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MAKING HISTORY

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On the Cover:

Stan Hirsch (right, with pilot Stan Butryn) developed Project FIRESCAN at the Northern Fire Laboratory to detect fires using infrared photography from a U.S. Army Mohawk aircraft. Within a few years, managers adopted this technology to identify problem areas within fires, establish safety zones for firefighters, and locate spot fires. This was one in many innovative projects in the ongoing history of the facility, renamed the Missoula Fire Lab. For a glimpse into other efforts and the history of the lab, see the article "50 Years of Service: The Missoula Fire Sciences Laboratory." Photo: Harold Pontecarvo, Forest Service.

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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Anchor Point

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

USDA Forest Service, Fire and Aviation Management—an Organization of Wildland Fire Professionals

In recent Anchor Point articles, I've talked about the National Cohesive Wildland Fire Management Strategy and how it will ultimately help us to all come together, regardless of agencies or jurisdictions, to solve the problems of wildfire in the United States. I've covered the importance of reinforcing fire doctrine and risk management to safely and effectively manage wildfire when it occurs and the importance of these two factors in everything we do, every time we do it. In this edition, I'd like to talk about professionalizing wildland fire management.

When I say that I believe in professionalizing the wildland fire management program, I mean that everyone involved in the wildland fire management profession will abide by a code of conduct and adhere to a set of strict ethical standards and professional qualifications that will place our organization above the rest. We will aim for our fire and aviation management profession to be the most respected, admired wildland firefighting organization in the world—and that admiration will be derived from and anchored in our diversity, knowledge, skills, and abilities.

You might ask where one will acquire these knowledge, skills, and abilities. This will be done through a combination of education, training, and experience. As wildland fire management professionals, we are expected to deal with a set of circumstances and emergency management factors uncommon to any other profession. Our ability to derive favorable outcomes that result in a benefit to society is truly unique.

As I travel around the world and speak to groups about wildland fire management, it is apparent that, unlike European foresters, we, as U.S. wildland fire management professionals, need to understand ecological relations as well as emergency management relationships. We are expected to bridge the gap between natural resource management and emergency management—unlike others within our organizations. We are expected to not only be skilled at both; we need to be leaders in both. To become leaders, we need to also consider the diversity of our programs and of our organization and to expand that diversity into the future.

I am proud of who we are—who we have become, and the work we do. I am especially proud of programs, such as the National Wildland Firefighter Apprenticeship Academy, the Advanced Wildland Firefighter training program at Schenck Job Corps, and the Veteran's Green Corps, that assist us in building future capacity for the wildland fire profession. I am proud of the energy that goes into ensuring the integrity of our wildland fire qualifications and certification program.

Success will bring these components together into a complete package, with a plan that can be implemented locally and sustained nationally, building a wildland fire profession with professional ethics, a code of conduct, a philosophy, and professional qualifications that create equity and opportunity for every individual who wants to be involved in fire and aviation management—who wants to be a wildland fire management professional. ■

Greening Fire: Forest Service Style

Jennifer Letz, Thomas Fuchtman, and Heather Davis

The impacts of wildfire are not always confined to the effects of fire alone, but sometimes extend to the consequences of suppression-related operations. As always, scale plays a role in the extent of effects, and a group of Forest Service employees are exploring ways to minimize the ecological footprint of firefighting operations.

> The team, composed almost entirely of current or former firefighters, was quick to focus its energy on two of the biggest sustainability issues facing fire camps: waste management and bottled water use.

From Fire to Fire Camp

Most wildfires begin with a small spark. Due to the swift actions of initial attack crews, the majority of these fires never stray far from their point of ignition. Yet, occasionally, a small fire will grow until its size and scope over-tax the efforts of local fire crews. At this point, an interagency incident management team (IMT) is asked to take the reins and manage fire operations.

A critical function of an IMT is to establish a fire camp—a hub of firefighting efforts where crews eat, sleep, and refuel while operations, planning, logistics, and administration specialists plan the intricate daily operations required of a large incident. Literally overnight, a small, full-service city is created, capable of supporting anywhere from 100 to 2,000 incident staff. Catering services, showers, supply tents, portable toilets, and fuel trucks are just a few of the support components in a camp, providing firefighters with everything they need to ensure a safe and productive shift on the fireline. This impressive logistical feat is accomplished by the coordinated efforts of the IMT's logistics section, fire caches, dispatchers and buying teams, host unit leadership, and private contractors.

Sustainable Operations at Fire Camp

In the shadows of this monumental feat hides a problem that, until recently, was simply justified as an acceptable consequence of emergency operations. The problem was

Jennifer Letz is the sustainable operations specialist for the Deschutes and Ochoco National Forests and Pacific Northwest Region Fire and Aviation in Bend, OR. She is chair of the Western Collective Greening Fire Team. Tom Fuchtman retired as a member of the Greening Fire Team and assistant fire management officer on the Santa Fe National Forest in Cuba, NM, in July 2011. Heather Davis is a student in the Forest Service Student Career Employment Program pursuing a graduate degree in engineering and working for the Western Collective in Bozeman, MT.

A fire camp is the hub of firefighting efforts, where crews eat, sleep, and refuel. The support portion of the Scott Mountain Fire Camp in McKenzie Bridge, OR, includes overhead tents, shown in the foreground, and shower and catering services in the background. Photo: Jennifer Letz, 2010.

not something in the camps. It was something missing from camps: sustainable operations. Sustainable operations, in this context, are defined as actions that support work activities, yet minimize negative environmental, financial, and social impacts. Initiatives such as recycling; waste mitigation; and fuel, water, and energy conservation were largely absent from fire camps. Fire camp was one of the few places left in the Forest Service where waste—in all its forms—was still an acceptable cost of business.

That's not to say that waste is embraced or endorsed by IMTs or firefighters. Quite the opposite is true: the fire community has become increasingly vocal about its desire to see improvements in sustainability at camps. Incident managers across the Nation have attempted and occasionally succeeded in addressing some of these issues—a noteworthy effort, considering the extremely complex logistics involved in operating fire camps. Yet, these efforts have been largely unorganized and have not permeated the fire community as the norm. What, then, is needed to transition these attempts at sustainability from incidental efforts to standard policy? The answer lies in integrating top-down and bottom-up approaches to engage all levels, agencies, and partners in the fire community.

> The Western Collective utilizes the time and talents of Forest Service employees at all levels of the agency across the Western United States to promote and integrate sustainable operations.

National Policy, the Western Collective, and the Greening Fire Team

The top-down approach to greening fire gained some footing in 2009 with a number of changes in Federal policy. Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," issued October 5, 2009, further clarified the Federal Government's previous mandates by requiring agencies to "eliminate waste, recycle, and prevent pollution" and improve efforts in green purchasing and energy efficiency. Two months before the Executive order was released, Tom Harbour, Director of Fire and Aviation Management for the Forest Service, released a letter requesting the fire community take a hard look at such elements as purchasing, fleet, and fire camp operations so that the fire program could "align our traditional land stewardship work with practices that reduce our consumption and overall use of resources."

The bottom-up approach advanced with similar energy in 2009. Not long ago, efforts within the Forest Service to operate more sustainably were scattered and unorganized. The need for a structured support system for sustainable initiatives within the agency led to the development of a unique internal organization called the Western Collective for Sustainable Operations (Western Collective). The Western Collective, created in 2009, is a "place-based" organization that utilizes the time and talents of Forest Service employees at all levels of the agency across the Western United States to promote and integrate sustainable operations.

The board of the Western Collective is composed of the deputy regional foresters from the Forest Service's Northern, Rocky Mountain, Southwest, Intermountain, Alaska, and Pacific Northwest Regions and

A truckload of bottled electrolyte drink. Many companies transport bottled beverages in cardboard trays and shrink wrap, adding to the waste stream of fire camp. Photo: Jennifer Letz, 2010.

the deputy director of the Rocky Mountain Research Station. The board provides administrative support to a number of Western Collective teams addressing sustainability challenges within the agency. The board's leadership links agency policy and direction with operations on the ground for employees willing to tackle real sustainability issues and work towards pragmatic solutions.

Building on the momentum provided by the Executive order and Fire and Aviation Management Director Tom Harbour's letter, the Western Collective created the Greening Fire Team in the fall of 2009 to examine fire operations as a whole and determine where best to integrate sustainable operations. The team, composed almost entirely of current or former firefighters, was quick to focus its energy on two of the biggest sustainability issues facing fire camps: waste management and bottled water use. The team tapped the members' collective experience of fire operations and fire camp management to create a game plan for integrating sustainable operations into the fire camp community while maintaining firefighter health and safety.

Waste Stream Analysis

The highly mobile and specialized nature of fire camps has promoted a reliance on disposable materials. Camps quickly become terrific waste generators, and one of the first tasks of a facilities unit leader is to order a dumpster to handle discarded items.

Most waste is generated during the building, daily operations, and demobilization phases of a camp's lifespan. Often, large, 30-cubic-yard (23-m^3) dumpsters, supplied by a local commercial waste hauler, are brought into the camp to collect the waste. Depending on the size of a camp, the waste hauler may return once or twice a day to deliver another empty dumpster and haul away the full one. Typically, the waste—a significant percentage of which is recyclable materials—is trucked to a local landfill where it becomes the burden of a nearby community.

There are several ways to reduce waste generated in fire camps. First, recycling can be offered and encouraged; second, disposable products can be replaced with durable products; and third, purchasing procedures can be changed to encourage buying products that have less packaging, are more durable, or are made of biodegradable materials. Historically, camp

Backhaul from a spike camp deposited in a fire camp trash dumpster. Note the number of recyclable items, including cardboard and plastic bottles. Photo: Jennifer Letz, 2009.

The contents of a sack lunch. The large amount of packaging adds to the waste stream of a fire camp. Photo: Jennifer Letz, 2010.

managers have been unable to implement such strategies due to a number of factors, including transportation limitations to remote camps, lack of local recycling or purchasing resources, or lack of information about local resources communicated to the IMT.

Before the team could make recommendations for reducing waste, it needed to know what was going into the camp dumpsters. The Greening Fire Team began by performing a waste stream analysis—also known by the more colorful term "dumpster diving." The team partnered with the U.S. Environmental Protection Agency to develop a waste stream audit process to ensure a safe, uniform collection process and consistent analysis standards.

The Greening Fire Team performed audits at six fire camps in four States (Colorado, Idaho, Montana, and Oregon) in 2010. Two or three team members traveled to each camp and spent a day digging through dumpsters, talking to incident managers, and observing fire camp operations. Incident managers were eager to share stories of their challenges and successes implementing recycling programs and ideas to improve sustainable operations on site.

Waste auditors typically found that establishing recycling was considered a low priority when setting up a camp and often did not occur until the third day. In many cases, a significant portion of items that could be recycled were sent to the landfill because of this delay. Auditors also found that discarded food was a significant component of waste.

Changing the current mentality will require a phased-in approach, reassuring firefighters that the efficiency of filling hydration systems can be equal to or greater than the safety and convenience of bottled water use.

In 2011, the Greening Fire Team will compile the findings from each audit to glean the true composition of fire camp waste. They will also examine camp purchasing records to gain a more accurate picture of the lifecycle of supplies at a fire camp. Armed with this knowledge, the Greening Fire Team and others will work with IMTs and the

Forest Service employee Katie Newcomb sorts trash during a waste audit. Note: The 5-gallon (19-L) buckets are hot cans that were also found in the trash dumpster. Photo: Jennifer Letz, 2010.

Firefighters are encouraged to drink at least 1 quart (1 L) of water per hour during operations, equaling a minimum of 3 gallons (11 L) per person per 12-hour shift, or twenty-three 16.9 oz (0.5 L) bottles of water. Based on IMT deployments in 2009, it is estimated that over 2 million bottles of water were purchased.

Manufacture of the containers alone requires:

- 50,000 gallons (190,000 L) of petroleum (the raw material),
- 201,183 megajoules of electricity,
- 625,000 gallons (2,370,000 L) of water used to make the plastic, and
- 375,000 lbs (170,000 kg) of CO_2 emitted during production.

Source: <http://www.newdream.org/water/calculator.php>.

fire community to reduce recycling setup times, improve recycling rates at camps, and recommend greener purchasing options.

"The Western Collective group is excited about the progress that is being made in the Greening Fire Team. This showcases how working across regions can produce the desired results of recycling and duplicating success."

–Faye Krueger, Deputy Regional Forester, Region 3

Bottled Beverage Reduction

A familiar sight at fire camps is a mass of pallets piled high with cases of bottled water, but firefighters have not always relied on the prepackaged 16.9 oz (.5 L) bottles to provide hydration on the fireline. Until the mid-1990s, firefighters traditionally filled personal canteens from potable water trucks, "water buffalos," or a local water source. Five-gallon (19-L) cubitainers—"cubies"—still common today, were the primary receptacle crews used to refill canteens on the fireline. Now, it is estimated that an average fire year can necessitate the purchase, transport, and disposal of over 2 million bottles of water.

The transition from bulk potable water to bottled water was an interesting process. Unlike other changes or improvements instituted through policy or hard research, the rising use of bottled water at fire camps was driven by a number of social factors, including concern over communicable diseases and the increasing general popularity of bottled water in the United States.

A firefighter fills a 5-gallon (19-L) jerry can from a potable water truck—a relatively rare occurrence since bottled water became the primary source of drinking water at fire camps.Photo: Jennifer Letz, 2010.

The Greening Fire Team agreed that this reliance on bottled water was unnecessarily wasteful, and the team created an informal survey to gauge the opinions of the fire community. More than 150 people participated, and the poll revealed that more than 73 percent of respondents were interested in seeing bottled water use reduce significantly or disappear altogether. Survey respondents and other fire community members listed a range of reasons for their dislike of bottled water, including lack of space in crew rigs to store full and empty bottles, the number of bottles needed to fill one canteen or hydration bladder, the propensity of the round bottles to roll away if dropped, and the waste of money and resources involved in packaging bottled water.

Conversely, many members of the fire community expressed their distrust in the "old" ways of supplying water. Memories of rusty potable water trucks, cubies filled with mystery substances, and long lines at water buffalos left some people hesitant to move away from bottled water, which is often believed to be untainted, with its seals and redundant packaging.

With this information, the Greening Fire Team decided to promote the elimination of bottled beverages whenever possible in fire camps. However, the team understood that the complete elimination of bottled beverages in fire camps is not a realistic goal due to factors such as accessibility or the unavailability of local potable water sources. In addition, water availability for firefighter hydration practices must always meet established policies

"Linking the innovative, learning culture of the fire community with the passion and ideas of the sustainable operations community was a no-brainer. Our fire operations require significant resources of all kinds. There are tremendous opportunities to find real-life, pragmatic, and long-lasting changes in our overall environmental footprint in the fire world. It's most exciting to see that many of those opportunities will also produce significant cost savings."

– Anna Jones Crabtree, Executive Director, Sustainable Operations Western Collective and procedures and should never threaten the health and safety of firefighters. The team also recognized that returning to the "old days" of water delivery would not be a panacea, and new technology and water transport methods should be researched.

The team spent 2010 researching a number of hydration alternatives, ultimately partnering with a type 1 IMT to field-test recommendations, such as requiring sanitary conditions at potable water trucks, ordering water cooler-type 5-gallon (19-L) containers and reusable personal water bottles for those who don't leave camp, or purchasing 1-gallon jugs of water for field supply. Unfortunately, the IMT was never dispatched, so field-testing will be attempted again in 2011.

The Greening Fire Team challenges the notion that bottled water is the best way to hydrate firefighters and the cultural mentality and habits that promote its use. Changing the current mentality will require a phased-in approach, reassuring firefighters that the efficiency of filling hydration systems can be equal to or greater than the safety and convenience of bottled water use. The team also recognizes that time and a substantial educational component will be necessary to change current practices to a preferable condition of sustainability.

Sustainable Operations Mandates

Executive Order 13514

(e) promote pollution prevention and eliminate waste by:

- (i) minimizing the generation of waste and pollutants through source reduction;
- (ii) diverting at least 50 percent of nonhazardous solid waste by the end of FY 2015

Letter of Direction–Tom Harbour, Director of Fire and Aviation Management

"We must seriously consider all opportunities to incorporate sustainable operations practices into our routine operations. The resources we use to accomplish our resource management responsibilities are an integral part of our stewardship role. Actions should be taken at all incident camps to reduce our energy and fuel sources where available; implement both waste prevention and recycling activities; and purchase bio-based products and limit the use of bottled water."

25 August 2009

An improvised recycling station in fire camp. Recycling stations often appear late in fire camp establishment. Photo: Jennifer Letz, 2010.

