Fire Management *today*

Volume 74 • No. 1 • 2014

What Have We Learned?

USDA
United States Department of Agriculture
Forest Service

Fire Management Today is published by the Forest Service of the U.S. Department of Agriculture, Washington, DC. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department.

Fire Management Today is for sale by the Superintendent of Documents, U.S. Government Printing Office, at:
Internet: bookstore.gpo.gov Phone: 202-512-1800 Fax: 202-512-2250
Mail: Stop SSOP, Washington, DC 20402-0001

Fire Management Today is available on the World Wide Web at <http://www.fs.fed.us/fire/fmt/index.html>.

September 2014

Fire Management today

Volume 74 • No. 1 • 2014

On the Cover:

A fire-gutted vehicle is one result of an intentional vehicle burnover conducted by the Forest Service and CALFIRE to test safety equipment. See the article in this issue for details. Photo by Ryan Myers.

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.

Contents

Short Features

Anchor Point

by Tom Harbour
Director, Fire and Aviation Management
Forest Service

The National Cohesive Wildland Fire Management Strategy: Together, We Can Do More!

Addressing wildfire in the United States is not simply a fire management, fire operations, or wildland-urban interface challenge: it is a more complex land management and societal issue. For the past 3 years, fire officials from across the Nation have been working together to create a national cohesive strategy that constitutes a shared vision for present and future wildland fire and land management activities. The Forest Service, together with our partners at the U.S. Department of the Interior, National Association of State Foresters, National League of Cities, and State Governors, has led this interagency initiative.

The primary factors identified that present both the greatest challenges and greatest opportunities for making a positive difference in addressing America's wildland fire problems include ***restoring and maintaining resilient landscapes, creating fire-adapted communities, and responding to wildfire.*** Building upon the foundation of previous efforts to address wildland fire management across America, the key to this strategy's success is its inclusiveness across all land ownerships.

The past two decades have seen a rapid escalation of severe fire behavior, home and property loss, higher costs, increased threats to communities, and worsening land conditions. Trends call for a broad-based, cohesive response to address the mounting challenges. This national strategy allows stakeholders systematically and thoroughly to develop a dynamic approach to planning for, responding to, and recovering from wildland fire in America.

Wildland fire managers know that, to be successful, we need to reach beyond Federal agencies. To be successful, we need an approach that builds on past efforts—including the National Fire Plan, the 10-Year Comprehensive Strategy, and the corresponding Implementation Plan. Past efforts were most successful when they were most inclusive, extending across the entire fire community and including a wide range of Federal, tribal, State, local, and nongovernmental stakeholders. In April 2014, we completed and released the final phase of the National Cohesive Wildland Fire Management Strategy.

Does that mean we are finished? No: we are far from finished with our work. I'd like to focus here on the restoration and maintenance of resilient landscapes through an active fuels management program.

When we think of a fuels management program, we can no longer afford to think only in terms of a wildland fire management program. The program must be an integrated fuels management program that involves natural resource and land use program managers and planners; it must be a comprehensive plan through which, together, we achieve the most difference on the ground. It is a program that works, first, through managers ***within*** our own organization and, then, looks for opportunities to work along with our neighbors and partners to achieve its goals. There are good examples of works in progress in several States that are outside of but still supported by the Forest Service.

The Montana Cohesive Strategy Pilot Program

A Forest Service grant provided means for the Montana Department of Natural Resource Conservation (DNRC) to:

- Allocate funding for fuels mitigation cost-share assistance to treat 100 acres of family-owned forest lands in the wildland-urban interface near West Yellowstone, MT. This work is scheduled to begin this field season. Currently, the local fire district is conducting hazard assessments on all properties in the project area.
- Use a new computer model developed by the Forest Service's Fire Lab to conduct an assessment on the effectiveness of past DNRC fuels mitigation

grants on reducing fire behavior and protecting firefighters and structures. The DNRC has hired a technician to apply the model, and the agency will complete the subsequent analysis and report by the end of the 2014 field season.

- Provide funding and support for eligible wood and biomass projects and business development. This summer, the DNRC will advertise a request for proposals in concert with the Forest Service's Woody Biomass Utilization Grant Program.
- Fund a forest products promotion and support specialist and partially fund the existing forest product and biomass program manager. Working with other DNRC staff, these personnel have initiated the following efforts:
  – **A competitive grants program.** The program supports eligible wood and biomass project and business development.
  – **The "Buy Montana Wood" promotional marketing campaign.** A key product of this effort will be a directory of Montana wood products with a Web site interface and interactive map.
  – **Coordination of the *Montana Forest Products Retention Roundtable***. The roundtable is a forum for stakeholders to create partnerships, discuss issues, and develop solutions for maintaining and enhancing the State's forest products industry infrastructure.
  – **Montana Forest Products Industry Week.** Created by the Montana legislature, this designated week and accompanying year-round efforts promote educational and outreach activities addressing Montana wood products, forest management, and the link among healthy forests, productive mills, vibrant communities, and other benefits.
  – **Development of a "Cohesive Wildfire and Forest Management Strategy" appendix to *Montana Forest Action Plan for Southern and Southeastern Montana*.** The areas of southern and southeastern Montana have experienced extreme fire behavior in the past several years. The strategy addresses significant issues related to resilient landscapes, fire adapted communities, and effective response to wildfire. The southern part of the State also lacks significant markets for wood products to underwrite the costs of high-priority forest treatments.

The Oregon Cohesive Strategy Program

The Forest Service executed this award on August 27, 2012, for Oregon officials to:

- Develop a landscape-level, collaborative approach to address the three parts of the Cohesive Wildfire Strategy for the northern Blue Mountain region;
- Analyze regional opportunities to create demand for additional biomass utilization; and
- Address commonalities of the first two objectives through a demonstration project.

To date, the Oregon group has:

- Partnered with Sustainable Northwest, a regional nonprofit organization, the Forest Service, and the Oregon Department of Energy to deliver an all-day education workshop on biomass heat technologies and opportunities in La Grande, OR. More than 45 participants—including local landowners, facility managers, elected officials, timber industry representatives, consultants, and local citizens—attended the workshop.
- Received seven applications for biomass grant funding.
- Reviewed and provided support for grant-funded opportunities for two joint Forest Service–private lands fuel-treatment projects (Cove II and Mt. Howard).
- Provided input and consulted on a wildfire simulation hosted by the Umatilla National Forest and conducted by the National Incident Management Organization in the Mill Creek Watershed, which provides drinking water to the city of Walla Walla, WA. The simulation occurred in March 2013 and included two States, three counties, and multiple wildfire agencies.

These are just two good examples of how we can work together with our partners to make a difference. Today, I challenge all wildfire management professionals, forest planners, and other program managers to work together in developing an integrated fuels management program to support the Forest Service motto of "caring for the land and serving people" and a cohesive strategy goal to restore and maintain resilient landscapes. Concurrently, you should reach out to your neighbors; other Federal, tribal, State, and local governments; and nongovernmental organizations that have an interest in wildland fire management or in developing an integrated fuels management program, such as those discussed above. ***Together, we can do more***! ■

Burning To Learn: An Engine Burnover Project To Improve Firefighter Safety

Ryan Myers

WHOOMP!!! The big dually tire exploded off of its rim, causing viewers in the observation area to flinch and the fire engine to list slightly downhill. Flames now engulfed three of the four engines; spectators gawked, firefighters scanned for spot fires, reporters snapped pictures, and data collection devices ran. It was mid-morning on June 3, 2013, on the CALFIRE training grounds near Ione, CA. We were witnessing the second "in season" engine burnover project, led by the San Dimas Technology and Development Center (SDTDC), designed to test and measure various outputs when fire equipment is overrun by wildfire.

Four type-3 engines stand on the midslope road during the overburn project setup in Ione, CA. Photo by Ryan Myers, 2013.

This was a test of questions that, if asked in the heat of operations, generally come too late: "If a fire shelter is used as a heat shield inside an engine cab, will it help survivability?" "What kinds of toxins are released by the heating of combustibles inside the cab of this engine, and what are the consequences of inhalation?" "If plastic door handles melt, are firefighters trapped in an engine cab?" The group conducting this experiment was seeking answers to just these types of questions.

The Story Begins

The burnover project arose from concerns of equipment operators—primarily bulldozer operators—in the field regarding the effectiveness of safety equipment and practices recommended for use during vehicle burnover situations. The initial project proposal sought an evaluation of protective equipment (such as hose laggings, fire curtains, and fire shelters) and procedures (such as vehicle orientation relative to the fire front) and the development of testing methods for assessment of proposed solutions.

> The engine burnover project is designed to test and measure various outputs when fire equipment is overrun by wildfire.

Data collection device and sensor connecting wires are prepared for installation in and on fire engines. Photo by Ryan Myers, 2013.

Ryan Myers is an operations specialist for the Forest Service, Fire and Aviation Management Staff.

When the project began, the original objectives were:

- To develop protocols and test procedures for validating manufacturer's claims on protective equipment for vehicles and equipment,
- To assess the effectiveness of protective equipment as it pertains to operator safety, and
- To provide data and recommendations for the development of guidelines and standard operating procedures for equipment operators and crews caught in a burnover situation with their vehicles.

Setting Up the Test

In order to accomplish these objectives, the team at SDTDC partitioned the study into three phases:

Phase 1: Live-fire tests on closed-cab and open-cab bulldozers in different operating configurations and using different protective systems (completed July 2010).

Phase 2: Live-fire tests on type-3 and type-6 wildland fire engines in different operating configurations and using different protective systems (completed October 2011).

Phase 3: Development of laboratory test parameters for heat and flame exposure on protective equipment and assemblies, measurement of the concentration of gasses from thermally degraded plastics, and mechanical material tests on fire curtain materials and laggings (thermal insulation around pipes or wires) (completed June 2013).

The burnover project arose from concerns of equipment operators in the field regarding the effectiveness of equipment and practices recommended for use during vehicle burnover situations.

Sensors are mounted inside the cab of a fire engine to gather data during the burn. Photo by Ryan Myers, 2013.

On the morning of the burn, the incident management team set up an observation area on the facing slope of the ravine. Photo by Ryan Myers, 2013.

The phase 2 engine burnover was performed on two type-3 and two type-6 engines. The phase 3 engine burnover (observed by the author) was performed on four type-3 fire engines placed midslope in 2–3 acres of chamise and chaparral. For both experiments, researchers measured ambient temperatures, heat flux, wind speed, particulate matter, and gases released inside the cabs of the fire engines. Testing personnel placed monitoring equipment at the test site: thermocouples (75 on each engine), heat flux transducers, video cameras, fire behavior packages, fire atmospheric sampling systems, and infrared cameras.

Technicians outfitted the type-3 engines with different types of safety equipment according to the vehicle model: fire curtains and fire shelters deployed in the cabs, air conditioning and air re-circulating systems, and an external water protection system. Standard fire shelters containing data collection sensors were also deployed on the same mid-slope road among the engines.

Additional Phase 3 Objectives

For phase 3, additional objectives became important:

- Provide science-based recommendations for engine operators and crews in the event of a wildland fire entrapment and/or burn-over,
- Validate the effectiveness of equipment marketed to protect engine operators,
- Gather data to support future studies on shelter deployment locations around fire apparatus,
- Observe the synergistic effect of complex variables in a real fire environment to provide parameters (such as temperature effects, heat fluxes, and toxicities) for further testing, and
- Obtain data to assess the survivability of the interior of wildland fire engines in specific configurations and fire behaviors.

Partners in the Test

Numerous agencies and organizations provided support for this experiment, including the following:

- San Dimas Technology and Development Center,
- Missoula Technology and Development Center,

The start of the firing operation: fire personnel have lit both flanks of the burn area to contain the burn, and the principal fire has begun to burn at the bottom of the ravine. Photo by Ryan Myers, 2013.

The flame front approaches the vehicles from below. By reducing available fuels, the flanking fire on the right has protected one engine (behind the smoke plume) from the main flame front. Photo by Ryan Myers, 2013.

- Pacific Southwest Research Station,
- Rocky Mountain Research Station,
- San Bernardino National Forest,
- Angeles National Forest,
- Bureau of Land Management,
- CALFIRE,
- Roscommon Equipment Center,
- Commonwealth Scientific Industrial Research Organization (Australia),
- University of California-Riverside,
- Boise Mobile Equipment,
- Navistar, and
- Campbell Scientific.

As the flame front reaches the vehicles on the road, rubber and plastics on the engines begin to burn. Photo by Ryan Myers, 2013.

The aftermath: direct flame impingement consumed the three engines on the left while the engine on the right survived the fire. Photo by Ryan Myers, 2013.

The Test Unfolds

In Ione on the day of the test, surrounding grass and brush was dry, the temperature was quickly approaching the mid-80s, and the wind was blowing out of the west—right to left from the VIP viewing area, 200 meters north of the hillside test site. The management team used the incident command structure to ensure span of control and to distribute responsibilities into functional areas, as would typically be done on any wildland fire, prescribed fire, or other natural disaster response. Sam Wu of SDTDC and M. Ramirez of CALFIRE shared incident command: Wu focused on setting equipment and gathering data, while Ramirez focused on the prescribed burn. Under them, several agency representatives, as well as section chiefs, managed logistics, planning, and finance.

With firefighters deployed to contain the burn to the test site, the operations section chief gave the signal for the firing group to start the fire. Personnel lit the left and right flanks of the burn area first to contain the fire's flanks, a terratorch completed the firing operation at the bottom of the hillside and the fire burned up the slope. A remote-controlled helicopter with an attached video camera flew over the heads of the firefighters as a type-2 helicopter was making "laps" between a water source and the burn, dropping buckets on the unburned, downwind flank.

With the flanking fires to the left and right removing fuels to create containment buffers, the downslope fire roared up the hillside toward the four engines on the road. One engine was spared the brunt of the

A couple of hours after lighting, only a shell remained of one of the engines. Photo by Ryan Myers, 2013.

uphill fire run, owing to its proximity to the nearby flanking fire. The flame front quickly overtook the remaining three engines. The rubber tires and the plastic parts on the body of the engines were the first to catch, but after several minutes of direct flame exposure, outlines of all three of the engines were difficult to distinguish from the flames that engulfed them. The vegetation near the engines was consumed faster than the burning engines, and soon, only the engines remained aflame. Perimeter operations contained the burn until the available fuel within the test site was consumed.

The Aftermath

When the flames subsided, the remains of three charred fire engines sat on the blackened hillside, smoldering and rippling with residual heat. Mixed emotions appeared to hang over the observation area: a quiet reverence for victims of past fire tragedies—which, no doubt, bore a resemblance to this scene—and also an air of anticipation for the insights that may be gained from the day's efforts. The fourth engine, spared by the flanking fire's buffer and appearing relatively unscathed, flashed its emergency lights throughout the test and held its brilliant green paint as if in defiance of the surrounding devastation, representing the hope that the efforts of this test may eventually save firefighters' lives.

When the flames subsided, the remains of three charred fire engines sat on the blackened hillside, smoldering and rippling with residual heat.

The test operation successfully coordinated multiple agencies, hand crews, fire engines, dozers, a type-2 helicopter, and various overhead personnel, as well as providing valuable images and information to public information officers, reporters, and photographers. The cost per acre for preparation of this burn, had this been a standard prescribed fire, would have been unacceptably high. However, given the objectives and potential improvements in firefighter safety, it seems a small price to pay and a worthy investment.

