D'Amico and Bill Halainen

Over the 16 years prior to 1988, Yellowstone National Park managed 235 fires under its natural fire policy. Only 15 of those fires were larger than 100 acres (4.05 ha), and all were extinguished naturally. But the summer of 1988 turned out to be the driest in the park's recorded history, and the season's fires gradually built up to a ferocity unfamiliar to recent memory. By late July, fires within the park had burned almost 100,000 acres (40,500 ha) as dry fuels and high winds combined to make the larger fires nearly uncontrollable. On the worst single day of the summer, August 20, high winds pushed fire across more than 150,000 acres (60,700 ha).

Despite the widespread misconception that all fires were initially "allowed" to burn, only 31 of the 248 fires that started in the greater Yellowstone area in the 1988 fire season were so managed. In the end, seven major fires were responsible for more than 95 percent of the burned acreage. Five of those fires were ignited outside the park, and three of them were human-caused fires that firefighters attempted to control from the beginning. More than 25,000 firefighters—as many as 9,000 at one time—attacked Yellowstone fires in 1988, at a total cost of about $120 million. A total of 793,000 of the park's 2,221,800 acres (321,000 of 899,000 ha), or about 36 percent, burned.

> During the 1930s, some managers in the NPS began talking about curtailing the universal application of fire suppression to all lands.

Although the fires were out by fall, the impacts of this extraordinary season continued. Across the Nation, the U.S. Department of the Interior, National Park Service (NPS), and other Federal land management agencies suspended and updated their fire management plans, assisted by the ecological assessment of a panel of independent scientists, and revised national fire management policies. Extensive evaluations of the effects of the fires on the natural community were begun and continue to this day. In addition, the fire community began looking at the causes of the fires, the lessons that had been learned, and the actions needed in the future. Because of its mission and management policies, the impacts on the NPS were particularly consequential and ushered in a new age of fire management.

The NPS Mission

The legislation establishing the NPS in 1916 (referred to simply as the Organic Act) stipulated, in its

A crown fire approaches the Old Faithful Lodge, Yellowstone National Park, WY, September 1988. Photo: Jeff Henry, National Park Service.

Roberta D'Amico is the communication director for Fire and Aviation Communications, National Park Service, Boise, ID. Bill Halainen is retired from the National Park Service and an avid historian and writer.

most salient passage, that the agency's mission was to "conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." Key words in this passage are "enjoyment" and "unimpaired," and they have been the subject of much review and opinion, legal and otherwise, in the nearly 100 years since the NPS was created. Taken together, the terms invite a contradiction in the mission: human use on the one hand and protection of the resource on the other. The passage on interpretation of the Organic Act found in the current version of *Management Policies*, the NPS's comprehensive policy statement, summarizes this discussion and provides clear direction to managers on how to interpret the act:

> "The enjoyment that is contemplated by the statute is broad; it is the enjoyment of all the people of the United States and includes enjoyment both by people who visit parks and by those who appreciate them from afar. It also includes deriving benefit (including scientific knowledge) and inspiration from parks, as well as other forms of enjoyment and inspiration. Congress, recognizing that the enjoyment by future generations of the national parks can be ensured only if the superb quality of park resources and values is left unimpaired, has provided that when there is a conflict between conserving resources and values and providing for enjoyment of them, conservation is to be predominant."

> Park supervisors insisted that "resource managers could restore fire to its natural role in parks and wilderness…in a way that is acceptable to the public."

The NPS, then, has a mandate to protect park lands, prevent their degradation and impairment, and maintain natural processes underway as they were before the encroachments of contemporary civilization. That mandate, however, was not always clear. It has taken many years for the NPS to fully comprehend the implications of this policy, and the history of fire management in the agency mirrors the evolution of this understanding.

The Beginnings of Fire Management

Yellowstone National Park became the country's first national park in 1872. Although the park was assigned to the U.S. Department of the Interior, no Federal agency received specific authority to manage this vast area. There was no organization or entity to protect the park, manage its many resources, or prepare it for visitors—and, above all, there was no funding for such. It wasn't until 14 years later that the Secretary of the Interior asked the Secretary of War to provide soldiers to protect the park from human exploitation.

In the summer of 1886, a cavalry troop arrived in the park and took charge. Just days before they arrived, fires beyond human control raged within park boundaries. The cavalry quickly found itself in the business of fire suppression. The Army determined that intentionally set fires and human-caused fires along roads or developed areas posed the biggest threat to the landscape and so concentrated its suppression efforts on controlling these fires: a pattern that was to persist for many years.

This precedent proved strong. Fire suppression was among the earliest management goals of the Nation's only national park. When Sequoia, General Grant, and Yosemite national parks were established in 1890, the policy of fire suppression and the utilization of the military were also applied to these areas. Patrols were also undertaken to guard against livestock trespass and illegal logging.

Over the ensuing years, a culture of fire "control" grew within the NPS and its kindred agencies, particularly in the Forest Service. For the next 50 years, fire suppression reigned as this country's dominant wildland fire management strategy. Even so, total fire suppression had its opponents.

First Efforts at Managed Natural Fire

During the 1930s, some managers in the NPS began talking about curtailing the universal application of fire suppression to all lands. Eivind T. Scoyen, the superintendent at Glacier National Park at that time, had seen first-hand the futility of trying to control large fires in remote backcountry areas. By 1950, he was the superintendent of Sequoia National Park and supported the designation of a large research area in the park that would be excluded from fire suppression. He convinced his superiors to accept this strategy, and the principle marked an important alternative to current policy. For the first time, the rationale for letting these "natural" fires burn was not simply economic; it was also ecological. The 1950s was also a significant decade for the NPS fire program. In 1958, Everglades National Park became the first national park to use prescribed fire (known then as research burns) on the landscape.

In 1964, Yosemite National Park instituted a policy that all fires above 8,000 feet (2,400 m) be permitted to burn if reconnaissance and evaluation showed that they could be contained by natural fuel breaks and that minimal harmful effects would result. While the reduction in suppression costs helped justify this fire management policy, the key consideration was the ecological benefit of fire. This "new" concept was not a popular one, though, and the principle was largely ignored by policymakers at higher levels.

That began to change after the NPS completed a landmark study on resource management. In 1962, the Secretary of the Interior charged a committee with looking into wildlife management problems inside our country's national parks. This special group (named after its chair, Dr. Starker Leopold, son of famed conservationist Aldo Leopold) determined that our national parks should be managed as whole, interdependent ecological systems, or "ecosystems." The "Leopold Report" also argued for a new direction regarding the role of fire. Managers in the NPS began to recognize the benefits of fire's presence as well as the harmful consequences of its absence.

Enlightened and encouraged by the Leopold Report, the NPS changed its fire policies in 1968. The agency now recognized fire as an "ecological process." As long as fires could be contained within prescribed fire management units and would accomplish approved management objectives, naturally ignited fires were allowed to burn.

Shortly thereafter, Sequoia and Kings Canyon National Parks, which abut each other, established a "natural fire management zone"— more popularly known as the "let-burn zone." This zone included areas above 9,000 feet (2,700 m), except where fuels were continuous across the park boundary onto other non-NPS lands. Within a few years, this fire program began showing measurable results, and park supervisors insisted that it proved that "resource managers could restore fire to its natural role in parks and wilderness…in a way that is acceptable to the public." Other parks soon followed suit, establishing similar programs. At nearly the same time, the Forest Service implemented similar programs focusing on wilderness resources in the Selway, Bitterroot, and Gila National Forests.