Next Steps

As the Greening Fire Team enters its second year, its work changes from research to integrating outreach services. While team members continue researching sustainable practices and making recommendations, they would like the fire community to see them as a resource for information and assistance in implementing sustainable fire operations. The team is not limiting its efforts to trash mitigation and bottled water reduction, but will also examine other issues, such as fuel use in mobile and stationary motors, rechargeable versus nonrechargeable battery use, food waste, transportation, and nonpotable water conservation. Through research, education, and partnership, the team believes that a safer, cleaner, and fiscally sound fire camp is achievable. Contact the Greening Fire Team at: <GreeningFire@fs.fed.us> ■

Repurposed Vehicles: A Tale of Two Trucks

Gregory Gettys and Otis Wayne Kennedy

We take them to parades. We send them to birthday parties. We show them off to schools during fire safety week. They are the highlight of any child's tour to a fire station. Ask citizens what image first pops into their mind when you say "fire department," and it is guaranteed most of them will say, "fire truck!"

> As fire and rescue services have evolved and expanded over the years, so have the apparatus in which we respond.

As fire and rescue services have evolved and expanded over the years, so have the vehicles (apparatus) in which we respond. If you travel around North Carolina and visit fire departments, it is easy to see innovation and ingenuity taking place in fire apparatus design and use.

Oak Hill Fire and Rescue

Such an example of innovation in apparatus design and use can be found in Morganton, NC. Oak Hill Fire and Rescue is a 2-station, 38-member volunteer fire and rescue department located in western Burke County that provides fire, rescue, and paramedic-level emergency medical services to the citizens it serves. The fire district covers 57 square miles (148 km^2) and contains more than 2,000 structures. The district's terrain is quite unique in that it contains a complex mix of both urban and rural areas. Oak Hill provides mutual aid and medical response to the city of Morganton, a very urbanized, populated area, as well as to other Burke County fire departments, including Lake James, Chesterfield, and Jonas Ridge. Oak Hill also provides fire protection and rescue services to one of North Carolina's most densely wooded areas, the Pisgah National Forest.

Need: Access to Remote Areas

It is because of this diverse landscape that Oak Hill fire captain Gregg Gettys, a member of Oak Hill Fire and Rescue since 1983, first identified a need, more than 8 years ago, for some type of specialized apparatus to provide improved fire and rescue services to remote, rural regions of Oak Hill's district. According to Gettys, there are numerous residences and properties in heavily wooded areas of the district that traditional pieces of fire apparatus would have difficulty accessing. For years, the department has provided these areas with the best fire and rescue protection possible; however, Gettys knew something more could be done. That's when he began investigating the possibility of acquiring a vehicle designed for rugged terrain and capable of being outfitted with firefighting equipment.

> There are numerous residences and properties in heavily wooded areas of the district that traditional pieces of fire apparatus would have difficulty accessing.

Gettys' search led him to the military's M-35 cargo truck, commonly known as a "deuce-and-a-half." While doing research, Gettys came across a Government-sponsored program that offers surplussed Department of Defense vehicles to fire departments protecting rural areas. This program is known as the Federal Excess Personal Property Program (FEPP).

In North Carolina, the FEPP works through a cooperative agreement with the Forest Service and the North Carolina Forest Service. Once the North Carolina Forest Service obtains excess property from the USDA Forest Service, it then loans the property to fire departments for use in fire suppression for as long as the departments have a use for the equipment. Gettys saw this as an invaluable opportunity for his department and requested the acquisition of an M-35.

Gregg Gettys is a fire captain with Oak Hill Fire and Rescue in Morganton, NC, and Otis Kennedy is the Chief of West End Fire and Rescue in West End, NC.

This vehicle has fulfilled its duties well on wrecks, residential structure fires, and several forest fires.

The new Oak Hill Fire and Rescue multipurpose apparatus is the culmination of efforts by many members of the community. Photo: Courtesy of Oak Hill Fire and Rescue.

The controls of the new Oak Hill fire and rescue vehicle reflect a heritage of strength and durability. Photo: Courtesy of Oak Hill Fire and Rescue.

A New Firefighting Unit

After completing the necessary paperwork and acquisition processing, Oak Hill received its deuce-and-a-half. Since the acquisition, many modifications have been made to the apparatus in order to meet the specific response needs of Oak Hill Fire and Rescue. Luckily, in 1998, as part of a U.S. military extended-service program, the truck had been upgraded to include a new Caterpillar engine, Allison 1545 automatic transmission, electronically controlled central tire inflation system, air-assisted steering, super-single radial tires, and an improved heater and defrost system. While the apparatus has 4,000 total miles (6,400 km), these new components had seen only 450 miles (720 km) of use.

With these improvements already made, Oak Hill was able to focus on the primary goal of outfitting the truck as a firefighting unit. For a minimal fee, Gettys was able to acquire a 32-horsepower Waterous pump, 500-gallon (1,890 L) water tank, and a complement of forestry hoses, valves, fittings, and nozzles for the apparatus. All of this equipment was installed with the help of District 2 forestry mechanic Danny Hayes. With the aid of local Oak Hill Ironworks, a skid unit was fabricated for the apparatus cargo area. The skid unit provides for interchangeable bed configurations, allowing for future expansion and flexibility in use. The apparatus was painted by individuals from the North Carolina Department of Corrections. Stevens Signs Company of Icard, NC, provided identifying graphics and pin striping.

The newly recommissioned M-35 officially went into service in August 2010 during the recent North Carolina South Atlantic Fire Expo. Many visitors may have seen it on the apparatus show floor alongside a variety of other unique fire–rescue apparatus. Oak Hill Fire and Rescue intends to deploy the apparatus on wildland–urban interface incidents, special operations incidents involving off-road access routes, and various incidents during winter months, when the area is subject to harsh, inclement weather. Future plans for the apparatus include addition of a hydraulic winch, turret nozzle, and other equipment that will upgrade the apparatus to a National Wildlife Coordinating Group type III engine.

"Innovation" can be defined in different ways: while some view innovation in terms of modernization, others see it in any unique action taken to improve a limiting situation. In this case, Oak Hill Fire and Rescue members identified a problem in providing fire and rescue protection to citizens in locations inaccessible to modern fire apparatus and took proactive steps to address that problem with the procurement and customization of this apparatus. Innovation, combined with care and a concern for the community, makes this piece of apparatus truly unique.

West End Fire and Rescue

West End is a rural community located in Moore County, in the Sandhills region of North Carolina. West End Fire and Rescue responds to roughly 600 calls a year in all types of terrain and weather conditions, including unroaded hills, high summertime temperatures, and freezing rain. Accessibility of equipment and manpower to incident sites is crucial to serving the needs of the community, and transportation can be particularly challenging.

For years, the U.S. military has invested time and money in the development of response-oriented equipment to serve many different purposes. In connection with the North Carolina Forest Service and the FEPP, West End Fire and Rescue has also converted a military vehicle to fire and rescue use.

All-Terrain, All-Weather Vehicle

The new vehicle, a 1970 deuce-and-a-half cargo truck, enables the West End Fire and Rescue to transport equipment and manpower into areas that would be inaccessible to a conventional fire truck. West End Fire and Rescue acquired this vehicle at minimal expense, leaving the group able to invest roughly $1,000 into modifications.

The truck has become a multipurpose truck for all types of incidents, and a 4x4 of this nature makes access to and success in the job go hand-in-hand. The crew now has the capability to transport water and supply lines of all sizes on any terrain, and bad weather is no obstacle in any fire, rescue, or emergency medical situation.

Standard equipment maintained on the unit for rescue work includes extrication tools, a medical supplies bag, defibrillator, cribbing, fire extinguishers, and fire hoses. When not loaded with rescue gear, the vehicle serves as a large multipurpose brush truck, with a 500-gallon (1,890 L) water tank and a gasoline-powered pump. Housing a very large winch on the front bumper increases the reliability of off-road movement.

This vehicle has fulfilled its duties well on wrecks, residential structure fires, and several forest fires. Further customizing will continue in the future, and the unit will serve the crew very well in all capacities for many years to come. ■

The truck has become a multipurpose truck for all types of incidents, and a 4x4 of this nature makes access to and success in the job go hand-in-hand.

The West End truck has become the preferred vehicle for all incidents with difficult access. Photo: Courtesy of West End Fire and Rescue

Working With American Indian Tribes on Wildland Fires: Protecting Cultural Heritage Sites in Northwestern California

Frank K. Lake

Federal agencies have a responsibility to American Indian tribes and tribal communities for the management and protection of tribal trust resources for reservation and public lands within tribes' ancestral lands and territories (Pevar 2002, Wilkinson and The American Indian Resources Institute 2004). The Indian Self Determination and Education Assistance Act (1975: Public Law 93-638) also provides mechanisms for establishing working relationships regarding the management of Federal programs (e.g., compact or cooperative agreements). The Federal Land Policy and Management Act (1976: Public Law 94-579) requires coordination with approved tribal management plans for the purposes of development and revisions of such plans and is inclusive of programs or projects. Federal Government consultation, such as government-to-government protocol agreements with federally recognized tribes (Executive Order 13175, 2000), provides one mechanism for raising concerns and understanding potential impacts to cultural resources and related tribal trust resources resulting from Federal fire management activities. Memoranda of Understanding (MOUs) and fire management agreements between tribes and Federal agencies provide a framework for clarifying the agencies' and tribes' roles in collaborative and cooperative fire management for the protection, security, and mitigation of impacts to tribal trust and cultural and heritage resources.

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> Federal agencies have a responsibility to American Indian tribes and tribal communities for the management and protection of tribal trust resources.

A New Structure of Cooperation

Because the nature of cooperation between Federal agencies and tribal entities is different than cooperation among Federal, State, and local fire management agencies, a different set of agreements and a whole new set of positions are necessary to ensure proper and timely communication and efficient action. MOUs and fire management agreements allow for the identification of agency and tribal representatives who have the authority and are responsible for making decisions pertaining to wildland fire management actions.

In the Pacific Northwest and California, such MOUs introduce a number of positions specific to the unique relationship. These positions include special representatives for both the Federal agencies and for the tribes at various levels of operations involvement. Heritage resource advisors (Federal: Forest Service) and heritage consultants (tribal: Karuk), for example, are field personnel who coordinate and work with agency fire incident management teams (IMTs) to prevent, reduce, or mitigate impacts to cultural heritage and natural resources during wildfire management and burned area emergency response (BAER) operations and activities. The agency heritage resource advisor directs the work of the heritage consultant coordinator and heritage consultants. The agency heritage resource advisor is responsible for requesting heritage consultant(s) assistance when and where it is needed. These heritage consultant coordinators and level I heritage consultants are, at a minimum, light-duty fireline qualified (National Fire Equipment System [NFES] 2724, 2010) and may have additional training, credentials, knowledge, or expertise related to archaeological, cultural, or natural resources of tribal significance (NFES 1831, 2004).

Consultation and Collaborative Wildland Fire Planning

The Forest Service is committed to consulting with federally recognized American Indian tribes regarding Federal management activities. The government-to-government protocol agreement sets the foundation for agency and tribal consultation. Other agreements and plans of various types define the cooperation between Federal agencies and tribes. The MOUs tier to the government-to-government protocol agreement, and provisions are made for cooperation in land and resource management plans (LRMPs) or related fire management plans (FMPs) that specify goals, objectives, and desired management actions for reservation or public lands.

Tribal concerns can be addressed in various planning documents, including LRMPs and FMPs, affording national forest staff various ways to incorporate those concerns into fire response. The development of LRMPs and FMPs requires tribal consultation but not collaborative development; LRMPs may identify designated management areas of cultural significance to tribes, detail area-specific management objectives, and include clarification of responsibilities for these areas. When wildland fires on public lands occur within a tribe's ancestral lands or territory or within these LRMP-designated areas of cultural significance, MOUs and fire management agreements provide opportunities for further consultation and potential collaboration with tribes or tribal community members.

The Framework of Response

An MOU and fire management agreement can be combined in the same document. These agreements specify the purpose of the agreement, the statement of mutual benefits and interest to the agency and the tribe, the responsibilities of the agency and the tribe, and what is mutually agreed and understood between the parties regarding their roles in protection of resources. Additionally, and specific to wildland fire management, these agreements state who is involved in initial response for wildfires and fire complexes, the actions or activities for which they are responsible, and what guidelines apply to incident management and post-wildfire activities, such as BAER activities. Furthermore, these documents describe the specifics of positions, duties, and organizational structure for wildland fire management.

For example, in the MOU between the Karuk Tribe and the Six Rivers and Klamath National Forests, the stated purpose of the agreement is to continue the governmental cooperation between parties concerning wildland fire and fire management activities. The document further states that such cooperation "provides for the protection of significant cultural resources important to the Tribe, Forest Service, and the public." The document also includes direction for rates of pay that are commensurate with the complexity of incident management organizational roles and responsibilities outlined in attachments to the MOU.

Incident Roles

Official positions within the tribe specified in the MOU or fire management agreement ensure that cultural resource considerations are observed. Federal representatives are designated to communicate with those tribal representatives at all levels with planning and operations. During operations, provisions are made to include representatives of the tribe in site-specific actions to preserve or restore cultural heritage sites and related tribal trust resources. Figure 1 presents one possible organization of roles for Federal and tribal interaction.

> Before the fire season, the tribal council compiles a list of authorized tribal wildland fire staff to represent the tribe's interests pertaining to incident activities.

Tribal Duty Officer and Designated Tribal Government Representatives

Before the fire season, during development or renewal of agreements, the tribal council compiles a list of authorized tribal wildland fire staff to represent the tribe's interests pertaining to incident activities. This list includes: a tribal duty officer, designated tribal government representative(s), heritage consultant coordinator(s), and heritage consultant(s). The designated tribal government representative serves as agencies' primary point of contact within the tribe for wildland fire notification. The tribal duty officer or designated tribal governmental representative ensures that individuals identified by the tribe to be hired by the agency have necessary qualifications, certifications, and requirements. During multiple wildland fire incidents, the tribal duty officer or designated tribal governmental representative identifies and directs each incident-specific designated tribal government representative to coordinate efforts with incident commander(s) (ICs) and IMTs. As appropriate and necessary, the designated tribal government representatives can complete

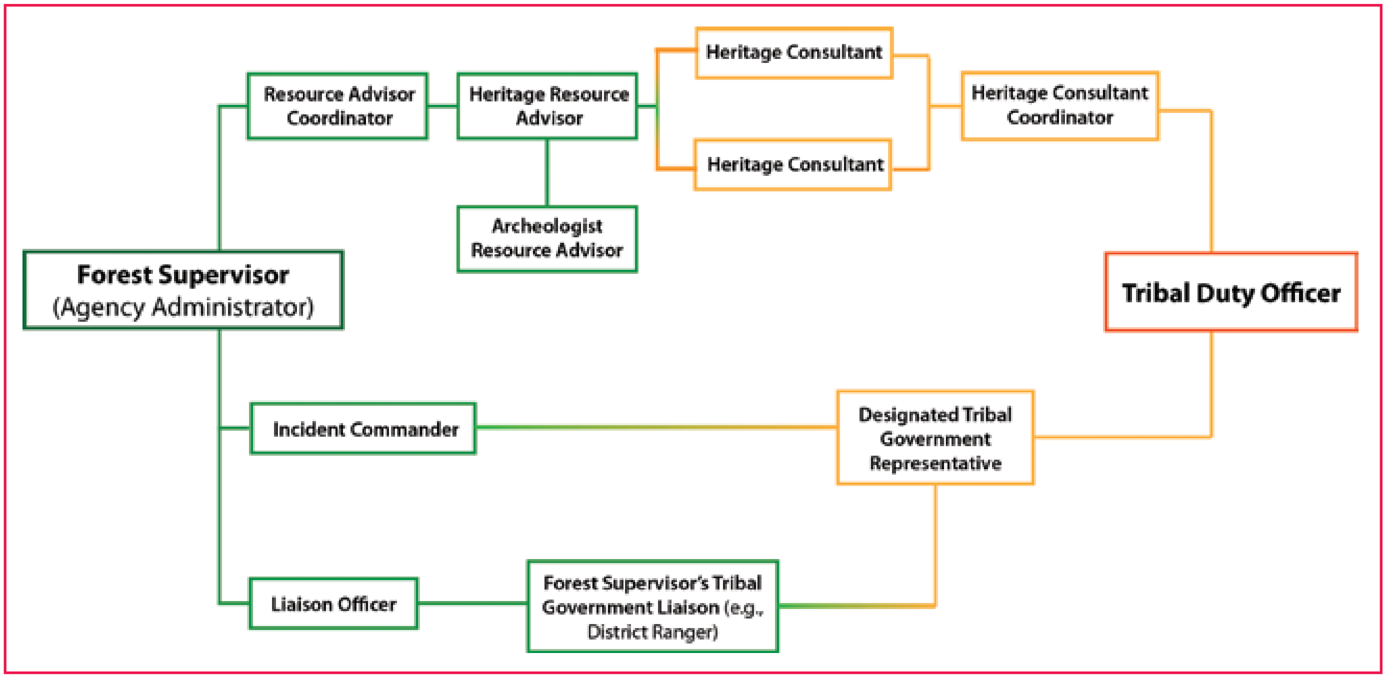

Figure 1—*The Forest Service and tribal governments establish positions and roles to facilitate fire management interaction on lands of mutual interest. Exact roles are defined in the memorandum of understanding generated for the specific tribal area; the depicted positions represent one possible configuration. Organization of Federal positions is given in the Forest Service qualifications handbook (Forest Service 2005).*

the qualification requirements of the Interagency Standards for Fire and Aviation Operations (NFES 2724, 2010: the "Red Book") or Department of the Interior, Bureau of Indian Affairs (BIA) (National Interagency Fire Center 2010: the "Blue Book").