Test results analysis is ongoing. For more information, please contact:

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Safety and the Agency, Part 1: Understanding Accident Mitigation

Jim Barnett

Forest Service Manual (FSM) 6700 outlines how the agency intends to ensure adequate protection for Forest Service employees and property, as well as the visiting public. The direction also outlines the circumstances—in the form of accidents—that generate an investigation, the roles and responsibilities of participants in such investigations, and the products of these investigations. Investigations may end with specific recommendations or a finding of a "null alternative"—that is, that no change in existing procedures can be recommended (see table 1). Whatever the outcome, the intended result of such investigations is to promote safe operations by individuals with very different roles and personalities in an environment that is never completely predictable. Once the investigation report is signed and considered official, a variety of staff turn the recommendations into actions within four categories of mitigation or a null alternative. The four categories of mitigation are: (1) policy, (2) procedures, (3) training, and (4) technology. Integration of recommended mitigation measures presents its own set of challenges at each level and point in application.

Jim Barnett is a former aviation management specialist and management training officer with the Forest Service, Fire and Aviation Management in Washington, DC.

When confidence trumps caution, bad things tend to happen.

Systemic Approaches to Accident Avoidance

Accident avoidance, or "premitigation," starts with the individual. From their first exposure to operations, firefighters possess a level of reliance on procedure and a sense of self-preservation that assist in maintaining an accident-free environment. These motivators persist while the firefighter's knowledge, skills, and abilities are being developed. The key to successfully avoiding accidents is the development of equal parts confidence and caution. A support network is also essential in the ability to move beyond basic position qualifications to higher levels of proficiency. Management practices guide firefighters on how not to cause, contribute to, or become victims of an accident. The cornerstone of such management support network is policy. Existing policies must be applied through training and, afterward, proper use of operations guidelines. Application of such policies and guidelines is left to training and, in some cases, development of new tools and technologies. All of these are amendable and subject to ongoing feedback and revision.

The key to successfully avoiding accidents is the development of equal parts confidence and caution.

Table 1.—*Mitigation Alternatives.*

Category	Action
Null Alternative	Alternatives may not exist or are deemed unreasonable, unachievable, or lack a positive benefit ratio
Policy	Agency stated and published employee obligations
Procedure/ Process	New or updated via policy (normally, through the Forest Service Handbook), training, and/or guide (including standard use of technology)
Training	New or updated training course materials via course(s), simulations, or elements of a position task book
Technology	Introduction or improvement of a technology or "tool" (for example, hand tools, fire shelter, equipment, or aircraft)

Policy

If an internal accident finding requires a policy update, agency experts craft new policy language that "must," "shall," or "will" be followed "to the letter" as a binding standard. Issuing a national FSM, Forest Service Handbook (FSH), or interim directive may require an extensive review and multiple concurrences (including the employees' union) and will be processed through Forest Service, Office of Regulatory and Management Services (ORMS) in the National Office. Approved policies go into effect after they are signed by the Chief or Deputy Chief and posted by ORMS. Regional foresters have the authority to approve regional policy or supplements as long as they do not lessen or violate national policy (see table 2).

Few new firefighters have more than a general sense of agency policies. More frequently, they are aware that all five agencies (Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and the Bureau of Indian Affairs) that share Federal firefighting responsibility differ slightly in some of their policies. These differences are reinforced by the Interagency Standards for Fire and Aviation Operations or "Red Book." This guide contains restatements of key differences in agencies policies. The 2011 Red Book cover letter defers Forest Service policy control to FSM 5108 (actually a misprint for "FSM 5107").

Periodically, firefighting agencies look to coordinate their individual policies, but this may not be achieved—or even be prudent.

Few new firefighters have more than a general sense of agency policies.

Logic indicates that the closer an accident is, in time and space, the lower the number of options that exist to prevent it.

While some firefighters argue for the elimination of confusion, others support independent policy development that addresses each agency's specific issues, environments, responsibilities, and perspectives. While this debate continues, each agency must continue to train according to its existing policies.

Guides

The Forest Service has a number of reasons for not recognizing the Red Book or any specific document as an operational guide. Operational guides present information as needed and appropriate for use in various situations; policy documents are not intended to advocate specific actions. Policy language and intent is a moving target. Simply republishing policy may not always be helpful in the field. Unlike policy, guidance can't be violated as identified in its defined meaning: "advise or show the way," "form an opinion or make a decision or calculation," or "influence a course of action."

Many guides beyond the Red Book contain suggested procedures, data tables, and other reference material that applies to everything from specialized aviation operations to prescribed fire planning. These guides contain many procedures or processes that have been identified or updated based on accident recommendation. These guides are agency-specific or sponsored by the National Wildfire Coordinating

Table 2.—*Direction Instruments*

Type	Goal	Applicability Period
Forest Service Manual	Binding standards	Until superseded
Forest Service Handbook	Binding standards/processes	Until superseded
Interim Directive	Single policy/chapter update	18 Months*
Chief	Single policy update	1 year
Regional Supplement	Binding regional standards**	Until superseded
Regional Forester	Regional policy update**	1 year

* Limited to an initial 18-month period and one additional 18-month period.
** Not already covered or restricted by agency policy.

Training: Costs and Benefits

The Forest Service is known for its extensive training requirements. The South Canyon Incident spurred these requirements, which compelled Forest Service managers to drastically depart from other agencies' training requirements by adding NWCG "Suggested Courses" to existing training requirements. This decision more than doubled the number of courses needed to progress from the most basic Firefighter 2 rating to Type 1 Incident Commander. This management decision has added a significant amount of time to the professional development process. Though some local units are able to provide accelerated training at the local level to address the added requirements, available training slots and limited travel funds for additional regional-level and national-level courses can slow individual training schedules. Slowing the formal training process has both positive and negative effects. One potential upside to the delay is that it causes most firefighters to remain longer at a given position or level. This extended exposure is significantly more effective than most classroom training in developing practical skills, knowledge, and capabilities through hands-on experience. Because most Forest Service firefighters remain in a position longer, they are often more proficient than their average counterparts in another agency.

Increased Forest Service training requirements also come with at least four negative consequences, including (1) not having the energy and money required for the added training; (2) losing some personnel to other agencies with an easier and quicker qualification system; (3) slowing the exposure of firefighters to training that often may contain higher level discussions, processes, and guidelines that are integrated into regional-level and national-level courses; and (4) according to statistics, allowing fewer Forest Service personnel to reach the top tiers of incident management or reach those tiers only as they near retirement age. Another way of looking at the last negative consequence is that, as the Forest Service struggles to increase competency, the experience of agency leadership on more complex incidents is decreasing.

In addition to practical considerations of training, policy (in the form of FSH 5109.17, Fire and Aviation Management Qualification Handbook) can also hamper promotion: specific provisions limit a regional forester's ability to supplement agency training to broaden a firefighter's experience and thus sets a barrier to advancement outside of a few very narrow qualification criteria. A final unique aspect of FSH 5109.17 is an outline of the criteria and process for decertification of an individual's position qualifications.

Group (NWCG), an interagency group that oversees several shared program goal areas or systems, including training.

Training

Like policy documents and operational guides, NWCG-sponsored training course content is periodically updated to reflect recommended changes that are intended to increase safety. Although course material updates may take up to a decade, NWCG provides a number of options for including newly defined mitigations. Instructors can individually add items to their instructional content; course developers may add information or discussion to the Annual Wildland Fire Safety Refresher course; and National Advanced Fire and Resource Institute (upper-division course) instructors may update their outlines prior to any presentation. Informal discussions may also take place locally, regionally, or within any number of workshops and other forums.

Whether imparting important accident mitigation measures or simple procedures, NWCG training materials and delivery are based on sound adult learning principles. Extensive lecture-based courses are just a small part of available training tools: lecture-based and online courses tend to be less effective than those that contain hands-on drills, realistic scenarios, and other problemsolving or decisionmaking challenges. Field training can significantly increase short-term and long-term retention.

The effectiveness of course content and delivery plays a significant role in the most basic form of behavior modification. Exposure during training, not only to new information, but also how and when that information is best utilized, promotes appropriate response behavior. Such training serves a broader goal in the development of situational awareness; this awareness can be increased and reinforced through repetition of actions through drills. Supervision, task books, and other evaluation tools can provide feedback intended to reinforce awareness, behavior, and appropriate action.

Technology

Much of Fire and Aviation Management's presuppression budget is committed to acquisition, replacement, maintenance, and development of technologies and tools that equip firefighters to overcome challenges. Most tools and technologies have been laboratory and field tested to assure safety, quality, and durability. Whether as simple as a Pulaski blade cover or as complex as a computer fire-behavior modeling application, standards, procedures, and prudent use of that technology are supported by guides, training, and policies.

Integrating technology into the safety chain starts with personal protective equipment. Associated policy statements are simple and general in order to be all-encompassing. For example, FSM 6716.03 states that units should "Acquire, maintain, and use personal protective equipment for all recognized hazardous jobs when engineering and administrative means of eliminating the hazard are not feasible."

Simple policy statements and training bolster a commonsense approach to safety—though they have yet to eliminate easily avoidable injuries, such as hand burns resulting from individuals not wearing gloves.

> Training serves a broader goal in the development of situational awareness.

Technology tends to be an area where costs exceed other mitigation options. For instance, statistics show that the fire shelters that were designed in the 1960s were deployed by more than 1,100 firefighters and are credited with saving more than 300 lives. Despite these positive estimates, sufficient data exists from fatal fires to warrant integration of additional engineering and technological improvements to fire shelters. In 2000, the Forest Service's Missoula Technology and Development Center was tasked with developing new criteria, as the first step in replacing the old fire shelter models. Ultimately, research, contracting, and purchasing may cost many millions of dollars.

Summary

FSM 5107 states: "The Forest Service recognizes that the nature of the wildland fire environment is often dynamic, chaotic, and unpredictable. In such an environment, reasonable discretion in decision-making may be required… Forest Service employees must use their best judgment in applying the guidance contained in these references to real-life situations."

Whether based in policy, process, training, or technology, internal or external accident mitigation is intended to benefit the health and safety of those working in the wildfire environment. No policy will ever lead to a continuous sequence of decisions that are both effective and completely safe. No guide will ever lead to complete situational awareness in an environment of infinite variables. No training will ever lead to every firefighter's having and properly using every resource or technology available at every moment. Accident mitigation is reactionary, cumbersome, and never 100-percent effective. Still, the current process stands as a compelling and universally embraced method for improving safety and continuing to save lives. ■

Analyzing Size Distribution of Large Wildfires

Lloyd C. Irland

Interest in extreme fires and fire years is rising (Williams and others 2011; FEM 2013; Climate Central 2012), and while an extensive scientific study would employ long-term and more complete datasets with a more geographic focus, such datasets are rare at present.

Recent work for the Northeastern Forest Fire Protection Compact contains several useful, simple-to-use tools for studying very large fires. This article examines the 112 largest fires nationally from 1997 to 2011 from the National Interagency Fire Center (NIFC) wildfire list and analyzes them from an extreme-value viewpoint, presents analysis methods, and points out some of their general implications for fire operations.

How Big Is "Big?" How Extreme Is "Extreme?"

Fire analysis tends to use long-term averages of area burned and/or fire size. The problem with this approach is that it essentially consigns the occasional extreme events to outlier status. Extreme-value analysis offers a different perspective to fire analysis than analysis of long-term averages. Some fire managers find extreme-value analysis to be useful. Such analysis is common in the insurance and financial industries for studying the frequency and impacts of hurricanes. Fire science is also now beginning to take advantage of this approach. Shifting the focus of analysis to extreme events is comparatively simple and can make use of simple graphics that bring out patterns not easily read from tables of data or from statistically estimated equations.

> We know that the average is not a good way to describe a highly skewed probability distribution.

Of the top 112 fires in the United States from 1997 to 2011 that burned a total of almost 25 million acres (10 million hectares [ha]), the top 5 percent burned 18 percent of the cumulative total. Of these, 39 fires exceeded 200,000 acres (80,000 ha), and the peak-to-mean ratio of acreage burned was 5.5 (see table 1).

Of the top 112 fires, 7 of the largest 10 fires were in Alaska. Two of the top 112 fires began in 2007 and 2011 as swampland fires in the Okefenokee National Wildlife Refuge (ONWR) in Georgia and Florida. We considered nine of the fires as grassland or rangeland fires; four of them occurred in what we might think of as "the East," from east Texas to Florida. We defined two of the fires as "forest/rural:" the 1998 Volusia County, FL, fires and the 2011 East Texas Complex Fire. Other fires in the database include fires in the contiguous 48 States other than the East, grass fires, California fires, and Texas fires. (The groups in table 1 and figure 1 are based on annotations in the NIFC database, are very rough, and are used for illustrative purposes only.)

Area burned, of course, is hardly the only indicator of impact. The 2001 Bastrop County, TX, Complex burned 35,000 acres (14,000 ha), with 1,300 homes destroyed and

Quiz: (1) Which State had the largest average size of fire in the United States from 1997 to 2001: California, Alaska, or Georgia? (2) Which State had the lowest degree of extreme fire behavior, as measured by the ratio of the peak size fire to the average size fire? (3) What proportion of the total area burned by extreme fires was in Alaska?

To find the answers, download the database from the National Interagency Fire Center and analyze it yourself—or simply read this article (answers at the end).

Lloyd C. Irland is a forest protection consultant formerly with the Maine Forest Service. He recently completed a major study for the Northeastern Forest Fire Protection Compact that deals, in part, with measuring extreme fire risks in the region.

Table 1.—*Characteristics of the 112 U.S. fires of more than 100,000 acres (40,000 ha), 1997–2011.*

Location	No. fires	Total acres	Average size	Maximum	Ratio of peak to mean
		---------------*thousand acres*---------------			
Alaska	31	9,857	318	1,306	4.1
California	11	1,762	160	279	1.7
Forest/rural	2	216	108	111	na
Grass	8	2,574	322	907	2.8
ONWR (GA)	2	697	349	388	na
Other West	58	11,295	195	652	3.3
Totals	**112**	**26,401**	**na**	**na**	**5.5**

na=not available
Source: Calculations from NIFC database.

$325 million in insured losses (see figure 1).

The size of the single largest fire for each year is also of interest (see figure 2). Over the entire dataset period, the record was Alaska's Taylor Complex Fire in 2004 at 1.3 million acres. The second largest was the Texas East Amarillo Complex Fire of 2006. The Murphy, Rainbelt, and Inowak Fires, all in Alaska, at roughly 600,000 acres (24,000 ha) each, follow these in size. In contrast, in 2001, no fire exceeded 100,000 acres (40,000 ha).

Although a trend line drawn through these numbers shows a slight upward slope, the trend is clearly not statistically significant. We cannot say that the size of the largest annual fire in the United States has changed for the studied time period. In 5 of these years (see figure 3), a single newsworthy fire exceeded 7 percent of the total annual area burned for that year. In some years, big fires come in bunches (see figure 4). In 2004, almost 5 million acres (2 million ha) burned in fires exceeding 100,000 acres (40,000 ha) in size; in 2007 and 2009, it was just over 3 million acres (1.2 million ha).