By the middle of the 1970s, the NPS promoted natural and prescribed fire as common practice. Most of the major national parks (including Yellowstone, Yosemite, Saguaro, Grand Teton, and Everglades national parks) had established similar programs. The NPS approved Yellowstone's first fire management plan in the spring of 1972, though it designated only two prescribed natural fire zones. A 1975 revision designated the entire park as a prescribed natural fire zone. Managed natural fire soon became an accepted practice throughout the NPS.

A firefighter monitors the Southwest Prescribed Fire at Devils Tower National Monument, WY, October 2007. Photo: Keith Mitchell, National Park Service.

Advances and Challenges

In 1975, the lightning caused Waterfall Canyon Fire in Grand Teton National Park produced smoke that spread across Jackson, WY, totally obscuring the surrounding mountain vistas. The thick smoke sparked a strong, antagonistic public outcry, with some people accusing the park of having a "scorched earth" policy toward fire. With each day that the conditions continued, whatever support that was once held for the policy of allowing natural fires to burn quickly diminished. In Wyoming and elsewhere across the country, large segments of the general public either didn't understand the scientific basis behind allowing such fires to burn or simply didn't trust the "natural fire" message. Nonetheless, resource managers continued to support the program.

Experience gained from these first naturally ignited fire "experiments" proved to be instrumental in changing fire policy within all Federal land management agencies. The term "fire control" was, appropriately, replaced by "fire management." The Forest Service, long committed to fire suppression, now accepted the value of fire and the philosophy of "fire management."

Discussions in the mid-1970s to late-1980s centered around appropriate planning requirements and national environmental policy compliance for managing "prescribed natural fire" in large wilderness areas. While this time period witnessed the successful implementation of many important, collaborative "natural fire" plans, progress was nearly derailed by two events: the 1978 Ouzel Fire in Rocky Mountain National Park and the 1988 fires in Yellowstone National Park.

The 1978 Ouzel Fire marked the first time a prescribed natural fire genuinely threatened a community. This escaped natural fire represented a significant public relations and program-support problem for the NPS. What's more, the Ouzel Fire led to the perception that people's homes were in jeopardy due to a Federal agency's irresponsibility.

In the wake of the 1989 national review, the "prescribed natural fire" programs at several national parks and a few national forest wilderness areas were reinstated. But, in many areas, fire managers were slow to promote the use of naturally ignited fire to benefit resources.

Although the fire started in a "low-risk zone" and was closely monitored and managed for more than a month, sudden high winds pushed it out of the zone and toward a town just outside the park's boundary. It was saved by a feature of topography: a small ridge deflected the driving winds upward, halting the fire front and sparing the town.

The fire was finally controlled at month's end, but it rekindled an old argument between national and local constituencies regarding fire management practices. A board of review investigating the fire concluded that the planning: (1) was not properly implemented, (2) did not adequately incorporate ecological information about Rocky Mountain National Park, and (3) did not place enough emphasis on external considerations, such as adjoining development.

The second major event came in 1988, when fires in Yellowstone burned across the landscape, prompting major media attention and policy debates. In the aftermath of the Yellowstone fires, the Secretaries of Agriculture and of the Interior assembled a special fire policy review team to evaluate the wilderness fire policies of both the NPS and the Forest Service. In its findings, this review team reaffirmed the fundamental importance of fire's natural role, but it also recommended that fire management plans be strengthened by establishing clear management decision criteria and accountability. This fire policy review team also deemed that interagency cooperation had to be improved.

Meanwhile, both Secretaries suspended all prescribed natural fire programs effective on June 1, 1989, and directed their agencies henceforth to suppress all natural fires in national parks and wilderness areas. Until all fire management plans conformed to the new Federal standards, these natural fire programs were not to be continued.

A New Start and New Challenges

In the wake of the 1989 national review, the "prescribed natural fire" programs at several national parks and a few national forest wilderness areas were reinstated. But, in many areas, fire managers were slow to promote the use of naturally ignited fire to benefit resources, particularly following the harrowing and traumatic fire year of 1994, when 34 wildland firefighters died in the line of duty. The National Fire Policy, revised in 1995, reiterated that the first priority of all Federal wildland fire programs is firefighter and public safety, but also stated that wildland fire was an essential ecological process and an agent of natural change that had to be considered in planning. Under the mandate of this new policy, the Federal system focused on a fire's effects rather than the origin of a fire as the basis for decisionmaking. By the end of the 1990s, the new Federal wildland fire policy had

As stewards of park lands, NPS fire managers balance diverse, complex, and sometimes opposing objectives to allow fire to play its natural role whenever and wherever possible.

successfully reinvigorated "wildland fire use" programs. Managers received the support that they needed to enable their naturally ignited fire programs to develop and mature. Finally, Federal land management agencies developed a systematic national approach to wildland fire response focused on firefighter and public safety and land restoration based on the best available science and designed to span agency boundaries. As this country entered the new century, science-based response to naturally ignited fire had an integral place in resource management.

But, once again, a dark cloud was fast approaching to show that there was still more than science alone to be considered. By the year 2000, a series of drought years across the West contributed to a critical change in regional fire patterns. In early May of 2000, a prescribed burn in New Mexico's Bandelier National Monument escaped control lines. The subsequent Cerro Grande Fire burned more than 48,000 acres (19,400 ha), and the fire front swept down into the town of Los Alamos, NM, where it destroyed 255 homes. The public and political outcry was immediate and loud.

An interpretive park ranger discusses the Comb Fire with campers in Cedar Grove, Sequoia, and Kings Canyon National Parks, CA, August 2005. Photo: Sheila Lindquist, National Park Service.

In 2001, the Secretaries of Agriculture and of the Interior gathered the interagency Federal wildland fire policy working group to review the implementation of the policy. This group also examined specific issues raised by the Cerro Grande Fire investigation teams and recommended several changes to the 1995 wildland fire policy, primarily to clarify its purpose and intent, as well as to address issues not fully covered in the guidance. Recommendations focused on five key themes in fire management to improve strategic direction and activities: (1) ecosystem sustainability, (2) fire planning, (3) fire operations, (4) interagency coordination, and (5) program management and oversight. The result was the adoption of the *Interagency Standards for Fire and Fire Aviation Operations*—which brought all Federal wildland fire management agencies' policies into a single document—and revision of the *Wildland Fire Use Implementation Procedures Reference Guide*—which outlined standardized procedures for planning and implementation of naturally ignited fire response.

Policy development continued in the following years. In 2003, an interagency group developed a strategy for Federal wildland fire management policy addressing the safety of firefighters and the sequencing of fire use events. The group addressed operational differences among the Federal wildland fire management agencies in seven operational clarifications and provided guidance for consistent implementation of Federal fire policy.

Because of differences between individual agencies' procedures, the operational clarifications created some confusion among firefighters deployed on fires, so another task group was convened to review these additions and recommend new guidance for implementing Federal wildland fire policy. The guidance, released in March 2009, not only affirms existing policy, but also allows fire staffs to adjust management of fires to fit conditions of weather, fuels, and affected values; the current social and political climate; and land and resource management objectives. In one example, it is now acceptable to suppress or slow fire spread along one portion of a fire's perimeter due to potential negative effects while simultaneously managing and monitoring fire activity on another portion of its perimeter to achieve positive resource effects.