Tribal Government Liaison and Heritage Resource Advisor

The forest supervisor or line officer identifies and appoints a heritage resource advisor and a tribal government liaison to work with the tribal duty officer and designated tribal government representatives for the incident. Depending on the size and complexity of the incident(s), the forest supervisor or designated Forest Service agency administrator representative (e.g., a district ranger), in consultation with the heritage resource advisor and designated tribal government representatives, will determine whether to hire heritage consultants from the tribe(s) to address specific cultural and related tribal trust resources potentially at risk.

The agency heritage resource advisor serves in a critically important position, coordinating with the Federal resource advisor coordinator on tribal or cultural issues. The heritage resource advisor is selected for his or her familiarity with the cooperative agreements; fire and archaeological qualifications; and knowledge of and experience with local tribal customs, beliefs, and practices. The heritage resource advisor is assigned to the IMT planning section chief and directs the work of the tribe's heritage consultant coordinator and, if employed, the heritage consultants.

> The heritage resource advisor is selected for his or her familiarity with the cooperative agreements; fire and archaeological qualifications; and knowledge of and experience with local tribal customs, beliefs, and practices.

Heritage Consultant Coordinator and Heritage Consultants

The heritage consultant coordinator is a tribal representative who may be hired by Federal agencies as needed on incidents potentially involving American Indian cultural resources. In conjunction with the designated tribal government representatives, the heritage consultant coordinator coordinates activities and input from the heritage consultants and works with the heritage resource advisor or planning section chief.

As specialists hired for incidents, heritage consultants serve as the bridge between tribal concerns and fire management operations. The type of involvement and responsibilities of heritage consultants are determined by their level: I or II.

Level I heritage consultants work for and are directed by the heritage resource advisor. Level I heritage consultants are usually tribal members (or descendants) who have cultural and personal knowledge of the local landscape, vegetation, cultural resources, and tribally significant areas or sites and are assigned to work in specific locations (e.g., branches or divisions) of the incident. Level I heritage consultants may work with IMT branch chief(s), division supervisor(s), fire observer(s), resource advisor(s), or type I or II fire crew leader(s). Their work involves planning for reconnaissance of proposed firelines or the construction of selected contingency firelines or related fire operations (e.g., establishing safety zones or drop sites).

Level II heritage consultants are often tribal elders, practitioners, ceremonial leaders, or others who have significant knowledge of specific areas where incident management activities are proposed or are taking place. Level II heritage consultants can and may participate with nonfireline activities such as contingency planning and planning incident activities to prevent, reduce, or mitigate impacts to cultural resources, archaeological areas and sites, and culturally significant habitats or areas. The duties and responsibilities of level II heritage consultants are to provide local cultural knowledge and recommendations applicable to specific areas for incident planning and operations to lessen or mitigate potential undesired impacts to cultural and tribal trust resources. For example, a tribal spiritual leader may evaluate planned actions to construct fireline near a sacred site and propose changes to incident operations to reduce impacts to site quality and use.

How It Works: Handling an Incident

In late June 2008, lightning storms in northwestern California ignited wildfires on the Klamath and Six Rivers National Forests. These incidents spread to encompass areas within the Karuk and Yurok Tribes' ancestral territories. As individual wildfires spread, some were managed as separate fires and some merged into complexes. For example, the Blue 2 and Siskiyou fires merged to form the Siskiyou Complex, which spanned the two national forests and two tribal territories (fig. 2). Incident management organization varied in scale, from type III, II, and I to national incident management organization teams.

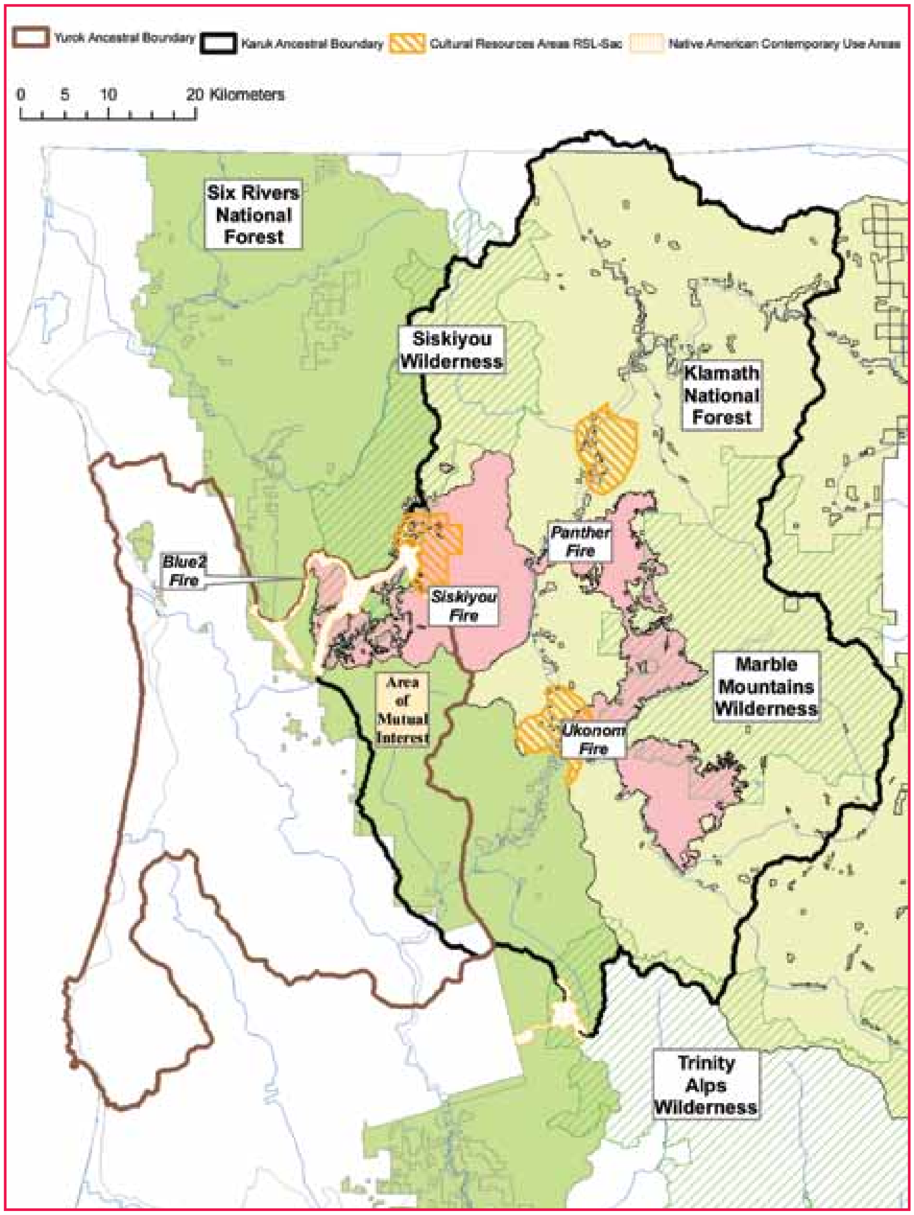

Figure 2—*Yurok and Karuk ancestral tribal territories, national forests, Native American contemporary use area, and 2008 wildfire perimeters. Map: Janet Werren, Forest Service, Pacific Southwest Research Station.*

The Six Rivers National Forest LRMP recognizes and has designated Native American contemporary use areas as culturally significant areas containing ceremonial districts, ancient and contemporary village and camp sites, numerous sacred areas, and other recorded and potential archaeological sites. The Klamath National Forest designates Cultural Management Areas in their LRMP. Due to tribal sensitivity and wildfire management concerns in these culturally significant areas, the two national forests utilized MOUs with the Yurok and Karuk Tribes to make use of the expertise of designated tribal government representatives and level I and II heritage consultants. In addition, numerous archaeologist resource advisors were assigned to work with the heritage consultant coordinators and level I heritage consultants.

Agency administrators' (e.g., line officers) briefing and delegation of authority documents followed the MOUs' roles for agency and tribal positions (NFES 2724, 2010, Appendices D and H). (The resource advisor coordinator and heritage resource advisor were, in this case, involved in the drafting of these documents.) Most IMTs lack familiarity with such agreements involving American Indian tribes, in part due to the recent development of such agreements and because the qualifications, duties, and supervisory roles of tribal heritage consultants must be defined for each IMT and incident.

At times, the lack of agency and contractor knowledge of—and sometimes lack of sensitivity to—American Indian customs, beliefs, practices, sacred areas, or sites strained working relationships between Indians and non-Indians. Other times, ineffective communication, human misunderstandings, and other errors resulted in undesired consequences. Larger incidents and longer tours (e.g., cycles of 14 days on/2 days rest, for up to 3 months) resulted in a greater duration of stress and cumulative fatigue for firefighting personnel.

Historical and political differences between the two tribal governments and appointed tribal representatives regarding acceptable activities or actions within shared tribal "mutual areas of interest" presented additional challenges to collaborative wildland fire management. In remote and limited-access areas (e.g., wilderness), specific challenges arose when two wildfire incidents (Blue 2 and Siskiyou) occurred within the two tribes' ancestral territories and a designated cultural resource management area (similar to a Native American contemporary use area). Differences between IMTs and tribe representatives over how and where contingency firelines should be located and constructed and the use of burnout or firing operations increased the complexity of management options. The Karuk Tribe's fire crew is a type 2 initial attack hand crew, an interagency resource made available through a cooperative agreement with the BIA. In some situations, the crew worked with resource advisors and level I heritage consultants when both tribes desired to limit the amount of nontribal fire personnel within particularly sensitive or sacred areas.

Many IMTs worked with tribes, respecting local tribal beliefs and spiritual sites. Overall, use of MOUs for heritage consultant coordinators and level I or II heritage consultants increased tribal participation and improved tribal input to wildland fire management and BAER operations.

Outcome Assessment

The use of MOUs with components of fire management agreements between American Indian tribes and Federal agencies can significantly improve consultation and collaboration regarding wildland fire management. In the 2008 fires, localized collaborative decision-making promoted results that were generally consistent with tribal values and agency goals and objectives. Increased tribal participation with incident operations facilitated protection or reduced potential impacts to culturally significant resources, areas, and sites.

The complexity and size of incidents allowed for scaling of the level of participation or positions by tribes. Designated tribal government representatives, heritage consultant coordinators, and level I or II heritage consultants were able to work with agency fire personnel during incident and BAER activities. In addition to and separate from wildland fire MOUs, other opportunities exist for tribal participation and involvement with incidents, such as the U.S. Department of the Interior, BIA administratively determined hires for tribal fire crews (type II or I), fallers, and equipment operators (e.g., for chainsaws, water trucks, chippers, or excavators).

Recommendations

Because of the recent development and utilization of wildland fire management MOUs, IMTs and wildland fire personnel need to be familiarized with positions and duties of all tribal parties involved. Several recommendations, if implemented, could improve the effectiveness of wildland fire MOUs with tribes:

1. Enhance programmatic tribal capacities and assumption of leadership roles (see Indian Self Determination and Education Assistance Act).
2. Develop, review, modify, and approve agreements prior to each wildfire season.
3. Have agency and tribal personnel complete all necessary qualifications and trainings prior to the beginning of the upcoming wildfire season.
4. Standardize resource advisor training sessions, certification task books, and other materials to promote familiarity with and renewal or revision of agreements with tribes.
5. Include local tribal issues in regional or local unit-specific training. For example, address tribal customs and protocols in local prefire season training with tribal representatives and agency personnel, or address cultural and heritage resources and sensitivity to tribal issues in regional firefighter refresher training sessions.
6. Ensure that BIA-sponsored tribal personnel have records or certificates of qualifications that adequately comply with NWCG or Interagency standards. Perceived differences in training standards between the BIA and the Forest Service can complicate or hamper tribe member participation.
7. Include copies of the current wildland fire management MOU for each tribe in line officer briefings and delegation of authority documents and in IMT information packets.
8. Review and clarify positions, roles, responsibilities, and duties among IMTs, agency line officers, and tribal personnel per agreements.

At times, the lack of agency and contractor knowledge of—and sometimes lack of sensitivity to—American Indian customs, beliefs, practices, and sacred areas or sites strained working relationships between Indians and non-Indians.

9. Compile and organize all tribally significant data pertaining to tribal ancestral territories, areas of mutual interest, special cultural management areas (e.g., Native American contemporary use areas or other cultural management areas) or other geospatially referenced information for areas where wildland fires or management of fires could impact cultural and heritage resources. This data should include information from LRMPs specific to tribes, cultural resources, heritage or historic areas, and archaeological sites. This data can be helpful for assessing tribal concerns and values at risk for Wildland Fire Decision Support System–Rapid Assessment of Values-at-Risk planning. If desired by tribes, provide site record information from agencies (e.g., heritage programs and archaeologists) with the appropriate level of sensitivity to the IC operations chief. Site records are confidential, but designated tribal government representative(s) and heritage resource advisors should be able to work directly with information centers and tribal heritage preservation officers to ensure they have the proper information on site records to protect the archaeological resources and sacred sites.
10. At incident briefings, describe and clarify roles, qualifications, and planning and operations coordination with tribal personnel. This can provide opportunities for updating each other regarding emerging issues and operational strategies.
11. If tribe-owned equipment or operators are hired in administratively determined crews, have documentation for rates of pay, proof of insurance, and required certificates.
12. Make hardcopy and digital forms of all necessary documents available to agency and tribal leadership for incident planning.

Additional information about wildland fire management MOUs with tribes can be obtained from the Forest Service, Pacific Southwest Region, Klamath and Six Rivers National Forests; the Karuk Tribe; or the Yurok Tribe. Contact Frank K. Lake regarding his experience working as a resource advisor coordinator and research ecologist with tribes on wildland fires, forestry, ethnobotany, and fire management in northwestern California.

Acknowledgements

I am grateful to Paul Claeyssens, Deschutes National Forest; LeRoy Cyr, Six Rivers National Forest; and Carl Skinner, Pacific Southwest Research Station, for their review and suggested revisions to earlier versions of this article. I am grateful to Janet Boomgarden, Forest Service grants and agreements specialist, for her knowledge about and access to agency-tribe agreements; to Janet Werren, Pacific Southwest Research Station

Fire Management Operations: Tribal Perspective

According to Bob McConnell, a member of the Yurok Tribe and the cultural resources coordinator, who served as a designated tribal representative on the Blue 2 Fire in 2008, "It is important for other tribes to know about and be able to utilize tribal fire management MOUs." McConnell has been requested by other tribes nationally to share the example of the Yurok tribe fire management MOU with the Six Rivers and Klamath National Forests.

According to McConnell, the agreements facilitate the inclusion of tribal desires, concerns, and perspectives in wildland fire management within their ancestral territory. "Some incident management teams are not very familiar with the agreements. There can be some resistance to incorporation of tribal values and personnel recommendations if incident commanders are not familiar with tribal consultation or agreements."

In particular, the agreements familiarize incident management teams (IMTs) with the inclusion of tribal values in incident planning and operational efforts. McConnell relates, "In northwestern California, tribes are [politically] active and voice their concerns and interest regarding management of their ancestral territory. Many IC [incident command] teams may not be accustomed to having to work with tribes." He goes on, "The agreement worked as well as it could given the complexity of the incident. Multiple wildfires involving different levels of IMTs and a long fire season increased the challenges. When tribal perspectives were shared, and the adoption or recognition of these values by IMT personnel happened, relations improved."