Simply ranking any list of fires (or fire years) and charting the result…renders legible patterns that would not be discernible on a time-series chart or a tabular list.

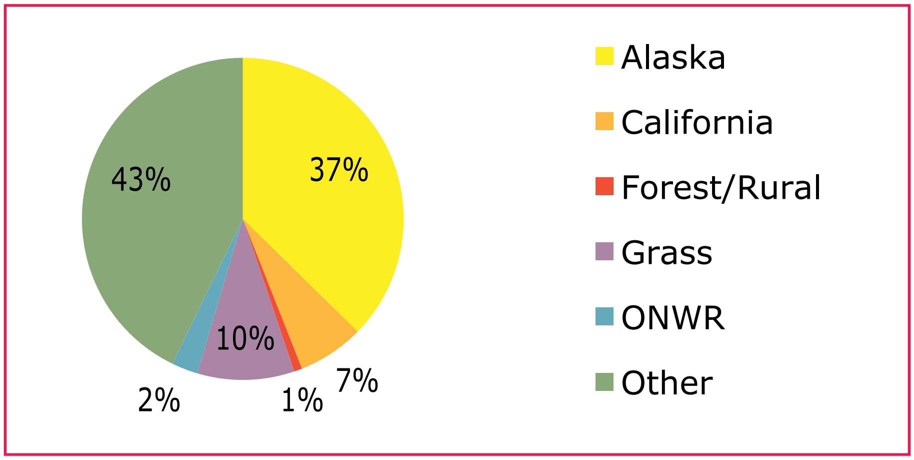

Figure 1.—*Area burned in the 112 largest U.S. fires from 1997–2011, by region/type.*

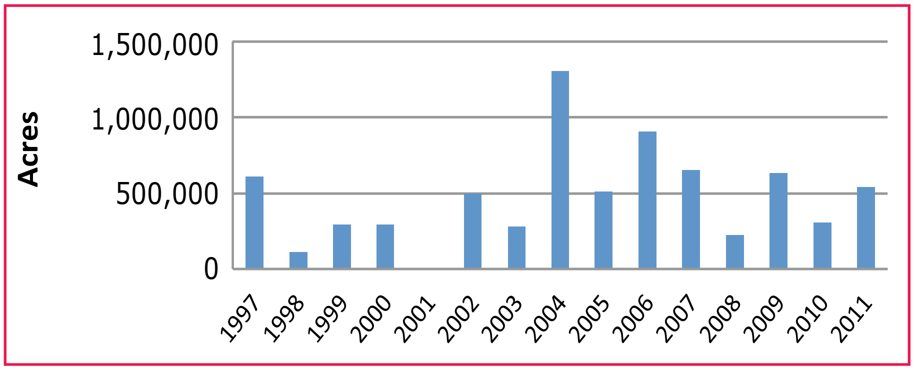

Figure 2.—*Single largest fire each year, 1997–2011.*

Analyzing Fire Data

If fire sizes are not distributed normally, why would we keep talking about average fire sizes when we know that the average is not a good way to describe a highly skewed probability distribution? Spreadsheet software has come to our aid by making it easy to sort, rank, and chart fire sizes in ways that tell us a lot more than simple averages. Several useful aids can assist in studying events like large wildfires that occur in highly skewed sizes. These are (1) ranked distributions, (2) frequency distributions and plots, and (3) excess plots.

Ranked Data

Simply ranking any list of fires (or fire years) and charting the result yields significant insights (see figure 5). It renders legible patterns that would not be discernible on a time-series chart or a tabular list. A pattern such as this emerges: there are large numbers of very small fires, many kept small by prompt control action; there are significant numbers of medium sized fires; and there are very small numbers of extremely large fires.

In some areas, fire numbers and area burned have declined from the "bad old days" of the 1930s and earlier. But while the *level* of curves plotted to reflect these numbers moves downward, their *shape*, indicating extreme behavior, often does not change.

One way to compare the fire experiences of different regions is to chart the ranked fires, standardizing the areas to one for each region: that is, after ranking by size, divide the

The study of extreme fire events is important in determining their return intervals for planning purposes.

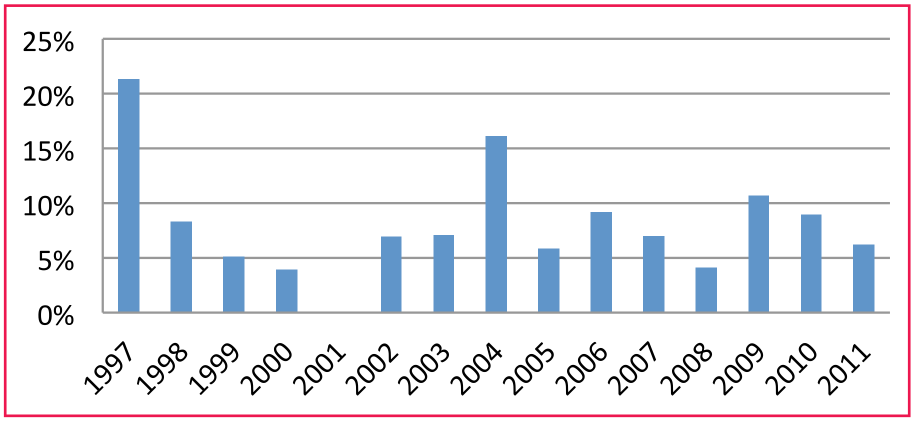

Figure 3.—*Percent of total area burned nationally in the single largest fire, by year.*

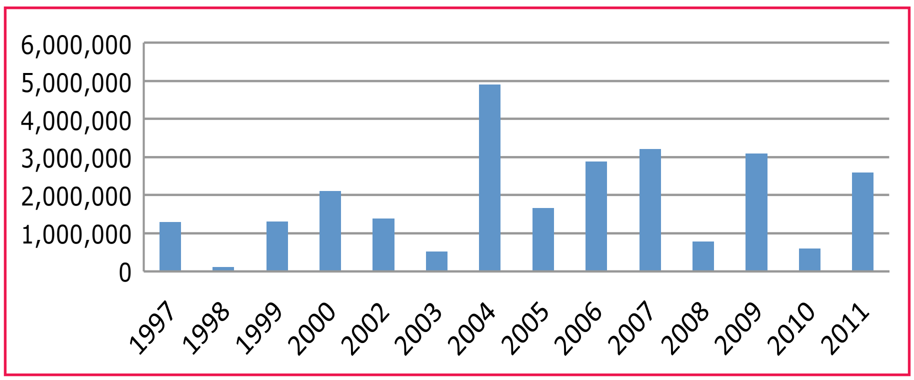

Figure 4.—*Total area burned in fires greater than 100,000 acres (40,000 ha) by year, 1997–2011.*

Data Sources on Large Fires

Twenty largest California wildfires, 1932–2009:
<http://www.fire.ca.gov/about/downloads/20LACRES.pdf>

Top 100 Northern Region wildfires, 2003–2011:
<http://gacc.nifc.gov/nrcc/predictive/intelligence/ytd_historical/eoy/Top100Wildfires.htm>

National large fire database (updated to 2012):
<http://www.nifc.gov/fireInfo/fireInfo_stats_lgFires.html>

Lake States large fires:
<http://www.ncrs.fs.fed.us/gla/natdist/firedb.htm>

Canada national large fire database, 1990–1999:
<http://cwfis.cfs.nrcan.gc.ca/en_CA/lfdb>

burn areas by the smallest area in the group so that the fire size distribution can be readily compared across regions. Figure 6 shows some interesting points, as measured by the steepness of the slopes. First, the grassland fires exhibit the highest degree of extreme behavior. Second, California stands out as having numerous very large fires, though they generally do not exhibit extreme behavior when compared to the other groupings—the exception being the 2003 Cedar Fire. Plainly, the "Other" grouping covers several Western States that merit their own analysis.

Frequency Distributions

Spreadsheet add-ins are readily available to run frequency distributions and descriptive statistics and charts. We used one such add-in to generate the frequency distribution in table 2. It can be plotted as a bar chart.

Scientists often translate the above frequency information into a log-log plot, which helps illustrate the nature of the mathematical law underlying the analysis of the size distribution of fires. The slope of the line tells us how the frequency changes as fire sizes increase (see figure 7). The linear relationship strongly suggests a power-law relationship. A power law will not always apply, and for this paper, we have already truncated the size distribution by omitting all fires below 100,000 acres—which is most of them.

Common sense would suggest that combining fires over such a time period and across conditions as diverse as Georgia, Alaska, and California would make such a chart meaningless. For many purposes, this is true. If, however, the fires in Alaska and the large ONWR fires (which ignited in swamplands and were managed for natural processes) are removed from the dataset, the distribution of fire sizes is almost identical for all categories: the slope of the line is almost exactly the same as for the list of 112 fires nationwide.

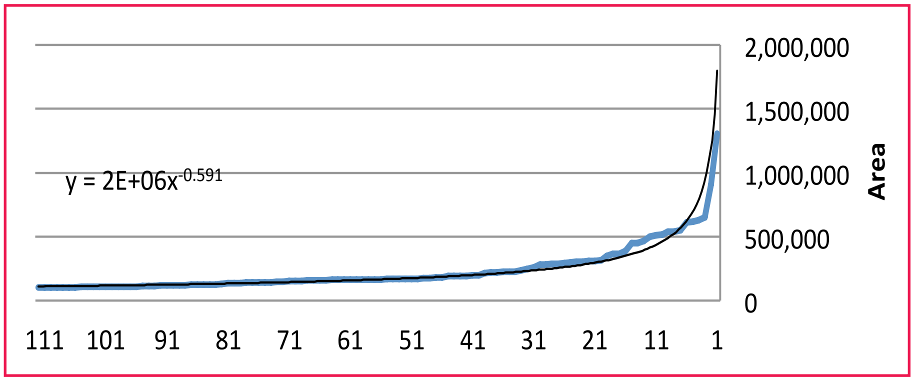

Figure 5.—*Fires above 100,000 acres (40,000 ha) nationally, 1997–2011.*

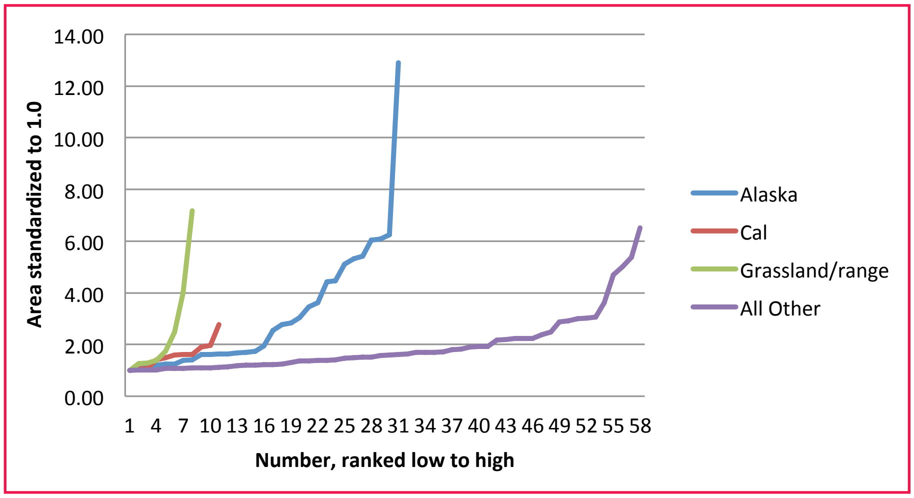

Figure 6.—*Largest fires by type/area normalized to 1.0.*

Table 2.—*All U.S. fires of more than 100,000 acres (40,000 ha), 1997–2011.*

Upper limit of size class (acres)	Frequency (no. of fires)	Cumulative (percent)
200,000	73	65.18
400,000	24	86.61
600,000	9	94.64
800,000	4	98.21
1,000,000	1	99.11
1,200,000	0	99.11
1,400,000	1	100.00
Larger than 1.4 million	0	100.00
Totals	**112**	**100.00**

Scientists and engineers study such distributions by setting up mathematical formulas with interesting names such as "generalized extreme value distributions," "negative binomial," or "Poisson distributions" (see, for example, Sun and Tolver 2012; for a reading list, see Irland 2013; for a valuable study on California, see Holmes and others 2008). Such formulas can be important for testing hypotheses or forecasting. Analyses shown here, however, are entirely descriptive and make no assumptions about underlying probability distributions. Some simpler summary measures (such as peak-to-mean ratio; see table 1 above) are easily calculated.

Making Excess Plots

An excess plot simply plots the degree to which successively large fires exceed their next largest fires in rank. As is common with other weather-driven phenomena, such as hurricanes, large wildfires exhibit excess plots showing that the very largest fires can be far larger than the next in rank order (see figure 8). These wildfire excess plots indicate that the very next big fire could be 10 to 15 percent worse than the current record in a given region, and not simply 1 percent larger.

The dataset used here is useful for illustrative purposes only. It cannot tell us much about the long-term incidence of extreme fires; a much longer series of data is needed to study extreme fire events meaningfully. CALFIRE has compiled a listing of the worst fires in California from 1932 to 2009. A plot of the fires on that list shows that most large California fires are NOT extreme events: the slope of the plotted curve is rather mild (see figure 9). The excess plot shows, though, that successively large fires can be 20,000 to 30,000 acres (8,000 to 12,000 ha) larger than the previous record. No one would be surprised to see this pattern continue: one day, a 300,000-acre (120,000-ha) monster fire will be seen.

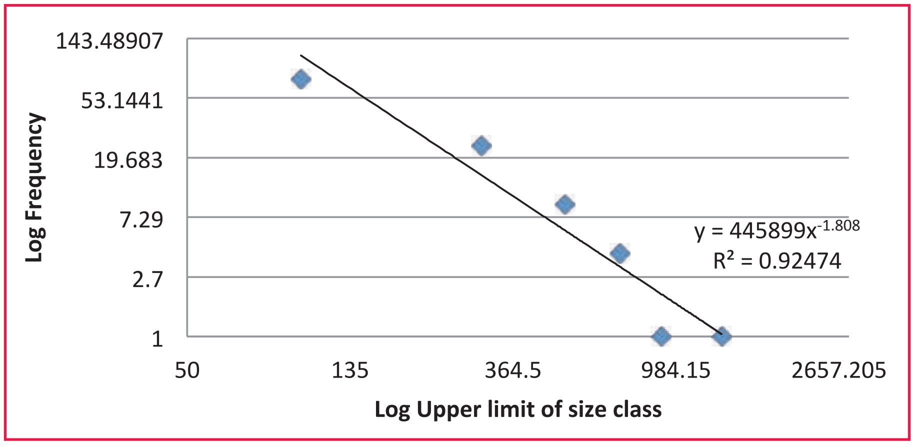

Figure 7.—*Log plot of all U.S. fires above 100,000 acres (40,000 ha), 1997–2011.*

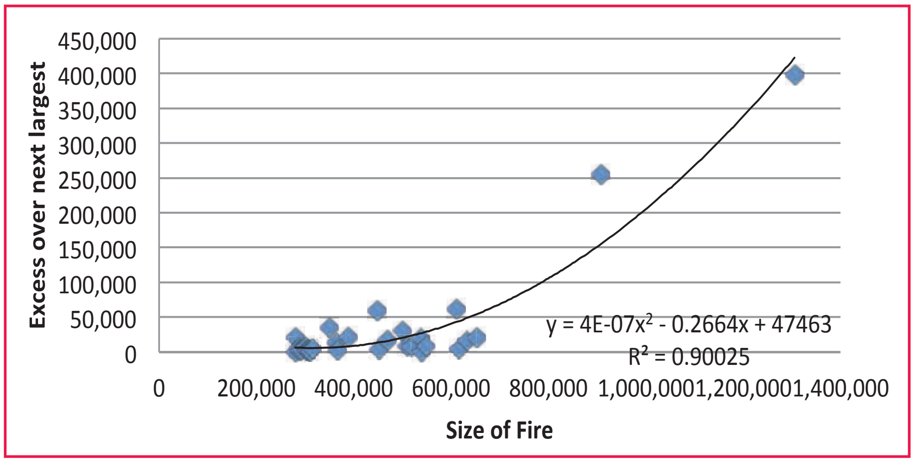

Figure 8.—*Excess plot of the top 30 U.S. fires by area, 1997–2011.*

The slope of the curve of ranked large fires is rather mild in comparison to the experience of other regions in more recent years. The extremes in successive fires are not large in context (see figure 10) because the State does not exhibit truly extreme behavior in fire sizes—though perhaps it does in damages or suppression costs. A more detailed analysis might subdivide California, for instance, into the Los Angeles basin and other regions.