NPS Fire Management Today

"Fire is fire" is a familiar catchphrase in the fire management community, recognizing that fire is both a tool and a process that shapes the landscape. Today, NPS managers use the goals and objectives established in their fire management plans to plan prescribed fires and respond to unplanned fire, while maintaining human safety as the number one priority at all levels of decisionmaking. As stewards of park lands, NPS fire managers balance diverse, complex, and sometimes opposing objectives to allow fire to play its natural role whenever and wherever possible. ■

Wildland Fire Decision Support System Air Quality Tools

A new air quality portal provides wildland fire decisionmakers with access to a variety of real-time and forecast air quality information.

Sim Larkin, Tim Brown, Pete Lahm, and Tom Zimmerman

Smoke and air quality information have an important role in wildland fire decisionmaking that is reinforced in the 2009 "Guidance for Implementation of Federal Wildland Fire Management Policy." A key intent of the guidance is to allow consideration and use of the full range of strategic and tactical options that are available in the response to every wildland fire. This guidance directs that wildland fire responses will be developed through evaluations of situational assessment and analysis of hazards and risk. It also defines implementation actions and directs documentation of decisions and rationale. Smoke and air quality are now among the top issues in decisionmaking, both on wildfires (unplanned ignitions) and prescribed fires (planned ignitions).

The Wildland Fire Decision Support System (WFDSS) is a new Web-based system designed to integrate science and technology in support of risk-informed decisionmaking for wildland fires. This system currently incorporates access and use of numerous datasets and models, including weather analyses, fire behavior prediction tools, economic assessment tools, and landscape data acquisition and analysis processes, to provide users with critical information when making decisions on wildland fires. WFDSS replaces three past wildland fire decision analysis and documentation systems as a single system applicable for all wildland fires. Developed over the past 4 years, this system was delivered for use in 2009, but Federal agencies have chosen to implement it on an agency-specific and sometimes phased-in approach. Since April 2009, use of WFDSS has resulted in documentation and analysis for more than 7,500 wildfires by the five Federal wildland fire management agencies and by 17 States and Alaska Native corporations in partnership with Federal agencies. This fire season, all five Federal wildland fire agencies are implementing WFDSS to a much greater degree and some require WFDSS on all wildland fires.

WFDSS replaces three past wildland fire decision analysis and documentation systems as a single system applicable for all wildland fires.

Air quality is a human health and safety factor related to all fire, and air quality tools are needed as part of the decision analysis and documentation process to support management decisions on unplanned as well as planned ignitions. In response to recent medical findings, the U.S. Environmental Protection Agency (EPA) has strengthened virtually all air quality standards. The increase in wildfire activity and emissions along with the need to increase the use of prescribed fire present a substantial challenge in meeting those standards. This challenge further supports the need and use of air quality tools, particularly on long-duration wildfires, which are well-suited for air quality analyses to address public and air regulatory concerns regarding smoke impacts. Geographic information system (GIS) layers like the EPA National Ambient Air Quality Standard (NAAQS) nonattainment areas are being incorporated into WFDSS along with the creation of a new WFDSS Air Quality component (WFDSS-AQ) to assist in those analyses.

WFDSS-AQ

The goal of WFDSS-AQ is to advance decisionmaking through the acquisition, analysis, and con-

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sideration of air quality information. Decisionmakers linked to the larger collection of available air quality tools can markedly improve situational analyses and outcomes.

Currently, WFDSS-AQ is a standalone Web portal where users can access specific air quality tools as needed to gain a variety of information. Version 1.0 is now available in beta version as an experimental design that can be accessed directly through the Web (<http://firesmoke.us/wfdss>) or through a link from WFDSS. The WFDSS-AQ will be evaluated based on user feedback throughout the 2010 western wildfire season. User comments are encouraged and can be submitted via a feedback form at the bottom of the portal window.

Eight air quality tools are available through the WFDSS-AQ portal covering the contiguous United States. Future iterations will include additional tools as well as regional components and increased data integration with WFDSS.

Users can filter the eight air quality tools available on WFDSS-AQ using the following attributes to meet their specific needs:

- TEXT-BASED: the information returned from the tool is provided as text;
- GRAPHICAL: the information returned from the tool is provided graphically, generally as a map or time series;
- ATMOSPHERIC CONDITIONS: the tool provides information about the state of the atmosphere (weather, climate) that can be used to infer air quality conditions or potential dispersion of smoke;
- SMOKE: the tool provides information on smoke concentrations directly (forecasted or observed);
- INSTANT ACCESS: information is returned from the tool immediately, generally with "one-click" access from the portal;
- EASY TO USE: a subjective assessment of the air quality tool's user interface—those marked as such have little or no learning curve required to access data;
- LOCALIZED: the tool utilizes the fire location from WFDSS to provide information local to the fire;
- REGIONAL: the tool utilizes the fire location from WFDSS to provide information from a regional area around the fire; and
- INTERACTIVE: the tool's interface allows the user to manipulate parameters, input data, and rerun the underlying model, thereby allowing the user to interact with the tool's model and customize results.

Additionally, a second set of attributes is assigned based on the time period of the information presented by the tool:

- USES CLIMATOLOGICAL DATA: for tools that utilize and provide historical information;
- CURRENT CONDITIONS: for tools that provide the real-time (or near-real-time) conditions;
- 7 DAY+ FORECAST: for tools that provide forecasts extending into the future 7+ days;
- 3 DAY+ FORECAST: as above, but for forecasts extending 3+ days (note that all tools meeting 7 DAY+ FORECASTS will also be listed in this attribute); and
- 1 DAY+ FORECAST: as above, but for forecasts extending 1+ days (note that all tools meeting 3 DAY+ FORECASTS will also be listed in this attribute).

Each tool is listed on the page with a number of attributes that can help the user filter down to those tools that meet his or her specific needs (see sidebar).

Included AQ Tools

Smoke Guidance Point Forecast and Smoke Guidance Regional Maps

Many different pieces of information available from weather and smoke forecast models are relevant to air quality. These include simple measures such as mixing height and transport winds as well as derived quantities such as the Haines index, all of which are important for understanding a fire's potential smoke impact. These tools, from the National Fire Consortia for the Advanced Modeling of Meteorology and Smoke (FCAMMS) and hosted at the Desert Research Institute (DRI), provide a single point of access to a variety of these elements. This can inform decisionmakers about fire and smoke activity that may influence their respective area. Fine particulate matter ($PM_{2.5}$) smoke concentration values are also available through forecasts enabled by the BlueSky Smoke Modeling Framework using SMARTFIRE fire information (reflecting primarily wildfires). The Point Forecast tool produces a text summary listing of smoke dispersion parameters for the location of the fire (fig. 1a), while the Regional Maps can be viewed at either regional or national (CONUS) scale (fig. 1b). Both tools utilize National Weather Service model forecast guidance available at 7.5-mile (12-km) resolution out to 3 days and 25-mile (40-km) resolution out to 7 days.

Diurnal Surface Wind Pattern Analysis

Wind speed and direction can be critical factors affecting air quality impacts. This tool, provided by DRI's Western Regional Climate Center, provides climatological wind roses from the collected network of remote automated weather stations (RAWS) for the site nearest a fire. The wind roses are divided into day and night, utilizing the full period of the RAWS data record to develop the climatology (fig. 1c). The bars on the wind rose represent the percentage of time from that direction, and the color indicates the percentage of time that particular range of speed occurs.