In addition to incident management teams, many firefighters at all levels—from branch chief and division supervisors to type II crews—were not accustomed to having to work with tribal heritage resource advisors. At morning briefings, tribal designated representatives were able to address the fire personnel and crews. McConnell recalls how this really helped people new to working with tribes. "Daily communication was important to inform the fire crews of [tribal] issues. Incident coordination and working relationships improved when tribal representatives could directly address firefighters about issues, concerns, and particular tribal

Reconnaissance of a contingency fireline by a Yurok heritage consultant and an archeologist resource advisor in a tribal sacred area of the Siskiyou Wilderness, Blue 2–Siskiyou Complex, 2008. Photo: Bob McConnell, Yurok Tribe.

geographic information systems specialist, for map development; to Robert (Bob) McConnell, Yurok Tribe, for his sidebar and photo contribution; Bill Tripp, Karuk Tribe for his comments and review; and to the Yurok and Karuk Tribes' fire management personnel for knowledge shared.

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values. Fire crews began to understand why tribes desired certain actions and bought into mitigation strategies"—for example, regarding the culturally and ecologically important tree, Port Orford cedar, strategies to prevent cedar root disease and protect sacred sites and areas.

At times, McConnell had to address the various ways some fire personnel did not recognize the contemporary living cultures of tribal people. For example, the approach of non-native archaeologist resource advisors, based on their training, was to record everything concerning cultural use sites, while the preference of many tribal heritage consultants was to not record site specifics out of deference for ongoing use. With this in mind, McConnell worked with archaeologist resource advisors to scout potential contingency lines during construction of firelines. "This is different from the agency perspective and approach to archaeological site documentation. Nonlocal archaeologist resource advisors had philosophical differences with how to address prehistoric use versus continued site use by contemporary tribal practitioners."

Communication challenges were ongoing, as each operational shift, new IMT, creation of new wildfire complex, and influx of new firefighters posed challenges to tribal representatives. In particular, McConnell recounts, "Planning meetings with IC went fair to okay most of the time. At least one time, both tribes [Yurok and Karuk] agreed to a plan of action, but the IC changed fire management actions despite the tribal desires. The tribes maintained their 'No' position to the proposed action." In this situation, the IC chose a different course of action than what was desired by the tribes.

Another challenge stemmed from separate tribal recommendations for the same area in establishing precomplex unified control to the merging of the Blue 2 and Siskiyou fires. Working with the Blue 2 Fire IMT, McConnell was shown a map of the Siskiyou Wilderness with the fire containment boundary drawn through Elk Valley, an area held sacred to both tribes. He consulted with Yurok tribal leaders and elders about the proposed actions. The Yurok Tribe suggested using a recreational trail as the fireline versus a natural feature, the ridge. "This recreational wilderness trail was recon'ed and flagged, and then nothing was done for a while." During this time, the Karuk Tribe, independently addressing the southwestern boundary of the Siskiyou Fire, proposed a different fireline location through the same area. "The lack of coordination between the IMTs for the two incidents resulted in overlapping searches for suitable contingency lines."

Furthermore, "Tradeoffs also had to be made regarding recreational backpacker versus tribal spiritual use, as well as whether the trail could be made into a fireline." Conflicting opinions arose as to whether to mark the trail with flagging and open it for use as a fireline or to maintain the tribal practitioners' spiritual seclusion, privacy, and use. Differences arose in tribal preferences as to where to put the fireline.

Despite these day-to-day challenges, overall tribal fire management agreements facilitated more effective consultation, coordination, and collaborative wildfire incident planning with tribes. The Yurok Tribe, for instance, was able to have representatives involved with incident planning and operations at all levels. McConnell hopes that other tribes and fire managers who work with or will have to work with tribes on wildland fires can learn from the Yurok Tribe's experience.

For more information on tribal MOUs and fire planning, contact Bob McConnell at <rmcconnell@yuroktribe.nsn.us>.

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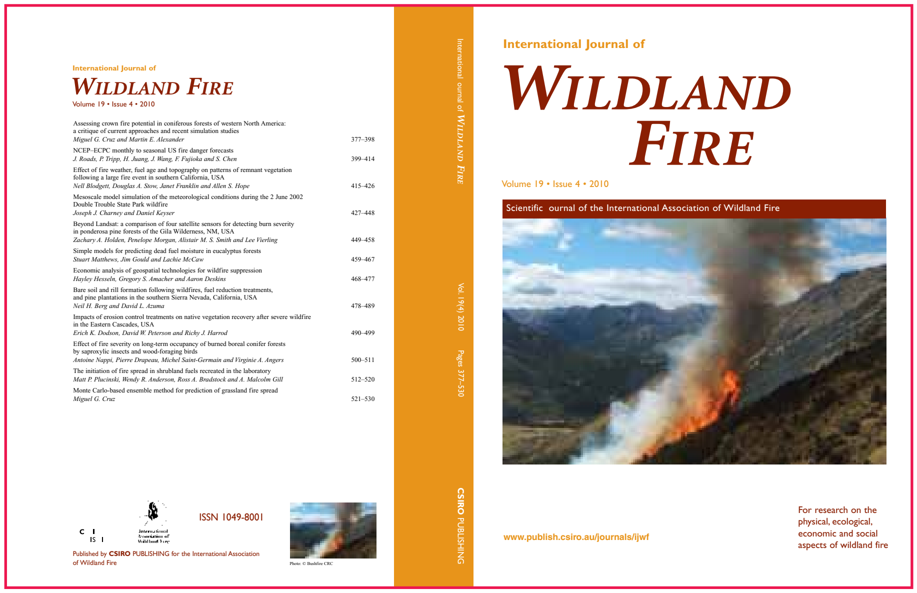
A Celebration of Excellence in Wildland Fire Science: *The International Journal of Wildland Fire* Is 20 Years Old

Martin E. Alexander

The International Association of Wildland Fire (IAWF) is a non-profit, professional organization founded to promote a better understanding of wildfire. It is built on the belief that an understanding of this dynamic natural force is vital for natural resource management, firefighter safety, and harmonious interaction between people and their environment.

The IAWF is dedicated to facilitating communication within the entire wildland fire community and providing global linkage for people with shared interest in wildland fire and comprehensive fire management. Publications such as the proceedings of wildland fire safety summits (Alexander and Butler 2008) and the *International Journal of Wildland Fire* contribute to this communication objective.



Happy Birthday to You!

The IAWF is pleased to be able to celebrate two decades of publishing the *International Journal of Wildland Fire*, of which the Forest Service, led by Bill Sommers,* was an early supporter. Since 1991, the IAWF has published more than 800 articles in the journal, covering a very wide range of wildland fire-related topics of both a basic and applied research nature—for example: fire behavior, fire suppression, prescribed fire, firefighter safety, fire danger rating, fire effects, fire detection, and fire history. The sidebar, "A Selection of Fire Management-Oriented Articles From the International Journal of Wildland Fire, Volumes 1–20," illustrates some of the insights into fire operations and policy that the journal provides to the wildland fire management community.

Present Status

Currently, the *International Journal of Wildland Fire,* published on behalf of IAWF by CSIRO Publishing, Australia (<http://www.publish.csiro.au/journals/ijwf>), publishes 8 issues each year, totaling approximately 90 articles. In 2009, the IAWF Board of Directors elected to include online access to past and present issues of the *International Journal of Wildland Fire* as one of the benefits of membership in the association. Free online access to this resource, including archival material dating back to 1991, is available through the IAWF Web site <http://www.iawfonline.org/> by simply selecting *Member Log-in* and then *IJWF Online*. This online access to the journal constitutes a great resource of technical and scientific literature.

Dr. Marty Alexander is an adjunct professor of wildland fire science and management in the Department of Renewable Resources and the Alberta School of Forest Science and Management at the University of Alberta in Edmonton, Alberta, Canada. He served as an associate editor of the International Journal of Wildland Fire for 10 years (1993–2002). Dr. Alexander has been a member of the International Association of Wildland Fire Board of Directors since 2008 and the Journal's Editorial Advisory Committee since 2009. As one of the many founding members of the association, he officially became a life member in 2003, when he received the International Wildland Fire Safety Award.

*Bill Sommers was the Forest Service Director of Forest Fire and Atmospheric Sciences Research from 1986 to 1997, and the Director of Vegetation Management and Protection Research from 1997 until he retired in 2000.

To a Promising Future

The *International Journal of Wildland Fire* is aimed not only at the international wildland fire research community, but also at practioners and policymakers who have a requirement to ensure their policies and practices reflect the latest scientific evidence. The journal thus provides an invaluable source of research findings of direct relevance to the global wildland fire management community. Here's wishing for many more, happy returns!

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50 Years of Service: The Missoula Fire Sciences Laboratory

Jane Kapler Smith, Diane Smith, and Colin Hardy

On September 12, 1960, the brand new Northern Forest Fire Laboratory was dedicated in Missoula, MT. The fire lab's mission was—and is—to improve scientific understanding of wildland fire so it can be managed more safely and effectively in the field. The first scientists to work at the fire lab initiated research that continues to be used, refined, and extended.

The questions studied and the technology used at the fire lab have evolved continually since 1960, and the lab's name has changed more than once. Today, it is the Missoula Fire Sciences Laboratory. But the original focus—developing a greater understanding of wildland fire and using the best technology available to get that knowledge into the hands of fire managers—has been a way of life for fire lab scientists for a half-century.

Dedication of the Northern Forest Fire Laboratory, now the Missoula Fire Sciences Laboratory, in Missoula, MT, on September 12, 1960. The facility includes a 66-foot-high combustion chamber, inside the tall part of the building, that allows for burn tests in controlled conditions. Photo: Forest Service.

Fuel Moisture and Fire Danger

In the late 19th and early 20th centuries, severe, life-destroying fires plagued forests in the United States. To help field rangers predict and suppress such fires, the Forest Service initiated a fire research program. In the 1920s, Harry Gisborne—the agency's first full-time fire research scientist—began

Recent experiments in the fire lab's burn chamber simulate various thresholds and limitations to fire spread on a hillside. Photo: Forest Service.

Jane Kapler Smith is an ecologist, Diane Smith is an historian, and Colin Hardy is the program manager at the Missoula Fire Sciences Laboratory in Missoula, MT.

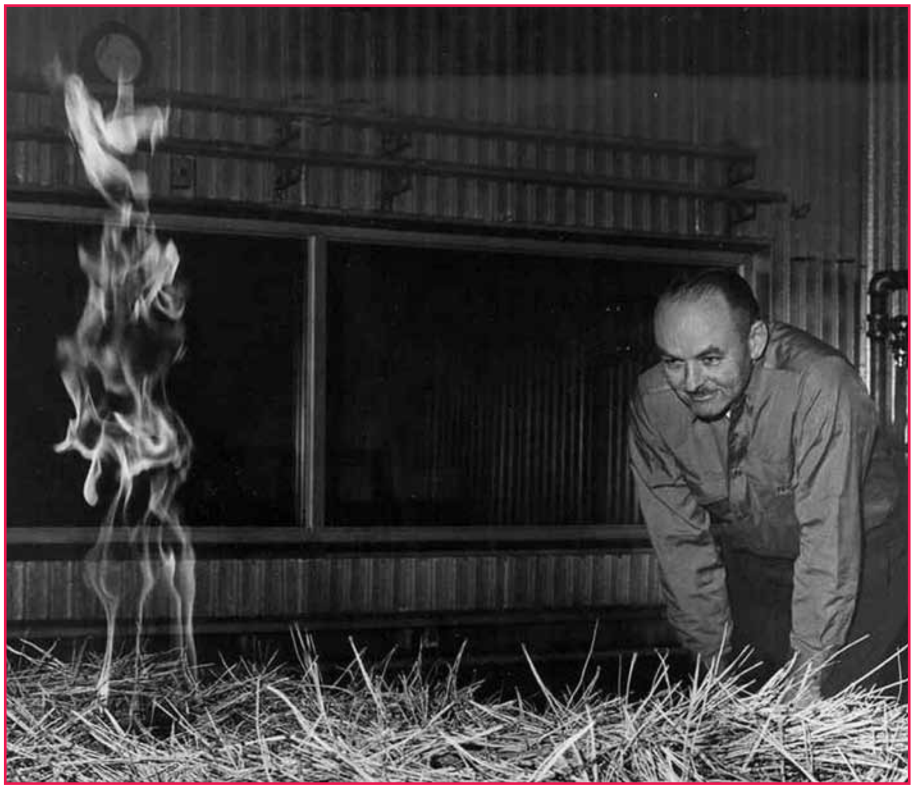
developing a way to predict fire danger. Believing that the moisture content of fuels was key to understanding flammability, Gisborne weighed known amounts of fuel regularly, calculated their moisture content, and related the changes to ambient weather conditions. These results were immediately put to use in the field to assess fire potential, but it was also clear that laboratory experiments were needed. This need was met with the opening of three research laboratories, including the Missoula fire lab in 1960. Jack Barrows was the first director of the lab.

After successfully securing funding for the fire lab, Jack Barrows' next chore was to identify and hire researchers to work in the new facility. Barrows brought in foresters, physicists, and engineers to develop quantitative indicators of fire danger. Within 5 years, these scientists had conducted more than 200 experimental burns and identified thresholds of fuel moisture that could be used to identify "red-flag" conditions when fire danger was increasing rapidly. Continued experiments contributed to release of the National Fire Danger Rating System (NFDRS) in 1972, which provided managers with a standard system for assessing fire danger from local weather observations.

With revisions in 1978 and 1988, the NFDRS still forms the basis for local fire danger rating, which is shared with the public on hundreds of Smokey Bear signs throughout the Nation. In 1994, fire lab scientists developed the Wildland Fire Assessment System (WFAS), which consolidates data from thousands of local weather stations to map fire danger across the country (fig. 1), alerting field managers to regional changes and emerging needs for fire suppression.

Computer Tools for Fire Prediction

A crucial component of the NFDRS was the fire model developed by Richard (Dick) Rothermel and published in 1972. The model predicts the spread and intensity of surface fire based on fuel properties, fuel moisture, wind, and slope. Soon after publication, the model was



Jack Barrows, chief of the fire laboratory in 1960, works in the wind tunnel of the new facility. Photo: Forest Service.

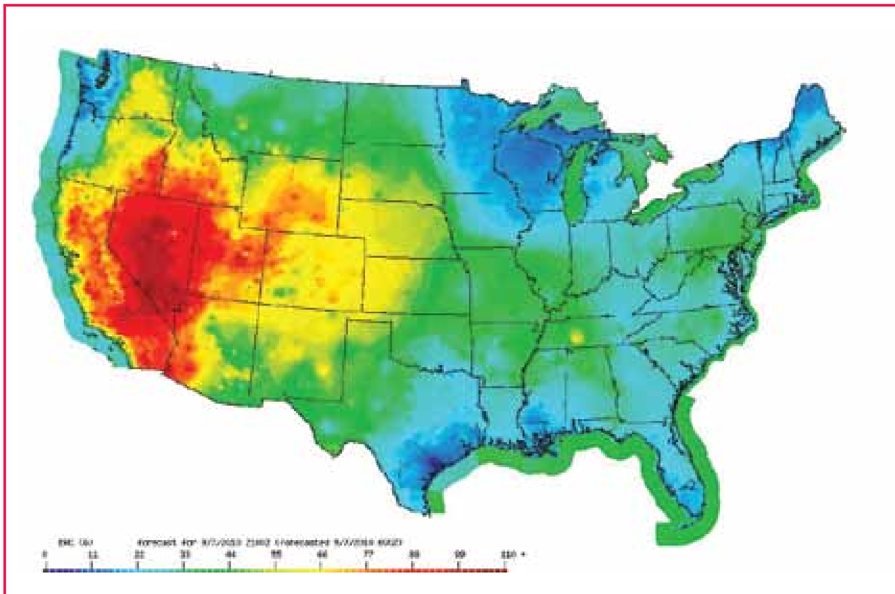


Figure 1—*Fire Danger Class map for conterminous United States, September 9, 2010. Source: Larry Bradshaw, Missoula Fire Sciences Laboratory.*

put to work predicting wildland fire behavior:

- Initially, a system of graphs and charts captured model results. Soon, hand-held calculators were programmed to predict fire spread in the field.
- In the mid-1970s, the Rothermel model was integrated with dozens of supporting models into the BEHAVE system for predicting fire behavior in multiple weather and fuel conditions.
- In the 1990s, the availability of geospatial data on fuels and topography allowed the Rothermel model to be integrated with other models into programs for predicting fire perimeters and spatial fire behavior, including FARSITE (fig. 2).
- In 2007, new systems were initiated for simulating fire growth under thousands of weather scenarios so that managers could estimate the likelihood of fire impacts.