The Upshot

The study of extreme fire events is important in determining their return intervals for planning purposes. Flood-control engineering commonly uses this approach in defining the extents of a 100-year design flood. In contrast, the applied concept of return periods for large wildfires is just beginning.

Extreme fires are not random, perverse, unlikely combinations of previously unrelated forces: they are normal. They are not accidental or "freak" events; they are simply rare. Exactly when and how they will occur is clearly not predictable.

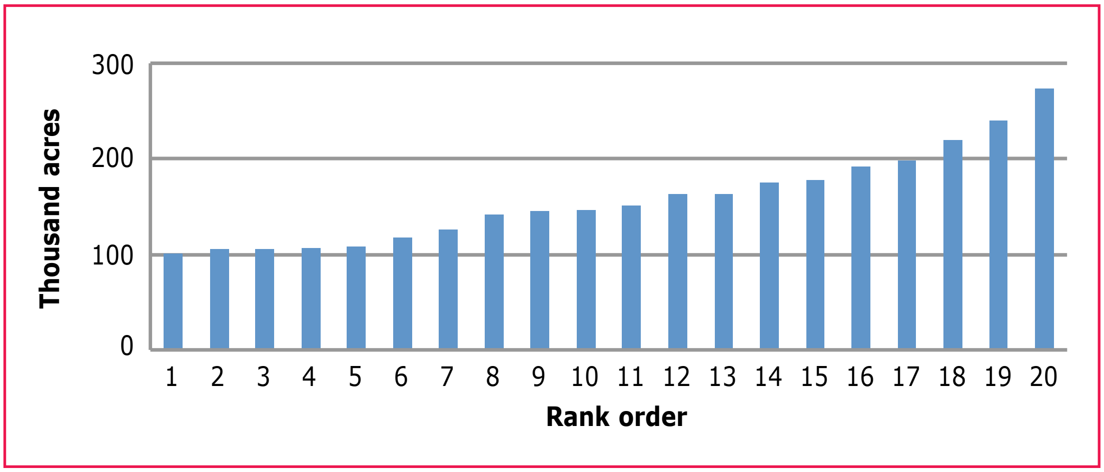

Figure 9.—*Largest California wildfires, 1932–2009.*

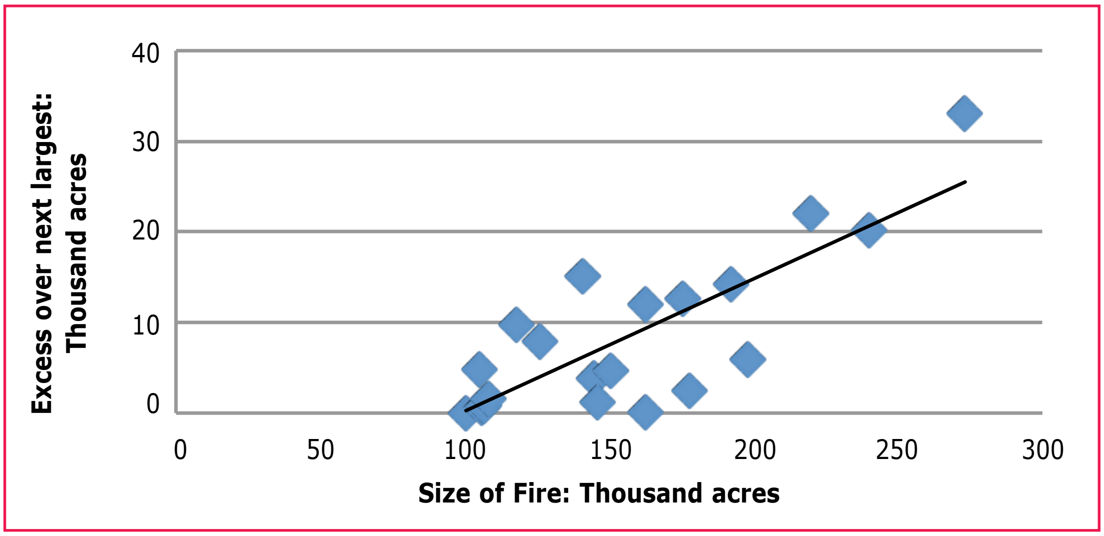

Figure 10.—*Excess plot of the 20 top California wildfires, 1932–2009.*

Studying them scientifically with the usual statistical methods is hindered by the small sample sizes in most of our datasets (see the sidebar for available datasets). During the years 1997–2011, only 11 fires larger than 500,000 acres (200,000 ha) occurred, in widely varying circumstances. Developing meaningful statistical generalizations from such a sample is impossible. The most important observation supported by this national data is that there is no reason why the next extreme fire could not be 10 to 20 percent larger than the largest one experienced to date.

Quiz answers:

1. Georgia: the two fires in the Okefenokee National Wildlife Refuge (lying partly in Florida).
2. California: they ALWAYS have large fires.
3. 37 percent.

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ArcFuels: An ArcMap Toolbar for Fuel Treatment Planning and Wildfire Risk Assessment

Nicole M. Vaillant and Alan A. Ager

Fire behavior modeling and geospatial analysis can provide tremendous insight to land managers in defining both the benefits and potential impacts of fuel treatments in the context of land management goals and public expectations. ArcFuels is a streamlined fuel management planning and wildfire risk assessment system that creates a trans-scale (stand to large landscape) interface for applying existing forest and fire behavior models within an ArcGIS® platform to design and test fuel treatment alternatives. ArcFuels does this through a custom toolbar designed for use with ArcMap® (see figure 1).

The ArcMap framework helps users incorporate data from a variety of sources to address issues that typify many fuel treatment projects. ArcFuels was built to accommodate both raster data (such as LANDFIRE data, available at <http://www.landfire.gov>) and forest inventory data to characterize fuels in the landscape. The structure of ArcFuels provides users with a logical flow from stand-to-landscape analysis of vegetation, fuel, and fire behavior using a number of existing models.

Nicole Vaillant is a fire ecologist, and Alan Ager is an operations research analyst with the Pacific Northwest Research Station, Western Wildland Environmental Threat Assessment Center.

ArcFuels and Fuel Treatment Planning

ArcFuels adds a spatial context to the Forest Vegetation Simulator (FVS) (Crookston and Dixon 2005) and facilitates its application for both stand and landscape modeling of fuel treatments (see figure 2). All functionality and extensions available for use within FVS are available in ArcFuels, including the Fire and Fuels Extension (FFE-FVS) (Rebain 2010), which accesses a carbon model and a climate extension (Crookston and others 2010).

Much stand-level modeling involves validating data and iteratively examining different treatment combinations on individual stands or a suite of stands in a coordinated landscape fuel treatment strategy. The ArcFuels stand-level analysis using FFE-FVS typically involves simulating activities (such as thinning), as well as surface fuel treatments (such as pile burning, mastication, or broadcast burns), and examining the resulting changes to potential fire behavior and effects (such as tree mortality). Users can also apply the validation or assess-

Figure 1.—*ArcFuels10 toolbar.*

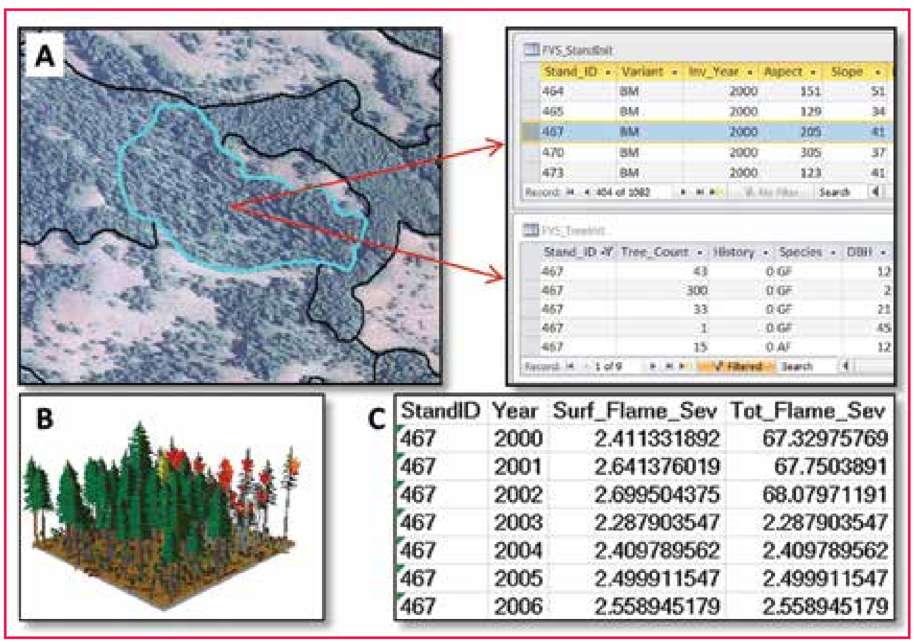

Figure 2.—*ArcFuels provides a way to spatially link a stand shapefile to FVS/FFE-FVS data (A) to run individual stands, select stands, or select an entire landscape. When running an individual stand, the user can run the stand visualization system to automatically visualize the FVS/FFE-FVS data (B), and FFVS/FFE-FVS outputs are automatically written to an Excel workbook. The surface and total flame length (in feet) for a simulated wildfire under severe conditions using FFE-FVS (C).*

ment of fuel treatment prescriptions at the stand level to larger landscapes in developing landscape-level treatment alternatives.

At the landscape level, analysts typically use raster data or FFE-FVS outputs to build the input files for fire behavior modeling in FlamMap (Finney 2006). They can also use post-treatment stand development and fuel dynamics in FFE-FVS to determine retreatment frequency over time at both the stand and landscape levels.

Regardless of the fuel treatment plan, users can apply treatments to landscape data in two ways through ArcFuels: (1) by simulating all stands through FFE-FVS with treatment prescriptions, or (2) by altering raster data to represent post-treatment conditions by using appropriate stand-level FFE-FVS runs, monitoring data, or expert opinion to determine treatment adjustment factors.

> The structure of ArcFuels provides users with a logical flow from stand-to-landscape analyses of vegetation, fuel, and fire behavior using a number of existing models.

ArcFuels and Fire Behavior Modeling

ArcFuels is linked to both stand-level and landscape-level fire behavior models. At the stand level, the user can complete fire behavior modeling within FFE-FVS through the ArcFuels interface and then export outputs in the format needed to run NEXUS (Scott 1999). ArcFuels has quick links to open both FOFEM (Reinhardt and others 1997) and BehavePlus (Heinsch and Andrews 2010) for external use, though it does not provide any inputs to those programs.

At the landscape level, ArcFuels contains links to open both FARSITE (Finney 1998) and FlamMap. Running FlamMap or FARSITE requires a landscape file (LCP), a binary file containing a compilation, or "sandwich," of geospatial data—including elevation, slope, aspect, fuel model, canopy cover, canopy height, canopy-base height, and canopy-bulk density—that characterizes the landscape.

ArcFuels streamlines the process of building LCPs from attributed shapefiles, raster data, or FVS/FFE-FVS output databases. Users can apply treatments rapidly through options in ArcFuels, outputting both raster files and LCPs. They can also use a suite of tools to postprocess outputs from FlamMap for further analysis in ArcMap. Once the fire behavior outputs are entered into ArcMap, users can assess fuel treatment performance in terms of changes to the types of fire, wildfire probabilities, spread rates, and fireline intensity (see figure 3).

ArcFuels and Wildfire Risk Assessments

Wildfire risk is the likelihood of a fire occurring, the associated fire behavior when a fire occurs, and the effects of the fire (Calkin and others 2010, Finney 2005, Scott 2006). A quantitative definition of fire risk includes fire behavior probabilities and fire effects for highly valued resources (HVRs) (see figure 4). Finney (2005) calls this quantitative definition "expected net value change (NVC)." The expected NVC can include financial, ecological, or other values at present day or future discounted values and can reflect both the positive and the negative impacts of fire.

Analysts can quantify fire effects through response functions that describe the impact of fire by flame length categories on HVRs or via FFE-FVS modeling, in which the effects are quantifiable (for example, the impact of flame length on tree survival). When wildfire benefits are not considered, expected NVC can be simplified as expected loss (EL). Using outputs from FlamMap5 and other geospatial data on HVRs, ArcFuels streamlines the calculation and processing of risk metrics, such as NVC, EL, and conditional flame length.