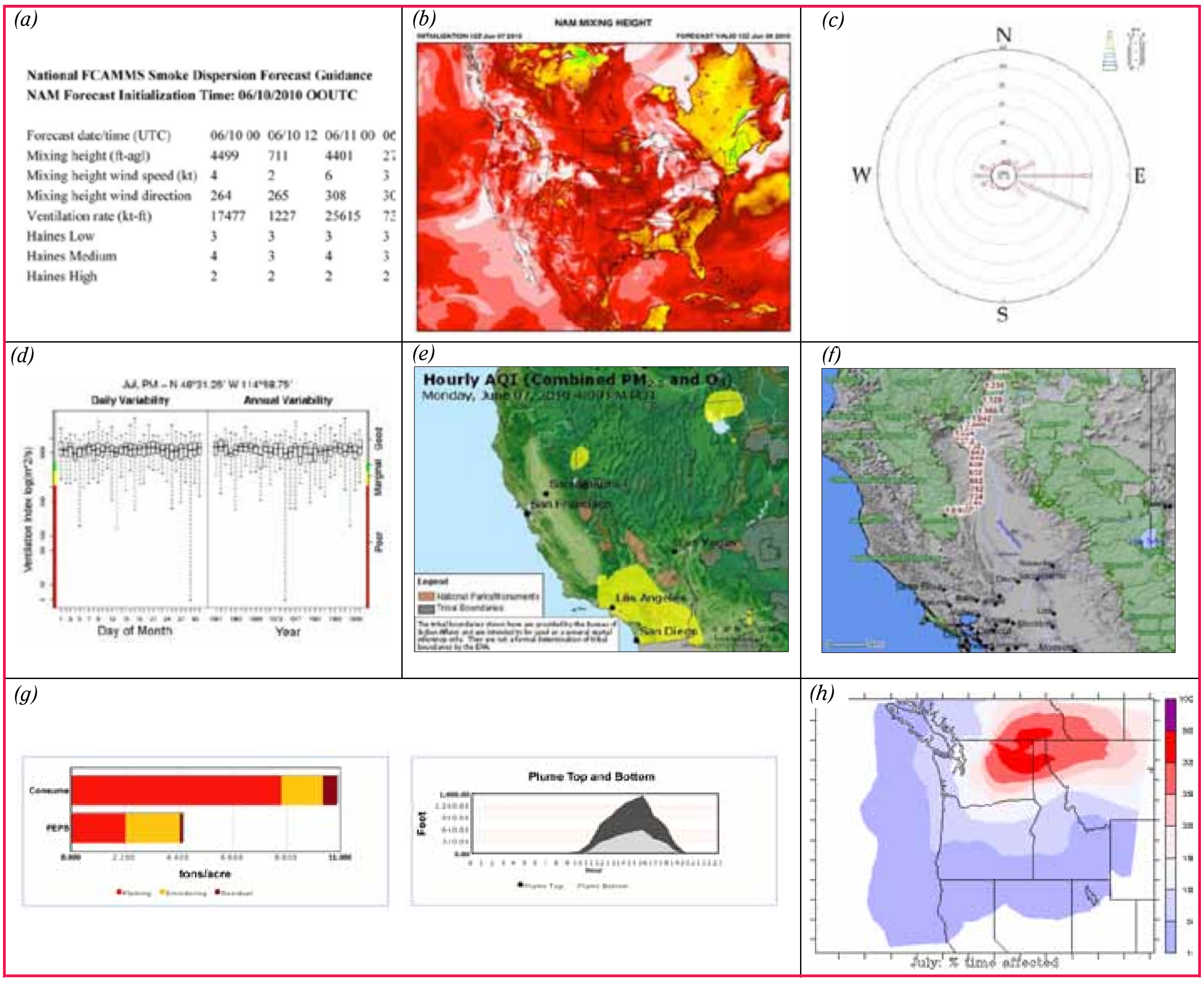

Figure 1—*Examples of air quality information accessible through the WFDSS-AQ portal: (a) point forecast text table of weather and smoke information; (b) national map of mixing height [from National FCAMMS]; (c) daytime wind rose [from RAWS station data]; (d) climatology summary of ventilation index values [from VCIS]; (e) current conditions map of hourly AQI [from AIRNow]; (f) custom trajectories from fire locations [from SMARTFIRE Viewer]; (g) custom fuels, plume, and dispersion modeling [from BlueSky Playground]; (h) custom probabilistic impact maps based on climatological weather [from AQUIPT]. Additional types of output are also available.*

How To Use the WFDSS-AQ Site

Access the WFDSS-AQ portal site from WFDSS or by going directly to <http://firesmoke.us/wfdss>. In WFDSS, select *Fire Related Links* under the Information Tab, then select *Weather Related Links* and *Air Quality* and follow the steps below.

Step 1: Check your location of interest
Upon arriving on the Web site, check (or enter, if not accessing through WFDSS) the location of interest (usually the location of the active fire) using a Google Maps interface or by entering the latitude and longitude.

Step 2: Select your tool(s)
After the fire location information is set, scan down the list of tools. This list can be filtered to meet the user's requirements by selecting the pertinent attributes. Each tool is briefly described through a listing that shows: the name of the tool; a tag line describing what the tool provides; the organization that created and runs the tool; a minigraphic of sample output; a bulleted listing of the models, data, and other highlights of the tool; and a list of attributes assigned to the tool (see image below). The WFDSS-AQ help section on the side or at the bottom of the screen describes in further detail some potential uses for the tool's information output, caveats on the limitations and assumptions of the tool, and how to navigate the tool's Web site. At the bottom of the listing is a button that takes the user to the tool's site and attempts to drill down, set common controls, and—whenever possible—present the user with useful information via a single click.

The WFDSS-AQ portal (http://firesmoke.us/wfdss). The site can be accessed from within WFDSS, or as a stand-alone portal for other purposes, such as training.

Climatological Ventilation Index Point Statistics

Ventilation index, the product of mixing height and surface transport wind speed, is useful for understanding the ability of the atmosphere to remove smoke from the local area—the higher the ventilation index, the greater the rate that smoke is cleared from the local area. This tool provides a 40-year climatology of mixing height, surface transport wind, and ventilation index via the Ventilation Climate Information System (VCIS) developed by the Forest Service AirFire Team. It shows typical conditions at the location (based on modeled winds and interpolated mixing height fields), which can serve as a guide for planning purposes or to discern how unusual current conditions are. The information is depicted at a 3.1-mile (5-km) resolution across CONUS, and several different graphical summaries of point location are available for each calendar month (e.g., fig. 1d).

Current Air Quality Conditions Map

A number of regional air quality monitoring networks exist that monitor conditions related to the NAAQS standards, such as $PM_{2.5}$ or ozone concentrations. Air quality data from most Federal, State, and local government monitors are collected via the EPA's AirNow program. The data from these sites are presented via maps showing the air quality index (AQI) equivalent values (fig. 1e). An AQI of green ("good") or yellow ("moderate") is below the NAAQS level, while orange or above represents the potential for health impacts for various groups. WFDSS-AQ currently accesses information available to the public, but work is underway to enable WFDSS users to access all the monitoring data and technical tools in EPA's AirNow program. Both national and regional maps are available.