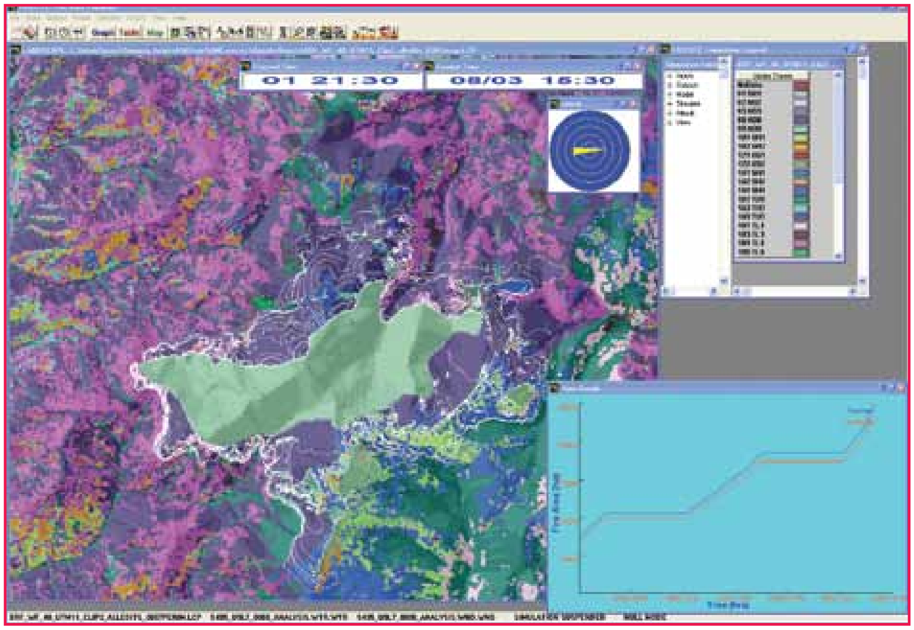


Figure 2—*Computer modeling is used extensively to predict fire spread across landscapes. Here, FARSITE shows fuel types, topography, and potential fire growth on the landscape. Source: Chuck McHugh, Missoula Fire Sciences Laboratory.*

Scientific Measurement of Fuels

How much fuel is available to feed a fire? In the early 1970s, scientist Jim Brown developed methods for measuring the amount of woody, shrub, and herbaceous fuels on the forest floor. Some of these measurements were consolidated into tables of numbers that feed the Rothermel fire model. Today, 40 such quantitative descriptions of fuel complexes are in use throughout the United States. A recent innovation enables managers to match field observations with photographs of known amounts of fuel to improve the accuracy, precision, and efficiency of fuel biomass estimation.

Scientist Jim Brown measures the fuels on the forest floor to establish fuel loading relationships. This 3- by 3-foot (1- by 1-m) area contained about 10 pounds (4.5 kg) of woody fuel. "Brown's transects" remain the standard for fuel load estimation in the field. Photo: Forest Service, 1972.

Fire spread in the forest canopy is more complex than on the forest floor. Careful dissection of hundreds of tree crowns in the late 1990s enabled scientists to describe the vertical distribution of crown fuels. Research currently underway uses fractal mathematics to generate three-dimensional models of crown fuels (fig. 3). These models can be used to describe fuel properties that are difficult to measure directly, such as surface area and distribution of particle sizes in tree crowns. This approach will improve managers' ability to predict crown

Figure 3—*Research currently underway uses fractal mathematics to generate three-dimensional models of crown fuels. Source: Russ Parsons, Missoula Fire Sciences Laboratory.*

fire behavior and estimate fire effects in the complex, discontinuous fuels of the canopy.

Fire and Forest Ecology

Through the 1960s, managers became increasingly aware of fire as a natural agent of change and renewal. In the early 1970s, scientist Robert (Bob) Mutch helped managers develop area-specific prescriptions for allowing some lightning fires to burn in the Selway-Bitterroot Wilderness. The first such fire occurred in 1972 and covered all of 600 square feet (58 m^2). Since that time, lightning fires have burned more than 500,000 acres (202,000 ha) in the Selway-Bitterroot and Frank Church River of No Return Wilderness areas, producing an intricate mosaic of habitats across the landscape. Managers of natural areas across the country now recognize and welcome the ecological benefits of fire.

Most ecosystems have a specific relationship with fire, known as the fire regime: how often fires occur and their size, season, and severity. Beginning in the 1970s, research forester Steve Arno used fire scars on trees to determine the frequency of surface fires in forests of the northern Rockies. In recent years, research forester Emily Heyerdahl has used fire scars and tree growth rings to determine the climate during years of widespread fires in Idaho and western Montana. She identified 32 years when fires were widespread throughout the region. These years had warm springs followed by warm, dry summers.

In the late 1960s, the fire lab, with multiple collaborators, initiated a rigorous field study addressing the role of fire in forests of spruce, fir, and western larch—the Miller Creek-Newman Ridge project.

In more than 30 publications, scientists reported the effects of prescribed fire in clearcut units on tree regeneration, small mammals, physical and chemical properties of soils, hydrology, re-establishment of shrubs and herbs, and smoke production. Since that time, fire lab scientists have studied ecosystem-level fire effects throughout the United States, particularly in forests dominated by ponderosa pine, Douglas-fir, lodgepole pine, and whitebark pine. Research on whitebark pine has led to international collaboration as scientists and managers seek ways to restore this unique ecosystem.

Emily Heyerdahl cuts through a stump to examine tree rings. Dendroecological techniques enable scientists to use dead wood to learn about the history of fire in the area. Photo: Forest Service.

Researchers at the site of the Miller Creek prescribed fire weigh water cans before and after a 1968 broadcast burn to calculate energy release in burning fuels. Photo: Forest Service.

International Connections

The fire lab not only produces new knowledge but also packages knowledge from around the world so it can be readily used by fire managers. From 1978 to 1981, fire lab scientists authored two of the six "Rainbow series" publications that detail how fire affects various ecosystem components. A comprehensive revision of this series began in 2000, with fire lab scientists editing four of the six new volumes.

The First Order Fire Effects Model contains equations from research nationwide that predict tree mortality, fuel consumption, soil heating, and smoke emissions from fire. Ecologists at the fire lab also synthesize knowledge from thousands of studies, packaging the results in the Internet-based Fire Effects Information System (<http://www.fs.fed.us/database/feis>), which currently hosts literature reviews covering more than 1,200 species.

The fire lab's first smoke measurements were obtained from instruments located at Miller Creek in 1967. But local information is not sufficient: fires on all continents contribute to pollutants and greenhouse gases in the atmosphere. In 1987, the fire lab began studying the chemistry of smoke from burning biomass, whether from wildfires, cooking fires, or charcoal production. Chemists conducted field experiments in Brazil, South Africa, Russia, Mexico, and many other countries to describe the compounds in smoke, how they change over time, and where they go. Chemist Wei Min Hao contributed results to the United Nations' Intergovernmental Panel on Climate Change, which earned the Nobel Peace Prize in 2007 for increasing understanding of climate change.

Fire lab scientists have contributed to and edited four of the six national syntheses of fire effects research, the Wildland Fire in Ecosystems series. (Not pictured: "Effects of Fire on Cultural Resources and Archaeology.")

Studies of fire in landscapes in other countries helped broaden the experience and applicability of fire analysis. Here, smoke samples are taken in a 2006 controlled burn in Mexico. Photo: Forest Service.

The Biomechanics of Fire

What kind of fire behavior would kill organisms in the soil? How much heat does it take to kill a tree? In the early 1980s, fire lab scientists conducted experiments measuring the transfer of heat from fire into soil and living organisms. Using the knowledge gained in these experiments, they developed a model to predict soil heating. This model helps managers predict the effects of fires on soil fertility, underground plant parts, and organisms in the soil. Later experiments looked at heat transfer through the bark of trees into living cells. The FireStem model developed jointly between the Missoula Fire Sciences Laboratory and the Forest Service Northern Research Station describes heat transfer through tree bark. FireStem helps managers predict tree mortality based on fire behavior.

Ecosystems are constantly changing. How can the changes associated with fire be predicted? Starting in the 1970s, scientists used state-and-transition diagrams (fig. 4) to illustrate patterns of vegetation change after fire. When probabilities are assigned to these pathways, they can serve as predictive models. However, these models assume that the environment remains unchanged through time. In contrast, the FIRE-BioGeoChemical Succession Model (FIRE-BGC), initially developed in the 1990s, bases predictions on the flow of material and energy through ecosystems as influenced by weather, climate, fire, and many other factors. An updated version of the model is currently being used to explore potential changes in ecosystems due to changes in climate (fig. 5).

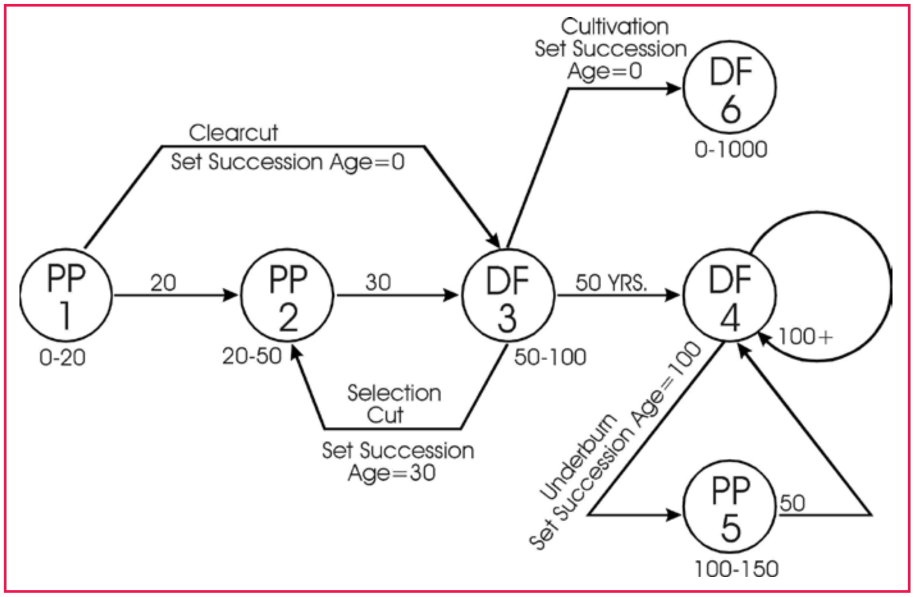


Figure 4—*State-and-transition diagram uses a graphical technique developed in the 1970s to show potential paths of forest change. PP=ponderosa pine; DF=Douglas-fir. Source: Bob Keane, Missoula Fire Sciences Laboratory.*

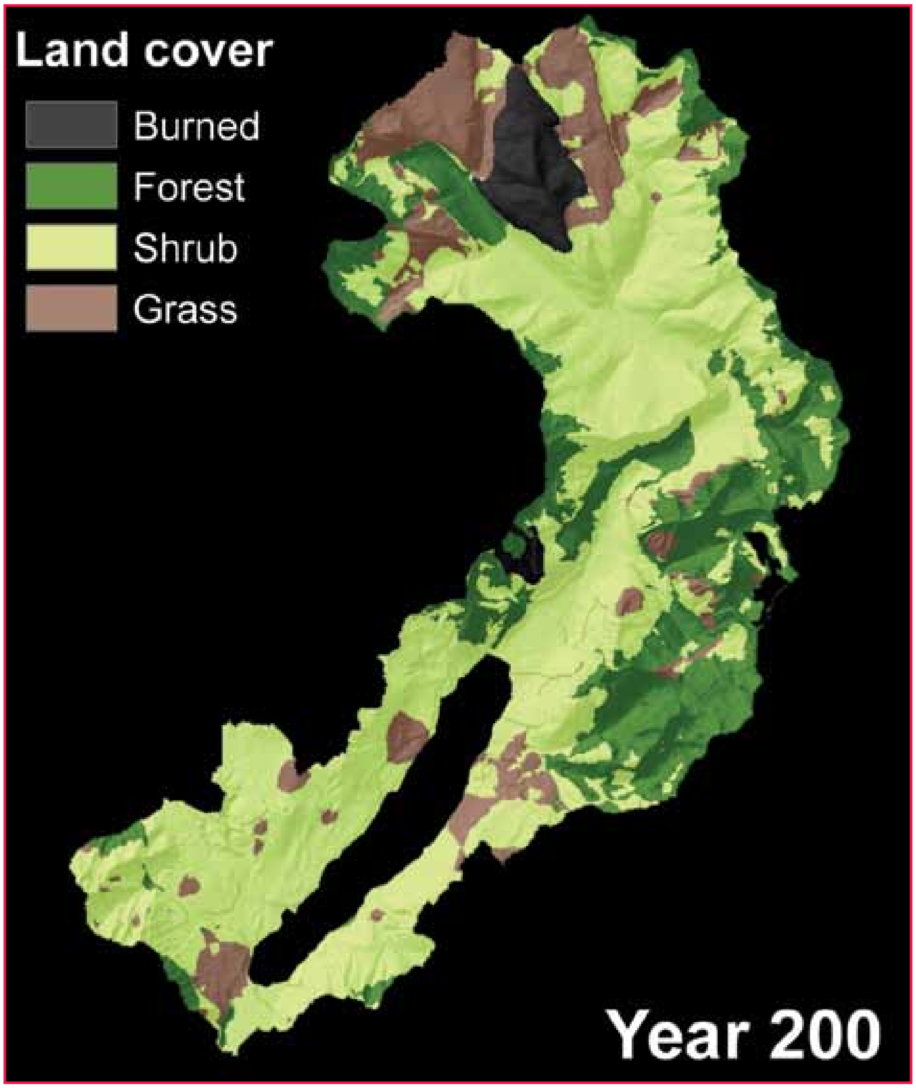


Figure 5—*In a watershed dominated by forest in 2009, FIREBGCv2 predicts shrubs will dominate after 200 years of influence from changed climate and wildfire. Source: Rachel Loehman, Missoula Fire Sciences Laboratory.*

Finding Fires

The sooner a manager knows where a fire is, the better—but it is not easy to locate fires in the vast expanse of America's wildlands. In 1962, fire lab scientists began using aerial infrared photography to detect and map fires. Within a few years, managers adopted this technology to identify problem areas within fires, establish safety zones for firefighters, and locate spot fires. Infrared flights could map 3,000 square miles (7,770 km^2) in an hour. Today's moderate resolution imaging spectroradiometer (MODIS) satellite sensor detects "hot spots" across the country several times a day. The fire lab receives this information via a globe-shaped satellite dish on the roof of the facility. Scientists use the data to map the burned area of ongoing fires; this helps predict smoke production, the height of smoke plumes, and smoke dispersion rates—all matters of concern for safety and human health. Smoke data also help scientists estimate the interactions between fire and climate change.

Research at the Missoula Fire Sciences Lab continues to build on what has been learned in the past, and new technology is opening entire new fields of inquiry. A few examples:

- Light Detection and Ranging (LIDAR) imagery describes smoke plumes in ever greater detail.
- Mathematical models are being used to map wind flow (fig. 6). This information improves the accuracy of fire spread predictions.
- Field work increases managers' ability to predict tree mortality caused by fire and bark beetles.

A satellite receiving dish installed on the roof of the fire lab collects infrared data several times a day to map "hot spots" across the United States. Photo: Forest Service.

- Experimental work contributes to improved guidelines for safety of firefighters and homes.

The Missoula Fire Sciences Laboratory continues to produce new knowledge for safer, more effective, and ecologically appropriate management of wildland fire.