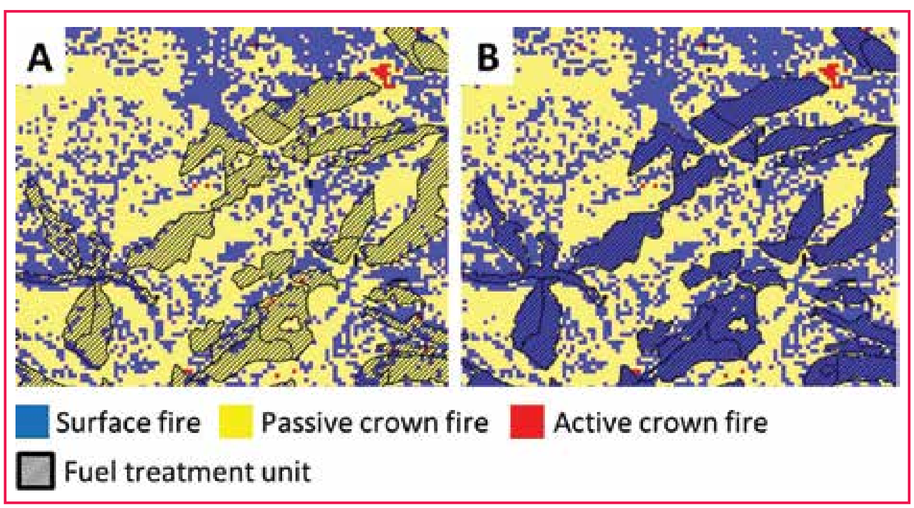

Figure 3.—*Maps of crown fire potential before (A) and after (B) fuel treatments as predicted with FlamMap.*

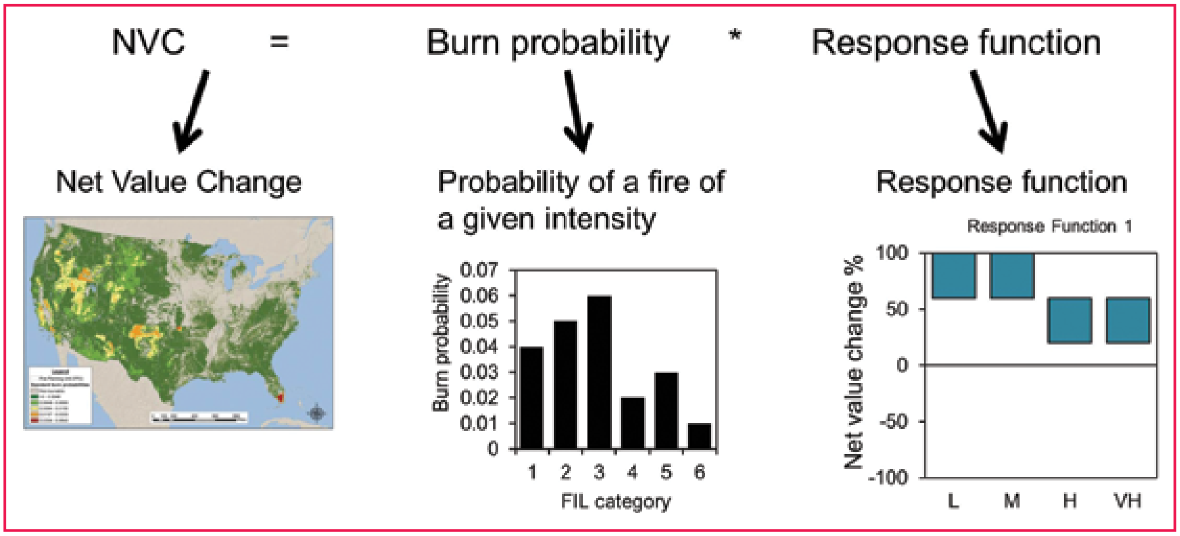

Figure 4.—*Calculating net value change for a single highly valued resource. Burn probability describes the probability of a fire for a given intensity, and the response function describes the change in the value at that intensity.*

Downloading ArcFuels

ArcFuels is available for both ArcGIS 9 and ArcGIS10 as ArcFuels9 and ArcFuels10. The primary difference between the versions is that ArcFuels10 includes wildfire risk assessment tools. Other minor differences exist between the functionality of ArcFuels9 and ArcFuels10. Please visit the Web site, <http://www.fs.fed.us/wwetac/arcfuels/>, to download ArcFuels, linked programs, supporting documentation and tutorials, and demonstration data. For more information about ArcFuels, contact Nicole Vaillant at <nvaillant@fs.fed.us>.

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Providing Information During Disasters and Incidents

Karen Takai

As in the old westerns, the incident management team rides into the challenges of fighting fires, hurricanes, and other threats to townsfolk. We come to help restore order out of chaos and to give communities assurance that the situation is being resolved. As public information officers (PIOs) on the team, our goal is to get the most current, vital information out to families; communities; the media; Washington, DC, administrators; and the world.

The Demand for Information

What PIOs actually do and accomplish is changing from what we used to do (the "old school") to what we now have to do (the "new school"). The role and tools of PIOs are in a major transition in response to worldwide changes in communication technologies and the rise of social media networks. Society now demands realtime disaster information during initial attack, even while situational chaos and an absence of infrastructure interfere with fulfilling that demand. Understanding the process of disaster response helps us to understand the realities of information communication and how PIOs respond to them.

The response to natural disasters can include a mix of planned, expected, contingent, and unforeseen elements.

Karen Takai is a public information officer for the Forest Service, Southwest Area Type 1 Incident Management Team 1.

> The role and tools of public information officers are in a major transition in response to the worldwide changes in communication technologies and the rise of social media networks.

Disaster strikes!

- In the first 24 hours, the Type 1 Team is called out.
- PIOs on the team call-out roster respond to the incident (a total of three on the Southwest Incident Management Team 1).
- In 12 to 24 hours, the team is "on the ground" but can legally take over the management of the incident when it has the official "Delegation of Authority" document signed and in place. This document defines the agreement and expectations between the team and the hosting unit of the incident.

Most of the local infrastructure is down!

- PIOs immediately need to collect accurate information and start disseminating updates through phones ("Are there phones?"), social media ("Do we have connectivity?"), and media outlets ("Do we have a central distribution location?").
- PIOs immediately start to receive information requests from frantic, local community members; government agencies; the State's Governor; Washington, DC, entities; and media organizations around the world.

The landscape is in total chaos!

- Accurate information is limited. Do PIOs have enough information to confirm or deny developments?
- Rumors abound. What rumors need to be addressed immediately to avoid further confusion and panic?
- Not all information on current operations and outcomes may be useful. Has release of specific information been approved by the incident commander and by the host unit public affairs officer (PAO)?

Large incidents now generate global interest, and the public expects realtime, detailed, on-demand information.

Gone are the days when information was faxed to media stations and hundreds of individual phone calls were made to a public that wanted additional information. Multimedia and social media have changed the world of information, and the demand for it only increases. Leaders and PIOs must embrace these communication tools or become obsolete.

And yet, the demand for face-to-face communication has not abated. The local communities affected by the incident initially resort to multimedia outlets but rely heavily on further information from community meetings, face-to-face meetings with leaders, newspapers, local radio stations, and traplines of information posted at a central location and updated daily.

This will not change. The PIO's main goal is to reach those immediately affected by the incident with relevant and timely information in whatever format is most effective. As PIOs, we must be well versed in the technological changes and in all media formats. These changes have been occurring for the last 15 years. The expectations of the world are that we can offer information in the formats that are currently popular and that we change outlets with the emerging platforms that meet the demands of our diverse audiences.

How We Work

New Media, New Demands

Initial attack information is usually handled by the local unit's PAO or PIO, depending on the size and location of the incident and the Government level of interest. As the size of an incident escalates, the PIO or PAO is immediately expected to provide information in all media formats: print, video, and electronic. It is unrealistic to expect that one PIO could satisfy all these demands: giving in-person interviews to the media, participating in a social media dialogue, responding to congressional inquiries, and producing community notifications. In years past, a Type 1 incident management team could travel with 10 PIOs, and they could handle traplines, news releases, media notifications, and personal interactions for the whole incident. With the changes in the size of incidents and the speed of their devastation, it would be challenging for a team to work with less than 20 PIOs on a Type 1 incident.

This is the new school, and both information needs and formats have changed. Communication tools now include cellphones, electronic notepads, and satellite phones for the times when cell towers are down or connectivity is unavailable—and this is commonly the case. The availability of such tools is a dream for most; most PIOs will use their own cellphones and computer notepads to process incident information while the (ICP) post is being created to provide support with phones, Internet, and computers. A camp can take from 1 to 3 days to become functional. Years ago, the Government had the latest high-technology tools. Now, we find that society has the latest and greatest equipment, while we are challenged to keep up.

Large incidents now generate global interest, and the public expects realtime, detailed, on-demand information.

Keeping Up and Staying Sane

The widespread use of computers and social media has sped up communications and heightened the intensity of demand during fire incidents. The following description illustrates how a situation might unfold.

> I am notified by dispatch that the team has been activated. I gather my gear and, with luck, another resourced PIO accompanies me as I head out. As lead PIO for the Type 1 Southwest Incident Management Team, my cellphone might well be backed up with 125 messages as I head to the incident. To prioritize the calls, I hand my phone to a PIO, have the PIO screen the calls, and note the most pressing requests so that I can then respond to them immediately.
>
> The home unit is still managing the incident but is overwhelmed due to the limited resources it has available. Phones, electricity, and water systems are down and chaos is everywhere. The sheriff is evacuating communities and directing evacuees to shelters that have not yet been set up. Members of the media are showing up everywhere, and rangers are calling me to get someone to corral them. The situation is still in the initial attack phase—and I have only three staff members.
>
> Issues will be resolved but will take some time. From across the country—in areas where there is still TV reception, working landlines, cellphone connectivity, and electricity for lights—calls are coming in, and people are wondering why we are not resolving the situation.

Demands reaching us from the world outside are distractions from our main focus: to bring order to chaos. Our main focus is to identify, prioritize, and work on solutions as a team. We continue to swat distractions and turn the incident, at first, into a controlled chaos, and then, after many days, a controlled and organized incident.

I meet my team members and in-brief with the host unit's PAO and leadership. This meeting is where we find out what the host unit's expectations are. I receive current weather conditions and find out what resources are available to support the information cadre. What are the expectations of the hosting unit, and what would the unit like us to do regarding social media outlets, news releases, and communication with local administrators. Meanwhile, the incident is still ramping up outside the doors. I order additional PIOs, if needed, reaching out to different levels—PIOF, PIO2, and PIO1—to support the incident.

Managing Chaos

In the midst of an incident, all decisions take on new urgency and all shortcomings threaten to unravel operations. Sometimes it seems that anything that can go wrong will.

Fundamental questions come to mind: is there a bank of phones I can use as a call center? In one case, I am given a call center with 25 phones. After a day of angry cellphone calls, I check with the center manager and he or she finds out that only six phone lines are working. People are complaining that they can't get through. We send emails with releases to update agencies, the media, the local community, and Washington, DC, administrators, but our email notification system indicates that many are being rejected. We have not encountered this before and are a bit baffled. After a day of research, we find the system we are using can only send out 300 emails per day, and we need to be sending more than 1,000 due to the demand for information. The demand for social media and Internet updates for incidents is dramatically increasing. We are now in a new arena. Agency administrators are complaining that they are not receiving emails, the Governor is calling Washington, and Washington is calling me.

The communications paradigm has shifted, incidents are bigger, and the tools of the past are obsolete. Demands put additional pressure on the crisis information function. Thanks to the National Interagency Fire Center, we now have a way to bring on an emailing service that will successfully support thousands of emails going out throughout the day. The email service is located outside of the local infrastructure and will not crash due to brownouts, downed telephone wires, and lack of electricity. There is a cost to the service, but do we have an option?

Calls come in from the Members of Congress; the State's Governor; Washington, DC, administrators, and a multitude of others. Needless to say, not all are happy about response time and the level of information being forwarded. Again, the outside world is plugged into a multitude of different social media formats, their electricity and cell phones are working, and everyone wants information immediately. Unfortunately, we do not have electricity, phones, and social media at our fingertips.

Entering the world of disaster, the PIOs are behind the curve from the minute they get the call to go into the disaster area. We assess the situation and assign duties to the social media and operations PIOs. After painful lessons learned, we keep our social media expert out of the disaster area to ensure connectivity and access to the Internet to strategize and implement the social media plan. Once the main ICP is operational, we will stage a social media contact at the ICP's information center so that the lead social media PIO can travel between the duty station and the main ICP, which could take from 12 to 24 hours. The operations PIO immediately goes to the operations section of the incident and gets the timeliest information for the other PIOs working in the information center to release to the community. After approval of the information, the operation's PIO will group-text the information to all PIOs in the field.

As the incident progresses, there is a change in the feeling from the community. There are no immediate fixes. Everything community members have come to rely on is compromised and the reality of the situation is devastating. This fire incident will obviously affect the community for years and lifetimes to come. Most displaced community members are unprepared for the discomfort, chaos, disorganization, fear, and general lack of reassurance. For some, life now is surreal, and some are in shock.

In the midst of an incident, all decisions take on new urgency and all shortcomings threaten to unravel operations.

When the numbness wears off, emotions return, anger surfaces, and some community members may look for someone to blame for their loss. Some members of the public may accuse the response agencies of mismanagement and a lack of timely response by the firefighters. Some members of the media may encourage conflict, and soon the PIOs are in a difficult position. Confrontational media members and some politicians may influence their audiences to turn communities against the very people who have come to help. We are put on the spot as reporters' question official timelines and incident response measures.

We are now in constant communication with community groups. They are afraid, angry, and frustrated—and understandably so: this is a disaster. It is the PIO's job to work with communities, provide a sense of perspective, and begin the healing.

On the other hand, some individuals in the community begin to thank us for our efforts, bring us cookies, and hang hand-painted signs of thanks along the route we travel. The two extremes—demand/anger and thanks—keep us going. This is what we are trained for, and when we soar.

This article provides a very simplified picture of the life of a PIO. Gunning along for 16-hour days are the norm for PIO leads and support staff. During an incident, we take on many roles:

Writer, graphic designer, counselor, strategist, computer expert, network builder, creative and analytical thinker, social media hub, media relations and interview providers, PIO trainers and monitors, congressional escorts, and psychological counselors.

Tasks encompass both incident information setup and operations wrap-up, including dealing with the after-effects of the incident, and include:

Becoming familiar with each person involved and affected; facing and addressing the consequences of loss; creating and maintaining work relationships; practicing diplomacy; ordering, scheduling, and training personnel in new tasks; making split-second decisions; taking videos and photographs; archiving all records and communications; writing meaningful biographies of the deceased; escorting families of the fallen; and planning memorials.

We interact, document, file, photograph, film, and clean. We follow each incident with an immediate after-action review (AAR) and a later followup AAR to ensure that the lessons learned are followed through. We also must ensure that each one of the PIOs have done his or her own healing and is emotionally intact from some of the most stressful and yet honorable work a person can do.

The Personal Part

But the work doesn't end with the operational part. As an ongoing point of contact, I will continue with the issues generated by incidents for months, even if it is only answering followup questions from the media, writing thank-you notes to all who supported the incident management team, or checking on our PIO cadre to make sure we all have some sense of closure.

Personal after-effects are unavoidable. The stress of every incident takes a piece out of me, and every fatality takes a piece of my heart. In 2013, we dealt with 20 fatalities associated with operations, from conducting personal interviews with friends and family to arranging memorial services. These are life-changing experiences for most, and as professionals and individuals, we will have to process some measure of sadness all of our lives.

The Team

Ultimately, many things hold us together as individuals and team members and keep us going: the mission, the people we serve, and the team to which we belong. All deserve recognition. This article is dedicated to all the PIOs nationwide: in State, Federal, county, and city agencies, and to those PIOs that come to us as ADs (administratively determined personnel). We could not accomplish the necessary work that we do without all of them. To each and every PIO I have worked with: thank you for your dedication to change and bringing the PIO world to the next level and for the dedication and hard work you have done to support the incident information mission and me. ■

A New Truck for Avoca

Martin Brammier

The Avoca Rural Fire Department serves the community of Avoca and the rural citizens of its district in the southeast corner of Nebraska. Though the community is small, the department boasts a membership of 23 active firefighters, 4 auxiliary firefighters, and 3 cadets. With close ties to the community, the department works with a great sense of pride. Much of this can be attributed to its building a more competent and reliable department over time.