Fire-Specific Smoke Trajectories

Smoke trajectories can provide a quick way to examine the likely geographic extent of plume impact. This tool, provided by the SMARTFIRE Viewer created by the Forest Service AirFire Team and Sonoma Technology, Inc. (STI), allows the user to create trajectories on a while-you-wait basis, with response times of just a few seconds. Although they lack the spread of a full-plume model, these trajectories, coupled with the tool's ability to quickly create many different trajectories from nearby starting locations, can provide the user with a quick look at a fire's likely smoke transport. The tool is provided via a Web-based customizable GIS viewing system that allows the user to see fire location information from ground reports, satellite detects, and sensitive receptor locations (fig. 1f). The trajectories are run using the National Weather Service's meteorological model guidance forecast and the HYSPLIT model. The viewer provides multiple zoom levels and background layers for viewing purposes.

Customized Fuels, Consumption, and Smoke Modeling

One of the most complex tools available through WFDSS-AQ, the BlueSky Playground by the Forest Service AirFire Team and STI, features a relatively simple interface (fig. 1g) that allows the user to walk through a series of steps: from fire activity information through fuel loading, fire consumption, fire emissions, and plume rise, all the way to surface smoke concentrations. At each step, the user can choose from a variety of embedded models (e.g., CONSUME 3 and FEPS for consumption), and directly edit the model inputs. All modeling is done while-you-wait, with response times generally under 1 minute. The user can go back, edit previous choices, and experiment with different models or model options, thereby gaining insight into model variability.

Probabilistic Smoke Impacts Based on Past Weather

The most complicated modeling system available through WFDSS-AQ, this tool (based on the Air Quality Impacts Planning Tool [AQUIPT] by the Forest Service AirFire Team) is meant for advanced modelers with an understanding of statistics. The objective is to use historical weather information to build a probabilistic forecast of a planned fire or unplanned fire of long duration.

Such a forecast is most useful when the period of interest is multiple weeks to months into the future, when weather forecast models cannot predict the weather directly. Utilizing a 30-year climatology, the tool runs multiple scenarios of the planned fire for the period of interest. This period can be set by date conditions (e.g., the month of June or the last week in September) or identified based on standard meteorological burn parameters (e.g., ranges of wind speed, temperature, and relative humidity). The output is a statistical representation of the smoke impacts modeled from the fire during past periods that meet the specified conditions. In this way, the tool provides information on what the probabilistic impacts of a fire occurring during the specified period would have been and can serve as a guide for what may occur in the future. Maps of average impact, maximum impact, and percent time above a threshold impact level (e.g., the NAAQS standard for $PM_{2.5}$) are provided (e.g., fig. 1h).

Future Development

The WFDSS-AQ portal is designed to better incorporate air quality tools into a larger decision support framework. It will continue to undergo evaluation and evolution based on user feedback and emerging requirements. More and better tools will be required in order to fully address air quality, especially given changing regulations such as the new lower standards for ozone under the NAAQS. Improved user interfaces, more tailored graphics, and a closer integration with WFDSS will be necessary to enable users to access and utilize air quality information without undue burden. WFDSS-AQ is just the first step in this process, and we invite everyone to test out the WFDSS-AQ site and provide feedback.

Acknowledgments

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Coarse Estimation of Local Fire Return Intervals for Fire Management

Matthew Tuten

Fire Return Intervals and Fire Management

The fire return interval is an often-cited indicator of historical fire regime conditions. The interval is often expressed as the mean number of years between two fires recorded in the tree ring record within a specific site or given area. Several detailed accounts of this indicator and others (Weibull median probability interval, natural fire rotation, and fire extent) are used in fire ecology literature to describe fire regimes in many ecosystem types (Agee 1993). Unfortunately, detailed fire history studies are time consuming and expensive by nature: they require trained personnel for the collection of fire-scarred tree cross-sections, preparation of cross-sections within a woodshop, and the application of dendrochronological methods for analysis. For these reasons, local estimates of this important fire regime parameter are typically unavailable at the project level for fire management purposes.

Fire managers must make use of forest inventory data and the available published information regarding fire regime parameters of the ecosystem types they manage in the development of local fire management plans. Study areas and fire regimes described in the literature may be similar to or substantially different from those requiring management attention. But in most situations, even a coarse level of site-specific understanding of historical fire regime conditions would be preferable to management action based upon distant, and likely different, ecosystems.

Distributions of fire return intervals developed from fire-scarred tree cross-sections can be used where detailed fire history studies are a budgetary or logistical impossibility.

Assessing the Local Fire Return Interval

To gain a rapid, coarse-level understanding of the fire return interval at the project scale (50–1000 acres; 20–400 ha), distributions of fire return intervals developed from fire-scarred tree cross-sections can be used where detailed fire history studies are a budgetary or logistical impossibility. The development of fire interval distributions is still somewhat time-consuming by managers but can be completed in a fraction of the time required for detailed fire regime assessments.

The steps required are as follows:

1. *Define the study area.* The area should be comprised of an area a) that is relatively homogenous in forest structure (species composition, age, fire history) and abiotic conditions (aspect, slope, soils, etc.) and b) where significant questions regarding historical fire regime conditions exist. Examples of these areas might include areas containing documented threatened or endangered species populations, high-visibility or high-use areas, or areas with localized unique ecological characteristics (e.g., exposed rock layers, isolated habitats, or rare species assemblages).
2. *Devote a predetermined amount of time for the field collection of fire-scarred tree cross-sections.* This will require personnel trained in the use of chainsaws and data collection materials and procedures. Within the defined area, collect a set number of fire-scarred sections from which data can be extracted. It makes no sense to collect a large number of samples or extremely decomposed samples if time is not available to devote to preparing and analyzing these specimens. Special effort should be made to disperse sampling throughout the project area. (If a portion of the site is completely devoid of fire evidence, this should be considered and addressed in the final analysis.)

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3. *Mount sections to plywood backing, label specimens, and cut and finish (sand) the specimen surfaces for analysis.*
4. *For each cross-section, count the number of tree rings between the fire-scarred rings and document and present descriptive statistics summarizing this information for each sample.*
5. *Create distributions of all intervals and determine point mean fire interval (PMFI) statistics.* These can be calculated and recorded in an electronic spreadsheet.

Results of Two Studies

The following are two examples of the application of this method. For each study, significant questions relating to local historical fire regimes existed and a limited amount of time was available for data collection and analysis. The first study site is located in the Bradshaw Mountains in Arizona at an elevation of 6,800 to 7,400 feet (2,070 to 2,260 m). The second study site is located on the north slope of the San Juan Mountains in central Colorado at an elevation of 9,100 to 9,500 feet (2,280 to 2,900 m). Both sites appear to have been historically dominated by ponderosa pine (*Pinus ponderosa*), as evidenced by an abundance of pine stumps, but in the last century appear to have been succeeded by dense growth of more mesic species such as white fir and Douglas-fir.

For each project, four to six trained personnel collected field data over 1 to 2 days. The preparation of specimens using a table saw and power sander took 2 and 1 days, respectively, to complete. Laboratory analysis of the prepared specimens required only a microscope and the ability to count rings and distinguish fire scars. For all sections, only the number of years between fires was recorded; no dates were associated with fire events. The entire process for each site, including data analysis, was completed along with other project work in less than 3 months.