For more information, visit <http://firelab.org>. A history of the Missoula Fire Sciences Laboratory is in press. To receive a copy, email dianemsmith@fs.fed.us." ■

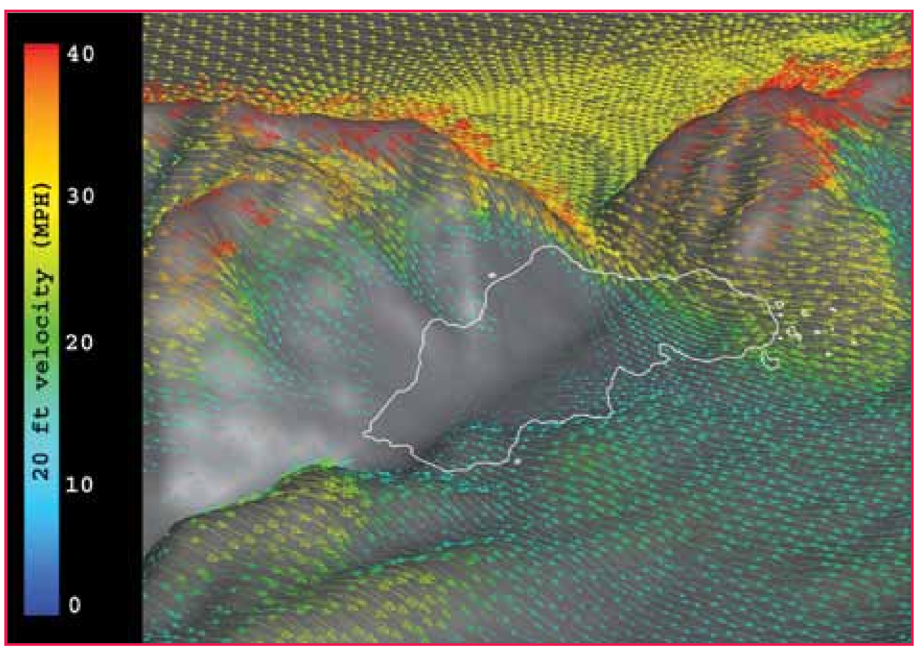


Figure 6—*WindWizard predicts wind patterns across a landscape, 2010. Source: Bret Butler, Missoula Fire Sciences Laboratory.*

Estimated Smoldering Probability: A New Tool for Predicting Ground Fire in the Organic Soils on the North Carolina Coastal Plain

James Reardon and Gary Curcio

In the Southeastern United States, fires in pocosin wetlands and other similar vegetation communities with deep organic soils are a serious concern to fire managers. Highly flammable shrubs, such as gallberry and fetterbush, and small evergreen trees, such as red and loblolly bay, create the potential for extreme surface fire behavior. Moreover, deep organic soils allow excessive ground fire smoldering in these communities. The combustion of organic soils produces large amounts of persistent smoke, which is linked to health concerns and increases the potential for vehicle accidents due to reduced visibility.

Wetland Ground Fires: A Challenge to Suppress

Ignitions in pocosins can quickly "blow up," creating major fire runs that defy control efforts until weather or fuel conditions change. In May of 1986, the Topsail Fire made several major runs and remained uncontrolled for a week in eastern North Carolina. A successful backfire operation involved the mass firing of 10,000 acres (4,000 ha) and created a convective plume reaching 15,000 feet (4,500 m) and fire spread rates of 2 to 2.5 miles per hour (3.2 to 4 km per hour). More recently in North Carolina, the Evans Road Fire of June 2008 made major fire runs encompassing 7,000 to 12,000 acres per day (3,000 to 5,000 ha per day). In the aftermath of these runs,

Ignitions in pocosins can quickly "blow up," creating major fire runs that defy control efforts until weather or fuel conditions change.

Fireline preparation and back-firing on the Evans Road Fire. Photo: U.S. Fish and Wildlife Service.

Smoldering combustion and organic soil consumption on the Evans Road Fire. Photo: Bonnie Strawser, U.S. Fish and Wildlife Service.

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ground fire in the organic soils consumed up to 36 inches (91 cm) of organic soil and generated massive smoke plumes that impacted communities along the eastern coast for 2 months (Bailey and others 2009).

Suppression of smoldering ground fires presents serious challenges to fire managers. In these wetlands, suppression alternatives are often limited by accessibility, and soils often cannot support the weight of heavy equipment. Frequently, the extent and severity of smoldering makes flooding the only viable option for dealing with ground fires. For example, the ground fire on the Evan's Road Fire was contained by over 2 billion gallons (8 billion L) of water. The water was moved through existing drainage networks, with some water sources more than 35 miles (56 km) from the fire.

Assessing Ground Fire Potential

Tools for evaluating the potential for ground fire in organic soils are limited. Managers commonly use water levels in shallow water table wells and drainage ditches as indicators of local ground fire risk. Intermediate or regional scale estimates of potential are commonly evaluated using the Keetch Byram Drought Index (KDBI). However, our previous research has reported that the KDBI and water level measurements are inconsistent estimators of ground fire risk in these soils (Reardon and others 2009).

Currently, a network of fire danger stations monitors surface fire conditions, but they do not monitor ground fire potential. Due to the lack of suitable methods to evaluate ground fire risk, fire managers often must rely heavily on broad guidelines developed from local knowledge and past experiences. Their judgments are often based on visible characteristics, not on other, more subtle changes in fuel characteristics, such as moisture changes. Although their decisions often result in positive outcomes, fire managers are sometimes surprised by extreme surface fire behavior and unexpected smoldering in what were initially considered benign fuels.

An efficient means of evaluating ground fire potential in organic soils would help managers use prescribed fire with minimal or limited resources and would increase the effective use of wildfire personnel and equipment resources during suppression activities.

Estimated Smoldering Probability

Ground fire in pocosin soils is associated with a porous root mat layer that is dominated by moderately decomposed organic material and fine to small roots (fig. 1), as well as a dense muck layer composed of highly decomposed organic material. The ability to predict ground fire in these soil layers is limited by our understanding of the moisture levels supporting smoldering combustion. To determine the moisture threshold between smoldering and nonsmoldering conditions, we collected soil samples from several sites on the North Carolina Coastal Plain and burned the soils in laboratory experiments. The laboratory burning experiments simulated common field conditions during

Figure 1—*Root mat soil layer. This layer was between 12 and 18 inches (30 and 45 cm) thick on the burn units. Photo: Jim Reardon, Forest Service.*

which an ignition source establishes a ground fire in the root mat and continues smoldering into adjacent soil.

Based on this laboratory work, we developed the Estimated Smoldering Probability (ESP) model as a predictive tool for use in the organic soils of these shrub-dominated wetland communities (Reardon and others 2007). This probability model reflects the chance of continued smoldering after a successful ground ignition, when smoldering becomes dependent on soil moisture and soil properties. Model scenarios represent common ignition situations such as lightning strikes, a flaming combustion front, or burning embers. At low probabilities, continued smoldering is not likely and control may require limited resources. At high probabilities, there is a good chance that most ignitions will be sustained and control will be more difficult.

Organic soils, including the root mat and muck layers in these wetlands, often have high moisture contents due to their ability to absorb and hold relatively large amounts of water. The percent moisture content of organic soils is determined based on the weight of water in the soil and the weight of the soil when it is dry. When the weight of water in the soil is greater than the soil dry weight, the percent moisture content exceeds 100 percent. Moisture contents of greater than 400 percent are common for saturated muck soils in North Carolina, and moisture contents greater than 800 percent have been reported for saturated feather moss soils in boreal black spruce forests.

Our analysis shows that the ESP of the root mat soil is related to moisture content and soil mineral content (fig. 2). For example, in root mat soils with a moisture content of 93 percent and an average mineral content of 4.5 percent, there is an estimated 50 percent probability of sustained smoldering. The ESP decreases to less than 10 percent in soils with moisture contents above 145 percent with the same mineral content (fig. 2). Although the ESP of the muck soils is also related to moisture content, it is insensitive to mineral content (fig. 3). Muck soils at moisture contents less than 140 percent have an ESP of 91 percent or greater, while muck soils at moisture contents greater than 250 percent have an ESP of less than 13 percent.

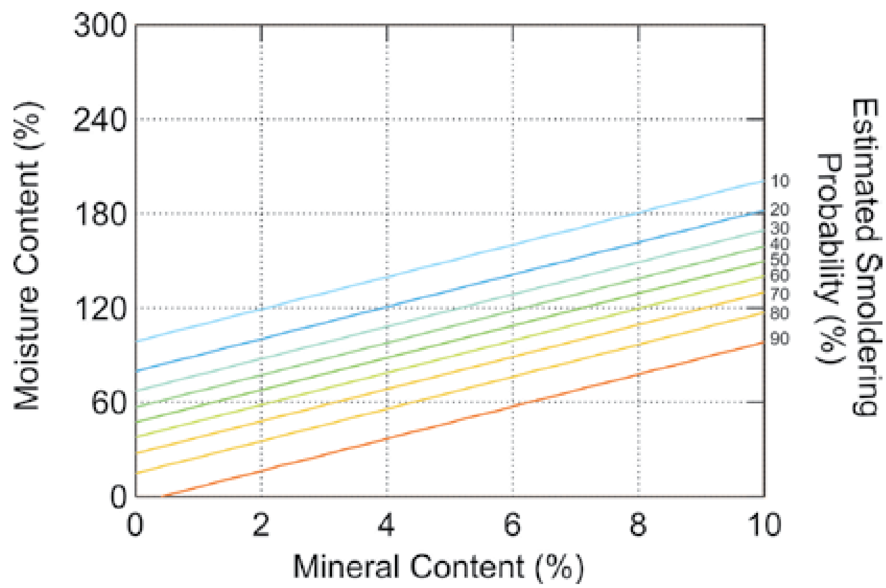

Figure 2—*The estimated smoldering probability in root mat soils as a function of soil moisture and soil mineral content.*

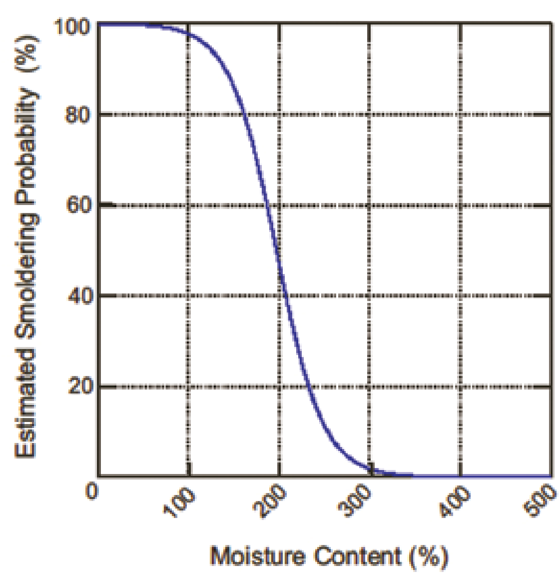

Figure 3—*The estimated smoldering probability in muck soils as a function of soil moisture.*

Small-Scale Field Tests

We conducted field tests of the ESP model using a series of small-scale research burns of approximately 4 to 6 acres (2 ha) and larger scale operational prescribed burns of approximately 100 to 800 acres (40 to 300 ha). We designed the small-scale burns to test the dry and wet moisture content limits of smoldering in these soils. In addition, we evaluated some widely accepted assumptions about smoldering combustion that were based on fire managers' past experiences and observations during these burns.

One burn, conducted during a period of extended drought and dry soil conditions, replicated laboratory observations of a ground fire that established in the dry root mat and spread downward into the muck soil. On the day of burning, the local water table was more than 30 inches (76 cm) below the soil surface and the water level in the ditches surrounding the burn unit was more than 3 feet (1 m) below the soil surface. The average root mat ESP was 84 percent, while the ESP was less than 10 percent at depths greater than 18 inches (46 cm) below the surface. Post-burn consumption measurements showed that ground fire consumed the root mat and stopped in the muck soil at moisture levels not expected to support smoldering.

The water depth in shallow water table wells and the water level in the adjacent drainage network are measures commonly used by managers to evaluate the risk of ground fire. Although conventional wisdom regarding the relationship between water table levels and the depth of smoldering consumption based on these measures suggested that smoldering would continue until

> Fire managers are sometimes surprised by extreme surface fire behavior and unexpected smoldering in what were initially considered benign fuels.

constrained by the water level, neither the laboratory results nor the depth of soil consumption during this burn supported this assumption.

Additional small-scale burns conducted during wet burning conditions replicated observations of laboratory experiments during which the ignition of the surface litter layer initiated smoldering in the upper root mat layer, but the vertical spread of smoldering was constrained by high moisture contents of the lower root mat layer. Again, this contrasts with the accepted assumptions that once smoldering was established, it would not be constrained by soil moisture content.

Large-Scale Field Tests

Although we conducted the small-scale research burns with limited soil and fuel variability, the larger scale burns included levels of variability normally encountered during operational burning and wildland fires. The larger scale burns tested the influence of soil characteristic variability on the application of the ESP model. We conducted these larger burns as part of the North Carolina Division of Forest Resources Operational Research Evaluation Burn Project, which was created to facilitate the use of new research findings and fire management tools to advance prescribed fire.

Wet burn in the Green Swamp, Brunswick County, NC. Photo: Gary Curcio, NC Division of Forest Resources.

The monitoring and evaluation of pre-burn ground fire potential or risk was an important part of the planning of these larger burns. A concise way of incorporating our research results into the decisionmaking process was a simple "Burn–No Burn" moisture content threshold based on an acceptable ESP level. We set the decision point at a moisture content threshold of 170 percent for the root mat soil horizons on these sites. This moisture threshold represents a probability of sustained smoldering of less than 5 percent with an assumed average mineral content of 5 percent (fig. 2). Burning at lower moisture contents and correspondingly higher ESP levels was considered an unacceptable risk due to the uncertainty of soil mineral content combined with the potential for long-lasting residual emissions from smoldering and the costs of suppressing a smoldering ground fire.

A pine woodland burn site with a thick root mat soil layer above a mineral soil layer was characterized by the presence of a pine overstory and a heavy shrub understory. Photo: Gary Curcio, NC Division of Forest Resources.

The thick organic soils along the southeastern Coastal Plain are a unique resource that are not well integrated in the burning decisionmaking process.

On the day of burning, the measured root mat soil moisture was above the moisture content threshold on all sites. The burns were successful, and the absence of sustained smoldering following the burns supports the use of ESP on a wide range of sites.

The Future of ESP

The thick organic soils along the southeastern Coastal Plain are a unique resource that is not well integrated in the burning decisionmaking process. Future increases in burning opportunities in these wetland communities are dependent on better, finer scale tools to evaluate the potential for organic soil consumption. Tools such as ESP can provide valuable insight on burning conditions that support the decisionmaking process and can ultimately help managers use fire with more confidence.

Acknowledgements

This project would not be possible without the work of Angie Carl and Margit Bucher at The Nature Conservancy; Danny Becker and Susan Cohen at Camp Lejeune, NC; and the North Carolina Division of Forest Resources. Funding for this work was provided by the Joint Fire Science Program and Department of Defense Strategic Environmental Research and Development Program.

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A Tool To Estimate the Impact of Bark Beetle Activity on Fuels and Fire Behavior

Michael J. Jenkins, Elizabeth G. Hebertson, Wesley G. Page, and Wanda E. Lindquist

Recent bark beetle outbreaks have resulted in the loss of hundreds of thousands of conifers on approximately 74 million acres (30 million hectares) of forest in western North America during the last decade. Stand conditions, drought, and warming temperatures have contributed to the severity of these outbreaks, particularly in high-elevation forests (USDA 2009). Many forests remain susceptible to bark beetle infestation and will continue to experience high levels of conifer mortality until suitable host trees are depleted or natural factors cause beetle populations to collapse.

Beetle, Fuel, and Fire Interactions

It has long been assumed that fuels altered by bark beetle outbreaks increase the probability of ignition and the potential for increased fire intensity. We reviewed literature relating to the effects of bark beetles on fuels and fire behavior and their implications for forest management (Jenkins and others 2008).

Our recent research has shown that bark beetles affect fuels by increasing litter and fine woody fuel loads and decreasing canopy sheltering, which dries fuels and allows for increased midflame windspeeds. These factors are most important in increasing the probability of ignition and rate of fire spread for the relatively short period (5–10 years) during a beetle epidemic when yellow to red needles are present in conifer stands. During this phase of bark beetle infestation, there is also an increased likelihood of crown fire initiation and spread due to the increased flammability of canopy fuels.

> We predicted potential fire behavior, including rate of spread, flame length, intensity, and potential for crowning.

In the post-bark beetle epidemic phase, fire potential may decrease, however, as canopy fuel continuity is lost and herbaceous and shrub fuels grow to dominate many forest cover types. There may be an increased likelihood of high-intensity fire several decades post-epidemic as standing and fallen snags share the site with advanced regeneration, creating fuel ladders in the presence of increased coarse woody fuels (Page and Jenkins 2007a and b; Jenkins 2011; Jorgensen and Jenkins 2011; Jenkins and others in review).

Simard and others (2011) also reported significant increases in litter and reduction in canopy bulk density during mountain pine beetle outbreaks in the Greater Yellowstone Area. They modeled fire behavior using Nexus and found no increase in crown fire potential during outbreaks, but increased probability of crown fire decades later in the post-outbreak stage.