Part of this development involves working with reliable, quality equipment. Recently, the department applied for and was given a grant to replace 20 pairs of outdated bunker gear. Without the grant, the department would not have been able to afford the nearly $56,000 cost that came with replacing the gear. Other gear had become antiquated as well. The chief officer, Martin Brammier, presented the rural board that oversees district spending with the benefits that the acquisition of updated equipment could provide to the community. The district representatives met the proposal for spending with apprehension, initially resisting it.

Seeking its own solution to the issue, the Avoca fire department negotiated with the Nebraska Forest Service's Fire Shop in Mead, NE, to acquire a new truck through the Federal Excess Personal Property program, which leases excess Federal property to rural communities. Coincidentally, the U.S. Department of Defense had decommissioned a number of airfield firefighting vehicles and made them available to the program. As a result, the Avoca fire department was able to lease a 1992 OshKosh P-19, paying $6,500 for a vehicle that had a base value of $212,000 at the time of delivery. The department then invested about $6,000 to repaint the vehicle and an additional $2,500 in added tools and equipment. The Avoca fire department also welcomed the assistance of the Fremont Rural Volunteer Fire Department in refinishing the truck.

When the Avoca fire department finished refurbishing the truck in February 2013, the department presented it to the rural board for inspection. The board's reaction was one of unanimous amazement that such a quality vehicle could be attained for a relatively small expenditure. The board recognized the value of the equipment and quickly reimbursed the department for its costs. In addition, the board gave the department financial support to upgrade other apparatus on the vehicle.

While the new vehicle is already a welcome addition to the department, the department is negotiating further enhancements with the rural board. Throughout this process, the Nebraska Forest Service has played a welcoming and supportive role in providing technical support, maintenance reviews, and onsite training of personnel for optimum vehicle performance. Obviously, the department looks on the new equipment with considerable pride and on the assistance of the Nebraska Forest Service with much appreciation. ■

Martin Brammier is the chief officer of the Avoca Volunteer Rural Fire District in Avoca, NE.

An OshKosh vehicle decommissioned by the Federal Government awaiting its next assignment. Photo by Martin Brammier.

Repainted and re-equipped, the fire truck is in service to the Avoca Volunteer Rural Fire District. Photo by Martin Brammier.

Flipping Firefighting Training

Mark Cantrell

Introduction

The challenges of shrinking budgets, lack of travel funds, and the ever-pressing need to train wildland firefighters has led to calls by instructors, training officers, and geographic area training representatives for new ways to safely conduct training. With the development of multimedia software and widespread access to the Internet, the concept of "blended learning" provides one potential option to satisfy that need.

Blended learning has been around for many years. It combines student online and instructor-led learning experiences with the expectation that the combination will promote more two-way interaction and student engagement than traditional learning models. Blended learning has emerged as the basis for a new training model called the "flipped instructional" model. While this model has quickly gained acceptance in academic circles, there is little information available about its applicability to training—specifically, to wildland firefighting training. In this article, we explore the flipped instructional model and its applicability to wildland firefighting training.

Flipping Defined

The goal of flipped instruction is to change the level of participant involvement in training, moving (1) the student from a passive role as an information sponge to an active participant, and (2) the instructor from a talking head to an activity facilitator. It challenges the instructor to design an active learning experience that builds on the online instruction or videos that students view prior to class. Silveira (2013) defined the flipped model of learning as "a form of blended learning that integrates the use of technology…to leverage the learning in a classroom so that an instructor can spend more time interacting with students instead of lecturing." The technique seeks to move the student from passive listening to empowered examination of course content in such a way that the student will retain it beyond the next quiz or test.

> Flipped instruction places online content and classroom content on an equal footing.

Flipped instruction places online content and classroom content on an equal footing. The intent is not simply to increase instruction time by making upcoming lesson content available outside of normal training hours, but to ensure that students have the most time possible to prepare for instruction, ask questions, and achieve lesson objectives. A flipped classroom is thus "an innovative model of learning that inverts the traditional teaching model by delivering didactic content through educational technology prior to the traditional lecture timeslot and focusing class time on active exercises and higher order concept mastery" (Dasgupta and Tuttle 2012). In wildland fire training, the combination of formats encourages students to grasp concepts, understand lesson content, participate in classroom discussion, and, as a result, become safe and effective in their duty positions.

Flipped instruction is experiential. "Blended learning and flipped classrooms are more than a simple alteration of the method by which information is imparted. To ensure that students gain the most from these approaches, students require authentic learning spaces where they can work collaboratively with teaching staff to achieve deeper understanding" (Chipchase 2013). The emphasis is on creating a designed learning experience in which the students can develop a higher or more engrained grasp of lesson material. The instructor becomes a facilitator or guide through the learning experience.

What Training Types Are Best Flipped?

Traditional demonstration-based and lecture-based lessons are prime candidates for recasting into flipped instruction. If a lesson has traditionally been taught through demonstration, creative online explanations and demonstrations prior to a classroom session help develop an understanding of what is expected of students so that they can immediately go into practice mode in the classroom. Wildland firefighting

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concepts, tools, and procedures—for example, hydraulics, portable water pump operations, and chain saw maintenance—can be demonstrated online and then practiced and evaluated in the classroom by the instructor.

Flipped instruction has been found to be effective. For example, physiotherapy instructors conducted a research project on the benefits of flipping and found that "high-resolution videos of practical skills with instructions can be made available to students prior to a practical class. This allows practical class time to be reserved for feedback on the skill… Thus, in the flipped practical class, physiotherapy educators spend less time demonstrating, more time interacting with students, and more time supporting rather than driving learning" (O'Toole 2013).

Some educators have found it helpful to have either synchronous (live chat) or asynchronous (email, a frequently asked questions Web page, or a blog) communications with students to accompany the explanation and demonstration portions of training. This is especially helpful with complex topics or higher levels of Blooms taxonomy of learning objectives. Instruction designers can further develop or revise the preclassroom portion of instruction in response to a pattern of students' questions, while the remainder of the questions can be addressed during the practice portion of instruction.

Mistakes To Avoid

When many people first learn about flipping, they often assume that it is only applicable to basic skills or concepts. In fact, flipping can lead to higher levels of understanding in more advanced subjects as well. Ferreri and others (2013) expand on this idea: "In-class time is then freed up to discuss complex topics and work with students, either individually or in small groups, [and] increased in-class student problem-solving with immediate feedback occurs." An instructor can focus on higher order effects or the upper levels of the learning taxonomy, having built upon lower level information.

> The emphasis is on creating a designed learning experience in which the students can develop a higher or more engrained grasp of lesson material.

Jon Bergman, one of the pioneers of the movement, helps us to avoid some common flipping mistakes in addressing his experience in traditional public school education: (1) keep videos short, (2) don't assume all students have the Internet at home, (3) don't lecture if students haven't watched your videos, (4) hold each student individually accountable for work, and (5) teach students how to watch your videos (Bergman 2014). These are great points to think about when considering if the flipped instructional model would work for certain lessons.

In addition, as the student prepares for the next lesson, don't limit the types of interaction that can occur only to the topics in the videos. Silveira (2013) lists a number of education technology tools that instructors may consider, such as "learning object repositories, lecture-capture technology, podcasts, Ipadio, digital imaging, streaming audio, and interactive case simulations." Schools are using a variety of education technology tools to motivate students to watch videos or do other preparatory work before the class session. Instructors have to be both creative and realistic in working with the most effective instructional formats.

Why Flipping for Wildland Fire Training?

The goal of wildland firefighting training is to develop safe and effective wildland firefighters. Wildland firefighting is, by its very nature, dangerous. As a performance-based profession, being able to safely and successfully accomplish a task is critical. With this in mind, we should train as realistically as safety and necessity permit. In a training environment, this generally means that the student needs to learn how to accomplish a task proficiently. Often, the best way to learn a task is to do it, so the faster instructors can get the student to safely practice a task, the better. This is where the flipped instructional model can help.

One of the challenges of traditional learning models is that students have varying levels of knowledge concerning the subject when they enter the classroom. By introducing the content to them before the class session, flipping enables the entire class to have a more equal understanding from which to build. Larson and Yamamoto (2013) elaborate on this: "Students with prior knowledge…did well in the assignments without watching the videos. However, the students who lacked the prior knowledge or lacked confidence benefited from watching the videos. This result implies that instructors can refer to students' prior knowledge and the difficulties of the content in order to decide which part of the class to flip." This does not simply replace the lecture with a video but creates an intentionally designed sequence of instructional steps to increase student retention of content.

The greatest value of flipping lies in maximizing instructor and student time and energy in actually practicing a skill or performing a task. Chipchase (2013) writes: "The value of a flipped class is in the repurposing of class time [so that] students can inquire about lecture content, test their skills in applying the knowledge or clinical skills, and interact with one another in hands-on activities." By designing a learning experience (both preclass and in class) to emulate real situations, instructors are able to help the student's understanding of a task and proficiency in completing it.

This two-part design suits the two-part format of flipping. Basic understanding can be achieved through preclass instruction, and once the students enter the classroom with sufficient knowledge of the material to ask pertinent questions, they will quickly be able to move to competent performance. Osborn and Vinton (2013) call flipping the combination of two key components of learning: educational technology and active learning. The instructor can combine these components to help the student get to the desired performance level in the most efficient and safest manner possible—which is the objective of wildland firefighting training.

How National Wildfire Coordinating Group Training Has Flipped

Since 2008, National Wildfire Coordinating Group (NWCG) has experienced solid success with our distance-learning program and has found that the blended format has many benefits. The NWCG training blended format moves cognitive content in psychomotor lessons online for explanation and demonstration phases prior to classtime. Students must complete the online portion of a lesson, and the learning content management system records the results of an online final assessment. Once students complete these two steps, the training system issues a completion certificate that the students then provide to their unit training officer. The system also provides a completion certificate to the course coordinator or lead instructor as an "entrance ticket" to the field or classroom portion of the course. During the field day, students immediately move into practicing hands-on activities as the instructor cadre and students engage in practicing the appropriate fireline duties.

The use of blended-learning courses results in a significant cost savings, provides for standardization of instruction, and maximizes hands-on time with students and instructors in a performance-based training system.

NWCG training has flipped many courses in order to maximize instructor cadre and student activity-based learning time. In addition, many other benefits have come about from using this flipped model to our courses: reduced temporary duty for training, cost savings for the hosting unit, increased student satisfaction, and development of competence and proficiency in a shorter period of time. While the NWCG distance-learning program model, by literal definition, may be considered "blended learning," it still wholeheartedly embodies the flipped instructional model. It does this by putting cognitive learning content online and then skills application by the instructor cadre and students in the classroom or field environment.

In 2013, the NWCG distance-learning program produced more than 13,000 online completions (see figure 1) in a combination of both online-only and blended-learning courses. The use of blended-learning courses results in a significant cost savings, provides for standardization of instruction, and maximizes hands-on time with students and instructors in a performance-based training system.

Future Flipping Research Efforts

Research into the effectiveness of flipping technical training is generally lacking: the concept of the flipped instructional model is still relatively new and, as such, does not have a lot of research to support its effectiveness relative to traditional instructional models. Yet, the flipped instructional model has the potential to significantly enhance the way wildland firefighting train-

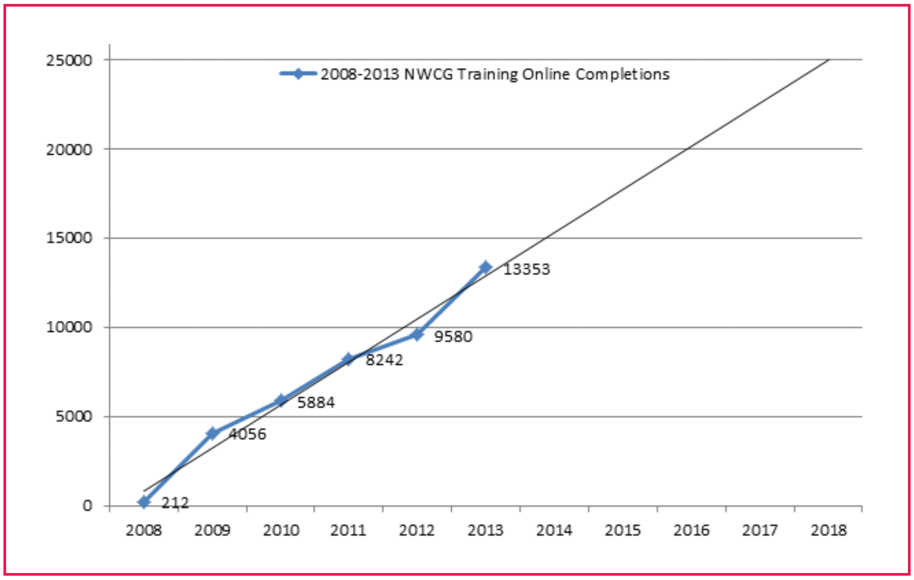

Figure 1.—*2008-2013 NWCG training online completions with linear projection through 2018.*

ing is designed and conducted. By developing an understanding of the flipped instructional model and examining the training types that work best for flipping, trainers can begin to envision its application. As they seek ways to apply the flipped instructional model, knowledge of common flipping mistakes will help trainers communicate the best first steps to take when considering this model. The success NWCG training has had with this model will hopefully serve as a guide for other wildland fire training units.

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Success Stories Wanted!

We'd like to know how your work has been going! Provide us with your success stories within the state fire program or from your individual fire department. Let us know how the State Fire Assistance (SFA), Volunteer Fire Assistance (VFA), the Federal Excess Personal Property (FEPP) program, or the Firefighter Property (FFP) program has benefited your community. Feature articles should be up to about 2,000 words in length; short items of up to 200 words.

Submit your feedback, articles, stories, and photographs by email or traditional mail to:

Fire Management Today
USDA Forest Service
Fire and Aviation Management
1400 Independence Ave., SW
Mailstop 1107
Washington, DC 20250

Email: firemanagementtoday@fs.fed.us

If you have any questions about your submission, you can contact one of the FMT staff at the email address above or by calling 202-205-1503.

Safety and the Agency, Part 2: External Influences on Fire and Aviation Management

James K. Barnett

Forest Service manuals and handbooks are full of binding standards intended to protect and guide employees. Training, tools, and information bolster safe operational objectives. Everyone from the Chief of the Forest Service to forest resource experts provide input and oversight for how Fire and Aviation Management (FAM) personnel achieve agency safety objectives. Although agency oversight is extensive and continuous, there are also many external influences. No other program invites more scrutiny from external sources than the FAM program, and scrutiny is increasingly expensive and carries both positive and limiting aspects.

One of Many: Interlacing Missions and Jurisdictions

No branch of any Federal agency is autonomous, and jurisdictions cross governmental boundaries, even in critical situations. For example, safety concerns on public roads preclude exceeding the posted speed limit even when an incident response vehicle is responding to a fire, use of an engine siren must conform to civic ordinances, and the role of emergency medical technicians is regulated on a State-by-State basis. Many safety and law enforcement duties fall on the local county sheriff when an accident, State-recognized crime, or search-and-rescue operation occurs on Forest Service land. Local jurisdictions provide a number of emergency-related services and can thus make a positive contribution when fire managers are pursuing Forest Service objectives.

No branch of any Federal agency is autonomous, and jurisdictions cross governmental boundaries, even in critical situations.