Pooled distributions of all fire intervals measured at each site are shown in figures 1 and 2. For each scarred section, a PFMI was determined from all scars on that specimen. The mean, standard deviation, and range of all PMFIs determined for each site are shown in table 1.

While these methods of data analysis and description were intentionally less rigorous than those typically employed in published fire history studies, the differences between the results for the two sites are nonetheless striking. The pooled fire interval distributions and the PMFI statistics appear to describe two very different historical fire regimes. For the Arizona site, the pooled fire interval distribution is skewed dramatically to the lower interval classes. Additionally, the mean PMFI was very short (6 years), and little variability in fire interval length (std. dev. = 2.4 years) was observed in the 28 cross-sections collected within the study area. At this site, the argument for a frequent-fire

	Tree cross-sections(n)	Mean PMFI	Standard Deviation	Range of Per-Tree Fire Interval Means
Central AZ	28	6.0	2.4	1-13.5
Central CO	17	50.0	29.1	14-100

Point mean fire interval (PMFI) statistics for central Arizona and Colorado study sites.

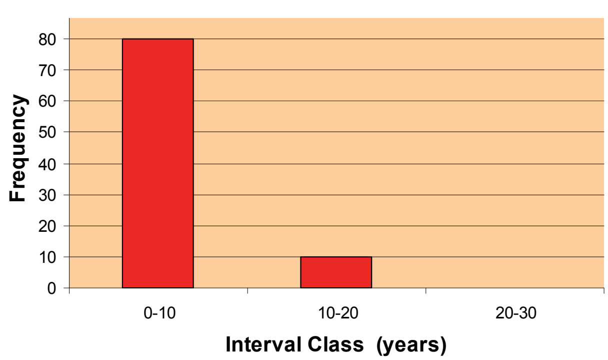

Figure 1—*Fire regime distribution, central Arizona. In 28 collected sections, there were 90 measured fire return intervals. The most common interval class (80 of 90 measurements) was in the 0-10 year interval. As a result, the central Arizona fire regime is considered a "frequent fire regime" (0- to 35-year fire return interval).*

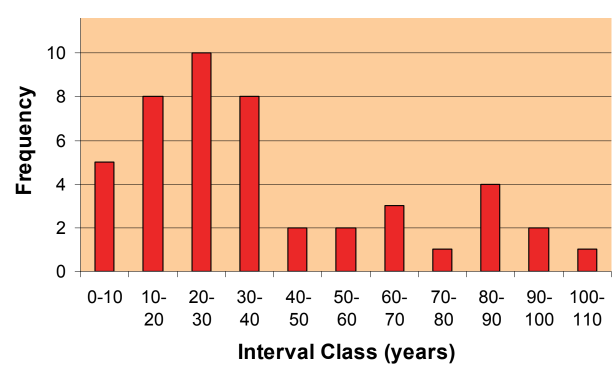

Figure 2—*Fire interval distribution, central Colorado. Forty-six intervals were measured in 17 collected sections. There was a broad distribution of intervals, though most were grouped in the more frequent interval classes. As a result, the central Colorado fire regime is considered a "frequent to moderate frequency" fire regime (0- to 100-year fire return interval).*

While these methods of data analysis and description were intentionally less rigorous than those typically employed in published fire history studies, the differences between the results for the two sites are nonetheless striking.

regime (<35 years between fires), based upon the interagency fire regime condition class (FRCC) definition (Hann et al. 2004), is very strong, if not overwhelming.

For the Colorado site, the data paints a different picture. At this site, a much smaller proportion of measured intervals were shorter than 10 years; most fell within the 20- to 40-year range. Many moderate length fire return intervals (40–110 years) were also observed in this distribution. The mean PMFI from the 17 cross-sections collected at this site was much higher and more variable, indicating a mix of different observed fire interval lengths across the study area.

Study Limitations

The results of these small-scale studies are not entirely free of ambiguity. It was assumed that the fires observed on each cross-section occurred prior to Euro-American settlement during a period of intact historical fire regimes, as no post-settlement records of fires within either area exist. It is possible that this assumption does not reflect reality: the absence of records does not prove the absence of fires, and fire regimes potentially initiated by previous cultures are not considered. Additionally, fire intervals from different time periods are combined when data from individual cross-sections are pooled together: this could have serious implications as interval data from particularly wet or dry time periods could dominate the pooled distribution. Finally, because no dendrochronological cross-dating methods were employed, it is possible that intervals may be slightly larger or smaller to the degree that overlooked or misinterpreted rings were present within the tree ring record for each scarred cross-section.

Interpretation

Even with these shortcomings, fire interval data produced from cross-sections can be used managerially. At the Arizona site, it is clear from the findings of this study that fire frequency in historical times (prior to the 1870s) is markedly different from fire incident over the last century. The time period since the last historical fire is over eight times the longest fire interval measured (18 years) from 28 cross-sections. This data fits well with published fire history studies from similar surrounding areas (Dieterich and Hibbert 1990).

At the Colorado site, the situation is less clear. A mix of long and short intervals was observed from the fire-scarred cross-sections. When compared to the interval distribution from the Arizona site, the pooled fire interval distribution exhibits little evidence of a frequent-fire regime (<35 years) (Hann et al. 2004). A large range and high variability of mean PMFI was observed among cross-sections at this site (table 1). These results, coupled with accounts from other published studies in similar Colorado forests (Kaufman and others 2006, Veblen 2003), seem to signify that a mix of short- to moderate-length fire return intervals was common at this site in historical times.

Conclusion

It is well known that the long-term management of fire frequency in ponderosa pine forests may have extremely broad ecological implications for ecosystem structure and function. It is also one of only a few fire regime parameters that can be easily controlled and documented through fire management. The methods employed in these two studies yield practical information related to this single, but very important aspect of historical fire regimes.

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A Foundation for Initial Attack Simulation: The Fried and Fried Fire Containment Model

Jeremy S. Fried and Burton D. Fried

Why Simulate Initial Attack?

Fire protection planners have long sought analytic approaches for evaluating the effectiveness and efficiency of fire protection organizations. A reasonably faithful representation of initial attack is a key requirement for almost any analysis in exploring alternative configurations of initial attack.

Early Efforts

Simplistic simulations of initial attack date to the 1970s: for example, in the Forest Service National Fire Management Analysis System's Initial Action Assessment (NFMAS-IAA) model and the U.S. Department of the Interior's Airpro model. In the NFMAS-IAA model, which sought to identify the configuration of initial attack resources that would minimize firefighting costs and the net change in resource values resulting from fires, the fire containment process was represented in caricature—in other words, as a highly simplified version of the real world. The model tracked two numbers separately as the simulation of initial attack progressed: 1) the perimeter of a growing, 2:1 length-to-width ratio ellipse representing a freely burning, uncontained fire and 2) the length of fireline that could be constructed as modeled firefighting resources "arrived" at the fire. If the two values, perimeter length and constructed fireline length, converged, the fire was declared contained. If this did not occur within a specified time or before the fire had grown to a specific size, an escape event was declared. Although computationally simple, this convention (or algorithm) produced overestimates of fire size—sometimes by a factor of 10 or more—because no "credit" was given for the effects of line-building efforts by early-arriving resources in slowing in the growth of the fire.