Online Resources

Fire managers will increasingly encounter timber fires burning in fuels affected by bark beetles. We have developed and maintain a Web site containing research findings and technology useful to forest health and wildland fire professionals responsible for managing conifer forests affected by bark beetles. The Web site is organized through tabs that access research papers, conference presentations, a photo guide for appraising bark beetle-affected fuels, a tutorial for modeling fire spread in bark beetle-affected fuels, an image gallery, and a comprehensive, up-to-date bibliography and links to other related Web sites and resources. The Web site is located at <http://www.usu.edu/forestry/disturbance/bark-beetles-fuels-fire/index.html> (fig. 1).

Photo Guide for Fuels

The photo guide at this Web site contains images of typical fuels associated with endemic, epidemic, and post-epidemic

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populations of bark beetles in Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), and Engelmann spruce (*Picea engelmannii*) forests in the Intermountain Region of the Western United States (fig. 2). The primary bark beetle species infesting Douglas-fir, lodgepole pine, and Engelmann spruce are Douglas-fir beetle (*Dendroctonus pseudotsugae*), mountain pine beetle (*D. ponderosae*), and spruce beetle (*D. rufipennis*), respectively. All three forest types have experienced varying levels of bark beetle-caused tree mortality since the late 1980s.

Specialists within fire and forest health communities may use this photo guide in conjunction with other information to help characterize bark beetle-induced changes in fuels complexes over time. The photo guide provides a link to custom fuel models used for predicting potential fire behavior in bark beetle-affected landscapes.

> The photo guide contains images of typical fuels associated with endemic, epidemic, and post-epidemic populations of bark beetles in Douglas-fir, lodgepole pine, and Engelmann spruce forests in the Intermountain Region of the Western United States

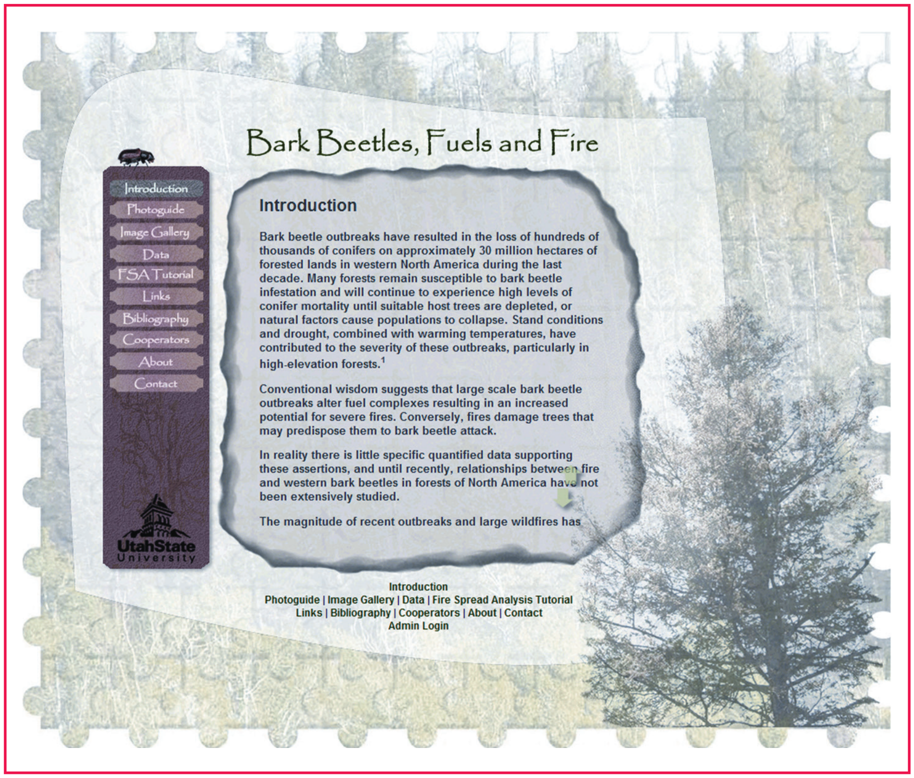

Figure 1—*The Bark Beetles, Fuels, and Fire project Web site at* <http://www.usu.edu/forestry/disturbance/bark-beetles-fuels-fire/index.html>.

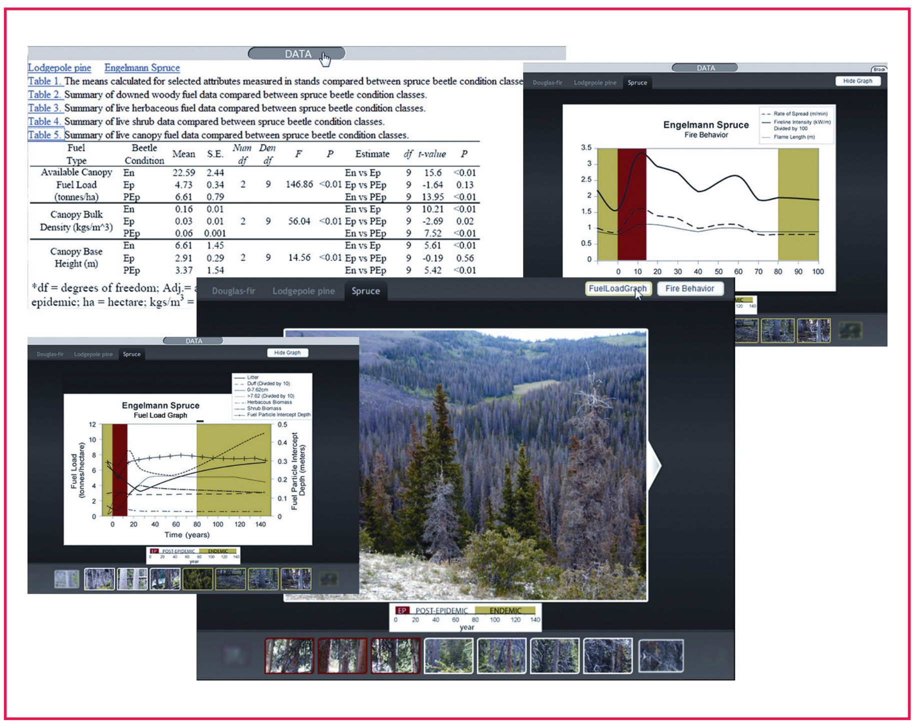

Figure 2—*The Bark Beetle, Fuels, and Fire Photo Guide provides appraisals of fuels associated with endemic, epidemic, and post-epidemic populations of bark beetles in Douglas-fir, lodgepole pine, and Engelmann spruce forests in the Intermountain Region of the Western United States. Fuels data, fuel load, fire behavior model output, and photographs are available for each study site.*

Study Sites and Fuels Data

Fuels data used in developing this photo guide were collected from a number of stands in each of the three major forest types. These data are available by clicking on the data tab in the photo guide section of the Web site.

We classified selected stands in each forest type as either endemic, epidemic, or post-epidemic for assessment of bark beetle-induced fuel loading. We defined stands with endemic populations of bark beetles as those having no evidence of current or older tree mortality attributed to bark beetle infestation. We defined stands with epidemic populations of bark beetles as those having increasing levels of tree mortality and/or at least four clumps of two or more standing infested trees per acre (five or more per hectare). We only sampled plots with at least one infested tree in epidemic stands. We defined post-epidemic stands as those that had more than 60 percent host-tree mortality generally older than 5 years. However, only plots with greater than 80 percent host-tree mortality were sampled in post-epidemic stands. The specific locations of stands sampled by bark beetle population level in each forest type are provided in Table 1.

Two-dimensional fire growth and intensity simulations that help predict the consequences of bark beetle-altered fuels on fire hazard at the landscape scale are vital to fire planners and land managers.

We collected ground, surface, and canopy fuels data on plots systematically distributed throughout endemic, epidemic, and post-epidemic stands in each of the three forest types. Ground and surface fuels were measured using methods developed by Brown (1971), Brown and others (1982), and Anderson (1974). We collected data used for calculating canopy fuels (total available canopy fuel load and crown bulk density) from healthy and bark beetle-affected trees on variable-radius plots superimposed from plot center using methods developed by Brown (1978), Call and Albini (1997), and Page and Jenkins (2007a). We also used fixed- and variable-radius plots to collect standard forest mensuration data (tree species, diameter at breast height, crown class, tree heights, tree ages, and regeneration). Other data recorded included the slope, aspect, and habitat type of each plot. Page and Jenkins (2007a) provide a detailed discussion of these methods.

Photos of Fuel Loads

Following the collection of fuels data, we took digital photos of all fuels transects from plot center. We selected camera settings to obtain high-resolution, high-quality photos suitable for publication. The set of images used in this guide were those that best represented the spectrum of bark beetle-affected fuels observed in endemic, epidemic, and post-epidemic stands when compared to average fuel appraisal and fire prediction outputs. We did not provide fuel appraisals or fire behavior predictions for individual images because of the variability of fuels encountered in bark beetle-affected stands and because fire behavior estimates were deemed unrealistic at an individual photo scale.

Table 1—*Locations of stands used for data and images contained in the Bark Beetles, Fuels, and Fire Web site.*

Forest Type	Bark Beetle Population Level		
	Endemic	Epidemic	Post-epidemic
Engelmann spruce	LaSal Mountains* Fishlake Hightop	Wasatch Plateau Fishlake Hightop	Wasatch Plateau Fishlake Hightop
Douglas-fir	S. Wasatch Mountains Uinta Mountains (E)	S. Wasatch Mountains Uinta Mountains (E)	S. Wasatch Mountains Uinta Mountains (E)
Lodgepole pine	Uinta Mountains (W) Sawtooth National Recreation Area	Uinta Mountains (W) Sawtooth National Recreation Area	Uinta Mountains (E)

*LaSal Mountains: Manti-LaSal National Forest, southeastern Utah; Fishlake Hightop: Fishlake National Forest, southcentral Utah; Wasatch Plateau: Manti-LaSal National Forest, southcentral Utah; Uinta Mountains (E): Ashley National Forest, northeastern Utah; Uinta Mountains (W) and S. Wasatch Mountains: Uinta-Wasatch-Cache National Forest, northern Utah; Sawtooth National Recreation Area, central Idaho.

Custom Fuel Models

We used the measured fuel characteristics to construct custom fuel models using the methods developed by Burgan and Rothermel (1984). This work produced fuel models customized to the actual set of fuel conditions resulting from bark beetle activity over the course of epidemics. With these custom fuel models and average worst case fire weather estimates, we predicted potential fire behavior (rate of spread, flame length, intensity, and potential for crowning) using the Rothermel (1983) fire spread model and BEHAVEplus.

Image Gallery

Images used in the photo guide and others taken during the project are organized in the image gallery of the Web site. Each image is labeled by species, bark beetle condition, and location, representing a broad geographic range in the Intermountain West.

Spread Model Tutorial

Two-dimensional fire growth and intensity simulations that help predict the consequences of bark beetle-altered fuels on fire hazard at the landscape scale are vital to fire planners and land managers. The Fire Spread Analysis (FSA) tutorial tab brings up information for using custom fuel models and the landscape-scale fire behavior models FARSITE and FlamMap to simulate fire spread across bark beetle-affected landscapes. Experienced fire managers will find the tutorial useful in simulating the effect of bark beetles on fire spread.

As an example, we used aerial detection survey maps from 2000 to 2006, our custom fuel models, historic weather data, and data from the Landscape Fire and Resource Management Planning Tools (LANDFIRE) project to create FARSITE/FlamMap landscapes (fig. 3). These landscapes were then used to model and compare fire growth and intensity in a lodgepole pine forest prior to and during a current mountain pine beetle epidemic on the Sawtooth National Forest, ID. Figure 4, a and b, shows the FARSITE projections of endemic and current epidemic mountain pine beetle conditions, respectively. The different colors represent the probability of fires growing from the ignition point to a given boundary over the randomly selected, 3-day weather window. The acres in the output legend display the cumulative acre sizes that include all of the polygons with higher probabilities. For example, the "less than 5 percent" acre value represents the size of the entire polygon including all of the smaller polygons within it. Interpretation of these FARSITE model simulations should consider the weather windows used and the limitations inherent in conventional surface and crown fire spread and initiation models (e.g., live canopy fuel moisture).

> Our recent research has shown that bark beetles affect fuels by increasing litter and fine woody fuel loads and decreasing canopy sheltering.

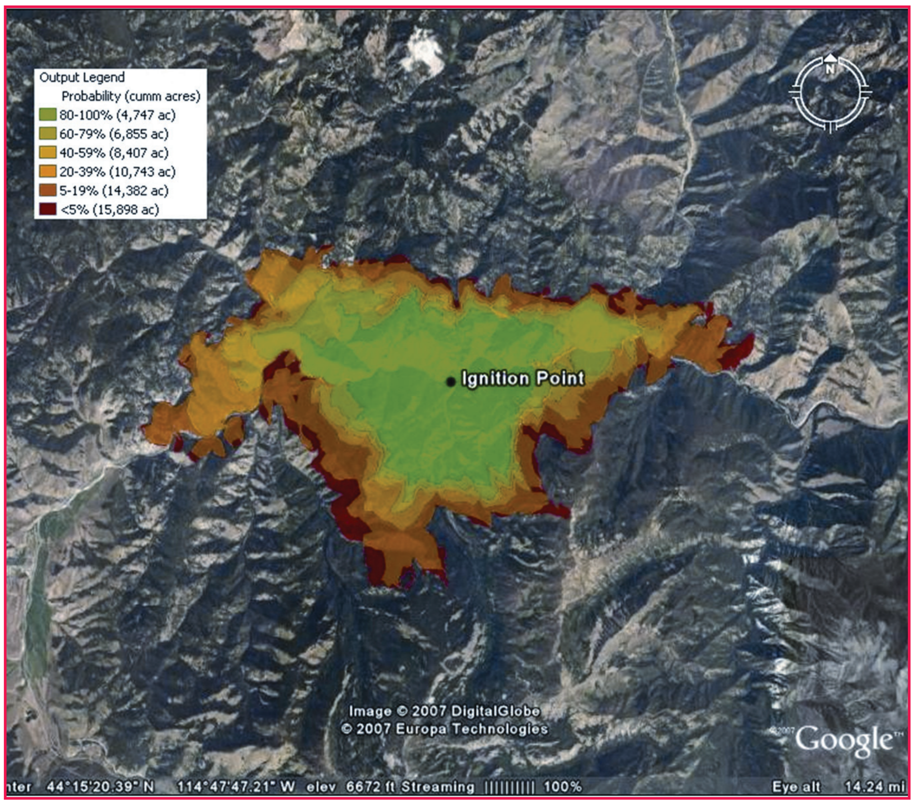

Figure 3—*FARSITE/FlamMap landscape created using aerial detection survey maps (2000–2006), custom fuel models, historic weather data, and data from the LANDFIRE project. The different colors represent the probability of fires growing from the ignition point to a given boundary over randomly selected, 3-day weather periods. The acres in the output legend display the cumulative acre sizes that include all of the polygons with higher probabilities. For example, the "less than 5 percent" acre value represents the size of the entire polygon including all of the smaller polygons within it.*

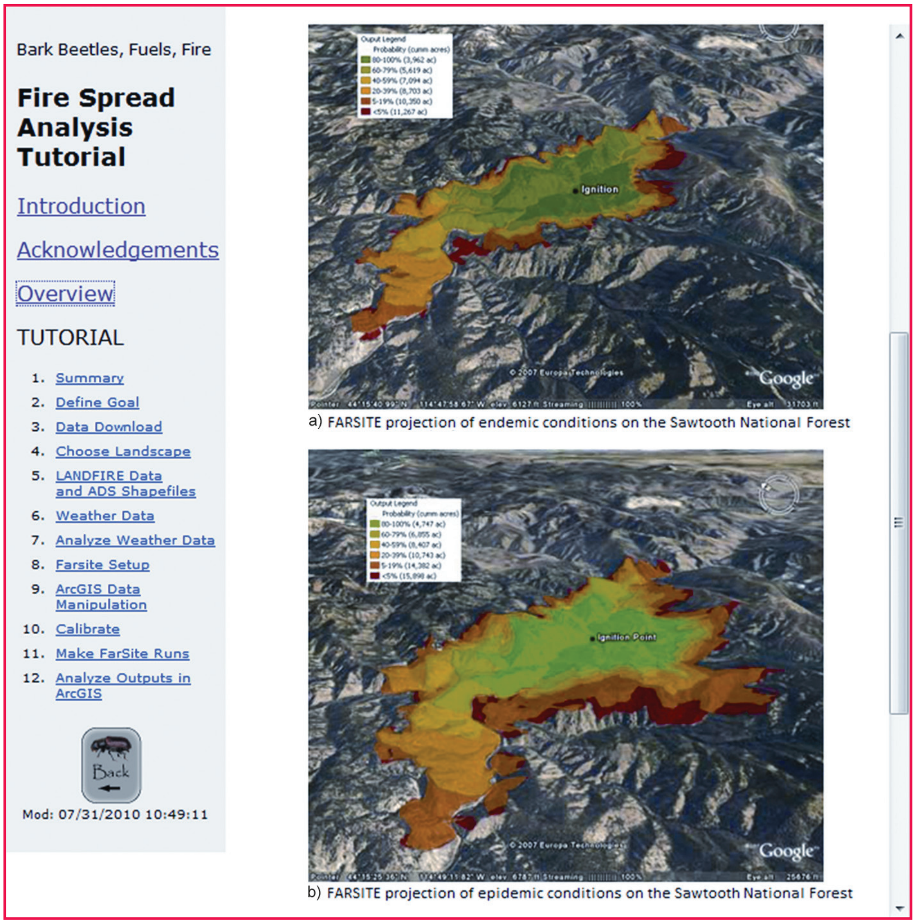

Figure 4—*Screen capture from Web site showing FARSITE projections of (a) endemic and (b) current epidemic mountain pine beetle conditions.*

Bibliography

The Bark Beetle, Fuels, and Fire Web site manages literature using Digital Commons. The Digital Commons is an institutional repository that brings together all of the pertinent research under one application with an aim to preserve and provide access to that research. The institutional repository provides open access to scholarly works, research, reports, publications, and courses produced by researchers working with bark beetles, fuels, and fire. Coordinated by the Merrill-Cazier Library, the Utah State University's digital repository joins other universities worldwide in the ongoing development of new knowledge. The institutional repository is an excellent vehicle for working papers or copies of published articles and conference papers, presentations, theses, and other works not published elsewhere. The Bark Beetle, Fuels, and Fire Web site bibliography is fully searchable, and university librarians work with publishers to manage copyright issues and provide users access to portable document format (PDF) versions of papers.