Local jurisdictions often benefit from suppression efforts, and some level of reciprocity occurs for those supportive and influential communities that receive federally allocated grant money to address local fuels build-up. For instance, fuel treatments around municipalities are a commonsense approach to the fact that some forest fires burn down houses and some house fires burn down forests.

Federal and State Wildfire Suppression Organizations

A century ago, when local firefighting organizations were being formed, the focus was on community objectives. Common objectives and fiscal realities eventually united their efforts into county, State, and Federal fire suppression organizations.

This efficiency came at the cost of ever-increasing demands for conformity. Even after consolidation, differences in resource objectives, fiscal capabilities, and personnel qualifications continued. Limiting factors, such as incompatible communications equipment, inferior firefighting equipment, and limited operational experience contributed to clear safety concerns, violations, and fatalities. Once these organizations matured, they formed the National Wildfire Coordinating Group (NWCG), which eventually took on the role of uniting organizations on various governmental levels and operating support systems to mitigate disparities in capabilities and promote safe operations.

Over the past 30 years, consolidation has limited or eliminated numerous safety issues that contribute to fire suppression-related accidents. However, despite all the coordination that NWCG can muster, there are many nonfire entities that still affect safety and accident mitigation for Federal agencies responsible for wildfire suppression.

Federal Nonfire Influences

Whether related to public safety, a fatal wildfire accident, operations support, or jurisdictional oversight, numerous entities actively

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or passively have influence on FAM operations, including safety concerns. For example, Presidential administrations have increasingly influenced agency policies and procedures through the Office of Management and Budget. Serious response shortfalls to Hurricane Katrina spawned Presidential Directive-5, formally recognizing the National Interagency Incident Management System (NIIMS) as the definitive disaster-response system for all Federal agencies and State or other organizations that accept Federal funds. Although NIIMS was developed and used by Federal fire suppression organizations since the early 1980s, administration of NIIMS was given to the U.S. Department of Homeland Security, whose primary agent was the Federal Emergency Management Agency. This single Presidential directive in 2003 may have created the biggest shift in operations authority since Federal agencies started consolidating suppression efforts.

Congress also affects agency operations by making budget allocations and requiring Forest Service representation at selected committee hearings. Through specific offices, the Forest Service responds to information and other congressional requests. For example, the Legislative Affairs Staff coordinates expert Forest Service testimony at congressional hearings, and the Office of Regulatory and Management Services (ORMS) manages constituents' letters that have been forwarded by Members of Congress for response by the agency. If the subject involves disaster response or fire and aviation operations, ORMS seeks a draft response from FAM, edits and administers their response, and returns copies of the response to the requesting congressional staff and its constituents.

Legislative responses to operational details are not unknown, and, in rare cases, Congress has added safety-related requirements affecting the Forest Service through "riders" attached to more general pieces of legislation. In the mid-1990s, for instance, Congress passed a bill that eliminated the Forest Service's authority to inspect most fixed-wing aircraft that they might contract for during any given year.

Liability concerns may also now affect the process of decisionmaking, leading to less specific operational requirements or greater pressure on incident managers to control all aspects of operations, however minor.

The U.S. Department of Agriculture's Office of Inspector General (OIG) is regularly involved in FAM audits. The primary goal of such audits is to identify systemic faults and make recommendations for inclusion of correctives in agency procedures. Agency experts may have limited input to the draft report contributed near the end of the audit process. Agency experts also have limited authority to challenge audit conclusions, and there is no established appeal process in these cases.

The National Transportation and Safety Board (NTSB) independently investigates all public aircraft crashes that involve agency or agency-contracted aircraft. Although the NTSB findings may generate a need for an agency policy update, more often, the board will work with the Federal Aviation Administration (FAA) to update Federal aviation regulations, if warranted. Between 2002 and 2005, review of the aging contract air tanker fleet brought agency aviation experts together with numerous entities, including NTSB, FAA, and a select panel on aviation safety.

Some influences are established through interactions with other Government agencies and can be extremely advantageous to the agency. The National Weather Service (NWS) was, for example, an indispensible resource. The NWS assisted the Forest Service in closely monitoring fire weather and producing general and spot weather forecasts that have significantly increased situational awareness on wildfire incidents. Although budget and organizational changes at NWS eventually ended the fire-weather forecasts by NWS forecasters, NWS still allows Forest Service fire forecasters unrestricted access to its data and products.

Other influences are the result of different operational goals and standards. So, for example, U.S. military, State National Guard, and personnel of foreign countries are not obligated to adhere to agency standards during cooperative operations, unless those standards are bound by specific agreements. If agreements are activated and training requirements are met, these resources can have a profound influence on operational objectives. The agreements also identify liaisons that are assigned to ensure safe and prudent operations.

Public and Private Organizations

Individual citizens may influence agency policy or operations via the congressional letter process previously outlined. Private contractors and their personnel are not obligated to follow agency policies unless specifically referenced in their current contracts (including maintenance schedules for equipment and special-use aircraft). To ensure minimum safety standards, contracts often identify the role of a qualified Forest Service liaison for equipment and equipment operators on an incident. Small businesses can also elicit extensive support from their congressional representatives regarding the terms of such contracts.

Table 1 provides an overview of the various reviews of Forest Service FAM policies and operations, their sources, and their primary objectives. Table 2 describes some of the influences on policy and operations and their sources.

Table 1.—*Accident and Systematic Reviews*

Review type	Primary objective	Reviewers
After Action Review	Sharing information about successes and problems	Event participants
Audit (Office of Inspector General)*	Reviewing specifically defined policy or operational topic for weaknesses	Auditors–rarely possess topic-related expertise
Individual Performance Review (National Wildfire Coordinating Group format)	Providing constructive criticism, whether on an incident or associated with hiring unit duties	Direct supervisor
Large Incident Close-Out Meeting (Interagency process)	Sharing information about large incident successes and problems	Incident management team, line officers, and other interested representatives
Lessons Learned Board (Interagency sponsored)	Developing topical information to improve future actions	Permanent board member
National Transportation and Safety Board	Recognizing procedural or technological failures	Highly trained technical experts
Occupational Safety and Health Administration	Recognizing policy failures relating to workplace safety	Highly trained technical experts
Panel	Assessing systematic problems and recommending alternatives	Frequently, external experts
Review board	Developing an understanding of and suggesting fixes for contributing factors to a single event	Variety of subject experts
Study	Assessing systematic problems, making recommendations, and suggesting mitigation, as appropriate	Subject experts

* Each department of the Federal Government has an independent Office of Inspector General.

Table 2.—*Sample subjective external influence strengths and limitations.*

Mitigation/support	Strengths	Limitations
Evaluations	Receive nearly instant feedback associated with general or specific successes	Often lack specific need for improvement; understate weaknesses or how to address them
Studies	Include experts focused on systematic or specific problems	Generally lack methods to accomplish findings
Audits	Tend to be unbiased because it is performed by outside viewers	Lack of topical expertise of outside viewers may limit their ability to make recommendations that fully measure topic complexities
Review boards	Include experts looking at very specific circumstances and working outward to understand causal factors	Additional recommendations do not always serve the best interest of safety, the individual, or the organization

Summary

The notion that FAM is an autonomous organization that is given unrestricted authority to put out wildfires is an unrealistic simplification. Many outside organizations affect how FAM operates. FAM works with Federal agencies, State and local governments, as well as with local organizations. Opinions vary, but policy recommendations and suggestions are taken into consideration and analyzed at the national level. FAM must maintain not only its ability to deal with climate change and technological updates, but must also keep up with new and changing partners and organizations that have investments in safety. ■

Contributors Wanted!

Fire Management Today is a source of information on all aspects of fire behavior and management at Federal, State, tribal, county, and local levels. Has there been a change in the way you work? New equipment or tools? New partnerships or programs? To keep up the communication, we need your fire-related articles and photographs! Feature articles should be up to about 2,000 words in length. We also need short items of up to 200 words. Subjects of articles published in *Fire Management Today* may include:

Aviation
Communication
Cooperation
Climate Change
Ecosystem management
Equipment/Technology
Fire behavior
Fire ecology
Fire effects
Fire history
Fire science
Fire use (including prescribed fire)
Fuels management
Firefighting experiences
Incident management
Information management (including systems)
Personnel
Planning (including budgeting)
Preparedness
Prevention/Education
Safety
Suppression
Training
Weather
Wildland-urban interface

Building a Spatial Database of Fire Occurrence in Hawaii

Andrew D. Pierce and Elizabeth Pickett

Introduction

Wildfire in Hawaii is an often overlooked, yet extremely important facet of total fire protection in the State, with hundreds to thousands of wildfires burning annually (see figure 1). In Hawaii, fire suppression agencies traditionally have used widely different incident reporting formats with varying types of information and levels of detail recorded per fire event. This creates serious challenges in comprehensively mapping and identifying fire trends and emerging problems at community, county, and State levels. The Hawaii Wildfire Management Organization (HWMO) has led a multiyear, multipartner effort to build relationships among fire response agencies and resource managers, promote compatible reporting processes among fire agencies, and compile the first-ever multiagency, statewide wildfire history database.

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Elizabeth Pickett is the executive director of the Hawaii Wildfire Management Organization.

The wildfire history map produced by this effort will aid in (1) developing federally compliant community wildfire protection plans (CWPP), (2) supporting ecological research

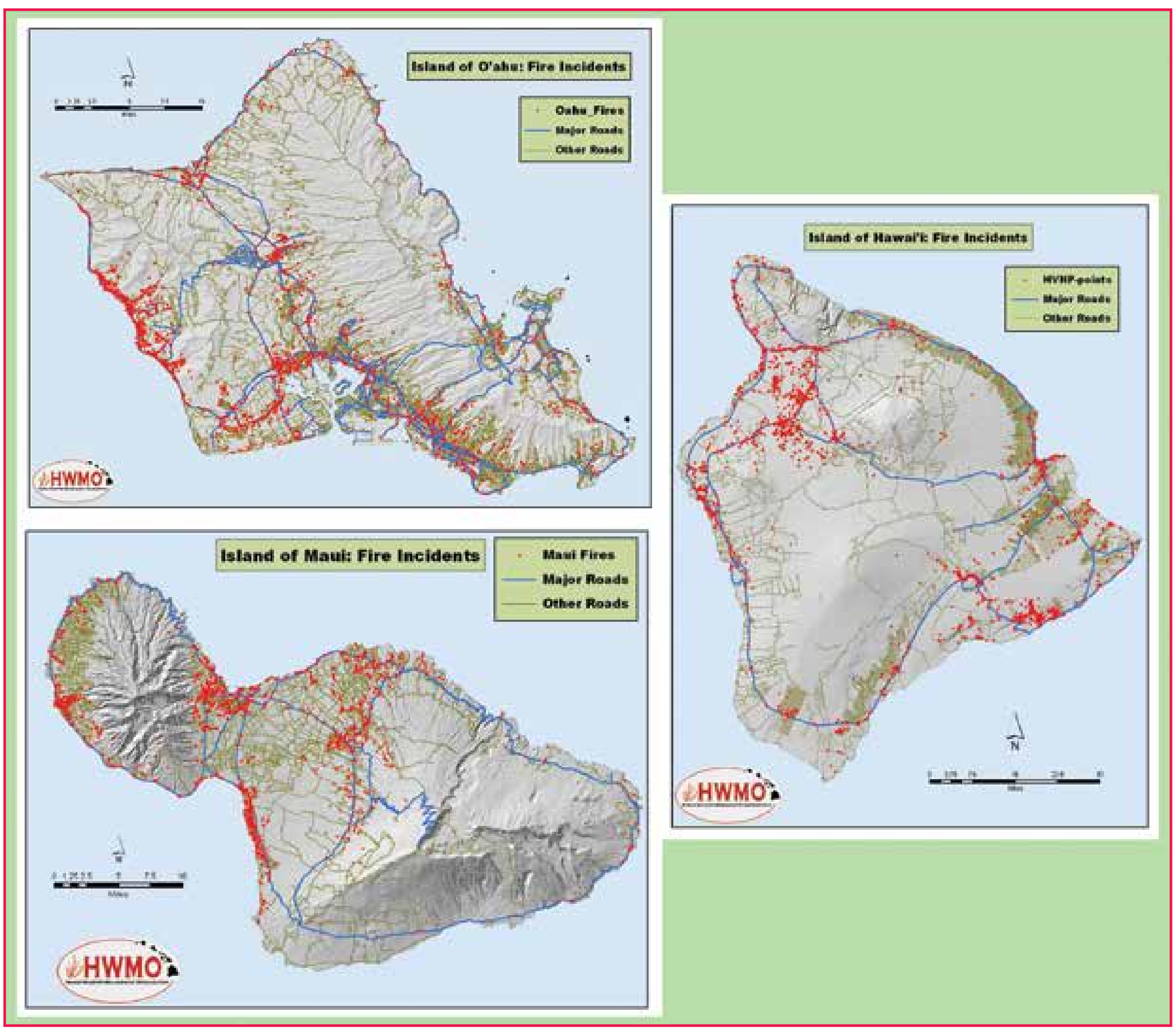

Figure 1.—*A map of three of the Hawaiian Islands shows the spatial concordance between wildfire ignitions and roads.*

to elucidate relationships between environmental and social drivers of wildfire, (3) communicating with national and local funding agencies and grantors regarding the extent and detail of fire occurrence and threat in Hawaii, (4) securing external resources to address fire issues, and (5) engaging communities in wildfire preparedness activities.

We see fire history mapping as a central tool for making advances in successful management of the wildfire threat in Hawaii. We also view this first mapping effort in Hawaii as a template for fire history work on other Pacific islands dealing with fire threats.

Assembling a fire history database involves several steps:

1. Assembling the fire history database, including securing data-sharing agreements and data, compiling a quality-controlled master list, assigning spatial location, and adding supporting spatial data that includes social and biophysical information layers;
2. Identifying data uses, including fire protection planning and fire research; and
3. Creating an efficient method for making database updates.

Completing these steps required considerable communication and coordination, analysis, and design.

Collecting Fire Record Data

Fire record data comes from a variety of sources, including all four county fire departments (Hawaii County, Maui County, Kauai County, and Honolulu City and County), the Division of Forestry and Wildlife (DOFAW) within the Hawaii Department of Land and Natural Resources (DLNR), and Hawaii Volcanoes National Park (HVNP). To our benefit, these entities encompass all county, State, and Federal fire response agencies—except for the U.S. Department of Defense, whose records are classified for security reasons. Our main tasks were to (1) secure agreements between HWMO and the participating suppression agencies to share fire event records and coordinate the logistics of record sharing, including electronic file transfers and paper record transportation; (2) transfer all records into a master list in electronic format and apply quality control measures to the list to condense duplicate fire reports submitted by multiple agencies; (3) assign spatial locations to each fire record appropriate for mapping in a geographic information system (GIS); and (4) assemble supporting biophysical and social data.

A wildfire incident burns in invasive grass-dominated drylands of west Hawaii. Photo by Eric Moller, 2011.

Securing Agreements and Data

HWMO, a 501(c)3 nonprofit organization, was the primary lead on securing the agreements and fire event records. Thanks to strong professional relationships, numerous discussions, and coordination efforts spanning 2 years, each agency provided HWMO some form of access to its records. Although many records came digitally, some databases were incomplete, requiring arrangements to review the paper source documents.