> The fire's rate of spread at the front of the line-building effort will be continually increasing as the unit moves closer to the head of the fire, where fire spread rate is maximum.

Scaling Up, Enhancing Realism

Capturing the essence of fire management in a simulation context typically requires simulating initial attack for thousands of simulated fires in any given scenario due to the considerable local, spatial, and temporal, real-world variability in fire occurrence, fire behavior, firefighting capacity, and firefighting challenge (as manifest in fireline productivity). Modelers often simulate containment of fire events from multiple fire seasons (either by running event data from actual fire seasons or from "synthetic" seasons simulated so as to be consistent with the distributions of fire occurrence, behavior, etc. from actual fire seasons). While one could attempt to simulate the growth and containment of each wildfire in a spatially explicit modeling environment such as FARSITE, this approach is time-intensive, and it is not clear if there are advantages to using this technique over modeling a broad range of fire behaviors with response times and fireline productivities based on representative geographic information system data. Instead, contemporary initial attack models, such as the California Fire Economics Simulator (CFES) version 2 and the Interagency Fire Program Analysis' Initial Response Simulator (FPA-IRS), simulate containment on thousands of such quasi-spatially represented fires. Both of these models rely on the Fried and Fried containment algorithm (Fried and Fried 1996), which models the effect of suppression efforts on fire growth, allows simulation of any mathematically representable fire shape, provides for "head" and "tail" attack tactics as well as parallel attack (building fireline parallel to but at some offset distance from the free-burning fire perimeter, alone and in combi-

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nation with "firing out"), and supports dynamic (variable) forward rates of spread and fireline productivity over the course of initial attack (fig. 1).

How It Works

The following scenario illustrates how the simulation works:
A single firefighting unit arrives at the scene of a fire. The fire spreads at a constant forward rate of spread, calculated from slope, fuels, and weather data for the location (extracted from enterprise data). The unit anchors at the tail (heel) and begins line construction. The unit works its way around the fire perimeter (fig. 2). If the line holds and the unit is catching the fire, there will be a net decrease in overall fire spread. No further spread will occur where the perimeter is contained, but the fire's rate of spread at the front of the linebuilding effort will be continually increasing as the unit moves closer to the head of the fire, where fire spread rate is maximum.

Note that, in a head attack, the opposite is true: even if fireline production is declining—for example, due to engines running out of water or crews becoming exhausted—there will still be a chance of containing the fire as linebuilding efforts approach the tail.

The algorithm represents one flank of the contained fire perimeter as a differential equation in which location of the constructed containment line is a function of the ratio of fireline productivity to forward rate of spread. For simplicity and computational tractability, the second flank is assumed to be a mirror image of the first flank.

If, in the above example, the unit is unable to make net progress toward the head of the fire, for example, because the aggregate linebuilding rate is dwarfed by the rate of perimeter expansion, linebuilding resources become inadequate for the task, engines run out of water, or hand crews become exhausted, the fire would "outrun" the suppression resources and exceed simulation limits.

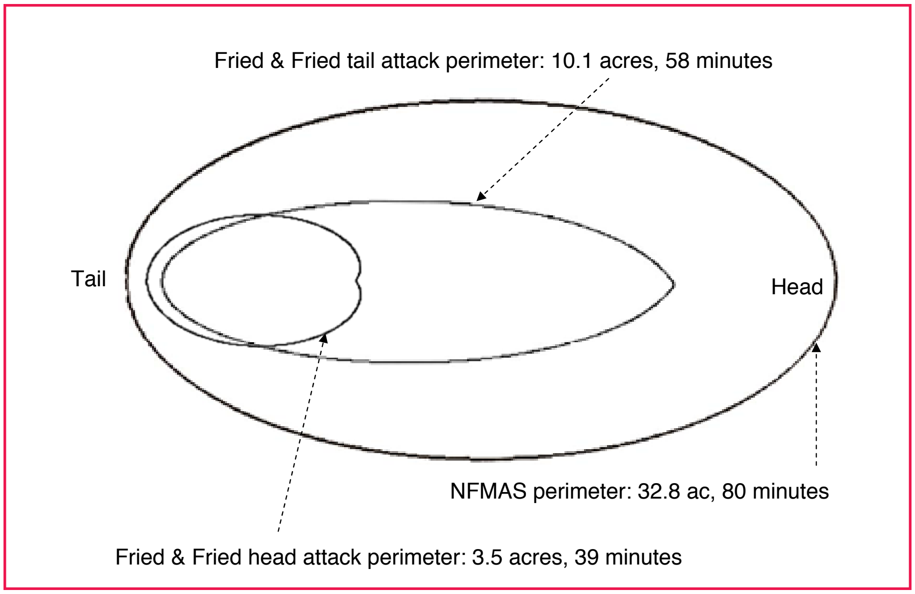


Figure 1—*Final simulated perimeters, sizes, and containment times of a fire that is 0.01 acres at report time, has a forward rate of spread of 20 chains/hour, is assumed to have a 2:1 length-to-width ratio elliptical shape when free-burning (not suppressed), and is attacked on two flanks 20 minutes after reporting by two resources, each producing fireline at 35 chains per hour, using the NFMAS algorithm and the Fried and Fried algorithm with tail and head attack options.*

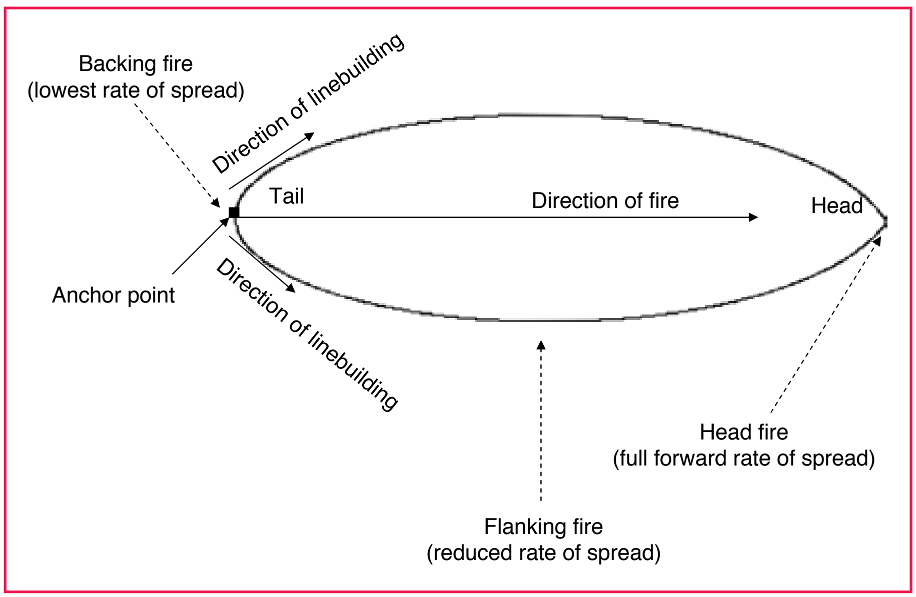
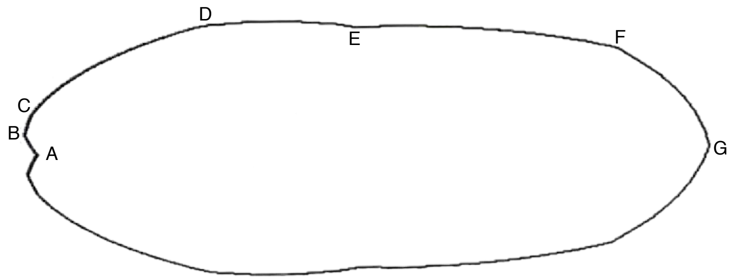