Summary and Future Direction

The goal of the Web site is to provide a clearinghouse for bark beetle, fuels, and fire research, resources, and information. The Utah State University Disturbance Ecology Lab will maintain the Bark Beetle, Fuels, and Fire Web site with periodic searches to locate pertinent literature for updating the bibliography. The image gallery is a fluid resource and is continually expanding as our work moves to other bark beetle-host systems and as we revisit stands that are in transition to the post-epidemic condition. We encourage others engaged in bark beetle, fuels, and fire research to contribute to the Web site or provide the site managers with links to other information and useful Web sites.

The next phase in our research is to characterize fuel and fire behavior in high-elevation five-needle pines affected by mountain pine beetle. These species occupy a wide geographic but limited elevational range, often in "sky islands" in the Intermountain ecoregion. The ecosystems are ecologically important and especially sensitive to threats posed by climate change, changing fire regimes, habitat fragmentation, and white pine blister rust.

We will use results of previous research to extensively sample high-elevation five-needle pines across a large geographic range in western North America. Our goal is to produce a spatially explicit population model using a species–landscape approach and high-elevation five-needle pines as the focus species.

For information, questions, or comments on the Web site, or to contribute your work to the bibliography, contact Mike Jenkins at <mike.jenkins@usu.edu>.

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Exploring the Mega-Fire Reality 2011

14–17th November 2011, Tallahassee, FL

<http://www.megafirereality.com>

Exploring the Mega-fire Reality 2011

A Forest Ecology and Management Conference in association with *Forest Ecology and Management:* the #1 most cited journal in forestry

Dear Colleagues,

On behalf of the Conference Committee, we look forward to welcoming you to "Exploring the Mega-fire Reality"—the first conference of the international journal *Forest Ecology and Management*.

In many parts of the world, both the area and intensity of wildland fires have increased alarmingly. Not only are fires increasing in number, but the *nature* of these fires is also changing. We see mega-fires of increasing size and intensity in many parts of the world including Siberia, Alaska, Canada, United States, and particularly in Asia and Australia.

In 2009, the "Black Saturday" mega-fire in Australia burned more than 1.1 million acres (450,000 ha), destroying over 2,000 homes and killing 173 people. As we prepare this welcome, the Wallow Fire that started on May 29, 2011, in east-central Arizona has burned through 495,000 acres (200,000 ha), and this largest fire on Arizona's historical record continues to grow. These mega-fires raged despite the highest preparedness budgets for firefighting and fire suppression on record.

Knowledge and insights about mega-fires are developing around the world, and we hope that progress will be greatly enhanced by bringing together experts from a broad range of disciplines in forest ecology and management. Global warming, over-accumulation of fuels in fire-prone forests, and growth at the wildland-urban interface all suggest that the fire protection strategies we have used in the past may no longer serve us so well in the future.

Dan Binkley

Peter Attiwill

We look forward to an exciting and productive conference.

Peter Attiwill and Dan Binkley

Co-Chairs, the Conference Committee

18th November: Field trip to Tall Timbers – the home of the study of Fire Ecology

(Only 50 spaces available for the field trip!)

Fire Management Today Announces 2010 Photo Contest Winners

As part of an ongoing series, *Fire Management Today* hosted a photography contest in 2010 in order to present images of firefighting scenes and operations to its readers. Photos are recognized here for their superb depiction of firefighting conditions and efforts.

We asked interested people to submit images in one or more of six categories:

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

Judging and Award Criteria

We evaluated photos submitted in three steps. First, we looked at each photograph for technical characteristics, such as focus, clarity, and resolution. Then, the judging panel made sure that images depicting firefighting operations demonstrated accepted safety standards and practices—unless the intent of the image was to convey the opposite. Finally, the judging panel viewed and rated the images on the following representative criteria:

Composition

- Is the composition skillful and dynamic?
- Is the image balanced or unbalanced? Is the balance or imbalance appropriate? If there is a main center of interest, is it well placed in the frame?

Lighting

- Does the lighting show off the subject well?
- Is the contrast level appropriate and effective?

Subject/Interest

- Does the subject have interesting connotations or associations?
- Are the colors and patterns effective?
- Does the image contain interesting textures?
- Does the image contain interesting juxtapositions?

Originality

- Does the image show an original subject or an original approach to a conventional subject? Is it anonymous in approach, or does it show a visual signature or convey a personal vision?

Story/Mood

- Does the image effectively tell a story or convey a mood?

Digital manipulation of an image was not a disqualifier for high rating, but digital effects were judged independently on their effectiveness.

Awards

Based on the responses to these and related questions, we made the awards based on both relative and absolute merit. For example, in a category with numerous high-quality images, photographs were given First, Second, and Third Place awards, with Honorable Mention awards for photographs that also merited acknowledgement. Otherwise, for categories in which only a limited number of photographs could be rated as excellent, awards were restricted to those photographs.

The resulting award-winning photographs are presented on the following pages. Images of interest that are not presented here will be retained for future use in *Fire Management Today*, either as issue covers or to enliven pages throughout the publication as space allows. Our thanks go out to everyone who participated in the contest. We appreciate their efforts, first of all, in service to our national resources and, then, in taking the added effort in recording the conditions of that service. ■

Do you have an image that tells a story about wildland firefighting? Would you like to see your photo in print? Turn to the inside back cover for information about our next photo contest.

FMT Photo Experts

Judges for this year's photo contest were drawn from personnel well acquainted with firefighting operations and communications. The judging panel took the role of safety experts who could review the photographed scenes for accepted safety practices and content experts who rated images on their individual merits. Our thanks go to these judges for their willingness to share their time and knowledge. The judging panel included:

Gordon M. Sachs

Gordy Sachs is the disaster and emergency operations specialist for the Forest Service, Fire and Aviation Management, assigned to national headquarters in Washington, DC. In this role, he serves as Forest Service liaison to Federal Emergency Management Agency (FEMA) headquarters staff and coordinates interagency efforts related to Federal firefighting support during disaster response. He also coordinates the national cadre for Emergency Support Function 4 (ESF4), firefighting, under the National Response Framework (NRF). He serves on several national committees and workgroups related to the NRF and National Incident Management System (NIMS), and chairs the National Wildfire Coordinating Group's NRF/NIMS Committee.

Kent Evans

Kent Evans is a fire management staff officer for the National Forests and Grasslands in Texas. After earning his bachelor and master of science degrees from Texas A&M, he worked for 2 years as a range conservation officer for the Bureau of Land Management (BLM) in New Mexico, where he hit his first fire. He spent the next 32 years with the Forest Service in a variety of jobs: range conservation officer, biologist, assistant ranger, ecosystem specialist, district ranger, and staff officer in such places as the Lyndon B. Johnson National Grassland, Sabine National Forest, Chattahoochee National Forest, Cherokee National Forest, Talladega National Forest, and the National Forests in Texas. He maintains his line qualifications as an incident commander type 3 (ICT3) and safety officer type 2 (SOF2) (prescribed burn fire boss type 2 [RXB2] expired) and assists FEMA as an ESF4 primary leader. In addition to responding to fires, floods, and hurricanes, he spent 2 years coordinating the permit and leading the venue risk management team on the Cherokee National Forest for the skiing World Cup, U.S. Team Trials, and 1996 Olympic events.

Karl Perry

Karl Perry is the national audiovisual manager for the Forest Service. He is responsible for audiovisual information programs in the Forest Service, including the administration of national and headquarters audiovisual activities. He serves as the agency audiovisual manager regarding policy, and the audiovisual specialist responsible for the production of national audiovisual and photographic products. Karl has more than 30 years of Federal service, has worked as a freelance photographer for Times-Mirror, and has had many of his photos published in various publications and magazines.

First Place, Wildland-urban Interface. *Close call on the 2007 Jocko Lakes Fire, Lolo National Forest, MT. Photo: John Prendergast, Forest Service, Fire and Aviation Management, National Incident Management Office, Medford, OR.*

First Place, Wildland Fire. *Burnout operation conducted by Engine 431 and Cedar City Fuels Crew on the north side of the Kolob Fire near Zion National Park, UT, 2008. Photo: Dirk Huber, Ashley National Forest, Vernal, UT.*

Second Place, Wildland Fire. *Landscape scale burning on the 2007 Jocko Lakes Fire, Lolo National Forest, MT. Photo: John Prendergast, Forest Service, Fire and Aviation Management, National Incident Management Office, Medford, OR.*

Third Place, Wildland Fire. *Brushy fire in the Chiricahua Mountains, Coronado National Forest, AZ, in 2010. With the help of delayed aerial ignition devices (DAIDS), crews were able to secure the road in John Long Canyon. The photo was taken by Taylor Amos while posted as a lookout above Cub Trail (Cub Lookout).*

First Place, Aerial Resources. *P-3 aircraft retardant drop below Hanging Rock, Blossom Fire, Rogue River-Siskiyou National Forest, OR, 2005. Photo: John Prendergast, Forest Service, Fire and Aviation Management, National Incident Management Office, Medford, OR.*

Second Place, Aerial Resources. *A heavy air tanker drops retardant to protect the Pine Valley Subdivision during the 2006 LaBarranca fire near Sedona, AZ. Photo: John Coil, Sedona Fire District, Sedona, AZ.*

Third Place, Aerial Resources. *A California Air National Guard Blackhawk Helicopter sips from Booze Lake in the William Coe State Park near Gilroy, CA, during the Lick Fire of 2007. Photo: Jeff Shelton, Orange County Fire Authority, Oceanside, CA.*

First Place, Prescribed Fire. *Engine 431, Kings Peak Wildland Fire Module, and Engine 631 burn piles on Reservation Ridge of the West Zone of the Ashley National Forest, 2009. Photo: Dirk Huber, Ashley National Forest,Vernal, UT.*

Second Place, Prescribed Fire. *Crewmembers of Engine 431 regroup after lighting a prescribed fire unit in the Anthro Mountain prescribed burn on the West Zone of the Ashley National Forest, UT, 2009. The burn was conducted to improve greater sage-grouse brood-rearing habitat. Photo: Dirk Huber, Ashley National Forest,Vernal, UT.*

Third Place, Prescribed Fire. *North Zone crews on the Picnic/Cavern/Kine fuels reduction prescribed burn just outside Nemo, SD, on the Black Hills National Forest, 2009. Photo: Bradley Hershey, Forest Service, Boxelder Job Corps Center and Nemo Volunteer Fire Department, Nemo, SD.*

First Place, Ground Resources. *Engine 431 supports a burnout operation on the Petty Mountain Fire on the West Zone of the Ashley National Forest, 2003. The fire was conducted to improve bighorn sheep habitat. Photo: Dirk Huber, Ashley National Forest, Vernal, UT.*

Second Place, Ground Resources. *Captain of Engine 431 on the Fork Fire of the Southern Ute Agency near Ignacio, CO, uses a pencil hose to help contain a fire, 2009. Photo: Dirk Huber, Ashley National Forest, Vernal, UT.*

Third Place, Ground Resources. *Breakdown on the Poe Cabin Fire, Riggins, ID, 2007. Photo: Kevin Oldenburg, National Park Service, Vanderbilt Mansion and Eleanor Roosevelt National Historic Sites, Hyde Park, NY.*

First Place, Miscellaneous. *An early morning storm brings little rain and spectacular lightning to the Cibola National Wildlife Refuge, AZ, on the Colorado River south of Blythe, CA, in 2006. Four days earlier, lightning from another storm ignited the Cibola Fire. Photo: John Coil, Sedona Fire District, Sedona, AZ.*

Second Place, Miscellaneous. *Scars from a previous wildfire in the Bob Marshall Wilderness, MT, still remain in 2008, while the fire dependent community rebuilds itself. Photo: Terra Fondriest, AZ.*

Third Place, Miscellaneous.*The eradication of juniper trees encroaching into a ponderosa pine community on the Yellowstone Prescribed Burn on the West Zone of the Ashley National Forest, 2007. Photo: Dirk Huber, Ashley National Forest,Vernal, UT.*

Honorable Mention, Ground Resources. *Firefighters are transported by jetboat in the Rogue River Canyon, Blossom Fire, Rogue River-Siskiyou National Forest, OR, 2005. Photo: John Prendergast, Forest Service, Fire and Aviation Management, National Incident Management Office, Medford, OR.*

Honorable Mention, Aerial Resources. *Tanker drop on the Barker Branch Fire, Cumberland Ranger District, Daniel Boone National Forest, 2010. Photo: Evelyn Morgan, Daniel Boone National Forest, Winchester, KY.*

Honorable Mention, Prescribed Fire. *Public notice and safety signage for the Pole Creek Prescribed Burn on the Kemmerer Ranger District, Bridger-Teton National Forest, WY, 2010. Photo: Lara Oles, Bridger-Teton National Forest, Kemmerer,WY.*

Honorable Mention, Wildland Fire. *Burnout operations on the B&B Complex, Deschutes National Forest, OR, 2003, involving multiple agencies combined into engine strike under the Oregon Conflagration Act. This was a tremendous learning opportunity for many departments whose personnel are more experienced with structural fires. Photo: Melanie Fullman, Ottawa National Forest, Ironwood, MI.*

Honorable Mention, Miscellaneous. *Fall shadows highlight the rebirth of the jack pine forest 5 months after the Meridian Boundary Fire on the Mio Ranger District, Huron-Manistee National Forest, 2010. Photo: Philip Huber, Huron-Manistee National Forest, Mio, MI.*

Fire Management today

Announcing the 2011 Photo Contest!

The Fire and Aviation Management branch of the Forest Service began conducting photo contests in 2000 for its quarterly publication, *Fire Management Today (FMT)*. Over the years, we have had hundreds of photos submitted, giving us an inside look at your wildland fire experiences.

This year, we look forward to seeing your best fire-related images in our 2011 Photo Contest. Photos in the following categories will be considered: Wildland Fire, Prescribed Fire, Aerial Resources, Ground Resources, Wildland-Urban Interface Fire, and Miscellaneous (fire effects, fire weather, fire dependent communities, etc.). The contest is open to everyone, and you may submit an unlimited number of entries taken between 2009 and 2011.

Guidelines for contributors and the mandatory release form can be found on the *FMT* Web site: <http://www.fs.fed.us/fire/fmt/index.html>. Entries must be received by 6 p.m. eastern time on Friday, December 2, 2011.

Winning images will appear in *FMT* and may be publicly displayed at the Forest Service national office in Washington, DC. As appropriate, we may use a photo contest image in an *FMT* article or as a cover photo. If your photo is used in *FMT*, we will supply you with a free copy of the issue so that you can see your contribution to the publication.

Winners in each category will receive the following awards:

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

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