The inclusion of preferred and "if-available" data make the database as robust as possible. These data are primarily needed to help assess patterns outside of basic fire regime parameters.

Compiling a Quality Controlled Master List

The agencies delivered records in various formats. Most records were provided in digital form, but because some of the digital records were incomplete, we reviewed the paper records and added missing information. One agency's paper records were so much more precise and comprehensive than the digital records that we opted to recreate a digital record from them.

Once all records were in satisfactory digital form, we worked to normalize the information in them. For example, some records contained very specific location information and others did not, while some data fields (for example, costs, equipment, personnel, and mutual aid) were unique to a particular source and not addressed by all agencies.

We extracted common fire incident data from each database record and organized them into five main categories: occurrence date, location, response, fire behavior and effects, and weather (see table 1). Each of these categories contained essential information that was either included in the comprehensive database for all fires or entered from the written records. We deemed mandatory data absolutely necessary for the database to be usable.

We also asked agencies to include fire size with their fire records, though we had to make a determination as to what constituted a single fire incident. We reviewed data on spotting and re-ignition and combined multiple records of a single fire into a single record. Incident number information was likewise used to consolidate fire records.

The inclusion of preferred and "if-available" data makes the database as robust as possible. These data are primarily needed to help assess patterns outside of basic fire regime parameters, including agency resource commitment, fuel type, and the initial weather conditions at the time of each fire.

Assigning Spatial Location

Fire perimeter data were extremely sparse, and while many records contained latitude and longitude

Table 1.—*Fire data added to the fire record database from the individual fire reports.*

Occurrence	**Date of fire**	Response	**First station responding**
	Time of alarm		**First agency responding**
	Time of response		**Incident number**
	Date controlled		Fire name
	Time controlled		Other agencies involved
	Duration		Other stations involved
	Cause	Fire behavior and effects	**Size**
Location	**Address or location verbal description**		**Spot fire**
	Zip code		**Reignition**
	City		Fuel type
	Island		*Intensity*
	Latitude		*Rate of spread*
	Longitude		*Depth of burn*
	Coordinate system	Weather	Relative humidity at first response
	Property use		Wind speed at first response
	Shapefile of perimeter		Wind direction at first response
			Temperature at first response

Mandatory—Recorded for all fires and researched to add when needed.
Preferred—Recorded if given or if interpretable from records.
If possible—Only recorded if specifically given.

coordinates as part of their fire records, others did not. Sometimes, we had to derive such coordinates: for example, we gleaned many of the latitude and longitude coordinates from house addresses or road intersections in narrative fire descriptions or derived them from identifiable topographical features in available fire imagery.

First-responders hand-drawn maps and landowners' expert opinion provided fire perimeter data, when available. HVNP, on the other hand, provided excellent fire perimeter data due to their natural resource management focus and careful recordkeeping. Fortunately, the point locations of many small fires suffice for most spatial analyses at the county or subcounty level, and point location data for larger fires is sufficient for trend analysis. Furthermore, almost all fires had some record of size in acres, enabling nonspatial analyses of burned area trends by county or subcounty region.

Supporting Spatial Data

To support ecological research, fire adaptation studies, and mitigation planning efforts, we integrated spatial information on biological, climatological, and sociological data into the database. Each data source described below was added to a single, statewide geodatabase to allow for biophysical and sociological analysis across spatial scales.

Social Data Layers

Our social data layers included population information and road network maps. We compiled U.S. census data for 2010 at the block level for both total population and population density figures (Census Bureau 2010) and added road network maps (Office of Planning 2009) to the database as well. These data layers are expected to help identify ignition patterns in Hawaii, as lightning is rare in the islands and volcanic ignitions are currently limited to the Island of Hawaii.

> The intent of this effort was not only to characterize long-term fire history trends, but also to keep track of emerging patterns and hazardous conditions.

Biophysical Data Layers

The biophysical data layers in the database can be divided into roughly three categories: climate, topography, and current and potential vegetation. These data are useful in identifying the biophysical correlates of fire activity. We chose climate averages for this project to help assess general patterns of fire occurrence in Hawaii rather than temperature and precipitation data specific to each fire occurrence. While the latter would be more useful for identifying the drivers of variability in fire occurrence and size, the former helps us explore the as-yet-unknown general patterns of fire in Hawaii.

Our normalized climate data comprises precipitation and temperature, and we gridded these data for the entire State of Hawaii. The data come from two sources. Precipitation data are from the Rainfall Atlas of Hawaii (Giambelluca and others 2013) and are gridded monthly for average rainfall and for annual average rainfall. Temperature data for 1971–2000 (PRISM 2006) include gridded monthly and yearly average high and low temperatures.

The national elevation dataset portion of the U.S. Geological Survey's national map (USGS 2013), an online mapping resource, provided the basis for the map topography. In addition to elevation, we added slope and aspect to the database. We obtained potential vegetation and existing vegetation cover data from the LANDFIRE project (Rollins and Frame 2006).

Data Uses

Fire Protection Planning

The original intent for this project was to create a fire history database and statewide map that would enable better wildfire protection planning. Until the completion of this project, the extent and trends of wildfire occurrence in Hawaii had not been well articulated, making targeted prevention and mitigation efforts a challenge. In particular, many of the most fire-prone areas in the State have not undergone a CWPP process. HWMO and others were tasked with acquiring fire history for each CWPP on an area-by-area basis—a time-consuming and costly process that limits the number of communities that could benefit from CWPPs. Executing this statewide all-agency collection of fire history records concurrently with a separate statewide street-level hazard assessment process gives all communities in Hawaii access to the information needed to understand their wildfire-related issues, hazards, and risk, and to complete a CWPP based on accurate and complete fire occurrence data.

Fire Regime Research

The extent to which fires in Hawaii can be analyzed in a cohesive fire regime or regimes (Agee 1993) has never been ascertained, and wildfire in Hawaii outside of research on the grass-fire cycle (for example, by D'Antonio and others 2011) as a relevant landscape disturbance is rarely mentioned in the scholarly literature. A notable exception is Chu and others (2002), who correlated annual burned area and annual fire starts with the El Niño-Southern Oscillation. The major limitations of this study are its reliance on only one data source (DLNR-DOFAW) for fire information and its narrow temporal window (1976-1997). With observed drying (Chu and others 2010) and warming (Giambelluca and others 2008) of the Hawaiian Islands, it is almost certain that more areas and vegetation types in the State will be prone to fire in the future. Our database seeks to establish current fire regime parameters for the State of Hawaii, including frequency, size, yearly area burned, seasonality, and whether these parameters vary by land use or land cover, vegetation type, climate, or social factors. Given the high diversity of climate types in the State, it is our expectation that fire regime parameters will vary significantly both within and across the archipelago.

Database Limitations

Because most of the fire records were given as point locations and estimates of area burned, and because response personnel rarely mapped fire boundaries, the vast majority of the fire records are limited to point locations. Additionally, the records from each agency do not cover the same span of years, making trends and patterns useful for community use and agency planning, but less ideal for scientific analysis of data.

Database Updates

The intent of this effort was not only to characterize long-term fire history trends, but also to keep track of emerging patterns and hazardous conditions as areas are developed, drought conditions increase, and other drivers of fire emerge. To achieve the latter,

Table 2.—*Summary of fire occurrence and area burned attributes for fires added to the database. Comprehensive reporting of wildfires as differentiated from structure fires began at different times on different islands: Maui, 2000; Oahu, 2001; Kauai, 2000; Hawaii, 2004.*

Year	Maui			Kauai			Oahu			Hawaii		
	Ignitions	Area burned (ac)	Average size (ac)	Ignitions	Area burned (ac)	Average size (ac)	Ignitions	Area burned (ac)	Average size (ac)	Ignitions	Area burned (ac)	Average size (ac)
pre-2000	9	29,201	3,244.56	8	8.25	1.03	265	21,542.46	81.29	190	62,983.69	331.49
2000	139	3.1	0.02	2	5.1	2.55	2	1,300.00	650.00	5	5,358.21	1,071.64
2001	183	442	2.42	27	694.9	25.74	550	1,240.35	2.26	5	0.75	0.15
2002	138	235	1.70	7	10.9	1.56	559	2,832.10	5.07	15	4,091.93	272.80
2003	236	8,019.1	33.98	5	692.7	138.54	910	7,150.20	7.86	13	9,520.89	732.38
2004	200	981	4.91	11	209.6	19.05	541	583.00	1.08	162	2,866.69	17.70
2005	279	1,417.4	5.08	110	954.6	8.68	921	11,445.30	12.43	252	32,515.30	129.03
2006	231	8,516.3	36.87	99	288.1	2.91	551	1,736.55	3.15	243	4,094.30	16.85
2007	243	8,529.2	35.10	147	1,224.1	8.33	608	8,498.50	13.98	259	20,256.50	78.21
2008	223	3,691.97	16.56	101	141.62	1.40	382	345.32	0.90	191	4,419.70	23.14
2009	188	8,006.83	42.59	103	326.39	3.17	500	1,678.79	3.36	155	3,050.34	19.68
2010	236	7,709.17	32.67	161	178.73	1.11	507	1,745.12	3.44	240	5,570.50	23.21
2011	177	233.41	1.32	78	67.24	0.86	314	263.77	0.84	135	1,944.18	14.40
2012*	234	421.46	1.80	124	338.72	2.73	374	2,389.77	6.39	49	131.69	2.69
2013**							52	61.00	1.17			
Grand Total	**2,716**	**77,406.94**	**28.50**	**983**	**5,140.95**	**5.23**	**7,036**	**62,812.23**	**8.93**	**1,914**	**156,804.66**	**81.93**

*Data for 2012 is incomplete for Hawaii. **Data for 2013 is incomplete for Oahu.

HWMO is (1) securing records on a biannual basis of fires that have occurred since the last data collection and (2) working with agencies to shift reporting protocol toward more compatible formats (particularly in regard to location information) in order to simplify quality control and generation of location coordinates.

Informal agreements are in place with partner agencies to provide updated records. Promoting consistent—or, at least, compatible—records and uniform geographic information collection methods for fire location is proving to be complicated and time-consuming. However, the results of this first fire-history database and mapping effort have already helped articulate wildfire occurrence in Hawaii and enabled better planning and mitigation for all agencies (see table 2). For example, the degree of spatial colocation between fire ignitions and road networks was surprising (see figure 1), and it has already increased agency interest in supporting ongoing efforts to move future wildfire event-recording toward greater consistency. The Pacific Fire Exchange (PFX), a joint fire science program and knowledge exchange consortium serving Hawaii and United States-affiliated islands of the Pacific, facilitated this project by connecting HWMO and researchers. PFX will continue to support the use and development of the fire history database through local extension and outreach work performed by HWMO, the University of Hawaii at Manoa, and the Forest Service.

Acknowledgments

We appreciate the assistance of Miles Nakahara, Wayne Ching, Joe Molhoek, Eric Moller, Darren Rosario, James Kino, Robert Westerman, Jeffrey Farris, Jeffery Murray, Jay Hatayama, Lance DaSilva, Patrick Porter, Mike Ito, and David Benitez, all of whom worked with HWMO to negotiate and coordinate data sharing; Pablo Beimler, who reconciled the fire records and assisted with geolocating missing fire locations; Orlando Smith in GIS analyses and mapping; and Tom Loomis, Andrew Tarnas-Raskin, and Mark Wasser for additional project support.

Elizabeth Pickett was supported with funds awarded to HWMO via two grants from the Hawaii State Fire Assistance Wildland/Urban Interface Grant Program and by generous private donations. The Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry, provided in-kind support in office space and vehicles.

Dr. Pierce was funded by the Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry and the U.S. Army Garrison, Hawai'i; the College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa via the U.S. Department of Agriculture, National Institute of Food and Agriculture, Hatch and McIntire-Stennis Programs; and the Strategic Environmental Research and Development Program (SERDP) of the U.S. Department of Defense.

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Fire Management Today Photo Contest

In 2013, *Fire Management Today* held a photo contest in search of recent wildland fire response activities. Response to the call for images was widespread and showed both the wide range of activities and creativity on the part of photographers. We would like to thank all participants for their contributions.

Photos were judged in several categories. These were:

- Ground Resources,
- Aerial Resources,
- Prescribed Fire, and
- Miscellaneous.

Volunteer judges selected the top-rated entries from the many photos that showed the necessary work that goes into fire operations, including ground and aerial resources. ■

Photo Contest Judges

Dale Dague. Dague has worked in Fire and Aviation Management as branch director for Disaster/Emergency Operations and International Fire in the Washington Office since 2003. During his career with the Forest Service, he has served in wildland fire management positions in California and Montana prior to moving to the Washington Office. Dague has a Bachelor of Science degree in Natural Resources Management from California State Polytechnic University at San Luis Obispo.

Jason Steinmetz. Steinmetz is an emergency management specialist for Fire and Aviation Management in the Washington, DC, office of Disaster and Emergency Operations. Steinmetz began his career with the Forest Service at the age of 15 on the Wallowa-Whitman National Forest and has worked on many different aspects of wildland fire and emergency management. He has spent the last 2 years focusing on the National Incident Management System and the Incident Command System.

Kaari Carpenter. Carpenter started with the Forest Service in 1990, specializing in timber and fuels management while working on the Stanislaus, Eldorado, and Tahoe National Forests in the Pacific Southwest Region. She has been involved in fire management her entire career, including 6 years with a Type 2 Incident Management Team. She moved to Washington, DC, in 2012 as the manager of the National Fire Desk.

Photo Contest Winners

Ground Resources

Honorable Mention: *Type-6 engine, Terra Fondriest*

A type-6 engine, used as a holding resource during a prescribed burn, follows the road during a fall burn at the Buffalo National River in 2012.

1st place: *802 Air Tractor SEAT, Randall C. Thomas*

At the Coeur d' Arlene Air Tanker Base, an 802 Air tractor SEAT is being marshaled into the upper pit in 2012.

2nd place: *K13, Darko Muhic*

A Cougar helicopter of the Slovenian Air Force transports water in a helitank during firefighting operations in 2013.

3rd place: *Proficiency exercise, Randall C. Thomas*

The Alberta Rappel Crew conducts a proficiency exercise while being staged at an air tanker base.

1st place: *Holding the line, Katie Isacksen*

The Middle Fork Ranger District hand crew holds the line during a meadow restoration burn on the Willamette National Forest in 2012.

2nd place: *Wetland blacklining, James Remuzzi*

The holding crew keeps a watchful eye during a blacklining operation on a prescribed fire on a Great Dismal Swamp wetland mitigation burn in Chesapeake, VA, during 2012.

3rd place: *Habitat improvement burn, James Remuzzi*

Prescribed fire personnel use a Polaris Ranger to ignite a strip head fire for a habitat improvement burn in Rappahannock County, VA, in 2011.

Honorable Mention: *Firefighter, Terra Fondriest*

A fire crewmember at the Buffalo National River carries a drip torch and hand tool during a prescribed burn in 2012.

1st place:
Willamette National Forest meadow burn, Katie Isacksen

A tree torches during a meadow restoration burn on the Middle Fork Ranger District of the Willamette National Forest during 2012.

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