Figure 2—*Schematic representation of a tail attack on an elliptical fire that would have a 2:1 length to width ratio if free-burning. Rate of spread at the point of linebuilding increases steadily as firefighters get closer to the head.*



Label Point	Arriving resource	Arrival Time minutes	Change in Production Rate chains per hour
A	Small crew	5	+2
B	Small engine	25	+6
C	Large crew	30	+25
D	Air tanker	40	+240
E	Air tanker	41	-240
F	Bulldozer	55	+45
G	#N/A	62	Fire contained

Figure 3—Perimeter of a fire attacked from the tail by five resources. Note that 1) as production rate changes with the arrival of resources, forward progress in containing the fire adjusts accordingly, 2) the air tanker drop is modeled as a one minute long burst of high productivity between points D and E, 3) production rates are halved by the model to fulfill the assumption of symmetry between the two fire flanks, and 4) the final fire shape is more elongated than the assumed 2:1 free-burning elliptical shape because attack was from the tail. (Successful head attacks result in less elongated fire shapes.)

Inputs to the Algorithm

For each fire to be modeled, the Fried and Fried algorithm requires the following inputs: (1) reporting time, (2) fire size at reporting time, (3) forward rate of spread, (4) length-to-width ratio of the ellipse, (5) type of attack (head, tail, or parallel), (6) offset distance (if parallel), and (7) simulation size and time limits. In addition, for each ground-based line-building resource dispatched to the fire (for example, fire engines, bulldozers, or hand crews), the algorithm requires the following inputs: (1) time of arrival; (2) initial productivity (in chains per hour); (3) time at which productivity drops from an initial, high rate to a lower, more sustainable rate; and (4) the associated sustainable production rate. Air tanker and helicopter drops of water and retardant are represented somewhat differently. The length of containment line corresponding to a drop is a required input, but the algorithm translates this distance to a rate of line production that will continue for 1 minute, resulting in the specified length of containment line. Thus, a drop that produced 10 chains (200 m) of fire line would be represented by the algorithm as 600 chains (12,070 m) per hour for 1 minute (600 chains per hour x 1 hour/60 minutes = 10 chains per minute). Such drops can generate rapid linebuilding progress that is quite noticeable on a plot of the fire perimeter (fig. 3).

Will the Fire Be Contained?

The algorithm outputs whether or not the fire could be contained with the available resources and, if so, the containment time and final size of the fire in perimeter and area. Using all of the input data provided, the Fried and Fried algorithm represents the one-flank containment boundary as a differential equation and then attempts to solve it using numerical integration. Solution of the equation is successful if the resources are sufficient to contain the fire and fails if the resources are not.

The differential equation can fail mathematically if the linebuilding rate is less than the spread rate of the fire and firefighters would be overcome by the fire unless they abandon the attack. In this situation, the algorithm attempts to "re-run" the simulation, delaying the initiation of attack until the arrival of the next firefighting resource or until the simulation time limit is exceeded. If re-runs are unsuccessful in achieving containment, the fire is labeled "outrun" and classified as having exceeded simulation limits.

If the solution of the differential equation does not fail mathematically, then the simulated fire may be contained. Because the one-flank containment line is fully represented in the model following solution of a differential equation, it is computationally straightforward to calculate the area "under" that flank using numerical approximations and then double the result to get the full area of the contained fire. If this area exceeds the simulation size limit or the containment time exceeds the simulation time limit, the fire is classified as exceeding simulation limits; otherwise, it is classified as contained.

What We Can Learn

We can learn much in analyzing the parameters of fires that exceed simulation limits. Some fires could have been contained by initial attack resources but not within the specified size or time limits. These limits are typically set at the point at which a fire would transition from an initial attack fire to an extended attack fire or when the shape for a free-burning fire changes from a shape easily represented by an algebraic function, such as an ellipse, to a more complex, irregular shape in response to geographical or environmental conditions (for example, when the fire has become large enough to extend fingers up adjacent canyons or when wind direction has changed significantly since fire ignition). For other fires, there is little hope of ever achieving containment with initial attack because the production rates of firefighting resources are no match for a rapid forward rate of spread.

Some fires fall in a middle ground, in which containment is possible but risky. On such fires, containment involving airdrops would be possible except that a retardant or water drop could push the containment efforts on the ground toward the head of the fire, where the local spread rate is closer to the full forward rate of spread; working where the spread rate is high may overwhelm ground-based firefighting resources, triggering a provisional "exceeds simulation limits" classification. In other instances, a drop-off in the fireline production rate of ground forces can trigger an outrun condition and represent a provisional "exceeds simulation limits" status. In still others, an upward, diurnal adjustment to the forward rate of spread as a fire burns from morning into afternoon may trigger the "outrun" condition. In all three scenarios, the fire can be rerun by the algorithm with a delayed initiation of containment effort, but only a subset of such fires will ultimately be classified as "contained."

We can learn something about the efficacy of our dispatch rules from patterns in modeled fires that exceed simulation limits, identify areas where availability of resources is an issue, and provide guidance on prioritizing areas for fuels management. Because the resource arrival times are known from the inputs and the containment time is known from the outputs, it is also possible to use models built on this algorithm to examine resource utilization—the specific resources assigned to fight the fire—both for specific fires and for all fires in a fire season. If costs are assigned to modeled resource utilization according to initial attack parameters, then it is also possible to assess some components of firefighting costs through the model.

Algorithm realism and flexibility have proven instrumental in facilitating simulation of a wide range of scenarios, including alternative budgets, initial attack configurations, fuels, and changing climates.

Caveats and Applications

The Fried and Fried containment algorithm was designed to represent initial attack scenarios only. It does not address extended attack fires for which (1) an elliptical fire shape assumption is likely unrealistic, (2) quite different containment tactics may be deployed, (3) fuel types (and thus both forward rate of spread and fireline production rates) may vary over the containment boundary, and (4) spot fires may figure prominently in the firefighting challenge. Moreover, simplified assumptions—such as airdrop-created fireline being "permanent," at least over the time-scale of initial attack—make them less useful for modeling multiday fires. However, the comparatively short but critically important period of initial attack imposes no artificial limitation on the usefulness of the algorithm in a strategic planning and budgeting system.

Models such as CFES and FPA-IRS, both of which employ this algorithm as the initial attack simulation engine, are well-suited to marginal analysis—examining the effects of incremental changes to budgets and, ultimately, the configuration of initial attack on fire suppression effectiveness. CFES has been used by the State of California to help ensure consistency in fire response across the State. FPA-IRS generates lists of fire scenarios that exceed simulation limits and passes them to FPA's large-fire module, a modeling system that accounts for landscape-scale fuel management and firefighting organization in addressing large wildland fires and defining final fire areas.

This containment algorithm is also integrated into the BEHAVE fire modeling system so that outcomes for specific fires can be easily analyzed. Algorithm realism and flexibility have proven instrumental in facilitating simulation of a wide range of scenarios, including alternative budgets, initial attack configurations, fuels, and changing climates. These attributes have contributed to acceptance of simulation results by managers and firefighters alike.

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